GEOHYDROLOGICAL - AND CONTAMINATION RISK ASSESSMENT STUDY FOR PORTION 348 OF THE FARM WATERKLOOF 305 JQ, RUSTENBURG, NORTH WEST PROVINCE.

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EXECUTIVE SUMMARY

This document presents the results of a Hydrogeological Investigation and Contamination Risk Assessment study aimed at establishing a baseline reference of hydrogeological data to form part of an application for the proposed construction of a new filling station which is planned for Portion 348 of the Farm Waterkloof 305 JQ. 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 site is located on the southern side of the Arnoldistad Road which links the Rustenburg Kroondal Road (R104) with the Rustenburg Olifantsnek Road (R24). Refer to Figure 1 and 2.

The proposed filling station will not abstract groundwater to supply in the water demand, but will use bulk municipal water, municipal sewer infrastructure and electricity available in the area.

The aim of this study is to serve as a base line groundwater reference study and contamination risk assessment. HK Geohydrological Services Pty Ltd was appointed by Hydroscience cc, to do a geohydrological baseline - and contamination risk assessment study for the planned development.

A desk study was performed to gather relevant geological and hydrogeological information. A hydro-census followed the desk study to establish borehole information in the region of the proposed filling station. The purpose of this survey was to gather relevant hydrogeological information to study the groundwater regime, current groundwater use and borehole coordinates in the area.

Twenty eight (28) boreholes could be found in the study area and beyond the boundaries of the study area in a 1km radius of the proposed site. An area of 1km in radius from the centre of the proposed filling station site was covered.

Eighteen (18) of the twenty eight (28) boreholes are currently equipped. Most of the boreholes located close to the south east which is on the Agricultural Research Council are no longer in use although some of them are equipped. The equipment from some of the boreholes is removed and the boreholes are open and abandoned and no longer protected. Most of the pump houses are in a dilapidated state due to neglect.

A geological walk over study was done of the proposed filling station site to study the in-situ geology. One test pit was dug during a previous study on a site located a few hundred meters south east and prepared for double ring inflow meter tests. The aim of the test was to establish percolation rate for the upper soils to facilitate the contamination risk assessment.
The water level depths were used to construct the groundwater flow directions to understand the groundwater movement direction on site. The percolation rate tests, geology, estimated water level depth and estimated groundwater flow directions were utilized to calculate the contamination risk for the site.

During the hydrogeological study the following conclusions could be made:

- The groundwater level depth measured in BH WK 1, the borehole close to the site is 12.19(mbgl) metres below ground level.
- The hydro-census data gives a broad picture that groundwater abstracted in the area is low.
- On the proposed Filling station site, the surface water flow directions and groundwater flow directions are in a south south-eastern direction towards the Hex River.
- Borehole BH WK 1 shows very fresh water with an EC level of 51.1mS/m. The TDS is low at 295mg/l. The Chloride level is also very low at 11.7mg/l, which show that the water is recently recharged. The water from BH WK 1 can be chemically categorized as Class 0, which can be used for domestic purposes without treatment. The water quality from this borehole is extremely good. This borehole is ideally located and will show contamination immediately and is therefore ideally located in the aquifer to be used as groundwater monitoring facility.
- The E.coli and Total coliform counts for borehole BH WK 1 are both below 1, which show no contamination.
- Water from borehole BH WK 1 was also sent to Organic Analyses Laboratory to be analysed for the hydro-carbons BTEXN and TPH. All the parameters analysed for show below detection limit.
- The vulnerability of the Groundwater Aquifer due to the Hydrogeological Conditions at the proposed filling station site can be rated as medium risk.
- The soil and scree layer as well as the un-weathered Bronzitite are fairly impermeable and will slow down vertical travel of contaminated water to travel at a rate of 0.9m/d. The weathered Bronzitite is fairly permeable.
- The sand 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.
- Nitrates, phosphates and chlorides will be minimally reduced.
- The top layer will form a fair barrier to the movement of biological contaminants but will have little reduction in chemical contaminants.
- On this site the hydraulic flow time is in the region of 13 days. This may be adequate for
bacteriological break down.

- The significance of the potential impacts in the construction phase is rated as “Low”.
- With mitigation, the significance of these activities is rated as “Negligible”.
- The significance of the potential impacts during the operational phase is “Moderate”.
- With mitigation, the significance of these activities is rate as “Low”.
- The groundwater monitoring network as stipulated in Section 9 must be implemented as recommended.

The following mitigation measures are recommended in the Construction Phase:

- Contamination of surface water if the temporary latrines are not used and construction workers “go to the bush”.
- Contamination of groundwater during the testing phase when pipes and or equipment may leak.
- Contamination from fuel and oil leaks from construction vehicles.
- Contaminated storm water running from the site under construction.

