HYDROGEOLOGICAL AND CONTAMINATION RISK ASSESSMENT STUDY FOR THE PLANNED FILLING STATION, TO BE LOCATED ON PORTION 135 OF THE FARM BOSCHOEK 103 JQ, RUSTENBURG, LOCATED IN THE NORTH WEST PROVINCE

Prepared for

Hydro Science

P.O. Box 1322

Ruimsig

1732

by

HK Geohydrological Services Pty Ltd

Report No: G 2019/032

November 2020

Author: JHB Kruidenier

Pr. Sci. Nat: Number 400106/15

25th Avenue 327		25th Avenue 327
Villieria		Villieria
Pretoria	Cell: 082 872 5705	Pretoria
0186	Email: henk@geo-logic.co.za	0186

EXECUTIVE SUMMARY

This document presents the results of a Hydrogeological Assessment study which aim to establishing a reference of hydrogeological data to form part of an application for the proposed construction of a new filling station, to be located on Portion 135 of the Farm Boschoek 103 JQ near Rustenburg, North West Province.

The proposed site is located in Boshoek, on the northern side of the R565. The area of the development is 1.3933 ha in extent. The proposed filling station will include a standard filling station with a canopy covered forecourt, a convenience store and underground tanks (UST) for both petrol and diesel.

The proposed filling station will abstract groundwater to supply in the water demand. The water demand for the planned filling station is 15m^3/d. The aim of this study is to serve as a base line groundwater reference study.

HK Geohydrological Services Pty Ltd was appointed by Hydro Science to do a geohydrological assessment study for Portion 135 Farm Boschoek 103 JQ.

A desk study was performed to gather relevant geological and geohydrological information. A hydro - census followed the desk study to establish information such as water levels and borehole depths in existing boreholes in the region of the proposed Boshoek filling station. The purpose of this survey was to gather relevant geohydrological information to study the groundwater regime, geohydrological information of current groundwater use, water level depth and borehole coordinates in the area. Seven boreholes, including the one on site borehole of the proposed filling station site, could be found in a 1 km radius from the proposed filling station site. Four water level depths could be measured in the seven boreholes visited during the field visit.

A geological walk-over study was done to determine the in-situ geology. One test pit was prepared for a double ring inflow meter test. The aim of this test was to establish percolation rates for the relevant soil zones or host rock to facilitate the contamination risk assessment. A geophysical study investigated the geological integrity of the host rock of the site. This data was used to guide the final conclusions of the geohydrological risk assessment.

The percolation rate test, geology - and groundwater occurrence information were utilized to determine the geohydrological risk for the site. A groundwater monitoring program was proposed to facilitate groundwater monitoring during the implementation phase of the project.

During the hydrogeological study the following conclusions could be made:

- Borehole BH 1 can be used at a rate of 1.5l/s for 12h/d or 64.8m^3/d to supply in the water demand for the filling station.
- The water demand for the filling station is 15m^3/d.

- The borehole can provide in the water demand for the filling station site.
- The water level depth on the proposed development site is 15.75 metres below casing level.
- Residents in the area use groundwater as the only water source.
- Bulk water and sanitation lines are not available in the village.
- According to the Groundwater Protocol document, Version 2, the vulnerability of the Groundwater Aquifer due to the Hydrogeological Conditions at the proposed filling station site can be rated as **Medium** risk.
- The surface material layer that is found on site has a medium capacity to absorb contaminants and a medium capacity to create an effective barrier to contaminants.
- A high reduction of bacteria and viruses will be evident in the unsaturated aquifer if a sanitation leak does happen.
- Some reduction of Nitrates and phosphates will occur and chloride will be minimally reduced.
- Little reduction of chemicals such as hydrocarbons is expected.
- During the construction phase the potential impacts without mitigation measures are rated as **"Negligible"** to **"Low"**. With mitigation measures the significance of the impact is rated as **"Negligible"**.
- During the operational phase the significance of the impacts without mitigation measures are rated as **"Moderate"**. With mitigation measures the significance of the impact is rated as **"Negligible"**.

The following mitigation measures are recommended in the Construction Phase:

- Construction should preferably take place in the dry season, as surface water runoff is minimal.
- Additional storm water concentration must be contained.
- Latrines should be kept away from sensitive drainage areas. Temporary latrines used during construction must be connected to the bulk sewerage lines if possible. Alternatively portable latrines should be sealed units that can be cleaned by truck and the waste must be taken to a suitable sewage facility for treatment. They should be well maintained and regularly cleaned and sewage should not be allowed to directly access the groundwater. Latrines must be used as a first priority. "Go to the bush" must be prohibited.
- No uncontrolled discharges from the construction camp should be permitted.

- All vehicles shall be properly maintained and serviced so that no oil leaks occur on site.
- Any stockpiled soil and rock should have storm water management measures implemented.
- The large roof structures to be implemented may enhance storm water volumes that need to be managed.
- A storm water plan must be available and used during all the phases of construction. This must include siltation ponds handling storm water concentrations.
- Vehicles and machines on site must be maintained properly to ensure that oil spillages are kept at a minimum.
- Spill trays must be provided for refuelling of plant vehicles.

The following mitigation measures are recommended in the Operational Phase:

- Storm water originating from the filling station surface area must be treated as dirty water.
- Clean water and dirty water systems must be separated.
- Storm water must be directed away and around the filling station sites.
- Leak detection systems must be implemented in all fuel storage and transmission lines and tanks.
- Air monitoring systems must be implemented around the storage tanks.
- Borehole BH 1 is situated ideally to monitor groundwater impacts. This borehole must be monitored for BTEXN and TPH parameters as well as major cat and anions to serve as a baseline value. If contamination is detected the groundwater monitoring cycle must be shortened to a two monthly cycle.
- The spillage of fuels, chemicals and or sewerage water must be immediately reported to the assigned Departments stipulated in the water use licence document and other documents stipulating monitoring practices.
- An emergency accidental spillage plan must be in place and workers must be trained to handle such accidents.
- No uncontrolled discharges resulting in pollution of the receiving environment and aquifer shall be permitted.
- Chemical storage areas should be sufficiently contained, and the use of chemicals should be controlled.
- Water seeping into filled levels on site must be prevented.
- Water pumped from any sump or temporary dewatering pit should be pumped into a dirty

water system and should not be allowed to enter any clean water system, natural drainage line, or the aquifer.

- All water retention structures, including storm water dams, retention ponds etc. should be constructed to have adequate freeboard to be able to contain water from 1:50 year rain events

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1. INTRODUCTION

1.1 Background

This document presents the results of a Hydrogeological Assessment study which aim to establishing a reference of hydrogeological data to form part of an application for the proposed construction of a new filling station, to be located on Portion 135 of the Farm Boschoek 103 JQ near Rustenburg, North West Province.

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1.2 Scope of investigation

The scope of work can be defined as follows:

1) Desk study of the geology and groundwater regime.
2) Hydro-census of existing boreholes and surface water bodies in a radius around the planned development area.
3) Geophysical survey to study the integrity of the geology below the planned filling station sites by doing a Electromagnetic survey.
4) Do a double ring inflow meter tests to be able to calculate the hydraulic conductivity of the unsaturated zones in the different lithological horizons for the filling station sites.
5) Taking of water, sand or soil samples from an existing borehole (if available) for quality analyses and BTEXN and TPH parameters.
6) Chemical water quality assessment for the proposed production borehole.
7) Collect information on existing threats to groundwater quality.
8) Assess risk from the fuel storage system
9) Hydrogeological impact assessment for the site.
10) Compilation of a hydrogeological study report which will contain the hydro-census

information, geological description, groundwater flow directions, surface water bodies and boreholes.

11) Groundwater monitoring network and monitoring programme for long term monitoring of the groundwater regime.

Figure 1: Regional locality map.

2. CLIMATE AND REGIONAL SETTING

The planned Boschoek Filling Station north of Rustenburg is located on the boundary of quaternary sub-catchment A22F. The site is located in Weather Bureau section number 0513 and on the boundary of rainfall zone A2G. The closest rainfall station still in use is 0547831. This weather station is located 21km north west of the proposed filling station site.

The rainfall period for this station covers the years from 1912 to 1929. The Mean Annual Precipitation (MAP) for the period from 1923 to 1953 is 640mm/a. Rainfall occurs as typical summer thunderstorms with heavy lightning and strong winds. Summer rainfall is typically from October to April, in which approximately 92.34 % of rainfall normally occurs. The typical dry period is between May and September each year, covering the winter months.

The proposed development area is located in Evaporation Zone 2B. The closest Evaporation station A2E024, the Bospoortdam station which is located approximately 25km south east of the proposed Boschoek filling station site gives a mean annual evaporation (MAE) of 1977mm for the S-Pan value. The evaporation measurements cover the years1976 to 1979.

The proposed site are located in Hydro Zone Q with a Mean Annual Runoff (MAR) of 10 to 20mm per annum.

3. METHODOLOGY

A desk study was performed to gather relevant geological and geohydrological information. A hydro - census followed the desk study to establish information such as water levels and borehole depths in existing boreholes in the region of the proposed Boshoek filling station. The purpose of this survey was to gather relevant geohydrological information to study the groundwater regime, geohydrological information of current groundwater use, water level depth and borehole coordinates in the area. Seven boreholes, including the one on site borehole of the proposed filling station site, could be found in a 1 km radius from the proposed filling station site. Four water level depths could be measured in the seven boreholes visited during the field visit.

A geological walk-over study was done to determine the in-situ geology. One test pit was prepared for a double ring inflow meter test. The aim of this test was to establish percolation rates for the relevant soil zones or host rock to facilitate the contamination risk assessment. A geophysical study investigated the geological integrity of the host rock of the site. This data was used to guide the final conclusions of the geohydrological risk assessment.

