DHS GROUNDWATER
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Groundwater Impact Assessment for the Upgrade of Wastewater Treatment Works and Sewer Reticulation, Woodlands, Eastern Cape

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Prepared for:

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Author’s Resume

Divan Stroebel is a SACNASP registered and active member of the Groundwater Division, the Geological Society of South Africa, hydrogeologist and professional geoscientist with more than 18 years of industry experience. He obtained his B.Sc. (Geology) degree in 2005 and his B.Sc. Honours (Geology) degree in 2006 from Stellenbosch University. From 2007, he worked throughout Africa as an exploration geologist in base metal, iron ore and gold exploration. In 2009 he joined a hydrogeological consultancy and completed additional groundwater modules at the Institute for Groundwater Studies (IGS), University of Free State. These modules included Aquifer Mechanics, Groundwater Chemistry, Groundwater Geophysics, Groundwater Modelling and Groundwater Management.

He was employed by mining giant, Rio Tinto in 2010 in Guinea as a Geologist, after which he was the Superintendent Geologist at Goldfields’ Kloof mine from 2012. He joined AEON at the Nelson Mandela University (NMU) in 2014 as Associate Research Manager for the Karoo Shale Gas Research Programme- focused on Karoo hydrogeology.

Divan’s technical experience includes all aspects of mineral exploration, extraction and reserve management as well as hydrogeological assessments (basic, environmental management plan, permits and licensing, legal query, impact assessments, integrated waste water management plans and external audits), aquifer characterisation, groundwater supply development, groundwater and surface water characterisation and monitoring as well as water quality assessments.

Divan is very active in the hydrogeological community and has attended, presented at and co-organised numerous water-research workshops and conferences. In June 2016, he was appointed as a visiting researcher at Queen’s University, Belfast. In China (2017), he successfully completed an international training programme on the Sustainable Development of Water Resources in Arid Regions for Developing Countries.

During his time at AEON, Divan researched the Groundwater Hydrochemistry and Aquifer Connectivity Baseline of the Eastern Cape Karoo. In anticipation of the controversial hydraulic fracturing planned for the Eastern Cape, he has obtained unique experience in the determination of salinity, aquifer yields and groundwater levels of the Karoo’s scarce groundwater resources and has published an article in a special publication by the Geological Society of London on fractured aquifers on the topic. https://sp.lyellcollection.org/content/479/1/129

Divan is the founder and owner of DHS Groundwater Consulting Services and leads the team as principal hydrogeologist, overseeing all projects from inception to completion.

Declaration of Consultants Independence

I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;

• I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;

• I have the necessary qualifications and guidance from professional experts in conducting specialist reports relevant to this application, including knowledge of the relevant Act, regulations and any guidelines that have relevance to the proposed activity;

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• All the particulars furnished by me in this document are true and correct.

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Executive Summary

DHS Groundwater Consulting Services (Pty) Ltd was appointed by the Koukamma Local Municipality to conduct a specialist groundwater impact assessment for the proposed upgrade of the Woodlands Wastewater Treatment Works (WWTW) and its associated sewer reticulation infrastructure, situated in the Eastern Cape Province. This investigation forms part of the environmental authorization process and is aimed at evaluating the potential impacts on the local groundwater system during both the construction and operational phases of the development.

The assessment included:

- A geohydrological characterisation of the site and surrounding area;
- A hydrocensus to identify groundwater use within a 1 km radius;
- A Source–Pathway–Receptor (SPR) risk assessment to evaluate potential groundwater contamination pathways;
- The formulation of mitigation and monitoring strategies to safeguard groundwater quality.

According to data from the Department of Water and Sanitation (DWS) and the National Groundwater Archive (NGA), the area is underlain by a low- to moderate-yielding fractured aquifer system, typical of the deeper formations within the Cape Fold Belt. Although no groundwater users were identified within 1 km of the site, 19 registered boreholes were found within a 5 km radius. Additionally, no boreholes are recorded within the designated Groundwater Response Unit (GRU) that encompasses the site.

Hydrochemical data suggest that groundwater quality in the broader region is variable, with electrical conductivity (EC) typically ranging from 70–150 mS/m. While this may reflect “acceptable” quality, concentrations of sodium (Na), chloride (Cl), and iron (Fe) often exceed SANS 241-1:2015 drinking water standards, pointing to salinity and quality concerns potentially related to underlying geology or anthropogenic influences.

Aquifer vulnerability, as determined through DRASTIC modelling, is classified as moderate, indicating some susceptibility to contamination under certain conditions. However, the Aquifer Management Index (AMI) and Groundwater Quality Management Index (GQMI) identify the site as a high-risk area due to the presence of a "Minor to Major" aquifer system. This underscores the importance of preventative management to avoid degradation of this sensitive groundwater resource.

The SPR model identified potential contamination sources, including:

- Accidental spillage or mishandling of hazardous substances during construction;
- Leaks or failures from pipelines, sludge drying beds, and other WWTW components;
- Inadequate containment of waste or chemicals on-site.

While the deep water table and unsaturated vadose zone offer some natural protection, they are not sufficient to prevent long-term contamination if appropriate mitigation measures are not implemented. Receptors include both the deep aquifer system and the surrounding ecological environment.

Risk Assessment Findings:

- Construction Phase: Risk to groundwater is classified as minor-negative.
- Operational Phase: Risk increases to moderate-negative due to the continuous operation of wastewater infrastructure and potential leak sources.
- Residual Risk: With full implementation of the proposed mitigation measures, both risks can be reduced to negligible-negative.

Key Recommendations:

- Monitoring Network: Install at least three monitoring boreholes (one upgradient and two downgradient) to assess baseline and ongoing groundwater quality.
- Pre-Construction Installation: Monitoring boreholes must be installed prior to construction to establish pre-development conditions.
- Monitoring: Conduct quarterly groundwater and monthly effluent sampling, analysed by SANAS-accredited laboratories, to track changes and detect contaminants early.
- Containment Measures: Ensure secure storage of chemicals and fuel, implement secondary containment systems, and enforce site hygiene protocols.
- Rapid Response Plan: Develop and maintain a response protocol to address any contamination incidents quickly and effectively.

Conclusion:

The proposed WWTW upgrade and associated infrastructure pose identifiable risks to groundwater quality. However, with the implementation of a comprehensive groundwater monitoring network, targeted mitigation strategies, and strict operational controls, these risks can be effectively managed. This will ensure that the aquifer system remains protected, the surrounding environment remains intact, and long-term groundwater sustainability is upheld for both ecological and human use.

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List of Abbreviations

Term	Definition
%	Percentage
CDT	Constant Discharge Test
CFU	Colony Forming Unit
DEA	Department of Environmental Affairs
DRO	Diesel Range Organics
DWAF	Department of Water Affairs & Forestry
DWS	Department of Water & Sanitation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Program
EWR	Ecological Water Requirement
GA	General Authorisation
GMA	Groundwater Management Area
GMU	Groundwater Management Unit
GQM	Groundwater Quality Management
GRDM	Groundwater Resource Directed Measures
GRO	Gasoline Range Organics
GRU	Groundwater Resource Unit
Ha	Hectare
K	Hydraulic Conductivity
km	Kilometre
km^2	Square Kilometre
l/h	litres/hour
l/s	litres/second
LDPE	Low density polyethylene
M	meter
m/d	Meters per day
m^3	Cubic Meters

Term	Definition
m^3/a	Cubic Meters/annum
$m^3/ha/a$	Cubic Meters/hectare/annum
mamsl	meters above mean sea level
mbcl	meters below casing level
mbgl	meters below ground level
ML/d	Mega Litre/day
mm/a	Millimetres/annum
Mm^3/a	Million Cubic Meters/annum
mS/m	Millisiemens per meter
NEMA	National Environmental Management Act
NGA	National Groundwater Archive
nm	not measured
NTU	Nephelometric Turbidity Units
NWA	National Water Act
^oC	Degrees Centigrade
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
SANS	South African National Standards
SWL	Static water level
T	Transmissivity
TMG	Table Mountain Group
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
WARMS	Water Use Authorization & Registration Management System
WRC	Water Research Commission
WULA	Water Use Licence Application

1 Introduction

DHS Groundwater Consulting Services (Pty) Ltd was appointed by the Koukamma Local Municipality to conduct a groundwater impact assessment for the proposed upgrade of the wastewater treatment works (WWTW) and sewer reticulation system in Woodlands, Eastern Cape. The purpose of this assessment is to evaluate the potential impacts of both the construction and operation of the upgraded WWTW and associated sewer infrastructure on the local groundwater environment.

2 Scope of Work

The objective of this assessment is to:

- Complete a geohydrological characterisation of the groundwater in the vicinity of the site;
- Complete an assessment of the groundwater use in the area by means of a hydrocensus, up to a maximum distance of 1 km from the site;
- Propose measures to mitigate identified negative impacts;
- Advise on a monitoring program as part of an environmental management plan;

This report is not intended to be an exhaustive description of the assessment, but rather serves as a specialist geohydrological assessment to evaluate the overall geohydrological character of the site, to inform the impact assessment, and propose mitigation measures where applicable.

3 Methodology

It must be stated that no intrusive groundwater investigations were done and reporting is thus based on and limited to observations made during the site visit, hydrocensus and the collation of available information. The work completed for the purposes of compiling a geohydrological report comprised the following:

3.1 Desktop Study

Undertake a desk study of existing information available from relevant literature, the National Groundwater Archive (NGA)[1], the Water Use Authorization & Registration Management System (WARMS)[2], the National Water Resources Monitoring (NWRM) Network, the Water Management System (WMS) and published geological and geohydrological maps and reports.

3.2 Site Visit & Hydrocensus

A site visit was conducted to evaluate the geology, geohydrology and potential receptors of possible groundwater impacts. A hydrocensus was carried out within maximum distance of a 1km radius to identify legitimate groundwater users, the groundwater potential and quality.

[1] http://www3.dwa.gov.za/NGANet

[2] Department of Water and Sanitation. Section 21(a) of the National Water Act, Taking Water From A Water Resource. DW760 Report. Accessed: February 2025.

3.3 Aquifer Vulnerability Assessment

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (DWAF, 2005)[3] and recompiled in 2013 was used to assess the project area in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer".*

3.4 Aquifer Characterisation

The aquifer(s) underlying the project area was classified in accordance with "A South African Aquifer System Management Classification"[4] developed by the Water Research Commission and DWAF.

3.5 Impact Assessment

The methodology used herein is broadly consistent to that described in the Environmental Impact Assessment Regulations[5] in terms of the NEMA[6].

The risk associated with the groundwater abstraction for the property pertains to both the construction and operational phases. Each impact was assessed individually and graded using a numerical system on the following factor.

- Intensity
- Duration
- Extent
- Probability

The values assigned to each factor were used to calculate the significance of each impact. Each individual impact was assessed and re-assessed after the appropriate mitigation was applied.

The "Impact Assessment Methodology" is presented in Chapter 8.

[3] DWAF, 2005. Groundwater Resources Assessment Project, Phase II (GRAII). Department of Water Affairs and Forestry, Pretoria.

[4] Department of Water Affairs and Forestry & Water Research Commission (1995). A South African Aquifer System Management Classification. WRC Report No. KV77/95.

[5] Environmental Impact Assessment Regulations, 2014 published under Government Notice No. 982 in Government Gazette No. 38282 of 4 December 2014

[6] National Environmental Management Act, 1998 (Act No. 107 of 1998) ("NEMA")

4 Setting

4.1 Site Location

The site is located within the Eastern Cape in the Koukamma Local Municipality in the settlement of Woodlands. (Figure 1). The settlement is approximately 15km south-west of the town of Kareedouw within the Tsitsikamma.

