Hydrogeological & Hydrological Impact Assessment for Annesley Salt Mine

Hydrogeological & Hydrological Impact Assessment Report

Report Prepared for

Annesley Salt (Pty) Ltd

Report Number 528347

Report Prepared by

srk consulting

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Glossary

Abstraction	The act of removing groundwater from an aquifer by means of pumping from boreholes or wells.
Aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to store and transmit water; and to yield economical quantities of water to boreholes or springs. An aquifer is the storage medium from which groundwater is abstracted.
Brine	Brine is water with relatively high concentration of salt (usually sodium chloride) normally >100 000 mg/l.
Blow yield	The volume of water per unit of time blown from the borehole during drilling. Blow yield gives an indication of the rate at which groundwater can be abstracted from a borehole.
Electrical conductivity (EC)	Electrical conductivity is a measure of how well a material accommodates the transport of electric charge. The more salts dissolved in the water, the higher the EC value. It is used to estimate the amount of total dissolved salts, or the total amount of dissolved ions in the water.
Formation	A body of rock identified by lithic characteristics and stratigraphic position. Different formations have different geohydrological properties.
Fractured-rock Aquifer	Aquifers where groundwater occurs within fractures and fissures in hard-rock formations.
Groundwater	Water found in the subsurface in the saturated zone below the water table. Groundwater is a source of water and is an integral part of the hydrological system.
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.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.
Ephemeral	A water body that does not flow or contain water year-round, in response to seasonal rainfall and run-off.
Fauna	The collective animals of a particular region, habitat or geological period.
Feasibility study	The determination of the technical and financial viability of a proposed project.
Fossil	Rare objects that are preserved due to unusual circumstances.
Flora	The collective plants of a particular region, habitat or geological period.
Geohydrology	The study of the character, source and mode of occurrence of groundwater
Hydrogeology	In South Africa the term geohydrology and hydrogeology are used interchangeably. In theory hydrogeology is the study of geology from the perspective of its role and influence in hydrology, while geohydrology is the study of hydrology from the perspective of the influence on geology.
Hydrology	(The study of) surface water flow.
Intergranular Aquifer	Aquifers where groundwater is contained in original intergranular interstices of sedimentary and weathered formations.

pH	pH is the negative logarithm of the hydrogen ion concentration in solution. pH is the measure of the acidity or alkalinity of a solution.
Saline Water	Water that is generally considered unsuitable for human consumption or for irrigation because of its high content of dissolved solids.
Sustainable yield/ Safe yield	Safe yield is defined as the maximum rate of withdrawal that can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head or deterioration in water quality in the aquifer.
Perennial river	A river that flows year-round
Water table	The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is equal to that of the atmosphere. It marks the top of the groundwater body.
Transmissivity	The rate at which groundwater flows horizontally through an aquifer.

Acronyms and Abbreviations

DWAF	Department of Water Affairs and Forestry (now DWS)
DWS:	Department of Water and Sanitation
EC:	electrical conductivity
h:	hour
L/s:	litres per second
m/s	Metres per second
m^3/a:	cubic metres per annum
m^3/d:	cubic metres per day
m^3/h:	cubic metres per hour
m^3/m:	cubic metres per month
mbc:	metres below collar
mbgl:	metres below ground level
mm:	millimetres
mS/m:	milli-Siemens per metre

1 Introduction

1.1 Appointment

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by Annesley Salt (Pty) Ltd to pump test three water supply boreholes, and conduct hydrogeological and hydrological impact assessments in support of the Water Use License Application (WULA) for the proposed mining of salt on a portion of the Remainder of the Farm Annesley no. 338 in the Kalahari West, Northern Cape.

1.2 Background

The proposed salt mine is situated on a portion of the farm known as the Remainder of the Farm Annesley no. 338, which is located approximately 120 km north of Upington, and approximately 35 km southwest of Noenieput, in the Northern Cape Province.

The site is located in Bloupan at latitude -27.588867^{o} and longitude 20.489743^{o}, and extends over an area of 100 ha. The site locality is shown in Figure 1-1.

According to the information provided by Annesley Salt, highly saline groundwater (brine) will be abstracted from three existing boreholes at the salt pan and pumped to ten 100 m x 60 m evaporation ponds (0.6 ha each), from where the salt will be cyclically harvested six times a year (see breakdown of harvest cycles in Table 1-1). The proposed salt mine requires *c*.17 550 m^3 of brine per harvest cycle, which equates to 105 300 m^3 of total brine abstracted over a period of nine months per annum (i.e. over *c*.285 days per annum). This equates to an average abstraction rate of 370 m^3/d, i.e. *c*.15.42 m^3/h, or *c*.4.28 L/s. Salt is not harvested during the cold winter months from 31 May to 20 August, as the evaporation rate is too low for good quality salt crystals to form; hence, no water is abstracted from the boreholes during this period.

The proposed abstraction will be fractionally divided between the three boreholes depending on the yield, i.e. abstraction of *c*.14 m^3/h from boreholes HN1 and HN2, and 4.5 m^3/h from borehole HN3.

Table 1-1: Estimated cyclical and annual groundwater demand of the proposed salt mine

Harvest Cycle	Period	Duration (Weeks)	Description	Abstraction (Litres)
1	21 Aug to 2 Oct	6	Pump 14 000 L/h x 24 h/day for 2 days (21 & 22 Aug) = 672 000 L x 2 boreholes (HN1 and HN2)	1 344 000
			Pump 4 500 L/h x 24 h/day for 2 days (21 & 22 Aug) = 216 000 L x 1 boreholes (HN3)	216 000
			Pump 14 000 L/h x 12 h/day for 41 days (from 23 Aug to 2 Oct) = 6 888 000 L x 2 boreholes (HN1 and HN2)	13 776 000
			Pump 4 500 L/h x 12 h/day for 41 days (from 23 Aug to 2 Oct) = 2 214 000L x 1 boreholes (HN3)	2 214 000
			Rest boreholes for 5 days from 3 to 7 Oct while harvesting the salt	0
			Total abstraction for harvest cycle 1	**17 550 000**
2	8 Oct to 19 Nov	6	Pump 14 000 L/h x 24 h/day for 2 days (8 & 9 Oct) = 672 000 L x 2 boreholes (HN1 and HN2)	1 344 000
			Pump 4 500 L/h x 24 h/day for 2 days (8 & 9 Oct) = 216 000 L x 1 boreholes (HN3)	216 000
			Pump 14 000 L/h x 12 h/day for 41 days (from 10 Oct to 19 Nov) = 6888000 L x 2 boreholes (HN1 and HN2)	13 776 000
			Pump 4 500 L/h x 12 h/day for 41 days (from 10 Oct to 19 Nov) = 2 214 000 L x 1 boreholes (HN3)	2 214 000
			Rest boreholes for 5 days from 20 to 24 Nov while harvesting the salt	0
			Total abstraction for harvest cycle 2	**17 550 000**

Harvest Cycle	Period	Duration (Weeks)	Description	Abstraction (Litres)
3	25 Nov to 6 Jan	6	Pump 14 000 L/h x 24 h/day for 2 days (25 & 26 Nov) = 672 000 L x 2 boreholes (HN1 and HN2)	1 344 000
			Pump 4 500 L/h x 24 h/day for 2 days (25 & 26 Nov) = 216 000 L x 1 boreholes (HN3)	216 000
			Pump 14 000 L/h x 12 h/day for 41 days (from 27 Nov to 6 Jan) = 6888000 L x 2 boreholes (HN1 and HN2)	13 776 000
			Pump 4 500 L/h x 12 h/day for 41 days (from 27 Nov to 6 Jan) = 2 214 000 L x 1 boreholes (HN3)	2 214 000
			Rest boreholes for 5 days from 7 to 11 Jan while harvesting the salt	0
			Total abstraction for harvest cycle 3	**17 550 000**
4	12 Jan to 23 Feb	6	Pump 14 000 L/h x 24 h/day for 2 days (12 & 13 Jan) = 672 000 L x 2 boreholes (HN1 and HN2)	1 344 000
			Pump 4 500 L/h x 24 h/day for 2 days (12 & 13 Jan) = 216 000 L x 1 boreholes (HN3)	216 000
			Pump 14 000 L/h x 12 h/day for 41 days (from 14 Jan to 23 Feb) = 6888000 L x 2 boreholes (HN1 and HN2)	13 776 000
			Pump 4 500 L/h x 12 h/day for 41 days (from 14 Jan to 23 Feb) = 2 214 000 L x 1 boreholes (HN3)	2 214 000
			Rest boreholes for 5 days from 24 to 28 Feb while harvesting the salt	0
			Total abstraction for harvest cycle 4	**17 550 000**
5	1 Mar to 12 Apr	6	Pump 14 000 L/h x 24 h/day for 2 days (1 & 2 Mar) = 672 000 L x 2 boreholes (HN1 and HN2)	1 344 000
			Pump 4 500 L/h x 24 h/day for 2 days (1 & 2 Mar) = 216 000 L x 1 boreholes (HN3)	216 000
			Pump 14 000 L/h x 12 h/day for 41 days (from 3 Mar to 12 Apr) = 6888000 L x 2 boreholes (HN1 and HN2)	13 776 000
			Pump 4 500 L/h x 12 h/day for 41 days (from 3 Mar to 12 Apr) = 2 214 000 L x 1 boreholes (HN3)	2 214 000
			Rest boreholes for 5 days from 13 to 17 Apr while harvesting the salt	0
			Total abstraction for harvest cycle 5	**17 550 000**
6	18 Apr to 30 May	6	Pump 14 000 L/h x 24 h/day for 2 days (18 & 19 Apr) = 672 000 L x 2 boreholes (HN1 and HN2)	1 344 000
			Pump 4 500 L/h x 24 h/day for 2 days (18 & 19 Apr) = 216 000 L x 1 boreholes (HN3)	216 000
			Pump 14 000 L/h x 12 h/day for 41 days (from 20 Apr to 30 May) = 6888000 L x 2 boreholes (HN1 and HN2)	13 776 000
			Pump 4 500 L/h x 12 h/day for 41 days (from 20 Apr to 30 May) = 2 214 000 L x 1 boreholes (HN3)	2 214 000
			Rest boreholes for 5 days from 31 May to 4 June while harvesting the salt	0
			Total abstraction for harvest cycle 6	**17 550 000**
Estimated Total Abstraction per Year				**105 300 000**
Estimated Total Abstraction per Year in m^3				**105 300**

1.3 Scope of Work

As no detailed Scope of Work (SoW) was provided, SRK proposed the following SoW, which was accepted by the client:

Hydrogeology

- Collate available geohydrological information for the site;
- Assess the aquifer vulnerability and geohydrological impacts related to groundwater abstraction at the salt mine;
- Conduct step, 24-hour constant discharge (CDT) and recovery tests on three existing boreholes at the site earmarked for water supply; and
- Analyse the data and compile a basic hydrogeological impact report (this report).

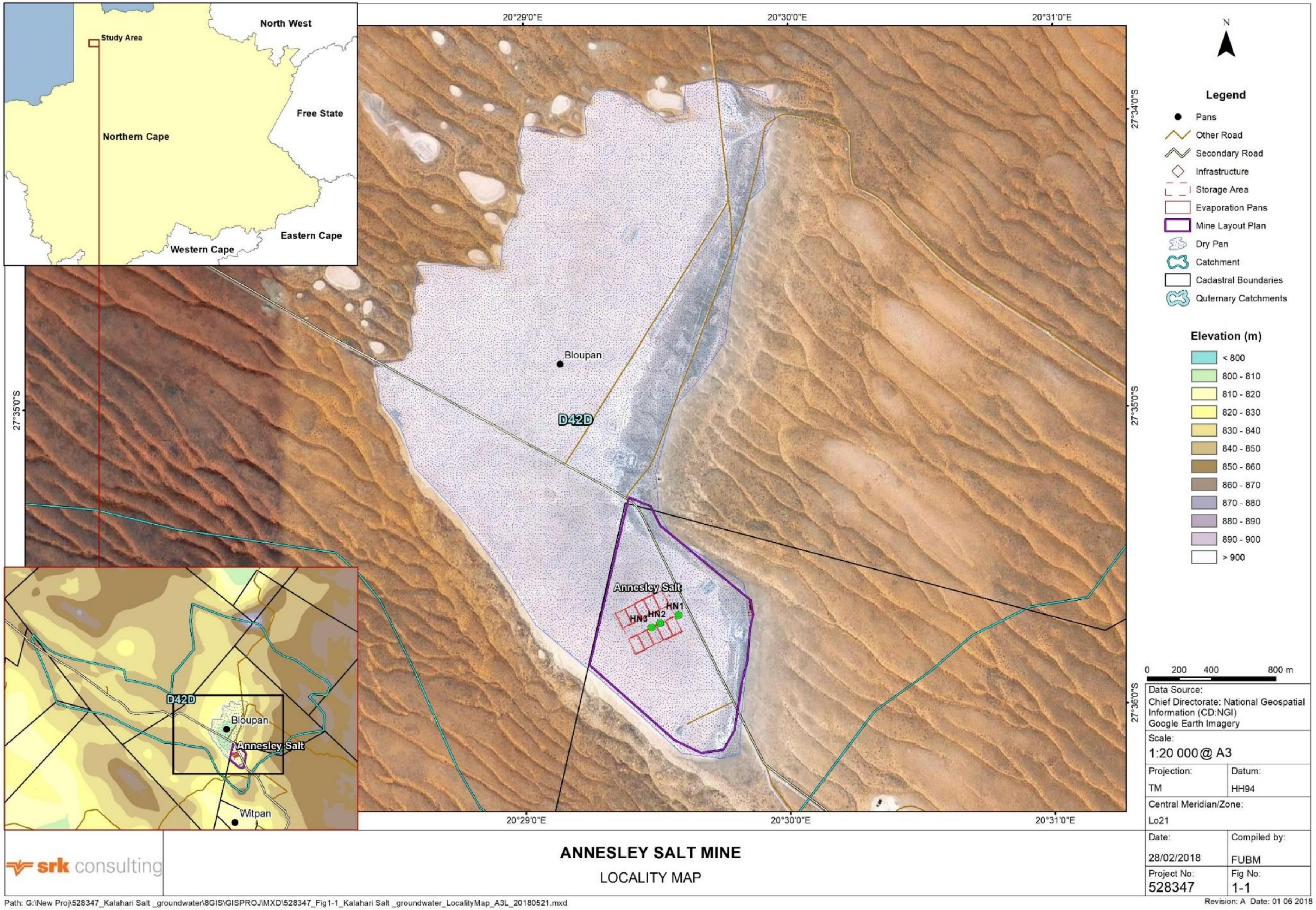
Hydrology

- Collate and analyse available hydrological information for the site including catchment characteristics, rainfall and design rainfall data;
- Review information on proposed activities, relevant historical reports and photographs of the site;
- Delineate the salt pan's catchment, morphology etc.;
- Conduct a basic hydrological impact assessment;
- Propose mitigation measures;
- Analyse the data and compile a basic hydrological impact report (this report).

1.4 Water uses

The following legislative water use framework applies:

- Section 21(a) of the National Water Act: Taking water from a water resource. This is due the abstraction of hypersaline groundwater for salt mining.
- Section 21(b) of the National Water Act: Storing of water. This is due to the fact that water will be stored temporarily in the evaporation ponds.
- Section 21(c) of the National Water Act: Impeding or diverting the flow of water in a watercourse. This is due to the fact that the natural flow of water, in the unlikely event that a very large rainfall event occurs and fills the salt pan, might be impeded by the evaporation dams.
- Section 21(i) of the National Water Act: Altering the beds, banks and characteristics of a watercourse. The increase in salt due to evaporation might impact the water quality in the salt pan and thus its 'characteristics'. The structure of the evaporation dams will also alter the bed of the watercourse and vehicles accessing the site may alter the banks.
- Section 21(g) of the National Water Act: Disposing of waste in a manner that may detrimentally impacts on a water resource. The Evaporation ponds are not lined and hence the dams may change the concentration of salt in the groundwater. Similarly, during rainfall events the concentration of salt in the surface water may be different than it would otherwise have been.


North West
Study Area
Free State
Northern Cape
Eastern Cape
Western Cape
20°29'0"E
20°30'0"E
20°31'0"E
27°34'0"S
27°35'0"S
27°36'0"S
Bloupan
D42D
Annesley Salt
HN1
HN2
HN3
Witpan
N
Legend
Pans
Other Road
Secondary Road
Infrastructure
Storage Area
Evaporation Pans
Mine Layout Plan
Dry Pan
Catchment
Cadastral Boundaries
Quternary Catchments
Elevation (m)
< 800
800 - 810
810 - 820
820 - 830
830 - 840
840 - 850
850 - 860
860 - 870
870 - 880
880 - 890
890 - 900
> 900
0 200 400 800 m
Data Source:
Chief Directorate: National Geospatial Information (CD:NGI)
Google Earth Imagery
Scale:
1:20 000@ A3
Projection: TM
Datum: HH94
Central Meridian/Zone: Lo21
Date: 28/02/2018
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ANNESLEY SALT MINE
LOCALITY MAP
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2 Hydrogeology

2.1 Desk study

Bedrock at the site consists of tillite and shale of the Dwyka Group, belonging to the Karoo Supergroup (Council for Geoscience, 1988). The rocks of the Dwyka Group are covered by calcrete (Photo 2-1) and dune sand (Photo 2-2) of the Gordonia Formation of the Kalahari Group (Figure 2-1).

Photo 2-1: Dwyka rock terraces occurring along the edges of Bloupan with calcrete along the centre of the pan.

Photo 2-2: Minor vegetation cover on the sand dunes during the dry seasons.

Groundwater is found in the weathered fractured-rock aquifers of the Dwyka Group tillite and shale (Dwyka Aquifer). According to the Department of Water and Sanitation's (DWS) 1:500 000 geohydrological map sheet 2718, Upington/Alexander Bay, the site's median borehole yield is classified as B3, where between 0.5 and 2.0 L/s can be expected (Figure 2-2).

The site is located within Quaternary catchment D42D. This catchment is listed under Zone A of the Groundwater Taking Zones in the Revision of General Authorisations (GA) in Terms of Section 39 of the National Water Act, 1998 (DWAF 2004 & 2012). For Zone A, no water may be taken under GA except as set out under Schedule 1[1] (DWS, 2016).

