CLANWILLIAM DAM RAISING PROJECT ENVIRONMENTAL AUTHORISATION AMENDMENT PROCESS – GEOHYDROLOGY REVIEW AND MONITORING PLAN UPDATE

24 AUGUST 2025

COMPILED FOR

ZITHOLELE CONSULTING



Directors: DuToit Wilken; Hendrik Botha
email: henri@elemental-s.co.za
contact: +27 71 102 3819
web: www.elemental-s.co.za

Gauteng Office
460 The Wishbone North
Lynnwood
Pretoria
0081

Free State Office
23 Roggeveld Street
Roodia
Sasolburg
1947

Elemental Water Services Propriety Limited
Registration Number: 2024/085036/07
Established: 2024

REPORT DETAILS

Report Title	CLANWILLIAM DAM RAISING PROJECT ENVIRONMENTAL AUTHORISATION AMENDMENT PROCESS – GEOHYDROLOGY REVIEW AND MONITORING PLAN UPDATE	
Client	ZITHOLELE CONSULTING	
Report Number	EWS25-317	
Report Revision	FINAL 1	
Date of Report	24 AUGUST 2025	
Author	Hendrik Botha MSc. Pr.Sci.Nat (400139/17) Elemental Water Services Proprietary Limited Head – Elemental Water Services 071 102 3819 henri@elemental-s.co.za	24/08/2025 6:20:24 Pr.Sci.Nat (400139/17)

REPORT VERSION HISTORY

FINAL 1	2025-08-24

EXECUTIVE SUMMARY

Elemental Water Services Proprietary Limited (EWS) was appointed by Zitholele Consulting to underate a peer review of the existing groundwater and environmental impact assessment (EIA) studies and monitoring plans for the proposed raising of the Clanwilliam Dam Wall Project, where work is proposed to take place on the eastern and western sides of the N7 National Road, and at the foot of the Clanwilliam Dam, near Clanwilliam, Western Cape, South Africa.

The peer review of the groundwater and EIA documentation for the Clanwilliam Dam raising project confirms that while groundwater was previously identified as a potential concern, the associated risks remain limited, localised, and primarily tied to construction-phase activities. The original Record of Decision (2009) imposed very broad and onerous groundwater monitoring conditions in the absence of a comprehensive hydrogeological assessment at the time. This review demonstrates that such requirements are disproportionate to the actual risk profile of the project. The aquifer systems underlying the dam footprint are of low to moderate yield, with limited connectivity to critical receptors, and the primary construction-related risks (fuel handling, batching plants, camps, quarries, and stockpiles) can be managed effectively through standard mitigation and housekeeping practices.

In line with South African best practice and DWS guidance, the review supports a pragmatic and risk-based relaxation of the groundwater conditions. Continuous borehole monitoring and extensive modelling are not justified. Instead, a simplified approach focused on surface-based spot checks, event-driven inspections, and clear response protocols for spills or abnormal conditions is sufficient to provide assurance during the construction phase. Once construction is complete and the new supply level is reached, a more detailed groundwater evaluation can be staged if spring or seep responses indicate a material change.

Overall, the peer review concludes that groundwater is not a primary limiting factor for this freshwater infrastructure project. A proportionate, phased monitoring strategy—relaxed during construction and reserved for adaptive investigation post-impoundment—offers a balanced pathway that meets regulatory requirements, aligns with the precautionary principle, and avoids unnecessary burden on the project.

CONTENTS PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

DETAILS OF AUTHOR

Mr Hendrik Botha
MSc Environmental Science – Geohydrology and Geochemistry (Pr.Sci.Nat.)
Hendrik (Henri) Botha is a Principal Hydrogeologist with over twelve (12) years of experience. He holds a BSc Hons. Degree in Hydrology and an MSc in Environmental Science in Geohydrology and Geochemistry. A registered SACNASP Professional Natural Scientist (400139/17) in the Earth Science Field, Henri is also a member of the Groundwater Division of GSSA, GAKZN and IMWA. Henri's expertise includes groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry, together with GIS and analytical and numerical modelling skills. General and applied logical knowledge are his key elements in problem-solving. Henri has a long-standing relationship with multiple clients in the mining and private sector and has completed various specialist hydrogeology and hydrology studies in South Africa, Nigeria, Namibia, Liberia, Malawi and Botswana.

CONFIDENTIALITY

The contents of this Report are of a confidential nature and intended for Zitholele Consulting (hereinafter referred to as the client), permitting authorities, if applicable, and South African law. Any unauthorised use, alteration, or dissemination of the contents of this Report is strictly prohibited. The protection of the information in this Report is awarded in terms of the *Promotion of Access to Information Act, 2002 (Act No. 2 of 2002)* and without limiting this claim, especially the protection afforded by Chapter 4 of the Act.

DISCLAIMER AND CONDITIONS OF OWNERSHIP

This report has been prepared exclusively for the Client in relation to the specific Project as agreed upon in the terms of engagement. The author/consultant retains full title and intellectual property rights over the contents, findings, and recommendations of this report until full and final compensation has been received as per the agreed payment terms.

In accordance with the **Constitution of the Republic of South Africa, 1996**, and relevant statutory provisions including the **Copyright Act No. 98 of 1978**, no part of this report may be copied, distributed, modified, or used — in whole or in part — for commercial, regulatory, or implementation purposes without the express written consent of the author/consultant.

Ownership of this report shall not transfer to the Client or any third party until:

- All agreed fees and disbursements have been settled in full.
- The author/consultant has confirmed receipt of final payment in writing.

Until such time, this report is submitted under a **conditional licence** for review and planning purposes only, and may not be submitted to authorities, financiers, or stakeholders as a final deliverable.

The author/consultant reserves the right to revoke any permissions granted under this conditional licence in the event of breach of contract or non-payment.

DECLARATION OF INDEPENDENCE

Elemental Water Services Proprietary Limited (EWS) was appointed to conduct this specialist study and to act as the independent specialist. EWS objectively performed the work, even if this resulted in views and findings that were not favourable. EWS has the expertise to conduct the specialist investigation and does not have a conflict of interest in undertaking this study. This Report presents the findings of the investigations, which include the activities set out in the scope of work.

This specialist report, based on the independent assessment, as per the requirements set out by the *National Environmental Management Act 107 of 1998* (NEMA) and the Department of Water and Sanitation (DWS), is independent and free of any external prejudice or influence. The contents of this specialist report are based solely on observations made during the physical site inspection and review of documents, as presented by the mine. The specialist further declares that, as a representative of Elemental Water Services Proprietary Limited:

- I act as the independent specialist for the Specialist Report.
- All work undertaken in relation to the assessment was conducted in an objective, independent and uninfluenced manner, even if this results in views and findings that are not favourable to the Licensee.
- There is no compromise on the objectivity exercised in undertaking the assessment.
- The relevant knowledge, expertise, and experience required to undertake this assessment are held by the specialist, including but not limited to NEMA and NWA, as well as relevant regulations and guidelines relevant to the activity.
- All information furnished in this Report is true and correct at the time of the assessment being finalised.
- I have expertise in conducting/compiling independent specialist assessments, including knowledge of NWA and any relevant legislation and guidelines that are relevant to the activity.
- I have no and have not engaged in conflicting interests while undertaking the assessment.
- I have undertaken to disclose to the Licensee 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 project by the Competent Authority and the objectivity of any report, plan or document prepared by me for submission to the Competent Authority.
- All the particulars I furnished in this Report are true and correct.
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of section 24F of the Act.
- I do not have and will not have any vested interest (either business, financial, personal or other) in the project other than remuneration for work performed.