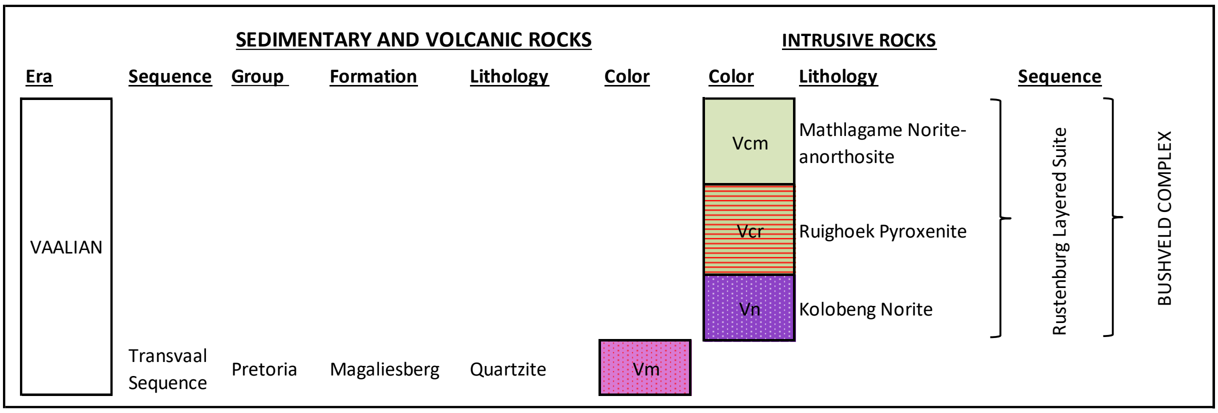
The percolation rate test, geology - and groundwater occurrence information were utilized to determine the geohydrological risk for the site. A groundwater monitoring program was proposed to facilitate groundwater monitoring during the implementation phase of the project.

4. GEOLOGICAL SETTING

The 1:250 000 Geological Series map no 2526 Rustenburg indicates that the Filling Station site lies on Kolobeng Norite and Ryghoek Pyroxenite which is part of the Rustenburg Layered Suite. The Kolobeng Norite lies on top of the Magaliesburg quartzite which is part of the Pretoria Group and the Transvaal Sequence.

On the site, the Kolobeng Norite is not visible, but the weathering product is black turf which is visible on site.

Below is a short summary of the lithology of the interested area. The geology map is below on Figure 2, which show the regional geology. The development site is marked in red.



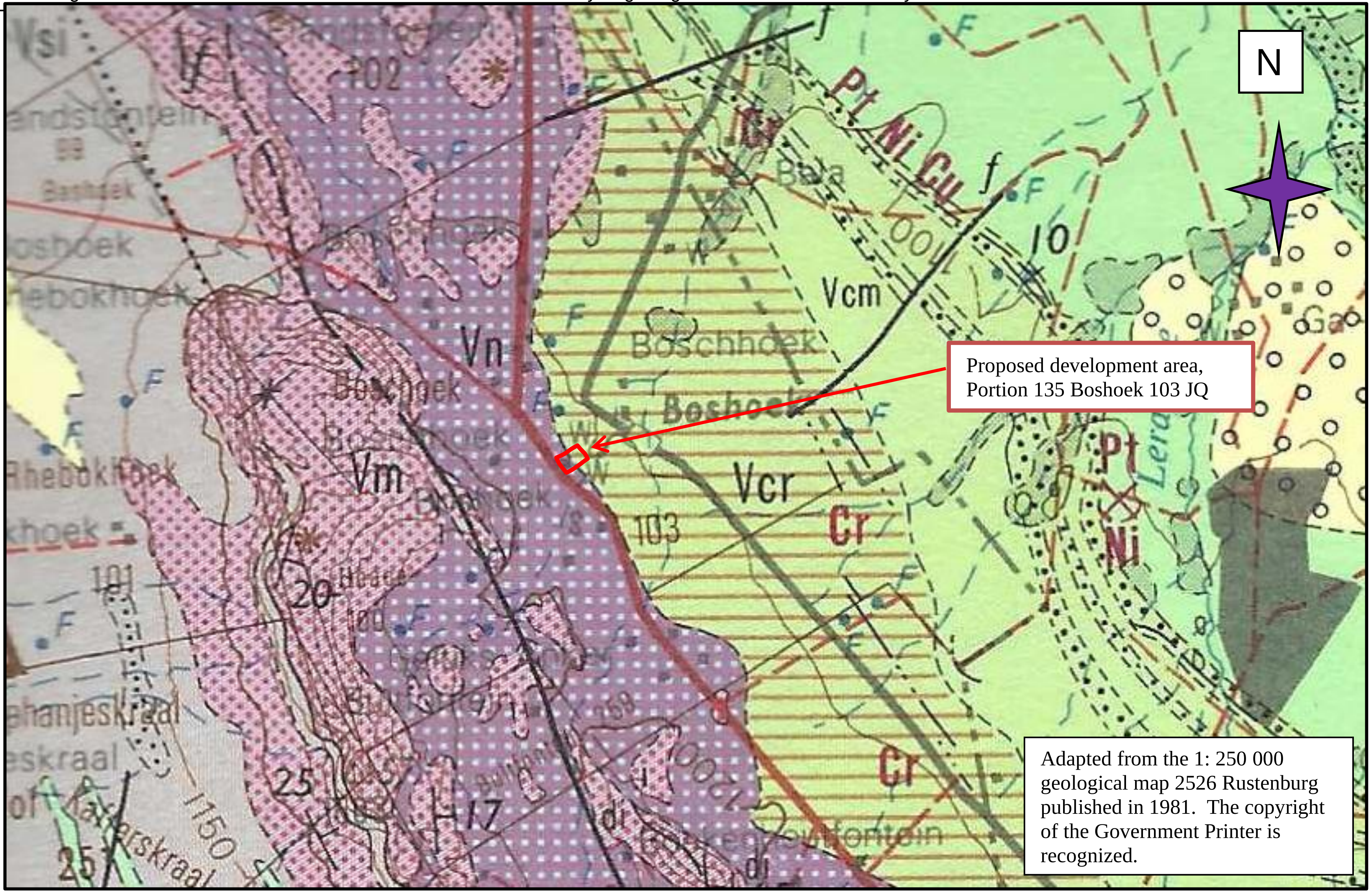


Figure 2: 1: 250 000 Geological map of the area around the Boshoek village.

5. FIELD WORK

5.1 Hydro census data

The hydro census aimed to gather information such as water level depths, borehole depth where possible, water end-user and contact details of owners of the boreholes. Seven boreholes could be found in the region on and around the site. One existing borehole was found on site which is used as groundwater production borehole for the excisting house on site. Water level depths could be taken in four of the seven boreholes visited. The water level depth as measured in the four boreholes range between 15.08metres below ground level (mbgl) and 18.05mbgl. The water level depth at the proposed filling station site as measured in the existing borehole is 15.75 metres below ground level (mbgl).

The hydro-census data gives a broad picture on groundwater utilization in the region. Most of the boreholes are in use and is equipped with small submersible pumps. Water from these boreholes is used for domestic and garden irrigation purposes. Water is pumped at low rates estimated by the small pumps installed and the short duty cycles reported of only a few hours per day.

The positions of the boreholes visited and the double ring inflow meter test position are given on Figure 3, 4 and 5 with more information on water level depths and coordinates in Table 1 below. Figure 4 is a more detailed map and shows the positions of the boreholes and surface water tributaries in more detail.

TABLE 1: Borehole hydro census details

BH	Lat	Long	Altitude (mamsl)	WL Depth (mbgl)	WL height (mamsl)	Remarks
BH 1	25.50030˚	27.09269˚	1167	15.75	1154	Production borehole located on Portion 135 of the Farm Boshoek 103 JQ. Equipped with a small submersible pump.
H/BH1	25.50131˚	27.09258˚	1168	17.9	1150	Submersible pump. 32mm pipe D Sekano – 082 805 2864 – Portion 56 Boschhoek.
H/BH2	25.50215˚	27.09133˚	1172	---	---	Closed up. Filling Station. Submersible pump. 50mm pipe. Can not measure water level
H/BH3	25.50272˚	27.09299˚	1170	18.05	1152	Submersible pump. 50mm pipe. Water pumped to 5000l tank. Petri Huurder – 082 572 1857
H/BH4	25.50105˚	27.09330˚	1166	15.08	1151	No Equipment
H/BH 5	25.50021˚	27.09350˚	1165	---	---	No pump
H/BH 6	25.50148˚	27.09066˚	1172	---	---	Closed up. Submersible pump. Can not measure water level Alex 084 583 3309

