KONGIWE

THE RECOMMISSIONING OF THE WITHOK TAILINGS STORAGE FACILITY IN THE CITY OF EKURHULENI, GAUTENG PROVINCE

Integrated Water and Waste Management Plan (IWWMP) Report

Date: 6 March 2025

DWS Reference: WU38174

Report Information

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Executive Summary

Project Background

Ergo Mining (Pty) Limited (Ergo), a wholly owned subsidiary of DRDGOLD Limited, within which the group's eastern surface retreatment assets are consolidated, is a major surface gold tailings retreatment operation that focuses on historic and abandoned TSFs. Ergo holds various Mining Rights (MR) in respect of slimes dams and sand dumps extending 65 km from western Johannesburg to eastern Ekurhuleni, with most activities occurring on the central and eastern sections of the Witwatersrand mining belt.

At present, reprocessed tailings are deposited on the Brakpan TSF. The Brakpan TSF is expected to reach its maximum height and capacity in the future, and Ergo is investigating other deposition sites in the area which will enable them to continue with their reclamation operations.

Ergo has identified the footprint of the original Withok TSF as a potential deposition site.

Purpose and Scope

The purpose of this document is to provide sufficient information that will enable informed decision making through a detailed description of the proposed water use scenario in respect to the relevant water management measures. A list of the general and specific management commitments pertaining to this Integrated Water and Waste Management Plan (IWWMP) is also included to show Ergo's commitment towards continuous improvement in water management and to reduce the impacts on water resources to as low as reasonably practicable.

This IWWMP is the technical information document in support of the WULA for the relevant water uses under Section 21 of the National Water Act, 1998 (NWA). This document is based on the following technical guidelines:

- Best Practice Guideline 1.1: Integrated Mine Water and Waste Management developed by the Department of Water Affairs (DWAF, 2008);
- Operational Guideline to assist in the compilation of an Integrated Water and Waste Management Plan, First Edition: February 2010;
- External Guideline: Generic Water Use Authorisation Application Process, as compiled by the DWA, dated November 2007; and
- Regulations regarding the procedural requirements for water use licence applications and appeals, Government Notice 267, dated 24 March 2017.

In summary, this IWWMP presents:

- General information pertaining to the operation and a background description of the activity, description of the property and the specific purpose for the development of the IWWMP;
- A broad description of Ergo's proposed project for the Recommissioning of the Withok TSF, setting out its products, business and corporate policies;
- Water uses (new, existing lawful, exemptions and general authorisations);
- Environmental context (climate, surface water, groundwater and socio-economic environment);
- Analysis and characterisation of activities (organisational structure, training, awareness, monitoring and control);
- Risk assessment in relation to process water, stormwater, groundwater and waste (methodology, potential impacts and significance of risks to the environment);
- Water and waste management strategies, specifically focussing on process water, stormwater, groundwater and waste; and
- The regulatory status of water use activities accompanied by the section 27 motivation.

Water Use Activities

A detailed list of water use activities and description of these activities is included in Chapter 3.The following water use activities are being applied for as part of the Proposed Project.

- Section 21 (a): Taking water from a water resource;
- Section 21 (b): The Storing water;
- Section 21 (c): Impeding or diverting the flow of water in a watercourse;
- Section 21 (i): Altering the bed, banks, course or characteristics of a watercourse; and
- Section 21 (g): Disposing of waste in a manner which may detrimentally impact on a water resource.

Main Water and Waste Related Risks and Mitigation Measures

A detailed risk assessment/best practice for the activities of the Project is included in Chapter 6 of this report. The main water uses and waste related risks for the activities are associated with wetland, surface and groundwater impacts. Mitigation measures are discussed in Chapter 6 of this report, with a detailed water and waste management plan included in Chapter 7 of the report. The water and waste management plan focuses on minimising the impact of the activities on water resources.

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Abbreviations

ABBREVIATION/ SYMBOL	DESCRIPTION
BAR	Basic Assessment Report
BBBEE	Broad-Based Black Economic Empowerment
CA	Competent Authority/Authorities
CARA	Conservation of Agricultural Resources Act, 1983 (No. 43 of 1983)
CBA	Critical Biodiversity area
CoE	City of Ekurhuleni Metropolitan Municipality

ABBREVIATION/ SYMBOL	DESCRIPTION
CoP	Code of Practice
CR	Critical Endangered
CRR	Comments and Response Report
DFFE	Department of, Forestry and Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
DWS	Department of Human Settlements, Water and Sanitation
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
ELU	Existing Lawful Use
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EMPr	Environmental Management Programme
EMO	Ergo Mining Operations Proprietary Limited
EN	Endangered
ESA	Ecological Support Area
FEPA	Freshwater Ecosystem Priority Areas
GDARD	Gauteng Department of Agriculture and Rural Development
GISTM	Global Industry Standard on Tailings Management
GGDA	Gauteng Growth and Development Agency Strategic Plan
GSDF	Gauteng Spatial Development Framework
Ha	Hectare
HDPE	High-density polyethylene
HPA	High Priority Area
HGM1	Channelled valley bottoms
HGM2	Hillslope seeps
I&AP	Interested and Affected Party
IWULA	Integrated Water Use Licence Application
IWWMP	Integrated Water and Waste Management Plan
LC	Least Concerned
LOO	Life of Operation
mamsl	metres above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MAT	Mean Annual Temperature
MHSA	Mine Health and Safety Act, 1996 (Act No. 29 of 1996)
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
MR	Mining Right
MSDF	Metropolitan Spatial Development Framework (MSDF),
Mt	Million tonnes
$\mu g/m^3$	Microgram per cubic metre
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
NBSAP	National Biodiversity Strategy and Action Plan
NDP	National Development Plan
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NEM:BA	National Environmental Management: Biodiversity Act, 2004 (Act No.10 of 2004)
NEMLAA	National Environmental Laws Amendment Act, 2014 (Act No. 25 of 2014)
NEM:PAA	National Environmental Management: Protected Areas Act (Act No. 57 of 2003)
NEM:WA	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)

ABBREVIATION/ SYMBOL	DESCRIPTION
NEPAD	New Partnership of Africa's Development (
NFEPA	National Freshwater Ecosystem Priority Area
NGO	Non-Governmental Organisations
NHRA	National Heritage Resources Act, 1999 (Act No. 25 of 1999)
NNR	National Nuclear Regulator
NPAES	National Protected Areas Expansion Strategy
NP	Not Protected
NT	Near Threatened
NWA	National Water Act, 1998 (Act No. 36 of 1998)
PA	Protected Area
PAIA	Promotion of Access to Information Act, 2000 (Act No. 2 of 2000)
PAOI	Project Area of Interest
PFA	Project Focus Area
PI	Plasticity Index
PPP	Public participation process
PV	Photovoltaic
RLE	Red List Ecosystems
RoD	Record of Decision
RWD	Return Water Dam
SACAD	South African Conservation Areas Database
SANS	South African National Standards
SAHRA	South African Heritage Resources Agency
SANBI	South African National Biodiversity Institute
SAPAD	South African Protected Areas Database
SCC	Species of Conservation Concern
SDF	Spatial Development Framework
SOP	Standard Operating Procedure
SPLUMA	Spatial Planning and Land Use Management Act, 2013 (Act No. 16 of 2013)
SSRP	Regulations on Safety Standards and Regulatory Practices
TDS	Total Dissolved Solids
TLB	Tip Load Bucket
Tpm	Tonnes per month
TSF	Tailings storage facility
VU	Vulnerable
WML	Waste Management Licence
WRF	Weather and Research Forecasting
WULA	Water Use Licence Application
ZOI	Zone of Influence

1 Introduction

1.1 Structure of this Integrated Water and Waste Management Plan

This Integrated Water and Waste Management Plan (IWWMP) has been compiled in terms of the provisions of Appendix D of the Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals (GNR 267) published in terms of the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Table 1-1 cross-references the various sections in this report with these requirements.

Table 1-1: Structure of the IWWMP in line with Appendix D of GNR 267.

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1.2 Project Background

Ergo Mining (Pty) Ltd (Ergo) is reprocessing Tailings Storage Facilities (TSFs) in the East Rand of Gauteng. At present, reprocessed tailings are deposited on the Brakpan TSF. It is anticipated that in the future the Brakpan TSF will eventually reach its maximum designed height and capacity and Ergo is investigating other viable deposition sites in the area, which will enable it to continue with its reclamation operations.

Ergo has identified the Withok TSF footprint as a potential deposition site. The Withok TSF footprint, which is situated immediately south of the Brakpan TSF, is a historic TSF footprint (approximately 550 ha), with the original Withok TSF having been reclaimed over several years ending 2006.

The recommissioning of the Withok TSF entails the upgrading of the current footprint to allow for the redevelopment of the Withok TSF. Section 2 contains a detailed description of the proposed infrastructure for the Project.

The proposed recommissioned Withok TSF will require authorisation in terms of the National Water Act, 1998 (Act No. 36 of 1998) (NWA) for Section 21 water uses. An Integrated Water Use Licence Application (IWULA) has been prepared and submitted in accordance with the Water Use Licence Application and Appeals Regulations 2017 published in GNR 267 on 24 March 2017, and is supported by this IWWMP.

1.3 Applicant Details

The contact details of the responsible personnel are provided in Table 1-2 below.

Table 1-2: Contact Details of Applicant

Applicant:	Ergo Mining (Pty) Ltd
Registration No.:	2007/004886/07
Primary Contact:	Masala Tshamano
Head Office Address:	Constantia Office Park, Cnr 14th Avenue and Hendrik Potgieter Road, Cycad House, Building 17, Ground Floor, Weltevreden Park, 1709
Postal Address:	PO Box 12442, Selcourt, Springs, 1567
Telephone:	011 278 9600

1.4 Property Description

The Withok TSF area and proposed project infrastructure are located on portions 77, 78, 79 and 80 of the farms Withok 131 IR, portions 14, 15 and 20 of Vlakfontein 161 IR and Portion 11 of Rooikraal 156 IR, in the magisterial sub-district of Benoni, within the City of Ekurhuleni Metropolitan Municipality (CoE). The TSF is situated 7km south of Brakpan. Tsakane is situated directly east across the R23 from the TSF. The Rooikraal TSF, which is currently being reclaimed, is located directly west of the Withok TSF.

Table 1-3: Property Details

Application Area (ha)	The Proposed Project area covers an area of approximately 550 ha. The proposed TSF will cover 400ha.
Magisterial District	Ward 99 of the City of Ekurhuleni Metropolitan Municipality (CoE)
Distance and Direction from Nearest Town	The Withok TSF is located directly (approximately 1km) west of Tsakane and 7 km east of Vosloorus.

Refer to Table 1-4 below for farm portions that are directly affected by the Proposed Project.

Table 1-4: Description of the Directly Affected Properties

Farm Name	Farm ID	Portion	SG Code	Landowner
Withok 131	IR	77	T0IR00000000013100077	Ergo Mining Pty Ltd
Withok 131	IR	78	T0IR00000000013100078	Ergo Mining Pty Ltd
Withok 131	IR	79	T0IR00000000013100079	Ergo Mining Pty Ltd
Withok 131	IR	80	T0IR00000000013100080	Ergo Mining Pty Ltd
Vlakfontein 161	IR	14	T0IR00000000016100014	Ergo Mining Pty Ltd
Vlakfontein 161	IR	15	T0IR00000000016100015	Ergo Mining Pty Ltd
Vlakfontein 161	IR	20	T0IR00000000016100020	Ergo Mining Pty Ltd
Rooikraal 156	IR	11	T0IR00000000015600011	Ergo Mining Pty Ltd

1.5 Regional Setting and Location of Activity

The Withok TSF is situated within wards 99 of the CoE, 7 km south of Brakpan. Refer to Figure 1-1 for the Proposed Project's regional orientation and Figure 1-2 for the local orientation.

The area is predominantly surrounded by agricultural holdings, the Rooikraal TSF, the Brakpan TSF and the residential area of Tsakane.

The following infrastructure is currently encountered in the surrounding area:

- National and provincial roads;

- Agricultural holdings;
- Power lines;
- Slurry and water pipelines; and
- Other TSFs (Brakpan TSF and Rooikraal TSF).

1.6 Purpose of IWWMP

The WULA and Appeals Regulations, 2017 (Government Notice R267) under the National Water Act, 1998 (No. 36 of 1998) (NWA), regarding the procedural requirements for water use licence applications (WULAs) requires that an IWWMP must be submitted with the IWULA if the purpose of a water use is for industry or mining.

The original intent of an IWWMP was aimed at collating and rationalising the information submitted for WULAs, but subsequently it has also developed to:

- Provide the regulatory authorities with focused and structured information to meet their general information needs;
- Articulate the required management measures and actions to achieve the water and waste related performance on an ongoing basis; and
- Provide direction and guidance to the water user on water and waste management of any activity.

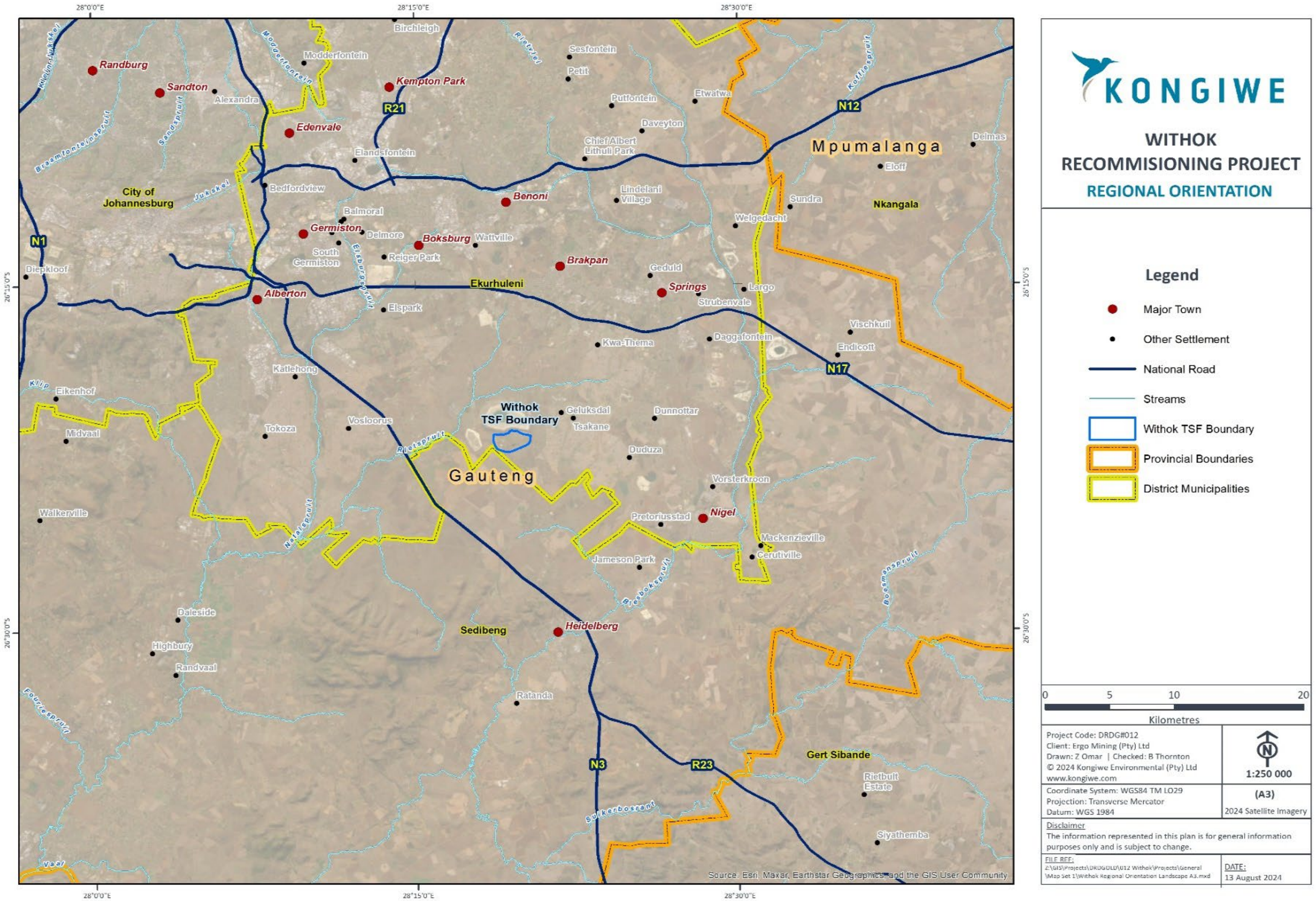


Figure 1-1: Withok TSF Regional Orientation

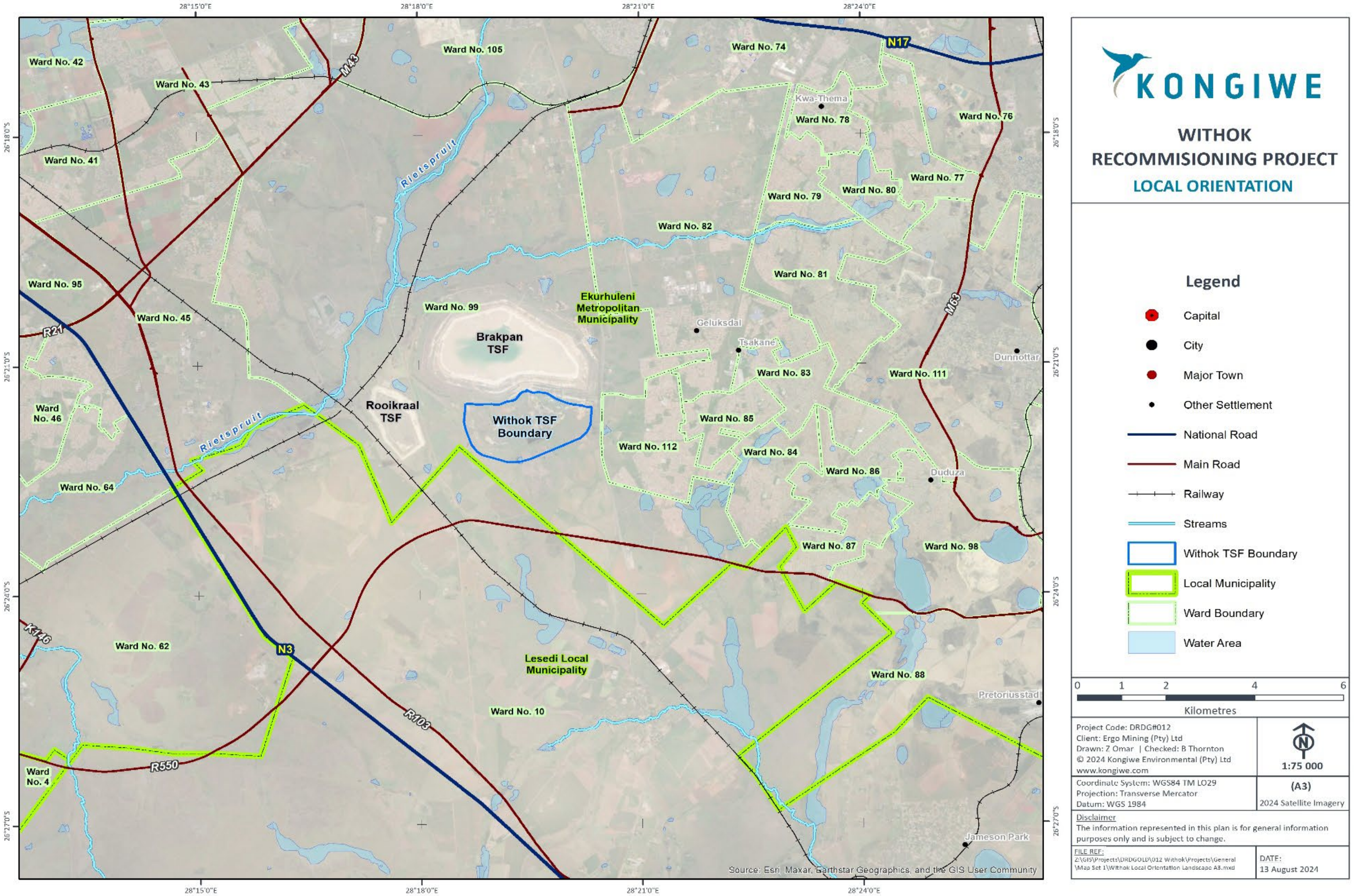


Figure 1-2: Withok TSF Site Orientation

2 Conceptualisation of Activity

This section describes a broad description of the activities, processes and products related to the Proposed Project. It also provides the background information of the organisational structure of the water user i.e., Ergo, and all the business and corporate policies related to the environment.

2.1 Description of Activity

Ergo has identified the Withok TSF footprint as a potential deposition site. The Withok TSF footprint, which is situated immediately south of the Brakpan TSF, is a historic TSF footprint (approximately 550 ha), with the original Withok TSF having been reclaimed over several years ending 2006.

The recommissioning of the Withok TSF entails the upgrading of the current footprint to allow for the redevelopment of the Withok TSF.

2.2 Extent of Activity

The footprint of the total project area is 550ha, while the footprint required for the recommissioning of the Withok TSF is approximately 400ha.

2.3 Key Activity Related Processes and Products

The proposed Withok TSF will buttress the southern flank of the Brakpan TSF and will be utilised as a reprocessed tailings deposition site. The intended recommissioning of the Withok TSF is to utilise the similar methodology as previously deployed, i.e. cyclone deposition with a floating decant pumping system. However, the first phases (lower portion) of development will be on a centreline basis to provide a much wider underflow prism, improving geotechnical characteristics and drainage. The principle of cyclone upstream deposition is to create a sufficiently robust underflow perimeter wall to contain the overflow with adequate freeboard and inherent stability to avoid overtopping and to prevent side slope failure.

The water management plan details during the life of operation are detailed in Section 5.2.

The Withok TSF will be designed, constructed and managed as per the Code of Practice for Mine Residue Deposits (SANS 10286) and the Dam Safety Regulations (GNR. 139 of 24 February 2012). Ergo is cognisant of the Global Industry Standard on Tailings Management (GISTM). The final life of the Withok TSF design, construction, operation and monitoring will align with these requirements where appropriate.

Refer to Figure 2-1. for the proposed project infrastructure.

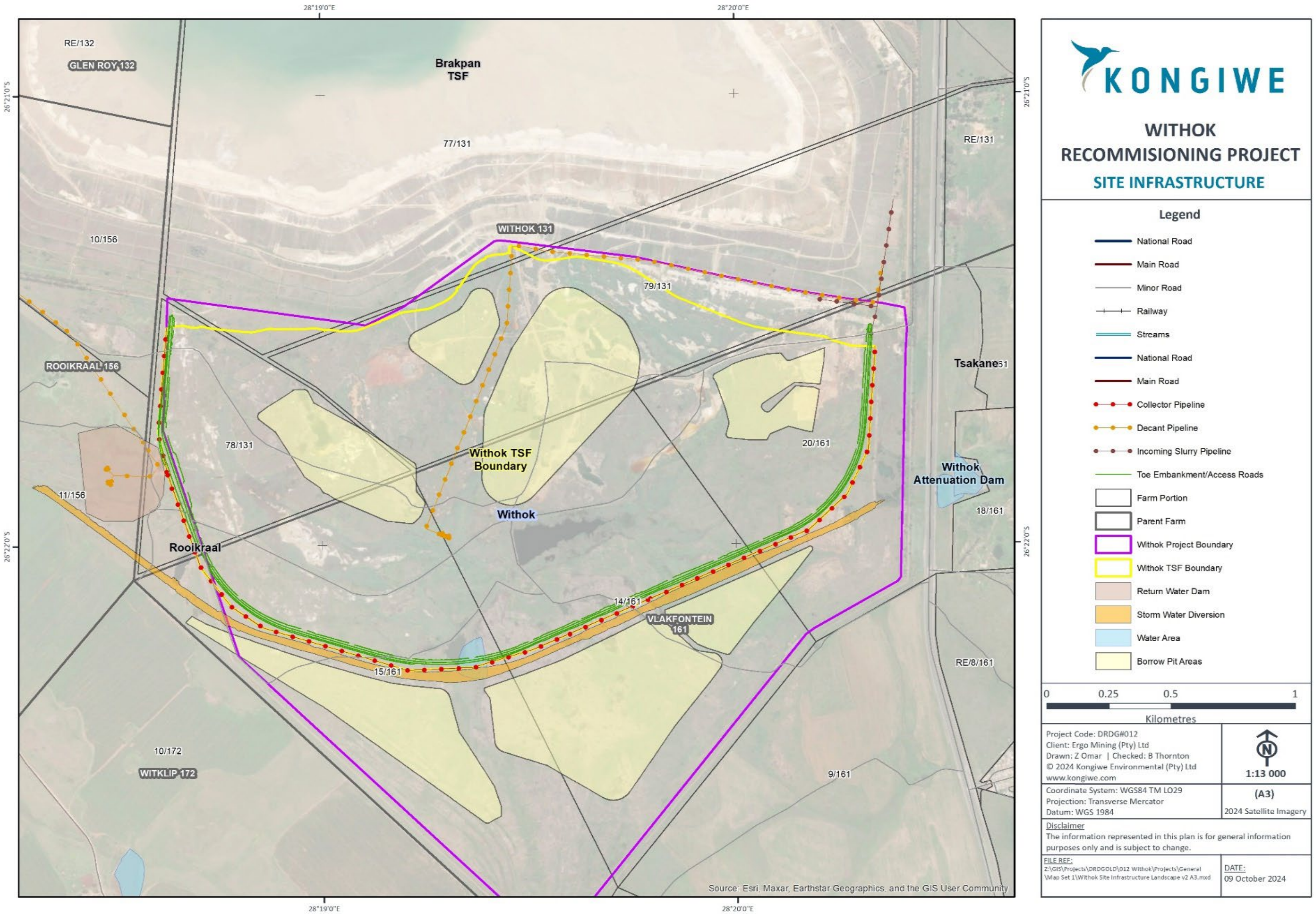


Figure 2-1: The Proposed Project site infrastructure

2.4 Activity Infrastructure Description

The following facility components are currently present on site:

- Access roads;
- Withok TSF footprint;
- Withok pump station;
- Attenuation dam, sump and diversion pipeline;
- National and provincial roads (N17);
- Agricultural holdings;
- Power lines;
- Slurry and water pipelines; and
- Other TSFs (Brakpan TSF and Rooikraal TSF).

The recommissioning of the Withok TSF entails the following: Upgrading of the current footprint to allow for the redevelopment of the Withok TSF. This will involve the following civil work.

- A sump and stormwater diversion trench;
- A toe embankment which acts as an access road and slurry distribution pipeline servitude;
- A starter embankment;
- An HDPE liner;
- Drainage outlet pipe platforms (cross walls);
- Toe drain, intermediate drain, main drain, radial, basin drain, interface blanket drain, as well as below liner seepage cutoff/collector drains;
- A decant berm and pool wall;
- Drainage collector pipes;
- A return water dam (approved DWS liner system) and return water pumping system;
- A floating decant barge pumping system, as well as a decant pipeline;
- Slurry feed pipelines;
- Slurry distribution pipelines;
- An HDPE pipe ring main;
- 250mm diameter cyclones, complete with feed pipes, valves, overflow pipes;
- Deposition of tailings;
- Water management;
- Temporary construction camp; and
- Borrow pits for material required during civil works and concurrent rehabilitation of the side slopes of the Withok TSF.

2.5 Activity Life Description

The Proposed Project is divided into a number of stages, as shown in Figure 2-2 below.

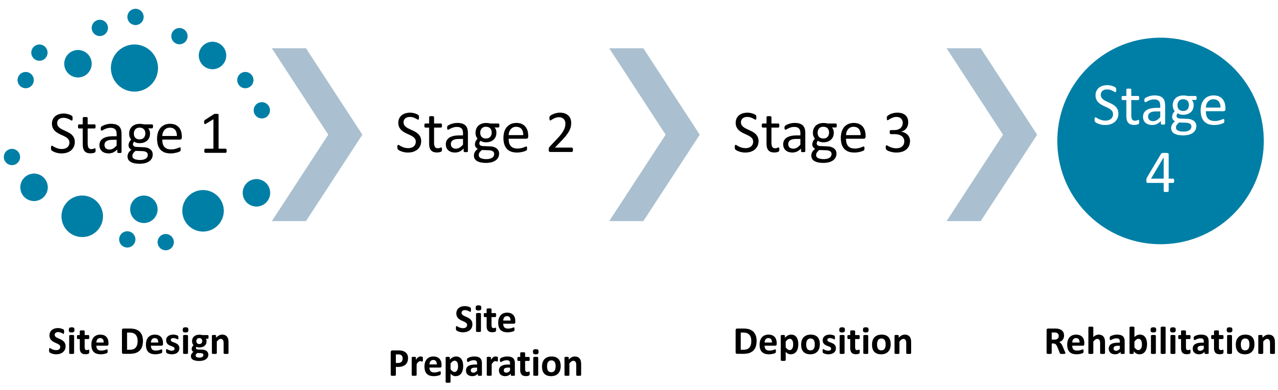


Figure 2-2: Project Process

2.6 Estimated Project Timeframes

Based on an average deposition rate of 1.3 million tpm, the design life of the facility is approximately 24 years. It is expected that there would be a 2-year construction and ramp-up period which would include the placement of infrastructure and site preparation and earthworks, followed by a 20-year Life of Operation (LOO) where active deposition would take place with concurrent rehabilitation of the side slopes, ending with 2- years to rehabilitate the site.

Table 2-1 gives an indication of the estimated timeframes in relation to the implementation of the actions, activities or processes for the Proposed Project.

Table 2-1: Estimated timeframes and deadlines of the different phases associated with the Proposed Project

Phase	Timeframe
Pre-Construction Phase and Construction for the site	2 years
Deposition starting at Withok TSF	20 years
Decommissioning and rehabilitation of Withok TSF	2 years

2.7 Life-Cycle Phases of the Project

The following table is summary of the activities that will occur at the different phases of the Recommissioning of the Withok TSF.

Table 2-2: Summary of activities per phase

Activity	Description
Pre-Construction	
1	Removal of vegetation and site clearance
2	Preparation of access roads should this be required
3	Initiation of a community forum for engagement throughout the project life cycle
4	Start implementing monitoring plans, Authorisation, Licensing and EMPr conditions.
5	Employment of workers
Construction phase	
6	Operation of construction machinery and vehicles
7	Earth works for foundations of TSF, RWD and stormwater infrastructure
8	Borrow pit establishment for construction and cladding materials
9	Construction of pipelines and electricity reticulation and power line
10	Instatement of waste management and dust control measures on site
Operational Phase	
11	Deposition Activities (including concurrent rehabilitation)
12	Operation of pipes
13	Operation of RWD and pump station and the associated infrastructure
14	Continued community engagement
Decommissioning	
15	Decommissioning and rehabilitation activities
16	Closure forum to be established with key stakeholders.
Post-Closure	
17	Post- Closure Monitoring.
18	Rehabilitation activities

2.7.1 Pre-Construction Activities

Pre-construction activities will include the development and implementation of all the required monitoring plans as stipulated by the Water Use Licence (WUL) as well as Environmental Management Programme (EMPr). These monitoring plans must start as early as possible prior to the commencement of the Proposed Project and continue until rehabilitation has successfully been completed and/or as stipulated by the WUL and/or EMPr.

2.7.2 Construction Phase Activities

The construction phase of the Proposed Project involves constructing starter embankments. These embankments form the foundational structure that will support the tailings. Concurrently, drainage systems are installed to manage water flow and prevent erosion. Following the construction of the embankments, the next step would be to install the pipelines required for tailings delivery and distribution. These pipelines are responsible for transporting the residue generated from the beneficiation process received at the Brakpan TSF valve slab to the Withok TSF.

Further to this, pipeline construction and electricity reticulation will be undertaken. The RWD, catchment paddocks, sump and stormwater diversion trenches will be constructed. The RWD and the catchment paddocks will be lined.

Employment will be allocated for the project, and communities will be engaged regarding the commencement of activities on site.

Furthermore, temporary and mobile (container) site infrastructure will be established at the site. Potable water will be sourced from Rand Water via existing water connections and/or infrastructure with contingency for JoJo tanks should this be required.

2.7.3 Operational Phase Activities

Once site preparation and the construction are completed, deposition activities will begin.

As the recommissioning of the Withok TSF progresses, one of the primary ongoing activities will be raising of embankments. This will be achieved through cyclone deposition with a floating decant pumping system. However, the first phases (lower portion) of development will be on a centreline basis to provide a much wider underflow prism, improving geotechnical characteristics and drainage.

Throughout the operation phase, continuous monitoring and quality control are necessary. This involves regular inspections and testing to ensure that the construction materials and methods meet the required standards. Monitoring systems are employed to track the structural integrity of the embankments, the flow of tailings, and water levels. Quality control measures include testing the compaction of embankment materials, checking for any signs of erosion or instability and ensuring that all construction activities adhere to the design specifications and safety regulations. These practices are essential to identify and address any issues promptly, ensuring the long-term stability and safety of the TSF.

During the operational phase, it is advised that continual monitoring of both surface and ground water is conducted. This information needs to be collected and used to update specific water models and to monitor and evaluate the impact of the operation. It is additionally advised that continual site inspections be undertaken to ensure that the implemented mitigation measures are operating as required.

2.7.4 Decommissioning Phase Activities

Once deposition is completed, the Withok TSF will need to be rehabilitated. The side slopes will be progressively cladded. The cladding provides a natural growing medium for the vegetation but must also fulfil other crucial requirements. Firstly, the cladding must contain sufficient gravel to impart “armouring” for erosion resistance (water and wind) and, secondly, the clay content and Plasticity Index (PI) must not be too high that moisture is prevented from evapotranspiration from the surface. Consequently, material stockpiled for cladding also needs to be selective.

The side slopes will require vegetating once the cover material has been placed. The vegetation is to consist of a mix of trees, shrubs, and grasses of suitable indigenous vegetation. .

Stormwater from the rehabilitated side slopes will be released to the environment utilising the existing chutes after rehabilitation is completed and the closure approved.

The recommended closure concept is to paddock and grass the top surface, while treating drain flows. The drain water can be treated to discharge quality and released into the receiving environment. Alternatively, this water can be treated to higher water quality standards and utililised accordingly. The brine from the treatment process would have to be pumped to the top surface to designated paddocks where it will be evaporated. There will be significant periods where the paddocks are dry so no long-term brine ponds are expected to form.

The applicable parts of the operating infrastructure, i.e., power supply, seepage recycling and water storage dams and pump stations will be used and/or repurposed to suit the post-closure requirements.

2.7.5 Post – Closure Activities Phase Activities

Post-closure activities will entail the assessment of rehabilitation and will address any further rehabilitation requirements. Monitoring must occur for at least five years after decommissioning and rehabilitation, or until satisfactory results are achieved. During this phase, preparatory work will be done to apply for closure as per the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) requirements.

2.8 Health and Safety

Ergo operates in accordance with the Mine Health and Safety Act (MHSA) and associated regulations. This includes creating a safe and healthy work environment and providing the necessary protection and training to staff to ensure their health and safety is not compromised.

Hazardous substances will be adequately stored and labelled. All regulations pertaining to safe use, handling, processing, storage, transport and disposal of hazardous substances; protection of equipment, structures and water sources and the surface of land; dumps and structures connected to recommissioning operations; the monitoring and control of those environmental aspects which may affect the health and safety of persons will be applied on site. Regulations pertaining to provision of water, ablution facilities and staff health and safety will be applied on site.

2.9 Key Water Uses and Waste Streams

2.9.1 Water Uses

The following water uses are triggered in terms of Section 21 of the NWA at for the Recommissioning of the Withok TSF:

- Section 21 (a): Taking water from a water resource;
- Section 21 (b) Storing water;
- Section 21 (c): Impeding or diverting the flow of water in a watercourse;
- Section 21 (i): Altering the bed, banks, course or characteristics of a watercourse; and
- Section 21 (g): Disposing of waste in a manner which may detrimentally impact on a water resource.

Refer to Section 3.6 for a detailed summary of water uses triggered by the Proposed Project in terms of the NWA.

2.9.2 Waste Streams

The anticipated waste streams from the Proposed Project are limited to tailings, polluted mine water, hydrocarbon waste, and general waste. These include:

- **Domestic/General** waste from the site offices, change houses and workshops which can include paper and cardboard, wood, plastic, metal, glass and organic articles such as food residue.
- **Construction and demolition** waste from site clearance, such as vegetation, soil, and debris. Additionally, civil works activities, including the construction of infrastructure like the sump, stormwater diversion trench, toe embankment, starter embankment, and drainage systems, produce waste materials such as concrete, metal, and HDPE liner offcuts.
- **Hydrocarbons and waste oils** from the site construction workshops are hazardous waste as they display some hazardous properties.
- **Tailings** waste from the deposition of tailings onto the Withok TSF.

Refer to Section 7 of this report for more details pertaining to the waste generated on site and the management thereof.

2.10 Organisational Structure of Activity

Ergo has a simple and efficient structure. All operations are consolidated into one operating entity, Ergo Mining (Pty) Ltd. Ergo is wholly owned by Ergo Mining Operations Proprietary Limited (EMO). Following the roll-up of the stake of the broad-based black economic empowerment (BBBEE) partners in EMO into DRDGOLD Limited, EMO is now a wholly-owned subsidiary of DRDGOLD. The roll-up involved the substitution by the BBBEE partners, Khumo Gold SPV Proprietary Limited (Khumo) and the DRDSA

Empowerment Trust (the Trust) for a direct holding in DRDGOLD. The agreement provided Khumo with an 8.1% interest and the Trust with a 2.4% interest in DRDGOLD.

Figure 2-3: Ergo Group Structure

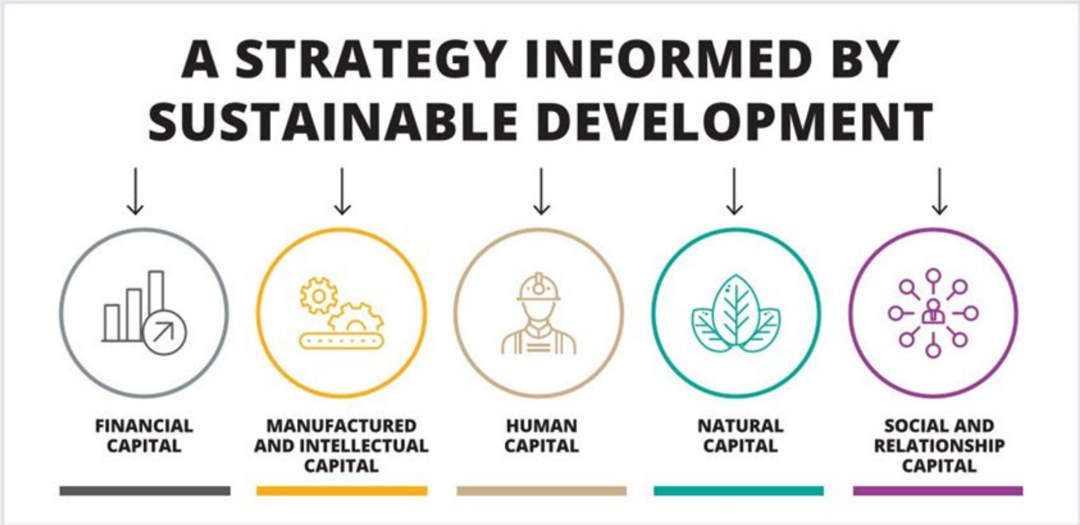
2.10.1 Business and Corporate Policies

DRDGOLD has a Sustainability Policy in place. The sustainability focus areas, which support and are sustained by DRDGOLD's financial, intellectual and manufactured capital include:

- Natural capital: water, land and energy;
- Social and relationship capital: communities and broader society, including government and regulators; and
- Human capital and intellectual capital: employees – their development and protection.

STRATEGIC APPROACH TO SUSTAINABILITY

In the early days of gold mining in Johannesburg, there was limited understanding and focus on the future environmental impacts of mine residue depositioning. In the decades that followed, a second, equally challenging situation arose when a city sprung up around these dumps, with residential communities growing and moving ever closer to the mines.



This was aggravated by the forced displacement of communities and the social engineering of the apartheid era, and poorly managed urban influx and development policies since democracy. This has resulted in hundreds of thousands of people living in formal and informal communities, much too close to mine dumps – dumps that were closed to a standard of environmental containment that assumed community presence much further away.

We deal with this dilemma by taking an integrated approach to social and natural capital. They are inextricably linked, and delivering value in respect of the one, also brings us closer to our goals in respect of the other. Our aim is to leave an enduring legacy by permanently removing many of the old mine dumps scattered around the Witwatersrand that were either built where they did not belong in the first place, or that had become inappropriately situated because of the movement of people and our new urban reality.

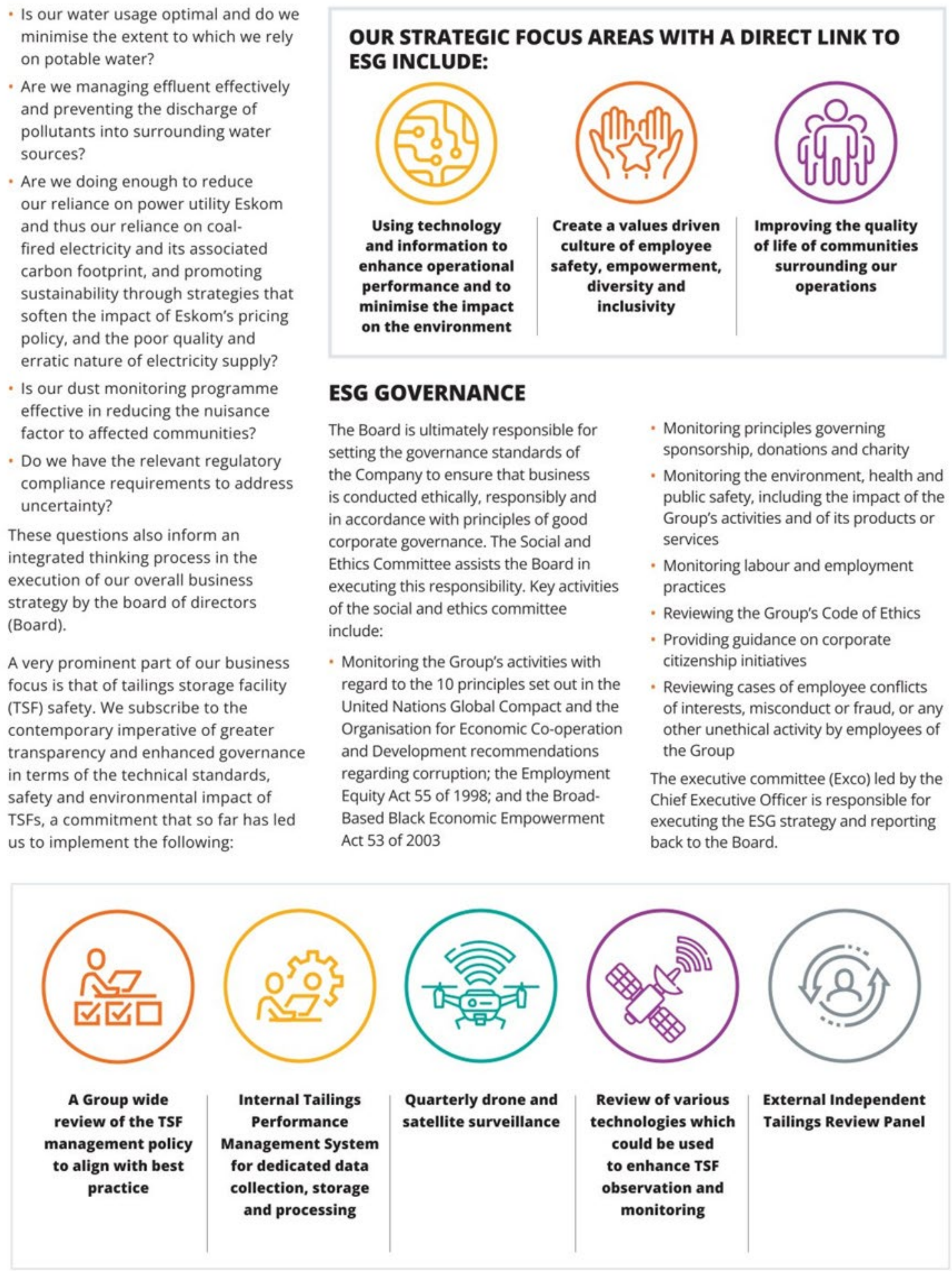
We do this by reprocessing the dumps and redepositing resultant waste onto tailings storage facilities that are managed in accordance with contemporary standards of environmental and geo-technical standards, cleaning environmentally sensitive areas in the process and freeing up land for redevelopment. This yields both a substantial environmental dividend as well as a social dividend in improving the quality of life of affected communities whilst also creating financial value, allowing sustainable land use to take place in areas previously sterilised. The value delivery is therefore truly integrated and firmly aligned with the principles of sustainable development.

Our process is technology-based requiring a specialised skillset on the part of our employees. Hazardous reagents are used in our metallurgical process which requires sharp focus on safety and governance while the prominence of water and electricity consumption requires acute awareness and ongoing development to limit and reduce our impact on the environment. ESG is key to our commitment to sustainable development and our goals of reversing the environmental legacy of early mining, limiting and reducing our impact on natural resources and of improving the quality of life of our affected communities.

With every project we challenge ourselves to ensure that our values, ambitions and actions are aligned.

We ask ourselves:

- Do we provide an inclusive workspace that promotes diversity?
- Do we provide our employees and women in particular with a working environment that is both physically and emotionally safe?
- Is our workforce trained and equipped to deal with the ever-changing factors influencing our business and the increasingly prominent role of technology?



- Is our water usage optimal and do we minimise the extent to which we rely on potable water?
- Are we managing effluent effectively and preventing the discharge of pollutants into surrounding water sources?
- Are we doing enough to reduce our reliance on power utility Eskom and thus our reliance on coal-fired electricity and its associated carbon footprint, and promoting sustainability through strategies that soften the impact of Eskom's pricing policy, and the poor quality and erratic nature of electricity supply?
- Is our dust monitoring programme effective in reducing the nuisance factor to affected communities?
- Do we have the relevant regulatory compliance requirements to address uncertainty?

These questions also inform an integrated thinking process in the execution of our overall business strategy by the board of directors (Board).

A very prominent part of our business focus is that of tailings storage facility (TSF) safety. We subscribe to the contemporary imperative of greater transparency and enhanced governance in terms of the technical standards, safety and environmental impact of TSFs, a commitment that so far has led us to implement the following:

OUR STRATEGIC FOCUS AREAS WITH A DIRECT LINK TO ESG INCLUDE:

- **Using technology and information to enhance operational performance and to minimise the impact on the environment**
- **Create a values driven culture of employee safety, empowerment, diversity and inclusivity**
- **Improving the quality of life of communities surrounding our operations**

ESG GOVERNANCE

The Board is ultimately responsible for setting the governance standards of the Company to ensure that business is conducted ethically, responsibly and in accordance with principles of good corporate governance. The Social and Ethics Committee assists the Board in executing this responsibility. Key activities of the social and ethics committee include:

- Monitoring the Group's activities with regard to the 10 principles set out in the United Nations Global Compact and the Organisation for Economic Co-operation and Development recommendations regarding corruption; the Employment Equity Act 55 of 1998; and the Broad-Based Black Economic Empowerment Act 53 of 2003
- Monitoring principles governing sponsorship, donations and charity
- Monitoring the environment, health and public safety, including the impact of the Group's activities and of its products or services
- Monitoring labour and employment practices
- Reviewing the Group's Code of Ethics
- Providing guidance on corporate citizenship initiatives
- Reviewing cases of employee conflicts of interests, misconduct or fraud, or any other unethical activity by employees of the Group

The executive committee (Exco) led by the Chief Executive Officer is responsible for executing the ESG strategy and reporting back to the Board.

- **A Group wide review of the TSF management policy to align with best practice**
- **Internal Tailings Performance Management System for dedicated data collection, storage and processing**
- **Quarterly drone and satellite surveillance**
- **Review of various technologies which could be used to enhance TSF observation and monitoring**
- **External Independent Tailings Review Panel**

Figure 2-4: DRDGOLD's sustainability policy (DRDGOLD Limited ESG Fact Sheet 2022)

3 Regulatory Water and Waste Management Framework

3.1 Legislative Framework

This chapter provides an overview of the policy and legislative context relevant to the water use activities of the Proposed Project. There are a number of legal and regulatory frameworks which regulate water management in South Africa. A summary of these are provided in Table 3-1 with specific detail relating to the National Water Act 36 of 1998 (NWA) and National Environment Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA) provided in the remainder of this section.

The foundation for Environmental Preservation is entrenched in the Constitution of South Africa (Act No. 108 of 1996). Following the birth of democracy in South Africa, legislative and environmental policies and regulations have undergone a large transformation, and various laws and policies were promulgated with a strong emphasis on environmental concerns and the need for sustainable development. The Constitution provides environmental rights (contained in the Bill of Rights, Chapter 2 (Section 24)) and includes implications for environmental management. The environmental rights are guaranteed in Section 24 of the Constitution, and state that:

"E*veryone has the right –*

- *To an environment that is not harmful to their health or well-being and*
- *To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that:*
  - *Prevent pollution and ecological degradation;*
  - *Promote conservation and*
  - *Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."*

To ensure that the various spheres of the social and natural environmental resources are not overlooked, additional legislation and regulations have been promulgated in addition to those contained within the Constitution. The additional legislature and regulations ensure that there remains a key focus on various industries or components of the environment, and to ensure that the objectives of the Constitution are effectively implemented and upheld on an on-going basis. In terms of Section 7, a positive obligation is placed on the State to give effect to the environmental rights.

Table 3-1: Applicable National Legislation and Guidelines

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
The Constitution of South Africa, 1996 (Act 108 of 1996) Section 24 of the Act states that everyone has the right to an environment that is not harmful to their health or well-being; to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecological sustainable development and use of natural resources while promoting justifiable economic and social development. Section 32 of the Act states that every person has a right to information held by the State and to information held by other people that is required in the exercise or protection of a right. Section 33 of the Act states that everyone has a right to just and procedurally fair administrative action. The Proposed Project aligns with the Constitution of South Africa by eliminating a pollution source and consolidating the final residue from beneficiation process into a single, concentrated area. This approach will enhance the environment for both current and future generations	As per the Requirements of NWA and the NWA Regulations, alternative activities that are less taxing on the environment and resources must be investigated where possible. The draft IWWMP was made available for public review (as per Appendix C of this report). The Appeal Process will be described to all stakeholders through the IWULA Record of Decision (RoD) notification described in Public Participation Process (PPP) report included in this report as Appendix C.
The One Environmental System In terms of the One Environmental System established by the NEMLAA, an Environmental Authorisation (EA) in respect of a Listed Activity must be issued within 300 days of the application being submitted. This system aims to streamline the licensing processes for environmental authorisations and water use.	Ergo proposes to recommission the Withok TSF and submit the required documents within the prescribed timeframes.
Mine Health and Safety Act (MHSA), Act 29 of 1996 (as amended): Although the Mineral and Petroleum Resources Development Act, 2002, does not apply to this project, Ergo operates in accordance with the MHSA and associated regulations. This includes creating a safe and healthy work environment and providing the necessary protection and training to staff to ensure their health and safety is not compromised.	Although not strictly addressed in the IWWMP protecting the environment contributes to a safe working environment. MHSA regulations will be worked into the mine's Code of Practice (COP) and Standard Operating Procedures (SOPs).

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
Hazardous substances will be adequately stored and labelled. All regulations pertaining to safe use, handling, processing, storage, transport and disposal of hazardous substances; protection of equipment, structures and water sources and the surface of land; dumps and structures connected to reclamation operations; the monitoring and control of those environmental aspects which may affect the health and safety of persons will be applied on site. Regulations pertaining to provision of water, ablution facilities and staff health and safety will be applied on site.	
National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) The overarching principle of the NEMA is sustainable development. It defines sustainability as meaning the integration of social, economic and environmental factors into planning, implementation and decision making to ensure the development serves present and future generations. Section 2 of NEMA provides for the NEMA principle which apply throughout the Republic to the actions of all organs of state that may significantly affect the environment and in conjunction with other appropriate and relevant considerations. The NEMA principles serve as the general framework within which environmental management and implementation plans must be formulated and serve as a guideline by reference to which any organ of state must exercise any function when taking any decision in terms of the NEMA or any statutory provision concerning the protection of the environment. NEMA authorises the Minister of the Department of, Forestry and Fisheries and the Environment (DFFE) to issue Regulations relating to the administration of the Act[1], which has been done with the publication of the EIA 2014 Regulations, as amended. Section 24(2) allows the Minister to identify activities which may not commence without environmental authorisation from the competent authority. This identification has been done in accordance with listing notices referred to as Listing Notice 1, Listing Notice 2 and Listing Notice 3. The NEMA also allows the Minister to determine which authority will be the competent authority to receive and evaluate applications for EAs. Listing Notice 1 identifies activities of limited scale and effect, which need to be assessed by a fairly simple process referred to as a BA, where after a Basic Assessment Report (BAR) is submitted to the competent authority. Listing Notice	It is the objective of this application to align to NEMA. The National Environmental Management Act (NEMA) serves as the primary legislation governing sustainable development. The principles outlined in NEMA are applicable to all prospecting and mining operations, including reclamation activities, as well as any related matters or activities such as the deposition of tailings.

1 Sections 24(5) and Section 44

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
2 identifies activities of significantly greater magnitude, which require evaluation through an initial Scoping Phase followed by an EIA and an EMPr. This process is generally referred to as the S&EIR process. Listing Notice 3 relates to activities limited to specified geographical areas and matters of concern to the various provinces which require a BAR process to be dealt with by the provincial authority concerned. Regulation 16 (1) prescribes the general application requirements and states that an application for an EA must be made on the official application form obtainable from the CA and must, amongst others, include proof of payment of the prescribed application fee. Regulation 21 provides for the submission of the Scoping Report to the Competent Authority (CA) for consideration and states that the scoping report must contain all the information set out in Appendix 2 to the EIA 2014 Regulations, as amended. In terms of regulation 22, the CA must, after considering the Scoping Report, either accept the report, with or without conditions and advise the applicant to proceed with the plan of study for EIA or refuse the EA. Once the Scoping Report is accepted by the CA, the applicant must submit the EIA Report inclusive of specialist reports and an EMPr which have been subjected to a PPP. The timeframes for submission of the Scoping Report and the EIA Report inclusive of the timeframes within which the CA must consider the reports and approve the EA are prescribed in regulations 21 to 24 of the EIA 2014 Regulations. Once a decision on the EA application has been reached, the CA must notify the applicant in writing of the decision and give reasons for the decision.	
Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) The MPRDA contains provisions relating to TSFs. This must be read together with the EIA 2014 Regulations, as amended, and the assessment of impacts relating to pollution control, where appropriate, must form part of the EMPr.	Ergo proposes the Recommissioning of the Withok TSF in accordance with the provisions of the MPRDA.
National Water Act, 1998 (Act No. 36 of 1998) (NWA)	A WULA will be required for the Recommissioning of the Withok TSF and an application has been submitted to the DWS.

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
In terms of the NWA, the national government, acting through the Minister of Water and Sanitation, is the public trustee of South Africa's water resources, and must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons (section 3(1)). In terms of the NWA a person may only use water without a license if such water use is permissible under Schedule 1 (generally domestic type use) if that water use constitutes a continuation of an existing lawful water use (water uses being undertaken prior to the commencement of the NWA, generally in terms of the Water Act of 1956), or if that water use is permissible in terms of a general authorisation issued under section 39 (general authorisations allow for the use of certain section 21 uses provided that the criteria and thresholds described in the general authorisation is met). Permissible water use furthermore includes water use authorised by a license issued in terms of the NWA. Section 21 of the NWA defines water uses which are governed in terms of the Act and for which a WUL is required. In terms of section 40 (1) of the NWA "a person who is required or wishes to obtain a licence to use water must apply to the relevant responsible authority for a licence." These water uses, in terms of Section 21, are as follows: **(a) taking water from a water resource;** **(b) storing water;** **(c) impeding or diverting the flow of water in a watercourse;** (d) engaging in a stream flow reduction activity contemplated in Section 36; (e) engaging in a controlled activity identified as such in Section 37(1) or declared under Section 38(1); (f) discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit; **(g) disposing of waste in a manner which may detrimentally impact on a water resource;** (h) disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process; **(i) altering the bed, banks, course or characteristic of a watercourse;** (j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and	

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
(k) using water for recreational purposes. It is not likely that sub-sections **(d), (e), (f), (h), (j) or (k)** will apply to the Proposed Project. The IWULA must be prepared and submitted in accordance with the Water Use Licence Application and Appeals Regulations 2017 published in GNR 267 on 24 March 2017 and must generally be supported by a Technical Report, as well as conceptual design drawings of all water related infrastructure.	
National Environmental Management: Biodiversity Act, 2004 (Act No.10 of 2004) (NEM:BA) The NEM:BA provides for the management and conservation of South Africa's biodiversity within the framework of NEMA, as well as the protection of species and ecosystems that warrant national protection and the sustainable use of indigenous biological resources. The South African National Biodiversity Institute (SANBI) website and GIS tools were utilised to determine whether any nationally protected and threatened ecosystems occur on site. The Proposed Project falls within the Gauteng Province, which has a provincial Biodiversity Assessment Protected Area Expansion Strategy. This strategy has been incorporated and considered throughout the compilation of this report.	NEM:BA was used to inform whether activities triggered Listing Notice 3 The required specialist studies were undertaken as part of the impact identification and mitigation identification phase.
National Environmental Management: Protected Areas Act (NEM:PAA), Act 57 of 2003 as amended The National Environmental Management Protected Areas Act (Act No. 57 of 2003) (NEM:PAA) concerns the protection and conservation of ecologically viable areas representative of South Africa's diversity and its natural landscapes and seascapes, and includes *inter alia*: ❖ The establishment of a national register of all national, provincial and local protected areas; ❖ The management of those areas in accordance with national standards; and ❖ Inter-governmental co-operation and public consultation in matters concerning protected areas. Sections 48 to 53 of the NEM:PAA lists restricted activities that may not be conducted in a protected area. Section 48 states that no person may conduct commercial prospecting or mining activities in a:	SANBI website and GIS tools were utilised to determine if the project area overlaps with Critical Biodiversity Areas (CBAs). The Regulations have been utilised to determine the need for any additional listed scheduled activities under GNR 985.

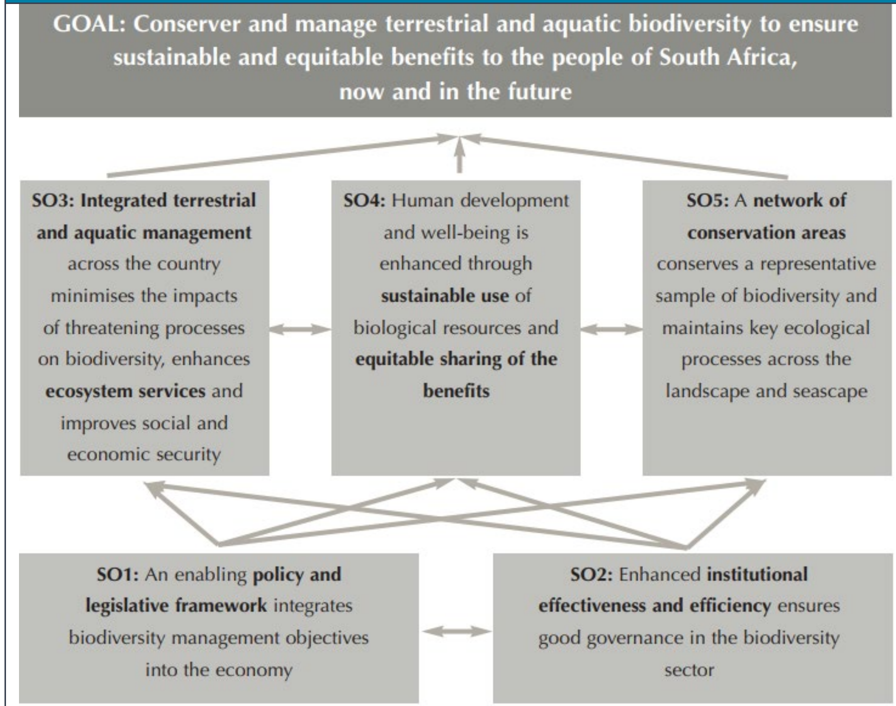
Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
❖ Special nature reserve or nature reserve; ❖ Protected environment without the written permission of the Minister and the Cabinet member responsible for minerals and energy affairs; and Protected area referred to in Section 9: ❖ (b) world heritage sites; and ❖ specially protected forest areas, forest nature reserves and forest wilderness areas declared in terms of the National Forests Act (No. 84 of 1998); The Proposed Project falls in an area identified in the 2018 Gauteng Environmental Management Framework's Focus Areas for land-based protected areas expansion.	
National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA) The NHRA aims to promote good management of cultural heritage resources and encourages the nurturing and conservation of cultural legacy so that it may be bestowed to future generations. The Act requires all developers (including mines) to undertake cultural heritage studies for any development exceeding 0.5 ha. It also provides guidelines for impact assessment studies to be undertaken where cultural resources may be disturbed by development activities. ❖ The South African Heritage Resources Agency (SAHRA) will need to approve the heritage assessment undertaken as part of the impact assessment process. The Withok TSF may represent 'Historical Settlements and Townscapes' as per the NHRA if it was established more than 60 years ago. The dump and other associated mining infrastructure are integral components of the historical mining townscapes and settlements of the East Rand. This will be verified during the EIA phase of the project and if needed, appropriate authorisations will be sought via the NHRA.	A Heritage Impact Assessment has been undertaken as part of the specialist studies conducted.
Nuclear Energy Act 1999, (Act 46 of 1999) (NEA), the National Nuclear Regulator Act 1999, (Act No. 47 of 1999) (NNRA)	The requirements of the Act and Regulations

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
and the Regulations on Safety Standards and Regulatory Practices (SSRP) (GN R388 of 28 April 2006). The NEA established a framework for the management of nuclear material and the NNRA was enacted to provide for the establishment of the National Nuclear Regulator to regulate nuclear activities and safety standards. These Acts and the SSRP will be considered and their requirements implemented where applicable.	were considered when assessing the Project impacts and developing the associated mitigation measures. These will continue to be considered moving forward.
Conservation of Agricultural Resources Act (No. 43 of 1983) The Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA) includes the use and protection of land, soil, wetlands and vegetation and the control of weeds and invader plants. This is the only legislation that is directly aimed at conservation of wetlands in agriculture. The Act contains a comprehensive list of species that are declared weeds and invader plants dividing them into three categories. These categories are as follows: ❖ Category 1: Declared weeds that are prohibited on any land or water surface in South Africa. These species must be controlled, or eradicated where possible; ❖ Category 2: Declared invader species that are only allowed in demarcated areas under controlled conditions and prohibited within 30m of the 1:50 year floodline of any watercourse or wetland; and ❖ Category 3: Declared invader species that may remain but must be prevented from spreading. No further planting of these species is allowed. In terms of the Act, landowners are legally responsible for the control of alien species on their properties. Failure to comply with the Act may result in various infringement consequences and in some instances imprisonment and other penalties for contravening the law.	The protection of land, soil, wetlands and vegetation and the control of weeds and invader plants will be contained within the IWWMP.
The South African National Roads Agency Limited and National Roads Act, 1998 (Act No. 7 of 1998) The National Road Traffic Regulations, 2000 places specific duties on the consignor and consignee of dangerous goods. A consignor means the person who offers dangerous goods for transport (i.e. hazardous waste) and a consignee is the person who accepts dangerous goods, which have been transported in a vehicle. Both consignor and consignee must comply with the requirements of several SANS standard specifications and codes of practice relevant to dangerous goods	The requirements of the Act and Regulations has been considered when assessing the project impacts and developing the associated mitigation measures in the IWWMP.

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
which have been incorporated into the regulations. The property owner is responsible for: ❖ Offloading of the dangerous goods; ❖ Providing the dangerous goods offloading supervisor; and ❖ Ensuring that the loading and offloading are carried out by qualified employees trained in the relevant procedures. Ergo must, in line with Section 54 of the Act and GN R225, provide evidence that the company has appointed responsible personnel to oversee the off-loading of dangerous goods at its operations. A driver of a vehicle transporting dangerous goods is required to undergo training at an approved training body.	
Spatial Planning and Land Use Management Act, 2013 (Act No. 16 of 2013) (SPLUMA) The SPLUMA was promulgated in May 2015. SPLUMA is a framework act for all spatial planning and land use management legislation in South Africa. It seeks to promote consistency and uniformity in procedures and decision-making in this field. SPLUMA will also assist municipalities to address historical spatial imbalances and the integration of the principles of sustainable development into land use and planning regulatory tools and legislative instruments.	The footprint of the Withok TSF is already in existence and falls within a High control zone (outside the urban development zone) (Zone 3).
Hazardous Substances Act, 1973 (Act No. 15 of 1973) The Regulations for Hazardous Chemical Substances apply to an employer or a self-employed person who carries out work at a workplace which may expose any person to the intake of hazardous chemical substances at that workplace. Regulations 14 and 15 provide for the labelling, packaging, transportation and storage and the disposal of hazardous chemical substances respectively. These regulations set out specific requirements which form part of an employer's duty to provide and maintain, as far as reasonably practicable, a working environment that is safe and without risk to the health of his or her employees.	The requirements of the Act and Regulations has been considered when assessing the project impacts and developing the associated mitigation measures in the IWWMP.
National Development Plan, 2030 The National Development Plan (NDP) offers a long-term perspective. It defines a desired destination and identifies the	The requirements of this Plan has been considered when assessing the project impacts

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
role different sectors of society need to play in reaching that goal. As a long-term strategic plan, it serves four broad objectives: 1. Providing overarching goals for what we want to achieve by 2030. 2. Building consensus on the key obstacles to us achieving these goals and what needs to be done to overcome those obstacles. 3. Providing a shared long-term strategic framework within which more detailed planning can take place to advance the long-term goals set out in the NDP. 4. Creating a basis for making choices about how best to use limited resources. The Plan aims to ensure that all South Africans attain a decent standard of living through the elimination of poverty and reduction of inequality. The core elements of a decent standard of living identified in the Plan are: ❖ Housing, water, electricity and sanitation; ❖ Safe and reliable public transport; ❖ Quality education and skills development; ❖ Safety and security; ❖ Quality health care; ❖ Social protection; ❖ Employment; ❖ Recreation and leisure; ❖ Clean environment; and ❖ Adequate nutrition. The Proposed Project falls in line with the goals of the NDP in creating a decent standard of living for all South Africans by removing a pollution source to the surrounding conservation and protected areas adjacent to the project site.	and developing the associated mitigation measures in the IWWMP.

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
Action Plan of the Environmental Initiative of the New Partnership of Africa's Development, 2003. This Action Plan was established with the aim of encouraging sustainable development, conservation and acceptable use of biodiversity in Africa. It has been recognised that a healthy and productive environment is a prerequisite for the success of New Partnership of Africa's Development (NEPAD), together with the need to systematically address and sustain ecosystems, biodiversity and wildlife. Six areas have been identified: ❖ Combating land degradation, drought and desertification; ❖ Conserving Africa's wetlands; ❖ Preventing and controlling invasive alien species; ❖ Conservation and sustainable use of coastal and marine resources; ❖ Combating climate change in Africa; and ❖ Cross-border conservation and management of natural resources.	As the Proposed Project will contribute in continuing to remove pollution sources, such as the TSFs, the objectives of the NEPAD to systematically address and sustain ecosystems, biodiversity and wildlife has been considered during the impact assessment of the project.
South Africa's National Biodiversity Strategy and Action Plan The National Biodiversity Strategy and Action Plan (NBSAP) sets out a framework and a plan of action for the conservation and sustainable use of South Africa's biological diversity and the equitable sharing of benefits derived from this use. The NBSAP was prepared by the former Department of Environmental Affairs and Tourism (DEAT), during the period May 2003 to May 2005. The goal of the NBSAP is to conserve and manage terrestrial and aquatic biodiversity to ensure sustainable and equitable benefits to the people of South Africa, now and in the future. In support of this goal, five key strategic objectives (SOs) have been identified, each with a number of outcomes and activities. The schematic below represents the objectives and their interconnection in achieving the NBSAP "Goal", although the project is related to reclamation, the following would still apply:	The Proposed Project is cognisant of the obligation to protect and preserve the integrity of the environment as well as its biodiversity. Principles of this plan has been taken into consideration during the impact assessment of the project.

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
 Through the NSBA, it is recognised that biodiversity cannot be conserved through protected area networks only. All stakeholders, from private landowners and communities to business and industry must get involved in biodiversity management. The Proposed Project would need to incorporate operational systems that minimise the impacts of threatening processes on biodiversity during the operational phase of the project, and by streamlining specialist recommendations during the implementation of all phases of this project.	
Promotion of Access to Information Act, 2000 (Act No. 2 of 2000) The PAIA gives effect to the constitutional right of access to any information held by the state and any information that	The requirements of the Act have been and will continue to be considered when assessing and involving the public and registered interested

Applicable Legislation and Guidelines used to compile the report.	Reference where Applied
is held by another person and that is required for the exercise or protection of any rights; and to provide for matters connected therewith.	and affected parties.
National Environmental Management Act; National Appeal Regulations, 2014 The purpose of these regulations is to regulate the procedure contemplated in section 43(4) of the National environmental management act relating to the submission, processing and consideration of a decision on an appeal. This Act is used to help guide and understand the appeal process and the procedures may follow.	The requirements of the Act will be considered if an appeal may need to be or is lodged for the project.

Table 3-2: Applicable Provincial and Local Policies, Guidelines and By-Laws

Policies, Guidelines and By-Laws	
Gauteng Mine Residue Areas Strategy, 2012 The aim of the project as a whole is contribute to making more land available from the mine dumps in Gauteng to be used for other purposes, in line with government priorities. The objectives for the project are as follows: ❖ To evaluate current pollution problems caused by mining activities and suggest how they should be addressed; ❖ To quantify the amount of land under mining activities and classify them in terms of impacts and potential for reclamation; ❖ To investigate which mining areas could be made available to be used for other purposes; and To provide preliminary and conceptual recommendations on the short-term priorities for the reclamation of the mining sites which could be economically sustainable.	The Proposed Project is in line with the objectives of the Strategy. The guidelines of the Strategy have been considered throughout the WULA.
Gauteng Nature Conservation Bill, 2014 The Bill was established in 2014, and contains the following objectives: ❖ To provide for the sustainable utilisation and protection of biodiversity within Gauteng; ❖ To provide for the protection of wild and the management of alien animals; protected plants; aquatic biota and aquatic systems;	Aspects of this Bill are applicable to the Proposed Project. Where applicable, these have been considered throughout the WULA process and have been included within the reporting documents.

<table>
<tr><th colspan="2">Policies, Guidelines and By-Laws</th></tr>
<tr><td>❖ To provide for the protection of invertebrates and the management of alien invertebrates;
❖ To provide for professional hunters, hunting outfitters and trainers;
❖ To provide for the preservation of caves, cave formations, cave biota and karst systems;
❖ To provide for the establishment of zoos
❖ To provide for the powers and establishment of Nature Conservators;
❖ To provide for administrative matters and general powers; and to provide for matters connected therewith.</td><td></td></tr>
<tr><td><u>Gauteng Conservation Plan Version 3.3</u>

The main purposes of C-Plan 3.3 are:

❖ To serve as the primary decision support tool for the biodiversity component of the Environmental Impact Assessment (EIA) process;
❖ To inform protected area expansion and biodiversity stewardship programmes in the province;
❖ To serve as a basis for development of Bioregional Plans in municipalities within the province.

C-Plan 3.3 is a valuable tool to ensure adequate, timely and fair service delivery to clients of GDARD, and is critical in ensuring adequate protection of biodiversity and the environment in Gauteng Province.</td><td>Aspects of this Plan are applicable to the Proposed Project. Where applicable, these have been considered throughout the WULA process and will be included within the reporting documents.</td></tr>
<tr><td><u>Gauteng Environmental Implementation Plan, 2016</u>

The purpose of the EIP is to:

❖ Coordinate and harmonise environmental policies, plans and programmes and decisions to (i) minimise the duplication of procedures and functions; and (ii) promote consistency in the exercise of functions that may affect the environment;
❖ Give effect to the principle of cooperative governance in Chapter 3 of the Constitution;
❖ Secure the protection of the environment across the country as a whole;
❖ Prevent unreasonable actions in respect of the environment that is prejudicial to the economic or health interests of other provinces or the country as a whole; and</td><td>Aspects of this Plan are applicable to the Proposed Project. Where applicable, these have been considered throughout the WULA process and will be included within the reporting documents.</td></tr>
</table>

Policies, Guidelines and By-Laws	
❖ Enable monitoring of the achievement, promotion and protection of a sustainable environment.	
Gauteng Growth and Development Agency Strategic Plan 2014-2019 The main purpose of the GGDA Strategic Plan is: ❖ Addressing the persistent racial imbalances regarding ownership and general configuration of Gauteng's economy; ❖ Addressing the spatially distorted economic development legacy of apartheid rule; ❖ Broadening the base of economic development beyond the Province's dominant metropolitan municipal areas; ❖ The socio-economic transformation envisaged for the second phase of transition to a national democratic society; and ❖ Achieving the outcomes of creating decent work, economic inclusion and equality.	The Proposed Project will contribute towards employment creation within the province and will also contribute positively towards economic growth within the region through both its development and operation.
Ekurhuleni Regional Spatial Development Framework,2015 The Ekurhuleni Spatial Development Framework (SDF) provides a framework for making resource-effective decisions that can help mitigate the following identified issues in the municipal zone: ❖ Increasing pressure on the natural environment and green infrastructure; ❖ Urban sprawl and fragmentation; ❖ Spatial inequalities and the job-housing mismatch; ❖ Exclusion and disconnection emanating from high potential underused areas; ❖ Lack of securitisation and gated developments, and disconnected street networks (high cul-de-sac ratios and low intersection densities); ❖ Inefficient residential densities and land use diversity. The Proposed Project is anticipated to contribute to decreasing the pressure on the natural environment by removing a pollution source to conservation and protected areas.	Aspects of this SDF are applicable to the Proposed Project. Where applicable, these have been considered throughout the WULA process and have been included within the reporting documents.
Ekurhuleni Environmental Management Framework (EMF), 2007	Aspects of this EMF are applicable to the Proposed Project. Where applicable, these have

Policies, Guidelines and By-Laws	
The aim of the EMF for the CoE is to provide a framework that identifies and illustrates the general environmental characteristics of the municipality: The critical issues within the EMF are the identification of constraint zones and geographical areas. The development constraint zones within the EMF refer to the environmental suitability of land parcels for various types of land uses or activities. The types of development constraint zones identified in the EMF include: ❖ low to no constraint zone; ❖ agricultural constraint zone; ❖ geotechnical constraint zone; ❖ hydrological constraint zone; and ❖ ecological constraint zone.	been considered throughout the WULA process and have been included within the reporting documents.
Ekurhuleni Bioregional Plan (BRP), 2014 Subsequent to the approval of the Ekurhuleni BRP, the Guidelines for the compilation of the bioregional plans were set in terms of the National Environmental Management: Biodiversity Act. CoE, together with the South African Biodiversity Institute (SANBI) and the Gauteng Department of Agriculture and Rural Development (GDARD), developed the CoE Bioregional Plan. The purpose of the bioregional plan is to inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. This is done by providing biodiversity priority areas, referred to as 'critical biodiversity areas and ecological support areas', with accompanying land use planning and decision-making guidelines. Critical biodiversity areas within the bioregion are the portfolio of sites that are required to meet the region's biodiversity targets and need to be maintained in the appropriate condition for their category. The Ekurhuleni Metropolitan Municipality Bioregional Plan identified the following categories: ❖ Critical Biodiversity Area One; ❖ Critical Biodiversity Area Two;	Aspects of this EMF are applicable to the Proposed Project. Where applicable, these have been considered throughout the WULA process and have been included within the reporting documents.