The groundwater storage and resource potential of Quaternary catchment D42D was derived from the DWS, national groundwater resource assessment phase 2 (GRA2) dataset (DWAF, 2005). As boreholes cannot harvest all the available recharge in an area, an exploitability factor (DWA IF, 2005) was used to calculate the volume of groundwater that can actually be abstracted from boreholes (i.e. the utilisable exploitation potential). Reported abstraction was subtracted from this calculated value to determine the utilisable groundwater exploitation potential of the catchment. These calculated values are summarised in Table 2-1.

[1] Not taking more than 10 cubic metres from groundwater on any given day.

Table 2-1: Groundwater storage and resource potential of Quaternary catchment D42D

Drainage Region	Extent (km^2)	Volume of Water stored in Aquifer (m^3)	5m Drawdown Storage Volume (m^3)	Est. Abstraction (m^3/a)	Mean Potential Recharge (m^3/a)	Mean Groundwater Resource Potential (m^3/a)	Mean Utilisable Groundwater Exploitation Potential (m^3/a)
D42D	16 209	6 089 570 000	317 942 000	789 589	12 296 920	15 119 884	15 010 500

The GRA2 data indicates that Quaternary catchment D42D has an estimated mean potential recharge of approximately *c*.12.3 million cubic metres per annum (Mm^3/a) and an utilisable groundwater exploitation potential (UGEP) of *c*.15 Mm^3/a. The potential volume of water stored in the D42D aquifers is estimated at *c*.6 089.6 Mm^3.

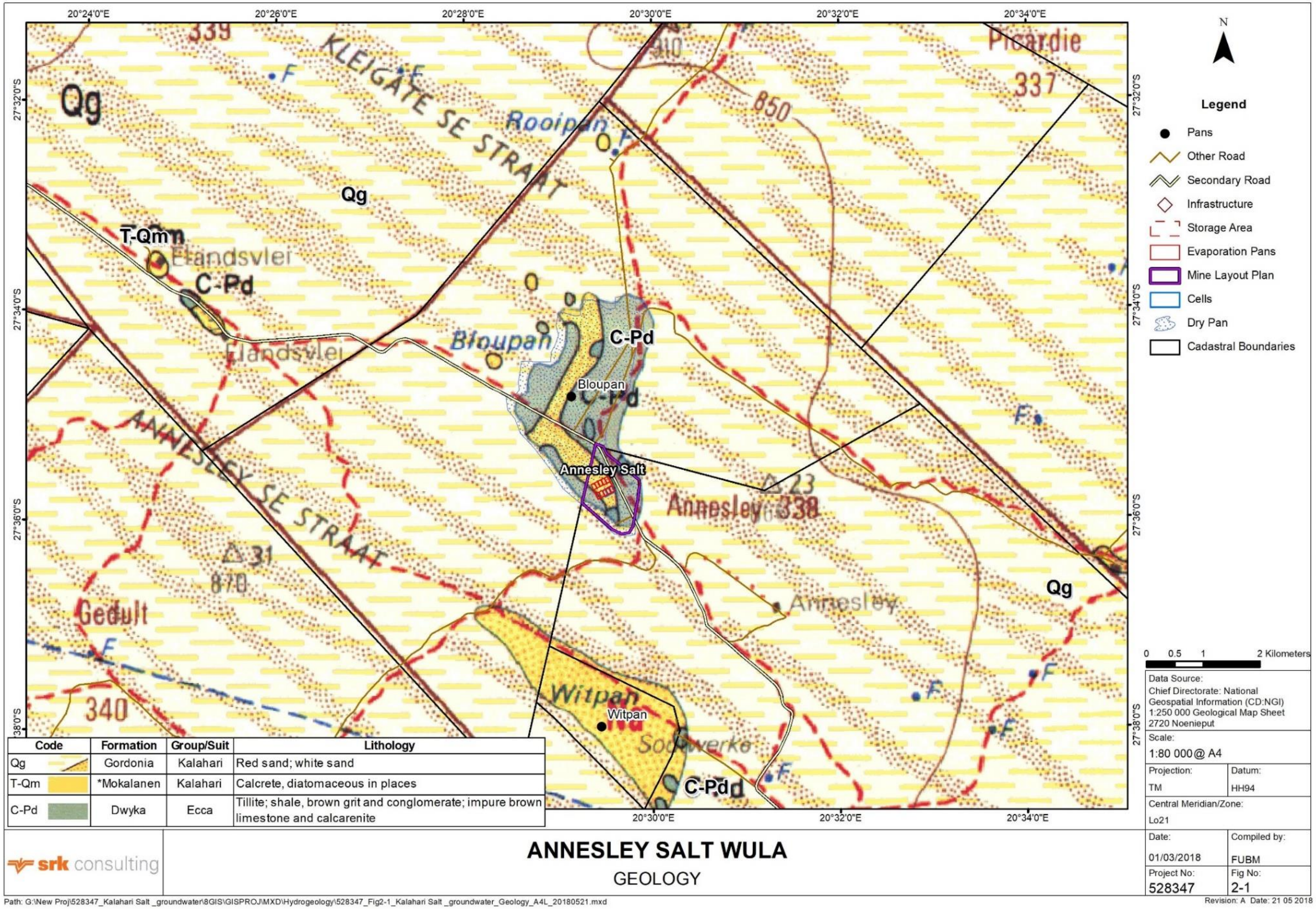
In comparison, the annual water demand of Annesley Salt proposed salt mine is 105 300 m^3/a, which equates to *c*.0.7 % of UGEP and <0.002 % of aquifer storage. This demand will be obtained from three existing boreholes located in the salt mining area (Figure 2-3), with abstraction spreading over six harvest cycles (six weeks each) during the warmer months of the year, i.e. pumping for approximately nine months per annum, with an average abstraction of *c*.14 m^3/h from NH1 and NH2, and *c*.4.5 m^3/h from borehole NH3.

A total 258 859 m^3/a of groundwater is registered on the DWS [2]database by 14 water users in Quaternary catchment D42D, which equates to *c*.1.7 % of UGEP and *c*.0.004 % of aquifer storage (see Appendix A for information received from the DWS). Of this registered amount, 254 359 m^3/a is registered for mining use, presumably for salt mining.

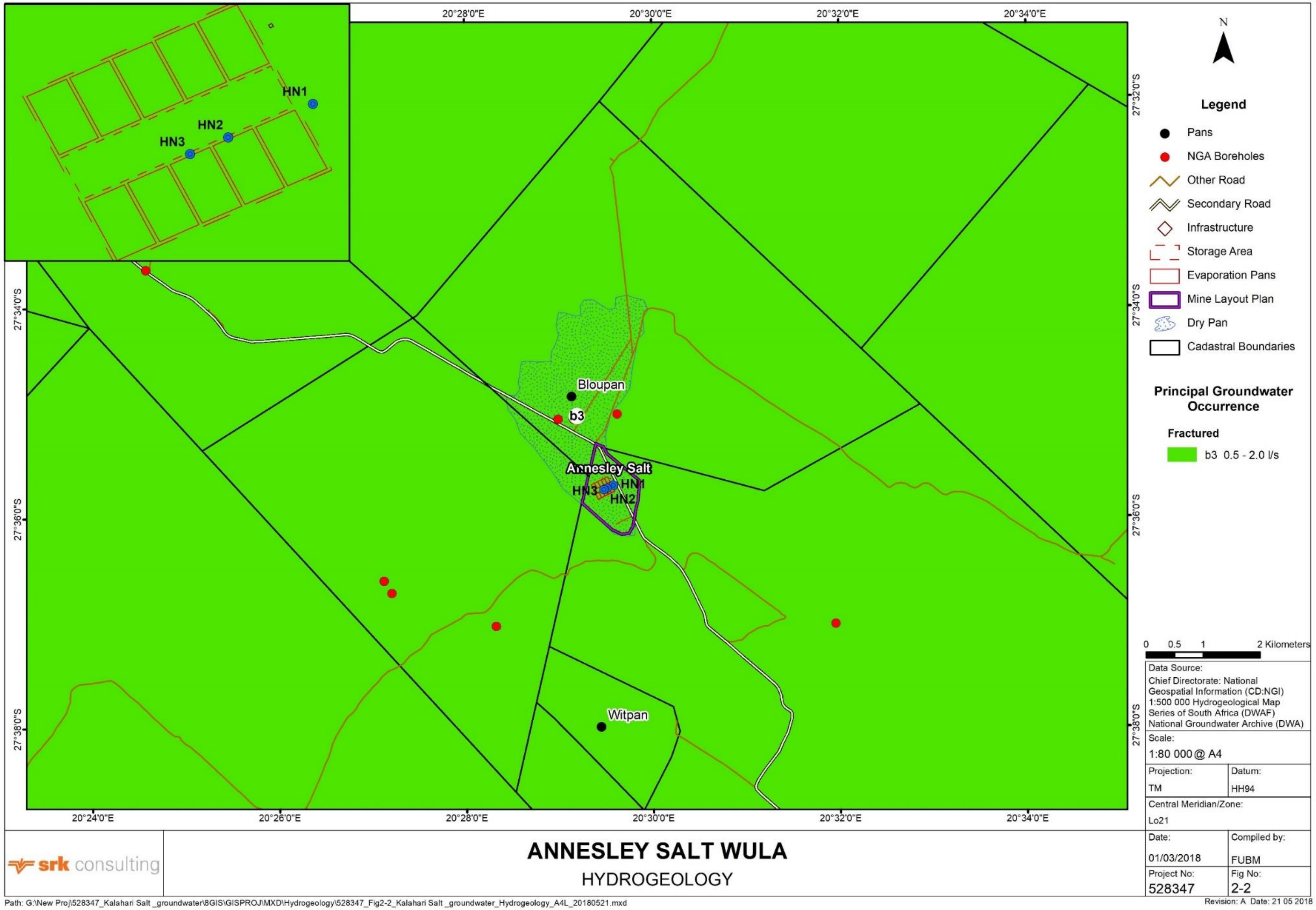
Should a WUL be granted to Annesley Salt for the proposed abstraction, the combined abstraction from the brine aquifer in Quaternary catchment D42D will amount to *c*.364 159 m^3/a, which equates to 2.43 % of UGEP and *c*.0.006 % of aquifer storage.

Based on the available groundwater information, and the above comparisons, it can be concluded that there is more than adequate brine/groundwater available in the Quaternary catchment D42D aquifers to satisfy the water demand of the existing registered users and Annesley Salt's proposed new salt mine at Bloupan.

[2] 2016 Database



Code	Formation	Group/Suit	Lithology
Qg	Gordonia	Kalahari	Red sand; white sand
T-Qm	*Mokalanen	Kalahari	Calcrete, diatomaceous in places
C-Pd	Dwyka	Ecca	Tillite; shale, brown grit and conglomerate; impure brown limestone and calcarenite



HN1
HN2
HN3
20°28'0"E
20°30'0"E
20°32'0"E
20°34'0"E
27°32'0"S
27°34'0"S
27°36'0"S
27°38'0"S
Bloupan
b3
Annesley Salt
Witpan
20°24'0"E
20°26'0"E
N
Legend
Pans
NGA Boreholes
Other Road
Secondary Road
Infrastructure
Storage Area
Evaporation Pans
Mine Layout Plan
Dry Pan
Cadastral Boundaries
Principal Groundwater Occurrence
Fractured
b3 0.5 - 2.0 l/s
0 0.5 1 2 Kilometers
Data Source:
Chief Directorate: National Geospatial Information (CD:NGI)
1:500 000 Hydrogeological Map Series of South Africa (DWAF)
National Groundwater Archive (DWA)
Scale:
1:80 000 @ A4
Projection: TM
Datum: HH94
Central Meridian/Zone: Lo21
Date: 01/03/2018
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Project No: 528347
Fig No: 2-2
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ANNESLEY SALT WULA
HYDROGEOLOGY
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2.2 Existing boreholes information

Information on existing boreholes for a 10 km radius around the site was downloaded from the DWS National Groundwater Archives (NGA). The information for these boreholes is summarised in Table 2-3 and their positions are shown in Figure 2-3. All seven NGA boreholes are listed as abandoned.

Annesley Salt is planning to use three existing boreholes in their mining area on the salt pan to abstract 105 300 m^3/a of brine from the Dwyka Aquifer for the proposed new salt mine. See subsection 1.2 for details on the anticipated water demand. The details for these three boreholes are summarised in Table 2-2 and their positions shown in Figure 2-2 and Figure 2-3.

Table 2-2: Summary of available information for the Annesley Salt boreholes

Borehole ID	Latitude	Longitude	Depth (m)	Casing	Collar Height (magl)	Rest Water Level (mbgl)	Notes
Bloupan-HN1	S27.595694°	E20.491222°	26.8	uPVC		1.90	Existing borehole
Bloupan-HN2	S27.595461°	E20.491748°	35.5	uPVC		1.88	Existing borehole
Bloupan-HN3	S27.595417°	E20.494722°	46.6	uPVC		2.13	Existing borehole

The water table below the mine site is shallow, ranging from 1.88 to 2.13 mbgl. Seasonal water level variation (particularly during high rainfall periods) at the site is unknown.

2.3 Borehole pumping test results

AB Pumps carried out test pumping of the three boreholes, Bloupan-HN1, -HN2 and -HN3, in March 2018. The positions of these boreholes is indicated in Figure 2-2.

The test pumping data sheets and water level graphs are included in Appendix B, whilst the borehole information and test results for each borehole is summarised in the subsections below and in Table 2-4.

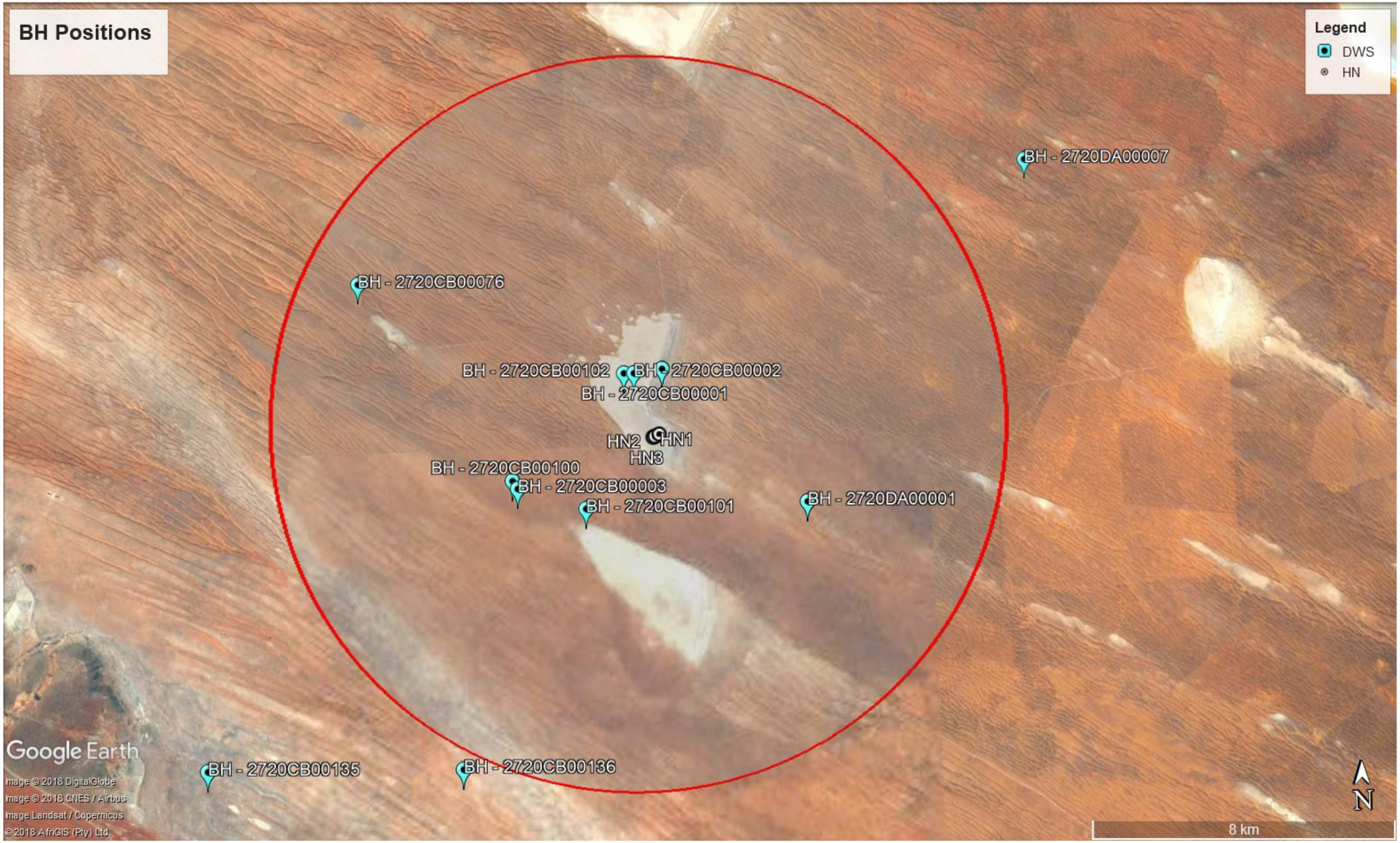
The pumping tests included four by 1 hr step drawdown tests and 24 h constant discharge tests with subsequent recovery monitoring after each test. The purpose of the step-tests was to establish the efficiency of a single borehole, and to provide preliminary information on the yield of the borehole (both from a quantitative and qualitative perspective). The purpose of the constant discharge test was to determine the hydraulic properties of the aquifer adjacent to the tested borehole and to investigate, identify and characterise nearby hydraulic boundaries. These data, together with the recovery test results, were used to determine the optimal and safe yield and pumping schedule for the borehole.

Borehole Bloupan-HN1 is located at latitude S27.595694° and longitude E20.491222°. The borehole is 26 m deep, and the test pump was installed at 18.5 mbgl. The pre-pumping water level was 1.90 mbgl. The test data and associated hydrographs are included in Appendix B.