The following mitigation measures are recommended in the operational phase:

- The filling station site storage facilities must constantly be maintained preferably by a contracted specialist.
- Safety precautions regarding the solid waste possibly generated is a highly specialised task which must be done by a specialist.
- The monitoring of possible leaks safeguards the facility against accidents and or spills. A leak detection system must be installed and maintained. This must be done by monitoring borehole BH WK 1 located on the down-stream side of the site.
- Storm water originating from the site must be contained.
- Storm water originating on the filling station service 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 site.
- The monitoring borehole must be monitored for Bacteriological parameters and for major cations and anions plus BTEXN and TPH parameters on a bi-annual basis before the implementation of the filling station started and continuously until the end of the operational phase of the filling station.
- Vehicles and machines on site must be maintained properly to ensure that hydro carbon and or oil spillages are kept at a minimum.
• An emergency accidental spillage plan must be in place and workers must be trained to handle such accidents.

• Water seeping into filled levels on site must be prevented.

• 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 Investigation and Contamination Risk Assessment study aimed at establishing a baseline reference of hydrogeological data to form part of an application for the proposed construction of a new filling station which is planned for Portion 348 of the Farm Waterkloof 305 JQ. 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.

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The proposed filling station will not abstract groundwater to supply in the water demand, but will use bulk municipal water, municipal sewer infrastructure and electricity available in the area.

The aim of this study is to serve as a base-line groundwater reference study and contamination risk assessment. HK Geohydrological Services Pty Ltd was appointed by Hydroscience cc, to do a geohydrological baseline - and contamination risk assessment study for the planned development.

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 in a radius around the planned development area.
3) Taking of water, sand or soil samples from an existing borehole (if available) for quality analyses and BTEXN and TPH parameters.
4) Chemical water quality assessment for one borehole.
5) Collect information on existing threats to groundwater quality.
6) Assess contamination risk from the fuel storage system.
7) Hydrogeological impact assessment for the site.
8) Compilation of a hydrogeological study report which will contain the hydro-census information, geological description, groundwater flow directions and boreholes.
9) Groundwater monitoring network and monitoring programme for long term monitoring of the groundwater regime.
Figure 1: Regional locality map.
Figure 2: Local locality map of the region around the development site which is the proposed Filling Station site (red)
2. **CLIMATE AND REGIONAL SETTING**

Portion 348 of the farm Waterkloof 305 JQ is located in quaternary sub-catchment A22H. The site is located in Weather Bureau section number 0511 and in rainfall zone A2F. The closest rainfall station still in use is 0511467. This weather station is located approximately 5km south west of the proposed development.

The rainfall period for this station covers the years from 1924 to 1989. The Mean Annual Precipitation (MAP) for the period from 1924 to 1989 is 711mm/a. Rainfall occurs as typical summer thunderstorms with heavy lightning and strong winds. Summer rainfall is typically from November to February, in which approximately 65% of rainfall normally occurs. The typical dry period is between May and September each year, covering the winter months.

Portion 348 of the farm Waterkloof 305 JQ is located in Evaporation Zone 3B. The closest Evaporation station A2E008, the Rustenburg station which is located approximately 10km north west of the proposed development, gives a mean annual evaporation (MAE) of 1 645mm for the S-Pan value and 2 054mm for the A-pan value. The evaporation measurements cover the years 1957 to 1979. The proposed site is located in Hydro Zone Q with a Mean Annual Runoff (MAR) of 20 to 50mm per annum.

3. **METHODOLOGY**

A desk study was performed to gather relevant geological and hydrogeological information. A hydro-census followed the desk study to establish borehole information in the region of the proposed filling station. The purpose of this survey was to gather relevant hydrogeological information to study the groundwater regime, current groundwater use and borehole coordinates in the area.

Twenty six (26) boreholes could be found in the study area and beyond the boundaries of the study area in a 1km radius of the proposed site. An area of 1km in radius from the centre of the proposed filling station site was covered.

Eighteen (18) of the twenty six (26) boreholes are currently equipped. Most of the boreholes located close to the south east which is on the Agricultural Research Council are no longer in use although some of them are equipped. The equipment from some of the boreholes is removed and the boreholes are open and abandoned and no longer protected. Most of the pump houses are in a dilapidated state due to neglect.

A geological walk over study was done of the proposed filling station site to study the in-situ geology. One test pit was dug during a previous study on a site located a few hundred meters south east and prepared for double ring inflow meter tests. The aim of the test was to establish
percolation rate for the upper soils to facilitate the contamination risk assessment.

The water level depths were used to construct the groundwater flow directions to understand the groundwater movement direction on site. The percolation rate tests, geology, estimated water level depth and estimated groundwater flow directions were utilized to calculate the contamination risk for the site.

4. GEOLOGICAL SETTING

The 1:250 000 Geological Series map no 2526 Rustenburg indicates that the area of interest lies on Tweelaagte Bronzitite, Groenfontein Hartzburgite and Kroondal Norite which is part of the Rustenburg Layered Suite. The Kroondal Norite lies on top of the Magaliesburg quartzite which is part of the Pretoria Group and the Transvaal Sequence. The Tweelaagte Bronzitite and Groenfontein Hartzburgite lie on top of the Kolobeng Norite and is also part of the Rustenburg Layered Suite.