Policies, Guidelines and By-Laws	
❖ Ecological Support Area One; ❖ Ecological Support Area Two; ❖ Protected areas; ❖ Important areas ❖ Other natural areas	
<u>The Centre for Environmental Rights - Mining and your Community: Know your Environmental Rights</u> To exploit a mineral, mining companies must get permission to mine from the government. This is known as an Environmental Authorisation. To get permission, the mining company is required to assess the environment and learn about the community and consult with everyone who will be affected by the proposed mining. The Guide published in 2014 by the CER discusses what rights communities and individuals who are affected by mining have, and what laws and processes must be followed by a mining company before it can start mining.	This IWWMP incorporates the recommendations and guidelines listed in the guide when undertaking Public Participation (PP). All PP is implemented according to the requirements listed in the NEMA EIA Regulations of 2014, as amended. Refer to Appendix C for an overview of Public Participation that has been undertaken.
<u>The Gauteng Province Environmental Management Framework, 2018</u> The GDARD decided to produce an Environmental Management Framework for the whole of Gauteng. The objective of the GPEMF is to guide sustainable land use management within the Gauteng Province. The GPEMF, inter alia, serves the following purposes: ❖ To provide a strategic and overall framework for environmental management in Gauteng; ❖ Align sustainable development initiatives with the environmental resources, developmental pressures, as well as the growth imperatives of Gauteng; ❖ Determine geographical areas where certain activities can be excluded from an EIA process; and ❖ Identify appropriate, inappropriate and conditionally compatible activities in various Environmental Management Zones in a manner that promotes proactive decision-making.	Aspects of this management framework are applicable to the Proposed Project. Where applicable, these have been considered throughout the WULA process and will be included within the reporting documents.

Policies, Guidelines and By-Laws	
The Public Participation Guidelines in terms of the National Environmental Management Act, 1998 Environmental Impact Assessment Regulations, 2017 This document aims to assist with the participation process of all interested and affected parties regarding any Proposed Project. This guideline provides information and guidance for proponents or applicants, interested and affected parties, competent authorities and environmental assessment practitioners on the public participation requirements of the act, as well as provides information on the characteristics of a vigorous and inclusive public participation process.	This guideline was used to ensure that all of the required steps are followed to ensure that a complete and successful public participation process is conducted.
Integrated Environmental Management Guideline on Need and Desirability, 2017 This document assists Environmental assessment practitioners on the best practice as well as how to meet the peremptory requirements prescribed by the legislation as well as sets out both the strategic and statutory context for the consideration of the need and desirability of a development involving any one of the NEMA listed activities. This document further sets out a list of questions which should be addressed when considering need and desirability of a proposed development.	This guideline was used to ensure that the need and desirability of the project was correctly considered and that the need and desirability of the project was thoroughly considered.

3.2 Summary of all Water Uses

Section 21 of the NWA defines water uses which are governed in terms of the Act and for which a WUL is required. In terms of section 40 (1) of the NWA "*a person who is required or wishes to obtain a licence to use water must apply to the relevant responsible authority for a licence*." The responsible authority for the WUL is the Department of Water and Sanitation (DWS), and the water uses in in terms of Section 21, are as follows:

- **(a) taking water from a water resource;**
- **(b) storing water;**
- **(c) impeding or diverting the flow of water in a watercourse;**
- (d) engaging in a stream flow reduction activity contemplated in section 36;
- (e) engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);
- (f) discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
- **(g) disposing of waste in a manner which may detrimentally impact on a water resource;**
- (h) disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
- **(i) altering the bed, banks, course or characteristic of a watercourse;**
- (j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
- (k) using water for recreational purposes.

The Section 21 water uses applicable to the Proposed Project are in Table 3-4.

3.3 Existing Lawful Water Uses

Section 32(1) of the NWA defines an Existing Lawful Water Use (ELU) as follows:

"*An existing lawful water use means a water use:*

(a) Which has taken place at any time during a period of two years immediately before the date of commencement of this Act and which;

(i) was authorised by or under any law which was in force immediately before the date of commencement of this Act;

(ii) is a stream flow reduction activity contemplated in section 36(1); or

(iii) is a controlled activity contemplated in section 37(1)."

OR

(b) Which has been declared an existing lawful water use under section 33."

There are no ELUs related to the Proposed Project. All water uses triggered by the Project are being applied for as part of the IWULA which will be submitted to the DWS.

3.4 Relevant Exemptions

Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources (GN R704) have been considered for the Proposed Project. The Proposed Project requires exemption in relation to GN R704.

Table 3-3 details the project activities, where Regulation GN R704 exemptions are applicable, as well as motivations for these exemptions.

Table 3-3: Regulation GN R704 Exemptions

Activity Descriptions	Applicable GN R704 Regulation	Motivation for exemption
Tailings deposition onto the Withok TSF area and the construction, operation, removal and rehabilitation of associated infrastructure (decant pipeline, collector pipeline, borrow pits, stormwater management infrastructure and access road) crossing an unchanneled valley-bottom (HGM 1) wetland and a seep (HGM 2)	4. No person in control of a mine or activity may- (a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become waterlogged, undermined, unstable or cracked; (b) except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest; (c) place or dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation;	The Proposed Project is the recommissioning of a TSF on a previously disturbed footprint. The Withok TSF footprint was established in 1977 prior the promulgation of the NWA. This footprint crosses wetlands. However, this location is preferred because it is an existing historical deposition site adjacent to the operational Brakpan TSF and its associated and existing infrastructure. Therefore, utilising the existing Withok TSF (brownfields) footprint is preferable than establishing a new greenfields site.

Activity Descriptions	Applicable GN R704 Regulation	Motivation for exemption
	7. Every person in control of a mine or activity must take reasonable measures to- (a) prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act;	
Dust suppression of operational area.	7. Every person in control of a mine or activity must take reasonable measures to- (a) prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act;	Dust Suppression of the operational area is undertaken with process water to minimise and control airborne dust on site.

3.5 Generally Authorised Water Uses

No general authorisations (GAs) are applicable to the Proposed Project. The project requires full licensing of water use activities.

3.6 New Water Uses to be Licensed

The water uses to be licensed for the Recommissioning of the Withok TSF project are listed in Table 3-4.

Table 3-4: Proposed Water Uses for the Withok Recommissioning project

Map Number	Site Name	Description	Purpose of activity	Dimensions/capacity within water use areas	Materials used in building the structure	Farm Portion(s)	Co-ordinates
Section 21 (c) and (i)							
1	Withok TSF and associated infrastructure (decant pipeline, collector pipeline, borrow pits, stormwater management infrastructure and access road) crossing an unchanneled valley-bottom (HGM 1) wetland and a seep (HGM 2)	Tailings deposition onto the Withok TSF area and the construction, operation, removal and rehabilitation of associated infrastructure (decant pipeline, collector pipeline, borrow pits, stormwater management infrastructure and access road) crossing an unchanneled valley-bottom (HGM 1) wetland and a seep (HGM 2)	Deposition of tailings.	Length: 2 910 m Width: 1 624 m Height: 103 m	In-situ material, HDPE liner, Tailings	Portions 77, 78 and 79 of Withok 131 IR Portions 14, 15 and 20 of Valkfontein 161 IR Portion 11 of Rooikraal 156 IR	1 Start: 26° 21' 30,976" S 28° 18' 37,557" E 1 End: 26° 21' 53,755" S 28° 20' 15,772" E
2	Return water dam (RWD) crossing an unchanneled valley-bottom (HGM 1) wetland	The construction, operation, removal and rehabilitation of the proposed RWD crossing an unchanneled valley-bottom (HGM 1) wetland.	Containment of side slope stormwater and drain water before it returned to the process.	Length: 222 m Width: 200 m Height: 0 m	In-situ material and HPDE liner	Portion 11 of Rooikraal 156 IR and Portion 78 of Withok 131 IR	2 Start: 26° 21' 44,984" S 28° 18' 24,436" E 2 End: 26° 21' 55,489" S 28° 18' 35,897" E
3	Sump and Diversion Trench crossing an unchanneled valley-bottom (HGM 1) wetland	The construction, operation and rehabilitation of the proposed sump and diversion trench within 500 m of an unchanneled valley-bottom and seep wetland.	Diversion of stormwater water from the attenuation dam for the safety of operations.	Length: 3 955 m Width: 276 m Depth: 3 m	In-situ material	Portions 14, 15, 18 and 20 of Vlakfontein 161 IR Portion 11 of Rooikraal 156 IR	3 Start: 26° 21' 52,149" S 28° 18' 18,220" E 3 End: 26° 21' 48,619" S 28° 20' 24,384" E
4	Collector Pipeline and Incoming Slurry Pipeline	The construction, operation, removal and rehabilitation of the proposed Collector Pipeline and Incoming Slurry Pipeline within 500m of unchanneled valley-bottom (HGM 1) and seep (HGM 2) wetlands.	Collection and transportation of side slope stormwater and drain flows, and the removal of pipelines at the end of life of project. Transportation of slurry and the removal of	Length: 4 560 m Width: 1 m Height: 1 m	HDPE, geofabric wrapped stone and sand	Portions 14, 15 and 20 of Vlakfontein 161 IR Portion 78 of Wlithok 131 IR	4 Start: 26°21'14.26"S 28°20'23.04"E 4 End:

Map Number	Site Name	Description	Purpose of activity	Dimensions/capacity within water use areas	Materials used in building the structure	Farm Portion(s)	Co-ordinates
			pipelines at the end of life of project.				26°21'25.96"S 28°20'7.37"E
5	Decant Pipeline crossing an unchanneled valley-bottom (HGM 1) wetland	The construction, operation and removal of the proposed decant pipeline crossing an unchanneled valley-bottom (HGM 1) wetland	Transportation of decant water during and the removal of pipelines at the end of life of project	Length: 530 m Height: 1 m Width: 1 m	HDPE steel	Portion 79 of Withok 131 IR	5 Start: 26° 21' 26,128" S 28° 20' 7,106" E 5 End: 26° 21' 26,128" S 28° 20' 7,106" E
6	Borrow Pit Area	Excavating borrow pit within 500 m of unchanneled valley-bottom and seep wetlands	Sourcing material required during civil works and for concurrent rehabilitation of the TSF side slopes.	Depth: 2-5 m Length: 1 488 m Width: 344 m	Not applicable	Portion 15 of Vlakfontein 161 IR	6 Start: 26° 22' 10,236" S 28° 18' 40,164" E 6 End: 26° 22' 36,171" S 28° 19' 25,731" E
7	Borrow Pit Area	Excavating a borrow pit within 500 m of unchanneled valley-bottom and seep wetlands	Sourcing material required during civil works and for concurrent rehabilitation of the TSF side slopes.	Depth: 2-5 m Length: 1 503 m Width: 642 m	Not applicable	Portions 9, 15 and 20 of Vlakfontein 161 IR	7 Start: 26° 22' 0,571" S 28° 20' 11,053" E 7 End: 26° 22' 27,233" S 28° 19' 25,370" E
8	Attenuation Dam	Attenuation dam upgrade within 500m of unchanneled valley-bottom and seep wetlands.	Containment of drainage from the Tsakane township	Depth: 7.5 m Length: 655 m Width: 435 m Capacity: 621,000m^3	In-situ material and concrete	Portions 18 (RE) of Vlakfontein 161 IR	8 Start: 26°21'44.51"S 28°20'31.45"E 8 End: 26°22'2.40"S

Map Number	Site Name	Description	Purpose of activity	Dimensions/capacity within water use areas	Materials used in building the structure	Farm Portion(s)	Co-ordinates
							28°20'30.94"E
Section 21 (g)							
9	Tailings deposition on the Withok TSF area	Deposition of tailings on the Withok TSF area.	Deposition of tailings	Area: 400 Ha Volume in m^3/anumm: 15 600 000 m^3/annum Storage capacity: 310 000 000 m^3	Tailings	Portions 77, 78 and 79 of Withok 131 IR, Portions 14, 15 and 20 of Vlakfontein 161 IR, Portion 80 of Withok 131 IR and Portion 11 of Rooikraal 156 IR.	26° 21' 47.518" S 28° 19' 42.547" E
10	Access Roads - Dust Suppression	Dust suppression of access roads	Management of dust on site.	Volume in m^3/anumm: 19 940 m^3/annum Storage capacity: not applicable	Tailings	Portions 14, 15 and 20 of Vlakfontein 161 IR Portion 78 of Wlithok 131 IR	26° 22' 15.145" S 28° 19' 21.136" E
11	Return Water Dam	Containment of drain flow and dirty side slope runoff.	Management of drain flow and dirty side slope runoff.	Area: 11 Ha Volume in m^3/anumm: 3 528 000 m^3 Storage capacity: 65 000 m^3		Portion 11 of Rooikraal 156 IR and Portion 78 of Withok 131 IR	26°21'49.94"S 28°18'30.10"E

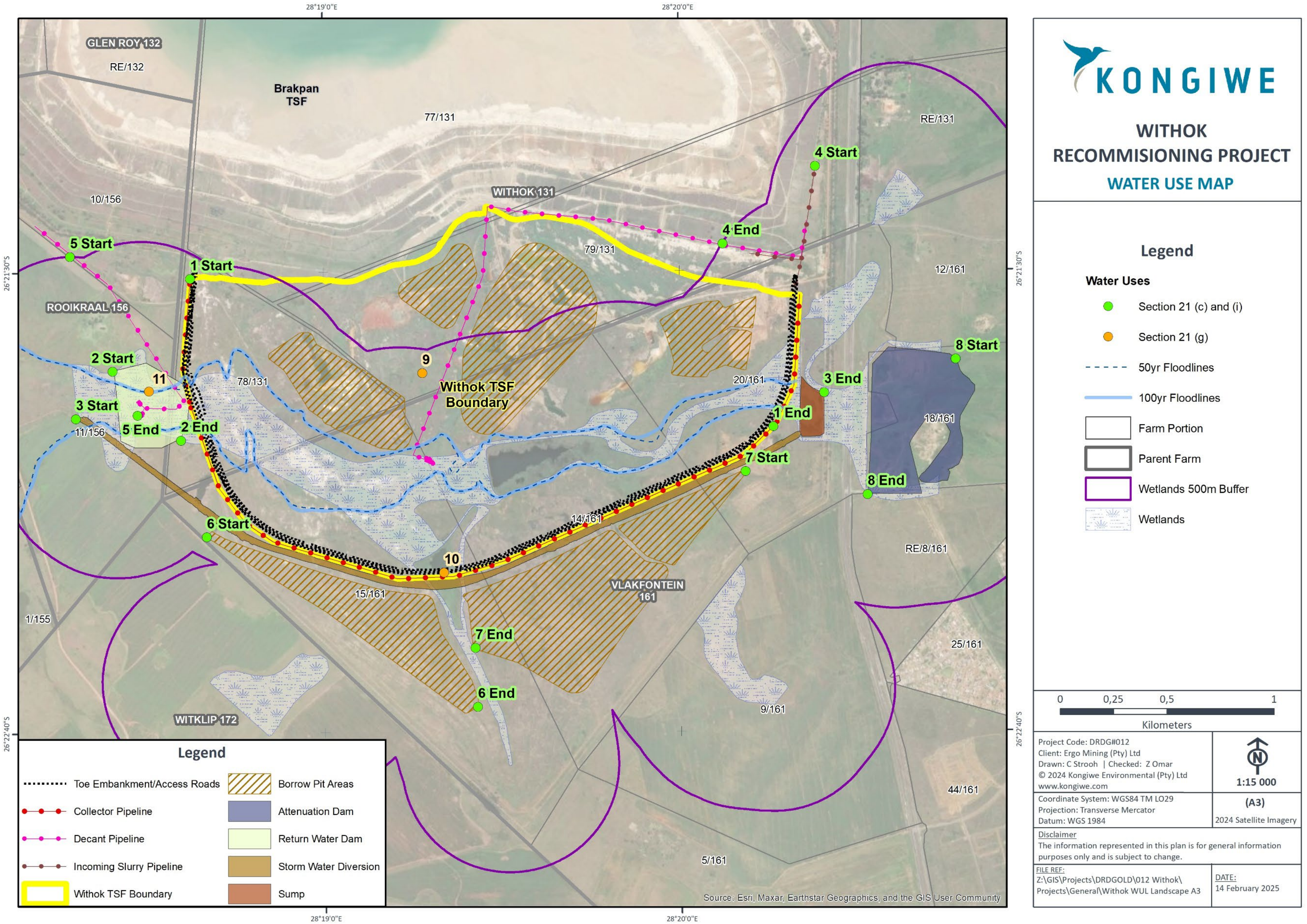


Figure 3-1: Proposed water use map

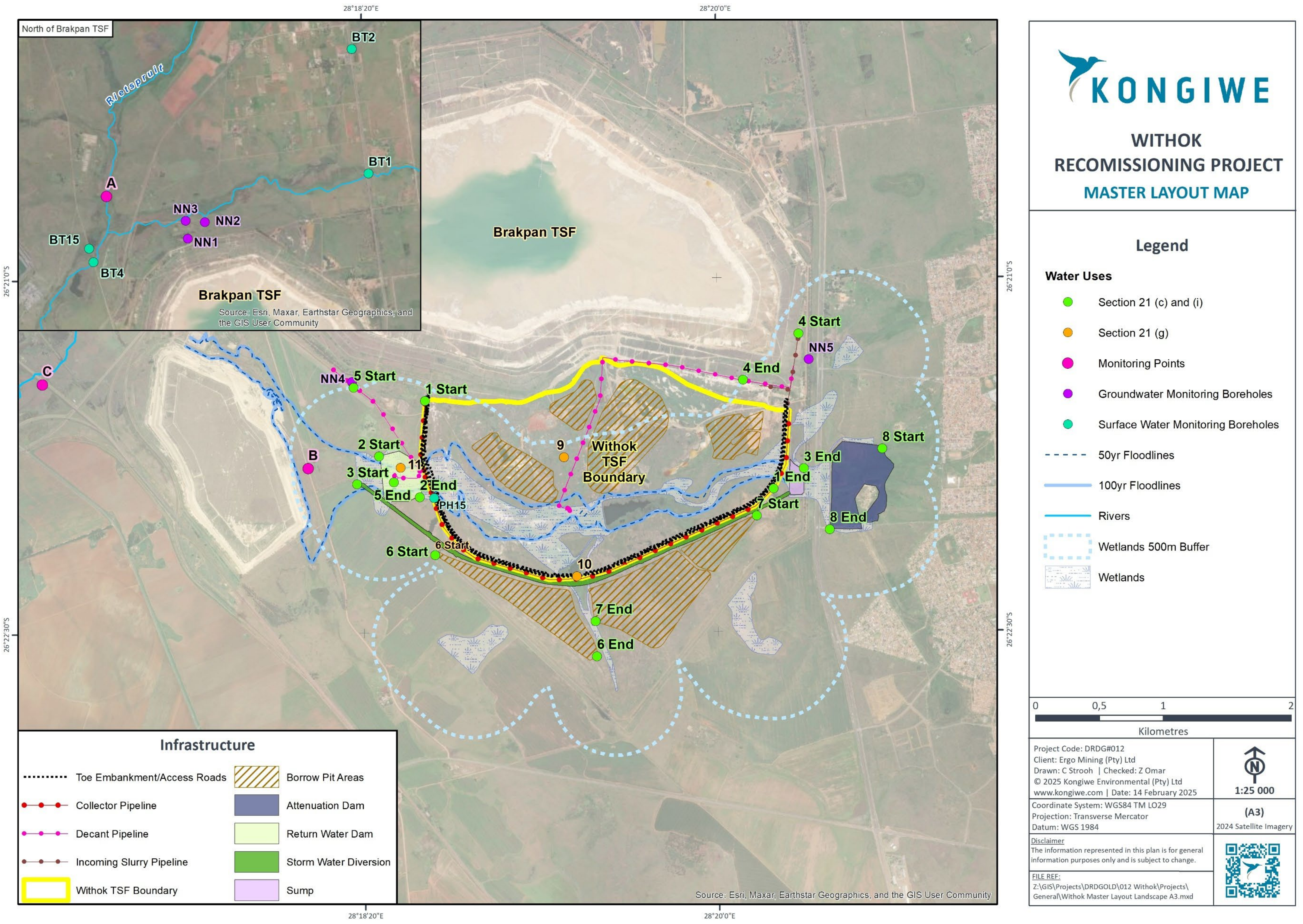


Figure 3-2: Master Layout Plan

3.7 Waste Management Activity (NEM:WA)

Listed activities as per the National Environmental Management: Waste Act, Act No. 59 of 2008 (NEM:WA) regulations have been identified for the establishment of a residue stockpile or residue deposit classified as Category B (Cat B-11); and for the construction of a facility for a waste management activity listed in Category B (Cat B-10). Authorisation is being applied for as part of the NEMA application.

3.8 Other authorisations (EIAs, EMPs, RODs, Regulations)

Ergo intends to acquire an EA for the Proposed Project in accordance with the NEMA and the NEM:WA. The Competent Authority (CA) for the EA application is the Department of Mineral Resources and Energy (DMRE). The required EA application has been made to the DMRE.

The adjacent Brakpan TSF has an approved WUL (Reference No.: 08/C22C/CGI/425), issued on 26 February 2011.

4 Present Environmental Situation

Information on the status of the environment in which the Proposed Project is situated is contained in this chapter. This information is provided to assist the reader with understanding the receiving environment within which the project is proposed, and features of the biophysical, social, and economic environment that could be directly or indirectly affected by, or alternatively could impact on, the proposed development. This information has been sourced from existing available information and the on-site specialist investigations conducted as part of the IWULA. The full impact assessments undertaken by the independent specialists, including detailed descriptions of the affected environment, are attached as appendices of this IWWMP.

4.1 Climate

The Recommissioning of Withok TSF falls within the Highveld climatic zone which can be associated by warm, rainy summers and cold winters. The area's wettest months occur from October through to March, with the driest months occurring over the period of June to August. The Proposed Project falls within the Soweto Highveld Grassland vegetation type. This is characterised by summer rainfall with a warm temperature with frequent occurrence of frost (in winter). This vegetation unit experiences thermic continentality, with high extremes between maximum and minimum winter temperature, along with large thermic diurnal differences (Mucina, 2006). The mean annual temperature (MAT) of 15°C indicates a transition between a cool-temperate and a warm-temperate climate. Frost is frequent during the winter months. The Mean Annual Precipitation (MAP) for the region in 662 mm (Mucina, 2006).

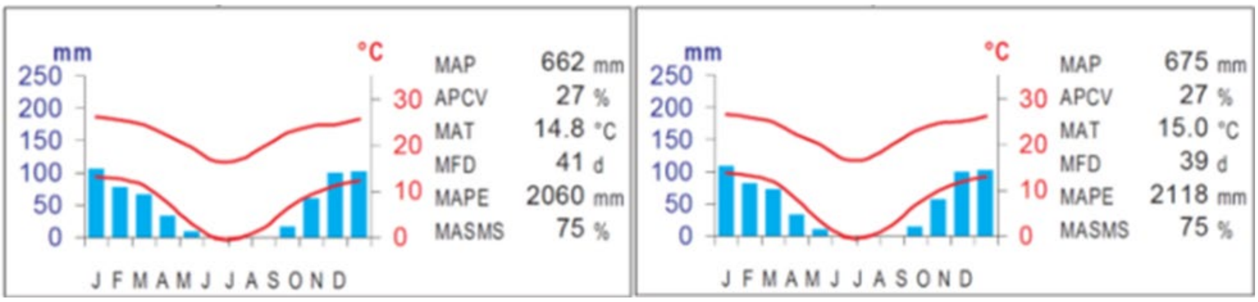


Figure 4-1: Climate based on the Soweto Highveld Grassland (left) and the Tsakane Clay Grassland (right) Vegetation Types (TBC, 2024).

4.1.1 Rainfall

Daily rainfall data for the area was obtained from the CCWR (Computing Centre for Water Research, University of Kwazulu Natal) database. Gauge number 0476736 (Springs (RWB)) was used. The gauge is located 12 km northwest of the site. The data spans the period 1903 to 2000. South African Weather Services' (SAWS) daily rainfall was also purchased for gauge 0476766 Springs Olympia Park and used to extend the rainfall record. This is the closest active/recently active SAWS rainfall station, located approximately 16 km northwest of the TSF complex.

The site has a MAP of 688 mm and the average monthly rainfall is indicated in Figure 4-2. The wettest months occur from October through to March, with the driest months occurring over the period of June to August. Rainfall is mostly in the form of convective thunderstorms, which are often brief, but regularly high in intensity. Tropical and frontal rainfall systems also occur in the region but are not as common.

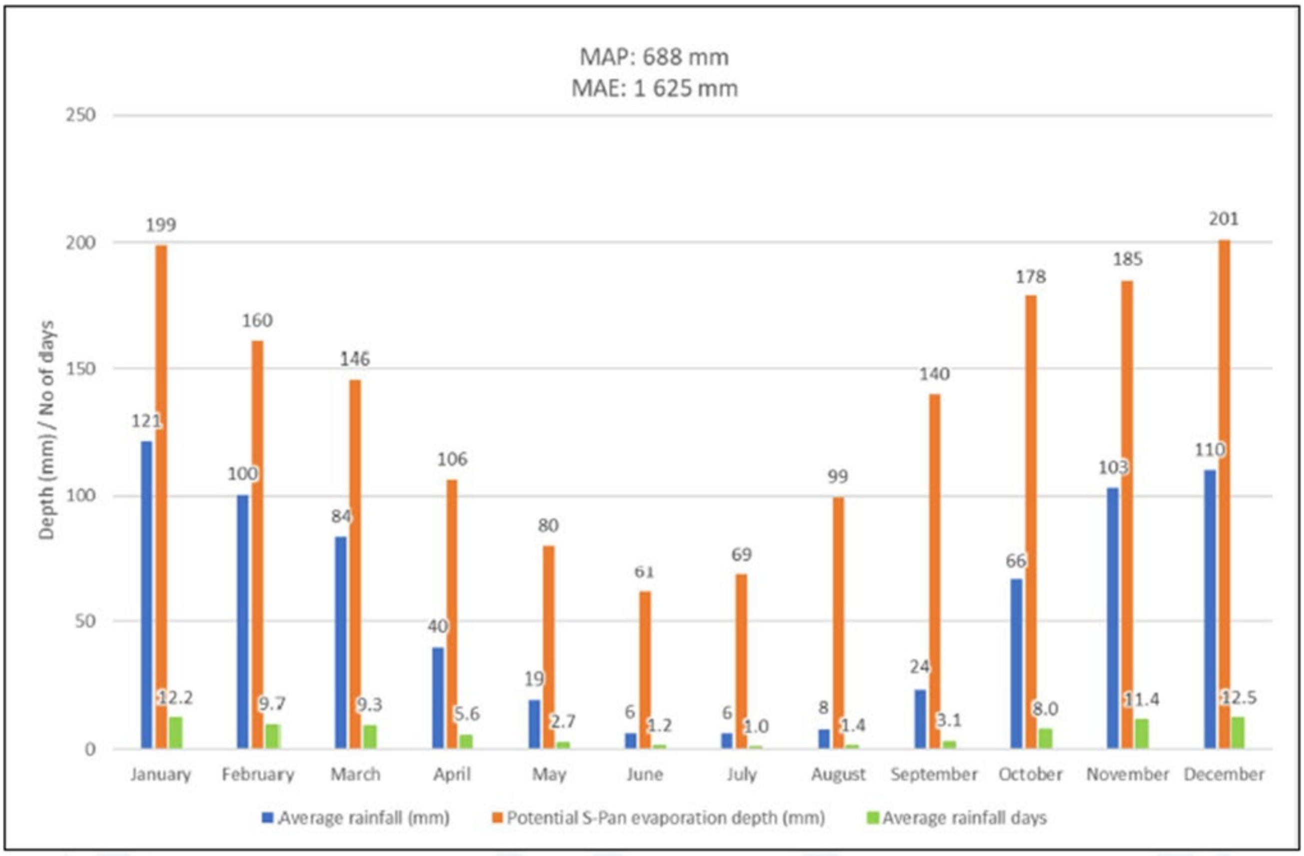


Figure 4-2: Average monthly rainfall totals for the project area (Springs weather station) (iLanda,2025)

4.1.2 The peak 24-hr rainfall

The peak 24-hr rainfall depths are presented in Table 4-1. The daily rainfall record was analysed and the annual maximum series was extracted from the data. This annual maximum series was statistically analysed to determine various T-year recurrence interval 24-hour storm depths. A Log Pearson Type 3 distribution was selected as the most appropriate statistical fit. The rainfall record is long, consists of good data, is representative of the TSF complex, and is suitable to be used to calculate peak rainfall.

Table 4-1: Peak 24-hr Rainfall Depths for the TSF Complex (iLanda, 2025)

Recurrence interval (year)	24-hour rainfall depth (mm)
2	52
10	85
20	99

Recurrence interval (year)	24-hour rainfall depth (mm)
50	119
100	136
200	153
1 000	199

4.1.3 Evaporation

Evaporation plays a crucial role in mining tailing operations, particularly in areas with high evaporation rates like Brakpan, Withok and Rooikraal area. Factors Influencing Evaporation:

- **Climate:** High temperatures, low humidity, and wind speeds contribute to increased evaporation rates.
- **Tailing characteristics:** The size, shape, and composition of tailing particles affect evaporation. Finer particles tend to have higher evaporation rates.
- **Water content:** The amount of water present in the tailings influences evaporation. Higher water content leads to increased evaporation.
- **Solar radiation:** Direct sunlight exposure enhances evaporation.

The Recommissioning of the Withok TSF proposed site is adopted monthly evaporation for indicated in Table 4-2. Evaporation is highest over the summer months, with December and January being the highest, and lowest over the winter months.

Table 4-2: Symons Pan and open water evaporation for the project (iLanda, 2025)

Month	Symons Pan Evaporation (mm)	Open Water Evaporation Factor	Open Water Evaporation (mm)
January	199	0.84	167
February	160	0.88	141
March	146	0.88	128
April	106	0.88	94
May	80	0.87	70
June	61	0.85	52
July	69	0.83	57
August	99	0.81	81
September	140	0.81	113
October	178	0.81	144
November	185	0.82	152
December	201	0.83	167
Total	**1 625**	**N/A**	**1 366**

4.1.4 Temperature

The average midday temperatures range from 26°C in June to 17°C in January (Figure 4-3). During winter, the temperature drops to 4°C on average during the night. The overall mean annual temperature is 15°C, with the climate transitioning between cool temperate and warm-temperate. Winters are dry with frequent frost that occurs from mid-April to September. Summers are mild with temperatures that are seldom above 26°C - 30°C (Mucina & Rutherford, 2006).

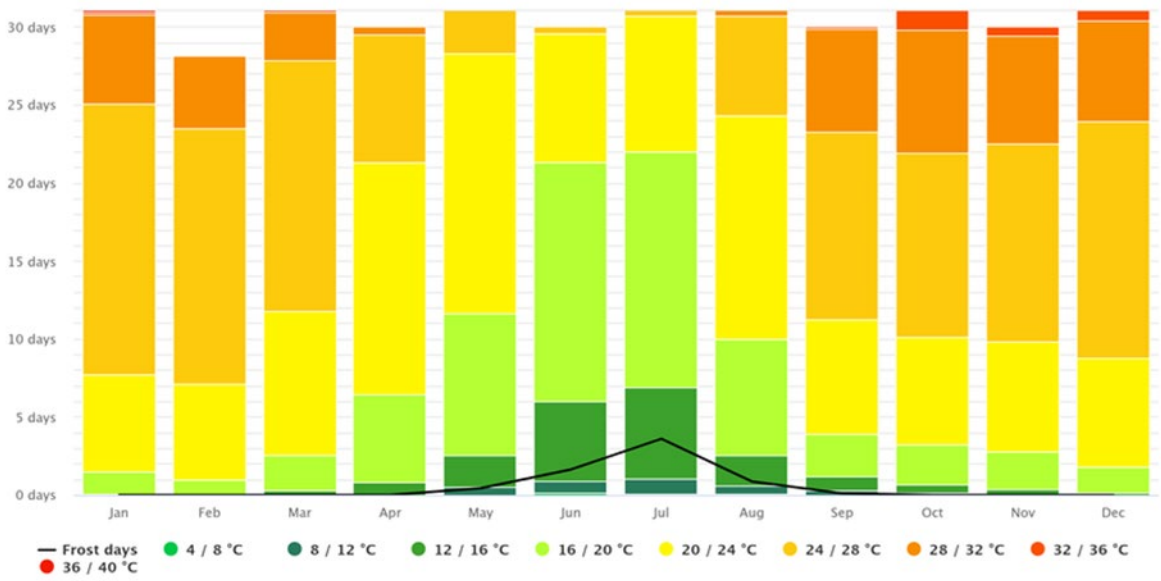


Figure 4-3: Simulated historical temperature for Brakpan, South Africa (meteoblue.com).

4.1.5 Wind Direction

Wind roses graphically present wind conditions over a period of time at a specific location. Wind roses for the project are presented in (Figure 4-4) below. In the wind roses, the length of each spoke represents the percentage of time that the wind blew from that direction during the period. The percentage scale is presented on the concentric grey lines (the circle scale increment is indicated on each of the wind roses). Each spoke is divided by colour into wind speed ranges.

The predominant winds at the Withok TSF (as given by the WRF data for the period from 2021 to 2023) are from a west-south-westerly and east-south-easterly directions for almost 10% of the time (Figure 4-4). **The highest number of winds with speeds greater than 6 m/s are expected from the west.** The average hourly wind speed predicted by the WRF model is approximately 2.0 m/s. Calm conditions (wind speeds below 0.5 m/s) are predicted for approximately 3 % of the time.

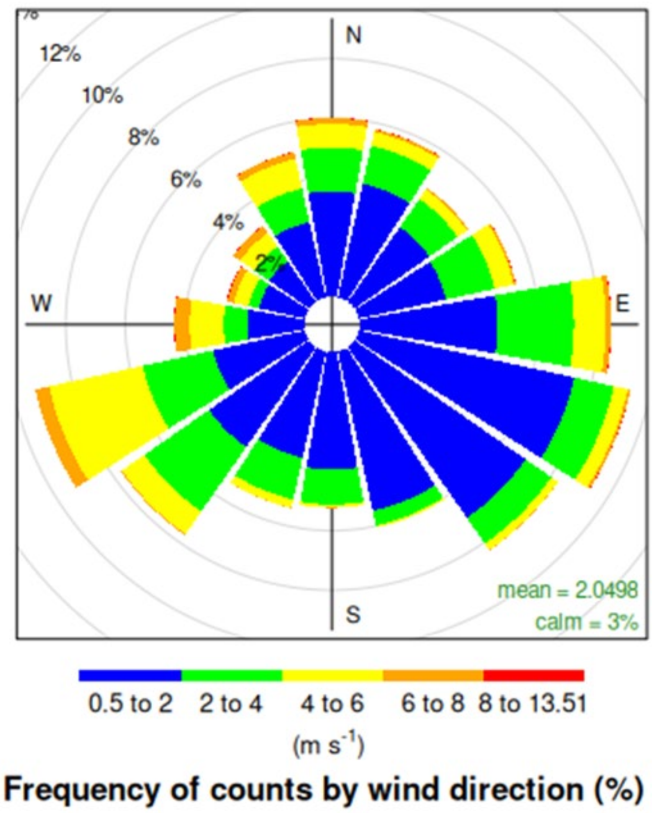


Figure 4-4: Wind rose of the average winds produced by the WRF model for the Withok TSF, for the years 2021-2023

The seasonal variations in wind direction for the Withok TSF site are illustrated in (Figure 4-5). In spring, the highest number of winds originate from the west-south-westerly direction. The highest number of winds with speeds above 6 m/s originate from the west and west-south-westerly directions. In summer, the predominant wind is experienced from the east and the highest number of winds with speeds above 6 m/s originate from the westerly direction. In autumn, the predominant wind is experienced from the west-south-westerly direction and the highest number of winds with speeds above 6 m/s also originate from the west-south-westerly direction. In winter, the predominant wind is experienced from the south-westerly direction and the highest number of winds with speeds above 6 m/s originate from the west-north-westerly and westerly directions. In all the seasons, winds with the highest speeds tend to not coincide with the dominant wind directions and often originate from the west. Average wind speeds are highest in spring, and most of the calm conditions are experienced in autumn.

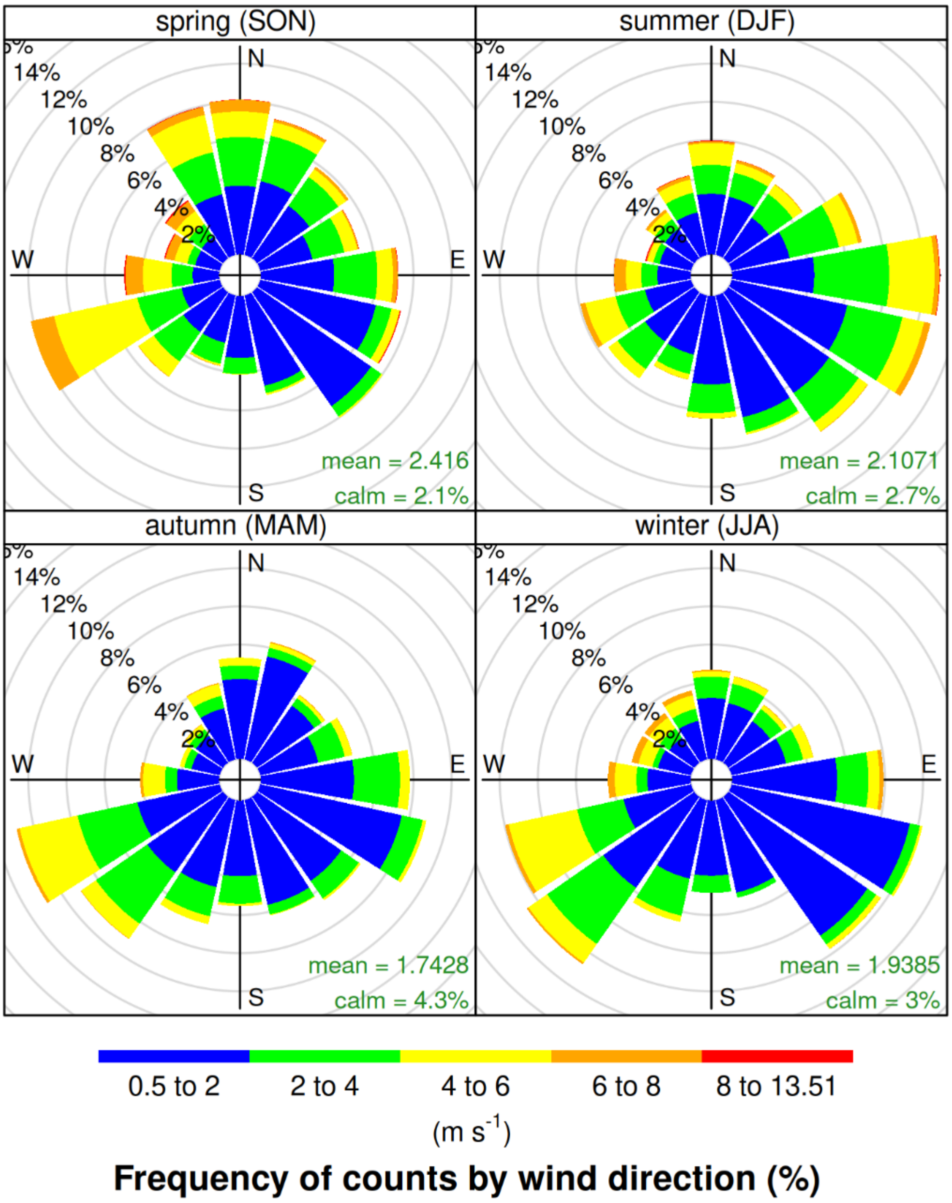


Figure 4-5: Seasonal wind roses produced by the WRF model for the Withok TSF for the years 2021-2023.

4.2 Topography

The topography describes the generally flat with a gentle slope of the earth surface and the site varies from 1 550 metres above mean sea level (mamsl) to 1 590 (mamsl) as shown on Figure 4-6. The proposed project site falls within Sub-district of Brakpan Ekurhuleni Metropolitan Municipality which is characterised by its distinct relatively flatness. The Withok TSF is situated on open and relatively flat land south of the confluence of the Rietspruit River and one of its tributaries. A series of prominent ridges runs from west to east to the south of the TSF. The elevation of the project area is approximately 1 575 m above mean sea level.

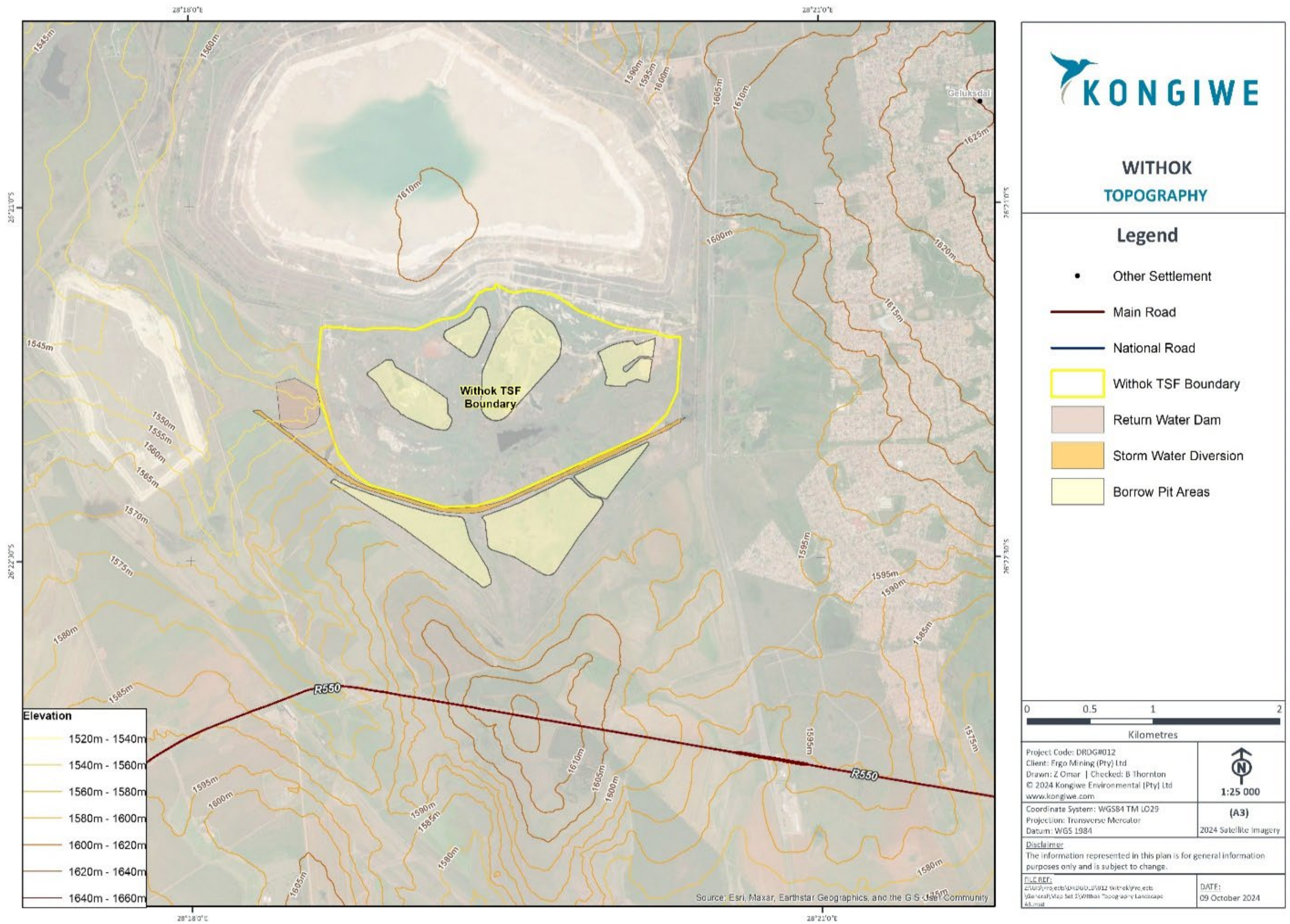


Figure 4-6: Project area Topography

4.3 Geology

The existing Withok TSF footprint is underlain by the Ventersdorp and Transvaal Supergroup formations, which have been intruded by post-Karoo dolerite. The Withok TSF site is adjacent the Malmani dolomite, in particular the Oaktree and Monte Christo formations. The dolomite becomes thinner towards the southeast where it extends beneath the Withok TSF footprint (Groundwater Abstract, 2018).

The geology of the project area is characterised by the Madzaringwe Formation shale, mudstone and sandstone from the Karoo Supergroup or the Karoo Suite dolerites which feature prominently in this area. To the west, the rocks of Ventersdorp, old Transvaal and Witwatersrand Supergroups are significant with the south being characterised by the Volksrust Formation from the Karoo Supergroup. Additionally, basaltic igneous rocks from the Ventersdorp Supergroup's Klipriviersberg Group can be found in the area (Mucina and Rutherford, 2006).

There are some patches of dolomitic rocks on the Witkhok TSF footprint which are being considered in terms of design and construction.

4.3.1 The Ventersdorp Supergroup

The Ventersdorp Supergroup is a geological formation situated in the Brakpan-Withok area, within the Ekurhuleni Municipality of Gauteng Province, South Africa. The Ventersdorp Supergroup is of significant economic importance due to its rich mineral deposits. The supergroup is host to several gold and uranium deposits, which have been mined extensively in the Brakpan-Withok area. The Ventersdorp Contact Reef, in particular, is a significant gold-bearing reef that has been mined for many years.

This supergroup is a sequence of volcanic and sedimentary rocks that form part of the larger Witwatersrand Basin. The Ventersdorp Supergroup is a thick sequence of rocks that were deposited approximately 2.7 billion years ago during the Neoarchean era. The supergroup is divided into several groups, including the Ventersdorp Contact Reef, the Ventersdorp Lavas, and the Platberg Group. Strata in the Witwatersrand group generally dip at variable angles in a south or south-westerly direction. Geological faults are present in the area and orientated parallel to local streams. Figure 4-8 shows the geology of the project area.

4.3.2 The Transvaal Supergroup

The Old Transvaal Supergroup and the Witwatersrand Supergroup are two distinct geological formations that are present in the Brakpan-Withok area. The Old Transvaal Supergroup is characterized by a series of volcanic and sedimentary rocks, while the Witwatersrand Supergroup is characterized by a series of sedimentary rocks. Both supergroups are host to several gold and uranium deposits, which have been mined extensively in the Brakpan-Withok area. The Old Transvaal Supergroup is older than the Witwatersrand Supergroup, and the two supergroups are separated by a series of faults and unconformities.

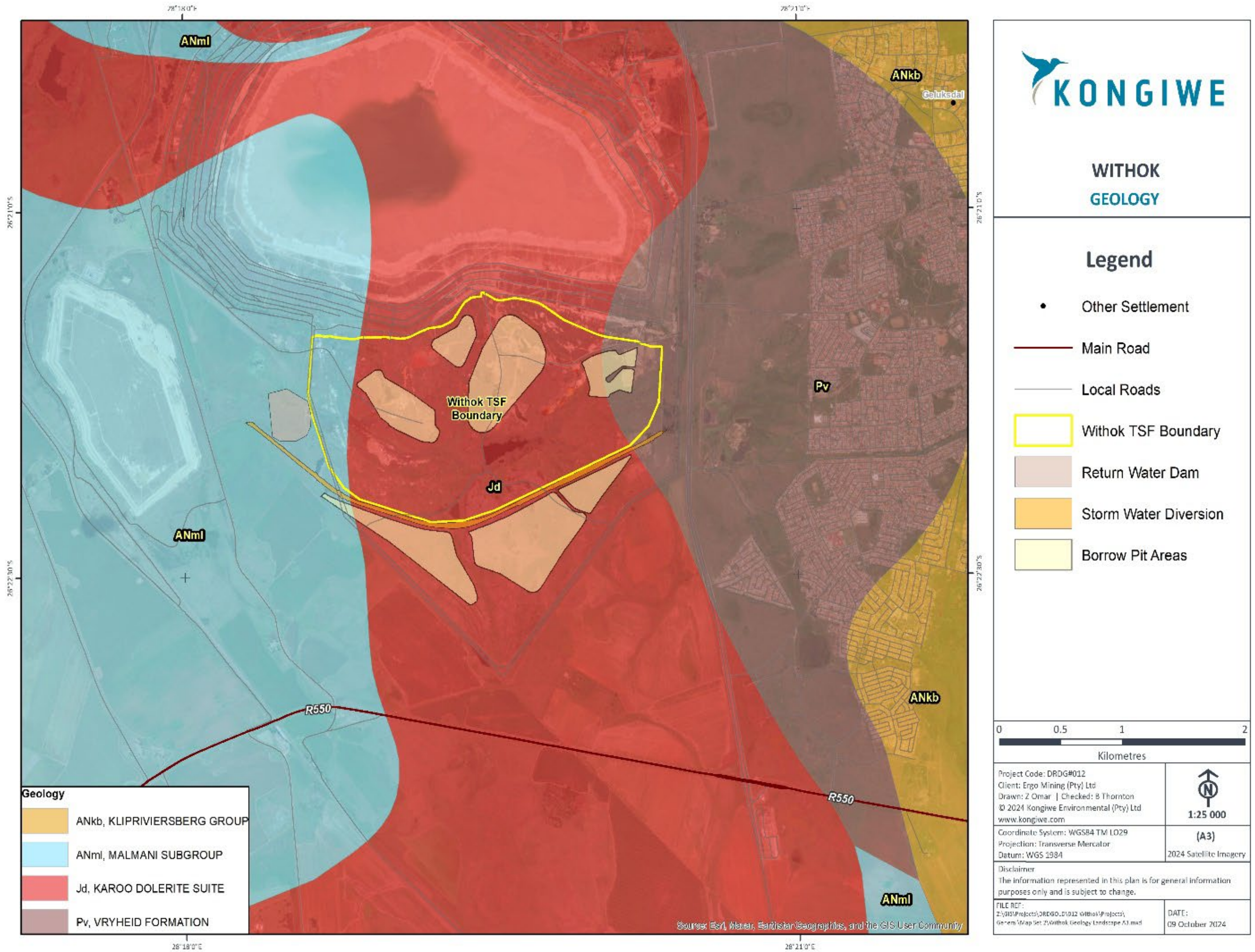


Figure 4-7: Regional Geology map

4.4 Soils, Land Capability and Land Use

4.4.1 Soils

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by two different land types namely the Ea 20 and Da 1 land types. Ea land types consist of one or more of the following soils: Vertic, Melanic, and red structured diagnostic horizons, of which these soils are all undifferentiated. The Ba land types consist of plinthic catena with upland duplex and margalitic soils being rare and red soils being widespread. The Withok TSF area falls within the Ea20 land type with a small portion of the TSF area falling with the Ba1 land type. The land terrain units for the featured Ba 1 and Ea 20 land types of area illustrated in (Figure 4-8) with the expected soils list:

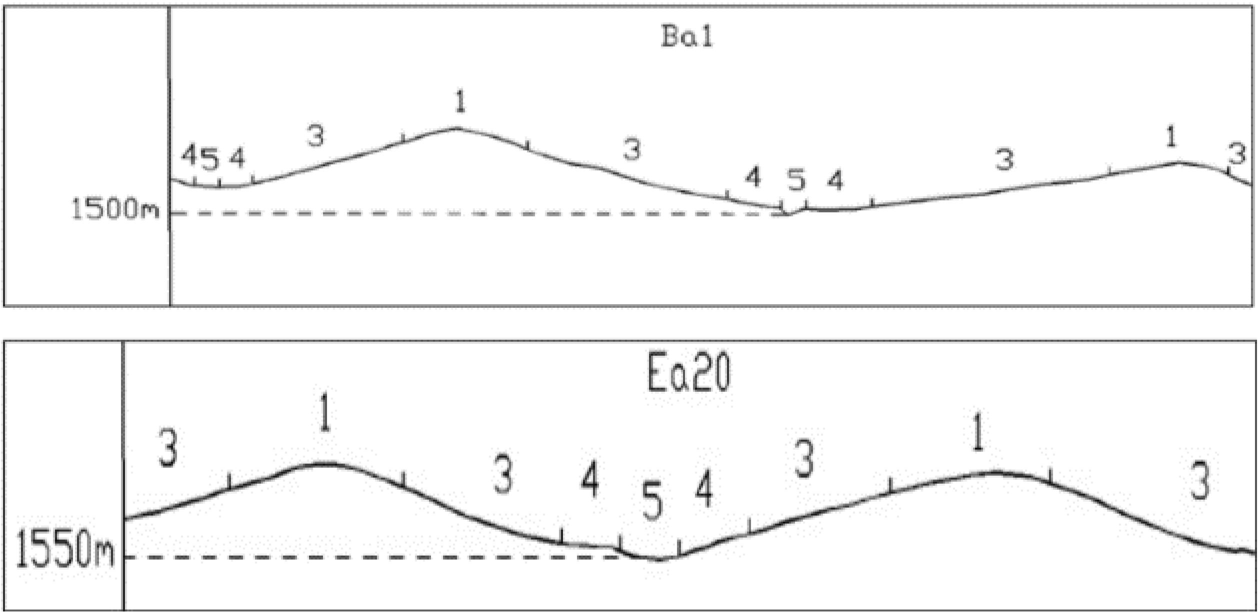


Figure 4-8: Illustration of the land type terrain unit (Land Type Survey Staff, 1972 - 2006)

4.4.2 Land capability

Land capability refers to the ability of land to support specific uses without causing damage. It takes into account physical factors such as soil type, slope, drainage, and climate to determine the best potential uses for a given area of land. The land capability of the Brakpan-Withok area in Ekurhuleni Municipality, Gauteng Province, can be described as follows:

- Physical Characteristics
  - Topography: The area is generally flat, with some gentle slopes.
  - Soil: The soils in the area are predominantly sandy loams, with some clay loams.
  - Climate: The area has a subtropical highveld climate, with warm summers and mild winters.

- Land Capability Classification: Based on the physical characteristics, the land capability of the Brakpan-Withok area can be classified as follows:
    - Agricultural Capability: The area is suitable for dryland farming, with crops such as maize, soybeans, and wheat.
    - Urban Development Capability: The area is suitable for urban development, with a high potential for residential, commercial, and industrial development.
    - Conservation Capability: The area has limited conservation value, due to the presence of urban development and agricultural activities.

4.4.3 Land Use

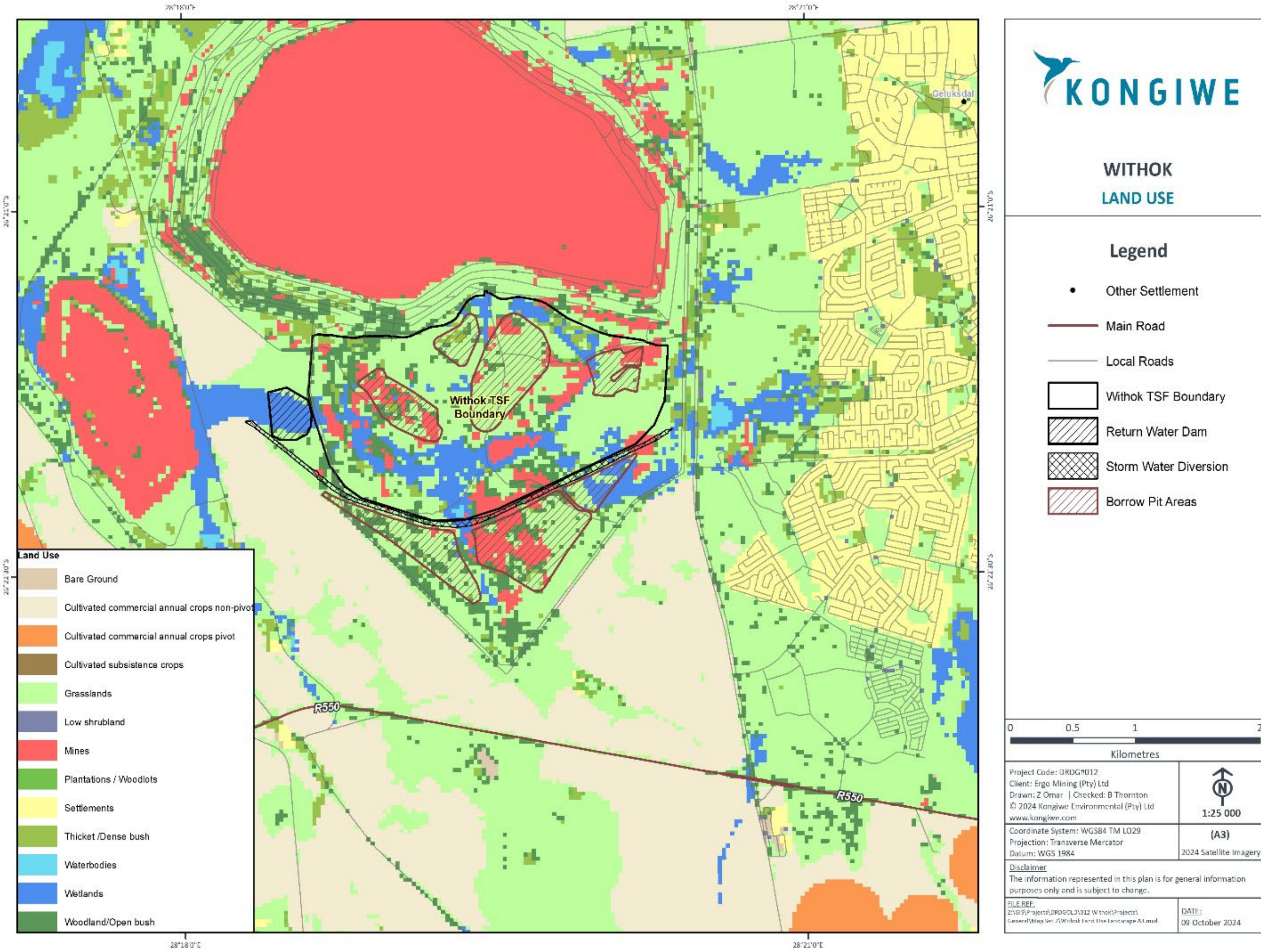
The land use around the Withok TSF is a mixture of bare ground, agricultural land, grasslands, residential settlements, mines and water bodies traversing the site (Figure 4-10). The current land use patterns in the Brakpan-Withok area are:

- Urban Development: The area is characterized by a mix of residential, commercial, and industrial development.
- Agriculture: The area is used for dryland farming, with crops such as maize, soybeans, and wheat.
- Mining: The area has a history of mining, particularly for gold.

The following infrastructure is encountered in the area:

- Access roads;
- Withok TSF footprint;
- Withok pump station; and
- Attenuation dam, sump and diversion pipeline.
- National and provincial roads (N17);
- Agricultural holdings;
- Power lines;
- Slurry and water pipelines; and
- Other TSFs (Brakpan TSF and Rooikraal TSF).

According to the Region E Spatial Development Framework (SDF) (2015), the Withok TSF falls within the Zone 2: Agricultural 2b, which is a predominated moderate - high agricultural land potential land. The proposed location for the recommissioned TSF is on previously disturbed historic TSF footprint where the original Withok TSF was before it was reclaimed. Figure 4-10



summarises the land use in the area.

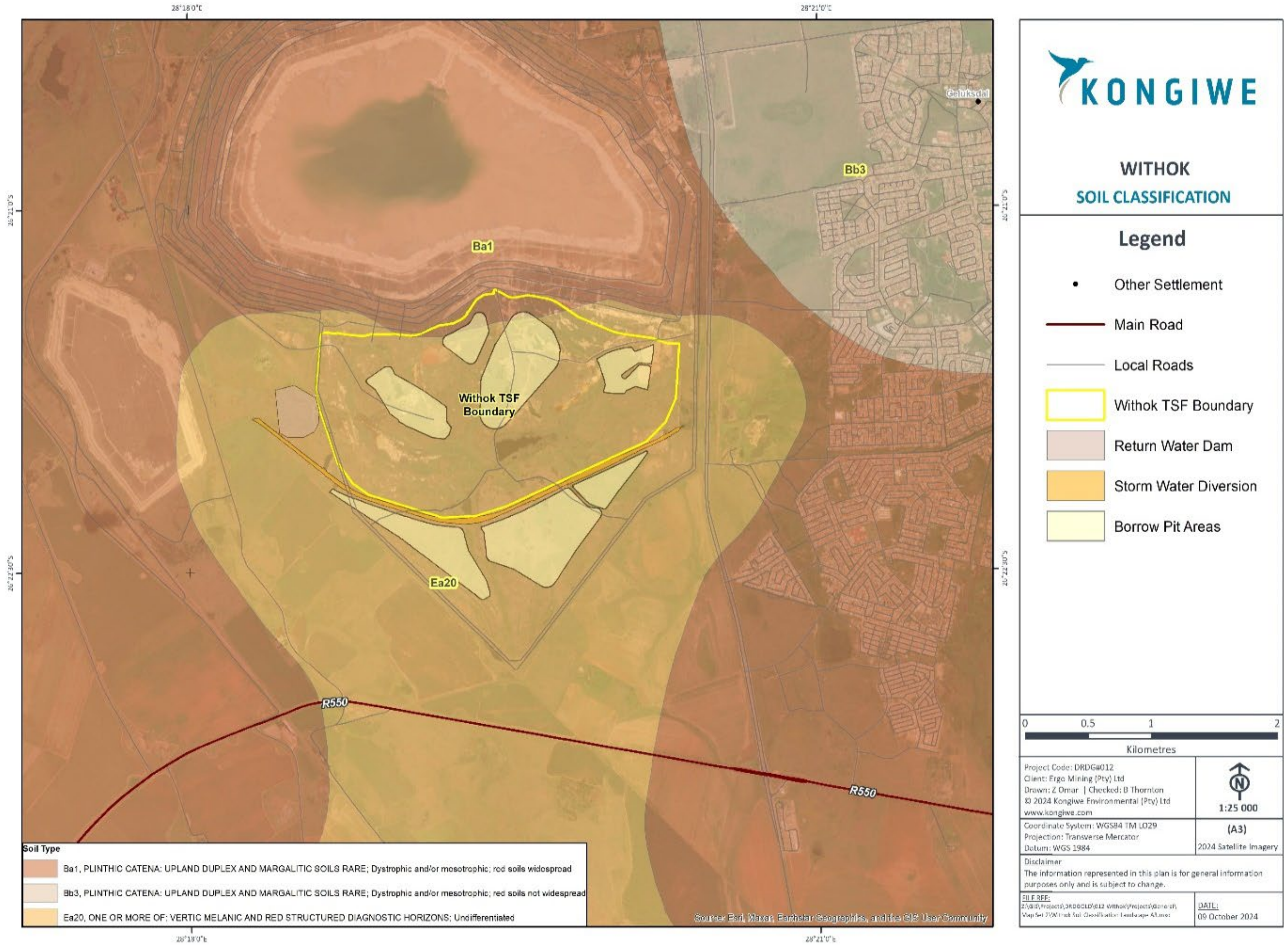


Figure 4-9: Soil classification of the Project area

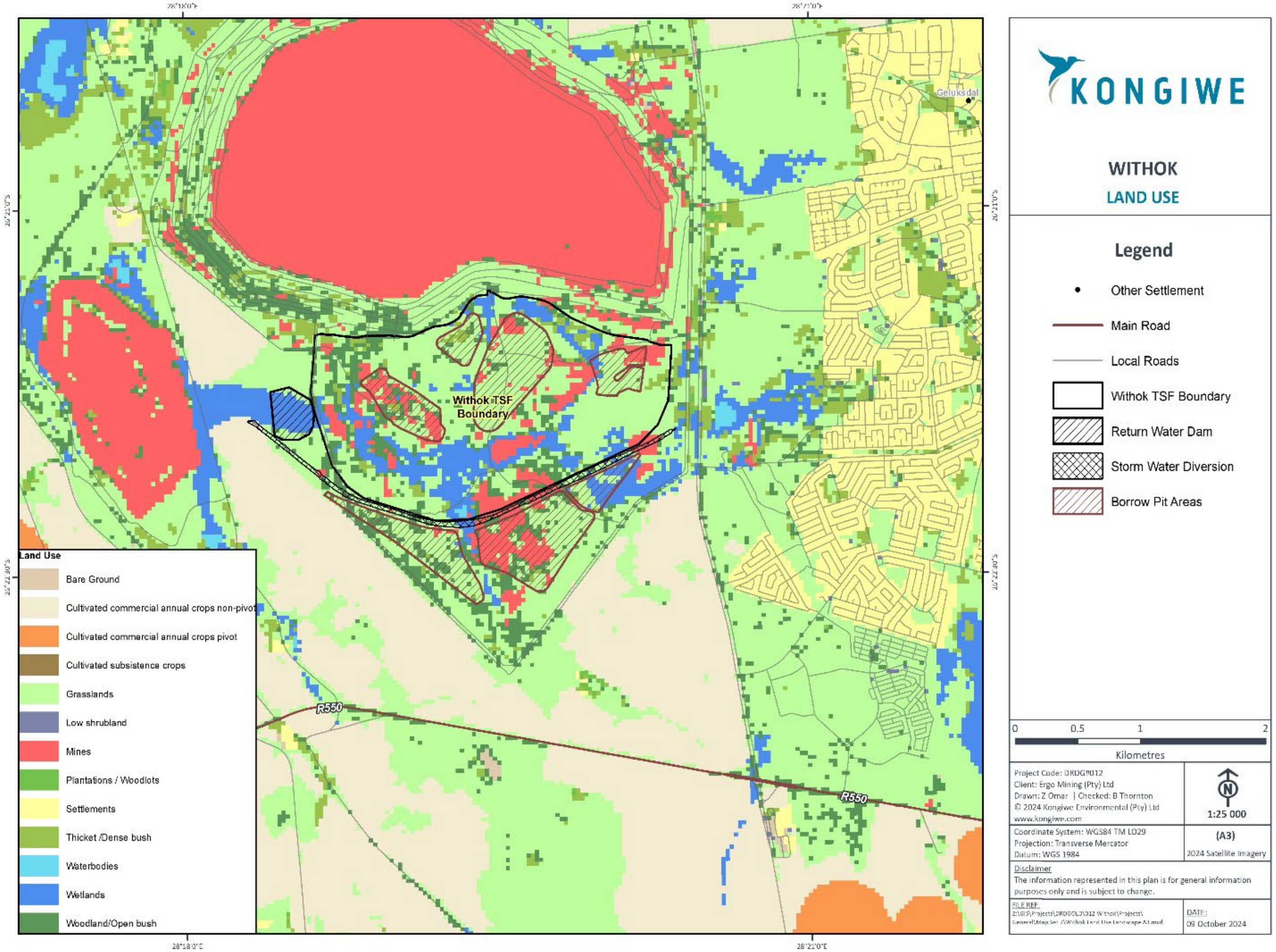


Figure 4-10: Land uses of the Proposed Project site and surrounding area

4.5 Surface Water

Refer to Specialist Study: Appendix A – Surface water

4.5.1 Regional Catchment

The DWS has divided South Africa into primary, secondary, tertiary and quaternary catchments. Primary catchments are the largest defined catchments for South Africa, of which there are 22, and are assigned a letter ranging from A – X (excluding O). Secondary catchments are subdivisions of the primary catchments, and are the second largest catchments in South Africa, and are assigned the primary catchment letter within which they are located, and a number e.g. A5 (secondary catchment 5 located within primary catchment A). Similarly, tertiary catchments are subdivisions of secondary catchments and are represented for example by A53 (tertiary catchment 3 located within secondary catchment A5). Lastly, quaternary catchments are the smallest defined catchments and are assigned the tertiary catchment number, along with a quaternary catchment letter e.g. A53D (quaternary catchment D located within tertiary catchment A53). Further divisions into sub-quaternary reaches have also been implemented.

Further to the above, the DWS have divided South Africa into 9 Water Management Areas (WMAs). The 9 WMAs include the Limpopo, Olifants, Inkomati-Usuthu, Pongola-Mtamvuna, Vaal, Orange, Mzimvubu-Tsitsikamma, Breede-Gouritz and Berg-Olifants. Not all of the WMAs have been formalised (iLanda Water Services, 2025).

The proposed Withok TSF complex is located approximately 14 km southwest of Springs, in quaternary catchment C22C. The Rietspruit flows north to south past the western flank of the Brakpan TSF. The Rietspruit is a tributary of the Kliprivier, which flows into the Vaal River, upstream of the Vaal Barrage but downstream of the Vaal Dam (iLanda Water Services, 2025).

An unnamed water course runs through the footprint of the proposed Withok TSF. The catchment of this water course is largely urbanised with the townships of Geluksdal and Tsakane. An attenuation dam has been constructed as part of the initial Withok TSF project to attenuate flood peaks from this unnamed stream so that they could be routed safely under the old facility through a "spinal culvert". This attenuation dam is still operational.

The unnamed water course flows towards the Rooikraal TSF which diverts the stream around the TSF before it flows into the Rietspruit. The unnamed water course has an ill-defined channel throughout its length. The valley bottom is generally wide and well vegetated. The channel slope is gentle.

4.5.2 Surface Water Runoff

According to the WR2012 study, quaternary catchment C22B has a Mean Annual Runoff (MAR) of 23.12 million cubic metres (mcm).

4.5.3 Mean Annual Runoff

The mean annual runoff for the quaternary catchments C22C is 21.38 Mm^3 (Middleton and Bailey, 2009). The mean annual runoff value in Table 4-4 was scaled from the quaternary catchment runoff, based on relative catchment size. The catchment boundaries and size are shown in Figure 4-11.

Table 4-3: Mean annual Runoff

Stream	Mean annual run-off (Mm^3 /a)
Unnamed water course	0.95

4.5.4 Normal Dry Weather Flows

The normal dry weather flows are based on the average monthly flows documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009) for quaternary catchment C22C. The flows were scaled based on relative catchment size. The dry weather flows are presented in Table 4-4. The dry weather flows have been highlighted in bold text. (iLanda Water Services, 2025).

Table 4-4: Normal Dry Weather Flows in M^3/Months (Highlighted in Bold Text)

Months	Unnamed Water Course
Oct	**38 681 m^3**
Nov	64 989 m^3
Dec	85 046 m^3
Jan	134 871 m^3
Feb	183 337 m^3
Mar	165 805 m^3
Apr	84 925 m^3
May	**53 542 m^3**
Jun	**40 469 m^3**
Jul	**35 911 m^3**
Aug	**32 100 m^3**
Sep	**30 474 m^3**

4.5.5 DWS Classes and Resource Quality Objectives

The NWA specifies that water resources are to be protected and managed through the classification of water resources and Resource Quality Objectives (RQOs) and the setting of the reserve. The Classes and RQOs of Water Resources for Catchments of the Upper Vaal (Government Notice No. 468, 22 April 2016) (DWS, 2016), was consulted to obtain the classes and RQOs for the quaternary catchments within which the Recommissioning of the Withok TSF is located. Quaternary catchments C23C does not have any classes or RQOs set.

4.5.6 Water Quality

The water quality data was compared against the Klip River in-stream water quality objectives. The water quality data was also compared against the SANS 241 - 1:2015 drinking water standards. The operations measure water quality at many locations. The water quality results from these locations were provided by the operations. Data from November 2023 to October 2024 (the latest 12 months on record) were analysed.

The results show the following:

- Withokspruit upstream of the Brakpan TSF complex (BT1)
  - The water quality is considered good and generally within the SANS 241:2015 drinking water limits. Turbidity is elevated but this is attributed to cattle and human activities within the channel upstream of the monitoring point.
  - Nitrates are slightly elevated. This is attributed to the urban activities upstream.
- Withokspruit tributary upstream of the Brakpan TSF complex (BT2)
  - The water quality is considered fair and generally within the SANS 241:2015 drinking water limits.
- The catchment is impacted by industrial and historical mining activities, which are the likely causes of the slight deterioration in water quality across many parameters, the most notable being chloride, sulphate, fluoride, sodium and magnesium.
  - Withokspruit downstream of the Rietspruit confluence (BT15 and BT4)
  - The water quality at these two locations is considered very poor but shows periods of good quality during the wet season. This could indicate poor quality baseflow that is diluted by cleaner storm flow.
  - Cyanide and antimony are elevated in BT15. This may be coming from the Rietspruit, but this assertion is not conclusive.
  - BT4 water quality is generally better than BT15 during the wet season, possibly due to the influence of the Withokspruit. Again, this assertion is not conclusive without a monitoring point in the Rietspruit just upstream of the Withokspruit confluence.
- Spinal culvert outfall (PH21). This is water that is routed from the attenuation dam upstream of the R23.
  - The water quality at PH21 is considered good overall.
  - The elevated manganese is considered background.