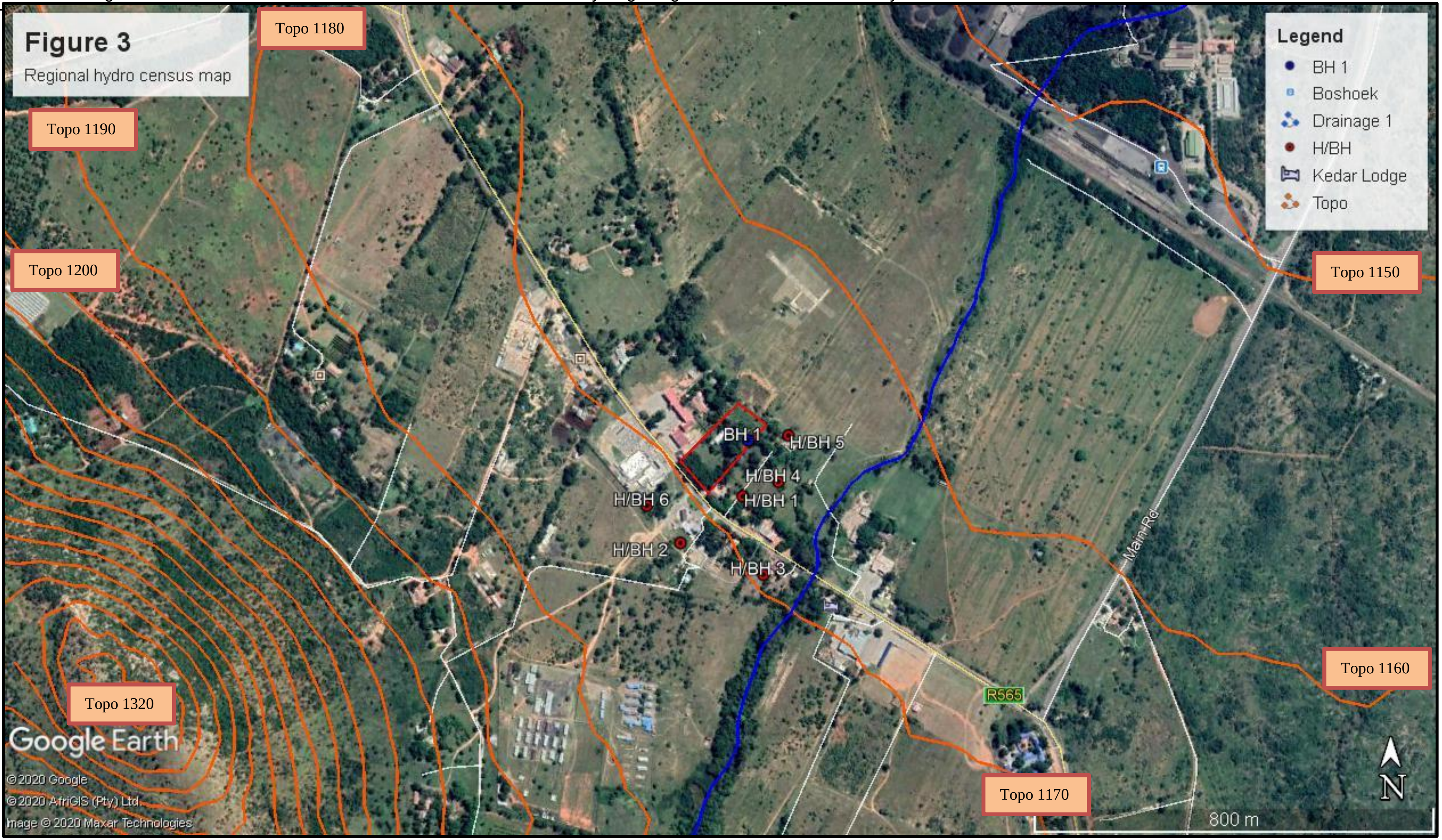


Figure 3: Regional Hydro Census Map.

Figure 4: Detail locality map.

5.2 Test pits and percolation tests

To facilitate the contamination risk assessment study, the infiltration rate of the upper soil was measured on the development site. Infiltration rates of the upper soils or the Hydraulic Conductivity of the unsaturated zone are measured in the field by using a double-ring infiltrometer. This method describes a procedure for field measurement of the infiltration rate of soils. Infiltration rate is defined as a soil characteristic, determining and describing the maximum rate at which water can enter the soil under specified conditions, including presence of an excess of water. Infiltration rates have application to problems such as erosion rates, leaching and drainage efficiencies, irrigation, water spreading, rainfall runoff, and evaluation of potential septic-tank disposal fields, among other applications.

Rates determined by ponding of large areas are considered the most reliable method of determining infiltration rate, but the high cost makes the infiltrometer-ring method more feasible and economical. The infiltration rate is controlled by the least permeable zone in the subsurface soils. The double-ring infiltrometer is used to help divergent flow in layered soils by providing an outer water barrier to encourage only vertical flow from the inner ring. Many other factors affect the infiltration rate in addition to the soil structure, for example, the condition of the soil surface, the moisture content of the soil, the chemical and physical nature of the soil and the applied water, the head of applied water, and the temperature of the water. The tests done at the same site are not likely to give identical results and the rate measured by the procedure described in this test method is primarily for comparative use. Some aspects of the test, such as the length of time the tests should be conducted and the head of water to be applied, must depend upon the experience of the user, the purpose for testing, and the kind of information that is sought.

Two open cylinders, one inside the other, are driven into the ground and partially filled with water, which is then maintained at a constant level. The volume of water added to maintain the water level constant is the measure of the volume of water that infiltrated the soil. The volume infiltrated during timed intervals is converted to an infiltration velocity, usually expressed in inches per hour or centimeters per hour or centimeter per second. The minimum infiltration velocity is equivalent to the infiltration rate.

One new test pit was prepared, on surface near the existing production borehole, for a double ring inflow meter test. The infiltration rate of the test pit can be found described in Table 2 below. The position of this test pit can be found on Figure 5 below.

Test pit 01 is located on the north western side of the existing borehole position. The test was done on surface and lasted for 6 hours. The hydraulic conductivity rate measured at this pit is 4.3×10^{-3}cm/s or 4.0 m/d, which relates to a very high hydraulic conductivity rate.

TABLE 2: Information on test pit

Co-ordinates	Time	Time period (Min)	Elapsed Time (Min)	Total Quantity of water (ml)	Infiltration rate (cm/s)	Infiltration rate (cm/h)	Infiltration rate (m/d)
Pit 1 -25.92466° 028.04080°	09:00	15	15	7000	1.0305×10^{-2}	37.00	9.77
	09:15	15	30	6000	8.8330×10^{-3}	31.77	8.38
	09:30	15	45	5500	8.0968×10^{-3}	29.12	7.68
	09:45	15	60	4700	6.9191×10^{-3}	24.89	6.56
	10:00	30	90	9000	6.6247×10^{-3}	23.93	6.28
	10:30	30	120	10500	7.7288×10^{-3}	27.8	7.33
	11:00	30	150	9000	6.6247×10^{-3}	23.83	6.28
	11:30	30	180	5700	4.1956×10^{-3}	15.09	3.98
	12:00	30	210	9000	6.6247×10^{-3}	23.83	6.28
	12:30	30	240	8000	5.8886×10^{-3}	21.18	5.58
	13:00	30	270	6500	4.7845×10^{-3}	17.21	4.54
	13:30	30	300	7300	5.3733×10^{-3}	19.33	5.10
	14:00	30	330	6500	4.7845×10^{-3}	17.21	4.54
	14:30	30	360	6500	4.7845×10^{-3}	17.21	4.54
	15:00	30	390	6000	4.4165×10^{-3}	15.89	4.19
	15:30	30	420	5700	4.1956×10^{-3}	15.09	3.98

Figure 5: Position of the Test pit 1 relative to the borehole and two geophysical traverses

5.3 Geophysical study

A geophysical survey was done to gather information on the physical condition of the geology of the site. The electromagnetic method was used to do the geophysical investigation. The geophysical method used is explained below.

The Electromagnetic method (EM 34) attempts to measure the conductivity of rock. The application in ground water exploration can be found in the fact that there is a relationship between the conductivity of a formation and the porosity thereof, the connection between pores, the volume of water in the pore and the conductivity of the water in the pore. The method can be used to do lateral profiling of strata and found application in the following situations.

a) the identification of thin linear zones of conductivity, in particular fracture zones, fault zones, weathered dykes and contact zones of different hydrological regimes.

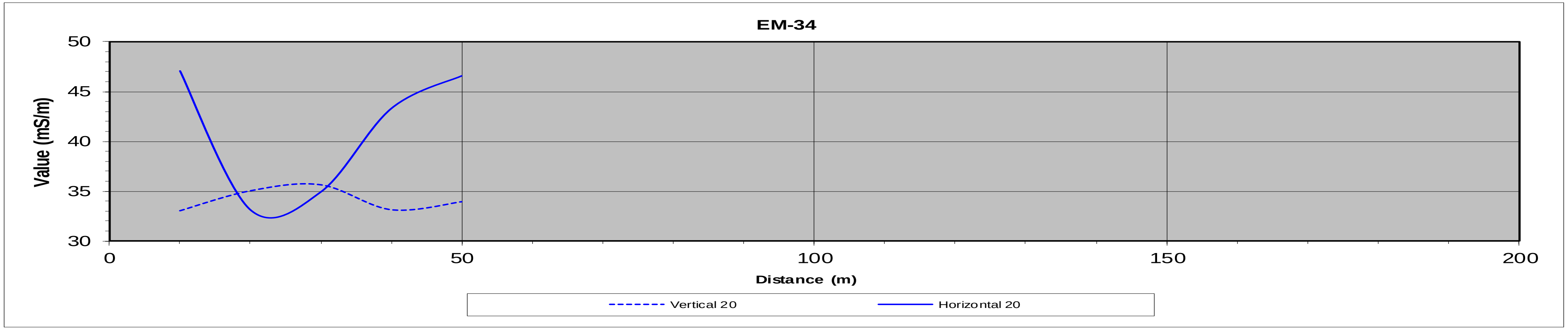
b) the identification of contamination plumes

Two traverses were done during the geophysical study. The position of Traverse 1 and 2 can be seen on Figure 5. The physical traverse data can be seen on Figure 6 and 7. From the data of the two traverses it can be seen that weathered norite is evident on site. Sandy loam is also expected to be on top of the weathered norite.

