Executive summary

In-Situ Groundwater Consulting cc. was appointed by McCormick Property Development cc to conduct a specialist geohydrological study and risk assessment to form part of an Environmental Impact Assessment for the proposed Filling Station at the Maake Plaza Shopping Centre on the remainder of the farm Rita 668LT, Maake Area, Limpopo Province.

The tank farm will include underground storage of two ULP tanks of 46 & 23m^3 as well as a 23m^3 LRP tank and a 23m^3 Diesel tank. All underground installations will comply with SABS 089 Part 3. Steel tanks shall comply with SABS 1535 and all work with SABS 0131 Part 3. Water and Sanitation infrastructure will be linked to the Maake Plaza Shopping Centre's services. The Maake Plaza Shopping Centre's water supply borehole (H08-1793) is situated some 400m to the west between the Thabina River and a water supply canal running parallel to the river. To the north and south of the borehole, small-scale rural farming is practiced with water being channeled from the canal to the fields along hand-dug trenches.

The study area falls within quaternary sub-catchment area **B81D** (Midgley *et al.,* 1994) of the Luvuvhu and Letaba Water Management Area (WMA) and is drained by the Thabina River which joins the Letsiltele River some 10km to the northeast.

The geology of the area comprises quartz-mica schists of the Rubbervale Formation of the Murchison Greenstone Belt. Bedrock is overlain by a thin surficial transported soil (< 0.5m) and thick residuum (± 3m) derived from the Insitu weathering of the schist. An average permeability value of 0.002m/day and average effective porosity value of 32.5% is indicated for the residuum soil profile. Apart from the Thabina Fault transecting the western boundary of the investigation area, roughly outlining the river course of the Thabina River, geophysical traversing indicated the presence of a dolerite dyke with almost the same orientation as the R36, located between the proposed filling station and the R36, as well as another dyke with a SE-NW orientation located between the Thabina River and a water supply canal running parallel to the river, some 400m west of the proposed filling station.

Two monitoring boreholes were drilled up gradient (H08-1872) and down gradient (H08-1873) of the proposed filling station. The soil profile ranged between 2m and 4m in depth. Both boreholes penetrated highly weathered, weathered quartz-mica schist, encountering fresh bedrock between 37m and 38m below surface, respectively. Borehole H08-1872 intersected the identified dyke between the proposed filling station and the R36 at a depth between 33m and 36m below surface, confirming the geophysical results. Water supply borehole (H08-1793) was drilled along the western contact zone of dyke identified between the Thabina River and a water supply canal, transecting weathered and fractured quartz-mica schist to a depth of 32m until solid, hard rock was encountered.

The observed and potential groundwater usage increases the risk in terms of the impact on human receptors significantly. Apart from the Maake Plaza Shopping Centre's water supply borehole (H08-1793), five other water supply boreholes are located within 1 km of the proposed filling station area and another three some 3km to the east. The current groundwater abstraction volume from the investigation area by existing users is approximately 377.28m^3/day. Existing boreholes that has the potential to be utilized as future production boreholes could abstract an additional 459.07m^3/day, bringing the total groundwater abstraction possible from existing sources in the investigation area to 836.35m^3/day. Incorporating the Maake Plaza Shopping Centre's water supply borehole's sustainable capacity, the maximum total groundwater abstraction from existing sources in the investigation area calculates to a volume of 1073.95m3/day.

Owing to the unconsolidated nature of the regolith, the development of a perched water table at shallow depth, i.e. with 1.5m of ground level, is unlikely. The average water level depth is some 21.39 mbc, which in conjunction with the average weathering depth of 35.67m, yields an average saturated aquifer thickness of 14.28m. The general groundwater flow direction is towards the west, and thus towards production borehole H08-0881 and the Thabina River, which constitutes the western discharge boundary of the subject area's flow regime. Assuming a groundwater gradient no larger than 2%, subject to the estimated values for hydraulic conductivity and porosity, the groundwater seepage velocity in the secondary weathered zone aquifer is estimated at 0.052 m/day, or 18.98 m/year.

Poor water quality is only due to microbiological properties whereas physical and chemical quality is generally ideal. Routine water sampling and analysis for faecal contamination is therefore imperative. The site is a 'greenfield' site. It can thus be concluded that both the soils and the groundwater is unpolluted in terms of petroleum contamination at this point in time.

The area is underlain by a Minor Aquifer System. The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Ground Water Quality Management Index of 3 for the area, indicating that medium level ground water protection may be required.

During the rating and ranking procedure of impacts, no impact had the "no-go" implication for certain aspects of the project and all impacts can be countered by appropriate mitigation and training of all personnel.

In conclusion, considering the available information, the proposed Filling Station at the Maake Plaza Shopping Centre on the remainder of the farm Rita 668LT might have some impact on the environment, but as long as proper management procedures are in place, the effect will be minimal. The filling station does create long-term jobs that translate into a positive economic effect on the social environment.

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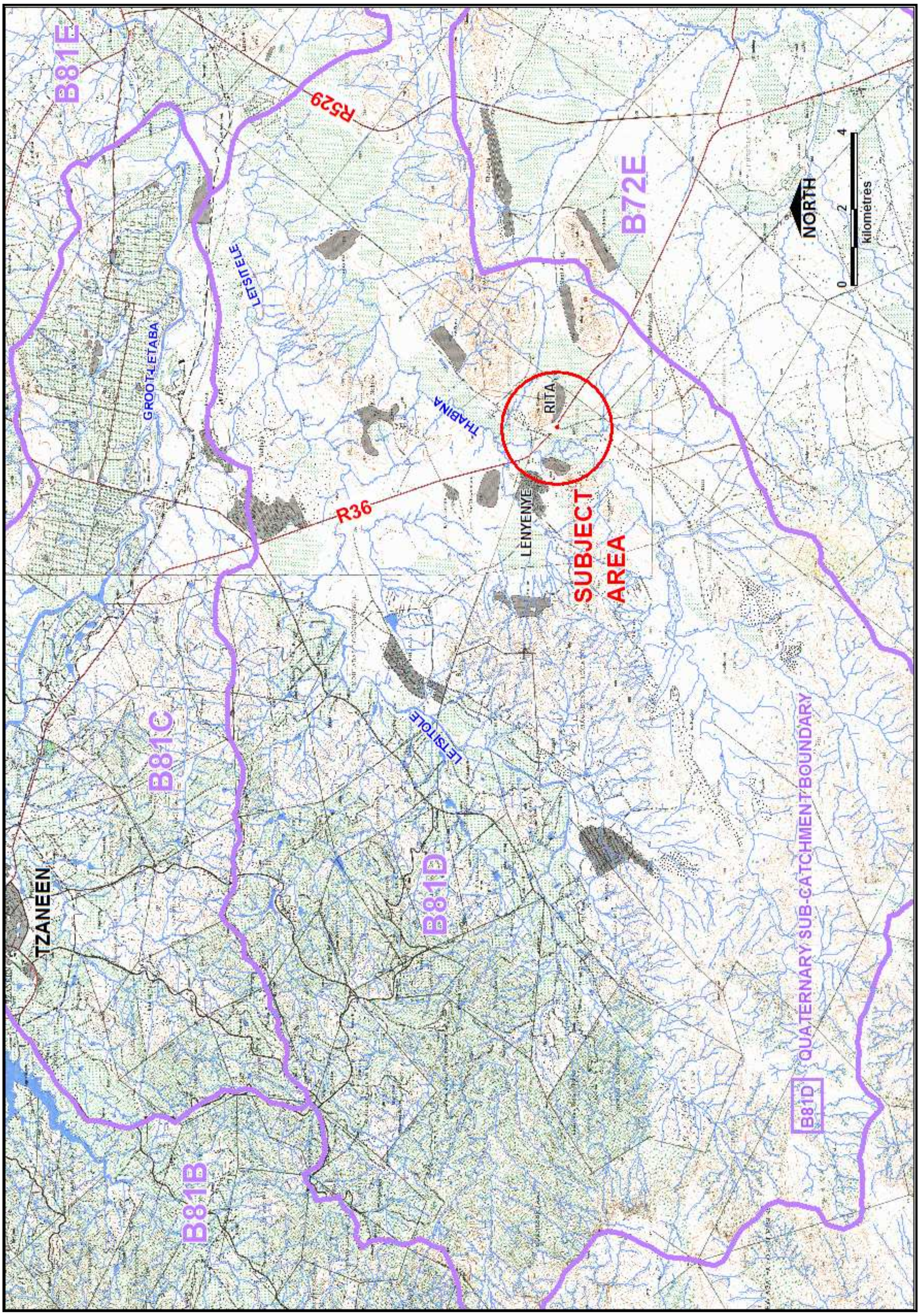
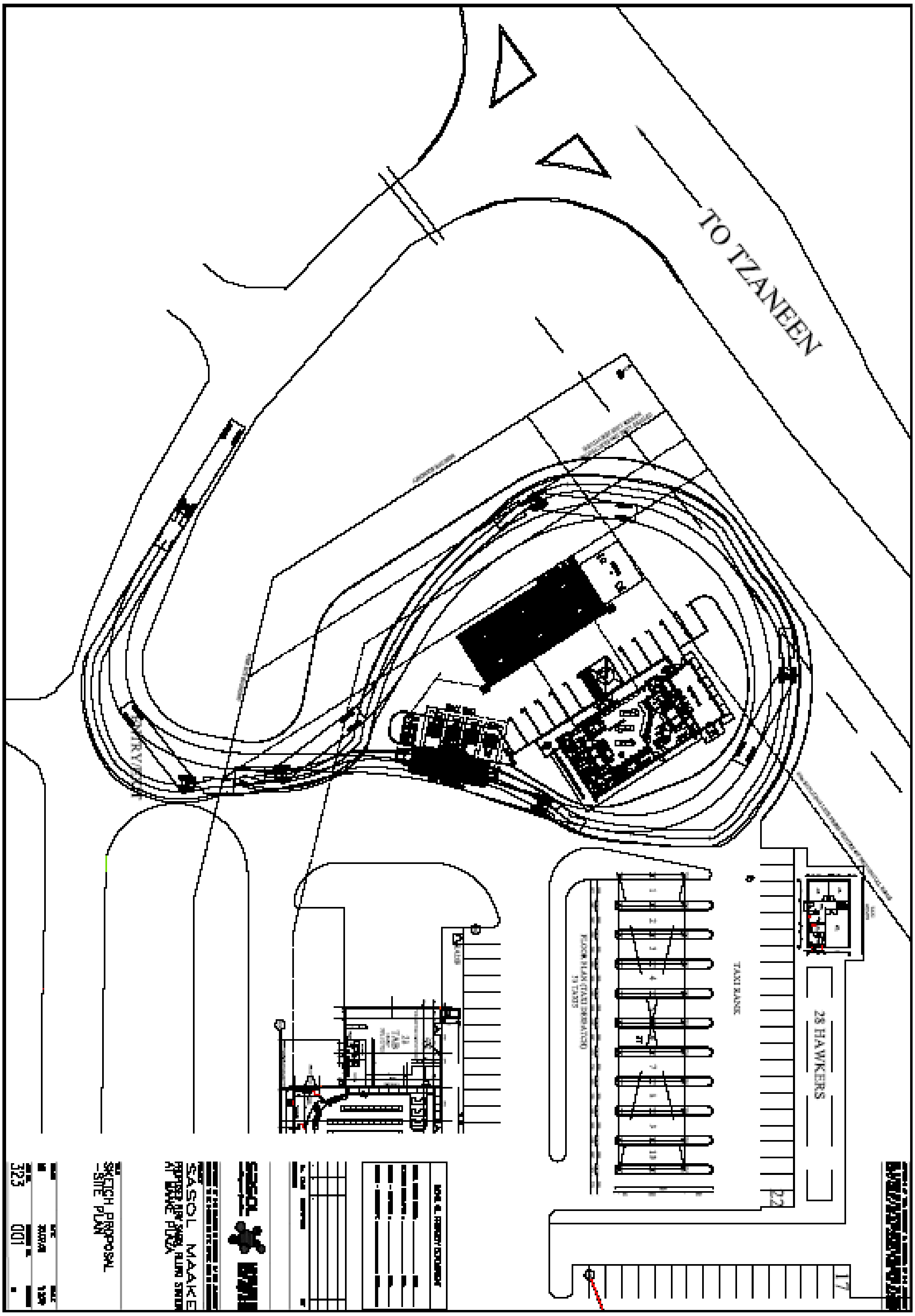


FIGURE 2. Site Plan.