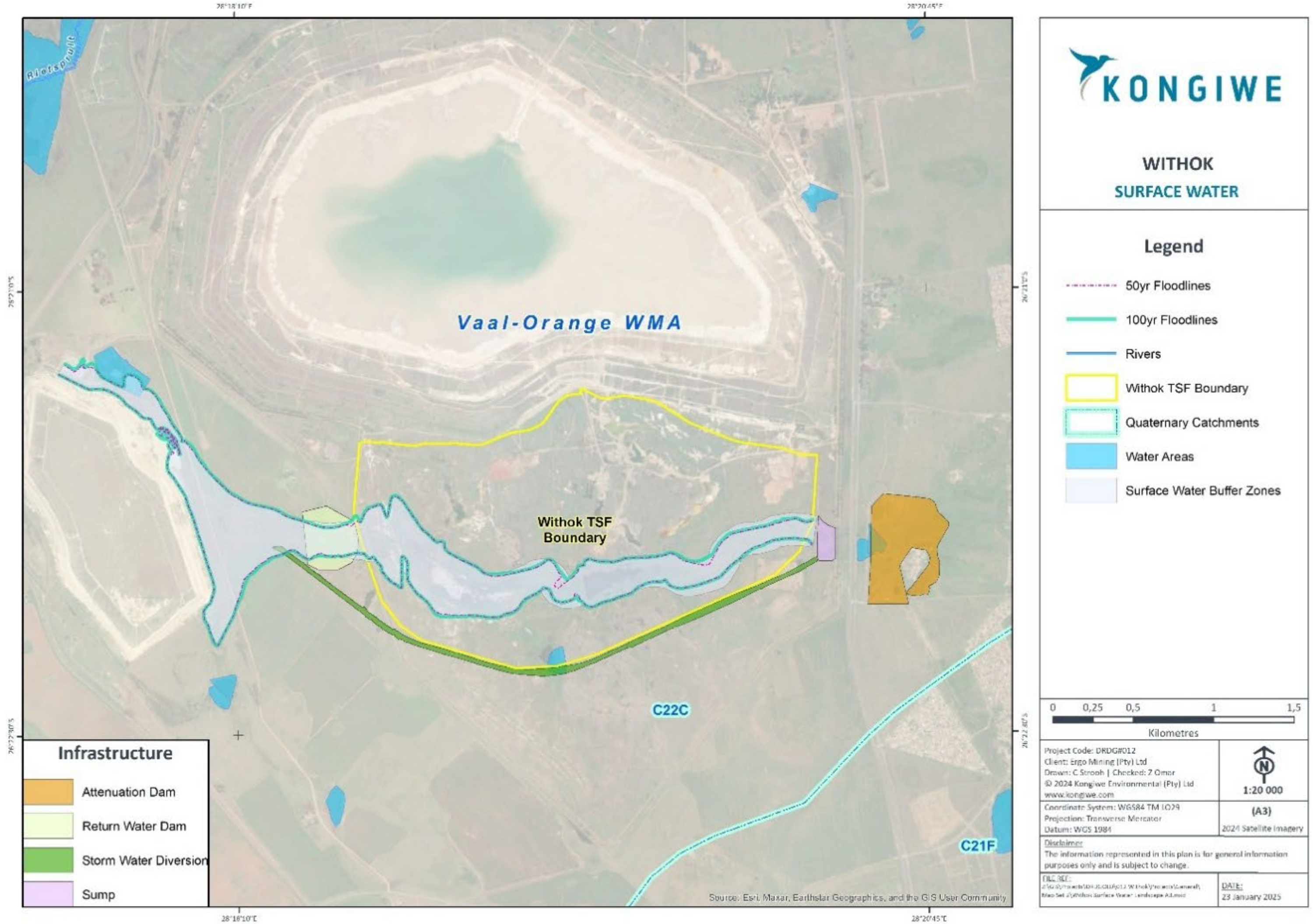


Figure 4-11: Catchment Delineation

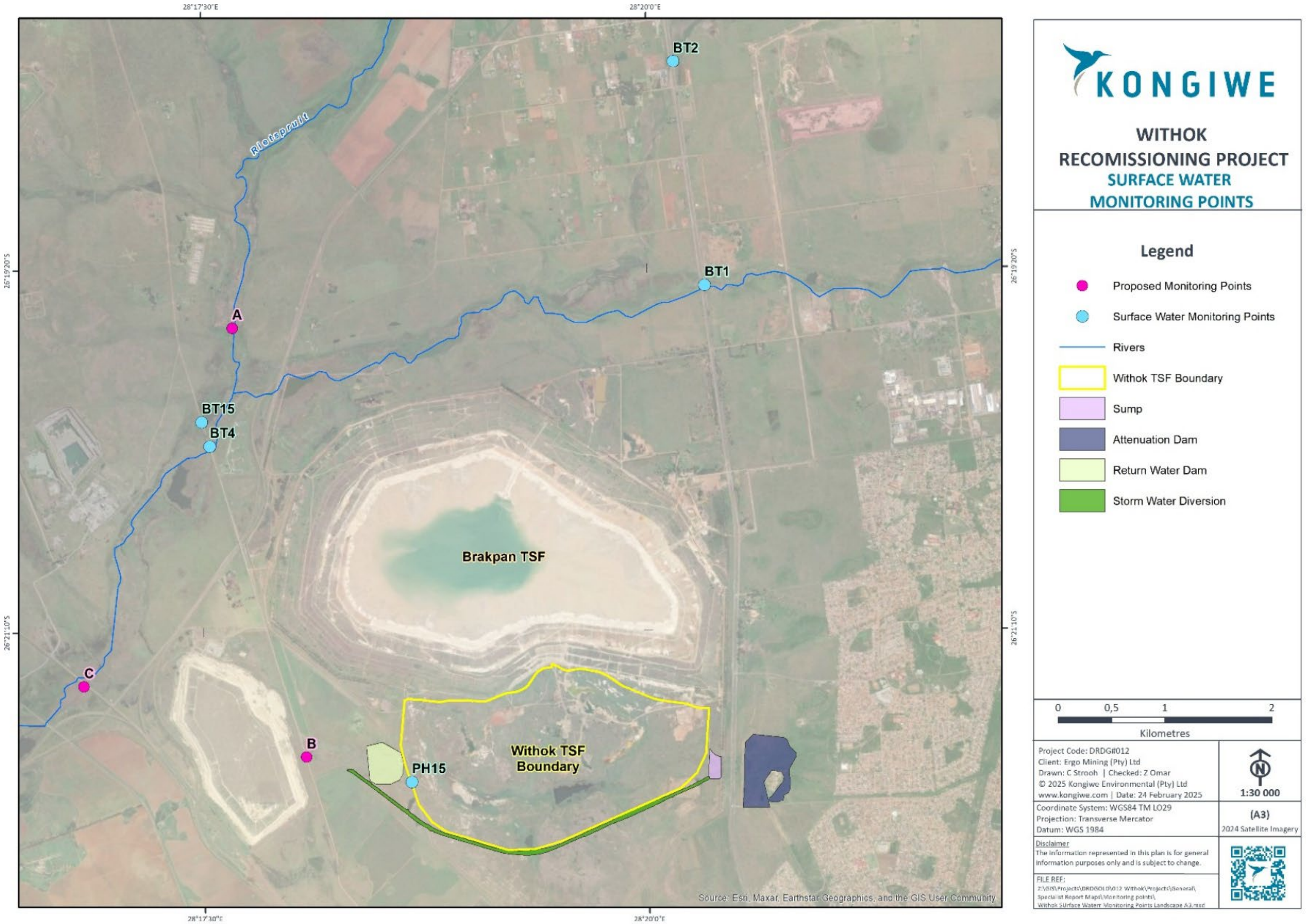


Figure 4-12: Surface water monitoring points

Table 4-5: Water Quality upstream at BT4 (iLanda, 2025)

Parameter	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sept-24	Oct-24
pH - Value @ 25 ºC		3.9	6.8	6.7	6.5			7.2	5	4.9	3	3.8
Electrical Conductivity in mS/m @ 25°C		197	83.1	155	124			107	285.0	290.0	500.0	343.0
Total Dissolved Solids @ 180°C mg/ℓ		1866	670	1156	932			720	2340	2506	4524	2904
Suspended Solids at 105°C									26	37	44	28
Turbidity in N.T.U									24	42	38	18
Chloride as Cl mg/ℓ		109	37	81	100			79	136	139	196	166
Sulphate as SO_4 mg/ℓ		883	347	579	417			257	1,409	1,367	2,653	1,883
Fluoride as F mg/ℓ		0.2	0.4	0.7	0.5			0.5	0	0	1	0
Nitrate as N mg/ℓ		0.4	1.7	1.8	3.6			5.5	3	<0.1	<0.1	1
Nitrite as N mg/ℓ		<0.05	0.7	0.4	2.9			1.1	0	<0.05	<0.05	<0.05
Bromide as Br mg/ℓ		<0.1	0.4	<0.1	<0.1			<0.1	<0.1	<0.1	<0.1	<0.1
Total Cyanide as CN mg/ℓ		<0.07	<0.07	<0.07	<0.07			<0.07	0.13	0.83	<0.07	<0.07
Free and Saline Ammonia as N mg/ℓ		18	0.9	12	2.0			1.1	23.00	24.00	47.00	35.00
Sodium as Na mg/ℓ		86	43	83	94			81	142	194	304	207
Potassium as K mg/ℓ		14.6	10.2	14.4	24			11.2	25.0	28.0	23.0	24.0
Magnesium as Mg mg/ℓ		59	27	50	47			37	110	134	278	162
Aluminium as Al (Dissolved) mg/ℓ		0.700	<0.100	<0.100	<0.100			0.107	0.5	0.4	25.0	4.1
Antimony as Sb (Dissolved) mg/ℓ		<0.001	<0.001	0.001	<0.001			0.001	<0.001	<0.001	<0.001	<0.001
Arsenic as As (Dissolved) mg/ℓ		0.001	<0.001	0.001	<0.001			<0.001	0.001	0.002	0.004	0.003
Barium as Ba (Dissolved) mg/ℓ		0.049	0.042	<0.025	0.036			0.026	0.05	0.06	<0.025	0.04
Boron as B (Dissolved) mg/ℓ		<0.025	0.051	0.047	0.036			0.033	0.09	<0.025	0.12	0.03
Cadmium as Cd (Dissolved) mg/ℓ		<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	0.00	<0.001
Hexavalent Chromium as Cr mg/ℓ		<0.025	<0.025	<0.025	<0.025			<0.025	<0.025	<0.025	<0.025	<0.025
Total Chromium as Cr (Dissolved) mg/ℓ		<0.010	0.012	<0.010	0.021			0.012	<0.010	<0.010	0.027	<0.010
Copper as Cu (Dissolved) mg/ℓ		0.163	<0.010	<0.010	<0.010			0.030	<0.010	0.053	0.72	0.304
Iron as Fe (Dissolved) mg/ℓ		0.048	<0.025	<0.025	<0.025			<0.025	19	22	14	7
Lead as Pb (Dissolved) mg/ℓ		<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	0.009	0.001
Manganese as Mn (Dissolved) mg/ℓ		9.38	2.89	5.31	3.53			1.77	12	17	16	17
Mercury as Hg (Dissolved) mg/ℓ		<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001
Uranium as U (Dissolved) mg/ℓ		0.019	<0.001	0.002	0.004			0.016	0.01	0.013	1.39	0.244

LEGEND				
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value			

Table 4-6: Water Quality on site at PH21

Parameter	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sept-24	Oct-24
pH - Value @ 25 ºC	7.2	7.2	7.0	7.2	7.0							
Electrical Conductivity in mS/m @ 25°C	90.2	84.3	27.5	60.4	24.2							
Total Dissolved Solids @ 180°C mg/ℓ	600	474	156	308	160							
Suspended Solids at 105°C												
Turbidity in N.T.U												
Chloride as Cl mg/ℓ	60	61	17	32	15							
Sulphate as SO_4 mg/ℓ	146	131	43	79	42							
Fluoride as F mg/ℓ	0.2	0.2	0.5	0.3	0.3							
Nitrate as N mg/ℓ	0.1	<0.1	0.8	0.6	1.2							
Nitrite as N mg/ℓ	<0.05	<0.05	**2.0**	<0.05	0.8							
Bromide as Br mg/ℓ	<0.1	<0.1	0.5	<0.1	<0.1							
Total Cyanide as CN mg/ℓ	<0.07	<0.07	<0.07	<0.07	<0.07							
Free and Saline Ammonia as N mg/ℓ	32	27	0.9	15	1.7							
Sodium as Na mg/ℓ	60	70	16	38	13							
Potassium as K mg/ℓ	13.0	16.2	6.4	7.2	6.2							
Magnesium as Mg mg/ℓ	17	23	6	21	6							
Aluminium as Al (Dissolved) mg/ℓ	<0.100	<0.100	0.133	<0.100	0.146							
Antimony as Sb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	0.001	<0.001							
Arsenic as As (Dissolved) mg/ℓ	0.002	0.001	0.001	0.001	0.001							
Barium as Ba (Dissolved) mg/ℓ	0.094	0.096	0.062	<0.025	0.042							
Boron as B (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025							
Cadmium as Cd (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001							
Hexavalent Chromium as Cr mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025							
Total Chromium as Cr (Dissolved) mg/ℓ	<0.010	0.011	0.017	<0.010	<0.010							
Copper as Cu (Dissolved) mg/ℓ	<0.010	0.020	<0.010	<0.010	<0.010							
Iron as Fe (Dissolved) mg/ℓ	0.218	0.253	0.076	0.043	0.160							
Lead as Pb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001							
Manganese as Mn (Dissolved) mg/ℓ	**4.37**	**6.46**	<0.025	**3.85**	0.065							
Mercury as Hg (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001							
Uranium as U (Dissolved) mg/ℓ	<0.001	0.001	<0.001	0.002	<0.001							
LEGEND												
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.								
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value											

4.6 Groundwater

Refer to Specialist Study: Appendix B – Geohydrological Report (Ground water)

4.6.1 Conceptual Hydrogeological Model

The Withok TSF project area is underlain by both Karoo and Transvaal Supergroup rocks. Sedimentary rocks from the Karoo Supergroup, together with Karoo dolerite intrusions and dolomites from the Malmani group, all underlie the TSF footprint area. (Delta H Water Systems Modelling, 2024).

Based on the conceptual hydrogeological understanding of the site, the following hydro-stratigraphic units underlie the proposed Withok TSF footprint:

- Topsoil/gravel (average thickness of 2 m). This acts as a shallow perched aquifer in areas where the impermeable dolerite sill is present.
- Shallow weathered aquifer (thickness between 3 m and 22 m).
- Fractured and Karst aquifer within both Karoo and Transvaal Supergroup rocks.
  - Fractured aquifer comprising the Klipriviersberg Group and Karoo Formations, Turffontein Subgroup and Black Reef quartzite.
  - Karst aquifer within the dolomites of the Chuniespoort Group of the Malmani Supergroup.

4.6.2 Groundwater Levels

As part of the geotechnical drilling conducted during 2016, five groundwater monitoring boreholes were drilled around the TSF footprint area. The depth to groundwater in the boreholes varied between 1.9 and 5.9 metres below ground level (m bgl). The groundwater levels obtained during the hydrocensus, conducted by iLEH during 2016, indicated groundwater levels ranging from surface to 21m bgl, with an average groundwater level of 4.8m bgl. Similarly, the newly drilled interception boreholes (excluding the TSF wells, Water Hunters 2020, 2021, 2024) showed groundwater levels between 2.15 and 5.24 m bgl, with an average of 3.28 m bgl.

The shallow groundwater levels are indicative of a perched or shallow aquifer system, with local mounding due to seepage from the TSF resulting in shallower water levels in its proximity.

4.6.3 Aquifer Characteristics Site Investigations

Aquifer characterisation is done based on existing information, guidelines and maps provided by the DWS. This system was created as it allows the grouping of aquifer areas into types according to their associated supply potential, water quality and local importance as a resource

4.6.4 Groundwater Vulnerability

Groundwater vulnerability is a measure indicating how susceptible an aquifer is to contamination. Aquifer vulnerability is used to represent the intrinsic characteristics that determine the sensitivity of various parts of an aquifer to being adversely affected by a contaminant load imposed from the surface.

4.6.5 Aquifer Classification

According to the Hydrogeological Map (1:500 000) series, the regional hydrogeology is characterized as a 'Karst aquifer' with a typical potential water yield of more than 5.0 litres per second. Chemical weathering of karstic aquifers, such as the dolomites from the Malmani Group forming part of the Transvaal Supergroup, results in voids providing primary storage capacity with high transmissivity values, and with a micro-fractured matrix providing secondary storage capacity with limited groundwater movement. Secondary features such as fractures/ faults and bedding planes further enhance the groundwater flow.

A summary of the classification scheme is provided in Table 4-7. In this classification system, it is important to note that the concepts of Minor and Poor Aquifers are relative, and that yield is not quantified. Within any specific area, all classes of aquifer are likely, in theory, to be present.

Table 4-7: Aquifer classification scheme after Parsons and Conrad (1998).

Aquifer	Description
Sole source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources, should this aquifer be impacted upon or depleted.
Major aquifer region	High-yielding aquifer of acceptable quality water.
Minor aquifer region	Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor-quality water.
Poor aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer that will never be utilized for water supply and that will not contaminate other aquifers.
Special aquifer region	An aquifer designated as such by the Minister of Water

4.6.6 Aquifer Susceptibility

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

4.6.7 Baseline Groundwater Quality

The baseline (background) groundwater quality for the Brakpan and Withok TSF site is based on the latest available monitoring results t, applying median concentrations calculated over the monitoring period from

January 2018 to November 2023. The groundwater quality results were compared to available standards, including the SANS 241:2015 Drinking Water Quality Standards and IFC Mining Effluent guidelines (2007). Positions of the various monitoring boreholes are depicted in Figure 4-13. The boreholes located on or adjacent to the Withok TSF footprint are: WitBH2, WitBH4, BT6, BT8 and B23. Sampling results are available for Wit BH2, Wit BH4 and BT8.

Overall, several water quality guideline exceedances were noted for the median concentrations calculated from 2018 to 2023:

- The electrical conductivity (EC), total dissolved solids (TDS) and SO4 exceeded the SANS 241:2015at BH4.
- pH limits are not exceeded.
- Chloride exceeded the SANS 241:2015 standards in borehole BT8.
- Cyanide exceeded the SANS 241:2015 standard in borehole B8.
- Aluminium exceeded the SANS 241:2015 limit in borehole WitBH2.
- SANS 241:2015 limits for Cd were exceeded in borehole BT8..
- The SANS 241:2015 limit for Co was exceeded in boreholes WitBH4.
- Magnesium concentrations exceeded SANS 241:2015 limits in BT8.
- The Manganes limits of the SANS 241:2015 standards were exceeded in boreholes WitBH4 and BT8.
- Sodium concentrations exceeded SANS 241:2015 standards in borehole BT8.
- Lead concentrations exceeded SANS 241:2015 standards in boreholes WitBH2 and BT8.

Table 4-8: Median groundwater quality of background boreholes monitored between 2018 to 2023 (in mg/L).

Name	SANS (2015)	IFC Mining effluent (2007)	WitBH2	WitBH4	BT8
No. of samples			30	52	59
Date			Jan2018-Aug2021	Jan2018-Nov2023	Jan2018-Nov2023
pH	5-9.7	6-9.0	8.2	7.9	8.7
EC (mS/m)	170		74.95	87.85	545
TDS	1200		429	589	4340
Cl	300		43.5	61.5	743
SO4	500		70	211	1856
NO3 as N	11		0.3	0.3	0.4
NO2	0.9		1.6	0.2	0.3
NH3 as N	1.5		26	6.1	3.7
Orthophos-phate as P			2.4	0.1	0.2
Cyanide as CN	0.2	1	<0.07	0.11	0.1
Al	0.3		0.697	<0.100	0.166
As	0.01	0.1	0.007	0.004	0.001
Ba	0.7		0.321	<0.025	0.276
B	2.4		0.368	0.045	0.083
Ca	150		15	39	22
Cd	0.003	0.05	<0.001	<0.001	0.006
Co	0.5		0.162	1.952	0.236
Cr	0.05		0.011	0.012	0.0245
Cu	2	0.3	0.031	0.028	0.041
F	1.5		0.3	0.2	0.4
Fe	2	2	0.037	0.09	0.0715
K	50		4	10	5
Mg	70		2	36	337
Mn	0.4		0.034	0.518	0.474
Hg	0.006	0.002	<0.001	0.001	0.002
Na	200		98	54	704
Ni	0.07	0.5	<0.025	<0.025	0.056
Pb	0.01	0.2	0.012	<0.001	0.017
Sb	0.02		0.001	0.001	<0.001
Se	0.04		0.002	<0.001	0.002
Si			32	1.2	1
U	0.03		<0.001	<0.001	0.002
Zn	0.5	0.5	0.026	<0.025	0.039

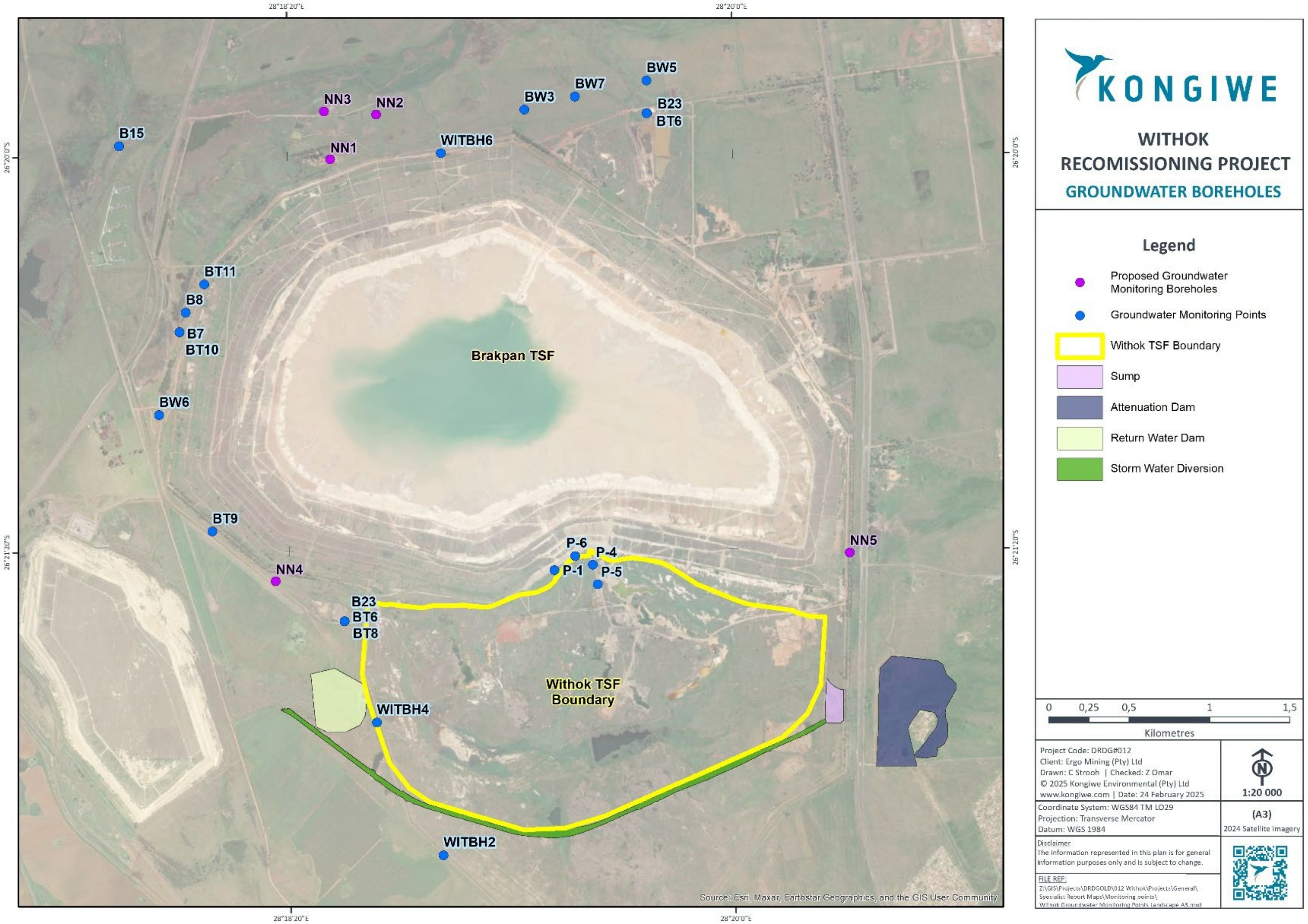


Figure 4-13: Locality map of current and proposed monitoring boreholes.

4.6.8 Groundwater Contaminant Modelling

The seepage plume emanating from the Brakpan-Withok TSF complex is primarily associated with the Brakpan TSF. The lined Withok expansion will essentially reduce the recharge over its footprint, which leads to less dilution of the existing Brakpan seepage plume and thereby an increase in its concentrations. The seepage contributions from the Withok TSF extension are on the other hand negligible. This is further discussed below.

The simulated 2023 sulphate plume from Brakpan TSF along with observed median sulphate concentrations are shown in Figure 4-14. Based on the model simulations, the seepage plume has reached the Withokspruit north of the TSF and is likely to contribute as groundwater baseflow to the discharge in the spruit with sulphate concentrations of up to 900 mg/L. The western lobe of the seepage plume extends for a cutoff value of 250 mg/L sulphate approximately 520m towards the Rietspruit.

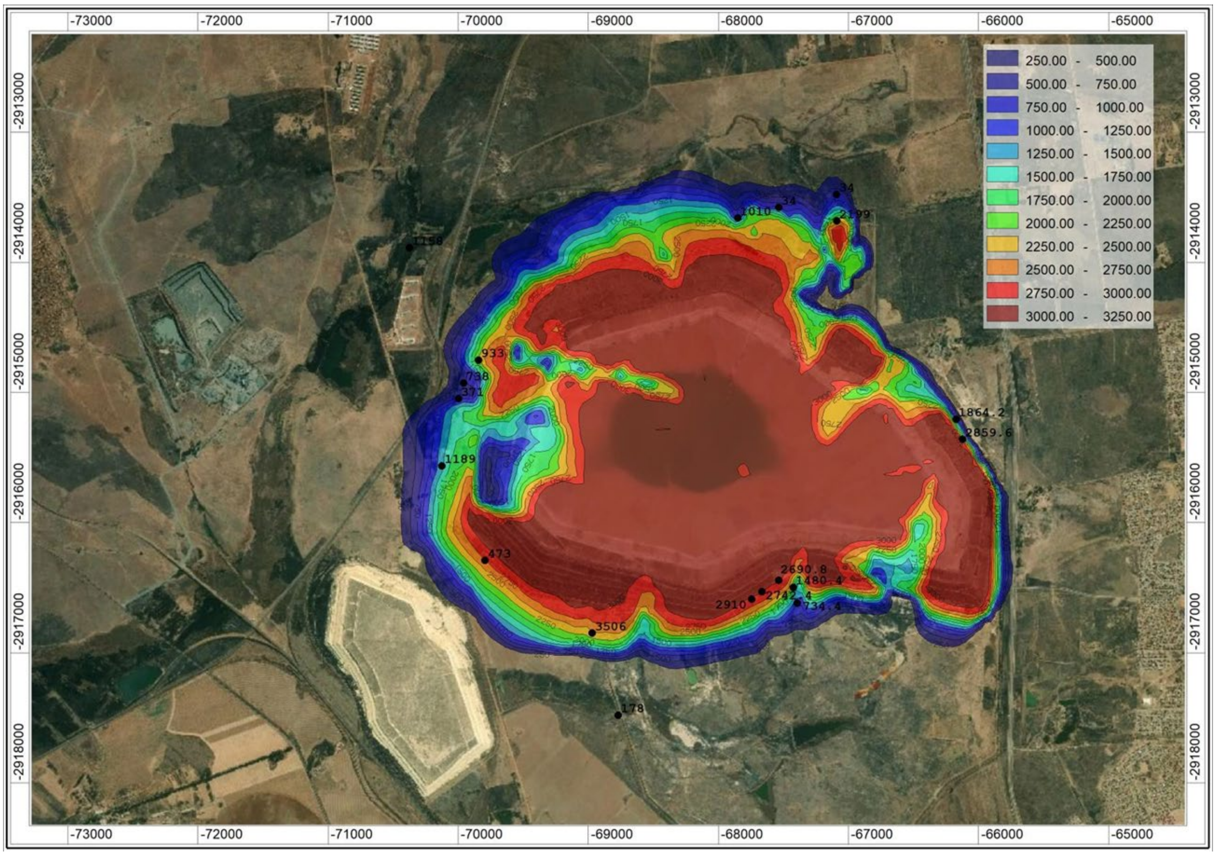


Figure 4-14: Simulated 2023 sulphate plume and observed concentrations for the Brakpan TSF.

The installed interception well system manages to contain the plume or “pull back” the 250 mg/L sulphate isoline by around 400m in the west and up to 275m in the north as well as bringing about a reduction in plume concentrations (beyond the TSF footprint itself) in comparison to the unmitigated scenario. Furthermore, maximum sulphate concentrations within the baseflow towards the Withokspruit are predicted to reduce to 800 mg/L.

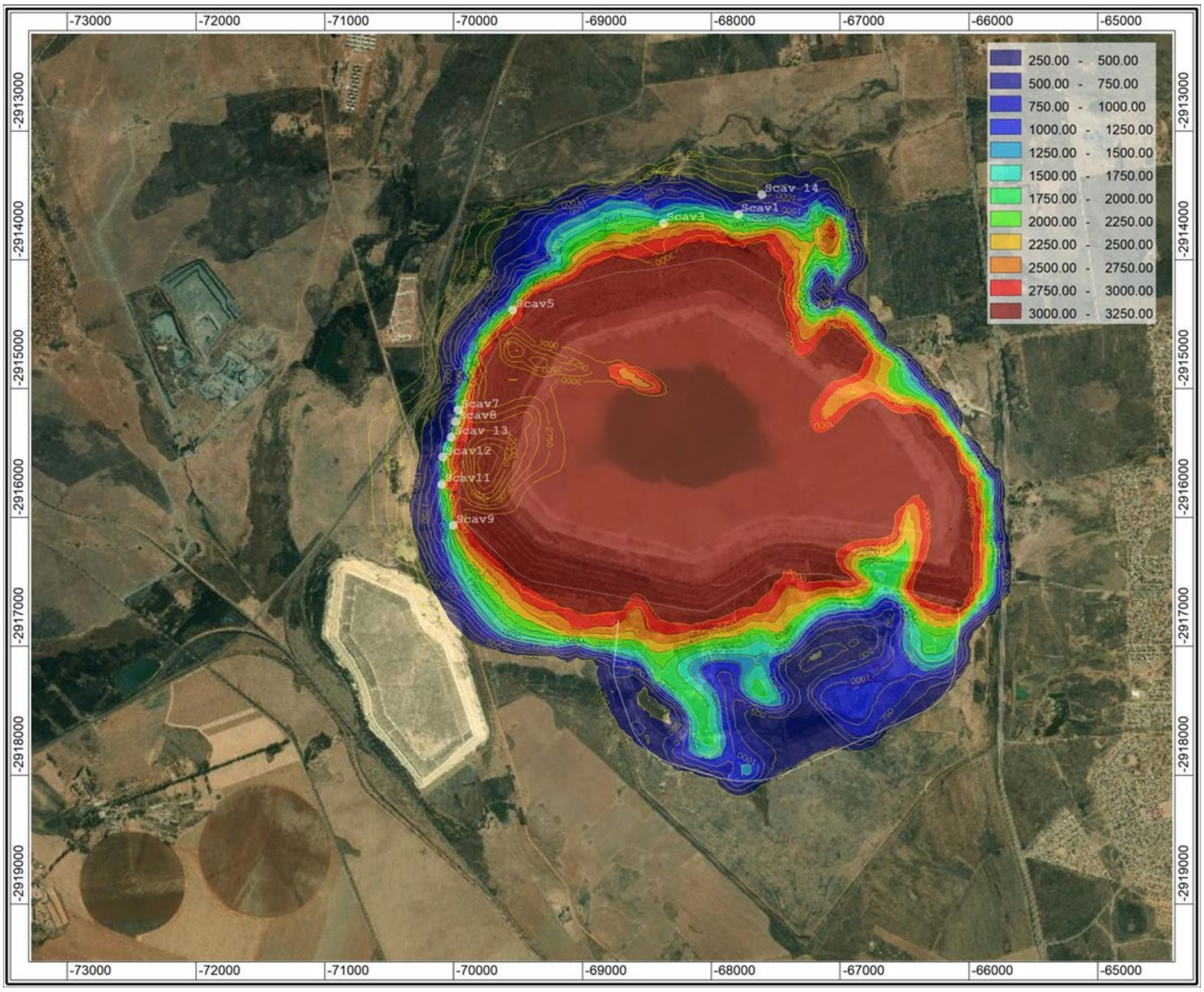


Figure 4-15: Simulated sulphate concentrations in the shallow aquifer at the end of active deposition onto the Brakpan-Withok TSF complex (2049) for the mitigated scenario (unmitigated 2049 concentrations indicated by yellow contour lines).

The interception well system achieves a further minor reduction in the northern and western plume extent and concentrations in comparison to the life of facility extent, but a significant reduction (up to 900m) in comparison to the unmitigated scenario.

The installed hydraulic containment system (i.e., the current interception wells) appears to be feasible and effective but should be augmented by additional interception wells at the north-west edge of the Brakpan TSF to achieve a more comprehensive plume containment within 50 years.

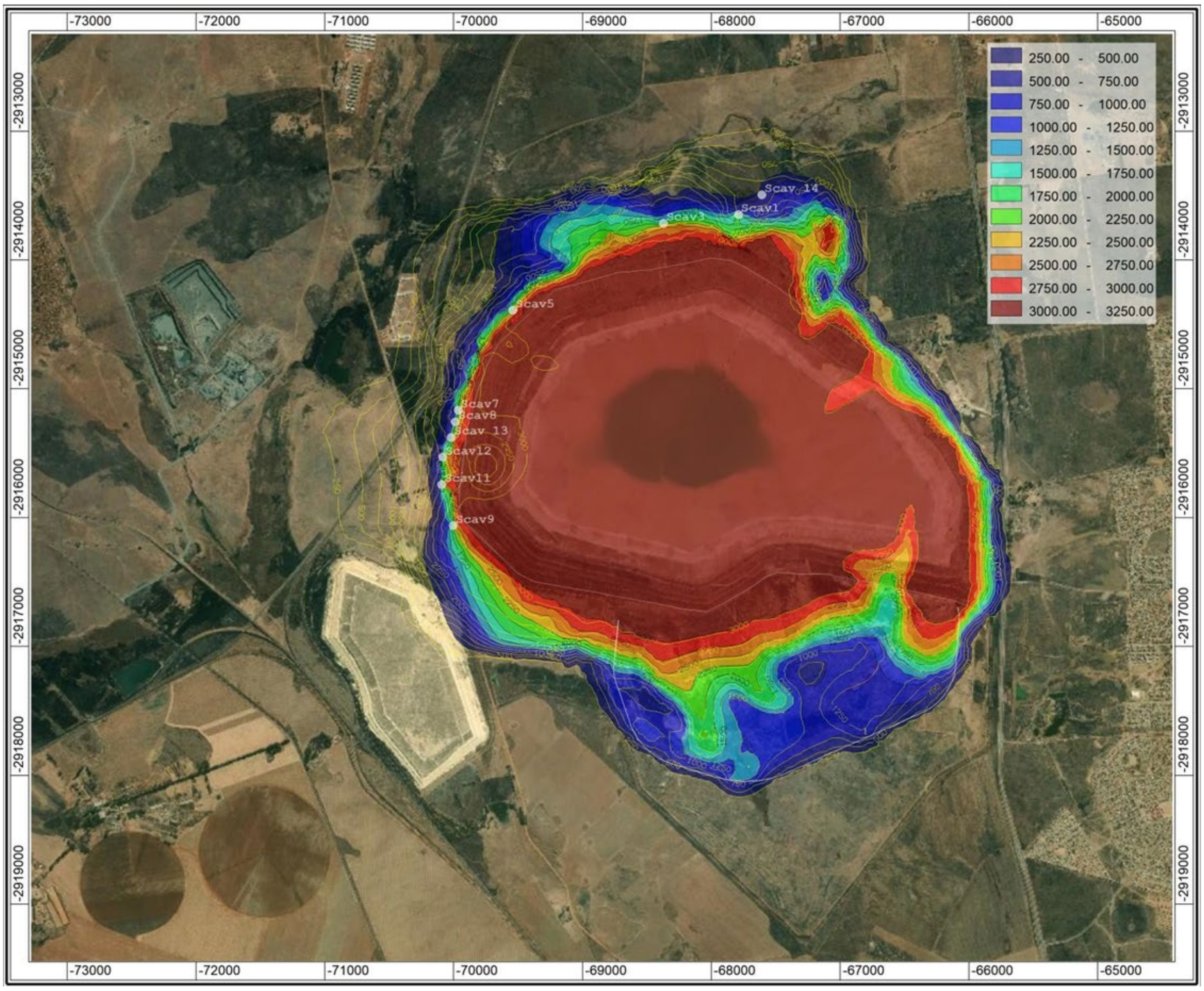


Figure 4-16: Simulated sulphate concentrations in the shallow aquifer 50 years post closure for the mitigated scenario (unmitigated concentrations indicated by yellow contour lines).

4.7 Biodiversity

Refer to Specialist Study: Appendix D– Terrestrial Biodiversity Compliance Statement

4.7.1.1 Habitat Assessment

Four (4) main habitat types were identified across the PAOI and include:

- Degraded Grassland;
- Transformed area;
- Wetlands and grassland Habitat; and
- Wetlands Habitat.

Table 4-9: Descriptions of the habitat types delineated for the PAOI

Habitat	Description and Condition
Degraded Grassland	This habitat unit is characterised by secondary growth grassland habitat that has not fully recovered from historical clearing due to anthropogenic activities, such as human and vehicle ingress, invasions by alien and invasive plants, overgrazing by livestock and the edge effects associated with the nearby mining activities and the adjacent TSF, as well as inadequate rehabilitation procedures. Due to the high levels of disturbance, this habitat never regained full ecological function and is associated with high numbers of alien and invasive plants, such as*, Datura stramonium, Verbena bonariensis, V. brasiliensis, Bidens Pilosa, Tagetes minuta, Erigeron bonariensis, Acacia mearnsii* and *Eucalyptus camaldulensis*. Some sections of this habitat unit are in better condition than others, particularly those bordering on the water resource habitat, with good potential for rehabilitation back to an ecologically stable state. The areas of the site that overlap with the ESA are still representative as such and with active rehabilitation, have the potential to function as a valuable ecological corridor. Dominant indigenous species include, *Melinis repens, Themeda triandra, Cymbopogon pospischilii, Hyparrhenia hirta, Paspalum dilatatum*, *Cynodon dactylon*, *Aristida congesta* and *Seriphium plumosum.* Additional common grassland species associated with disturbance and secondary growth are expected, as well as some provincially protected species, particularly geophytes. No fauna or flora SCC were observed, and none are expected to be resident in the PAOI. Some fauna SCC may make use of the PAOI for foraging and as a movement corridor.
Modified Grassland	This habitat unit is characterised by secondary growth grassland habitat that has not recovered as well from historical clearing as the degraded grassland due to inadequate rehabilitation procedures, and still contains areas of visible tailings material from the previous land use as a TSF in 1996, as well as tailings material leaching from the adjacent TSF. Anthropogenic impacts are more severe here and include, human and vehicle ingress, invasions by alien and invasive plants, overgrazing by livestock and the edge effects associated with the nearby mining activities and the adjacent TSF. Due to the high levels of disturbance, this habitat never regained full ecological function and is associated with high numbers of alien and invasive plants, such as*, Datura stramonium, Verbena bonariensis, V. brasiliensis, Bidens Pilosa, Tagetes minuta, Erigeron bonariensis, Acacia mearnsii* and *Eucalyptus camaldulensis*, as well as areas of bare ground associated with tailings material. Anthropogenic activity has substantially modified this area's primary ecological functions and species composition.

Habitat	Description and Condition
	Dominant indigenous species include, *Cymbopogon pospischilii, Hyparrhenia hirta, Paspalum dilatatum*, *Cynodon dactylon* and *Gomphocarpus fruticosus.* Additional common grassland species associated with disturbance and secondary growth are expected, as well as some provincially protected species, particularly geophytes. No fauna or flora SCC were observed, and none are expected to be resident in the PAOI. Some fauna SCC may make use of the PAOI for foraging and as a movement corridor.
Water Resource	This is a non-terrestrial habitat made up of wetlands and drainage features within the PAOI. This habitat unit is associated with hydrophytes, such as *Phragmites australis*, as well as high numbers of alien plant species, such as, *Arundo donax* and *Verbena brasiliensis.* No fauna or flora SCC were observed, and none are expected to be resident in the PAOI. Some fauna SCC may make use of the PAOI for foraging and as a movement corridor. Additional information regarding this habitat unit may be found in the accompanying freshwater assessment (TBC, 2024).
Artificial Water Resource	This is a non-terrestrial habitat made up of artificial wetlands and dams within the PAOI. This habitat unit is associated with hydrophytes, such as *Phragmites australis*, as well as high numbers of alien plant species, such as, *Arundo donax* and *Verbena brasiliensis.* No fauna or flora SCC were observed, and none are expected to be resident in the PAOI. Some fauna SCC may make use of the PAOI for foraging and as a movement corridor. Additional information regarding this habitat unit may be found in the accompanying freshwater assessment (TBC, 2024).

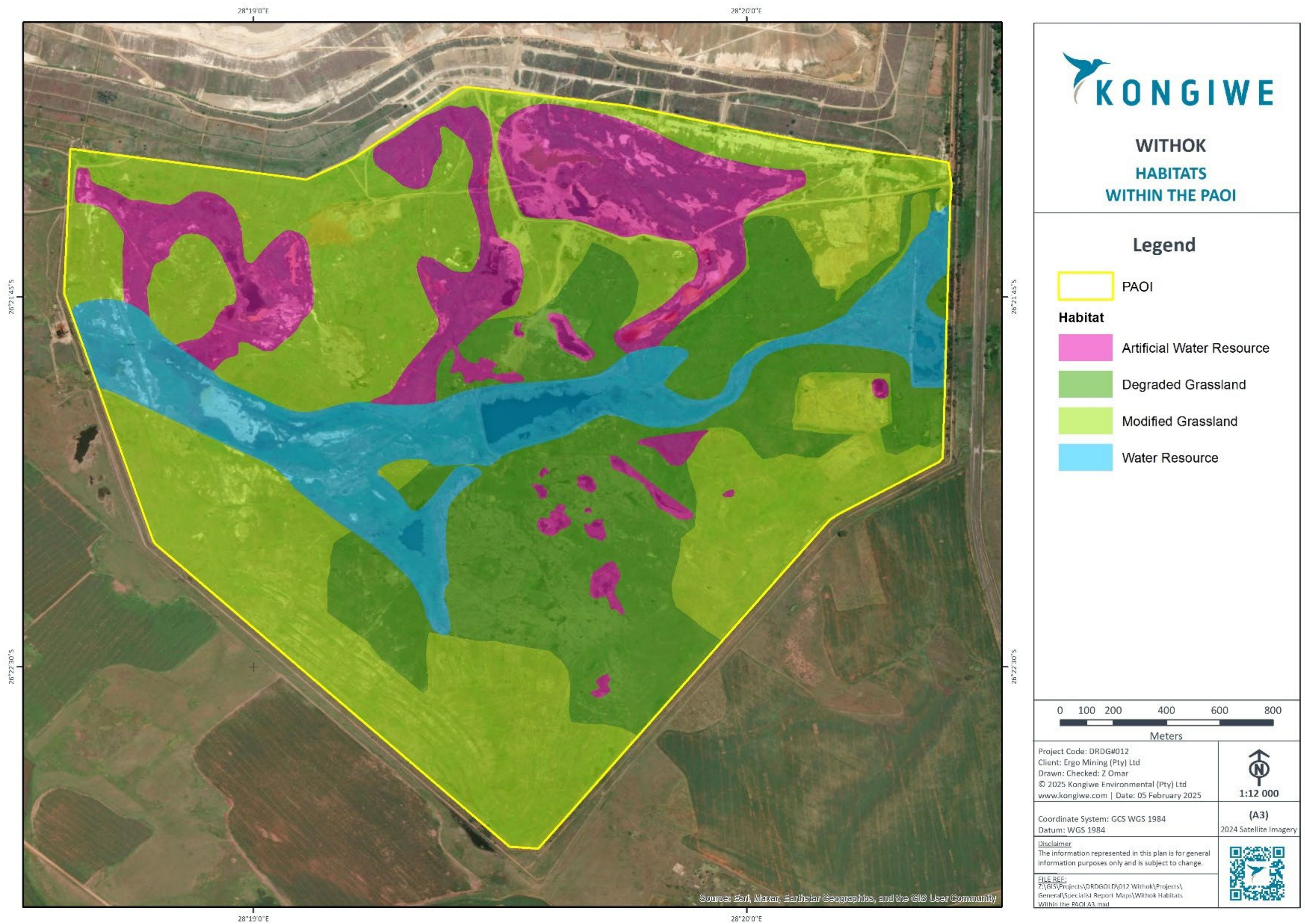


Figure 4-17: Identified habitat types

4.7.1.2 National Web- based Environmental Screening Tool

According to the National Web-based Environmental Screening Tool Report generated (Regulation 16(1)(v) of the Environmental Impact Assessment Regulations 2014, as amended), the PAOI presents with the following sensitivities:

- **Terrestrial Biodiversity Theme** - as "Very High" attributed to the presence or possible presence of the Avalon Private Nature Reserve, Critical Biodiversity Areas 1 & 2, Ecological Support Areas 1 & 2, the National Protected Area Expansion Strategy, the Vulnerable Soweto Highveld Grassland, and the Endangered Tsakane Clay Grassland;
- **Plant Species Theme** - as "Medium" attributed to the presence or possible presence of numerous medium sensitivity plant species;
- **Animal Species theme** - as "High" attributed to the presence or possible presence of numerous "High" and "Medium" sensitivity animal species; and
- **Aquatic Biodiversity Theme** - as "Very High" attributed to the presence or possible presence of Ecological Support Areas 1 & 2 and seep, depression and valley-bottom wetlands of the Mesic Highveld Grassland Bioregion.

The allocated sensitivities for each of the relevant themes are either disputed or validated for the overall PAOI in Table 4-10 below. A summative explanation for each result is provided as relevant. The specialist-assigned sensitivity ratings are based largely on the SEI process followed in the previous section, and consideration is given to any observed or likely presence of SCC species.

Table 4-10: Summary of the screening tool vs specialist assigned sensitivities

Screening Tool Theme	Screening Tool	Specialist	Tool Validated or Disputed by Specialist - Reasoning
Animal Theme	High	**Low**	Disputed – Habitat exists in a largely degraded or modified state with high levels of anthropogenic disturbance, particularly those associated with the adjacent TSF, as well as historical land clearing. No SCC observed and unlikely to be resident, although some may use the habitats on site for foraging and as a movement corridor.
Plant Theme	**Medium**	**Low**	Disputed – Habitat exists in a largely degraded or modified state with high levels of anthropogenic disturbance, particularly those associated with the adjacent TSF. High numbers of alien and invasive plants. No SCC observed and unlikely to occur.
Terrestrial Theme	Very High	**Low**	Disputed – Habitat exists in a largely degraded or modified state with high levels of anthropogenic disturbance, particularly those associated with the adjacent TSF, and has therefore lost much of its ecosystem functionality. Habitat will not recover without human intervention and will continue to degrade over time without rehabilitation. Rehabilitation efforts thus far have been inadequate to return the ecosystem to a functional state.

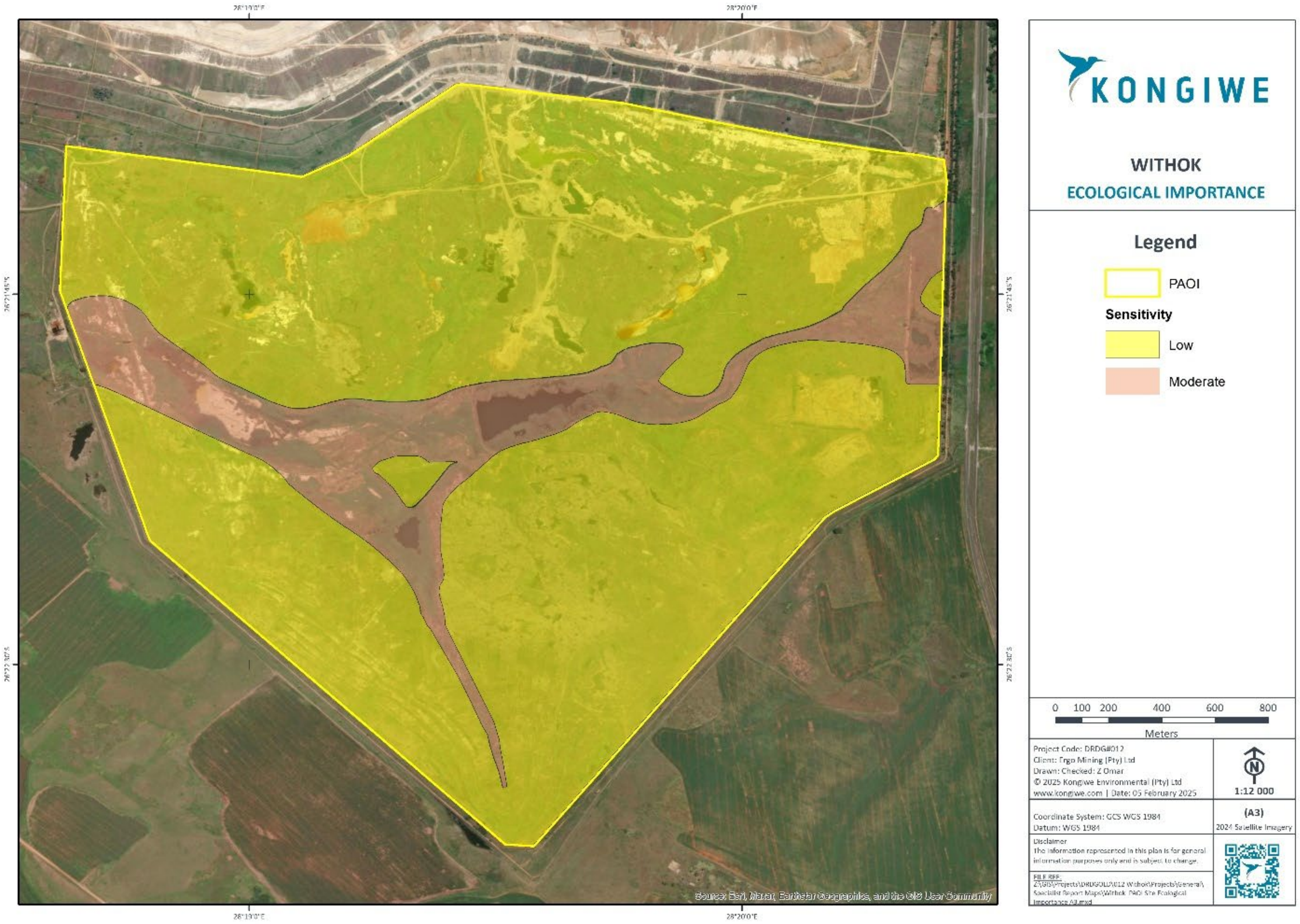


Figure 4-18: Map illustrating the site ecological importance for the PAOI

4.8 Wetlands

Refer to Specialist Study: Appendix E–Wetland Impact Assessment

Wetland is an area where water covers the soil, either seasonally or permanently. It can be saltwater, freshwater, or a mix of both. Wetlands function as distinct ecosystems and are characterized by vegetation adapted to wet soil.

4.8.1 Survey Results NFEPA Wetlands

During the site visit numerous artificial watercourses were identified within the project area of influence. These include unchannelled valley-bottom; Artificial depression within unchannelled valley bottom; Artificial seep; Excavated area; Drainage trench; Disturbed areas resulting in artificial wetland conditions

Additionally, s**everal artificial features were observed which are attributed to the nature of the historical land use (a TSF) and owing to extensive reshaping of the topography during the site's rehabilitation stages after decommissioning of the old TSF.** The artificial seep features are a result of hydrological inputs via trenched drains from the adjacent Brakpan TSF. Other artificial areas include depressions located within the unchannelled valley-bottom and throughout the site, that are assumed to be a result of reshaping during the rehabilitation stages of the old TSF and ongoing excavations, respectively. Due to the depth of excavation and reshaping activities within the unchannelled valley-bottom in conjunction with the surrounding topography, the artificial depressions do display dam-like characteristics.

Wetland units were identified within the encompassing 500m PAOI. Importantly, the project components (TSF, pipeline and pumpstation) do not traverse any natural watercourses, ensuring minimal disruption to the natural hydrological environment. Due to the artificial characteristics of these systems, no further assessment has been undertaken.

It must also be noted that by implementing this project, clean surface water will be diverted around the southern part of the Withof TSF footprint which will enable the water to remain cleaner and not flow through an old TSF footprint. This in itself improves the water resource downstream.

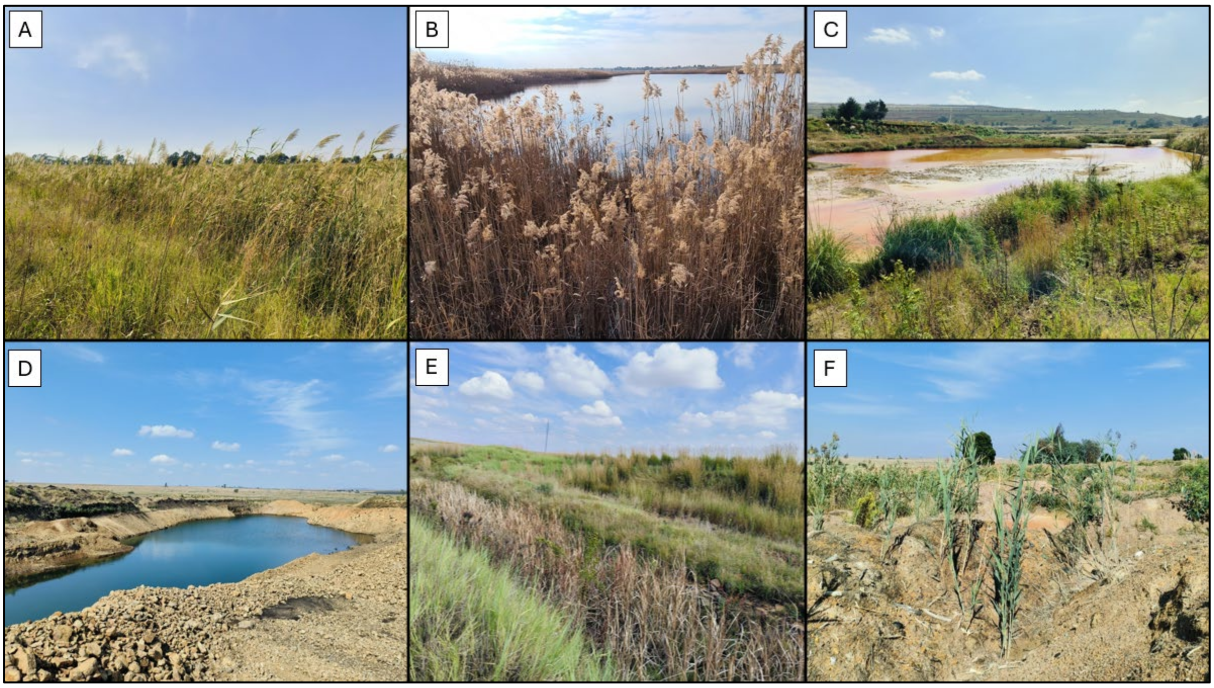


Figure 4-19: Representative photographs of the different wet areas within the project area. A) Unchannelled valley-bottom; B) Dam within unchannelled valley-bottom; C) Artificial seep; D) Excavated area; E) Drainage trench; & F) Disturbed areas resulting in artificial wetland conditions

4.8.2 Ecological Sensitivity

Table 4-11 provides a comparison between the Environmental Screening Tool and the specialist determined Site Ecological Importance (SEI) of the project. The specialist-assigned sensitivity ratings are based largely on the SEI process.

Table 4-11: Summary of the Screening Tool Sensitivity versus the Specialist assigned Site Ecological Importance (SEI) for the Field Survey Area of the Project Area

Features	Screening Tool Theme	Environmental Screening Tool Sensitivity	Specialist Sensitivity	Tool Validated or Disputed by Specialist - Reasoning
Valley-bottoms	Aquatic Biodiversity Theme	Very High	Moderate	Screening Tool Sensitivity disputed. Rational for the specialist assigned 'Moderate' rating: These wetland areas are relatively large in size, exhibiting surface saturation in some approaches with the presence of hydrophytes. They have connectivity to other systems within the local catchment and are considered to be hydrological drivers to those systems. Although these systems

Features	Screening Tool Theme	Environmental Screening Tool Sensitivity	Specialist Sensitivity	Tool Validated or Disputed by Specialist - Reasoning
				have suffered historical impacts from anthropogenic influences, they provide habitat and a water source in a disturbed environment. The potential for them to support freshwater biodiversity therefore remains. The size, hydrological nature of the system and the provision of aquatic and wetland habitat increases its importance in the maintenance of biodiversity.
Seeps	Aquatic Biodiversity Theme	Very High	Moderate	Screening Tool Sensitivity disputed. Rational for the specialist assigned 'Moderate' rating: Although much smaller, this wetland has connectivity to the valley-bottom. Whilst exhibiting impact from the surrounding residential development, the wetlands do have importance as a biodiversity corridor and as a hydrological driver for downstream systems in a limited capacity.
		Low	Low	Rational for the specialist assigned 'Low' rating: A wetland feature was identified within this area, but it has been modified by the agricultural fields. It is not expected that there is surface water present and the vegetation within the unit is not anticipated to increase its importance as a fully functional habitat.
Artificial Drainage Features and Artificial Wetlands	Aquatic Biodiversity Theme	Low	Low	Screening Tool Sensitivity validated. Rational for specialist assigned "Low" rating: The drainage features present as excavated trenches. These drainage features exhibit flows from the TSF, or when an exceptional amount of rainfall is experienced in a short period and. Whilst they do provide an exit point for attenuated surface runoff, the features are not perceived to contribute significantly to freshwater biodiversity and the water is directed to the return-water dams or artificially excavated areas. Most of the artificial seep wetlands are sustained by the artificial channelling mentioned above and are a result of human intervention which can be infilled; hence they are not considered to exhibit natural ecological sensitivity.

Features	Screening Tool Theme	Environmental Screening Tool Sensitivity	Specialist Sensitivity	Tool Validated or Disputed by Specialist - Reasoning
In-stream Dams	Aquatic Biodiversity Theme	Very High	Moderate	Screening Tool Sensitivity disputed. Rational for the specialist assigned 'Moderate' rating: These features occur within the stream path of wetlands and therefore have connectivity to the systems. They are perceived to play an important role in provisioning benefits and hydrodynamics of the downstream wetlands. Attributed to connectivity, the features will display the same ecological sensitivity as the wetland they occur in and as such have the potential to impact on these systems.
Remaining Area	Aquatic Biodiversity Theme	High	Low	Screening Tool Sensitivity Disputed. Rational for the specialist assigned 'Low' rating: A water feature was identified within this area, but it has been completely modified by the adjacent TSF and is now fully sustained by the hydrological inputs directed into the system. The vegetation of the system has also been extensively modified which has also led to an alteration of the type and quality of habitat that is provided.
		Low	Low	Screening Tool Sensitivity Validated. Rational for the specialist assigned 'Low' rating: Much of the PAOI has been historically modified through agricultural and mining activity and is not perceived to contribute significantly to freshwater resources apart from providing hydrological inputs. No natural wetlands were identified in these areas.

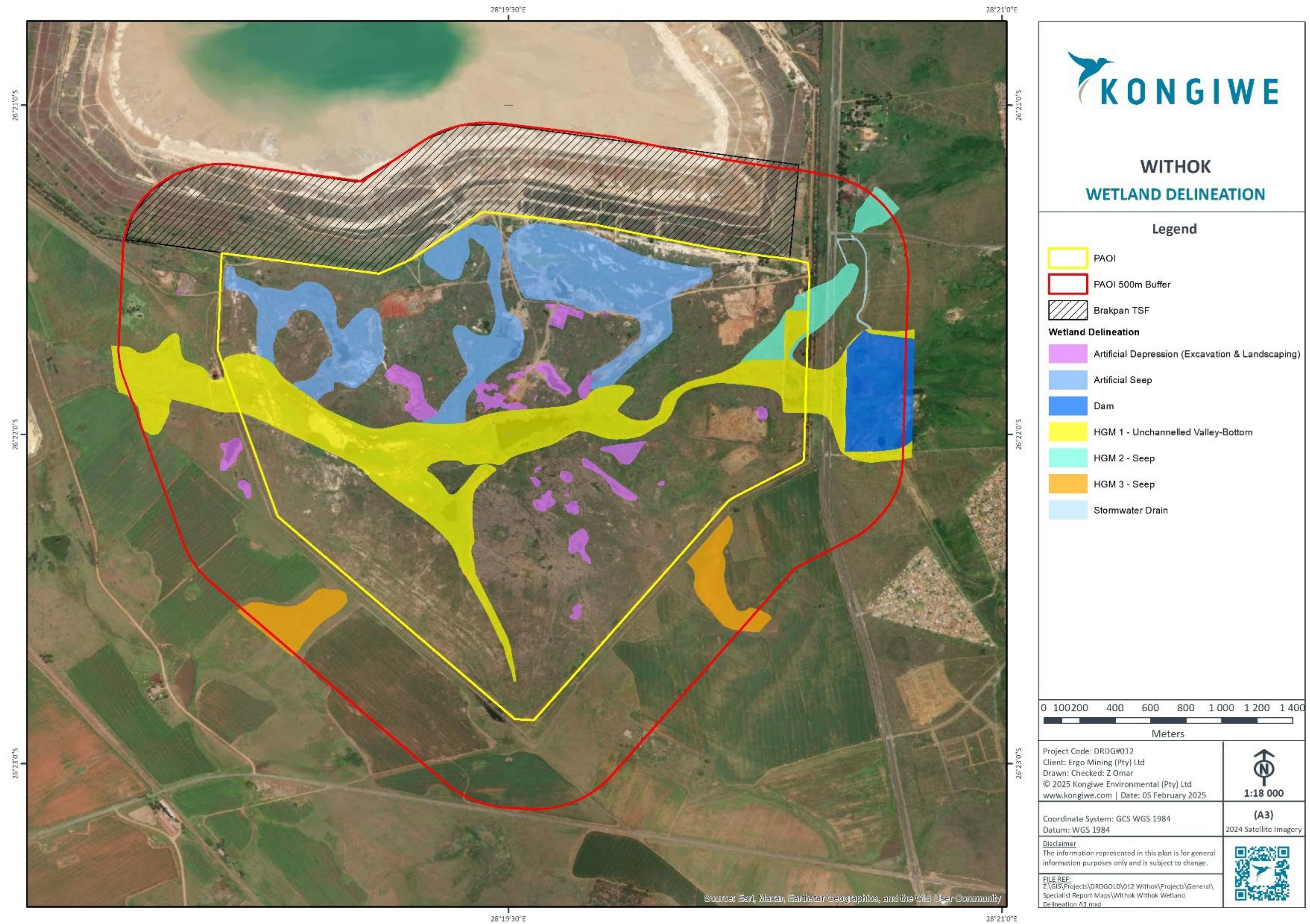


Figure 4-20: Wetlands identified

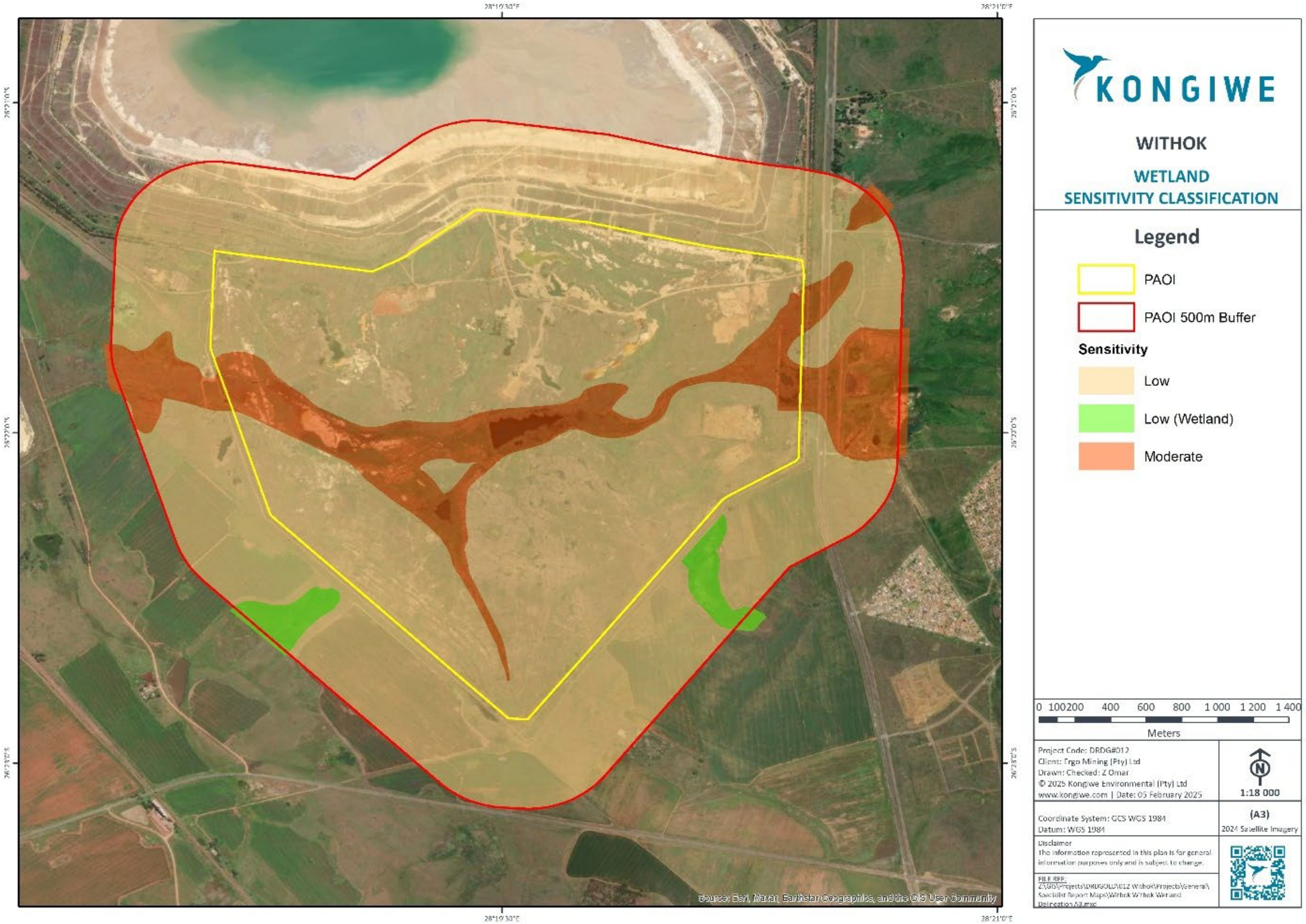


Table 4-12: Sensitivity classification of the project area of influence and respective freshwater resources

4.9 Socio – Economic Environment

The Proposed Project has the potential to result in both positive and negative social impacts. As such, it is important that the socio-economic baseline conditions are understood to ensure accurate identification and assessment of potential impacts associated with the Proposed Project.

Gauteng is the largest urban economy in Africa, with a population estimated to be 15.8 million, (Gauteng Spatial Development Framework 2030) (GSDF). In terms of land area, Gauteng is the smallest province in South Africa but also densely populated. Table 4-13 below provides an overview of the socio-economic baseline information for Gauteng province.

Table 4-13: Socio-economic baseline information: Gauteng at a glance

Description	Statistics
Demographics	
Population size	15 888 000
Population by size	Majority of the population (54.5%) is made up of the population group between the ages of 16-60.
Language	Isizulu is the most spoken language, approximately 19.8%
Migration	Approximately 93.9% of the population is born in South Africa (slightly less than the rate in South Africa)
Households	
Number of households	5 384 000, with 19.1% of the population reside in informal dwellings
Service Delivery	
Access to water services	98.4% are getting water from a regional or local service provider.
Access to electricity	82.7% have access to electricity.
Toilet facilities	88.7% have access to flush or chemical toilets.
Education	
Educational level	80.2% of individuals aged 5-24 are attending some form of schooling.
Employment	
Employment status	67% stated that they receive salaries as their main form of income
Unemployment status	37%
Economics	
Economic sectors	Manufacturing sector providing 14% of the total provincial output, followed by construction at 3%, mining at 2% and agriculture at under 0.5%.
Average annual income	R57 500 nearly double the amount in South Africa

4.9.1 Baseline description

4.9.1.1 The Local Area

The social area of influence for the project is categorized into three spheres. The immediate communities surrounding the project are considered to be within a 2km radius of the Tailings Storage Facility (TSF). This area is potentially affected by physical environmental impacts, such as dust and noise.

The local economic impacts of the project are expected to be felt in the City of Ekurhuleni (CoE) Wards 82, 99, and 112. These areas may benefit from supply-linked employment opportunities. The project's location in Gauteng province also means that the provincial economy may be impacted. At a national level, the project's macro-economic impacts, such as exports and tax contributions, are expected to be felt. These impacts have the potential to benefit the national economy (Kootbodien et al. 2020).

4.9.1.2 Socio-Economic Sensitive Areas in the Vicinity of the Project site

The project area is surrounded by various land uses. To the west, the area is characterised by degraded mining areas. Residential areas, including Villa Liza, Dawn Park, and Vosloorus, are located to the north-west and west of the project site.

Agricultural land is the primary land use to the south of the project area, with the Suikerbosrand nature reserve located approximately 12 km to the south-west. The residential area of Tsakane, located to the east of the R23, is the primary social receptor within the 2 km radius of the project area.

Additionally, agricultural areas and smallholdings to the north and north-west of the project site may be considered socially sensitive receptors due to cumulative impacts from the Brakpan TSF.

4.9.1.3 Demographic baseline

The City of Ekurhuleni (CoE) and Gauteng province have experienced high population growth rates since 2011, driven by in-migration. Ward 99, where the project is located, has a diverse population with high economic activity and a significant proportion of foreign-born residents. Despite high growth rates, Ward 99 has relatively low population densities, indicating a larger rural component

Table 4-14:: Basic Demographic of the Area,2011 and 2022

AREA	Population nr 2022	Population growth % 2011-2022	Households nr 2022	Household growth nr 2011-2022	Population density, persons/km2 2022	Average household size 2022	% Females 2022	Econ active 2022
CoE	4 066 691	2,3%	1 421 003	3,1%	2 055	2,9	48,9%	73%
CoE Ward 99	56 131	2,3%	19 543	3,1%	646	2,9	45,1%	74%

AREA	Population nr 2022	Population growth % 2011-2022	Households nr 2022	Household growth nr 2011-2022	Population density, persons/km^2 2022	Average household size 2022	% Females 2022	Econ active 2022
CoE Ward 82	36 803	2,3%	11 415	3,1%	1 438	3,2	51,3%	72%
CoE Ward 112	35 242	2,3%	10 990	3,1%	6 526	3,2	50,9%	70%
Gauteng	15 099 422	1,9%	5 318 665	2,8%	830	2,8	49,5%	72%
South Africa	62 027 503	1,7%	17 828 778	1,9%	50	3,5	51,5%	67%

Source: Stats SA, Census 2011 and 2022 Note: Ward information based on population and household growth rates in CoE since 2011

Apart from relatively high population growth rates, households also tend to split into smaller units over time resulting in household growth rates above population growth in all the local ward areas. The high growth in the number of households furthermore place extra pressure on municipal service delivery within the local area.

4.9.2 Basic Household Services

According to the 2022 Census, household service backlogs decreased nationally, as well as in Gauteng and the City of Ekurhuleni (CoE). However, a significant portion of households in CoE still lack access to basic services, including housing and water.

In Ward 99, a high percentage of the population lives in informal houses/shacks, with an estimated 6,000 households in 2011. Basic service delivery, including access to improved sanitation and regular waste services, is lacking. Approximately 31% of households in Ward 99 rely on pit latrines without ventilation, which can have negative implications for groundwater quality.

Table 4-15: Backlogs in Basic Household, Basic Services. 2011 and 2022

Category	CoE	Ward 99	Ward 82	Ward 112	Gauteng	National
Informal houses, 2022	11,9%	-	-		11,5%	11,5%
Informal houses, 2011	22,6%	43,4%	1,2%	3,2%	20,2%	20,4%
Without piped water inside the house 2022	26,2%	-	-	-	25,0%	40,3%
Without piped water inside the house 2011	42,8%	-	-	-	37,9%	53,7%
Without flushed toilets, 2022	8,8%	-	-	-	10,3%	29,2%
Without flushed toilets, 2011	13,7%	35,6%	1,4%	0,8%	14,6%	39,9%
No electricity for lighting, 2022	6,9%	-	-	-	6,8%	5,3%
No electricity for lighting, 2011	17,8%	-	-	-	12,6%	15,2%
No regular waste services, 2022	11,4%	-	-	-	15,0%	33,7%

Category	CoE	Ward 99	Ward 82	Ward 112	Gauteng	National
No regular waste services, 2011	11,6%	12,8%	3,3%	1,7%	11,7%	38,0%

4.9.2.1 Basic Education and skills level of the Labour Force

As indicated in the table below, a relatively lower percentage of the adult population in CoE is unskilled (without completed secondary schooling) in 2022, i.e. 41% compared to 50% nationally and 41% in Gauteng. The adult population in the project Ward 99 however had a much higher levels of unskilled labour namely 59%, also much higher than in the other adjacent wards.

Table 4-16: Education levels: percentage of the adult population above 21 years, 2022

Category	CoE	Ward 99	Ward 82	Ward 112	Gauteng	National
Without schooling	4%	7%	3%	5%	4%	7%
Some but less than secondary education	37%	52%	37%	45%	37%	43%
Completed secondary education	45%	39%	48%	44%	43%	38%
With tertiary education	14%	2%	12%	6%	16%	12%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Stats SA Census, 2011 and 2022 Ward information based on population and household growth rates CoE since 2011

In Ward 99, only 2% of the labour force has tertiary qualifications, indicating a shortage of skilled labour. Adjacent wards, such as Ward 82, have higher percentages of semi-skilled labour.

The area surrounding the project lacks adequate education infrastructure. Ward 99 has only 2 primary schools and 1 secondary school, with higher-than-average classroom sizes. Despite higher matric pass rates in CoE than nationally, the pass rate declined from 89% in 2017 to 85% in 2020. (Department of Basic Education, 2020

Table 4-17: Education Facilities, 2022

Category	CoE	Ward 99	Ward 82	Ward 112	National
Primary schools/10 000 people	1,5	0,4	1,4	1,4	3,8
Secondary schools/10 000 people	0,8	0,2	1,1	0,9	3,3
Pupil: educator ratio	28,4	36,5	31,9	30,7	24,9
Grade 12 pass rate (2020)	85,4%	n.a	n.a	n.a	76,2%

Source: Department of Basic Education, 2020 and 2022

4.9.2.2 Safety and Security

The project falls within the Brakpan Police precinct, with the nearest police stations being Brakpan (12km north), Tsakane (4km east), and Vosloorus (9km west).

The project falls within the Brakpan Police precinct, with the nearest police stations being Brakpan (12km north), Tsakane (4km east), and Vosloorus (9km west).