On the site, the Tweelaagte Bronzitite is visible as an outcrop. The Tweelaagte Bronzitite, Groenfontein Hartzburgite and Kroondal Norite are intrusive rocks that are normally light to blue in colour and weathers to a coarse grained medium yielding aquifer and later to turf or black silty and clayey clay.

Below is a short summary of the lithology of the interested area. The geology map is below on Figure 3 which shows the regional geology. The development site is marked in red.

Below is a short summary of the lithology of the interested area:
Figure 3: Regional geological map

Adapted from the 1:250 000 geological map 2628 Rustenburg published in 1986. The copyright of the Government Printer is recognized.
5. FIELD WORK

5.1 Desk study and Hydro-Census Data

Reports on previous studies in the area were used to serve as background information. The information on the location of the boreholes and water level depths could be used. These boreholes were revisited during the hydro-census done for this study.

Information on twenty six (26) boreholes could be found in a 1km radius from the central part of the proposed filling station site. These boreholes are located around the proposed site. Refer to Figure 4. Water level depths could be measured in fourteen (14) of the twenty six (26) boreholes. The water level depth, measured in the boreholes, range from 4.17mbgl to 16.51mbgl.

The area has a rural element with agricultural development on some of the plots. To the north and west of the site, housing developments are established. These establishments use bulk water supply and do not make use of groundwater. To the east of the site, the Agricultural Research Council established small plots on which agricultural research crops are planted. Irrigation is done with surface water from a canal. Currently, no boreholes could be found that is used for water abstraction for crop irrigation. It seems that all boreholes are abandoned and not in use for farming practices and that only a few boreholes are used for domestic purposes at the Agricultural Research Council.

To the west of the proposed filling station site various lodge facilities are developed. The facilities all use groundwater for domestic purposes.

Borehole BH WK 1 is located directly downstream of the proposed filling station development site. A water sample was taken from this borehole, which is recommended to be used as monitoring facility. This borehole is used to provide domestic water to four houses on the farm portion.

The hydro-census data gives a broad picture that groundwater abstracted in the area is low. A large number of the existing boreholes were previously used for irrigation purposes. Some of these boreholes are still equipped but not used for abstraction purposes. The boreholes in the area are now mostly used for domestic purposes.
Figure 4: Hydro-census map.
### TABLE 1: Borehole Hydro-Census information

<table>
<thead>
<tr>
<th>Borehole number</th>
<th>Co - ordinates</th>
<th>Water level (mbgl)</th>
<th>Ground water Elevation (mamsl)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH 1</td>
<td>25°7'44'0.316&quot; S 27°17'2.688&quot; E</td>
<td>1163</td>
<td>4.17</td>
<td>1159</td>
</tr>
<tr>
<td>BH 2</td>
<td>25°7'43'30.3&quot; S 27°16'45.5&quot; E</td>
<td>1172</td>
<td>8</td>
<td>1164</td>
</tr>
<tr>
<td>BH 3</td>
<td>25°7'44'9.4&quot; S 27°16'35.8&quot; E</td>
<td>1167</td>
<td>8.45</td>
<td>1159</td>
</tr>
<tr>
<td>BH 5</td>
<td>25°7'43'37.6&quot; S 27°16'13.4&quot; E</td>
<td>1183</td>
<td>9.93</td>
<td>1173</td>
</tr>
<tr>
<td>BH 6</td>
<td>25°7'44'9.6&quot; S 27°16'35.3&quot; E</td>
<td>1167</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>BH 7</td>
<td>25°7'43'43.8&quot; S 27°16'13.8&quot; E</td>
<td>1183</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>H/BH 9</td>
<td>25°7'44'0.1&quot; S 27°16'50.5&quot; E</td>
<td>1164</td>
<td>6.91</td>
<td>1157</td>
</tr>
<tr>
<td>H/BH 10</td>
<td>25°7'44'7.8&quot; S 27°16'46.1&quot; E</td>
<td>1164</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>H/BH 11</td>
<td>25°7'44'0.7&quot; S 27°16'46.4&quot; E</td>
<td>1164</td>
<td>8.21</td>
<td>1156</td>
</tr>
<tr>
<td>H/BH 12</td>
<td>25°7'44'0.4&quot; S 27°16'47.7&quot; E</td>
<td>1164</td>
<td>7.91</td>
<td>1156</td>
</tr>
</tbody>
</table>
### 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 geology. This was done previously on another site which is located a few hundred meters to the east of the proposed filling station 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
metres per day or centimeters per hour or centimeter per second. The minimum infiltration velocity is equivalent to the infiltration rate.

One test pit was done previously for a double ring inflow meter test. The infiltration rate of the test pit done for the previous study can be found described in Table 2 below.

The hydraulic conductivity rate measured at this pit range from 0.89 m/d in the middle of the test to 1.59 m/d at the beginning of the test, which relates to a medium hydraulic conductivity which is typical of silty sand.