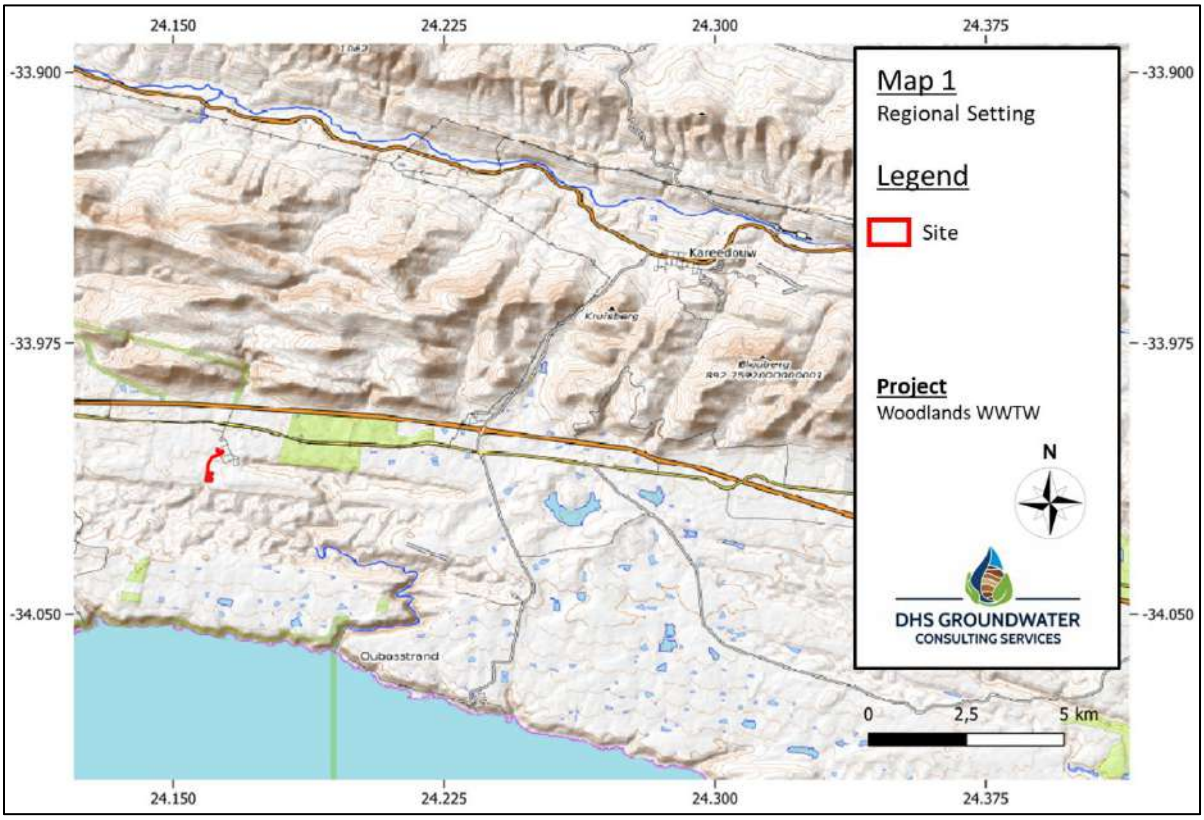


Figure 1. Site locality.

4.2 Topography and Surface Drainage

The site is situated within quaternary catchment K80D, part of the Mzimvubu-Keiskamma Water Management Area (WMA). A topographical survey indicates that the terrain is varied, with relatively steep slopes along the southern and western boundaries, and gentler inclines running along a north-south axis through the central portion of the site. The highest elevation—approximately 229 meters above mean sea level (mamsl)—is located at the northernmost point, while the lowest point, around 202 mamsl, lies along the southern boundary. Surface water drainage follows the natural topographical gradients, generally flowing from northeast to southwest toward a non-perennial stream, which ultimately discharges into the Groot River to the southeast.

4.3 Climate

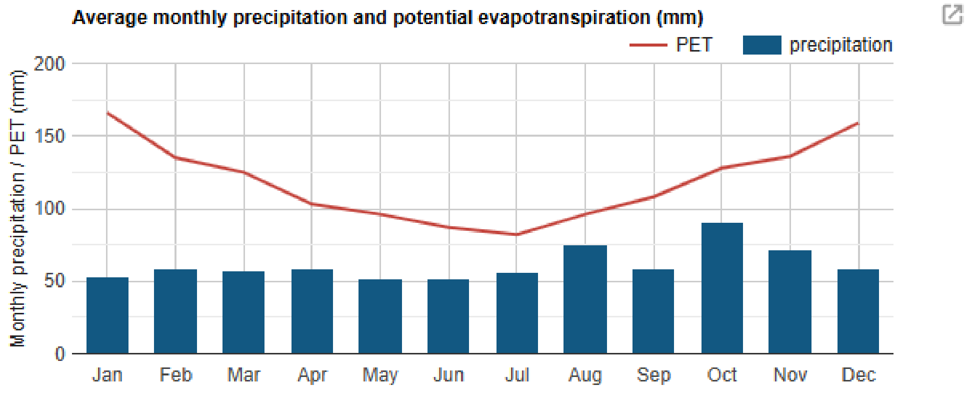
The weather is mild without extreme conditions with an average maximum summer temperature of 26.33°C and an average minimum summer temperature of 15°C. The winter months are at an average maximum temperature of 18.66°C with an average minimum temperature of 6.33°C . Winds ranging between 10 – 20 km/h is common with the predominant wind directions being southwest and northwest.

Meteorological data obtained from SamSam Water Climate Tool[7] is presented in Figure 2. Figures of 745 mm for the mean annual precipitation (MAP) and 1427 mm for the potential evapotranspiration (PET) is reported. The PET exceeds the MAP by an order of magnitude, resulting in a negative moisture index. Rainfall within the study area is bimodal where both summer and winter rainfall occurs, a feature typical of the south-east coastal region of the country.

Latitude, longitude: -34.0071, 24.1664

SamSamWater Climate Tool

The average annual rainfall (1970-2000) for this location is 745 mm per year.
Average monthly rainfall and potential evapotranspiration (PET) values are displayed in the chart and table below.



description	PET	precipitation
01 - January	166	53
02 - February	135	59
03 - March	125	58
04 - April	103	59
05 - May	96	52
06 - June	87	52
07 - July	82	56
08 - August	96	75
09 - September	108	59
10 - October	128	91
11 - November	136	72
12 - December	159	59
Total	1,427	745

To copy the data for use in other software: click on the icon in the top-right corner of the table to open in a new tab. There you can select and copy the values.

Close

The data in this tool is sourced from WorldClim v2 and Global Aridity Index and Potential Evapotranspiration (ET0) Climate Database v2. For questions or remarks on the data, please contact these organisations.

Figure 2. Precipitation and evapotranspiration within the project area.

[7] https://www.worldclim.org/ & Global Aridity Index and Potential Evapotranspiration Climate Database v2

4.4 Geology

According to the 1:250 000 Geological Series (3324 Port Elizabeth[8]), the site is situated within the Cape Fold Belt (CFB), a prominent geological feature that stretches approximately 1 300 km along the southern and western margins of South Africa[9 10]. The CFB is a classic example of a foreland fold-thrust belt, formed during the late Paleozoic as a result of compressional tectonic forces associated with the collision of the Falkland Plateau and the southern margin of Gondwana. It is predominantly composed of sedimentary rocks from the Cape Supergroup, which were deposited in a shallow marine environment from the early Ordovician (around 500 million years ago) to the early Carboniferous (approximately 340 million years ago).

The Cape Supergroup is stratigraphically divided into three main groups: the Table Mountain Group, the Bokkeveld Group, and the Witteberg Group. Of these, the Table Mountain Group underlies the site and is characterized by resistant quartzitic sandstones interbedded with minor shale and siltstone layers. The basal Peninsula Formation is present in the northern part of the site, followed by a sequence of the Cederberg, Goudini, and Skurweberg Formations extending southwards across the central portion of the site (Figure 3).

[8] 1:250 000 Geological Map (3324 Port Elizabeth). Geological Survey, 1975.

[9] Booth, P.W.K., Stratigraphic, Structural and Tectonic Enigmas Associated with the Cape Fold Belt: Challenges For Future Research. South African Journal of Geology 2011; 114 (3-4): 235–248. doi: https://doi.org/10.2113/gssajg.114.3-4.235.

[10] Miller, W., de Wit, M. J., Linol, B., & Armstrong, R. (2016). New Structural Data and U/Pb Dates from the Gamtoos Complex and Lowermost Cape Supergroup of the Eastern Cape Fold Belt, in Support of a Southward Paleo-Subduction Polarity. Regional Geology Reviews, 35–44. doi:10.1007/978-3-319-40859-0_4.

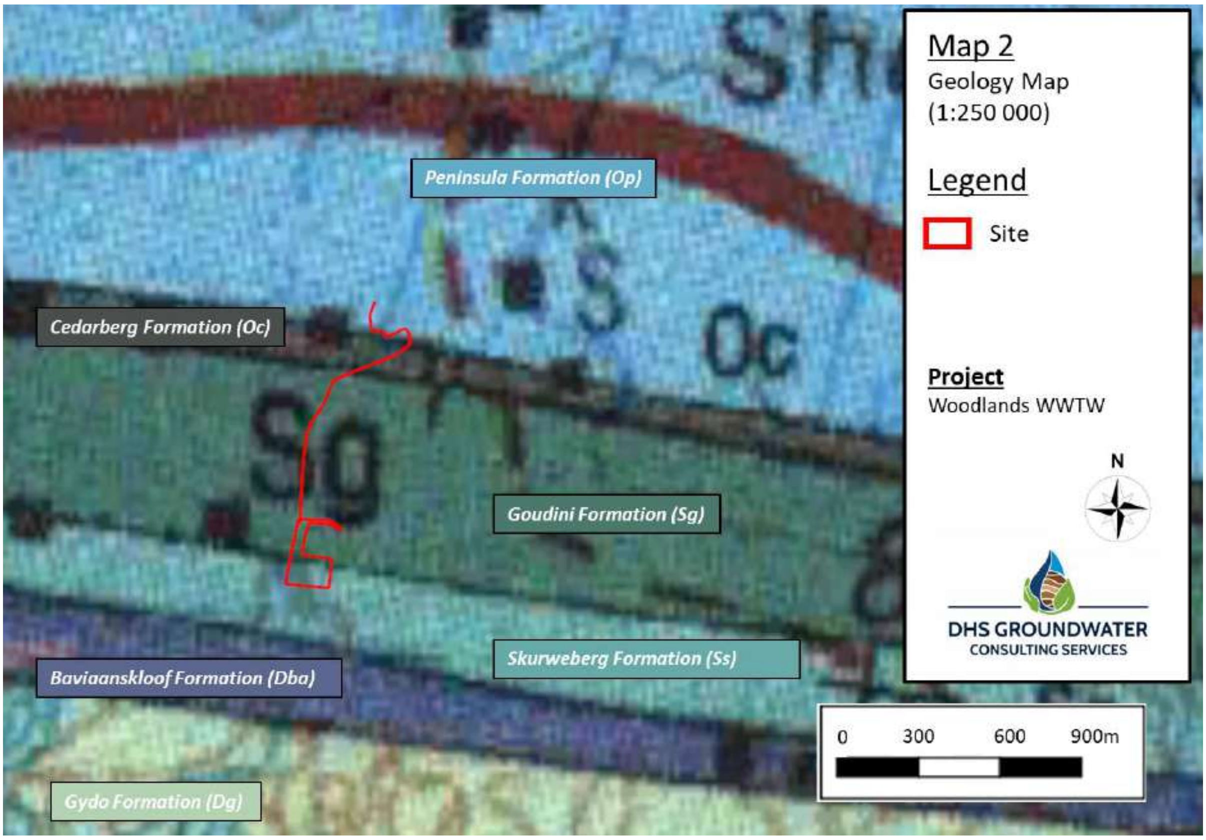


Figure 3. 1:250 000 Geological map.

The lithostratigraphy is shown in Table 1.

Table 1. Lithostratigraphy of underlying geology.

Supergroup	Group	Subgroup	Formation	Lithology
Cape Supergroup	Table Mountain	Nardouw	Baviaanskloof (Dba)	Feldspathic Sandstone and Shale
			Skurweberg (Ss)	Quartzitic Sandstone
			Goudini (Sg)	Quartzitic Sandstone, Shale, Siltstone
			Cedarberg (Oc)	Shale, Siltstone, Subordinate Sandstone
			Peninsula (Op)	Quartzitic Sandstone

4.5 Geohydrology

4.5.1 Desktop Study

4.5.1.1 General Groundwater Understanding

Groundwater refers to water located in the saturation zone, which lies beneath the aeration (or unsaturated) zone. The unsaturated zone functions like a sponge, allowing water to seep down into the saturation zone. The boundary between these two zones is called the water table, as depicted in Figure 8[11].

[11] KRUSEMAN, G.P. & DE RIDDER, N.A. 1991. Analysis and Evaluation of Pumping Test Data. Second

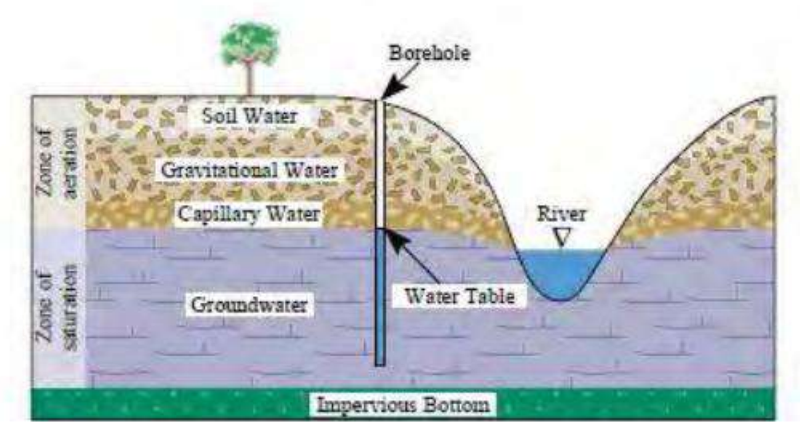


Figure 4. The basic concept of groundwater[6].

