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Hydrogeological study

for

Luthuli WWTW

***Compiled** for:*

AdiEnvironmental cc

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Site Location:	Luthuli, Mpumalanga Province
Compiled For:	AdiEnvironmental cc
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- I have no bias with regard to this project or towards the various stakeholders involved in this project.
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Customer Satisfaction:

Feedback regarding the technical quality of this report (i.e. methodology used, results discussed and recommendations made), as well as other aspects, such as timeous completion of project and value of services rendered, can be posted onto GPT’s website at www.gptglobal.com.

EXECUTIVE SUMMARY

Geo Pollution Technologies (Pty) Ltd (GPT) was appointed by AdiEnvironmental cc to conduct a hydrogeological impact study for the proposed Luthuli Wastewater Treatment Works in KwaMhlanga, Mpumalanga Province. AdiEnvironmental is in the process of applying for a WUL for the Luthuli WWTW and require hydrogeological assessment to be conducted as part of the application.

A 5-hectare section of the proposed WWTW site has been fenced to prevent encroachment from informal settlement and to restrict any further expansion of the adjacent graveyard. A single access gate with a guardhouse and an internal access road will be constructed to control entry to the site.

The WWTW is designed for modular development, with each module capable of treating 3 megalitres per day (ML/d). This modular approach allows for future expansion in response to population growth, urban development, and improvements in water supply to the drainage area.

The treatment works will consist of the following components:

- Inlet works – including screening, grit removal, and a flow measurement facility;
- Biological reactor – for the biological treatment of wastewater;
- Clarifiers – with a pump station for return activated sludge (RAS) and waste activated sludge (WAS) management;
- Chlorination facility – with flow measurement prior to final discharge into the receiving river;
- Sludge drying beds – including a return system for supernatant;
- Main pump station – for conveying flows through the treatment process.

Supporting infrastructure will include an administration building and an electrical room.

All infrastructure will be located outside the 90-metre wetland buffer zone and beyond the identified flood risk buffer line, in accordance with environmental and planning regulations.

The site is situated approximately on the western edge of the Luthuli Village, near the eastern banks of the Enkeldoringspruit. A graveyard is located directly east of the site, and this might have an impact on the groundwater quality.The area is characterised by relatively flat terrain, with a gentle slope of approximately 0.2% descending westward towards the Enkeldoringspruit.

The investigated area falls within the 2528 Pretoria 1:250 000 geology series maps. According to the map, the area is underlain by the Lebowa Granite Suite, specifically consisting of Nebo Granite. This includes pink, coarse-grained granite and red to medium-grained varieties near the top. Fluorite is present as an accessory mineral, disseminated throughout these rocks.

According to the explanation of the 1: 500 000 general hydrogeological[1] map the site area is characterised by an Intergranular and fractured aquifer system. Intergranular and fractured aquifers represent a complex interaction of groundwater movement within the same lithological units. These aquifers are characterised by the presence of both intergranular voids and secondary fractures, allowing groundwater to exist in two distinct yet interconnected modes. Groundwater at the site is primarily found in deeper weathered zones, with less common occurrences along faults, fractures, and dyke contacts.

[1] Du Toit, H.C., & Van Lelyveld, M., (2014). An explanation of the 1:500 000 General Hydrogeological Map. Phalaborwa 2330. DWAF.

Recharge to the shallow, unconfined aquifer was calculated using the RECHARGE program developed by the Institute for Groundwater Studies at the University of the Free State, South Africa. The calculated recharge percentage equates to approximately 3.6%.

A hydrocensus was conducted on 28 August 2025 within a 1 km radius of the site. However, based on information provided by local residents, the survey area was extended to include certain upstream sections of the adjacent community. During the hydrocensus, 13 groundwater boreholes were identified. However, several of these could not be inspected due to the absence of the owners, who were not available to grant access. While the community primarily receives water from Thembisile Hani municipality via water tankers, a number of residents rely on private boreholes for their water supply.

Four (4) electromagnetic and magnetic traverses were conducted outside the study area’s boundary, approximately 20 meters from the site fence on each side. The station spacing for both the electromagnetic and magnetic methods was set at 10 meters.

Based on targets identified during the geophysical survey, three drilling locations were selected and drilled between 21 and 22 August 2025. The target from Traverse 1 was drilled and designated as MON01, Traverse 2 as MON02, and Traverse 3 as MON03. The naming convention "MON" refers to "Monitoring Borehole," followed by a numerical identifier. The drilling logs confirmed that the site is underlain by clay and red to pink granite from the Lebowa Granite Suite.

Falling head testing was conducted on the drilled monitoring boreholes. Data acquired from the falling head tests was used to calculate a first estimation of the hydraulic conductivity (K)which range from 0.0054 to 0.0186 m/d.

Groundwater samples were collected from two hydrocensus boreholes on August 28th and the 3 newly drilled monitoring wells on the 22nd of August and sent for analysis. The chemical analysis results were compared to the SANS 241-1:2015[2]

The analysis revealed the following exceedances:

- Fluoride: Exceeds the chronic health limit in borehole LB01, MON01, MON02, and MON03
- Iron: Iron levels in borehole MON01, MON02, and MON03 exceed aesthetic limits.
- Manganese: Manganese concentrations exceed the aesthetic limits in MON02 and MON03.
- Aluminium: Exceeds the Operational limits for LB07, MON01, MON02, and MON03
- E. coli: E. coli was detected in MON01, MON02, and MON03 and exceeded the Acute health limits
- Total Coliforms: All concentrations exceed the operational limit of 10 cfu/100ml. Extremely high concentrations were noted in the newly drilled borehole MON01, MON02 and MON03.

The GDT calculated a vulnerability value of 54% for the aquifer which is classified as medium. Based on South African Aquifer System Management Classification the aquifers are classified as a “Minor Aquifer System. A Groundwater Quality Management Index of 4 was estimated for the study area from the ratings for the Aquifer System Management Classification. According to this estimate a medium level of groundwater protection is required for the aquifer, tributaries and boreholes in use near and on the site (if any).

[2] SANS 241-1:2015 (edition2).

Based on Darcy's flow equation, potential pollutants from the wastewater treatment works are estimated to migrate through the groundwater at a rate of 0.01 to 0.05 m/day toward the Enkeldoringspruit. This suggests a slow rate of pollution movement. The risk to the downgradient stream is reduced due to the low permeability of the underlying clay and granite geology, as well as the relatively flat topography. However, the shallow groundwater table, at approximately 5.27 m below ground level, increases the potential risk of groundwater contamination. This risk can be mitigated through the implementation of appropriate management and control measures. In light of the above, the site is considered suitable for the construction of a WWTW, provided that appropriate management protocols and mitigation measures are implemented.

Hydrogeological Impacts

The aim of the impact assessment is to access the likely hydrogeological impact that the proposed development might have on the groundwater regime during the construction, operational and decommissioning phase. The following interactions were identified and could potentially impact the groundwater environment:

- Construction phase:
  - Site clearing, including the removal of vegetation, topsoil and subsoil and the establishment of infrastructure resulting in the potential increase of surface runoff and reduced recharge within cleared areas.
  - General construction activities (including use of vehicles and machinery as well as storage and handling of waste and hazardous material) resulting in the potential contamination of the shallow groundwater aquifer due to spillages and leaks.
- Operational phase:
  - Deposition of sludge and waste or chemical containment facilities have the potential to generate seepage to the underlying groundwater environment. Poor seepage quality from the sludge drying beds or waste treatment facilities can migrate into the groundwater environment.
  - The release of effluent from a Wastewater Treatment Works (WWTW) into the surrounding environment could introduce a variety of contaminants, depending on quality, to the groundwater regime. For groundwater, the main concern is potential seepage of effluent through the soil. Ultimately, the quality of both surface and subsurface water resources can be affected by effluent releases.

Recommendations:

- The three newly drilled boreholes should be purged and resampled before start of operations, to ensure the water quality results accurately reflect the conditions prior to operation on site.

- The three onsite boreholes and background monitoring (hydrocensus borehole) LB07 should be monitored on a quarterly basis, and a factual report should be compiled annually.

- Implement a monitoring program to routinely assess water quality in possible receptor boreholes, the groundwater aquifer, and the Enkeldoringspruit. The monitoring program should specifically include testing for microbial contaminants. Following the monitoring a contingency plan for rapid response in case of acute contamination events should be developed. This should include emergency procedures, communication strategies, and resources for addressing public health concerns.

- Drilling a borehole at the cemetery could help in establishing if contamination from the graveyard is influencing the WWTW site.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
ERT	Electrical resistivity tomography
km^2	Square kilometre
K	Hydraulic Conductivity
L/s	Litres per second
mamsl	Metres above mean sea level
m	metre
mm	Millimetre
mm/a	Millimetres per annum
mS/m	Millisiemens per metre
m^3	Cubic metre
MAP	Mean Annual Precipitation
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NWA	National Water Act (Act No. 36 of 1998)
ppm	Parts per million
TDS	Total Dissolved Solids
WMA	Water Management Area

DEFINITIONS

Definition	Explanation
Aquiclude	A geologic formation, group of formations, or part of formation through which virtually no water moves
Aquifer	A geological formation which has structures or textures that hold water or permit appreciable water movement through them. Source: National Water Act (Act No. 36 of 1998).
Borehole	Includes a well, excavation, or any other artificially constructed or improved underground cavity which can be used for the purpose of intercepting, collecting or storing water in or removing water from an aquifer; observing and collecting data and information on water in an aquifer; or recharging an aquifer. Source: National Water Act (Act No. 36 of 1998).
Boundary	An aquifer-system boundary represented by a rock mass (e.g. an intruding dolerite dyke) that is not a source of water, and resulting in the formation of compartments in aquifers.
Cone of Depression	The depression of hydraulic head around a pumping borehole caused by the withdrawal of water.
Confining Layer	A body of material of low hydraulic conductivity that is stratigraphically adjacent to one or more aquifers; it may lie above or below the aquifer.
Dolomite Aquifer	See “Karst” Aquifer
Drawdown	The distance between the static water level and the surface of the cone of depression.
Fractured Aquifer	An aquifer that owes its water-bearing properties to fracturing.
Groundwater	Water found in the subsurface in the saturated zone below the water table.
Groundwater Divide or Groundwater Watershed	The boundary between two groundwater basins which is represented by a high point in the water table or piezometric surface.
Groundwater Flow	The movement of water through openings in sediment and rock; occurs in the zone of saturation in the direction of the hydraulic gradient.
Hydraulic Conductivity	Measure of the ease with which water will pass through the earth's material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (m/d).
Hydraulic Gradient	The rate of change in the total hydraulic head per unit distance of flow in a given direction.
Infiltration	The downward movement of water from the atmosphere into the ground.
Intergranular Aquifer	A term used in the South African map series referring to aquifers in which groundwater flows in openings and void spaces between grains and weathered rock.
Karst (Karstic)	The type of geomorphological terrain underlain by carbonate rocks where significant solution of the rock has occurred due to flowing groundwater.

Definition	Explanation
Karst (Karstic) Aquifer	A body of soluble rock that conducts water principally via enhanced (conduit or tertiary) porosity formed by the dissolution of the rock. The aquifers are commonly structured as a branching network of tributary conduits, which connect together to drain a groundwater basin and discharge to a perennial spring.
Monitoring	The regular or routine collection of groundwater data (e.g. water levels, water quality and water use) to provide a record of the aquifer response over time.
Observation Borehole	A borehole used to measure the response of the groundwater system to an aquifer test.
Phreatic Surface	The surface at which the water level is in contact with the atmosphere: the water table.
Piezometric Surface	An imaginary or hypothetical surface of the piezometric pressure or hydraulic head throughout all or part of a confined or semi-confined aquifer; analogous to the water table of an unconfined aquifer.
Porosity	Porosity is the ratio of the volume of void space to the total volume of the rock or earth material.
Production Borehole	A borehole specifically designed to be pumped as a source of water supply.
Recharge	The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.
Recharge Borehole	A borehole specifically designed so that water can be pumped into an aquifer in order to recharge the ground-water reservoir.
Saturated Zone	The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.
Specific Capacity	The rate of discharge from a borehole per unit of drawdown, usually expressed as m3/d•m.
Specific Yield	The ratio of the volume of water that drains by gravity to that of the total volume of the saturated porous medium.
Storativity	The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.
Transmissivity	Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.
Unsaturated Zone (Also Termed Vadose Zone)	That part of the geological stratum above the water table where interstices and voids contain a combination of air and water.
Watershed (Also Termed Catchment)	Catchment in relation to watercourse or watercourses or part of a watercourse means the area from which any rainfall will drain into the watercourses or part of a watercourse through surface flow to a common point or points. Source: National Water Act (Act No. 36 of 1998).
Water Table	The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is equal to that of the atmosphere.

HYDROGEOLOGICAL STUDY

LUTHULI WWTW

1 INTRODUCTION

Geo Pollution Technologies (Pty) Ltd (GPT) was appointed by AdiEnvironmental cc to conduct a hydrogeological impact study for the Luthuli Wastewater Treatment Works in KwaMhlanga, Mpumalanga Province. AdiEnvironmental is in the process of applying for a WUL for the Luthuli WWTW and require hydrogeological assessment to be conducted as part of the application.

2 SCOPE OF WORK

The scope of work consists of a site visit and hydrocensus, borehole siting, drilling, aquifer testing, chemical analysis and reporting.

3 METHODOLOGY

3.1 Desktop Study

Gather, collate, and assess existing data to understand the prevailing groundwater conditions in terms of geology, hydrogeology, recharge and groundwater availability.

3.2 Site Visit & Hydrocensus

A site visit and hydrocensus were conducted. The hydrocensus extended to a radius of 1km from the site boundary. The assessment involved a census of existing boreholes and data on the boreholes. Water levels were measured, and any available information on borehole yields was obtained.

3.3 Geophysical Survey

A ground geophysical survey was conducted in order to identify geological structures that may act as preferential groundwater flow paths. Published geological and hydrogeological data was used to identify target areas to be surveyed. The survey consisted of magnetic and electro-magnetic surveying. The results of the survey were used to identify drilling targets up and downstream of the site.

The data was then analysed to map and interpret features such as faults, dykes, and mineral deposits and to determine suitable borehole locations. This optimized the borehole siting process by providing valuable information on subsurface conditions, ensuring efficient water extraction through well-placed and designed boreholes.

3.4 Borehole Drilling

Upon completion of the geophysical survey, three boreholes were drilled, serving a fourfold purpose: (1) verifying the geology; (2) determining aquifer parameters through hydraulic testing; (3) assessing groundwater quality; and (4) providing future monitoring boreholes.

The boreholes were drilled to a maximum depth of 30 meters and constructed using uPVC casing, gravel packs, lockable caps, concrete plinths, and marker poles. A qualified hydrogeologist supervised the drilling, and details such as geology, water strike depths, yields, and casing design were recorded.

3.5 Aquifer Testing

Following the drilling, falling head tests (slug tests) were performed on boreholes with measurable water levels to determine the hydraulic conductivity of the fractures penetrated by the boreholes. This data was used to calculate groundwater flow velocity.

3.6 Sampling and Chemical Analysis

Samples were taken from the boreholes and submitted to a SANAS-accredited laboratory for analysis of major anions, cations, selected metals, and microbiological parameters.

3.7 Reporting

A report detailing the findings of the study was compiled. The report complies with the DWS requirements for hydrogeological reports (GNR 267: Regulations regarding the procedural requirements for water use licence applications and appeals).

4 WATSE WATER TREATMENT WORKS DESCRIPTION

The WWTW is designed for modular development, with each module capable of treating 3 megalitres per day (ML/d). This modular approach allows for future expansion in response to population growth, urban development, and improvements in water supply to the drainage area.

The treatment works will consist of the following components:

- Inlet works – including screening, grit removal, and a flow measurement facility;
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Supporting infrastructure will include an administration building and an electrical room.

All infrastructure will be located outside the 90-metre wetland buffer zone and beyond the identified flood risk buffer line, in accordance with environmental and planning regulations.

A 5-hectare section of the proposed WWTW site (locality description in following section) has been fenced to prevent encroachment from informal settlement and to restrict any further expansion of an existing graveyard adjacent to the site. A single access gate with a guardhouse and an internal access road will be constructed to control entry to the site.

5 GEOGRAPHICAL SETTING

5.1 Site Location, Topography and Drainage

The site is situated on the western edge of the Luthuli Village, near the eastern banks of the Enkeldoringspruit (Figure 1). A graveyard is located directly east of the site, and this might have an impact on the groundwater quality.

The topography, as shown in Figure 2, typically provides a reliable first approximation of the hydraulic gradient in the unconfined aquifer. The area is characterised by relatively flat terrain, with a little steeper slope descending south and westward towards the Enkeldoringspruit with an average gradient of 3% and a maximum of 12,5% in some areas. The site itself is located near the eastern bank of a river bend.

The site is situated in the Limpopo-Olifants water management area and in the B31D quaternary catchment. Locally drainage is towards the Enkeldoringspruit, southwest of the site.

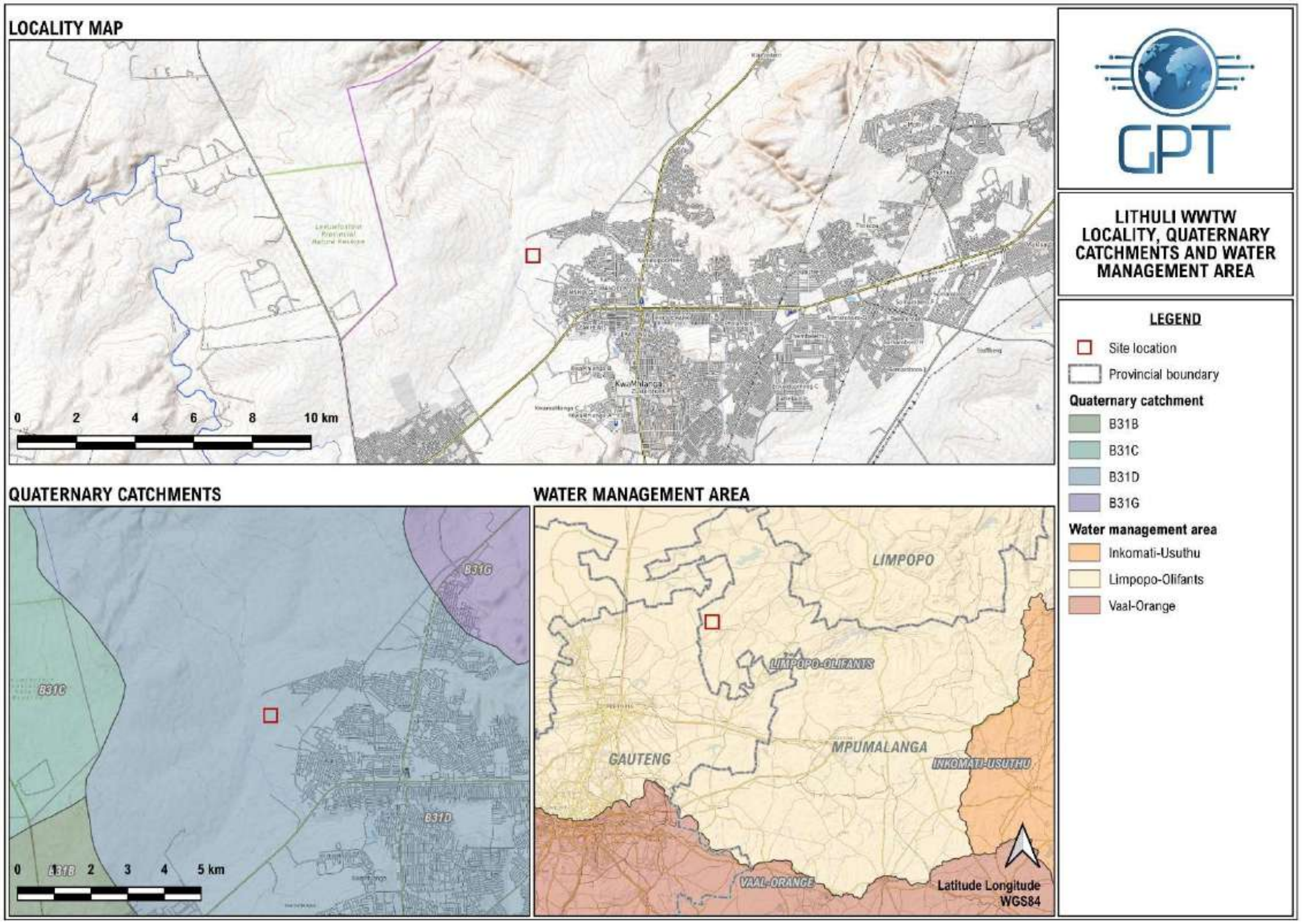


Figure 1: Site Location and Quaternary Catchment Boundaries

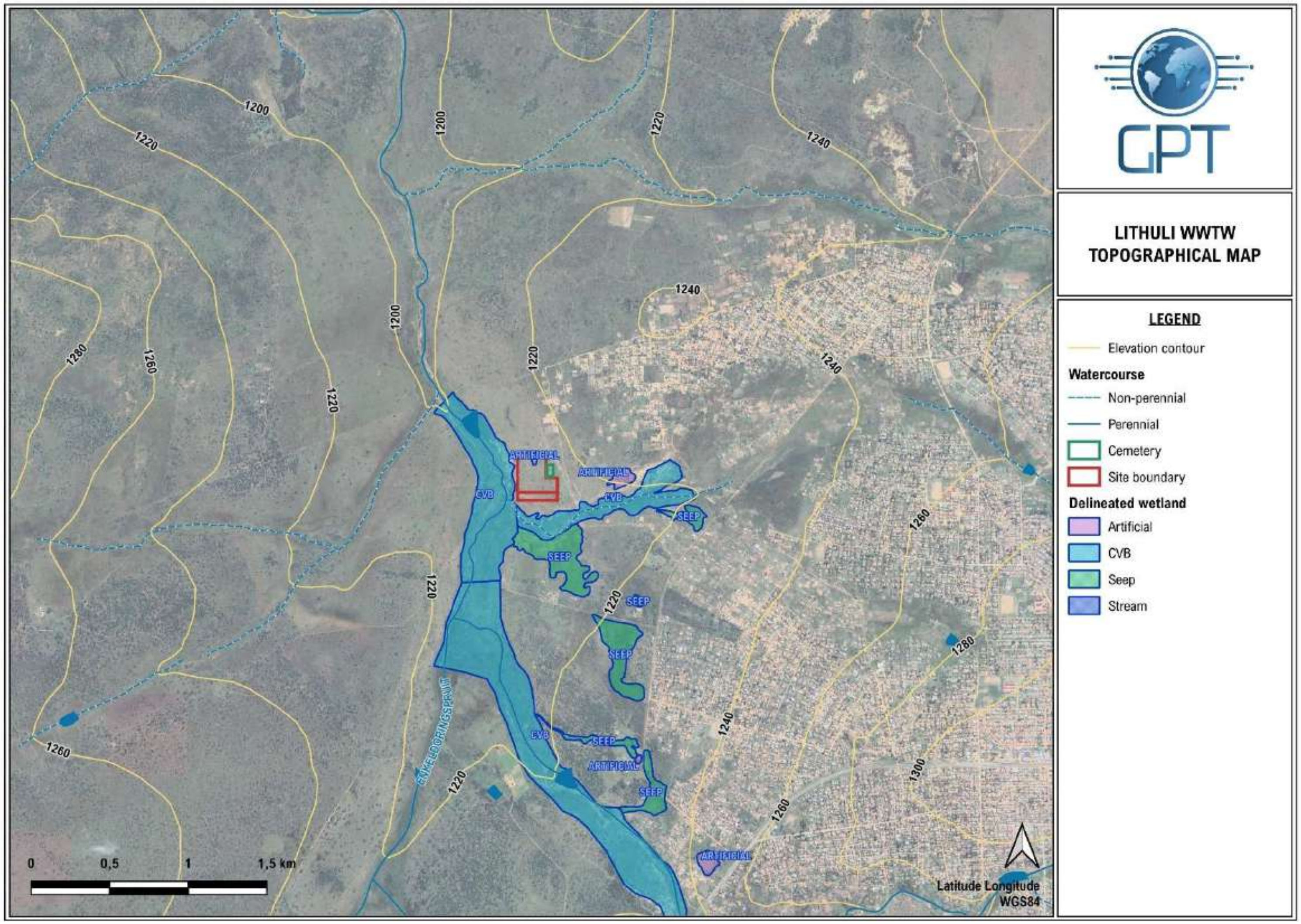


Figure 2: Site Topography

5.2 Climate

Climatic data was obtained from the Samsam Climate tool.[3] The average annual rainfall for this location is 639 mm per year, with the high rainfall months between November and March. The site is located in the summer rainfall region of Southern Africa.