24/08/2025
6:20:24
Pr.Sci.Nat (400139/17)

Hendrik Botha
24 AUGUST 2025

1 INTRODUCTION

Elemental Water Services Proprietary Limited (EWS) was appointed by Zitholele Consulting to underate a peer review of the existing groundwater and environmental impact assessment (EIA) studies and monitoring plans for the proposed raising of the Clanwilliam Dam Wall Project, where work is proposed to take place on the eastern and western sides of the N7 National Road, and at the foot of the Clanwilliam Dam, near Clanwilliam, Western Cape, South Africa.

1.1 Background

The original EIA for the project was done in the late 2000s, and the Record of Decision (still assessed and issued under the Environmental Conservation Act) was issued in 2009. The project entails refurbishment and raising of the Clanwilliam Dam wall by 13 meters and incorporating water flow monitoring equipment, etc, downstream of the dam wall. The impact of this dam wall raising is that a large area of land will be inundated once the dam wall construction has been completed and the new supply level of the dam has been reached. DWS has already bought out all of the farms that will be affected by this during the process between 2009 and now.

The EIA reports for the dam raising application are available. The original site construction plan, as per the ROD and DWAF (2007) Environmental Impact Assessment report, is shown in Figure 1.1. From the review of the reports and specialist studies, it seems no comprehensive groundwater study was undertaken to inform the EIA at the time, resulting in a recommendation by the specialist that a comprehensive study be undertaken. The requirements for groundwater monitoring in the RoD and EMPr are also extensive to the point that the DWS feel that it is way beyond the scope of the construction project. DWS would therefore like to have the condition reassessed and amended to provide more realistic monitoring requirements for the groundwater-related impacts.

The condition in the RoD states: Condition G.14. Appropriate measures to mitigate the impacts on groundwater resources must be determined, designed and implemented, with extensive groundwater monitoring to be done to inform these measures." DWS is further proposing to stagger the study requirements in that the Department is proposing that groundwater monitoring, with monitoring reports reporting on impacts and mitigation of impacts, be undertaken during the construction phase and once construction is done, to undertake an extensive groundwater study at that point.

Construction has already started, and the current state of the site as of August 2025, with work camps and work areas, is shown in Figure 1.2.