### TABLE 2: Information on Test Pits

<table>
<thead>
<tr>
<th>Co-ordinates</th>
<th>Time period (Min)</th>
<th>Elapsed Time (Min)</th>
<th>Total Quantity of water (ml)</th>
<th>Infiltration rate (cm/s)</th>
<th>Infiltration rate (cm/h)</th>
<th>Infiltration rate (m/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit 1</td>
<td>15</td>
<td>15</td>
<td>1250</td>
<td>1.84 X 10^{-3}</td>
<td>6.625</td>
<td>1.590</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>30</td>
<td>1000</td>
<td>1.472 X 10^{-3}</td>
<td>5.300</td>
<td>1.272</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>45</td>
<td>700</td>
<td>1.030 X 10^{-3}</td>
<td>3.710</td>
<td>0.890</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>60</td>
<td>1100</td>
<td>1.619 X 10^{-3}</td>
<td>5.830</td>
<td>1.399</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>90</td>
<td>2000</td>
<td>1.472 X 10^{-3}</td>
<td>5.300</td>
<td>1.272</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>120</td>
<td>1500</td>
<td>1.104 X 10^{-3}</td>
<td>3.975</td>
<td>0.954</td>
</tr>
</tbody>
</table>

5.3 Water quality

One (1) water sample was retrieved for water quality analyses. The one sample was taken from borehole BH WK 1 which is ideally located down - stream to serve as groundwater monitoring borehole for the proposed filling station site.

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 and E. Coli count. The water was also analysed for hydrocarbons such as BTEXN and TPH. This analysis is discussed under hydrocarbons.

The results of the chemical and bacteriological analyses performed on the groundwater sample are presented in Table 3. 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. Please refer to Appendix A: Water Quality Analyses Certificate from Aquatico Laboratory for the original water analyses.

**Chemical Water Quality**

Borehole BH WK 1 shows very fresh water with an EC level of 51.1mS/m. The TDS is low at 295mg/l. The Chloride level is also very low at 11.7mg/l, which show that the water is recently
recharged. The water from BH WK 1 can be chemically categorized as Class 0, which can be used for domestic purposes without treatment. The water quality from this borehole is extremely good. This borehole will show contamination immediately and is therefore ideally located in the aquifer. This borehole is recommended to be used as groundwater monitoring facility.

**Bacteriological Water Quality**

The E.coli and Total coliform counts for borehole BH 1 are both below 1 which show no contamination.

**Hydrocarbon analyses**

Water from borehole BH WK 1 was also sent to Organic Analyses Laboratory to be analysed for the hydro-carbons BTEXN and TPH. All the parameters analysed for show below detection limit.
### Table 3: Water quality of borehole BH WK 1.

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Unit</th>
<th>Risk</th>
<th>Standard limits</th>
<th>BH WK 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH value at 25 C</td>
<td>pH units</td>
<td>Operational</td>
<td>≥ 5 to ≤ 9.7</td>
<td>8.32</td>
</tr>
<tr>
<td>Electric Conductivity at 25 C</td>
<td>mS/m</td>
<td>Aesthetic</td>
<td>≤ 170</td>
<td>51.1</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/l</td>
<td>Aesthetic</td>
<td>≤ 1200</td>
<td>296</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>Mg CaCO3/l</td>
<td></td>
<td></td>
<td>219</td>
</tr>
<tr>
<td>Chloride as Cl</td>
<td>mg/l</td>
<td>Aesthetic</td>
<td>≤ 300</td>
<td>11.7</td>
</tr>
<tr>
<td>Sulphate as SO4</td>
<td>mg/l</td>
<td>Acute health - 1</td>
<td>≤ 500</td>
<td>48.4</td>
</tr>
<tr>
<td>Nitrate (NO3) as N</td>
<td>mg/l</td>
<td>Acute health - 1</td>
<td>≤ 50</td>
<td>3.83</td>
</tr>
<tr>
<td>Ammonia as N</td>
<td>mg/l</td>
<td>Aesthetic</td>
<td>≤ 1.5</td>
<td>0.031</td>
</tr>
<tr>
<td>Orthophosphate (PO4) as P</td>
<td>mg/l</td>
<td></td>
<td></td>
<td>0.011</td>
</tr>
<tr>
<td>Fluoride as F</td>
<td>mg/l</td>
<td>Chronic health</td>
<td>≤ 1.5</td>
<td>0.263</td>
</tr>
<tr>
<td>Calcium as Ca</td>
<td>mg/l</td>
<td></td>
<td></td>
<td>12.8</td>
</tr>
<tr>
<td>Magnesium as Mg</td>
<td>mg/l</td>
<td></td>
<td></td>
<td>66.4</td>
</tr>
<tr>
<td>Sodium as Na</td>
<td>mg/l</td>
<td>Aesthetic</td>
<td>≤ 200</td>
<td>4.02</td>
</tr>
<tr>
<td>Potassium as K</td>
<td>mg/l</td>
<td></td>
<td></td>
<td>1.25</td>
</tr>
<tr>
<td>Aluminium as Al</td>
<td>mg/l</td>
<td>Operational</td>
<td>≤ 0.3</td>
<td>≤0.002</td>
</tr>
<tr>
<td>Iron as Fe</td>
<td>mg/l</td>
<td>Chronic health</td>
<td>≤ 2</td>
<td>≤0.004</td>
</tr>
<tr>
<td>Manganese as Mn</td>
<td>mg/l</td>
<td>Chronic health</td>
<td>≤0.5</td>
<td>≤0.001</td>
</tr>
<tr>
<td>E.coli</td>
<td>CFU/100ml</td>
<td>Acute health – 1</td>
<td>Not detected</td>
<td>1</td>
</tr>
<tr>
<td>Total coliform</td>
<td>CFU/100ml</td>
<td>Acute health - 2</td>
<td>≤10</td>
<td>1</td>
</tr>
<tr>
<td>Total hardness</td>
<td>mgCaCO3/l</td>
<td></td>
<td></td>
<td>306</td>
</tr>
</tbody>
</table>
6. HYDROGEOLOGICAL ASSESSMENT