Table 1: Climatic Data

Month	Average Monthly Rainfall (mm)	Mean Monthly Evaporation (mm)
January	114	202
February	86	175
March	75	175
April	41	145
May	13	132
June	5	115
July	4	124
August	5	158
September	17	190
October	60	212
November	106	195
December	113	203
Annual	639	2030

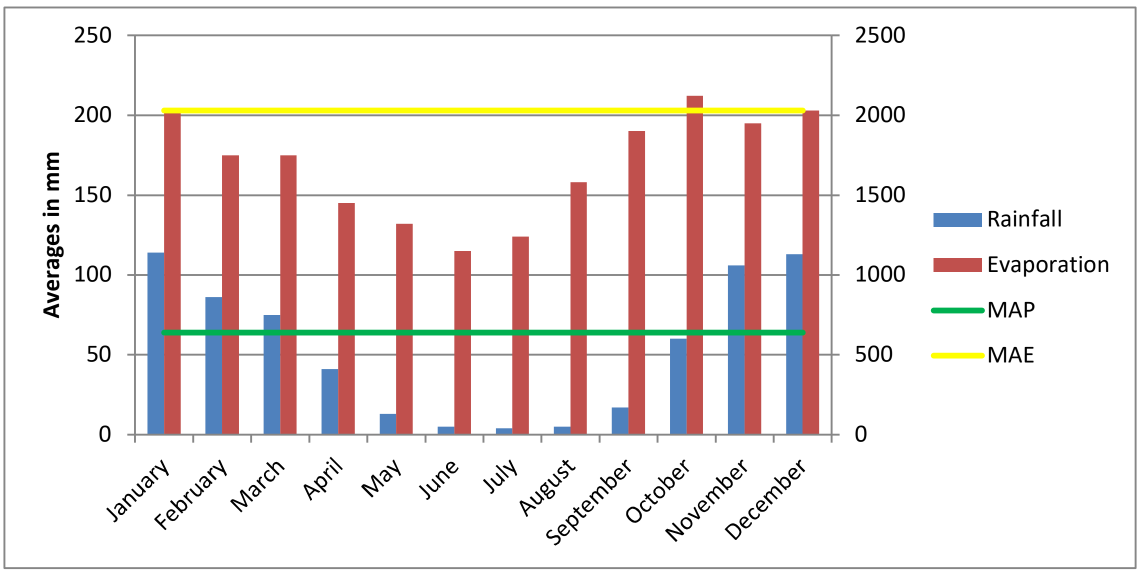


Figure 3: Climatic data representation

[3] https://www.samsamwater.com/climate Date of access:2025/08/25

6 PREVAILING GROUNDWATER CONDITIONS

6.1 Geology

The Luthuli area falls within the 1:250 000 geological map sheet 2528 Pretoria. The geology of the area forms part of the Bushveld Igneous Complex, one of the largest layered igneous intrusions in the world, known for its rich mineral deposits and complex magmatic history. The area is predominantly underlain by rocks of the Lebowa Granite Suite, specifically the Nebo Granite. This granite is typically pink and coarse-grained, with red to medium-grained varieties occurring near the upper portions. Fluorite is present as an accessory mineral, disseminated throughout the rock.

Underlying the Nebo Granite is the Rashoop Granophyre Suite, which consists mainly of granitic granophyre. This unit in turn overlies the Kwaggasnek Formation, characterized by massive, generally red, porphyritic felsite, with minor occurrences of pyroclastic rocks and interbedded sandstone or quartzite.

The granite typically weathers to form sandy, well-drained soils, though these are often nutrient poor. Although no major mineralisation is currently exploited in the immediate area, the presence of fluorite and the regional setting within the Bushveld Complex suggests minor mineral potential. Structural features are limited locally, but regional lineaments may influence groundwater movement and rock fracturing. The geology of the site and surrounding area is shown in Figure 4 below.

The comparatively low storage capacity of granitic rocks is reflected in the appearance of numerous springs and seepages resulting from a rise in groundwater rest levels following recharge events.

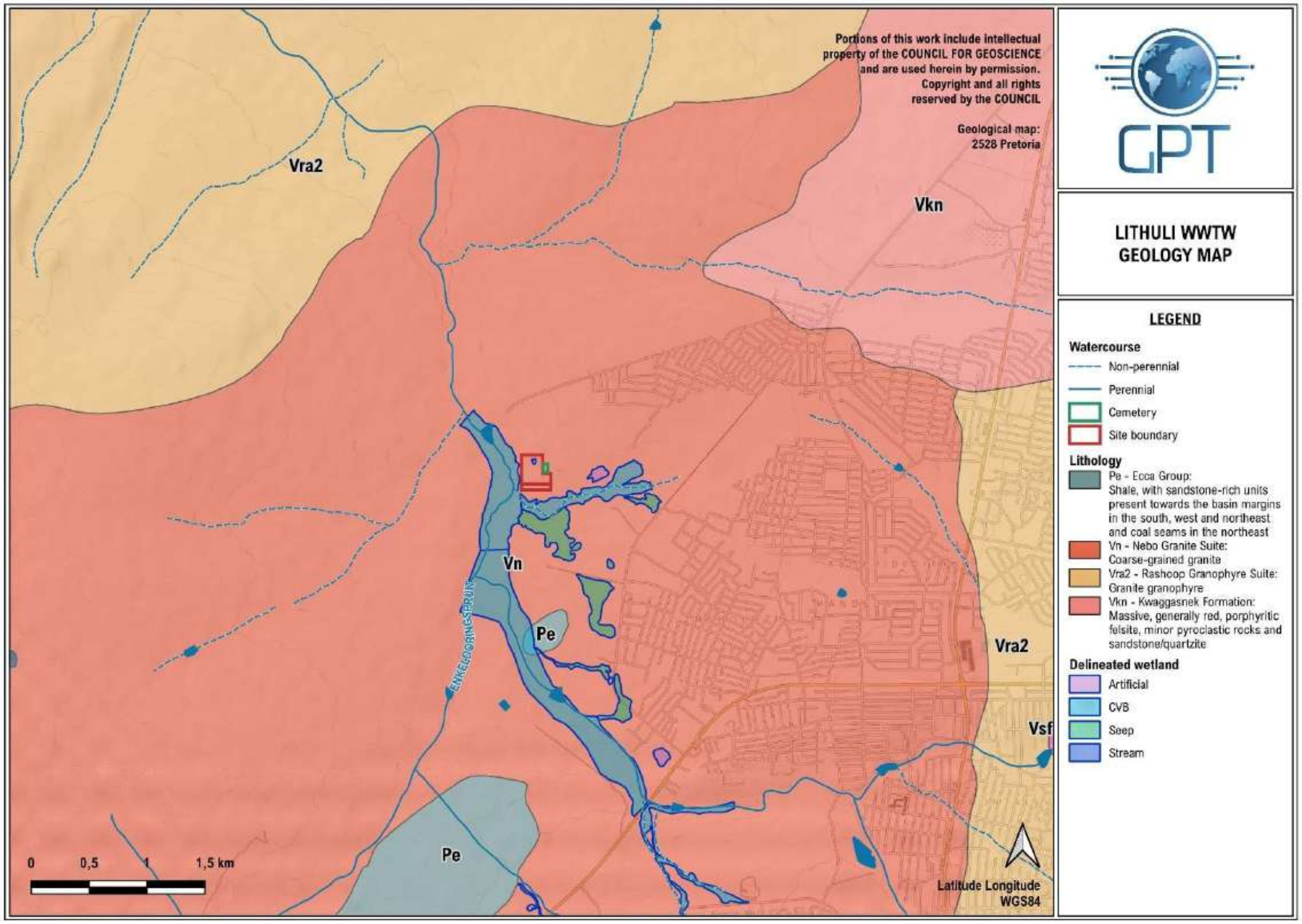


Figure 4: Regional Geology Map (1:250 000 geology series map)

6.2 Hydrogeology

According to the explanation of the 1: 500 000 general hydrogeological[4] map the site area is characterised by an Intergranular and fractured aquifer system.

Intergranular and fractured aquifers represent a complex interaction of groundwater movement within the same lithological units. These aquifers are characterised by the presence of both intergranular voids and secondary fractures, allowing groundwater to exist in two distinct yet interconnected modes.

In intergranular aquifers, groundwater is primarily stored in the voids between granules and grains of geological materials, such as sandstones or weathered granite. These openings can be classified as either primary or secondary in nature. Primary openings originate from the deposition processes of the material, while secondary openings arise from weathering and other geological processes that alter the material over time. The capacity of these aquifers to store and yield water is significantly influenced by various factors, including the size, roundness, and distribution of the grains, as well as the clay content and density of compaction.

Conversely, fractured or secondary aquifers are characterised by groundwater movement through a network of joints, cracks, fractures, and faults. In these aquifers, the groundwater is primarily contained within these fractures, joints, and fissures, as well as in the transitional zones between weathered and solid rock, including bedding planes. The interconnectedness of these fractures allows for the movement of groundwater, albeit at varying rates, depending on the size and connectivity of the fractures.

The groundwater regime at the site could prove to have up to two aquifer systems present at the Luthuli WWTW. The first aquifer system can be in the form of a shallow, saprolitic aquifer with a weathered, intergranular rock base above the contact of fresh bedrock. Groundwater is likely to be encountered in the saturated weathered material below the groundwater rest level. The main source of recharge into the shallow aquifer is rainfall that infiltrates the aquifer through the unsaturated (vadose) zone. Vertical movement of water is faster than lateral movement in this system as water moves predominantly under the influence of gravity.

The second aquifer system will be characterised by fractured bedrock. Groundwater at the site is primarily found in deeper weathered zones, with less common occurrences along faults, fractures, and dyke contacts. Due to the intergranular and fractured nature of the underlying rock, the groundwater yield is considered low—82% of recorded boreholes produce less than 2 L/s. The water table is typically shallow, rarely deeper than 15 m below the surface. The low storage capacity of the granitic rocks is evident from the frequent appearance of springs and seepages after rainfall, as groundwater levels rise in response to recharge events.[4]

[4] Barnard, H.C., (2000). An explanation of the 1:500 000 General Hydrogeological Map. Johannesburg 2526. DWAF.

6.3 Groundwater Recharge Calculations

Recharge to the shallow, unconfined aquifer was calculated using the RECHARGE program developed by the Institute for Groundwater Studies at the University of the Free State, South Africa. The calculated recharge percentage equates to approximately 3.6%.

Table 2: Recharge calculation for the shallow unconfined aquifer

Recharge Estimation			
Method	**mm/a**	**% of rainfall**	**Certainty (Very High = 5; Low = 1)**
Aquiworx 2016	20.97	3.5	4
Chloride	5	0.9	1
Various schematic maps			
Soil	22.2	3.5	4
Geology	43.5	6.8	1
Vegter	32	5	2
Acru	10	1.6	1
Harvest Potential	25.0	3.9	4

6.4 Groundwater Availability Assessment

Due to the intergranular and fractured nature of the underlying rock, the groundwater yield is considered low—82% of recorded boreholes produce less than 2 L/s, the maximum yield from 354 record was 14.6 L/s.

According to chemical data it can be seen that groundwater can be regarded as safe for any intended use on the basis of the average pH and EC value of 7.6 and 60 mS/m respectively. Significant coefficients of variation are indicated for sulphate, fluoride and nitrate, therefore caution should be given when water associated with this unit is considered for human consumption.[4]

7 HYDROCENSUS

A hydrocensus was conducted on 28 August 2025, within a 1 km radius of the site. However, based on information provided by local residents, the survey area was extended to include certain upstream sections of the adjacent community.

During the hydrocensus, 13 groundwater boreholes were identified. However, several of these could not be inspected due to the absence of the owners, who were not available to grant access. While the community primarily receives water from Thembisile Hani municipality via water tankers, a number of residents rely on private boreholes for their water supply via direct pumping or water tankers. Data collected during the hydrocensus is presented in Table 3 and a map of the hydrocensus boreholes in Figure 8.

On the site itself a seepage pool (Photo 1) was observed, likely formed due to water moving along the shallow soil horizon on top of the relatively low storage capacity of the granitic rocks. The pool was likely formed because of excavation activities, creating an artificial wetland. The effect seen of water seeping into the excavation were also observed in the multiple channelled valley bottoms observed close to the river in the vicinity of the site, where similar pools form near the river. This pattern is also evident in aerial imagery. A map of the features is presented in Figure 5.

Table 3: Hydrocensus groundwater boreholes identified.

BH ID	Latitude	Longitude	Collar height	WL (mbcl)	WL (mbgl)	Pump Installed	Pump Type	Water Use	Additional Notes
LB01	-25.38709	28.68796	0	0	0	No	n/a	Domestic	Artesian well, community members fill their buckets with water here, supplies water to approximately 150 households.
LB02	-25.37865	28.69125	NM	NM		Yes	Submersible	Abandoned	Borehole closed in a concrete manhole and locked. Pump is no longer working.
LB03	-25.37867	28.69118	0.25	2.44	2.19	No	n/a	Not used	Borehole casing hammered shut, borehole not used
LB04	-25.37941	28.69268	0.06	20.6	20.54	Yes	Submersible	Domestic	
LB05	-25.38255	28.69337	0.06	5.35	5.29	Yes	Submersible	Domestic & Agricultural	
LB06	-25.38298	28.69263	NM	NM		Yes	Submersible	Domestic & Agricultural	Borehole buried under a concrete slab.
LB07	-25.37865	28.68943	0.15	3.27	3.12	Yes	Submersible	Domestic	
LB08	-25.37853	28.68785	NM	NM		Yes	Submersible	Domestic	Borehole sealed shut, no access
LB09	-25.37696	28.69791	NM	NM		Yes	Submersible	Domestic	Borehole buried beneath the ground, borehole supplies water to multiple households.
MON01	-25.38585	28.68520	0.79	3.61	2.82	No	n/a	Monitoring	Monitoring Borehole
MON02	-25.38466	28.68408	0.78	3.03	2.25	No	n/a	Monitoring	Monitoring Borehole
MON03	-25.38368	28.68555	0.76	4.12	3.36	No	n/a	Monitoring	Monitoring Borehole
Municipal Borehole	-25.37992	28.70045	Municipal borehole, closed in a secure fence. No access						
BH on Property	-25.37644	28.70257	Borehole on property - no access						
BH on Property	-25.38211	28.69281	Borehole on property - no access						
BH on Property	-25.37739	28.69988	Borehole on property - no access						
BH on Property	-25.37825	28.69964	Borehole on property - no access						

Photo 1: Seepage pool

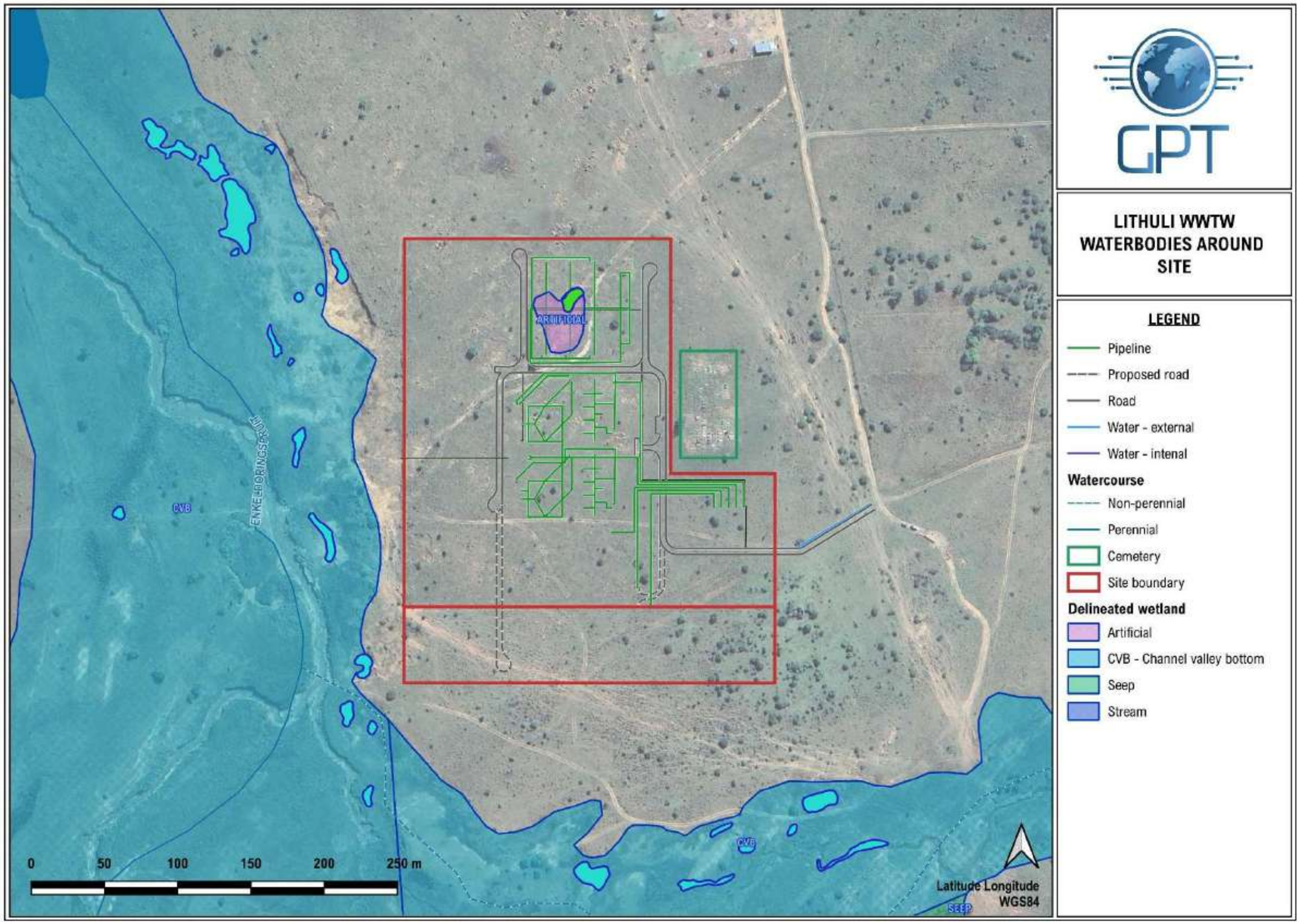


Figure 5:Seepage pool and channelled valley bottom map.

7.1 Groundwater levels

Out of the thirteen (13) boreholes identified eight (8) were available for groundwater measurement. Static water levels ranged between artesian conditions (daylighting on surface) and the maximum of 20.54 mbgl, with an average groundwater level of 4.94 mbgl. The groundwater levels measured are presented in Table 3 and the groundwater flow direction within the area is in a predominantly southern direction and is shown in Figure 9.

Typically, a strong relationship is expected between topography and static groundwater levels, as this relationship helps distinguish boreholes with water levels in equilibrium from those with anomalous levels caused by factors such as pumping or local hydrogeological variations. A regression value (R^2) of 0.752 was calculated (Figure 6) from boreholes where water levels were measured. Excluding the outlier borehole water level at LB04, yields a regression coefficient (R^2) of 0.9867 (Figure 7). The deeper water level measured at LB04 is most likely due to recent pumping, the borehole is equipped with a pump, and the tank was full during at the time when a sample was taken. The high regression value for the site indicates a strong correlation between topography and static water levels, suggesting that static water levels closely follow surface topography.