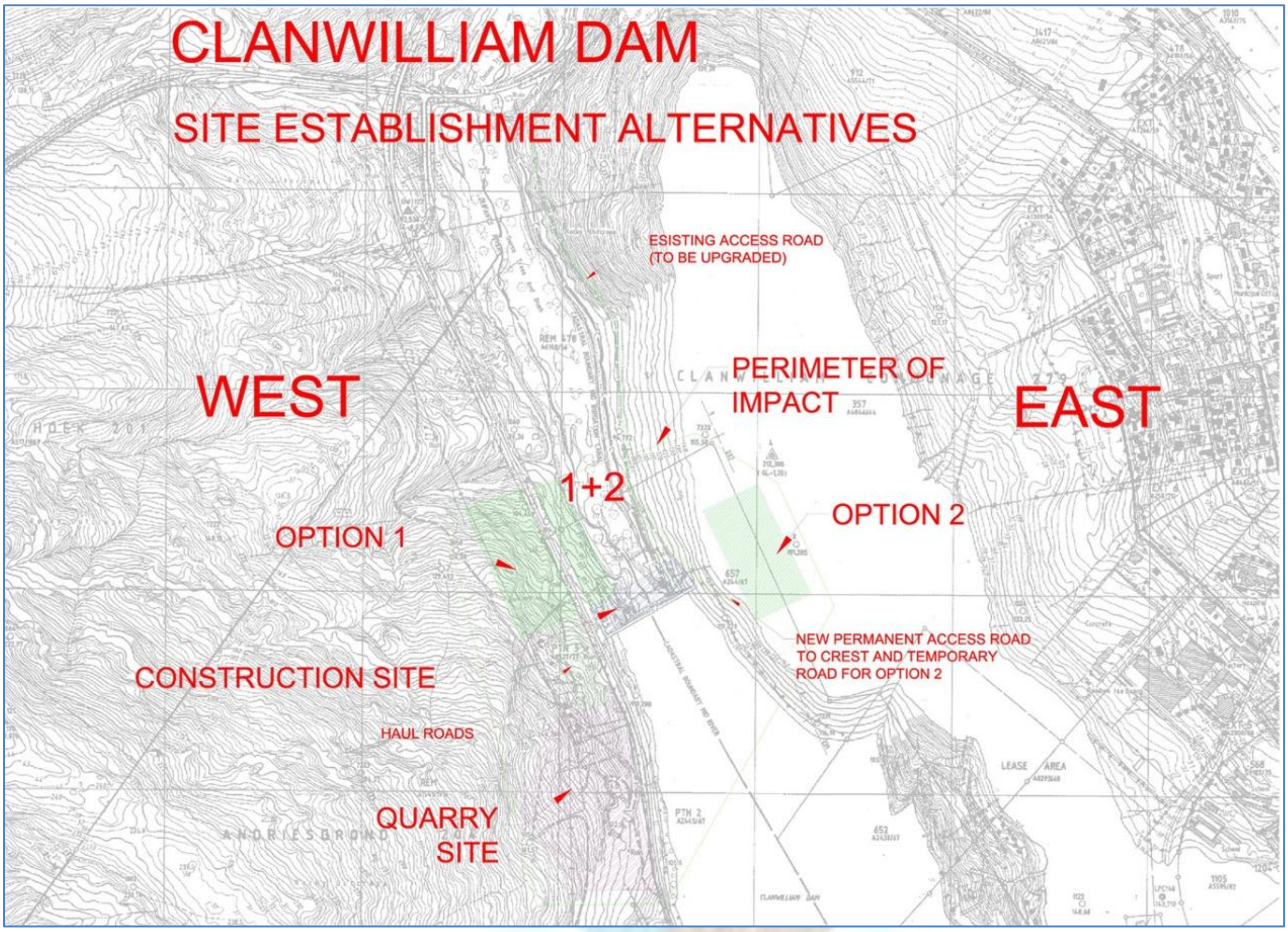

Figure 1.1: Proposed work areas 2007

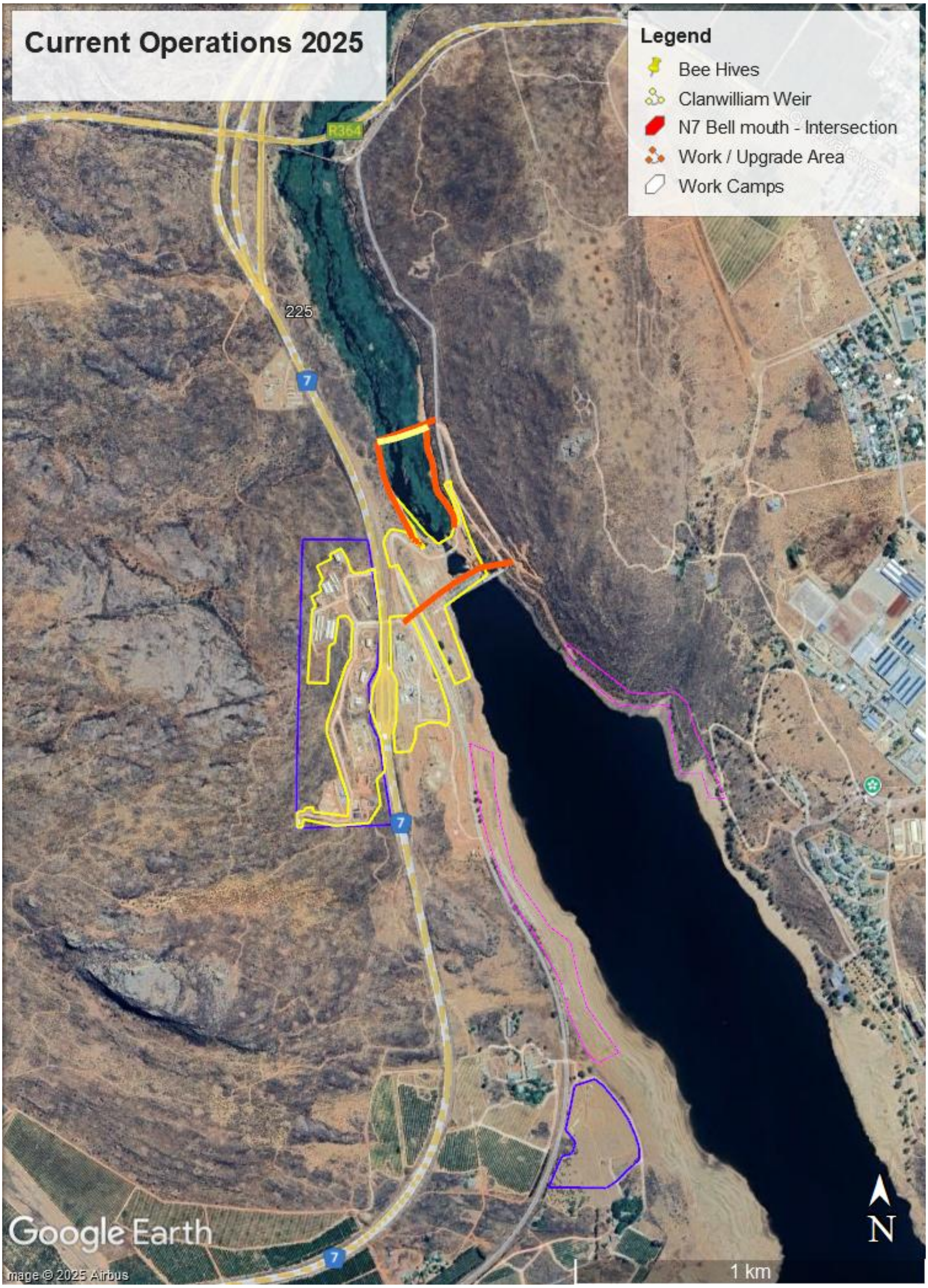

Figure 1.2: Current layout of the upgrade project and progress so far [Aug 2025]

1.2 Scope of work and objectives

The scope of work associated with this investigation was as follows:

1. Review the existing EIA and specialist study information and reports.
2. Confirm whether the impacts identified are relevant.
3. Identify any new impacts that may have been overlooked.
4. Comment on whether the requirements of the groundwater-related conditions can be relaxed.
5. Propose a more realistic/appropriate groundwater monitoring plan, or how the existing plan can be relaxed.
6. Compile this short memo-style report addressing the above-mentioned.

1.3 Available reports and data

The following information and reports were reviewed, specifically focusing on the potential groundwater impacts and monitoring requirements:

- Site layout presentation (PPTX file).
- Site layout includes water and sewer layout [pdf map].
- Proposed raising of Clanwilliam Dam and Associated Realignment of Affected Roads - Environmental Final Impact Report [Volume 1 to 4] (DWAF, 2007).
- Signed ROD [22 Feb 2010].
- Comparison of the Authorised ss Current Clanwilliam Dam Raising Programme Construction Footprint [Report ID: 23011-46-Rep-003, Zitholele Consulting 24 April 2024].
- Feasibility Study for the Raising of Clanwilliam Dam – Groundwater Resources (DWAF, 2009)
- Water Allocation Registry Management System (WARMS) 2024 datasets (WARMS, 2024).
- SADC Groundwater Information Portal (SADAC GIP, 2025) and National Groundwater Archive (NGA, 2025) data for the project area.
- Water Resources of South Africa 2012 Study (WR2012): Executive Summary Version 1. WRC Report No. K5/2143/1 (Bailey & Pitman, 2015).
- 1:250 000 Geological Series - 3218 Clanwilliam (CGS, 1973).
- Groundwater Resource Assessment II (DWAF, 2006).
- 3117 Calvinia - 1:500 000 Hydrological Map Series of the Republic of South Africa (King et. al., 1998).

- Literature on similar geology and hydrogeology:
    - A South African Aquifer System Management Classification (Parsons, 1995).
    - Aquifer Classification of South Africa (DWA, 2012).
    - The relationship between South African geology and geohydrology (Lourens, 2013).
    - DWS aquifer classification maps (DWS, 2012)
- Online resources:
    - The National Integrated Water Information System (NIWIS)
    - Water Management System (WMS) and Resource Quality Objectives (RQS) as maintained by DWS - https://www.dws.gov.za/iwqs/

2 GENERAL SETTING AND PRINCIPAL HYDROGEOLOGICAL CONDITIONS

The Clanwilliam Dam is a concrete gravity dam on the Olifants River near Clanwilliam in South Africa's Western Cape. Originally built in 1935 and raised in 1964, a significant project is underway to raise the dam wall by 13 meters to increase its water storage capacity for agriculture and to include a hydroelectric facility, with completion estimated around 2028.

The Project falls on the boundary of Quaternary catchment E10G and W10J of the Berg-Olifants Water Management Area (WMA) (DWS, 2016). Elevations for the region range from 40 to 600 metres above mean sea level (mamsl), and the elevation at the dam wall is in the order of 80 mamsl. The **average** mean annual evaporation (MAE) for the project area is in the order of 1600 mm/yr, **average** mean annual precipitation (MAP) in the order of 334 mm/yr, and the **average** mean annual runoff (MAR) for all the quaternary catchments combined is in the order of 64 mm/yr.

The major geological and hydrological conditions associated with the Project Site are captured below and based on an independent review of public data and the reports that were reviewed.

2.1 Local geology and soils

According to the 1:250 000 geology series map (CGS, 1973) the surface geology is characterised quartzite sandstone with thin conglomerate shale lenses (C1Q2), underlain by shale and tillite and conglomerate layers (C1S2G) and quartzite sandstone with minor shale and conglomerate layers (C1Q1) all part of the Table mountain Group (TMG) – refer to Figure 2.1.

The upper contact of the Table Mountain Group (the Nardouw Formation) and the lower parts of the Bokkeveld Group are exposed on the floor and the lowest slopes of the valley south of the Clanwilliam Dam in the Olifants River Syncline, as well as to the northeast of Clanwilliam. To the north, northwest and west of Klawer, the distinctive character of the TMG landscape changes to that of Namaqualand. Details of the Bokkeveld stratigraphy are not relevant to this study. There is a close relationship between the drainage patterns, surface water quality and the structural geology.

The Olifants River drains sub-parallel to the fold axis of the ORS from its headwaters in the South up to the confluence with the Doring River. This orientation is associated with the lower-lying valley formed by the erosion of the softer shales of the upper TMG and Bokkeveld Groups between the two parallel mountain ranges bordering the Citrusdal Syncline and the Clanwilliam Trough.

The Doring River has an east-west orientation and drains westwards into the Olifants River at approximately 31o 52′ S and 18o 37′ E south of Klawer. Beyond this confluence, the river course is controlled by the topography of the Sandveld Group. Sandy alluvium is present along the length of the Olifants River with widths reaching 2.5 km in the study area. In the southernmost region of the river, the alluvium's composition changes to boulders, cobbles and coarse gravel that overlay the Nardouw Formation. As the Olifants River approaches the Clanwilliam Dam, the riverbed becomes increasingly starved of sediment while the downstream Bulshoek Barrage acts as a sediment trap (DWAF, 2007).