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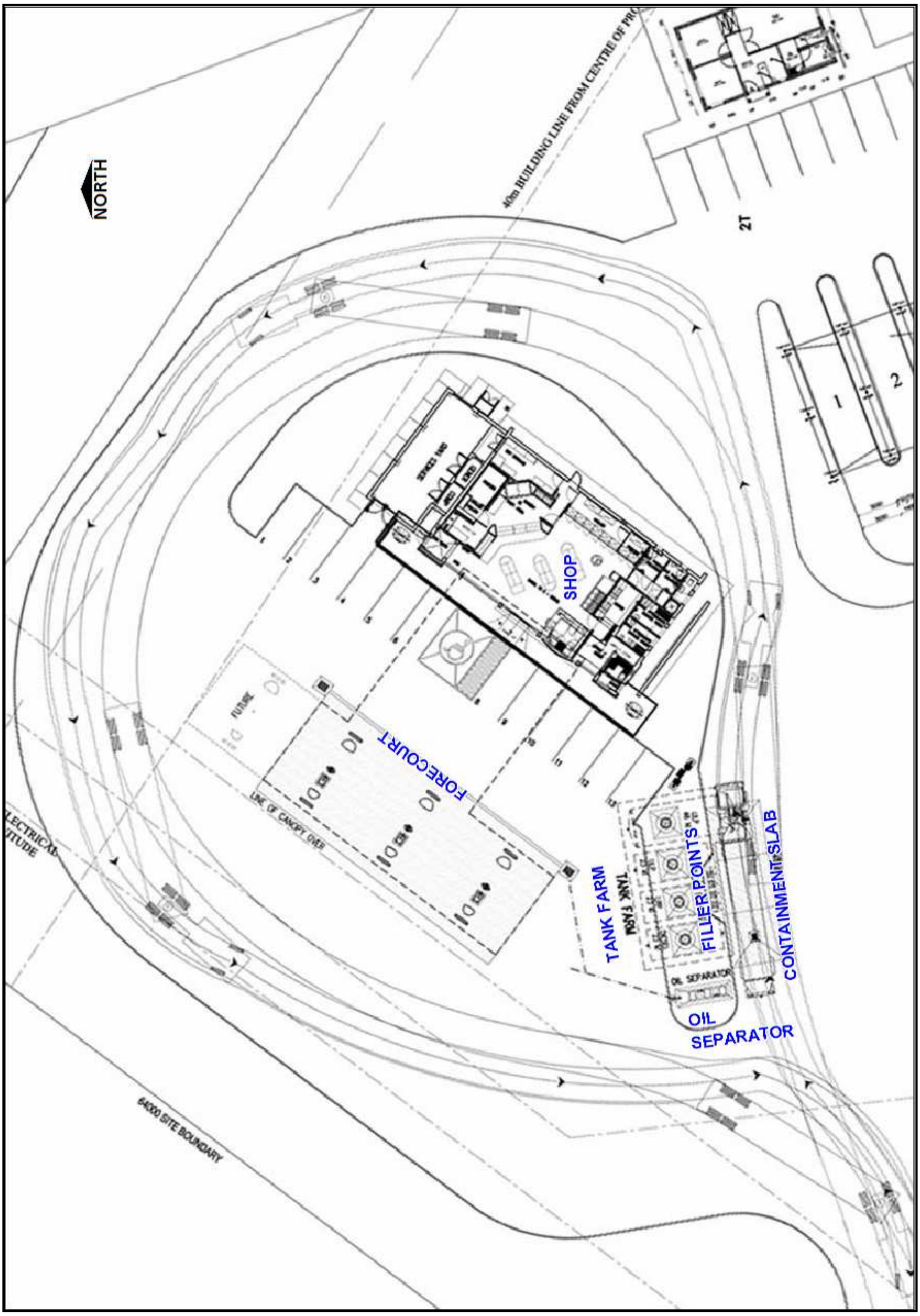

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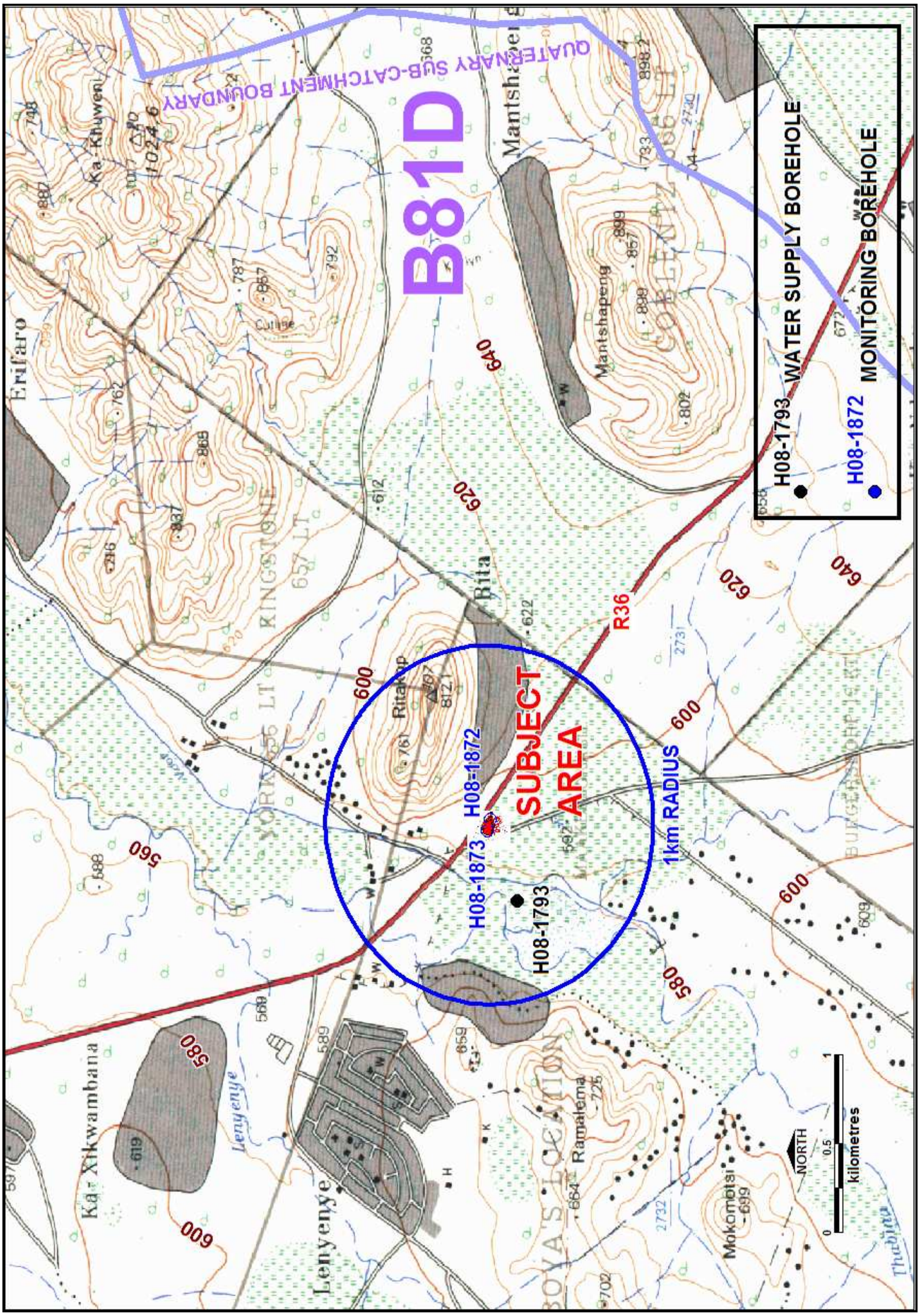


1. INTRODUCTION

1.1. Background

In-Situ Groundwater Consulting cc. was appointed by McCormick Property Development cc to conduct a specialist geohydrological study and risk assessment to form part of an Environmental Impact Assessment for the proposed Filling Station at the Maake Plaza Shopping Centre on the remainder of the farm Rita 668LT, Maake Area, Limpopo Province.

The storage of petroleum products is a listed activity as proclaimed in Regulation 1182 as published in Regulation Gazette 5999 on 5 September 1997 and is therefore subject to the Environmental Conservation Act (Act No 73 of 1989) in South Africa.

Previous work performed by In-Situ Groundwater Consulting cc. at the Maake Plaza Shopping Centre, included the commissioning of a water supply source (borehole H08-1793), as well as the compilation of a geohydrological report to confirm the availability, sustainability and suitability of the water source as supportive documentation for the Centre's water use license application to DWAF.

1.2. Scope of Work

The following scope of work applies to this study:

- Conduct a detailed desk study gathering existing information from topographical maps, ortho-photos, geological maps, hydrological information, published and unpublished reports etc.
- Request all borehole data in the catchment area from GPM Consultants in Limpopo Province,
- Verify all received borehole data and identify additional water users through a hydrocensus at and around the proposed development to assess the groundwater utilization in the area.
- Commission two groundwater monitoring boreholes according to the prescribed specifications of Department of Water Affairs and Forestry:
  - Optimal placement of monitoring boreholes incorporating geophysics and related infrastructure;
  - Supervision during construction;
  - Recording of all relevant geohydrological information such as water strike, blow yields and geology;
  - Perform pumping tests on the boreholes in order to determine the aquifer's hydraulic characteristics.
  - Take water samples for quality analyses, organic as well as inorganic.

- Based on all the abovementioned regional and site specific data, a specialist report will be compiled on the groundwater depths, quality, flow directions and velocity. From this information, potential impact zones will be identified, including a first order risk assessment to determine the potential for groundwater contamination.

2. PHYSICAL DESCRIPTION OF THE SITE

The planned filling station is to be situated along the R36 some 21.4km southeast of Tzaneen 9km northwest of the R36/R529 junction at the Maake Plaza Shopping Centre on the remainder of the farm Rita 668LT (Longitude: E30.28757; Latitude: S23.97605 WGS84).

The regional locality of the proposed filling station is portrayed Figure 1, while a site plan indicating the position of the proposed filling station in relation to the R36 is portrayed in Figure 2.

3. PROJECT DESCRIPTION

The proposed site layout plan indicating the tank farm, the filler points with their associated containment slab, the forecourt & canopy cover, shop, services court and oil separator for the new filling station is indicated in Figure 3.

The tank farm will include underground storage of two ULP tanks of 46 & 23m^3 as well as a 23m^3 LRP tank and a 23m^3 Diesel tank. The filler points and its associated containment slab are located south of the forecourt, immediately south of the tank farm, while the oil separator is located to the immediate west of the tank farm.

All underground installations will comply with SABS 089 Part 3. Steel tanks shall comply with SABS 1535 and all work with SABS 0131 Part 3:

- Tank farm:
  - Fuel storage tanks are proposed to be installed underground, which ensures better temperature stability, which in turn reduces breathing losses from the tanks due to fluctuations in temperature;
  - Tanks are to be coated with glass-fibre-reinforced polyester as per SANS 1535 to reduce the risk of corrosion posed by the sub-surface environment;
  - Tanks will be fitted with monitoring devices, including on-line leak detection, for purposes of pro-actively detecting any potential product loss (leaks) which might potentially result in pollution or contamination;

- Pump sumps and containment manholes will serve as containment tools in the event of a leak;
- The tank farm is to be covered with a 200mm thick concrete slab, and tanks will be buried at least 1m below ground (1m cover over fuel tanks);
- All submersible pumps shall include a leak detector that automatically checks the integrity of the pipework on the pressure side of pipework;
- Submersible pumps will be flame or explosion proof.

- Piping:
  - Corrosion-resistant “PetroPlus” piping is to be used for secondary containment around piping. The secondary piping will ensure that, in the event of a leak occurring in the piping, any fuel leaking from the pipe will be contained and will not come into direct contact with soil or groundwater;
  - Piping will conform to SANS 1830 and will be non-metallic and flexible. Plastic is inherently more corrosion-resistant than metals, and the flexible design eliminates unnecessary joints and elbows which are potential sources for leakages;
  - Sasol does not allow pipe joints underground, in order to reduce the risk of pipe failure.
- Fuel dispensers:
  - Fuel dispensers will be equipped with automatic nozzles, which automatically prevent vehicles from being overfilled and therefore reduces potential fuel spillage;
  - Dispensary nozzles will be equipped with splash guards to help prevent fuel spill in the event of an overfill;
  - Each dispenser will be fitted with a safety shear valve;
  - A single header may be run from the pump to the dispenser island with branches leading to each dispenser, but each branch shall have its own isolating valve located in a manhole.
- Forecourt and paving:
  - The forecourt is to consist of a 150mm-thick concrete slab, which forms an impermeable layer. In the event of a fuel spill on the forecourt due to an overfill, fuel will therefore be contained and will not infiltrate into the ground. The risk of soil or groundwater contamination is therefore greatly reduced;
  - A containment concrete slab around the surface of the tank farm will ensure that, should a spill occur during delivery of fuel from road tankers into the underground fuel storage tanks, the fuel will be contained, preventing infiltration into soil and/or groundwater;
  - Sufficient fire extinguishers will be provided. One 9kg dry chemical power type extinguisher will be provided to each pump island.
- Miscellaneous:

- o Vents will be placed in a safe place and the installations will be done according to SANS 10089-3. Fugitive emissions due to the storage of fuel will thus be minimised;
- o Vent pipes are to be at a minimum of 3.6m above ground to minimise potential health risk associated with possible fugitive emissions;
- o Daily dip inspections as well as regular stock reconciliations will also indicate possible loss of product. This is another pro-active means of detecting potential risks of pollution or contamination.

Water and Sanitation infrastructure will be linked to that of the Maake Plaza Shopping Centre.

4. THE RECEIVING ENVIRONMENT - GROUNDWATER

4.1. Regional Setting

The subject area falls within the jurisdiction of the Greater Tzaneen Local Municipality (NP3333) of the Mopani District Municipality (DC33).

The proposed filling station falls within quaternary sub-catchment area **B81D** (Midgley *et al.,* 1994) of the Luvuvhu and Letaba Water Management Area (WMA). Sub-catchment B81D covers an area of 1147km^2 and has a mean annual precipitation of 700-800mm, a mean annual evaporation of 1500-1600mm and a mean annual run-off of 200-500mm. Rainfall station 0679508 at Lenyenye (just eats of the investigation area) recorded a MAP of 756mm/annum over the period 1905 to 1989. Therefore, 756mm/annum would be a close approximation of the average rainfall figure for the immediate catchment (study) area.