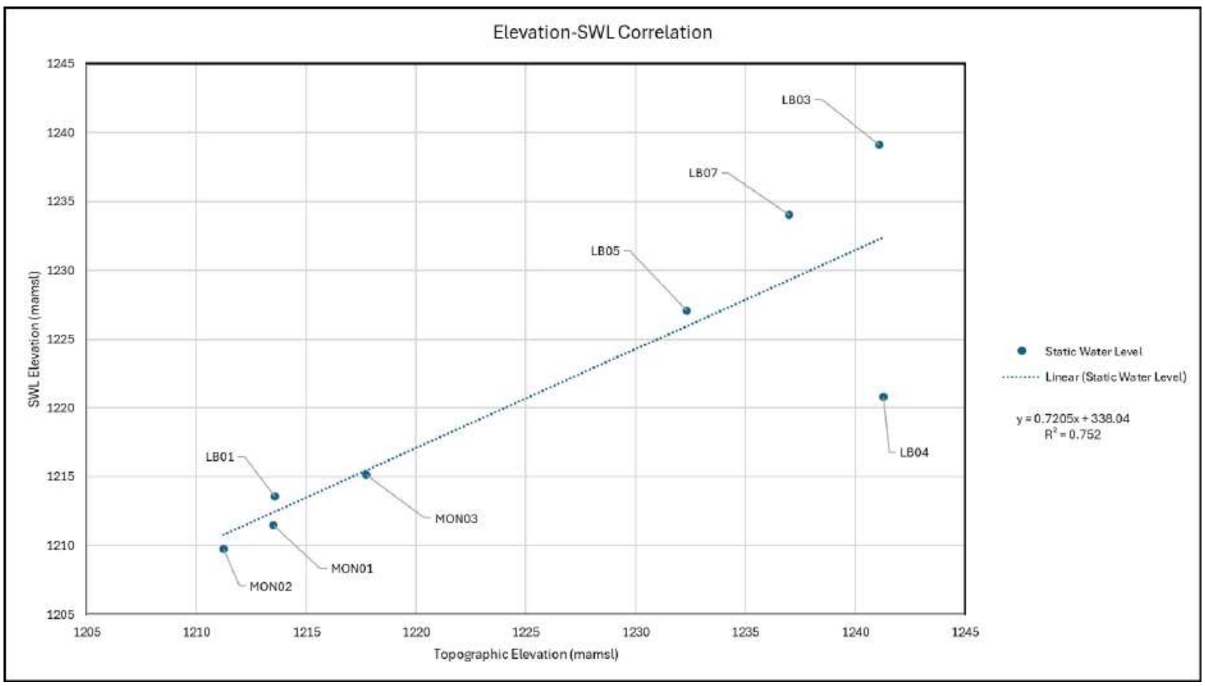


Figure 6: Correlation of groundwater levels and elevations of static boreholes

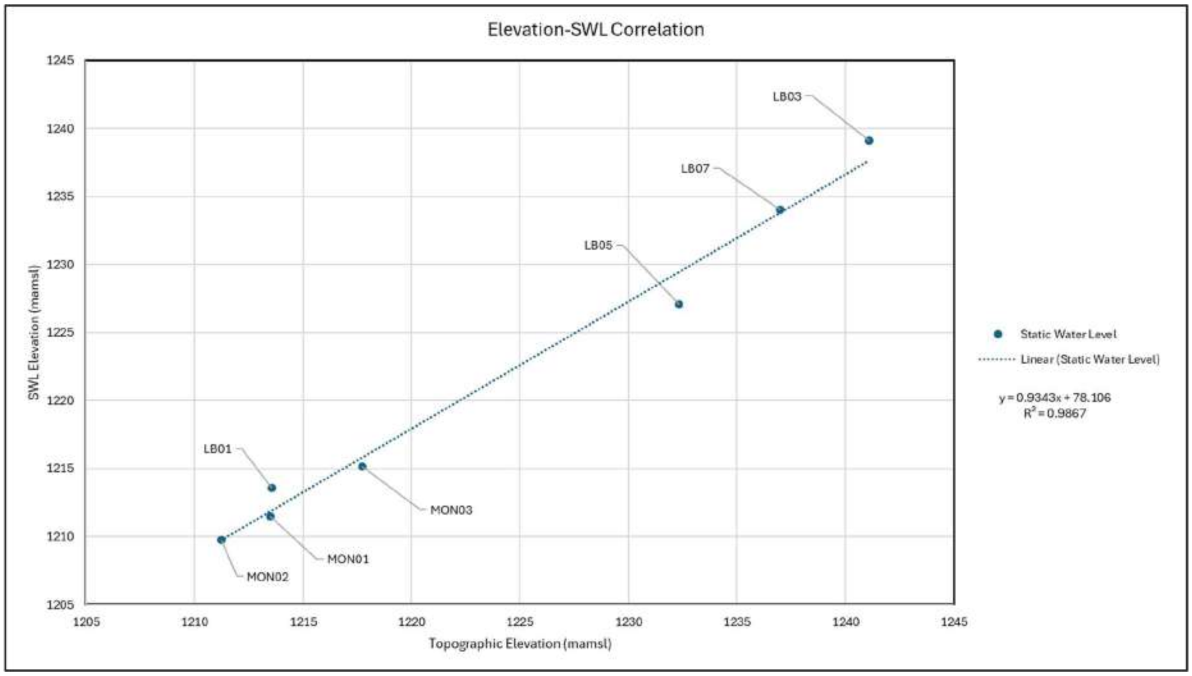


Figure 7: Abbreviated correlation of groundwater levels and elevations of static boreholes

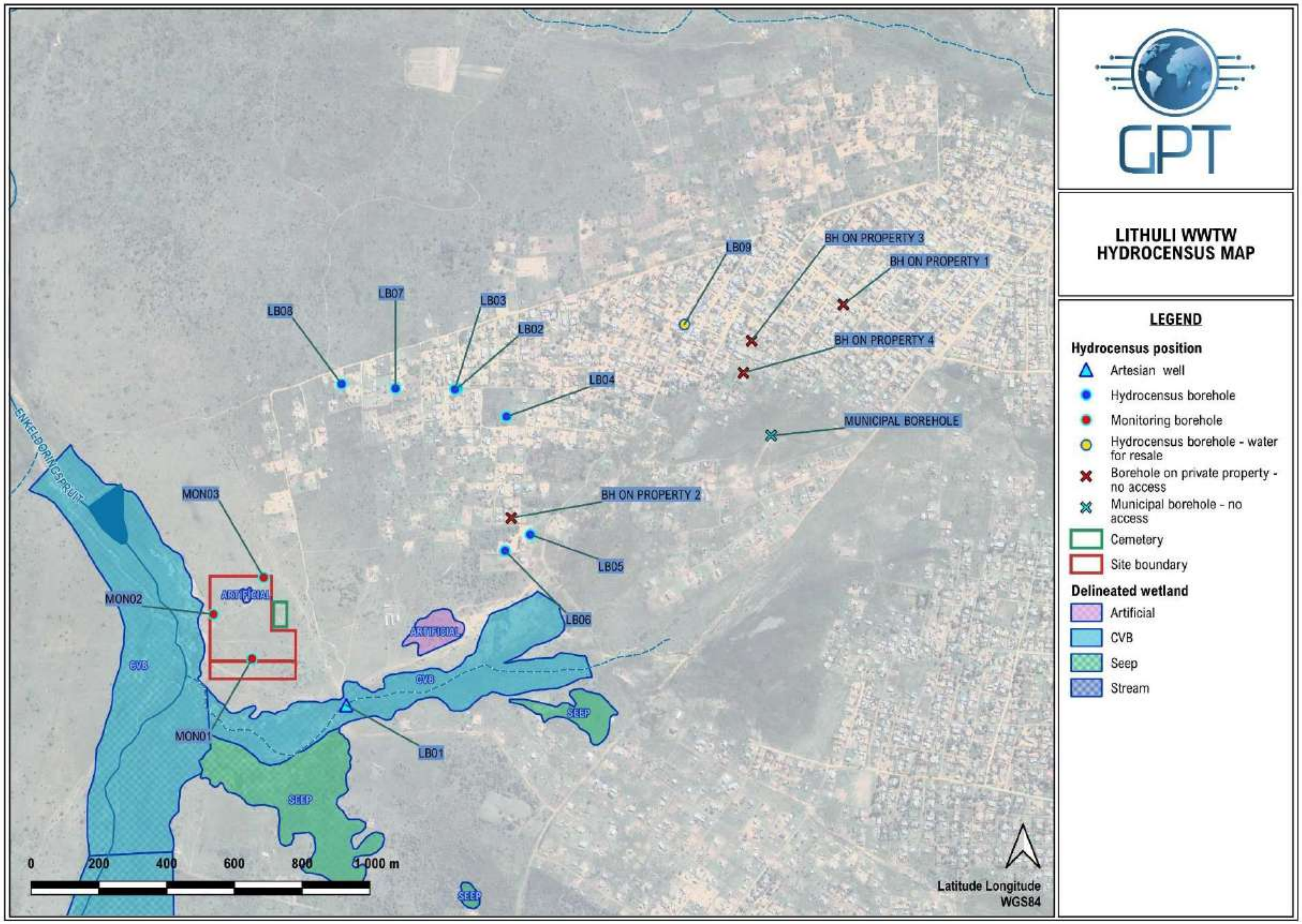


Figure 8: Hydrocensus map.

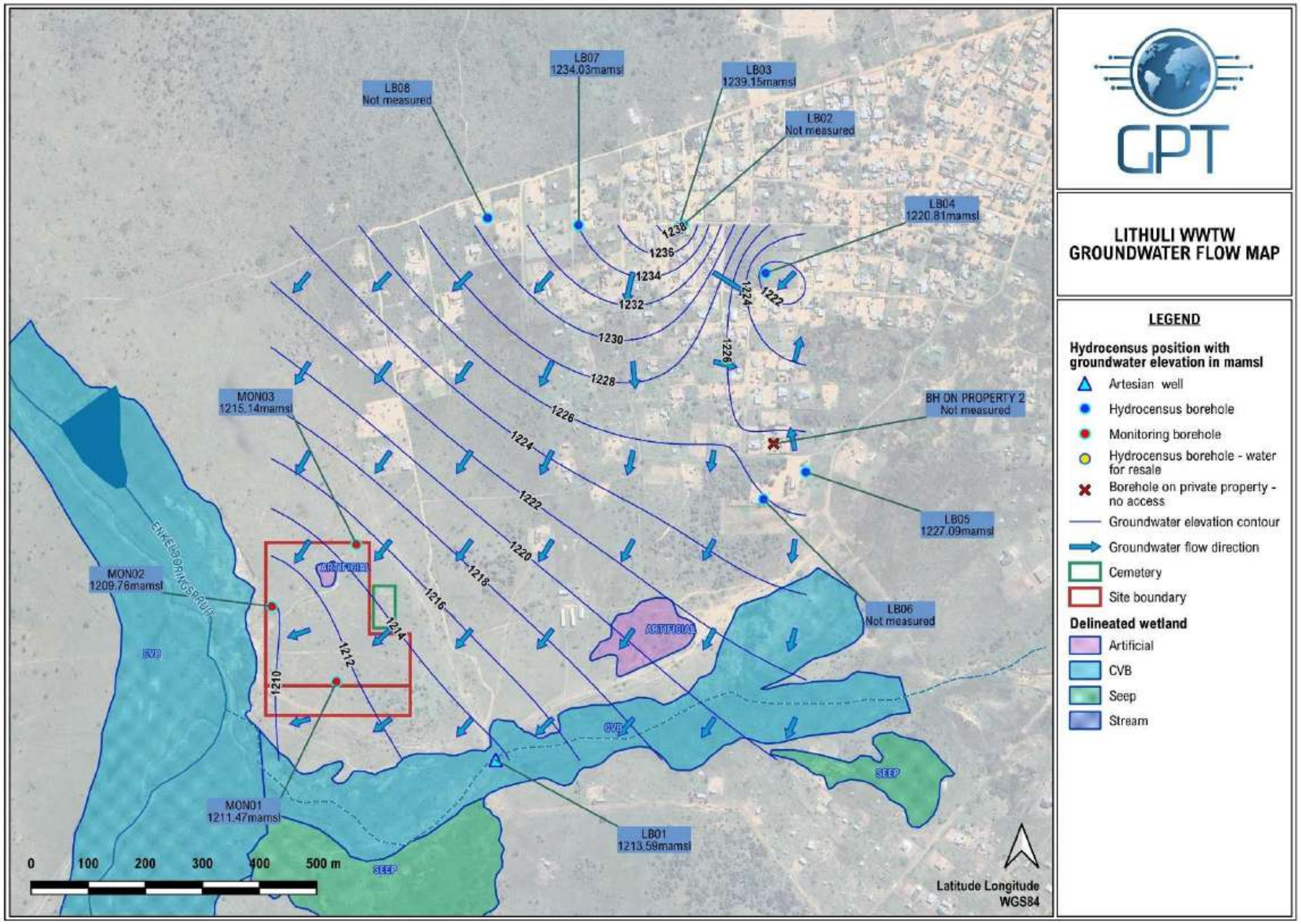


Figure 9: Contoured water levels of the water table.

8 GEOPHYSICS

In order to delineate and target geological structures that may act as preferential groundwater flow paths, a ground geophysical survey was conducted. The survey was done using electromagnetic and magnetic methods.

8.1 Magnetic Survey

Many earth materials contain magnetic minerals such as magnetite, ilmenite and pyrrhotite. When geological units contain such magnetic minerals, these units may become magnetised by the earth's magnetic field and may then have magnetic fields associated with them. These local magnetic fields that are due to the magnetised geological units will be superimposed on the earth's regional magnetic field. Measurements taken in the vicinity of magnetised geological units will therefore show local variations or departures from the undisturbed magnetic field of the earth. These departures are referred to as anomalies. The shapes of the anomalies are dependent on a number of factors regarding the physical properties and dimensions of the magnetised geological units. By incorporating existing knowledge on the geological conditions at the site being surveyed, the magnetic anomalies recorded during a survey may be interpreted in terms of the local geological conditions.

8.2 EM Survey

The electromagnetic method is based on the principle that time-varying induced electromagnetic radiation of the subsurface will cause electric currents to flow in the subsurface. The currents induced in the subsurface are also time-varying and cause time-varying magnetic fields in the area around the source. The induced magnetic field can be measured and interpreted, and the interpretations can be made regarding the apparent conductivity of the subsurface.

Faults and contact zones generally have a higher porosity than the surrounding rock material. When water naturally flows through these zones it has higher water content than the surrounding area which subsequently causes the area to have a higher apparent electrical conductivity. These areas will be indicated in the data as areas with higher conductivity or lower resistivity values.

8.3 Field Survey

Four (4) electromagnetic and magnetic traverses were conducted outside the study area's boundary, approximately 20 meters from the site fence on each side. The station spacing for both the electromagnetic and magnetic methods was set at 10 meters. The table below provides a summary of the traverse details.

Table 4: Details of ground geophysical traverses.

Line No	Start Coordinate (WGS84)		End Coordinate (WGS84)		Traverse Length (m)	Target Identified at (m)	Drilling Target Coordinates (decimal degrees)	
Traverse 1	-25.386089°	28.686894°	-25.386130°	28.683833°	300	170	-25.385899°	28.685176°
Traverse 2	-25.386013°	28.683755°	-25.383530°	28.683660°	270	150	-25.384672°	28.684001°
Traverse 3	-25.383443°	28.683742°	-25.383149°	28.686516°	270	190	-25.383721°	28.685402°
Traverse 4	-25.383152°	28.686618°	-25.386087°	28.686727°	320	none	-	-

The following figures present the results of the EM and magnetic surveys, aligning them according to similar distances and allowing easy visually comparison. The magnetic data is presented as magnetic field strength (in nanotesla) plotted against distance, while the electromagnetic (EM) results are shown as conductivity (in milli Siemens per meter) plotted against distance. Additionally, the data is plotted with an aerial map showing the extent of the traverses.

The green arrow on the figures indicates the selected drilling target location, identified based on observed data trends in both the magnetic and resistivity profiles and preferred borehole locations according to site infrastructure layout.

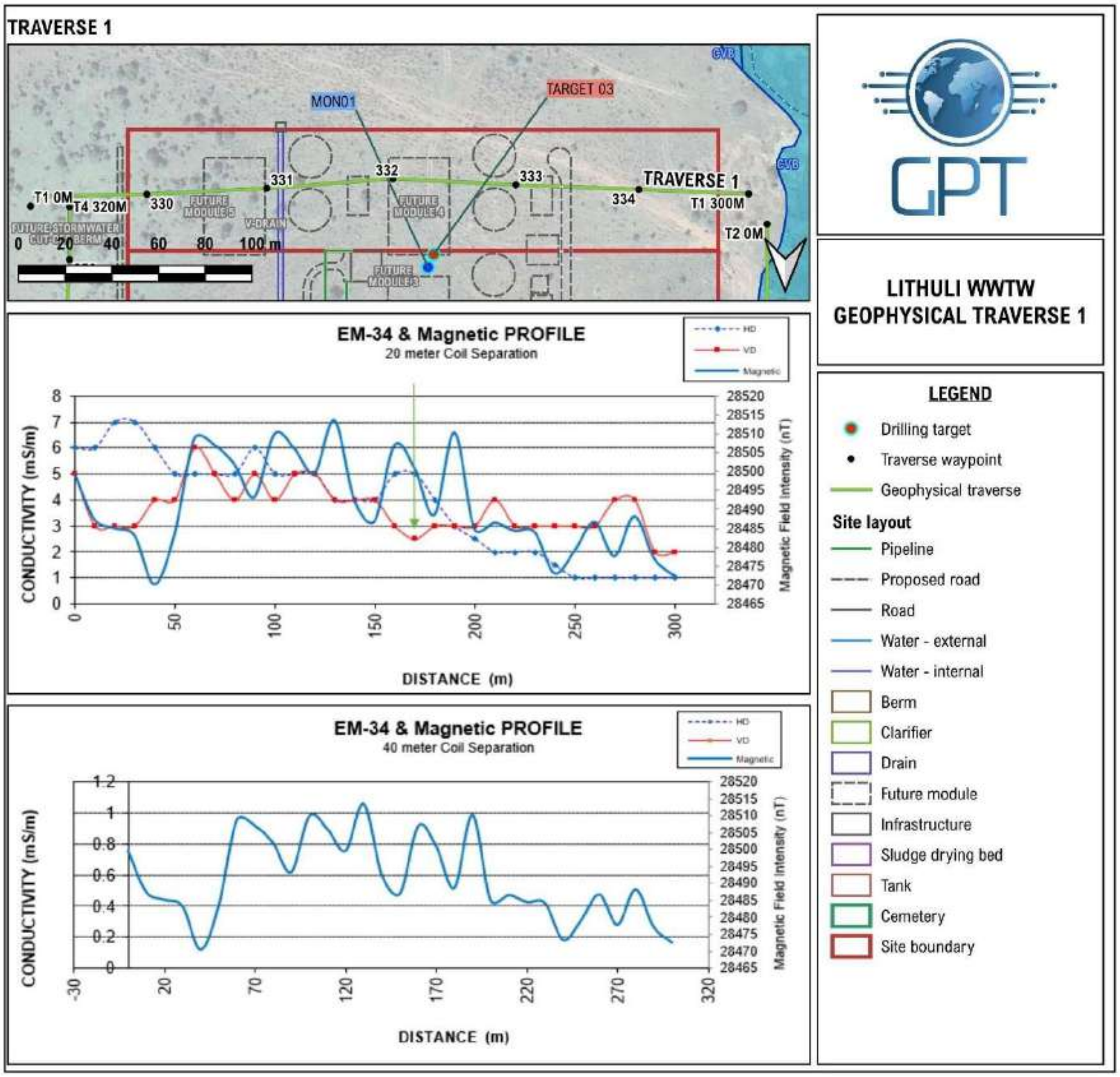


Figure 10: Map showing the location of the geophysical traverse and geophysical results for Traverse 1.