According to the Land Types of South Africa databases (ARC, 2006), the soils in the area fall within the **Fc** and **Ia** types. Soils associated with these groups typically entail:

- **Fc** - Shallow soils (Mispah & Glenrosa forms) predominate; usually lime throughout much of the landscape.
- **Ia** - Deep alluvial soils comprise >60% of land type [associated with the Olifants River drainage area and flood plains].

According to Soil Conservation Service (SCS) data for the project area, the soils are divided into "**Type A/B**" soils. SCS curve number is a function of the ability of soils to allow infiltration of water, land use and the antecedent soil moisture condition. Table 2.1 provides a summary of the hydrological soil characteristics of the different SCS soil types. The soils have a **moderate erosion potential**.

Table 2.1: Summary of SCS soil type hydrological characteristics (Muthu, 2015)

Hydrological Soil	Type of Soil	Run-off Potential	Final Infiltration Rate (mm/hr)	Remarks
Group A	Deep, well-drained sands and gravels	Low	>7.5	High rate of water transmission
Group B	Moderately deep, well-drained with moderately fine to coarse textures	Moderate	3.8 – 7.5	Moderate rate of water transmission

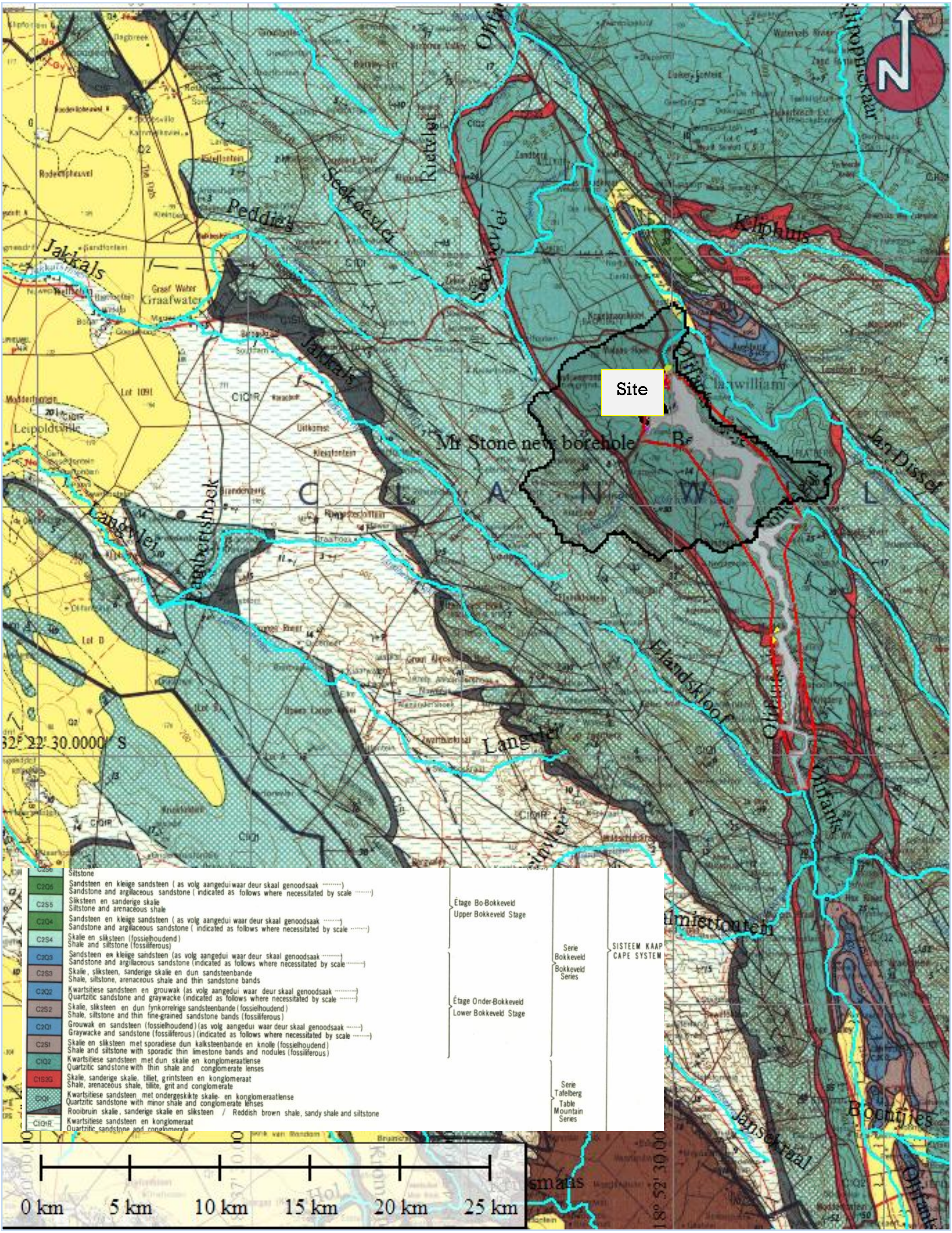

Figure 2.1: Local surface geology

2.2 Aquifer characteristics, classification, and groundwater recharge

The general aquifer characteristics and aquifer classification are summarised in Table 2.2.

Table 2.2: Overview of aquifer characteristics and classification

General Aquifer Characteristics & Classification

The Project Site is underlain by **arenaceous rock** of the TMG– refer to Figure 2.2.

The aquifer has a **low-moderate hydraulic conductivity** (K-value) and **low-moderate porosity** (n-value). Typical literature hydraulic conductivity of the weathered and fractured country rocks and storage are summarised as follows (Lixiang Lin, 2006–2007); (Lin & Xu (2006), n.d.):

Parameter	Typical range
Hydraulic conductivity, K	0.001–0.01 m/day ($\approx 1.2\times10^{-8}$–1.2×10^{-7} m/s)
	Occasionally up to ~0.2 m/day ($\approx 2.3\times10^{-6}$ m/s)
Intrinsic permeability, k (approx., 20 °C)	~10^{-15} to 2×10^{-13} m^2
Transmissivity, T	~1–100 m^2/day (typical); ~0.4–275 m^2/day (observed range in TMG tests)
Porosity (matrix/total of sandstone)	~1.0–3.6 % (matrix/core)
Effective fracture porosity	~0.05–0.6 %
Regional modelling porosity (for storage bracketing)	~2.5–15 % (assumed range)

The aquifer can be referred to as being primarily **fractured** (King et al., 1998).

The aquifer present is classified as a **Major Aquifer** system and generally targeted for groundwater supply (Parsons, 1995) – refer to Figure 2.3. The regional aquifer system has a **moderate susceptibility to pollution** – refer to Figure 2.4.

The aquifers underlying the study area are considered low to moderate yielding, with reported yields ranging from 2 to 5 l/sec (b4 aquifer type).

Aquifer Zones and Classification

Available literature and site observation data suggest that the area is characterised by:

- An unconfirmed to semi-confined weathered aquifer zone. This zone has a moderate permeability, and the groundwater table is generally driven by rainfall recharge.
- A deeper confined fractured aquifer system is associated with deeper TMG sediments. Recharge to this zone is via the weathered zone and is less than what the weathered zone receives (estimated in the order of <3% of the MAP).

The Clanwilliam reach the TMG units present, including the **Peninsula Aquifer** (thick, high-potential where fractured), overlain by the **Cederberg shale/aquitard** and the **Nardouw/Skurweberg** units; local thicknesses cited for the dam-raising study suggest Peninsula ~1,300 m, Skurweberg ~120 m, Rietvlei ~120 m.