An aquifer is a geological formation that holds sufficient water for economical uses, such as domestic consumption[12]. There are two main types of aquifers: porous shallow weathered aquifers and deep fractured rock aquifers. The porous shallow weathered aquifers are made up of individual grain particles like sand, gravel, and silt. In contrast, fractured rock aquifers are geological formations where groundwater flows along fractures, joints, and other discontinuities in the rock[6]. Geology plays a crucial role in groundwater flow, as the type of geological formation determines how groundwater moves[7].

It is important to note that geology and groundwater are in very close relation to each other because the type of geology governs the flow of groundwater[7].

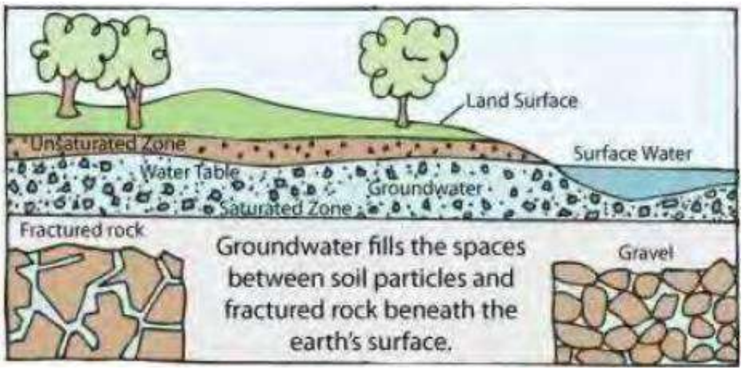


Figure 5. The basic concept of aquifers.

Unless otherwise stated, the published 1:500 000 General Hydrogeological Map[13] and associated explanatory booklet[14] were used as basis to describe the geohydrological conditions.

Edition. International Institute for Land Reclamation and Improvement. Publication 47. Wageningen, the Netherlands.

VAN TONDER, G., BARDENHAGEN, I., RIEMANN, K., VAN BOSCH, J., DZANGA, P. & XU, Y. 2001. Manual on Pumping test analysis in fractured rock aquifers. University of the Free State, Bloemfontein. South Africa.

[13] 1:500 000 General Hydrogeological Map, Port Elizabeth 3324 (1998)

[14] MEYER, P S (1999). An explanation of the 1:500 000 General Hydrogeological Map Port Elizabeth 3324. Department of Water Affairs and Forestry, Pretoria.

4.5.1.2 Aquifer Types and Borehole Yields

Groundwater within the project area occurs predominantly within fractured aquifers with reported yields of 0.5 – 2.0 L/s.

4.5.1.3 Depth to Groundwater

The static groundwater level generally occurs at approximately 20.16 metres below surface. It must be stated that this is low resolution interpolation and is an average. It is not intended to define water level depths on small scale.

4.5.1.4 Groundwater Recharge and Baseflow

The study area falls within quaternary catchment K80D. The mean annual precipitation and annual recharge figures for the study area is presented in Table 2. Vegter's (1995)[15] recharge and baseflow maps were used to obtain a first estimate of regional recharge and groundwater contribution to rivers and streams (baseflow).

Table 2. Regional Rainfall, Recharge and Baseflow.

Mean Annual Precipitation (mm):	745
Annual Recharge (mm):	50 - 75
Percentage Recharge of MAP:	6.71% - 10.06%
Annual Baseflow (mm):	50 - 100
Percentage Baseflow of MAP:	6.71% - 13.42%

4.5.1.5 Groundwater Quality

Electrical Conductivity (EC) of groundwater in the area is generally between 0 and 70 mS/m[16]. This is considered as an "ideal" water quality with respect to drinking water standards.

4.5.1.6 Aquifer Vulnerability

The national scale Groundwater Vulnerability Map, which was developed according to the DRASTIC methodology (DWAF, 2005) and recompiled in 2013 was used to assess the aquifers underlying the site in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer"*.

[15] Vegter, J.R. (1995). An explanation of a set of national groundwater maps; WRC Report No. TT 74/95. Water Research Commission, Pretoria.

[16] Murray R, Beker K, Ravenscroft P, Musekiwa, C AND Dennis, R. (2012). A Groundwater Planning Toolkit for the Main Karoo Basin: Identifying and quantifying groundwater development options incorporating the concept of wellfield yields and aquifer firm yields. WRC Report No. 1763/1/11, Pretoria, South Africa.

The DRASTIC method takes into account the following factors:

- D = depth to groundwater (5)
- R = recharge (4)
- A = aquifer media (3)
- S = soil type (2)
- T = topography (1)
- I = impact of the vadose zone (5)
- C = conductivity (hydraulic) (3)

The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor.

Aquifer Vulnerability is rated as follows:

Green represents the least vulnerable region that is only vulnerable to conservative pollutants in the long term when continuously discharged or leached
Yellow represents the moderately vulnerable region, which is vulnerable to some pollutants, but only when continuously discharged or leached.
Red represents the most vulnerable aquifer region, which is vulnerable to many pollutants except those strongly absorbed or readily transformed in many pollution scenarios.

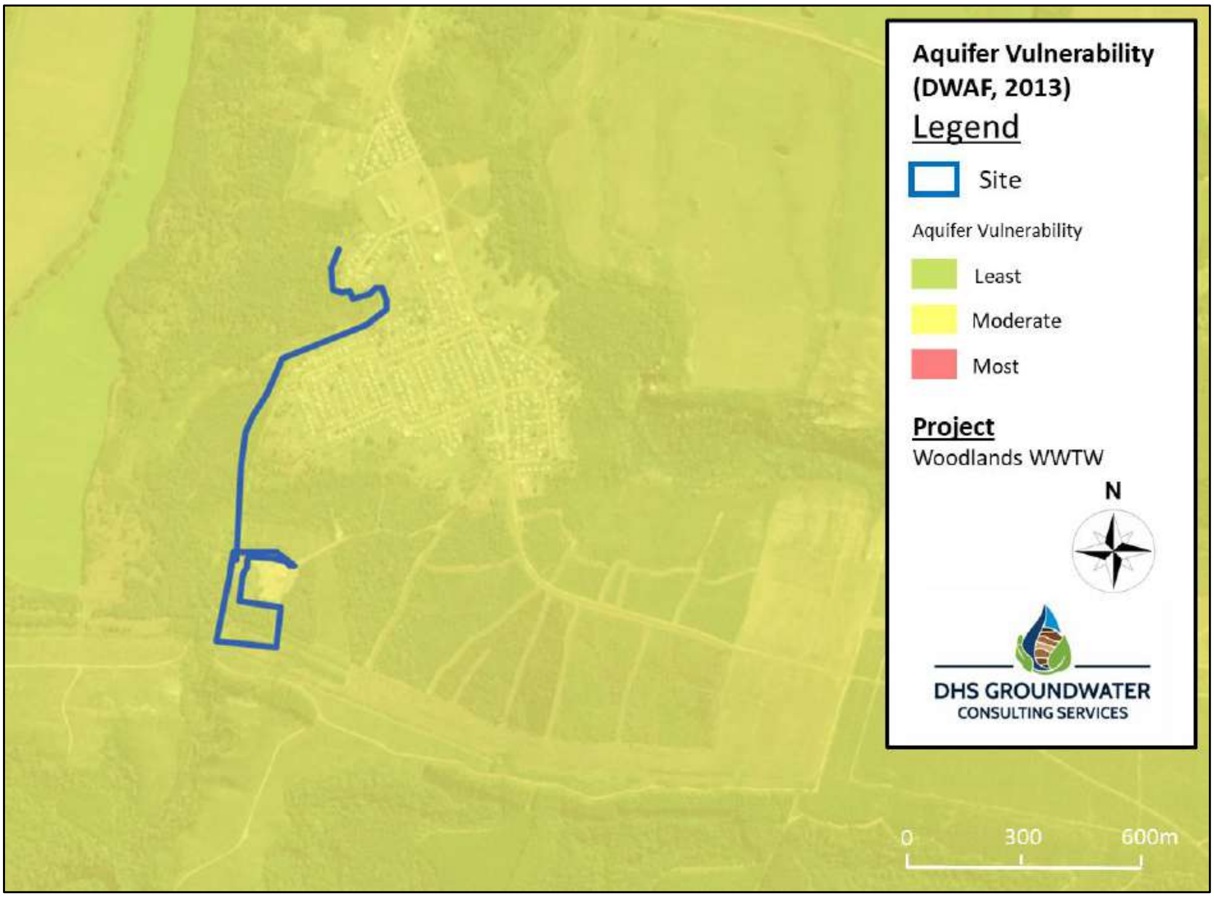


Figure 6. Regional groundwater vulnerability for the study area (DWAF, 2013).

The vulnerability of the aquifers within the project area is rated as "moderate" vulnerable to pollutants. Please note this is a low resolution, regional interpolation of the aquifer vulnerability. A site-specific DRASTIC model is discussed in section 8.2.

5 Site Specific Assessment

5.1 Existing Groundwater Information

The boreholes as identified from the various databases are shown in the below (Figure 7). Note that no boreholes were identified within a one kilometre radius of the site.

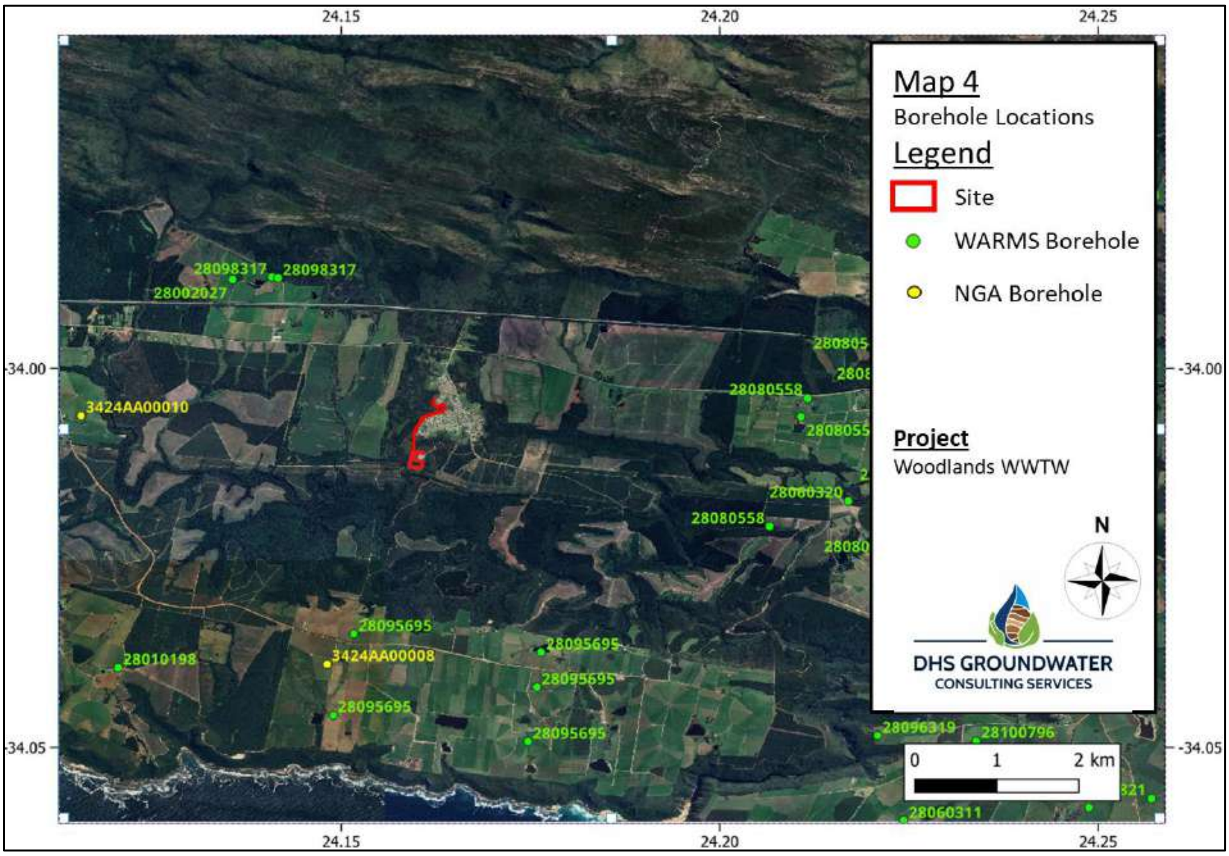


Figure 7. Borehole locations.

5.1.1 National Groundwater Archive

A desktop hydrocensus was carried out within a one-kilometre search radius around the site boundaries. This was done to determine groundwater use in the area. A search of the National Groundwater Archive (NGA), which provides data on borehole positions, groundwater chemistry and yield, when available, was carried out to identify proximal boreholes. These sites are then typically verified in the field and provide background information on the area, should they exist.

A search of the NGA produced no boreholes within a 1 km radius from the site. The search radius was extended to 5 km and three boreholes were identified. A summary of the borehole data contained in the database is presented in Table 3.

Table 3. Summary of data contained in the NGA.