TABEL 3: Geophysical survey information

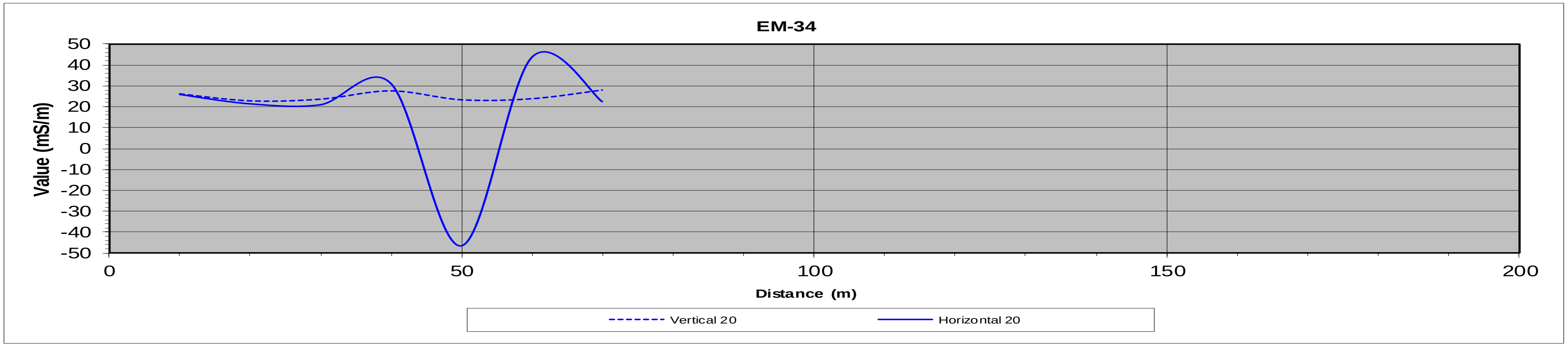
Line Number and Length	Position of Structure on Line	Geological Structure
Traverse 1 50m in length	The line is to short to delineate geological structures.	The conductive (30 to 36mS/m) material is expected to be weathered norite with most probably deap loam sandy soil on top.
Traverse 2 60m in length	The line is to short to delineate geological structures.	The fairly conductive (20 to 30mS/m) material is expected to be weathered norite with most probably loam sandy soil on top. An electric cable at position 60 meters on the traverse show a very large anomalous peak.

Figure 6: Electromagnetic data of Traverse 1



COUNTRY: RSA **FARM:** Boshoek **DIRECTION:** E - W **DATE:** 10/06/2020
PROVINCE: Gauteng **TRAVERSE NO:** Traverse 1

Figure 7: Electromagnetic data of Traverse 2



COUNTRY: RSA **FARM:** Boschoek **DIRECTION:** E - W **DATE:** 09/06/2020
PROVINCE: Gauteng **TRAVERSE NO:** Traverse 2

5.4 Test pumping of production borehole

The borehole BH 1 was submitted to a Constant Discharge Test of 24 hours of 1440 minutes by using the professional yield testing equipment. The water level response to water abstraction was measured constantly during the test to be able to calculate the aquifer parameters Storativity and Transmisivity. The water level of the borehole was constantly measured during the entire test procedure.

A **Constant Discharge Test** consist of pumping a borehole at a specific rate for a duration that can vary from a couple of minutes to 24 hours, with a sudden switch off of the pump after the pump cycle, with a recovery test following immediately afterwards. The Constant Discharge Curves was analysed by using the Basic FC, FC inflection point, Cooper-Jacob and Barker/Bangoy methods, to give an indication of Transmisivity and Storativity values.

Borehole **BH 01** (S 25,50030˚, E27.09269˚) has a static water level at 15.75 metres below ground level.

The borehole was submitted to a constant discharge test with duration of 1440 minutes at a rate of 0.63 ℓ/s. The pump was switched off after 1440 minutes or 24 hours. The water level draw down was 3.56metres below the original static water level. The borehole was allowed recovery for 360 minutes. During the 360 minute recovery period the water level recovered back to 0.15 meters below the original static water level.

TABLE 4: Test Pumping Results

BH No. BH Depth & Static Water Level	Constant Discharge Test			Comment on the Water Level Recovery Rate of the Constant Discharge Test
	Rate (l/s)	Duration. (min)	Draw Down (m)	
BH 01 Static water level: 15.75m 9 June 2020	0.63	1440	3.56m	93.8% in 360minutes
ST - Step Test CDT - Constant Discharge Test SWL - Static Water Level in metres below ground level		Dur. – Duration D/D – Draw down		

5.5 Borehole abstraction recommendation

The Constant Discharge Curve of the borehole was analysed by using the Flow Characteristic program which was developed by the Institute of Groundwater Studies of the University of the Free State. The Basic FC, FC inflection point, Cooper-Jacob and Barker/Bangoy methods was used to calculate the Transmisivity and Storativity values. The average recommended abstraction rate (based on a 24 hour duty cycle) of these methods were used to calculate the recommended yield for 12 hours per day. The recommended abstraction rate for the borehole is given for each individual method described above. The average recommended abstraction rates for the borehole are given in Table 5. A summary of the methods used for the recommended abstraction rates and the Graphical presentations of the draw down curves and recovery curves can be found below. Table 4 listed above, gives a summary of the pump test data. Table 5 gives the abstraction schedule recommendations made for the borehole submitted to scientific test pumping procedures.

TABLE 5: Recommended abstraction schedule for production borehole

Borehole No.	Recommended Abstraction Rate		Dynamic water Level (mbcl)	Comments
	For 12h/d	in m^3/d		
BH 1	1.5ℓ/s	64.8	20	Water level 15.75(mbgl)

6. BASELINE CHEMICAL PARAMETERS

6.1 Water quality sampling

One sample was taken from borehole BH 1 located on site. This water sample can be regarded as representative of the aquifer below the proposed filling station site. If surface contamination does take place at the filling station site this contamination will presents itself in borehole BH 1 over time. If groundwater contamination occurs, borehole BH 1 is ideally located to serve as groundwater monitoring facility. Refer to Figure 4 and Figure 6 for the location of the borehole with regards to the site boundaries.

6.2 Water quality parameters

The water sample was preserved and delivered to Aquatico Laboratories, an accredited water laboratory, to be analysed for water quality purposes. The analyses include the major cation and anions, Total Coliform Bacteria count, E. Coli count, BTEXN and TPH parameters. The results of the chemical and bacteriological analyses performed on the groundwater sample are presented in Table 7. The quality of water is classified according to the SANS 241-1 and 2: 2011 as in the Publication "South African National Standard" Part 1 and Part 2, SABS. Refer to the Water Quality Analyses Certificate from Aquatico Laboratory, in Appendix A, for the original water analyses. Table 6 below gives the risk guideline involved for using the water for domestic purposes.

Chemical Water Quality

The chemical water quality analyses of borehole BH 1 show that none of the chemical parameters measured for is above the standard limits. Chemically the water of borehole BH 1 is good quality water that can be used without treatment.

Bacteriological Water Quality

The bacteriological count for E.Coli Count for Borehole BH 1 is <1 CFU/100ml or undetected. The water from borehole BH 1 does not need to be chlorination prior to human consumption

Table 6: Risk guideline legend

Aesthetic	Determinand that taints water with respect to taste, odour and colour and that does not pose an unacceptable health risk if present at concentration values exceeding the numerical limits specified.
Operational	Determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure.
Acute Health - 1	Routinely quantifiable determinand that poses an immediate health risk if consumed with water at concentration values exceeding the numerical limits specified.
Acute Health - 2	Determinand that is presently not easily quantifiable and lacks infomration pertaining to viability and human infectivity which, however, does pose immediate unacceptable health risks if consumed with water at concentration values exceeding the numerical limits specified.
Chronic Health	Determinand that poses an unacceptable health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified.
	Exceeds Acute health - 1, Acute health - 2 and Chronic health guideline values
	Exceeds only Operational and Aesthetic guideline values

Table 7: Water quality analyses for Borehole BH 1.

Determinant	Unit	Risk	Standard limits	BH 1
pH value at 25 C	pH units	Operational	≥ 5 to ≤ 9.7	7.09
Electric Conductivity at 25 C	mS/m	Aesthetic	≤ 170	29.4
Total Dissolved Solids	mg/ℓ	Aesthetic	≤ 1200	249
Total alkalinity	Mg CaCO3/l			130
Chloride as Cl	mg/ℓ	Aesthetic	≤ 300	10.5
Sulphate as SO4	mg/ℓ	Acute health - 1	≤ 500	7.54
Nitrate (NO3) mg/ℓ N	mg/ℓ	Acute health - 1	≤ 50	1.07
Ammonia as N	mg/ℓ	Aesthetic	≤ 1.5	<0.008
Orthophosphate (PO4) as P	mg/ℓ			0.039
Fluoride as F	mg/ℓ	Chronic health	≤ 1.5	<0.263
Calcium as Ca	mg/ℓ			23.4
Magnesium as Mg	mg/ℓ			19.1
Sodium as Na	mg/ℓ	Aesthetic	≤ 200	11.5
Potassium as K	mg/ℓ			1.06
Aluminium as Al	mg/ℓ	Operational	≤ 0.3	<0.002
Iron as Fe	mg/ℓ	Chronic health	≤ 2	<0.004
Manganese as Mn	mg/ℓ	Chronic health	≤0.5	0.001
E.coli	CFU/100mℓ	Acute health – 1	Not detected	<1
Total coliform	CFU/100mℓ	Acute health - 2	≤10	8
Total hardness	mg$CaCO_3$/ℓ			137

7. GEOLOGICAL AND HYDROGEOLOGICAL ASSESSMENT

7.1 Regional groundwater level depth and groundwater contours

Water level depths could be measured in four of the seven boreholes visited. The water level depths measured in the boreholes available range between 15.08 and 18.05 metres below ground level (mbgl). The water level depth in borehole BH 1, at the site measured 15.75 mbgl.