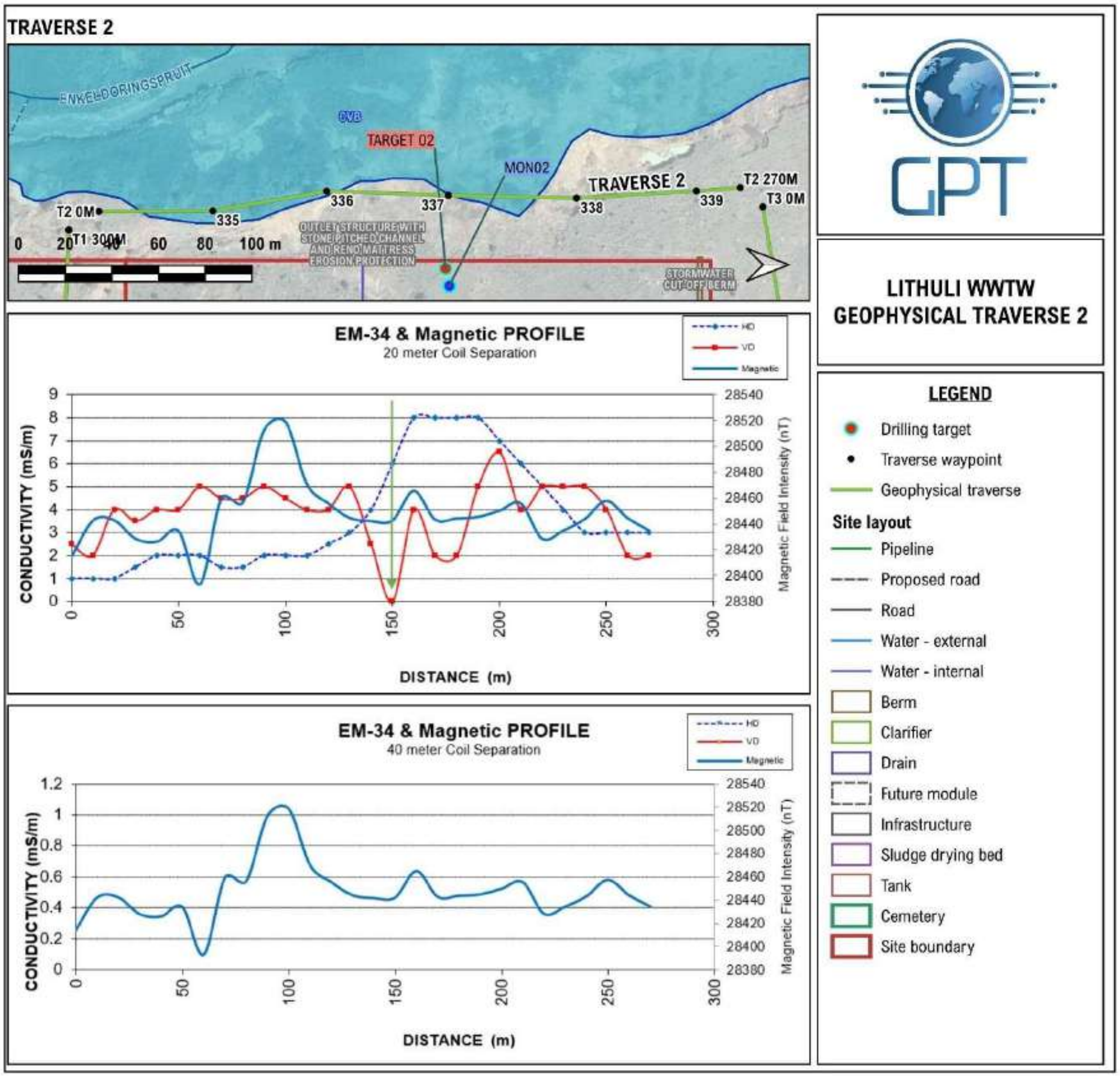


Figure 11: Map showing the location of the geophysical traverse and geophysical results for Traverse 2

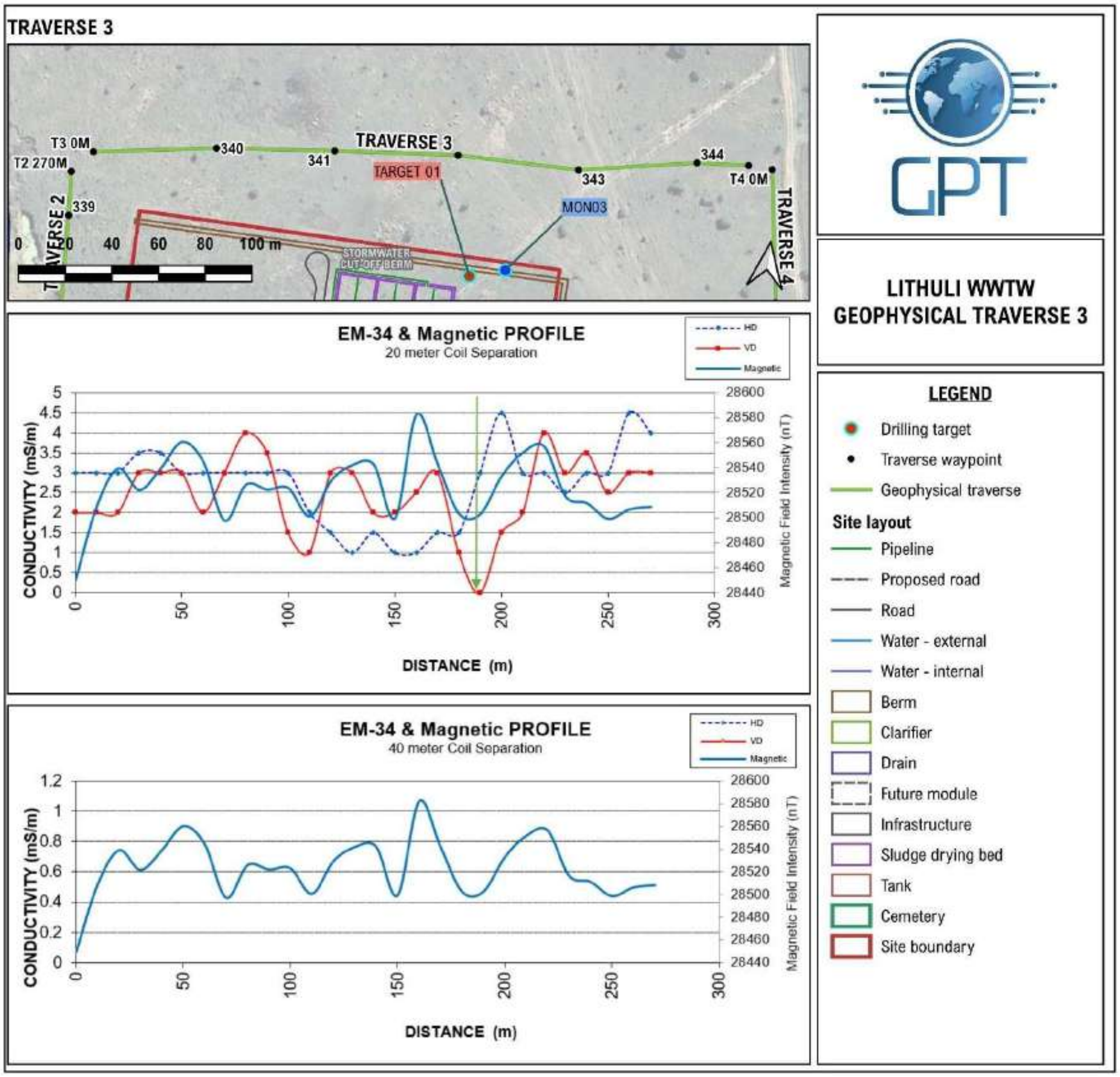


Figure 12: Map showing the location of the geophysical traverse and geophysical results for Traverse 3

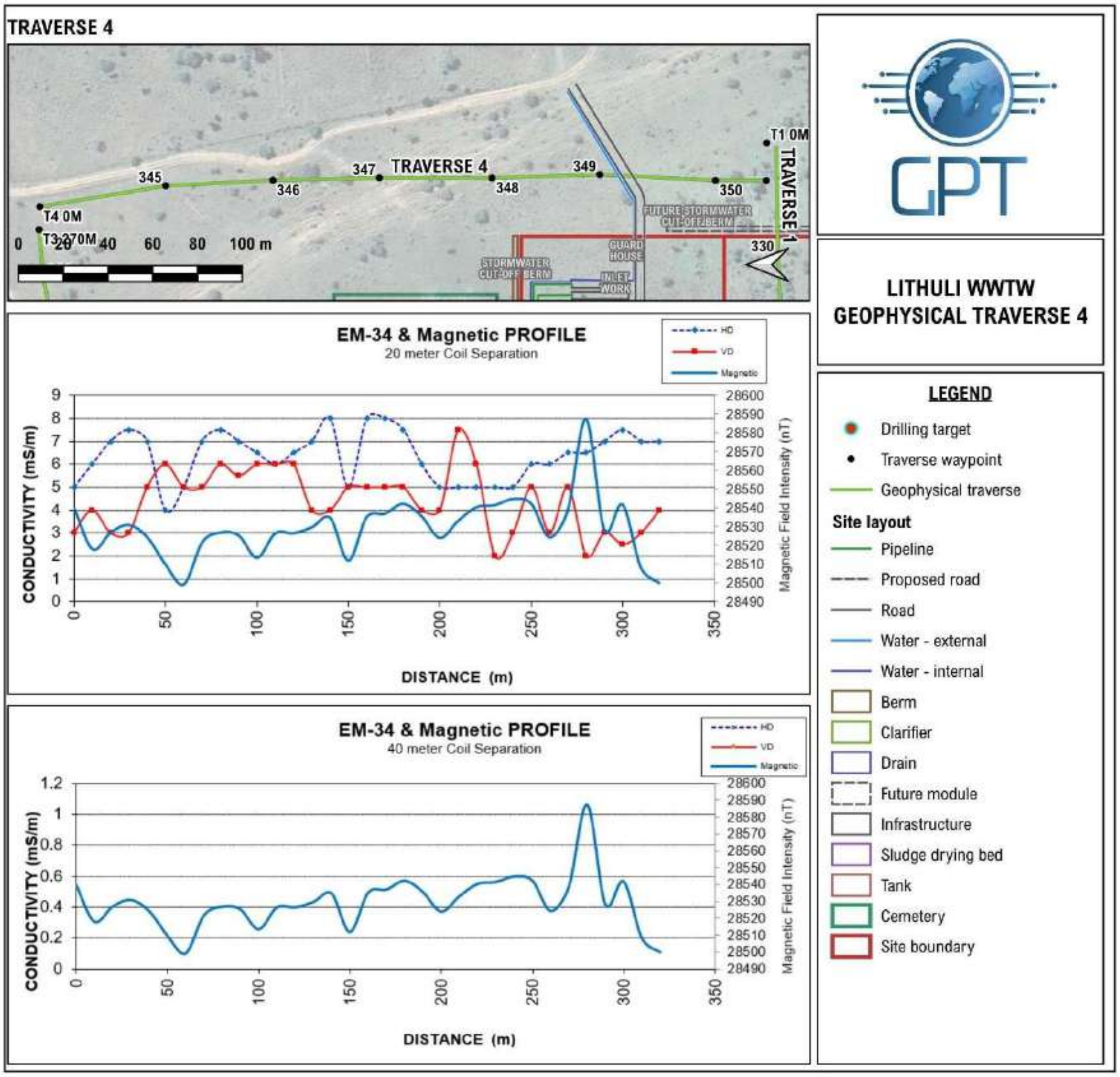


Figure 13: Map showing the location of the geophysical traverse and geophysical results for Traverse 4

9 BOREHOLE DRILLING

Based on targets identified during the geophysical survey, three drilling locations were selected and drilled between 21 and 22 August 2025. The target from Traverse 1 was drilled and designated as MON01, Traverse 2 as MON02, and Traverse 3 as MON03. The naming convention "MON" refers to "Monitoring Borehole," followed by a numerical identifier.

All three boreholes were drilled using a 165 mm bit to a depth of 30m and fitted with 125 mm UPVC casing. The table below gives a breakdown of the depths and type of PVC screen installation. A bentonite seal was installed within the first meter, and for the headworks, a concrete plinth, marker pole, and a lockable casing cap were added. The bentonite seal prevents surface water infiltration into the groundwater by blocking the preferential flow path created during drilling through the geological layers. The drilling of the boreholes was supervised by a qualified hydrogeologist, who recorded essential information, including the geological profile, geological zones, water strikes, borehole depth, and casing installation. The locations of the boreholes are shown in Figure 6, and details of each borehole are presented in Table 3. Photos of the completed boreholes are shown in Photo 2 to Photo3.

During drilling, no waters strikes were encountered, and the boreholes could therefore not be developed however, seepage was encountered in all three boreholes. Each borehole is considered successful, with sufficient water for sampling as part of the groundwater monitoring program. The lithology encountered during drilling validates the geological series maps and is characteristic of the Nebo Granite Suite. The drilling logs are presented in Figure 15 and Figure 16 below and further detail the geology encountered at the drilling locations.

Table 5. Details of the monitoring boreholes drilled at the proposed Luthuli WWTW.

BH ID.	Coordinates (WGS84)		Borehole Depth (m)	Casing Installation	Static water level (mbgl)
MON01	-25.385849°	28.685200°	30	0-2m Solid Screen 2-30m Perforated Screen	2.82
MON02	-25.384657°	28.684076°	30	0-2m Solid Screen 2-30m Perforated Screen	2.25
MON03	-25.383679°	28.685550°	30	0-2m Solid Screen 2-30m Perforated Screen	3.36

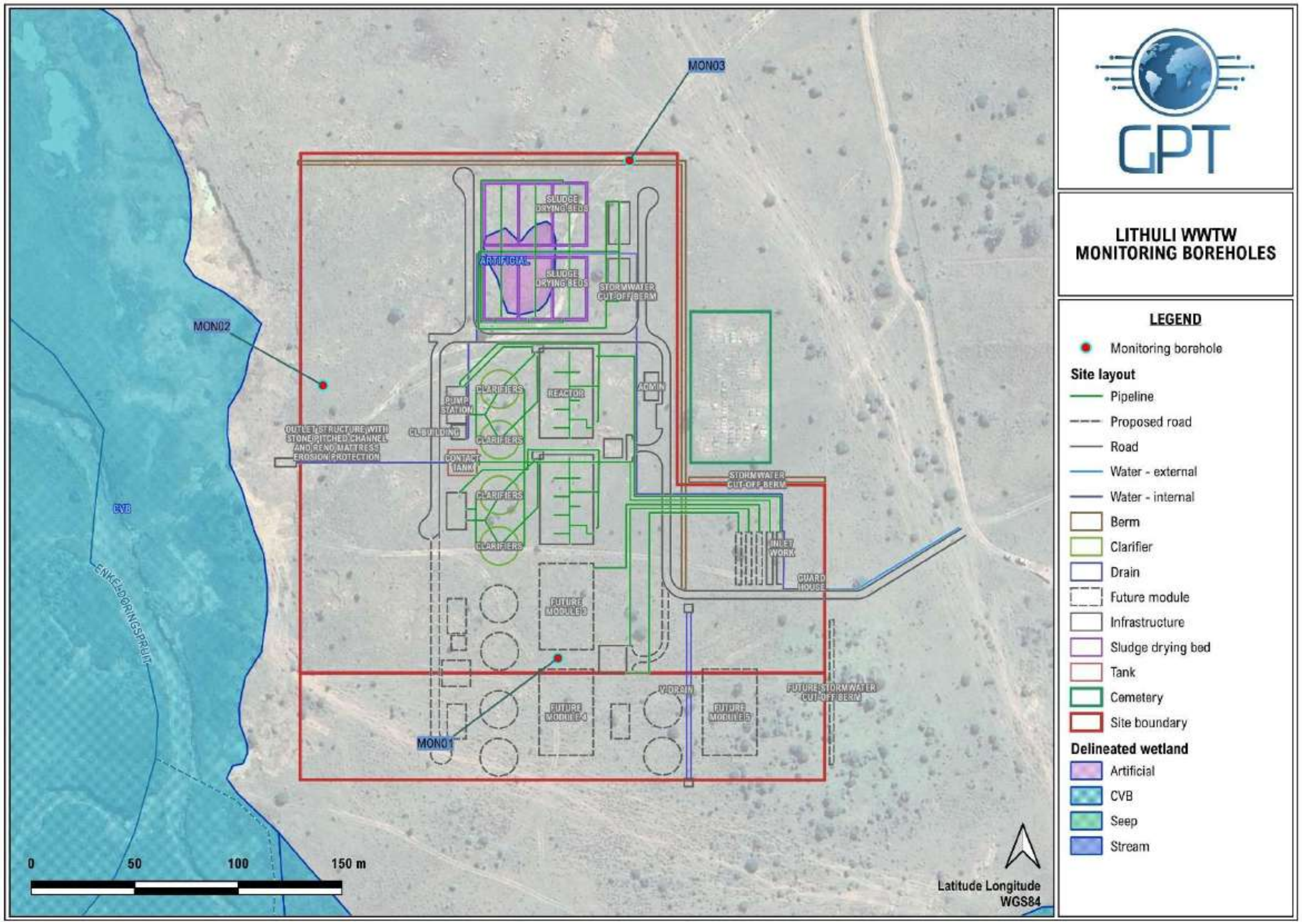


Figure 14: Location of newly drilled monitoring boreholes.