Table 2-3: Summary of the NGA borehole information within a 10 km radius of Annesley Salt

Geosite ID	Type	Latitude	Longitude	Elevation (mamsl)	Farm	Depth	Water Level (mbgl)	Date measured	EC (mS/m)	pH	Status
2720BD00004	Borehole	-27.36424	20.90065	840	Goeboe Goeboe 251/59	-	-	-	-	-	Abandoned
2720BD00001	Borehole	-27.35396	20.89509	860	Goeboe Goeboe 251/59	108	-	-	-	-	Abandoned
2720BD00005	Borehole	-27.35368	20.92093	870	Goeboe Goegoe 251/59	-	-	-	-	-	Abandoned
2720BD00029	Borehole	-27.35313	20.90482	870	Goeboe Goeboe 251/59	132	-	-	-	-	Abandoned
2720BD00002	Borehole	-27.35174	20.90898	870	Goeboe Goeboe 251/59	132	-	-	-	-	Abandoned
2720BD00006	Borehole	-27.33091	20.77565	850	Vrysoutpan 251/58	162	-	-	-	-	Abandoned
2720BD00003	Borehole	-27.29618	20.92149	870	Goeboe Goeboe 251/59	177	44.5	01/01/1982	5410	7.6	Abandoned

- = No information available



srk consulting	**Annesley Salt WULA** Google Earth Image Showing Borehole Positions	Project No. 528347

Figure 2-3: Google Earth image showing borehole positions within a 10 km radius of Annesley Salt

Borehole Bloupan-HN2 is located at latitude S27.595461° and longitude E20.491748°. The borehole is 35.5 m deep, and the test pump was installed at 30.5 mbgl. The pre-pumping water level was 1.88 mbgl. The test data and associated hydrographs are included in Appendix B.

Borehole Bloupan-HN3 is located at latitude S27.595417° and longitude E20.494722°. The borehole is 46.6 m deep, and the test pump was installed at 42.5 mbgl. The pre-pumping water level was 2.13 mbgl. The test data and associated hydrographs are included in Appendix B.

The pumping test results for the three boreholes are summarised in Table 2-4. The influence of pumping on the water level of each borehole is graphically presented in Appendix B.

Table 2-4: Summary of pumping test results

Description	Borehole ID		
	Bloupan-HN1	**Bloupan-HN2**	**Bloupan-HN3**
Pre-pumping rest water level	1.62 mbgl	1.41 mbgl	1.47 mbgl
Pump intake depth	17.80 mbgl	30.03 mbgl	41.84 mbgl
Available drawdown before pump suction	16.18 m	28.62 m	40.37 m
Step 1: Drawdown @ pumping rate	0.21 m @ 0.66 L/s	0.18 m @ 0.82 L/s	0.71 m @ 0.83 L/s
Step 2: Drawdown @ pumping rate	0.37 m @ 1.21 L/s	0.26 m @ 1.59 L/s	1.25 m @ 1.48 L/s
Step 3: Drawdown @ pumping rate	0.95 m @ 3.05 L/s	0.76 m @ 3.41 L/s	9.78 m @ 3.27 L/s
Step 4: Drawdown @ pumping rate	3.54 m @ 6.38 L/s	2.06 m @ 6.64 L/s	39.03 m @ 5.56 L/s
Step 5: Drawdown @ pumping rate	14.86 m @ 10.14 L/s	4.97 m @ 11.20 L/s	-
Pump suction occurring	5 min into Step 5	-	7 min into Step 4
Pumping rate during pump suction	9.67 L/s	-	3.48 L/s
Recovery deficit after pump switch-off	0.01 m after 110 min	0 m after 70 min	0 m after 70 min
CDT pumping rate and duration	6.17 L/s for 24 h	8.23 L/s for 24 h	2.76 L/s for 24 h
Maximum drawdown at end of CDT	3.94 m	3.63 m	7.21 m
Recovery deficit after pump switch-off	0 m after 24 h	0 m after 16 h	0 m after 3 h
% Recovery	100%	100%	100%
Step duration = 60 min each			

Both boreholes HN1 and HN2 have good yields, whilst borehole HN3 has a moderate yield in comparison. The yields of all three boreholes are, however, considered as good for this area. Recovery was rapid, with full recovery occurring within 3 to 24h of pump shutdown. This is indicative of a large, well developed fractured-rock aquifer.

To estimate optimum pumping rates, pumping schedules and aquifer parameters, the test pumping data were analysed by means of an Excel based software package developed by Van Tonder *et al* (2002). In the software package, various methods such as the Flow Characteristic method (FC-method), porous aquifer solutions (Theis and Cooper-Jacob methods), fractional pumping test analysis (Barkers Generalised Radial Flow Model), and the recovery method were used to estimate a risk-based sustainable yield for the borehole. In addition, aquifer parameters such as transmissivity (T) and the storage coefficient (S) were determined. In the FC-Analysis the following aquifer input parameters were used:

- Effective recharge of 0 mm per annum.
- Data were extrapolated for 30 years.

- In calculating the 'safe' yield of Bloupan-HN1, HN2, and HN3 the following was allowed for:
  - Abstraction of *c*.93 300 m³/a from both boreholes HN1 and HN2 at an average pumping rate of 3 L/s. The boreholes are c.130 m apart;
  - Abstraction of *c*.31 100 m³/a from HN3 which is *c*.50 m away from HN2 at an average pumping rate of 1 L/s.

Summaries of the results and recommended management options for the three boreholes are presented in Table 2-5, Table 2-6, and Table 2-7.

Table 2-5: Recommended management options for borehole Bloupan-HN1

Summary		Main	BH HN1				
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m²/d)	Late T (m²/d)	S	AD used
☑	Basic FC	2.66	1.41	216	41.7	2.75E-03	15.0
☐	Advanced FC						
☐	FC inflection point						
☑	Cooper-Jacob	4.06	2.63		108.7	1.04E-03	15.0
☑	FC Non-Linear	3.47	3.06		152.0	1.00E-03	15.0
☑	Recovery	3.22					
☑	Barker	3.92	3.00	K_f = 75	S_s =	1.00E-03	15.0
	Average Q_sust (l/s)	3.47	0.57	b = 1.32	Fractal dimension n =	2.09	

Recommended abstraction rate (L/s)		3.00	for 24 hours per day
Hours per day of pumping	12	4.24	L/s for 12 hours per day

Amount of water allowed to be abstracted per month	7776	m³
Amount of water allowed to be abstracted per day	256	m³
Borehole could satisfy the basic human need of		persons
Is the water suitable for domestic use (Yes/No)	N	

Recommended pump depth below surface (m)	20
Total Casing length	Unknown
Blow yield (l/s)	Unknown
Critical pumping depth that water level must not exceeded (mbgl)	17
Depth of borehole (m)	26.8
Rest water level (mbgl)	1.62

Management recommendations

Pumping Rate for 24 hr/day schedule	3.00 L/s
Pumping Rate for 12 hr/day schedule	4.00 L/s

Table 2-6: Recommended management options for borehole Bloupan-HN2

Summary | Main | **BH HN2**

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
☑	Basic FC	4.81	1.36	268	420.8	3.30E-03	5.0
☐	Advanced FC						
☐	FC inflection point						
☑	Cooper-Jacob	2.71	1.75		336.9	2.19E-06	5.0
☑	FC Non-Linear	3.72	3.28		412.0	1.01E-03	5.0
☑	Recovery	4.94					
☑	Barker	4.82	1.32	K_f = 575	S_s =	3.30E-04	5.0
	Average Q_sust (l/s)	4.20	0.97	b = 0.18	Fractal dimension n =	2.14	

Recommended abstraction rate (L/s)		3.00	for 24 hours per day
Hours per day of pumping	12	4.24	L/s for 12 hours per day

Amount of water allowed to be abstracted per month	7776	m^3
Amount of water allowed to be abstracted per day	256	m^3
Borehole could satisfy the basic human need of		persons
Is the water suitable for domestic use (Yes/No)	N	

Recommended pump depth below surface (m)	20
Total Casing length	Unknown
Blow yield (l/s)	Unknown
Critical pumping depth that water level must not exceeded (mbgl)	17
Depth of borehole (m)	35.3
Rest water level (mbgl)	1.41

Management recommendations

Pumping Rate for 24 hr/day schedule 3.00 L/s
Pumping Rate for 12 hr/day schedule 4.00 L/s

Table 2-7: Recommended management options for borehole Bloupan-HN3

Summary | Main | **BH HN3**

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
☑	Basic FC	0.72	0.31	21	20.5	1.65E-03	10.0
☐	Advanced FC						
☐	FC inflection point						
☑	Cooper-Jacob	0.19	0.13		26.1	1.44E-03	10.0
☑	FC Non-Linear	0.57	0.50		104.0	1.01E-03	10.0
☑	Recovery	2.50					
☑	Barker	0.88	0.46	K_f = 15	S_s =	2.00E-03	10.0
	Average Q_sust (l/s)	0.97	0.89	b = 0.83	Fractal dimension n =	2.22	

Recommended abstraction rate (L/s)		1.00	for 24 hours per day
Hours per day of pumping	12	1.41	L/s for 12 hours per day

Amount of water allowed to be abstracted per month	2592	m^3
Amount of water allowed to be abstracted per day	85	m^3
Borehole could satisfy the basic human need of		persons
Is the water suitable for domestic use (Yes/No)	N	

Recommended pump depth below surface (m)	20
Total Casing length	Unknown
Blow yield (l/s)	Unknown
Critical pumping depth that water level must not exceeded (mbgl)	17
Depth of borehole (m)	42.5
Rest water level (mbgl)	1.47

Management recommendations

Pumping Rate for 24 hr/day schedule 1.00 L/s
Pumping Rate for 12 hr/day schedule 1.40 L/s

Based on the well test results, we recommend pumping the three boreholes as follows:

Bloupan-HN1

- 3 L/s (10.8 m^3/hr) for 24 h/day pumping schedule (259 m^3/day); or
- 4 L/s (14.4 m^3/hr) for 12 h/day pumping schedule (173 m^3/day).

Bloupan-HN2

- 3 L/s (10.8 m^3/hr) for 24 h/day pumping schedule (259 m^3/day); or
- 4 L/s (14.4 m^3/hr) for 12 h/day pumping schedule (173 m^3/day).

Bloupan-HN3

- 1 L/s (3.6 m^3/hr) for 24 h/day pumping schedule (86 m^3/day); or
- 1.4 L/s (5.0 m^3/hr) for 12 h/day pumping schedule (60 m^3/day).

2.4 Groundwater quality

Water samples were collected at the end of each pumping test and submitted to Talbot Laboratories after completion of all three of the pumping tests in April 2018. The analysis results are summarised in Table 2-8. The groundwater from all three boreholes indicates an EC of more than 31 000 mS/m. The TDS of the three boreholes exceeds 225 000 mg/L, which is more than 6 times higher than that for seawater. This hypersaline (brine) groundwater cannot be used for human or animal consumption, or for irrigation purposes. The only practical use is source water supply for evaporative salt mining. The analysis certificates are in Appendix C.

On the hydrogeological map of the region, the groundwater EC is indicated as >1 000 mS/m in the study area (DWAF, 2001), whilst an EC of 5 410 mS/m is reported in the NGA for borehole 2720BD00003 (see Table 2-3 and Figure 2-3). This highly saline groundwater also cannot be used for human or animal consumption, or for irrigation purposes.

Table 2-8: Summary of chemical analysis for the Annesley Salt boreholes

Determinand	Units	Results		
		Bloupan-HN1	Bloupan-HN2	Bloupan-HN3
Electrical Conductivity at 25ºC	mS/m	31 240	31 840	32 400
Total Dissolved Solids at 180 ºC	mg/L	226 888	230 326	243 280
pH at 25ºC	pH Units	9	9	9.4
Ammonia as N	mg/L	<0.11	<0.11	0.21
Chloride as Cl	mg/L	118 639	123 950	123 047
Sulfate as SO_4	mg/L	17 536	17 142	19 787
Fluoride as Fl	µg/L	98 000	106 000	82 000
Nitrate as N	mg/L	412	433	407
Nitrite as N	mg/L	0.58	0.6	1.2
Calcium as Ca	mg/L	0.57	<0.12	<0.12
Magnesium as Mg	mg/L	0.12	<0.07	<0.07
Potassium as K	mg/L	34	34	38
Sodium as Na	mg/L	113 100	137 759	134 330
Total Organic Carbon	mg/L	8.4#	6.7#	8.5#
Turbidity	NTU	1.5	0.9	0.9
Aluminium as Al	mg/L	<0.02	<0.02	<0.02
Antimony as Sb	mg/L	0.47	0.59	0.3
Arsenic as As	mg/L	0.36	0.41	0.34
Cadmium as Cd	mg/L	<0.02	<0.02	<0.02
Chromium as Cr	mg/L	<0.02	<0.02	<0.02
Cobalt as Co	mg/L	<0.02	<0.02	<0.02
Copper as Cu	mg/L	0.02	<0.02	<0.02
Iron as Fe	mg/L	<0.02	<0.02	<0.02
Lead as Pb	mg/L	<0.03	<0.03	<0.03
Manganese as Mn	mg/L	<0.02	<0.02	<0.02
Mercury as Hg	mg/L	<0.002	<0.002	<0.002
Nickel as Ni	mg/L	<0.02	<0.02	<0.02
Selenium as Se	mg/L	0.75	0.83	0.68
Uranium as U	mg/L	0.18	0.23	0.17
Vanadium as V	mg/L	0.56	0.63	0.65
Zinc as Zn	mg/L	<0.02	<0.02	<0.02

3 Hydrology

3.1 Project information pertinent to hydrology

The project information pertinent to hydrology includes:

- As part of the operation, ten evaporation ponds of 100 m x 60 m each are proposed (i.e. a total extent of 100.35 ha) and will be constructed within the Bloupan pan. The evaporation ponds will be excavated 300 mm below natural ground level (ngl). After excavation, a 150 mm salt floor will be constructed. The walls of the evaporation ponds will be 600 mm high and will be constructed 150 mm below ngl and 450 mm above ngl. Periodically, groundwater (brine) will be used to add water to the ponds. The water depth in the ponds will be limited to 50 mm (maximum of 75 mm). The formation of salt crystals will raise the floor of the ponds periodically by 150 mm until harvest time every 6 weeks – hence, the water level should remain 375 mm below the top of the dam walls.
- The 5 m wide and 600 mm high walls will serve as roads for vehicles to drive on. Vehicles will also operate in the salt pan or evaporation ponds to recover the salt.
- The boreholes (Bloupan-HN1, HN2, and HN3) are positioned on the 5 m wide road. The standpipes of the boreholes are approximate 300 mm above the road height or 750 mm above ngl.
- Access to the site will mostly be via existing roads, with the district gravel road to Noenieput running along the site. A small 5 m wide access road (not paved) links the operations to this road.

3.2 Climate

3.2.1 Rainfall

The rainfall in the area is low. The two closest stations (which are 26.8 km and 38.9 km away) indicated the following:

- 128 mm mean annual rainfall at Vrouenspan station; and
- 147 mm at the Noenieput (Pol) station.

This data was verified by SRK using available weather station data. The daily rainfall data for the closest station (Vrouenspan) have been summarized to represent the average monthly rainfall, which is graphically presented in Figure 3-1 below.

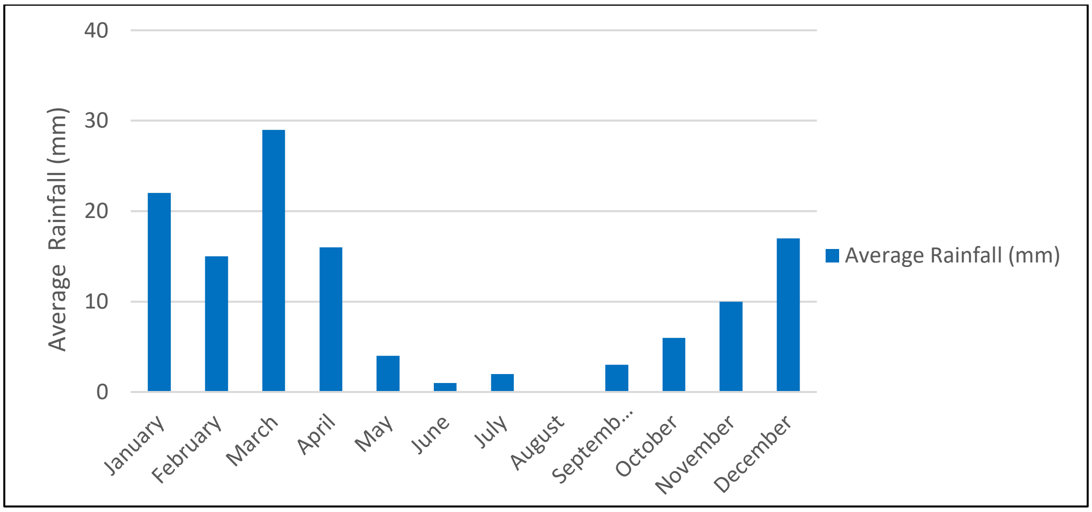


Figure 3-1: Average rainfall per month at the nearest rainfall station (Vrouenspan).

Although the rainfall is low, it occurs as short-lived but intense isolated or scattered thunderstorms during the summer months. The rainfall station details of Vrouenspan, along with five other rainfall stations considered in the hydrological assessment are provided in Table 3-1.

Table 3-1: Rainfall stations in the vicinity of Annesley Farm 338.

Station name	Station number	Distance from site (km)	Record available (years)	Mean annual precipitation (mm)
Vrouenspan	0351708_W	26.8	44	128
Noenieput (Pol)	0387240_W	38.9	70	147
Zwartmodder	0316061_W	47.4	54	155
Witdraai (Pol)	0424357_W	72.3	52	171
Askham	0424509_W	73.3	50	181
Witdraai (Gemsbok) (Pol)	0424354_W	76.9	32	186

The rainfall intensity data (also known as design rainfall data) for the site are in

. Design rainfall data were extracted from the Design Rainfall estimation software (Gorven, 2002).

Table 3-2: Design rainfall values for Annesley Farm 338

Design Rainfall Data (mm) interpolated from six closest stations							
Mean annual rainfall	112	mm	Latitude	-27.58887	degrees		
Altitude	826	mamsl	Longitude	20.48974	degrees		
Storm duration	Return Period (Years)						
	2	5	10	20	50	100	200
5 minutes	6.3	9.9	12.5	15.3	19.2	22.5	25.9
15 minutes	11.9	18.7	23.6	28.8	36.2	42.3	48.8
1 hour	17.9	28.1	35.6	43.4	54.5	63.7	73.5
1.5 hours	20.2	31.7	40.1	49	61.5	71.8	82.9
2 hours	22	34.5	43.7	53.3	66.9	78.2	90.3
8 hours	28.7	45	57	69.6	87.4	102.1	117.8
24 hours	35.5	55.6	70.5	86	107.9	126.1	145.6

3.2.2 Evaporation

Evaporation far exceeds rainfall at the site. Although no records are available from the nearest station, the estimated evaporation is above 2 600 mm per annum according to the S-pan and A-pan methods (WR, 2012).