Terrain morphology (Kruger, 1983) is characterized by hills and lowlands. Differences in relief range between 130-450m. Slopes of <5% occupy more 20-50% of the area.
Drainage density (after Kruger, 1983) ranges between 0.5-2km.km^{-2} and is classified as medium. Stream frequency is also classified as low to medium (0 - 6stream.km^{-2}).

The area is drained by the Thabina River which joins the Letsiltele River some 10km to the northeast.

The study area falls within soil mapping unit 3 of the Institute for Soil, Climate and Water (ISCW) broad natural homogeneous soil zone (BNHSZ) regions (Schulze et. al, 1997). This assigns a soil depth of 900 to 1200mm to 100% of unit 3. The soils comprising unit 3 typically support a slow drainage rate (25-30% clay content).

Lowveld Sour Bushveld is the dominant veld type (Acocs, 1988).

4.2. Local Setting

The geohydrological study area is situated between two tributaries of the Thabina River on the farms Mogoboya's Location, York 656 LT, Kingstone 657 LT and Coblentz 666 LT. It is framed by the Thabina River in the west and the quaternary sub-catchment boundary **B81D** (as defined by WRC) in the east, encompassing Ritaskop and Mantshapeng. It is framed by lines of latitude 23° 57' and 24° 00' S a nd lines of longitude 30° 16'and 30° 20' E and falls on 1:50 000 toposheet 2330 CD.

Physiographically, the area of investigation constitutes rather flat terrain (elevations of between 620 and 580m amsl), gently sloping downwards towards the west and the Thabina River with two prominent topographical features in the form of Ritaskop and Mantshapeng rising to altitudes of 899m amsl.

The Maake Plaza Shopping Centre's water supply borehole (H08-1793) is situated between the Thabina River and a water supply canal running parallel to the river (Figure 4). To the north and south of the borehole, small-scale rural farming is practiced with water being channeled from the canal to the fields along hand-dug trenches.

4.3. Water Legislation – General Authorisation

The Department of Water Affairs and Forestry has promulgated a General Authorisation in Gazette no.26187, Notice no. 399 published on 26 March 2004 in terms of the National Water Act (Act No. 36 of 1998) in which certain activities identified as taking, storing or disposing water uses were generally authorised. The purpose thereof is to allow certain water uses whose activities fall within the General Authorisation to continue with that activity without having to apply to the Department for a license provided that the use is within the conditions set out in the General Authorisation. With reference to this publication the following:

- The secondary/tertiary/quaternary drainage regions pertaining to primary drainage region B are excluded from General Authorisation for the taking of surface water [Section 21(a)].
- No groundwater may be taken from Quaternary Sub-catchment B81D under General Authorisations, except as set out under Schedule 1 and Small Industrial Users.
    - Quaternary Sub-catchment B81D is excluded from General Authorisations for storage of water [Section 21(b)] in excess of 10 000 m^3.
- The discharge of waste or water containing waste into a water resource through a pipe, canal, sewer or other conduit; and disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process [Sections 21(f) and (h)] is permitted up to 2 000 m^3 on any given day provided the discharge:

- complies with the prescribed wastewater limit values;
- does not alter the natural ambient water temperature of the receiving water resource by more than 2 degrees Celsius; and
- is not a complex industrial wastewater,
- does not impact on a water resource or any other person's water use, property or land; and
- is not detrimental to the health and safety of the public in the vicinity of the activity,
- a person who discharges wastewater into a water resource in terms of this authorisation must submit a registration form for registration of the water use before commencement of the discharge,
- the water user must ensure the establishment of monitoring programmes to monitor the quantity and quality of the discharge prior to the commencement of the discharge, as prescribed by the authorization,
- Upon the written request of the responsible authority the registered user must (a) ensure the establishment of any additional monitoring programmes; and (b) appoint a competent person to assess the water use measurements made in terms of this authorisation and submit the findings to the responsible authority for evaluation.
- Subject to the previous provision above, the water user must submit the prescribed monitoring information on a monthly basis to the responsible authority,
- any information on the occurrence of any incident that has or is likely to have a detrimental impact on the water resource quality must be reported to the responsible authority.
- the water user must follow acceptable construction, maintenance and operational practices to ensure the consistent, effective and safe performance of the discharge,
- all reasonable measures must be taken to provide for mechanical, electrical, operational, or process failures and malfunctions of the discharge system,
- any property or land in respect of which a water use has been authorised in terms of this notice must be made available for inspection by an authorised person in terms of section 125 of the National Water Act.

- A person may not discharge storm water runoff from any premises containing waste, or water containing waste emanating from industrial activities and premises, into a water resource. [Sections 21(f) and (h)].
- In terms of Section 21(g), the disposing of waste in a manner which may detrimentally impact on a water resource, storage of up to 5000 m^3 of domestic and/or biodegradable industrial wastewater for the purpose of re-use is permitted provided the storing of the wastewater:

- does not impact on a water resource or on any other person's water use, property or land; and
  - is not detrimental to the health and safety of the public in the vicinity of the activity.
- The storage of domestic and/or biodegradable industrial wastewater for the purpose of disposal [Section 21(g)] is permitted up to 10 000 m^3 per property or land; or up to 50 000 m^3 in a wastewater pond system per property or land provided the storing of wastewater:
  - does not impact on a water resource or on any other person's water use, property or land;
  - and is not detrimental to the health and safety of the public in the vicinity of the activity.
- The disposal of domestic and/or biodegradable industrial wastewater [Section 21(g)] is permitted up to up to 1 000 m^3 on any given day into:
  - a wastewater pond system; or into an evaporation pond system;
  - into a wastewater irrigation system as set out above;
  - an on-site disposal facility for grey water generated by a single household; or up to 1 m^3 of biodegradable industrial wastewater on any given day; and domestic wastewater to a communal conservancy tank serving no more than 50 households;
  - domestic wastewater generated by a single household not permanently linked to a central waste collection, treatment and disposal system to an on-site disposal facility; and
  - storm water runoff from any premises not containing waste or wastewater from industrial activities and premises;
  - provided the disposing of wastewater does not impact on a water resource or on any other person's water use, property or land; and is not detrimental to the health and safety of the public in the vicinity of the activity.

Wastewater storage dams and wastewater disposal sites must be located:

- outside of a watercourse;
- above the 100 year flood line, or alternatively, more than 100 m from the edge of a water resource or a borehole which is utilised for drinking water or stock watering, which ever is further; and
- on land that is not, or does not, overlie, a Major Aquifer (identification of a Major Aquifer will be provided by the Department upon written request).

A person who disposes of wastewater in terms of this authorisation must submit a registration form for registration of the water use before the commencement of the disposal if more than

50 m^3 of domestic wastewater or biodegradable industrial wastewater is disposed of on any given day.

The water user must ensure the establishment of monitoring programmes to monitor the quantity and quality of the wastewater prior to storage or disposal, as
Follows:

- for the storage of wastewater, the quantity must be recorded monthly; or
- for the disposal of wastewater, the quantity must be gauged or metered and recorded monthly.
- Upon the written request of the responsible authority, the water user must -
- ensure the establishment of any additional monitoring programmes; and
- appoint a competent person to assess the water use measurements made in terms of this authorisation, and to submit the findings to the responsible authority for evaluation.
- the water user keep a written record of the following wastewater storage or wastewater disposal and related activities –
    - the location of the storage dam or wastewater disposal site;
    - the quantity of wastewater stored or disposed of or re-used;
    - the quality of wastewater stored or disposed of, where applicable;
    - details of the monitoring programme;
    - details of failures and malfunctions of any wastewater disposal system or wastewater storage dam that the registered user is responsible for, and such information must be made available upon written request to the responsible authority.

A person who disposes of wastewater in terms of this authorisation must adhere to the prescribed record-keeping and disclosure of information, precautionary practices and inspections.

A copy of the General Authorisation promulgated in Goverment Gazette No. 26187, on 26 March 2004 in terms of the National Water Act (Act No.36 of 1998) is attached in Appendix I.

4.4. Regional Geology

The area of investigation is underlain by chlorite schists of the Weigel, La France and Mac Kop Formations and quartz-mica schists of the Rubbervale Formation of the Murchison Greenstone Belt (Figure 5). The chlorite schists are fine to medium grained, strongly foliated and fissile rocks which range in colour from greenish grey to brownish green. They are composed predominantly of chlorite and quartz; with minor constituents that include plagioclase, orthoclase, biotite and carbonate. These schists could represent either original shales or intermediate or mafic tuffs. The light-coloured quartz-mica schists consist of quartz, sericite and a little chlorite. They are believed to have been derived largely from acid lavas.

Diabase dykes area abundant in the area and is described as medium-grained, dark-grey to blackish grey rock composed essentially of labradorite and augite. Secondary alterations like sericitization of plagioclase and uralitization of pyroxene are fairly common. The contact zone between these dykes and the country rock often contains open fractures as a result of thermal shrinkage at the time of cooling of the dyke; consequently open spaces develop between the dyke and the country rock with potentially high storage capacity. These aquifers are classified as contact secondary aquifers and are the dominant aquifer type of borehole H08-1793, the water supply borehole to the Maake Plaza Shopping Centre.

Alluvial deposits occur along the Thabina River to the west of the Maake Plaza site and borehole H08-1793.

The Thabina Fault transecting the western boundary of the investigation area roughly outlining the river course of the Thabina River displaces the Rubbervale Formation and might represent a left-lateral strike-slip fault that was probably later reactivated as a normal fault.

4.5. Local Geology

The local geology, in addition to the geotechnical investigation performed for the Maake Plaza Shopping Centre, will be described at the hand of the magnetic geophysical survey which was commissioned to identify any potential preferential flow zones or geological structures, as well as the commissioned water supply and monitoring boreholes.

A map indicating the geophysical traverse lines, the localities of the newly commissioned monitoring boreholes, as well as the delineation of the interpreted dyke position to the east of the proposed filling station is presented in Figure 6.

4.5.1 Geotechnical Investigation

No outcrops were noted during the geotechnical investigation performed by Geo3 cc. and in all instances the bedrock schist of the Rubbervale formation is overlain by a thin surficial transported soil (< 0.5m) and thick residuum derived from the Insitu weathering of the schist. Nine pits were excavated to a depth of 3m without refusal. Grading and Atterberg Limit test results indicate the regolith to be fine grained (grading modulus mostly < 0.4) and classifies predominantly as *CL* in terms of the Unified Soil Classification Test. The regolith has a *medium* potential expansiveness with a predicted surface heave of up to 20mm.

FIGURE 5. Regional Geology (Council for Geoscience).