6.1 Groundwater Level Depth

The water level depth information of the boreholes was used to create the groundwater level contour map. The groundwater level contour map, Figure 5 explains the groundwater flow directions with the light blue arrows. The water level depth in the area range between 4.17 and 16.51 metres below ground level.

6.2 On Site Surface Water Drainage and Groundwater Movement

Surface water drainage is perpendicular to the surface contours and groundwater flow is perpendicular to the groundwater contours.

The groundwater flow directions is shown as light blue arrows on Figure 5 and show the groundwater flow directions in the area on and around the proposed site. On the proposed filling station site, the groundwater flow direction is south south-east. To a large degree the surface water flow directions are also in a south south-eastern direction towards the Hex River.
Figure 5: Groundwater contour map (dark blue lines) showing the surface contours (brown) and groundwater flow directions (light blue).
7. **CONTAMINATION RISK ASSESSMENT**

7.1 **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. This system gives a classification on a regional scale which normally is seen as such.

a) **Aquifer Classification**

The aquifer at the proposed filling station site is classed as a *minor* aquifer region 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 introduction 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.**

7.2 **Water Resources**

Borehole BH WK 1 is located directly 80 to 100 metres (depending on the position of the storage tanks) south west of the proposed filling station site. This borehole is used as a production borehole for the four houses. Currently, the borehole is equipped with a submersible pump. This borehole is ideally located to serve as groundwater monitoring facility. The water table measured at this borehole is 12.19 metres below ground level. The Hex River is located 222 metres downstream of the proposed filling station site.

7.3 **Assessment of the Vulnerability of the Underground Water Resources**

The vulnerability of the underground water sources is related to the distance that the contaminant 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
Table 4: Vulnerability of groundwater aquifer due to hydrological conditions

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

In Table 4 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 12.19 metres which is fairly deep.

For surface spills on the filling station site, the travel distance vertically will be in the region of 12 metres. The soil and scree layer as well as the un-weathered Bronzitite are fairly impermeable and will slow down vertical travel of contaminated water to travel at a rate of 0.9m/d. The weathered Bronzitite is fairly permeable.
Table 5: Assessment of the reduction of contaminants in the unsaturated zone

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

Table 5 above shows that the sand 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, phosphates and chlorides will be minimally reduced. The top layer will form a fair barrier to the movement of biological contaminants but will have little reduction in chemical contaminants.

7.4 Existing threats to groundwater quality

No existing threat to groundwater sources is detected in the region other than possible contamination from French drain systems of the farm houses in the area.

7.5 Contamination risk from an on-surface contamination source

As far as the contamination risk from the planned 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 sand layer on surface and the un-weathered status of the Bronzitite host rock sufficiently protect the aquifer below from on surface leaks.

The upper soil’s hydraulic conductivity measured in test pit Pit 1 is 0.9m/d measured at its slowest rate. The hydraulic flow time to the water table = depth to water table ÷ permeability. On this site, the hydraulic flow time will be in the order of 13 days at its slowest rate if a water level depth of 12mbgl is taken for the site. This may be adequate for bacteriological break down.

7.6 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 that is in use, be prescribed. These safe distances depend on many factors due to the highly variable and uncertain nature of the factors that control the dispersion of pathogenic organisms and / or hydro carbons 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 150m to the calculated distances (This ensures a minimum safe distance of 150m 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.

Borehole BH WK 1 is located 80 to 100 meters downstream from the position of the proposed filling station site. Borehole BH WK 1 is used for water abstraction and will also be used as monitoring facility.

7.7 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 recommended safe distances prescribed are applied, surface water contamination will be negligible.

The proposed most southern boundary of the proposed filling station site is 300 metres from the Hex River tributary. The proposed filling station site must be carefully planned to accommodate storm water around the entire site. Special precautions must be made to ensure that possible accidental spills at the filling station site will not enter the Hex River.

8. ENVIRONMENTAL IMPACT ASSESSMENT

8.1 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 6 below.