3.3 Nearby water bodies, floodlines and riparian habitat

The nearest water body to the proposed project is the salt pan in which the project will be located. Other salt pans (nearest is about 3 km from the project) are also located in the area (Figure 2-3). No rivers or streams were observed on satellite images (Google earth).

Floodline determination is beyond the scope of the current project, and is not necessary for determining impacts as the project is clearly within a pan that may be inundated occasionally. Nonetheless, it can be stated that the floodline is likely to lie very close to the salt pan or possibly be contained within it given the evaporative, non-draining conditions.

No true riparian habitat exists, as water in the salt pan is extremely intermittent and saline. For example, during a 1 in 2 year, 24 hour storm event, only 35.5 mm of rain are likely in the pan itself and little runoff is expected from the catchment (See Section 3.2.1 and 3.5).

3.4 Stream and salt pan morphology

No stream morphology is described as no streams or rivers were observed. The salt pan on the other hand is seen as a water body and a seasonal/partial wetland.

A few short, localised drainage channels (possibly natural erosion lines) were observed on the slopes around the salt pan (what would be the banks in a typical pan). These small channels indicate that water probably periodically flows into the salt pan from the immediate surrounds. The pan is likely to become inundated in times of intense rainfall events during the summer months. Thereafter, water will slowly evaporate leaving any salts behind.

Other hydrological losses are not expected to be significant because the pan is the lowest point in the landscape and thus water cannot flow downstream and seepage through the bed of the pan will be very low (the most likely reason why the pan exists in this location at all, and also the reason that salts naturally concentrate in the pan with time).

The morphology of the salt pan is shown in Photo 3-1 – a depression with a bed that is flat and hardened with crystallised salts on the surface. It is underlain by clay and weathered tillite with very low permeability.

Photo 3-1: The salt bed (foreground) and banks (background) of the salt pan

3.5 Catchments, surface flow and sediment regime

As indicated in the insert map of Figure 3-2, the salt pan is located in Quaternary catchment D42D. The immediate catchment draining to the salt pan is also shown in Figure 3-2. This catchment was delineated using the twenty-meter contours available on topographic maps of the area. The catchment area was conservatively delineated wherever there was doubt as to its exact boundary (due to the low resolution topographical data available). The catchment area for the salt pan was estimated to be 92 km^2 in extent.

Note that the catchment has no outlet. Essentially the immediate catchment is an isolated catchment disconnected from the larger Quaternary catchment. The likely reason for this non-draining nature of the catchment is as follows:

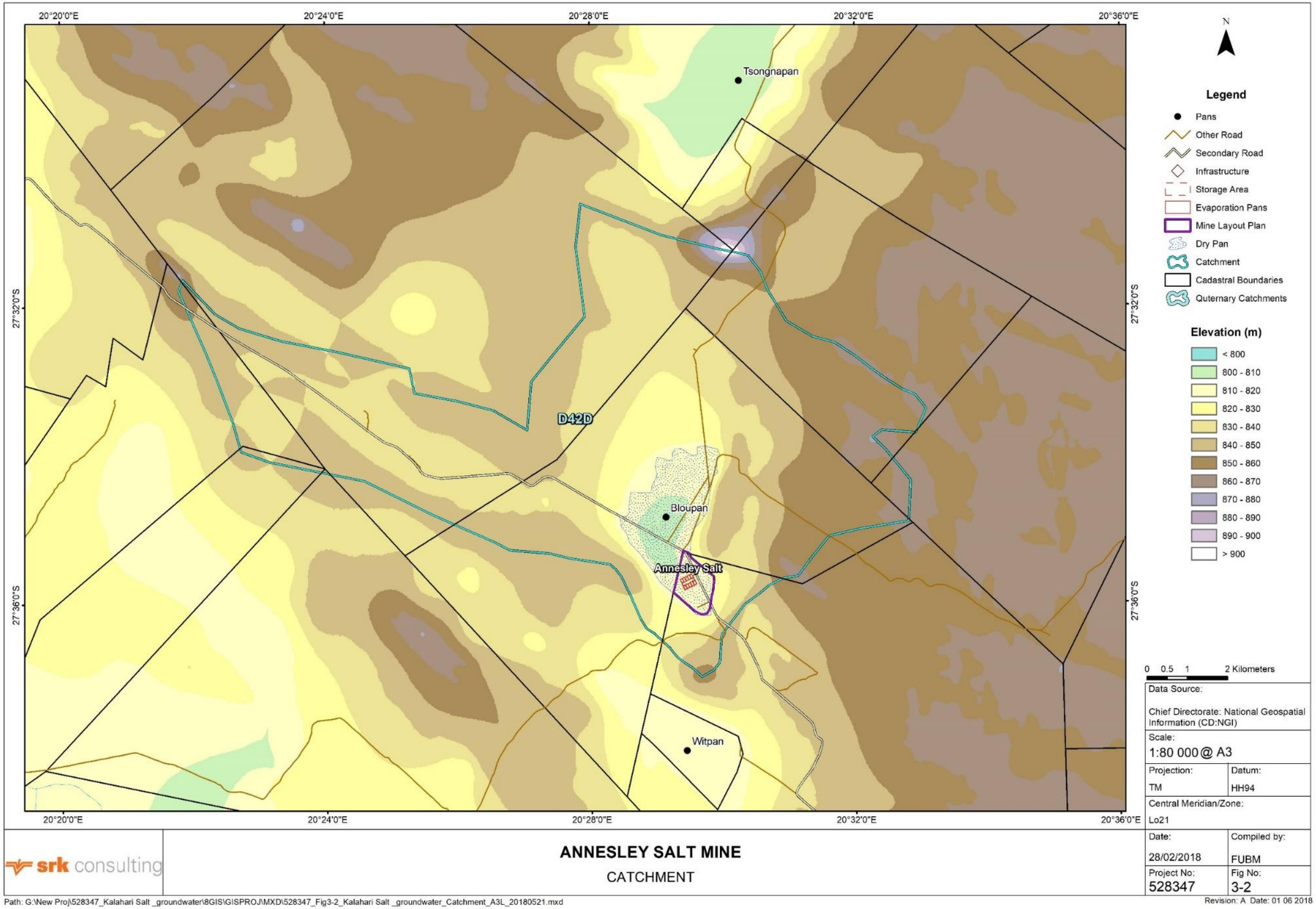
- The catchment is characterised by relatively flat slopes generally below 3 degrees with minor slopes of > 10 degrees along the edges of pans (as shown on Figure 3-3). The slightly vegetated sandy dunes (as shown in Photo 3-1) have soil depths up to a few metres deep, interspersed with rocky calcrete areas. Due to these characteristics, most of the rain infiltrates into these dunes rather than reporting as surface flows.
- At times, large rainfall events might occur in succession that result in the catchment being saturated and then generating surface flows. In such cases (which will be rare), surface flow might be generated. Due to the topography of the area (Figure 3-2), all surface flow would drain to the salt pan as it lies in a depression (i.e. at the low point in the system).
- Theoretically, and over time, the salt pan could fill up and eventually overtop and connect to the greater catchment. This, however, is highly unlikely because evaporation greatly exceeds rainfall (2 000 mm vs 200 mm - Section 3.2.1 and Section 3.2.2) – hence, a negative water balance occurs even during the summer rainfall months.
- The fact that a crust of salt has precipitated on the pan bed adds to the evidence that this is a non-draining (as shown in Photo 3-2), evaporative system except in extremely rare circumstances.

Photo 3-2: Old evaporation pond being filled during a pumping test and in the background, more vegetated dunes are observed at the site.

The sediment regime on the site is characterised by little movement due to absence of surface water flows and shallow topographical gradients (hence low flow velocities). The dunes within the catchment are stable, and are vegetated, and thus limited sediment transport is expected. As noted in Section 3.4, a few short, localised drainage channels (possibly natural erosion lines) were noted on the banks of the salt pan, indicating that some localised sediment transport into the salt pan has occurred. This small-scale sediment transport is probably intermittent, and probably occurs during high rainfall events (i.e. rarely) only – hence and would manifest where localised slopes are steeper.

3.6 Surface water quality

It is not possible to collect surface water samples for quality analysis at the site, as standing surface water is such a rare occurrence.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D42D
Bloupan
Annesley Salt
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Legend
Pans
Other Road
Secondary Road
Infrastructure
Storage Area
Evaporation Pans
Mine Layout Plan
Dry Pan
Catchment
Cadastral Boundaries
Quternary Catchments
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ANNESLEY SALT MINE
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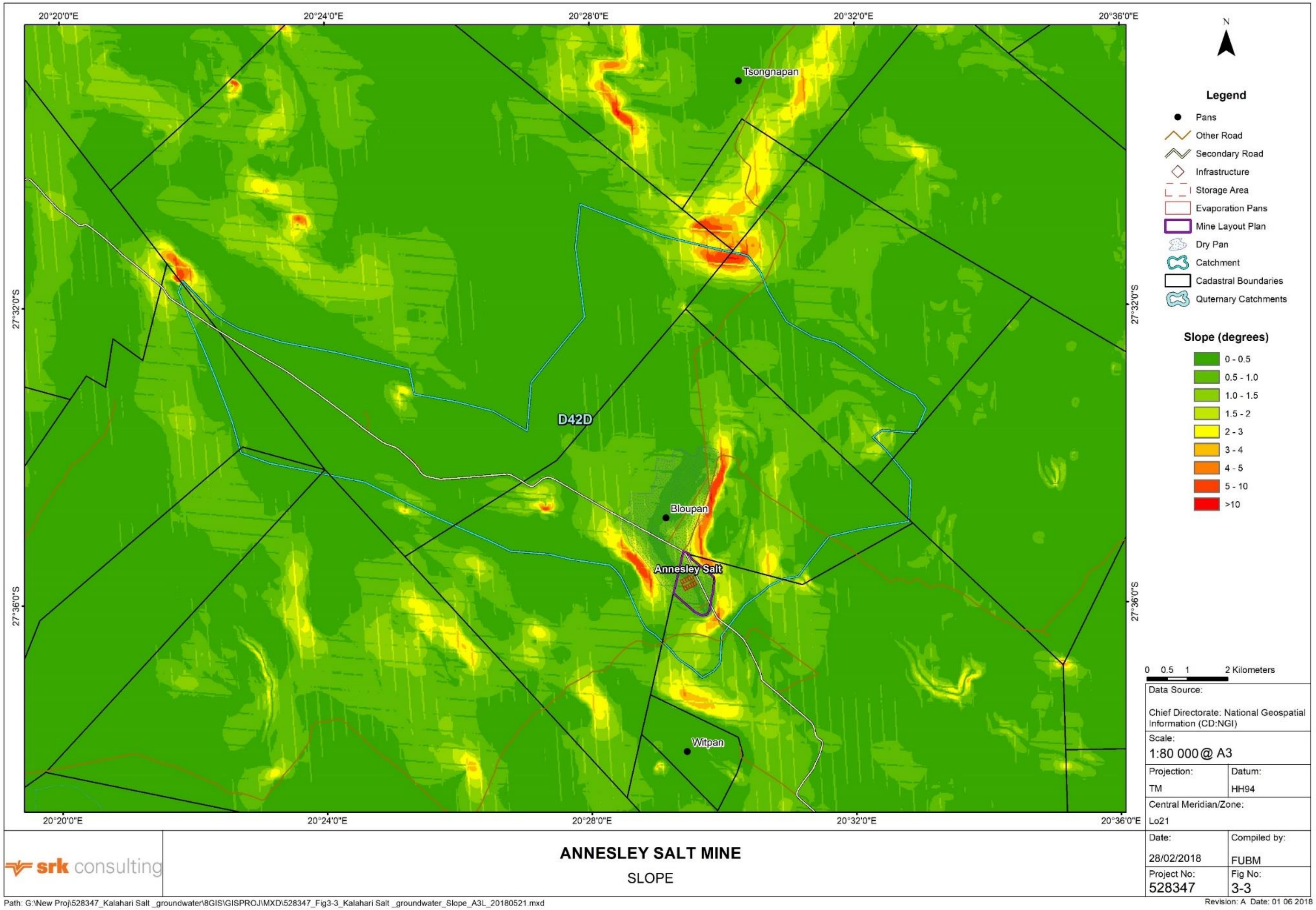
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Bloupan
Annesley Salt
Witpan
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Legend
Pans
Other Road
Secondary Road
Infrastructure
Storage Area
Evaporation Pans
Mine Layout Plan
Dry Pan
Catchment
Cadastral Boundaries
Quaternary Catchments
Slope (degrees)
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Revision: A Date: 01 06 2018

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Annesley Salt WULA
Google Earth Image Showing Mine Layout at Bloupan

Project No.
528347

Figure 3-4: Google Earth image showing the layout of the proposed Annesley Salt mine at Bloupan

4 Impact Assessment

4.1 Hydrogeology

From the information available and discussed in this report, the following potential impacts to the groundwater resources have been identified:

1. Drawdown of the water table in the local Dwyka Aquifer by abstraction of *c*.105 300 m^3/a of hypersaline groundwater for salt mining.
2. Contamination of the groundwater resource by onsite sanitation facilities.
3. Increase of groundwater salinity beneath the mine site.
4. Contamination of the groundwater resources by fuel and oil spills from construction and mine vehicles.

The severity of the potential groundwater impacts without mitigation measures is rated in Table 4-1, and with proposed mitigation measures implemented is rated in Table 4-2. The impact severity rating methodology used is included in Appendix D.

Abstraction of Groundwater for Salt Mining

There is a slight local risk of lowering the local water table in the near vicinity (likely <1 km radius) of the mine by abstraction of 105 300 m^3/a brine from the Dwyka Aquifer beneath the site. This potential impact is rated as moderate, and it can be mitigated to low by resting the boreholes during harvesting of the salt and during the winter season (31 May to 20 August) when high quality salt crystals do not form.

Aquifer Contamination from onsite sanitation facilities

There is a slight risk of contamination of the Dwyka Aquifer by onsite sanitation facilities. This potential impact is rated as low, and it can be mitigated to very low by appropriate engineering design, good housekeeping and regular maintenance of these facilities.

Aquifer Contamination from Oil and Fuel Spills

There is a slight risk of contamination of the Dwyka Aquifer by oil and fuel spills from construction and operational vehicles. This potential impact is rated as low, and it can be mitigated to very low by appropriate engineering design, good housekeeping and regular maintenance of infrastructure.

Increase in Aquifer Salinity at the Mine Site

During preparation of the hard salt crystal floor in the Evaporation ponds, there is likely to be a slight increase in brine salinity beneath the mine by infiltration of evaporation-enriched brine through the extremely low permeable [3]clay surface of the salt pan. This extremely low infiltration rate is expected to decrease further once the hard floor is established. Any slight increases in brine salinity will be an advantage for the mine, as this will result in a slightly higher salt production. Due to the zone of drawdown in the local aquifer by pumping from the three boreholes at the mine, this slightly saltier brine will migrate towards the boreholes, where it will be recycled back to the Evaporation ponds. Over the long term, abstraction of brine beneath the natural salt pan is likely to draw in slightly less saline water from the aquifer around the salt pan. It must be born in mind that the groundwater in the Dwyka Aquifer around the salt pan has very poor quality (with reported ECs of >1 000 mS/m (DWAF,2001),

[3] Published hydraulic conductivity of clay and weathered tillite is 10^{-9} to10^{-13} m/s (de Marsily, 1986).

and this water is not fit for any use other than source water for salt mining. To further illustrate this point, the reported EC for abandoned NGA borehole 2720BD00003 (Table 2-3 and Figure 2-3) is 5 410 mS/m. This impact is rated as low, and it remains low after mitigation by abstraction from the three boreholes and pumping the brine back to the evaporation ponds.

4.2 Hydrology

From the information available and discussed in this report, the following potential impacts to the surface water resources have been identified:

1. Contamination of surface water (when present) by onsite sanitation facilities.
2. Contamination of the surface water resources (when present) by fuel and oil spills from construction and operational vehicles or from hazardous substances (however, no hazardous substances are currently envisaged in the proposed normal operations).
3. Contamination of the surface water with water of a differing salinity in the event of extreme storms that overwhelms the evaporation ponds, resulting in overtopping.
4. Altering flow in a water course due to the Evaporation ponds.
5. Alteration of the beds or banks of the salt pan, changing their morphology.

The severity of the potential surface impacts without mitigation measures are rated in Table 4-3, and with mitigation measures implemented in Table 4-4. The impact severity rating methodology used is included inAppendix D.

Contamination of surface water by onsite sanitation facilities

In the rare event that surface water pools in the salt pan, there is a slight risk of contamination by onsite sanitation facilities if they are poorly managed. This potential impact is rated as low, and it can be mitigated to very low by appropriate engineering design, good housekeeping and regular maintenance of these facilities.

Contamination of surface water from Oil and Fuel Spills or other hazardous substances

In the rare event that surface water pools in the salt pan, there is a slight risk of contamination by oil and fuel spills that have collected on the surface of the salt pan, or on the surrounding roads from construction and operational vehicles. This potential impact is rated as low, and it can be mitigated to very low by good housekeeping and regular maintenance of vehicles.

No hazardous substances are required for the project (e.g. Acids), but if at any time such substances are stored and used on site, they must be stored as per the supplier's instructions, bunded as per regulation and checked regularly for leaks or spills.

Modified surface water salinity due to mining

When surface water collects in the salt pan, it will interact with salt in the ponds. However, even in an extreme rainfall event (e.g. 1:200 year storm), the proposed 600 mm bund will not overtop. As such, the brine dams themselves will provide all necessary attenuation as at all times the water level will remain 375 mm below the top of the dam walls. For a 1 in 200 year, 24 hour event of 145.6 mm of rainfall (less than 15 cm of rain depth), the depth of water in the ponds could increase by 145.6 mm due to direct rainfall, but that is still well below the 375 mm of freeboard in the ponds. Stockpiles will be placed within the designated storage area between the ponds which is protected by berms (5 m wide and 600 mm high walls) such that they cannot be mobilised into the pan, or elsewhere, during rainfall events.