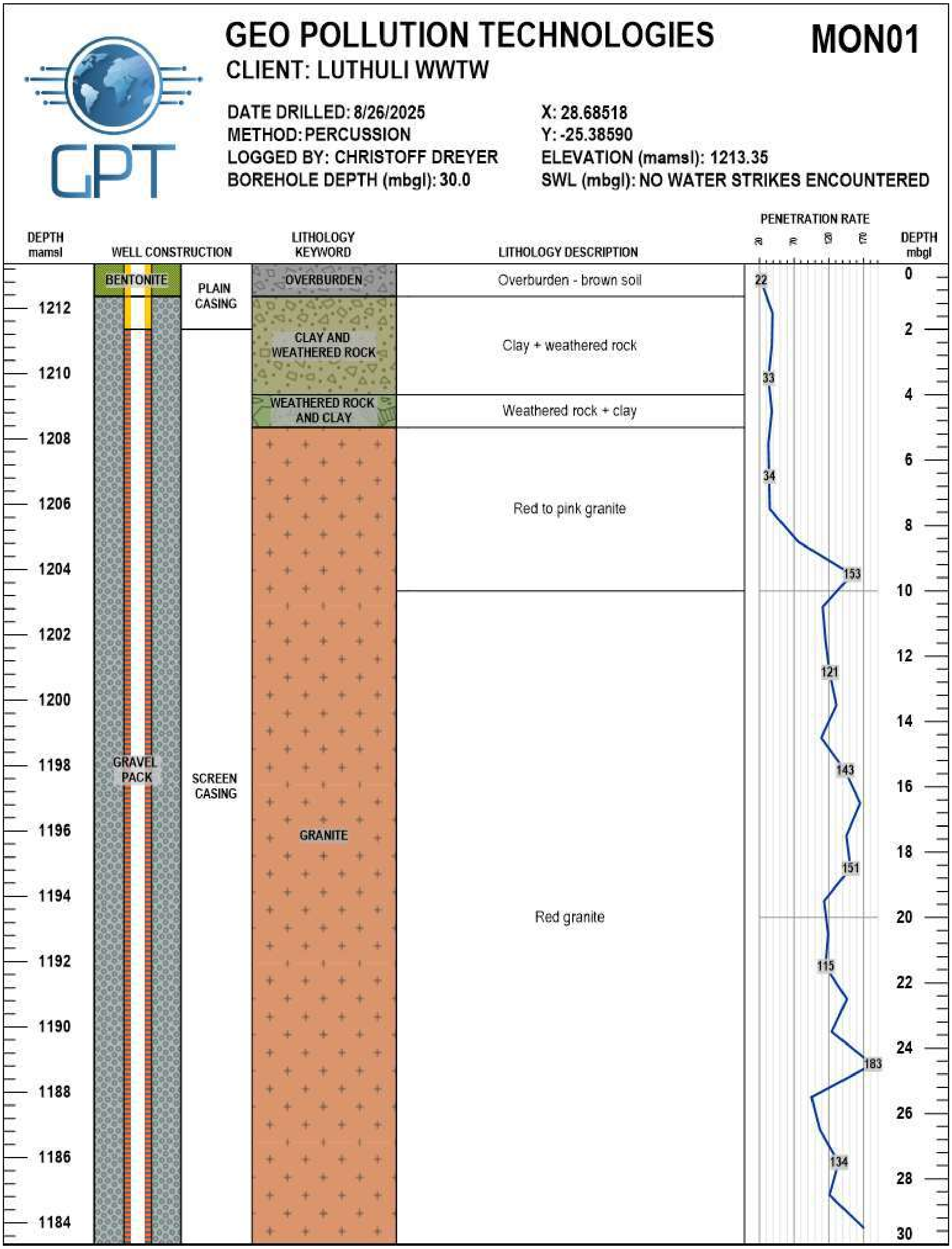


Figure 15: MON01 Borehole Log

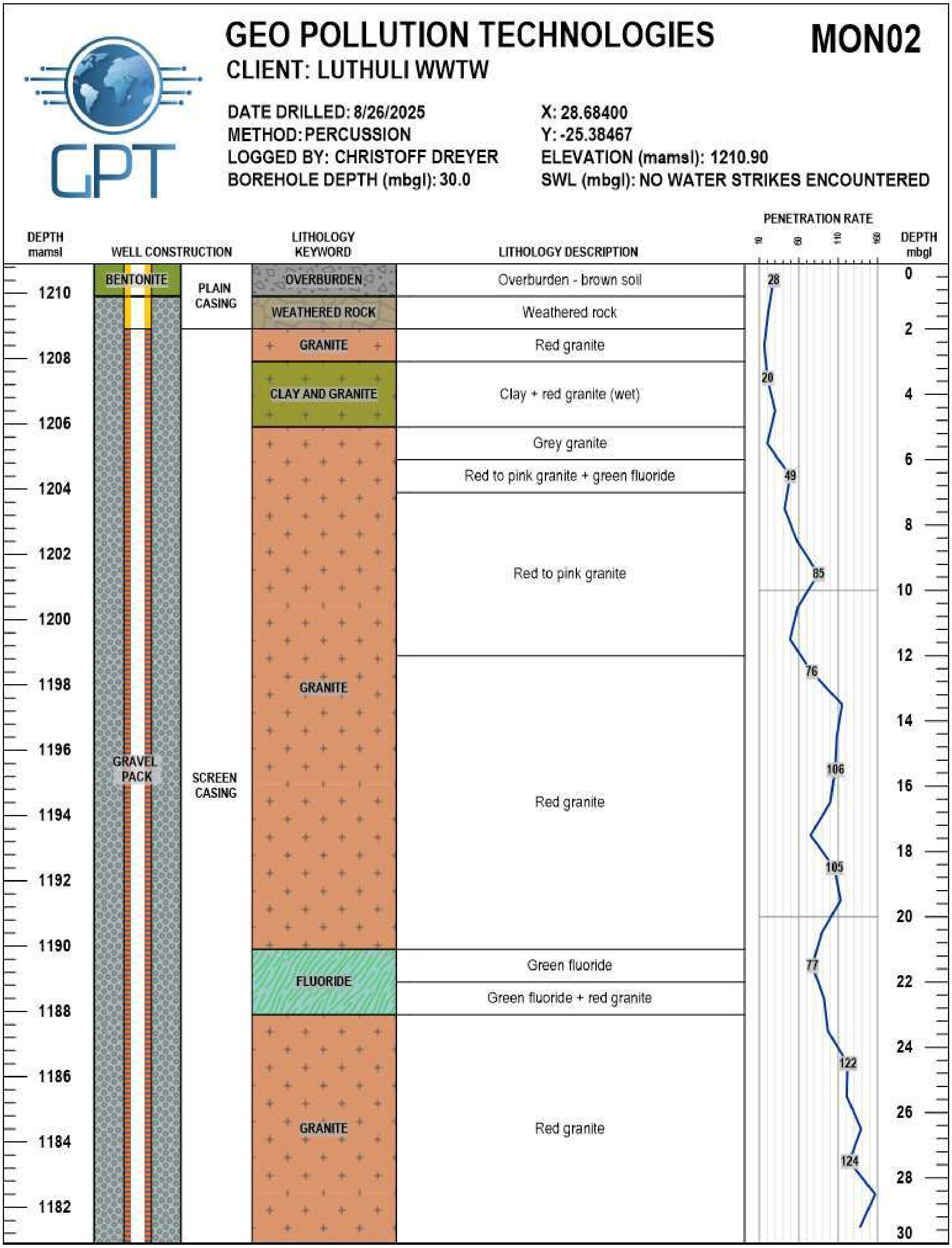


Figure 16: MON02 Borehole Log

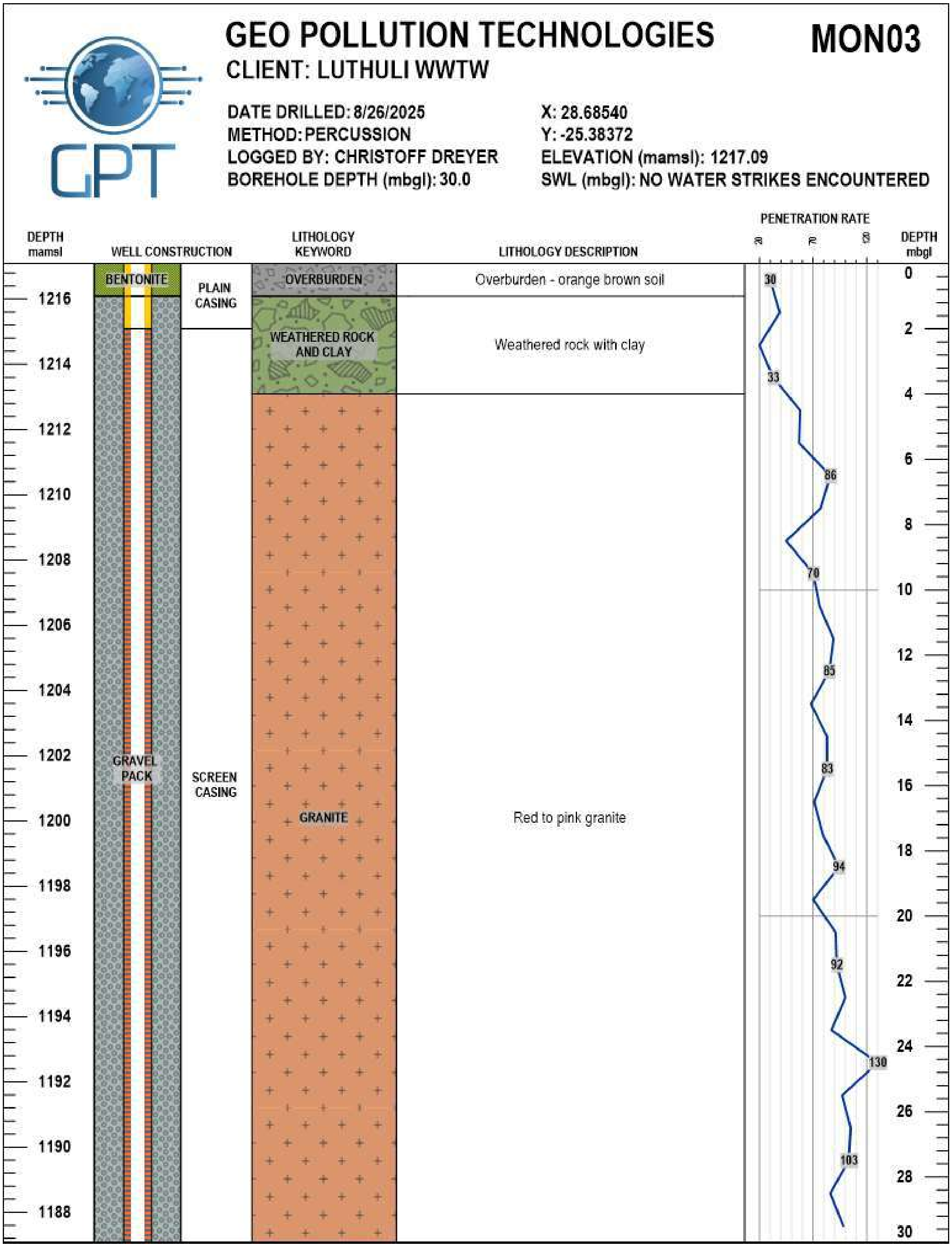


Figure 17: MON03 Borehole Log

Photo 2: MON01 after complete installation

Photo 3: MON02 after complete installation

Photo 4: MON03 after complete installation

10 FALLING HEAD TESTS

Aquifer testing was conducted on the drilled monitoring boreholes. The testing was conducted through falling head tests.

Falling head tests are conducted in boreholes as an initial estimate of the hydraulic conductivity of the porous media directly surrounding the well. In these tests, a sudden water level change is introduced by adding or removing a volume of water (slug), and the recovery rate of the water level is monitored. While this method offers valuable information on the permeability of the immediate subsurface, it has the limitation of only assessing the hydraulic conductivity close to the well, which may not represent larger-scale conditions across the entire site[5].

During the testing, a datalogger was lowered into the well, and logging was initiated to record pressure at 20-second intervals. A slug was then introduced into the well, creating a temporary rise in water level, which was monitored as it subsided. The hydraulic conductivity was subsequently estimated using the Flow Characteristic (FC) Programme for Aquifer Test Analysis[6], developed by

[5] Kresic, N. (2010). *Hydrogeology 101: Introduction to Groundwater Science and Engineering*. Retrieved from: https://www.un-igrac.org/sites/default/files/resources/files/Kresic_Hydrogeology_101_rev-1-Optimised.pdf

[6] University of the Free State, Faculty of Natural and Agricultural Sciences, Institute for Groundwater Studies (IGS). https://www.ufs.ac.za/natagri/departments-and-divisions/institute-for-groundwater-studies-(igs)-home/boreholes/free-pumping-test-programme

Prof. Gerrit van Tonder, Dr. Modreck Gomo, and Mr. Fanie de Lange at the Institute for Groundwater Studies (IGS). The results of the falling head tests are presented in the abbreviated graphs below.

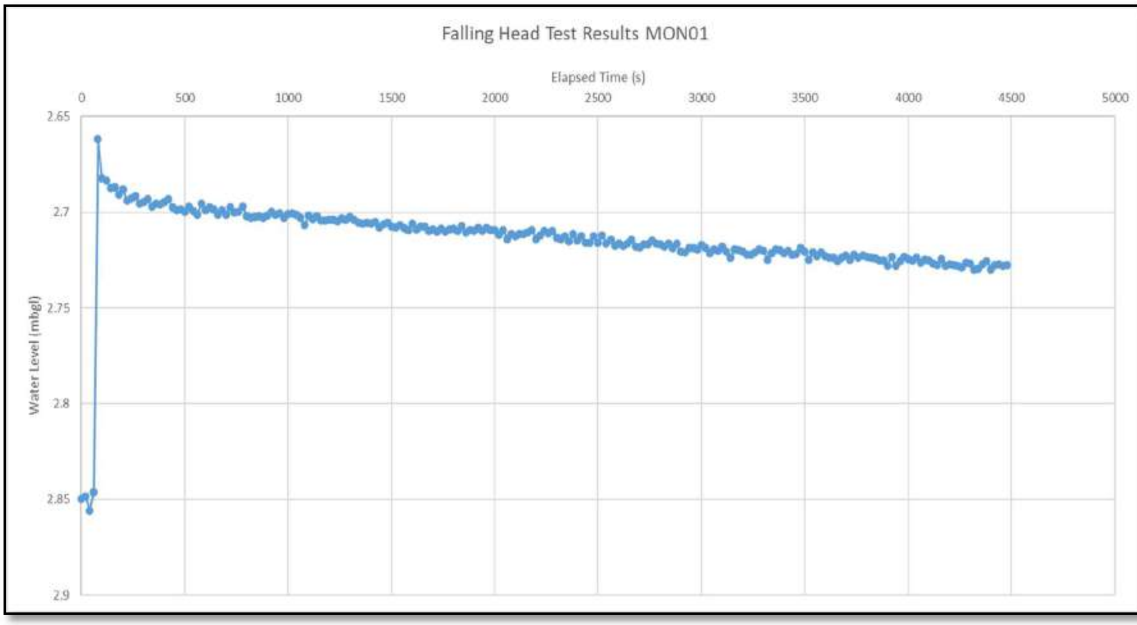


Figure 18: MON01 Test Results

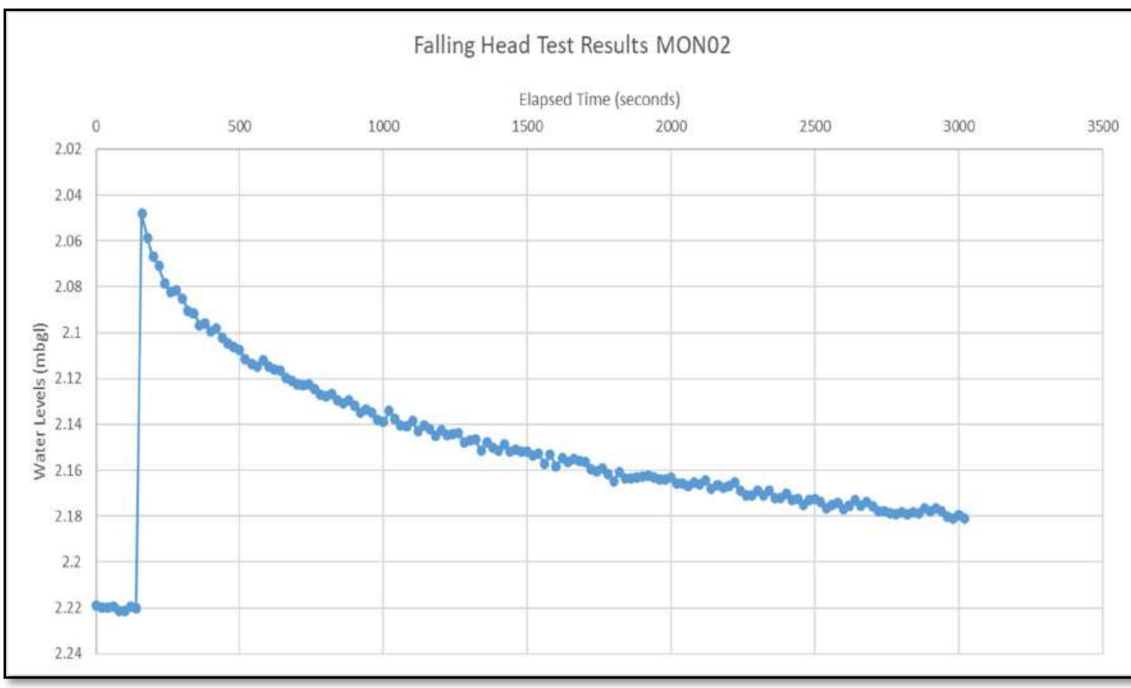


Figure 19: MON02 Test Results

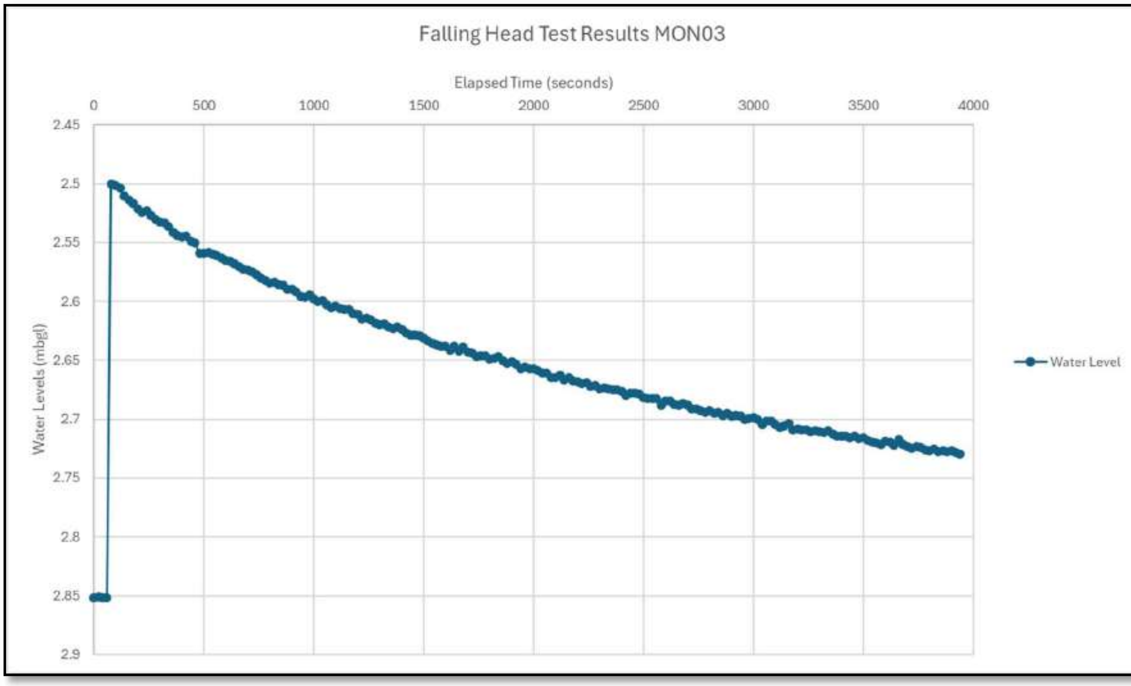


Figure 20: MON03 Test Results

Data acquired from the falling head tests was used to calculate the hydraulic conductivity (K). The table below outlines the parameters used in the hydraulic conductivity estimations along with the resulting calculated values. Hydraulic conductivity provides an indication of the ease with which water moves through the subsurface and is used to calculate rates of groundwater movement. The hydraulic conductivities at the site range from 0.0054 to 0.0186 m/d.

Table 6: Hydraulic Conductivity Estimate and Parameters

Borehole ID	Radius of the borehole (m)	Distance from Water level to the end of the open well screen (m)	Length of well screen open to flow (m)	Estimated Hydraulic Conductivity (m/d)
MON01	0.0625	27.15	27.15	0.0054
MON02	0.0625	27.78	27.78	0.0186
MON03	0.0625	26.64	26.64	0.0102

Hydraulic conductivity (K) measured in m/d can be defined as: *"the volume of a fluid passing through a porous medium in a unit time under a specific hydraulic gradient and moving through a unit area perpendicular to the flow direction."*. Darcy's flow equation was used to calculate the groundwater flow velocity on-site. Darcy's Law states that the rate of flow through a porous medium is proportional to the loss of head, and inversely proportional to the length of the flow path. Alternatively, Darcy's Law can be rewritten to be defined by the following equation:

V = (Ki)/n

Where:

V = Flow velocity

K = Hydraulic Conductivity

i = Groundwater gradient/surface slope

n = Porosity

The groundwater flow velocity was calculated using:

- an estimated groundwater gradient of 3% to 12,5%, determined from the general slope between the site elevation and the river at the boundary.
- the highest obtained K-value calculated for the site assuming a worst-case scenario
- and a maximum porosity of 5% (0.05)[1] from literature. [7].

The groundwater flow velocity on-site was calculated to be between:

V = (0.0186 x 0.03)/0.05 = 0.01 m/d	V = (0.0186 x 0.125)/0.05 = 0.05 m/d

Based on Darcy's flow equation; potential pollutants originating from the wastewater treatment works and seeping to the groundwater would migrate at an estimated rate of 0.01 to 0.05 m/d towards the Enkeldoringspruit. This suggests a slow rate of pollution movement. The risk to the downgradient stream is reduced due to the low permeability of the underlying clay and granite geology, as well as the relatively flat topography. However, the shallow groundwater table, at approximately 5.27 m below ground level, increases the potential risk of groundwater contamination. This risk can be mitigated through the implementation of appropriate management and control measures.

11 GROUNDWATER QUALITY

Groundwater samples were collected from two hydrocensus boreholes on August 28th and the 3 newly drilled monitoring wells on the 22nd of August and sent for analysis. The chemical analysis results were compared to the SANS 241-1:2015[8] drinking water quality guidelines (Table 7). The guidelines stipulate the following risks:

- Acute Health: Determinant that poses an immediate unacceptable health risk if present at concentrations exceeding the limits.
- Aesthetic: Determinant that affects water taste, odor, or color but does not pose an unacceptable health risk if present at concentrations exceeding the limits.
- Chronic Health: Determinant that poses an unacceptable health risk if ingested over an extended period at concentrations exceeding the limits.
- Operational: Determinant that that is essential for assessing the efficient operation of treatment systems and risks to infrastructure.

[7] Kruseman, G.P., & de Ridder, N.A. (1991). *Analysis and Evaluation of Pumping Test Data* (2nd ed., completely revised).

[8] SANS 241-1:2015 (edition2).

The analysis revealed the following exceedances:

- Fluoride: Exceeds the chronic health limit in borehole LB01, MON01, MON02, and MON03
- Iron: Iron levels in borehole MON01, MON02, and MON03 exceed aesthetic limits.
- Manganese: Manganese concentrations exceed the aesthetic limits in MON02 and MON03.
- Aluminium: Exceeds the Operational limits for LB07, MON01, MON02, and MON03
- E. coli: E. coli was detected in MON01, MON02, and MON03 and exceeded the Acute health limits
- Total Coliforms: All concentrations exceed the operational limit of 10 cfu/100ml. Extremely high concentrations were noted in the newly drilled borehole MON01, MON02 and MON03.

The three newly drilled wells show extremely high concentrations of E. coli and faecal coliforms. These three boreholes are newly drilled boreholes and since the WWTW is not yet in operation, such high values are regarded as anomalous, since such high values were not observed in the up and downstream samples taken during the hydrocensus.

The boreholes in question were not developed during drilling due to a lack of water strikes. After a few days, however, sufficient seepage allowed for proper water sampling. The presence of *Escherichia coli* in the samples confirms the presence of faecal contamination, likely from warm-blooded animals. This could possibly be attributed to:

- o That the site was used as grazing pasture for livestock, such as cows, leaving manure around the site area. The contaminants could have been transported along the shallow soil horizon, which, combined with the relatively low storage capacity of granitic rocks, may have mobilized the contaminants and recharged the borehole.
- o Newly drilled boreholes that haven't been developed can become stagnant. This stagnant environment, particularly if there's organic material present, can promote bacterial growth, including coliforms. If the borehole wasn't flushed or purged, the first water samples can reflect localized microbial bloom rather than the true aquifer conditions.
- o A graveyard is located immediately to the east of the site, which might influence the water quality.
- o Anthropogenic influences can't be excluded.

The boreholes should therefore be purged and resampled before operation starts to ensure that the water quality results accurately reflect the conditions prior to operation on site.

Additional constituents analysed for and not reported in the comparison table can be viewed in Appendix II.

Table 7: Water quality analysis vs SANS 241 2015 Drinking Water Quality

Determinant	Risk	Unit	Standard limits	LB 01	LB 07	MON 01	MON 02	MON 03
Physical and aesthetic determinants								
Conductivity at 25 °C	Aesthetic	mS/m	170	33,6	14,1	35,7	30,4	42,1
Total dissolved solids	Aesthetic	mg/L	1 200	235	99	250	213	295
pH at 25 °C [b]	Operational	pH units	5 to 9.7	7,98	6,96	7,53	7,44	7,34
Chemical determinants — macro-determinants								
Nitrate as N (NO_3 - N)	Acute health	mg/L	11	BDL	5,98	BDL	BDL	BDL
Nitrite as N (NO_2 - N)	Acute health	mg/L	0,9	BDL	BDL	BDL	BDL	BDL
Sulfate as SO_4^{2-}	Acute health	mg/L	500	4,82	6,28	12,05	8,55	4,26
	Aesthetic	mg/L	250	4,82	6,28	12,05	8,55	4,26
Fluoride as F^-	Chronic health	mg/L	1,5	7,98	0,21	2,54	3,24	2,97
Ammonia as N	Aesthetic	mg/L	1,5	BDL	BDL	0,28	0,05	0,05
Chloride as Cl^-	Aesthetic	mg/L	300	30,37	20,99	22,88	25,44	42,25
Sodium as Na	Aesthetic	mg/L	200	72,03	20,09	51,09	42,35	58,59
Zinc as Zn	Aesthetic	mg/L	5	BDL	BDL	0,08	BDL	BDL
Chemical determinants — micro-determinants								
Arsenic as As	Chronic health	mg/L	0,01	BDL	BDL	BDL	BDL	BDL
Boron as B	Chronic health	mg/L	2,4	BDL	BDL	BDL	BDL	BDL
Total chromium as Cr	Chronic health	mg/L	0,05	BDL	BDL	BDL	BDL	BDL
Copper as Cu	Chronic health	mg/L	2	BDL	BDL	BDL	BDL	BDL
Iron as Fe	Aesthetic	mg/L	0,3	BDL	0,11	0,76	0,69	0,7
Lead as Pb	Chronic health	mg/L	0,01	BDL	BDL	BDL	BDL	BDL
	Chronic health	mg/L	0,4	BDL	BDL	BDL	BDL	BDL
Manganese as Mn	Aesthetic	mg/L	0,1	BDL	BDL	0,06	0,13	1,19
Nickel as Ni	Chronic health	mg/L	0,07	BDL	BDL	BDL	BDL	BDL
Aluminium as Al	Operational	mg/L	0,3	0,05	0,4	2,12	1,77	0,39
Microbiological determinants								
E. coli [a] or faecal coliforms [b]	Acute health	cfu/100 mL	0	0	0	200	1350	25
Total coliforms [d]	Operational	cfu/100 mL	10	38	115	40000	770000	50000
BDL = Below Detection Limit								

12 SPATIAL ANALYSIS OF GROUNDWATER CHEMISTRY

The results from the chemical analyses were plotted on a pie diagram in Figure 21.

The pie charts show both the individual ions present in a water sample and the total ion concentrations in mg/ℓ. The scale for the radius of the circle represents the total ion concentrations, while the subdivisions represent the individual ions. It is very useful in making quick comparisons between waters from different sources and presents the data in a convenient manner for visual inspection.

From the map the following can be seen:

- The dominant anion in borehole MON01, MON02, MON03 and LB01 is bicarbonate, and the cation is sodium and calcium, while the dominant anion in LB07 is chloride and the dominant cation is sodium and potassium.
- This indicates a similar signature in Background monitoring borehole LBO1 and the three newly drilled onsite boreholes.