7.2 Regional groundwater movement

Norite normally forms a fractured and weathered groundwater regime. In a fractured and weathered groundwater regime the groundwater contours to a large degree will follow or mimic the surface contours. It can therefore also be expected that in general the groundwater flow will mimic the surface water flow. The surface contours can be used as indicator in which direction groundwater flow will be.

The proposed filling station site is located on a north eastern sloping topography. This will mean that groundwater and surface water will flow will be in a north eastern direction. The blue arrows on Figure 8 show the regional groundwater movement directions according the surface contours and water level depths available. The groundwater and surface water flow directions in general are from the topographic high areas in the south west towards the topographical low areas in the north east, towards the existing drainage system which drains towards the north east.

7.3 On site surface water drainage and groundwater movement

On the proposed filling station sites surface water drainage and groundwater flow is towards the topographic low areas which is to the north east north and west. Due to the localtion of the site, which is on a topographick high, means that groundwater is constantly flowing towards the site. This phenomina will have a positive effect on the sustainability of the groundwater source of the site.

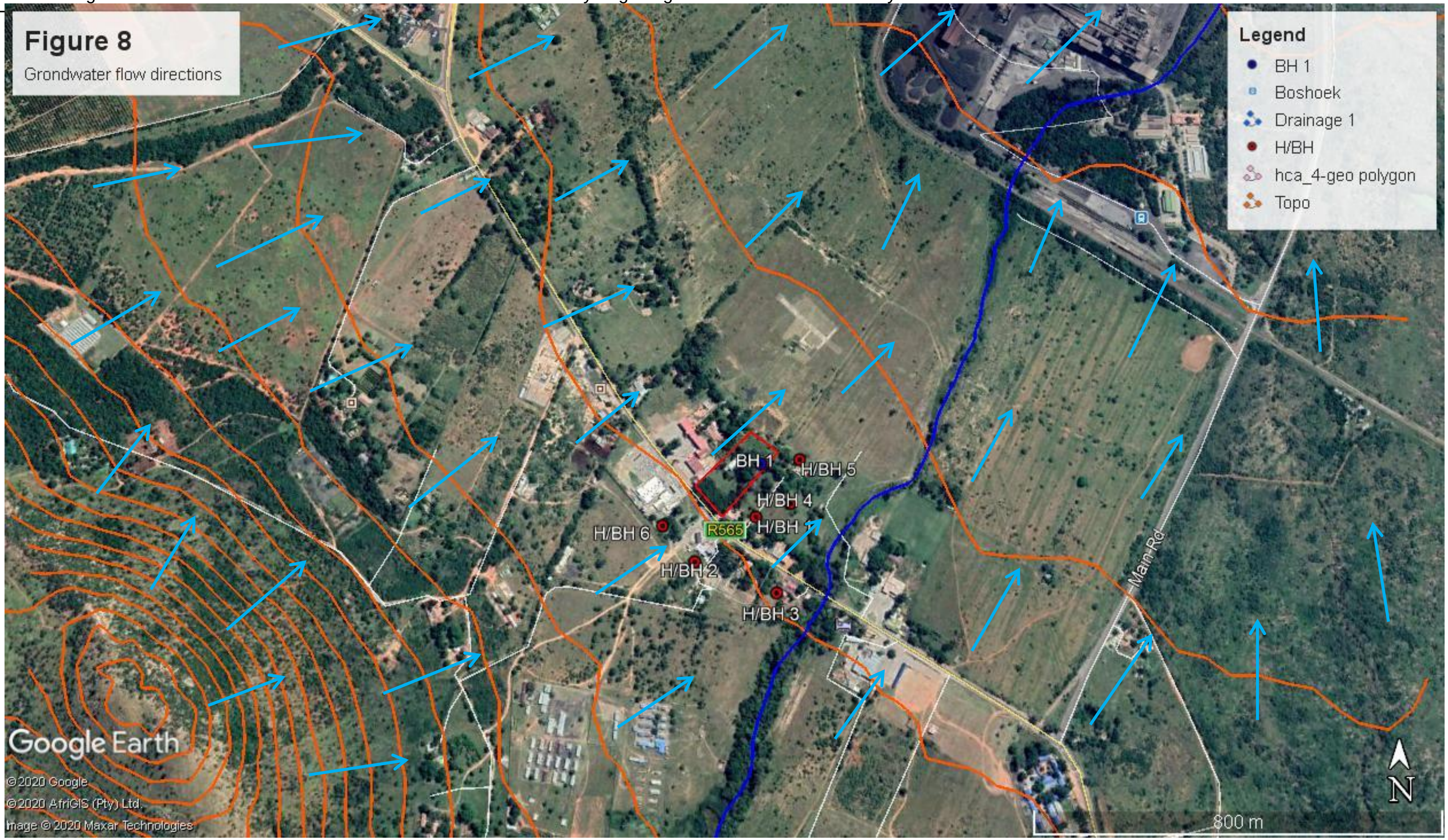


Figure 8: Surface water flow and expected groundwater flow directions. (Light blue arrows)

8. CONTAMINATION RISK ASSESSMENT

8.1 Parsons rating system

The “Parsons Rating System” is an aquifer classification system developed to implement a strategy for managing groundwater quality in South Africa. Classification, vulnerability and susceptibility are rated for a specific aquifer to be studied.

a) Aquifer Classification

The aquifer at the proposed Filling station on Portion 847 (A Portion of Portion 122 of the farm Knopjeslaagte 385 JR is classed as a **minor** aquifer and can be described as a low to moderately yielding aquifer system of variable water quality.

b) Aquifer vulnerability

A **least** tendency or likelihood does exist for contamination to reach a specific position in the groundwater system after continuous ly discharged or leached at some location above the uppermost aquifer.

c) Aquifer susceptibility

The aquifer is rated to have a **Low** susceptibility. Susceptibility is a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification.

d) Groundwater Quality Management Classification

The **GQM index of this option is rated at 2**, with a **Low** protection level needed.

8.2 Water resources

One borehole that is recommended to be used to supply in the water demand for the filling station is located on the development portion. The groundwater movement on the filling station site is in a north eastern direction towards the lower topography. Bulk water supply and bulk sewerage lines are not available for this site.

8.3 Assessment of the vulnerability of the underground water resources

The vulnerability of the underground water sources is related to the distance that contaminants must flow to reach the water table and the ease with which it can flow through the soil and rock layers above the water table. An assessment of the soil and rock types and the distance to the water table can be used to obtain a vulnerability class. (Groundwater Protocol document, Version 2, dated March 2003). Five broad classes of aquifer vulnerability are defined in Table 8 below.

Table 8: Vulnerability of groundwater aquifer due to hydrological conditions

Vulnerability Class	Measurements	Definition
Extreme (Usually highly fractured rock and/or high groundwater table)	High risk and short distance(<2m) to water table	Vulnerable to most pollutants with relatively rapid impact from most contamination disposed of at or close to the surface
High (usually gravely or fractured rock, and/or high water table)	High risk and medium distance(2-5m) to water table	Vulnerable to many pollutants except those highly absorbed, filtered and/or readily transformed
Medium (usually fine sand, deep loam soils with semi-solid rock and average water table > 10m)	Low risk and medium to long distance to water table	Vulnerable to inorganic pollutants but with negligible risk of organic or microbiological contaminants
Low (usually clay or loam soils with semi-solid rock and deep water table >20m)	Minimal and low risk and long to very long distance to water table	Only vulnerable to the most persistent pollutants in the very long term
Negligible (usually dense clay and/or solid impervious rock with deep water table)	Minimal risk with confining layers	Confined beds present with no significant infiltration from surface areas above aquifer.

In Table 8 above, according to the Groundwater Protocol document, Version 2, dated March 2003 in Table A, the vulnerability of the Groundwater Aquifer due to the Hydrogeological Conditions at the proposed filling station site can be rated as **Medium** risk. The distance from the surface to the aquifer is in the region of 15.75 metres according the water level measured at borehole BH 1.

For surface spills on the filling station site the travel distance vertically will be an estimated 15.75 metres to the water table. The permeability rate measured on site is medium at a rate of 4.0m/d. It is recommended that all water accumulated on the service area of the filling station sites need to be captured and treated as contaminated surface water. Retention ponds or oil traps need to be established for this purpose. Clean storm water must be channelled away or around the site and can be released into the drainage features.

For underground leakages the un-weathered norite normally is solid and forms continuous solid layering. The un-weathered norite can form a safety barrier to protect the aquifer below the proposed filling station.

Table 9 below show that the surface material layer that is found on site have a medium capacity to absorb contaminants and a medium capacity to create an effective barrier to contaminants. A high reduction of bacteria and viruses will be evident in the unsaturated aquifer if a sanitation leak does happen. Nitrates and phosphates will be reduced to some extent and chloride will be minimally reduced. A little reduction of hydrocarbons is expected.