BH Id	Latitude (°)	Longitude (°)	Water Use	BH Depth (m)	SWL (mbgl)	Yield (L/s)
3424AA00008	-34.03902	24.14813	-	90	36	-
3424AA00001	-34.00624	24.11563	-	121.9	-	-
3424AA00010	-34.00624	24.11564	-	10.06	-	-
			n	3	1	-
			Min	10.06	36	-
			Max	121.9	36	-
			Median	90	36	-

5.1.2 Water Use Authorization & Registration Management System (WARMS)

The WARMS database (updated February 2025) provides (but is not limited to) data on borehole positions, groundwater use and registered abstraction volume. The WARMS indicated there are zero boreholes within the 1 km search area of the site. The search was extended to a 3 km radius which identified two boreholes. The identified WARMS site are summarised in Table 4.

Table 4. Summary of data contained in the WARMS.

Register No.	Latitude (°)	Longitude (°)	Water Use	Registered Volume m^3/a
28002027	-33.988249	24.135649	AGRICULTURE: IRRIGATION	123677
28010198	-34.03944	24.12056	AGRICULTURE: IRRIGATION	2496
28060320	-34.0175	24.216972	AGRICULTURE: IRRIGATION	36050
28080558	-34.003917	24.211611	AGRICULTURE: IRRIGATION	110000
28080558	-34.006361	24.21075	AGRICULTURE: IRRIGATION	110000
28080558	-34.020806	24.206611	AGRICULTURE: IRRIGATION	55800
28080558	-34.000472	24.225833	AGRICULTURE: IRRIGATION	33600
28080558	-34.02175	24.224194	AGRICULTURE: IRRIGATION	30000
28080558	-33.99775	24.22275	AGRICULTURE: WATERING LIVESTOCK	8400
28095695	-34.035	24.15167	AGRICULTURE: IRRIGATION	187200
28095695	-34.03742	24.17639	AGRICULTURE: WATERING LIVESTOCK	5000
28095695	-34.04922	24.17468	AGRICULTURE: WATERING LIVESTOCK	5000
28095695	-34.04576	24.14896	AGRICULTURE: WATERING LIVESTOCK	5000
28095695	-34.04202	24.17587	AGRICULTURE: WATERING LIVESTOCK	5000
28098317	-33.987917	24.140861	INDUSTRY (URBAN)	37284
28098317	-33.988056	24.141667	INDUSTRY (URBAN)	31356

5.2 Hydrocensus

A hydrocensus was conducted on 10 April 2025 to establish groundwater use within the larger project area. The hydrocensus extended to a minimum distance of ~1km from the site boundaries, except where a river or a surface water body exist.

The hydrocensus did not extend past such a feature as surface water bodies are usually hydraulically connected to an aquifer, act as a constant-head boundary and a groundwater pollution plume or cone of depression would theoretically not extend past a constant head boundary. Any information pertaining to the abstraction, yield and quality of groundwater was sought.

No groundwater users were identified within a 1km radius of the site.

5.3 Groundwater Flow Direction

Groundwater elevations generally mirror surface topography, moving from higher to lower elevations and discharging at natural low points such as valleys or springs. In the study area, five-meter contour intervals shown in Figure 8 indicate inferred groundwater flow directions. The site features relatively flat terrain in the northern section, transitioning to steeper slopes toward the southwest. The highest elevation is located in the northeastern portion of the site, while the lowest lies toward the southwest. Given this topographical gradient, groundwater is expected to flow in a southwesterly direction, ultimately draining toward the adjacent valley.

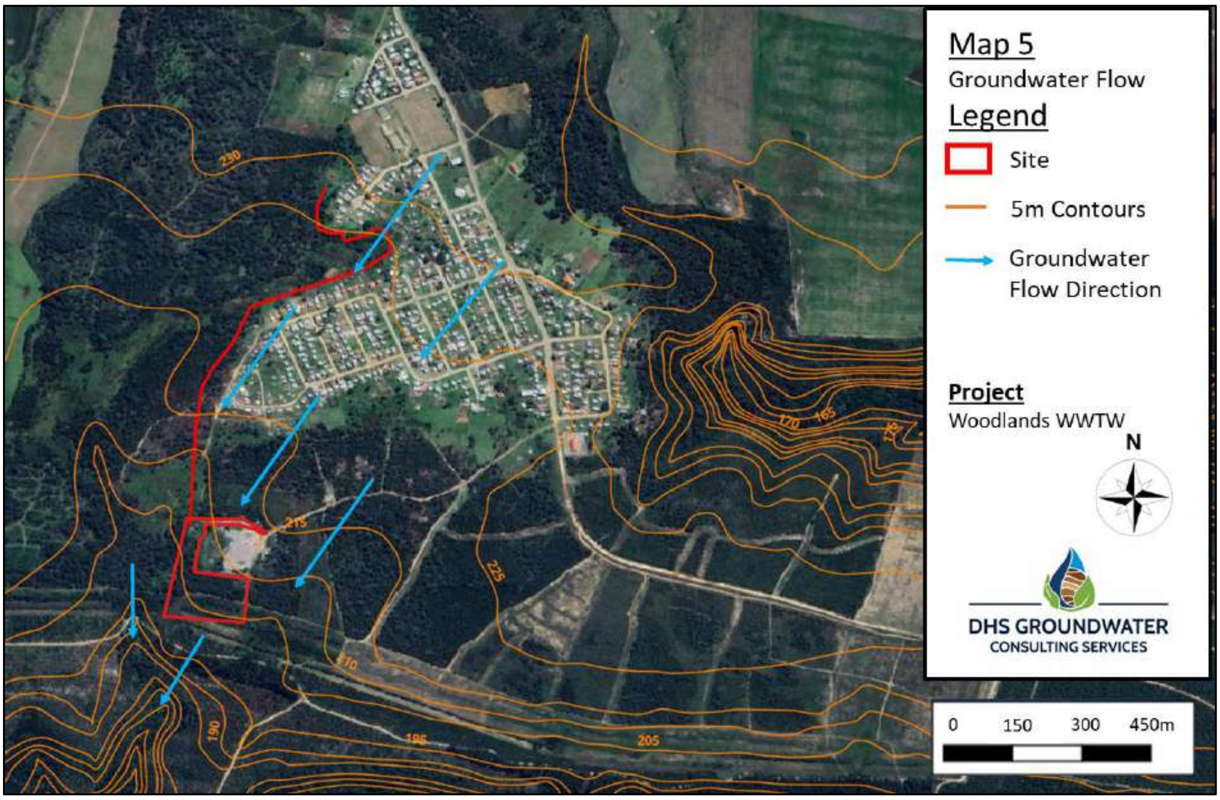


Figure 8. Map with 5m contours showing the inferred groundwater flow direction.

5.4 Groundwater Response Unit

In order to define a more localised area within which groundwater and groundwater users may be affected by potential pollutants, a "Geohydrological Response Unit" (GRU), is delineated. It is defined as a groundwater system that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit. Criteria to map a GRU would include:

1. Areas of similar geology;
2. Groundwater elevations generally mimic surface topography, and groundwater flows from higher lying ground towards lower lying springs or valleys (drainage lines), therefore surface water catchment boundaries may be used as surrogate for groundwater divides;
3. Rivers/Streams acting as a constant head boundary;
4. Impermeable dykes/lineaments acting as no-flow boundaries; and lastly
5. Expert judgement and interpretation.

For this study area there are drainage features that enable the definition of a more localised aquifer (i.e., a GRU).

The GRU has been defined as follow:

- The northern boundary was defined by a topographic high;
- The western, eastern and southern boundary was defined by the topographic lows/valleys.

The mapped GRU covers a total area of 826 ha and is indicated in Figure 9.

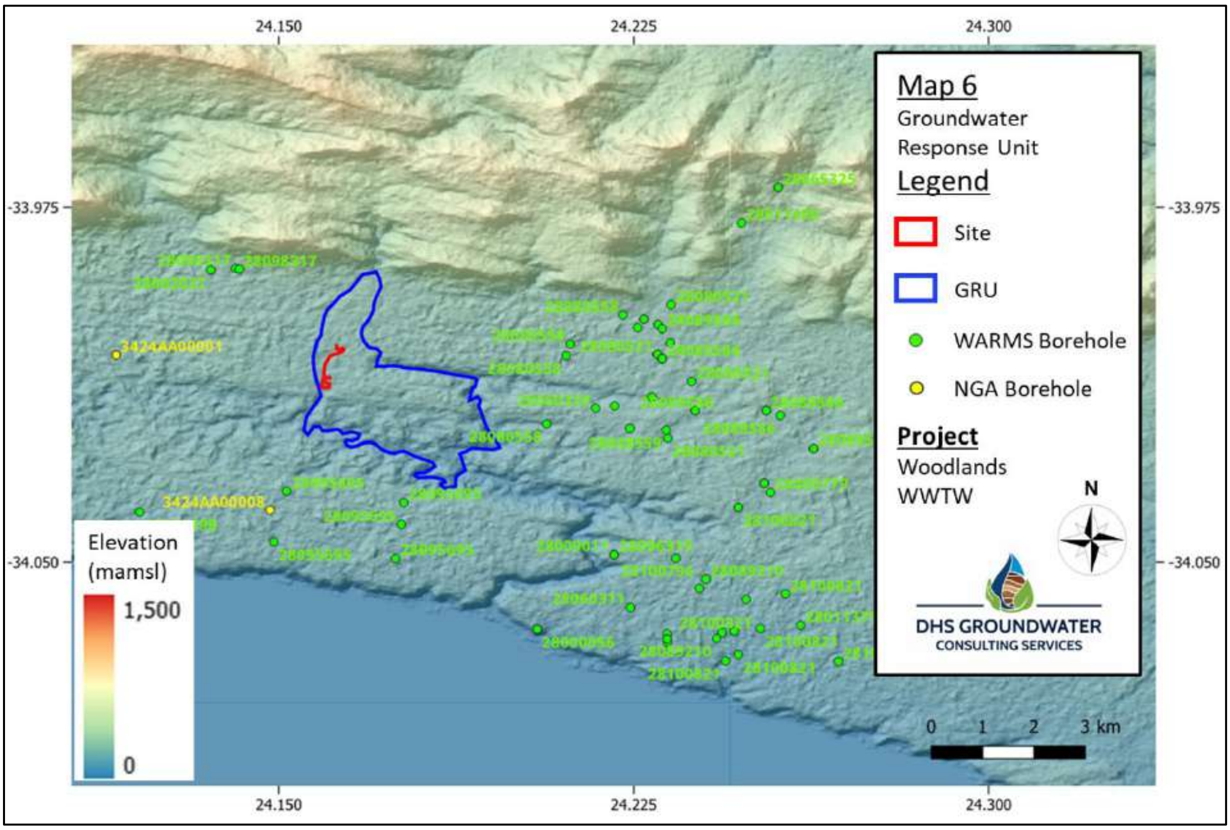


Figure 9. Mapped GRU shown on 30m digital elevation model.

<u>It is important to note that no groundwater users were identified within the GRU from both the DWS databases and from hydrocensus.</u>

5.5 Groundwater Quality

No groundwater samples were collected during the hydrocensus, as no active groundwater users were identified in the immediate vicinity of the site. However, as discussed in Section 4.5.1.5, available electrical conductivity data suggests that groundwater quality in the area is expected to range from ideal to good for drinking purposes.

DHS Groundwater Consulting Services has previously conducted groundwater quality assessments in the broader region, which indicate that local groundwater chemistry often exhibits elevated concentrations of sodium (Na), chloride (Cl), and iron (Fe). These parameters frequently exceed the limits specified in the South African National Standard for drinking water quality (SANS 241-1:2015, Edition 2)[17].

6 Aquifer Classification

The aquifer(s) underlying the project area were classified in accordance with "A South African Aquifer System Management Classification, December 1995" by Parsons. Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

- Sole Aquifer System: An aquifer which is used to supply 50% 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 the available information, the aquifer system in the study area can be classified as a "Minor to Major Aquifer System." These aquifers primarily play an ecological role by sustaining baseflow to surface water bodies and supporting local ecosystems. While they typically yield only modest quantities of groundwater, pockets of highly productive aquifers do exist within the region, capable of supporting more substantial groundwater abstraction where geological conditions are favourable.

In order to achieve an Aquifer System Management Index and a Groundwater Quality Management Index a point scoring system, as presented in Table 5 and Table 7 below, was used.

[17] SABS drinking water standards (SANS 241-1:2015) Second Edition. SABS Standards Division, March 2015. ISBN 978-0-626-29841-8

Table 5. Ratings for the Aquifer System Management and Second Variable Classifications.

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

The values in Table 5 are naturally subjective, but is based on the aquifer descriptions given previously. The importance of each aquifer should provide guidance on the protection to be assigned to each area.

The level of protection required of a groundwater system depend, amongst other, on the aquifer system classification class and the fractured extent and connectivity of the aquifers. The assumption is that a higher fracture presence results in a higher aquifer connectivity. An aquifer system management index can be derived with the following equation:

Aquifer System Management Index = Aquifer System Management Class x Fracturing

= 3 x 3 = 9

Table 6. Ratings for the Aquifer System Management Index.