Recharge to the underlying aquifers generally ranges from 4% to 5% of the MAP (DWAF, 2006) and decreases to <3% for deeper aquifer units. The regional groundwater table is situated at an order of 16.3 metres below ground level (mbgl), and generally follows the topography.

The shallow aquifer zones are important contributors to groundwater baseflow to streams and rivers, where gaining rivers and streams occur, as well as for the formation of springs at daylighting sandstone/siltstone formations with the surface topography (King et al., 1998). Baseflow to rivers/wetlands ranges from 2 to 38 mm/yr.

The farmers use the groundwater to augment surface water supplies or for use as an emergency supply during summer, largely for the irrigation of citrus in the area upstream and downstream of the dam. The dam wall itself is situated on the Skurweberg Formation (DWAF, 2007).

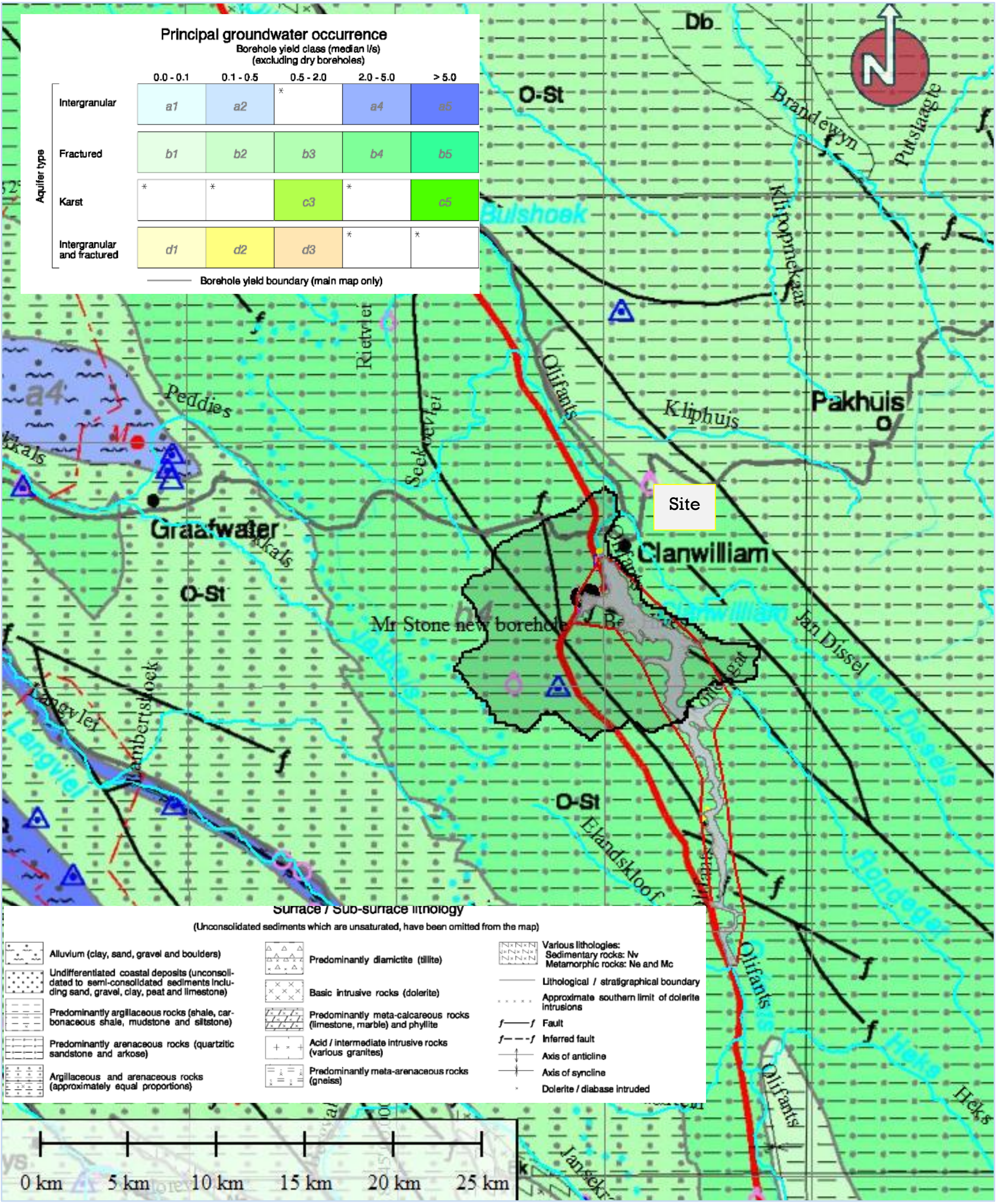

Figure 2.2: Local hydrogeology setting

Figure 2.3: Aquifer classification map (DWS, 2012)

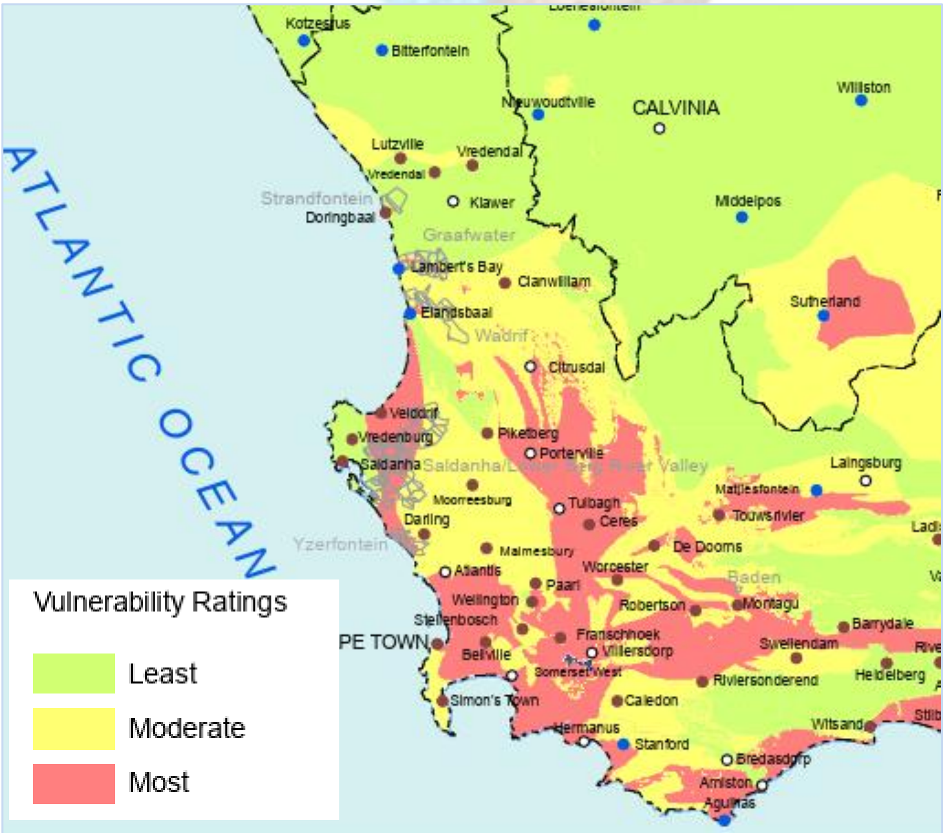

Figure 2.4: DWS Aquifer Vulnerability Map for South Africa

3 PEER REVIEW SUMMARY

It was noted that the DWAF (2007) Groundwater Report's primary emphasis is on groundwater availability, recharge, and sustainable abstraction yields from the Table Mountain Group (TMG) aquifers. The study appears to be a regional water resources optimisation study, rather than a project-specific assessment of the construction and operation impacts of the Clanwilliam Dam raising. In contrast, the EIA Report (DWAF, 2007) does address several groundwater risk and monitoring concerns.