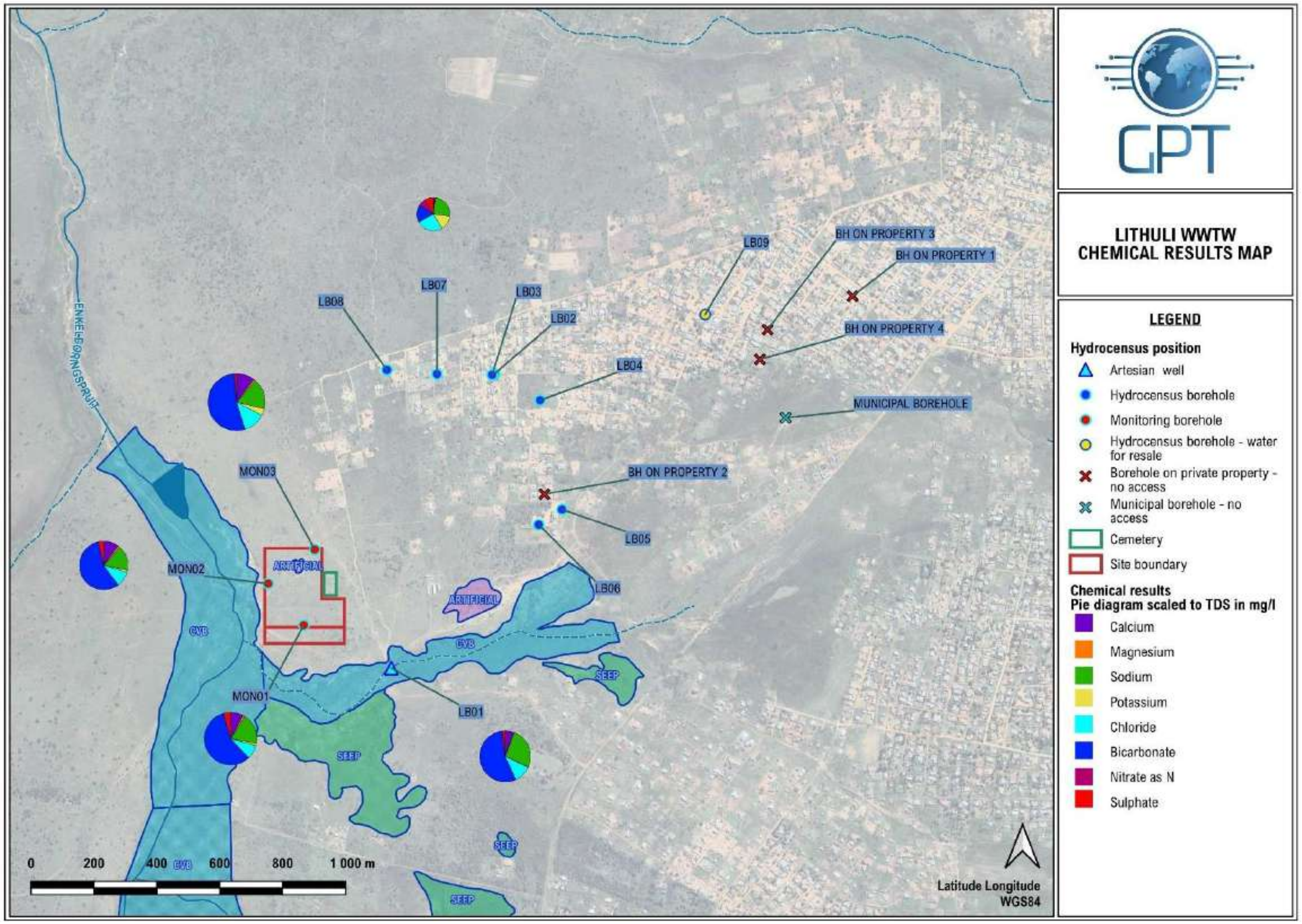


Figure 21: Pie Diagram Map

13 AQUIFER CHARACTERISATION

The term aquifer refers to a strata or group of interconnected strata comprising of saturated earth material capable of conducting groundwater and of yielding usable quantities of groundwater to boreholes and /or springs (Vegter, 1994). In the light of South Africa's limited water resources, it is important to discuss the aquifer sensitivity in terms of the boundaries of the aquifer, its vulnerability, classification and finally protection classification, as this will help to provide a framework in the groundwater management process.

13.1 Aquifer Vulnerability

Aquifer vulnerability assessment indicates the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. Stated in another way, it is a measure of the degree of insulation that the natural and manmade factors provide to keep contamination away from groundwater.

- Vulnerability is high if natural factors provide little protection to shield groundwater from contaminating activities at the land surface.
- Vulnerability is low if natural factors provide relatively good protection and if there is little likelihood that contaminating activities will result in groundwater degradation.

The following factors influence groundwater vulnerability:

- Depth to groundwater: Indicates the distance and time required for pollutants to move through the unsaturated zone to the aquifer.
- Recharge: The primary source of groundwater is precipitation, which aids the movement of a pollutant to the aquifer.
- Aquifer media: The rock matrices and fractures which serve as water bearing units.
- Soil media: The soil media (consisting of the upper portion of the vadose zone) affects the rate at which the pollutants migrate to groundwater.
- Topography: Indicates whether pollutants will run off or remain on the surface allowing for infiltration to groundwater to occur.
- Impact of the vadose zone: The part of the geological profile beneath the earth's surface and above the first principal water-bearing aquifer. The vadose zone can retard the progress of the contaminants.

The Groundwater Decision Tool (GDT) was used to quantify the vulnerability of the aquifers underlying the site using the below assumptions.

- Depth to groundwater below the site was estimated from water levels measured within the 500m radius during the hydrocensus inferred to be at mean of ~5.27 mbgl.
- Groundwater recharge of 3.6%.
- Sandy-clayey loamy clay (Sa-Cl-Lm-Cl) vadose zone.
- Gradient of 0.2% were assumed and used in the estimation.

The aquifer vulnerability for a contaminant released from surface to a specified position in the groundwater system after introduction at some location above the uppermost aquifer was determined using the criteria described below and assuming a worst-case scenario:

- Highly vulnerable (> 60), the natural factors provide little protection to shield groundwater from contaminating activities at the land surface.
- Medium Vulnerable = 30 to 60%, the natural factors provide some protection to shield groundwater from contaminating activities at the land surface, however based on the contaminant toxicity mitigation measures will be required to prevent any surface contamination from reaching the groundwater table.
- Low Vulnerability (< 30 %), natural factors provide relatively good protection and if there is little likelihood that contaminating activities will result in groundwater degradation.

The GDT calculated a vulnerability value of 54%, classifying the underlying aquifers at the site as having a medium vulnerability to contamination.

13.2 Aquifer Classification

The aquifer(s) underlying the subject area were classified in accordance with "A South African Aquifer System Management Classification, December 1995. [9]"

The main aquifers underlying the area were classified in accordance with the Aquifer System Management Classification document. The aquifers were classified by using the following definitions:

- Sole Aquifer System: An aquifer which is used to supply 50% 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 (Electrical Conductivity of less than 150 mS/m).
- 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 groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Based on that the location of the site the aquifer system in the area is classified as a Minor Aquifer System.

In order to achieve the Aquifer System Management and Second Variable Classifications, as well as the Groundwater Quality Management Index, a points scoring system as presented in Table 8 and Table 9 was used.

Table 8: Ratings – Aquifer System Management and Second Variable Classifications

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	
Major Aquifer System:	4	
Minor Aquifer System:	2	2
Non-Aquifer System:	0	
Special Aquifer System:	0 – 6	
Second Variable Classification (Weathering/Fracturing)		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

Table 9: Ratings – Groundwater Quality Management (GQM) Classification System

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

As part of the aquifer classification, a Groundwater Quality Management (GQM) Index is used to define the level of groundwater protection required. The GQM Index is obtained by multiplying the rating of the aquifer system management and the aquifer vulnerability. The GQM index for the study area is presented in Table 10.

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 **medium.**

The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

= 2 x 2 = 4

Table 10: GQM Index for the Study Area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 – 3	Low Level	
3 – 6	Medium Level	4
6 – 10	High Level	
>10	Strictly Non-Degradation	

13.3 Aquifer Protection Classification

A Groundwater Quality Management Index of 4 was estimated for the study area from the ratings for the Aquifer System Management Classification. According to this estimate a **medium level groundwater protection** is required for the aquifer. Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.

DWS's water quality management objectives are to protect human health and the environment. Therefore, the significance of this aquifer classification is that measures must be taken to limit the risk to the following environments.

- The protection of the underlying aquifer.
- The protection of the boreholes in use surrounding the site.
- The protection of the Enkeldoringspruit flowing past the downgradient south-western border of the site.

14 HYDROGEOLOGICAL IMPACTS

It is the aim of this chapter to assess the likely hydrogeological impact that the proposed development might have on the groundwater regime.

14.1 Assessment Criteria

In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project.

An explanation of the impact assessment criteria is defined below.

Table 11: Impact Assessment Criteria

EXTENT	
Classification of the physical and spatial scale of the impact	
Footprint	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Site	The impact could affect the whole, or a significant portion of the site.
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
DURATION	
The lifetime of the impact that is measured in relation to the lifetime of the proposed development.	
Short term	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.
Short to Medium term	The impact will be relevant through to the end of a construction phase (1.5 years).
Medium term	The impact will last up to the end of the development phases, where after it will be entirely negated.
Long term	The impact will continue or last for the entire operational lifetime i.e. exceed 30 years of the development, but will be mitigated by direct human action or by natural processes thereafter.
Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY	
The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself. The intensity is rated as	
Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY	
This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:	
Improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %).
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25 %.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50 %.

Highly Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %.
Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %.

14.1.1 Mitigation

The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

14.1.2 Determination of Significance-Without Mitigation

Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact “without mitigation” is the prime determinant of the nature and degree of mitigation required. Where the impact is positive, significance is noted as “positive”. Significance is rated on the following scale:

Table 12: Significance-Without Mitigation

NO SIGNIFICANCE	The impact is not substantial and does not require any mitigation action.
LOW	The impact is of little importance but may require limited mitigation.
MEDIUM	The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels.
HIGH	The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

14.1.3 Determination of Significance- With Mitigation

Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation is rated on the following scale:

Table 13: Significance- With Mitigation

NO SIGNIFICANCE	The impact will be mitigated to the point where it is regarded as insubstantial.
LOW	The impact will be mitigated to the point where it is of limited importance.
LOW TO MEDIUM	The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels.
MEDIUM	Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.
MEDIUM TO HIGH	The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.
HIGH	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

14.1.4 Assessment Weighting

Each aspect within an impact description was assigned a series of quantitative criteria. Such criteria are likely to differ during the different stages of the project's life cycle. In order to establish a defined base upon which it becomes feasible to make an informed decision, it was necessary to weigh and rank all the criteria.

14.1.4.1 Ranking, Weighting and Scaling

For each impact under scrutiny, a scaled weighting factor is attached to each respective impact. The weighting factor also provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspect criteria.

Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high impact will score a relatively higher weighting than that which is of lower importance.

Table 14: Description of assessment parameters with its respective weighting

EXTENT		DURATION		INTENSITY		PROBABILITY		WEIGHTING FACTOR (WF)		SIGNIFICANCE RATING (SR)	
Footprint	1	Short term	1	Low	1	Improbable	1	Low	1	Low	0-19
Site	2	Short to Medium	2			Possible	2	Low to Medium	2	Low to Medium	20-39
Regional	3	Medium term	3	Medium	3	Likely	3	Medium	3	Medium	40-59
National	4	Long term	4			Highly Likely	4	Medium to High	4	Medium to High	60-79
International	5	Permanent	5	High	5	Definite	5	High	5	High	80-100
MITIGATION EFFICIENCY (ME)						**SIGNIFICANCE FOLLOWING MITIGATION (SFM)**					
High			0.2			Low				0 - 19	
Medium to High			0.4			Low to Medium				20 - 39	
Medium			0.6			Medium				40 - 59	
Low to Medium			0.8			Medium to High				60 - 79	
Low			1.0			High				80 - 100	

14.1.4.2 Identifying the Potential Impacts Without Mitigation Measures (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned weightings, resulting in a value for each impact (prior to the implementation of mitigation measures).

- Significance Rating (WOM) = (Extent + Intensity + Duration + Probability) x Weighting Factor

14.1.4.3 Identifying the Potential Impacts With Mitigation Measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it was necessary to re-evaluate the impact.

14.1.4.4 Mitigation Efficiency (ME)

The most effective means of deriving a quantitative value of mitigated impacts is to assign each significance rating value (WOM) a mitigation efficiency (ME) rating. The allocation of such a rating is a measure of the efficiency and effectiveness, as identified through professional experience and empirical evidence of how effectively the proposed mitigation measures will manage the impact.

Thus, the lower the assigned value the greater the effectiveness of the proposed mitigation measures and subsequently, the lower the impacts with mitigation.

- Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency

or WM = WOM x ME

14.1.4.5 Significance Following Mitigation (SFM)

The significance of the impact after the mitigation measures are taken into consideration. The efficiency of the mitigation measure determines the significance of the impact. The level of impact is therefore seen in its entirety with all considerations taken into account.

14.2 Impact Assessment

Three impact scenarios will be considered in this section and are:

- Construction Phase: The conditions expected to prevail during the construction phase.
- Operational Phase: The conditions expected to prevail during the operation of the site.
- Decommissioning Phase: Ceasing of onsite activities

The impact assessment was conducted based on the available information and the activities described for each project phase. Any activities not accounted for, or additional processes that may arise during the project's lifespan, could affect the findings of this assessment. Should project processes be modified, the impact assessment should be updated accordingly.

14.3 Construction Phase

The construction phase applies to the proposed construction of the Waste Water Treatment Work (WWW), and associated infrastructure, Inlet works (with screening, grit removal and flow measurement facility); Biological reactor; Clarifiers (with pump station to handle return and waste activated sludge); Chlorination facility (with flow measurement prior to river discharge); Sludge drying beds (with supernatant return facility); Main pump station, administration building and an electrical room will also be provided. This will also involve the construction of access and haul roads. This will involve vegetation clearance for the establishment for the above-mentioned infrastructure.

The following interactions, that will be undertaken during the construction phase, could potentially impact the groundwater environment:

- Site clearing, including the removal of vegetation, topsoil and subsoil and the establishment of infrastructure resulting in the potential increase of surface runoff and reduced recharge within cleared areas.
- General construction activities (including use of vehicles and machinery as well as storage and handling of waste and hazardous material) resulting in the potential contamination of the shallow groundwater aquifer due to spillages and leaks.

14.3.1 Groundwater Contamination (Accidental Spills)

The increased activity in the project area to establish the surface infrastructure may result in accidental spillages or leaks from construction vehicles which have the potential to contaminate the shallow groundwater aquifer. The underlying aquifer has a medium vulnerability to contaminants released from surface. Despite the medium vulnerability good housekeeping and the mitigation measures mentioned below are recommended to ensure the impact on the shallow aquifer from accidental spills remains low. The objective of the management measures is to avoid or minimize adverse impacts to the shallow aquifer by avoiding or minimizing pollution from project activities. Proposed mitigation measure are included in Table 16.

Accidental spills can occur for the duration of the project but the impacts will only be discussed under the construction phase. The above-mentioned are to be applied through the life of operations.

14.3.2 Groundwater Resource

During the construction phase site clearing, including the removal of vegetation, topsoil and subsoil and the establishment of infrastructure will take place. This will cause disturbance to the natural landscape, vegetation, topsoil and upper subsoil. As a result of the above-mentioned activities, within the Project area, there will be increased surface runoff and reduced recharge to the underlying aquifer within the built up and disturbed areas.

The objective of the management measures is to ensure that the impact to the underlying aquifer is minimised by restricting the area cleared of vegetation to the minimum, managing the increased surface run-off by allowing clean water to bypass dirty water areas and flow into the natural environment. Proposed mitigation measures are indicated in Table 16

14.3.3 Impact Rating- Construction Phase

The impact assessment determines the significance of potential impacts by evaluating the relevant temporal and spatial scales through the extent, magnitude, and duration criteria and calculates an overall indication of significance. The significance of the hydrogeological impacts, along with the groundwater management and mitigation measures are presented in the table below.

Table 15: Construction phase

Impacts	Aspect	Extent	Duration	Intensity	Probability	Weighting Factor	Significance = Extent + Intensity + Duration + Probability) x Weighting Factor		Mitigation Efficiency (ME)	Significance Rating (WM) = Significance Rating (WOM) × Mitigation Efficiency	
Construction Impacts	Potential hydrocarbon contamination	1	2	1	3	1	7	Low	0.2	1.4	Low
	Erosion due to construction process that disturbs the natural landscape, vegetation, topsoil and subsoil.	2	3	1	4	2	20	Low-Medium	0.6	12	Low

Table 16: Mitigation measures - construction phase

Significance Rating (WOM)	Impact	Management Options	Significance Rating (WM)
Construction Phase			
7	Potential hydrocarbon contamination)	• Maintain vehicles at designated workshops or service bays which are designed to contain any spills of hydrocarbons or grease into oil separation traps. • Wash vehicles at designated wash bays which are designed to contain any oil and grease. • Spill containment kits must be located at workshops and hydrocarbon storage facilities. The spill kits must be maintained in good working order and stock • Hydrocarbon and chemical storage areas and facilities must be located on a hardstanding (paved or concrete) impermeable area which is bunded to contain the • Drip trays must be used when vehicles break down outside of designated workshop or service areas. • Oil and grease collection traps need to be cleaned and emptied to prevent overflow. The condition of the oil and grease collection traps need to be maintained • Chemical and hazardous waste must be disposed of at an appropriate waste facility designed to handle and storage the specific waste material being disposed of. • Train personal and contractors to use the proper site methodology in reporting, handling and disposing of hydrocarbon and chemical waste according to the safety • Groundwater monitoring should be conducted to keep a record of the groundwater quantity and quality trends.	1.4
20	Erosion due to construction process that disturbs the natural landscape, vegetation, topsoil and subsoil.	• Implementation and management of a Storm Water Management Plan (SWMP). • The footprint of the WWTW area must be kept to what is absolutely necessary from a design point of view to minimise the extent of disturbance to the natural landscape, vegetation, topsoil and subsoil.	12

14.4 Operational Phase

The operational phase will involve the development of sludge drying beds, a chlorination facility, clarifiers and any possible releases of effluent from the WWTW. Activities in this phase can also result in accidental hydrocarbon spill that may potentially impact on the hydrogeological environment and resource if not managed. The following interactions, that will be undertaken during the operational phase, could potentially impact on the groundwater environment:

- Deposition of sludge and waste or chemical containment facilities have the potential to generate seepage to the underlying groundwater environment. Poor seepage quality from the sludge drying beds or waste treatment facilities can migrate into the groundwater environment.
- The release of effluent from a Wastewater Treatment Works (WWTW) into the surrounding environment could introduce a variety of contaminants, depending on quality, to the groundwater regime. For groundwater, the main concern is potential seepage of effluent through the soil. Ultimately, the quality of both surface and subsurface water resources can be affected by effluent releases.

14.4.1 Groundwater Contamination (Sludge Drying beds, wastewater containment facilities, clarifiers, biological reactors, Chlorination facility

The Sludge drying beds and wastewater conveyance structures have the potential to generate seepage to the underlying groundwater environment if not properly lined or maintained. Leachate from improperly dried or poorly managed sludge can percolate through the soil and contaminate groundwater. Additionally, wastewater conveyance structures such as pipes or channels can develop leaks, allowing untreated or partially treated wastewater to infiltrate the surrounding soil and reach the groundwater. Damaged liners or bunding at the chlorination facility can result in seepage into the groundwater system and streams nearby. If there is a power outage it can result in overflowing or improper disinfectant.

As mentioned above wastewater can enter the soil and reach the groundwater system, the release of effluent can potentially affect the groundwater regime depending on the quality of the effluent.

As described in Section 6.1 the underlying aquifer has a medium vulnerability to contaminants released from surface. Despite the medium vulnerability good housekeeping and the mitigation measures mentioned below are recommended to ensure the impact on the shallow aquifer from seepage & effluent release remains as low as possible. The objective of the management measures is to avoid or minimize adverse impacts to the shallow aquifer by avoiding or minimizing pollution from project activities. Proposed mitigation measures are included in Table 18.

14.4.2 Impact Rating- Operational Phase

The impact assessment determines the significance of potential impacts by evaluating the relevant temporal and spatial scales through the extent, magnitude, and duration criteria and calculates an overall indication of significance. The significance of the hydrogeological impacts, along with the groundwater management and mitigation measures are presented in the table below.

Table 17: Impact Rating- Operational Phase

Impacts	Aspect	Extent	Duration	Intensity	Probability	Weighting Factor	Significance = Extent + Intensity + Duration + Probability) x Weighting Factor		Mitigation Efficiency (ME)	Significance Rating (WM) = Significance Rating (WOM) × Mitigation Efficiency	
Operational Impacts	Groundwater contamination due to seepage from sludge and waste or chemical containment facilities	3	4	3	4	4	56	Medium	0.4	22.4	Low-Medium
	Possible effluent released into Groundwater, surface water, and/or wetland	3	4	3	4	4	56	Medium	0.4	22.4	Low-Medium

Table 18: Mitigation Measures - Operational Phase

Significance Rating (WOM)	Impact	Management Options	Significance Rating (WM)
Operational Phase			
56	Groundwater contamination due to seepage from sludge and waste or chemical containment facilities and Possible effluent released into Groundwater, surface water, and/or wetland	• Ensure impermeable liners beneath all sludge drying beds to prevent leachate percolation, an install leachate collection systems beneath the sludge drying beds to capture and return supernatant for treatment. All sludge and pollution control facilities must be designed by accredited professionals to best practice guidelines and accepted standards, to limit or prevent seepage to the subsurface. • Prevent leakage or seepage from wastewater conveyance structures by regular inspection and maintenance of pipelines and joints. • Ensure effluent meets legal discharge standards before it is discharged. Maintain and calibrate flow meters. • Establish a groundwater monitoring network and conduct routine sampling on a quaterly basis. • The stormwater management plan in place needs to ensure the capture of dirty water and that it is separated from the clean water, and the stormwater should be diverted away from potential contamination zones using cut-off drains or bunds. Provide stormwater diversion bunds to prevent clean runoff entering drying beds. • Stormwater infrastructure needs to be inspected and maintained throughout the operational phase to ensure continued diversion of clean water and dirty water. • Design the site to prevent ponding • All waste and sludge material should be placed in the designated storage areas. • Contain chlorine and other chemicals on impervious surfaces within a bunded area to prevent accidental leaks entering the ground. Provide spill response kits and protocols for immediate containment. • Regularly inspect and maintain containers, bund walls hardstanding and effluent dams. • Install overflow alarms, flow sensors, and standby pumps. Include emergency storage capacity and develop and test emergency response procedures. Maintain backup power supply (generators) for critical systems. Conduct routine plant inspections and maintenance.	22.4

14.5 Decommissioning Phase.

The decommissioning phase will involve the decommissioning of the plant Rehabilitation and closure of WWTW, and associated infrastructure, office and residential facilities, clarifiers, chlorination facility, and sludge drying beds needs to be in accordance with the rehabilitation and closure plan.