Table 6: Rating matrix legend for groundwater impacts

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>Improbable</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Probable</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Highly Probable</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Definite</td>
<td>5</td>
</tr>
<tr>
<td>Duration</td>
<td>Short term</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Medium term</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Long term</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Permanent</td>
<td>5</td>
</tr>
<tr>
<td>Scale</td>
<td>Local</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Site</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Regional</td>
<td>3</td>
</tr>
<tr>
<td>Magnitude/Severity</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>8</td>
</tr>
<tr>
<td>Significance</td>
<td>Sum (Duration, Scale, Magnitude) x Probability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negligible</td>
<td>&lt;20</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>&lt;40</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>&lt;60</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

8.2 Impact identification and significance ratings

The impact matrix is listed below to show detailed 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.

8.2.1 Potential impacts during construction phase

The significance of the potential impacts in the construction phase is rated as “Low”. The significance score range from 4 to 20: The probable impacts are:

- Contamination of surface water if the temporary latrines are not used and construction workers “go to the bush”.
- Contamination of groundwater during the testing phase when pipes and or equipment may leak.
- Contamination from fuel and oil leaks from construction vehicles.
- Contaminated storm water running from the site under construction.
With mitigation measures in place, the significance of these activities is rated as “negligible”.

8.2.1.1 Management 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. 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.
- A storm water plan must be available and used during all the phases of construction. This must include siltation ponds handling storm water concentrations.

8.2.2 Potential impact during operational phase

The significance of the potential impacts during the operational phase is “Moderate”. The probable impacts are:

- Contamination of surface water and tributaries.
- Contamination of groundwater.

With mitigation, the significance of these activities is rated as “Low”.

8.2.2.1 Management and mitigation measures

The following mitigation measures are recommended in the operational phase:

- The filling station site storage facilities must be constantly maintained preferably by a contracted specialist.
- Safety precautions regarding the solid waste possibly generated is a highly specialised task which must be done by a specialist.

- The monitoring of possible leaks safeguards the facility against accidents and or spills. A leak detection system must be installed and maintained. This must be done by monitoring borehole BH WK 1 located on the down-stream side of the site.

- Storm water originating from the site must be contained.

- Storm water originating on the filling station service 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 site.

- The monitoring borehole must be monitored for Bacteriological parameters and for major cations and anions plus BTEXN and TPH parameters on a bi-annual basis before the implementation of the filling station started and continuously until the end of the operational phase of the filling station.

- Vehicles and machines on site must be maintained properly to ensure that hydro carbon and or oil spillages are kept at a minimum.

- An emergency accidental spillage plan must be in place and workers must be trained to handle such accidents.

- Water seeping into filled levels on site must be prevented.

- 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 7: Significance Rating

<table>
<thead>
<tr>
<th>Nr</th>
<th>Activity</th>
<th>Without or With Mitigation</th>
<th>Probability</th>
<th>Duration</th>
<th>Scale</th>
<th>Magnitude/ Severity</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Score</td>
<td>Magnitude</td>
<td>Score</td>
<td>Magnitude</td>
<td>Score</td>
<td>Magnitude</td>
</tr>
<tr>
<td></td>
<td><strong>Construction Phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Contamination of groundwater from temporary construction camp latrines</td>
<td>WOM</td>
<td>2</td>
<td>Probable</td>
<td>1</td>
<td>Short Term</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WM</td>
<td>1</td>
<td>Improbable</td>
<td>1</td>
<td>Short Term</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Contamination of surface water from latrines</td>
<td>WOM</td>
<td>2</td>
<td>Probable</td>
<td>1</td>
<td>Short Term</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WM</td>
<td>1</td>
<td>Improbable</td>
<td>1</td>
<td>Short Term</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Contamination of groundwater from leaching of faulty pipe fittings and pumps during testing phase</td>
<td>WOM</td>
<td>2</td>
<td>Probable</td>
<td>3</td>
<td>Medium Term</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WM</td>
<td>1</td>
<td>Improbable</td>
<td>3</td>
<td>Medium Term</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Contamination of surface water from fuel leaks from vehicles</td>
<td>WOM</td>
<td>2</td>
<td>Probable</td>
<td>3</td>
<td>Medium Term</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WM</td>
<td>1</td>
<td>Improbable</td>
<td>3</td>
<td>Medium Term</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Operational Phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Contamination of groundwater from leaching of sewerage systems</td>
<td>WOM</td>
<td>4</td>
<td>Highly Probable</td>
<td>4</td>
<td>Long Term</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WM</td>
<td>2</td>
<td>Probable</td>
<td>3</td>
<td>Medium Term</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Contamination of surface water from spills of hydrocarbons</td>
<td>WOM</td>
<td>4</td>
<td>Highly Probable</td>
<td>4</td>
<td>Long Term</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WM</td>
<td>2</td>
<td>Probable</td>
<td>3</td>
<td>Medium Term</td>
<td>2</td>
</tr>
</tbody>
</table>
9. 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 proposed filling station site.

The main focus of a monitoring system must be to monitor and detect possible leakages before the environment is damaged. The hydrocarbon storage facility must have a monitoring system attached. These systems must be able to detect a faulty system rather than detect leakages outside the geohydrological system.

A groundwater monitoring borehole can detect pollutants before the river system is polluted and environmental damage is done.