From the review of the EIA Report (DWAF, 2007) and Groundwater Feasibility Reports (DWAF, 2009), the following key groundwater / hydrological risks were identified:

- Inundation of recharge areas – low-lying alluvial deposits and shallow aquifers upstream will be submerged, reducing natural recharge potential
- Alteration of groundwater–surface water interactions – changing water levels in the reservoir will modify gradients and potentially increase leakage from or into fractured aquifers.
- Changes in groundwater flow paths – the dam is located within faulted Table Mountain Group (TMG) aquifers; raising the wall may redirect preferential groundwater flow pathways.
- Potential reduction in baseflow contributions – downstream rivers and tributaries that rely on groundwater discharge may experience reduced flows during low-flow seasons.
- Spring and seep impacts – perennial springs in the Olifants River catchment may be affected by changes in aquifer pressure regimes.
- Mobilisation of deeper poor-quality water – inundation and hydraulic changes may draw saline or mineralised water from Bokkeveld formations into productive aquifers.
- Nutrient and pesticide leaching – expansion of irrigation following dam raising increases the risk of nitrate and agrochemical infiltration into shallow groundwater.
- Sedimentation and turbidity – increased erosion and sediment input from construction activities could degrade groundwater quality in shallow alluvial aquifers.
- Hydrocarbon and chemical contamination – fuel and hazardous substances stored during construction present a contamination risk to local aquifers.
- Over-abstraction risks – increased reliance on groundwater to supplement dam supply may lead to local drawdowns and reduced aquifer yields.
- Loss of elastic storage – confined aquifers provide limited recoverable storage; unsustainable abstraction could reduce long-term yield.

- Equity and allocation disputes – expanding borehole development could create competition and legal challenges regarding water rights.
- Baseline data gaps – insufficient hydrological and hydrogeological data increase uncertainty about potential impacts and recovery.
- Uncertainty in recharge estimates – highly variable rainfall patterns complicate predictions of sustainable groundwater yield.
- Risk of inadequate adaptive management – without robust monitoring and updated groundwater models, conjunctive use strategies may fail to buffer against drought or climate variability.

3.1 Probability of the identified risks

In terms of the **probability** of the above-mentioned occurring during the lifecycle of the project, and in the context of the reports that have been reviewed, the following is anticipated:

- Inundation of recharge zones/alteration of flow paths: **Low** – Raising the dam wall will inevitably submerge certain recharge areas, but this is a predictable impact rather than an uncontrolled risk. With adaptive water balance management, long-term significance remains low. Indundation of water will further improve aquifer recharge.
- Impact on springs and baseflows: **Low** – With spring census and monitoring networks installed, early warning signs of spring reductions can be managed adaptively. The presence of a dam is predicted to improve baseflow to the aquifer and rivers and streams connected to the weathered zone (i.e. increase groundwater-surface water interaction surface areas due to a new flood plain). Any increase in the storage level which increases the hydraulic gradient in the Skurweberg fractures is likely to enhance the rate of groundwater flow along this path and increase the surface-water outflow at the spring sites. This is viewed as favourable rather than a hazard to spring water users.
- Fuel, hydrocarbon, or cement contamination (construction phase): **Very Low** – If bunded storage, spill kits, drip trays, and good housekeeping are strictly enforced.
- Agrochemical leaching (operational phase, linked to irrigation expansion): **Low** – With correct agricultural extension support (fertiliser management, buffer zones), this is manageable. The dam further presents a source for irrigation, and can be considered rather of groundwater resources.
- Sedimentation/turbidity into shallow aquifers: **Low** – If erosion/sediment controls (silt traps, phased clearing, riparian buffers) are implemented.

- Over-abstraction of TMG aquifers: **Low** – Provided abstraction follows a licensed yield ceiling, and monitoring boreholes detect drawdown early. Groundwater abstraction is not part of this project, and therefore, the foreseen impact will be marginal.
- Loss of elastic storage/aquifer depletion: **Very Low** – If pumping tests, model calibrations, and adaptive pumping protocols are respected. The Project in question is a surface water-related Project, and therefore is predicted to enhance recharge in flood plains associated with the Clanwilliam Dam flood plain. The predicted impact on aquifer depletion is low.
- Failure of adaptive management due to poor follow-up: **Very Low** if DWAF/DWS monitoring protocols are enforced and compliance audits are routine. For the greater catchment, ongoing monitoring by DWS for climate change impacts, as well as regional-scale dewatering effects, should be mandatory. However, for the construction and maintenance of the Clanwilliam Dam Project, the predicted impact in terms of groundwater quality and quantity impacts is **low**. Short-term monitoring should be adequate.

3.2 Key conclusion drawn

The key groundwater impacts from raising the Clanwilliam Dam wall include changes to aquifer recharge and flow regimes, risks to spring and baseflows, water quality vulnerabilities, potential over-abstraction in TMG aquifers, and uncertainties arising from monitoring and management gaps. The EIA Report identifies groundwater impacts from inundation, altered flow regimes, risks to spring and baseflow systems, potential contamination from construction and agriculture, over-abstraction pressures, and uncertainties due to limited monitoring. These impacts highlight the need for a comprehensive monitoring programme, conjunctive water-use management, and clear groundwater protection measures.

The most significant regional scale impact is that of the predicted groundwater mound that will form underneath the Clanwilliam Dam will increase in elevation, with an expected increase in spring flow rates, as well as the occurrence of 'new' springs along the preferred flow paths as defined by fractures, faults and joints in the Skurweberg Sandstone underlying and abutting the dam. This is viewed as a positive impact, as existing spring users as well as new spring users may benefit from the added artificial recharge to springs and wells connected to the groundwater mound.

EWS is of the opinion that the groundwater risks associated with the Project **have been adequately assessed** on a local and regional scale. All impacts are still relevant, and based on the information provided for this review, **no additional impacts are foreseen.** As mentioned above, the Groundwater Report (DWAF, 2009) does mention several concerns that are more regionally based as opposed to local impacts relating to the dam wall expansion and road expansion project. The EIA Report (DWAF, 2007) does evaluate the local scale and probable regional scale impacts and concludes that the overall risk associated with the construction and operational phase of the Project is **low**.

3.3 Monitoring requirements

In summary, the Groundwater Resources Report specifies the following monitoring requirements, which appear to be more regionally focused:

- The feasibility study recommended a fairly detailed groundwater monitoring programme to support conjunctive use of TMG aquifers:
- Establish exploration and monitoring boreholes – strategically drilled to track aquifer responses to abstraction and dam operations.
- Install spring-flow monitoring network – based on a comprehensive spring census, to discriminate between flows from different TMG aquifers.
- Monitor spring baseflows vs storm responses – separating short-term rainfall-driven floods from long-term aquifer recharge signals.
- Install borehole monitoring infrastructure – piezometers and observation wells to track aquifer storage and hydraulic heads.
- Recharge monitoring – use of rainfall gauges and infiltration studies to refine recharge estimates across different zones
- Update and refine groundwater flow models – steady-state and transient simulations to track aquifer dynamics and sustainable yields.
- Develop a long-term aquifer management plan – based on the "Monitor–Model–Manage" framework.