Table 9: Assessment of the reduction of contaminants in the unsaturated zone

Unsaturated Zone Conditions	Factor Effecting Reduction			Contamination Reduction			Comments
	Rate of flow in unsaturated zone	Capacity of the media to absorb contaminants	Capacity to create an effective barrier to contaminants	Bacteria and Viruses	Nitrates and Phosphates	Chlorides	
Clay	Very slow <10mm/d	High	High	Very high reduction	High Reduction	High Reduction	Very Good barrier to movement of contaminants. May have problems with water retention in pit
Silt	Slow 10-100mm/d	Medium	High	High Reduction	Some Reduction	Minimal Reduction	Good barrier to movement of biological contaminants, but little reduction in chemical contaminants.
Sandy loam	Slow 10-100mm/d	Medium	High	High Reduction	Some Reduction	Minimal Reduction	Good barrier to movement of biological contaminants, but little reduction in chemical contaminants.
Fractured or weathered sandstone	Medium 0.1 - 10m/d	Medium	Medium	High Reduction	Minimal Reduction	Minimal Reduction	Fair barrier to movement of biological contaminants, but little reduction in chemical contaminants.
Fine sand	Medium 0.1 - 10m/d	Minimal	High	High Reduction	Minimal Reduction	Minimal Reduction	Good barrier to movement of biological contaminants, but little reduction in chemical contaminants.

8.4 Existing threats to groundwater quality and surface water quality

One existing drainages were found in a 2km radius from the proposed filling station site. Each of the plots in the region does have its own French drain system to accommodate the sewerage generated on each plot. The existing French drain systems found on the plots are to widespread to pose a risk to the groundwater regime. The water from the existing borehole BH 1 show no chemical or bacteriological contamination of the geohydrological regime at the proposed filling station site. The drainage is 220 meters to the south east of the proposed filling station site. The proposed filling station pose no risk to the drainage feature due to the long distance from the drainage feature.

8.5 Contamination risk from an on-surface contamination source

As far as the contamination risk from the planned storage tanks of the filling station is concerned, the assessment is based on the level of risk of the source. Risk levels are based on three factors: 1) attenuation ability in unconsolidated materials; 2) contamination load and travel time of degradable pollutants, in aquifer systems and 3) vulnerability of the aquifer and behavior of interstitial water regimes. Soil or unconsolidated material may provide a very effective attenuation buffer for certain contaminants and may have a very low attenuation on other contaminants. The nature of the soil materials and the thickness of this zone, are key issues in determining attenuation capacity. The sandy loam layer on surface may have some ability to protect the aquifer below from, firstly on surface spills and secondly, underground leaks.

The upper soil's hydraulic conductivity measured in test pit 1 is 4.0m/d measured at its slowest rate. The hydraulic flow time to the water table = depth to water table ÷ permeability. If an estimated water table of 15.75 metres is used vertical travel time, as measured in the top surface soil, of water from surface to the aquifer may be in the region of 3.9 days which can be regarded as a short period.

8.6 Position in respect of domestic water sources

The location of a possible contamination source, in relation to water sources utilised for human consumption, is of primary concern. In most of rural Southern Africa and at many farming communities around our cities, the only domestic water supplies are obtained from boreholes.

It is therefore essential that minimum distances between possible contamination sources and the nearest domestic water resource be prescribed. These safe distances depend on the many factors due to the highly variable and uncertain nature of the factors that control the dispersion of pathogenic organisms from a contamination source. The criteria for determining the distance of a contamination source from water resources must therefore be conservative.

The recommended safe distances are based on the acceptable soil's permeability range, in conjunction with the maximum survival times of bacteria, viruses and the breakdown of chemical components. Conservatism has been achieved through the effects of the harsh environmental conditions prevalent in most of Southern Africa, which lowers maximum pathogen survival periods, and by adding a moderate safety factor of 150 m to the calculated distances (This ensures a minimum safe distance of 150 m at all times). Due to the importance of ensuring pollution free domestic water resources, lowering of the recommend distances has not been considered for the more arid regions of the sub-continent.

The filling station will use water from borehole BH 1 which is located on the site. Other groundwater users in the area use water from the other boreholes in the vicinity of the site are the boreholes listed in Table 1 of this report. Boreholes H/BH 1, H/BH 4 and H/BH 5 is 60 to 90 metres from the proposed filling station site boundary. Boreholes H/BH 4 and H/BH 5 is not equipped and not in use. Borehole H/BH 5 is the only borehole that can be regarded as located down-stream of the proposed filling station site. The rest of the boreholes found is located upstream of the proposed filling station site. These boreholes can therefore be regarded as not at risk from the proposed filling station site.

8.7 Position in respect of drainage features

The positioning of a contamination source, in relation to a drainage feature of any description, is of cardinal importance. Drainage features, including lakes, dams, rivers, streams, gullies, gulley heads and marshes should not be affected in any way by pollutants emanating from a possible contamination source. These drainage features must also not pose a flood hazard to any contamination source (contamination sources must be located above the 1 in 100 year flood level). These limitations necessitate the prescription of minimum distances between contamination sources and the nearest drainage feature.

The approach taken is virtually the same as for domestic water sources, the only difference being the reduction of the safety factor to 100 metres, and a further decrease of the recommended distances for arid regions (rainfall < 500mm). If the recommend safe distances prescribed is applied, surface water contamination will be negligible.

A drainage feature is located 220 meters south east of the proposed filling station site. This drainage feature originates in the geological ring structure which consist of mountains formed in a ring. The entire ring structure drains towards the Boshoek village. The groundwater catchment area of this ringstructure is at least 9km^2 which means that the groundwater availability in Boshoek is not in question due to the seasonal additional groundwater flow towards Boshoek Village. The drainage feature is more than the safety factor of 100m from the proposed filling station site. The geohydrological risk factor of the proposed filling station on the drainage feature is therefore limited.

9. ENVIRONMENTAL IMPACT ASSESSMENT

9.1 Assessment methodology

An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under investigation for meeting a project need. Assessment of impacts will be based on the Department of Environmental Affairs (DEA) (1998) Guideline Document: EIA Regulations. The significance of the aspects/impacts of the process is rated by using a matrix derived from Plomp (2004) and adapted to some extent to fit this process. This matrix uses the consequence and the likelihood of the different aspects and associated impacts to determine the significance of the impacts.

The **significance** of the impacts will be determined through a synthesis of the criteria below:

Probability This describes the likelihood of the impact actually occurring.

Improbable: The possibility of the impact occurring is very low, due to the circumstances, design or experience.

Probable: There is a probability that the impact will occur to the extent that provision must be made therefore.

Highly Probable: It is most likely that the impact will occur at some stage of the development.

Definite: The impact will take place regardless of any prevention plans, and there can only be relied on mitigatory actions or contingency plans to contain the effect.

Duration: The lifetime of the impact

Short term: The impact will either disappear with mitigation or will be mitigated through natural processes in a time span shorter than any of the phases of the project.

Medium term: The impact will last up to the end of the phases of the project, where after it will be negated.

Long term: The impact will last for the entire operational phase of the project but will be mitigated by direct human action or by natural processes thereafter.

Permanent: Impact that will be non-transitory. Mitigation either by man or natural processes will not occur in such a way or in such a time span that the impact can be considered transient.

Scale: The physical and spatial size of the impact

Local: The impacted area extends only as far as the activity, e.g. footprint of the project.

Site: The impact could influence the whole, or a measurable portion of the affected properties.

Regional: The impact could affect the area including the neighbouring areas.

Magnitude/ Severity: Does the impact destroy the environment, or alter its function.

Low: The impact alters the affected environment in such a way that natural processes are not affected.

Medium: The affected environment is altered, but functions and processes continue in a modified way.

High: Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.

Significance: This is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required.

Negligible: The impact is non-existent or unsubstantial and is of no or little importance to any stakeholder and can be ignored.

Low: The impact is limited in extent, has low to medium intensity; whatever its probability of occurrence is, the impact will not have a material effect on the decision and is likely to require management intervention with increased costs.

Moderate: The impact is of importance to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and management intervention will be required.

High: The impact could render development options controversial or the project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in mitigation.

A matrix rating and assigning weights for the impacts is shown in Table 10 below.

Table 10: Rating matrix legend for groundwater impacts

Aspect	Description	Weight
Probability	Improbable	1
	Probable	2
	Highly Probable	4
	Definite	5
Duration	Short term	1
	Medium term	3
	Long term	4
	Permanent	5
Scale	Local	1
	Site	2
	Regional	3
Magnitude/Severity	Low	2
	Medium	6
	High	8
Significance	**Sum (Duration, Scale, Magnitude) x Probability**	
	Negligible	<20
	Low	<40
	Moderate	<60
	High	>60

9.2 Impact identification and significance rating

The impact matrix is listed below to show detail activities and the related impacts of each individual activity. The potential impact identification is divided into impact during Construction phase and Operational phase. The management and mitigation measures are discussed for each phase.

9.2.1 Potential impacts during construction phase

The potential impacts without mitigation measures in the construction phase are rated as **"Negligible"** to **"Low"**. The significance score range from 22 to 36: With mitigation measures the significance of the impact is rated as **"Negligible"**. The probable impacts are:

- Contamination of surface water from site levelling and excavations
- Contamination of surface water if the temporary latrines are not used and workers "go to the bush".
- Contamination of fuel leaks and oil leaks from construction vehicles.

9.2.1.1 Management and mitigation measures during construction phase

The following mitigation measures are recommended in the Construction Phase:

- Construction should preferably take place in the dry season, as surface water runoff is minimal.
- Additional storm water concentration must be contained.
- Latrines should be kept away from sensitive drainage areas. Alternatively portable latrines should be sealed units that can be cleaned by truck and the waste must be taken to a suitable sewage facility for treatment. They should be well maintained and regularly cleaned and sewage should not be allowed to directly access the groundwater. "Go to the bush" must be prohibited.
- No uncontrolled discharges from the construction camp should be permitted.
- All vehicles shall be properly serviced so that no oil leaks occur on site.
- Any stockpiled soil and rock should have storm water management measures implemented.
- The large roof structures to be implemented may enhance storm water volumes that need to be managed.
- A storm water plan must be available and used during all the phases of construction. This must include siltation ponds handling storm water concentrations.
- Vehicles and machines on site must be maintained properly to ensure that oil spillages are kept at a minimum.
- Spill trays must be provided for refuelling of plant vehicles.