Table 4-18: Crime Statistics, 2022

Indicator	Brakpan precinct	National
Crime rate per 1000 people	32	26
Violent crimes [1)] per 1000 people	9	10
Increase in crimes (2015-2022)	-31%	-23%

Source: SAPS (2023) Including murder, attempted murder, rape, robbery, assault

The Brakpan and Tsakane areas surrounding the project have experienced violent community protests in recent years. In 2021, protests in Brakpan's Location Road Settlement involved looting and xenophobic attacks. In 2023, Tsakane residents protested against intermittent water and electricity supply, damaging public property. (SABCnews, 2023)

4.9.2.3 The Structure of the Local Economy

The CoE is the fifth-largest metropolitan economy in South Africa, with an economic output of R416 billion in 2022 and employing around 1.15 million people. The economy is dominated by finance and business services, services, and manufacturing sectors. (Stats SA,2022)

The mining sector contributes only 2.2% to the local economy and has declined at an average annual rate of 0.6% since 2008. In contrast, the finance and services sectors have experienced high growth rates. The three local wards relevant to the project area (CoE wards 99, 82, and 112) contribute around 2.4% to the jobs in the CoE municipality. Economic development in the area is centred around the Tsakane mall and includes retail, industrial, and entertainment activities. (CoE, 2021)

The main economic centres in the CoE Region E include Nigel, Carnival City, and linear development along the N17. Residents of Region E also commute to nearby areas such as Benoni, Brakpan, and Johannesburg for employment opportunities. (CoE, 2015)

4.9.2.4 The Local economic contribution of Ergo Reclamation Activities

The Recommissioning of the Withok TSF support various reclamation activities of DRDGOLD through a network of pipelines, pumping stations operated by Ergo.

DRDGOLD provides employment to 927 permanent employees and 2,155 specialist service providers. The company also creates supply-linked jobs through its spending on local suppliers and contributes R405m in income tax.

DRDGOLD has a R53m corporate social investment budget, focusing on poverty alleviation, income generation, and job creation in local areas. The Broad-Based Livelihoods Programme has reached over 8,000 participants, promoting economic activity in various sectors. (DRDGOLD, 2023)

4.9.2.5 Composition of the Labour force

The unemployment rate in the local wards adjacent to the Project was significantly higher in 2011 than the municipal and national unemployment rates, especially in Ward 99 where the project is situated. In contrast, informal employment made a relatively low contribution to employment opportunities in these wards (Stats SA, 2011).

4.9.2.6 Income and poverty levels

In 2018, poverty levels in CoE were lower than the national average and relatively low compared to other metros in South Africa. Ward 99 had the highest poverty rate, followed by Ward 112 in the Tsakane area. In contrast, Ward 82 (Geluksdal and Labore) had a significantly lower poverty rate, below the metro average.

4.9.2.7 Economic Infrastructure

The project area is surrounded by several national and provincial roads, including the N17, N3, R550, and R23. Rail infrastructure includes the Rooikop-Mapleton freight line.

The City of Ekurhuleni (CoE) has upgraded its power supply network and stabilized electricity infrastructure in various areas. CoE also plans to roll out grid-tied renewable energy, with a solar farm already established at the OR Tambo Precinct. (CoE, 2021)

4.9.2.8 Socio-Economic Development Prioritise and Initiatives

The CoE Growth and Development Strategy 2055 (CoE, 2021) identifies five strategic imperatives for the metropolitan area:

- Re-industrialise for job creation and economic growth purposes (including a focus on agricultural (export) sector; manufacturing sector, transport and logistics, tourism and investment attraction, bio-life and pharma, Research and Development, healthcare)
- Re-urbanise including the development of informal settlements policy and the establishment of a functional land invasion unit.
- Re-govern: Effective cooperative governance.
- Re-mobilise: To achieve social empowerment.

- Re-generate sustainable environmental benefit.

The Regional Spatial Development Plan for Region E of CoE (CoE, 2015) highlights the following development priorities for the region:

- **Sustainability and conservation:** This involves managing the area in an integrated manner and protecting and optimising its environmental qualities. It also concerns the retention and protection of high potential agricultural land in order to enhance sustainable food production in the area.
- **Liveability**: This involves creating a liveable urban environment, emphasising the study area's unique and special sense of place.
- **Accessibility**: This refers to using the strengths of the area to diversify and strengthen the economic base of the broader area.
- **Connectivity:** This refers to integrating movement networks linking the study area to local and regional transport routes and sub-regional residential areas.

In terms of active mining concerns in the area the plan provides the following general guidelines:

- For any mining activity detail environmental studies need to be done.
- No residential development should be permitted / allowed other than in existing urban structures.
- Employee transport required outside the metropolitan public transport services will be the responsibility of the mining company.
- All buildings on the mining land should be subjected to normal municipal management and town planning requirements.

5 Analysis and Characterization of Water Use Activity

5.1 Site Delineation for Characterisation

As described in Section1.4, the Withok TSF is situated within wards 99 and 112 of the CoE, 7 km south of Brakpan. The Proposed Project site covers approximately 400 ha. The area is predominantly surrounded by agricultural holdings, the Rooikraal TSF, the Brakpan TSF and the residential area of Tsakane. Please refer to Figure 5-1 for the Proposed Project's infrastructure map.

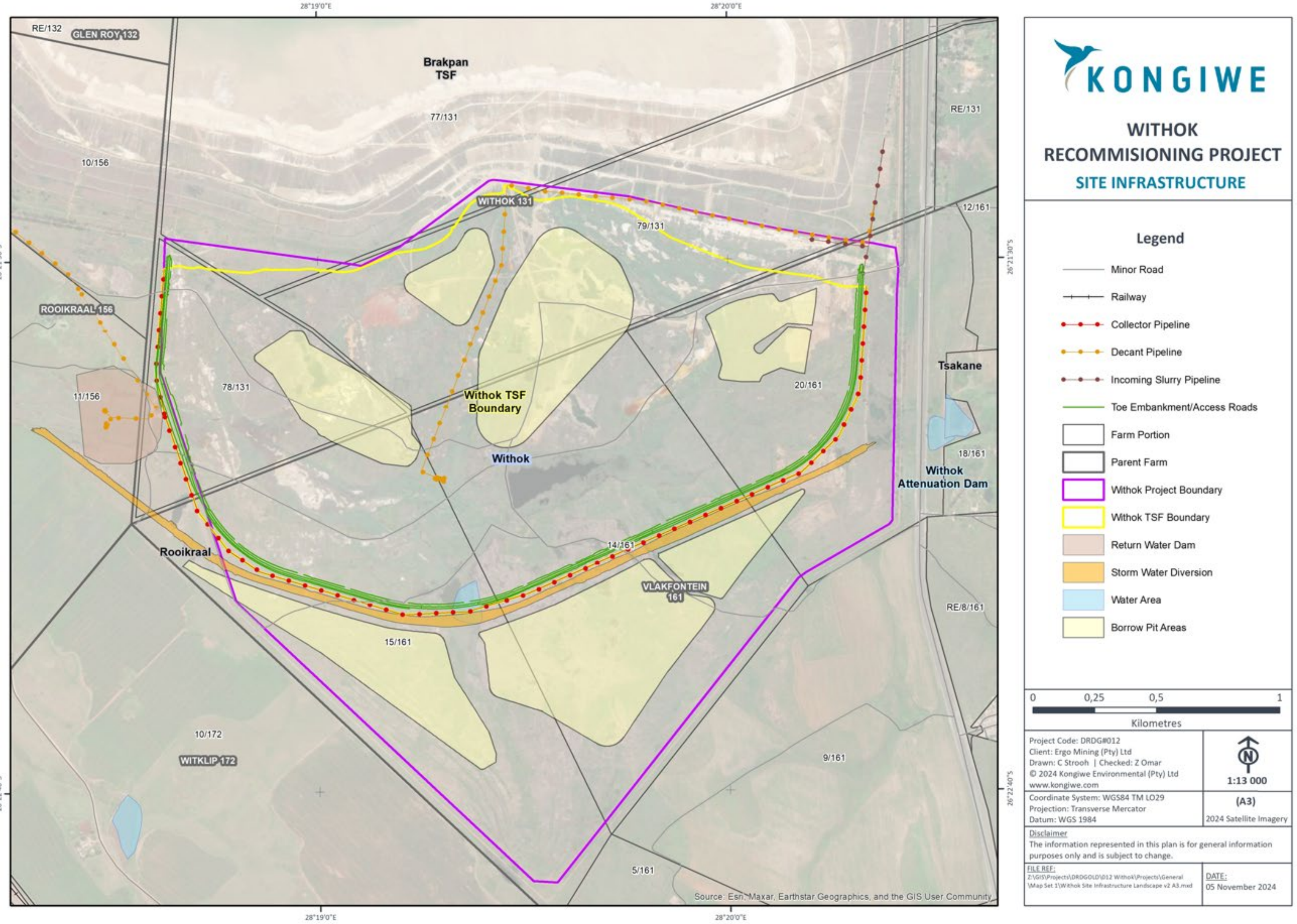


Figure 5-1: Proposed Project Infrastructure Design

5.2 Water and Waste Management

5.2.1 Water Supply

Process water for the recommissioning activity will be supplied by Ergo from the internal water network, potable water will be purchased from the municipality, with a contingency for portable JoJo tanks or connection to an existing water pipeline infrastructure.

5.2.2 Water Balance

A daily time-step GoldSim model was created to simulate the water balance of the Withok TSF complex. The model includes a stochastic rainfall generator for probabilistic analysis, a modified SCS catchment model, and a detailed reservoir model accounting for evaporation, rainfall, and stormwater inflows. The pollution control dam was sized to meet the 50-year spillage frequency requirement in accordance with GN R704 of the NWA (iLanda Water Services, 2025).

A probabilistic analysis using 300 stochastically generated rainfall sequences assessed the tailings storage facility's behavior from 2027 to 2051, with a 2-year comissioning period. The model accounts for antecedent moisture conditions and uses dynamic tailings footprints based on capacity and survey data, with a constant deposition rate of 1.3 Mtpm.

A static footprint scenario was modelled to generate a water balance diagram and calculate the average return, using the end-of-life scenario. The 105-year recorded daily rainfall data was applied to the TSF complex to determine the average water balance, which is essential for environmental authorisations and provides typical system flows for the TSF complex.

5.2.3 Drain flow Management Water

5.2.3.1 Drain flow Simulations

Drain flows are collected from the various drains and piped to a collector pipe system that runs around the perimeter of the tailings storage facility. The collector pipe system is designed so that it will flow half full, or less at peak discharge. Although the water balance shows that average drain flow is expected to be approximately 4 350 m^3/day at full basin development, the system has been designed for drain flows of 4 800 m^3/day, as stochastic seepage flows reach 4 800 m^3/day at the 99th percentile at full basin development (iLanda Water Services, 2025).

Additionally, some seepage from the Brakpan TSF is also accounted for as well as the storm water from catchment paddock number 7 discharging to manhole 8. These additional flows are discussed in the following section.

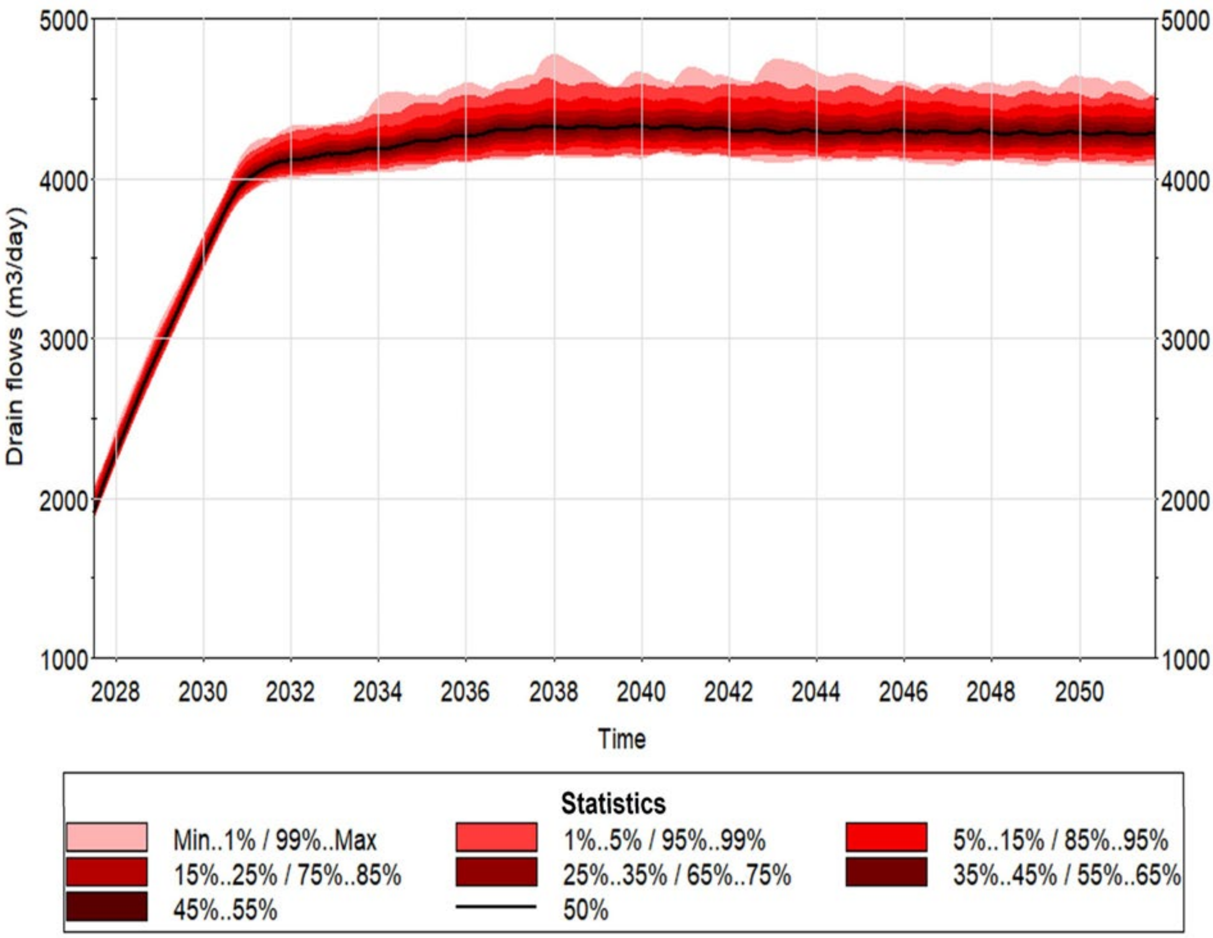


Figure 5-2: Simulated Drain

5.2.3.2 Collector pipe sizing

The collector pipe has a total length of 4 347 m. It is split 608 m / 3 739 m north / south of the outlet to the return water dam. The collector pipe has a longitudinal gradient of 1:250 (V:H). The pipe sizing is detailed below.

Table 5-1: Design Flow Rates for the Collector Pipe

Line	Total flow	Stormwater	Drain flow
Line 1 - 17(l/s)	87	40	47
Line 20 - 18 (l/s)	39	0	39*
Total (l/s)	126	40	89
Total (m^3/day)	10 900	3460	7440

5.2.3.3 Pool Management and Decant Water Results

5.2.3.3.1 Barge Decant

The barge must have a capacity of 54 000 m^3/day (3 000 m^3/hr @ 18 hrs/day). This is approximately 100% of slurry water requirements. The design storm decant times using this pumping capacity are considered acceptable and are summarised in Table 5-2.

This pump capacity is designed for operational flexibility and extreme storm management. The normal operating barge decant will be significantly less than this, as shown in the water balance outputs in Figure 5-3. The simulated barge pumping volumes are shown in Figure 5-3.

Table 5-2: Design Storm Decant Rates

Design storm	Storm volume	Decent rate	Time to decant
50-yr, 24-hr	261 500 m^3	54 000 m^3/day (3 000 m^3/hr @ 18hrs/day)	4.8 days
10 000 yr, 24-hr	673 100 m^3		12.5 days
10 000 yr, 24-hr	802 900 m^3		38.2 days

** Note: Times exclude process water pumping and meteorological losses or gains during this period*

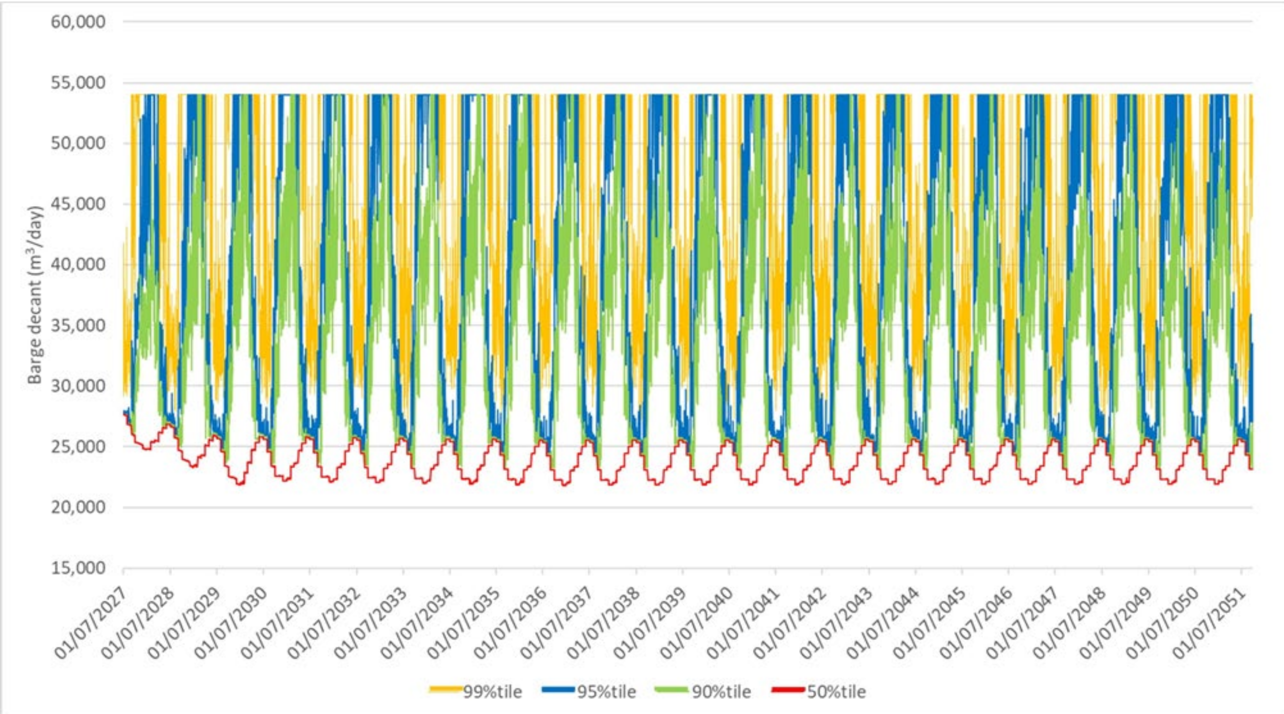


Figure 5-3: Simulated Barge pumping

5.2.3.4 Pool Management

The simulated pool storage results show that the pool storage is not excessive, and the proposed decant infrastructure is sufficient to manage the pool and provide adequate freeboard. At peak simulated pool storage, the pool is estimated to be approximately 50% of the basin capacity, assuming the basin has a capacity of 4.5 $Mm^{3.}$ The maximum simulated storage occurred as a result of a simulated storm depth of 400mm. This is equivalent to the PMP (high) storm depth.

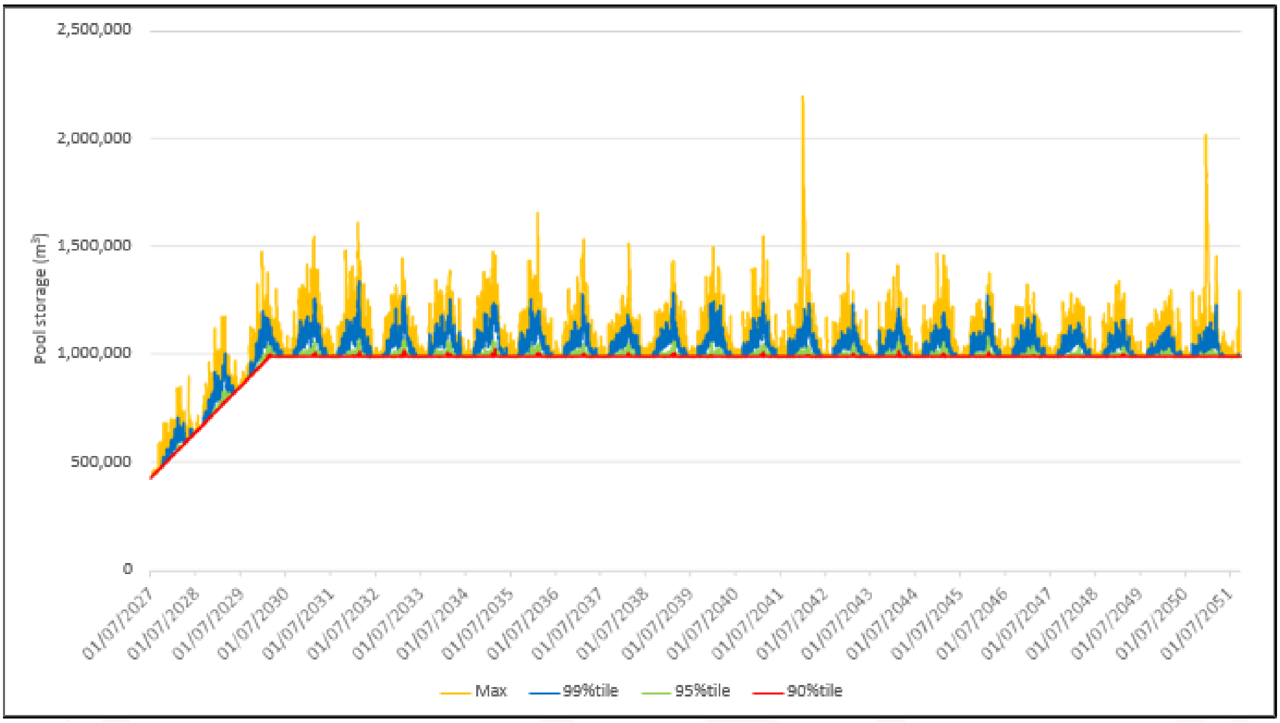


Figure 5-4: Simulated Barge pumping

5.2.4 Return Water Dam

The return water dam must have a capacity of at least 65 000 m^3 to comply with GN 704 of the South African National Water Act. This assumes that water will be returned to process at up to 9 800 m^3/day. The simulated storage is shown in Figure 5-4. The simulated pumping return to process is shown in Figure 5-6.

The inflow water to the return water dam comprises drain flow and dirty side slope water. The simulations show that return water dam storage capacity in excess of 65 000 m^3 will be utilised during periods of extreme rainfall if available. Additional storage beyond 65 000 m^3 is not required for legal compliance but will provide additional operational flexibility and is recommended.

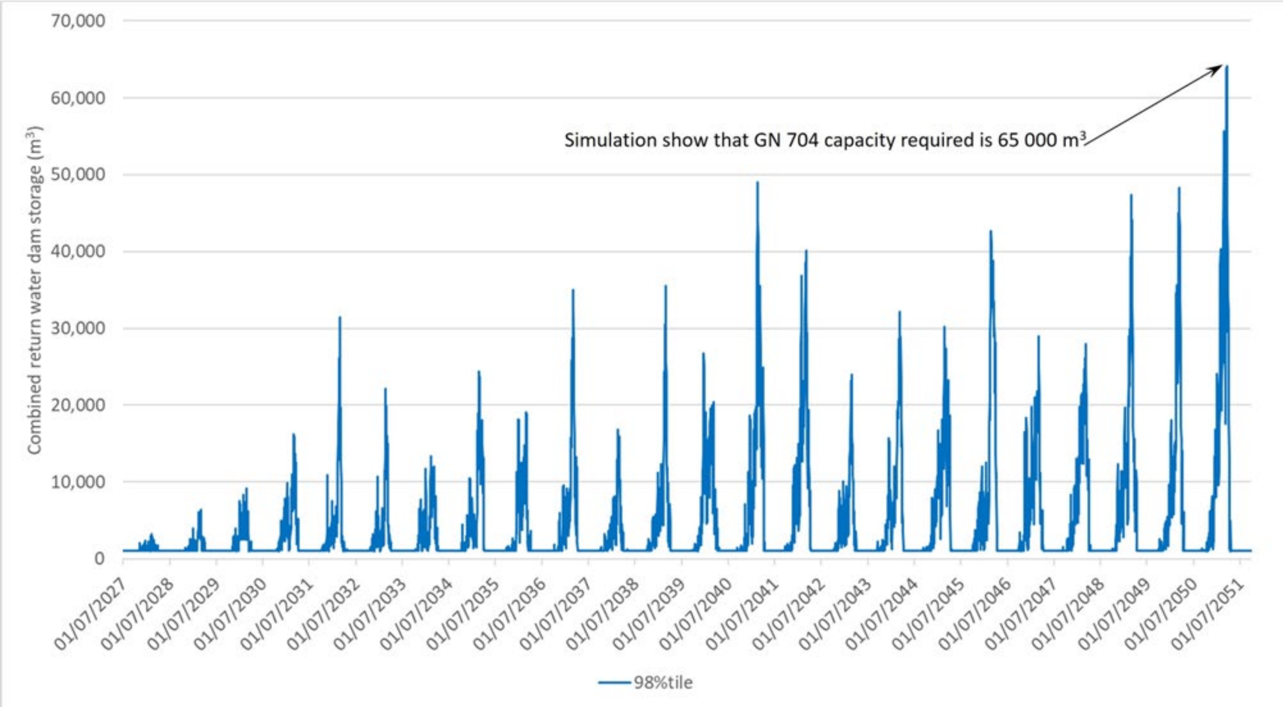


Figure 5-5: Simulated Return Water Dam Storage

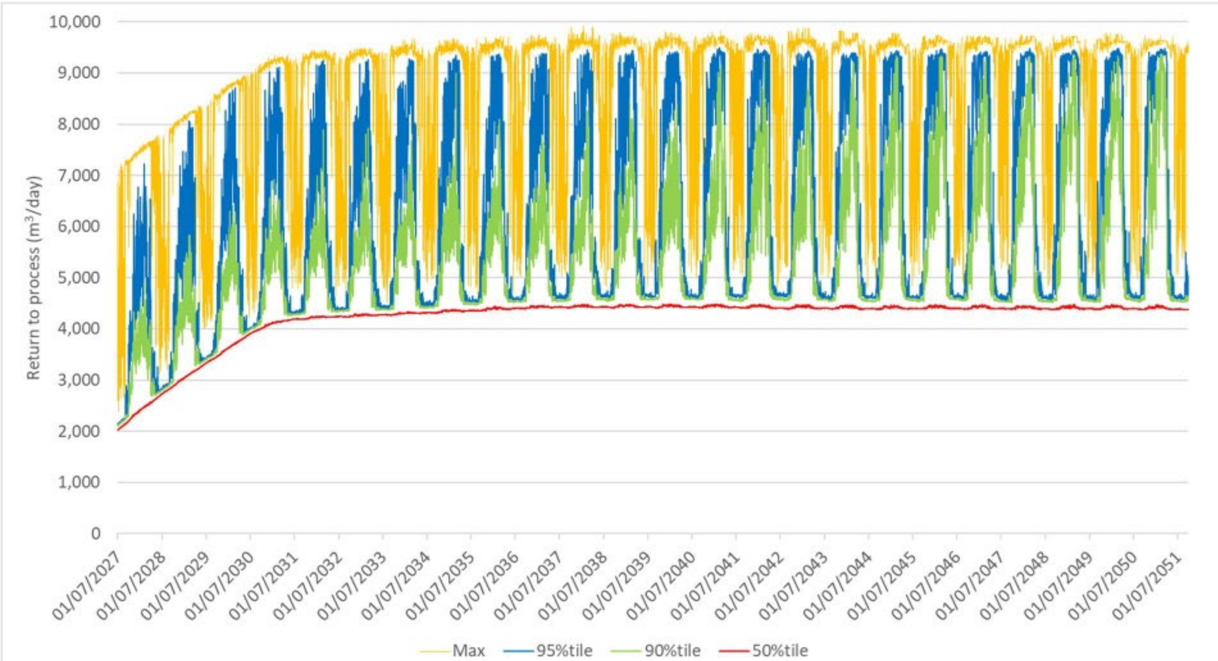


Figure 5-6: Simulated Return to Process from the Return Water Dam

5.2.5 Operational Water balance and returns

The average monthly and annual returns for the TSF at end of life are shown in Figure 5-7.

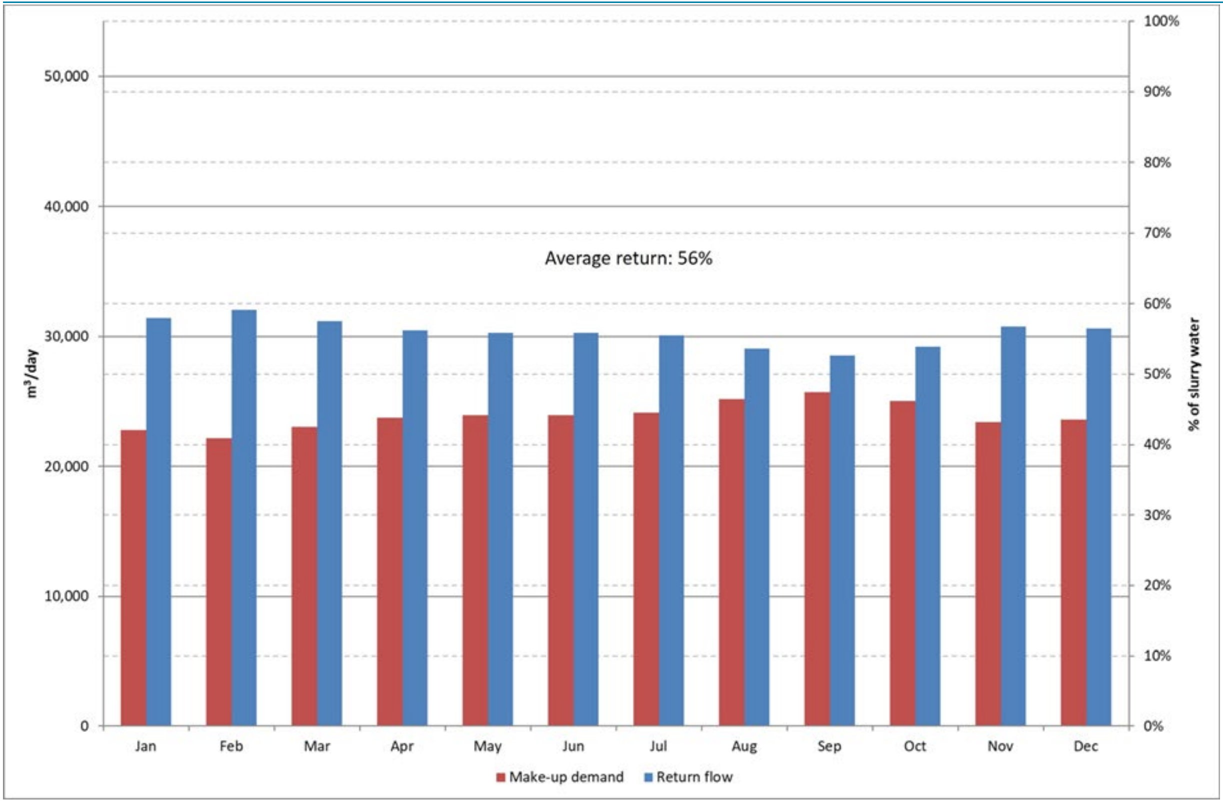


Figure 5-7: Average Monthly and Annual Returns

5.2.6 Waste Management

Waste management will be uniformly conducted for the Proposed Project.

5.2.6.1 General Waste

General waste will be stored in clearly demarcated waste skips, in designated areas on the project site. The waste will frequently be disposed of at a local municipal domestic waste handling facility. The waste skips will be demarcated as follows:

- Green: general waste;
- Black: hazardous waste; and
- Blue: steel / scrap waste.

5.2.6.2 Construction and Demolition Waste

Construction and demolition waste will involve segregating and sorting waste materials on-site into separate containers.

5.2.6.3 Hydrocarbon Waste

These waste streams will be separated and clearly labelled into categories such as hydrocarbon waste suitable for recycling (e.g., lubricating oils, transformer oils, grease, degreasing fluids) and contaminated hydrocarbon waste (e.g., rags, hydrocarbon-contaminated soil, spill clean-up materials). Good quality, non-corroded containers will be used and kept securely closed.

5.2.6.4 Tailing Waste

Tailings waste deposited within the Withok TSF will be managed using a comprehensive plan that encompasses design, construction procedures, water management, monitoring, emergency preparedness, waste minimisation, documentation, and community interaction.

5.2.6.5 Borrow Pits and Rehabilitation waste

Waste materials such as topsoil, overburden, and quarry debris will be segregated to facilitate reuse and proper disposal. Furthermore, rehabilitation planning will be integrated into the quarrying process, with a detailed plan addressing soil stabilisation, re-vegetation, and erosion control measures as well as regular monitoring and maintenance ensure the effectiveness of rehabilitation efforts.

5.2.6.6 Sewage Effluent

No sewage effluent will be generated on the project site as mobile toilets (honey suckers) will be utilised and replaced on a weekly basis.

5.2.6.7 Industrial Waste

Industrial waste will be contained in steel skips or bins and removed by licenced contractors and disposed of in a licenced industrial waste disposal site located off the project site.

5.2.7 Reuse and Recycling

The water usage strategy for the project is designed to operate as a closed water system and therefore most of water on site will be captured and re-used as much as possible, thereby creating a complete balance. This water balance operation is required to minimise the water losses that occur during operations and conserve and re-use as much water as possible to attain a closed water system. Adhering to this water balance model will produce a sustainable and socially responsible water balance scheme.

Measures will be taken to ensure that water is re-used as much as possible, these include:

- Water in the catchment paddocks as well as return water dam, as a result of seepages or rainfall will be reused for various reclamation operations and deposition activities. This will ensure that the water levels are kept at a minimum at all times.

5.3 Stormwater Water Management

Refer to Appendix F – Water Management Plan

The purpose of the conceptual Stormwater Management Plan (SWMP) is to ensure that clean and dirty water are adequately separated, by diverting clean water away from dirty areas and ensuring that dirty water from the operation is captured, contained and managed appropriately in accordance with GN R704 and DWS' best practice guidelines.

5.3.1 Stormwater Management principle

The storm water management principles are summarised as follows:

- Dirty stormwater is routed to the catchment paddocks either directly from the slope above them, or via chutes from higher up slopes.
- Dirty stormwater collected in the catchment paddocks is either evaporated or routed to the return water dam and recycled back to the process.
- All stormwater from cladded and rehabilitated areas is conveyed to the catchment paddocks using chutes. This water is managed as part of the dirty water system.
- Stormwater conveyance infrastructure is sized for the tailings storage facility at final height (1 660 mamsl). The design is modular allowing for simple capacity increases if they are required in the future.

5.3.2 External Catchment Stormwater Management

5.3.2.1 Attenuation Dam

The Withok TSF footprint is located in a drainage line flowing east to west, with a catchment area of 1 050.5 ha, primarily urbanised with the township of Tsakane. Stormwater flows into an attenuation dam, which has a capacity of 621 000 m³ and a dead storage of 1 700 m³. The dam is continuously emptied through two 450 mm steel pipes, but one pipe is partially blocked due to debris. The lack of grates on the inlet structure poses a significant risk, as debris from Tsakane could block the outlet. The dam was reported inoperable from January 2015 to May 2016. To prevent debris blockages, a grating structure should be installed, preferably made of concrete to deter theft. Additionally, the current stormwater diversion channels may be insufficient for large flood events.

5.3.2.2 Clean Stormwater Diversion Channel Sizing

5.3.2.2.1 Clean Stormwater Diversion Flood Peak

The capacity of the attenuation dam is sufficient to manage the volume of a 50-year storm, ensuring that it does not overtop. The outflow will peak at 1.7 m³/s. However, for a 100-year storm event, the dam will exceed its capacity, resulting in overflow. In this scenario, the peak outflows will reach 38.3 m³/s, or 39.3

m^3/s if only one outlet pipe is operational, based on historical instances of outlet pipe failure. The clean stormwater diversion has been designed to accommodate this peak flow.

The overflow from the attenuation dam is expected to cause flooding downstream along the R23, with no additional attenuation measures in place. Additionally, a secondary catchment area of 325 Ha, which has a shorter time to concentration, will contribute to the flow before the larger flood peak from the attenuation dam catchment. The clean diversion is appropriately sized to manage the larger flood peak of 39.3 m^3/s.

5.3.2.2.2 Clean Stormwater Diversion Channel Sizing

The regulation GN 704 requires the clean stormwater diversion channel sizing to be sized for the 50-year design storm, it was deemed prudent to oversize the channel for added capacity and safety.

According to the GN 704 regulation, the clean stormwater diversion channel is required to be sized for the 50-year design storm. However, to ensure additional capacity and safety, it was deemed prudent to oversize the channel beyond the minimum requirement. This decision provides an extra margin of safety to accommodate potential variations in storm events.

5.3.2.3 Stormwater Management between the Clean Stormwater Diversion and the Catchment Paddocks

A 28.6 ha catchment exists between the clean stormwater diversion channel and the catchment paddocks, with stormwater draining to two low points or flowing west. The section draining west should be routed via an unlined trench (gravity outflow trench) that collects clean water and flows through a clean area, making the GN 704 regulation inapplicable. A 0.5 m deep trench will convey the 50-year flood peak, but a smaller trench can also be used. This trench will discharge into the clean stormwater diversion, with armouring providing protection against turbulence.

Stormwater draining to the low points at manholes 7 and 11 must be collected and routed to the drain flow collector pipe via penstocks. Fill is required to elevate the natural ground level (NGL) by 700 mm above the collector pipe soffit, enabling penstock installation.

5.3.2.4 Southern External Catchment Stormwater Management

A 106.4 ha catchment drains to a low point along the clean stormwater diversion, forming Impoundment two. Water balance modelling indicates that this impoundment may exceed a 5 m water depth during very high rainfall events. To reduce this depth, a diversion channel (Southern clean stormwater diversion) is proposed to reroute stormwater from 63 ha of the catchment to the west. A small impoundment will be required to bridge the valley.

A smaller 38.2 ha catchment drains toward a low spot near the clean stormwater diversion, known as impoundment three. No stormwater diversions are planned for this catchment due to impracticality, the small size of the catchment, and the flat bottom of -impoundment three, which reduces water depths in the area.

5.4 Operational Management

5.4.1 Organisational Structure

Ergo has all the required skills for the Project. Staff from the existing Ergo operations will be relocated to this project.

5.4.1.1 Resources and Competence

The operational management of the recommissioned Withok TSF will be outsourced to Fraser Alexander. This includes the coordination of all activities related to the deposition of final residue ensuring efficient and uninterrupted operations. Ergo will be responsible for routine maintenance and any necessary repairs to maintain best practices. Additionally, it will implement best practices for safety and environmental compliance with regulatory standards ensuring that all operational procedures are adhered to.

Ergo has a competent Environmental Management Co-ordinator who will be responsible for the environmental management on each site.

5.4.2 Environmental Communication Strategies

Mining management is required to establish procedures for the internal communication between the various levels and functions of the organisation, and receiving, documenting and responding to environmental risks for each phase of the project will take place for the management, administrative and worker sectors of Ergo, as well as contractors. The organisation shall conduct processes for external communication on its significant environmental aspects and record its decision in line with Ergo communication policy as well as conditions stated in the EA/EMPr or WUL.

5.4.3 Stakeholder Engagement Plan

The International Finance Corporation (IFC) Performance Standard 1 (PS1) requires that a Stakeholder Engagement Plan (SEP) and Grievance Mechanism (GM) be compiled for a project. The SEP needs to provide guidance for engagement with Stakeholders. This SEP has been developed to plan engagement activities for the Proposed Project.

Although compliance with IFC standards is not required for this project, Ergo will follow best practice and provide:

- A description of the regulatory and other requirements for Stakeholder Engagement (SE);
- A summary of the applicable South African legislation;
- A list of potential stakeholders identified for the project;
- Implementation plan for further consultation during the different phases of the project;

- A proposed grievance mechanism; and
- Management functions for the implementation of the SEP and grievance mechanism.

5.4.4 Internal Communication

Internal communication is done within the Administrative Sector.

5.4.5 External Communication Strategy

The following communication channels and media can be used to communicate environmental issues to individuals who are not employed by Ergo or its subcontractors:

- **Environmental Stakeholder engagement meeting**: An Environmental Stakeholder Engagement Meeting has been established and used as a forum to keep interested and affected parties (I&Aps) informed of the significant environmental aspects identified through the Environmental Impact Assessments and Management Plans. This is also the forum where I&APs get the opportunity to raise environmental concerns. Records are kept of all decisions and concerns. The Environmental Stakeholder engagement meeting is chaired by the Manager, or another appropriately appointed competent individual.
- **Publications:** Selected publications should be produced and used to communicate environmental issues to outside parties. Examples include newsletters and annual reports.
- **Communication from External Parties and Employees:** A clear communication point is established within the company through the Ergo communication procedure that determines who is responsible for liaison with the media in respect of any crisis that may arise. A complete procedure for media liaison is available to all employees. Communication from external I&APs may be received by email, fax, telephonically or by mail. Where required, a written response will be sent, on receiving such communication, by the appropriately appointed individual under signature of the Mine Manager, to the respective interested and / or affected party. All telephonic or facsimile correspondence received must be forwarded to the relevant department for action. All events or concerns will be captured and actioned on an existing and / or future database.
- **E-mail:** E-mail communication received must be stored, with replies, in an appropriate folder on a server. E-mail messages, relevant to environmental management, should be kept for a minimum of two years before deletion.
- **Mail:** Correspondence received by mail must be filed, along with the response (where relevant), within the relevant department’s filing system for a minimum period of two years. Paper correspondence will be archived in this department.
- **Storage of Correspondence:** All original correspondence must be retained by the Mine Manager for a minimum period of three years.
- **Environmental Reports:** Copies of relevant specialist study reports and Environmental Impact Assessments will be available on request from an external party by the Tailing Manager.
- **Queries from Interested and Affected Parties:** Response to queries about environmental impacts and aspects will be addressed by the relevant department and approved by the Tailing Manager.

- **Queries and Requests from the Media**: Requests for articles from the media on environmental issues regarding the road construction will be co-ordinated by the Corporate Communication manager according to the public communication strategy, with input from the relevant department, as approved by the General Manager, in line with the Ergo Public and Community Communication and Liaison Strategy. Due to the environmental awareness generated by induction, on the job training etc., employees are able to identify environmental problems, issues, concerns and pollution timeously.

5.4.6 Evaluation of the Environmental Plan and Awareness

The evaluation of the environmental awareness and training plan will be conducted by Ergo management. This evaluation will entail the auditing of the operation in both the construction and operation phases once the proposed activity has commenced. The environmental awareness and training plan described above is sufficient to make all those involved in the project aware of those risks that may occur as well as the necessary mitigation required to minimise these risks.

The environmental awareness and training plan indicates that Ergo is serious about the well-being of the environment and empowerment of the local people. Environmental issues will be discussed at monthly meetings scheduled at the mine.

5.4.7 Emergency Incident Reporting

Environmental incident reporting is a vital part of communication in the project. Employees are required to report any and all environmentally related problems, incidents and pollution, so that the appropriate litigator action can be implemented timeously. In the event of an environmental incident, the incident must be reported according to the Incident Reporting Procedure.

An Emergency Incident Preparedness and Response Plan needs to be developed

5.5 Monitoring and Control

5.5.1 Surface Water Quality Monitoring

A surface water quality monitoring programme is essential as a management tool to detect negative water quality impacts as they arise and to ensure that the necessary mitigation measures are implemented.

Based on the impact assessment and surface water quality data, the following surface water monitoring program is recommended:

- Water quality sampling should be done monthly, as is currently the case, at the locations shown in Figure 5-8.

Three additional monitoring locations should be considered:

- A: On the Rietspruit upstream of its confluence with the Withokspruit. This will allow distinction between Brakpan influences and Rietspruit influences. Withok TSF complex wated will share infrastructure with the Brakpan TSF, so this is relevant.
- B: Downstream of the Withok TSF complex to determine impacts by the Withok TSF complex.
- C: On the Rietspruit downstream of any potential Withok TSF complex impacts. The Rooikraal TSF is being remined. While the Rooikraal TSF footprint is likely to remain contaminated for some time, this monitoring point will also provide an indication of the impacts of this footprint. It is acknowledged that the Rooikraal TSF footprint is outside of the scope of work for this project.

The current parameters being monitored are considered acceptable and should be continued.

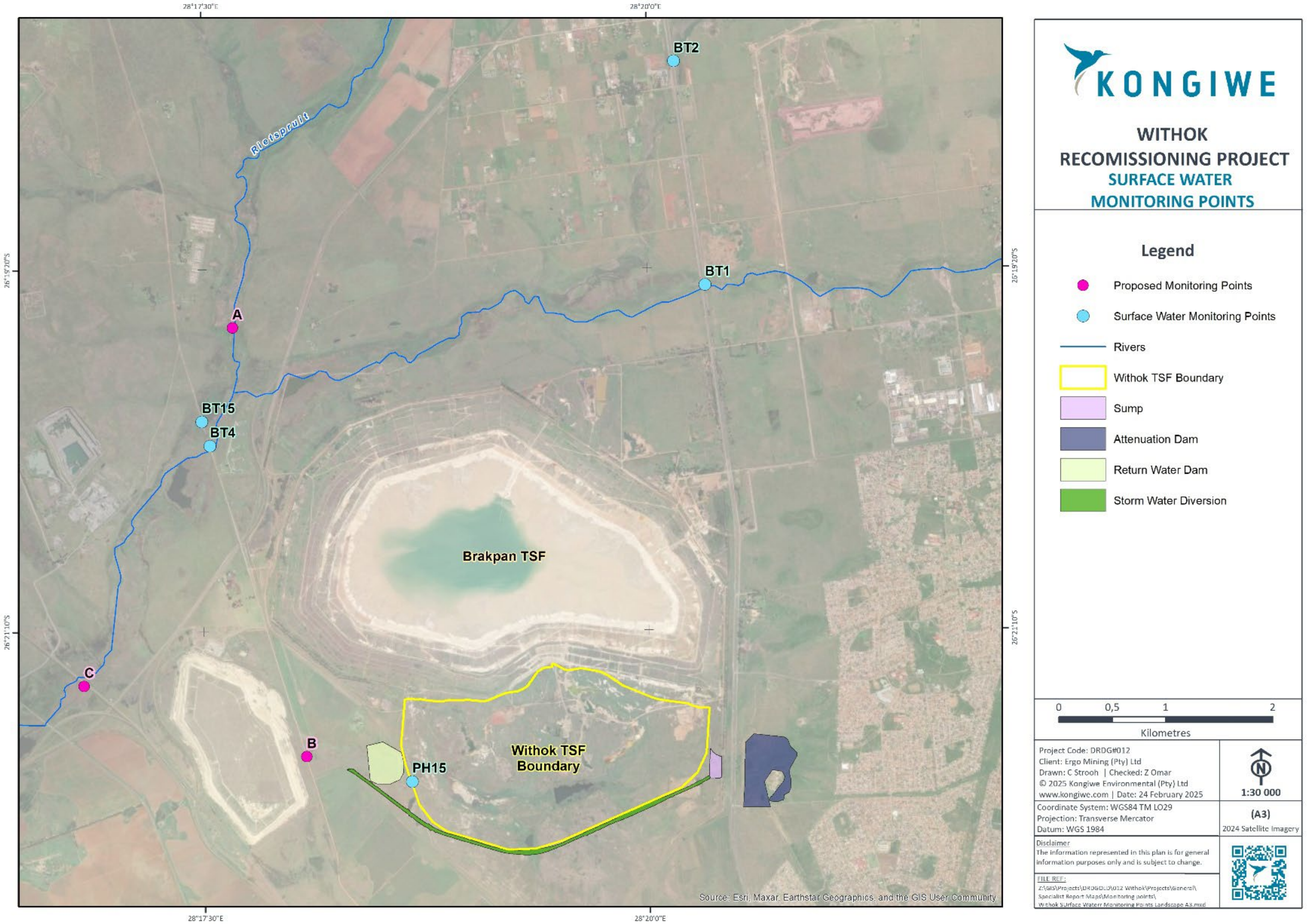


Figure 5-8: Surface Water Monitoring Locations

5.5.2 Stormwater Infrastructure

Water infrastructure should be monitored on a quarterly basis during the dry season, and on a monthly basis during the wet season. They should further be monitored immediately after any large storm events. Should blockages, silted up structures or breaches occur, immediate action should be undertaken to remove debris and repair breaches. Monitoring should be undertaken by the onsite Environmental Control Officer (ECO) or maintenance manager. Inspections must be recorded and should include the following:

- Date of inspection;
- Rainfall amount received prior to inspection;
- Photographs of blockages, silted up structures or breaches witnessed;
- What action was undertaken to fix issues, and the amount of time taken to address them; and
- Photographs post action taken.

Inspection reports should be kept ready and supplied to the DWS when requested, or as part of the WUL conditions.

5.5.3 Groundwater Monitoring

To monitor and prevent the spread of groundwater contamination, groundwater management procedures and practices have to be implemented that are in line with accepted practices and in accordance with the requirements of the Environmental Management Plan (EMP). It is recommended to implement the groundwater monitoring programme presented in this report. The key objectives of the groundwater monitoring programme are to:

- Detect short and long-term trends;
- Recognise changes in groundwater quality and levels;
- Measure impacts and define mitigation measures; and
- Develop improved monitoring systems.

Delta H proposes the drilling of 5 additional monitoring boreholes (NN1 to NN5) to better delineate the existing Brakpan TSF seepage plume, especially towards the Withokspruit. Based on observed concentrations, the monitoring boreholes should potentially be converted into interception wells

5.5.3.1 Monitoring Locations

The approximate locations of the proposed monitoring boreholes are given in Table 5-3. It must be emphasised that the locations of these new monitoring boreholes are only approximate locations based on predicted flow and transport directions, and that they will need to be refined based on ground geophysics and other infrastructure or safety concerns. The exact location of each monitoring borehole will require ground truthing and should be aided by geophysical methods to detect potential preferential flow paths.

Table 5-3: Approximate coordinates of proposed additional Brakpan TSF monitoring boreholes.

X	Y	ID
-69060	-2913970	NN1
-68775	-2913690	NN2
-69100	-2913670	NN3
-69400	-2916600	NN4
-65825	-2916420	NN5

The monitoring boreholes should be drilled at the approximate locations indicated in Figure 5-4 and given in Table 5-3.

- be accurately sited based on ground geophysics.
- be drilled to a depth of 40 m or the bottom of the weathered zone (plus 5 m into un-weathered rocks).
- be drilled with a final completion diameter (uPVC) of at least 165 mm (to allow for pumping equipment)
- be designed so that they can be equipped with a pump (i.e. suitable gravel pack, slotted casing and secure surface layout)

The recommendations above enable the monitoring boreholes to be transformed into abstraction/interception boreholes should environmentally critical concentration thresholds be breached in the future. It goes without saying that any proposed abstraction must be preceded by an application to the Department of Water and Sanitation for the required permissions.

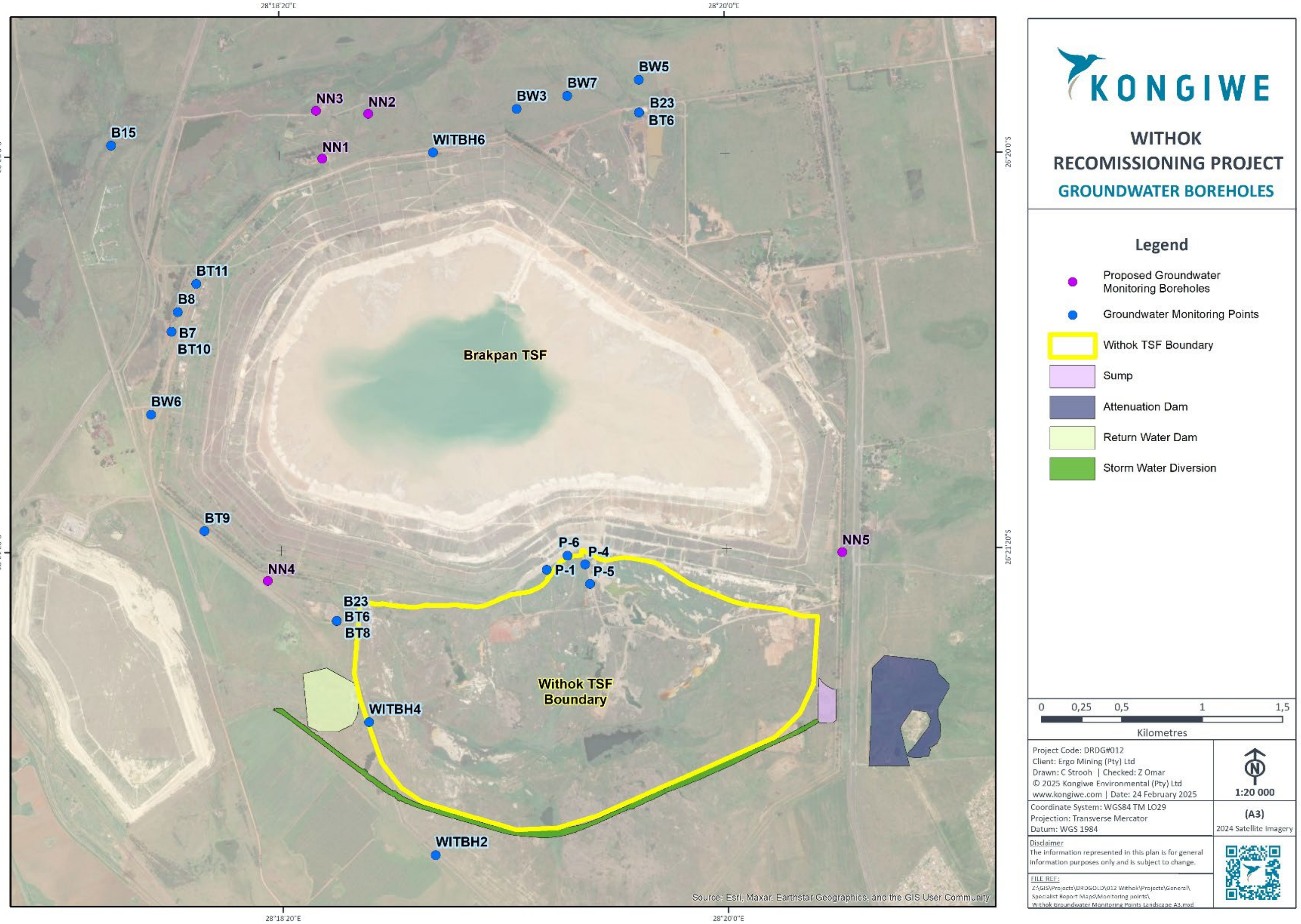


Figure 5-9: Groundwater monitoring boreholes.

5.5.3.2 Monitoring frequency

The following monitoring frequencies are recommended for the interception wells throughout the life of the TSF:

- Continuous real time monitoring of water levels, providing input to a digital algorithm to control abstraction rates
- Weekly calibration of abstraction rates with key indicator water quality measurements
- Monthly full spectrum analysis (Table 5-4).

The following independent confirmatory monitoring frequencies are recommended for monitoring boreholes during the construction and life of the TSF:

- Water levels: Monthly
- Water qualities: Quarterly
- The following monitoring frequencies are recommended post closure:
- Water levels: Quarterly
- Water qualities: Quarterly
- The monitoring frequency should be reviewed every 5 years post closure.

Table 5-4: A list of groundwater parameters to be monitored.

Description	Parameter	Comments
Potential heads	Static groundwater levels	Measured in metres below ground level (mbgl) and converted into metres above mean seal level (mamsl). Collar elevations of the boreholes need to be considered.
Physico-chemical parameters, field	pH, Electrical Conductivity (EC), Temperature, Redox-Potential (mV), colour and smell (if any)	Parameters to be measured during sampling in the field, should stabilize before sample is retrieved
Physico-chemical parameters, laboratory	pH, Electrical Conductivity (EC), Temperature, Redox-Potential (mV)	To assess deviations from field measurements
Major elements	Ca, Mg, Na, K, Total Alkalinity, SO_4, NO_3, NH_3, Total N, Cl, Total Dissolved Solids (TDS), CN (total and free)	Normal suite of parameter, NH3 and total N included due to redox sensitivity
Trace elements	Al, As, B, Ba, Cd, Co, Cr, Cu, F, Fe, Mn, Mo, Ni, Pb, U, Zn	Samples to be filtered and acidified on-site.

The following recommendations apply to the monitoring protocol for the TSF:

- The static groundwater levels should be measured in the boreholes without any preceding abstractions (obviously not applicable for interception wells).
- The boreholes should be purged (replacing approximately three times the stagnant water within the borehole) until the physico-chemical parameters stabilize and are determined. Samples for analysis should be retrieved after stabilization of the field parameters.
- Interception wells do obviously not need to be purged and can be sampled directly.
- Suitable sample containers should be utilised for the sample collection, i.e. plastic or glass containers for major elements and plastic or boron-glass containers for minor and trace elements.
- Samples for trace element analysis should be filtered and acidified ($HNO3$, $pH < 2$) on-site.
- Sample collection including determined physico-chemical parameters should be documented in a sample protocol for each site and signed off by the sampling personnel as part of the chain of custody.
- The samples should be delivered to an accredited laboratory as soon as possible for analysis of the above parameters.

5.5.3.3 Quality Assessment and Quality Control

Quality assurance means:

- Developing a system of activities to ensure that measurements meet defined standards of quality with a stated level of confidence;
- Defining monitoring objectives, quality control procedures to be followed and quality assessment;
- To define data quality objectives, including accuracy, precision, completeness, representativeness, and comparability; as well as
- Designing a network, selecting sampling sites, selecting instruments and designing the sampling system, as discussed above.

All monitoring equipment must be maintained as required, and calibration must be undertaken on a regular basis.

To ensure that the Groundwater Monitoring Strategy complies with the above, it is important that analytical laboratories used should be accredited for each type of analysis required, to ensure that accurate analytical methods are used.

While only one or two of the common major ions found in waters may be specified as key indicators, it is necessary to analyse for the full suite of common ions for quality control purposes and to detect discrete events and long-term trends in anion composition.

Special attention must be paid to sampling methods and to preservation and handling of samples prior to analysis. pH and conductivity must be measured in the field.

Close attention must be given to siting, logging and construction of monitoring boreholes and assessment of their condition must be made quarterly.

The following sampling protocol is proposed:

- Sterilised plastic bottles, with a plastic cap and no liner within the cap are required for the sampling. Sample bottles should be marked clearly with the borehole name, date of sampling, water level depth and the sampler's name;
- Water levels should be measured prior to taking the sample, using a dip meter (mbgl);
- Each borehole to be sampled should be purged (to ensure sampling of the aquifer and not stagnant water in the casing) using a submersible pump or a clean disposable polyethylene bailer. At least three borehole volumes of water should be removed through purging; or through continuous water quality monitoring, until the electrical conductivity value stabilizes;
- The following field measurements should be recorded on a field form for each sampling point: pH, EC and temperature;
- Samples should be kept cool in a cooler box in the field and kept cool prior to being submitted to the laboratory; and
- The pH and EC meter used for field measurements should be calibrated daily using standard solutions obtained from the instrument supplier.

5.5.4 Biomonitoring

The monitoring requirements for the project that must be included in the Water Use Licence Authorisation must make provision for the following:

An independent specialist must monitor the site bi-annually (once in the wet season and once in the dry season).

5.5.5 Waste Monitoring

Waste will be monitored in accordance with Ergo's Waste Policy. Waste streams identified will be separated so as to monitor the quantities of different waste streams that are generated and disposed of.

6 Risk Assessment / Best Practice Assessment

This Subchapter serves to provide insight on the major positive, negative and cumulative impacts associated with the Project. The potential impacts are discussed per environmental feature/ aspect. For more detail, please refer to the specialist study contained in the appendices.

6.1 Construction Phase

Ergo Mining will commence with the pre-construction and construction phase for its project related infrastructure in line with its approved environmental authorisations.

6.1.1 Biodiversity

The following potential impacts were considered on biodiversity (flora and fauna) during the construction phase:

- An impact to local vegetation and habitats;
- The spread of alien species;
- The impact of erosion;
- The impact from pipeline leak or spills; and
- The generation of noise, dust, and waste.

Table 6-1: Assessment of significance of potential construction impacts on vegetation and habitats.

Impact Name	Vegetation and Habitats		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Laydown and construction preparation activities (such as cement mixing, temporary toilets, etc.) must be limited to already modified areas and should take up the smallest footprint possible. • Develop post-mining environments, in conjunction with regional development plans; and the recreation of habitats, where possible; or structure altered landscapes to be compatible with regional habitats. • Areas of indigenous vegetation, even secondary communities outside of the direct project footprint, should not be fragmented or disturbed further if possible. • All vehicles and personnel must make use of existing roads and walking paths as far as possible, especially construction/operational vehicles. • The clearing of vegetation must be minimised where possible. All activities must be restricted to within the authorised areas.			

Impact Name	Vegetation and Habitats
• All laydown, chemical toilets etc. should be restricted to disturbed areas and not be placed in sensitive areas. Any materials may not be stored for extended periods of time and must be removed from the project area once the construction/closure phase has been concluded. • A hydrocarbon spill management plan must be put in place to ensure that should there be any chemical spill out or over that it does not run into the surrounding areas. A TSF operational plan must be put in place to avoid tailings spillage. The Contractor shall be in possession of an emergency spill kit that must always be complete and available on site. ○ Drip trays or any form of oil absorbent material must be placed underneath vehicles/machinery and equipment when not in use. ○ No servicing of equipment on site unless necessary. ○ All contaminated soil / yard stone shall be treated in situ or removed and be placed in containers. ○ Appropriately contain any generator diesel storage tanks, machinery spills (e.g., accidental spills of hydrocarbons oils, diesel etc.) in such a way as to prevent them from leaking and entering the environment. ○ Construction activities and vehicles could cause spillages of lubricants, fuels and waste material negatively affecting the functioning of the ecosystem. ○ All vehicles and equipment must be maintained, and all re-fuelling and servicing of equipment is to take place in demarcated areas outside of the PAOI. • The removal removes of any indigenous plant species from the PAOI or bringing any alien species in must be discouraged. This is to prevent the spread of exotic or alien species or the illegal collection of plants. • All construction waste must be removed from site at the closure of the construction phase. • Precautions must be taken against erosion damage that would be caused by unplanned pipe leaks. A leak warning and detection system must be installed. Dense indigenous pioneer grass seeds should also be planted across all bare earth areas to prevent erosion.	
Environmental Risk Significance (Post-mitigation)	Low -
Cumulative Impacts	No

Table 6-2: Assessment of the significance of potential construction impacts on fauna.

Impact Name	Fauna		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• The ecosystem present must be preserved, this includes areas not directly affected by project activities, and can be achieved by limiting project • Rehabilitation plans must be initiated during construction to minimise disturbed areas.			

Impact Name	Fauna	
• Follow any local and national policies and plans regulating and protecting biodiversity in the project area. • Clearing and disturbance activities must be conducted in a progressive linear manner, always outwards and away from the centre of the PAOI and over several days, so as to provide an easy escape route for all small mammals and herpetofauna. • The areas to be disturbed must be specifically and responsibly demarcated to prevent the movement of staff or any individual into the surrounding environments, signs must be put up to enforce this. • The duration of the activities should be minimised to as short a term as possible, to reduce the period of disturbance on fauna. • Noise must be kept to an absolute minimum during the evenings and at night to minimise all possible disturbances to reptile species and nocturnal mammals. • No trapping, killing, or poisoning of any wildlife is to be allowed and signs must be put up to enforce this. Monitoring must take place in this regard. • Outside lighting should be designed and limited to minimise impacts on fauna. All outside lighting should be directed away from any sensitive areas. • All construction and maintenance motor vehicle operators should undergo an environmental induction that includes instruction on the need to comply with speed limits, to respect all forms of wildlife. Speed limits must be enforced to ensure that road killings and erosion is limited. • Any holes/deep excavations must be dug in a progressive manner and shouldn't be left open overnight. Should any holes remain open overnight they must be properly covered temporarily to ensure that no small fauna species fall in. Holes must be subsequently inspected for fauna prior to backfilling. • If fencing is required: wildlife-permeable fencing with holes large enough for mongoose and other smaller mammals should be installed, the holes must not be placed in the fence where it is next to a major road as this will increase road killings in the area.		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

Table 6-3 Assessment of significance of potential construction impacts of alien plant species

Impact Name	Alien Plant Species		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• An Alien Invasive Plant (AIP) Management Plan must be compiled and implemented. This should regularly be updated to reflect the annual changed in AIP composition. • The footprint area of the construction should be kept to a minimum. The footprint area must be clearly demarcated to avoid unnecessary disturbances to adjacent areas. Footprints of the roads must be kept to prescribed widths.			

Impact Name	Alien Plant Species
• Early identification and Eradication: regular monitoring to detect invasive species on site, early and promptly removing them before they spread,	
Environmental Risk Significance (Post-mitigation)	Low -
Cumulative Impacts	No

Table 6-4: Assessment of significance of potential construction impacts of waste management.

Impact Name	Waste Management		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Waste management must be a priority, and all waste must be collected and stored effectively and responsibly according to a site-specific waste management plan. Dangerous waste such as metal wires and glass must only be stored in fully sealed and secure containers, before being moved off site as soon as possible. • Litter, spills, fuels, chemical and human waste in and around the PAOI must be minimised and controlled according to the waste management plan. • Toilets at the recommended Health and Safety standards must be provided. These should be emptied regularly and once no longer required, they must be pumped dry to prevent leakage into the surrounding environment and removed from site. • The Contractor should supply sealable and properly marked domestic waste collection bins and all solid waste collected shall be disposed of at a licensed disposal facility • Refuse bins will be responsibly emptied and secured. Temporary storage of domestic waste shall be in covered and secured waste skips.			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-5: Assessment of significance of potential construction impacts of erosion.

Impact Name	Erosion	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature	Negative	Negative
Magnitude	Moderate -	Minor -
Duration	Short Term	Short Term

Impact Name	Erosion	
Scale	Site or local	Site or local
Probability	Possible	Possible
Environmental Risk Significance (Pre-mitigation)		Medium -
Management Measures:		
• Speed limits must be put in place to reduce erosion. Soil surfaces must be wetted as necessary to reduce the dust generated by the project activities. Speed bumps and signs must be erected to enforce slow speeds. • Only existing access routes and walking paths may be made use of. • Areas that are denuded during construction need to be re-vegetated with indigenous vegetation to prevent erosion during flood events etc. • A stormwater management plan must be compiled and implemented if necessary. • Regular monitoring and maintenance of erosion control measures are essential to ensure their effectiveness.		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

Table 6-6: Assessment of significance of potential construction impacts of pipeline leaks and spills.

Impact Name	Pipeline Leaks or Spill	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature	Negative	Negative
Magnitude	Moderate -	Minor -
Duration	Short Term	Short Term
Scale	Site or local	Site or local
Probability	Possible	Possible
Environmental Risk Significance (Pre-mitigation)		Medium -
Management Measures:		
• Leak detection or any similar monitoring tool must be incorporated to try identifying leaks. • Use proper design and construction; use geographical maps, aerial photography, and satellite imagery to avoid geo-hazards along pipeline routes; ensure that compressors, pumps and surge suppression equipment are correctly sized. • Develop and implement comprehensive emergency response plans to minimize the impact of any leaks or spillages • Perform regular maintenance and proactive repairs on identified “at-risk “areas to prevent failures		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

6.1.2 Wetlands

The assessed wetlands exhibit impacts at local scale. These impacts result from present and historical land use relating to agricultural practices, developing in or in near proximity to wetlands and mining activities which have transformed the wetland habitats and has altered their natural hydrological regime and vegetation composition. The list below refers to the present-day local impacts observed within the assessed wetland areas:

- Wetland disturbance from grazing activities and other agricultural practises (crop fields);
- Altered hydrological inputs resulting from changes to the surrounding landscape;
- Altered geomorphology from historical agricultural practices;
- Loss of wetland vegetation from continual disturbances, historical land use and the establishment of alien invasive flora species in some approaches of the wetlands; and
- Wetland degradation from mining activities.

Table 6-7: Mitigated DWS Risk Assessment Matrix for wetlands in relation to the proposed development.

Activity	Impact	Significance (max = 100)	Risk Rating
Clearing of vegetation and site preparation to facilitate the development of the TSF	Loss of wetland area	**57**	**M**
	Altering surface flow patterns	**36**	**M**
	Erosion of surrounding landscape and subsequently the watercourses	**24**	**L**
	Sedimentation and siltation of watercourses	**28,8**	**L**
	Proliferation of invasive alien plants	**24**	**L**
Excavating and reshaping for the Banks of the TSF	Altering surface and subsurface flow patterns	**30**	**M**
	Erosion of surrounding landscape and subsequently the watercourses	**19,2**	**L**
	Sedimentation and siltation of watercourses	**24**	**L**
Soil stockpiling	Altering surface and subsurface flow patterns	**18**	**L**
	Erosion of surrounding landscape and subsequently the watercourses	**14,4**	**L**
	Sedimentation and siltation of watercourses	**14,4**	**L**
Storage of chemicals, mixes and fuel	Impaired water quality from spills and leaks	**10,8**	**L**

Activity	Impact	Significance (max = 100)	Risk Rating
Operation of heavy machinery and equipment within and in proximity to wetlands	Altering surface flow patterns through hardened surfaces	24	L
	Erosion of surrounding landscape and subsequently the watercourses	19,2	L
	Sedimentation and siltation of watercourses	14,4	L
	Wetland vegetation disturbance and proliferation of invasive alien plants	14,4	L
	Impaired water quality from spills and leaks	10,8	L
Installation and assembly of subsurface drainage systems	Altering surface and subsurface flow patterns	33	M
Backfilling of residual excavated areas	Altering surface and subsurface flow patterns	24	L
	Erosion of surrounding landscape and subsequently the watercourses	19,2	L
	Sedimentation and siltation of watercourses	14,4	L
Dewatering excavated areas in relation to water accumulation from rainfall and stormwater management and releasing water into the environment	Temporary alteration of hydrology within watercourse	19,2	L
	Erosion of watercourses from concentrated flows	19,2	L
	Sedimentation and siltation of watercourses	19,2	L
Domestic and industrial waste	Wetland degradation	9,6	L
	Impaired water quality	10,8	L
Ablution facilities	Impaired water quality from spills and leaks	16,2	L

6.1.3 Surface Water

Table 6-8: Summary of activities and impacts for the construction phase

Activity	Impact Description
Impacts due to topsoil stripping	Excessive silt washed into water courses
Impacts due to wash bays and workshops	Hydrocarbons and other pollutant washed into water courses
Impacts due to vehicle fleet-related pollution	Hydrocarbons and other pollutant washed into water courses

The ratings and proposed mitigation measures for the construction phase are provided in Table 5-17.

Table 6-9-: significance rating for the construction phase

NATURE OF IMPACT: Excessive washed into water courses, Hydrocarbons and other pollutant washed into water courses, Hydrocarbons and other pollutant washed into water courses.		
	Impact Rating without Mitigation	**Impact Rating with Mitigation**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Short term	Short term
Magnitude *(Major, Moderate, Minor)*	Moderate	Minor
Probability *(Definite, Possible, Unlikely)*	Possible	Possible
Calculated Significance Rating (Low, Medium, High)	**Medium**	**Low**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Irreversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	Yes	
Residual impacts • None foreseen		
Mitigation measures • Clearly define areas to be cleared. Do not clear past designated areas. Dry season construction is preferable where practical. • Wash bay discharge water should flow through an oil separator. • All vehicles should be well maintained and inspected for hydrocarbon leaks weekly. Fuel depots and refuelling areas. • should be bunded. Vehicle maintenance should be a key performance objective of the plant contractor.		

6.1.4 Groundwater

The most significant groundwater impacts that could potentially arise from the construction phase are as follows:

- Construction activities are only associated with the preparation of the ground for the lined Withok extension.

- Potential contamination of shallow groundwater resources due to accidental hydrocarbon or other chemical spillages from vehicles and operational activities might occur. Spillages are commonly minor and localised.

Table 6-10: Construction Phase water quality impacts

NATURE OF THE IMPACT: Accidental hydrocarbon or other chemical spillages from construction vehicles. Localised impacts on ambient groundwater quality due to accidental spillages		
	Impact Rating Without Mitigation	**Impact Rating with Mitigation**
Impact Status: (positive or negative)	**Negative**	**Negative**
Extent *(Local, Regional, International)*	Local	Local
Duration *(Short term, Medium term, Long term)*	Medium term	Short term
Magnitude *(Major, Moderate, Minor)*	Moderate -	Minor -
Probability *(Definite, Possible, Unlikely)*	Possible	Possible
Calculated Significance Rating (Low, Medium, High)	**Low**	**Low**
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Cumulative impacts (yes or no)	No	
Residual impacts - None		
Mitigation measures - Develop and maintain a Standard Operating Procedure to contain and remediate any accidental hydrocarbon or other chemical spillages. - Contain spillage using spill kits, excavate and dispose of contaminated material/soil at accredited disposal site.		

6.2 Operation Phase

This section comprises of the description of potential impacts associated with the proposed operation of the recommissioning project on the biophysical, socio-economic and heritage and cultural environment. These descriptions are followed by the impact tables which contain the assessment of the significance of each identified impact without, and then with mitigation measures.

6.2.1 Biodiversity

The following potential impacts were considered on biodiversity (fauna and flora) during operational phase:

- An impact to local Vegetation and Habitats;
- The spread of Alien Species;
- The impact of Erosion;
- The impact from Pipeline Leak or Spills; and
- The generation of dust, Noise and waste.

Table 6-11: Assessment of significance of potential operational impacts on vegetation and habitats.

Impact Name	**Vegetation and Habitats**		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Minor -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Low -
Management Measures:			

- Develop post-mining environments, in conjunction with regional development plans; and the recreation of habitats, where possible; or structure altered landscapes to be compatible with regional habitats.
- The clearing of vegetation must be minimised where possible. All activities must be restricted to within the authorised areas.
- All laydown, chemical toilets etc. should be restricted to disturbed areas and placed outside of sensitive areas. Any materials may not be stored for extended periods of time and must be removed from the project area once the construction/closure phase has been concluded.
- Areas that are denuded during construction need to be re-vegetated with indigenous vegetation, to prevent erosion during flood and wind events and to promote the regeneration of functional habitat. This will also reduce the likelihood of encroachment by alien invasive plant species. All grazing mammals must be kept out of the areas that have recently been re-planted.
- All footprints to be rehabilitated after construction is complete. Rehabilitation of the disturbed areas existing in the project area must be made a priority. Topsoil must also be utilised, and any disturbed area must be re-vegetated with plant and grass species which are endemic to this vegetation type.
- A hydrocarbon spill management plan must be put in place to ensure that should there be any chemical spill out or over that it does not run into the surrounding areas. A Withok TSF operational plan must be put in place to avoid tailings spillage. The Contractor shall be in possession of an emergency spill kit that must always be complete and available on site.
  - Drip trays or any form of oil absorbent material must be placed underneath vehicles/machinery and equipment when not in use.
  - No servicing of equipment on site unless necessary.
  - All contaminated soil / yard stone shall be treated in situ or removed and be placed in containers.