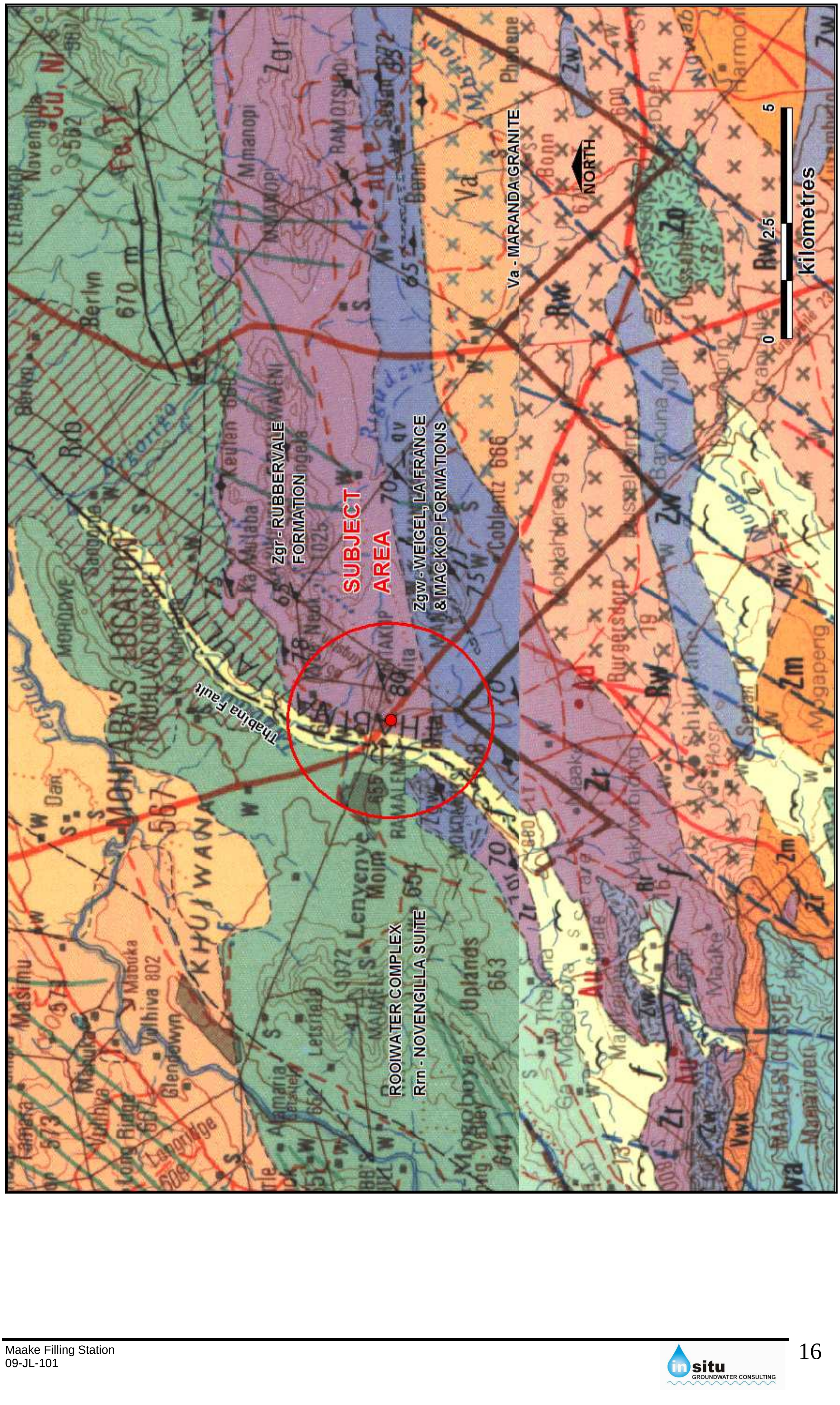
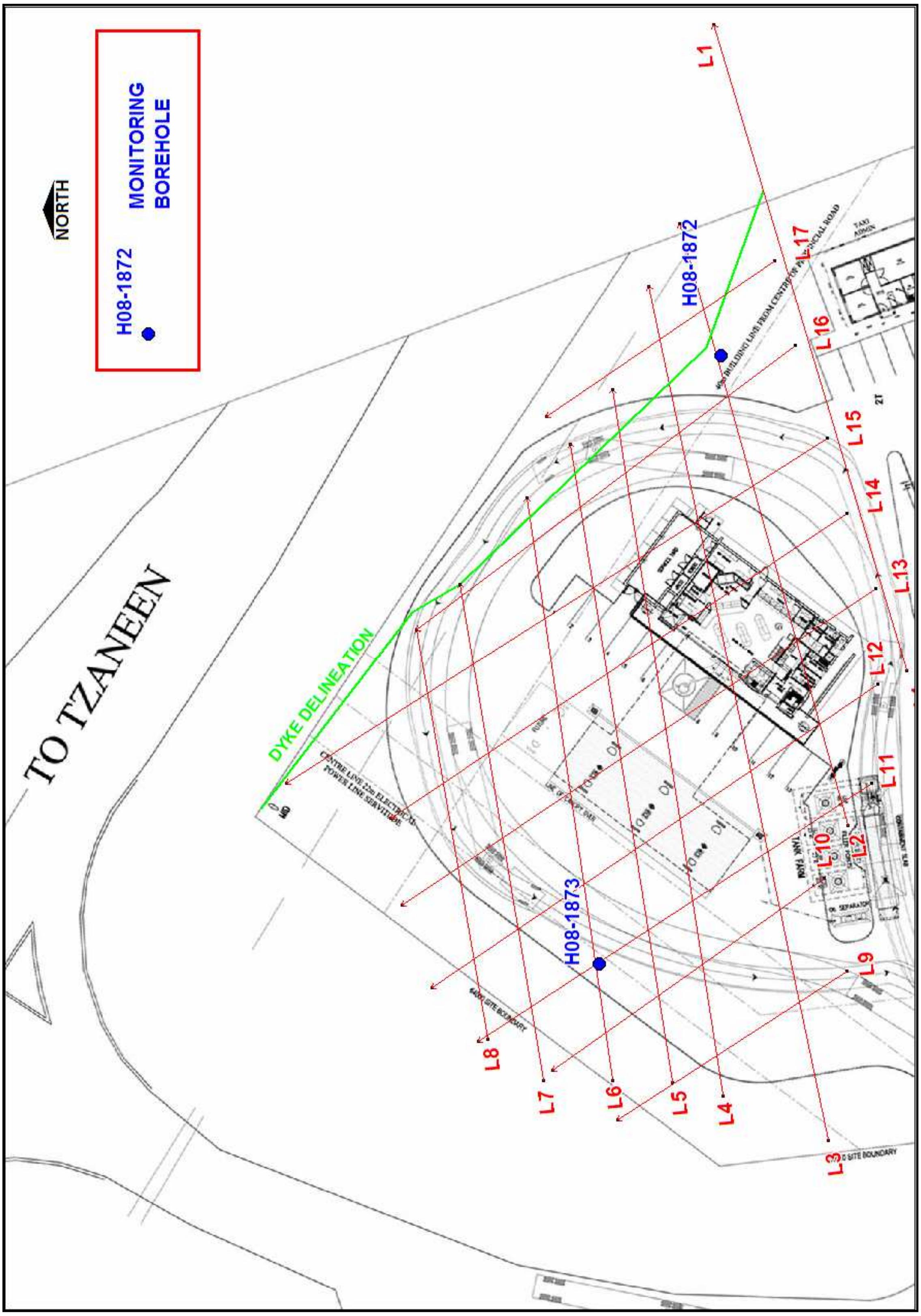


FIGURE 6. Map Indicating the Geophysical Traverse Lines.



Both the shallow and deeper residuum classifies as moderately and highly compressible respectively, which can possibly be attributed to leaching of the deeper residuum, while the shallow residuum has become consolidated through dessication. No groundwater seepage was encountered in any of the pits and owing to the unconsolidated nature of the regolith, the development of a perched water table at shallow depth, i.e. with 1.5m of ground level, is unlikely.

The abbreviated soil profile is described as:

- up to 0.5m of hillwash comprising dry, grey-brown, loose, open textured, *silty SAND*, overlying;
- up to 1.5m of residuum comprising moist, orange-brown, medium dense, open textured and fissured locally, *silty clayey fine SAND*, overlying;
- greater than 2m of residuum from decomposed schist comprising, slightly moist, dark orange-brown mottled and speckled maroon, medium dense to dense, *clayey silty fine SAND* with isolated weathered schist corestones.

An average permeability value of 0.002m/day and average effective porosity value of 32.5% is indicated for the residuum soil profile which is in line with known literature values.

A copy of Geo3's geotechnical investigation report for the Maake Plaza Shopping Centre is attached in Appendix II.

4.5.2 Geophysical Investigation

A geophysical VLF (Very Low Frequency) electromagnetic and magnetic survey was conducted on the site of the Maake Plaza in order to site ground water supply borehole locations with the highest probability of intersecting aquifers. Although no sustainable water supply was sourced through this survey, the presence of a dolerite dyke with almost the same orientation as the R36, located between the proposed filling station and the R36 was established.

Still with the aim of establishing a water supply source the focus of the geophysical investigation shifted to the area between the Thabina River and the Maake site where a successful borehole (H08-1793) was drilled in the contact zone between a dyke and the surrounding lithologies. This dyke is believed to have a SE-NW orientation and is located between the Thabina River and a water supply canal running parallel to the river.

4.5.3 Borehole Drilling

Borehole H08-1793 (water supply borehole) was successfully drilled 400-500m west of the Maake site (Figure 7). This borehole was drilled along the western contact zone of the identified dyke, to a depth of 50m, transecting weathered and fractured quartz-mica schist to a depth of 32m until solid, hard rock was encountered.

Two monitoring boreholes were drilled up gradient (H08-1872) and down gradient (H08-1873) of the proposed filling station. The soil profile ranged between 2m and 4m in depth. Both boreholes penetrated highly weathered, weathered quartz-mica schist, encountering fresh bedrock between 37m and 38m below surface, respectively.

Borehole H08-1872 intersected the identified dyke between the proposed filling station and the R36 at a depth between 33m and 36m below surface, confirming the geophysical results. The dolerite was noted as fractured.

Borehole construction and geological logs for the newly drilled monitoring boreholes are attached in Appendix III.

4.6. Regional Geohydrology

Groundwater is usually associated with the following geological features within hard rock terrain:

- Deeply weathered zones underlain by competent, hard bedrock with water being found on the contact zone,
- Secondary fractures found within the hard rock; aperture widths can be from millimetres to meters in thickness and may or may not contain groundwater,
- Contact zones found between the country rock and intrusions such as the dykes.

The published hydrogeological maps listed below have been studied in order to obtain a better understanding of the expected groundwater and geological conditions of the investigation area:

- The 1:250 000 2330 Tzaneen Geological Sheet (1985),
- The Groundwater Resources of the Republic of South Africa Map. Borehole Prospects, sheet 1 (1995),
- The Groundwater Resources of the Republic of South Africa Map. Saturated Interstices, sheet 2 (1995),
- The Hydrogeological Map Series of the Republic of South Africa, Phalaborwa Map, 1998, scale 1:500 000,

From these sources of groundwater information, the following could be deducted:

- The investigation area is underlain by the schists of the Murchison Greenstone Belt,
- The aquifer type is intergranular and fractured (d3),

- The average borehole yields are 0.5 – 2.0L/s,
- The probability of drilling a borehole with a yield of >2L/s (exploitability) is 30-40%,
- The probability of drilling a successful borehole (> 0.1L/s) (accessibility) is 40-60%,
- The mean annual precipitation for the area is between 700-800mm per annum,
- The average depth to groundwater is 10-20m below surface,
- Rainfall recharge rates to groundwater are between 75-110mm per annum,
- The groundwater component of base flow to streams and dams is negligible.

4.6.1 Data Request

Borehole data for the investigation area was obtained from GPM Consultants in Polokwane. GPM is the DWAF-appointed Groundwater Database Management Consultants for the whole Limpopo Province and all boreholes and groundwater-related data is captured and available on request from GPM. GPM assimilated 27 borehole data points within the investigation area of which only 8 have been tested and is recommended as sustainable water sources in the investigation area.

4.6.1.1 Borehole depths

From the 27 borehole data points, borehole depth measurements are available for 21 boreholes. Borehole depths range from 10m to 108m, but the average borehole depth drilled in the investigation area is 45m.

4.6.1.2 Static water levels

Static water levels are available from 12 boreholes and on average the depth to water level over the investigation area is approximately 22m. A few perched water tables were found, scattered throughout the area.

4.6.1.3 Recommended borehole abstraction rates

Recommended borehole yields range from 0.44 to 28.67m^3/day with most of the production boreholes pumping between 1.0 and 2.5L/s.

4.6.1.4 Water chemistry classification

Water samples analyzed from tested boreholes in the investigation area are either classified as Class 0 (ideal water quality) or Class 2 (marginal water quality). Water chemistry results were available from 9 boreholes in the investigation area.

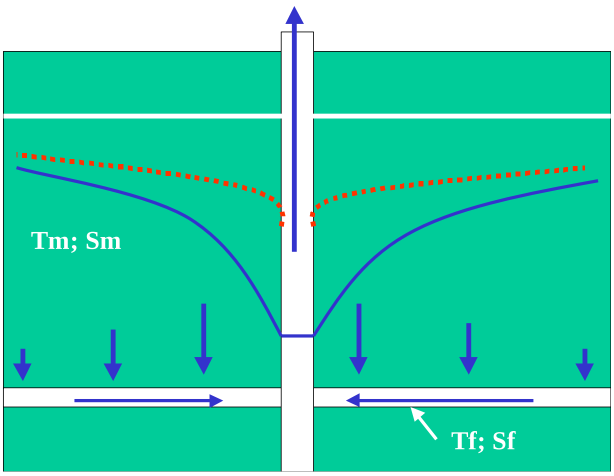
4.7. Local Geohydrology

The area of investigation is underlain by lithologies which were subjected to shearing, fracturing and metamorphism under green schist facies conditions and intruded by numerous diabase dykes. Aquifers in the area are predominantly secondary in nature and vary in their lateral extent, thickness and distribution.

- Structural secondary aquifers: Aquifers associated with geological structures such as dykes, faults, fractures, and joints. Generally these aquifers exhibit high transmissivity but low storage capacity.
- Weathered secondary aquifers: Aquifers generally exhibit low transmissivity; storage capacity varies between very low and low and the aquifer is often semi-confined by overlying layers of lesser permeability.
- Contact secondary aquifers: Aquifers associated with geological contacts. Water transmissivity is generally high and storage capacity may be enhanced by seepage from overlying alluvial or weathered deposits.

The secondary aquifers in the investigation area are classified as double porosity systems, conceptionally consisting of two major components: matrix rock blocks and fractures, each with its own character and behaviour, in which groundwater flow takes place. The fractures serve as higher conductivity conduits for flow if the apertures are large enough, whereas the matrix blocks may be permeable or impermeable, with most of the storage usually contained within the matrix (Kirchner and van Tonder, 1995). The hydraulic conductivities of fractured systems vary considerably and are dependent on:

- Aperture (distance between fracture walls),
- Frequency or spacing (density),
- Length,
- Orientation (random or preferred),
- Wall roughness,
- Presence of filling material,
- Fracture connectivity, channelling (preferred paths),
- Porosity and permeability of the rock matrix.



Close to the tested borehole the pressure in the large fractures decline rapidly relative to its rate of decline in the matrix blocks resulting in the development of a large localized pressure gradient between the piezometric head of the matrix block and that of the large conduit fracture.

Diagram 1: Conceptional model for the flow regimes in a double porosity system

The former therefore releases a relative large amount of water into the conductive fractures. Far from the pumping borehole, the pressure gradient between the fracture and matrix block is relatively small and water released from the matrix into the fracture is slow. During the first stages of pump testing water is abstracted from the fracture and linear flow dominates but as the fracture area dewatered and water is released from matrix storage into the conduit fractures, matrix flow becomes dominant over time.