The EIA Report, in contrast, focuses on the actual work areas associated with the project, namely the dam wall, contractor camps and roadways, and proposes the following for the construction and operational phases:

- Water quality monitoring of groundwater near construction sites – to detect contamination from fuels, lubricants, and cement wash-water
- Monitoring of shallow aquifers and seepage zones – especially in areas affected by construction material sourcing and road realignment

- Observation of alluvial aquifer responses in upstream and downstream zones to detect inundation or drawdown impacts.
- Monitoring of potential agrochemical leaching, associated with the expansion of irrigation, is supported by increased dam storage.
- Sedimentation and turbidity checks – near alluvial groundwater–surface water interaction zones.
- Post-construction groundwater quality monitoring – ongoing surveillance of nitrate, pesticide, and hydrocarbon contamination risks.

EWS believes that the **groundwater-related monitoring,** as proposed by the Groundwater Report and EIA Report, can be **relaxed**. A complex monitoring network within the work areas may not yield any additional information on a regional scale, except for local monitoring in the work areas.

4 PROPOSED MONITORING PLAN

Based on the Reports reviewed, and in line with the groundwater-related concerns raised in the said reports, it is proposed that:

- Short-term monitoring will be implemented for areas associated with active work areas, specifically site quantity and quality impact. This monitoring aims squarely at the EIA's construction-phase risks (sediment, water-quality, hazardous substances) without drilling on-site monitoring boreholes - using springs/seeps, alluvial contact points, and discharge checks to catch problems early.
- Long-term monitoring focuses on the regional scale impacts after the dam is completed – to be developed by the department over time, and not project-specific. This monitoring aims to invest drilling where it matters and to evaluate qualitative impacts associated with the TMG regional system, along fault/fractures and key aquifer units, with recharge-first logic. As mentioned previously, there is a potential for the formation of anthropogenic springs due to increased hydraulic gradients in the aquifer, which could lead to preferred flow paths as defined by fractures, faults and joints in the Skurweberg Sandstone underlying and abutting the dam.

4.1 Short-term (site-focused) - Construction & early operation (Years 0–2)

Objectives:

Catch and manage construction-related water-quality risks (hydrocarbons, cement wash water, sediment) and alluvial/shallow GW responses around the works, N7 tie-ins, and material sources. These are the impacts the EIA highlights for construction (water quality deterioration, sedimentation/erosion, hazardous substances).

Establishment of the monitoring system/network (construction phase – short term):

- Springs/seeps within ~2 km of the wall footprint and road works (map & tag each spring/weep line; use simple V-notch plates where feasible for repeatable readings)
- Alluvial contact points (riverbanks, dewatering sumps/outfalls) immediately upstream and downstream of works to track turbidity and any cement/hydrocarbon signatures.
- Existing lawful boreholes/wells within ~2–3 km (opportunistic only, no new drilling) for quarterly spot checks to corroborate spring/seeps trends.

Construction can drive sedimentation/erosion, deterioration of water quality, and risks from stored hazardous substances; these are best detected at seeps, shallow alluvium, and discharge points tied to the site works and N7 realignment.

Parameters & frequency:

- Field (weekly during active works; after >10 mm rainfall; monthly otherwise): EC, pH, temperature, turbidity/NTU.
- Lab (monthly during active works; quarterly otherwise): TSS, alkalinity, major ions (Ca, Mg, Na, K, Cl, SO_4, HCO_3), nitrate-N, TPH (if any hydrocarbon handling in the sub-area), and dissolved metals *only if* visual/field flags arise.
- Visual/operational checks (weekly): bund integrity, spill kits, cement wash-water containment, and silt-control efficacy (SED fences, traps) logged in the EMP site diary.

Triggers & responses:

- Hydrocarbons: any TPH detection → isolate source, replace absorbents, sample daily until non-detect.
- Cement influence: pH > 9.0 or spike in alkalinity at a discharge point → stop wash-water release, pump to lined containment for haul-off; resample within 24 h.
- Sediment: NTU/TSS at downstream points > upstream by >50% during dry weather → review erosion controls, install additional traps, reseed/cover disturbed areas; re-check in 48 h.
- Springs/seeps: step-change (>25%) in EC or sustained turbidity during dry spells → targeted site audit for leaks/stockpiles/runoff path; add straw bales/geo-fabric as interim control, then re-sample.

Governance & reporting:

- Fold into the project EMP with weekly checklists and a monthly one-pager (map, table of results, exceedances & actions). The EIA bundles construction monitoring under a generic EMP umbrella; your plan makes that concrete.

4.2 Long-term (regional) - Operation & conjunctive use

Objectives:

Track regional TMG aquifer behaviour (quantity first, quality pragmatic) under raised full storage water level (FSL) and any conjunctive-use development. It is proposed that a dedicated study be undertaken to ensure that the monitoring program ties in with DWS Environmental Management Frameworks (EMFs) for the greater project area, as well as existing monitoring networks such as the Water Management System (WMS) and Resource Quality Objectives (RQS).

Regional network establishment:

- **TMG monitoring boreholes (6–10 sites):**
  - Identify NW–SE megafault trends (e.g., Klawer-linked structures) and within the Peninsula and Nardouw/Skurweberg units up- and downstream of the dam (synclinal axis and limbs).
  - Drill boreholes to the required effective depths that best represent the full aquifer thickness, or zone associated with inflow from the predicted groundwater mound. This should be determined by dedicated geophysical investigations.
  - Equip 2–3 boreholes with loggers for continuous water level monitoring; the rest quarterly manual dips (or as determined by the existing DWS monitoring program for the region).
- **Spring-flow stations (8–12 priority springs):**
  - Gauge perennial springs that reflect TMG pressure response (classify by unit if possible).
  - The springs should be identified via dedicated hydrocensus and spring survey studies, and regulated by DWS.
- **Recharge & climate sentinels:**
  - It is proposed that dedicated rain gauges in the high-MAP recharge belt (Krakadouwberge/southern Cederberg) be installed, as well as 1 in the lowland area.
  - If possible, simple soil-moisture probes at two mountain-front sites can be considered to evaluate recharge pulses (if required and for drought predictions).

Parameters & frequency:

- Water levels: continuous (loggers) at index holes; monthly elsewhere; weekly spring discharges in Year 1, taper to monthly in Years 2–3 once seasonal envelopes are established.
- Chemistry (quarterly, taper to biannual or annual depending on trends): EC, pH, T, alkalinity, major ions; nitrate-N, chloride/sulphate (mixing/salinity flags).

- Isotopes (every 2 years at 3–4 sites): $\delta^{18}O/\delta^{2}H$ to fingerprint recharge elevation/seasonality if resources allow (optional but very informative for TMG).
- Rainfall: daily totals; compute rolling recharge indices aligned to the report's recharge-centric approach.

Analytical framework:

- Maintain seasonal "envelopes" for heads and spring flows; define operational bands (e.g., 10th–90th percentile after Year 2).
- Build a simple regional storage/yield model (the 2009 report explicitly orients to storage modelling and target-zone yield; keep it light initially, then refine).

Triggers & management:

- Drawdown: >1.0 m below the seasonal 10th percentile in any index hole for >60 days → investigate pumping patterns; if linked to abstractions, step down rates regionally per license conditions.
- Quality: >20% step-change in Cl^- or SO_4^{2-} season-adjusted median → targeted source check (salinity ingress, irrigation return), add a monthly chem cycle until stabilised.
- Springs: 30% flow reduction outside seasonal band → diagnose (rainfall deficit vs pressure decline); consider conjunctive-use balancing (e.g., surface releases vs pumping curtailments).