Aquifer System Management Index	**Level of Protection**	**Study Area**
<1	Limited	9
1 - 3	Low Level	
3 - 6	Medium Level	
6 - 10	High Level	
>10	Strictly Non-Degradation	

The ratings for the Aquifer System Management Classification and Second Variable Classification (Fracturing) yield an Aquifer System Management Index of 9 for the study area, indicating that a “high” level of groundwater protection is required in terms of prevailing groundwater flow regime management.

Table 7. Ratings for the Groundwater Quality Management (GQM) Classification System.

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

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

= 3 X 2 = 6

Table 8. GQM index for the study area.

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

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 6 for the study area, indicating that a "high" level of groundwater protection is required in terms of groundwater quality management.

In terms of DWS's overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exists, measures must be triggered to limit the risk to the environment. In this instance it would be the (1) protection of the "Minor and Major Aquifer", (2) the external groundwater users in the area, and (3) maintain baseflow to the surrounding ecosystems dependent on groundwater.

7 Preliminary Risk Assessment

In order to assess the risks associated with the proposed development at the site with specific reference of the operational working of the WWTW and associated sewage network, the "Source-Pathway-Receptor" principle was applied as outlined in the G4 Impact Prediction Best Practice Guideline for the Mining Industry (DWA, 2007)[18] . The following preliminary risk assessment is based on the information collected during the desktop study, literature review and fieldwork assessment.

7.1 Identified Sources

The sources of groundwater contamination for the development can be grouped into those associated with the construction phase as well as the operational phase.

7.1.1 Construction Phase

During the construction phase, several sources of pollution pose risks to both soil and groundwater contamination. These sources include:

- **Hydrocarbons, paint, solvents, cleaners, and other harmful chemicals**: These materials, if not managed properly, can leak or spill onto the ground, contaminating the soil and potentially reaching the groundwater. Improper use, storage, disposal, or spillage of these substances can lead to significant contamination risks.
- **Miscellaneous construction debris and dirt**: Construction debris, if not properly managed or disposed of, can also contribute to soil contamination. If hazardous materials are mixed with general waste, this can increase the risk of harmful substances leaching into the environment.
- **Improper storage or disposal of solid waste**: If solid waste materials are not stored and disposed of correctly during construction, there is a high chance of soil contamination, which can, in turn, affect groundwater. Waste left on-site or improperly disposed of can release contaminants over time.
- **Contaminants washed into stormwater systems**: If pollutants are spilled on hard surfaces like roads or concrete, they can be washed by rainwater into stormwater systems. From there, they may be discharged into the surrounding environment or directly into local streams, carrying contaminants that can further impact groundwater quality.

7.1.2 Operation Phase

Several potential groundwater pollutants may arise from the operation of a WWTW, with seepages being one of the primary concerns. These include:

- **Leakages from the sewage pipework system**: If the pipes transporting sewage are not properly maintained or sealed, they can leak untreated or partially treated sewage into the surrounding environment, potentially contaminating groundwater.
- **Leakages from the raw sewage holding tanks**: If there is a failure in the holding tanks (such as cracks or faulty seals), raw sewage can seep into the surrounding soil and eventually reach the groundwater, introducing harmful contaminants.

[18]DWA. 2007. Best Practice Guidelines: Impact Prediction (G4).

- **Leakages and leachate from the treatment plant**: The wastewater treatment process may generate leachate or other by-products that, if not properly contained, can leak into the ground and contaminate the surrounding soil and groundwater.
- **Discharge of improperly treated effluent**: If effluent is discharged and not properly treated to remove harmful substances, it could contaminate the soil and, eventually, the groundwater. Pollutants such as pathogens, heavy metals, and nutrients may be introduced into the groundwater system.
- **Leachate formation from improper disposal of sludge**: Leachate may percolate into the ground and contaminate aquifers with nutrients (nitrogen, phosphorus), heavy metals, and pathogens.
- **Inadequate stormwater management:** In the absence of proper stormwater management infrastructure, the treatment plant is at risk of flooding during heavy rainfall events. This can lead to the overflow or bypass of untreated or partially treated effluent, which may be discharged into the surrounding environment and subsequently infiltrate the soil, posing a risk to underlying groundwater resources.

7.2 Pathways

The potential risk pathways at the site are primarily related to the movement of contaminants through different layers of the soil and aquifer system:

- **The weathered soil/vadose zone and the shallow aquifer**: If contaminants leach into the soil and percolate downwards, they can enter the groundwater system. Once in the shallow aquifer, there is a significant risk that these contaminants could spread into the surrounding area, especially if the groundwater is in close proximity to surface water or wells used for drinking or irrigation.
- **The deeper fractured aquifer**: The presence of secondary fractures within the underlying aquifer can act as hydraulic pathways, allowing contaminants to travel deeper. If contaminants make it through the shallow aquifer, they could be transported along these fractures into the deeper aquifer, where the contamination might spread more extensively, affecting larger volumes of groundwater.

7.3 Receptor

The receptor of potential contaminants will be the following:

- Shallow and Deeper Aquifer;
- Surrounding environment.

Given the potential for contaminants to affect both the groundwater and the surrounding environment, it is clear that without mitigation plans, the risk of contamination is high.

7.4 Recommended Mitigation Plans

To prevent groundwater contamination, it is crucial to properly manage hazardous materials, debris, waste, and stormwater runoff during the construction phase. Implementing strict protocols for handling, storage, and disposal, along with effective spill containment measures, will significantly minimize the risk of pollution. Additionally, regular servicing and maintenance of infrastructure throughout the operational phase are essential to ensure long-term environmental protection.

Monitoring boreholes should be installed to assess both the shallow and deep aquifer. These boreholes will provide essential data and help track any changes in the aquifer over time. By regularly monitoring the groundwater, it will be easier to identify potential issues such as contamination. This data is crucial for making informed decisions about managing and protecting the groundwater system throughout the development and its operation.

8 Aquifer Impact Assessment

As outlined in section 7, the primary concern is the potential contamination of groundwater. To assess the vulnerability of the aquifer to pollution, three different assessment methods were employed:

- **Method 1 - Assessment of the reduction of contaminants in the unsaturated zone**: This method focuses on the unsaturated zone and evaluates how easily contaminants may travel from the surface through the soil and unsaturated zone to the water table. It examines the ability of the soil to filter or reduce contaminants before they reach the groundwater.
- **Method 2 - Aquifer vulnerability rating (DRASTIC Index)**: This method uses a rating system based on seven key hydrogeological parameters (such as depth to water, recharge, soil type, etc.) to assess the vulnerability of the aquifer. The DRASTIC Index generates a final vulnerability rating that helps indicate the likelihood of contamination based on the site's conditions.
- **Method 3 - NEMA (2014) Impact Assessment**: This method evaluates the potential risks of groundwater contamination during both the construction and operational phases of the project. Following the criteria established by the National Environmental Management Act (NEMA, 2014), it systematically scores and rates various factors to determine the overall risk to groundwater. Additionally, this assessment considers the potential impacts on groundwater recharge and the risk of flooding, ensuring a comprehensive evaluation of environmental risks.

These three methods collectively provide a comprehensive evaluation of groundwater vulnerability, taking into account the movement of contaminants, the specific characteristics of the aquifer, and the potential environmental impacts throughout the development process. Each method is designed to assess different aspects of the groundwater system, ensuring a thorough understanding of the risks involved.

8.1 Method-1: Assessment of the Reduction of Contaminants in the Unsaturated Zone

Vulnerability in the unsaturated zone refers to how easily contaminants can travel from the surface through soil and rock layers to the water table. This zone acts as the first barrier against groundwater contamination.

Literature indicates that soils in the vicinity of the site typically consists of deep, bleached and leached sandy soils with white to light yellow-brown colours[19]. DHS Groundwater Consulting Services has been involved in projects with a similar soil type overlying the Table Mountain Group of rocks with soils typically composed of medium dense to fine silty sand (dark brown) and sandy clays (orange-brown) with scattered pieces of sandstone and quartz gravel. A dense root-bed with organic rich topsoil of approximately 0mm-300mm thickness make up the top portion of the natural soil. It is anticipated that weathered, quartzitic sandstone of the Table Mountain Group is present from 2 - 3 mbgl, which transitions to fresh, unweathered quartzitic sandstone deeper.

The effectiveness of this layer in mitigating contaminants depends on several factors, including groundwater flow rate, the nature of the contaminants, and the soil's ability to absorb or retard pollutant movement.

Given the anticipated moderate clay content of the soil and the presence of a thick unsaturated zone composed of fractured quartzitic sandstone—expected to exhibit moderate permeability—contaminant movement is likely to range from moderate to rapid. The limited natural filtration and absorption capacity of this geological setting may result in minimal attenuation of contaminants, potentially increasing the risk of groundwater contamination. Table 9 evaluates contaminant reduction in an unsaturated zone consisting of mostly fractured sandstone, following the DWAF (1997) Protocol to Manage the Potential of Groundwater Contamination from On-Site Sanitation. A detailed assessment can be found in Appendix A.

The below table summarizes how well the unsaturated zone can filter and reduce contaminants, which is crucial in understanding the potential risks to groundwater contamination.

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

Unsaturated Zone conditions		Fractured or Weathered Sandstones
Factor affecting reduction	Rate of flow in unsaturated zone	Medium 0.1 - 10m/d
	Capacity of the media to absorb contaminants	Medium
	Capacity to create an effective barrier to contaminants	Medium
Contamination reduction	Bacteria and viruses	High reduction
	Nitrates and phosphates	Minimal reduction
	Chlorides	Minimal reduction
Comments		Fair barrier to the movement of biological contaminants, but little reduction in chemical contaminants.

[19] Van der Waals. (2011). Soil, Land Use, Land Capability and Agricultural Potential Survey: Proposed Tsitsikamma Community Wind Energy Facility: Tsitsikamma, Eastern Cape Province. Terrasoil Science.

Table 9 demonstrates that the unsaturated zone effectively reduces the movement of biological contaminants, significantly limiting their potential to reach groundwater. However, it provides minimal resistance to chemical contaminants, allowing them to migrate more easily and increasing the risk of groundwater contamination. This underscores the need for additional protective measures to manage chemical pollutants.

8.2 Method-2: Aquifer Vulnerability Rating (DRASTIC Method)

As discussed in section 4.5.1.6, in the DRASTIC method, aquifer vulnerability is determined within hydrogeological settings by evaluating seven parameters denoted by the acronym:

- **D**epth to groundwater – Determined from DWA and GRA2 data
- **R**echarge – Obtained from DWA and GRA2 data,
- **A**quifer media – Determined from geological maps and data from similar geological settings within the area,
- **S**oil media – Determined from data of similar geological settings within the area,
- **T**opography – Determined by digital elevation data,
- **I**mpact on vadose zone – Determined from geological maps and data from similar geological settings within the area,
- Hydraulic **C**onductivity – Protocol to Manage the Potential of Groundwater Contamination form on-site Sanitation (DWAF, 1997).

Groundwater vulnerability is assessed by assigning a rating to each relevant parameter based on its influence on contamination risk. These ratings are then weighted according to their significance and summed to determine the DRASTIC Index, which provides an overall measure of groundwater susceptibility to contamination.

A higher DRASTIC Index indicates an increased risk, identifying areas that require enhanced protection and mitigation measures. The results of this assessment, presented in Tables 10 and 11, outline the parameter ratings and calculated vulnerability levels specific to the site. These tables help prioritize areas where targeted management strategies are needed to minimize contamination risks.

Table 10. DRASTIC method: aquifer vulnerability rating for the proposed development.

Parameter	Effect	Rating										Weight	Site rating	Score
		1	2	3	4	5	6	7	8	9	10			
Depth to Water	Increasing depth to water increases time for natural attenuation or remediation of contaminant	>33m	25 - 33m	17 - 25m		10 - 17m		5 - 10m		2 - 5m	0 - 2m	5	3	15
Recharge	Increasing recharge leads to faster movement of contaminant	0 - 10mm/a	10 - 25mm /a	25 - 37mm/a		37 - 50mm/a	50 - 75mm/a	75 - 110mm/a	110 - 160mm/a	160 - 200mm/a	>200mm/a	4	6	24
Aquifer Media	Increasing porosity increases movement of contaminants		Compact sedimentary rocks with widely spaced fractures	Igneous and/or crystalline metamorphic rocks: fractured	Igneous and/or crystalline metamorphic rocks: fractured and weathered	Compact sedimentary rocks: fractures directly below groundwater		Compact sedimentary rocks: weathered and fractured	Massive dolomite / limestone. Sand and Gravel		Fractured dolomite / limestone with solution channels	3	7	21
Soil media (Drainage)	Increasing soil drainage decreases time for natural attenuation or remediation		Clay loam and silty clay	Silty clay loam, sandy clay and silty loam	Sandy clay loam and loam	Sandy loam	Sandy loam	Shrinking and/or aggregate clay. Loamy sand	Sand. Shrinking and/or aggregate clay	Sand	Sand	2	5	10
Topography (%Slope)	Increasing slope promotes runoff and decreases downward contaminant	>18		12 - 18		6 - 12				2 - 6	0 - 2	1	5	5
Impact of the Vadose Zone	Increasing vadose zone conductivity decreases time for natural attenuation or remediation of contamination		Mainly compact tillite	Mainly compact tillite and shale. Lava and Intrusives.	Mainly compact tillite, shale and sandstone. Assemblage of compact sedimentary strata, and extrusive and intrusive rocks	Compact sedimentary strata	Compact, dominantly arenaceous strata	Consolidated porous to compact sedimentary strata		Porous unconsolidated to semiconsolidated sedimentary strata	Dolomite, chert, subordinate limestone	5	7	35
Hydraulic Conductivity	Increasing vadose zone conductivity decreases time for natural attenuation or remediation of contamination	0.03 - 0.69m	0.69 - 1.35m	1.35 - 2.02m	2.02 - 2.68m	2.68 - 3.34m	3.34 - 10m				>10m	3	3	9
												Final score		**119**

The vulnerability index score (DRASTIC index) for the site is 119. Below is a classification table indicating the class description for the index range.