The proposed groundwater monitoring borehole BH WK 1 must be implemented as a groundwater monitoring borehole, Table 8 and Figure 6. 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).

9.1 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 groundwater.

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.
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.
9.2 Possible pollution sources
Potential pollution sources include the following:
1. Dirty water from the surface of the filling station service area.
2. Leakage of storage facilities, pumps and pipe network leading to un-expected leakage.
3. Sewerage system breakages.

9.3 Receiving environment
The following hydrological units may be impacted by the project and related activities:
- The tributary of the Hex River located 300 metres downstream and the Hex River network further downstream.
- The aquifer below the filling station site and the regional aquifer downstream of the filling station site.

9.4 Monitoring Network
The monitoring borehole BH WK 1 must be sampled. The position of borehole BHWK 1 is given on Figure 7. The water monitoring frequency for water samples are given in Table 8 below.

9.5 Monitoring Frequency
The one (1) sample point given above must be sampled bi-annually (before, during and after the construction phase start) and analysed for micro and macro chemical parameters, bacteriological parameters and hydro carbons (BTEXN and TPH). The water level depth must be measured and noted at the monitoring borehole as and when sampling is done.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Chemistry Sampling</th>
<th>Water Level Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring BH WK 1</td>
<td>Bi-Annually before construction starts</td>
<td>Monthly at borehole BH WK 1</td>
</tr>
</tbody>
</table>

9.6 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, cation-anion balances etc. This will ensure consistency in monitoring and the verification and validation of water quality data. Data from groundwater and surface water quality monitoring must be stored together electronically to enable trend analysis and waste load calculations to be carried out.
### Table 9: Sampling parameters

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Field measurements</th>
<th>Laboratory analysis: Chemical and bacteriological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>Water level depth in borehole BH WK</td>
<td>Refer to Table 3 for chemical and bacteriological parameters.</td>
</tr>
</tbody>
</table>

#### 9.7 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. Calibrate the field instruments before every sampling run. Read the manufacturers manual and instructions carefully before calibrating and using the instrument.

2. Purging a borehole can be done in the following ways:
   a. With a portable pump
   b. With an already installed submersible pump
   c. By lowering a bailer into the hole

3. Prior to sampling, measure the water level and record.

4. Install the pump (If not equipped) with the inlet close to the static water level.

5. Set up the EC, pH and temperature meter.

6. Start pumping and record the pumping rate in l/s.

7. Continuously measure the pH and EC values.

8. If the field chemistry stabilizes the borehole is purged. Note that approximately one column of water should be removed. The volume of water to be removed is calculated using the following formula:
   \[
   \text{Volume of standing water} = \pi \times R^2 \times H \times 1000, \text{ where}
   \]
   \[
   R = \text{radius of borehole in meter}
   \]
   \[
   H = \text{height of water column in meter}
   \]

9. Some boreholes are low yielding and go dry when purging. Leave the borehole to recover for a few hours. When returning, install the pump with the inlet close to the static water level and continue with the next step. Alternatively, bail the borehole.

10. 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.

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

12. Replace the cap immediately.

13. 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  

15. 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.

16. Complete the data sheet for the borehole

17. 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.
Figure 6: Monitoring Network.

Figure 6: Monitoring Network.
10. CONCLUSIONS

During the hydrogeological study the following conclusions could be made:

- The groundwater level depth measured in BH WK 1, the borehole close to the site is 12.19 (mbgl) metres below ground level.
- The hydro-census data gives a broad picture that groundwater abstracted in the area is low.
- On the proposed Filling station site, the surface water flow directions and groundwater flow directions are in a south-south-eastern direction towards the Hex River.
- Borehole BH WK 1 shows very fresh water with an EC level of 51.1 mS/m. The TDS is low at 295 mg/l. The Chloride level is also very low at 11.7 mg/l, which show that the water is recently recharged. The water from BH WK 1 can be chemically categorized as Class 0, which can be used for domestic purposes without treatment. The water quality from this borehole is extremely good. This borehole is ideally located and will show contamination immediately and is therefore ideally located in the aquifer to be used as groundwater monitoring facility.
- The E.coli and Total coliform counts for borehole BH WK 1 are both below 1 which show no contamination.
- Water from borehole BH WK 1 was also sent to Organic Analyses Laboratory to be analysed for the hydro-carbons BTEXN and TPH. All the parameters analysed for show below detection limit.
- The vulnerability of the Groundwater Aquifer due to the Hydrogeological Conditions at the proposed filling station site can be rated as medium risk.
- The soil and scree layer as well as the un-weathered Bronzitite are fairly impermeable and will slow down vertical travel of contaminated water to travel at a rate of 0.9 m/d. The weathered Bronzitite is fairly permeable.
- The sand 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.
- Nitrates, phosphates and chlorides will be minimally reduced.
- The top layer will form a fair barrier to the movement of biological contaminants but will have little reduction in chemical contaminants.
- On this site the hydraulic flow time is in the region of 13 days. This may be adequate for bacteriological break down.
- The significance of the potential impacts in the construction phase is rated as “Low”.