4.7.1 Hydrocensus

A hydro-census of all borehole locations within the study area supplied by GPM was conducted to verify coordinates, equipment status and current abstraction Of the original 27 data points only 8 were located in the field of which 3 boreholes were destroyed, and only 3 are still equipped. Of the three equipped holes, only 2 are still in working condition. Possibly due to theft and poor maintenance, most of the production boreholes (as indicated by GPM data) are currently not abstracting water from the immediate catchment area of borehole H08-1793.

Figure 7 shows the location and position of all the borehole data points pertaining to the hydro census survey. Table 1 is a summary of the details recorded:

Table 1: Summary of current or potential rural water supply production boreholes

Borehole	Position	Potential Abstraction (L/day)	Static water level (mbgl)	Status quo
H08-0670	23.97717°S 30.29294°E	10 800	35.67	Not located during census
H08-0756	23.97903°S 30.28797°E	235 872	10.07	Not located during census
H08-0881	23.97486°S 30.28494°E	64 800	9.4	Motorized – not working
H08-0930	23.97583°S 30.31806°E	28 800	38	Not located during census
H08-0934	23.97611°S 30.32000°E	28 800	38.90	Open BH only casing found in field
H08-1004	23.98264°S 30.29089°E	90 000	18.47	Open BH only casing & block found in field
H08-1031	23.97617°S 30.32211°E	5 760	28.56	Motorized – in working condition
H08-1604	23.97902°S 30.28794°E	371 520	15.47	Motorized – in working condition

FIGURE 7. Map Indicating the Hydro-census Survey Borehole Localities.

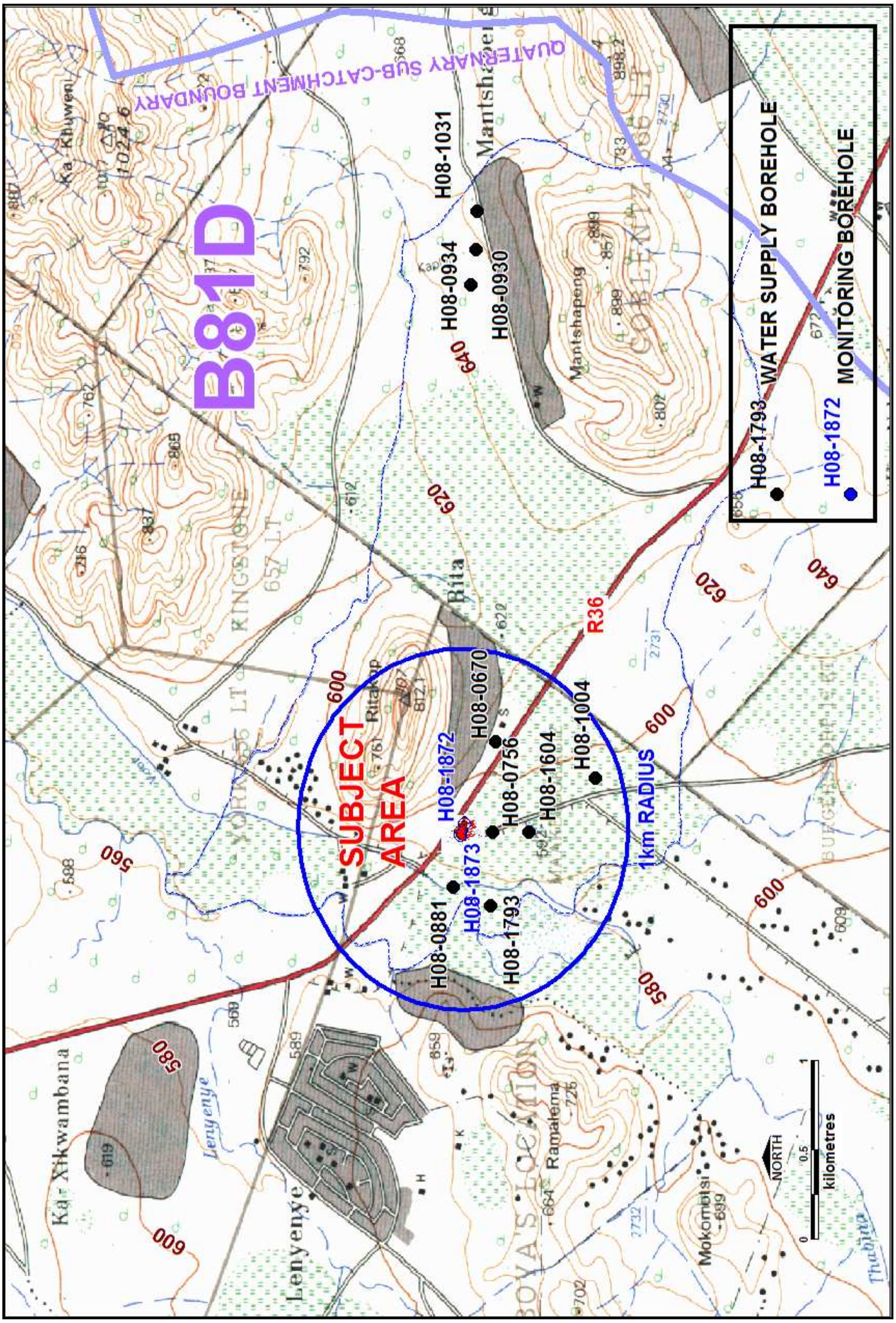
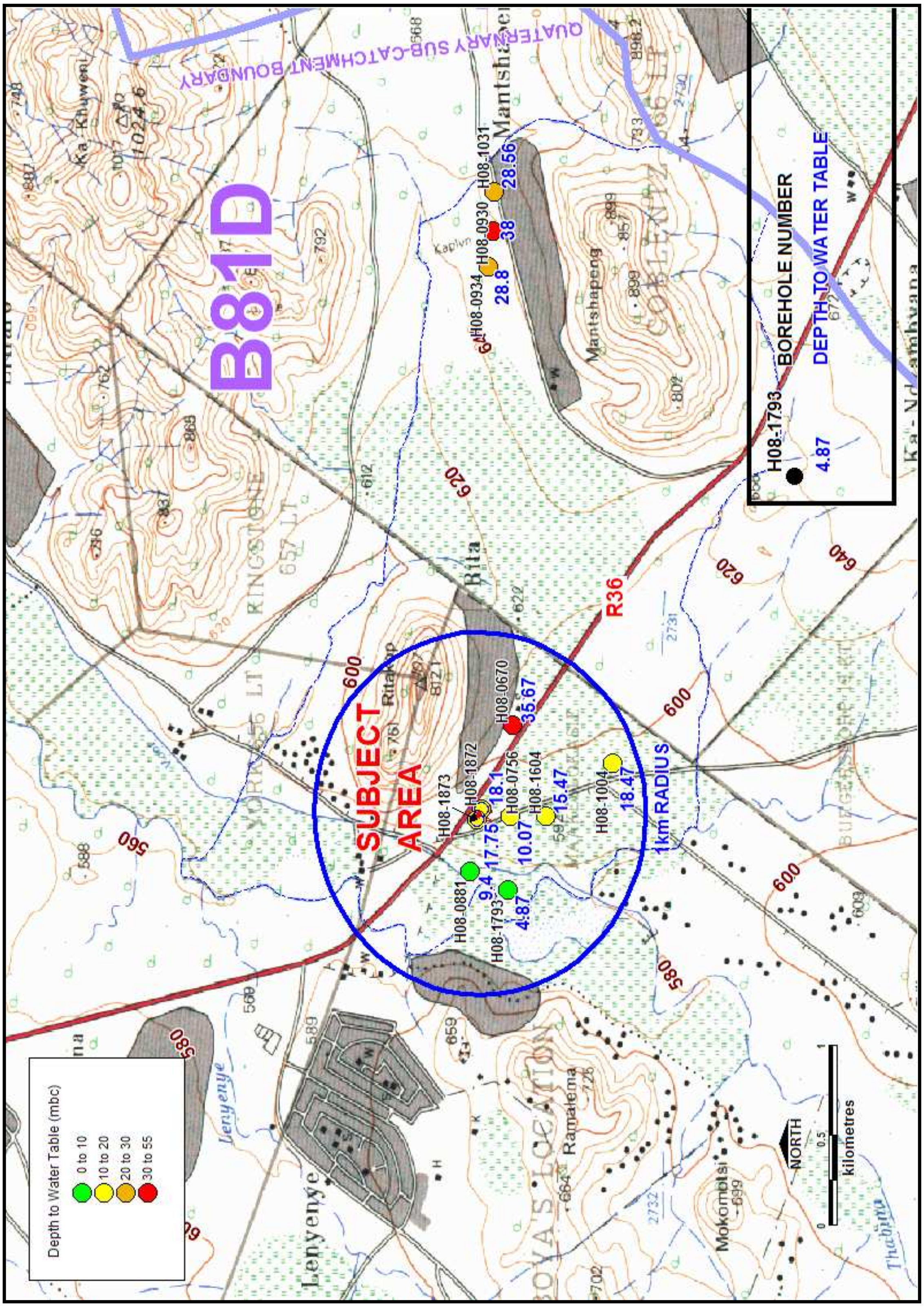


FIGURE 8. Depth to Water Table Distribution (mbc).



The current groundwater abstraction volume from the investigation area by existing users is approximately 377.28m^3/day. Existing boreholes that has the potential to be utilized as future production boreholes could abstract an additional 459.07m^3/day, bringing the total groundwater abstraction possible from existing sources in the investigation area to 836.35m^3/day.

Borehole H08-1793 that supplies water to the Maake Plaza Shopping Centre could optimally deliver a sustainable yield of 237.6m^3/day, although only 56m3/day is required by the centre. Incorporating the latter's sustainable yield calculates to a maximum, total groundwater abstraction from existing sources in the investigation area of 1073.95m3/day.

A Groundwater Balance Equation yielded a surplus and it was therefore concluded that there is sufficient groundwater available in the immediate catchment area for the utilization of borehole H08-1973 even at full capacity (19 800L/hr or 237.6m^3/day) without permanently removing water from storage or lowering the local groundwater levels.

4.7.2 Commissioning of Monitoring Boreholes

All boreholes were drilled under supervision of In-Situ Consulting according to SANS 10299 and specifications as laid down by the Department of Water Affairs and Forestry in their *"Minimum Standards and Guidelines for Groundwater Resource Development for the community Water Supply and Sanitation Program"*. The air rotary percussion method, ideally suited for hard rock formations, was applied.

The cuttings brought to the surface by air return from the bore were collected and described for each meter drilled. The lithologies described are presented in the borehole log in the Appendix III, together with all other relevant information pertaining to and obtained from the borehole. Water intersections were recorded, and the blow yield measured using a 20L drum and stopwatch.

During the commissioning of a water supply source for the shopping centre, 3 boreholes were drilled on site yielding less than 0.1L/s where after borehole H08-1793 was successfully drilled 400-500m west of the Maake site. This borehole was drilled along the western contact zone of the a dolerite dyke to a depth of 50m, transecting weathered and fractured schist to a depth of 32m until solid, hard rock was encountered. Water strikes were measured from 18 to 32m yielding a cumulative blow yield of 5L/s. Six and a half inch (165mm) diameter casing was installed to 35m depth with a thickness of 4mm. The borehole was gravel packed (according to specifications) and completed with a 3m deep sanitary seal.

For this study two monitoring boreholes were drilled up gradient (H08-1872) and down gradient (H08-1873) of the proposed filling station. They were drilled to respective depths of

45m and 47m below surface. Both boreholes penetrated highly weathered, weathered quartz-mica schist, encountering fresh bedrock between 37m and 38m below surface, respectively. Five inch (125mm OD) diameter pvc casing with a wall thickness of 6mm was installed from top to bottom with slotted section respectively between 33m to 45m and 29.5m to 47m below surface. Both boreholes were gravel packed (according to specifications) and completed with 3m deep sanitary seals and closed with steel plates welded onto the borehole collar. Water strikes were respectively encountered at 36-37m (blow yield of 2.00L/s) and 33-34m (blow yield of 0.05L/s).

Borehole H08-1872 intersected the identified dyke between the proposed filling station and the R36 at a depth between 33m and 36m below surface, confirming the geophysical results. The dolerite was noted as fractured.

4.7.3 Depth to Water Table

A thematic map highlighting the depth to water table distribution across the study area is portrayed in Figure 8.

No groundwater seepage was encountered in any of the nine pits excavated during the geotechnical investigation pertaining to the shopping centre. Geo3 cc. stated that owing to the unconsolidated nature of the regolith, the development of a perched water table at shallow depth, i.e. with 1.5m of ground level, is unlikely.

The unsaturated and saturated aquifer thickness is a function of the depth of weathering (physical thickness of the flow regime) and the depth to the water table. The average water level depth is some 21.39 mbc, which in conjunction with the average weathering depth of 35.67m, yields an average saturated aquifer thickness of 14.28m.

4.7.4 Groundwater Quality

Groundwater samples were collected from the newly commissioned monitoring boreholes and sent to both UIS Analytical Services in Centurion and to Labserve in Nelspruit for hydro-chemical analysis. The samples were taken according to the DWAF standards, at the end of the constant discharge test (H08-1872) in order to be representative of the water of a wider zone around the borehole, while a gab sample was taken from borehole H08-1873. Copies of the hydro-chemistry results are presented in Appendix IV.

The groundwater quality distribution and compliance, will be discussed using Standards South Africa's, (a division of SABS) specification for Drinking Water, SANS 241: 2006 Edition 6.1, as compliance criteria.