Activities in this phase can also result in accidental hydrocarbon spill that may potentially impact on the hydrogeological environment and resource if not managed (refer to Section 13.1 for the impact rating for accidental spills). The following interactions, that will be undertaken during the decommissioning phase, could potentially impact the groundwater environment:

Demolition and removal of infrastructure and general closure activities (including use of vehicles and machinery) resulting in the potential contamination of the shallow groundwater aquifer due to spillages and leaks.

14.5.1 Groundwater Contamination (Sludge and waste material)

During the decommissioning phase, all infrastructure, including hardstanding's, process areas, and associated wastewater management systems, must be properly dismantled, cleaned, and managed to prevent any potential contamination of soil and groundwater. Residual materials, waste, and chemicals must be safely removed or disposed of in accordance with environmental regulations, and the site should be rehabilitated to ensure long-term protection of water quality. The objective of the management measures is to avoid or minimize adverse impacts to the shallow aquifer by avoiding or minimizing pollution from project activities. Proposed mitigation measure include:

- Rehabilitation and closure of WWTW, and associated infrastructure, office and residential facilities, clarifiers, chlorination facility, and sludge drying beds needs to be in accordance with the rehabilitation and closure plan.
- A closure plan should be developed during the operational phase of the project and should any actions from the closure plan need to be actioned during the operational phase this should be actioned accordingly.
- As a minimum, groundwater monitoring should be monitored frequently during the first 5 years post closure to keep a record of the groundwater quantity and quality trends.

14.6 Impact Rating- Decommissioning Phase Cumulative Impact

The impact assessment determines the significance of potential impacts by evaluating the relevant temporal and spatial scales through the extent, magnitude, and duration criteria and calculates an overall indication of significance. The significance of the hydrogeological impacts, along with the groundwater management and mitigation measures are presented in the table below.

Table 19: Impact Rating- Decommissioning Phase

Impacts	Aspect	Extent	Duration	Intensity	Probability	Weighting Factor	Significance = Extent + Intensity + Duration + Probability) x Weighting Factor		Mitigation Efficiency (ME)	Significance Rating (WM) = Significance Rating (WOM) × Mitigation Efficiency	
Decommissioning Impacts	Groundwater, surface water, and/or wetland contamination	2	2	3	3	4	40	Medium	0.4	16	Low

Table 20: Mitigation Measures- Decommissioning phase

Significance Rating (WOM)	Impact	Management Options	Significance Rating (WM)
Decommissioning Phase			
40	Groundwater, surface water, and/or wetland contamination	• Rehabilitation and closure of WWTW, and associated infrastructure, office and residential facilities, clarifiers, chlorination facility, and sludge drying beds needs to be in accordance with the rehabilitation and closure plan. • A closure plan should be developed during the operational phase of the project and should any actions from the closure plan need to be actioned during the operational phase this should be actioned accordingly. • All contamination sources identified during the decommissioning phase must be remediated or eliminated prior to site closure. • Any areas affected by contamination should be rehabilitated and restored to acceptable environmental standards before final closure. • The decommissioning and demolition of infrastructure such as effluent dams or channels must be carried out in a manner that prevents the release of effluent or wastewater. In the event that any effluent is discharged, it shall comply with applicable legal discharge standards. • As a minimum, groundwater monitoring should be monitored frequently during the first 2 years post closure to keep a record of the groundwater quantity and quality trends.	16

15 GROUNDWATER MONITORING SYSTEM

15.1 Groundwater Monitoring Network

A groundwater monitoring system has to adhere to the criteria mentioned below. As a result the system should be developed accordingly.

15.1.1 Source, plume, impact and background monitoring

A groundwater monitoring network should contain monitoring positions which can assess the groundwater status at certain areas. The boreholes can be grouped classification according to the following purposes:

- **Source monitoring:** Monitoring boreholes are placed close to or in the source of contamination to evaluate the impact thereof on the groundwater chemistry.
- **Plume monitoring:** Monitoring boreholes are placed in the primary groundwater plume's migration path to evaluate the migration rates and chemical changes along the pathway.
- **Impact monitoring:** Monitoring of possible impacts of contaminated groundwater on sensitive ecosystems or other receptors. These monitoring points are also installed as early warning systems for contamination break-through at areas of concern.
- **Background monitoring:** Background groundwater quality is essential to evaluate the impact of a specific action/pollution source on the groundwater chemistry.

15.1.2 System Response Monitoring Network

Groundwater levels: The response of water levels to abstraction is monitored. Static water levels are also used to determine the flow direction and hydraulic gradient within an aquifer. Where possible all of the above-mentioned borehole's water levels need to be recorded during each monitoring event.

15.1.3 Monitoring Frequency

Quarterly monitoring of groundwater quality and groundwater levels is recommended. It is important to note that a groundwater-monitoring network should also be dynamic. This means that the network should be extended over time to accommodate the migration of potential contaminants through the aquifer as well as the expansion of infrastructure and/or addition of possible pollution sources.

15.2 Monitoring Parameters

The identification of the monitoring parameters is crucial and depends on the chemistry of possible pollution sources. They comprise a set of physical and/or chemical parameters (e.g. groundwater levels and predetermined organic and inorganic chemical constituents). Once a pollution indicator has been identified it can be used as a substitute to full analysis and therefore save costs. The use of pollution indicators should be validated on a regular basis in the different sampling positions. The parameters should be revised after each sampling event; some metals may be added to the analyses during the operational phase, especially if the pH drops.

15.2.1 Abbreviated analysis (pollution indicators)

Physical Parameters:

- Groundwater levels

Chemical Parameters:

- Field measurements:
    - pH, EC
- Laboratory analyses:
    - Major anions and cations (Ca, Na, Cl, SO4, NO3, PO4)
    - Other parameters (pH, TDS, EC)
    - Bacteriological indicators (E. coli, faecal coliforms).

15.2.2 Full analysis

Physical Parameters:

- Groundwater levels

Chemical Parameters:

- Field measurements:
    - pH, EC
- Laboratory analyses:
    - Anions and cations (Ca, Mg, Na, K, NO3, NO2, PO4 Cl, SO4, F, Fe, Mn, Al, and Alkalinity)
    - Physical parameters (pH, EC, TDS, COD)
    - Bacteriological indicators (E. coli, faecal coliforms).

15.3 Monitoring Boreholes

DWAF (1998) states that “A monitoring hole must be such that the section of the groundwater most likely to be polluted first, is suitably penetrated to ensure the most realistic monitoring result.”[10]

Three (3) monitoring boreholes have been drilled on site in localities identified to be most preferable for groundwater flow and spatially to intersect any possible contamination originating from onsite operations. In addition, a hydrocensus was conducted for the area, identifying additional boreholes suitable for monitoring. The proposed monitoring network in presented in Table 21. These boreholes are proposed to be monitored on a quaterly basis. Currently no source exist on site as operations has not yet commenced, no source monitoring is therefore included in the proposed monitoring network.

[10] Department of Water Affairs and Forestry (DWAF). (1998). Minimum Requirements for the Water Monitoring at Waste Management Facilities. CTP Book Printers. Cape Town.

However, a monitoring network should be dynamic. This means that the network should be extended over time to accommodate the migration of contaminants through the aquifer as well as the expansion of infrastructure and/or addition of possible pollution sources. An audit on the monitoring network should be conducted bi-annually.

Table 21: Proposed monitoring positions

BH ID	Latitude	Longitude	Reasoning	Frequency
LB01	-25.38709	28.68796	Impact Monitoring	Quarterly
LB07	-25.37865	28.68943	Background Monitoring	Quarterly
MON01	-25.38585	28.68520	Plume Monitoring	Quarterly
MON02	-25.38466	28.68408	Plume Monitoring	Quarterly
MON03	-25.38368	28.68555	Plume Monitoring	Quarterly

16 CONCLUSION & RECOMENDATIONS

Geo Pollution Technologies (Pty) Ltd (GPT) was appointed by AdiEnvironmental cc to conduct a hydrogeological impact study for the proposed Luthuli Wastewater Treatment Works in KwaMhlanga, Mpumalanga Province. AdiEnvironmental is in the process of applying for a WUL for the Luthuli WWTW and require hydrogeological assessment to be conducted as part of the application.

A 5-hectare section of the proposed WWTW site has been fenced to prevent encroachment from informal settlement and to restrict any further expansion of the adjacent graveyard. A single access gate with a guardhouse and an internal access road will be constructed to control entry to the site.

The WWTW is designed for modular development, with each module capable of treating 3 megalitres per day (ML/d). This modular approach allows for future expansion in response to population growth, urban development, and improvements in water supply to the drainage area.

The treatment works will consist of the following components:

- Inlet works – including screening, grit removal, and a flow measurement facility;
- Biological reactor – for the biological treatment of wastewater;
- Clarifiers – with a pump station for return activated sludge (RAS) and waste activated sludge (WAS) management;
- Chlorination facility – with flow measurement prior to final discharge into the receiving river;
- Sludge drying beds – including a return system for supernatant;
- Main pump station – for conveying flows through the treatment process.

Supporting infrastructure will include an administration building and an electrical room.

All infrastructure will be located outside the 90-metre wetland buffer zone and beyond the identified flood risk buffer line, in accordance with environmental and planning regulations.

The site is situated on the western edge of the Luthuli Village, near the eastern banks of the Enkeldoringspruit. A graveyard is located directly east of the site, and this might have an impact on the groundwater quality.The area is characterised by relatively flat terrain, with a gentle slope of approximately 0.2% descending westward towards the Enkeldoringspruit.

The investigated area falls within the 2528 Pretoria 1:250 000 geology series maps. According to the map, the area is underlain by the Lebowa Granite Suite, specifically consisting of Nebo Granite. This includes pink, coarse-grained granite and red to medium-grained varieties near the top. Fluorite is present as an accessory mineral, disseminated throughout these rocks.

According to the explanation of the 1: 500 000 general hydrogeological[11] map the site area is characterised by an Intergranular and fractured aquifer system. Intergranular and fractured aquifers represent a complex interaction of groundwater movement within the same lithological units. These aquifers are characterised by the presence of both intergranular voids and secondary fractures, allowing groundwater to exist in two distinct yet interconnected modes. Groundwater at the site is primarily found in deeper weathered zones, with less common occurrences along faults, fractures, and dyke contacts.

Recharge to the shallow, unconfined aquifer was calculated using the RECHARGE program developed by the Institute for Groundwater Studies at the University of the Free State, South Africa. The calculated recharge percentage equates to approximately 3.6%.

A hydrocensus was conducted on 28 August 2025 within a 1 km radius of the site. However, based on information provided by local residents, the survey area was extended to include certain upstream sections of the adjacent community. During the hydrocensus, 13 groundwater boreholes were identified. However, several of these could not be inspected due to the absence of the owners, who were not available to grant access. While the community primarily receives water from Thembisile Hani municipality via water tankers, a number of residents rely on private boreholes for their water supply.

Four (4) electromagnetic and magnetic traverses were conducted outside the study area's boundary, approximately 20 meters from the site fence on each side. The station spacing for both the electromagnetic and magnetic methods was set at 10 meters.

Based on targets identified during the geophysical survey, three drilling locations were selected and drilled between 21 and 22 August 2025. The target from Traverse 1 was drilled and designated as MON01, Traverse 2 as MON02, and Traverse 3 as MON03. The naming convention "MON" refers to "Monitoring Borehole," followed by a numerical identifier. The drilling logs confirmed that the site is underlain by clay and red to pink granite from the Lebowa Granite Suite.

Falling head testing was conducted on the drilled monitoring boreholes. Data acquired from the falling head tests was used to calculate a first estimation of the hydraulic conductivity (K)which range from 0.0054 to 0.0186 m/d.

Groundwater samples were collected from two hydrocensus boreholes on August 28th and the 3 newly drilled monitoring wells on the 22nd of August and sent for analysis. The chemical analysis results were compared to the SANS 241-1:2015[12]

The analysis revealed the following exceedances:

- Fluoride: Exceeds the chronic health limit in borehole LB01, MON01, MON02, and MON03
- Iron: Iron levels in borehole MON01, MON02, and MON03 exceed aesthetic limits.
- Manganese: Manganese concentrations exceed the aesthetic limits in MON02 and MON03.
- Aluminium: Exceeds the Operational limits for LB07, MON01, MON02, and MON03
- E. coli: E. coli was detected in MON01, MON02, and MON03 and exceeded the Acute health limits

[11] Du Toit, H.C., & Van Lelyveld, M., (2014). An explanation of the 1:500 000 General Hydrogeological Map. Phalaborwa 2330. DWAF.

[12] SANS 241-1:2015 (edition2).

- Total Coliforms: All concentrations exceed the operational limit of 10 cfu/100ml. Extremely high concentrations were noted in the newly drilled borehole MON01, MON02 and MON03.

The GDT calculated a vulnerability value of 54% for the aquifer which is classified as medium. Based on South African Aquifer System Management Classification the aquifers are classified as a “Minor Aquifer System. A Groundwater Quality Management Index of 4 was estimated for the study area from the ratings for the Aquifer System Management Classification. According to this estimate a medium level of groundwater protection is required for the aquifer, tributaries and boreholes in use near and on the site (if any).

Based on Darcy’s flow equation, potential pollutants from the wastewater treatment works are estimated to migrate through the groundwater at a rate of 0.01 to 0.05 m/day toward the Enkeldoringspruit. This suggests a slow rate of pollution movement. The risk to the downgradient stream is reduced due to the low permeability of the underlying clay and granite geology, as well as the relatively flat topography. However, the shallow groundwater table, at approximately 5.27 m below ground level, increases the potential risk of groundwater contamination. This risk can be mitigated through the implementation of appropriate management and control measures. Therefore, in our opinion, the site is considered suitable for the construction of a WWTW, provided that appropriate management protocols and mitigation measures are implemented.

Hydrogeological Impacts

The aim of the impact assessment is to access the likely hydrogeological impact that the proposed development might have on the groundwater regime during the construction, operational and decommissioning phase. The following interactions were identified and could potentially impact the groundwater environment:

- Construction phase:
    - Site clearing, including the removal of vegetation, topsoil and subsoil and the establishment of infrastructure resulting in the potential increase of surface runoff and reduced recharge within cleared areas.
    - General construction activities (including use of vehicles and machinery as well as storage and handling of waste and hazardous material) resulting in the potential contamination of the shallow groundwater aquifer due to spillages and leaks.
- Operational phase:
    - Deposition of sludge and waste or chemical containment facilities have the potential to generate seepage to the underlying groundwater environment. Poor seepage quality from the sludge drying beds or waste treatment facilities can migrate into the groundwater environment.
    - The release of effluent from a Wastewater Treatment Works (WWTW) into the surrounding environment could introduce a variety of contaminants, depending on quality, to the groundwater regime. For groundwater, the main concern is potential seepage of effluent through the soil. Ultimately, the quality of both surface and subsurface water resources can be affected by effluent releases.

Recommendations:

- The three newly drilled boreholes should be purged and resampled before start of operations, to ensure the water quality results accurately reflect the conditions prior to operation on site.

- The three onsite monitoring boreholes (plume) as well as hydrocensus boreholes LB01 (impact) and LB07 (background) should be monitored on a quarterly basis, and a factual report should be compiled annually.

- A contingency plan for rapid response in case of acute contamination events should be developed. This should include emergency procedures, communication strategies, and resources for addressing public health concerns.

- Drilling a borehole at the cemetery could help in establishing if contamination from the graveyard is influencing the WWTW site.

APPENDIX I: HYDROCENSUS FIELD SHEETS

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Water Sample form	Doc No., Rev No.:	5.4.3.5, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1

Project Details:

Site:	LITHULU WWTW	Proj. No:	ALLWW/25/13602	Proj. Manager.:	Christoff Dreyer	Client:	Adi Environmental

Site Details:

Site Address:	Field Team Leader:	Signature:	Site Description:
Lithulu Village East	0 Christoff		0

Sample No:	Cont. Vol.	Sample Date	Sample Time	Method Float	Method Pump	Reference point Ground level	Reference point Collar height (m)	Product Depth(m)	Water Depth(m)	LNAPL Thickness	Total depth (m)	Temp (°C)	DO (%)	pH	EC (µS/cm)	ORP mV	Sample Description
MONO1		28/08	:	x			0.79m		3.61								
MONO2		28/08	:	x			0.78m		3.03								
MONO3		28/08	:	x			0.76m		4.12								
			:														
			:														
			:														
			:														
			:														
			:														
			:														
			:														
			:														
			:														
			:														
			:														

Comments:
NT: Not taken
NM: Not Measured
CNM: Could Not Measure

GPT

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULI WWTW LITHULI WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB01	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner:	Public BH		
Address: Lithuli Village		Tel:	
		Fax:	
		Cell:	

Borehole / Monitoring Well Info

Field Measurements

Coordinates	Lat (S):	25.38709			
	Long (E):	28.68796			
Static water level (mbcl):		0m			
Borehole depth (m):		4.5m			
Casing Installed (Mark with an X):		PVC		Steel	X
		None		Both	
Casing Depth (m):		NM			
Borehole Diameter OD (mm):		170mm			
Collar height (magl):		ground level			

Borehole Condition

Headworks	Yes	No	Comment
Marker pole:		X	
Concrete Plinth:	✓		
Casing cap:		X	
Blocked:			
Comment:	Inside pump house		

Sampling

Sampled (Mark with an X):	Yes		X	No	
Sampling Method:	Bailed	X	Purge		Pumped
	Tap		Tank		
Sampling depth:	Surface level				
Sampling time:					
Sampling volume:					
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis
	Other				

Water Use

Select the applicable option:			Volume usage (l/day)
Domestic:	X	No of Households:	±150 houses
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):	Daily with buckets
Live stock:		No of:	
Agricultural:		Size of land (ha):	

Additional Borehole Information

Storage:						
Reservoir:	Yes		Unknown	No		
Tank type and volume:						
Dam type and volume:						
Borehole equipped with a pump	Yes		No	X		
Pump Type:	Subm		Mono		Wind	

Pump size (kW):		
Pump make and model nr:		
Yield (l/s):		
How often pumped:	As needed	
	Auto level control	

Notes

Photo

Artesian BH Insid pump house box, pump has been stolen.

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULU WWTW LITHULU WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB02	Field Technician:	0
Alternative Borehole Number:	H370041		

Site Information

Owner:	Public BH		
Address:		Tel:	
	Lithuli Village	Fax:	
		Cell:	

Borehole / Monitoring Well Info

Field Measurements

Coordinates	Lat (S):	25.37864			
	Long (E):	28.64125			
Static water level (mbd):		NM		NM	
Borehole depth (m):		NM			
Casing installed (Mark with an X):		PVC		Steel	
		None		Both	
Casing Depth (m):					
Borehole Diameter OD (mm):				NM	
Collar height (magl):				NM	

Borehole Condition

Headworks	Yes	No	Comment
Marker pole:		X	
Concrete Plinth:	✓		
Casing cap:	✓		
Blocked:			
Comment:			

Sampling

Sampled (Mark with an X):	Yes		No	X		
Sampling Method:	**Bailed**		**Purge**		**Pumped**	
	Tap		**Tank**			
Sampling depth:						
Sampling time:						
Sampling volume:						
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis	
	Other					

Water Use

Select the applicable option:				Volume usage (l/day)
Domestic:	X	No of Households:		unknown
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):		
Live stock:		No of:		
Agricultural:		Size of land (ha):		

Additional Borehole Information

Storage:						
Reservoir:	Yes	X	Unknown			
Tank type and volume:		2X	10 000ℓ			
Dam type and volume:						
Borehole equipped with a pump:	Yes	X	No			
Pump Type:	Subm	X	Mono		Wind	

Pump size (kW):		
Pump make and model nr:		
Yield (l/s):		
How often pumped:	As needed	
	Auto level control	

Notes

Photo

Borehole locked in concrete casing. Used to provide water to tanks, ~~[illegible]~~ residents say that pump is no longer working

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULU WWTW/LITHULU WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB03	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner:	Public BH		
Address:		Tel:	
	Lithuli Village	Fax:	
		Cell:	

Borehole / Monitoring Well Info

Field Measurements				**Borehole Condition**			
Coordinates	Lat (S):	25.37867		**Headworks**	**Yes**	**No**	**Comment**
	Long (E):	28.69118		Marker pole:		X	
Static water level (mbcl):		2.44m		Concrete Plinth:		X	
Borehole depth (m):		8m		Casing cap:	✓		
Casing installed (Mark with an X):		PVC / None	Steel / Both	Blocked:			
Casing Depth (m):				Comment:			
Borehole Diameter OD (mm):		~~[illegible]~~					
Collar height (magl):		25mm					

Sampling

Sampled (Mark with an X):	Yes	X	No		
Sampling Method:	**Bailed**	X	**Purge**		**Pumped**
	Tap		**Tank**		
Sampling depth:	2.5m				
Sampling time:					
Sampling volume:					
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis
	Other				

Water Use

Select the applicable option:				**Volume usage (l/day)**
Domestic:		No of Households:		
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):		
Live stock:		No of:		
Agricultural:		Size of land (ha):		

Additional Borehole Information

Storage:						Pump size (kW):		
Reservoir:	Yes		Unknown			Pump make and model nr:		
Tank type and volume:						Yield (l/s):		
Dam type and volume:						How often pumped:	As needed	
Borehole equipped with a pump:	Yes		No	X			Auto level control	
Pump Type:	Subm		Mono		Wind			

Notes	Photo
	Unused BH
	Borehole closed shut
	Borehole not developed

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULU WWTW LITHULU WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB04	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner: Sello	Chris		
Address:	Lithuli Village	Tel:	
		Fax:	
		Cell:	082 670 8326