Table 11. Vulnerability Index Classification

Index range	Class name
<89	Very low
90 – 105	Low
106 – 140	**Medium**
141 – 186	High
187 – 210	Very high
>211	Extremely high

The aquifer's vulnerability to potential pollution sources is classified as "MEDIUM," indicating a moderate risk of contaminants reaching the groundwater table. This suggests that pollutants can infiltrate through the soil and unsaturated zone, posing a threat to groundwater quality.

To mitigate this risk, stringent aquifer protection measures are essential. These should include enhanced monitoring, advanced wastewater treatment, secure containment of hazardous materials, and strict management of construction and operational activities. Implementing these safeguards will help prevent contamination and ensure long-term groundwater protection.

8.3 NEMA Impact Assessment

This assessment method follows the Environmental Impact Assessment (EIA) Regulations and the National Environmental Management Act (NEMA, 2014) to evaluate potential risks to groundwater. The primary concern is the release of contaminated water into the regional hydrological system, which could impact groundwater and aquifers. The assessment considers key factors such as the proximity of contamination sources, pollutant migration potential, and the overall sensitivity of the groundwater system, helping to determine the level of risk posed by the proposed development and guiding mitigation strategies.

In addition to contamination risks, the assessment examines potential impacts on groundwater recharge and flooding. Changes in surface runoff, impervious surfaces, and drainage patterns could disrupt natural recharge processes, leading to reduced groundwater levels. Furthermore, flooding could exacerbate contamination risks and alter groundwater flow. By evaluating these factors together, the assessment provides a comprehensive understanding of the environmental impacts of the development, ensuring that mitigation strategies address all potential risks.

The most significant impacts were individually assessed and graded using a numerical system to determine their overall significance. This process involved an initial evaluation, followed by a reassessment after applying mitigation measures to gauge their effectiveness. A detailed summary of the assessed impacts, mitigation measures, and the significance of each impact—both before and after mitigation—is presented in the tables below. These tables offer a clear overview of potential risks and the steps taken to minimize them, ensuring environmental and groundwater protection. The methodology followed for the NEMA impact assessment is discussed in Appendix B.

Table 12. Impact and risk ratings for the construction phase.

Project Phase	Construction			
Impact	Spillages of diesel, petrol, oil, paints, clears and other harmful chemicals. These substances may potentially percolate into the groundwater and enter the surrounding environment.			
Mitigatability	High		Mitigation exists and will considerably reduce significance of impacts.	
Potential Mitigation	i) Install the sewage and and wastewater infrastructure according to applicable national SANS standards (SANS1200 Part K:Civil Engineering Standard Specifications, SANS10400:The National Building Regulations and Building Standards Act, SANS 1913:Planning, Design, and Construction of Sanitation Systems, SANS 10252&SANS10253:Water Supply and Drainage Installations), DWS Guidelines and adhere to municipal regulations & by-laws. ii) Site to be monitored regularly for contaminant spillages and if detected, contact spillage remediation companies. iii) Separate, tightly cover and monitor toxic substances to prevent spills and possible site contamination. iv) Cover stockpiles of building materials like cement, sand and other powders. v) Regularly inspect stockpiles for spillages and store away from waterways or drainage areas. vi) Collect any wastewater generated from site activities during construction in settlement tanks then screen, discharge the clean water,and dispose of remaining sludge according to environmental regulations. vii) Install at least three monitoring boreholes into the water table, one upstream and two downstream of site.			
Assessment	**Without mitigation**		**With mitigation**	
Intensity	3	Damage to biophysical and/or social system components	1	Negligible damage to individual components of biophysical and / or social systems.
Duration	3	Medium term: 1-5 years	2	Short term: Less than 1 year
Extent	3	Local Area: Extending across the site and to nearby settlements	2	Limited: Limited to the site and its immediate surroundings
Type	-1	Negative	-1	Negative
Consequence	-9	Slightly detrimental	-5	Negligible
Probability	4	Probable: Has occurred here or elsewhere and could therefore occur	4	Probable: Has occurred here or elsewhere and could therefore occur
Significance	-36	Minor - negative	-20	Negligible - negative
Comment on Consequence and Significance	**After the implementation of mitigation measures, the consequence becomes negligible and the significance, negligible - negative.**			
Cumulative impacts	**Since the impact is negligible negative with mitigation, cumulative impacts to groundwater with other projects are not anticipated.**			

Table 13. Impact and risk ratings pertaining to potential groundwater contamination during the operational phase.

Project Phase	Operational			
Impact	i) Leakage from pipework associated with the WWTW ii) Leakage from sewage holding tank. iii) Leaks and leachate from the WWTW. iii) Dishcarge of improperly treated effluent. iv) WWTW failure. v) Flooding of WWTW during storms. vi) Leachate from the sludge storage facilities. All of the aforementioned impacts could percolate into the groundwater.			
Mitigatability	High		Mitigation exists and will considerably reduce significance of impacts.	
Potential Mitigation	i) Ensure the WWTW comply with SANS standards (SANS1200 Part K:Civil Engineering Standard Specifications, SANS10400:The National Building Regulations and Building Standards Act, SANS 1913:Planning, Design, and Construction of Sanitation Systems, SANS 10252&SANS10253:Water Supply and Drainage Installations, SANS1913:Planning, Design, and Construction of Sanitation Systems), NWA, Water Quality Guidelines (DWAF), NEMA & EIA Regulations, DWS WWTW Design Guidelines. ii) All areas where potential leachate may occur are to be covered with impermeable materials (including sludge disposal sites). iii) Ensure proper stormwater managemnet infrastructure is in place. iv) Regularly service the WWTW and inspect the integrity and efficacy of the WWTW. v) Ensure emergency procedures are in place to rapidly repair WWTW should failure occur. vi) Set up a comprehensive monitoring system to monitor the effluent quality. vii) Incorporate monitoring network as implemented during the construction phase into operational phase monitoring. viii) The WWTW and associated pipework to be monitored regularly for any leakages. ix) Should leakages be detected or the monitoring boreholes be contaminated, a baseline Phase 1 Contamination Assessment should be undertaken and the site remediated in consultation with a contamination remediation consultant and the Authorities.			
Assessment	**Without mitigation**		**With mitigation**	
Intensity	5	Very serious impacts and irreparable damage to components of biophysical and / or social systems	2	Minor damage to biophysical and / or social system components and species. Likely to recover over time. Ecosystem processes not affected
Duration	7	Permanent: The impact will remain long after the life of the project	2	Short term: Less than 1 year
Extent	3	Local Area: Extending across the site and to nearby settlements	2	Limited: Limited to the site and its immediate surroundings
Type	-1	Negative	-1	Negative
Consequence	-15	Highly detrimental	-6	Slightly detrimental
Probability	5	Likely: The impact may occur	4	Probable: Has occurred here or elsewhere and could therefore occur
Significance	-75	Moderate - negative	-24	Negligible - negative
Comment on Consequence and Significance	**After the implementation of mitigation measures, the consequence becomes slightly detrimental and the significance, negligible - negative.**			
Cumulative impacts	**Since the impact is negligible negative with mitigation, cumulative impacts to groundwater with other projects are not anticipated.**			

This groundwater risk assessment is based on the data collected during the desktop study and field assessment. While the data provides useful insights, several limitations were identified that need to be taken into account when evaluating the risks:

1. **Lack of Shallow and Deep Geology Logs:** There is no site-specific data available on the shallow subsurface or deep geological strata. As a result, information regarding the geological conditions at various depths is inferred from studies conducted on similar geological formations in the surrounding area.

2. **Absence of Aquifer Parameters**: The assessment does not include detailed aquifer parameters, such as permeability, porosity, or aquifer storage capacity, which are important for understanding how water moves through the subsurface and how contaminants may spread.

It is recommended that these limitations be addressed once the boreholes are installed. The acquired information will be used to accurately mitigate the risk.

A deep water table is indicated at approximately 20 metres below ground level (mbgl). This is supported by recorded water levels from boreholes within the NGA which is located within a 10km radius of the site. This significant depth reduces the likelihood of groundwater contamination from surface activities, as pollutants would need to travel through a substantial unsaturated zone before reaching the aquifer. However, the absence of detailed geological logs means that variations in water table depth, permeability and fracture networks remain uncertain.

To ensure the long-term protection of groundwater quality, mitigation measures should be implemented, focusing on:

- Early detection of contaminants or leaks through regular groundwater quality monitoring.
- Strict management of potential contamination sources, particularly wastewater treatment and effluent disposal, to prevent pollutants from infiltrating the water table.
- Proper site planning and containment strategies to minimize the risk of accidental spills or seepage into the subsurface.

Despite the identified data limitations, the risk of groundwater contamination from the proposed development is assessed as **moderate-negative**. With the implementation of appropriate mitigation measures, this impact can be further reduced to a **negligible-negative** level, ensuring minimal environmental consequences.

9 Environmental Management & Groundwater Monitoring Program

The primary objective of the proposed mitigation measures, designed to address the identified impacts as identified in Table 12 and Table 13, is to ensure the protection and monitoring of local groundwater quality throughout the various phases of the project. These measures are vital to safeguard the quality of groundwater resources, thus ensuring the sustainability of this essential resource for all users. The specific goals of these mitigation measures are as follows:

- **To ensure that Schedule 1 water users within the area** have access to groundwater supplies that meet the required standards of quality, ensuring that the water remains uncontaminated and fit for its intended purposes.
- **To ensure that registered groundwater users within the catchment area** continue to receive an adequate and uncontaminated water supply, safeguarding the long-term viability of the groundwater as a resource for agricultural, industrial, and domestic use.
- **To ensure the availability of groundwater of appropriate quality** to support groundwater-dependent ecosystems, including the baseflow that sustains rivers, streams, and wetlands in the area. These ecosystems rely on a consistent and clean supply of groundwater to thrive, making their protection an essential aspect of sustainable development.

To effectively monitor and safeguard groundwater quality, the installation of dedicated monitoring boreholes is essential. It is recommended that three boreholes be installed: one upgradient of the site to establish baseline (background) groundwater quality, and two downgradient to detect and track any potential contamination migrating from the site. This strategic placement will ensure comprehensive spatial coverage, enabling effective groundwater quality assessment both before construction begins and throughout the operational phase of the facility. The exact locations of the monitoring boreholes should be determined once the final spatial footprint of the WWTW has been established. However, it is essential that all boreholes are sited within 150 metres or closer to the facility to ensure effective monitoring of potential groundwater impacts.

9.1 Monitoring Boreholes

9.1.1 Timing of installation

The boreholes should be installed prior to the construction phase in order to establish baseline groundwater quality. This is essential for detecting any early signs of contamination during the construction phase. Monitoring will continue throughout the operational phase to ensure that the groundwater remains uncontaminated and that any potential issues are detected and addressed promptly.

9.1.2 Design and Construction of Boreholes

The boreholes should be appropriately designed and constructed to ensure that they provide reliable and accurate data throughout the project lifespan (see Figure 10).

- The following specifications are recommended for the piezometer installation:
    - **Borehole Diameter and Depth:** Drilling should not be smaller than 165mm in diameter. The depth should be sufficient to monitor the water table and deeper groundwater.
    - **uPVC Casing Diameter:** The borehole must be fitted with class 12, flush fit, threaded ended uPVC and be slotted from approximately 2.5m to the end of hole depth. The diameter of the PVC casing should not be less than 110 mm to provide adequate flow of groundwater and to allow for proper monitoring and sampling.
    - **Gravel/Filter Pack:** The hole annulus surrounding the borehole should be filled with a gravel/filter pack (typically between 2 and 3 mm in diameter). This ensures proper filtration and prevents fine particles from entering the borehole, which could potentially affect the accuracy of measurements.
    - **Bentonite Seal:** The top 2 meters of the annulus should be filled with a bentonite seal to prevent surface water or other contaminants from entering the piezometer and affecting groundwater readings.
    - **Protection and Marking:** Each borehole should be equipped with lockable protection to prevent tampering and damage. The boreholes should also be clearly marked and easily identifiable to ensure proper operation and maintenance throughout the development lifecycle.