The measured physical requirements, namely pH, EC and TDS are all within the SANS 241 Class I (recommended operational limit) ranges.

As far as the chemical requirements for the macro-determinants are concerned, all of the measured concentrations fall within the SANS 241 Class I (recommended operational limit) ranges, except the NO_3 concentration for borehole H08-1872 which falls within the Class II (max. allowable for limited duration) range. The Class II (health/operational) maximum consumption period for NO_3 is indicated as seven years. It should however be noted that the laboratory detection limit for NH_4 is higher than the SANS 241 Class II (max. allowable for limited duration) range.

Compliance with the SANS 241 Class I (recommended operational limit) ranges were met for all the measured micro-determinants except:

- The Fe concentration for sample H08-1872 falls within the Class II (max. allowable for limited duration) range. The Class II (aesthetic/operational) maximum consumption period for Iron is indicated as seven years.
- The Mn concentrations of both samples fall within the Class II (max. allowable for limited duration) range. The Class II (aesthetic/operational) maximum consumption period for manganese is indicated as seven years.

It should however be noted that the laboratory detection limits for Pb and Se exceed the Class I (recommended operational limit) ranges, while the detection limits for As, Cd and Sb exceed the SANS 241 Class II (max. allowable for limited duration) ranges.

As far as the Total Hardness is concerned, the water of both samples can be categorized as slightly hard. The Ryznar Index class values for both samples fall in the aggressive class indicating heavy corrosion (Carrier 1965). A negative Langelier Index (both samples) indicates that the water is under saturated with calcium carbonate and will tend to be corrosive in a distribution system. Experience has however shown that Langelier Index values in the range of -1 to +1 have a relatively low corrosion impact on metallic components of a distribution system.

No Faecal Coliforms were detected in any of the two samples. However, the Total Coliforms observed in sample H08-1873 exceed the SANS 241 Operational Water Quality Alert Value and can be classified as completely unacceptable with serious health affects in all users in terms of the document *"Quality of Domestic Water Supplies"* (Second edition, 1998)" as set forward by the Department of Water Affairs and Forestry, Department of Health and the Water Research Commission in 1998.

Borehole H08-1793 was classified as a Class 4 - Dangerous water quality *[Quality of Domestic Water Supplies"* (Second edition, 1998)] due to a very high Total Coliform Count during the compilation of a previous geohydrological report to confirm the availability, sustainability and suitability of this water supply source as supportive documentation for the Shopping Centre's water use license application to DWAF. Continuously disinfection through chlorination and routine analysis for faecal contamination is therefore imperative.

4.7.4.1 Hydro-chemical Facies

Hydro-chemical facies are defined as distinct zones that have cation and anion concentrations describable within defined compositional categories. The definition of a composition category is based on subdivisions of tri-linear diagrams such as Piper diagrams. For visual inspection of hydro-chemical data the result of the analysis was plotted on a semi-logarithmic Schoeller diagram and a tri-linear Piper diagram.

Both these diagrams permit the cation and anion compositions of the sample to be represented on single graphs in which major groupings or trends in the data can be discerned visually. The Schoeller diagram shows the total concentrations of the cations and anions whereas the tri-linear Piper diagram represents the concentrations as percentages.

The water supply borehole to the shopping centre (H08-1793) as well as the newly commissioned monitoring boreholes exhibits strong magnesium bicarbonate ($MgHCO_3$) characteristics, typical of relatively recent recharged or recharging water. The strong bicarbonate character of the boreholes reflects the general freshness of the aquifers in the area. All 3 samples plot as typical unpolluted water on both the Piper and Expanded Durov Diagrams.

In the Schoeller diagram, when compared with the newly commissioned monitoring boreholes the SO_4 concentration for the Maake Plaza Shopping Centre' water supply borehole appears slightly elevated and can probably be attributed to rural agricultural activities.

4.7.4.2 Groundwater Evolution

Groundwater evolution follows the classic Chebotrev Sequence. As groundwater moves along its flow paths in the saturated zone, an increase of total dissolved solids and most major ions occur due to the increased residence time and travel distance.

Crystalline rocks contain abundant aluminosilicate minerals (feldspar and mica) and quartz. As these minerals formed at temperatures and pressures far above those occurring at or near earth's surface, these minerals are thermodynamically unstable and tend to dissolve when in contact with water. The dissolution process is strongly influenced by the presence of dissolved CO_2 (acquired through infiltration of water through the soil horizon) and causes the groundwater to acquire dissolved constituents. When CO_2-charged waters that are low in dissolved solids encounter silicate minerals high in cations, aluminum and silica, cations and silica are leached, leaving behind clay minerals.

Relatively recent recharged groundwater has a high bicarbonate (HCO_3) concentration due to interaction with CO_2 in the soil horizon. This water reacts with carbonate and silicate minerals and Ca^{2+} and Mg^{2+} ions are added. Further movement through the subsurface exposes the water to cation exchange processes where Na^+ in clays exchange for Ca^{2+} and Mg^{2+} from the groundwater, thus increasing the Na^+ content of the water. At the end of the Chebotrev Sequence for groundwater evolution is the saline NaCl water that is not seen in the investigation areas.

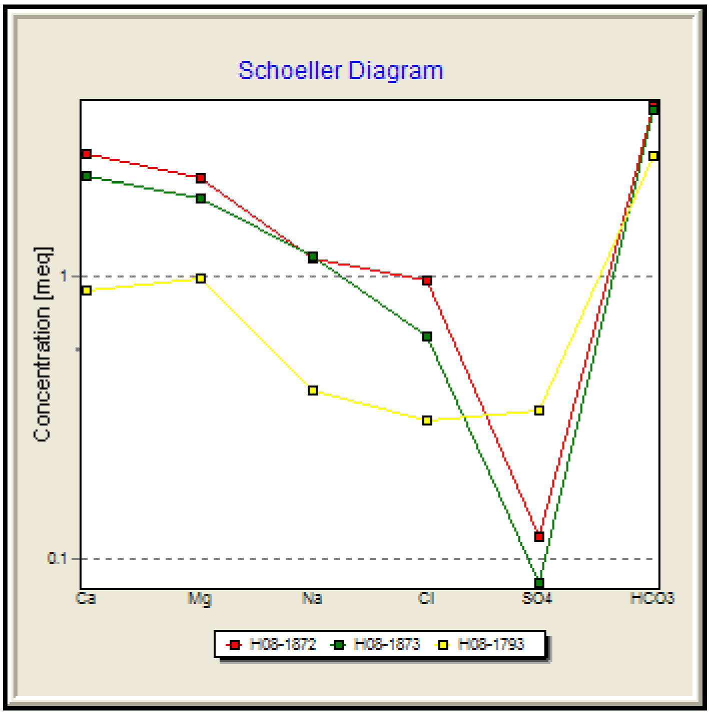


Diagram 2: Schoeller Diagram

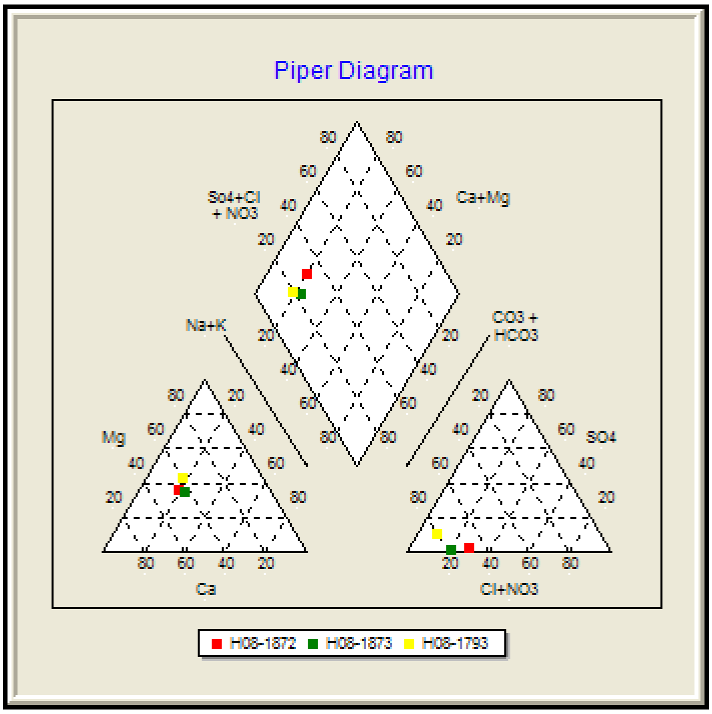


Diagram 3: Piper diagram

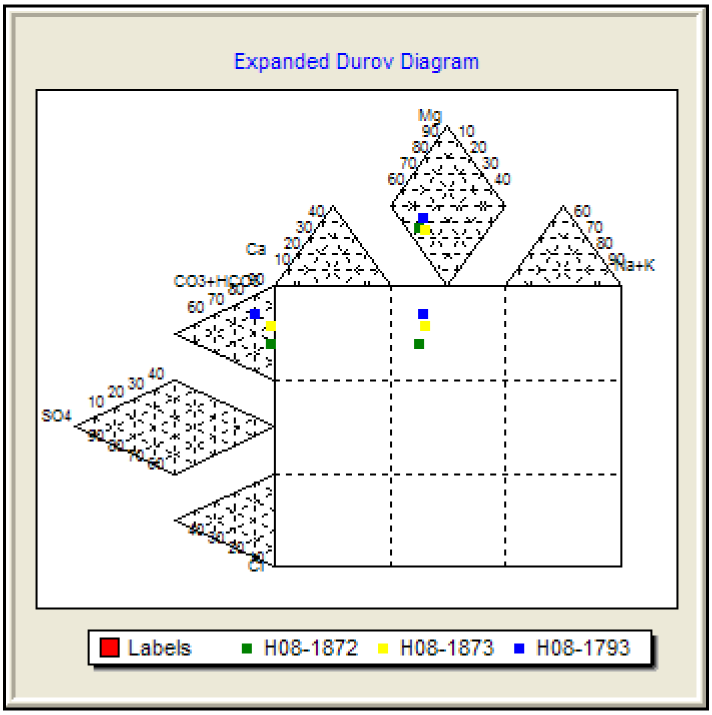


Diagram 4: Expanded Durov diagram

4.7.5 Lateral Extent of the Groundwater Zone

Two types of aquifer boundaries are anticipated to exist within the study area:

- Hydraulic aquifer boundaries such as surface infiltration sources which usually represent constant head influx boundaries, streams that act as groundwater discharge boundaries and groundwater divides which act as no-flow boundaries.
- Physical aquifer boundaries such as impermeable dolerite dykes and sills, or other geological discontinuities, for example where layers pinch out or outcrop.

The major lateral aquifer boundaries constituting the proposed groundwater zone for the subject area are indicated in Figure 9.

The boundaries to the subject area's groundwater zone are constituted by both ground water divides which act as no-flow boundaries as well as a number of streams acting as natural groundwater discharge boundaries.

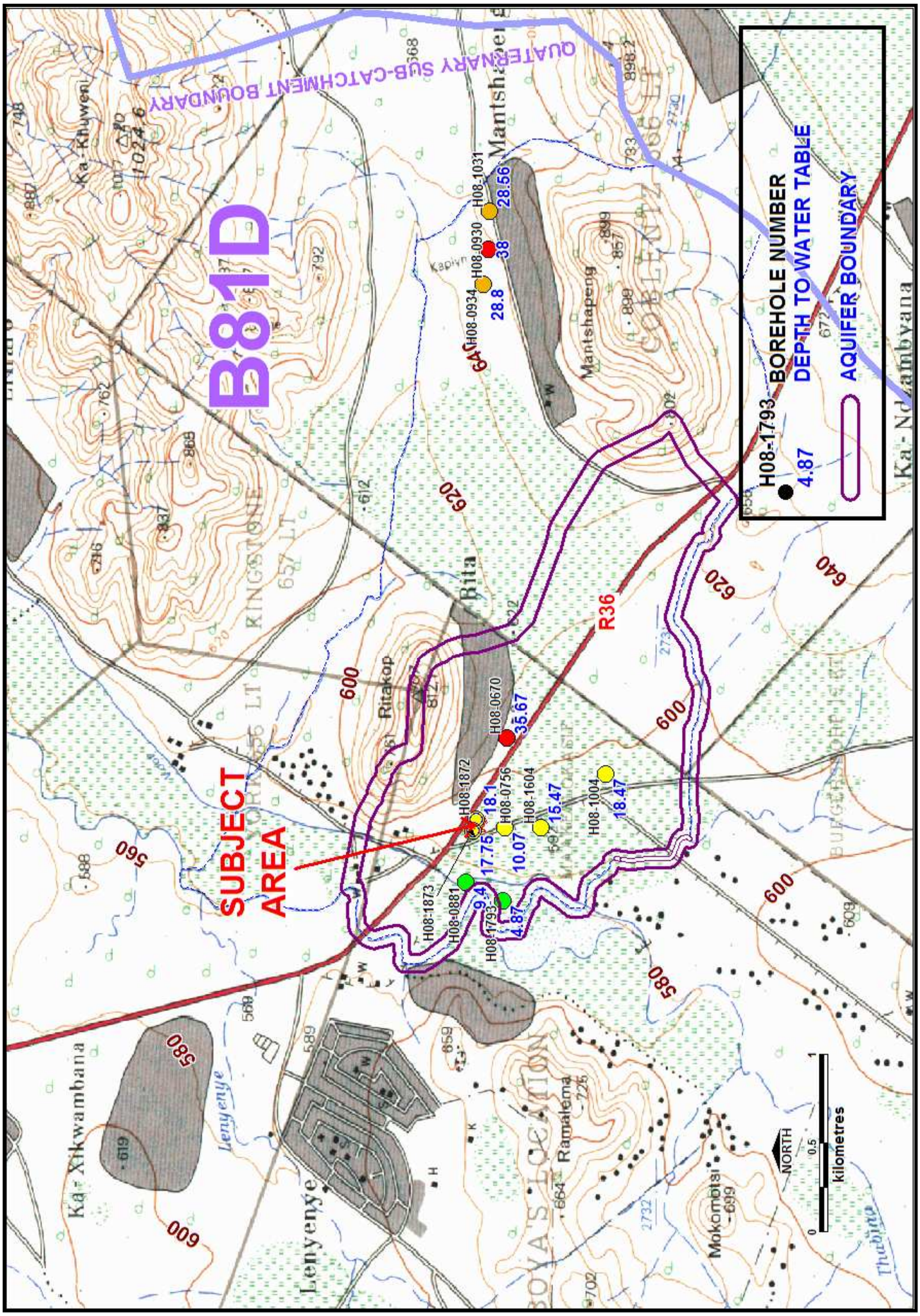
As can be seen in Figure 9, the subject area's groundwater regime is bounded in the north by a no-flow boundary constituted by the surface water divide separating the catchment areas of the two non-perennial tributaries of the Thabina River to the north and south of the proposed filling station.