The contributing catchment is likely to add very little runoff due to the permeable sands into which most of the water will infiltrate. Notwithstanding the very low likelihood of overtopping, the salt in the pan might mix with the surface water to produce localised salinities that differ from what they would naturally have been were the dam walls to be breached (e.g. erosion failure). However, these salinities are extremely unlikely to have a greater range than is natural for the salt pan due to salt saturation and dilution effects.

Altered flow in a water course due to the Evaporation ponds

In theory, the Evaporation ponds could impede water flowing across the salt pan. However, since flow is nearly negligible as it is a salt pan and not a stream, the impact is likely to be negligible.

Altered beds and banks

The Evaporation ponds and access to the salt pan itself with vehicles will alter the bed and banks of the salt pan. The impact could be increased if non-essential infrastructure (parking areas, offices) are located in the salt pan, and multiple routes are created as access into the pan (similarly if staff indiscriminately drive around the salt pan in general). However, if non-essential infrastructure, other items (e.g. construction material) is stored away from the salt pan, and staff use only one access road and do not drive into other areas of the salt pan, then the impact on the bed and banks will be very limited. It should be noted that traversing the salt pan with vehicles will result in extremely high maintenance risks to these vehicles (rust), and it is probable that the mine staff will avoid doing so as a general rule.

4.3 Cumulative impacts

Cumulative impacts on the salt pan will be very low, as no other project (salt mine) exist within the salt pan. No registered groundwater user exists within 10 km radius of the proposed Annesley Salt project (Figure 2-3 and Table 2-3). If Annesley Salt implements mitigation measures for all impacts, the impact to the hydrogeological environment (Table 4-5) and hydrological environment (Table 4-6) of the overall area will be categorised as having a low significance.

Table 4-1: Possible impacts of the proposed development on groundwater 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
Construction	Groundwater contamination by onsite sanitation facilities	Negative	-	Site	1	Short	2	Low	2	Low	4	Low	14
Construction	Increase in groundwater salinity beneath the mine site during preparation of the hard salt crystal Evaporation pond floors	Negative	-	Site	1	Short	2	Low	2	Low	4	Low	14
Construction	Groundwater contamination by oil and fuel spills from construction vehicles	Negative	-	Site	1	Short	2	Low	2	Low	4	Low	14
Operational	Lowering of the water table by abstraction of *c.*105 300 m³/annum of saline groundwater	Negative	-	Local	2	Long	4	Medium	3	Low	4	Moderate	30
Operational	Groundwater contamination by onsite sanitation facilities	Negative	-	Site	1	Long	4	Low	2	Low	4	Low	18
Operational	Increase in groundwater salinity beneath the mine site during salt mining	Negative	-	Site	1	Long	4	Low	2	Low	4	Low	18
Operational	Groundwater contamination by oil and fuel spills from mine vehicles	Negative	-	Site	1	Long	4	Low	2	Low	4	Low	18

Table 4-2: Possible impacts of the proposed development on groundwater with mitigation measures

Phase	Impact description	Status of Impacts		Spatial Scale of Impacts		Duration 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
Construction	Groundwater contamination by onsite sanitation facilities	Negative	-	Site	1	Short	2	Improbable	1	Low	4	Low	7
Construction	Increase in groundwater salinity beneath the mine site during preparation of the hard salt crystal Evaporation pond floors	Negative	-	Site	1	Short	2	Low	2	Low	4	Low	14
Construction	Groundwater contamination by oil and fuel spills from construction vehicles	Negative	-	Site	1	Short	2	Improbable	1	Low	4	Low	7

Essential mitigation measures:

- Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly.
- 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.
- Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site.
- Ensure vehicles and equipment are in good working order and drivers and operators are well trained.
- Ensure that good housekeeping and maintenance rules are applied.

Phase	Impact description	Status Rating	Status Quanti-tative Rating	Spatial Rating	Spatial Quanti-tative Rating	Duration Rating	Duration Quanti-tative Rating	Probability Rating	Probability Quanti-tative Rating	Magnitude Rating	Magnitude Quanti-tative Rating	Significance Rating	Significance Quanti-tative Rating
Operational	Lowering of the water table by abstraction of *c.*105 300 m³/annum of saline groundwater	Negative	-	Local	2	Long	4	Low	2	Low	4	Low	20
Operational	Groundwater contamination by onsite sanitation facilities	Negative	-	Site	1	Long	4	Improbable	1	Low	4	Low	9
Operational	Increase in groundwater salinity beneath the mine site during salt mining	Negative	-	Site	1	Long	4	Low	2	Low	4	Low	18
Operational	Groundwater contamination by oil and fuel spills from mine vehicles	Negative	-	Site	1	Long	4	Improbable	1	Low	4	Low	9

Essential mitigation measures:

- Rest boreholes during salt harvesting and during the winter season.
- Implement and follow water saving procedures and methodologies.
- Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly.
- 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.
- Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site.
- Ensure vehicles and equipment are in good working order and drivers and operators are well trained.
- Ensure that good housekeeping and maintenance rules are applied.
- Implement a groundwater monitoring system to monitor abstraction and water levels.

Table 4-3: Possible impacts of the proposed development on surface water 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
Construction	Contamination of surface water by onsite sanitation facilities	Negative	-	Local	2	Short	2	Low	2	Low	4	Low	16
Construction	Contamination of surface water from Oil and Fuel Spills	Negative	-	Local	2	Short	2	Low	2	Low	4	Low	16
Construction	Altered beds and banks of the salt pan	Negative	-	Local	2	Long	4	High	4	Medium	4	Moderate	40
Operational	Modified surface water salinity	Negative	-	Local	2	Short	2	Improbable	1	Minor	2	Low	6
Operational	Altered flow in the salt pan due to the Evaporation ponds	Negative	-	Site	1	Short	2	Low	2	Minor	2	Low	10
Operational	Altered beds and banks of the salt pan	Negative	-	Local	2	Long	4	High	4	Medium	4	Moderate	40
Operational	Contamination of surface water by onsite sanitation facilities	Negative	-	Local	2	Short	2	Low	2	Low	4	Low	16
Operational	Contamination of surface water from Oil and Fuel Spills	Negative	-	Local	2	Short	2	Low	2	Low	4	Low	16

Table 4-4: Possible impacts of the proposed development on surface water with mitigation measures

Phase	Impact description	Status of Impacts		Spatial Scale of Impacts		Duration 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
Construction	Contamination of surface water by onsite sanitation facilities	Negative	-	Site	1	Short	2	Improbable	1	Low	4	Low	7
Construction	Contamination of surface water from Oil and Fuel Spills	Negative	-	Site	1	Short	2	Improbable	1	Low	4	Low	7
Construction	Altered beds and banks of the salt pan	Negative	-	Site	1	Long	4	High	4	Minor	1	Low	24
Construction	**Essential mitigation measures:** • Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly. • 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. • Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site. • Ensure vehicles and equipment are in good working order and drivers and operators are well trained. • Ensure that good housekeeping and maintenance rules are applied. • All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks • Staff should access only the portions of the salt pan that it is absolutely necessary to access												
Operational	Modified surface water salinity	Negative	-	Site	1	Short	2	Improbable	1	Minor	2	Low	5
Operational	Altered flow in the salt pan due to the Evaporation ponds	Negative	-	Site	1	Short	2	Low	2	Minor	2	Low	10
Operational	Altered beds and banks of the salt pan	Negative	-	Site	1	Long	4	High	4	Minor	1	Low	24
Operational	Contamination of surface water by onsite sanitation facilities	Negative	-	Site	1	Short	2	Improbable	1	Low	4	Low	7
Operational	Contamination of surface water from Oil and Fuel Spills	Negative	-	Site	1	Short	2	Improbable	1	Low	4	Low	7
Operational	**Essential mitigation measures:** • Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly. • 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. • Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site. • Ensure vehicles and equipment are in good working order and drivers and operators are well trained. • Ensure that good housekeeping and maintenance rules are applied. • All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks • Staff should access only the portions of the salt pan that it is absolutely necessary to access • Manage the Evaporation ponds such that water levels remain well below the height of the containment barriers												

Table 4-5: Possible cumulative impacts of the proposed development on groundwater with mitigation measures

Phase	Impact description	Status of Impacts		Spatial Scale of Impacts		Duration 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
Construction	Groundwater contamination by onsite sanitation facilities	Negative	-	Local	2	Short	2	Improbable	1	Low	4	Low	8
Construction	Increase in groundwater salinity beneath the mine site during preparation of the hard salt crystal Evaporation pond floors	Negative	-	Local	2	Short	2	Low	2	Low	4	Low	16
Construction	Groundwater contamination by oil and fuel spills from construction vehicles	Negative	-	Local	2	Short	2	Improbable	1	Low	4	Low	8
Construction	**Essential mitigation measures:** • Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly. • 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. • Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site. • Ensure vehicles and equipment are in good working order and drivers and operators are well trained. • Ensure that good housekeeping and maintenance rules are applied.												
Operational	Lowering of the water table by abstraction of *c.*190 000 m³/annum of saline groundwater	Negative	-	Local	2	Long	4	Low	2	Low	4	Low	20
Operational	Groundwater contamination by onsite sanitation facilities	Negative	-	Local	2	Long	4	Improbable	1	Low	4	Low	10
Operational	Increase in groundwater salinity beneath the mine site during salt mining	Negative	-	Local	2	Long	4	Low	2	Low	4	Low	20
Operational	Groundwater contamination by oil and fuel spills from mine vehicles	Negative	-	Site	1	Long	4	Improbable	1	Low	4	Low	9
Operational	**Essential mitigation measures:** • Rest boreholes during salt harvesting and during the winter season. • Implement and follow water saving procedures and methodologies. • Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly. • 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. • Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site. • Ensure vehicles and equipment are in good working order and drivers and operators are well trained. • Ensure that good housekeeping and maintenance rules are applied. • Implement a groundwater monitoring system to monitor abstraction and water levels.												

Table 4-6: Possible cumulative impacts of the proposed development on surface water with mitigation measures

Phase	Impact description	Status of Impacts		Spatial Scale of Impacts		Duration 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
Construction	Contamination of surface water by onsite sanitation facilities	Negative	-	Local	2	Short	2	Improbable	1	Low	4	Low	8
Construction	Contamination of surface water from Oil and Fuel Spills	Negative	-	Local	2	Short	2	Improbable	1	Low	4	Low	8
Construction	Altered beds and banks of the salt pan	Negative	-	Local	2	Long	4	High	4	Minor	1	Low	28
Construction	**Essential mitigation measures:** • Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly. • 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. • Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site. • Ensure vehicles and equipment are in good working order and drivers and operators are well trained. • Ensure that good housekeeping and maintenance rules are applied. • All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks • Staff should access only the portions of the salt pan that it is absolutely necessary to access												
Operational	Modified surface water salinity	Negative	-	Local	2	Short	2	Improbable	1	Minor	2	Low	5
Operational	Altered flow in the salt pan due to the Evaporation ponds	Negative	-	Local	2	Short	2	Low	2	Minor	2	Low	12
Operational	Altered beds and banks of the salt pan	Negative	-	Local	2	Long	4	High	4	Minor	1	Low	28
Operational	Contamination of surface water by onsite sanitation facilities	Negative	-	Local	2	Short	2	Improbable	1	Low	4	Low	8
Operational	Contamination of surface water from Oil and Fuel Spills	Negative	-	Local	2	Short	2	Improbable	1	Low	4	Low	8
Operational	**Essential mitigation measures:** • Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly. • 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. • Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site. • Ensure vehicles and equipment are in good working order and drivers and operators are well trained. • Ensure that good housekeeping and maintenance rules are applied. • All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks • Staff should access only the portions of the salt pan that it is absolutely necessary to access • Manage the Evaporation ponds such that water levels remain well below the height of the containment barriers												

5 Water Balance

The water balance for the proposed Annesley Salt project was calculated as follows (Table 5-1):

Table 5-1: Water balance for the proposed Annesley Salt project

Source	Water In (m^3)		Use	Water Out (m^3)	
	day	annum		m^3/day	m^3/annum
Abstraction HN1 (x days/annum)	258	45 360	Evaporation	283	77 120
Abstraction HN2 (x days/annum)	258	45 360			
Abstraction HN3 (x days/annum)	258	14 580			
Mean annual direct rainfall on the ponds (128 mm/a)	25	7680			
Total in	283	112 980	Total out	283	112 980

The extent of the mine ponds is 100 m x 60 m each, which for the 10 ponds equates to 60 000 m^2, or 6 ha.

Potential evaporation rate for the area is 2 000 mm/a, therefore, the maximum evaporation potential for the 60 000 m^2 of ponds is 120 000 m^3/a, which is much higher than the proposed mine's evaporation requirements.

6 Stormwater Management Plan

The following stormwater management measures should be implemented during construction:

- Place oil traps under stationary machinery, only re-fuel machines at a designated fuelling station, construct structures to trap fuel spills at this fuelling station, immediately clean oil and fuel spills and dispose contaminated material (soil, etc.) at licensed sites only.
- Draw up and strictly enforce a procedure for the storage, handling and transport of different hazardous materials used on site. This procedure should be informed by hazardous material safety data sheets and discussions with the supplier.
- Ensure vehicles and equipment are in good working order, and drivers and operators are well-trained.
- Ensure that good housekeeping and maintenance rules are applied.
- All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks including any material stockpiles or parking areas.
- Staff should access only the portions of the salt pan that it is absolutely necessary to access for operations.
- Any construction material stockpiles should be protected by berms (or other mechanism) to ensure that material cannot be mobilised into the salt pan.
- Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly.

The following stormwater management measures should be implemented during operation:

- Ensure that onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly.
- Place oil traps under stationary machinery, only re-fuel machines at a designated fuelling station, construct structures to trap fuel spills at this fuelling station, immediately clean oil and fuel spills and dispose contaminated material (soil, etc.) at licensed sites only.
- Draw up and strictly enforced a procedure for the storage, handling and transport of different hazardous materials used on site.
- Ensure vehicles and equipment are in good working order and drivers and operators are well trained.
- Ensure that good housekeeping and maintenance rules are applied.
- All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks.
- Staff should access only the portions of the salt pan that it is necessary to access, avoiding establishing multiple access routes/roads.
- Manage the Evaporation ponds such that water levels remain well below the height of the containment barriers.
- The boreholes should be sealed by installing a bentonite sanitary seal around the borehole standpipes built to a minimum height of 600 mm such that the surface water will not enter the boreholes during an intense rainfall event.
- Stockpiles should be placed within the designated storage area and protected by berms (height of the containment barriers should be at least 450 mm) such that they cannot be mobilised into the pan.
- Stormwater plans should be updated after one year of operation.

Note: Formalised stormwater drainage is not required due to the flat terrain, low rainfall and location of the proposed operation within the salt pan. This should be reassessed after a year of operation when the stormwater plan is updated.

7 Conclusions

7.1 Hydrogeology

Based on the hydrogeology data and borehole test results presented in this report, we conclude that:

- The site contains sufficient groundwater resources to satisfy the water demand of the proposed Annesley Salt mine. The other salt mines and water users in the Quaternary catchment would not have any significant identified impacts. Therefore, from a hydrogeological perspective, there are no obvious or known reasons why a water use licence for abstraction of 105 300 m^3/a of brine from the three boreholes on the mine property should not be issued to Annesley Salt.
- No other groundwater users near the Annesley Salt site were identified that could be negatively impacted by the proposed development, nor have any significant or unacceptable impacts, or cumulative impacts, on the local aquifer been identified.

- Pumping tests results indicate that boreholes at Bloupan (HN1, HN2 and HN3), can sustainably supply sufficient quantities of water to satisfy the Annesley Salt mine's brine demand of 105 300 m^3/a for the life of mine at sustainable pumping rates.
- Chemical analyses indicates that the groundwater from all three boreholes tested is hypersaline and is classified as brine (TDS >225 000 mg/L), and unfit for any human or animal consumption, or for irrigation purposes. However, the groundwater is ideal for brine supply to the salt mine in the salt pan.

7.2 Hydrology

Based on the hydrology assessment presented in this report, we conclude that:

- The salt pan is almost certainly within an isolated, evaporative catchment.
- Rainfall is low, and comes predominantly in the form of isolated or scattered thundershowers.
- The catchment in general is permeable (referring to the sand dune cover) - hence any surface water will infiltrate and ponding in the salt pan will be a rare occurrence.
- The project will generally have impacts of low significance on surface water.
- Altering large portions of the bed and banks may cause a moderate environmental impact if no mitigations measures are implemented.

8 Recommendations

8.1 Hydrogeology

The recommendations arising from the borehole investigations are:

1. Bloupan-HN1 can be pumped at 3 L/s for a 24 h/day schedule, or at 4 L/s for a 12 h/day schedule.
2. Bloupan-HN2 can be pumped at 3 L/s for a 24 h/day schedule, or at 4 L/s for a 12 h/day schedule.
3. Bloupan-HN3 can be pumped at 1 L/s for a 24 h/day schedule, or at 1.4 L/s for a 12 h/day schedule
4. The minimum pump installation depth for Bloupan-HN1, HN2, and HN3 should be at 20 mbgl.
5. Expected pumped water levels for Bloupan-HN1, HN2 and HN3 to be approximately 15 mbgl.
6. A flow meter (preferably a magflow meter) to measure total water use should be installed at each borehole.
7. The water level in the boreholes should be measured and recorded at regular intervals by means of a dipmeter. Alternatively, automatic dataloggers may be installed in the boreholes to record the water level at pre-set intervals of (e.g. hourly).
8. A sample of the raw brine pumped from the boreholes should be collected annually, and submitted to an accredited laboratory for macro chemical, and trace metal analysis.
9. A low-level cut-off switch should be installed *c*.2 m above each pump intake.
10. A water use licence needs to be obtained from the DWS.

8.2 Hydrology

The main recommendations arising from the hydrology study are as follows:

1. All non-essential infrastructure should be located outside of the salt pan to minimise disturbance to the bed and banks.
2. Staff should access only the portions of the salt pan that it is necessary to access for operations, avoiding establishing multiple access routes/roads.