Impact Name	Vegetation and Habitats	
○ Appropriately contain any generator diesel storage tanks, machinery spills (e.g., accidental spills of hydrocarbons oils, diesel etc.) in such a way as to prevent them from leaking and entering the environment. ○ Construction activities and vehicles could cause spillages of lubricants, fuels and waste material negatively affecting the functioning of the ecosystem. ○ All vehicles and equipment must be maintained, and all re-fuelling and servicing of equipment is to take place in demarcated areas outside of the PAOI. • Precautions must be taken against the erosion damage that would be caused by unplanned pipe leaks. A leak warning and detection system must be installed. Dense indigenous pioneer grass seeds should also be planted across all bare earth areas to prevent erosion.		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

Table 6-12: Assessment of significance of potential operational impacts on fauna.

Impact Name	Fauna		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Minor -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Low -
Management Measures:			
• The areas to be disturbed must be specifically and responsibly demarcated to prevent the movement of staff or any individual into the surrounding environments, signs must be put up to enforce this. • Noise must be kept to an absolute minimum during the evenings and at night to minimise all possible disturbances to reptile species and nocturnal mammals. • No trapping, killing, or poisoning of any wildlife is to be allowed and signs must be put up to enforce this. Monitoring must take place in this regard. • Outside lighting should be designed and limited to minimise impacts on fauna. All outside lighting should be directed away from any sensitive areas. • All construction and maintenance motor vehicle operators should undergo an environmental induction that includes instruction on the need to comply with speed limits, to respect all forms of wildlife. Speed limits must be enforced to ensure that road killings and erosion is limited.			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-13: Assessment of significance of potential operational impacts of alien plant species.

Impact Name	Alien Plant Species		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• An Alien Invasive Plant (AIP) Management Plan must be compiled and implemented. This should regularly be updated to reflect the annual changed in AIP composition. • The footprint area of the construction should be kept to a minimum. The footprint area must be clearly demarcated to avoid unnecessary disturbances to adjacent areas. Footprints of the roads must be kept to prescribed widths. • Early identification and Eradication: regular monitoring to detect invasive species on site, early and promptly removing them before they spread.			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-14: Assessment of significance of potential operational impacts of erosion.

Impact Name	Erosion		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Speed limits must be put in place to reduce erosion. Soil surfaces must be wetted as necessary to reduce the dust generated by the project activities. Speed bumps and signs must be erected to enforce slow speeds. • Only existing access routes and walking paths may be made use of. • Areas that are denuded during construction need to be re-vegetated with indigenous vegetation to prevent erosion during flood events etc. • A stormwater management plan must be compiled and implemented if necessary. • Regular monitoring and maintenance of erosion control measures are essential to ensure their effectiveness.			
Environmental Risk Significance (Post-mitigation)			Low -

Impact Name	**Erosion**		
Cumulative Impacts			No

Table 6-15: Assessment of significance of potential operational impacts of waste management.

Impact Name	**Waste Management**		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Waste management must be a priority and all waste must be collected and stored effectively and responsibly according to a site-specific waste management plan. Dangerous waste such as metal wires and glass must only be stored in fully sealed and secure containers, before being moved off site as soon as possible. • Litter, spills, fuels, chemical and human waste in and around the PAOI must be minimised and controlled according to the waste management plan. • Toilets at the recommended Health and Safety standards must be provided. These should be emptied regularly and once no longer required, they must be pumped dry to prevent leakage into the surrounding environment and removed from site. • The Contractor should supply sealable and properly marked domestic waste collection bins and all solid waste collected shall be disposed of at a licensed disposal facility. • Refuse bins will be responsibly emptied and secured. Temporary storage of domestic waste shall be in covered and secured waste skips..			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-16: Assessment of significance of potential operational impacts of pipeline leaks or spills.

Impact Name	**Pipeline Leaks or Spill**	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature	Negative	Negative
Magnitude	Moderate -	Minor -
Duration	Short Term	Short Term
Scale	Site or local	Site or local
Probability	Possible	Possible

Impact Name	**Pipeline Leaks or Spill**	
Environmental Risk Significance (Pre-mitigation)		Medium -
Management Measures:		
• Leak detection or any similar monitoring tool must be incorporated to try identifying leaks. • Use proper design and construction; use geographical maps, aerial photography, and satellite imagery to avoid geo-hazards along pipeline routes; ensure that compressors, pumps and surge suppression equipment are correctly sized. • Develop and implement comprehensive emergency response plans to minimize the impact of any leaks or spillages • Perform regular maintenance and proactive repairs on identified "at-risk "areas to prevent failures.		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

6.2.2 Wetlands

The following impacts have been identified during the Operational phase:

Table 6-17: Mitigated DWS Risk Assessment Matrix for Wetlands in relation to the proposed development: Operational phase.

Activity	Impact	Significance (max = 100)	Risk Rating
Operation of TSF relating to consistent stockpiling of tailings material	Altering surface and subsurface flow patterns	**42**	**M**
	Sedimentation and siltation of watercourses	**28,8**	**L**
	Impaired water quality from residual tailings materials entering the system	**36**	**M**
Operation of drainage systems	Altering surface and subsurface flow patterns	**42**	**M**
	Sedimentation and siltation of watercourses	**28,8**	**L**
	Impaired water quality from residual tailings materials entering the system	**36**	**M**

The identified mitigation measures have been discussed.

6.2.3 Surface Water

Table 6-18: Summary of activities and impacts for the operational phase

Activity	Impact Description
Impacts due to wash bays and workshops	Hydrocarbons and other pollutant washed into water courses
Impacts due to vehicle fleet-related pollution	Hydrocarbons and other pollutant washed into water courses
Impacts due to leaking or burst dirty water pipes	Salts and other pollutant washed into water courses
Impacts due to leaking or burst slurry pipes	Polluted sediments, salts and other pollutant washed into water courses
Impacts due to catchment paddocks overflowing	Salts and other pollutant washed into water courses
Impacts due to catchment return water dam overflowing	Salts and other pollutant washed into water courses
Loss of catchment yield	Reduced catchment yield
Dam break	Polluted sediments, salts and other pollutant washed into water courses

The ratings and proposed mitigation measures for the operational phase are indicated below

Table 6-19: Significance rating of operational impact 1

NATURE OF IMPACT 1: Hydrocarbons and other pollutant washed into water courses, Hydrocarbons and other pollutant washed into water courses, Salts and other pollutant washed into water courses.		
	Impact Rating without Mitigation	**Impact Rating with Mitigation**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Medium term	Medium term
Magnitude *(Major, Moderate, Minor)*	Major	Moderate
Probability *(Definite, Possible, Unlikely)*	Definite	Possible
Calculated Significance Rating (Low, Medium, High)	**High**	**Medium**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Irreversible	
Irreplaceable loss of resources: (Yes or No)	No	

NATURE OF IMPACT 1: Hydrocarbons and other pollutant washed into water courses, Hydrocarbons and other pollutant washed into water courses, Salts and other pollutant washed into water courses.	
Can impacts be enhanced: (Yes or No)	Yes
Residual impacts • None, as the impact will cease provided that rehabilitation is done appropriately.	
Mitigation measures • Wash bay discharge water should flow through an oil separator. • All vehicles should be well maintained and inspected for hydrocarbon leaks weekly. Fuel depots and refuelling areas should be bunded. Vehicle maintenance should be a key performance objective of the plant contractor. • It is preferable to run the dirty water pipelines through areas already serviced by dirty water systems where possible. Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.	

Table 6-20: Significance rating of operational impact 2

NATURE OF IMPACT 2: Hydrocarbons and other pollutant washed into water courses, Polluted sediments, salts and other pollutant washed into water courses, Salts and other pollutant washed into water courses, Reduced catchment yield		
	Impact Rating without Mitigation	**Impact Rating with Mitigation**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Medium term	Medium term
Magnitude *(Major, Moderate, Minor)*	Major	Moderate
Probability *(Definite, Possible, Unlikely)*	Definite	Possible
Calculated Significance Rating (Low, Medium, High)	**High**	**Medium**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Irreversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	Yes	
Residual impacts • None, as the impact will cease provided that rehabilitation is done appropriately.		

NATURE OF IMPACT 2: Hydrocarbons and other pollutant washed into water courses, Polluted sediments, salts and other pollutant washed into water courses, Salts and other pollutant washed into water courses, Reduced catchment yield
Mitigation measures • Wash bay discharge water should flow through an oil separator**.** • It is preferable to run the slurry pipelines through areas already serviced by dirty water systems where possible. Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found. • Catchment paddocks must be sized must be sized in accordance with GN704. • The RWD must be sized in accordance with GN704.

6.2.4 Groundwater

The seepage plume emanating from the Brakpan TSF has and will continue to predominantly impact on the groundwater quality of the aquifer.

Due to the low seepage rate of the lined Withok TSF extension (2 mm/a), its direct seepage impacts are on the other hand marginal. Indirect impacts include a reduced dilution of the Brakpan seepage plume due to reduced recharge/seepage over its footprint area. The significance rating of impacts of the seepage plume emanating from the Brakpan-Withok TSF complex on the groundwater quality during the operational phase of the facility is provided in Table 9-36. They should be seen as related to the existing Brakpan TSF with no significant contributions of the lined Withok TSF extension.

It is important to note that hydraulic containment of the existing seepage plume is recommended to continue as a management measure and will improve observed plume concentrations significantly. The hydraulic plume containment will have to continue beyond the life of the facility until acceptable source and plume concentrations allow for monitored natural attenuation.

Table 6-21: Operational Phase Water quality impacts

NATURE OF THE IMPACT: Continuing deposition of tailings material onto the existing unlined Brakpan TSF and the lined Withok extension with subsequent seepage from the unlined TSF.		
	Impact Rating Without Mitigation	**Impact Rating with Mitigation**
Impact Status: (positive or negative)	**Negative**	**Negative**
Extent *(Local, Regional, International)*	regional	Local
Duration *(Short term, Medium term, Long term)*	Long term	Short term
Magnitude *(Major, Moderate, Minor)*	Major -	Major -

NATURE OF THE IMPACT: Continuing deposition of tailings material onto the existing unlined Brakpan TSF and the lined Withok extension with subsequent seepage from the unlined TSF.		
Probability *(Definite, Possible, Unlikely)*	Define	Possible
Calculated Significance Rating (Low, Medium, High)	**High**	**Medium**
Impact Status (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Cumulative impacts (yes or no)	No	
Residual impacts ❖ Deterioration of groundwater quality underneath the unlined Brakpan TSF		
Mitigation measures ❖ Continuous monitoring of source concentrations (i.e. within drains and interception boreholes) concentrations and downstream plume migration using proposed monitoring network. ❖ Hydraulic plume containment using proposed interception boreholes until acceptable plume concentrations allow for monitored natural attenuation.		

Seepage from the Brakpan TSF has changed, and will continue to change, the volume of groundwater in storage locally due to mounding of water table within the TSF and its surrounds. On the other hand, a localised lowering of the water table around the interception boreholes themselves is expected. Similarly, the lined Withok TSF extension will lead to reduced recharge underneath its footprint.

Table 6-22: Operational Phase Water quantity impacts

NATURE OF THE IMPACT: *Local changes of water table and associated local groundwater flow direction due to seepage from the unlined Brakpan TSF, hydraulic plume containment with interception boreholes and minor leakage from the lined Withok TSF extension.*		
	Impact Rating Without Mitigation	**Impact Rating with Mitigation**
Impact Status: (positive or negative)	**Negative**	**Negative**
Extent *(Local, Regional, International)*	Local	Local
Duration *(Short term, Medium term, Long term)*	Long Term	Long Term
Magnitude *(Major, Moderate, Minor)*	Minor -	Minor +
Probability *(Definite, Possible, Unlikely)*	Possible	Unlikely
Calculated Significance Rating (Low, Medium, High)	**Medium**	**Low**
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	

Can impacts be enhanced: (Yes or No)	No
Residual impacts ❖ None.	
Mitigation measures ❖ Continuous monitoring of water levels within the TSFs and monitoring boreholes. ❖ Continuous operation of the existing interception well system.	

6.3 Decommissioning Phase

This section comprises of the description of potential impacts associated with the closure, decommissioning and rehabilitation activities on the biophysical, socio-economic and heritage and cultural environment. These descriptions are followed by the impact tables which contain the assessment of the significance of each identified impact without, then with mitigation measures.

6.3.1 Biodiversity

The following potential impacts were considered on biodiversity (fauna and flora) during operational phase:

- An impact to local Vegetation and Habitats;
- The spread of Alien Species;
- The impact of Erosion;
- The impact from Pipeline Leak or Spills; and
- The generation of dust, and waste.

Table 6-23: Assessment of significance of potential impacts on vegetation and habitats .

Impact Name	**Vegetation and Habitats**		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Minor -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Low -
Management Measures:			
• Develop post-operation environments, in conjunction with regional development plans; and the recreation of habitats, where possible; or structure altered landscapes to be compatible with regional			

Impact Name	**Vegetation and Habitats**
habitats. • All laydown, chemical toilets etc. should be restricted to disturbed areas and placed outside of sensitive areas. Any materials may not be stored for extended periods of time and must be removed from the project area once the construction/closure phase has been concluded. • A hydrocarbon spill management plan must be put in place to ensure that should there be any chemical spill out or over that it does not run into the surrounding areas. A Withok TSF operational plan must be put in place to avoid tailings spillage. The Contractor shall be in possession of an emergency spill kit that must always be complete and available on site. • Precautions must be taken against the erosion damage that would be caused by unplanned pipe leaks. A leak warning and detection system must be installed. Dense indigenous pioneer grass seeds should also be planted across all bare earth areas to prevent erosion.	
Environmental Risk Significance (Post-mitigation)	Low -
Cumulative Impacts	No

Table 6-24: Assessment of significance of potential impacts on fauna.

Impact Name	**Fauna**		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Minor -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Low -
Management Measures:			
• The areas to be disturbed must be specifically and responsibly demarcated to prevent the movement of staff or any individual into the surrounding environments, signs must be put up to enforce this. • No trapping, killing, or poisoning of any wildlife is to be allowed and signs must be put up to enforce this. Monitoring must take place in this regard. • Outside lighting should be designed and limited to minimise impacts on fauna. All outside lighting should be directed away from any sensitive areas. . • All construction and maintenance motor vehicle operators should undergo an environmental induction that includes instruction on the need to comply with speed limits, to respect all forms of wildlife. Speed limits must be enforced to ensure that road killings and erosion is limited.			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-25: Assessment of significance of potential impacts of alien plant species.

Impact Name	Alien Plant Species		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• An Alien Invasive Plant (AIP) Management Plan must be compiled and implemented. This should regularly be updated to reflect the annual changed in AIP composition. • Early identification and Eradication: regular monitoring to detect invasive species on site, early and promptly removing them before they spread.			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-26 : Assessment of significance of potential impacts of waste management.

Impact Name	Waste Management		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Waste management must be a priority and all waste must be collected and stored effectively and responsibly according to a site-specific waste management plan. Dangerous waste such as metal wires and glass must only be stored in fully sealed and secure containers, before being moved off site as soon as possible. • Litter, spills, fuels, chemical and human waste in and around the PAOI must be minimised and controlled according to the waste management plan. • Toilets at the recommended Health and Safety standards must be provided. These should be emptied regularly and once no longer required, they must be pumped dry to prevent leakage into the surrounding environment and removed from site. • The Contractor should supply sealable and properly marked domestic waste collection bins and all solid waste collected shall be disposed of at a licensed disposal facility.			

Impact Name	**Waste Management**	
• Refuse bins will be responsibly emptied and secured. Temporary storage of domestic waste shall be in covered and secured waste skips.		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

Table 6-27: Assessment of significance of potential impacts of erosion.

Impact Name	**Erosion**		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Speed limits must be put in place to reduce erosion. Soil surfaces must be wetted as necessary to reduce the dust generated by the project activities. Speed bumps and signs must be erected to enforce slow speeds. • Only existing access routes and walking paths may be made use of. • Areas that are denuded during construction need to be re-vegetated with indigenous vegetation to prevent erosion during flood events etc. • A stormwater management plan must be compiled and implemented if necessary.			
Environmental Risk Significance (Post-mitigation)			Low -
Cumulative Impacts			No

Table 6-28:Assessment of significance of potential impacts of pipeline leaks or spills.

Impact Name	**Pipeline Leaks or Spill**		
Environmental Risk			
Attribute	**Pre-mitigation**	**Post-mitigation**	
Nature	Negative	Negative	
Magnitude	Moderate -	Minor -	
Duration	Short Term	Short Term	
Scale	Site or local	Site or local	
Probability	Possible	Possible	
Environmental Risk Significance (Pre-mitigation)			Medium -
Management Measures:			
• Leak detection or any similar monitoring tool must be incorporated to try identifying leaks.			

Impact Name	Pipeline Leaks or Spill	
• Use proper design and construction; use geographical maps, aerial photography, and satellite imagery to avoid geo-hazards along pipeline routes; ensure that compressors, pumps and surge suppression equipment are correctly sized. • Develop and implement comprehensive emergency response plans to minimize the impact of any leaks or spillages. • Perform regular maintenance and proactive repairs on identified "at-risk "areas to prevent failures.		
Environmental Risk Significance (Post-mitigation)		Low -
Cumulative Impacts		No

6.3.2 Wetlands

The following impacts have been identified in the decommissioning phase.

Table 6-29: Mitigated DWS Risk Assessment Matrix for wetlands in relation to the proposed project.

Activity	Impact	Significance (max = 100)	Risk Rating
Dewatering of TSF compartments	Altering surface and subsurface flow patterns	**33**	**M**
	Sedimentation and siltation of watercourses	**16,2**	**L**
	Impaired water quality from residual tailings materials entering the system	**16,2**	**L**
Excavating and reshaping TSF to pre-construction state	Altering surface and subsurface flow patterns	**33**	**M**
	Erosion of surrounding landscape and subsequently the watercourses	**21,6**	**L**
	Sedimentation and siltation of watercourses	**21,6**	**L**
Removal of TSF drainage systems	Altering surface and subsurface flow patterns	**33**	**M**
	Sedimentation and siltation of watercourses	**21,6**	**L**
	Impaired water quality from residual tailings materials entering the system	**21,6**	**L**
Rehabilitation of reworked area	Altering surface and subsurface flow patterns	**33**	**M**
	Sedimentation and siltation of watercourses	**16,2**	**L**
	Impaired water quality from residual tailings materials entering the system	**27**	**L**
	Proliferation of invasive alien plants	**21,6**	**L**

6.3.3 Surface Water

All supernatant and storm water on the basin will be pumped back to the process via a decant barge. All side slope water will be routed to the return water dam via the catchment paddocks. The catchment paddocks serve to desilt this water and to temporarily store it, before it is released to the return water dam via the drain flow collector system. The drain flow collector system is a below-surface piped system. The catchment paddocks have penstocks that feed into the drain flow collector system. The drain flow collector system discharges into the return water dam, via a silt trap.

The recommended closure concept is to paddock the top surface, while treating drain flows. The drain flow water can be treated to discharge quality and released into the receiving environment. Alternatively, this water can be treated to higher water quality standards and sold for domestic or industrial consumption. The brine from the treatment process would have to be pumped to the top surface where it will be evaporated. There will be significant periods where the paddocks are dry so no long-term brine ponds will form. Side slopes will be rehabilitated and runoff from these slopes will be clean and released to the environment, post closure.

The activities and impacts that are likely to occur during the closure and rehabilitation phase are summarised inTable 6-30.

Table 6-30: Summary of activities and impacts for the closure and rehabilitation phase

	Impact Description
Impacts due to the removal of surface infrastructure	Excessive silt washed into water courses
Impacts due to wash bays and workshops	Hydrocarbons and other pollutant washed into water courses
Impacts due to vehicle fleet-related pollution	Hydrocarbons and other pollutant washed into water courses

The ratings and proposed mitigation measures for the closure and rehabilitation phase are indicated in Table 6-31.

Table 6-31: Significance rating of closure impact 1

NATURE OF IMPACT: Excessive silt washed into water courses, Hydrocarbons and other pollutant washed into water courses, Hydrocarbons and other pollutant washed into water courses.		
	Impact Rating without Mitigation	**Impact Rating with Mitigation**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Long term	Medium term
Magnitude *(Major, Moderate, Minor)*	Major	Minor

NATURE OF IMPACT: Excessive silt washed into water courses, Hydrocarbons and other pollutant washed into water courses, Hydrocarbons and other pollutant washed into water courses.		
Probability *(Definite, Possible, Unlikely)*	Possible	Possible
Calculated Significance Rating (Low, Medium, High)	**Moderate**	**Low**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Irreversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	Yes	
Residual impacts • Possible, unless potential spills are rehabilitated.		
Mitigation measures • Clearly define areas to be cleared. Do not clear past designated areas. Dry season construction is preferable where practical. • Wash bay discharge water should flow through an oil separator. • All vehicles should be well maintained and inspected for hydrocarbon leaks weekly. Fuel depots and refuelling areas should be bunded. Vehicle maintenance should be a key performance objective of the plant contractor.		

6.3.4 Groundwater

Seepage from the Brakpan TSF and to a minor extent the Withok TSF extension will continue to impact on the ambient groundwater quality post closure. While lower seepage rates are expected once active deposition onto the TSFs ends, post closure seepage concentrations will have a significant impact on the ambient groundwater quality for several decades as the TSF complex drains down and the tailings material is leached out.

Table 6-32: Decommissioning and Closure Phase Water quality impacts

NATURE OF THE IMPACT: Local changes of water table and associated local groundwater flow direction due to seepage from the unlined Brakpan TSF, hydraulic plume containment with interception boreholes and minor leakage from the lined Withok TSF extension. *Impact on the local groundwater quality*		
	Impact Rating Without Mitigation	**Impact Rating with Mitigation**
Impact Status: (positive or negative)	**Negative**	**Negative**
Extent *(Local, Regional, International)*	Local	Local
Duration *(Short term, Medium term, Long term)*	Short term	Short term

NATURE OF THE IMPACT: Local changes of water table and associated local groundwater flow direction due to seepage from the unlined Brakpan TSF, hydraulic plume containment with interception boreholes and minor leakage from the lined Withok TSF extension. *Impact on the local groundwater quality*		
Magnitude *(Major, Moderate, Minor)*	Minor -	Minor -
Probability *(Definite, Possible, Unlikely)*	Possible	Possible
Calculated Significance Rating (Low, Medium, High)	High	**Low**
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Cumulative impacts (yes or no)	No	
Residual impacts ❖ Deterioration of groundwater quality underneath the unlined Brakpan TSF.		
Mitigation measures ❖ Continuous monitoring of source concentrations (i.e. within drains and interception boreholes) concentrations and downstream plume migration using proposed monitoring network. ❖ Hydraulic plume containment using proposed interception boreholes until acceptable plume concentrations allow for monitored natural attenuation.		

6.4 Emergency Incident

This section deals separately with the impacts that may occur in the unlikely event of a dam break/breach. This is considered an emergency incident and is assessed separately.

A tailings dam, by virtue of its existence above ground creates a Hazard, i.e., the potential to cause harm, particularly to the public. So, while the design, operation and management of the facility are intended to ensure that the hazard does not manifest, the possibility remains.

Consequently, it is prudent to forewarn potentially Affected Parties in the event of a pending failure. This is usually done by way of an Emergency Preparedness Plan (EPP) which requires that Affected Parties are identified. This in turn requires the potential inundation zone – termed the Zone of Influence (ZoI) – to be defined.

Such a Zone is a function of the size of the TSF and the topography of the surrounding area. Most of the Brakpan and Withok TSF complex is surrounded by sparsely populated undeveloped rural land, various residential areas are noted along the floodplain, especially to the west where urbanization could be impacted.

The following potential impacts could result from a dam break:

- An impact to local vegetation and habitats;
- An impact to local fauna;
- An impact on aquatic ecosystems;
- An impact on surface water quality;
- Impacts on infrastructure within the zone of influence;
- Impacts on developments within the zone of influence;
- Potential loss of lives;
- Loss of economic livelihoods;
- Health impacts as a results of contaminants in surface water.

Table 6-33: Dam Break Impacts

NATURE OF THE IMPACT: Dam Break		
	Impact Rating Without Mitigation	**Impact Rating with Mitigation**
Impact Status: (positive or negative)	**Negative**	**Negative**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Long term	Medium term
Magnitude *(Major, Moderate, Minor)*	Major -	Major -
Probability *(Definite, Possible, Unlikely)*	Possible	Unlikely
Calculated Significance Rating (Low, Medium, High)	**Major**	**Medium**
Reversibility: (Reversible or Irreversible)	Irreversible	
Irreplaceable loss of resources: (Yes or No)	Yes	
Cumulative impacts (yes or no)	No	
Residual impacts ❖ Contamination of land and surface water as a result of slime residues. ❖ Destruction of biodiversity and aquatic systems.		
Mitigation measures		

- Design TSF in line with Code of Practice for Mine Residue Deposits (SANS 10286) and the Dam Safety Regulations (GNR. 139 of 24 February 2012).
- Ergo to implement its Tailings Management Policy and a Tailings Storage Facility Management Standard.
- Develop an Emergency Preparedness Plan.
- Undertake a dam break analysis to determine the zone of influence.
- Consultation with I&APs in the Zone of Influence.
- Register Dam with the Dam Safety Office
- Align with the Global Industry Standard on Tailings Management (GISTM) where appropriate.
- **Build and operate the facility according to its design and construction criteria.**

6.5 Unplanned Events, Risks and Management Measures

Unplanned events and risks are unexpected incidents that may occur and are not planned for, resulting in an impact e.g. an extreme flood (1:200 year flood). These are Project risks which are not rated as impacts. These are indicated in Table 6-34 below.

Table 6-34: Potential risks and management strategies

Potential Project Risk (Unplanned Occurrences)	Aspect Potentially Impacted	Mitigation / Management / Monitoring
Hydrocarbon spills from vehicles and heavy machinery or hazardous materials or waste storage facilities.	Hydrocarbon contamination of surrounding surface water resources through surface water runoff.	❖ Hydrocarbons and hazardous materials must be stored in bunded areas that are sized according to legislated requirements; ❖ Refuelling must take place on lined and contained areas; ❖ Ensure that silt, oil traps and sumps are in good working condition and are serviced regularly; and ❖ Vehicles and heavy machinery should be serviced and checked on a regularly basis to prevent leakages and spills.
Spill/leaks from the proposed slurry pipeline.	Contamination of surface water resources.	❖ Regular inspections of the pipeline for any leaks.
Construction of the proposed pipeline below the 1:100 year floodline.	Pollution of surface water resources.	❖ Ensure that the pipeline is constructed above the 1:100 year floodline and that any supporting structures within the floodline are constructed to withstand a 1:100 year flood.
Sedimentation and erosion of storm water management infrastructure.	Overflow of dirty water contaminating clean areas.	❖ Regular inspections of stormwater management infrastructure, especially after large storm events.

6.6 Issues and Responses from Public Consultation Process

The Public Participation Process (PPP) has been developed to ensure compliance with the Integrated Environmental Authorisation and the Integrated Water Use Licence Application process. The public participation process offers stakeholders a fair opportunity to be informed about the Proposed Project, to raise issues of concern and to make suggestions for enhanced project benefits. The project team has considered all relevant issues and suggestions during the IWULA process.

Issues and responses documented during the public consultation process can be seen in the Comments and Responses Report (CRR) attached as **Appendix C9**.

6.7 Matters Requiring Attention/Problem Statement

The issues being raised, with validity, for the project are all centred around surface and groundwater pollution, process water sourcing, as well as groundwater quantity impacts. These issues have been analysed by specialists and mitigation measures have been recommended.

6.8 Assessment of Level and Confidence of Information

Detailed specialist studies have been conducted as part of the impact assessment for the proposed project development and the level of confidence of the information provided is medium to high level. More detailed information on the surface and groundwater quality impacts can only be determined once the project is operational, with real time data monitoring and information being interpreted.

In general, it can be stated that the extent and level of information available is adequate to support the development of the IWWMP for the Withok Recommissioning project.

7 Water and Waste Management

7.1 Water and Waste Management Philosophy (Process Water, Storm water, Groundwater and Waste)

The Ergo approach to water and waste management is through a hierarchy that strives to prevent waste/water pollution as far as practically possible; secondly, to reduce the production and impact of waste/wastewater; and thirdly, to reuse/recycle wastewater after treatment.

Ergo is committed to the following in regard to the proposed Recommissioning of the Withok TSF project:

- To plan, design, construct, operate, decommission and close the proposed projects in a responsible manner, and in accordance with its policies, strategies and all applicable legislative requirements;
- To minimise the impacts on the receiving environment by limiting the extent of the project footprint and by properly implementing engineered barriers, where possible, to prevent seepage of contaminants.
- To the implementation of long term water management measures and to conduct the required monitoring during all phases of the project; and
- To implement technically proven and acceptable rehabilitation measures during the operational, decommissioning and closure phases.

7.2 Strategies

To give effect to the water and waste management philosophies discussed in the previous chapters, the following strategies will be implemented:

7.2.1 Surface Water

- Construct and maintain adequate storm water control measures to keep clean and dirty water separate; and
- Monitor water quality at the identified monitoring positions

7.2.2 Groundwater

- Minimise the impact on groundwater resources through the design and construction of engineered barriers for all potential pollution sources;
- Implement ongoing monitoring of groundwater quality and levels to inform the detailed geochemical impact predictions and to validate groundwater models; and
- Implement long term water management strategies by managing groundwater levels.

7.2.3 Stormwater

- Separation of clean and dirty water in accordance with the requirements of GN 704;

- Collection, containment and conveyance of both clean and dirty water in adequately sized water management infrastructure as stipulated in GN 704; and
- On-going monitoring and measurement of water quantity and quality to support the wide water balance and water management.

7.2.4 Waste

- Implement waste separation;
- Maximise recycling and reuse of waste streams;
- Dispose of waste on authorised waste disposal facilities in accordance with legal requirements;
- Implement on-going waste monitoring to inform waste management; and
- Identification and rehabilitate contaminated land.

7.2.5 Process Water

- Source process water from Ergo water distribution system; and
- Reuse and Recycle as much water as practically possible during operations to feed Ergo's closed water system.

7.2.6 Potable Water

- Source water from municipal source o
- With a contingency for JoJo tanks.

7.3 Performance Objectives

The overall objective of water and waste management is to reduce or mitigate negative environmental consequences resulting from the project and to limit negative impacts as far as possible. The environmental objectives are to ensure that all necessary steps will be taken to ensure the following with regard to the identified reclamation impacts:

- That appropriate pollution control and other environmental protection measures are taken by the applicant, in accordance with all applicable laws and regulations;
- That the applicant will not degrade the degree of environmental setting beyond existing environmental conditions; and
- That, socio-economic and bio-physical conditions will be addressed to ensure that negative impacts associated with the project are kept to a minimum.

The following specific performance objectives have been identified for the project:

- Develop and update the water balance annually or as will be required by the IWUL;
- Contain dirty storm water;

- Monitor and record ambient water quality in the receiving surface water and various points on site to confirm/ assess the effectiveness of the implemented water pollution control measures;
- Prevent erosion;
- Assess the impact/s that the proposed project will have on local groundwater and surface water resources;
- Monitor groundwater levels; and
- Monitor the wetland areas.

7.3.1 Measures to Achieve and Sustain Performance Objectives

Management activities and mitigation measures will be implemented during construction, operation and decommissioning/rehabilitation at both project sites in to achieve the required performance objectives.

The following measures have been identified to achieve the set performance objectives (Table 7-1):

Table 7-1: Performance objectives relevant to the Recommissioning of the Withok TSF

Performance Objectives	Management Measure
Process Water	
Update water and salt balance	Update water balance annually or implement a water balance model that can be updated as needed
Surface Water	
Contain dirty storm water	Construct and maintain adequate storm water control measures to keep clean and dirty water separate
	Maintain return water dam and re-use stored water as possible
Minimise the contamination of surface water resources	Monitor water quality at the surface water monitoring points identified and compare them with the baseline water qualities to assess the effectiveness of the implemented water pollution control measures
	Interpret the results and institute remedial action as required
Groundwater	
Minimise the impact on local groundwater resources	Implement dedicated groundwater quality monitoring as required
	Implement the required monitoring to confirm the success of the implemented groundwater protection/mitigation measures
Maintain groundwater levels if possible	Implement dedicated groundwater monitoring to determine water levels compared to baseline water levels
Sensitive Landscapes	

Performance Objectives	Management Measure
Minimise impact on the wetlands and sensitive areas in and around the Withok TSF.	Implement a wetland monitoring programme to assess the ongoing impacts on the wetlands in and around the Withok TSF to determine changes and loss of vulnerable wetland types

7.4 Option Analyses and Motivation for Implementation of Preferred Options

7.4.1 The Property on which or Location where the Activity is Proposed to be Undertaken

The Proposed Project is the recommissioning of a TSF on a previously disturbed footprint. This location is preferred because it is an existing historical deposition site adjacent to the operational Brakpan TSF and its associated and existing infrastructure. Therefore, there can be no alternative sites in terms of the Project location. From an environmental impact perspective, utilising the existing Withok TSF (brownfields) footprint is better than a new greenfields site.

7.4.2 The Type of Activity to be Undertaken

The only optional activity for Ergo is to deposit reprocessed tailings onto the recommissioned TSF.

Gold reclamation and processing is the recovery and treatment of gold surface tailings.. According to DRDGOLD (2018), the retreatment business is high-volume and low-risk. Vast quantities of material are processed monthly through its plants to recover gold from old TSFs at a recovery rate that varies depending on the material being treated.

The depleting quantity and quality of gold recovered from underground mining operations in the province versus the extensive safety and environmental risks, as well as the labour and electricity costs associated with the activity has seen an underlining increase in the attractiveness of gold tailings reclamation. The recommissioning of the Withok TSF will enable the continued reclamation activities. This, together with the incentive to find a solution to Gauteng's TSF-related issues, has led to the 'Preferred Activity'.

Recommissioning the Withok TSF reduces the need to find an alternative "greenfields" site for a new TSF which would result in land sterilisation for any future use, as well as generating a new source of pollution.

Table 7-2: The advantages and disadvantages of the recommissioning of the TSF – Preferred Activity

Option	Advantage	Disadvantage
Recommissioning of the TSF (Preferred)	❖ Enables the continued operation of tailings retreatment leading to contribution to local economy. ❖ Enables the continued removal of other TSF's which are pollution	❖ Increased surface water, groundwater and air pollution. ❖ Failure risk if not engineered and operated correctly.

	sources and opens land after rehabilitation and cessation of project. ❖ Removes the need for the creation of a new TSF. ❖ Using an existing footprint reduces need to disrupt ecosystems for the construction of a new TSF. ❖ Upgrade and improvement of surface water and groundwater management infrastructure. ❖ Linked to existing infrastructure. ❖ The recommissioning of the TSF will allow Ergo to implement new construction and pollution prevention mechanisms on a previously disturbed footprint. ❖ Job creation during construction. ❖ Possible pollution will be earmarked to a previously impacted but re-commissioned to new best practice area.	
Establishing an alternative TSF	❖ Enables the continued removal of a pollution source after rehabilitation and cessation of project. ❖ Lining of TSF to prevent groundwater pollution. ❖ Job creation during construction.	❖ Additional pollution source in the East Rand. ❖ Land sterilisation. ❖ Loss of agricultural land. ❖ Destruction of fauna and flora habitat. ❖ Failure risk if not engineered and operated correctly.

7.4.3 The Design and Layout of the Activity

The current layout plan for the Proposed Project is considered as the preferred layout plan. The layout plan is dictated by the previously impacted TSF footprint and the adjacent Brakpan TSF, existing paddocks, associated infrastructure and the routes of the existing pipelines. There will be no expansion of the TSF footprint. The footprint will be smaller than the original footprint.

7.4.4 The Technology to be Used in the Activity

Process alternatives imply the investigation of alternative processes or technologies that can be used to achieve the same goal. This includes using environmentally friendly designs or materials and re-using scarce resources like water and non-renewable energy sources. Valid alternative technologies are continually investigated and will be implemented where applicable.

7.4.4.1 The recommissioning of the TSF is the "Preferred Activity" and there are no alternatives.

Ergo believes that it will implement the best available technology in the best possible combination, in a way which is cost effective for this specific project. Best practices (as utilised in the industry) have been selected and, where applicable, SANS standards and legislative requirements will be followed in design, construction and management of infrastructure and activities on site.

7.4.4.2 Recycling, Water and Electricity

Water which seeps from the TSF will collect in the RWD. From the RWD, it will be pumped into the Ergo process water circuit. Ergo is commissioning its solar project. This will be able to provide an alternative source of electricity to Ergo's operation.

7.4.4.3 The Operational Aspects of the Activity Recycling, Water and Electricity

The Proposed Project will convey the deposition of slurry onto the Withok TSF from the Ergo plant pumpstation via existing pipelines. Cyclone deposition will be used for the deposition of slurry.

7.4.4.4 Cyclone Deposition

The cyclone method of deposition is the preferred deposition technique. The principle of cyclone development is to create a sufficiently robust underflow perimeter wall to contain the overflow with adequate freeboard and inherent stability to avoid overtopping and to prevent side slope failure. Figure 7-1shows the basis of the operation of a cyclone.

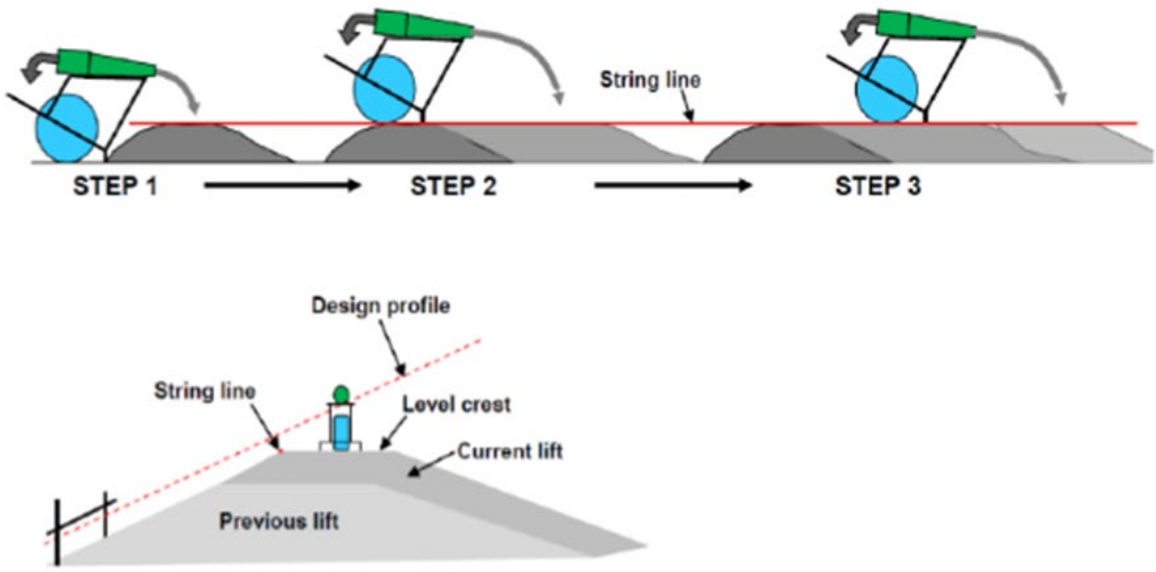


Figure 7-1: The operation of an advancing cyclone (©GeoTail, 2024)

The net effect is that the finer particles and most of the water leave the cyclone to form the "overflow", while the dewatered larger particles leave the cyclone to form a coarser "underflow" (Goldfields, 2024) as shown in Figure 7-2.

Figure 7-2: Illustration of "overflow" and "underflow" (©Gold Fields Limited, 2024).

Table 7-3: The advantages and disadvantages of the operational alternative considered

Option	Advantage	Disadvantage
Recommissioning of the Withok TSF and associated slurry and water pipeline (s)	❖ The Withok TSF is a previously contaminated site. ❖ The pipeline route is within SRPs owned by Ergo. ❖ HDPE lined steel pipelines have higher reliability. ❖ All of the pipelines leading from the Ergo plant are existing and operational.	❖ Re-establishing a TSF where one was reclaimed.

7.4.5 The "No-Go" Option

The Option of the project not proceeding would mean that the environmental and social status would remain the same as current. This implies that both negative and positive impacts would not take place. As such, the long-term negative impacts on the environment would not transpire; equally so, the long-term positive impacts such as environmental pollution source removal, economic development, skills development, retention of <1800 permanent jobs, and the availability of land for re-development at other TSFs being reclaimed by Ergo would not occur.

The only alternative land use is to leave the Withok TSF footprint as it stands.

The "No-Go" Option would reduce the life of Ergo's operations as no further TSF reclamation could take place once the Brakpan TSF reaches full capacity. This would mean that pollution caused by other abandoned TSFs would continue, rather than being removed by reclamation activities. This as a result would lead to continued land sterilisation, instead of making land available for much needed development.

Furthermore, this means that the attraction of the gold reserves located within the dumps could potentially enhance illegal mining, and if left as is, population settlement on or around the dumps could occur.

The 'No Project' alternative is not preferred due to the anticipated benefits of the proposed project. The expected indirect benefits resulting from the recommissioning of the TSF include the ability of Ergo to continue with its reclamation and processing activities. These will result in:

- The removal of sources of pollution and potential radiation in the East Rand area.
- Centralised deposition site which can be managed and controlled efficiently to reduce negative environmental impacts caused by abandoned and unrehabilitated TSFs across the area.
- The potential to unlock land for redevelopment, as read in the Metropolitan Spatial Development Vision.
- Continued supply of gold to the local and national markets, and therefore contribution to local, provincial and international economy.

7.5 IWWMP Action Plan (Priority Actions and Other Short, Medium and Long Term Actions)

Table 7-4: The Recommissioning of the Withok TSF Project's action plan

Performance Objectives	Management Measure	Responsible Department	Timeframe
Process Water			
Update water and salt balance	Update water balance annually or implement a water balance model that can be updated as needed	Hydrology	Annually or as instructed by the DWS
Surface Water			
Contain dirty storm water	Construct and maintain adequate storm water control measures to keep clean and dirty water separate	Engineering / Environmental	On-going after authorisation
	Maintain the return water dams and re-use stored water		
Minimise the contamination of surface water resources	Monitor water quality at the surface water monitoring points identified and compare them with the baseline water qualities to assess the effectiveness of the implemented water pollution control measures	Environmental / Geology	On-going
	Interpret the results and institute remedial action as required	Geology/Hydrology	On-going
Groundwater			
Minimise the impact on local groundwater resources	Implement dedicated groundwater quality monitoring as required	Hydrology/Environmental/Management	On-going
	Implement the required monitoring to confirm the success of the implemented groundwater protection/mitigation measures		

Performance Objectives	Management Measure	Responsible Department	Timeframe
Maintain groundwater levels if possible	Implement dedicated groundwater monitoring to determine water levels compared to baseline water levels		
Sensitive Landscapes			
Minimise impact on the wetlands and sensitive areas in and around the Withok TSF	Implement a wetland monitoring programme to assess the ongoing impacts on the wetlands in and around the reclamation area to determine changes and loss of vulnerable wetland types	Management/Environmental	On-going

7.6 Control and Monitoring

7.6.1 Monitoring of change in Baseline information

Reports of the updated Baseline information (for the project) will be submitted to the appropriate government departments as required and other formal institutions as stipulated by management objectives, conformance targets and applicable legislation and other legal requirements. All of these results will be shared with the DWS.

7.6.2 Audit and Report on Performance of Measures

The IWWMP action plan will be reviewed and updated annually or alternatively as required in terms of the WUL.

7.6.3 Audit and Report on Relevance of Action Plan

An audit on the IWWMP action plan should be conducted at least once annually by an independent external auditor, while internal audits should be conducted bi-annually.

8 Conclusion

8.1 Regulatory Status of Activity

This is a new development, and the activities applied for are new water uses requiring authorisation. Activities will only commence once approval of all the relevant authorities has been granted. The water uses are set out in 3.2.

8.2 Statement of Water Uses Requiring Authorisation, Dispensing with Licensing Requirement and Possible Exemption from Regulation

The water uses requiring authorisation are listed in Table 3-4.

8.3 Motivation in terms of Section 27 (1) of the NWA

Section 27 of the NWA specifies the following factors regarding water use authorisation that must be taken into consideration:

- The efficient and beneficial use of water in the public interest;
- The socio-economic impact of the decision whether or not to issue a licence;
- Alignment with the catchment management strategy;
- The impact of the water use, resource directed measures; and
- Investments made by the applicant in respect of the water use in question.

The motivation in terms of Section 27 for the planned water uses is listed in Table 8-1 below.

Table 8-1: Section 27 Motivation

Section	Content	Description of issues
27(1)(a)	Existing lawful water use	There are no existing lawful water uses taking place on the property. All water uses triggered are being applied for as part of the Integrated Water Use Licence Application (IWULA) and will be authorised in terms of a Water Use Licence (WUL) issued by the Department of Water and Sanitation (DWS).
27(1)(b)	Need to redress the results of past racial and gender discrimination	Ergo Mining (Pty) Limited (Ergo) acknowledges the importance of total commitment to transformation and empowerment in all aspects of its business. Its transformation initiatives include: ❖ Ownership structures in line with the relevant best practice codes on Broad-Based Black Economic Empowerment (BBBEE), in terms of the applicable legislation;

Section	Content	Description of issues
		❖ A recruitment policy based on the objective to employ the best professional and support staff who are representative of the racial, gender and cultural diversity and demographics of the Republic of South Africa; ❖ Procurement policies that meet the transformation and empowerment goals set by the relevant guidelines on the BBBEE; ❖ Skills development programmes that focus on the development of previously disadvantaged individuals in the employment of the company; and ❖ Social responsibility initiatives primarily aimed at the upliftment and education of previously disadvantaged individuals and communities.
27(1)(c)	Efficient and beneficial use of water in the public interest	Ergo's reuse/recycling policy, as well as the mitigation measures discussed in the Integrated Water and Waste Management Plan (IWWMP), means that all steps are taken to reduce any strain and/or pollution on both surface water and groundwater resources. These sustainable practices will result in safer water resources being available for the use of local communities within the vicinity of the project. The Proposed Project recognises the importance of efficient water use by implementing strategies to minimise water loss and promote the reuse of water throughout the tailings deposition process.
27(1)(d)	The socio-economic impact- (i) of the water use or uses if authorised; or (ii) of the failure to authorise the water use or uses	The Proposed Project will directly and indirectly contribute to the country's Gross Domestic Product (GDP), as well as enhance and further support workers and contractors employed or contracted to Ergo. Failure to authorise this IWULA would lead to halts in tailings deposition, and therefore significantly affecting the productivity and efficiency of Ergo's TSF reclamation efforts. Consequently, both the negative and positive outcomes associated with the proposed project, including residue deposition, skills development, and poverty alleviation, would not be realised. The expected indirect benefits of the Proposed Project include: ❖ Ongoing ability for Ergo to reclaim Tailings Storage Facilities across Gauteng and making sterilised land available for other uses;

Section	Content	Description of issues
		❖ Ongoing ability for Ergo to safely dispose of the final residue; ❖ Sustainable employment of Ergo employees; and ❖ Continued supply of gold to the local and international markets, and therefore contribution to local, provincial and national economy.
27(1)(e)	Any catchment management strategy applicable to the relevant water resource	The project is situated within the Vaal-Orange Water Management Agency (WMA) (previously the Vaal Water WMA), within quaternary catchment C22C in the Klip River Catchment. The water quality in the Vaal-Orange WMA varies from poor in highly developed areas, to good in the less developed areas. According to the Upper Vaal Internal Strategic Perspective (ISP) (DWS,2004), the vision for this WMA is to facilitate water conservation and demand management as a primary point of focus, to which Ergo is fully committed.
27(1)(f)	The likely effect of the water use to be authorised on the water resource and on other water users;	The disposal of residues on the TSF is likely to impact surface and groundwater resources. This impact manifest through contamination caused by seepages and runoff, which may carry harmful substances into nearby water resource and on other water users. The impacts have been anticipated prior to the recommissioning of the Withok TSF, and management measures such as the placement of the sump and stormwater diversion trench, HDPE liner and drains (intermediate drain, main drain, radial, basin drain, interface blanket drain) as well as below liner seepage cutoff/collector drains will be put in place to limit the amount of this possible contamination. All working areas will have a dirty water containment/management system to prevent pollution of clean water areas.
27(1)(g)	The class and the resource quality objectives of the water resource	Various studies of the Vaal River system show that it is under water quality and quantity stress as it is unable to meet the needs of its users adequately in respect of their quality and quantity requirements. From a water quality perspective, the current state of the Vaal River system shows unacceptably high nutrient and salt concentrations which are indicative of an unsustainable

Section	Content	Description of issues
		system. At present, an imbalance exists between sustainable and optimal water use and protection of the water resource. The proposed project is within the Upper Vaal WMA in quaternary catchment C22C in the Klip River Catchment. The Upper Vaal WMA is one of the 19 WMAs included in the Orange/Vaal River Basin. The Upper Vaal WMA is the most developed, industrialised and populous of the Orange/Vaal WMAs (DWAF, 2002). The Classes and Resource Quality Objectives of the Upper Vaal report (2016) does not contain information on resource quality objectives for the quaternary catchment C22C. Wetland features have been identified on site. Therefore, during both the construction and operation phases of the Proposed Project, measures to monitor and manage water quality will be implemented to ensure compliance with required standards.
27(1)(h)	Investments already made and to be made by the water user in respect of the water use in question	Significant financial investments have been made to date in respect to the water uses being applied for. Detailed specialist studies, modeling programmes, detailed engineering designs, drilling and laboratory analysis have been undertaken. Substantial nvestments on the Proposed Project will be required upon approval of the activities.
27(1)(i)	The strategic importance of the water use to be authorised	The recommissioning of the Withok TSF is essential for the continued safe disposal of residue, which is crucial for the ongoing viability of Ergo's tailings deposition. This proposed project will enhance the operational efficiency for Ergo's reclamation activities by providing a reliable and safe method for tailings disposal.
27(1)(j)	The quality of water in the water resource which may be required for the Reserve and for meeting international obligations	According to the Integrated Water Management of the Vaal River Catchment report (2009), the Vaal River is known as one of the most 'hardworking' rivers in South Africa and flows across the Upper, Middle and parts of the Lower Vaal WMAs. The Upper Vaal is the pivotal WMA out of the three because of its extensive level of urbanization and industrialization and therefore, its water resources have been highly developed and utilised. According to the National Water Resource Strategy (NWRS) of 2004, an upward trend in population and economic growth is foreseen in this WMA; hence future requirements of water will have to be met from additional inter-basin transfers from adjacent WMAs.

Section	Content	Description of issues
		According to the Classes and Resource Quality Objectives of Water Resources for Catchments of the Upper Vaal (DWS, 2016), the present ecological state (PES) of quaternary catchment C22C is considered as Class E (seriously modified). The Recommended Ecological Category (REC) is Class D (Largely Modified). Ergo acknowledges the need to maintain water quality for ecological reserves and to meet international obligations. In order to preserve the water reserve, water of poor quality cannot be released into the surrounding clean environment. Therefore, clean and dirty water will be separated on site. The recommissioning of Withok TSF project will implement best practices to ensure that water use does not compromise the ecological integrity of surrounding water bodies.
27(1)(k)	The probable duration of any undertaking for which a water use is to be authorised	Based on an average deposition rate of 1.3 million tons per month (tpm), the life of the proposed project is planned to be approximately 24 years. Therefore, it is requested that the licence be issued for a period of 24 years, with a condition for renewal.

8.4 Key Commitments

Ergo is committed to the correct implementation of the IWWMP action plan contained in this report and the water use licence conditions that will be stipulated in the WUL once issued.

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Appendix A:

Surface Water Impact Assessment

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WITHOK TAILINGS STORAGE FACILITY

SURFACE WATER SPECIALIST STUDY

BASELINE HYDROLOGY & IMPACT ASSESSMENT

Report prepared for

DRDGOLD LIMITED

DRAFT REPORT

Report prepared by

Bruce Randell

PhD (Eng), Pr Eng

January 2025 | Report no. 492-Rep-001-Rev 0

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TABLES

FIGURES

APPENDICES

Appendix C: CV of specialist who prepared the report

REVISION TRACKING

Rev 0: Original document

Disclaimer

The opinions expressed in this report have been based on the information supplied to by the Client. The opinions in this report are provided in response to a specific request from the Client to do so. iLanda has exercised all due care in reviewing the supplied information. Whilst iLanda has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. iLanda 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 iLanda's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this report, about which iLanda had no prior knowledge nor had the opportunity to evaluate.

1. INTRODUCTION

DRDGold commissioned iLanda Water Services CC (iLanda) to conduct a surface water specialist study for the proposed Withok tailings storage facility complex (TSF complex). The TSF complex consists of a single lined tailings storage facility that abuts against the southern flank of the Brakpan TSF. The TSF will be served by a new dedicated return water dam. Decant water is not pumped to the return water dam but rather returned to process via the Brakpan return water dam. Dirty storm water runoff from the side slopes and drain flow returns are routed to the return water dam before being returned to process.

1.1 Study Objectives and Terms of Reference

The study objectives and terms of reference are as follows:

- Baseline hydrological and water quality analysis
- Surface water buffer zone determination
- Surface water impact assessment

This report constitutes the outcome of the specialist studies undertaken by iLanda on behalf of DRDGold, related to the environmental impact of the proposed Withok tailings storage facility complex.

1.2 Battery Limits

The battery limits of the study are shown in Figure 1. All work is confined to this area unless otherwise specified.

1.3 Legislative and Policy Framework

The following legislation was adhered to:

- The South African National Water Act, Act 36 of 1998.
- GN 704, Regulations on the use of water for mining and related activities aimed at the protection of water resources (1999).
- Mineral and Petroleum Resources Development Act, Act 28 of 2002.

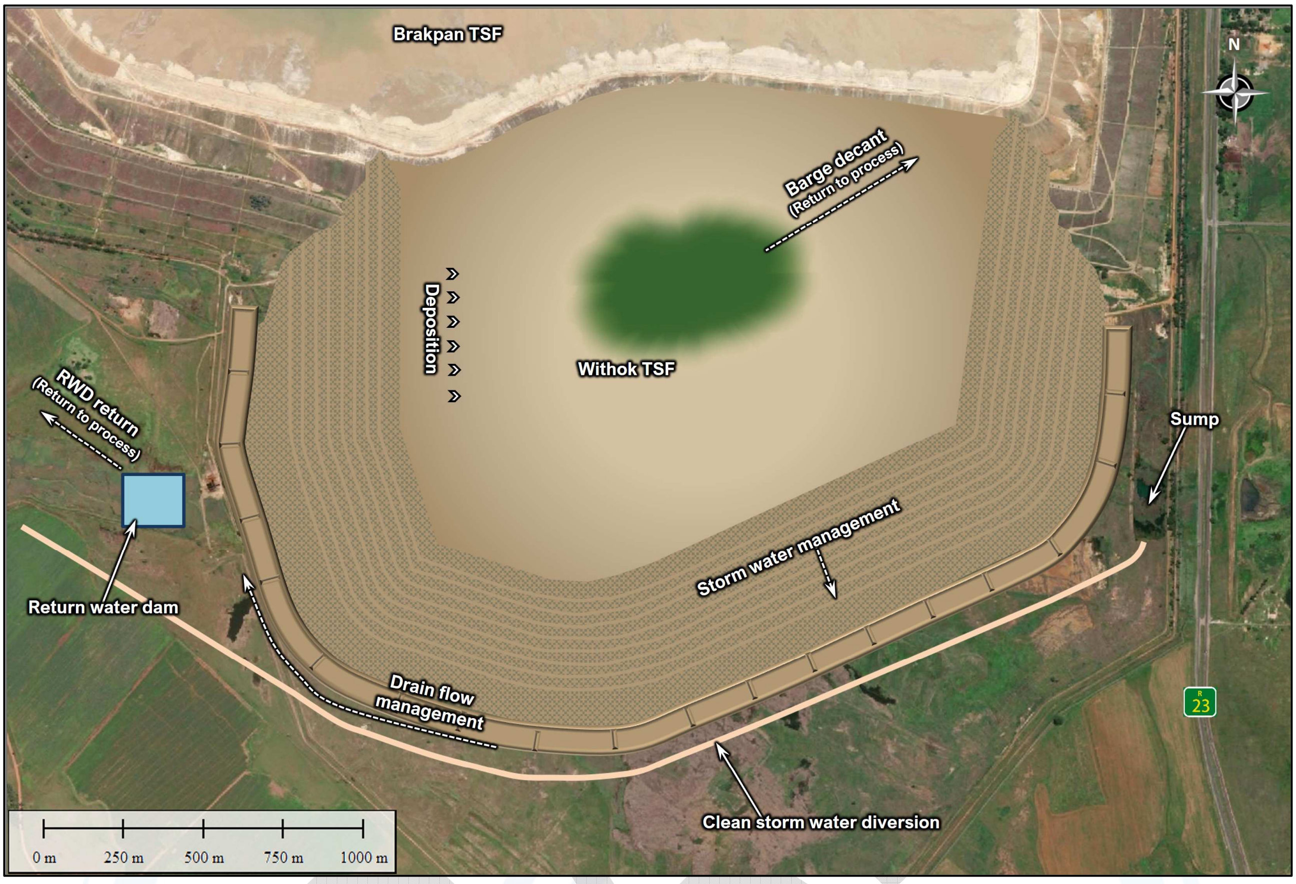


FIGURE 1: STUDY AREA AND BATTERY LIMITS

2. SPECIALIST DETAILS

This specialist report was compiled by Dr Bruce Randell. Dr Randell is a Water Resources Engineer with over 24 years' experience, mostly in water resources modelling and specialist surface water studies for environmental impact assessments. Dr Randell has B.Sc. (Civil Engineering) and PhD degrees. Dr Randell's PhD thesis was in water resources. Dr Randell's CV is attached in Appendix C.

3. REGIONAL SETTING

The proposed Withok TSF complex is located approximately 14 km south west of Springs, in quaternary catchment C22C, as shown in Figure 2 and Figure 3. The Rietspruit flows north to south past the western flank of the Brakpan TSF. The Rietspruit is a tributary of the Kliprivier, which flows into the Vaal River, upstream of the Vaal Barrage but downstream of the Vaal Dam.

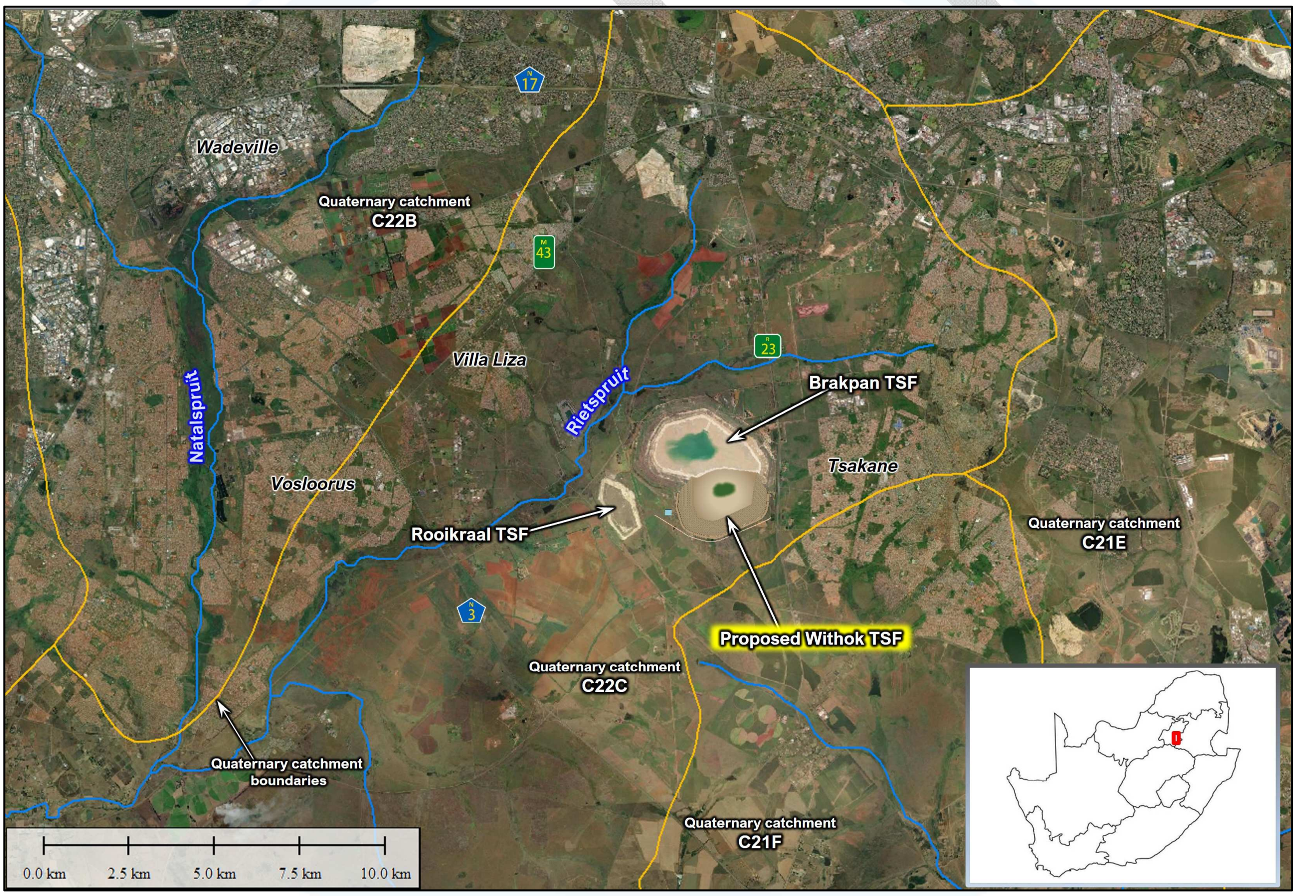


FIGURE 2: REGIONAL SETTING

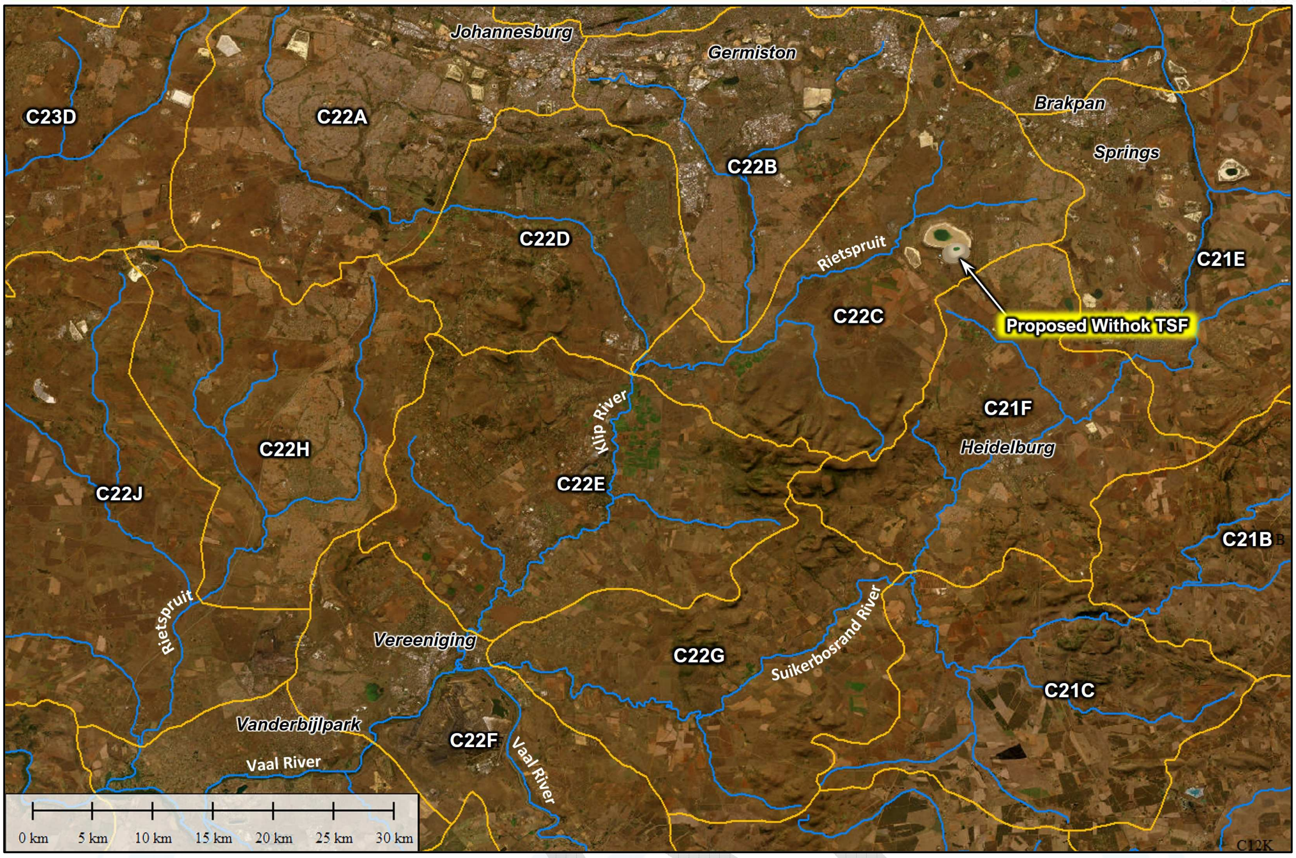


FIGURE 3: REGIONAL SETTING

4. LOCAL SETTING

The Withok TSF will be constructed on the same footprint that the original Withok TSF was constructed on. The original Withok TSF was remined in the early 2000's. As a result, the footprint is disturbed and heavily impacted by previous tailings dam activities as well as the current Brakpan TSF operations. Contaminated water from the Brakpan TSF is routed overland across this footprint and is intercepted at the Withok pump station (refer to Figure 4), where it is returned to the process.

An unnamed water course runs through the footprint of the proposed Withok TSF. The catchment of this water course is largely urbanised with the townships of Geluksdal and Tsakane (shown in Figure 4). An attenuation dam has been constructed as part of the initial Withok TSF project to attenuate flood peaks from this unnamed stream so that they could be routed safely under the old facility through a "spinal culvert". This attenuation dam is still operational and described in more detail in Section 4.1.

The unnamed water course flows towards the Rooikraal TSF which diverts the stream around the TSF before it flows into the Rietspruit.

The unnamed water course has an ill-defined channel throughout its length. The valley bottom is generally wide and well vegetated. The channel slope is gentle.

FIGURE 4: LOCAL SETTING

4.1 Attenuation Dam

The unnamed stream catchment area upstream of the R23 national road measures 1050.5 ha. The catchment is mostly urban with the townships of Geluksdal and Takane dominating the land use in the catchment. Storm water from this catchment flows into an existing attenuation dam, located east of the R23 national road. This dam was constructed to attenuate storm flows so that these flows could be piped under the original Withok TSF. The attenuation dam catchment is enlarged due to a series of channels that were excavated to route water into the attenuation dam.

The attenuation dam's capacity was measured using the latest available survey – 621 000 m^3. The dam has an estimated dead storage of 1 700 m^3. Further details are shown in Figure 13.

The dam is continuously emptied by two 450 mm diameter steel pipes constructed into an outlet structure. This is shown in Figure 5. One of the two 450 mm steel outflow pipes is partially blocked by a large piece of concrete and other debris. The outlet pipe was fully submerged. The 2nd pipe inlet is completely open and was flowing ⅔ full at the time of the inspection. The outlet end of the pipes was not inspected. There are no grates that cover the inlet structure. The inlet structure may have had grates at the time of construction, but these may have been stolen.

The dam is downstream of Takane and the water is full of debris from this township. Some of this debris could block the outlet pipes and render the dam inoperable. Aerial photography shows that the dam was inoperable from at least January 2015 to May 2016, where it was full. Highlands Hydrology (2016) reported that the outlet structure had been vandalised, although the nature of this vandalism was not reported. The outlet structure is easily accessible by foot and vehicle.

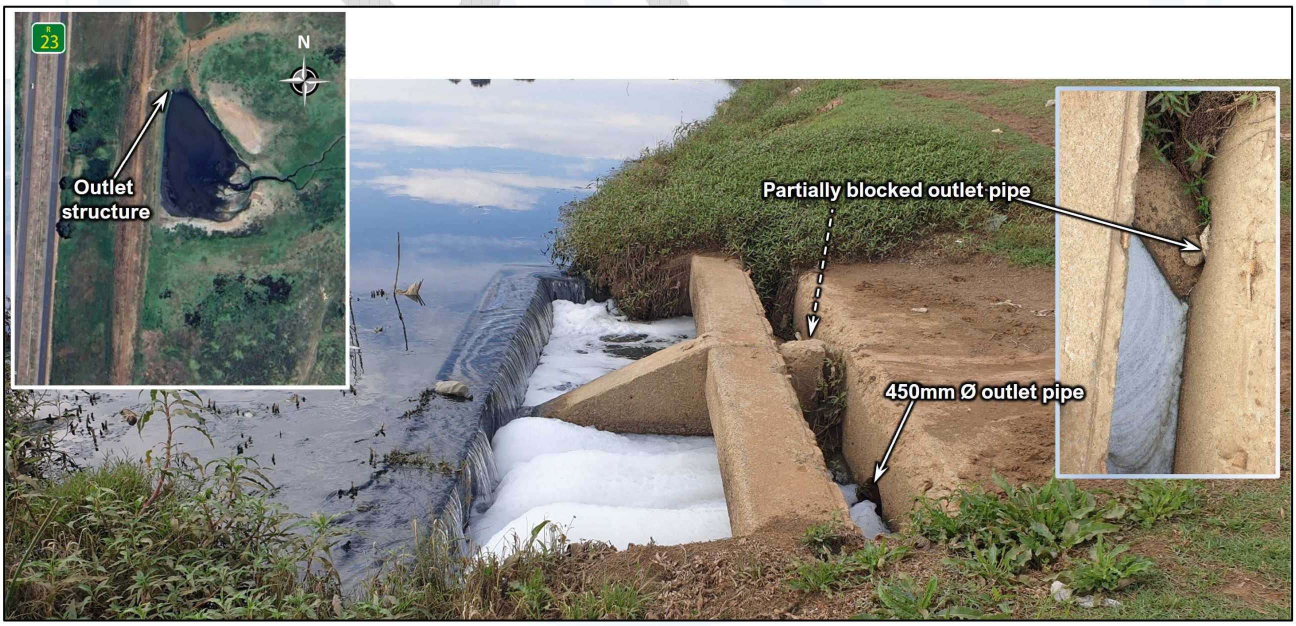


FIGURE 5: ATTENUATION DAM OUTLET STRUCTURE

5. CATCHMENT DESCRIPTION

The unnamed water course catchment is largely urbanised. The undeveloped parts of the catchment consist of dryland agriculture in the south and undeveloped grasslands in the north east.

The regional topography is shown in Figure 6.

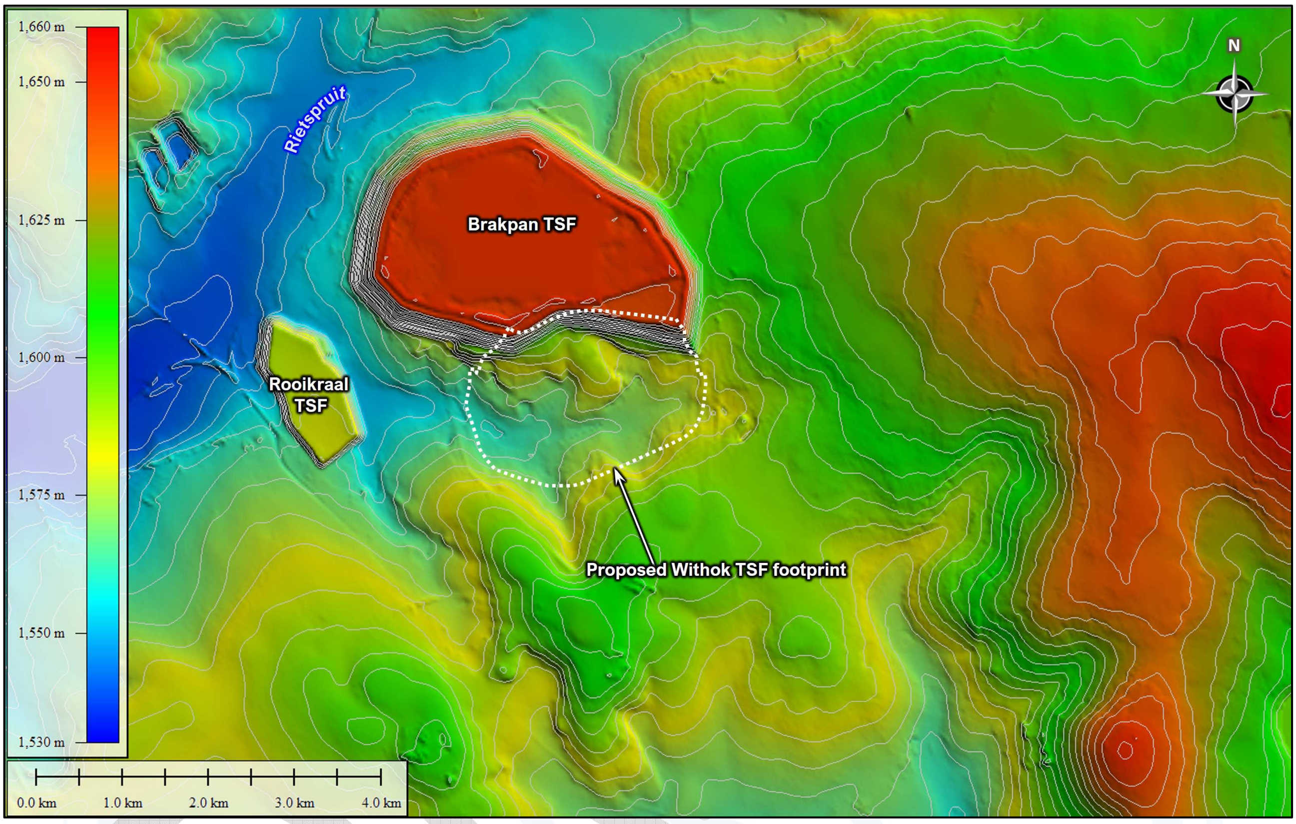


FIGURE 6: REGIONAL TOPOGRAPHY (SHOWING 5M CONTOURS)

6. BASELINE RAINFALL AND EVAPORATION

6.1 Mean Annual Precipitation and Evaporation

The mean annual precipitation of the TSF complex is 688 mm. The mean annual evaporation of the TSF complex is 1 625 mm (S-Pan). The monthly average rainfall, rainfall days, and evaporation rates are presented in Figure 7. The area has distinct wet and dry seasons. 91% of the proposed TSF's mean annual rainfall falls between October and April inclusively. 78% of the area's mean annual evaporation occurs during this period (Midgley et al., 1990).