9.2.2 Potential impact during operational phase

Safety precautions regarding the storage and refuelling of fuel is a highly specialised task which must be contracted to specialist. The monitoring of possible leaks is highly specialised and in general safeguard the facility against accidents and or spills. A leak detection system of the highest standard must be installed and maintained.

The significance of the impacts without mitigation measures are rated as **"Moderate"**. With mitigation measures the significance of the impact is rated as **"Negligible"**. The probable impacts are:

- Contamination of surface water with hydrocarbons from possible small spills of oil, diesel and petrol spilled on the paved areas.
- Contamination of groundwater with hydrocarbons spilled from storage tank leaks.

With mitigation, the significance of these activities is rate as **"Negligible"**.

9.2.2.1 Management and mitigation measures recommended during the operational phase

- Storm water originating from the filling station surface area must be treated as dirty water.
- Clean water and dirty water systems must be separated.
- Storm water must be directed away and around the filling station sites.
- Leak detection systems must be implemented in all fuel storage and transmission lines and tanks.
- Air monitoring systems must be implemented around the storage tanks.
- Borehole BH 1 can be used as groundwater monitoring point. This point must be monitored for BTEXN and TPH parameters as well as major cat and anions to serve as a baseline value. If contamination is detected the groundwater monitoring cycle must be shortened to a two monthly cycle.
- The spillage of fuels, chemicals and or sewerage water must be immediately reported to the assigned Departments stipulated in the water use licence document and other documents stipulating monitoring practices.
- An emergency accidental spillage plan must be in place and workers must be trained to handle such accidents.
- No uncontrolled discharges resulting in pollution of the receiving environment and aquifer shall be permitted.

- Chemical storage areas should be sufficiently contained, and the use of chemicals should be controlled.
- Water seeping into filled levels on site must be prevented.
- Water pumped from any sump or temporary dewatering pit should be pumped into a dirty water system and should not be allowed to enter any clean water system, natural drainage line, or the aquifer.
- All water retention structures, including storm water dams, retention ponds etc. should be constructed to have adequate freeboard to be able to contain water from 1:50 year rain events.

Table 11: Significance rating

Nr	Activity	Without or With Mitigation	Probability		Duration		Scale		Magnitude/ Severity		Significance	
			Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude
Construction Phase												
1	Contamination of surface water from site leveling and excavations	**WOM**	4	Highly Probable	1	Short Term	2	Site	6	Medium	36	Low
		WM	2	Probable	1	Short Term	2	Site	2	Low	10	Negligible
2	Contamination of surface water from not using temporary latrines	**WOM**	4	Highly Probable	1	Short Term	2	Site	6	Medium	36	Low
		WM	2	Probable	1	Short Term	2	Site	2	Low	10	Negligible
3	Contamination of surface water from fuel and oil leaks from construction vehicles	**WOM**	2	Probable	1	Short Term	2	Site	6	Medium	18	Negligible
		WM	1	Improbable	1	Short Term	2	Site	2	Low	5	Negligible
4	Contamination of ground water from fuel and oil leaks from construction vehicles	**WOM**	2	Probable	3	Medium Term	2	Site	6	Medium	22	Low
		WM	1	Improbable	3	Medium Term	2	Site	6	Medium	11	Negligible
Operational Phase												
1	Contamination of surface water with hydrocarbons and surface spills	**WOM**	4	Highly Probable	4	Long Term	2	Site	6	Medium	48	Moderate
		WM	2	Probable	4	Long Term	2	Site	2	Low	16	Negligible
2	Contamination of ground water with hydrocarbons from storage facilities.	**WOM**	2	Probable	4	Long Term	2	Site	6	Medium	24	Low
		WM	2	Probable	3	Long Term	2	Site	2	Low	14	Negligible

10. MONITORING PROTOCOL

It is important to have a monitoring system in place to monitor the potential impacts on the environment such as surface and groundwater quality in the area around the filling station site.

The main focus of a monitoring system must be to monitor possible leakages before the environment is damaged. The systems that are put on site such as the storage tanks and fuel lines must have a monitor system attached. These systems must be able to detect a faulty system rather than detect fuel outside the system. The proposed monitoring borehole on Figure 9 must be used as a groundwater monitoring points. Table 12 and Table 13 describe the frequency and parameters to be monitored.

Monitoring programmes are site-specific and need to be tailored to meet a specific set of needs or expectations (DWA 1998). The approach followed in developing this monitoring protocol was taken from the DWAF Best Practice Guideline – G3: Water Monitoring Systems (DWA, 2006b).

10.1 Monitoring objectives

Monitoring, measuring, evaluating and reporting are key activities of the monitoring programme. These actions are designed to evaluate possible changes in the physical and chemical nature of the aquifer and geo-sphere and to predict/detect potential impacts on the ground water.

The key objectives of the monitoring of groundwater changes are:

1. To provide reliable groundwater data that can be used for management purposes.
2. The early detection of changes in groundwater quality and quantity.
3. Provide an on-going performance record on the efficiency of the Water Management Plan.
4. Obtain information that can be used to redirect and refocus the Water Management Plan.
5. Determine compliance with environmental laws, standards and the water use licence and other environmental authorizations.
6. Refine the conceptual and numerical (management) models.

This will ensure that management is timely warned of problems and unexpected impacts that might occur, and can be positioned to implement mitigation measures at an early stage.

10.2 Possible pollution sources

Potential pollution sources include the following:

1. Fuel storage tanks.
2. Dirty water from the paved surface of the fuel depot.

10.3 Receiving environment

The following hydrological units may be impacted by the project and related activities:

- The aquifer below the filling station site and the regional aquifer downstream of the filling station.

- Drainage feature located 220 meters to the south east of the proposed filling station site.

10.4 Monitoring network

The one groundwater production borehole must be used as groundwater monitoring facility. The location of this borehole can be seen on Figure 4 and the coordinates can be found on Table 1.

10.5 Monitoring frequency

The proposed monitoring points must be sampled bi-annually and analysed for micro and macro chemical parameters, BTEXN and TPH parameters.

Table 12: Monitoring Frequency

Site name	Chemistry Sampling	Water Level Measurements
BH 1	Bi-Annually before construction start	Monthly at BH 1

10.6 Sampling parameters

An accredited laboratory, with the necessary quality assurance, must carry out analysis of key samples. Quality control measures should be in place and may include blanks, standards, duplicates, caution-anion balances etc. This will ensure consistency in monitoring and the verification and validation of water quality data. Data from groundwater quality monitoring must be stored together electronically to enable trend analysis and waste load calculations to be carried out.

Table 13: Sampling Parameters

Sample Type	Field measurements	Laboratory analysis: Chemical, BTEXN and TPH
Groundwater	pH, EC, temperature (measured with instrument during sampling)	Refer to Table 7 and Appendix A BTEXN and TPH analyses must be included

10.7 Sampling procedures

The sampling procedure for groundwater should be done according to the protocol by Weaver, 1992. The actions can be summarised as follows:

1. For pH and EC, calibrate the field instruments before every sampling run. Read the manufacturers manual and instructions carefully before calibrating and using the instrument.

2. Sample for chemical constituents – remove the cap of the plastic 1 litre sample bottle, but

do not contaminate inner surface of cap and neck of sample bottle with hands. Fill the sample bottle without rising.

3. Use glass bottle for BTEXN and TPH sample.

4. Leave sample air space in the bottle (at least 2.5 cm) to facilitate mixing by shaking before examination.

5. Replace the cap immediately.

6. Complete the sample label with a water resistant marker and tie the label to the neck of the sample bottle with a string or rubber band. The following information should be written on the label

    a. An unique sample number and description

    b. The date and time of sampling

    c. The name of the sampler

7. Place sample in a cooled container (e.g. cool box) directly after collection. Try and keep the container dust-free and out of any direct sunlight. Do not freeze samples.

8. See to it that the sample gets to the appropriate laboratory as soon as possible. Samples for chemical analysis should reach the laboratory preferably within seven days. BTEXN and TPH samples must reach the laboratory within 8 hours of sampling.

11. CONCLUSIONS

During the hydrogeological study the following conclusions could be made:

- Borehole BH 1 can be used at a rate of 1.5l/s for 12h/d or 64.8m^3/d to supply in the water demand for the filling station.
- The water demand for the filling station is 15m^3/d.
- The borehole can provide in the water demand for the filling station site.
- The water level depth on the proposed development site is 15.75 metres below casing level.
- Residents in the area use groundwater as the only water source.
- Bulk water and sanitation lines are not available in the village.
- According to the Groundwater Protocol document, Version 2, the vulnerability of the Groundwater Aquifer due to the Hydrogeological Conditions at the proposed filling station site can be rated as **Medium** risk.
- The surface material layer that is found on site has a medium capacity to absorb contaminants and a medium capacity to create an effective barrier to contaminants.
- A high reduction of bacteria and viruses will be evident in the unsaturated aquifer if a sanitation leak does happen.
- Some reduction of Nitrates and phosphates will occur and chloride will be minimally reduced.
- Little reduction of chemicals such as hydrocarbons is expected.
- During the construction phase the potential impacts without mitigation measures are rated as **"Negligible"** to **"Low"**. With mitigation measures the significance of the impact is rated as **"Negligible"**.
- During the operational phase the significance of the impacts without mitigation measures are rated as **"Moderate"**. With mitigation measures the significance of the impact is rated as **"Negligible"**.