Other recommendations, in summary, include:

1. Onsite sanitation facilities are appropriately designed, are well maintained and serviced regularly during construction and operation.
2. Oil and fuel from storage, maintenance and handling (e.g. vehicles) and any hazardous substances are well managed such that spills and leaks do not contaminate the environment.

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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 hydrogeological and hydrological practices.

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Appendix A: Water Use Registrations for D42D

Water Resource Use Registrations in D42D - received from the DWS on 18 Nov 2016

DWS Office Name	Catchment Code	WU Sector	Resource Type	Latitude	Longitude	Registered Volume (m^3/a)
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.74811	20.73167	10 800
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.87420	20.90788	2 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.63320	20.49265	38 538
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.67810	20.88902	10 800
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.62000	20.53000	2 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.35411	20.82953	129 821
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.84467	20.88981	21 600
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.44532	20.43640	20 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.85850	20.90650	2 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.74125	20.74885	2 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.72964	20.74158	10 800
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.85360	20.89975	2 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	MINING	BOREHOLE	-27.86970	20.90876	2 000
LOWER ORANGE - NORTHERN CAPE UPINGTON OFFICE	D42D	AGRICULTURE: IRRIGATION	BOREHOLE	-26.97642	20.70647	4 500
Total						**258 859**
Mining						**254 359**

Appendix B: Pump Test Data Sheets and Graphs

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P1947
BBR	
PRODUCTION BONUS:	
EC meter number	

CONSULTANT: SRK

DISTRICT: NOENIEPUT

PROVINCE: NC

FARM / VILLAGE NAME : ANNESLEY SALT PANS

DATE TESTED: 13/03/2018

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS: hddd °mm 'ss.s " OR hddd °mm.mmm ' OR hddd.ddddd

LATITUDE: 27 ° 35 ' 41.9 "

LONGITUDE: 20 ° 29 ' 34.4 "

BOREHOLE NO: HN-01

TRANSMISSIVITY VALUE:

TYPE INSTALLATION: OPEN

BOREHOLE DEPTH: (mbgl) 26.80

COMMENTS:

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	AVN
Date sample taken			If consultant took sample, give name:			DATA CHECKED BY:	AVN
Time sample taken							

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	COMMENTS:			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	26.00
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	1.9
CASING DETECTION:	NO	PVC	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	0	LOGGERS FOR pH AND EC:	NO	0

It is hereby acknowledged that upon leaving the site, all existing equipment is in an acceptable condition.

NAME: ________________ **SIGNATURE:** ____________

DESIGNATION: ________________ **DATE:** ____________

BOREHOLE TEST CONTROL SHEET

Groundwater Solutions t/a AB PUMPS

Borehole number:	HN-01	Old / Alternative number:	
Contractor:	AB PUMPS	Supervisor:	
Operator:		Rig number & Type rig:	

EXISTING EQUIPMENT

Type pump	Depth	Condition	Drive unit	Condition	Pump house	Condition	Remarks

TESTING EQUIPMENT

Pump type	Depth installed (m)	Date & time (started)	Date & time (completed)
	18.50	01/03/2018 10H08	

MULTI-RATE OR STEPTEST DETAILS

STEP	DURATION (MIN)	RECOVERY (MIN)	YIELD (L/S)		DRAWDOWN (m)
1	60		0.66	l/s	0.21
2	60		1.22	l/s	0.37
3	60		3.03	l/s	0.95
4	60		6.35	l/s	3.54
5	7	240	9.87	l/s	14.83
6				l/s	
7				l/s	
8				l/s	
Calibration:				l/s	
TOTAL:	247	240	21.13	l/s	19.90
COMMENT:					

CONSTANT RATE DISCHARGE TEST

Pump type	Depth installed (m)	Date & time (started)		Date & time (completed)	
0	18.50	01/03/2018	18H28		
Yield l/s	**Drawdown (m)**	**Duration (min)**		**Recovery (min)**	
6.16	3.94	1440		1440	
Total: (Multi-rate and Constant Discharge rate)		1687		1680	
COMMENT:					

MAINTENANCE

Work time: hour	Transport existing equipm. Km	Travelling (To fix); Km
List of parts replaced or repaired:		

	Borehole number	Duration (min) CONSTANT	Drawdown (m)	Hand/logger	Distance (m)
Observation Hole 1	HN-02	SEE DATA			127.6
Observation Hole 2	HN-03	SEE DATA			185.9
Observation Hole 3					0
Observation Hole 4					
Observation Hole 5					

GENERAL

ESTABLISHMENT	From:		To:			
Site Move	From project#		To #:	P1947	Travelling km:	
	Village	Borehole no	Village	Borehole no		
			ANNESLEY SALT PANS	HN-01		
Maintenance:	Work time hr		Parts repaired/ replaced		Travelling km	
After test measurements	Water level	1.90	Borehole depth	26.00	Casing depth m	PVC

Water level before installing test pump: (mbch)		1.9	
Depth before installing test pump:		26.80	
Testpump Installed	**Once** /Twice /More	Reason:	
Installed Testpump	**<10 l/s** / >10ls/s	Reason:	
Was existing equipment re-installed:			If not where was it left:
GPS Unit number:			
EC Unit number:		0.00	

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1947	MAP REFERENCE:	0	PROVINCE:	NC
BOREHOLE NO:	HN-01			DISTRICT:	NOENIEPUT
ALT BH NO:	0			SITE NAME:	ANNESLEY SALT PANS
ALT BH NO:	0				
BOREHOLE DEPTH (m)	26.80	DATUM LEVEL ABOVE CASING (m):	0.40	EXISTING PUMP:	0
WATER LEVEL (mbdl):	2.32	CASING HEIGHT: (magl):	0.30	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	18.50	DIAM PUMP INLET (mm):	165.00	PUMP TYPE:	0

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:	01/03/2018	TIME:	10H08		DATE:	01/03/2018	TIME:	11H08		DATE:	01/03/2018	TIME:	12H08	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.15		**1**		**1**	0.26	1.02	**1**		**1**	0.59	1.36	**1**	
2	0.15		**2**		**2**	0.26		**2**		**2**	0.72	2.17	**2**	
3	0.17		**3**		**3**	0.31	1.15	**3**		**3**	0.83		**3**	
5	0.18		**5**		**5**	0.31		**5**		**5**	0.92	3.02	**5**	
7	0.18	0.63	**7**		**7**	0.33	1.22	**7**		**7**	0.91		**7**	
10	0.18	0.66	**10**		**10**	0.33		**10**		**10**	0.91	3.03	**10**	
15	0.19		**15**		**15**	0.33	1.22	**15**		**15**	0.95	3.04	**15**	
20	0.19	0.66	**20**		**20**	0.33		**20**		**20**	0.95		**20**	
30	0.20		**30**		**30**	0.36		**30**		**30**	0.95	3.04	**30**	
40	0.21	0.66	**40**		**40**	0.36	1.20	**40**		**40**	0.95	3.05	**40**	
50	0.21		**50**		**50**	0.36		**50**		**50**	0.95		**50**	
60	0.21	0.66	**60**		**60**	0.37	1.21	**60**		**60**	0.95		**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	01/03/2018	TIME:	13H08		DATE:	01/03/2018	TIME:	14H08		DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	1.84	5.35	**1**		**1**	8.24		**1**	0.90	**1**			**1**	
2	2.10		**2**		**2**	9.48	10.14	**2**	0.65	**2**			**2**	
3	2.82	6.36	**3**		**3**	9.76		**3**	0.49	**3**			**3**	
5	3.23		**5**		**5**	14.86	9.87	**5**	0.31	**5**			**5**	
7	3.22	6.35	**7**		**7**	14.86	9.83	**7**	0.27	**7**			**7**	
10	3.29	6.36	**10**		**PI**	14.86	9.67	**10**	0.20	**10**			**10**	
15	3.42		**15**					**15**	0.15	**15**			**15**	
20	3.45	6.36	**20**					**20**	0.13	**20**			**20**	
30	3.48		**30**					**30**	0.11	**30**			**30**	
40	3.53	6.37	**40**					**40**	0.09	**40**			**40**	
50	3.53	6.38	**50**					**50**	0.07	**50**			**50**	
60	3.54		**60**					**60**	0.05	**60**			**60**	
70			**70**					**70**	0.04	**70**			**70**	
80			**80**					**80**	0.03	**80**			**80**	
90			**90**					**90**	0.02	**90**			**90**	
100			**100**					**100**	0.01	**100**			**100**	
110			**110**					**110**	0.01	**110**			**110**	
120			**120**					**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240					**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch) 1.92
S/W/L:(mbgl) 1.62

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

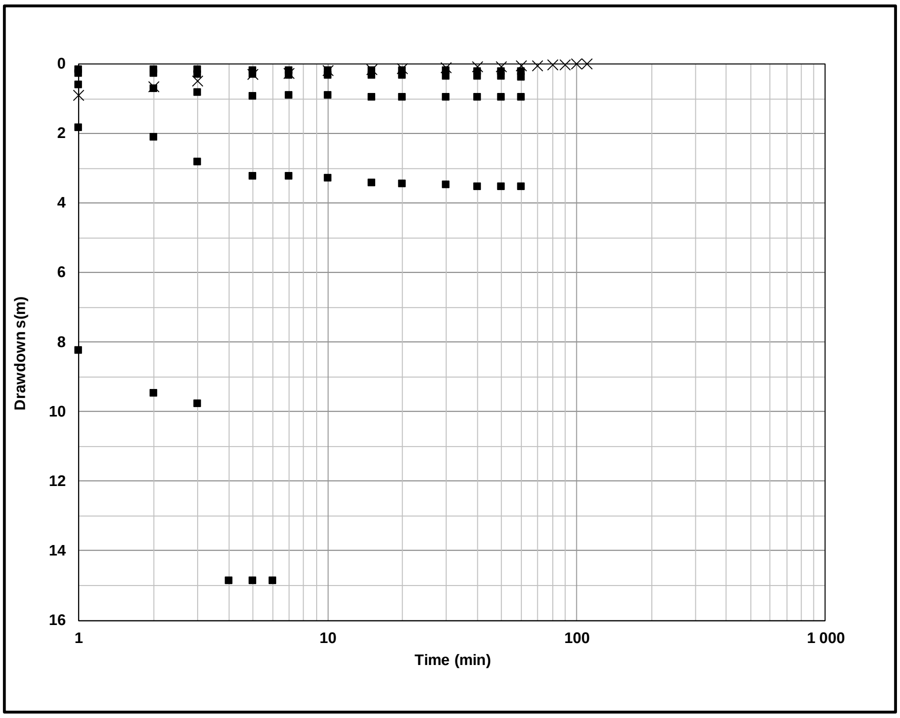
BOREHOLE TEST RECORD SHEET

PROJ NO :	P1947	MAP REFERENCE:	0	PROVINCE:	NC
BOREHOLE NO:	HN-01		0	DISTRICT:	NOENIEPUT
ALT BH NO:	0			SITE NAME:	ANNESLEY SALT PANS
ALT BH NO:	0				
BOREHOLE DEPTH:	26.80	DATUM LEVEL ABOVE CASING (m):	0.40	EXISTING PUMP:	0
WATER LEVEL (mbdl):	2.33	CASING HEIGHT: (magl):	0.30	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	18.50	DIAM PUMP INLET(mm):	165	PUMP TYPE:	0

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED		**TEST COMPLETED**			
DATE: 01/03/2018	TIME: 18H28	DATE:	TIME:	TYPE OF PUMP:	0

					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:			NR:			NR:	
DISCHARGE BOREHOLE					Distance(m);			Distance(m);			Distance(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME MIN	RECOVERY (M)	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)
1	0.95		**1**	0.88	**1**			**1**			**1**	
2	1.26	4.66	**2**	0.68	**2**			**2**			**2**	
3	1.46		**3**	0.55	**3**			**3**			**3**	
5	1.90	5.56	**5**	0.48	**5**			**5**			**5**	
7	2.28	6.13	**7**	0.41	**7**			**7**			**7**	
10	2.72	6.17	**10**	0.38	**10**			**10**			**10**	
15	2.99		**15**	0.37	**15**			**15**			**15**	
20	3.11	6.17	**20**	0.31	**20**			**20**			**20**	
30	3.18		**30**	0.30	**30**			**30**			**30**	
40	3.18	6.17	**40**	0.26	**40**			**40**			**40**	
60	3.26		**60**	0.25	**60**			**60**			**60**	
90	3.30	6.16	**90**	0.23	**90**			**90**			**90**	
120	3.30	6.16	**120**	0.21	**120**			**120**			**120**	
150	3.31		**150**	0.20	**150**			**150**			**150**	
180	3.31	6.16	**180**	0.18	**180**			**180**			**180**	
210	3.32		**210**	0.17	**210**			**210**			**210**	
240	3.32	6.17	**240**	0.15	**240**			**240**			**240**	
300	3.32		**300**	0.14	**300**			**300**			**300**	
360	3.33	6.16	**360**	0.13	**360**			**360**			**360**	
420	3.36		**420**	0.12	**420**			**420**			**420**	
480	3.40	6.13	**480**	0.11	**480**			**480**			**480**	
540	3.42	6.17	**540**	0.09	**540**			**540**			**540**	
600	3.44		**600**	0.07	**600**			**600**			**600**	
720	3.44	6.15	**720**	0.06	**720**			**720**			**720**	
840	3.51		**840**	0.05	**840**			**840**			**840**	
960	3.79	6.11	**960**	0.04	**960**			**960**			**960**	
1080	3.94		**1080**	0.03	**1080**			**1080**			**1080**	
1200	3.94	6.17	**1200**	0.02	**1200**			**1200**			**1200**	
1320	3.94	6.17	**1320**	0.01	**1320**			**1320**			**1320**	
1440	3.94	6.17	**1440**	0.00	**1440**			**1440**			**1440**	
1560			**1560**		**1560**			**1560**			**1560**	
1680			**1680**		**1680**			**1680**			**1680**	
1800			**1800**		**1800**			**1800**			**1800**	
1920			**1920**		**1920**			**1920**			**1920**	
2040			**2040**		**2040**			**2040**			**2040**	
2160			**2160**		**2160**			**2160**			**2160**	
2280			**2280**		**2280**			**2280**			**2280**	
2400			**2400**		**2400**			**2400**			**2400**	
2520			**2520**		**2520**			**2520**			**2520**	
2640			**2640**		**2640**			**2640**			**2640**	
2760			**2760**		**2760**			**2760**			**2760**	
2880			**2880**		**2880**			**2880**			**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):				1440		**W/L**			**W/L**			**W/L**
Average yield (l/s):				6.17								



STEP DRAWDOWN TEST DATA PLOT

▪ = Drawdown data.
X = Recovery data.

LOCALITY

NC
ANNESLEY SALT PANS

BOREHOLE NO:

HN-01

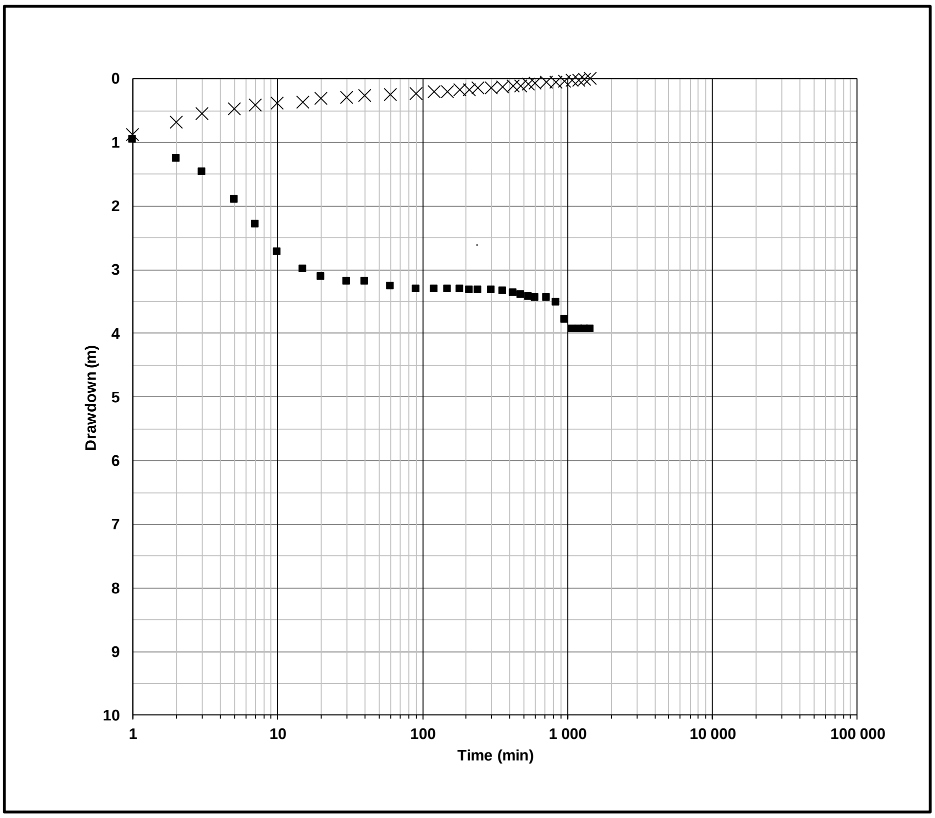
DATE TESTED

13/03/2018

DISCHARGE RATES (Q)

Q1 =	**0.66**	l/s
Q2 =	**1.22**	l/s
Q3 =	**3.03**	l/s
Q4 =	**6.35**	l/s
Q5 =	**0.00**	l/s

S.W.L = **1.62** m.b.g.l.



CONSTANT DISCHARGE TEST DATA PLOT

▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

HN-01

DATE TESTED

01/03/2018

Q = **6.2** l/s.

S.W.L = **1.62** m.b.g.l.

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P1947
BBR	
PRODUCTION BONUS:	
EC meter number	

CONSULTANT: SRK CPT

DISTRICT: NOENIEPUT

PROVINCE: NC

FARM / VILLAGE NAME : ANNESLEY SALT FARMS

DATE TESTED: 13/03/2018

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS: hddd ° mm ' ss.s " OR hddd ° mm.mmm ' OR hddd.ddddd °

LATITUDE: 27 ° 35 ' 43.5 "

LONGITUDE: 20 ° 29 ' 41.0 "

BOREHOLE NO: HN-02

TRANSMISSIVITY VALUE:

TYPE INSTALLATION: OPEN

BOREHOLE DEPTH: (mbgl) 35.35

COMMENTS:

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	
Date sample taken			If consultant took sample, give name:			DATA CHECKED BY:	
Time sample taken							

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	COMMENTS:			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	35.35
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	1.88
CASING DETECTION:	NO	1	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	0	LOGGERS FOR pH AND EC:	NO	0

It is hereby acknowledged that upon leaving the site, all existing equipment is in an acceptable condition.