The construction of the boreholes should be supervised and managed by a qualified geohydrologist to ensure that the installations meet industry standards and are placed in optimal locations for monitoring purposes. The geohydrologist should oversee the entire process, from design to installation, ensuring that the piezometers are constructed in accordance with best practices. No installation should be undertaken without the consultation or supervision of a geohydrologist, as their expertise is critical for the successful monitoring of groundwater quality and levels.

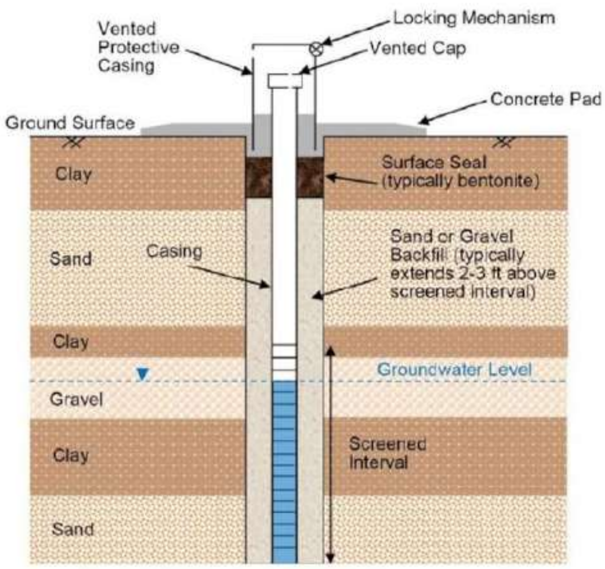


Figure 10. Typical example of a monitoring borehole installation.

9.2 Effluent Quality Monitoring

In addition to monitoring groundwater quality, it is crucial to also monitor the effluent quality. Regular sampling and analysis of the effluent will help ensure that the treatment processes are effective and that no contaminants are being released into the groundwater system. This will provide additional layers of protection, particularly for areas in close proximity to the WWTW and the sewage storage tanks.

9.3 Groundwater Monitoring Program

A comprehensive groundwater monitoring program should be developed to outline the specific parameters to be monitored, as well as the frequency of sampling and analysis. Table 14 below presents a proposed list of parameters and recommended monitoring frequencies that should be included in the program. It is essential that this data be captured in an appropriate electronic database, which will facilitate easy retrieval and submission to the relevant authorities as required by regulations. Additionally, the data should be reviewed by a geohydrologist on a quarterly basis to ensure that no contamination is occurring and that groundwater quality remains within acceptable limits.

9.4 Sampling Standards

Groundwater sampling should be conducted in accordance with the SANS 5667-11:2015 standard, which outlines the procedures for groundwater sampling, including the use of proper equipment, handling protocols, and analytical methods. Following these standards ensures that the data collected is accurate, reliable, and consistent, allowing for effective monitoring and timely intervention if necessary.

By implementing these mitigation measures and ensuring regular, systematic monitoring, the risk of groundwater contamination can be significantly reduced, and the long-term sustainability of local water resources can be maintained. The early detection capabilities afforded by the piezometer network will provide valuable insights into groundwater quality, allowing for proactive management and timely corrective actions if any issues are identified. The comprehensive monitoring program, in conjunction with the oversight of qualified professionals, will help ensure that both the development and the surrounding environment are adequately protected throughout the project lifecycle. The proposed monitoring is presented in Table 14.

Table 14. Proposed Monitoring Requirements.

Class	Parameter	Frequency	Motivation
Physical	Static groundwater levels	Monthly	Temporal variation
Chemical	Faecal Coliforms, COD, pH, Ammonia as Nitrogen, Nitrate/Nitrite as Nitrogen, Chlorine as free Chlorine, EC, Orthophosphate as phosphorous, Fluoride, Soap oil or grease, Major ions and trace elements.	Effluent Monthly, Monitoring Boreholes Quarterly	Changes in chemical and microbial composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions.

9.5 Additional Mitigation Measures

In addition to installing monitoring boreholes and monitoring groundwater and effluent quality, the following management and mitigation measures are recommended:

a. Waste Containment and Infrastructure

- Use synthetic/geotextile liners and impermeable surfaces approved by the Department of Water and Sanitation (DWS) in areas where sewage and associated waste are handled.
- Construct all sewer lines and pipes to ensure leak-proof systems that prevent contamination.
- Ensure that sewage holding tanks and accommodation facilities are properly managed to prevent overflow and spillage.

b. Inspection, Maintenance, and Leak Prevention

- Conduct regular inspections and upgrades of pipes and associated infrastructure to maintain system integrity.
- Install leak monitoring devices in the sewage system to enable early detection and proactive groundwater contamination prevention.
- Keep the facility clean and well-maintained at all times to reduce the risk of pollution.

c. Waste Management and Disposal

- Dispose of all waste at registered landfill sites; on-site dumping and disposal in surrounding areas are strictly prohibited.
- Properly clean up and dispose of spills or sludge at a registered landfill site to prevent environmental hazards.
- Ensure that all waste-handling surfaces are impermeable to prevent leaks and seepage.

d. Stormwater and Runoff Management

- Implement an effective stormwater management system to prevent runoff from coming into contact with waste.
- Divert and control stormwater to reduce contamination risks.
- By implementing these measures, the risk of groundwater contamination, infrastructure failure, and regulatory non-compliance can be significantly reduced.

10 Post Closure Management Plan

With respect to groundwater and geology predicted potential impacts, the following remediation measures must be considered when the facility suspends all activities and the facility closes.

- Upon completion of activities, the site must be rehabilitated through appropriate landscaping, levelling, topsoil dressing, and land preparation. Alien plant species must be eradicated, and vegetation must be established as required by the Environmental Control Officer.
- Boreholes must be securely sealed to prevent damage and to avoid debris accumulation.
- All temporary infrastructure and construction structures must be completely removed from the site.
- Rehabilitation structures must be regularly inspected for debris accumulation, blockages, instability, and erosion. Any identified issues must be promptly addressed with remedial and maintenance actions.
- Topsoil backfilling must only be conducted when the soil is dry and should not take place immediately after rainfall events.
- Whenever possible, topsoil should be reused in situ during construction or replaced immediately after construction in a given area is completed.
- Topsoil must be returned to the same location from which it was originally stripped.
- The adjudicated authority must monitor the regrowth of invasive plant species for a period of one (1) year.
- All disturbed areas must be re-vegetated using indigenous plant species suitable for the local environment.

11 Discussion

According to the Department of Water and Sanitation (DWS), the project area is underlain by a low- to moderate-yielding fractured aquifer system, primarily associated with deeper geological formations typical of the Cape Fold Belt. This interpretation is supported by borehole water level and geological data obtained from the National Groundwater Archive (NGA), specifically within a 10 km radius of the site. Although no groundwater users were identified within a 1 km radius, 19 registered boreholes are recorded within a 5 km radius. Additionally, no boreholes are listed within the designated Groundwater Response Unit (GRU) that encompasses the site.

Literature sources indicate that groundwater in this region typically exhibits electrical conductivity (EC) values ranging from 0–70 mS/m, which corresponds to “ideal to good” water quality according to general classification systems. However, field investigations conducted by DHS Groundwater Consulting Services across the broader region suggest that groundwater chemistry often exceeds the South African National Standard (SANS 241-1:2015, Edition 2) for drinking water, particularly in terms of sodium (Na), chloride (Cl), and iron (Fe) concentrations.

In practice, EC values typically fall within the 70–150 mS/m range, reflecting elevated salinity levels likely influenced by lithological and hydrogeological conditions.

Aquifer vulnerability at the site is classified as “moderate” based on national-scale DRASTIC data, an established model for assessing groundwater susceptibility to contamination. When localized site parameters are applied to the DRASTIC model, this classification remains consistent. Despite the moderate intrinsic vulnerability, both the Aquifer Management Index (AMI) and the Groundwater Quality Management Index (GQMI) classify the site as a high-risk area due to the presence of a “Minor to Major” aquifer system. These classifications underscore the strategic importance of implementing proactive groundwater protection measures to maintain both quality and long-term resource availability.

To systematically evaluate the potential impacts of the proposed development during construction and operation, the Source–Pathway–Receptor (SPR) model was applied. This approach assesses how pollutants may migrate from their origin (source), through environmental media (pathway), to a receiving system (receptor). Potential contamination sources include:

- Spillage or mishandling of fuels, lubricants, and chemicals during construction;
- Inadequate containment or storage of hazardous materials;
- Leaks or failures from wastewater treatment infrastructure, including pipelines and sludge drying beds or disposal areas.

While the depth to groundwater provides some natural protection by delaying vertical contaminant migration, the vadose (unsaturated) zone and the deeper fractured aquifer serve as both potential pathways and receptors. This highlights the necessity of implementing robust containment and management strategies to prevent pollutant ingress.

Identified receptors include the vadose zone, the deeper fractured aquifer system, and potentially surrounding terrestrial and aquatic environments, should contaminants migrate laterally or reach surface discharge points. Based on the hydrogeological risk assessment, the potential for groundwater contamination during the **construction phase** is assessed as **minor-negative**, while the **operational phase** poses a **moderate-negative** risk. These risks can be significantly reduced through the implementation of the following key mitigation measures:

- Proper on-site containment of hazardous substances;
- Installation of secondary spill containment infrastructure;
- Scheduled maintenance and inspection of all wastewater and sludge handling systems;
- Design and installation of a dedicated groundwater monitoring network.

With these measures in place, the residual risk of aquifer contamination is expected to decrease to **negligible-negative**. Furthermore, it is strongly recommended that a comprehensive groundwater and effluent quality monitoring programme be established and maintained throughout the lifespan of the wastewater treatment works (WWTW). This should include baseline assessments, routine sampling, and the use of automated early-warning detection systems where feasible, to facilitate immediate responses to any signs of contamination.

In conclusion, although the proposed WWTW and associated infrastructure present potential risks to groundwater resources, these risks are manageable. By applying rigorous environmental safeguards, including continuous monitoring and proactive management during both construction and operational phases, adverse impacts can be minimized.

This approach will not only safeguard the integrity of the underlying aquifer system but also protect surrounding ecosystems and support sustainable water resource management in the region.

12 Conclusion & recommendations

The following recommendations are made to ensure the protection of groundwater resources to mitigate the potential risks of contamination during both the construction and operational phases of the development:

- **Mitigation Measures:** Implement and strictly adhere to prescribed mitigation measures to minimize environmental impact and ensure compliance with relevant regulations.
- **Monitoring Network Installation:** It is strongly recommended that the monitoring network be installed prior to the commencement of the proposed development. This will ensure that data is available to monitor groundwater quality from the outset and allow for early detection of any potential issues during the construction phase. This network will also be essential for monitoring during the operational phase to ensure continuous assessment of groundwater quality and to detect any contamination risks promptly.
- **Borehole Installation:** At least three monitoring boreholes should be installed to effectively detect any potential contaminants and enable monitoring of groundwater quality over time.
- **Regular Monitoring:** To track changes in groundwater quality and chemical parameters should be recorded quarterly from each of the installed boreholes. Additionally, effluent quality should also be regularly tested to assess the potential impact of the WWTW.
  - **Laboratory Testing:** All groundwater and effluent samples should be sent to an accredited SANAS laboratory for analysis. Sample collection, handling, and transport should strictly adhere to laboratory standards to ensure the accuracy and integrity of the results.
- **Rapid Response Plan:** A rapid response plan should be developed in the event that any contamination is detected during the monitoring process. This plan should include clear procedures for identifying the source of contamination, containing the issue, and mitigating any potential environmental impacts. It should also outline specific actions to address contamination quickly and effectively, reducing the risk of groundwater or environmental degradation.

Conclusion:
By implementing the recommended monitoring network and mitigation measures outlined above, the risk of groundwater contamination during both the construction and operational phases can be reduced to negligible - negative. This will ensure that groundwater quality is continuously protected and that any potential issues are addressed promptly, safeguarding the health and sustainability of the surrounding ecosystem and water users.

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14 Appendix

14.1 Appendix A: Assessment of the reduction of contaminants in the unsaturated zone

Table 15. Assessment of the reduction of contaminants in the unsaturated zone

Unsaturated zone conditions	Factor affecting reduction			Contaminant reduction			Comments
	Rate of flow in unsaturated zone	Capacity of the media to absorb contaminants	Capacity to create an effective barrier to contaminants	bacteria and viruses	nitrates and phosphates	chlorides	
clay	very slow <10mm/d	high	high	very high reduction	high reduction	high reduction	Very good barrier to the movement of contaminants. May have problems with water retention in pit.
massive shales	very slow <10mm/d	high	high	very high reduction	high reduction	high reduction	Very good barrier to the movement of contaminants. May have problems with water retention in pit.
solid granites	very slow <10mm/d	minimal	high	high reduction	high reduction	high reduction	Good barrier to the movement of contaminants. Horizontal flow may be more relevant than vertical flow.
silt	slow 10-100mm/d	medium	high	high reduction	some reduction	minimal reduction	Good barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
sandy loam	slow 10-100mm/d	medium	high	high reduction	some reduction	minimal reduction n	Good barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
bedded shales	slow 10-100mm/d	high	high	very high reduction	some reduction	minimal reduction	Good barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
weathered or fractured granites	slow to medium 0.01-10m/d	minimal to medium	minimal to low	high reduction	minimal reduction	minimal reduction	Fair barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
fractured or weathered sandstones	medium 0.1-10m/d	medium	medium	high reduction	minimal reduction	minimal reduction	Fair barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
cavernous limestones/ calcretes	medium 1-100m/d	medium	medium	high reduction	some reduction	minimal reduction	Good barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
fine sand	medium 0.1-10m/d	minimal	high	high reduction	minimal reduction	minimal reduction	Good barrier to the movement of biological contaminants, but little reduction in chemical contaminants.
coarse sand and gravels	fast 10-1000m/d	minimal	low	some reduction	minimal reduction	minimal reduction	Poor barrier to the movement of contaminants.