5 CONCLUDING REMARKS

The peer review of the groundwater and EIA documentation for the Clanwilliam Dam raising project confirms that while groundwater was previously identified as a potential concern, the associated risks remain limited, localised, and primarily tied to construction-phase activities. The original Record of Decision (2009) imposed very broad and onerous groundwater monitoring conditions in the absence of a comprehensive hydrogeological assessment at the time. This review demonstrates that such requirements are disproportionate to the actual risk profile of the project. The aquifer systems underlying the dam footprint are of low to moderate yield, with limited connectivity to critical receptors, and the primary construction-related risks (fuel handling, batching plants, camps, quarries, and stockpiles) can be managed effectively through standard mitigation and housekeeping practices.

In line with South African best practice and DWS guidance, the review supports a pragmatic and risk-based relaxation of the groundwater conditions. Continuous borehole monitoring and extensive modelling are not justified. Instead, a simplified approach focused on surface-based spot checks, event-driven inspections, and clear response protocols for spills or abnormal conditions is sufficient to provide assurance during the construction phase. Once construction is complete and the new supply level is reached, a more detailed groundwater evaluation can be staged if spring or seep responses indicate a material change.

Overall, the peer review concludes that groundwater is not a primary limiting factor for this freshwater infrastructure project. A proportionate, phased monitoring strategy—relaxed during construction and reserved for adaptive investigation post-impoundment—offers a balanced pathway that meets regulatory requirements, aligns with the precautionary principle, and avoids unnecessary burden on the project.

6 BIBLIOGRAPHY

ARC, 2006. *Lan Types of South Africa,* s.l.: Pretoria: Agricultural Reserach Council.
Bailey, A. & Pitman, W., 2015. *Water Resources of South Africa 2012 Study (WR2012): Executive Summary Version 1. WRC Report No. K5/2143/1,* Gezina, South Africa: Water Research Commission Report.
CGS, 1973. *1:250 000 Geological Series - 3218 Clanwilliam,* s.l.: CGS.
Department of Agricultural Development, D., 1991. *Soil Classification - A Taxonomix System for South Africa,* s.l.: s.n.
DMEA, 1998d. *1:250 000 Geological Series - 2930 Durban,* s.l.: s.n.
DWA, 2012. *Aquifer Classification of South Africa map,* s.l.: Hydrological Services - Groundwater Information..
DWAF, 1996a. *South African Water Quality Guidelines (2nd Edition). Volume 4: Agricultural Use: Irrigation,* South Africa: Department of Water Affairs and Forestry.
DWAF, 2006. *Groundwater Resource Assessment II,* s.l.: s.n.
DWAF, 2007. *Proposed raising of Clanwilliam Dam and Associated Realignment of Affected Roads - Environmental Final Impact Report [Volume 1 to 4].,* s.l.: s.n.
DWAF, 2009. *Feasibility Study for the Raising of Clanwilliam Dam – Groundwater Resources ,* s.l.: s.n.
DWS, 2011. *The Groundwater Dictionary - A Comprihensive Reference of Groundwater Related Terminology. 2nd Edition.,* s.l.: s.n.
DWS, 2012. *Aquifer Classification of South Africa,* s.l.: s.n.
DWS, 2016. *New Water Management Areas,* South Africa: Government Gazette No. 40279.
FAO, 1980. *Food and Agriculture Organization (FAO) - Drainage design factors,* s.l.: FAO Irrigation and Drainage Paper No. 38. Rome.
King et. al., 1998. *3117 Calvinia - 1:500 000 Hydrological Map Series of the Republic of South Africa,* s.l.: s.n.
Le Roux, P. et al., 2011. *Hydropedological interpretation of the soils of selected catchments with the aim of improving efficiency of hydrological models,* s.l.: Pretoria: Water .
Lin & Xu (2006), n.d. *A tensor approach to the estimation of hydraulic conductivities in Table Mountain Group aquifers of South Africa (Water SA, Vol. 32 No. 3, 2006),* s.l.: s.n.
Lixiang Lin, 2006–2007. *Hydraulic properties of the Table Mountain Group (TMG) aquifers (PhD thesis, University of the Western Cape),* s.l.: s.n.
Lourens, P., 2013. *The relationship between South African geology and geohydrology,* s.l.: IGS, University of the Free State, Bloemfontein. Masters Dissertation..
Muthu, A. &. S. M., 2015. *Estimation of Surface Runoff Potential using SCS-CN Method Integrated with GIS. ,* s.l.: Indian Journal of Science and Technology. 8. 10.17485/ijst/2015/v8i28/83324. .
Parsons, R., 1995. *A South African Aquifer System Management Classification,* s.l.: Water Research Commission Report No. KV 7795.
Parsons, R., 1995. *A South African Aquifer System Management Classification,* s.l.: Water Research Commission Report No. KV 7795.
SADAC GIP, 2025. *SADC Groundwater Information Portal,* s.l.: s.n.
Van Tol, J., Le Roux, P. & Lorentz, S., 2013. *Hydropedological Classification of South African Hillslopes,* Vadoze Zone Journal, 2-10: s.n.
WRC, 2015. *http://www.waterresourceswr2012.co.za/resource-centre/.* [Online].

APPENDIX A: DISCLAIMER

The opinions expressed in this Report have been based on site /project information supplied to Elemental Water Services Proprietary Limited (EWS) and are based on public domain data and data supplied to EWS by the client. EWS has acted and undertaken this assessment objectively and independently.

EWS has exercised all due care in reviewing the supplied information. Whilst EWS has compared key supplied data with expected values, the accuracy of the results and conclusions is entirely reliant on the accuracy and completeness of the supplied data. EWS does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this Report apply to the site conditions and features as they existed at the time of EWS investigations, as well as those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which EWS had no prior knowledge nor had the opportunity to evaluate.

APPENDIX B: CV OF SPECIALIST

Elemental
WATER SERVICES

Hendrik Botha

Principal Hydrogeologist & Director

LinkedIn:

CORE SKILLS

- Project management
- Analytical and numerical groundwater modelling
- Geochemical assessments and geochemical modelling
- Hydropedology and soil pollution assessments
- Hydrology, floodline modelling, yield modelling, storm water management
- Groundwater vulnerability, impact, and risk assessments
- Technical report writing
- GIS and mapping

DETAILS

Qualifications

- BSc Chemistry and Geology (Environmental Sciences) (2012)
- BSc Hons Hydrology (Environmental Sciences) (2013)
- MSc Geohydrology and Hydrology (Environmental Sciences) (2014-2016)

Membership

- Groundwater Division of GSSA
- Groundwater Association of KwaZulu Natal Member
- International Mine Water Association (IMWA)

Languages

- Afrikaans – Speak, read, write.
- English – Speak, read, write.

Projects undertaken in

- South Africa
- Nigeria
- Namibia
- Liberia
- Malawi
- Botswana

PROFILE

Hendrik (Henri) Botha is a Principal Hydrogeologist. He holds an MSc in Environmental Science in Geohydrology & Geochemistry and a BSc Hons. Degree in Hydrology. He is registered as a SACNASP Professional Natural Scientist in the Earth Science Field. Groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry together with GIS and analytical and numerical modelling skills, are some of his sought-after expertise. General and applied logical knowledge are his key elements in problem-solving.

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

- Project Management of water and environmental projects for mining, industrial and agriculture sectors.
- Integrated Water Investigations
- Waste Classification and Impact Assessments
- Aquifer vulnerability assessments
- Geochemical sampling, data interpretation and modelling
- Groundwater impact and risk assessments
- Numerical and Conceptual Visual Modelling (Visual Modflow, ModflowFLEX, Voxler, RockWorks, Surfer and Excel)
- Hydropedology (Hydrological Soil Types) & Soils Assessments
- Floodline Modelling (HEC-RAS)
- Conceptual Stormwater Management Assessments and EPA SWMM modelling
- Surface Water Yield Assessments
- Water and Salt Balance

SCAN ME
PROJECT RECORD

1