NAME: ________________ **SIGNATURE:** ______________

DESIGNATION: ________________ **DATE:** ______________

BOREHOLE TEST CONTROL SHEET

Groundwater Solutions t/a AB PUMPS

Borehole number:	HN-02	Old / Alternative number:	
Contractor:	AB PUMPS	Supervisor:	
Operator:		Rig number & Type rig:	

EXISTING EQUIPMENT

Type pump	Depth	Condition	**Drive unit**	Condition	**Pump house**	Condition	**Remarks**

TESTING EQUIPMENT

Pump type	**Depth installed (m)**	**Date & time (started)**	**Date & time (completed)**
	30.50	04/03/2018 08H00	

MULTI-RATE OR STEPTEST DETAILS

STEP	**DURATION (MIN)**	**RECOVERY (MIN)**	**YIELD (L/S)**		**DRAWDOWN (m)**
1	60		0.86	l/s	0.18
2	60	120.00	1.57	l/s	0.26
3	60		3.36	l/s	0.76
4	60		6.62	l/s	2.06
5	60		10.87	l/s	4.97
6				l/s	
7				l/s	
8				l/s	
Calibration:				l/s	
TOTAL:	300	120	23.28	l/s	8.23
COMMENT:					

CONSTANT RATE DISCHARGE TEST

Pump type	**Depth installed (m)**	**Date & time (started)**		**Date & time (completed)**	
0	30.50	04/03/2018	15H03		
Yield l/s	**Drawdown (m)**	**Duration (min)**		**Recovery (min)**	
8.22	3.63	1440		960	
Total: (Multi-rate and Constant Discharge rate)		1740		1080	
COMMENT:					

MAINTENANCE

Work time:	hour	Transport existing equipm.	Km	Travelling (To fix);	Km
List of parts replaced or repaired:					

	Borehole number	**Duration (min) CONSTANT**	**Drawdown (m)**	**Hand/logger**	**Distance (m)**
Observation Hole 1	HN01	SEE DATA			127.6
Observation Hole 2	HN03	SEE DATA			58.3
Observation Hole 3					0
Observation Hole 4					
Observation Hole 5					

GENERAL

ESTABLISHMENT	From:		To:			
Site Move	From project#		To #:	P1947	Travelling km:	
	Village	Borehole no	Village	Borehole no		
			ANNESLEY SALT FARMS	HN-02		
Maintenance:	Work time hr		Parts repaired/ replaced		Travelling km	
After test measurements	Water level	1.88	Borehole depth	35.35	Casing depth m	PVC
Water level before installing test pump: (mbch)			1.88			
Depth before installing test pump:			35.35			
Testpump Installed	**Once** /Twice /More		Reason:			
Installed Testpump	**<10 l/s** / >10ls/s		Reason:			
Was existing equipment re-installed:		**Yes:**		If not where was it left:		
GPS Unit number:						
EC Unit number:			0.00			

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1947	MAP REFERENCE:	0	PROVINCE:	NC
BOREHOLE NO:	HN-02			DISTRICT:	NOENIEPUT
ALT BH NO:	0			SITE NAME:	ANNESLEY SALT FARMS
ALT BH NO:	0				

BOREHOLE DEPTH (m)	35.35	DATUM LEVEL ABOVE CASING (m):	0.38	EXISTING PUMP:	0
WATER LEVEL (mbdl):	1.88	CASING HEIGHT: (magl):	0.09	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	30.50	DIAM PUMP INLET (mm):	165.00	PUMP TYPE:	0

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:	08H00	TIME:	04/03/2018		DATE:	09H00	TIME:	04/03/2018		DATE:	10H00	TIME:	04/03/2018	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.18		**1**		**1**	0.18	1.20	**1**		**1**	0.63	2.97	**1**	
2	0.18	0.86	**2**		**2**	0.18		**2**		**2**	0.71		**2**	
3	0.18		**3**		**3**	0.22	1.57	**3**		**3**	0.71	3.33	**3**	
5	0.09	0.81	**5**		**5**	0.22		**5**		**5**	0.71		**5**	
7	0.08		**7**		**7**	0.22	1.57	**7**		**7**	0.71	3.36	**7**	
10	0.09	0.82	**10**		**10**	0.22		**10**		**10**	0.72		**10**	
15	0.09		**15**		**15**	0.23		**15**		**15**	0.74	3.38	**15**	
20	0.10	0.82	**20**		**20**	0.23	1.59	**20**		**20**	0.75		**20**	
30	0.10		**30**		**30**	0.24		**30**		**30**	0.75	3.39	**30**	
40	0.10	0.82	**40**		**40**	0.25	1.59	**40**		**40**	0.75		**40**	
50	0.14		**50**		**50**	0.25		**50**		**50**	0.75	3.41	**50**	
60	0.18	0.82	**60**		**60**	0.26		**60**		**60**	0.76		**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	11H00	TIME:	04/03/2018		DATE:	12H00	TIME:	05/03/2018		DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	1.45	5.66	**1**		**1**	2.42		**1**	0.50	**1**			**1**	
2	1.78		**2**		**2**	2.65	7.79	**2**	0.36	**2**			**2**	
3	1.91	6.59	**3**		**3**	3.40		**3**	0.26	**3**			**3**	
5	1.98		**5**		**5**	3.60	9.00	**5**	0.22	**5**			**5**	
7	1.99	6.62	**7**		**7**	3.84		**7**	0.15	**7**			**7**	
10	1.99		**10**		**10**	4.03	9.84	**10**	0.10	**10**			**10**	
15	1.99	6.63	**15**		**15**	4.62	10.87	**15**	0.07	**15**			**15**	
20	2.02		**20**		**20**	4.74	11.04	**20**	0.06	**20**			**20**	
30	2.04	6.64	**30**		**30**	4.85		**30**	0.05	**30**			**30**	
40	2.04		**40**		**40**	4.87	11.19	**40**	0.03	**40**			**40**	
50	2.04	6.64	**50**		**50**	4.90		**50**	0.03	**50**			**50**	
60	2.06		**60**		**60**	4.97	11.20	**60**	0.02	**60**			**60**	
70			**70**		**70**			**70**	0.00	**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240					**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch)

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1947	MAP REFERENCE:	0	PROVINCE:	NC
BOREHOLE NO:	HN-02		0	DISTRICT:	NOENIEPUT
ALT BH NO:	0			SITE NAME:	ANNESLEY SALT FARMS
ALT BH NO:	0				
BOREHOLE DEPTH:	35.35	DATUM LEVEL ABOVE CASING (m):	0.38	EXISTING PUMP:	0
WATER LEVEL (mbdl):	2.50	CASING HEIGHT: (magl):	0.09	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	30.50	DIAM PUMP INLET(mm):	165	PUMP TYPE:	0

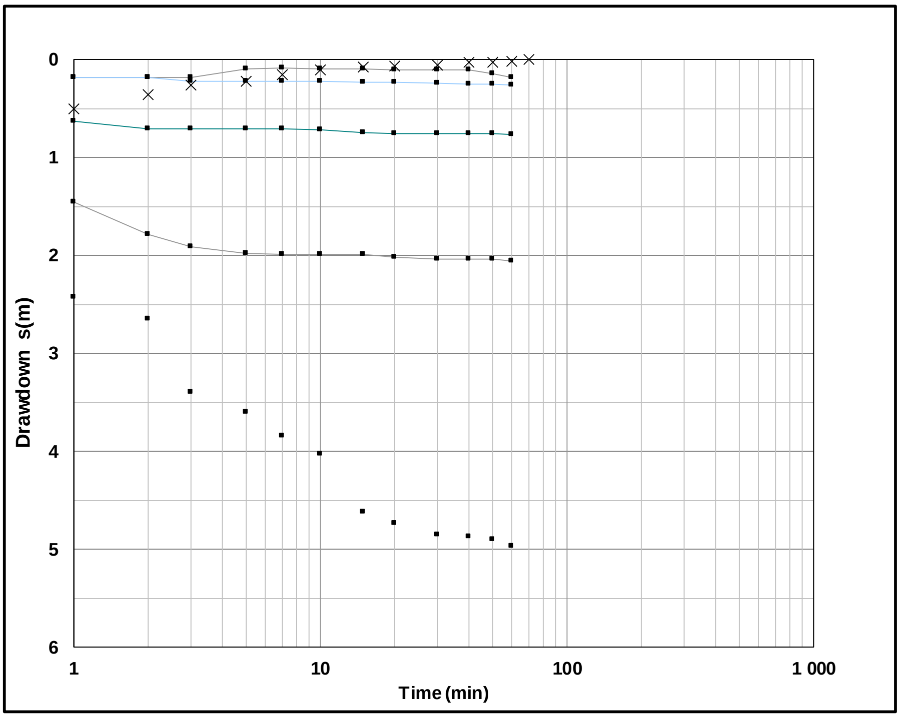
CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				**TEST COMPLETED**			
DATE:	04/03/2018	TIME:	15H02	DATE:		TIME:	

TYPE OF PUMP: 0

DISCHARGE BOREHOLE					OBSERVATION HOLE 1 NR: Distance(m);			OBSERVATION HOLE 2 NR: Distance(m);			OBSERVATION HOLE 3 NR: Distance(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME MIN	RECOVERY (M)	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)
1	2.01		**1**	0.52	**1**			**1**			**1**	
2	2.37		**2**	0.43	**2**			**2**			**2**	
3	2.56	7.74	**3**	0.37	**3**			**3**			**3**	
5	2.67		**5**	0.33	**5**			**5**			**5**	
7	2.87	8.05	**7**	0.32	**7**			**7**			**7**	
10	2.97	8.17	**10**	0.29	**10**			**10**			**10**	
15	3.13		**15**	0.28	**15**			**15**			**15**	
20	3.20	8.20	**20**	0.28	**20**			**20**			**20**	
30	3.34		**30**	0.24	**30**			**30**			**30**	
40	3.35	8.21	**40**	0.22	**40**			**40**			**40**	
60	3.38		**60**	0.18	**60**			**60**			**60**	
90	3.44	8.22	**90**	0.17	**90**			**90**			**90**	
120	3.47		**120**	0.17	**120**			**120**			**120**	
150	3.51	8.22	**150**	0.16	**150**			**150**			**150**	
180	3.54	8.22	**180**	0.14	**180**			**180**			**180**	
210	3.54		**210**	0.13	**210**			**210**			**210**	
240	3.54	8.22	**240**	0.13	**240**			**240**			**240**	
300	3.57		**300**	0.12	**300**			**300**			**300**	
360	3.57	8.23	**360**	0.08	**360**			**360**			**360**	
420	3.60	8.24	**420**	0.08	**420**			**420**			**420**	
480	3.60		**480**	0.07	**480**			**480**			**480**	
540	3.61	8.23	**540**	0.06	**540**			**540**			**540**	
600	3.63	8.24	**600**	0.05	**600**			**600**			**600**	
720	3.63		**720**	0.03	**720**			**720**			**720**	
840	3.64		**840**	0.01	**840**			**840**			**840**	
960	3.62	8.22	**960**	0.00	**960**			**960**			**960**	
1080	3.62		**1080**		**1080**			**1080**			**1080**	
1200	3.63	8.23	**1200**		**1200**			**1200**			**1200**	
1320	3.64	8.23	**1320**		**1320**			**1320**			**1320**	
1440	3.63		**1440**		**1440**			**1440**			**1440**	
1560			**1560**		**1560**			**1560**			**1560**	
1680			**1680**		**1680**			**1680**			**1680**	
1800			**1800**		**1800**			**1800**			**1800**	
1920			**1920**		**1920**			**1920**			**1920**	
2040			**2040**		**2040**			**2040**			**2040**	
2160			**2160**		**2160**			**2160**			**2160**	
2280			**2280**		**2280**			**2280**			**2280**	
2400			**2400**		**2400**			**2400**			**2400**	
2520			**2520**		**2520**			**2520**			**2520**	
2640			**2640**		**2640**			**2640**			**2640**	
2760			**2760**		**2760**			**2760**			**2760**	
2880			**2880**		**2880**			**2880**			**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):						**W/L**			**W/L**			**W/L**
Average yield (l/s):												

STEP DRAWDOWN TEST DATA PLOT



■ = Drawdown data.
X = Recovery data.

LOCALITY

NC
ANNESLEY SALT FARMS

BOREHOLE NO:

HN-02

DATE TESTED

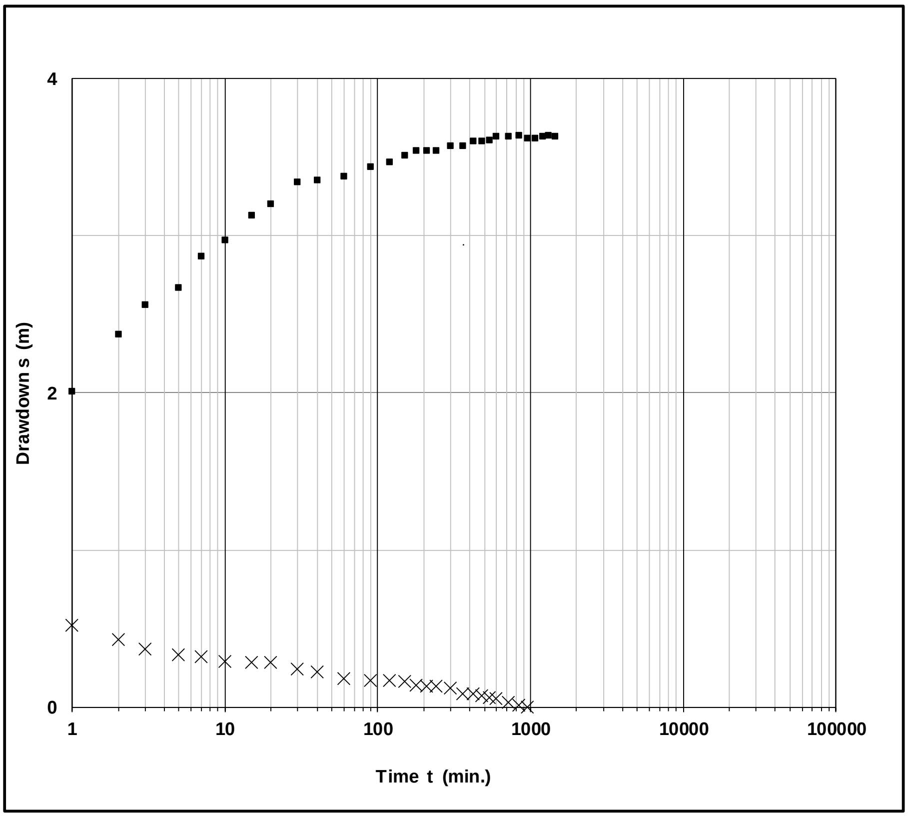
13/03/2018

DISCHARGE RATES (Q)

Q1 =	**0.86**	l/s
Q2 =	**1.57**	l/s
Q3 =	**3.36**	l/s
Q4 =	**6.62**	l/s
Q5 =	**0.00**	l/s

S.W.L = **1.88** m.b.g.l.

CONSTANT DISCHARGE TEST DATA PLOT



■ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

HN-02

DATE TESTED

04/03/2018

Q = **0.0** l/s.

S.W.L = **2.50** m.b.g.l.

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PROJECT #	P1947
BBR	
PRODUCTION BONUS:	
EC meter number	

CONSULTANT: SRK CPT
DISTRICT: NOENIEPUT
PROVINCE: NC
FARM / VILLAGE NAME : NOENIEPUT

DATE TESTED: 06/03/2018

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS: hddd ° mm ' ss.s " OR hddd ° mm.mmm ' OR hddd.ddddd

LATITUDE: 27 ° 35 ' 44.5 "
LONGITUDE: 20 ° 29 ' 28.4 "

BOREHOLE NO: HN-03
TRANSMISSIVITY VALUE:
TYPE INSTALLATION: OPEN
BOREHOLE DEPTH: (mbgl) 46.60

COMMENTS:

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	AVN
Date sample taken			If consultant took sample, give name:			DATA CHECKED BY:	AVN
Time sample taken							

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:		m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:		m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:		m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	COMMENTS:		
RECOVERY:			STEP 5:		l/s			
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)		
AFTER CONSTANT:		h	STEP DURATION:		min			

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	46.60
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	2.13
CASING DETECTION:	NO	PVC	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	0	LOGGERS FOR pH AND EC:	NO	0

It is hereby acknowledged that upon leaving the site, all existing equipment is in an acceptable condition.