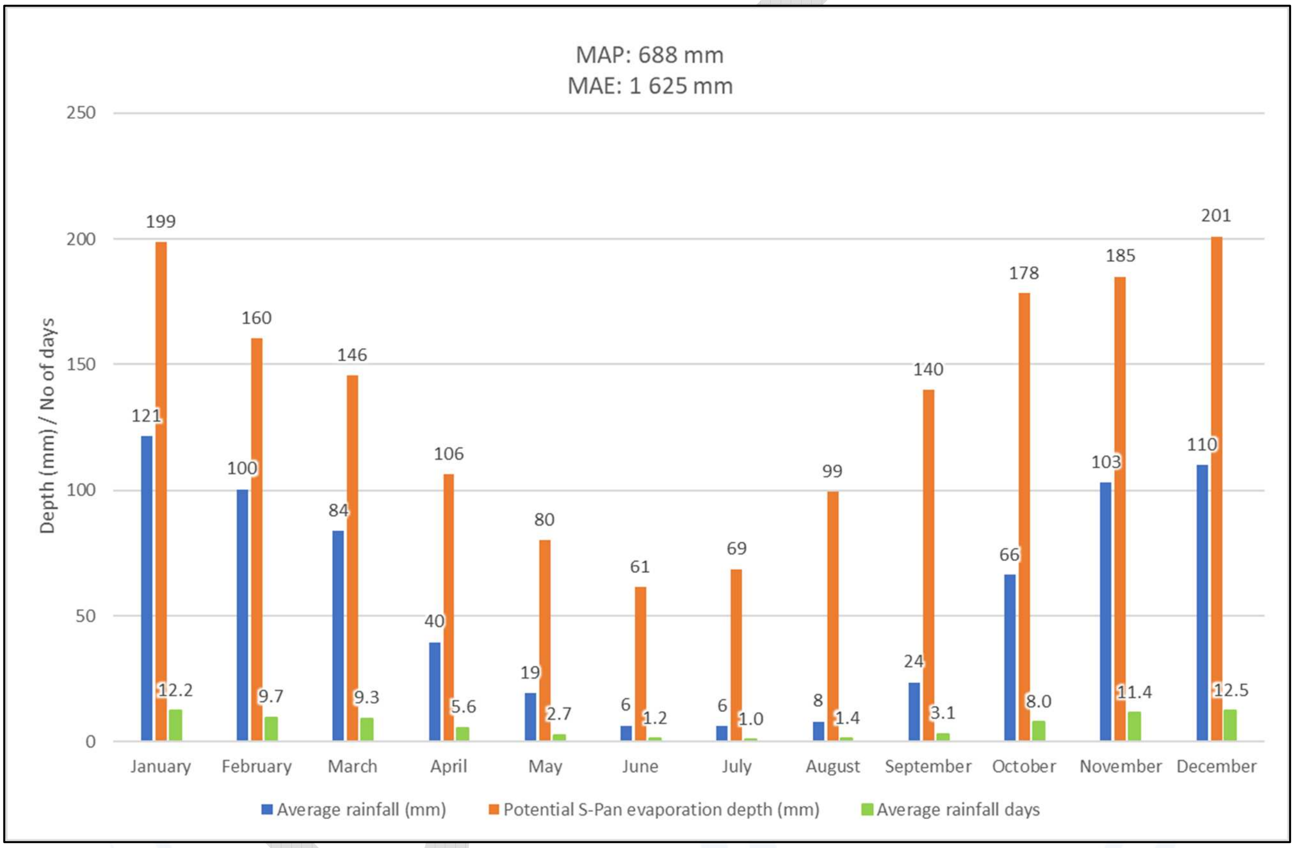


FIGURE 7: CLIMATE DATA SUMMARY

6.2 Climatic water balance

The Department of Water and Sanitation require a climatic water balance that incorporates a list of years which have the wettest six months of the year, either November to April or May to October. In this case November to April is wetter than May to October. The wettest six months between November and April are listed in Table 1.

TABLE 1: WETTEST YEARS BETWEEN NOVEMBER AND APRIL

Rating	Year	Total rainfall between November and April (mm)
Wettest year	2000	965.3
2nd wettest year	1975	949.2
3rd wettest year	1917	885.5
4th wettest year	1955	878.9
5th wettest year	1996	862.5
6th wettest year	1967	787.9
7th wettest year	1944	786.2
8th wettest year	1987	766
9th wettest year	1942	756.1
10th wettest year	1978	753.5

6.3 Sources of rainfall data

Daily rainfall data for the area was obtained from the CCWR (Computing Centre for Water Research, University of Kwazulu Natal) database. Gauge number 0476736 (Springs (RWB)) was used. The gauge is located 12 km north west of the TSF complex. The data spans the period 1903 to 2000. South African Weather Services' (SAWS) daily rainfall was also purchased for gauge 0476766 Springs Olympia Park and used to extend the rainfall record. This is the closest active/recently active SAWS rainfall station, located approximately 16 km north west of the TSF complex. The gauge locations are shown in Figure 8.

The Springs Olympia Park gauge has a data gap in December 2003 which was patched with data from the CCWR gauge. December 1991 was used to infill the data. December 1991 is the closest December to the December average and contained no extreme rainfall events (else this would skew the peak rainfall statistics). Data beyond January 2009 was too patchy and not used. The gauge was closed in September 2009.

The combined record spans September 1903 to December 2008.

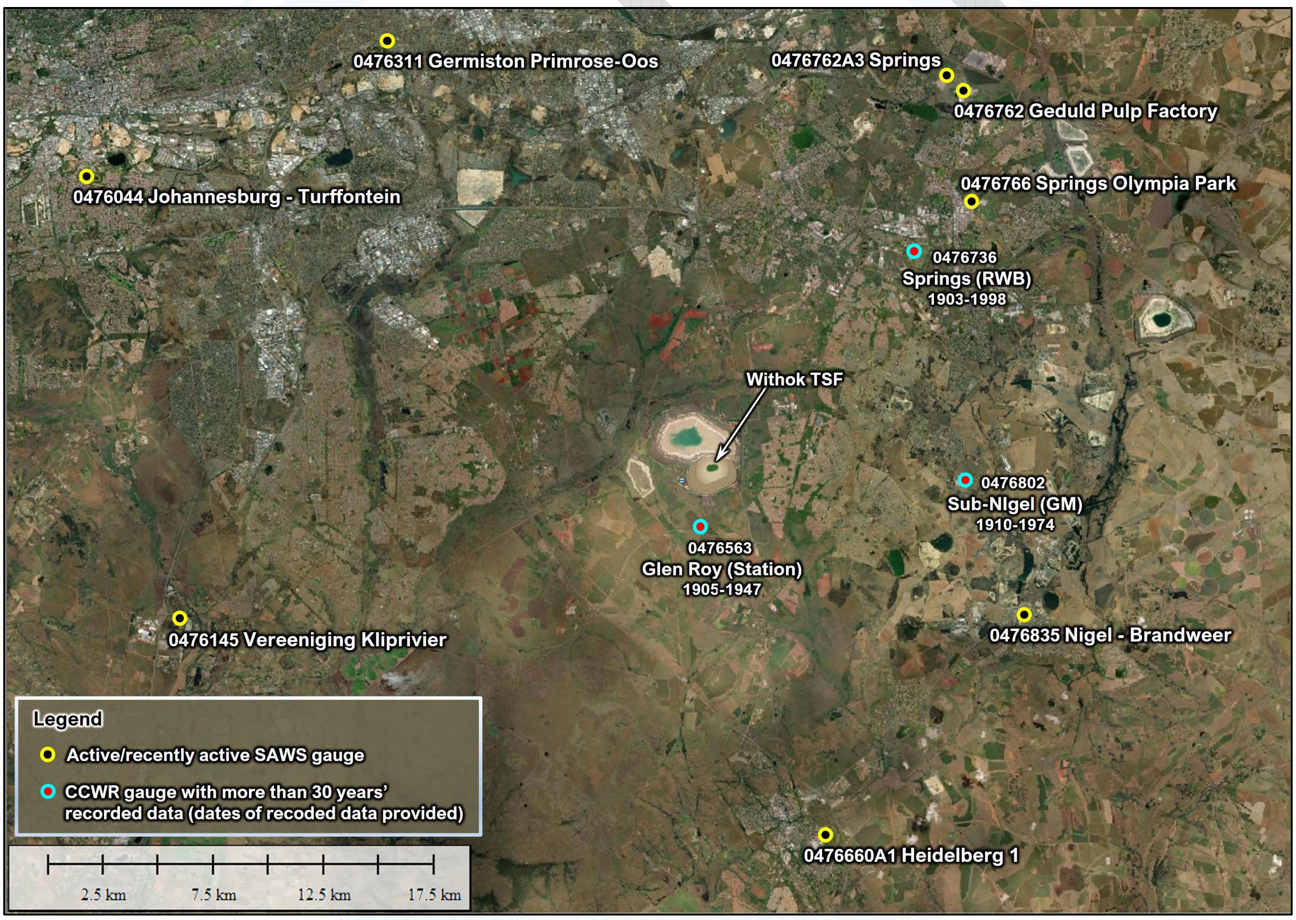


FIGURE 8: NEAREST RAINFALL STATION LOCATIONS

6.3.1 Rainfall gauge selection

There are no currently operational/recently operational South African Weather Services (SAWS) rainfall stations in close proximity to the TSF site. The closest SAWS rainfall stations are shown in Figure 8. There are CCWR gauges that are closer than any of the SAWS gauges. The CCWR gauges are a combination of recorded and patched data spanning approximately the 20th century. Three of these gauges have more than 30 years' recorded data (with the remaining data being patched data). These are shown in Figure 8.

The Glen Roy gauge is very close to site but only contains recorded data from 1905 to 1947. The rest of the record is patched by the CCWR. The Springs and Sub-Nigel gauges have far longer recorded records and are still acceptably close to the site with similar elevations. There are no significant topographical features in the area so both these gauges will provide representative data. The Springs and Sub-Nigel gauges are a similar distance from the complex, but the Springs gauge has a longer, and more recent recorded record than the Sub-Nigel gauge. It is also close to a recently active SAWS gauge. This CCWR gauge (0476736 Springs (RWB)) was therefore selected as the rainfall gauge and is paired with the SAWS gauge 0476766 Springs Olympia Park to provide additional data.

6.4 Sources of evaporation data

The mean annual evaporation was sourced from the average evaporation for quaternary catchment C22C, documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009). Its monthly distribution was sourced from the Water Resources of South Africa Study data set, zone 11A (Midgley et al., 1990). The data is considered representative of the site.

6.5 Peak Rainfall Data

6.5.1 Maximum Monthly Rainfall Data

The maximum monthly rainfall data was distilled from the daily rainfall record (discussed in section 6.3) and is presented in Table 2.

TABLE 2: MAXIMUM MONTHLY RAINFALL DATA (MILLIMETRES)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
189	344	264	337	383	272	139	149	65	70	87	167

6.5.2 Peak 24-hr Rainfall Data

The peak 24-hr rainfall depths are presented in Table 3.

The daily rainfall record, discussed in section 6.3, was analysed and the annual maximum series was extracted from the data. This annual maximum series was statistically analysed to determine various T-year recurrence interval 24-hour storm depths. A Log Pearson Type 3 distribution was selected as the most appropriate statistical fit. This fit is shown in Figure 9. The rainfall record is long, consists of good data, is representative of the TSF complex, and is suitable to be used to calculate peak rainfall.

TABLE 3: PEAK 24-HR RAINFALL DEPTHS FOR THE TSF COMPLEX

Recurrence interval (year)	24-hour rainfall depth (mm)
2	52
10	85
20	99
50	119
100	136
200	153
1 000	199

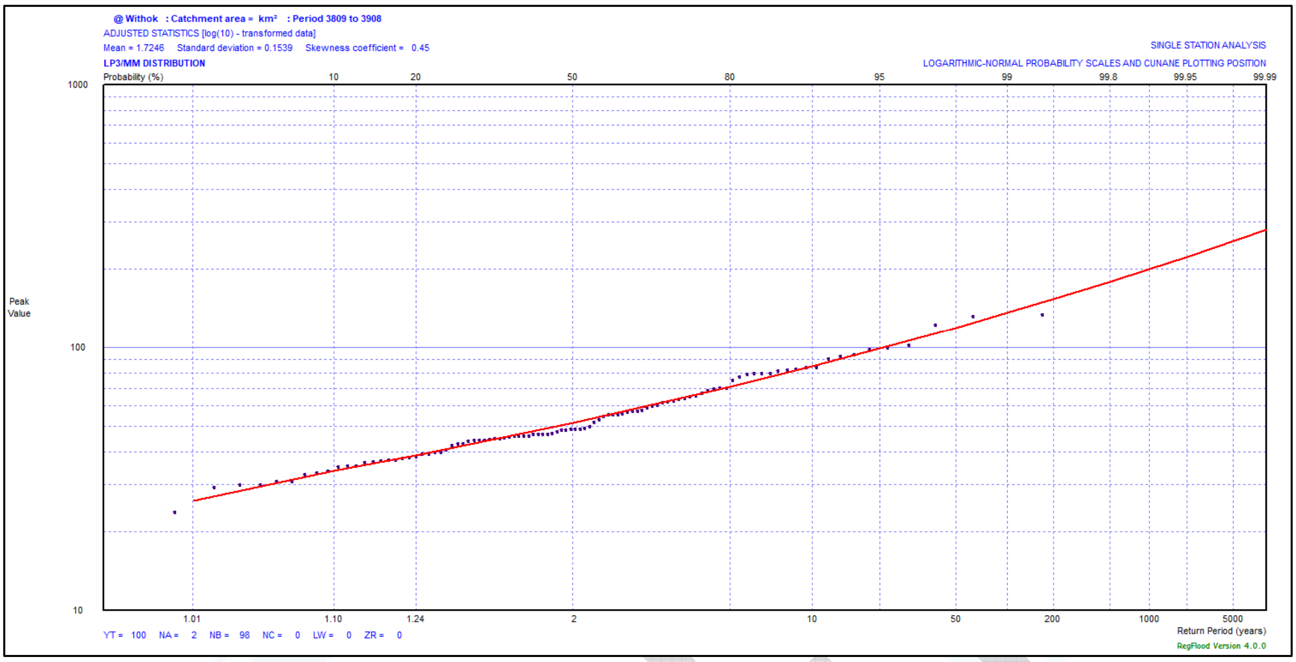


FIGURE 9: LOG PEARSON TYPE 3 STATISTICAL FIT TO THE ANNUAL MAXIMUM SERIES

7. BASELINE HYDROLOGY

7.1 Catchment Delineation

The catchment was delineated using the surveyor general's 5m contours. The catchment is shown in Figure 10.

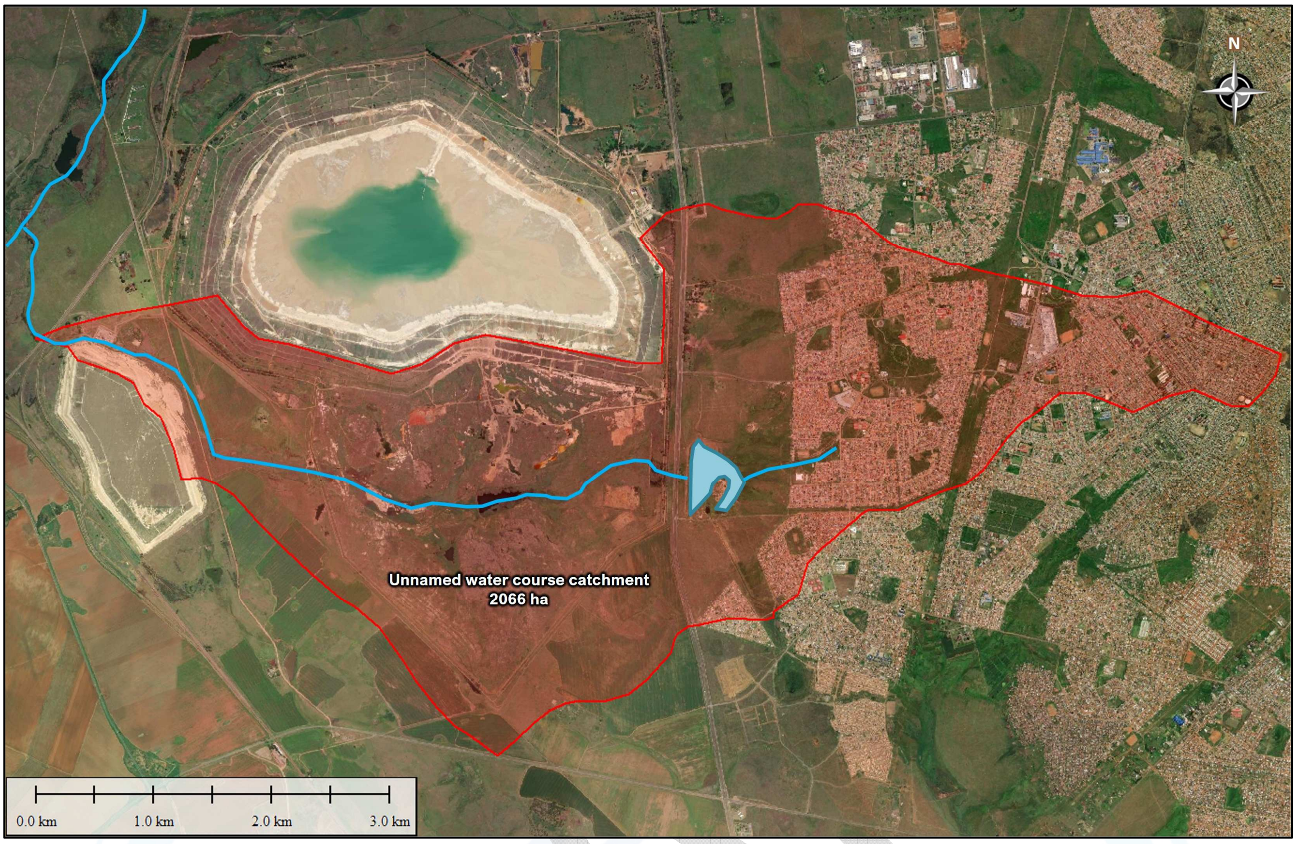


FIGURE 10: CATCHMENT DELINEATION

7.2 Mean Annual Runoff

The mean annual runoff for the quaternary catchments C22C is 21.38 Mm^3 (Middleton and Bailey, 2009). The mean annual runoff value in Table 4 was scaled from the quaternary catchment runoff, based on relative catchment size. The catchment boundaries and size is shown in Figure 10.

TABLE 4: MEAN ANNUAL RUNOFF

Stream	Mean annual run-off (Mm^3/a)
Unnamed water course	0.95

7.3 Normal Dry Weather Flows

The normal dry weather flows are based on the average monthly flows documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009) for quaternary catchment C22C. The flows were scaled based on relative catchment size. The dry weather flows are presented in Table 5. The dry weather flows have been highlighted in bold text.

TABLE 5: NORMAL DRY WEATHER FLOWS IN M^3/MONTH (HIGHLIGHTED IN BOLD TEXT)

Month	Unnamed water course
Oct	**38 681 m^3**
Nov	64 989 m^3
Dec	85 046 m^3
Jan	134 871 m^3
Feb	183 337 m^3
Mar	165 805 m^3
Apr	84 925 m^3
May	**53 542 m^3**
Jun	**40 469 m^3**
Jul	**35 911 m^3**
Aug	**32 100 m^3**
Sep	**30 474 m^3**

7.4 Flood Flow Analysis

The 50-year and 100-year flood peaks for the unnamed water course, at its confluence with the Rietspruit, are presented in Table 6. The flood peaks were calculated for the catchment shown in Figure 10.

TABLE 6: PEAK FLOWS IN THE RIVERS AND STREAMS

River	50-yr	100-yr
Unnamed water course	41.9 m^3/s	57.7 m^3/s

The flood peaks were calculated as follows:

7.4.1 Catchment upstream of the attenuation dam

The catchment area upstream of the R23 national road measures 1050.5 ha. The catchment is mostly urban with the township of Takane dominating the land use in the catchment. Storm water from this catchment flows into the attenuation dam, located east of the R23 national road, as shown in Figure 11. The attenuation dam is discussed in more detail in Section 4.1 on page 6. The flood peaks and flood volumes flowing into this attenuation dam are shown in Figure 11. The flood peaks were calculated using the Rational Method and the flood volumes were calculated using the SCS flood volume method.

The attenuation dam's capacity was measured using the latest available survey – 621 000 m^3. The dam has an estimated dead storage of 1 700 m^3. Further details are shown in Figure 13.

The 50-yr storm volume (shown in Figure 11) is slightly less than the capacity of the attenuation dam. The dam therefore will not overtop, and dam outflows will be limited to the flow in the pipes. Hydraulic analysis shows that this flow will peak at 1.7 m^3/s.

The 100-year storm volume is larger than the dam capacity. Hydraulic analysis shows that the dam will overtop in the event of a 100-yr design storm. The outflow (pipe outflow plus overflow) peaks at 38.3 m^3/s. However, by assuming that only one outlet pipe is functioning, this outflow peaks at 39.3 m^3/s. This is not an overly conservative assumption:

- In 2015/16, both the outlet pipes were not functioning.
- One outlet pipe is largely blocked at the time of writing.

The attenuation dam hydrographs are shown in Figure 12. These flow rates will result in the R23 flooding. No attenuation downstream of the attenuation dam is considered. This attenuation capacity will already be full by the time the attenuation dam overflows.

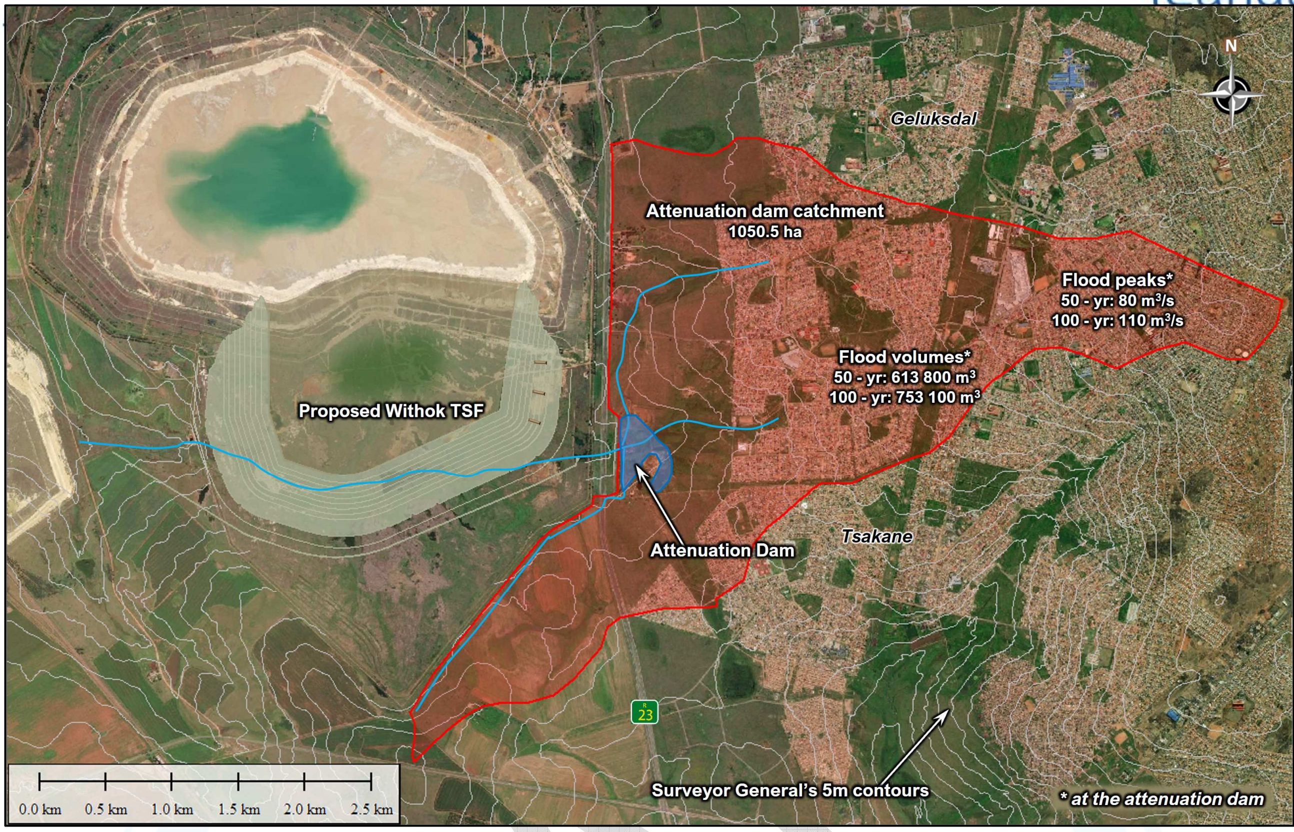


FIGURE 11: ATTENUATION DAM CATCHMENT

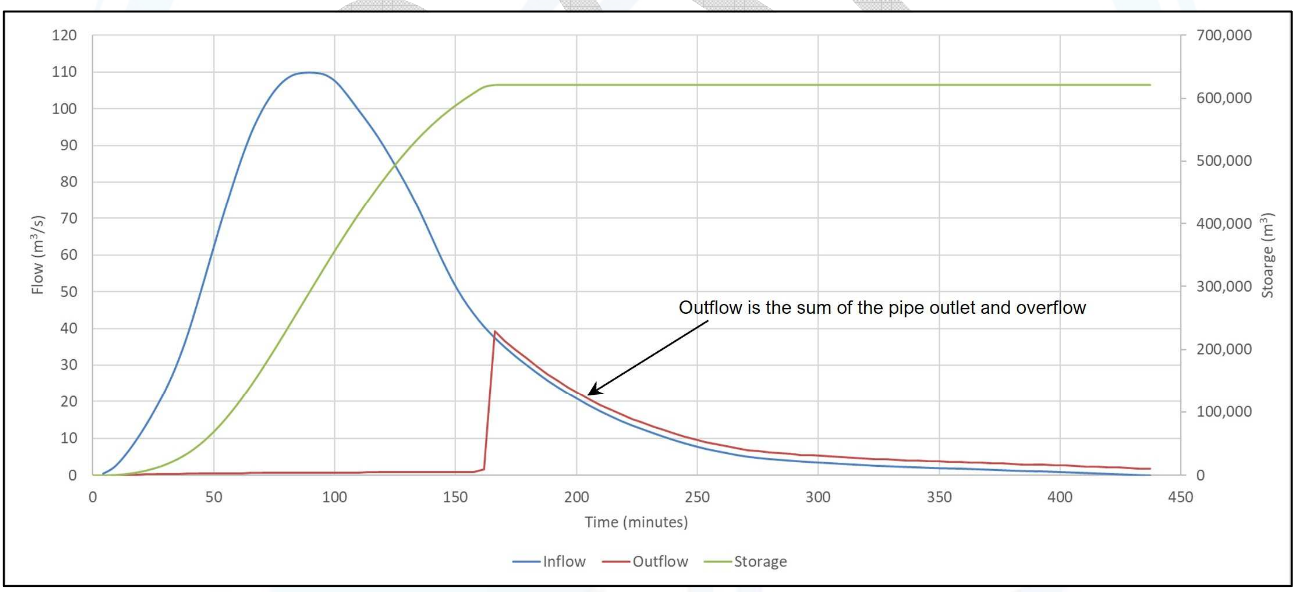
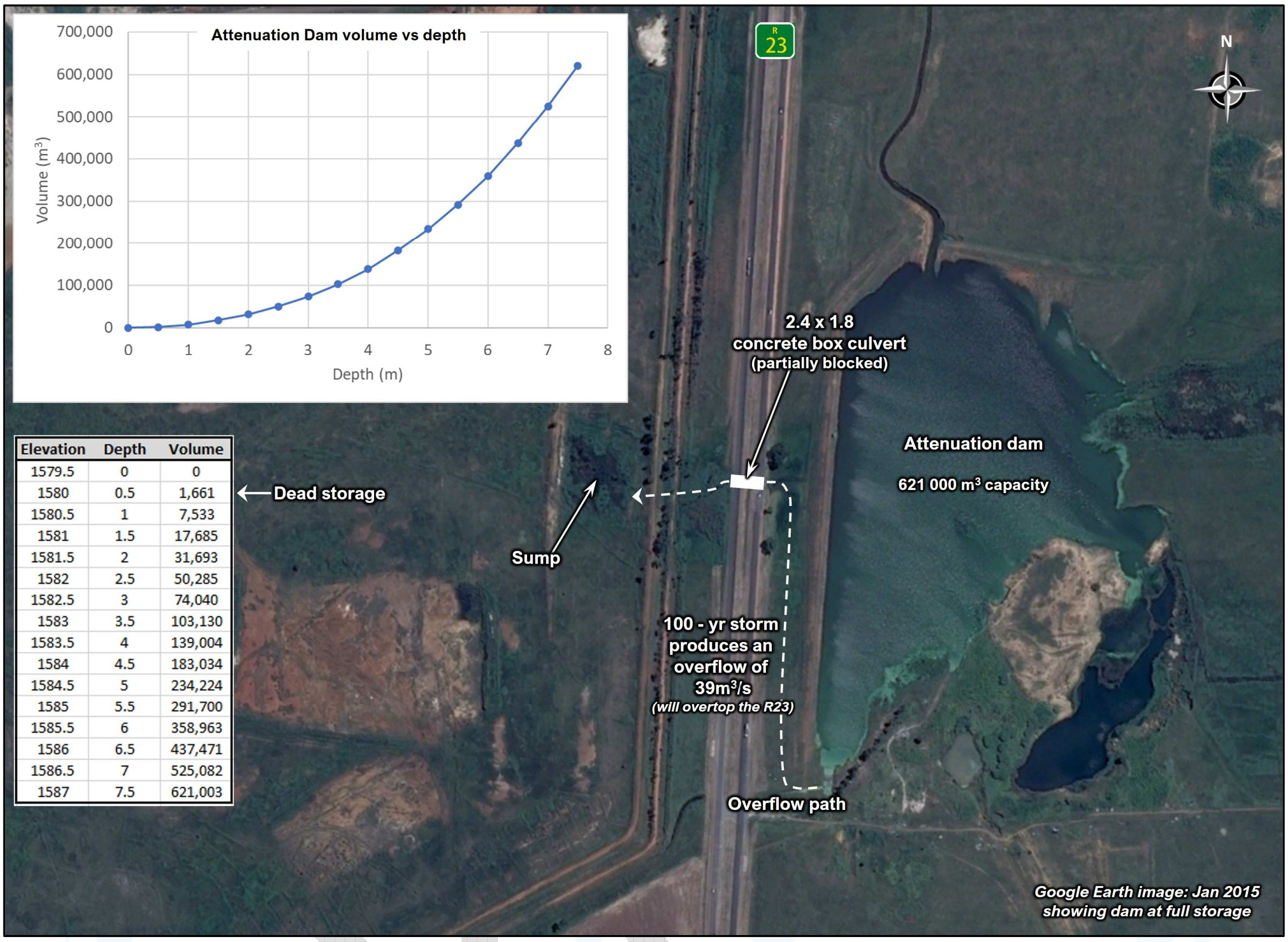


FIGURE 12: ATTENUATION DAM HYDROGRAPHS



Elevation	Depth	Volume
1579.5	0	0
1580	0.5	1,661
1580.5	1	7,533
1581	1.5	17,685
1581.5	2	31,693
1582	2.5	50,285
1582.5	3	74,040
1583	3.5	103,130
1583.5	4	139,004
1584	4.5	183,034
1584.5	5	234,224
1585	5.5	291,700
1585.5	6	358,963
1586	6.5	437,471
1586.5	7	525,082
1587	7.5	621,003

FIGURE 13: ATTENUATION DAM

7.4.2 Catchment downstream of the attenuation dam

The catchment downstream of the attenuation dam measures 1015.5 ha. This catchment is shown in Figure 14. The 50-yr and 100-yr flood peaks from this catchment are 41.9 m^3/s and 57.7 m^3/s respectively. Because of the attenuation dam, the flood peaks from the catchment upstream of the dam will be lagged and the unnamed water course will see two flood peaks come through. The first flood peak (the larger ones) will be generated by the catchment downstream of the attenuation dam. The second flood peak (the smaller ones) will be experienced when the attenuation dam overflows. The largest of the two flood peaks is therefore the design flood peaks to use.

Note that when the Withok TSF complex is constructed, a significant amount of the catchment downstream of the attenuation dam will be taken up by the TSF infrastructure. Runoff from this infrastructure will be captured in the dirty water system and returned to the process. The flood peaks from the catchment downstream of the attenuation dam will then be significantly lower.

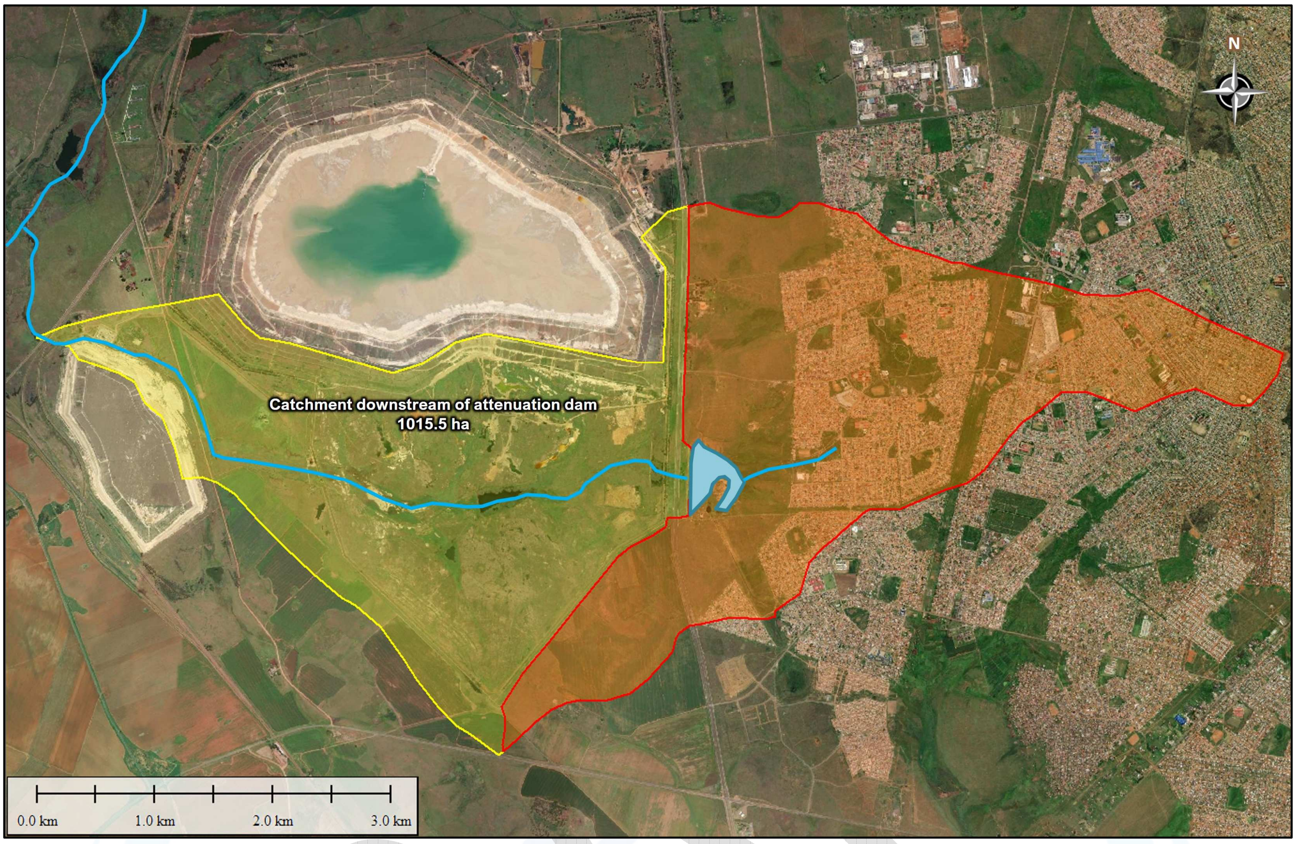


FIGURE 14: CATCHMENT DOWNSTREAM OF THE ATTENUATION DAM

8. BUFFER ZONES

8.1 Floodlines

The backwater analysis was performed using HEC-RAS within Geo HEC RAS. The area was surveyed by an independent surveyor using LIDAR. A DTM was produced from the LIDAR data. Cross sections for the unnamed water course were taken from the DTM.

Generally, a Manning's n of 0.045 was used outside the overbank stations. Within the overbank stations, the Manning's n varied from 0.026 to 0.08, depending on vegetation cover and morphology.

The flood peaks presented in Table 6 were used to calculate the floodlines. The 50-year and 100-year floodlines are shown in Figure 15. The accuracy of the survey data cannot be verified. It is assumed that the survey data is a true reflection of the topography within the study area. The accuracy of the floodlines is dependent on the accuracy of the survey data.

8.2 Buffer Zones

The surface water buffer zone is the greater of the 100-year floodline or 100 m from a water course.

Section 4a of Government Notice 704 (GN 704) of the South African National Water Act states the following: "*No person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse…*".

Section 4b of GN 704 of the South African National Water Act states the following: "*No person in control of a mine or activity may … carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse…*"

A pollution control dam and a residue storage facility are required as part of the operations so Section 4a of GN 704 will apply. The surface water buffer zone therefore is the greater of the 100-year floodline or 100 m from a water course. The surface water buffer zones are shown in Figure 18.

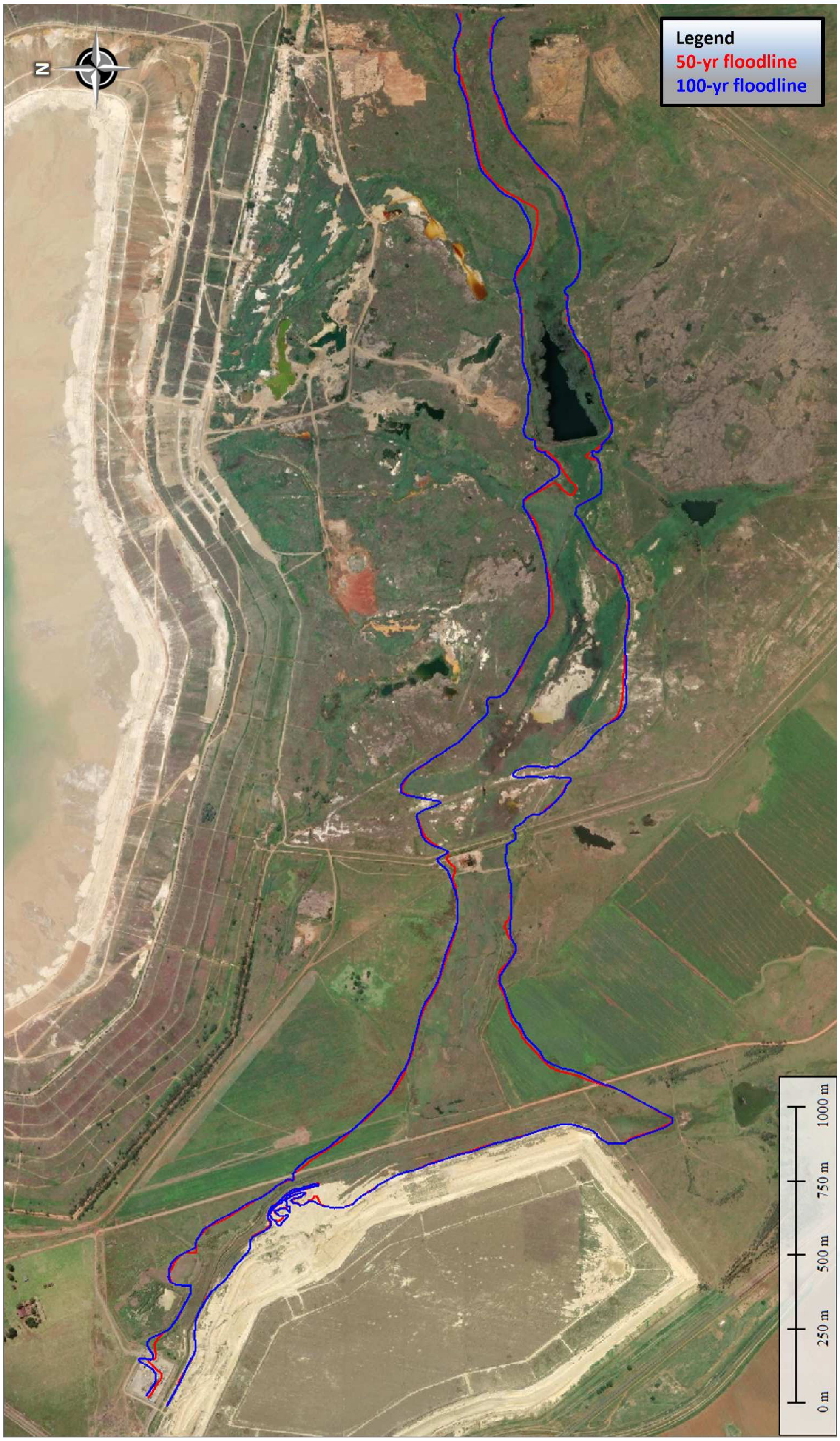


FIGURE 15: FLOODLINES

FIGURE 16: SURFACE WATER BUFFER ZONES

9. WATER QUALITY

9.1 Surface Water Users

The water quality data was compared against the Klip River in-stream water quality objectives, as documented in Compliance Africa, 2024. These water quality objectives are shown in Figure 17. The water quality data was also compared against the SANS 241 - 1:2015 drinking water standards.

Variables	Measured as	Ideal Catchment Background	Acceptable Management Target	Tolerable Interim Target	Unacceptable
Physical					
Conductivity	mS/m	< 80	80 - 100	100 - 150	> 150
Dissolved Oxygen (O_2)	mg/l O_2		> 6.0	5.0 - 6.0	< 5.0
pH	pH units	6.0 - 9.0			< 6.0; > 9.0
Suspended Solids	mg/l	< 20	20 - 30	30 - 55	> 55
Organic					
Chemical Oxygen Demand (COD)	mg/l	< 15	15 - 30	30 - 40	> 40
Macro Elements					
Aluminium (Al)	mg/l		< 0.3	0.3 - 0.5	> 0.5
Ammonium (NH_4 as N)	mg/l	< 0.5	0.5 - 1.5	1.5 - 4.0	> 4.0
Chloride (Cl)	mg/l	< 50	50 - 75	75 - 100	> 100
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l	< 0.5	0.5 - 1.0	1.0 - 1.5	> 1.5
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l	< 1	1 - 2	2 - 4	> 4
Nitrate (NO_3 as N)	mg/l	< 2	2 - 4	4 - 7	> 7
Phosphate (PO_4 as P)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Sodium (Na)	mg/l	< 50	50 - 80	80 - 100	> 100
Sulphate (SO_4)	mg/l	< 200	200 - 350	350 - 500	> 500

FIGURE 17: WATER QUALITY OBJECTIVES (IMAGE SOURCE: COMPLIANCE AFRICA, 2024)

9.2 Sample Locations and Analysis

The operations measure water quality at many locations. Five of these are pertinent to the proposed Withok TSF complex, as shown in Figure 18. The water quality results from these locations were provided by the operations. Data from November 2023 to October 2024 (the latest 12 months on record) were analysed and are summarised in Figure 19 to Figure 23.

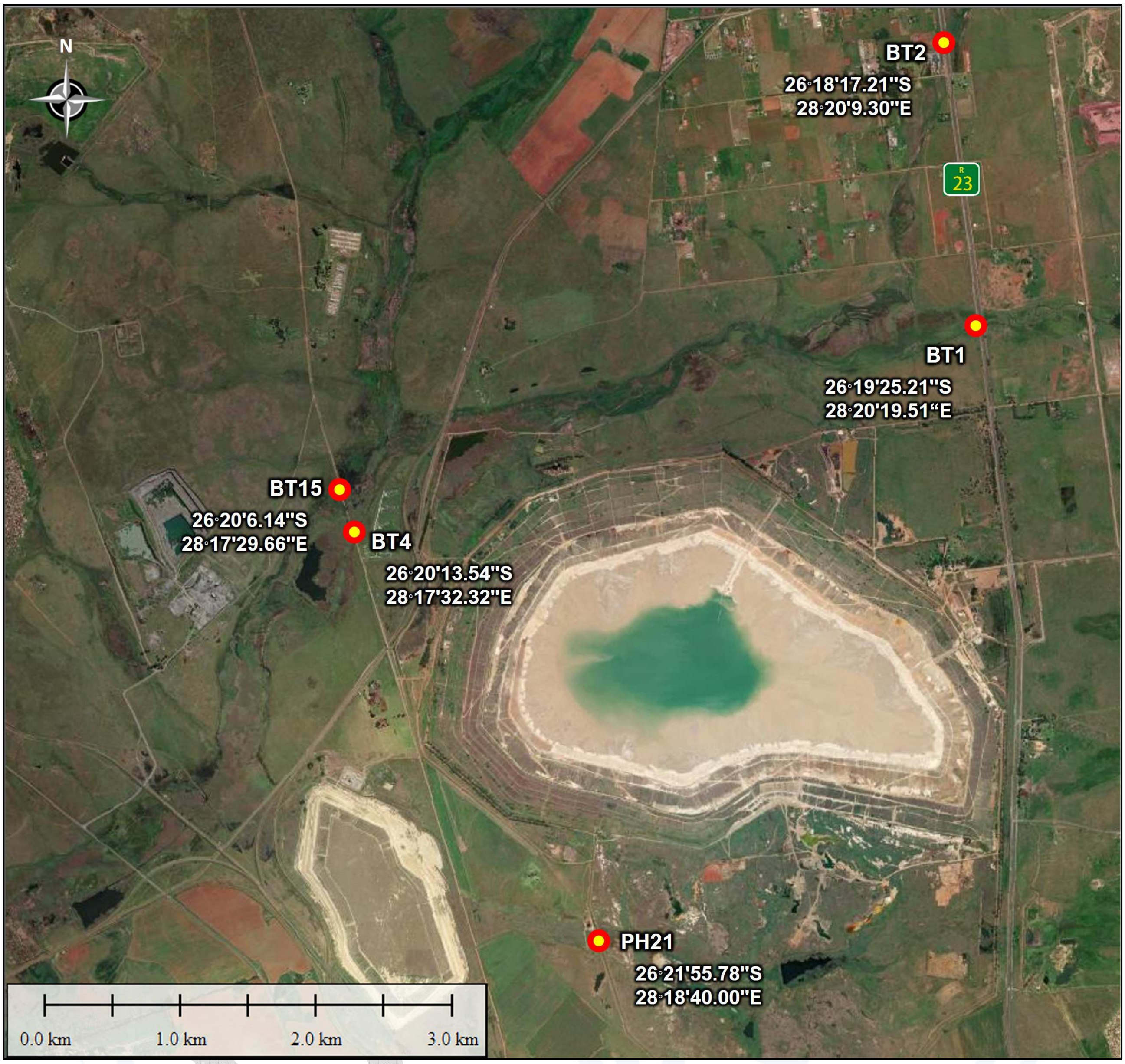


FIGURE 18: WATER QUALITY MONITORING POINTS

BT1

Parameter	Nov/23	Dec/23	Jan/24	Feb/24	Mar/24	Apr/24	May/24	Jun/24	Jul/24	Aug/24	Sep/24	Oct/24
pH - Value @ 25 ºC	9.2	7.1	9.1	7.5	7.1			7.8	7.5	7.6	7.5	7.5
Electrical Conductivity in mS/m @ 25°C	52.4	46.4	31.1	49.2	37.0			53.8	54.7	56.3	25.0	59.1
Total Dissolved Solids @ 180°C mg/ℓ	414	402	208	286	210			334	334	352	144	372
Suspended Solids at 105°C									25	30	27	34
Turbidity in N.T.U									7.1	14	10	45
Chloride as Cl mg/ℓ	54	41	18	36	38			45	43	47	10	48
Sulphate as SO_4 mg/ℓ	<2	<2	68	15	39			41	45	43	10	33
Fluoride as F mg/ℓ	0.3	0.2	0.3	0.5	0.4			0.2	0	0	0	0
Nitrate as N mg/ℓ	2.8	6.2	0.6	4.2	4.4			5.4	5	4	<0.1	6
Nitrite as N mg/ℓ	2.8	<0.05	0.07	1.0	0.3			0.2	1	0	<0.05	0
Bromide as Br mg/ℓ	<0.1	<0.1	0.5	0.2	<0.1			<0.1	<0.1	0.3	0.3	0.7
Total Cyanide as CN mg/ℓ	<0.07	<0.07	<0.07	<0.07	<0.07			<0.07	<0.07	<0.07	<0.07	<0.07
Free and Saline Ammonia as N mg/ℓ	2.8	<0.1	<0.1	0.3	0.1			<0.1	0.20	0.50	0.20	<0.1
Sodium as Na mg/ℓ	52	41	16	36	28			48	50	48	14	50
Potassium as K mg/ℓ	9.1	8.0	6.4	8.0	10.2			7.2	9.2	10.2	2.4	11.2
Magnesium as Mg mg/ℓ	12	12	8	12	8			15	15	16	8	16
Aluminium as Al (Dissolved) mg/ℓ	0.331	<0.100	<0.100	<0.100	0.125			<0.100	<0.100	<0.100	<0.100	0.4
Antimony as Sb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	0.001	0.001			0.001	<0.001	0.00	<0.001	<0.001
Arsenic as As (Dissolved) mg/ℓ	0.006	0.004	0.001	0.002	0.002			0.001	0.001	0.002	0.001	0.004
Barium as Ba (Dissolved) mg/ℓ	0.055	0.057	0.054	0.039	0.044			0.069	0.06	0.07	0.05	0.10
Boron as B (Dissolved) mg/ℓ	<0.025	<0.025	0.034	0.028	<0.025			<0.025	0.06	<0.025	<0.025	0.03
Cadmium as Cd (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chromium as Cr mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	<0.025	<0.025	<0.025	<0.025
Total Chromium as Cr (Dissolved) mg/ℓ	0.025	<0.010	0.010	0.011	<0.010			0.012	0.01	0.012	<0.010	<0.010
Copper as Cu (Dissolved) mg/ℓ	<0.010	0.021	<0.010	<0.010	<0.010			0.028	<0.010	<0.010	<0.010	<0.010
Iron as Fe (Dissolved) mg/ℓ	0.447	<0.025	<0.025	<0.025	0.096			<0.025	<0.025	<0.025	<0.025	0.662
Lead as Pb (Dissolved) mg/ℓ	0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	0.001	0.003
Manganese as Mn (Dissolved) mg/ℓ	0.242	0.056	<0.025	<0.025	<0.025			<0.025	<0.025	<0.025	<0.025	0.477
Mercury as Hg (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001
Uranium as U (Dissolved) mg/ℓ	0.002	<0.001	<0.001	0.001	<0.001			<0.001	0.001	0.002	0.002	0.002

LEGEND				
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value			

FIGURE 19: SUMMARY OF WATER QUALITY DATA (BT1)

BT2

Parameter	Nov/23	Dec/23	Jan/24	Feb/24	Mar/24	Apr/24	May/24	Jun/24	Jul/24	Aug/24	Sep/24	Oct/24
pH - Value @ 25 ºC	7.7	7.5	7.3	7.5	7.5			7.8	7.8	7.6	7.8	7.1
Electrical Conductivity in mS/m @ 25°C	114	120	94.4	100	93.4			97.8	92.3	93.7	115.0	164.0
Total Dissolved Solids @ 180°C mg/ℓ	900	1110	750	686	676			660	614	648	784	1254
Suspended Solids at 105°C									21	28	15	15
Turbidity in N.T.U									3.9	12	3.1	18
Chloride as Cl mg/ℓ	60	81	46	54	55			64	47	52	70	106
Sulphate as SO_4 mg/ℓ	261	327	311	229	249			238	211	208	249	534
Fluoride as F mg/ℓ	0.7	0.4	0.4	0.8	0.6			0.2	0	1	1	0
Nitrate as N mg/ℓ	<0.1	<0.1	<0.1	0.4	0.1			0.3	2	0	<0.1	1
Nitrite as N mg/ℓ	<0.05	<0.05	<0.05	<0.05	<0.05			<0.05	<0.05	<0.05	<0.05	<0.05
Bromide as Br mg/ℓ	0.2	<0.1	0.8	0.2	<0.1			<0.1	0.7	0.7	1.3	1.6
Total Cyanide as CN mg/ℓ	<0.07	<0.07	<0.07	<0.07	<0.07			<0.07	<0.07	<0.07	<0.07	<0.07
Free and Saline Ammonia as N mg/ℓ	0.3	<0.1	<0.1	0.3	0.4			<0.1	<0.1	<0.1	0.20	<0.1
Sodium as Na mg/ℓ	82	83	47	59	57			58	55	56	77	98
Potassium as K mg/ℓ	11.2	7.5	12.5	8.8	11.0			7.3	7.2	8.8	8.9	7.3
Magnesium as Mg mg/ℓ	45	41	31	31	32			35	32	31	41	63
Aluminium as Al (Dissolved) mg/ℓ	<0.100	0.106	<0.100	<0.100	<0.100			<0.100	<0.100	<0.100	<0.100	<0.100
Antimony as Sb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	0.001	<0.001			<0.001	<0.001	0.00	<0.001	<0.001
Arsenic as As (Dissolved) mg/ℓ	0.002	0.001	0.001	0.003	0.003			0.002	0.001	0.002	0.002	0.001
Barium as Ba (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	<0.025	<0.025	<0.025	0.03
Boron as B (Dissolved) mg/ℓ	0.115	0.117	0.094	0.086	0.060			0.067	0.10	0.07	0.07	<0.025
Cadmium as Cd (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chromium as Cr mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	<0.025	<0.025	<0.025	<0.025
Total Chromium as Cr (Dissolved) mg/ℓ	<0.010	<0.010	<0.010	<0.010	<0.010			0.010	<0.010	0.013	<0.010	<0.010
Copper as Cu (Dissolved) mg/ℓ	<0.010	0.022	<0.010	<0.010	<0.010			<0.010	<0.010	<0.010	<0.010	<0.010
Iron as Fe (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	<0.025	0.046	<0.025	0.793
Lead as Pb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	0.001	0.001
Manganese as Mn (Dissolved) mg/ℓ	<0.025	<0.025	0.220	0.218	<0.025			<0.025	<0.025	<0.025	0.085	9.84
Mercury as Hg (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001
Uranium as U (Dissolved) mg/ℓ	0.097	0.047	0.013	0.084	0.063			0.079	0.054	0.07	0.125	0.087

LEGEND				
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value			

FIGURE 20: SUMMARY OF WATER QUALITY DATA (BT2)

BT4

Parameter	Nov/23	Dec/23	Jan/24	Feb/24	Mar/24	Apr/24	May/24	Jun/24	Jul/24	Aug/24	Sep/24	Oct/24
pH - Value @ 25 ºC		3.9	6.8	6.7	6.5			7.2	5	4.9	3	3.8
Electrical Conductivity in mS/m @ 25°C		197	83.1	155	124			107	285.0	290.0	500.0	343.0
Total Dissolved Solids @ 180°C mg/ℓ		1866	670	1156	932			720	2340	2506	4524	2904
Suspended Solids at 105°C									26	37	44	28
Turbidity in N.T.U									24	42	38	18
Chloride as Cl mg/ℓ		109	37	81	100			79	136	139	196	166
Sulphate as SO_4 mg/ℓ		883	347	579	417			257	1,409	1,367	2,653	1,883
Fluoride as F mg/ℓ		0.2	0.4	0.7	0.5			0.5	0	0	1	0
Nitrate as N mg/ℓ		0.4	1.7	1.8	3.6			5.5	3	<0.1	<0.1	1
Nitrite as N mg/ℓ		<0.05	0.7	0.4	2.9			1.1	0	<0.05	<0.05	<0.05
Bromide as Br mg/ℓ		<0.1	0.4	<0.1	<0.1			<0.1	<0.1	<0.1	<0.1	<0.1
Total Cyanide as CN mg/ℓ		<0.07	<0.07	<0.07	<0.07			<0.07	0.13	0.83	<0.07	<0.07
Free and Saline Ammonia as N mg/ℓ		18	0.9	12	2.0			1.1	23.00	24.00	47.00	35.00
Sodium as Na mg/ℓ		86	43	83	94			81	142	194	304	207
Potassium as K mg/ℓ		14.6	10.2	14.4	24			11.2	25.0	28.0	23.0	24.0
Magnesium as Mg mg/ℓ		59	27	50	47			37	110	134	278	162
Aluminium as Al (Dissolved) mg/ℓ		0.700	<0.100	<0.100	<0.100			0.107	0.5	0.4	25.0	4.1
Antimony as Sb (Dissolved) mg/ℓ		<0.001	<0.001	0.001	<0.001			0.001	<0.001	<0.001	<0.001	<0.001
Arsenic as As (Dissolved) mg/ℓ		0.001	<0.001	0.001	<0.001			<0.001	0.001	0.002	0.004	0.003
Barium as Ba (Dissolved) mg/ℓ		0.049	0.042	<0.025	0.036			0.026	0.05	0.06	<0.025	0.04
Boron as B (Dissolved) mg/ℓ		<0.025	0.051	0.047	0.036			0.033	0.09	<0.025	0.12	0.03
Cadmium as Cd (Dissolved) mg/ℓ		<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	0.00	<0.001
Hexavalent Chromium as Cr mg/ℓ		<0.025	<0.025	<0.025	<0.025			<0.025	<0.025	<0.025	<0.025	<0.025
Total Chromium as Cr (Dissolved) mg/ℓ		<0.010	0.012	<0.010	0.021			0.012	<0.010	<0.010	0.027	<0.010
Copper as Cu (Dissolved) mg/ℓ		0.163	<0.010	<0.010	<0.010			0.030	<0.010	0.053	0.72	0.304
Iron as Fe (Dissolved) mg/ℓ		0.048	<0.025	<0.025	<0.025			<0.025	19	22	14	7
Lead as Pb (Dissolved) mg/ℓ		<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	0.009	0.001
Manganese as Mn (Dissolved) mg/ℓ		9.38	2.89	5.31	3.53			1.77	12	17	16	17
Mercury as Hg (Dissolved) mg/ℓ		<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001
Uranium as U (Dissolved) mg/ℓ		0.019	<0.001	0.002	0.004			0.016	0.01	0.013	1.39	0.244

LEGEND				
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value			

FIGURE 21: SUMMARY OF WATER QUALITY DATA (BT4)

BT15

Parameter	Nov/23	Dec/23	Jan/24	Feb/24	Mar/24	Apr/24	May/24	Jun/24	Jul/24	Aug/24	Sep/24	Oct/24
pH - Value @ 25 ºC	4.1	3.7	6.8	6.8	6.8			7.0	4.7	4.9	3	4.8
Electrical Conductivity in mS/m @ 25°C	276	204	83.5	156	116			156	365.0	310.0	515.0	346.0
Total Dissolved Solids @ 180°C mg/ℓ	2450	1804	656	1164	806			1130	3150	2756	4682	2984
Suspended Solids at 105°C	12	32	8	<5	8			<5	57	95	155	29
Turbidity in N.T.U	161	111	38	80	85			102	60	139	117	21
Chloride as Cl mg/ℓ	0.3	0.3	0.3	0.6	0.5			<0.2	170	149	209	174
Sulphate as SO_4 mg/ℓ	0.2	<0.1	0.7	0.5	3.4			3.3	1,861	1,489	2,831	1,975
Fluoride as F mg/ℓ	<0.05	<0.05	0.4	0.2	1.8			1.3	<0.2	0	1	0
Nitrate as N mg/ℓ	<0.1	<0.1	0.3	<0.1	<0.1			<0.1	2	0	0	1
Nitrite as N mg/ℓ	<0.1	<0.1	<0.1	0.3	<0.1			<0.1	<0.05	0	<0.05	<0.05
Bromide as Br mg/ℓ	<0.07	<0.07	<0.07	<0.07	<0.07			<0.07	<0.1	<0.1	0.1	<0.1
Total Cyanide as CN mg/ℓ	205	125	43	108	84			103	0.43	0.46	<0.07	<0.07
Free and Saline Ammonia as N mg/ℓ	38	17.6	9.7	18.4	20			15.3	30.00	27.00	52.00	38.00
Sodium as Na mg/ℓ	347	175	77	152	96			134	220	198	318	229
Potassium as K mg/ℓ	133	82	27	65	41			59	32.0	29.0	22.0	27.0
Magnesium as Mg mg/ℓ	<0.001	<0.001	<0.001	0.001	<0.001			<0.001	175	143	271	163
Aluminium as Al (Dissolved) mg/ℓ	<0.001	0.001	<0.001	0.001	<0.001			0.001	2.3	0.3	33.0	3.1
Antimony as Sb (Dissolved) mg/ℓ	0.064	0.053	0.043	0.028	0.034			0.046	0.00	<0.001	<0.001	<0.001
Arsenic as As (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	0.001	0.002	0.005	0.003
Barium as Ba (Dissolved) mg/ℓ	2.38	<0.025	<0.025	0.043	<0.025			<0.025	0.05	0.05	0.03	0.05
Boron as B (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	0.08	<0.025	0.13	0.04
Cadmium as Cd (Dissolved) mg/ℓ	<0.010	<0.010	0.012	<0.010	0.015			0.019	0.00	<0.001	0.00	<0.001
Hexavalent Chromium as Cr mg/ℓ	0.844	0.843	0.119	0.252	0.055			0.318	<0.025	<0.025	<0.025	<0.025
Total Chromium as Cr (Dissolved) mg/ℓ	0.060	0.164	<0.010	<0.010	<0.010			<0.010	<0.010	0.01	0.039	<0.010
Copper as Cu (Dissolved) mg/ℓ	0.073	0.061	<0.025	<0.025	<0.025				0.167	0.054	1.33	0.335
Iron as Fe (Dissolved) mg/ℓ	<0.025	0.087	<0.025	<0.025	0.047				58	48	33	32
Lead as Pb (Dissolved) mg/ℓ	13	11	2.85	6.75	2.26			4.66	<0.001	<0.001	0.004	<0.001
Manganese as Mn (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025			<0.025	18	16	30	18
Mercury as Hg (Dissolved) mg/ℓ	1.72	1.59	0.259	0.507	0.272			0.610	<0.001	0.001	<0.001	<0.001
Uranium as U (Dissolved) mg/ℓ	0.266	0.588	0.055	0.072	0.027			0.126	0.106	0.013	1.85	0.247

LEGEND				
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value			

FIGURE 22: SUMMARY OF WATER QUALITY DATA (BT15)

PH21

Parameter	Nov/23	Dec/23	Jan/24	Feb/24	Mar/24	Apr/24	May/24	Jun/24	Jul/24	Aug/24	Sep/24	Oct/24
pH - Value @ 25 ºC	7.2	7.2	7.0	7.2	7.0							
Electrical Conductivity in mS/m @ 25°C	90.2	84.3	27.5	60.4	24.2							
Total Dissolved Solids @ 180°C mg/ℓ	600	474	156	308	160							
Suspended Solids at 105°C												
Turbidity in N.T.U												
Chloride as Cl mg/ℓ	60	61	17	32	15							
Sulphate as SO_4 mg/ℓ	146	131	43	79	42							
Fluoride as F mg/ℓ	0.2	0.2	0.5	0.3	0.3							
Nitrate as N mg/ℓ	0.1	<0.1	0.8	0.6	1.2							
Nitrite as N mg/ℓ	<0.05	<0.05	2.0	<0.05	0.8							
Bromide as Br mg/ℓ	<0.1	<0.1	0.5	<0.1	<0.1							
Total Cyanide as CN mg/ℓ	<0.07	<0.07	<0.07	<0.07	<0.07							
Free and Saline Ammonia as N mg/ℓ	32	27	0.9	15	1.7							
Sodium as Na mg/ℓ	60	70	16	38	13							
Potassium as K mg/ℓ	13.0	16.2	6.4	7.2	6.2							
Magnesium as Mg mg/ℓ	17	23	6	21	6							
Aluminium as Al (Dissolved) mg/ℓ	<0.100	<0.100	0.133	<0.100	0.146							
Antimony as Sb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	0.001	<0.001							
Arsenic as As (Dissolved) mg/ℓ	0.002	0.001	0.001	0.001	0.001							
Barium as Ba (Dissolved) mg/ℓ	0.094	0.096	0.062	<0.025	0.042							
Boron as B (Dissolved) mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025							
Cadmium as Cd (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001							
Hexavalent Chromium as Cr mg/ℓ	<0.025	<0.025	<0.025	<0.025	<0.025							
Total Chromium as Cr (Dissolved) mg/ℓ	<0.010	0.011	0.017	<0.010	<0.010							
Copper as Cu (Dissolved) mg/ℓ	<0.010	0.020	<0.010	<0.010	<0.010							
Iron as Fe (Dissolved) mg/ℓ	0.218	0.253	0.076	0.043	0.160							
Lead as Pb (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001							
Manganese as Mn (Dissolved) mg/ℓ	4.37	6.46	<0.025	3.85	0.065							
Mercury as Hg (Dissolved) mg/ℓ	<0.001	<0.001	<0.001	<0.001	<0.001							
Uranium as U (Dissolved) mg/ℓ	<0.001	0.001	<0.001	0.002	<0.001							

LEGEND				
KLIP RIVER IN STREAM WQO	Ideal	Accept.	Tolerable	Unaccept.
SANS 241 DOMESTIC LIMIT EXCEEDANCES	Value			

FIGURE 23: SUMMARY OF WATER QUALITY DATA (PH21)

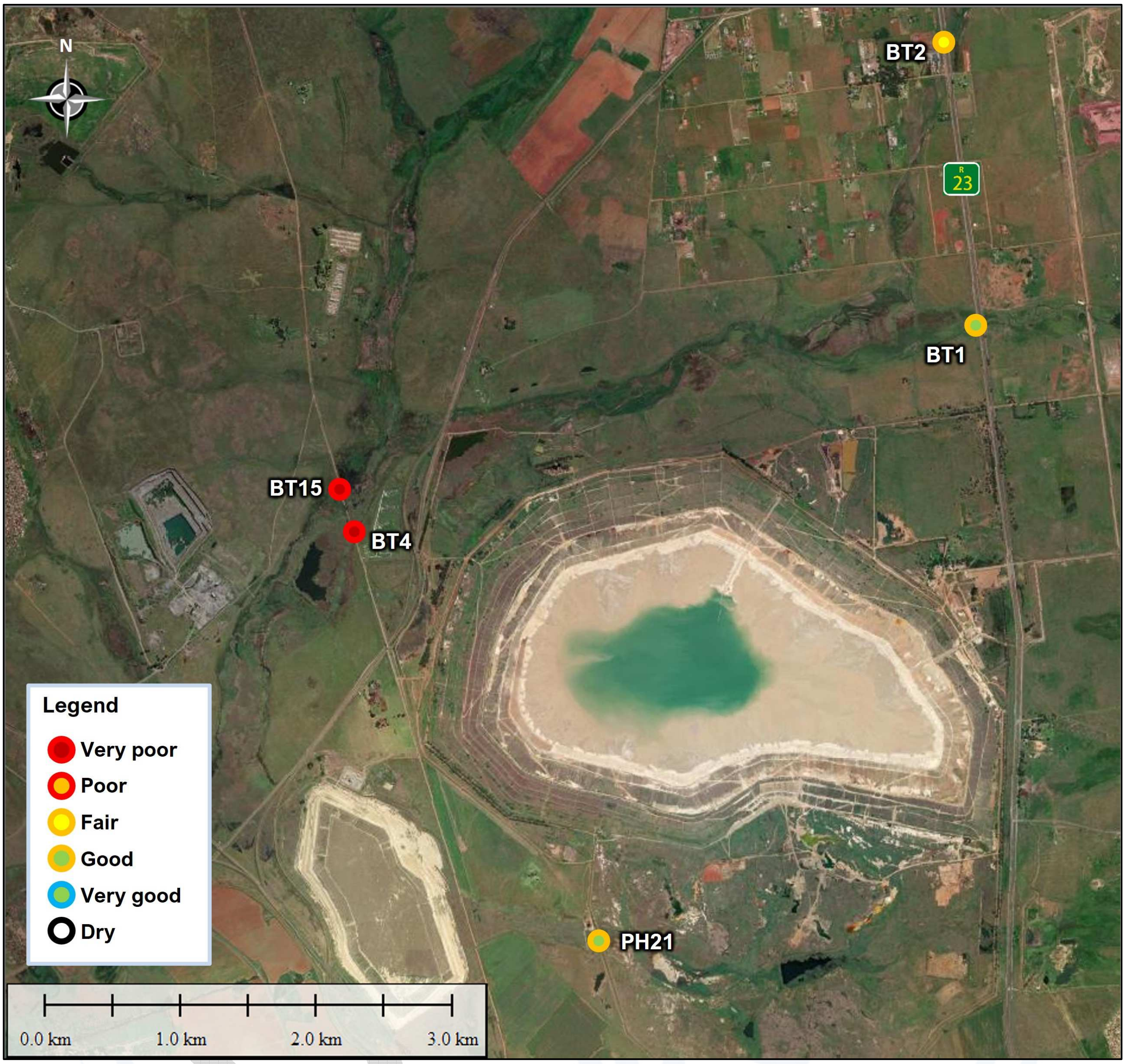


FIGURE 24: WATER QUALITY ANALYSIS SUMMARY

The results show the following:

- Withokspruit upstream of the Brakpan TSF complex (BT1)
  - The water quality is considered good and generally within the SANS 241:2015 drinking water limits. Turbidity is elevated but this is attributed to cattle and human activities within the channel upstream of the monitoring point.
  - Nitrates are slightly elevated. This is attributed to the urban activities upstream.
- Withokspruit tributary upstream of the Brakpan TSF complex (BT2)
  - The water quality is considered fair and generally within the SANS 241:2015 drinking water limits.

  - The catchment is impacted by industrial and historical mining activities, which are the likely causes of the slight deterioration in water quality across many parameters, the most notable being chloride, sulphate, fluoride, sodium and magnesium.
- Withokspruit downstream of the Rietspruit confluence (BT15 and BT4)
  - The water quality at these two locations is considered very poor but shows periods of good quality during the wet season. This could indicate poor quality baseflow that is diluted by cleaner storm flow.
  - Cyanide and antimony are elevated in BT15. This may be coming from the Rietspruit, but this assertion is not conclusive.
  - BT4 water quality is generally better than BT15 during the wet season, possibly due to the influence of the Withokspruit. Again, this assertion is not conclusive without a monitoring point in the Rietspruit just upstream of the Withokspruit confluence.
- Spinal culvert outfall (PH21). This is water that is routed from the attenuation dam upstream of the R23 and discussed in Section 4.1 on page 6.
  - The water quality at PH21 is considered good overall.
  - The elevated manganese is considered background.

10. IMPACT ASSESSMENT

10.1 Project Description

The project involves the operation of a tailings storage facility and its associated return water dam. The surface infrastructure will be:

- the tailings storage facility,
- catchment paddocks,
- return water dam,
- water and slurry pipelines,
- a clean storm water diversion that allows the attenuation dam outlet water to flow around the Withok TSF complex.

This is shown in Figure 25.

All supernatant and storm water on the basin will be pumped back to the process via a decant barge. All side slope water will be routed to the return water dam via the catchment paddocks. The catchment paddocks serve to desilt this water and to temporarily store it, before it is released to the return water dam via the drain flow collector system. The drain flow collector system is a below-surface piped system. The catchment paddocks have penstocks that feed into the drain flow collector system. The drain flow collector system discharges into the return water dam, via a silt trap.

The recommended closure concept is to paddock the top surface, while treating drain flows. The drain flow water can be treated to discharge quality and released into the receiving environment. Alternatively, this water can be treated to higher water quality standards and sold for domestic or industrial consumption. The brine from the treatment process would have to be pumped to the top surface where it will be evaporated. There will be significant periods where the paddocks are dry so no long-term brine ponds will form. Side slopes will be rehabilitated and runoff from these slopes will be clean and released to the environment.

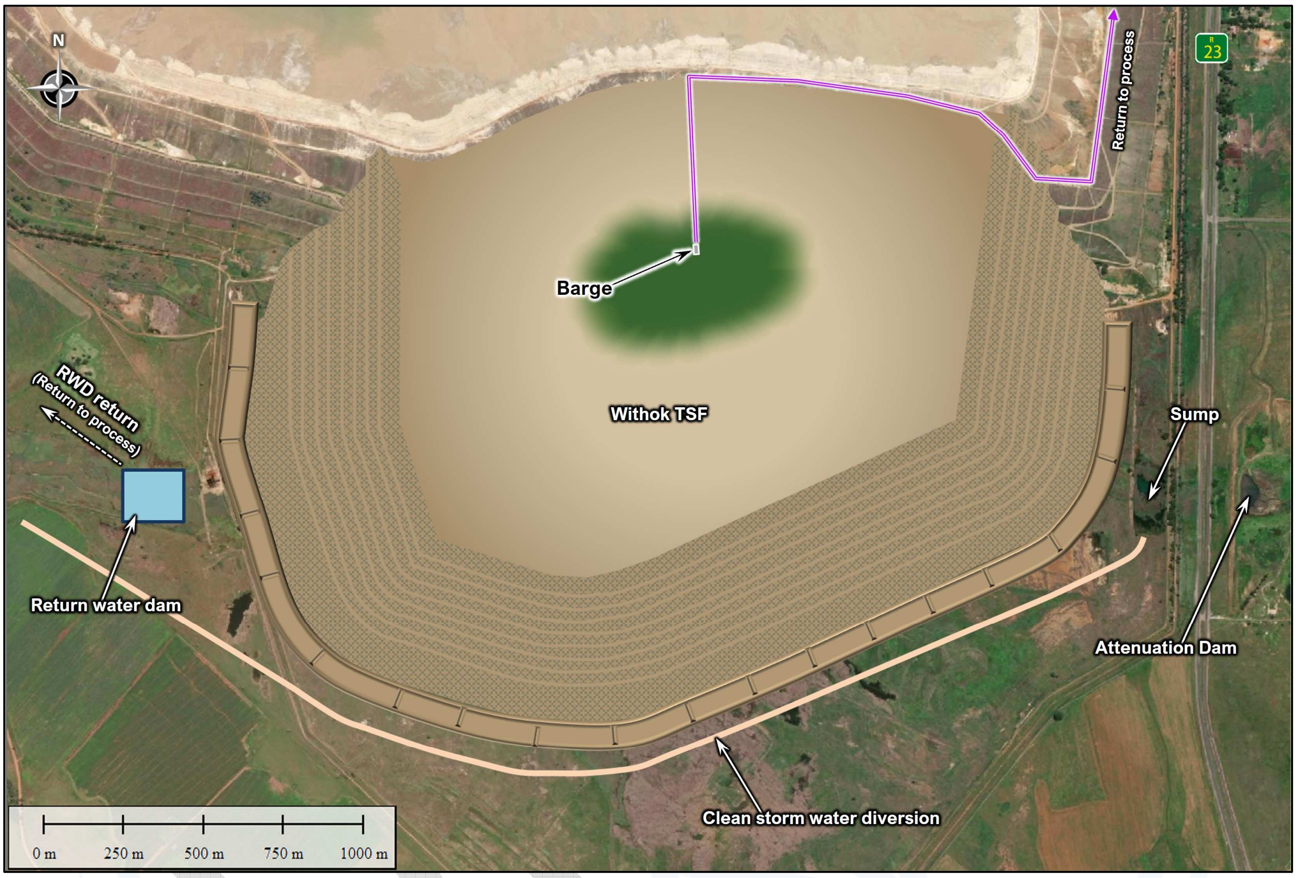


FIGURE 25: SURFACE INFRASTRUCTURE

10.2 Methodology for Impact Assessment

Activities on the proposed operations have been taken through an impact assessment prior to and post mitigation measures. The recommended mitigation measures have been included in the impact assessments. Impacts are assessed for the construction, operational, decommissioning and closure, and post closure phases of the project. The methodology used for the impact is to define impact consequence using the three primary impact characteristics of magnitude, spatial scale/ population and duration

The consequence rating methodology used is presented in Table 7 and Table 8. The significance rating methodology is presented in Table 9.