The rest of the subject area's flow regime is enclosed in the west by the Thabina River and in the south by the non-perennial stream located to the south of the proposed filling station, all constituting natural groundwater discharge boundaries. The Thabina River west of the proposed filling station constitutes the natural discharge boundary to the stations groundwater flow regime and therefore as its natural impact zone.

As previously stated, the Maake Plaza Shopping Centre's water supply borehole (H08-1793) is situated between the Thabina River and a water supply canal running parallel to the river (Figure 4). To the north and south of the borehole, small-scale rural farming is practiced with water being channeled from the canal to the fields along hand-dug trenches. The canal and trenches constitute constant head influx boundaries.

The two dolerite dykes identified during the geophysical surveys performed at and to the west of the Maake Plaza Shopping Centre, although they most likely constitute major preferential flow zones, are not believed to represent physical no-flow boundaries due to the fractured nature of the intersections penetrated in commissioned boreholes as well as the observed depth of weathering recorded in the boreholes.

FIGURE 9. Lateral Extent of the Groundwater Zone.



The Thabina Fault transecting the western boundary of the investigation area roughly outlines the river course of the Thabina River and probably, also constitutes a major preferential flow zone.

Although physical and hydraulic aquifer boundaries may become dynamic under conditions of major aquifer application, a Groundwater Balance Equation yielded a surplus concluding that there is sufficient groundwater available in the immediate catchment area for the utilization of borehole H08-1973 even at full capacity (19 800L/hr or 237.6m^3/day), as well as the other water supply boreholes, without permanently removing water from storage or lowering the local groundwater levels.

4.7.6 Receptor Identification

The following receptors were identified:

- The groundwater regime underlying the site.
- The Thabina River forming the western discharge boundary of the subject area's flow regime, the closest point being some 370m to the west of the proposed filling station.
- The preferential flow zones identified within the proposed filling station's flow regime.
- The water supply borehole for the Maake Plaza Shopping Centre.
- The other five rural water supply boreholes that occur within the proposed filling station's flow regime (of which only one is in a working condition and another two that could not be found during the hyro-census).

The potential contaminant migration or pathway at the site can be described as follow:

- Pollution generated at the site will migrate vertically through the ± 3m thick soil profile to the residual weathered schist.
- Small cracks, fissures and openings in the matrix rock will act as preferred pathways for the contamination migration vertically to the groundwater.
- The groundwater will be the transport medium for downstream migration of the contaminant. The migration rate will depend on the natural groundwater flow.

4.7.7 Permeabilty/Transmissivity

The permeability (k – m/day) of an aquifer is a measure of the ease with which ground water will move along the ground water pathway. The transmissivity (T – m^2/day) of an aquifer incorporates the thickness (d - m) of the saturated flow regime:

$T = k*d$

Transmissivity values were determined by performing pumping tests on boreholes H08-1872 and H08-1793. Respective values of 8.72 m^2/day and 35m^2/day were calculated. These values are high and are believed to be representative of the secondary structural aquifers.

Literature permeability values are indicated to range between 0.002m/day and 0.104m/day. Assuming an average saturated aquifer thickness of 14.28m and a maximum bulk permeability value of 0.104m/day, a T value of 1.4m^2/day is obtained for the secondary weathered aquifer.

A Pumping Test Report as well as a Water Source Evaluation Report for borehole H08-1872 is attached in Appendix V.

4.7.8 Porosity

Porosity plays a governing role in ground water seepage velocity, which relates not only to the rate at which ground water moves through the aquifer, but indeed also to the rate of dissolved contaminant migration, the latter which occurs through the mechanism of advection.

Based on literature values, a porosity value of 0.04 is proposed for the subject area.

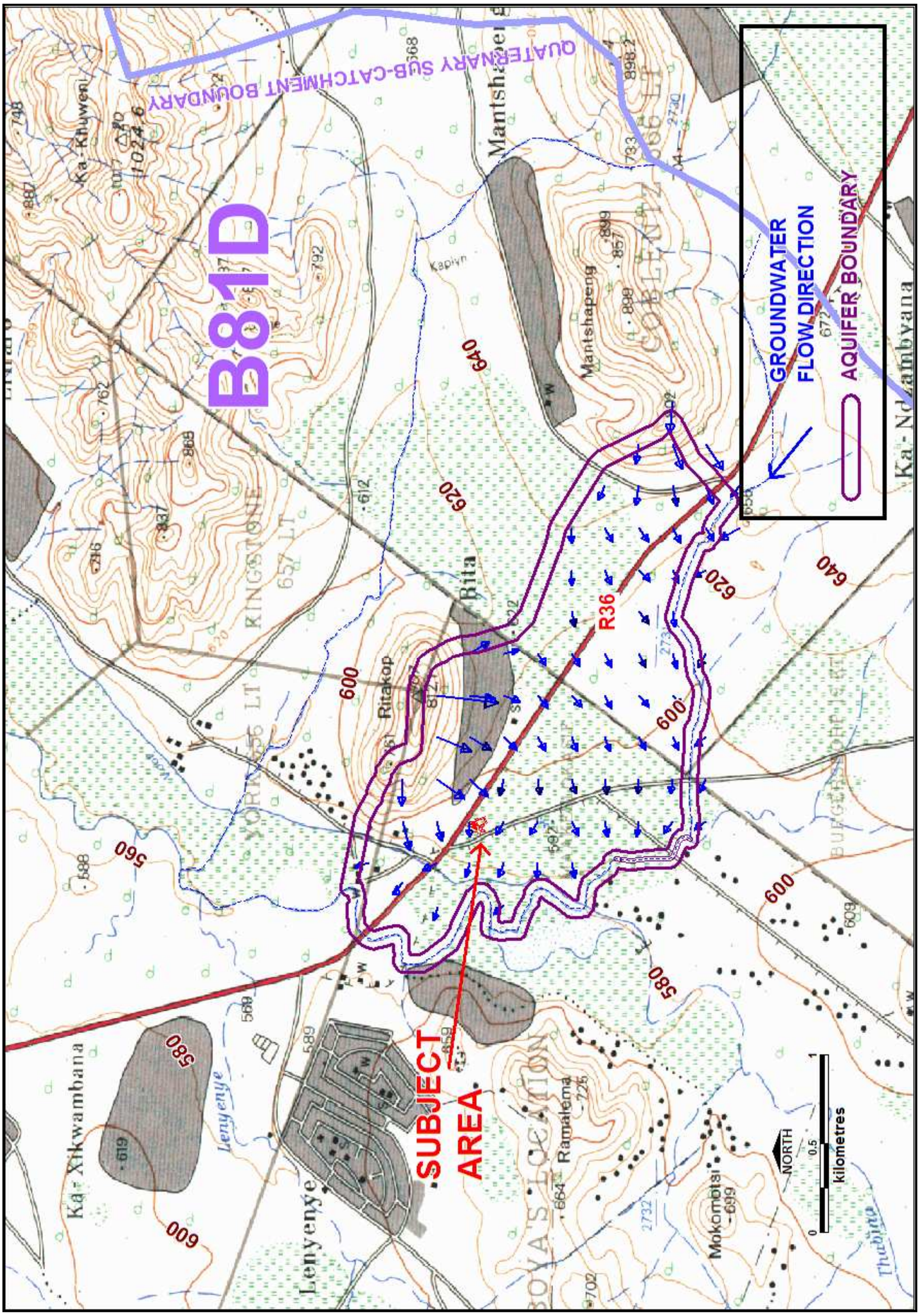
4.7.9 Groundwater Flow Directions and Velocity

The water table, under normal conditions is expected to emulate the surface topography. Groundwater flow although dynamic in the sense that directions might be manipulated by groundwater abstraction in the area, is thus towards the low lying areas i.e. the rivers and streams which represent natural aquifer discharge boundaries.

The available information was used to calculate groundwater flow directions which are presented in Figure 10. From this map it is evident that the general flow direction is towards the west, and thus towards production borehole H08-0881 and the Thabina River, which constitutes the western discharge boundary of the subject area’s flow regime.

Assuming a groundwater gradient no larger than 2%, subject to the estimated values for hydraulic conductivity and porosity, the groundwater seepage velocity in the secondary weathered zone aquifer is estimated at 0.052 m/day, or 18.98 m/year.

FIGURE 10. Groundwater Flow Directions.



4.7.9 Aquifer Classification / Strategic Value

The aquifer(s) underlying the subject area were classified in accordance with ***"A South African Aquifer System Management Classification, December 1995."***

Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

Sole Aquifer System:

An aquifer which is used to supply 50 per cent or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

Major Aquifer System:

Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 *mS/m* Electrical Conductivity).

Minor Aquifer System:

These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

Non-Aquifer System:

These are formations with negligible permeability that are regarded as not containing ground water in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, ground water flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Ratings for the Aquifer System Management and Second Variable Classifications:

Aquifer System Management Classification		
Class	**Points**	**Maake**
Sole Source Aquifer System: Major Aquifer System: Minor Aquifer System: Non-Aquifer System: Special Aquifer System:	6 4 2 0 0 - 6	- - 2 - -
Second Variable Classification Weathering/Fracturing		
Class	**Points**	**Maake**
High: Medium: Low:	3 2 1	- 2 -
Note: Preferential flow zones with high T-values in site's flow regime		

Ratings for the Ground Water Quality Management Classification System:

Aquifer System Management Classification		
Class	**Points**	**Maake**
Sole Source Aquifer System: Major Aquifer System: Minor Aquifer System: Non-Aquifer System: Special Aquifer System:	6 4 2 0 0 - 6	- - 3 - -
Aquifer Vulnerability Classification		
Class	**Points**	**Maake**
High: Medium: Low:	3 2 1	- - 1

The subject area aquifer(s), in terms of the above definitions, is classified as a **minor aquifer system**.

Level of ground water protection based on the Ground Water Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

GQM Index	Level of Protection	Maake
<1 1 - 3 3 - 6 6 - 10 >10	Limited Low Level Medium Level High Level Strictly Non-Degradation	- - 3 - -

Aquifer Vulnerability

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as **low**.

Aquifer Susceptibility

Aquifer susceptibility, a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and which includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification, in terms of the above, is classified as **low**.

Aquifer Protection Classification

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Ground Water Quality Management Index of 4 for the subject area, indicating that **medium** level ground water protection may be required.

In terms of DWAF's overarching water quality management objectives which is ***(1)*** protection of human health and ***(2)*** the protection of the environment, the significance of this aquifer classification is that if any potential risk exists, measures must be put in place to limit the risk to the environment, which in this case is the protection of the Primary Underlying Aquifer, the streams which drains the subject area, and the External Users' of ground water in the area.

5. RISK ASSESSMENT

Two different activities are associated with the development. Firstly the installation and construction has to take place (construction phase) before the filling station can be put into operation (operational phase). The potential impacts associated with the project proposal are described, and where appropriate, ranked by a significance assessment methodology.

The assessment of overall impact significance provides an indication of the extent to which the impacts either could have "no-go" implications for certain aspects of the project or will need to be countered by appropriate mitigation.

This section will look briefly at the different stages of the development as well as at measures that are taken to mitigate any potential impact. After the significance of each impact was determined a rank was awarded to each impact.

5.1. Significance Assessment Methodology

The significance of Environmental Impacts was assessed in accordance with the following method;

Significance is the product of probability and severity. Probability describes the likelihood of the impact actually occurring, and is rated as follows:

Improbable - Low possibility of impact to occur either because of design or historic experience.
Rating = 2

Probable - Distinct possibility that impact will occur.
Rating = 3

Highly probable - Most likely that impact will occur.
Rating = 4

Definite - Impact will occur regardless of any prevention measures.
Rating = 5

The severity rating is calculated from the factors given to intensity and duration. Intensity and duration factors are awarded to each impact, as described below.