NAME: ____________ **SIGNATURE:** ____________
DESIGNATION: ____________ **DATE:** ____________

BOREHOLE TEST CONTROL SHEET
Groundwater Solutions t/a AB PUMPS

Borehole number:	HN-03	Old / Alternative number:	
Contractor:	AB PUMPS	Supervisor:	
Operator:		Rig number & Type rig:	

EXISTING EQUIPMENT

Type pump	Depth	Condition	Drive unit	Condition	Pump house	Condition	Remarks

TESTING EQUIPMENT

Pump type	Depth installed (m)	Date & time (started)	Date & time (completed)
	42.50	06/03/2018 09H38	

MULTI-RATE OR STEPTEST DETAILS

STEP	DURATION (MIN)	RECOVERY (MIN)	YIELD (L/S)		DRAWDOWN (m)
1	60	120	0.84	l/s	0.71
2	60		1.48	l/s	1.25
3	60		3.27	l/s	9.78
4	9		5.56	l/s	39.03
5				l/s	
6				l/s	
7				l/s	
8				l/s	
Calibration:				l/s	
TOTAL:	189	120	11.15	l/s	50.77
COMMENT:					

CONSTANT RATE DISCHARGE TEST

Pump type	Depth installed (m)	Date & time (started)		Date & time (completed)	
0	42.50	06/03/2018	15H32		
Yield l/s	**Drawdown (m)**	**Duration (min)**		**Recovery (min)**	
2.71	7.21	1440		180	
Total: (Multi-rate and Constant Discharge rate)		1629		300	
COMMENT:					

MAINTENANCE

Work time: hour	Transport existing equipm. Km	Travelling (To fix); Km
List of parts replaced or repaired:		

	Borehole number	Duration (min) CONSTANT	Drawdown (m)	Hand/logger	Distance (m)
Observation Hole 1	HN-01	SEE DATA			185.9
Observation Hole 2	HN-02	SEE DATA			58.3
Observation Hole 3					0
Observation Hole 4					
Observation Hole 5					

GENERAL

ESTABLISHMENT	From:		To:			
Site Move	From project#		To #:	P1947	Travelling km:	
	Village	Borehole no	Village	Borehole no		
			NOENIEPUT	HN-03		
Maintenance:	Work time hr		Parts repaired/ replaced		Travelling km	
After test measurements	Water level	2.13	Borehole depth	46.60	Casing depth m	

Water level before installing test pump: (mbch)		2.13	
Depth before installing test pump:		46.60	
Testpump Installed	**Once** /Twice /More	Reason:	
Installed Testpump	**<10 l/s** / >10ls/s	Reason:	
Was existing equipment re-installed:			If not where was it left:
GPS Unit number:			
EC Unit number:		0.00	

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1947	MAP REFERENCE:	0	PROVINCE:	NC
BOREHOLE NO:	HN-03			DISTRICT:	NOENIEPUT
ALT BH NO:	0			SITE NAME:	NOENIEPUT
ALT BH NO:	0				
BOREHOLE DEPTH (m)	46.60	DATUM LEVEL ABOVE CASING (m):	0.36	EXISTING PUMP:	0
WATER LEVEL (mbdl):	2.13	CASING HEIGHT: (magl):	0.30	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	42.50	DIAM PUMP INLET (mm):	165.00	PUMP TYPE:	0

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:	06/03/2018	TIME:	09H38		DATE:	06/03/2018	TIME:	10H38		DATE:	06/03/2018	TIME:	11H38	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.38		**1**		**1**	0.95	1.44	**1**		**1**	2.88	2.80	**1**	
2	0.41		**2**		**2**	0.98		**2**		**2**	3.32		**2**	
3	0.48		**3**		**3**	1.02	1.46	**3**		**3**	3.91	3.22	**3**	
5	0.56	0.50	**5**		**5**	1.03		**5**		**5**	5.43		**5**	
7	0.56		**7**		**7**	1.08	1.46	**7**		**7**	6.35		**7**	
10	0.70	0.83	**10**		**10**	1.10		**10**		**10**	7.22	3.25	**10**	
15	0.71		**15**		**15**	1.14	1.48	**15**		**15**	8.31		**15**	
20	0.71	0.84	**20**		**20**	1.15		**20**		**20**	8.71	3.27	**20**	
30	0.71	0.84	**30**		**30**	1.18	1.48	**30**		**30**	8.94		**30**	
40	0.71		**40**		**40**	1.24		**40**		**40**	9.05	3.27	**40**	
50	0.71	0.83	**50**		**50**	1.25	1.48	**50**		**50**	9.63		**50**	
60	0.71		**60**		**60**	1.25		**60**		**60**	9.78		**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	06/03/2018	TIME:	12H38		DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	17.19		**1**	19.58	**1**			**1**		**1**			**1**	
2	23.79	5.56	**2**	13.77	**2**			**2**		**2**			**2**	
3	35.50		**3**	7.67	**3**			**3**		**3**			**3**	
5	38.98		**5**	3.29	**5**			**5**		**5**			**5**	
7	39.03	3.48	**7**	1.70	**7**			**7**		**7**			**7**	
10	39.03	3.22	**10**	1.06	**10**			**10**		**10**			**10**	
15			**15**	0.45	**15**			**15**		**15**			**15**	
20			**20**	0.32	**20**			**20**		**20**			**20**	
30			**30**	0.19	**30**			**30**		**30**			**30**	
40			**40**	0.13	**40**			**40**		**40**			**40**	
50			**50**	0.03	**50**			**50**		**50**			**50**	
60			**60**	0.02	**60**			**60**		**60**			**60**	
70			**70**	0.00	**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240					**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch)

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

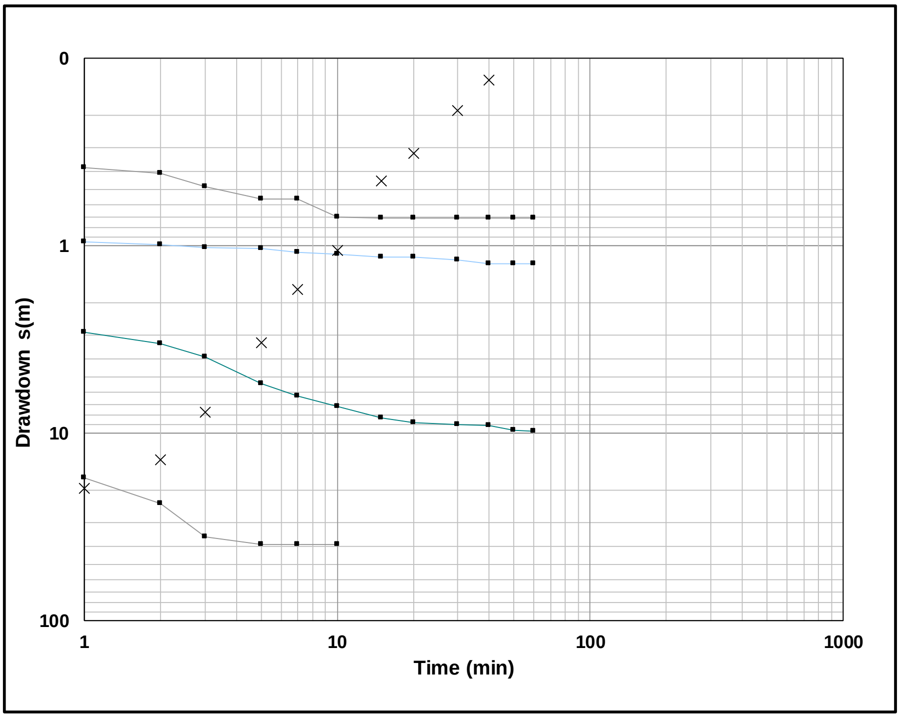
PROJ NO :	P1947	MAP REFERENCE:	0	PROVINCE:	NC
BOREHOLE NO:	HN-03		0	DISTRICT:	NOENIEPUT
ALT BH NO:	0			SITE NAME:	NOENIEPUT
ALT BH NO:	0				
BOREHOLE DEPTH:	46.60	DATUM LEVEL ABOVE CASING (m):	0.36	EXISTING PUMP:	0
WATER LEVEL (mbdl):	2.47	CASING HEIGHT: (magl):	0.30	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	42.50	DIAM PUMP INLET(mm):	165	PUMP TYPE:	0

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				TEST COMPLETED					
DATE:	06/03/2018	TIME:	15h32	DATE:		TIME:		TYPE OF PUMP:	0

DISCHARGE BOREHOLE					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:			NR:			NR:	
					Distance(m);			Distance(m);			Distance(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME MIN	RECOVERY (M)	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)
1	1.68		1	2.87	1			1			1	
2	2.04	1.88	2	1.60	2			2			2	
3	2.56	2.37	3	1.15	3			3			3	
5	3.29	2.65	5	0.71	5			5			5	
7	3.88	2.73	7	0.45	7			7			7	
10	4.39		10	0.28	10			10			10	
15	4.86	2.72	15	0.19	15			15			15	
20	5.13	2.70	20	0.16	20			20			20	
30	5.37		30	0.11	30			30			30	
40	5.55	2.71	40	0.09	40			40			40	
60	5.78		60	0.07	60			60			60	
90	5.99	2.70	90	0.05	90			90			90	
120	6.15		120	0.02	120			120			120	
150	6.26		150	0.01	150			150			150	
180	6.40	2.72	180	0.00	180			180			180	
210	6.70		210		210			210			210	
240	6.70	2.71	240		240			240			240	
300	6.96		300		300			300			300	
360	6.97	2.72	360		360			360			360	
420	6.98		420		420			420			420	
480	7.04	2.73	480		480			480			480	
540	7.06		540		540			540			540	
600	7.11		600		600			600			600	
720	7.15	2.74	720		720			720			720	
840	7.18		840		840			840			840	
960	7.20	2.74	960		960			960			960	
1080	7.21		1080		1080			1080			1080	
1200	7.20	2.76	1200		1200			1200			1200	
1320	7.20	2.76	1320		1320			1320			1320	
1440	7.21		1440		1440			1440			1440	
1560			1560		1560			1560			1560	
1680			1680		1680			1680			1680	
1800			1800		1800			1800			1800	
1920			1920		1920			1920			1920	
2040			2040		2040			2040			2040	
2160			2160		2160			2160			2160	
2280			2280		2280			2280			2280	
2400			2400		2400			2400			2400	
2520			2520		2520			2520			2520	
2640			2640		2640			2640			2640	
2760			2760		2760			2760			2760	
2880			2880		2880			2880			2880	
3000			3000		3000			3000			3000	
3120			3120		3120			3120			3120	
3240			3240		3240			3240			3240	
3360			3360		3360			3360			3360	
3480			3480		3480			3480			3480	
3600			3600		3600			3600			3600	
3720			3720		3720			3720			3720	
3840			3840		3840			3840			3840	
3960			3960		3960			3960			3960	
4080			4080		4080			4080			4080	
4200			4200		4200			4200			4200	
4320			4320		4320			4320			4320	
Total time pumped(min):						W/L			W/L			W/L
Average yield (l/s):												

STEP DRAWDOWN TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

LOCALITY

NC
NOENIEPUT

BOREHOLE NO:

HN-03

DATE TESTED

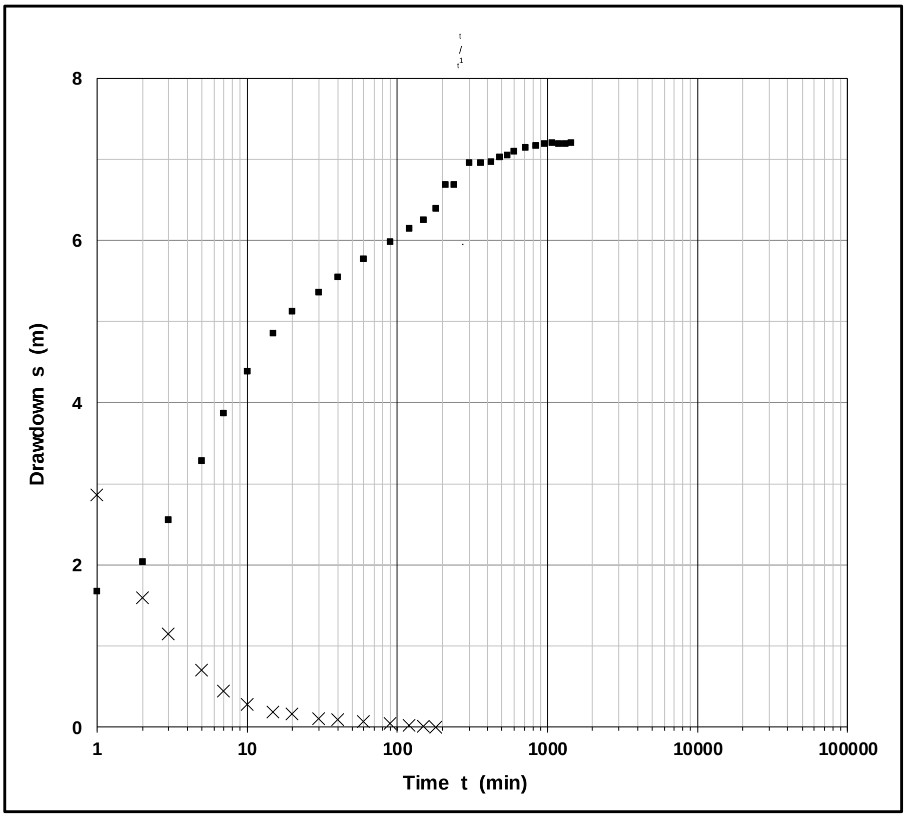
06/03/2018

DISCHARGE RATES (Q)

Q1 =	**0.84**	l/s
Q2 =	**1.48**	l/s
Q3 =	**3.27**	l/s
Q4 =	**5.56**	l/s
Q5 =	**0.00**	l/s

S.W.L =	**2.13**	m.b.g.l.

CONSTANT DISCHARGE TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

HN-03

DATE TESTED

06/03/2018

Q =	**0.0**	l/s.
S.W.L =	**2.47**	m.b.g.l.

Appendix C: Water Quality Analysis Certificates

sanas Testing Laboratory T0122 Talbot & Talbot

Talbot Laboratories (Pty) Ltd • Company Registration Number: 2016/334237/07
20 Pentrich Road, P.O Box 22598, Pietermaritzburg, 3200, KwaZulu-Natal

2018/04/11

ANALYTICAL REPORT

OUR REF: 002112/18
COMPANY NAME: AB PUMPS
CONTACT ADDRESS: PRIVATE BAG X39, BEACON BAY, EAST LONDON, 5205
CONTACT PERSON: AILENE VAN NIEKERK
QUOTE: QU03-0041
ORDER NUMBER: 112190
SAMPLE TYPE: BOREHOLE WATER
DATE SUBMITTED: 2018-03-14

Determinand	Units	Method No	Borehole Results		
			P1947 HN-01	P1947 HN-02	P1947 HN-03
Ammonia	mg N/ℓ	64G	<0.11	<0.11	0.21
Chloride	mg Cl/ℓ	16G	118 639	123 950	123 047
Dissolved Aluminium	mg Al/ℓ	87	<0.02	<0.02	<0.02
Dissolved Antimony	mg Sb/ℓ	89	0.47	0.59	0.3
Dissolved Arsenic	mg As/ℓ	88	0.36	0.41	0.34
Dissolved Barium	mg Ba/ℓ	87	<0.02	<0.02	<0.02
Dissolved Beryllium	mg Be/ℓ	87	<0.02	<0.02	<0.02
Dissolved Boron	mg B/ℓ	87	23	22	25
Dissolved Cadmium	mg Cd/ℓ	87	<0.02	<0.02	<0.02
Dissolved Calcium	mg Ca/ℓ	85	0.57	<0.12	<0.12
Dissolved Chromium	mg Cr/ℓ	87	<0.02	<0.02	<0.02
Dissolved Cobalt	mg Co/ℓ	87	<0.02	<0.02	<0.02
Dissolved Copper	mg Cu/ℓ	87	0.02	<0.02	<0.02
Dissolved Iron	mg Fe/ℓ	87	<0.02	<0.02	<0.02
Dissolved Lead	mg Pb/ℓ	87	<0.03	<0.03	<0.03
Dissolved Lithium	mg Li/ℓ	87	<0.02	<0.02	<0.02
Dissolved Magnesium	mg Mg/ℓ	85	0.12	<0.07	<0.07
Dissolved Manganese	mg Mn/ℓ	87	<0.02	<0.02	<0.02
Dissolved Mercury	mg Hg/ℓ	86	<0.002	<0.002	<0.002
Dissolved Molybdenum*	mg Mo/ℓ	87	0.32	0.29	0.2
Dissolved Nickel	mg Ni/ℓ	87	<0.02	<0.02	<0.02
Dissolved Selenium	mg Se/ℓ	88	0.75	0.83	0.68
Dissolved Silver*	mg Ag/ℓ	87	<0.01	<0.01	<0.01
Dissolved Strontium	mg Sr/ℓ	87	0.11	0.09	0.08
Dissolved Thallium	mg Tl/ℓ	87	<0.02	<0.02	<0.02
Dissolved Tin	mg Sn/ℓ	87	<0.02	<0.02	<0.02
Dissolved Titanium	mg Ti/ℓ	87	<0.03	<0.03	<0.03
Dissolved Uranium*	mg U/ℓ	87	0.18	0.23	0.17
Dissolved Vanadium	mg V/ℓ	87	0.56	0.63	0.65
Dissolved Zinc	mg Zn/ℓ	87	<0.02	<0.02	<0.02
Electrical Conductivity at 25°C	mS/m	2	31 240	31 840	32 400
Fluoride	µg F/ℓ	18A	98 000	106 000	82 000
Nitrate	mg N/ℓ	65Gc	412	433	407
Nitrite	mg N/ℓ	65Gb	0.58	0.6	1.2
Odour*	-	-	Odourless	Odourless	Odourless
pH at 25°C	pH units	1A	9	9	9.4
Potassium	mg K/ℓ	85	34	34	38
Sodium	mg Na/ℓ	84	113 100	137 759	134 330
Sulphate	mg SO4/ℓ	67G	17 536	17 142	19 787
Total Dissolved Solids at 180°C	mg/ℓ	41	226 888	230 326	243 280
Total Organic Carbon*	mg C/ℓ	-	8.4#	6.7#	8.5#
Turbidity	NTU	4	1.5	0.9	0.9

Technical Signatory:

Chemistry: Dr. Abie Khan

Microbiology: Jocelyn Winchester

- This report relates only to the samples tested. This report shall not be reproduced, except in full, without the written approval of **TALBOT LABORATORIES.**
- Tests marked with an asterisk (*) in this report are not SANAS accredited and are not included in the Schedule of Accreditation for our laboratory.
- Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
- If the microbiological sample requirements are not met on receipt at the laboratory, the accuracy of the test results may be in question.
- Uncertainty of Measurement (UOM) values for Talbot Laboratories (T0122) apply to tests analysed at 20 Pentrich Road and are identified in the attached Appendix. UOM values for subcontracted tests, marked with a #, are available on request
- Note: Results marked with a (#) have been sub-contracted to a peer laboratory.
- Note: Estimates of Uncertainty of Measurement may be obtained from the laboratory if required.

Appendix D: Impact Severity Rating 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 A-G.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 mitigation 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,

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

POTENTIAL ENVIRONMENTAL IMPACT	CRITERIA					SCORE	SIGNIFICANCE		
	Nature	P	D	S	M	TOTAL	L	M	H
CONSTRUCTION	-	3	4	2	4	30		M	
CONSTRUCTION MITIGATION	+	3	1	1	2	12	L		
OPERATION	-	3	1	1	4	18	L		
OPERATION MITIGATION	-	3	1	1	2	12	L		

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