TABLE 7: CONSEQUENCE RATING METHODOLOGY

Impact characteristics	Definition	Criteria
Magnitude	Major -	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate -	Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor -	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded
	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
Spatial scale or population	Site or local	Site specific or confined to the immediate project area
	Regional	May be defined in various ways, e.g. cadastral, catchment, topographic
	National/ International	Nationally or beyond
Duration	Short term	Up to 18 months.
	Medium term	18 months to 5 years
	Long term	Longer than 5 years

TABLE 8: CONSEQUENCE RATING METHODOLOGY

			Spatial scale/ Population		
			Site or Local	Regional	National/ International
MAGNITUDE					
Minor	**DURATION**	**Long term**	Medium	Medium	High
		Medium term	Low	Low	Medium
		Short term	Low	Low	Medium
Moderate	**DURATION**	**Long term**	Medium	High	High
		Medium term	Medium	Medium	High
		Short term	Low	Medium	Medium
Major	**DURATION**	**Long term**	High	High	High
		Medium term	Medium	Medium	High
		Short term	Medium	Medium	High

TABLE 9: SIGNIFICANCE RATING METHODOLOGY

Probability (of Exposure to Impacts)	Consequence Negative			Consequence Positive		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Definite	Medium	Medium	High	Medium	Medium	High
Possible	Low	Medium	High	Low	Medium	High
Unlikely	Low	Low	Medium	Low	Low	Medium

The impact assessment summary is shown below in Table 10. The full impact assessment as presented in Table 11.

TABLE 10: IMPACT ASSESSMENT SUMMARY

2	Activity	Impact description	Significance before mitigation	Significance after mitigation
Construction				
1	Impacts due to topsoil stripping	Excessive silt washed into water courses	Medium	Medium
2	Impacts due to wash bays and workshops	Hydrocarbons and other pollutant washed into water courses	Low	Low
3	Impacts due to vehicle fleet-related pollution	Hydrocarbons and other pollutant washed into water courses	Low	Low
Operation				
4	Impacts due to wash bays and workshops	Hydrocarbons and other pollutant washed into water courses	Medium	Low
5	Impacts due to vehicle fleet-related pollution	Hydrocarbons and other pollutant washed into water courses	Medium	Low
6	Impacts due to leaking or burst dirty water pipes	Salts and other pollutant washed into water courses	High	Medium
7	Impacts due to leaking or burst slurry pipes	Polluted sediments, salts and other pollutant washed into water courses	High	Medium
8	Impacts due to catchment paddocks overflowing	Salts and other pollutant washed into water courses	Medium	Low
9	Impacts due to catchment return water dam overflowing	Salts and other pollutant washed into water courses	High	Medium
10	Loss of catchment yield	Reduced catchment yield	High	High
11	Dam break	Polluted sediments, salts and other pollutant washed into water courses	Medium	Medium
Decommissioning and closure				
12	Impacts due to the removal of surface infrastructure	Excessive silt washed into water courses	Medium	Medium
13	Impacts due to wash bays and workshops	Hydrocarbons and other pollutant washed into water courses	Low	Low
14	Impacts due to vehicle fleet-related pollution	Hydrocarbons and other pollutant washed into water courses	Low	Low
Post closure				
15	Impacts due to leaking or burst dirty water pipes	Salts and other pollutant washed into water courses	High	Medium
16	Impacts due to the discharge of untreated contaminated water	Salts and other pollutant washed into water courses	High	Medium

TABLE 11: IMPACT ASSESSMENT

No.	Affected Environment	Activity	Impact Description	BEFORE MITIGATION						Cumulative Impact	Mitigation measures / Recommendations	AFTER MITIGATION					
				Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE			Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE
	Construction																
1	Surface water	Impacts due to Topsoil Stripping	Excessive silt washed into water courses	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Definite*	Medium	Yes	Clearly define areas to be cleared. Do not clear past designated areas. Dry season construction is preferable where practical.	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Definite*	Medium
2	Surface water	Impacts due to Wash Bays and Workshops	Hydrocarbons and other pollutant washed into water courses	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Possible*	Low	Yes	Wash bay discharge water should flow through an oil separator.	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Unlikely*	Low
3	Surface water	Impacts due to Vehicle Fleet-Related Pollution	Hydrocarbons and other pollutant washed into water courses	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Possible*	Low	Yes	All vehicles should be well maintained and inspected for hydrocarbon leaks weekly. Fuel depots and refuelling areas should be bunded. Vehicle maintenance should be a key performance objective of the plant contractor.	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Possible*	Low
	Operation																
4	Surface water	Impacts due to Wash Bays and Workshops	Hydrocarbons and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Definite*	Medium	Yes	Wash bay discharge water should flow through an oil separator.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
5	Surface water	Impacts due to Vehicle Fleet-Related Pollution	Hydrocarbons and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Definite*	Medium	Yes	All vehicles should be well maintained and inspected for hydrocarbon leaks weekly. Fuel depots and refuelling areas should be bunded. Vehicle maintenance should be a key performance objective of the plant contractor.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
6	Surface water	Impacts due to Leaking or Burst Dirty Water Pipes	Salts and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	Yes	It is preferable to run the dirty water pipelines through areas already serviced by dirty water systems where possible. Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Possible*	Medium
7	Surface water	Impacts due to Leaking or Burst Slurry Pipes	Polluted sediments, salts and other pollutant washed into water courses	*Major -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	Yes	It is preferable to run the slurry pipelines through areas already serviced by dirty water systems where possible. Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Possible*	Medium
8	Surface water	Impacts due to catchment paddocks overflowing	Salts and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Possible*	Medium	Yes	Catchment paddocks must be sized must be sized in accordance with GN704.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
9	Surface water	Impacts due to catchment return water dam overflowing	Salts and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	Yes	The RWD must be sized in accordance with GN704.	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Unlikely*	Medium
10	Surface water	Loss of catchment yield	Reduced catchment yield	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Definite*	High	Yes		*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Definite*	High
11	Surface water	Dam break	Polluted sediments, salts and other pollutant washed into water courses	*Major -*	*Long Term > 5 years*	*National/International*	High	*Unlikely*	Medium	Yes	Freeboard targets to be mainteined. Stability indicators to be monitored and phreatic level monitored. TSF design to be adhered to.	*Major -*	*Long Term > 5 years*	*National/International*	High	*Unlikely*	Medium
	Decomissioning and Closure																
12	Surface water	Impacts due to the Removal of Surface Infrastructure and Rehabilitation	Excessive silt washed into water courses	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Definite*	Medium	Yes	Clearly define areas to be cleared. Do not clear past designated areas. Dry season construction is preferable where practical.	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Definite*	Medium
13	Surface water	Impacts due to Wash Bays and Workshops	Hydrocarbons and other pollutant washed into water courses	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Possible*	Low	Yes	Wash bay discharge water should flow through an oil separator.	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Unlikely*	Low
14	Surface water	Impacts due to Vehicle Fleet-Related Pollution	Hydrocarbons and other pollutant washed into water courses	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Possible*	Low	Yes	All vehicles should be well maintained and inspected for hydrocarbon leaks weekly. Fuel depots and refuelling areas should be bunded. Vehicle maintenance should be a key performance objective of the plant contractor.	*Moderate -*	*Short Term < 18 months*	*Site or Local*	Low	*Possible*	Low
	Post- Closure																
15	Surface water	Impacts due to Leaking or Burst Dirty Water Pipes	Salts and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	Yes	It is preferable to run the dirty water pipelines through areas already serviced by dirty water systems where possible. Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Possible*	Medium
16	Surface water	Impacts due to the discharge of untreated contaminated water	Salts and other pollutant washed into water courses	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	Yes	Water treatment plant to be properly managed.	*Moderate -*	*Long Term > 5 years*	*Regional*	High	*Unlikely*	Medium

11. MONITORING PROGRAM

Based on the impact assessment and surface water baseline water quality data, the following surface water monitoring program is recommended:

- Water quality sampling should be done monthly, as is currently the case, at the locations shown in Figure 26.
- Three additional monitoring locations should be considered:
  - A: On the Rietspruit upstream of its confluence with the Withokspruit. This will allow distinction between Brakpan influences and Rietspruit influences. Withok TSF complex water will share infrastructure with the Brakpan TSF, so this is relevant.
  - B: Downstream of the Withok TSF complex to determine impacts by the Withok TSF complex.
  - C: On the Rietspruit downstream of any potential Withok TSF complex impacts. The Rooikraal TSF is being remined. While the Rooikraal TSF footprint is likely to remain contaminated for some time, this monitoring point will also provide an indication of the impacts of this footprint. It is acknowledged that the Rooikraal TSF footprint is outside of the scope of work for this project.
- The current parameters being monitored are considered acceptable and should be continued.

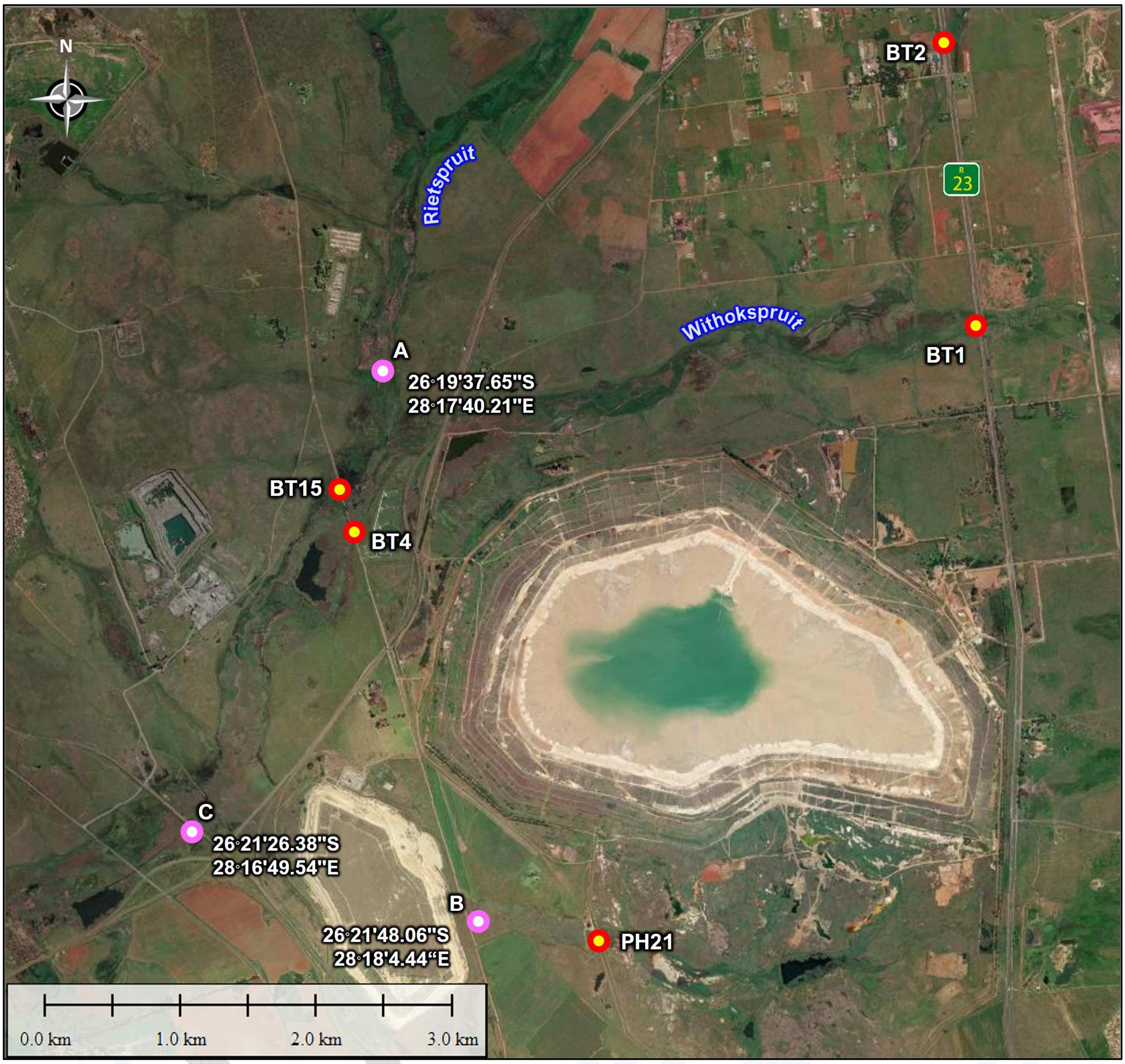


FIGURE 26: RECOMMENDED SURFACE WATER QUALITY SAMPLING LOCATIONS

12. REFERENCES

- Middleton, B.J. and Bailey, A.K., *Water Resources of South Africa*, 2005 study (WR2005), 2009. WRC Report No TT 382/08.
- Midgley, D.C., Pitman, W.V., Middleton, B.J., surface *Water Resources of South Africa*, 1990. WRC Report No 298/1.1/94, Volume 1.
- Highland Hydrology, 2016, *Hydrological Assessment of the Withok Tailings Complex Attenuation Dam*, Report No: Withok Hydro, September 2016.
- Compliance Africa,3rd Quarterly Water Quality Monitoring Report, September 2024.

Appendix A: Declaration of Independence

I, Bruce Randell declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. “the Protocols”) and in Government Notice No. 1150 of 30 October 2020.
- 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 the specialist report relevant to this application, 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 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;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of section 24F of the NEMA Act.

Signature of the Specialist

Name of Company: iLanda Water Services CC

Date: 18 January 2025

Appendix B: Undertaking Under Oath/ Affirmation

Appendix C: CV of specialist who prepared the report

Curriculum Vitae - Bruce Randell

EDUCATION AND QUALIFICATIONS

PR Eng

BSc (Civil Engineering) University of Witwatersrand, Johannesburg, 1996
PhD, University of Witwatersrand, Johannesburg, 2002
MDP, Unisa SBL, Johannesburg, 2007
Microsoft Certified Professional (TCP/IP) – NT4, 1998

EXPERIENCE SUMMARY

Water Resources Engineer with over 24 years' experience in mostly mining and heavy industrial projects.

April 2011 to Present

iLanda, Johannesburg, South Africa

Water Resources Engineer, Owner

I started my own consulting practice as a specialist hydrologist, Water Resources Engineer and Tailings Engineering. My water related work mainly involves water and salt balance determination and modelling. I am also involved in surface water specialist studies and impact assessments, water resources studies, floodline determination, audits and the design of weirs and other hydraulic infrastructure. My tailings related work includes Engineer of Record responsibilities, tailings dam surveillance and audits and dam break analysis. I specialise in numerical modelling of tailings storage facility water balances and mine-wide water balance modelling. I predominantly use GoldSim as my modelling tool. I have experience on projects throughout South Africa, Africa and Indonesia.

November 2017 to July 2020

Geo Tail Projects, Johannesburg, South Africa

Tailings Engineer, Director

My mine residue management involves some design work, tailings dam break analysis, tailings storage facility surveillance and auditing. I have experience on projects throughout South Africa, Lesotho and the rest of Africa on gold, copper, diamond, coal, nickel, iron ore and base metal operations.

Reason for leaving: Group restructuring. All my Geo Tail work is done through iLanda Water Services CC.

January 2008 to March 2011

Golder Associates Africa, Johannesburg, South Africa

Tailings Engineer, Resident Engineer

During my tenure within the tailings division I was involved in feasibility designs for tailings storage facilities and associated infrastructure in South Africa and the Democratic Republic of Congo. The designs included 2-D and 3-D design, drafting using AutoCAD, 3-D modelling, stability and freeboard analysis, surveillance and monitoring of operational tailings storage facilities, and water balance modelling. I completed detailed design projects where I designed silt traps, channels, storm water dams, underdrains and a penstock plug and reverse filter. During the final year of this period I was a resident Engineer on a 380 ha tailings storage facility construction project. My role included quality assurance on earthworks, reinforced concrete, roads, piping, building, structural steelwork, underdrains, and mechanical works. I was also required to do on-site design work, 3-D modelling, on-site drafting in AutoCAD, running of site meetings, client liaison, client representation and on-site document control.

Reason for leaving: Started iLanda Water Services CC.

August 2002 to December 2007

Golder Associates Africa, Johannesburg, South Africa

Water Resources Engineer, Operations Manager

During the early part of this period my role and experience in Golder Associates Africa was similar to that in Wates, Meiring and Barnard (see next section) but became more involved in the development and running of various water balance models for a wide variety of mining and heavy industrial applications. GoldSim was extensively used for modelling, as was various other mainstream software packages. I was also extensively involved in undertaking surface water specialist studies and impact assessments for EIA projects.

During the latter part of this period my work experience was dominated by water balance modelling and specialist study inputs for EIA's. I was extensively involved in developing and marketing a new product line which included water balance modelling to satisfy the requirements of the ICMI Cyanide Code. My client base was predominantly mining clients with some heavy industrial clients.

My role as Operations Manager of the Surface Water and Closure Division included the management of a merger with another company and the resulting new satellite office. I was again involved in significant staff management – both hiring new staff and managing staff underperformance.

Reason for leaving: Expand engineering and Tailings Engineering skills.

June 2002 to July 2002

Wates, Meiring and Barnard, Johannesburg, South Africa

Water Resources Engineer

I worked for Wates, Meiring and Barnard (WMB) as a hydrologist and modeller. My experience included hydrological studies, flood peak calculation. I was also involved with setting up REMIS applications for data management, general software design and water quality modelling, particularly for mining related pollution control dams. I was also part of the team developing the ISP for the Olifants river catchment in South Africa.

Reason for leaving: Golder Associates bought out WMB in August 2002.

1996 to 2002

Stephenson and Associates, Johannesburg, South Africa

Water Resources Engineer

While reading for my PhD, I was involved with a number of consulting projects. Experience included stream flow modelling, stream flow measuring, software design, water hammer analysis and surge protection design. I was also involved in sediment surveying, sediment modelling, floodline analysis and design of flood protection and alleviation measures. I constructed and tested a number of scale models including river models, pump stations, ogee crests and off channel flood control structures. I also tested the material properties of GRP pipe.

PROJECT RELATED EXPERIENCE

Tailings storage facility water balance modelling:

Custom-built GoldSim models are developed to simulate the water balance around a tailings storage facility. Modelling usually includes return water dam sizing. Rainfall inputs are generally stochastic to allow for scenario analysis, long-term analysis or the statistical analysis for short-duration projects. Tailings storage facility water balances have been completed on mining projects throughout Africa and South Africa on gold, diamond, copper, coal, nickel, base metal, and iron ore mines. Industrial projects have also been completed on power stations (ash dams), iron and steel works.

Mine water balance modelling:

Custom built GoldSim water balance models are developed for scenario analysis and water management decision making purposes on both operational and management levels. Projects completed throughout Africa and South Africa on gold, copper, coal, nickel, and base metal mines.

Open cast pit water balance modelling:

Custom built GoldSim models are used to calculate pit water make in opencast operations, including pits that have concurrent excavation and rehabilitation. Modelling takes into account the dynamics of the working pit configuration and rehabilitation progress during the simulation period. Rainfall inputs are generally stochastic to allow for scenario analysis, long-term analysis or the statistical analysis for short-duration projects. Modelling typically involves final void sizing for closure planning. Projects completed throughout Africa and South Africa on gold, copper, diamond, iron ore, and coal (with concurrent rehabilitation).

EIA surface water specialist studies and impact assessments:

I have conducted specialist surface water studies and impact assessments as part of small and large-scale EIA's and ESIA's. This involved baseline assessments, setup of surface water monitoring programs, general hydrology, hydraulics, hydraulic and hydrological modelling and impact assessments, reporting and attendance and presentations at open house/public meetings. Projects completed in the DRC, Mozambique and throughout South Africa on mining, heavy industrial, municipal and railway projects.

Flood peak and floodline calculation:

I have calculated floodlines on many river reaches in Mali, the DRC and throughout South Africa for housing developers, mining, industrial, municipal, and private clients. Large-scale floodlines have been completed for the entire Umhlatuze municipal area (Richards Bay, Empangeni and surrounds), and the Clover and Blesbokspruit (Benoni, Brakpan, Springs and Heidelberg).

Storm water management plans:

Storm water management plans (concept through to detailed design) have been completed on mining projects in the DRC, Lesotho and throughout South Africa on gold, diamond, copper, nickel, coal, base metal mines. Industrial projects completed throughout South Africa on chrome, steel plants, and aluminium smelters.

Pollution control dam sizing:

Pollution control dams are sized to comply with relevant legislation (e.g. Regulation 704 of the South African National Water Act). In the absence of legislative guidelines, the use of impact assessments on the receiving environment is to determine allowable releases and resultant dam sizing. Mining projects completed throughout Africa and South Africa on gold, diamond, copper, nickel, coal, base metal mines. Industrial projects completed throughout South Africa on power stations, chrome, steel plants, and aluminium smelters.

Tailings dam break analysis:

I have calculated tailings dam breach volumes, flows and floodlines for various typical failure scenarios on tailings dams. Mudflow analysis is performed using Flo2D. Water flow analysis is performed using Flo2D and HEC RAS.

Engineer of Record

I am the appointed Engineer of Record for the Liqhobong Diamond Mine RSF3 residue storage facility and associated infrastructure as of March 2024.

Tailings storage facility surveillance:

In accordance with South African mines' Code of Practice, I conducted tailings storage facility surveillance on numerous mines' tailings storage facilities. I have been the competent person for the Lubambe Copper Mine TSF in Zambia for 5 years. While at Golder, I headed up the surveillance group within the division which consisted of five technical staff and one administrative staff member. I was directly involved in the surveillance of nine tailings dams on two mines. Three of the nine dams were dormant, while the remaining six were active. As part of my surveillance responsibilities I did stability reviews and analysis, freeboard analysis, attended quarterly meetings and inspections and completed annual audit reports and inspections.

Catchment studies and runoff modelling:

Applications include runoff into pollution control dams, diversion canals, silt traps and through various hydraulic structures. Models used include ACRU, WRSM2000, WR90, RAFFLER and purpose-built GoldSim models. I have completed various projects throughout South Africa and Africa.

Infrastructure design:

Detailed design of small dams, silt traps, storm water channels, dissipation structures, Parshall flumes, headwalls, weirs, underdrains, and penstock plugs and reverse filters. The designs included the compilation of tender documents and bills of quantities and construction drawings.

Tailings storage facility feasibility design:

I completed feasibility and bankable feasibility design of tailings storage facility complexes in South Africa and the DRC. This included the tailings storage facility, return water dams, underdrains, storm water channels and other related infrastructure. The designs included the compilation of tender documents and bills of quantities.

Water quality modelling:

The water quality modelling related to pollution control dams involves modelling conservative variables, taking into account the surrounding catchments, dam operating rules, plant inputs and hydrology associated with the system. Daily continuous modelling is used in conjunction with relevant regulations (e.g. Regulation 704 of the South African National Water Act) to formulate solutions for clients.
Water resource projects involve determining the likely impact of process and contaminated storm water discharges from mines and industry. Mining projects completed throughout Africa and South Africa on gold, copper, nickel, coal mines (discard dumps and in pit water quality). Industrial projects completed throughout South Africa on power stations, chrome and steel plants, aluminium smelters, oil producers. Water resource projects completed in the DRC and throughout South Africa. Major rivers include the Olifants and Tugela Rivers in South Africa.

IWMP baseline hydrology and impact assessments:

I have conducted baseline hydrological assessment of the rivers that flow past two paper mills. This included ACRU and other rainfall-runoff modelling. GoldSim was used to do continuous daily modelling of the impacts of effluent from these mills into the receiving waters.

Mine water balance modelling for ICMI Cyanide code compliance:

I developed probabilistic mine-wide water balance models for scenario analysis and water management decision making purposes - a requirement of the ICMI Cyanide code. The models have been extensively audited and accepted as suitable water balance models for ICMI Cyanide code compliance. Project locations include South Africa, Namibia, Ghana, Mali, and Guinea.

Auditing:

I have been involved in GN704, storm water management plan implementation and water use licence auditing for power stations mines and industrial sites. I have experience as a lead auditor and as a specialist in support of a lead auditor.

Flow measuring:

I was involved in flow measuring in the field using both propeller and electromagnetic flow meters in the DRC and throughout South Africa on both small (50 ℓ/s) and large rivers (10 m^3/s).

Sediment surveying and modelling:

I was involved in the sediment surveys that were conducted on the Katse and Muela dams that form part of the Lesotho Highlands Water Project. My experience includes mapping floor profiles using sonar equipment and calculating sediment volumes.

PUBLICATIONS

Prediction model for the Caledon River – presented at the 4th Biennial Congress of the African Division of the International Association of Hydraulic Research, Windhoek, Namibia, 2000. (Co author)

A review of conjunctive use and a proposed model – poster presented at the XXVII IAHR Congress, Graz, Austria, 1999. (Sole author)

Artificial recharge and conjunctive use – Groundwater Hydrology workshop, Bulawayo, Zimbabwe, 1997. (Sole author)

LIST OF PROJECTS

Year	**Type of work/Project**	**Location**	**Country**
1999	Floodlines on the Clover and Blesbokspruit	Benoni, Springs	South Africa
1999	Water hammer analysis for the North South Carrier pipeline	Selibe Pikwe	Botswana
1999-2002	Sediment surveys for the Katse and Muela Dams		Lesotho
2003	Floodlines for all the perennial rivers in the greater Umhlatuze municipal area	Umhlatuze municipal area	South Africa
2003	Floodlines and levee design for Sasol Vanderbijlpark operations	Vandebijlpark	South Africa
2004	Salt balance modelling and impact assessment	Sappi Ngodwana	South Africa
2004	Storm water modelling for Iscor Vanderbijlpark	Vanderbijlpark	South Africa
2004	Hydrology modelling for Khutala colliery's waste discharge charge system	Khutala Colliery	South Africa
2004	Stormwater modelling for Beeshoek Mine	Postmasburg	South Africa
2004	Impact assessment of the Muela Dam	Butha Buthe	Lesotho
2005	ESIA surface water specialist study and impact assessment for the Camden power station return to service	Ermelo	South Africa
2005	Stormwater modelling for the Hillside aluminium smelter	Richards Bay	South Africa
2005	Closure cost modelling for Khutala Colliery	Khutala Colliery	South Africa
2005/6	ESIA surface water specialist study and impact assessment for the Tenke Fungarume Copper Mine	Tenke/Fungarume	DRC
2005/6	Water balance modelling and infrastructure sizing for the Tenke Fungarume Copper Mine	Tenke/Fungarume	DRC
2005-2019	Water balance modelling and infrastructure sizing for the Nkomati Mine	Nkomati Mine	South Africa
2005-2025	Approximately 50 floodlines for various mines in Africa	Various mines in Africa	
2006	ESIA surface water specialist study and impact assessment for the Moatize coal project	Tete	Mozambique
2006	ESIA surface water specialist study and impact assessment for the Heidelberg coal project	Heidelberg	South Africa
2006-8	Water balance modelling for the Highveld steel IWWMP and infrastructure sizing	Witbank	South Africa
2006-2008	Cyanide code compliant water balance modelling for Driefontein Gold Mine	Carletonville	South Africa
2006-2008	Cyanide code compliant water balance modelling for Beatrix Gold Mine	Welkom	South Africa
2006-2008	Cyanide code compliant water balance modelling for Kloof Gold Mine	Carletonville	South Africa
2006-2008	Cyanide code compliant water balance modelling for Sadiola Gold Mine	Kayes	Mali
2006-2008	Cyanide code compliant water balance modelling for Morila Gold Mine	Sanso	Mali
2006-2008	Cyanide code compliant water balance modelling for Yatela Gold Mine	Kayes	Mali

2006-2008	Cyanide code compliant water balance modelling for Siguiri Gold Mine	Siguiri	Guinea
2006-2008	Cyanide code compliant water balance modelling for Iduapriem Mine	Tarkwa	Ghana
2006-2008	Cyanide code compliant water balance modelling for Navachab Gold Mine	Karibib	Namibia
2007	Water balance modelling for the Cullinan TSF	Cullinan	South Africa
2008	Water balance modelling, infrastructure design and storm water management for the DeBeers TCP fines residue deposit	Kimberley	South Africa
2008	Mine wide water balance modelling for Sedibelo Mine	Pilanesberg	South Africa
2008/9	Tailings dam bankable PFS design - Rand Uranium Gelksdal 450Mt TSF	Fochville	South Africa
2008/9	Water balance modelling for Black Mountain Mine	Aggenys	South Africa
2008-2010	TSF surveillance monitoring - Driefontein No1, 2, 3, 4, 5 TSFs	Carletonville	South Africa
2008-2010	TSF surveillance monitoring - Kloof and Leeudoorn TSFs	Fochville	South Africa
2008-2009	TSF surveillance monitoring - Sadiola TSF and Yatela heap leach	Kayes	Mali
2009-2010	TSF surveillance monitoring - Ezulwini TSFs	Westonarea	South Africa
2009	Salt balance modelling at Nkomati Mine	Nkomati Mine	South Africa
2009	Return water dam sizing – Driefontein Gold Mine	Carletonville	South Africa
2009	Impact assessment of Sasol blowdowns	Secunda	South Africa
2010/11	Tailings dam design, Kinsenda mine	Tshinsenda	DRC
2010/11	Resident Engineer for the South Deep TSF construction	Fochville	South Africa
2010/11	Culvert detailed design for the South Deep TSF construction	Fochville	South Africa
2010/11	Resident Engineer for the Kloof underdrain installation	Fochville	South Africa
2011	Sediment survey for the Driefontein return water dams	Carletonville	South Africa
2011-2024	Water balance modelling and infrastructure sizing for over 80 coal mine projects in the Mpumalanga and Northern Kwa Zulu Natal coal fields	Mpumalanga/KZN coal fields	South Africa
2011-2025	Salt balance modelling for over 35 coal mine projects in the Mpumalanga and Northern Kwa Zulu Natal coal fields	Mpumalanga/KZN coal fields	South Africa
2011-2025	EIA surface water specialist studies and impact assessments for over 45 coal mine projects in the Mpumalanga and Northern Kwa Zulu Natal coal fields	Mpumalanga/KZN coal fields	South Africa
2011-2025	Storm water management plans for over 15 mines/TSF complexes and 2 aggregate processing operations throughout South Africa		South Africa
2012	Water balance modelling and infrastructure sizing for a new TSF at Bulyanhulu Gold Mine	Bulyanhulu	Tanzania
2012	Surface water monitoring program for Weda Bay Nickel Monitoring Program	Lelilef Sawai	Indonesia

2012	Water balance modelling, infrastructure sizing and PFS design for Phalanndwa Colliery	Delmas	South Africa
2012	Water balance modelling, infrastructure sizing and PFS design for Kangra Colliery	Piet Retief	South Africa
2012	Water balance modelling and infrastructure sizing for Letšeng Diamond Mine	Letšeng	Lesotho
2013-2020	Letšeng storm water management plan and bi-annual updates	Letšeng	Lesotho
2014/15	Water balance modelling and infrastructure sizing for the Liqhobong Diamond Mine	Liqhobong	Lesotho
2018	Mine-wide water and salt balance modelling for Khumani Mine	Kathu	South Africa
2018 and 2020	Water balance modelling and infrastructure sizing for Khumani Mine paste disposal facility, South Africa	Kathu	South Africa
2018-2025	TSF surveillance and responsible Engineer for the Lubambe TSF	Chililabombwe	Zambia
2019	TSF closure design and costing for the Lubambe TSF	Chililabombwe	Zambia
2019	Water balance modelling and infrastructure sizing for Khumani Mine	Kathu	South Africa
2019/2020	Water balance modelling and infrastructure sizing for the new Two Rivers Platinum Mine TSF	Burgersfort	South Africa
2019-2025	Dam break analysis for over 15 tailings storage facilities	Various mines in Southern Africa	Southern Africa
2020-2025	GISTM Technical Review Panel hydrology specialist for the Sishen tailings storage facility	Kathu	South Africa
2020-2025	GISTM Technical Review Panel hydrology specialist for the Kolomela tailings storage facility	Postmasburg	South Africa
2020	Water balance modelling and infrastructure sizing for Paling manganese mine	Postmasburg	South Africa
2020	Water balance modelling and infrastructure sizing for Theta Gold Mine,	Pilgrams Rest	South Africa
2021	Water balance modelling and infrastructure sizing for the Darwendale TSF	Harare	Zimbabwe
2021	ESIA for Minbos Phosphate Mine	Cabinda	Angola
2022	Storm water management infrastructure design for the Brakpan TSF	Brakpan	South Africa
2022	ICMI Cyanide code water stochastic/probabilistic water balance model for Sadiola Gold Mine	Sadiola	Mali
2022	EIA surface water specialist studies and impact assessments for FG landfill site	Midrand	South Africa
2022	Surface Water in Mining course preparation and presentation	Pretoria	South Africa
2022	Floating penstock design for the Lubambe TSF	Chililabombwe	Zambia
2022-2024	Water balance modelling for Liqhobong Diamond Mine	Liqhobong	Lesotho
2022-2025	Independent reviewer for the Sigma Colliery BPG G4 closure process	Sasolburg	South Africa

2020	Water balance modelling and infrastructure sizing for Kalgold mine	Mafikeng	South Africa
2023 - 2025	GISTM Technical Review Panel hydrology specialist for the Unki tailings storage facility	Gweru	Zimbabwe
2023-2025	GISTM Technical Review Panel hydrology specialist for the Mototolo tailings storage facility	Steelpoort	South Africa
2023-2025	GISTM Technical Review Panel hydrology specialist for the Mogalakwena tailings storage facility	Mokopane	South Africa
2023-2024	Storm water management infrastructure design for the Daggafontein TSF	Springs	South Africa
2023-2024	Storm water management infrastructure design for the Withok TSF	Brakpan	South Africa
2024	ESIA for Pak Yatirim power line project	Cuvango	Angola
2024	Water balance modelling for Letšeng Diamond Mine	Letšeng	Lesotho
2024	Engineer of Record for Liqhobong Diamond Mine’s RSF 3	Liqhobong	Lesotho
2024-2025	GISTM Independent Technical Review Board for the Dwarsrivier Khulu tailings storage facility	Steelpoort	South Africa
2025	GISTM Technical Review Panel hydrology specialist for the Amandelbult tailings storage facility	Mokopane	South Africa

Appendix B:

Groundwater Impact Assessment

Water Hunters CC

Brakpan-Withok TSF Complex - Groundwater Model Report

Project Number: Delh.2021.007-011

WATER HUNTERS

"Water is the final frontier"

Δh

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Water Hunters CC

Brakpan-Withok TSF Complex - Groundwater Model Report

Delh. 2021.007-011

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Table of Acronyms

ABA	Acid Base Accounting
ANC	Acid Neutralising Capacity
AP	Acid Potential
BTF	Brakpan Tailings facility
CO_3-NP	Carbonate Neutralisation Potential
DFFE	Department of Forestry, Fisheries and the Environment
DEM	Digital Elevation Model
GQM	Groundwater Quality Management
GRA	Groundwater Resource Assessment
LCT	Leachable Concentration Threshold
Mamsl	Metres above mean sea level
MPA	Maximum Potential Acidity
Mtpm	Million tonnes per month
NAG	Non-acid Generation
NEWA	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)
NGA	National Groundwater Archive
NNP	Net Neutralisation Potential
NP	Neutralisation Potential
NPR	Neutralisation Potential Ratio
PAG	Potentially Acid Generating
RDP	Relative Percentage Difference
SAP	Sulphide Acid Potential
TCT	Total Concentration Threshold
TSF	Tailings Storage Facility
WTF	Withok Tailings Facility

1. INTRODUCTION

1.1. BACKGROUND

Delta H (Delta-H Water System Modelling Pty Ltd) has been appointed by Water Hunters CC, in turn appointed by Ergo Mining Pty Ltd, a subsidiary of DRDGOLD Limited, to develop a three-dimensional numerical groundwater flow and transport model for the Brakpan-Withok Tailings Storage Facility (TSF) Complex. This report outlines the development of the conceptual and numerical model, simplifying assumptions and outcomes of predictive simulations. Following the model development and steady-state calibration, the numerical groundwater model will be used to predict potential impacts of seepage from the TSF on the ambient groundwater environment and mitigation measures, namely hydraulic plume containment by a scavenger well system.

1.2. DATA SOURCES AND DEFICIENCIES

The main data sources for the compilation of the groundwater specialist report were derived from previous reports. Limited new data were gathered as part of this study. In addition to referenced reports, the following data were utilised for the compilation of this report:

- Groundwater levels from the National Groundwater Archive (NGA)
- The 1:250 000 Geological Map 2626 for the East Rand
- The 1:500 000 Johannesburg Geohydrological Map
- New drilling and pumping test results
- Groundwater monitoring data provided by the client
- Delta H (2024). Withok TSF Seepage Model. Delta H report no.: Delh.2021.007-011, dated April 2024

2. GENERAL SETTING

The Brakpan-Withok TSF site is approximately 12 km southwest of DRDGOLD's Ergo Plant in Springs in the Eastern Basin of the Witwatersrand gold mining area within the Ekurhuleni Local Municipality, Gauteng Province (Figure 2.1). The area is characterised by a valley bottom (topographical depression) with rural and industrial development. The TSF falls within the quaternary catchment C22C of the Upper Vaal Water Management Area, with the Rietspruit flowing east to west north of the Brakpan TSF being a tributary to the southwest wards draining Withokspruit as the main drainage system in the area. A summary of the readily available hydrological data for the quaternary catchment is provided in Table 2.1.

Table 2.1: Summary of information for the quaternary catchment C22C (GRAII; DWAF 1996).

Quaternary catchment	Area (km^2)	Mean Annual Precipitation (mm/a)	Mean Annual Runoff (mm/a)	Mean Annual Baseflow (mm/a)	Mean Annual Recharge	
					mm/a	% of MAP
C22C	465.2	684	31	8	43.19	6.3

2.1. CLIMATE

The study area falls within the summer rainfall region, with a Highveld climate of warm to hot summers and cold, dry winters. The Mean Annual Precipitation (MAP) according to the GRA II (Ground Water Resource Assessment) produced by the Department of Water and Sanitation, is approximately 684 mm/a for quaternary catchment C22C, occurring mostly in the summer months.

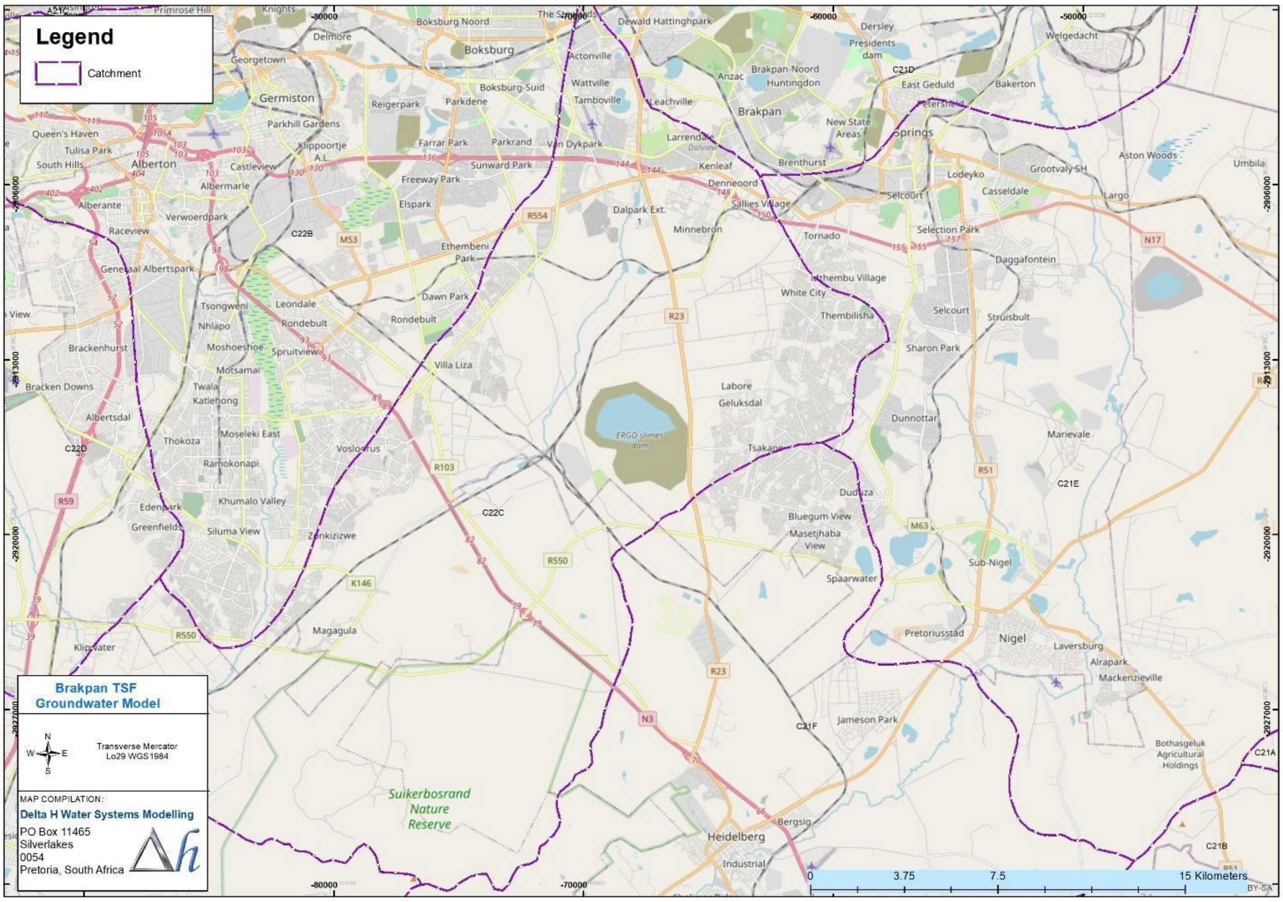

Figure 2.1: General Setting of the Brakpan-Withok TSF Complex.

3. SCOPE OF WORK

Delta H's Scope of Work (SoW) entailed the development of a three-dimensional numerical groundwater flow and transport model for the Brakpan-Withok TSF complex. Following the model calibration, the model would then be used to evaluate the impacts associated with the extension of the existing Brakpan TSF and the effectiveness of a hydraulic containment system comprising scavenger wells at the perimeter of the Brakpan TSF.

4. METHODOLOGY

4.1. DESK STUDY

The desk study entailed a review of the available groundwater related studies previously conducted for the TSF project. This included the following reports:

- iLEH 2016. Withok Tailings Storage Facility - Numerical Geohydrological Model – Final Report, report no. iLEH-DRD WIT 04-16, dated November 2016.
- Water Hunters 2020. Brakpan/ Withok TSF: Scavenger Well Development - Drilling and testing report, Final Draft, report no. SX_TR0219, dated August 2020.
- Water Hunters 2021. Withok TSF: Scavenger Well Development Phase 2 - Geophysics, drilling and aquifer testing, Final Draft, report no. 2021/04/0025, dated April 2021.
- Water Hunters 2024. Withok TSF - Depressurisation Borehole Implementation - Field work report. Draft report dated February 2024 (version 1.0).

4.2. HYDROCENSUS

No hydrocensus was undertaken as part of this study. Water levels were obtained from the National Groundwater Archive (NGA) maintained by the Department of Water and Sanitation, previous studies (iLEH 2016), and, more importantly, levels and qualities were collated from the ongoing site monitoring program, pumping tests of the newly drilled boreholes (Water Hunters 2020, 2021 and 2024).

4.3. GEOPHYSICAL SURVEY AND RESULTS

Detailed geophysical investigations of the site were conducted by Water Hunters (2020, 2021 and 2024) during Phase 1 and Phase 2 of the scavenger well development project.

4.4. DRILLING AND SITING OF BOREHOLES

Based on the outcomes of the geophysical investigations, Water Hunters (2020, 2021 and 2024) drilled a total of 24 boreholes consisting of scavenger wells and TSF wells, i.e. abstraction boreholes at the perimeter and within the TSF, as well as monitoring boreholes.

4.5. AQUIFER TESTING

Most of the newly drilled boreholes were tested by Water Hunters (2020, 2021 and 2024). A summary of results can be found in chapter 5.3.3.

4.6. SAMPLING AND CHEMICAL ANALYSIS

The assessment of ambient groundwater quality is based on a previous review of monitoring data and hydrocensus data undertaken by iLEH (2016), results of the continuous monitoring programme for the site (2018 to 2024), and water samples retrieved by Water Hunters (2020, 2021 and 2024) from newly drilled boreholes as summarised in chapter 5.6.

4.7. Acid Rock Drainage Assessment

Underflow and overflow samples for the Brakpan TSF were collected in 2019 and analysed for Acid Base Accounting (ABA) by Waterlab, Pretoria in November 2019. ABA (Sobek et al. (1978)) is a screening procedure whereby the acid-neutralising potential (assets) and acid-generating potential (liabilities) of rock samples are determined, with the difference (net neutralising potential, equity) then calculated. ABA is a static procedure and provides no information on the rate with which acid generation or neutralisation will proceed. Reaction rates are usually determined by kinetic weathering or leaching tests. It must be noted that acid-neutralising (or buffer) reaction rates of most minerals (apart from the carbonates) are typically slower than the sulphide oxidation rates in the rocks.

ABA tests calculate the acid potential (AP) of a sample due to the theoretical oxidation of the total sulphur content of the sample to sulphuric acid. As the AP is usually expressed in kg $CaCO_3$ per tonne of rock, the conversion factor is as follows:

$$AP = \frac{\text{Sulphur content (\%)} * \text{ 1000kg}}{100} * \frac{molecular\ weight\ of\ CaCO_3}{atomic\ weight\ of\ sulphur}$$

$$= sulphur\ content\ (\%) * 31.25kg\ CaCO_3\ per\ tonne$$

The AP can be converted into the Maximum Potential Acidity (MPA, expressed as kg H_2SO_4/tonne), which is commonly used in Australia by simply multiplying the AP with 0.98.

The neutralisation potential (NP) of a sample, mostly provided by carbonates hydroxides and silicates, is determined according to Sobek et al. (1978) by digestion of hydrochloric acid. The NP is expressed in kg $CaCO_3$ per tonne of rock, but can be converted into the Acid Neutralising Capacity (ANC, expressed as kg H_2SO_4/tonne), used in Australia by simply multiplying the NP with 0.98.

It must be noted that this theoretical and widely used neutralisation potential does not necessarily represent the real neutralisation potential that would occur in the field as it is site-specific to environmental conditions, mineralogy, kinetic reactions and dissolution rates (Morin and Hutt 2001).

Two key indicators are used to assess the risk of acid drainage:

1. The Net Neutralisation Potential (NNP) is calculated by subtracting the Acid Potential (AP) from the Neutralising Potential (NP):

NNP = NP – AP,

with negative NNP values indicating the potential to generate acidity and therefore a predicted net acid drainage water quality from the rock. Positive values indicate acid-neutralising potential or a predicted net alkaline drainage water quality from a rock sample, though some authorities (Canada) request NNP values larger than 20 before non-acid generation can be assumed.

2. The Neutralisation Potential Ratio (NPR) is calculated by dividing NP by the AP:

NPR = NP / AP,

with the following assessment criteria for a sample:

- NPR larger than 2 generally indicates non-acid generation (NAG), i.e. neutral or alkaline leachate, but in case of preferential exposure or reactivity of sulphides NPR larger than 4 is needed for complete acid neutralisation (Price et al., 1997).
- NPR between 1 and 2 is considered inconclusive or uncertain with regard to acid generation.
- NPR below 1 indicates potentially acid generating (PAG) material.

4.7.1. Paste pH

As part of the ABA procedure according to Sobek et al. (1978), the paste pH of a mixture of the pulverized rock sample and distilled water (pH typically 5.3) is determined. The measured pH value indicates whether a sample was at the time of analysis acidic (paste pH<5), near neutral (5<paste pH<10) or alkaline (paste pH>10). Acidic paste pH values indicate a non-reactive or absent neutralisation potential.

4.7.2. Sulphur specification

ABA assumes conservatively that all sulphur in the sample will react to form sulphuric acid, while in fact some of the sulphur may be present in non-acid producing sulphates (e.g. gypsum, barite), organic or elemental sulphur. If a significant part of the total sulphur occurs as sulphate sulphur instead of sulphide sulphur, the overall risk of acid generation is reduced. Furthermore, acid generation of samples with sulphide sulphur content below 0.3 % is considered short term (Price and Errington 1995, Soregaroli and Lawrence 1998) due to limited sulphur supply.

The sulphide acid potential (SAP) of a sample is then calculated according to

$$SAP = \ Sulphide\ sulphur\ content\ (\%) * 31.25\ kg\ CaCO_3\ per\ tonne$$

In general, the use of total sulphur for the determination of the maximum potential acidity is considered more reliable (Brady 1990), albeit questionable for e.g. ores from oxide deposits, slag, ash samples or other material samples oxidised during their processing.

4.7.3. Carbonate neutralisation potential

ABA assumes that the rate of mineral dissolution providing the Neutralisation Potential NP (carbonates hydroxides and silicates) is higher or equal to the rate of acid generation, which can realistically only be assumed for carbonate minerals like calcite or dolomite. Furthermore, the equilibrium pH ranges at which hydroxides and silicates buffer (once the carbonate minerals are depleted) are typically lower than 6 (e.g. gibbsite < pH 4.3, ferrihydrite < pH 3.5) and therefore insufficient to maintain a neutral mine drainage.

The Carbonate Neutralisation Potential (CO_3-NP), based on the inorganic carbon content (IC) of a sample as an indicator of the presence of carbonate minerals (including iron and manganese carbonates) alone, is given by:

$$CO_3\text{-NP (kg } CaCO_3\text{/tonne) = IC (\%) *83.3}$$

The following interpretations can be derived from a comparison of the two neutralisation potentials (Morin and Hutt 2001):

- CO_3-NP = NP: Neutralisation potential provided by reactive carbonate minerals.
- CO_3-NP > NP: Not all carbonate minerals are rapidly reactive (e.g. significant concentration of iron and manganese carbonates) or not all carbon is carbonate.
- CO_3-NP < NP: Non-carbonate minerals are major contributor to the neutralisation potential.

4.7.4. Net acid generation (NAG) test

Net acid generation tests directly determine the acid generating potential of sulphide minerals in a rock sample by oxidation with hydrogen peroxide (H_2O_2). Acid generation and acid neutralization reactions occur simultaneously, and the test provides therefore a net result of the amount of acid generated.

After complete oxidation of the sample, the final NAG pH is used as a screening criterion for the acid generation potential:

- NAG pH below 3.5 indicates a high risk of acid generation,
- NAG pH value larger than 5.5 indicates no risk of acid generation, and
- NAG pH value between 3.5 and 5.5 indicates a low risk of acid generation.

The supernatant of the test is titrated to a pH of 4.5 and 7.0 and the net acid potential in the form of kilograms of sulphuric acid produced per tonne of waste rock sample (kg H_2SO_4/t) calculated.

4.7.5. Leach testing and waste classification

Leach tests are commonly used as a preliminary screening process to identify potential constituents of concern based on a comparison against relevant water quality and effluent standards or other specified limits. In the context of this study, the total and leachable concentrations are used to classify the TSF samples in accordance to the National Environmental Management: Waste Act (NEMWA) – Norms and Standards, as specified in the Government Notices R. 634, 635 and 636 (Government Gazette No. 36784, 23/08/2013) pertaining to the National Environmental Management: Waste Act (Act No. 59 of 2008) by the Department of Environmental Affairs (DEA). According to the Government Notices, the leachable concentrations are determined using the Australian Standard Leaching Procedure (AS 4439.3-1997, bottle leaching procedure) and the total concentrations using aqua regia digestion. Since the mine residues represent non-putrescible waste (not containing organic matter that attract vermin or disease-causing vectors such as flies and rodents) to be disposed of without any other waste, water (pH 5) was used as leaching fluid. The solid phase is extracted over 18 hours in the laboratory with synthetic precipitation and a liquid-to-solid ratio of 20:1. Following extraction, the liquid extract is separated from the solid phase by filtration (combined with any potential initial liquid portion) and analysed. The applicable leachable or total concentration thresholds used by the authorities to classify the waste into several categories are given in Table 4.1.

Table 4.1: Waste type classification by total and leachable concentration thresholds (TCT and LCT) for landfill disposal.

Total concentration threshold	Link between TCT and LCT	Leachable concentration threshold	Waste Type	Landfill design
< TCT0	and	< LCT0	Type 4	Class D
< TCT1	and	< LCT1	Type 3	Class C
< TCT1	and	< LCT2	Type 2	Class B
< TCT2	or	< LCT3	Type 1	Class A
> TCT2	or	> LCT3	Type 0	Not allowed

Although the Australian Standard Leaching Procedure prescribed for the waste classification can determine the leachability of determinants, the liquid-to-solid ratio of 20:1 does not represent actual field conditions. Therefore, leachate concentrations are unlikely to represent the actual quality of seepage or run-off from a material stockpile or mine residue facility.

4.8. GROUNDWATER RECHARGE CALCULATIONS

The groundwater recharge rates were estimated based on previous studies (iLEH 2016) as well as the GRA II data set (Groundwater Resource Assessment Phase II, Department of Water and Sanitation, 2006). The seepage rates for the TSFs were determined using a three-dimensional seepage model (Delta H, 2024). This is a concurrent report, and no details are therefore reported here.

4.9. GROUNDWATER MODELLING

A three-dimensional numerical (finite-element) groundwater flow and transport model was developed for the Brakpan-Withok TSF complex. This provides a mathematical approximation of the real-world aquifer system, noting that there are always errors associated with groundwater models due to uncertainties in the data and inevitable limits in the capability of numerical methods to describe natural physical processes. There are also alternative conceptual models that can be used in describing the real-world system. However, numerical groundwater models are generally considered the best tools available to quantify / estimate groundwater and contaminant transport, and the results can be used in management decisions. The chosen software code, model set-up, assumptions and results are described in detail in chapter 7.

5. PREVAILING GROUNDWATER CONDITIONS

5.1. Geology

The project area is underlain by both Karoo and Transvaal Supergroup rocks. Sedimentary rocks from the Karoo Supergroup, together with Karoo dolerite intrusions and dolomites from the Malmani group, all underlie the TSF footprint area (Figure 5.1).

The outcomes from previous studies conducted at the project site are provided in this chapter. These studies included an extensive geotechnical drilling programme, completed during 2016 to confirm the site geology and the stability of the dolomite present. From the drilling programme the site geology comprises rocks of the Ventersdorp Supergroup (lava), the Transvaal Sequence (dolomite and quartzite) and the Karoo Sequence (mudstone and sandstone). Dolerite dykes and sills of post-Karoo age have intruded these host rocks. Two north-south striking faults are indicated on the Regional Geological map to also transect the project area. These faults were not definitely confirmed during the drilling programme. At best the faulting was pre-Karoo and hence covered by the younger formations. The Karoo formations are present as outliers to the east and central parts of the TSF footprint and consist of mudstone that rapidly grades into sandstone. The Transvaal formations present include dolomite, chert and wad of the Oaktree and Monte Christo Formations of the Malmani Subgroup and the Black Reef Formation. The dolomites are present in the west, thinning out towards the southeast where they extend underneath the TSF complex. An outlier of dolomite, chert and wad was identified in the central part of the TSF footprint during the 2016 drilling programme. Black Reef Quartzite outcrops on the valley flanks to the northeast of the TSF complex. The quartzite is faulted against post Karoo dolerite intrusive and andesitic lava of the Ventersdorp Supergroup. The andesitic lavas are the oldest rocks present and are found in a small area northeast of the TSF complex. An extensive dolerite sill (>20m thick) with associated dykes underlies approximately half of the TSF complex. Jointing is closed in fresh dolerite but open joints (5 – 20mm wide), with occasional infilling, were observed here in the weathered dolerite (iLEH, 2016).

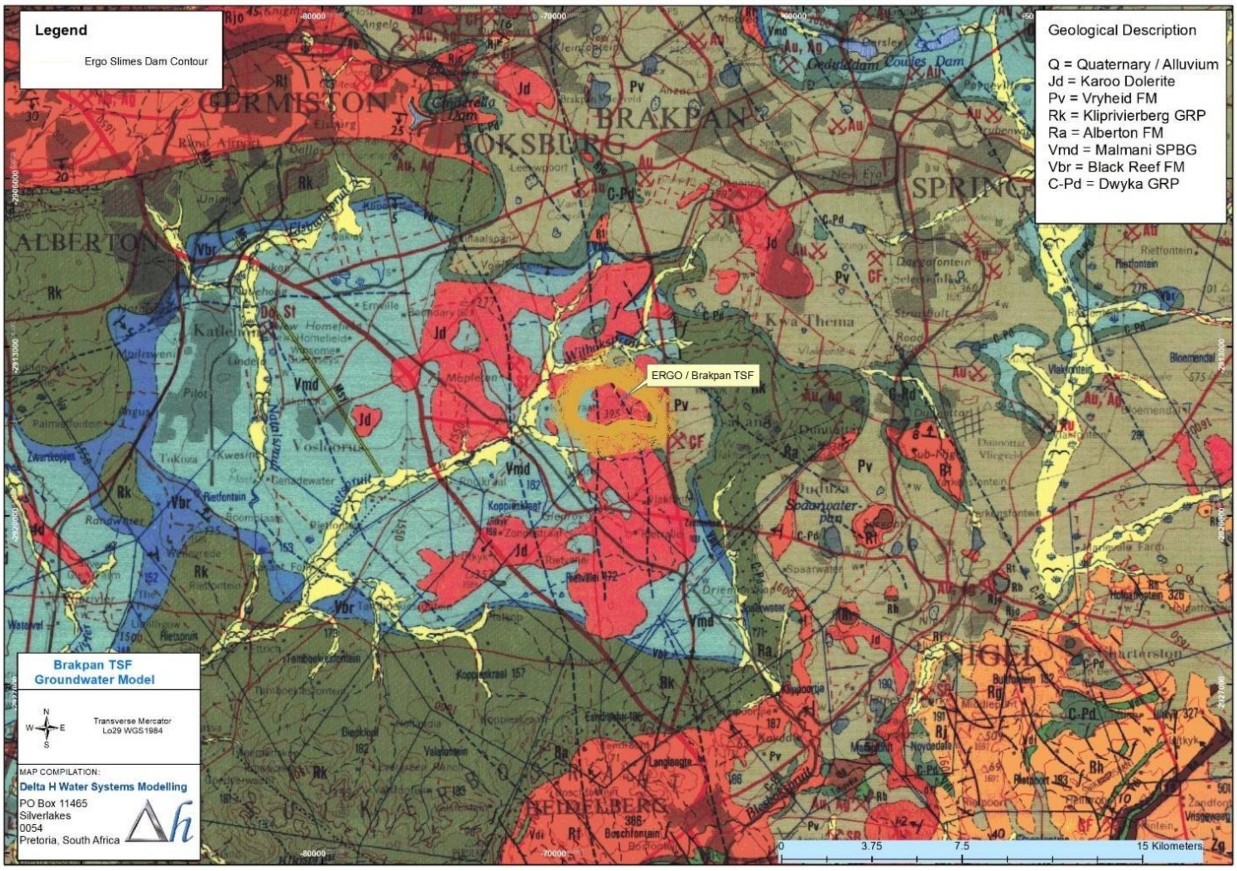

Figure 5.1: Regional geological setting.

5.2. ACID GENERATION CAPACITY

5.2.1. Acid rock drainage potential

Two composite underflow (coarse) and overflow (fines) samples were analysed for their acid generation potential by employing static methods including Acid-Base-Accounting (ABA), paste pH, sulphur speciation, carbonate neutralisation potential and Net Acid Generation (NAG) tests. The methodologies have been described in detail in Chapter 4.6, above. The paste pH analysis, sulphur speciation and NP analysis (with subsequently calculated AP, NNP and NPR) of the Brakpan Fines composite sample were run in duplicate for internal (laboratory) quality control purposes and the results are indicated by grey shading in Table 5.1. To assess the data quality, the commonly used Relative Percentage Difference (RPD) was calculated:

$$RPD = \frac{|a-b|}{average(a,b)} * 100\%$$

The following criterions were used to assess the RPD values:

1. RPD < 1% Excellent
2. RPD < 2.5% Good
3. RPD <10 % Average
4. RPD > 10% Poor

The internal data quality control assessment conducted for composite sample Brakpan Fines is indicated below. An excellent reproducibility (RPD<1%) were observed for:

- Total Sulphur (%)
- NAG pH4.5
- NAG pH7
- Net Acid Potential from NAG pH7
- Paste pH
- Acid potential (AP)
- Net Neutralisation Potential (NNP)

An average reproducibility (RPD<10%) was found for:

- Net Acid Potential from NAG pH4.5
- Neutralisation Potential (NP)
- Neutralisation Potential Ratio (NPR)

The sulphate sulphur and sulphide sulphur speciation analysis showed a poor reproducibility (RPD>10%) of sample Brakpan Fines, resulting from laboratory procedures. However, this does not change the overall classification of the sample and the data are therefore considered of acceptable quality for the purposes of an acid rock drainage assessment.

Results of the ABA, sulphur speciation and calculated SAP, NNP and NPR values for the TSF composite samples are summarised in Table 5.1, indicating whether the sample is potentially acid generating (PAG) or not acid generating (NAG).

Table 5.1: ABA results for the TSF composite samples and calculated NP, NNP and NPR values based on inorganic carbon content (duplicate sample results highlighted in grey) analysed November 2019.

	Sample ID	Brakpan Fines (OF)		Brakpan Coarse (UF)	RPD
	Lab ID	79118	79118 D	79119	79118 D
SULPHUR	Total Sulphur (%)	0.79	0.79	0.38	0.0%
	Sulphate Sulphur as S (%)	0.37	0.26	0.25	34.9%
	Sulphide Sulphur (%)	0.42	0.11	0.13	117.0%
CARBON	Total Carbon (%)	0.17		0.05	
	Organic Carbon (%)	0.15		0.04	
	Inorganic Carbon (%)	0.03		0.00	
	CO_3-NP ($CaCO_3$/t)	2.17		0.17	
NAG	NAG pH 4.5	2.70	2.70	2.60	0.0%
	pH 4.5 NAG (kg H_2SO_4/t)	9.41	9.02	23.00	4.2%
	NAG pH 7	4.50	4.50	4.50	0.0%
	pH 7 NAG (kg H_2SO_4/t)	1.96	1.96	3.33	0.0%
ACID BASE ACCOUNTING	Paste pH	8.1	8.1	7.4	0.0%
	Acid Potential (AP) (kg/t)	25.00	25.00	12.00	0.0%
	S^{2-}Acid Potential (SAP) (kg/t)	13.13	3.44	4.06	
	Neut Potential (NP)	2.71	2.95	1.73	8.5%
	Net Neut Potential (NNP)	-22.00	-22.00	-10.00	0.0%
	Neut Potential Ratio (NPR)	0.11	0.12	0.15	8.7%
	NNP-S^{2-}	-10.42	-0.49	-2.33	
	NPR-S^{2-}	0.21	0.86	0.43	
	NPR-CO_3	0.09	0.00	0.01	
	NPR-CO_3-S^{2-}	0.17	0.00	0.04	
	PAG/NAG	**PAG**	**PAG**	**PAG**	**PAG**

Paste pH results showed that the tested samples were neutral to alkaline in nature, with a pH ranging from 7.4 to 8.1 (Table 5.1). Nevertheless, all samples were classified as potentially short-term acid generating according to the ABA classifications described in chapter 4.7.

ABA test results indicated that the two composite samples had negative NNP values, suggesting that the materials are acid generating. In addition, the NPR values were less than one for both samples, supporting the findings that the sample materials are potentially acid generating (Table 5.1). When considering the neutralisation potential ratio vs. the percentage of total sulphur content, all samples are potentially long-term acid generating (Figure 5.2).

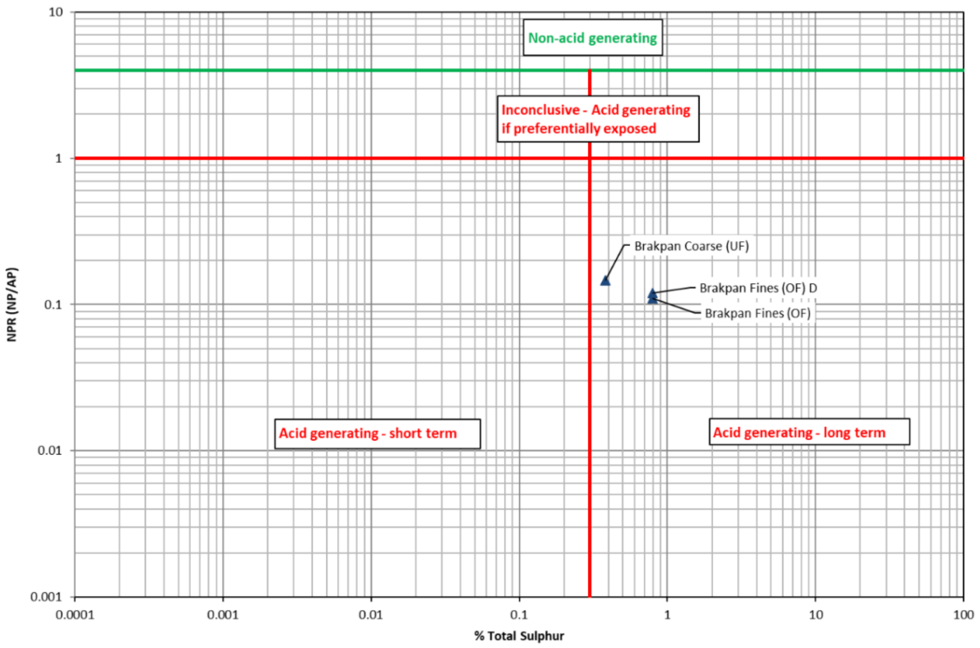

Figure 5.2: Neutralisation potential ratio versus total sulphur content (%).

The results obtained from the sulphur speciation showed the Brakpan Fines sample to contain more than 0.3% sulphide sulphur, classifying the sample as potentially long-term acid generating. Further to this, the acid generating sulphide sulphur content exceeded the sulphate sulphur content in the sample, although not in the duplicate. However, it should be noted that the sum of the sulphate and sulphide sulphur content in the Brakpan Fines duplicate sample did not match the measured total sulphur content due to analytical inaccuracies.

Based on the classification considering sulphide neutralising potential ratio (NPR-S2-, calculated using the sulphide acid potential (SAP)) versus percentage sulphide sulphur, samples for Brakpan Coarse 1 are classified as short-term acid generating (Figure 5.3), while the Brakpan Fines samples classify as long-term acid generating (with the duplicate disregarded due to incorrect laboratory results).

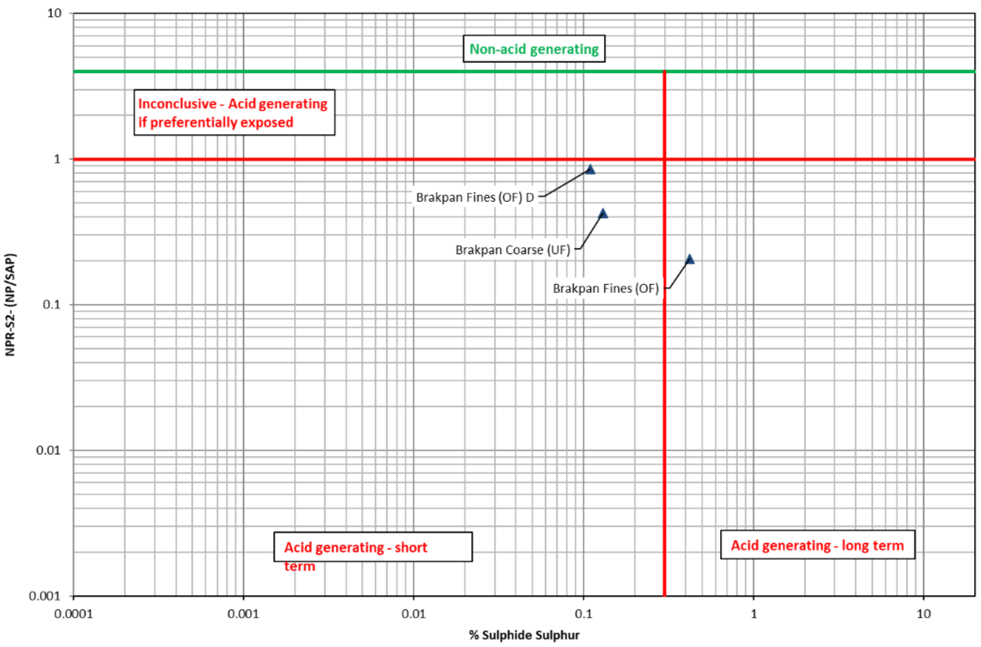

Figure 5.3 Sulphide neutralising potential ratio versus sulphide sulphur content (%).

ABA results under consideration of carbon speciation

Total carbon concentrations were relatively low in the samples, ranging from 0.05% to 0.17%, while inorganic carbon contents ranged from 0.002% to 0.03% (Table 5.1). It is the inorganic carbon content that is potentially significant from an acid neutralisation perspective as this gives rise to calculated carbonate neutralisation potential (CO3-NP, see chapter 4.7.3); this varied between 0.17 kg CaCO3/t and 2.14 kg CaCO3/t. A classification of the samples based on the Neutralising Potential Ratio calculated from the CO3-NP (NPR- CO3) and the sulphide acid potential versus the sulphide sulphur content is given in Figure 5-4. The calculation of the CO3-NPR yields the same sample classification as the sulphide neutralising potential ratio versus total sulphur classification above (Figure 5.4).

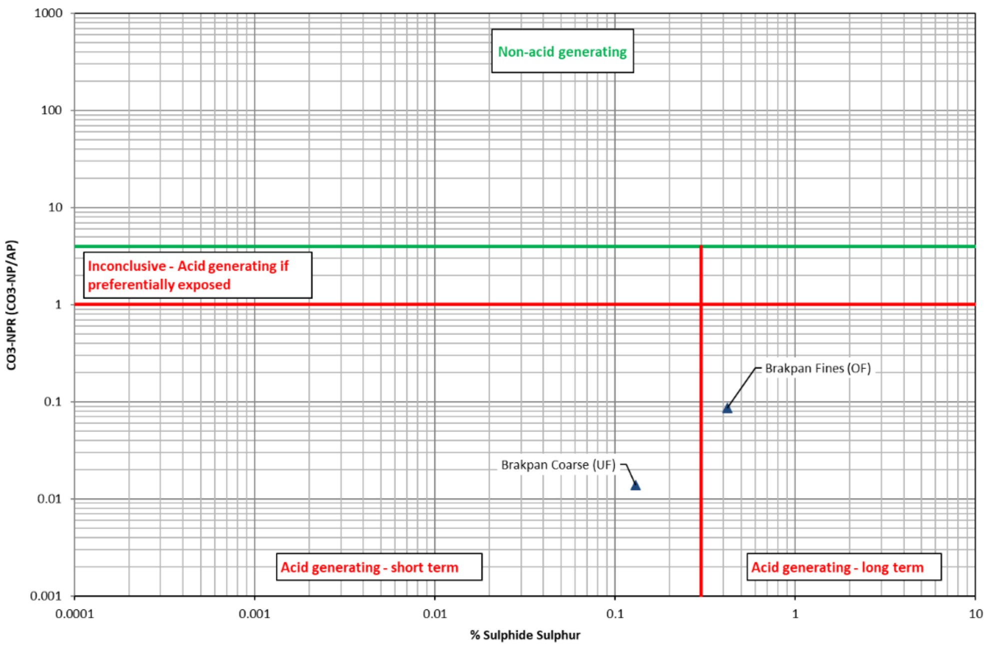

Figure 5.4: Carbonate neutralisation potential versus sulphide sulphur (%).

NAG test results

The NAG (net acid generating) pH is the result of oxidation of sulphide minerals in the samples by hydrogen peroxide (H_2O_2). The NAG test would also be expected to oxidise iron/manganese carbonate minerals in the samples and release the residual acidity associated with these minerals if present. All samples were classified as acid-generating according to the NAG pH versus the NPR (Neutralisation Potential Ratio, Figure 5.5). However, based on the NAG pH classification (chapter 4.7.4), all samples had a NAG pH of 4.5 and are of low risk with regard to acid generation.

Taking the various classification methods above into account, the Brakpan Coarse (UF) samples was classified as potentially short-term acid generating, while the Brakpan Fines (OF) sample has a long-term acid generation risk.

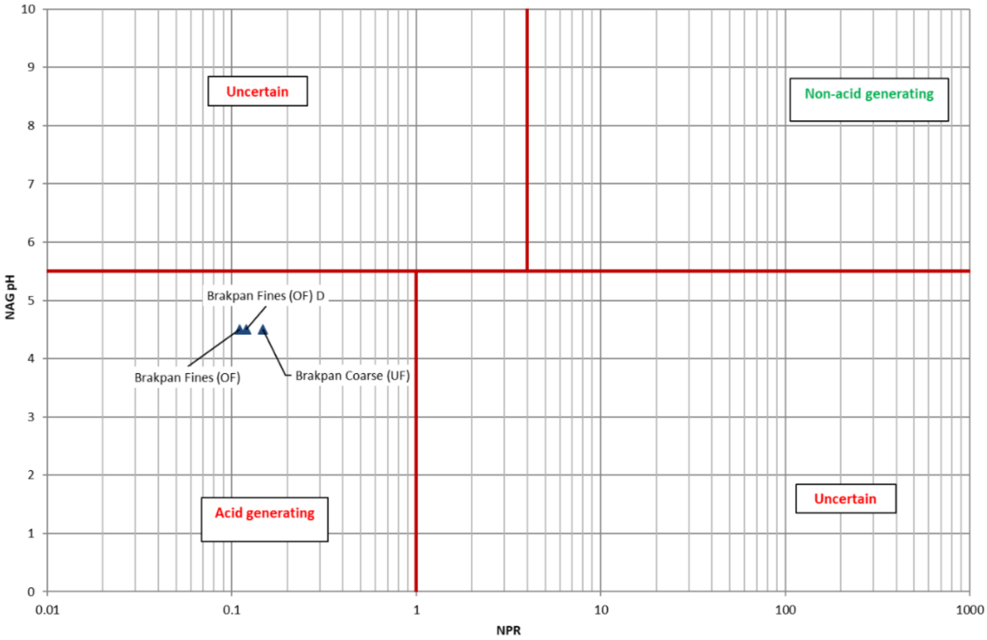

Figure 5.5: NAG pH versus neutralisation potential ratio.