The Intensity factor is awarded to each impact according to the following method:

Low intensity	-	nature and/or man made functions not affected (minor process damage or personnel injury may have occurred). Factor 1
Medium intensity	-	environment affected but natural and/or man made functions and processes continue (Some process damage or personnel injury may have occurred). Factor 2
High intensity	-	environment affected to the extent that natural and/or man made functions are altered to the extent that it will temporarily or permanently cease (Major process damage or personnel injury may have occurred). Factor 4

Duration is assessed and a factor awarded in accordance with the following:

Short term	-	<1 to 5 years - Factor 2
Medium term	-	5 to 15 years - Factor 3
Long term	-	impact will only cease after the operational life of the activity, either because of natural process or by human intervention – Factor 4.
Permanent	-	mitigation, either by natural process or by human intervention, will not occur in such a way or in such a time span that the impact can be considered transient - Factor 5.

The severity rating is obtained from calculating a severity factor, and comparing the severity factor to the rating in the table below. For example:

The Severity factor	=	Intensity factor x Duration factor
	=	2 x 3
	=	6

A Severity factor of six (6) equals a Severity Rating of Medium severity (Rating 3) as per table below:

RATING	FACTOR
Low Severity (Rating 2)	Calculated values 2 to 4
Medium Severity (Rating 3)	Calculated values 5 to 8
High Severity (Rating 4)	Calculated values 9 to 12
Very High severity (Rating 5)	Calculated values 13 to 16
Severity factors below 3 indicate no impact	

A Significance Rating is calculated by multiplying the Severity Rating with the Probability Rating.

The significance rating should influence the development project as described below:

- Low significance (calculated Significance Rating 4 to 6)
  - Positive impact and negative impacts of low significance should have no influence on the proposed development project.

- Medium significance (calculated Significance Rating ≥ 7 to 12)
  - Positive impact:

  Should weigh towards a decision to continue
  - Negative impact:

  Should be mitigated, before project can be approved.

- High significance (calculated Significance Rating ≥ 13 to 18)
  - Positive impact:

  Should weigh towards a decision to continue, should be enhanced in final design.
  - Negative impact:

  Should weigh towards a decision to terminate proposal, or mitigation should be performed to reduce significance to at least low significance rating.

- Very High significance (calculated Significance Rating ≥ 19 to 25)
  - Positive impact:

  Continue definite.
  - Negative impact:

  If mitigation cannot be effectively implemented, proposal should be terminated.

5.2. Assessment of Impacts

The impacts associated with the proposed development are summarised in Table 2 below.

Table 2: Significance Assessment of the impacts identified, and mitigation plans for the proposed filling station

Aspect	Possible Impacts	Significance of Impacts							
		Probability	Significance rating		Severity Factor	Severity Rating	Significance Rating	Mitigation Plan	Responsible Person
			Intensity	Duration					
1. Construction phase									
1.1. Waste water	Contamination of soil, groundwater	3	1	2	2	2	6 Low	No wastewater is expected to be generated during the construction phase.	Oil company / Contractor
2. Operational phase									
2.1. Accidental Spillages	Contamination of soil and ground water	5	4	4	16	5	25 Very High	On hard surfaces, the product will be covered and adsorbed with biodegradable absorbent materials. Spills on soil would require the determination of the lateral and vertical extent of the contamination and then based on the risk that the contamination pose to the receiving environment, remedial actions will be implemented.	Oil company / Site Manager
2.2 Overfill	Contamination of soil and groundwater	4	4	4	16	5	20 Very High	As part of the SABS 089-3 requirements, secondary containment features will be installed around the filler points and on top of the tanks. These units are sealed and facilitate the recovery of product in the event of an overfill or spill.	Oil company / Site Manager
2.3. Leaking Tank	Contamination of soil and groundwater	4	4	3	8	3	12 Medium	A Leak is detected immediately by means of reconciliation of delivery and use/sales. Monitoring wells (installed as per SABS 089-3 regulations) that are installed with the tanks serve as an early warning system. Tanks will be fitted with on-line leak detection, for purposes of pro-actively detecting any potential product loss. Leaks are also detected by means of visual inspection, smell and record keeping of fuel volumes. Pump sumps and containment manholes will serve as containment tools in the event of a leak.	Oil company / Site Manager

The risk that the proposed filling station poses to the rural and natural environments has to be considered in terms of the source, pathway and receptor principle. The proposed filling station is a potential source of petroleum pollution if an accidental release of product takes place. The most hazardous pathway through which the contamination can impact on human receptors is through groundwater ingestion.

Apart from the Maake Plaza Shopping Centre's water supply borehole (H08-1793) situated some 430m to the west of the proposed filling station between the Thabina River and a water supply canal running parallel to the river, five other water supply boreholes are located within 1 km of the proposed filling station area and another three some 3km to the east.

The current groundwater abstraction volume from the investigation area by existing users is approximately 377.28m^3/day. Existing boreholes that has the potential to be utilized as future production boreholes could abstract an additional 459.07m^3/day, bringing the total groundwater abstraction possible from existing sources in the investigation area to 836.35m^3/day.

Incorporating the Maake Plaza Shopping Centre's water supply borehole's sustainable capacity, the maximum total groundwater abstraction from existing sources in the investigation area calculates to a volume of 1073.95m3/day.

The observed and potential groundwater usage increases the risk in terms of the impact on human receptors significantly.

6. RECOMMENDATIONS

6.1. Spills and Leaks

Unfortunately spills and leaks do sometimes occur and then employees should react immediately. To minimise the risk of a spill or a leak which has occurred within his premises resulting in the environment becoming polluted the customer should follow the following procedures:

1. Spill and leak prevention
2. Spill response procedures
3. Spill reporting
4. Leak response procedures
5. Leak reporting

6.1.1. *Spill and Leak Prevention*

- All personnel who have anything to do with fuel or oil use and tank systems should know their individual responsibilities for controlling and/or reducing pollution. Employees should be well informed to apply the appropriate techniques.
- All employees involved in spillages or leaks must be informed about the spill/leak emergency response plan and must know how to act in the event of a spillage or leak. Equipment installed or used to avoid pollution should be operated efficiently and will be maintained.
- Spill clean up equipment, like absorbing fibres, squeegees, sandbags, etc. should be located in a clean, dry and easily accessible storage facility.
- Spill fighting material should be kept near places where spills and leaks are most likely to occur, i.e. near pumps. Customers should have materials like absorbing fibres and sandbags in place. The proposed procedure:
- Place two 200L bins at each area:
  - bin to be used for storage of unused fibres,
  - bin to be used for receiving the used fibres.
- Apply the fibres as per the instructions as soon as the spill occurs.
- Used fibres should be disposed of in an environmentally friendly way by either burning or dispatching to a class 1 waste dump.
- Ensure that Emergency Spill/Leak Response Plans and the necessary associated equipment are appropriate for your operation and are the subject of regular exercises, where possible in conjunction with the industry and/or local authorities. Provide regular training for key response employees in dealing with emergencies.

6.1.2. *Spill Response Procedure*

It is not possible to give detailed recommendations on how to clean up specific kinds of spillages as the method and materials used will depend on the type of product handled, the amount involved, the wind, the weather, equipment available, etc. However, all spills, minor or major, should be cleaned up as soon as they occur. Whatever the spill there are five basic steps in dealing with spillages:

1. Limit the spillage
2. Contain the spillage
3. Remove the spilled product
4. Final clean up and soil rehabilitation
5. Complete a spillage report

Containment of the oil near the point of spillage localizes the problem, minimises pollution and makes it easier to remove the pollution. Cleaning of the spill area depends on whether there is a major spill or a minor spill and whether there is a spill on paving or on soil. A major spill is any spill where more than 200 L of product is involved.

- Minor spillage (less than 200L):
  - Soak up the spill with unused fibres.
  - If the spill has soaked into the ground the soil should be ploughed to allow aeration.
  - Collect the used fibres in the bin for used fibres.

- Major spillage of oil or fuel on paving or non-permeable surfaces:
  - Wherever possible, try to limit the spillage by turning off all activities that caused the spill, i.e. closing a valve that has been accidentally opened, plugging the hole where the product is leaking or stop pumping through a ruptured pipeline, hose or overflowing tank.
  - Contain spill immediately with absorbing fibres, sandbags, sand or soil.
  - Prevent any of the spilt oil substance from entering your drain, storm water systems, septic tanks or from contaminating any natural water systems by forming a barrier from soil, sand, sandbags or absorbing material.
  - If any of the spill enters the storm water system the flow must be intercepted before it can contaminate other environments
  - If natural water systems are contaminated, use straw bales, absorbent, booms, and sandbag dams for containment of and absorption.
  - Mop up as much of the spillage as possible by using absorbing materials
  - Contact your Oil Company Field manager.

- Major spillage of oil or fuel on soil or permeable surface:
  - Wherever possible, limit the spillage by turning off all activities that cause the spill.
  - Contain the spill and prevent spread of the substance by using sandbags, sand or soil, absorbent booms or planking to divert flow.
  - Prevent any of the oil substances from entering your drains, storm water systems or septic tanks, or from contaminating any natural water systems by forming a barrier from soil, sand, sandbags or absorbing material.
  - Prevent any of the oil substances from contaminating groundwater. It may be necessary to remove contaminated soil for disposal or rehabilitation.
  - Remove and mop up as much as possible by using spill fighting materials.
  - Plough soil for aeration and apply fertilizer/suitable neutralising chemicals if viable.
  - Contact your Oil Company Field manager.

6.1.3. Spill Reporting

The Sasol Field manager should be notified whenever a spill in excess of 200L occurs. For oil spill incidents of lesser magnitude with impact on water sources, rivers, streams, etc., or that are likely to attract public or press attention, the oil company should be notified.

For every major spill (over 200L of product) that occurs, the Incident Report Form must be completed. Investigate spill cause and implement Recommendations for preventing re-occurrence. If water courses and ground water are contaminated, then the Local Department of Water Affairs must be notified. Site operating staff should check regularly, if the tank system, pipework and equipment are in good condition. Inform the oil company when tank systems, pipework or equipment need maintenance.

6.1.4. Leak Response Procedure

If the Stock Monitoring and Control Procedures are used properly it will be possible to detect a leak at an early stage. Damage to the environment and cleaning costs will then be minimised.

If an above ground tank is leaking it will be possible to detect the leakage by visual inspection of the tank. If the tank has a bund wall ensure draining outlets are closed. The procedure to be followed is:

- Shut down all activities from the leaking tank.
- If possible try to stop product from leaking out of the tank.
- Notify Oil Company immediately.
- Any loss or suspected loss must be confirmed in a letter addressed to your Sasol manager.
- For product pouring out of the tank, the Spill Response Procedure (section 7.2) has to be followed.

6.1.5. Spill and Leak Procedure

Notify the oil company immediately of any suspected leaks in a tank system or malfunctioning of their equipment. Any loss or suspected loss must be confirmed in writing.

For every suspected leak in above ground or under ground tanks the Incident Report Form must be completed.

Investigate leak cause (in co operation with the oil company) and implement recommendations for preventing re-occurrence.

6.2. Groundwater Monitoring Programme

The following monitoring programme is recommended.

Table 3: Proposed groundwater monitoring points

Monitoring System	Monitoring Point	Description
Groundwater	H08-1872	Newly commissioned monitoring borehole located up gradient from filling station
	H08-1873	Newly commissioned monitoring borehole located down gradient from filling station
	H08-1793	Water supply - drinking water
	H08-1604	External rural water supply borehole
	H08-0881	External rural water supply borehole

The following general comments relate to the proposed monitoring system design:

- Dedicated groundwater sampling points are proposed in Table 3.

- Sampling methodology:
  - The monitoring boreholes are to be sampled with disposable Teflon bailers just below the surface of the static water table.
  - External user's boreholes are to be sampled under application conditions.
  - Select and follow an accredited laboratory's (under the South African National Accreditation System (SANAS) in terms of SABS Code 0259, specifications for sample preservation, holding times and sampling bottles (specialized vials for organic analyses) as well as chain of custody.

- Monitoring schedule:
  - The proposed monitoring frequencies are summarized in Table 4.
  - The "Lists" of water qualities for analyses are presented in Tables 5.

Table 4: Proposed monitoring schedule

		Weekly	Monthly	Quarterly	Annually
Monitoring boreholes	H08-1872 H08-1873		[*] [^]	[*] [^] List 2	[*] [^] List 3
Drinking water	H08-1793	List 1	List 2	List 2	List 3
External User's	H08-1604 H08-0881				List 3

[*] = Monitor water level
[^] = Monitor presence of free product on water table with Teflon disposable bailer

Table 5: Proposed lists of variables for hydro-chemical analyses

LIST 1	LIST 2	LIST 3
pH Electrical Conductivity Faecal Coliforms	pH Electrical Conductivity NO_3, NH_4 Chemical Oxygen Demand Total Coliforms Faecal Coliforms	pH, EC, TDS, Ca, Mg, Na, K, Si, T-Alk, Cl , SO4, NO_3, F, Al, Fe, Mn NH_4 Chemical Oxygen Demand, Total Coliforms , Faecal Coliforms , Gasoline & Diesel Range Organic Scan

7. CONCLUSIONS

During the rating and ranking procedure of impacts, no impact had the “no-go” implication for certain aspects of the project and all impacts can be countered by appropriate mitigation and training of all personnel.

In conclusion, considering the available information, the proposed Filling Station at the Maake Plaza Shopping Centre on the remainder of the farm Rita 668LT might have some impact on the environment, but as long as proper management procedures are in place, the effect will be minimal. The filling station does create long-term jobs that translate into a positive economic effect on the social environment.

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