12. RECOMENDATIONS AND MITIGATION MEASURES

The following mitigation measures are recommended in the Construction Phase:

- Construction should preferably take place in the dry season, as surface water runoff is minimal.
- Additional storm water concentration must be contained.
- Latrines should be kept away from sensitive drainage areas. Temporary latrines used during construction must be connected to the bulk sewerage lines if possible. Alternatively portable latrines should be sealed units that can be cleaned by truck and the waste must be taken to a suitable sewage facility for treatment. They should be well maintained and regularly cleaned and sewage should not be allowed to directly access the groundwater. Latrines must be used as a first priority. "Go to the bush" must be prohibited.
- No uncontrolled discharges from the construction camp should be permitted.
- All vehicles shall be properly maintained and serviced so that no oil leaks occur on site.
- Any stockpiled soil and rock should have storm water management measures implemented.
- The large roof structures to be implemented may enhance storm water volumes that need to be managed.
- A storm water plan must be available and used during all the phases of construction. This must include siltation ponds handling storm water concentrations.
- Vehicles and machines on site must be maintained properly to ensure that oil spillages are kept at a minimum.
- Spill trays must be provided for refuelling of plant vehicles.

The following mitigation measures are recommended in the Operational Phase:

- Storm water originating from the filling station surface area must be treated as dirty water.
- Clean water and dirty water systems must be separated.
- Storm water must be directed away and around the filling station sites.
- Leak detection systems must be implemented in all fuel storage and transmission lines and tanks.
- Air monitoring systems must be implemented around the storage tanks.
- Borehole BH 1 is situated ideally to monitor groundwater impacts. This borehole must

be monitored for BTEXN and TPH parameters as well as major cat and anions to serve as a baseline value. If contamination is detected the groundwater monitoring cycle must be shortened to a two monthly cycle.

- The spillage of fuels, chemicals and or sewerage water must be immediately reported to the assigned Departments stipulated in the water use licence document and other documents stipulating monitoring practices.
- An emergency accidental spillage plan must be in place and workers must be trained to handle such accidents.
- No uncontrolled discharges resulting in pollution of the receiving environment and aquifer shall be permitted.
- Chemical storage areas should be sufficiently contained, and the use of chemicals should be controlled.
- Water seeping into filled levels on site must be prevented.
- Water pumped from any sump or temporary dewatering pit should be pumped into a dirty water system and should not be allowed to enter any clean water system, natural drainage line, or the aquifer.
- All water retention structures, including storm water dams, retention ponds etc. should be constructed to have adequate freeboard to be able to contain water from 1:50 year rain events

REFERENCES

1. American Geological Institute, **Glossary of Geology**, (Robert L. Bates and Julia A. Jackson, Ed), 1980.
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5. Johnson MR, Anhaeusser CR and Thomas RJ, **The Geology of South Africa**, 2006.
6. Water research Commission, **Manual on Quantitative Estimation of Groundwater Recharge and Aquifer Storativity**, (DB Bredenkamp et al), June 1995.
7. Water research Commission & Department of Water Affairs and Forestry, **Groundwater Resources of the Republic of South Africa**, (JR Vegter). August 1995.

APPENDIX A

Water quality analysis from Aquatico Laboratory aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: HK Geohydrological Services
Address: 25ste laan, 327, Villieria, Pretoria,
Report no: 87690
Project: Boshoek Filling station

Date of certificate: 17 June 2020
Date accepted: 15 June 2020
Date completed: 17 June 2020
Date received: 15 June 2020

Lab no:				16983
Date sampled:				15-Jun-20
Aquatico sampled:				No
Sample type:				Water
Locality description: **Analyses**				BH1
		Unit	**Method**	
A	pH @ 25°C	pH	ALM 20	7.09
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	29.4
A	Total dissolved solids (TDS)	mg/l	ALM 26	249
A	Total alkalinity	mg CaCO3/l	ALM 01	130
A	Chloride (Cl)	mg/l	ALM 02	10.5
A	Sulphate (SO_4)	mg/l	ALM 03	7.54
A	Nitrate (NO_3) as N	mg/l	ALM 06	1.07
A	Ammonium (NH_4) as N	mg/l	ALM 05	<0.008
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.039
A	Fluoride (F)	mg/l	ALM 08	<0.263
A	Calcium (Ca)	mg/l	ALM 30	23.4
A	Magnesium (Mg)	mg/l	ALM 30	19.1
A	Sodium (Na)	mg/l	ALM 30	11.5
A	Potassium (K)	mg/l	ALM 30	1.06
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004
A	Manganese (Mn)	mg/l	ALM 31	0.001
A	E.coli	CFU/100ml	ALM 40	<1
A	Total coliform	CFU/100ml	ALM 40	8
A	Total hardness	mg CaCO3/l	ALM 26	137

A = Accredited N = Non accredited Out = Outsourced Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; The results relates only to the test item tested; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory
The results apply to the sample received.

M. Swanepoel
Technical Signatory

www.aquatico.co.za 89 Regency Drive, R21 Corporate Park, Centurion, South Africa Tel: +27 12 450 3800 Fax: +27 12 450 3851

Cooper-Jacob method

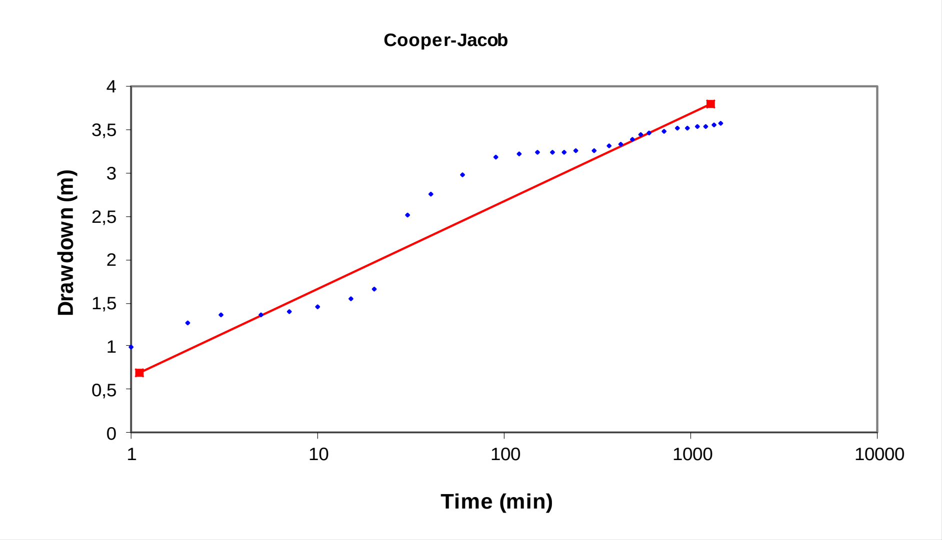
Main | Theis | Cooper-Jacob 2

BH 1

T(m^2/d) =	10,0	r_e (m)=	1,52	1,52
S =	1,51E-03	Q (l/s) =	0,64	

	No boundaries	1 no-flow	2 no-flow	Closed
Q_sust	2,37	1,19	0,78	0,59
Avg. Q_sust =	1,23	std. dev =	0,80	

including influence of bh's

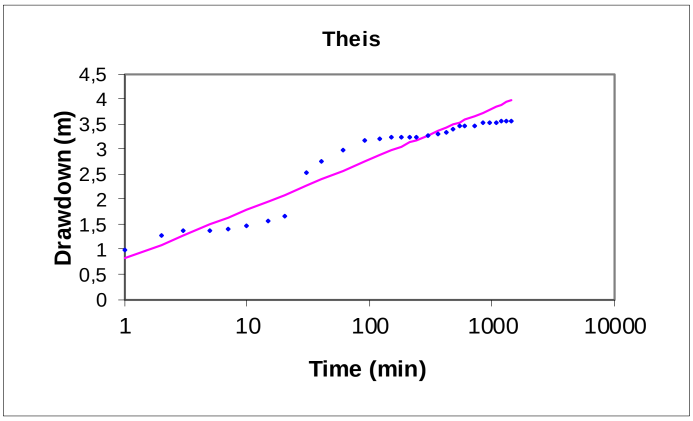


x0	**y0**	**x1**	**y1**
1,1	0,7	1280	3,8

Theis

T (m2/d)	S	r
10	1,10E-04	5,00

Top



Summary		Main		BH 1					
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)		Late T (m^2/d)		S	AD used
☑	Basic FC	1,82	0,80	16		14,5		1,38E-03	25,0
☐	Advanced FC			16		14,5		1,00E-03	25,0
☐	FC inflection point	0,53	0,06						14,2
☑	Cooper-Jacob	1,23	0,80			10,0		1,51E-03	25,0
☐	FC Non-Linear	2,49	2,20			34,0		5,06E-03	25,0
☑	Barker	1,48	0,52	K_f =	13592		S_s =	4,55E-04	25,0
	Average Q_sust (l/s)	1,51	0,29	b =	0,01	Fractal dimension n =		1,83	

Recommended abstraction rate (L/s)		**1,50**	for 24 hours per day
Hours per day of pumping	**12**	**2,12**	L/s for 12 hours per day

Amount of water allowed to be abstracted per month	**3888**	m^3
Borehole could satisfy the basic human need of	**5184**	persons
Is the water suitable for domestic use (Yes/No)	**Y**	