Note: light shading = minimal risk of contamination medium shading = low risk of contamination dark shading = higher risk of contamination

14.2 Appendix B: NEMA Impact Assessment Methodology

The assessment of the predicted significance of impacts for a proposed development is by its nature, inherently uncertain – environmental assessment is thus an imprecise science. To deal with such uncertainty in a comparable manner, a standardised and internationally recognised methodology has been developed. This methodology will be applied in this study to assess the significance of the potential environmental impacts of the proposed development.

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** (size or degree scale), which also includes the **type** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). For each predicted impact, the specialist applies professional judgement in ascribing a numerical rating for each of these criteria respectively as per Table 16, Table 17 and Table 18 below. These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

Consequence = type x (intensity + duration + extent)

Depending on the numerical result, the impact's consequence would be defined as either extremely, highly, moderately or slightly detrimental; or neutral; or slightly, moderately, highly or extremely beneficial. These categories are provided in Table 20.

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is also taken into account. The most suitable numerical rating for probability is selected from Table 19 below and applied with the consequence as per the equation below:

Significance = consequence x probability

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative. These categories are provided in Table 21.

Once the significance of an impact occurring without mitigation has been calculated, the specialist must also apply their professional judgement to assign ratings for the same impact after the proposed mitigation has been implemented.

The tables on the following pages show the scales used to classify the above variables, and define each of the rating categories.

Table 16. Definition of Intensity ratings.

Rating	Criteria	
	Negative impacts (Type of impact = -1)	**Positive impacts** (Type of impact = +1)
7	Irreparable damage to biophysical and / or social systems. Irreplaceable loss of species.	Noticeable, on-going benefits to which have improved the quality and extent of biophysical and / or social systems, including formal protection.
6	Irreparable damage to biophysical and / or social systems and the contravention of legislated standards.	Great improvement to ecosystem processes and services.
5	Very serious impacts and irreparable damage to components of biophysical and / or social systems.	On-going and widespread positive benefits to biophysical and / or social systems.
4	On-going damage to biophysical and / or social system components and species.	Average to intense positive benefits for biophysical and / or social systems.
3	Damage to biophysical and / or social system components and species.	Average, on-going positive benefits for biophysical and / or social systems.
2	Minor damage to biophysical and / or social system components and species. Likely to recover over time. Ecosystem processes not affected.	Low positive impacts on biophysical and / or social systems.
1	Negligible damage to individual components of biophysical and / or social systems.	Some low-level benefits to degraded biophysical and / or social systems.

NOTE: Where applicable, the intensity of the impact is related to a relevant standard or threshold, or is based on specialist knowledge and understanding of that particular field.

Table 17. Definition of Duration ratings.

Rating	Criteria
7	**Permanent:** The impact will remain long after the life of the project
6	**Beyond project life**: The impact will remain for some time after the life of the project
5	**Project Life:** The impact will cease after the operational life span of the project
4	**Long term**: 6-15 years
3	**Medium term:** 1-5 years
2	**Short term:** Less than 1 year
1	**Immediate:** Less than 1 month

Table 18. Definition of Extent ratings.

Rating	Criteria
7	**International:** The effect will occur across international borders
6	**National:** Will affect the entire country
5	**Province/ Region:** Will affect the entire province or region
4	**Municipal Area:** Will affect the whole municipal area
3	**Local:** Extending across the site and to nearby settlements
2	**Limited:** Limited to the site and its immediate surroundings
1	**Very limited:** Limited to specific isolated parts of the site

Table 19. Definition of Probability ratings.

Rating	Criteria
7	**Certain/ Definite:** There are sound scientific reasons to expect that the impact will definitely occur
6	**Almost certain/Highly probable:** It is most likely that the impact will occur
5	**Likely:** The impact may occur
4	**Probable:** Has occurred here or elsewhere and could therefore occur
3	**Unlikely:** Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
2	**Rare/ improbable:** Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the project but has happened elsewhere. The possibility of the impact manifesting is very low as a result of design, historic experience or implementation of adequate mitigation measures
1	**Highly unlikely/None:** Expected never to happen.

Table 20. Application of Consequence ratings.

Range		Significance rating
-21	-18	Extremely detrimental
-17	-14	Highly detrimental
-13	-10	Moderately detrimental
-9	-6	Slightly detrimental
-5	5	Negligible
6	9	Slightly beneficial
10	13	Moderately beneficial
14	17	Highly beneficial
18	21	Extremely beneficial

Table 21. Application of Significance ratings.

Range		Significance rating
-147	-109	Major - negative
-108	-73	Moderate - negative
-72	-36	Minor - negative
-35	-1	Negligible - negative
0	0	Neutral
1	35	Negligible - positive
36	72	Minor - positive
73	108	Moderate - positive
109	147	Major - positive

Despite attempts at providing a completely objective and impartial assessment of the environmental implications of development activities, environmental assessment processes can never escape the subjectivity inherent in attempting to define significance. The determination of the significance of an impact depends on both the context (spatial scale and temporal duration) and intensity of that impact. Since the rationalisation of context and intensity will ultimately be prejudiced by the observer, there can be no wholly objective measure by which to judge the components of significance, let alone how they are integrated into a single comparable measure.

Province of the
EASTERN CAPE
ECONOMIC DEVELOPMENT, ENVIRONMENTAL AFFAIRS & TOURISM

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST IN TERMS OF REGULATIONS 12 AND 13 OF THE AMENDMENTS TO THE ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS, 2014 AS AMENDED.

	(For official use only)
File Reference Number:	
NEAS Reference Number:	
Date Received:	

Application for environmental authorization in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Amendments to the Environmental Impact Assessment Regulations, 2014. This form is valid as of 6 January 2021.

PROJECT TITLE

UPGRADE OF A WASTEWATER TREATMENT WORKS AND INSTALLATION OF SMALL-BORE SEWAGE RETICULATION SYSTEM IN WOODLANDS, KOUKAMMA LOCAL MUNICIPALITY, SARAH BAARTMAN DISTRICT MUNICIPALITY , EASTERN CAPE

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Project Consultant:			
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4.2 The SPECIALIST

I, Divan Stroebel , declare that –

General declaration:

- I act as the independent Specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting environmental impact assessments, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in regulation **8** of the regulations when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing **-** any decision to be taken with respect to the application by the competent authority; and **-** the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will ensure that the comments of all interested and affected parties are considered and recorded in reports that are submitted to the competent authority in respect of the application, provided that comments that are made by interested and affected parties in respect of a final report that will be submitted to the competent authority may be attached to the report without further amendment to the report;

- I will keep a register of all interested and affected parties that participated in a public participation process; and
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- all the particulars furnished by me in this form are true and correct;
- will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations; and
- I realise that a false declaration is an offence and is punishable in terms of section 24F of the Act.

Disclosure of Vested Interest (delete whichever is not applicable)

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Amendments to Environmental Impact Assessment Regulations, 2014 as amended.

____

____

[signature]

Signature of the environmental assessment practitioner:

DHS Groundwater Consulting Serives

Name of company:

03/09/25

Date:

Signature of the Commissioner of Oaths: [signature]

Certified a true copy of the original
Date: 03/09/25
Ex Officio COMMISSIONER OF OATHS (RSA)
Cornelius Weimarans - Office Manager
Re-Solve Consulting (Pty) Ltd
105 Albert Road, Walmer, 6070
Port Elizabeth

03/09/25

Date:

Director

Designation:

[1] Curriculum Vitae (CV) attached

Official stamp (below).

DHS GROUNDWATER
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PRINCIPAL HYDROGEOLOGIST, DIRECTOR

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EXPERIENCE

Divan Stroebel is a SACNASP registered and active member of the Groundwater Division, the Geological Society of South Africa, hydrogeologist and professional geoscientist with more than 18 years of industry experience. He obtained his B.Sc. (Geology) degree in 2005 and his B.Sc. Honours (Geology) degree in 2006 from Stellenbosch University. From 2007, he worked throughout Africa as an exploration geologist in base metal, iron ore and gold exploration. In 2009 he joined a hydrogeological consultancy and completed additional groundwater modules at the Institute for Groundwater Studies (IGS), University of Free State. These modules included Aquifer Mechanics, Groundwater Chemistry, Groundwater Geophysics, Groundwater Modelling and Groundwater Management.

He was employed by mining giant, Rio Tinto in 2010 in Guinea as a Geologist, after which he was the Superintendent Geologist at Goldfields' Kloof mine from 2012. He joined AEON at the Nelson Mandela University (NMU) in 2014 as Associate Research Manager for the Karoo Shale Gas Research Programme- focused on Karoo hydrogeology.

Divan's technical experience includes all aspects of mineral exploration, extraction and reserve management as well as hydrogeological assessments (basic, environmental management plan, permits and licensing, legal query, impact assessments, integrated waste water management plans and external audits), aquifer characterisation, groundwater supply development, groundwater and surface water characterisation and monitoring as well as water quality assessments.

Divan is very active in the hydrogeological community and has attended, presented at and co-organised numerous water-research workshops and conferences. In June 2016, he was appointed as a visiting researcher at Queen's University, Belfast. In China (2017), he successfully completed an international training programme on the Sustainable Development of Water Resources in Arid Regions for Developing Countries.

During his time at AEON, Divan researched the Groundwater Hydrochemistry and Aquifer Connectivity Baseline of the Eastern Cape Karoo. In anticipation of the controversial hydraulic fracturing planned for the Eastern Cape, he has obtained unique experience in the determination of salinity, aquifer yields and groundwater levels of the Karoo's scarce groundwater resources and has published an article in a special publication by the Geological Society of London on fractured aquifers on the topic. https://sp.lyellcollection.org/content/479/1/129

Divan is the founder and owner of DHS Groundwater Consulting Services where he serves as principal hydrogeologist, overseeing all projects from inception to completion.

EMPLOYMENT HISTORY

January 2019 to Current

- Owner and principal hydrogeologist of DHS Groundwater Consulting Services providing hydrogeological consulting services.

June 2014 to December 2020

- Africa Earth Observatory Network (AEON), Port Elizabeth, RSA.
- Associate Research Manager and Consulting Hydrogeologist for the planning, execution and management of the Karoo Hydrogeological Baseline Research Programme prior to the anticipated hydraulic fracturing for shale gas in the Karoo.

March 2013- August 2013

- Theo Pegram & Associates (Pty) Ltd, Johannesburg, RSA.
- Contract Geologist assisting with start-up and closing-out of various projects.

September 2012- February 2013

- Gold Fields (Pty) Ltd, KDC East (Kloof Mine).
- Superintendent Geologist until Gold Field's unbundling in RSA.

October 2010- July 2012

- Rio Tinto, Simandou Iron Ore Project, Guinea.
- FIFO Exploration Geologist for mapping, planning and executing of a diamond and RC drilling programme.

January 2009 – September 2010

- GHT Consulting Scientists, Bloemfontein, RSA.
- Consulting Hydrogeologist for design and implementation of groundwater resource exploration and develop monitoring and remediation programmes at hazardous waste sites including

August 2007- December 2008

- G&T Exploration Services contracted to Sundance Resources.
- FIFO Exploration Geologist Iron Ore (Cameroon) and Gold (Tanzania).

January 2007 – July 2007

- Exxaro, Rosh Pinah Zinc Corporation, Rosh Pinah, Namibia, Geologist – Base metal mining and exploration.

EDUCATION

- BSc. Geology (2005, University of Stellenbosch)
- BSc. Geology Honours (2006, University of Stellenbosch)

PROFESSIONAL REGISTRATION

- South African Council for National Scientific Professions (SACNASP) - Member No. 400371/12
- Geological Society of South Africa - Member No. 967707
- Groundwater Division of the Geological Society of South Africa - Member No. 1220/23

RECENT CAREER HIGHLIGHTS

2018 - 2020

- Keynote speaker at various geoscientific conferences.
- Keynote speaker at Port Elizabeth MyCity talk convention 2019 on water development of NMBM

2017

- Published Article in Geological Society of London on Fractured Aquifers: http://sp.lyellcollection.org/cgi/reprint/SP479.3v1.pdf?ijkey=cAdcUL3KDL9AHaB&keytype=finite

2016

- Completed international training programme in China on development of water resources in arid regions.
- Published article abstract poster at 35th International Geological Congress.
- Visiting Researcher at Queen's University, Belfast, Northern Ireland.