Borehole / Monitoring Well Info

Field Measurements					Borehole Condition			
Coordinates	Lat (S):	25.37941			**Headworks**	**Yes**	**No**	**Comment**
	Long (E):	28.69268			Marker pole:		X	
Static water level (mbcl):		20,6			Concrete Plinth:	✓	X	
Borehole depth (m):		NM			Casing cap:	✓		
Casing installed (Mark with an X):		PVC	X	Steel	Blocked:			
		None		Both	Comment:			
Casing Depth (m):		NM						
Borehole Diameter OD (mm):		160mm						
Collar height (magl):		6mm						

Sampling

Sampled (Mark with an X):	Yes	X	No			
Sampling Method:	**Bailed**		**Purge**		**Pumped**	
	Tap	X	**Tank**			
Sampling depth:	Tank					
Sampling time:	12:00					
Sampling volume:						
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis	
	Other					

Water Use

Select the applicable option:				Volume usage (l/day)
Domestic:	✓	No of Households:	2	
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):		As needed
Live stock:		No of:		
Agricultural:		Size of land (ha):		

Additional Borehole Information

Storage:					Pump size (kW):		
Reservoir:	Yes	X	Unknown		Pump make and model nr:		
Tank type and volume:	10 000l				Yield (l/s):		
Dam type and volume:					How often pumped:	As needed	
Borehole equipped with a pump:	Yes	X	No			Auto level control	
Pump Type:	Subm	X	Mono	Wind			

Notes	Photo

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULI WWTW LITHULI WWTW	Project Number:	ALLWW/25/13602
Census date:	28/06	Project Manager:	Christoff Dreyer
Borehole Nr:	LB05	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner:	MHLBNGO		
Address:		Tel:	
	Lithuli Village	Fax:	
		Cell:	0779081665

Borehole / Monitoring Well Info

Field Measurements						**Borehole Condition**			
Coordinates	Lat (S):	25.38255				**Headworks**	**Yes**	**No**	**Comment**
	Long (E):	26.64337				Marker pole:		X	
Static water level (mbcl):		5.35				Concrete Plinth:	✓		
Borehole depth (m):		75m				Casing cap:	✓		
Casing installed (Mark with an X):		PVC		Steel	X	Blocked:			
		None		Both		Comment:			
Casing Depth (m):		NM							
Borehole Diameter OD (mm):		165mm							
Collar height (magl):		0.06m							

Sampling

Sampled (Mark with an X):	Yes	X	No			
Sampling Method:	**Bailed**	X	**Purge**		**Pumped**	
	Tap		**Tank**			
Sampling depth:	5.5m					
Sampling time:	12:16					
Sampling volume:						
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis	
	Other					

Water Use

Select the applicable option:				**Volume usage (l/day)**
Domestic:	X	No of Households:	10	
Garden/Landscape:	d	Watering cycle (Daily, Monthly, Weekly):		
Live stock:		No of:		
Agricultural:	X	Size of land (ha):		

Additional Borehole Information

Storage:					Pump size (kW):		
Reservoir:	Yes	X	Unknown		Pump make and model nr:		
Tank type and volume:	NM				Yield (l/s):		
Dam type and volume:					How often pumped:	As needed	
Borehole equipped with a pump	Yes	X	No			Auto level control	
Pump Type:	Subm	X	Mono	Wind			

Notes	**Photo**

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULU WWTW LITHULU WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB06	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner:	KUNENE		
Address:		Tel:	
	Luthuli village	Fax:	
		Cell:	072 2634733

Borehole / Monitoring Well Info

Field Measurements				Borehole Condition			
Coordinates	Lat (S):	25.38298		Headworks	Yes	No	Comment
	Long (E):	28.69263		Marker pole:		X	
Static water level (mbcl):		NM		Concrete Plinth:	X		
Borehole depth (m):		NM		Casing cap:	X		
Casing installed (Mark with an X):		PVC	Steel	Blocked:			
		None	Both				
Casing Depth (m):				Comment:			
Borehole Diameter OD (mm):		NM					
Collar height (magl):		NM					

Sampling

Sampled (Mark with an X):	Yes	X	No			
Sampling Method:	Bailed		Purge		Pumped	
	Tap	X	Tank			
Sampling depth:						
Sampling time:	12:26					
Sampling volume:						
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis	
	Other					

Water Use

Select the applicable option:				Volume usage (l/day)
Domestic:	X	No of Households:		
Garden/Landscape:	X	Watering cycle (Daily, Monthly, Weekly):		
Live stock:		No of:		
Agricultural:	X	Size of land (ha):		

Additional Borehole Information

Storage:						Pump size (kW):		
Reservoir:	Yes	X	Unknown			Pump make and model nr:		
Tank type and volume:	10 000 l					Yield (l/s):		
Dam type and volume:						How often pumped:	As needed	
Borehole equipped with a pump	Yes	X	No				Auto level control	
Pump Type:	Subm	X	Mono		Wind			

Notes	Photo
	Borehole sealed under a concrete slab

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULU WWTW LITHULU WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB07	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner:	MAMA ELIZABETH SEPOGOANE		
Address:	Lithuli Village	Tel:	
		Fax:	
		Cell:	0818155429

Borehole / Monitoring Well Info

Field Measurements					Borehole Condition			
Coordinates	Lat (S):	26.37864			**Headworks**	**Yes**	**No**	**Comment**
	Long (E):	28.68943			Marker pole:		X	
Static water level (mbd):		3.27			Concrete Plinth:		X	
Borehole depth (m):		UM			Casing cap:	✓		
Casing installed (Mark with an X):		PVC	Steel	X	Blocked:			
		None	Both		Comment:			
Casing Depth (m):		UM						
Borehole Diameter OD (mm):		165mm						
Collar height (magl):		0,15m						

Sampling

Sampled (Mark with an X):	Yes	X	No		
Sampling Method:	**Bailed**	X	**Purge**		**Pumped**
	Tap		**Tank**		
Sampling depth:	3,6m				
Sampling time:	12:41				
Sampling volume:					
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis
	Other				

Water Use

Select the applicable option:				Volume usage (l/day)
Domestic:	X	No of Households:	5	
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):		As needed
Live stock:		No of:		
Agricultural:		Size of land (ha):		

Additional Borehole Information

Storage:						Pump size (kW):		
Reservoir:	Yes	X	Unknown			Pump make and model nr:		
Tank type and volume:						Yield (l/s):		
Dam type and volume:						How often pumped:	As needed	X
Borehole equipped with a pump:	Yes	X	No				Auto level control	
Pump Type:	Subm	X	Mono		Wind			

Notes	Photo

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LITHULU WWTW_LITHULU WWTW	Project Number:	ALLWW/25/13602
Census date:	26/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB08	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner:	Justin Makarudze		
Address:	Lithuli Village	Tel:	
		Fax:	
		Cell:	0788475496

Borehole / Monitoring Well Info

Field Measurements					**Borehole Condition**			
Coordinates	Lat (S):	25.37853			**Headworks**	**Yes**	**No**	**Comment**
	Long (E):	28.68785			Marker pole:		X	
Static water level (mbcl):					Concrete Plinth:	[illegible]	X	
Borehole depth (m):					Casing cap:	✓		
Casing installed (Mark with an X):		PVC	X	Steel	Blocked:			
		None		Both				
Casing Depth (m):					Comment:			
Borehole Diameter OD (mm):								
Collar height (magl):								

Sampling

Sampled (Mark with an X):	Yes	X	No			
Sampling Method:	**Bailed**		**Purge**		**Pumped**	
	Tap	X	**Tank**			
Sampling depth:						
Sampling time:						
Sampling volume:						
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis	
	Other					

Water Use

Select the applicable option:				**Volume usage (l/day)**
Domestic:	X	No of Households:	2	
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):		
Live stock:		No of:		
Agricultural:		Size of land (ha):		

Additional Borehole Information

Storage:						Pump size (kW):		
Reservoir:	Yes	X	Unknown			Pump make and model nr:		
Tank type and volume:	10 000					Yield (l/s):		
Dam type and volume:						How often pumped:	As needed	X
Borehole equipped with a pump:	Yes	X	No				Auto level control	
Pump Type:	Subm	X	Mono		Wind			

Notes	Photo
	Borehole sealed in, no access.

UnKn=UnKnown

GEO POLLUTION TECHNOLOGIES
SAFETY, HEALTH, ENVIRONMENT AND QUALITY

Title:	Hydrocensus of Groundwater	Doc No., Rev No.:	5.4.3.9, Rev 01
Department:	Inorganics	Page No.:	Page 1 of 1
Project Name:	HYDROGEOLOGICAL ASSESSMENT FOR THE LUTHULI WWTW LUTHULI WWTW	Project Number:	ALLWW/25/13602
Census date:	28/08	Project Manager:	Christoff Dreyer
Borehole Nr:	LB01	Field Technician:	0
Alternative Borehole Number:			

Site Information

Owner: -ALFRED ALFRED NKADIMENG			
Address: 127 MAHLABATHINI - KWA-MHLANGA		Tel:	0728257435
		Fax:	0726691449
		Cell:	-

Borehole / Monitoring Well Info

Field Measurements					Borehole Condition			
Coordinates	Lat (S):	25,27696			**Headworks**	**Yes**	**No**	**Comment**
	Long (E):	28,69191			Marker pole:		X	
Static water level (mbcl):					Concrete Plinth:		X	
Borehole depth (m):					Casing cap:	X		
Casing installed (Mark with an X):		PVC	Steel		Blocked:			
		None	Both					
Casing Depth (m):					Comment:			
Borehole Diameter OD (mm):								
Collar height (magl):								

Sampling

Sampled (Mark with an X):	Yes	√	No			
Sampling Method:	**Bailed**		**Purge**		**Pumped**	
	Tap		**Tank**	X		
Sampling depth:						
Sampling time:	13:30					
Sampling volume:						
Type of sample (Mark with an X):	Full cations and Anion analysis		Bacteriological analysis		Hydrocarbon Analysis	
	Other					

Water Use

Select the applicable option:				**Volume usage (l/day)**
Domestic:	X	No of Households:		Multiple
Garden/Landscape:		Watering cycle (Daily, Monthly, Weekly):		Daily
Live stock:		No of:		
Agricultural:		Size of land (ha):		

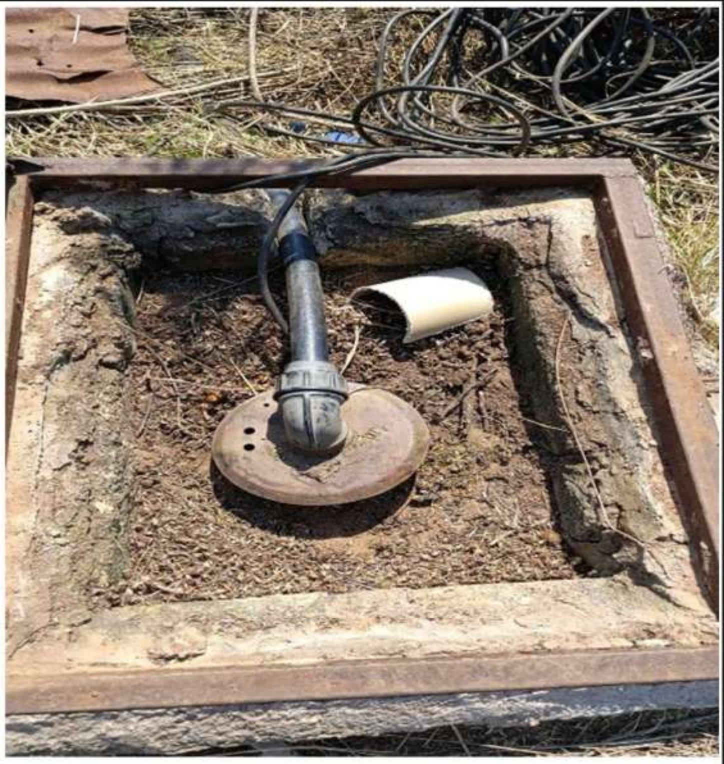
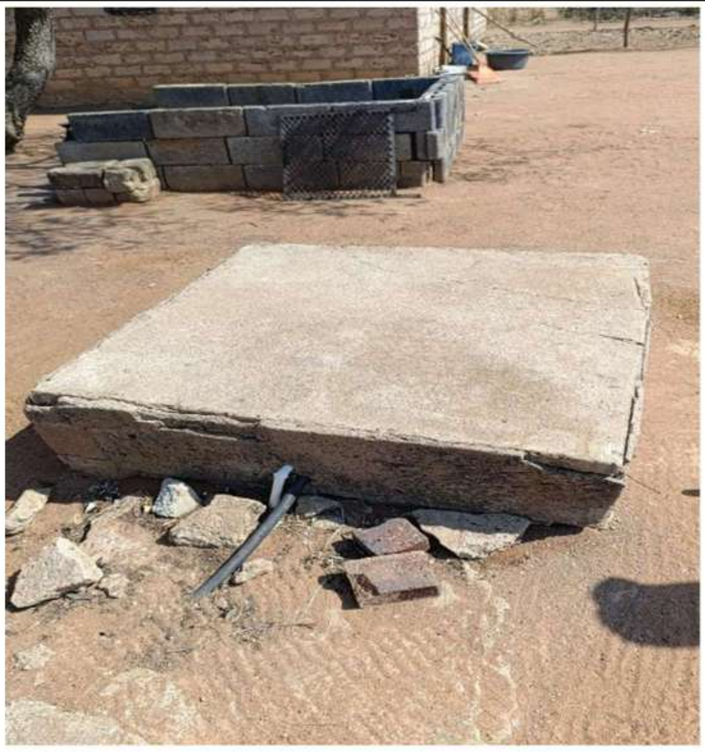
Additional Borehole Information

Storage:						Pump size (kW):	
Reservoir:	Yes		Unknown			Pump make and model nr:	
Tank type and volume:						Yield (l/s):	
Dam type and volume:						How often pumped:	As needed
Borehole equipped with a pump	Yes	X	No				Auto level control
Pump Type:	Subm	X	Mono		Wind		

Notes	Photo
	water selling Business Borehole buried beneath ground

UnKn=UnKnown

APPENDIX III: HYDROCENSUS PHOTOGRAPHIC RECORD

LB01		**LB02**	
LB03		**LB04**	
LB05		**LB06**	

LB07		**LB08**	
LB09		**MON01**	
MON02		**MON03**	

APPENDIX III: LABORATORY CERTIFICATE OF ANALYSIS

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TEST REPORT
60321A

Client and Project Information

Client:	Geo Pollution Technologies				
Address:	Unit B 203, Buchanan Square, 160 Sir Lowry Cape Town 7925	**Attention:** **Tel:** **Email:**	Willem van Biljon (021) 462-6822 willem@gptglobal.com	**Project number:** **Project name:**	ALLWW/25/13602 HYDROGEOLOGICAL ASS

Sample Information

Sample ID:	**LB 01**			**Date Received:**	2025/08/29
		Matrix:	Water	**Date Analysed:**	2025/08/30
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2025/09/12

Cations and Metals

Al	0.05	**Cu**	<0.05	**Na**	72.03
As	<0.05	**Fe**	<0.05	**Ni**	<0.05
B	<0.5	**K**	1.13	**Pb**	<0.05
Ca	14.82	**Mg**	1.36	**Si**	17.05
Cr	<0.05	**Mn**	<0.05	**Zn**	<0.05

Anions (Discrete Analyser)

Cl	30.37	**NO2**	<0.43	**SO4**	4.82	**NO2 as N**	<0.13	**NO3 + NO2 as N***	<0.5
F	7.98	**NO3**	<2.22	**PO4**	<0.61	**NO3 as N**	<0.5		

Other Parameters

pH	7.98	**P-Alk as CaCO3**	<0.6	**E.coli (colonies/100ml)***	0
EC (µs/cm)	336	**M-Alk as CaCO3**	125.20	**Total Coliforms (colonies/100ml)***	38
TDS by calc*	235	**CO3***	0.00		
NH3*	<0.02	**HCO3***	152.70		

Disclaimers

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6) Uncertainty of measurement for all methods included in the SANAS Schedule of Accreditation is available on request.
7) Cr(III) and Cr(VI) are assumed to be the two major oxidative states of Chromium.

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Client and Project Information

Client: Geo Pollution Technologies
Address: Unit B 203, Buchanan Square, 160 Sir Lowry
Cape Town
7925

Attention: Willem van Biljon
Tel: (021) 462-6822
Email: willem@gptglobal.com

Project number: ALLWW/25/13602
Project name: HYDROGEOLOGICAL ASS

Sample Information

Sample ID: LB 07
Units: mg/l [ppm] (unless stated elsewhere)
Matrix: Water
Container: Plastic
Date Received: 2025/08/29
Date Analysed: 2025/08/30
Date Issued: 2025/09/12

Cations and Metals

Al	0.40	**Cu**	<0.05	**Na**	20.09
As	<0.05	**Fe**	0.11	**Ni**	<0.05
B	<0.5	**K**	11.41	**Pb**	<0.05
Ca	1.05	**Mg**	0.53	**Si**	7.24
Cr	<0.05	**Mn**	<0.05	**Zn**	<0.05

Anions (Discrete Analyser)

Cl	20.99	**NO2**	<0.43	**SO4**	6.28	**NO2 as N**	<0.13	**NO3 + NO2 as N***	5.98
F	0.21	**NO3**	24.91	**PO4**	<0.61	**NO3 as N**	5.98		

Other Parameters

pH	6.96	**P-Alk as CaCO3**	<0.6	**E.coli (colonies/100ml)***	0
EC (µs/cm)	141	**M-Alk as CaCO3**	11.55	**Total Coliforms (colonies/100ml)***	115
TDS by calc*	99	**CO3***	0.00		
NH3*	<0.02	**HCO3***	14.09		

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Client and Project Information

Client:	Geo Pollution Technologies				
Address:	Unit B 203, Buchanan Square, 160 Sir Lowry Cape Town 7925	**Attention:**	Willem van Biljon	**Project number:**	ALLWW/25/13602
		Tel:	(021) 462-6822	**Project name:**	HYDROGEOLOGICAL ASS
		Email:	willem@gptglobal.com		

Sample Information

Sample ID:	**MON 01**	**Matrix:**	Water	**Date Received:**	2025/08/29
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Analysed:**	2025/08/30
				Date Issued:	2025/09/12

Cations and Metals

Al	2.12	**Cu**	<0.05	**Na**	51.09
As	<0.05	**Fe**	0.76	**Ni**	<0.05
B	<0.5	**K**	4.06	**Pb**	<0.05
Ca	21.34	**Mg**	3.40	**Si**	22.21
Cr	<0.05	**Mn**	0.06	**Zn**	0.08

Anions (Discrete Analyser)

Cl	22.88	**NO2**	<0.43	**SO4**	12.05	**NO2 as N**	<0.13	**NO3 + NO2 as N***	<0.5
F	2.54	**NO3**	<2.22	**PO4**	<0.61	**NO3 as N**	<0.5		

Other Parameters

pH	7.53	**P-Alk as CaCO3**	<0.6	**E.coli (colonies/100ml)***	200
EC (µs/cm)	357	**M-Alk as CaCO3**	128.20	**Total Coliforms (colonies/100ml)***	40000
TDS by calc*	250	**CO3***	0.00		
NH3*	0.28	**HCO3***	156.40		

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TEST REPORT
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Client and Project Information

Client: Geo Pollution Technologies
Address: Unit B 203, Buchanan Square, 160 Sir Lowry, Cape Town, 7925
Attention: Willem van Biljon
Tel: (021) 462-6822
Email: willem@gptglobal.com
Project number: ALLWW/25/13602
Project name: HYDROGEOLOGICAL ASS

Sample Information

Sample ID: MON 02
Units: mg/l [ppm] (unless stated elsewhere)
Matrix: Water
Container: Plastic
Date Received: 2025/08/29
Date Analysed: 2025/08/30
Date Issued: 2025/09/12

Cations and Metals

Al	1.77	**Cu**	<0.05	**Na**	42.35
As	<0.05	**Fe**	0.69	**Ni**	<0.05
B	<0.5	**K**	3.47	**Pb**	<0.05
Ca	25.37	**Mg**	3.30	**Si**	19.17
Cr	<0.05	**Mn**	0.13	**Zn**	<0.05

Anions (Discrete Analyser)

Cl	25.44	**NO2**	<0.43	**SO4**	8.55	**NO2 as N**	<0.13	**NO3 + NO2 as N***	<0.5
F	3.24	**NO3**	<2.22	**PO4**	<0.61	**NO3 as N**	<0.5		

Other Parameters

pH	7.44	**P-Alk as CaCO3**	<0.6	**E.coli (colonies/100ml)***	1350
EC (µs/cm)	304	**M-Alk as CaCO3**	117.00	**Total Coliforms (colonies/100ml)***	770000
TDS by calc*	213	**CO3***	0.00		
NH3*	0.05	**HCO3***	142.80		

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Address:	Unit B 203, Buchanan Square, 160 Sir Lowry Cape Town 7925	**Attention:**	Willem van Biljon	**Project number:**	ALLWW/25/13602
		Tel:	(021) 462-6822	**Project name:**	HYDROGEOLOGICAL ASS
		Email:	willem@gptglobal.com		

Sample Information

Sample ID:	**MON 03**	**Matrix:**	Water	**Date Received:**	2025/08/29
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Analysed:**	2025/08/30
				Date Issued:	2025/09/12

Cations and Metals

Al	0.39	**Cu**	<0.05	**Na**	58.59
As	<0.05	**Fe**	0.70	**Ni**	<0.05
B	<0.5	**K**	12.94	**Pb**	<0.05
Ca	34.88	**Mg**	3.85	**Si**	25.69
Cr	<0.05	**Mn**	1.19	**Zn**	<0.05

Anions (Discrete Analyser)

Cl	42.25	**NO2**	<0.43	**SO4**	4.26	**NO2 as N**	<0.13	**NO3 + NO2 as N***	<0.5
F	2.97	**NO3**	<2.22	**PO4**	<0.61	**NO3 as N**	<0.5		

Other Parameters

pH	7.34	**P-Alk as CaCO3**	<0.6	**E.coli (colonies/100ml)***	25
EC (µs/cm)	421	**M-Alk as CaCO3**	148.10	**Total Coliforms (colonies/100ml)***	50000
TDS by calc*	295	**CO3***	0.00		
NH3*	0.05	**HCO3***	180.70		

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