With mitigation, the significance of these activities is rated as “Negligible”.

The significance of the potential impacts during the operational phase is “Moderate”.

With mitigation, the significance of these activities is rated as “Low”.

The groundwater monitoring network as stipulated in Section 9 must be implemented as recommended.

11. RECOMMENDATIONS

The following mitigation measures are recommended in the Construction Phase:

- Contamination of surface water if the temporary latrines are not used and construction workers “go to the bush”.
- Contamination of groundwater during the testing phase when pipes and or equipment may leak.
- Contamination from fuel and oil leaks from construction vehicles.
- Contaminated storm water running from the site under construction.

The following mitigation measures are recommended in the operational phase:

- The filling station site storage facilities must constantly maintained preferably by a contracted specialist.
- Safety precautions regarding the solid waste possibly generated is a highly specialised task which must be done by a specialist.
- The monitoring of possible leaks safeguards the facility against accidents and or spills. A leak detection system must be installed and maintained. This must be done by monitoring borehole BH WK 1 located on the down-stream side of the site.
- Storm water originating from the site must be contained.
- Storm water originating on the filling station service 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 site.
- The monitoring borehole must be monitored for Bacteriological parameters and for major cations and anions plus BTEXN and TPH parameters on a bi-annual basis before the implementation of the filling station started and continuously until the end of the operational phase of the filling station.
- Vehicles and machines on site must be maintained properly to ensure that hydro carbon and or oil spillages are kept at a minimum.
• An emergency accidental spillage plan must be in place and workers must be trained to handle such accidents.

• Water seeping into filled levels on site must be prevented.

• 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
Appendix A
Water Quality Analyses Information
# Test Report

**Client:** HK Geohydrological Services  
**Address:** 25ste laan, 327, Villoria, Pretoria,  
**Report no:** 67459  
**Project:** HK Geohydrological Services  
**Date of certificate:** 13 May 2019  
**Date accepted:** 07 May 2019  
**Date completed:** 13 May 2019  
**Date received:** 07 May 2019

---

**Lab no:** S908  
**Date sampled:** 07-May-19  
**Aquatico sampled:** No  
**Sample type:** Water

**Locality description:**

<table>
<thead>
<tr>
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<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>pH at 25°C</td>
<td>ph</td>
<td>ALM 20</td>
</tr>
<tr>
<td>Electrical conductivity (EC) at 25°C</td>
<td>mS/m</td>
<td>ALM 20</td>
</tr>
<tr>
<td>Total dissolved solids (TDS)</td>
<td>mg/l</td>
<td>ALM 26</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>mg CaCO₃/l</td>
<td>ALM 01</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>mg/l</td>
<td>ALM 02</td>
</tr>
<tr>
<td>Sulphate (SO₄)</td>
<td>mg/l</td>
<td>ALM 03</td>
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<tr>
<td>Nitrate (NO₃) as N</td>
<td>mg/l</td>
<td>ALM 06</td>
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<tr>
<td>Ammonium (NH₄) as N</td>
<td>mg/l</td>
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<tr>
<td>Orthophosphate (PO₄) as P</td>
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<td>Fluoride (F)</td>
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<td>Calcium (Ca)</td>
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<td>Magnesium (Mg)</td>
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<td>Potassium (K)</td>
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<td>Aluminium (Al)</td>
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<td>Iron (Fe)</td>
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<tr>
<td>Manganese (Mn)</td>
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</tr>
<tr>
<td>Ecoli</td>
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<tr>
<td>Total coliform</td>
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<tr>
<td>Total hardness</td>
<td>mg CaCO₃/l</td>
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<tr>
<td>BTEX</td>
<td>µg/l</td>
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<tr>
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<td>OLM 01</td>
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<tr>
<td>m = p Xylene</td>
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<tr>
<td>TPH C10-C40</td>
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<td>OLM 04</td>
</tr>
<tr>
<td>C10 - C16</td>
<td>µg/l</td>
<td>OLM 04</td>
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A = Accredited  
N = Non-accredited  
Out = Outsourced  
Sub = Sub-contracted  
NR = Not requested  
RT = Results to follow  
N/A = Not able to determine  
ATF = 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. Swamipool  
Technical Signatory
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<table>
<thead>
<tr>
<th>Lab no:</th>
<th>8908</th>
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<tbody>
<tr>
<td>Date sampled:</td>
<td>07 May 19</td>
</tr>
<tr>
<td>Aquatico sampled:</td>
<td>No</td>
</tr>
<tr>
<td>Sample type:</td>
<td>Water</td>
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<tr>
<td>Locality description:</td>
<td>WR8H1</td>
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### Analyses

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Method</th>
<th>Unit</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>N C16 - C22</td>
<td>OLM 04</td>
<td>µg/l</td>
<td>&lt;10</td>
</tr>
<tr>
<td>N C22 - C30</td>
<td>OLM 04</td>
<td>µg/l</td>
<td>&lt;10</td>
</tr>
<tr>
<td>N C30 - C40</td>
<td>OLM 04</td>
<td>µg/l</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

*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.

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