5.2.2. Leachate chemistry and waste classification

The total and leachable concentrations of the fines and coarse tailings samples were analysed by Waterlab (Pty) Ltd., South Africa to determine the leachate quality, identify constituents of concern, and classify the waste. The total and leachable concentrations (liquid to solid ratio 1:20) along with the applicable thresholds used for the waste classification of the two samples are presented in Table 5.2 and Table 5.3, respectively. It is important to note that according to the Government Notices R. 634, 635 and 636 (Government Gazette No. 36784, 23/08/2013), the exceedance of a threshold value for any element or chemical substance determines the overall waste classification (Table 4.1).

Both samples exceeded the TCT0 threshold for total arsenic, barium, copper, and lead concentrations (aqua regia digestion) as indicated in Table 5.2. Additional constituents of concern are cyanide and nickel. Leachable concentrations exceeded the LTC0 threshold for sulphate in the coarse (UF) sample and for cyanide in the fines (OF) sample (Table 5.3).

Based on the exceedances above, both samples were classified as waste type 3 requiring a landfill design of class C.

Table 5.2: Total (aqua regia digestion) concentrations for the Brakpan TSF samples.

Totals	Brakpan Fines (OF)	Brakpan Coarse (UF)	Threshold		
Lab ID	79118	79119	TCT0	TCT1	TCT2
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
As, Arsenic	32	36.4	5.8	500	2 000
B, Boron	59	50	150	15 000	60 000
Ba, Barium	142	84.8	62.5	6 250	25 000
Cd, Cadmium	<0.400	<0.400	7.5	260	1 040
Co, Cobalt	10.8	18	50.0	5 000	20 000
CrTotal, Chromium Total	207.6	328.4	46 000	800 000	N/A
Cu, Copper	32.8	22.4	16.0	19 500	78 000
Hg, Mercury	<0.400	<0.400	0.93	160	640
Mn, Manganese	235	168	1 000	25 000	100 000
Mo, Molybdenum	<10	<10	40	1 000	4 000
Ni, Nickel	86	91.2	91	10 600	42 400
Pb, Lead	30.4	20.8	20	1 900	7 600
Sb, Antimony	<0.400	<0.400	10	75	300
Se, Selenium	<0.400	<0.400	10	50	200
V, Vanadium	<10	<10	150	2 680	10 720
Zn, Zinc	44	66	240	160 000	640 000
Inorganic Anions	mg/kg	mg/kg			
Cr(VI), Chromium (VI) Total [s]	<5	<5	6.5	500	2 000
Total Fluoride [s] mg/kg	<5	<5	100	10 000	40 000
Total Cyanide as CN	16	7.3	14	10 500	42 000

Table 5.3: Leachable (distilled water, 1:20) concentrations for the Brakpan TSF samples.

Leachable 1:20	Brakpan Fines (OF)	Brakpan Coarse (UF)	Threshold			
Lab ID	79118	79119	LCT0	LCT1	LCT2	LCT3
Units	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
As, Arsenic	0.022	0.007	0.01	0.5	1	4
B, Boron	<0.025	<0.025	0.5	25	50	200
Ba, Barium	<0.025	<0.025	0.7	35	70	280
Cd, Cadmium	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	0.042	<0.025	0.5	25	50	200
CrTotal, Chromium Total	<0.025	<0.025	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.010	<0.010	2.0	100	200	800
Hg, Mercury	<0.001	<0.001	0.006	0.3	0.6	2.4
Mn, Manganese	<0.025	<0.025	0.5	25	50	200
Mo, Molybdenum	<0.025	<0.025	0.07	3.5	7	28
Ni, Nickel	0.048	<0.025	0.07	3.5	7	28
Pb, Lead	<0.001	0.008	0.01	0.5	1	4
Sb, Antimony	0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	0.01	0.5	1	4
V, Vanadium	<0.025	<0.025	0.2	10	20	80
Zn, Zinc	<0.025	<0.025	5.0	250	500	2000
Inorganic Anions	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
Total Dissolved Solids*	318	422	1 000	12 500	25 000	100 000
Chloride as Cl	3	<2	300	15 000	30 000	120 000
Sulphate as SO4	209	258	250	12 500	25 000	100 000
Nitrate as N	<0.1	<0.1	11	550	1100	4400
Fluoride as F	<0.2	<0.2	1.5	75	150	600
Total Cyanide as CN	0.150	<0.02	0.07	4	7	28
pH	7.3	7				

5.2.3. Mineralogical analysis

A mineralogical analysis was conducted on the two Brakpan samples. The XRD results indicated that quartz was the major mineral component with 87% and 92% quartz, respectively (Table 5.4). The remainder of the matrix comprises muscovite, chlorite, gypsum, pyrophyllite and chloritoid with minor amounts of magnetite and pyrite for the Underflow sample. The absence of carbonate minerals supports the ABA findings that non-carbonate minerals contribute to the neutralising potential of the material such as muscovite and chlorite, which have a relatively low neutralising potential compared to carbonate minerals. The presence of gypsum suggests that some of the acid potential was neutralised - precipitating gypsum in the process.

Table 5.4: Major mineral composition (XRD Analysis) of the Brakpan TSF samples (all in weight%).

Compound Name	Ideal Chemical Formula	Brakpan Fines (OF)	Brakpan Coarse (UF)
Pyrite	FeS_2	0	0.3
Magnetite	Fe_3O_4	0.3	0.1
Quartz	SiO_2	86.5	91.9
Muscovite	$KAl_2((OH)_2\ Al\ Si_3\ O_{10})$	8.5	2.5
Chlorite	$(Mg,Fe)_5Al(AlSi_3O_{10})\ (OH)_8$	0.3	0.2
Gypsum	$CaSO_4{\bullet}2(H_2O)$	0.5	0.6
Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$	1.7	2
Chloritoid	$(Fe^{2+},Mg)_2Al_4Si_2O_{10}\ (OH)_4$	2.1	2.4

5.3. HYDROGEOLOGY

5.3.1. Unsaturated zone

The borehole log suggests that the depth of highly weathered material extends to up to 21 m below surface (iLEH, 2016). There is however no clear pattern in the depth of weathering. Pockets of weathering have developed and are mostly associated with the Karoo shales. The depth of weathering associated with the dolerite is shallower, ranging from 1 – 4m below surface. Dolerite weathering also results in an increase in clay content, which reduces the permeability (iLEH, 2016).

5.3.2. Saturated zone

Based on the conceptual hydrogeological understanding of the site, the following hydro-stratigraphic units underlie the TSF:

1. Topsoil/gravel (average thickness of 2 m). This acts as a shallow perched aquifer in areas where the impermeable dolerite sill is present.
2. Shallow weathered aquifer (thickness between 3 m and 22 m).
3. Fractured and Karst aquifer within both Karoo and Transvaal Supergroup rocks.
    a. Fractured aquifer comprising the Klipriviersberg Group and Karoo Formations, Turffontein Subgroup and Black Reef quartzite.
    b. Karst aquifer within the dolomites of the Chuniespoort Group of the Malmani Supergroup.

5.3.2.1. Shallow weathered aquifer

The weathered zone of the Ventersdorp lava, Transvaal dolomites and quartzites and the Karoo mudstone and sandstone (including post Karoo dolerites) hosts the unconfined or semi-confined shallow weathered aquifer. Localised perched aquifers may occur on clay layers or lenses. Due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments, the regional water quality is generally good, but the aquifer is, in the absence of an overlying confining layer, also vulnerable to pollution due to seepage from the TSF. Water intersections in the weathered aquifer are mostly above or at the interface to fresh bedrock (sandstone or sills), where less permeable layers of weathering products and capillary forces limit the vertical percolation of water and promote lateral water movement.

Work by iLEH (2016) summarised the shallow weathered aquifer as having developed on the relatively impermeable dolerite sill, and comprising of gravel, silt and clay, as well as weathered dolomite. This aquifer is unconfined in nature. The water table in this aquifer mimics the topography and drains on a regional scale into the local rivers and streams. At the time of the initial geotechnical investigation in 1983, the average depth to static groundwater levels was 7.4m. Groundwater levels have however progressively risen over the years because of recharge from the TSF complex, especially in the shallow perched aquifer. Groundwater now drains radially from the TSF complex due to the impact of artificial recharge from the TSF to the underlying aquifers. Information presented by GHT (2004) indicates that, except for the dolerite sill, the perched and deeper fractured rock aquifers are interconnected. Contamination from the shallow aquifer can therefore infiltrate into the deeper aquifer (iLEH, 2016).

5.3.2.2. Fractured Karoo and Pretoria Group aquifer

Previous studies summarised the deeper fractured aquifer as semi-confined in nature. The low permeability dolerite sill specifically confines the underlying fractured rock aquifer. Borehole yield is enhanced within the contact zones between the dolomite and the dolerite intrusions as well as by the effects of karstification. Boreholes drilled into the dolerite sill had uniformly low yields and, in most instances, no more than seepage. The dolerite is an aquitard, offering at best very slow transmission. The contact zone between the dolerite intrusive and the host rocks are also thought to provide preferential flow paths to groundwater. Groundwater yield in the Karoo shales and mudstones is also low and groundwater flow in these rocks is associated with fractures, faults, and bedding planes, typical of fractured rock aquifers, although overall the Karoo formation is more aquitard than aquifer (iLEH, 2016).

5.3.2.3. Karst aquifer system

Karst aquifers, form fissures and/or cavities through chemical weathering, mainly from rainfall, and give dolomites an extremely high permeability and storage capacity. Karst aquifers have typically high hydraulic conductivity (<10 m/d) but are known to be highly heterogeneous, with yields ranging from 0.5 to more than 5 L/s. Higher yields are typically associated with higher hydraulic conductivities along cavities or fissures. These aquifers are typically unconfined in nature. Groundwater flow through a karst aquifer is prone to contamination because of the very nature of the karstified host rock: Fissures and bedding partings in the rock are enlarged by chemical dissolution over time and provide preferential flow paths, through which water is transferred rapidly and almost unfiltered from input points. The enlarged fractures and bedding partings are responsible for a very heterogeneous distribution of permeability within the karst aquifer. In the study area yields of up to 4 L/s were recorded for boreholes that intersected the dolomitic aquifer. Results from the monitoring borehole drilling programme show that the permeability of the dolomitic aquifer targeted by the new boreholes is highly variable, between 0.002 and 0.8 m/d (assuming a saturated thickness of 100m). This supports the interpretation that the dolomitic aquifer is highly heterogenous in its nature. WITBH3 was drilled through the dolerite sill into the underlying chert and dolomite. The permeability of this borehole is higher than the other two boreholes, probably exceeding 1m/d (iLEH, 2016).

5.3.3. Hydraulic conductivity

Previous studies conducted at the site included Packer tests conducted during 1983 as part of the original TSF feasibility study (GHT, 2004). Slug tests were performed on monitoring boreholes drilled during 2013, and iLEH (2016) reported on aquifer tests conducted on five monitoring boreholes drilled during 2016.

Table 5.5: Summary of hydraulic conductivities K from previous studies conducted (source: iLEH, 2016).

Geology	No. of sample points	Average depth	Average K	
		m	m/d	m/s
Weathered chert	2	8.7	0.69	8.0E-06
Weathered dolerite	15	11.3	0.20	2.3E-06
Weathered dolerite and dolomite	7	14.0	0.11	1.3E-06
Weathered dolomite	12	15.7	0.11	1.3E-06
Weathered dolomite and chert	1	13.5	3.00	3.5E-05
Weathered dolomite and wad	8	11.9	0.37	4.3E-06
Weathered lava	1	8.0	0.13	1.5E-06
Weathered lava and dolerite	1	15.9	0.04	4.6E-07
Weathered quartzite	2	9.2	0.02	2.3E-07
Weathered shale	1	7.5	0.06	6.9E-07
Wad	1	6.3	0.01	1.2E-07
Fresh dolerite	5	7.9	0.11	1.3E-06
Fresh dolomite	2	19.1	0.14	1.6E-06
Geometric Mean			**0.12**	**6.2E-07**

Additional pumping tests of the newly drilled scavenger wells were conducted by Water Hunters (2020, 2021) and are summarised in Table 5-6. The significantly higher conductivity values of these new boreholes point to very successful siting, well development and seepage influences from the TSF (recharge boundary).

Table 5.6: Summary of aquifer parameters from aquifer test (Water Hunters 2020, 2021 and 2024).

Borehole ID	Main geology	Static WL	Recommended abstraction rate	FC Analyses (Cooper Jacob)			Slug Test Results (Average)
		mbgl	L/s	Late T (m^2/d)	Late K (m/d)	Late K (m/s)	(m/d)
Scav 1	Dolerite, with dolomite below	4.60	3.0	332.2	8.88	1.03E-04	
Scav 3	Dolerite	4.10	2.1	28.3	0.75	8.64E-06	
Scav 5	Chert and dolomite	3.45	3.0	332.8	8.63	9.99E-05	
Scav 7	Dolerite, with dolomite below	2.61	3.0	443.7	11.26	1.30E-04	
Scav 8	Dolerite, with dolomite below	2.67	3.0	443.7	11.28	1.31E-04	
Scav 9	Wad, with dolomite and chart below	2.24	2.3	95.1	2.39	2.77E-05	
Scav 10 (3-2610)	Dolerite and dolomite	3.56		60.5	3.68	4.26E-05	
Scav 11 (3-1760)	Dolomite	2.15		73.9	3.23	3.74E-05	
Scav 12 (4-540)	Wad, dolomite	3.38		25.1	1.16	1.34E-05	
Scav 13 (4-700)	Dolerite with dolomite below	2.89		689.1	40.27	4.66E-04	
Scav 14 (Scav 1b)	Quartz, basaltic lava	5.24		57.0	2.88	3.34E-05	
BH 5-210	Dolerite with dolomite below	2.51		38.0	1.69	1.96E-05	
TSF Well 1	TSF to 29m, rest shale, dolerite	26.10		1.0*	0.03	3.22E-07	
TSF Well 2	TSF to 26m, rest dolerite, dolomite	24.78		-	-	-	
DPP-1	Diamictite and shale	0.51	0.7				
DPP-2	Diamictite and shale	3.86	0.4				

Borehole ID	Main geology	Static WL	Recommended abstraction rate	FC Analyses (Cooper Jacob)			Slug Test Results (Average)
		mbgl	L/s	Late T (m^2/d)	Late K (m/d)	Late K (m/s)	(m/d)
P-1	Dolerite	12.8					0.084
P-4	Dolerite	1.9					0.045
P-5	Dolerite	35.2					0.001
P-6	Dolerite	29.0					0.010
P-7	Dolerite	2.8					0.555
Geometric Mean**				**121.0**	**4.36**	**5.05E-05**	**3E-02**

* FC Method instead of Cooper Jacob used
** Excluding TSF Wells

5.4. GROUNDWATER LEVELS

As part of the geotechnical drilling conducted during 2016, five groundwater monitoring boreholes were drilled around the TSF footprint area. The depth to groundwater in the boreholes varied between 1.9 and 5.9 metres below ground level (m bgl). The groundwater levels obtained during the hydrocensus, conducted by iLEH during 2016 (Figure 5.6), indicated groundwater levels ranging from surface to 21m bgl, with an average groundwater level of 4.8m bgl. Similarly, the newly drilled scavenger boreholes (excluding the TSF wells, Water Hunters 2020, 2021, 2024) showed groundwater levels between 2.15 and 5.24 m bgl, with an average of 3.28 m bgl. The shallow groundwater levels are indicative of a perched or shallow aquifer system, with local mounding due to seepage from the TSF resulting in shallower water levels in its proximity.

Additional regional water levels within the model domain were retrieved from the National Groundwater Archive maintained by the DWS. In view of the historical dewatering of the Malmani dolomites, water levels measured within the dolomites were excluded from further analysis.

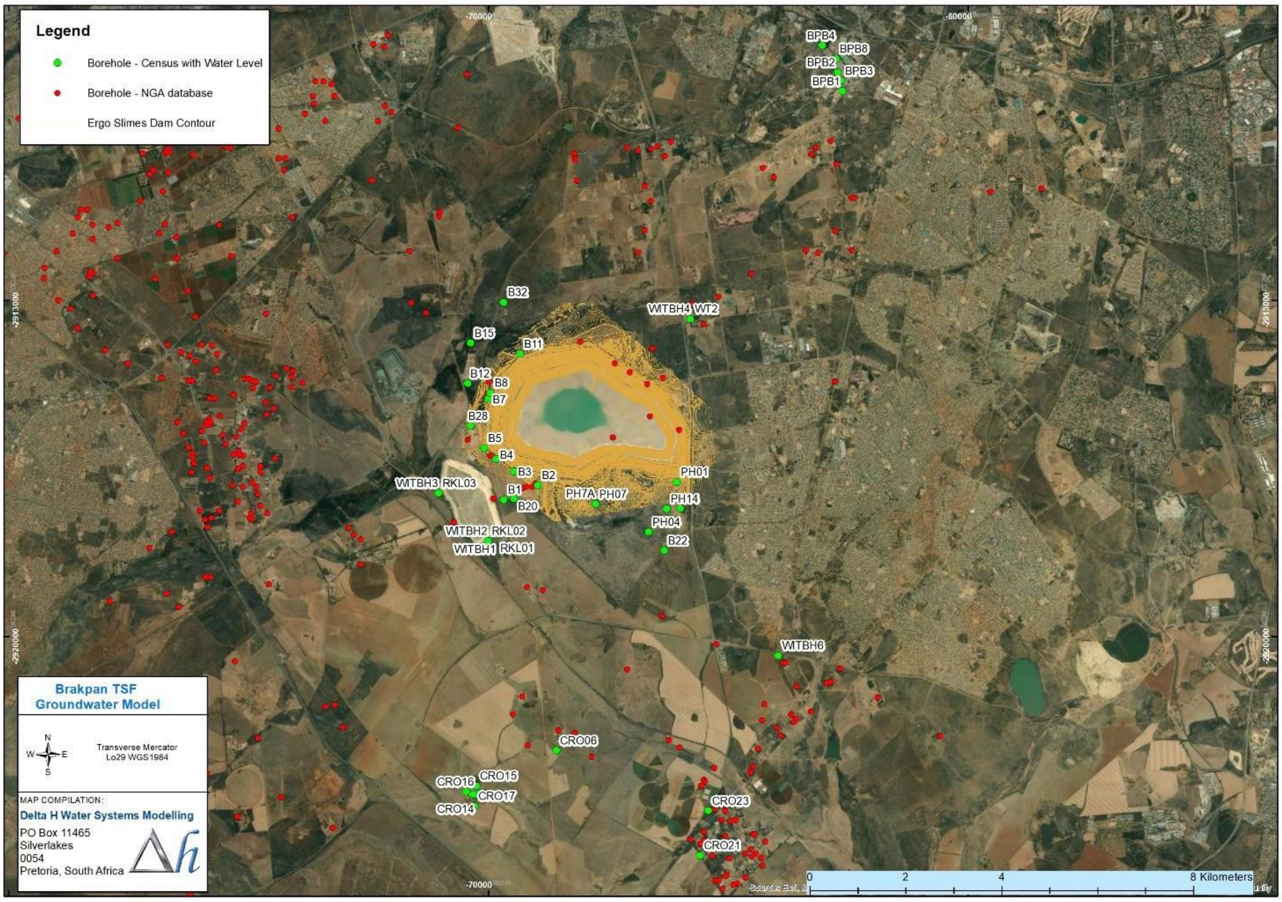

Figure 5.6: Hydrocensus data from iLEH (2016).

A plot of the groundwater table against surface elevation data for 162 boreholes in the larger project area (Figure 5.7) shows a reasonable correlation of 93% (R^2 = 0.93), indicative of an aquifer system where shallow groundwater conditions for the most part mimic surface topography, with groundwater flowing from higher lying ground towards lower lying ground and drainage systems (natural streams).

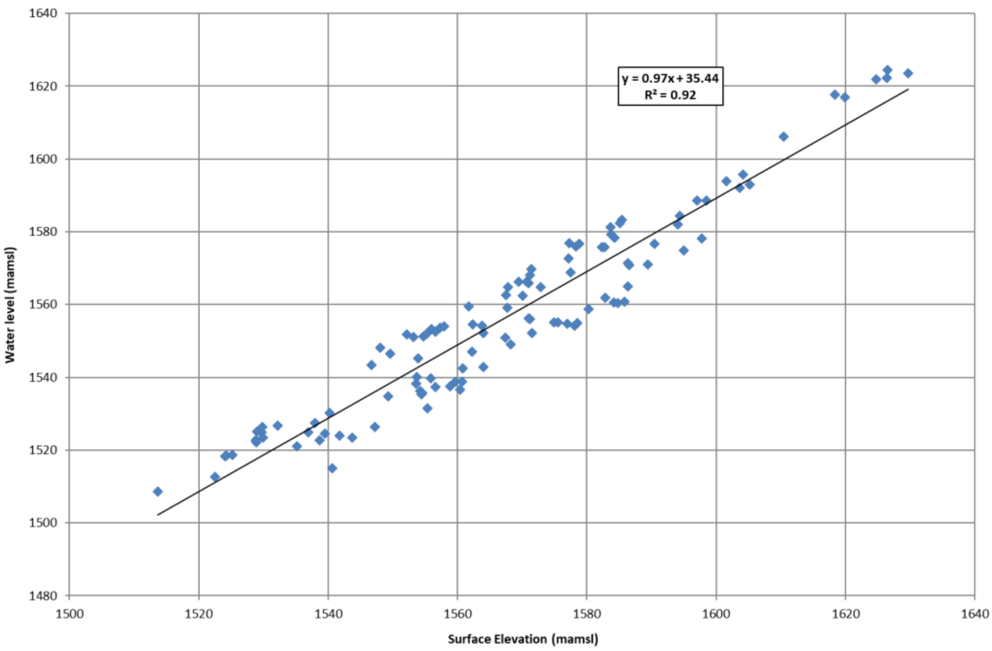

Figure 5.7: Correlation between surface topography and groundwater elevation.

A groundwater piezometric map was interpolated from the collated measured water levels using Bayesian interpolation, based on the established correlation between surface topography and groundwater levels. The Bayesian interpolation method uses correlated data to improve the spatial interpolation of the unknown variable, in this case the groundwater level. As a Universal Kriging algorithm, it relies on a mathematical description of the change (or variance) of a variable with distance, i.e. to what extent neighbouring observations are spatially correlated. Such correlation is expressed in a semi-variogram, as depicted in the empirical semi-variogram for the wider study area below (Figure 5.8) with the fitted Bayesian model used for the interpolation. The semi-variogram model is then used in combination with surface elevation and its correlation to the groundwater elevation as a qualified guess to improve the spatial interpolation of water levels.

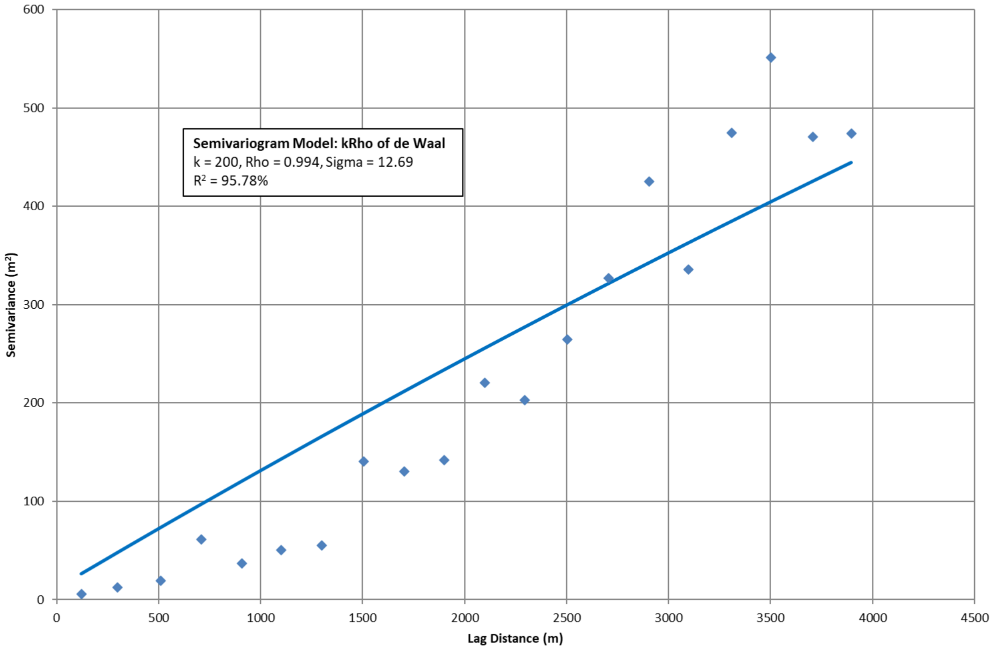

Figure 5.8: Empirical semi-variogram and fitted Bayesian model for the study area.

The interpolated (unconfined) groundwater piezometric map using Bayesian interpolation (with the model parameters given above), with elevated water table elevations around the Brakpan TSF clearly visible (Figure 5.9), was subsequently used as initial heads for the model calibration. It must be noted that initial heads only facilitate the mathematical convergence of a steady-state model, but do not change the outcome of the model i.e. the calculated steady-state heads

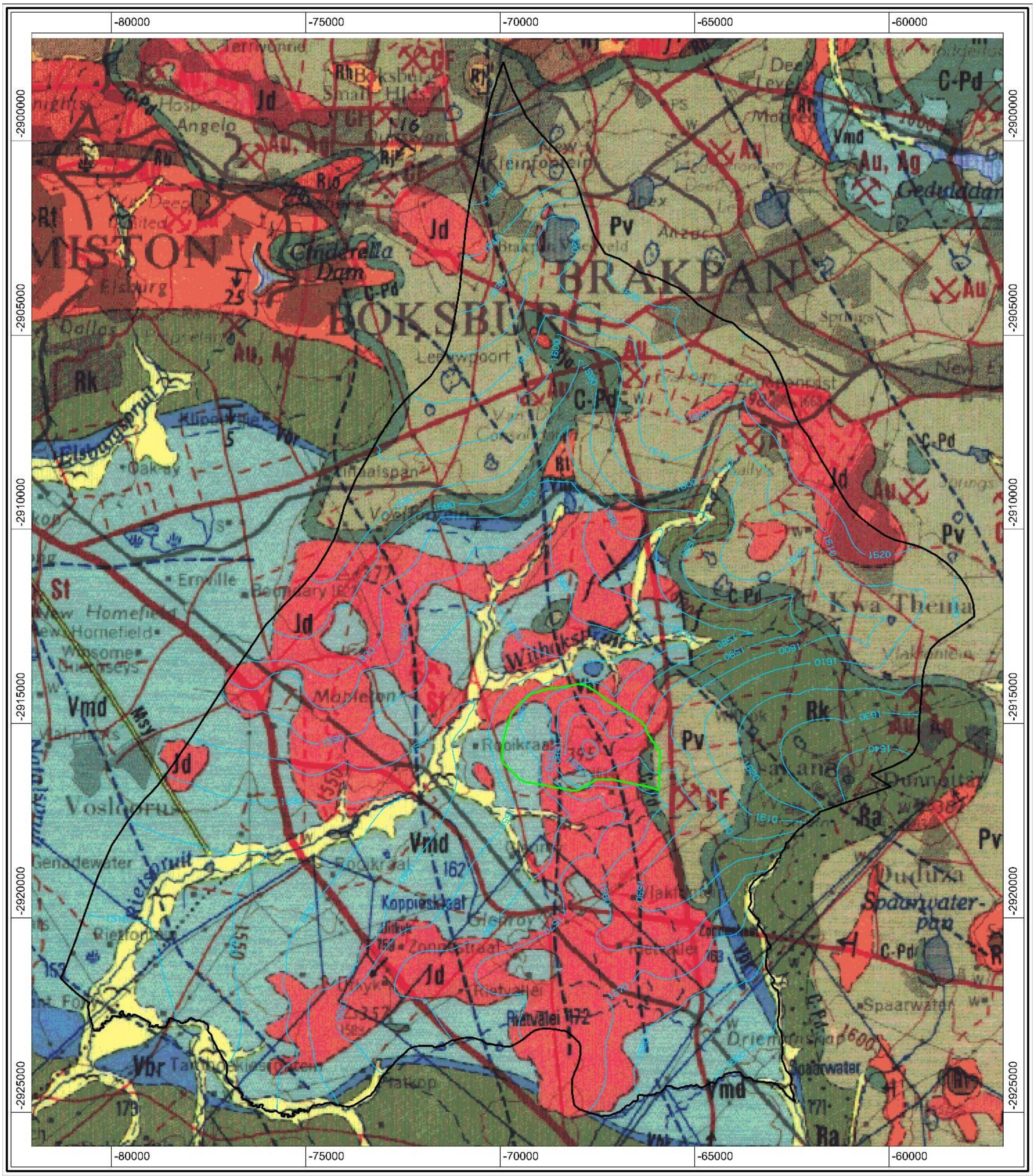

Figure 5.9: Interpolated shallow water table elevations for the model area.

5.5. POTENTIAL GROUNDWATER CONTAMINANTS

A recent (2019) water sample from the Brakpan TSF was collected by Kara Nawa Environmental Solutions. The sample was taken from the solution trench downstream of the TSF and represents flow towards the return water facility. The water sample had been exposed to the atmosphere for about 20 minutes and was well oxygenated due to turbulent flow. While other seepage might have mixed in the unlined trench, it is the nearest possible water sampling point representative of flow through the underflow section (outer wall of coarse fraction tailings) of the facility. The water sample was analysed by Waterlab (Pty) Ltd in November 2019. The results are presented in Table 5.7 and Table 5.8 and are compared to available standards, including the DWAF Class III Guidelines (1996), SANS (2015) Drinking Water Quality Standards, and DWS Groundwater quality limits (2017).

The following exceedances are noted for the highest indicated standard:

- pH (<5) all standards
- SO_4 (1000 mg/L), EC (520 mS/m) and TDS (3000 mg/L) of DWAF Class III
- NH_3 as N (1.5 mg/L) DWAF Class III and SANS (2015)
- Al (0.3 mg/L), Fe (2 mg/L) and Mn (0.4 mg/L) of SANS (2015)
- U (0.03 mg/L) and Pb (0.01 mg/L) for all standards
- Cl (300 mg/L) SANS (2015) and DWS Groundwater quality limits (2017)
- Co (0.5 mg/L) SANS 241 (2011) chronic health
- Cr (0.05 mg/L) and Ni (0.07 mg/L) WHO 2011 and SANS 241 (2011) chronic health
- Na (200 mg/L) SANS (2015) and DWS Groundwater quality limits (2017)
- Zn (0.5 mg/L) IFC Mining Effluent (2007)

Table 5.7: Water quality data (mg/L) of the Brakpan TSF drain flow - sampled in November 2019.

Name	SANS (2015)	DWAF Class III	DWS Groundwater quality limits (2017)	Brakpan Drain Flow
pH	5-9.7	6-9.0	5-9.7	3.5
EC (mS/m)	170	520	170	723
TDS	1200	3000	1200	9016
Total Alkalinity (CaCO3)				<5
Cl	300	1200	300	303
SO_4	500	1000	500	5526
NO_3 as N	11	40	11	<0.1
NH_3 as N	1.5	1.5		50
Al	0.3	0.15	0.003	106
As	0.01	0.01		< 0.010
B	2.4	WHO (2011)		0.324
Ba	0.7	WHO (2011)		< 0.010
Cd	0.003	WHO (2011) / SANS 241 (2011) – (Chronic Health)		< 0.010
Co	0.5	SANS 241 (2011) – (Chronic health)		1.25
Cr	0.05	WHO (2011) / SANS 241 (2011) – (Chronic Health)		0.065
Cu	2	1	2	0.058
Fe	2	0.1	0.3	920
Hg	0.006	0.01		< 0.010
Mg	500	DWAF TWQR Livestock Watering		402
Mn	0.4	0.05	0.1	39
Na	200	1000	200	282
Ni	0.07	WHO (2011) / SANS 241 (2011) – (Chronic Health)		2.75
Pb	0.01	0.01	0.01	0.021
U	0.03	0.03	0.03	4.31
Zn	0.5	IFC Mining Effluent (2007)		0.784

Table 5.8: Water quality of the Brakpan TSF drain flow sample collected in November 2019 for parameters without available standards.

Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)
Au	0.017	La	0.023
Be	0.016	Li	0.321
Ca	545	Nd	0.041
Ce	0.071	Sc	0.023
Dy	0.103	Si	32.0
Er	0.052	Sm	0.013
Gd	0.025	Sr	0.085
Hf	0.010	Ti	0.104
Ho	0.020	Y	0.020
K	50.0	Yb	0.031

5.6. GROUNDWATER QUALITY

5.6.1. Previous assessments

A previous assessment of the groundwater quality by iLEH in 2016 (Report No: iLEH-DRD WIT 04-16) considered the groundwater quality-monitoring database at the BTF and WTF up to 2007 compiled by Anglo American. This indicated the groundwater in the immediate vicinity of the TSF complex to be characterised by elevated sulphate and TDS concentrations influenced by seasonal fluctuations. The groundwater pH was observed to be neutral to alkaline in nature. In general, the sulphate concentration exceeded 1000 mg/L in both the shallow weathered and deeper fractured aquifers

- suggesting that the historical impact of the tailing deposits impacted the groundwater quality in both aquifers (refer to Appendix 4 of the iLEH report, 2016). A hydrocensus conducted by iLEH in 2016 showed that sulphate concentrations around the TSF complex varied between 2 and 2419 mg/L. Monitoring borehole B15, located 800 m northwest from the Brakpan TSF, showed the highest sulphate concentrations compared to other boreholes located closer to the TSF (B12, B7 and B8) suggesting potential contamination from the Ergo Process Plant and/or Benoni tailings dam upstream (iLEH, 2016).

5.6.2. Baseline groundwater quality

by the client, applying median concentrations calculated over the monitoring period from January 2018 to November 2023 (Table 5-9). The groundwater quality results were compared to available standards, including the SANS 241:2015 Drinking Water Quality Standards, IFC Mining Effluent guidelines (2007) and WUL groundwater quality limits (2017). Positions of the various monitoring boreholes are depicted in Figure 5.10.

Overall, several water quality guideline exceedances were noted for the median concentrations calculated from 2018 to 2023:

- The electrical conductivity (EC), total dissolved solids (TDS) and SO_4 exceeded both the SANS 241:2015 and WUL limits in most boreholes. Boreholes that are not influenced by seepage from TSFs, representing background groundwater qualities based on sulphate concentrations (<200 mg/L), include BW5 and BW7 - with concentrations ranging from 13 to 17 mg/L.
- The upper pH limit indicating an alkaline groundwater quality exceeded the IFC limit in BHBT9 and the SANS 241:2015 and WUL (2017) standards in borehole BW5.
- Chloride exceeded both the SANS 241:2015 and WUL (2017) standards in borehole BT8.
- Nitrite exceeded the SANS 241:2015 standard in boreholes WitBH2 and WitBH6.
- Ammonia was elevated in most boreholes (excluding WiTBH1, WiTBH3, and BW5) and exceeded the SANS 241:2015 standards.
- Cyanide exceeded the SANS 241:2015 standard in borehole B8.

- Aluminium exceeded the the SANS 241:2015 limit in borehole WitBH2 and most of the remaining borheoles exceeded the WUL (2017) limits for Al.
- Both SANS 241:2015 and WUL (2017) limits for Ca were exceeded in boreholes WiTBH6, BT10, BT11, BW3 and BW6.
- Both SANS 241:2015 and WUL (2017) limits for Cd were exceeded in boreholes BT8, B8, BW3 and BW6.
- The SANS 241:2015 limit for Co was exceeded in boreholes WitBH4.
- Iron exceeded the WUL (2017) limit in borehole BW3 and the SANS 241:2015 standard in borehole BW6.
- Magnesium concentrations exceeded both SANS 241:2015 and WUL (2017) limits in the majority of boreholes
- Manganese concentrations were exceeded for the WUL (2017) limits in boreholes BT9, BT10, B8, BW3 and BW5. The Mn limits of the SANS 241:2015 standards were exceeded in boreholes WitBH4, WitBH6, BT8, BT11, B15 and BW6.
- Sodium concentrations exceeded both SANS 241:2015 and WUL (2017) standards in boreholes WitBH6, BT8, and BW3.
- Nickel concentrations exceeded SANS 241:2015 and WUL (2017) standards in boreholes B8 and B15.
- Lead concentrations exceeded SANS 241:2015 and WUL (2017) standards in boreholes WitBH2, BT8, BT10, B8, B15, BW3 and BW6.
- Antimony exceeded the SANS 241:2015 standard in borehole WitBH6.
- Uranium concentrations exceeded SANS 241:2015 and WUL (2017) standards in borehole B15.

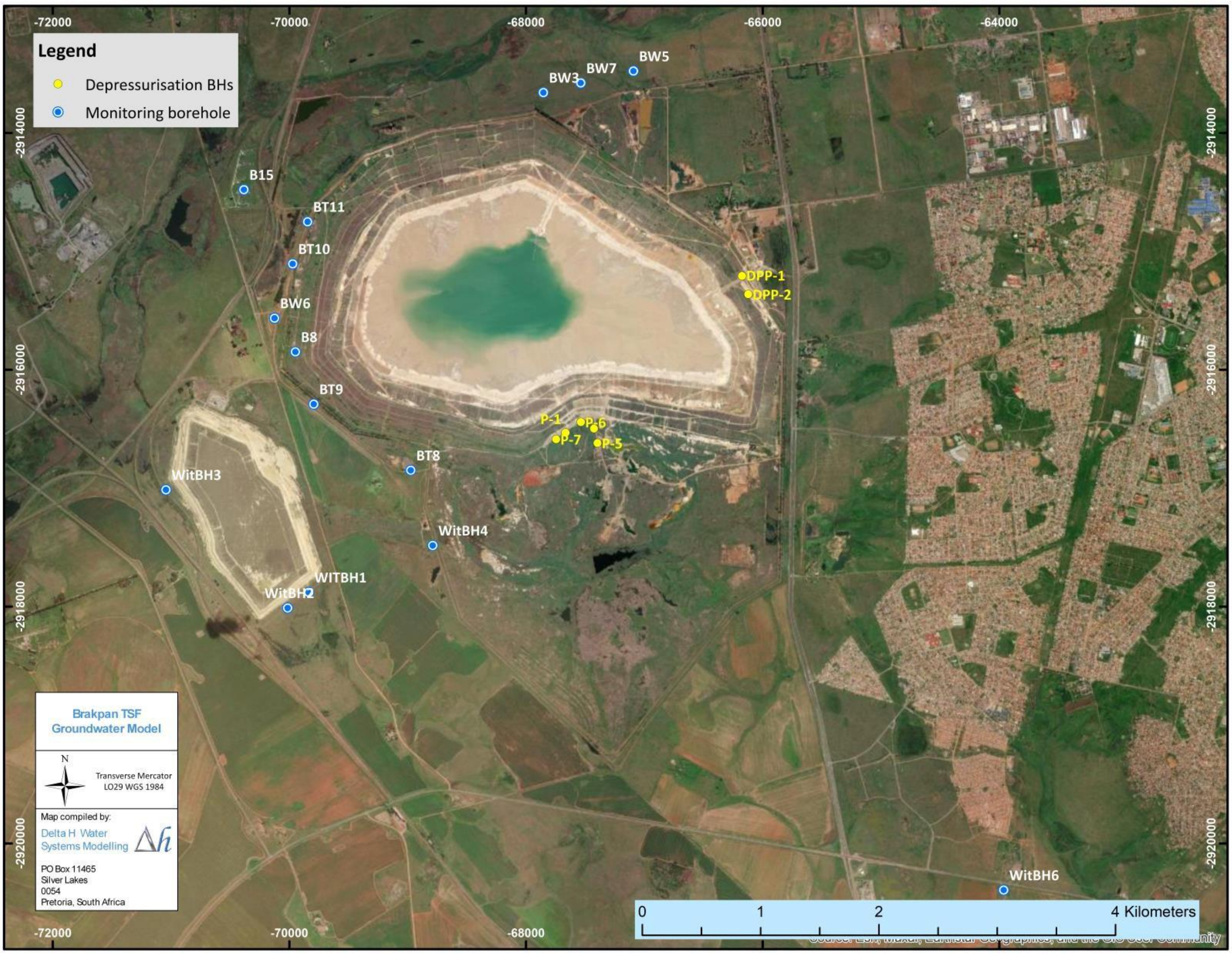

Figure 5.10: Locality map of current monitoring boreholes.

Table 5.9: Median groundwater quality of background boreholes monitored between 2018 to 2023 (in mg/L).

Name	SANS (2015)	IFC Mining effluent (2007)	WUL Groundwater quality limits (2017)	B2	B3	B4	B8	B9	B15	BT8	BT8 old	BT9	BT10	BT11	WITBH1	WITBH 2	WITBH 3	WITBH 4	WITBH 6	RKL02	Median
No. of samples				1	3	1	19	1	18	21	3	1	21	20	12	21	13	21	21	17	
pH	5-9.7	6-9.0	5-9.7	9.0	7.9	7.2	8.6	8.4	7.9	8.7	9.8	8.1	8.8	8.2	7.8	8.2	7.4	7.8	7.4	7.4	8
EC (mS/m)	170		170	396	315	178	304	117	120	384	512	125	272	125	102	75	54	57	530	301	178
TDS	1200		1200	3432	2914	1284	2508	602	883	2768	3742	744	2282	775	742	422	480	336	5158	2704	1284
Cl	300		300	347	206	112	191	180	84	349	778	175	254	184	83	43	10	52	281	186	184
SO_4	500		500	1892	1444	629	1471	20	403	1377	1731	3	1277	70	229	71	150	117	2890	1673	629
NO_3 as N	11		11	<0.1	0.400	4.000	0.150	<0.1	0.900	0.600	0.100	<0.1	0.100	0.100	0.400	0.200	3.250	0.250	0.650	0.450	0.400
NO2	0.9			<0.05	0.100	0.200	0.050	<0.05	0.200	0.900	<0.05	<0.05	0.060	0.250	0.080	0.400	0.060	0.100	1.400	0.050	0.100
NH_3 as N	1.5			1.7	22.0	11.0	11.0	7.6	2.9	11.0	3.7	12.0	3.7	6.5	0.2	26.0	0.2	6.0	30.0	4.0	6.50
PO_4 as P				<0.1	1.200	0.400	0.100	<0.1	0.250	0.100	<0.1	<0.1	0.100	0.100	0.100	2.500	0.100	0.700	0.400	0.600	0.250
Al	0.3		0.003	<0.100	0.116	<0.100	<0.100	<0.100	0.170	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	11.875	0.107	0.149	0.149
As	0.01	0.1		0.001	0.002	0.001	0.003	<0.001	0.009	0.002	<0.001	0.002	0.002	0.001	0.001	0.008	0.002	0.002	0.003	0.003	0.002
Ca	150		150	20	292	176	128	8	113	14	34	10	260	12	63	15	41	25	521	333	41.0
Cd	0.003	0.05	0.003	<0.003	0.004	<0.001	0.014	<0.003	0.003	0.006	<0.001	<0.003	0.003	0.003	<0.001	<0.001	<0.001	0.002	0.012	<0.001	0.004
Co	0.5			0.091	0.046	0.153	0.589	<0.025	0.066	0.069	0.047	<0.025	0.074	0.116	0.035	<0.025	0.025	3.720	0.203	0.336	0.082
Cr	0.05			<0.025	<0.010	<0.010	0.063	<0.025	0.012	0.044	<0.010	<0.025	0.051	0.020	<0.010	0.010	0.010	0.041	0.015	0.083	0.030
Cu	2	0.3	2	0.059	0.029	0.040	0.033	<0.010	0.019	0.034	0.062	<0.010	0.034	0.037	<0.010	0.013	<0.010	0.044	0.046	0.032	0.034
F	1.5		1.5	0.300	0.400	0.300	1.000	<0.2	0.500	0.300	<0.2	<0.2	0.200	0.250	0.400	0.300	0.300	0.200	0.300	0.300	0.300
Fe	2	2	0.3	<0.025	0.092	<0.025	0.224	<0.025	0.058	0.067	0.095	<0.025	0.056	0.044	0.029	0.044	<0.025	0.150	0.040	0.071	0.062
K	50			7.100	14.000	19.400	32.000	9.000	16.250	5.000	8.700	9.600	12.700	9.050	1.300	4.400	5.700	9.200	19.200	7.300	9.050
Mg	70		70	311	206	53	141	98	36	242	441	113	134	114	69	2	31	24	283	178	114
Mn	0.4		0.1	0.367	3.120	4.480	0.150	0.141	0.794	0.393	0.120	0.167	0.280	0.140	0.061	0.032	0.042	0.382	18.0	1.4	0.280
Na	200		200	485	187	134	344	58	98	514	1165	64	198	63	52	98	18	44	468	126	126
Ni	0.07	0.5	0.07	<0.025	0.161	0.266	0.058	<0.025	0.131	0.030	<0.025	<0.025	0.078	<0.025	<0.025	<0.025	<0.025	5.505	0.028	0.945	0.131
Pb	0.01	0.2	0.01	0.027	0.022	<0.001	0.019	<0.010	0.021	0.017	<0.001	<0.010	0.026	<0.001	<0.001	0.012	<0.001	0.002	0.020	0.042	0.021
Se	0.04			0.001	0.004	0.001	0.001	0.001	0.002	0.001	<0.001	0.005	0.001	0.002	0.001	0.002	0.001	0.002	0.003	0.002	0.001
U	0.03		0.03	<0.001	0.011	0.010	<0.001	<0.001	0.033	0.018	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.005	0.010	0.003	0.010
Zn	0.5	0.5	5	0.029	0.039	0.096	0.029	<0.025	0.035	0.030	0.025	<0.025	0.031	0.038	<0.025	<0.025	0.075	1.480	0.039	0.561	0.038

An assessment of the groundwater facies (or major ionic composition) of the various background boreholes obtained from a hydrocensus conducted by iLEH during 2016 showed that the water in monitoring borehole "B" and the "WITBH" series ranged from recently recharged groundwater dominated by Ca-Mg-HCO_3-SO_4 (B5), mixed groundwater types Mg-Na-Cl-HCO_3 (B32, WITBH03) and Na-HCO_3-SO_4 (WITBH02), to Mg-Ca-SO_4 (B28, B20, WITBH06) and Mg-Na-SO_4-Cl (B11, B12, B2) dominated facies (Figure 5.11). While the majority of monitoring boreholes (B28, B20, B15, B3, B31, B11, B12, B2, WITBH06 and WITBH04) seemed to be impacted by the emanating seepage plume from the Brakpan TSF (based on elevated sulphate concentrations dominating the water type), boreholes B5, B1 and B22 were dominated by Ca-Mg-HCO_3 and Mg-Na-HCO_3 facies indicative of unpolluted, recently recharged groundwater likely relating to the underlying dolomitic formations of the Transvaal Supergroup.

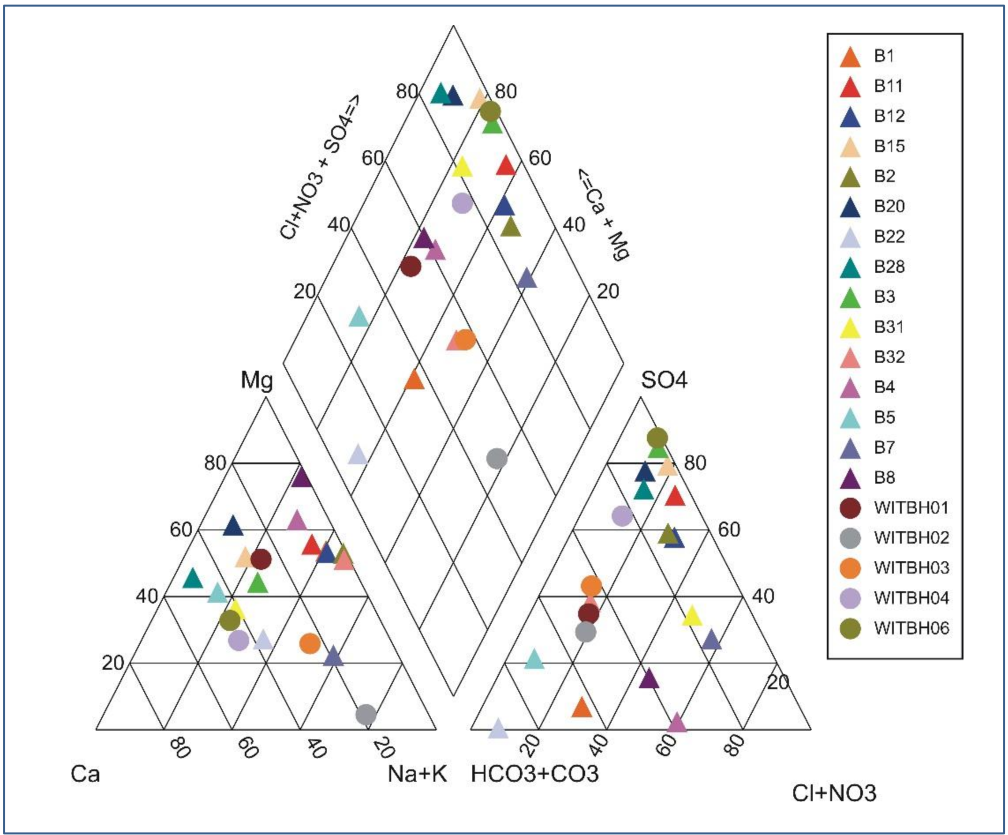

Figure 5.11: Piper diagram of the hydrocensus boreholes conducted by iLEH in 2016 (report No. iLEH-DRD WIT 04-16).

5.6.3. Seepage plume

The groundwater quality of nine (9) scavenger wells drilled within the plume emanating from the Brakpan TSF (Figure 5.12) was monitored by Water Hunters from January to March 2024 (Water Hunters, 2024, Technical Report, version 0.3). The groundwater quality data provided by Water Hunters was assessed against the SANS 241:2015 Drinking Water Standards, IFC Mining Effluent Guidelines (2007) and groundwater quality limits as stipulated in the water use licence (2017, licence no. 10/C22B/ACFGI/4976). Results indicated the following exceedances (Table 5.10):

- The pH limit of the WUL was exceeded in borehole Scav1.
- All nine boreholes exceeded the EC and TDS limits of the SANS 241:2015 drinking water standards and WUL limits.
- Chlorite limits of the SANS 241:2015 drinking water standards and WUL was exceeded in borehole Scav3.
- Sulphate concentrations exceeded the SANS 241:2015 drinking water standards and WUL limits in all boreholes.

- Free and saline ammonia exceeded the aesthetic limits of the SANS 241:2015 drinking water standards in boreholes Scav1, Scav5, Scav7, Scav8, Scav9, Scav11, and Scav12.
- Arsenic concentrations exceeded the IFC limit in borehole Scav1 and the SANS 241:2015 standard in borehole Scav7.
- All boreholes exceeded the calcium and magnesium limits stipulated in the SANS 241:2015 drinking water standards and WUL (2017).
- Cadmium exceeded the WUL and SANS 241:2015 limits in borehole Scav1.
- Copper exceeded the IFC standard in boreholes Scav1 and Scav7.
- Iron exceeded both the IFC and SANS 241:2015 standards in boreholes Scav1, Scav7, Scav9, Scav11, Scarv12 and Scav14. The more stringent WUL limit for iron was exceeded in boreholes Scav3, Scav5 and Scav8.
- Potassium exceeded the SANS 241:2015 limit in borehole Scav1.
- SANS 241:2015 drinking water standard for manganese was exceeded in boreholes Scav1, Scav5, Scav7, Scav8, Scav9, Scav11 and Scav12 and the WUL limit in borehole Scav14.
- Mercury exceeded the IFC standard in borehole Scav7.
- Sodium limits of the SANS 241:2015 drinking water standards and WUL (2017) were exceeded in boreholes Scav1, Scav5, Scav7, Scav8 and Scav11.
- Borehole Scav1 exceeded the IFC (2007) limit for nickel and boreholes Scav5, and Scav7 exceeded the WUL limit and SANS 241:2015 standard for nickel.
- Lead exceeded both the SANS 241:2015 standard and WUL limit in boreholes Scav1, Scav3, Scav7 and Scav8.
- Uranium exceeded both the SANS 241:2015 standard and WUL limit in borehole Scav1.
- Zinc exceeded both the SANS 241:2015 standard and WUL limit in boreholes Scav1 and Scav7.

Figure 5.12: Locality map of the scavenger borehole positions.

Table 5.10: Groundwater qualities obtained from nine scavenger boreholes in 2024 (Water Hunters, 2024) (in mg/L).

Name	SANS (2015)	IFC Mining effluent (2007)	WUL Groundwater quality limits (2017)	Scav1	Scav3	Scav5	Scav7	Scav8	Scav9	Scav11	Scav12	Scav14
pH	5-9.7	6-9.0	5-9.7	4.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
EC (mS/m)	170		170	519	427	436	390	442	349	484	327	184
TDS	1200		1200	4668	3634	3782	3820	4368	3362	4018	3116	1694
Total Alkalinity ($CaCO_3$)				<5	272	204	188	140	212	156	180	124
Cl	300		300	228	350	215	214	266	181	258	176	85
SO_4	500		500	2270	2340	2690	2270	2635	1787	3056	1842	814
NO_3 as N	11		11	<0.1	<0.1	0	<0.1	<0.1	<0.1	<0.1	<0.1	0
NO_2	0.9			<0.05	<0.05	<0.05	0	<0.05	<0.05	<0.05	<0.05	<0.05
NH_3 as N	1.5			113	0	11	13	20	9.9	35	15	1
Al	0.3		0.003	16.403	0.288	<0.1	<0.1	<0.1	0.359	<0.1	<0.1	<0.1
As	0.01	0.1		1.336	0.003	0.001	0.099	0.001	0.001	0.001	0.001	0.001
Ba	0.7			0.035	<0.025	0.027	<0.025	<0.025	0.042	<0.025	<0.025	<0.025
B	2.4			1.364	1.364	1.222	0.998	1.221	<0.025	0.836	0.771	0.198
Ca	150		150	449	519	518	428	501	430	576	338	209
Cd	0.003	0.05	0.003	0.009	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Cr	0.05			0.03	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Cu	2	0.3	2	0.452	0.013	0.037	0.478	<0.01	<0.01	<0.01	<0.01	<0.01
F	1.5		1.5	0	0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Fe	2	2	0.3	378.831	0.846	0.794	51.007	0.315	4.278	7.182	24.155	11.293
K	50			61	3	18	18	25	14	48	17	4
Mg	70		70	204	322	264	230	241	243	259	186	98
Mn	0.4		0.1	17.865	0.027	6.552	5.693	1.34	16.845	39.562	0.667	0.167
Hg	0.006	0.002		0.001	<0.001	0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Na	200		200	263	117	212	207	247	126	241	124	64
Ni	0.07	0.5	0.07	7.11	0.029	0.158	0.103	<0.025	<0.025	<0.025	<0.025	<0.025
Pb	0.01	0.2	0.01	0.058	0.018	0.003	0.029	0.012	<0.001	<0.001	<0.001	<0.001
Sb	0.02			<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001
Se	0.04			0.002	<0.001	0.001	<0.001	<0.001	0.006	<0.001	0.001	<0.001
Si as SiO_2				60	40	47	13	23	18	26	15	7
U	0.03		0.03	0.728	0.005	0.007	0.03	0.001	0.001	<0.001	<0.001	0.004
Zn	5	0.5	5	6.3	0	0	8.99	0	0	0	0	<0.025

The water composition of the scavenger wells was visualised with the aid of a Piper diagram (Figure 5.13). All nine scavenger wells indicated the same water type Ca-Mg-SO_4, whereby borehole Scav1 was relatively more enriched in sodium compared to the remaining boreholes. A Ca-Mg-SO_4 water type is typical for acid rock drainage, resulting in elevated sulphate concentrations due to the oxidation of sulphide-bearing minerals present in the waste material.

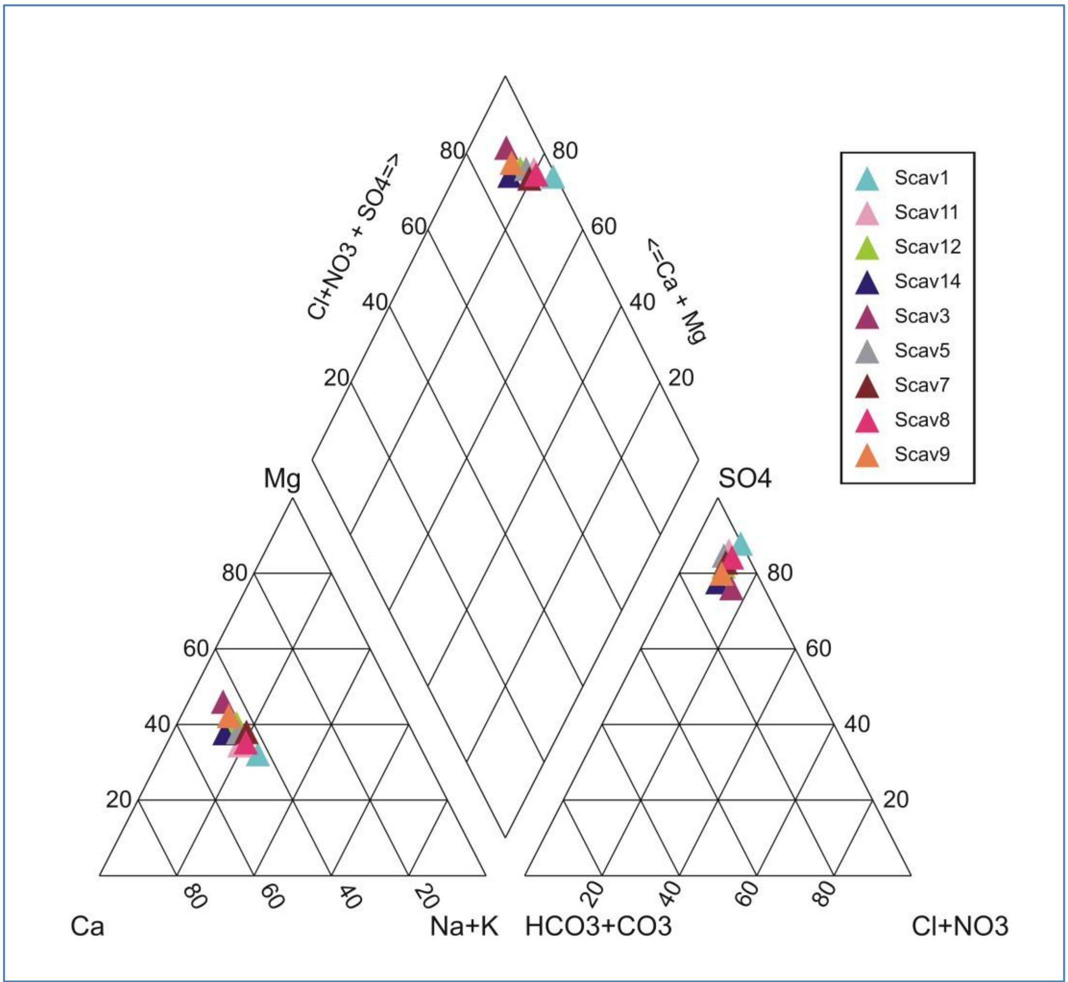

Figure 5.13: Piper diagram indicating the median water quality of the nine scavenger boreholes in the vicinity of the Brakpan TSF.

5.6.4. Depressurisation boreholes

Seven depressurisation boreholes were constructed by Water Hunters in February 2024 to increase the stability of the TSF wall. A hydrogeochemical analysis of the water quality (Table 5.11) indicated a similar water quality as for the monitored scavenger boreholes (Table 5.10) with sulphate concentrations ranging from 734 mg/L to 2910 mg/L, exceeding both the WUL (2017) and SANS 241:2015 limits. Other parameters including EC, TDS, Ca, Mg, and Na exceeded the WUL (2017) and SANS 241:2015 limits in most boreholes. Chloride, Fe and Mn concentrations were also elevated in boreholes P-1, P-6, P-7 and DPP-2. Ammonia concentrations were particularly high in borehole P-7 but also exceeded the SANS 241:2015 limits in boreholes P-1 and P-6.

Table 5.11: Groundwater quality of seven depressurisation boreholes in the vicinity of the TSF (in mg/L) (Water Hunters, February 2024).

Parameters	SANS (2015)	IFC Mining effluent (2007)	WUL Groundwater quality limits (2017)	DPP-1	P-4	P-1	P-5	P-6	P-7	DPP-2
pH	5-9.7	6-9.0	5-9.7	7	7.1	6.5	8.8	6.9	6.6	6.6
EC (mS/m)	170		170	462	360	658	193	605	648	630
TDS	1200		1200	3004	2342	4279	1256	3929	4211	4094
Al	0.3		0.003	<0.01	<0.01	0.02	<0.01	0.03	0.03	<0.01
As	0.01	0.1		<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Ca	150		150	516	295	616	74	553	626	641
Cu	2	0.3	2	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.01
Fe	2	2	0.3	0.07	0.29	20.45	<0.01	0.65	18.1	28.7
Mg	70		70	260	154	242	29	343	220	332
Mn	0.4		0.1	0.06	1.23	64.5	0.06	3.13	89.9	18.3
K	50			9	4	18	4	15	25	19
Na	200		200	38	270	367	265	248	382	217
Cl	300		300	200	134	372	105	320	393	366
F	1.5		1.5	<0.1	0.31	0.1	0.41	0.39	<0.1	0.12
Free & Saline Ammonia	1.5			<0.2	<0.2	2.47	0.96	1.92	13.3	0.31
NO_3 as N	11		11	0.3	0.5	<0.06	<0.06	4.6	<0.06	0.1
NO_2	0.9			0..01	0.01	0.02	0.01	0.15	0.01	0.02
Si				16.0	6.1	5.9	1.3	1.8	6.6	19.5
Ortho Phosphate as P				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
SO_4	500		500	1864	1480	2742	734	2691	2910	2860
Cr	0.05			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

6. AQUIFER CHARACTERISATION

6.1. GROUNDWATER VULNERABILITY

Groundwater vulnerability gives an indication of how susceptible an aquifer is to contamination. Aquifer vulnerability is used to represent the intrinsic characteristics that determine the sensitivity of various parts of an aquifer to being adversely affected by a contaminant load imposed from surface. Figure 6.1 shows the national groundwater vulnerability ratings underlying the project area, indicating the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. The method is based on the DRASTIC method, which includes the following parameters: **D**epth to water table; **R**echarge (net); **A**quifer media; **S**oil media; **T**opography; **I**mpact of the vadose (unsaturated) zone; and **C**onductivity (hydraulic). Based on the national results, the aquifer underlying the project area has a medium vulnerability rating, while the area towards the south has a high vulnerability rating.

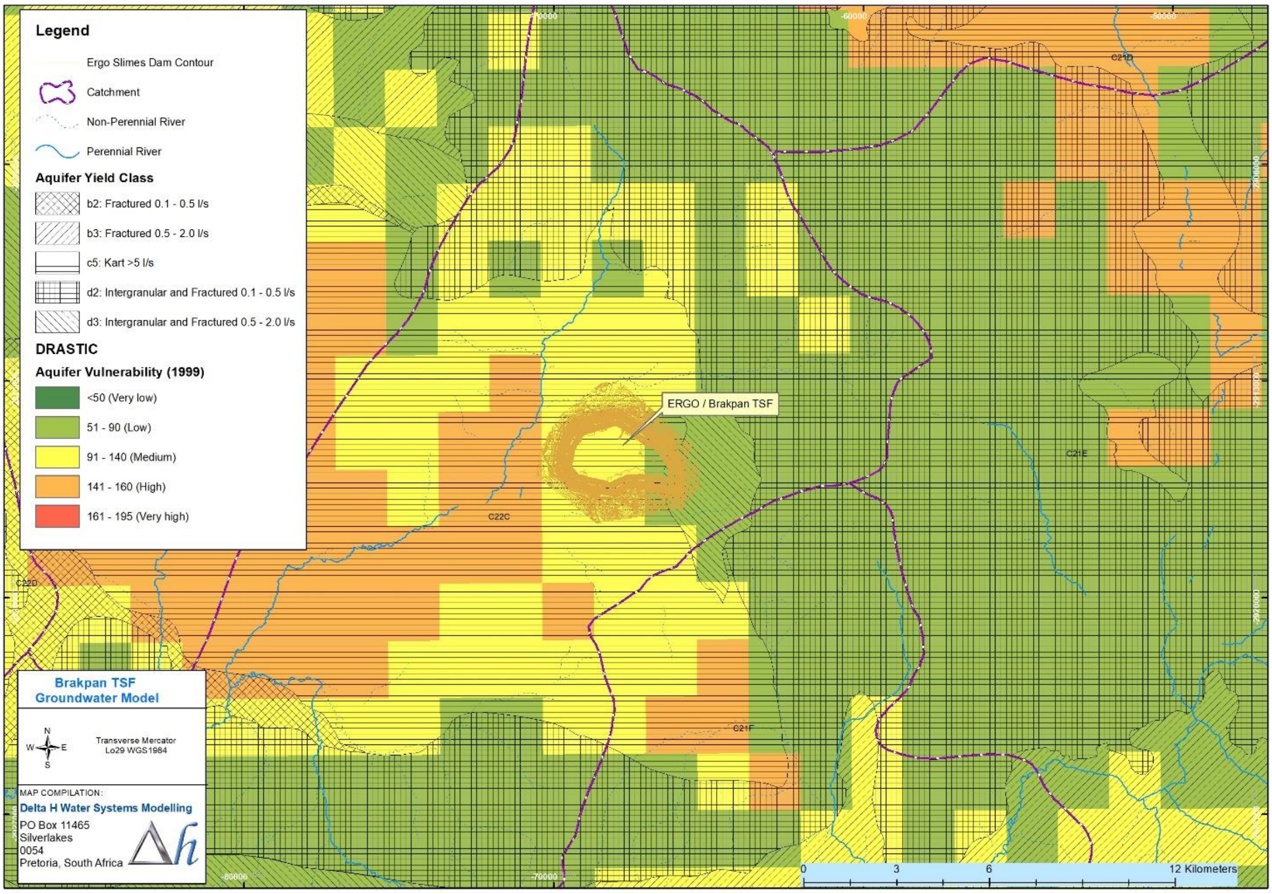

Figure 6.1: Groundwater vulnerability map for the project area.

The compilation of a groundwater vulnerability map, relying on the intrinsic natural properties of an area and aquifer, may not, however, be very meaningful in the context of this historically undermined project area. The natural aquifer properties in the project area have been extensively altered by open underground mine voids, land subsidence due to shallow undermining, neighbouring mining activities, mine residue deposits and acid rock drainage. The maps should therefore only be seen in regional context.

6.2. AQUIFER CLASSIFICATION

According to the Hydrogeological Map (1:500 000) series, the regional hydrogeology is characterized as a 'Karst aquifer' with a typical potential water yield of more than 5.0 litres per second. Chemical weathering of karstic aquifers, such as the dolomites from the Malmani Group forming part of the Transvaal Supergroup, results in voids providing primary storage capacity with high transmissivity values, and with a micro-fractured matrix providing secondary storage capacity with limited groundwater movement. Secondary features such as fractures / faults and bedding planes further enhance the groundwater flow. Based on the aquifer classification map (Parsons and Conrad, 1998), the aquifer system underlying the project area is regarded a "major aquifer" (Table 6.2).

A summary of the classification scheme is provided in Table 6.1. In this classification system, it is important to note that the concepts of Minor and Poor Aquifers are relative, and that yield is not quantified. Within any specific area, all classes of aquifer are therefore likely, in theory, to be present.

Table 6.1: Aquifer classification scheme after Parsons and Conrad (1998).

Aquifer	Description
Sole source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources, should this aquifer be impacted upon or depleted.
Major aquifer region	High-yielding aquifer of acceptable quality water.
Minor aquifer region	Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor quality water.
Poor aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer that will never be utilised for water supply and that will not contaminate other aquifers.
Special aquifer region	An aquifer designated as such by the Minister of Water

6.3. AQUIFER PROTECTION CLASSIFICATION

A Groundwater Quality Management (GQM) Index is used, as part of the aquifer classification, to define the level of groundwater protection required (Parsons 1995). The point scoring system and resultant classification of the site-specific project area are presented in Table 6.2.

Table 6.2: Groundwater Quality Management (GQM) Classification System.

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

The recommended level of groundwater protection based on the Groundwater Quality Management Classification is calculated as follows: GQM Index = Aquifer System Management x Aquifer Vulnerability = 4 x 2 = 8

A Groundwater Quality Management Index of 8 was estimated for the project area from the ratings for the Aquifer System Management Classification (Table 6.3). This level requires a high level of groundwater protection for the karst aquifer. Reasonable groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term. DWS's water quality management objectives are to protect human health and the environment and the significance of this aquifer classification is that if any potential risk exists, measures must be taken to limit the risk to the environment. In this case this means the protection of the underlying aquifer.

Table 6.3: GQM index for the project area.

Groundwater Quality Management Index	**Level of Protection**	**Project area**
<1 1 - 3 3 - 6 6 - 10 >10	Limited Low Level Medium Level High Level Strictly Non-Degradation	**8**

7. GROUNDWATER MODELLING

7.1. Software model choice

The software code chosen for the numerical finite-element modelling work was the 3D groundwater flow model SPRING, developed by the delta h Ingenieurgesellschaft mbH, Germany (König, 2011). The program, formerly known as SICK 100, was first published in 1970, and since then has undergone several revisions. The current saturated and unsaturated program module SPRING-SITRA is based on the well-known SUTRA model (Voss, 1984). SPRING is widely accepted by environmental scientists and associated professionals. SPRING uses the finite-element approximation to solve the groundwater flow equation. This means that the model area or domain is represented by a number of nodes and elements. Hydraulic properties are assigned to these nodes and elements, and an equation is developed for each node, based on the surrounding nodes. A series of iterations are then run to solve the resulting matrix problem utilising a pre-conditioning conjugate gradient (PCG) matrix solver for the current model. The model is said to have "converged" when errors reduce to within an acceptable range. SPRING is able to simulate steady and non-steady flow in aquifers of irregular dimensions.

SPRING solves the stationary flow equation independent of the density for variable saturated media as a function of the pressure according to:

$$-\nabla\left(K_{ij}\nabla h\right) = -\nabla\left(K_{perm}\frac{\rho g}{\mu}\nabla h\right) = q = -\nabla\left[\frac{K_{perm}\cdot k_{rel}}{\mu}(\rho g\nabla z + \nabla p)\right]$$

∇ $\left(\frac{\partial}{\partial x},\frac{\partial}{\partial y},\frac{\partial}{\partial z}\right)$

q Darcy flow
K_{ij} Hydraulic conductivity tensor
ρg Density $\cdot$ gravity
K_{perm} Permeability
μ Dynamic viscosity
k_{rel} Relative permeability
p Pressure

The relative hydraulic conductivity is hereby calculated as a function of water saturation, which in turn is a function of the saturation:

$$k_{rel}(S_r) = (S_e)^l\left[1-\left(1-(S_e)^{\frac{1}{m}}\right)^m\right]^2$$

$$S_e = \frac{S_r(p)-S_{res}}{S_s-S_{res}} = \left[1+\left(\frac{p_c}{p_e}\right)^n\right]^{\frac{1-n}{n}}$$

$S_r(p)$ Relative saturation dependent on pressure
S_e Effective saturation
l Unknown parameter, determined by van Genuchten to 0.5
m equal to $1-(1/n)$
n Pore size index
S_{res} Residual saturation
S_s Maximum saturation
p_c Capillary pressure
p_e Water entry pressure

Solving these equations for the relative saturation as a function of the capillary pressure $S_r(p_c)$ results in the capillary pressure- saturation function according to the Van Genuchten (1980) model as used in SPRING:

$$S_r(p_c) = S_{res} + (S_s - S_{res}) \cdot \left[1 + \left(\frac{p_c}{p_e}\right)^n\right]^{\frac{1-n}{n}}$$

The water entry pressure is a soil specific parameter and defined as the inverse of a = $1/p_e$ in the saturation parameters.

The density independent in-stationary flow equation for variable saturated media as a function of the capillary pressure is given as follows:

$$\rho\left(S_r(p_c)S_{sp} + \theta\frac{\partial S_r(p_c)}{\partial p}\right)\frac{\partial p}{\partial t} + \theta S_r(p_c)\frac{\partial \rho}{\partial t} - \nabla\left[\rho\frac{K_{perm}k_{rel}}{\mu}(\nabla p + \rho g \nabla z)\right] = q$$

The specific pressure dependent storage coefficient S_{sp} is hereby given as

$$S_{sp} = \alpha(1-\theta) + \beta\theta$$

α Compressibility of porous media matrix
β Compressibility of fluid (water)
θ Aquifer porosity

The transport equation for a solute in variably saturated aquifers is given as follows:

$$\theta S_r(p_c)\frac{\partial c}{\partial t} + \theta S_r(p_c)v\nabla c - \nabla\big(\theta S_r(p_c)\big(D_m\bar{\bar{1}} + D_d\big)\nabla c\big) = qc^* + R_i$$

qc^* Volumetric source/sink term with concentration c ∗
D_m Molecular diffusion
$\bar{\bar{1}}$ Unit matrix
D_d Hydrodynamic dispersion
R_i Reactive transport processes (sorption, decay, etc.)

The software derives quantitative results for groundwater flow and transport problems in the saturated and unsaturated zones of an aquifer.

7.2. MODEL SET-UP AND BOUNDARIES

The finite-element model was set-up as a three-dimensional groundwater model. The model domain covers a surface area of 319.46 km^2 and covers most of the quaternary catchment C22C as well as the northern part of catchment C21F. The eastern and north-western model boundaries follow topographical highs along quaternary catchment boundaries, while the south-western and southern boundaries follow drainage courses along a tributary to the Rietspruit and the Blesbokspruit respectively (with a small section along a topographic high closing the boundary between the two streams Figure 7.1). The chosen boundaries ensure a dependable water balance for the model domain, with rainfall recharge (and seepage) being the main driver of groundwater flow.

7.3. GEOMETRIC STRUCTURE OF THE MODEL

The model was spatially discretised into 119 547 nodes on 6 node layers, which make up 5 element layers with 129 566 elements (triangles and quadrangles) each - a total of 647 830 elements. The horizontal element size (side length) varies from a minimum of 20 m around the TSF to a maximum of 50 metres (Figure 7.1) further away from the area of interest and expected steep concentration gradients. The spatially variable discretisation of the finite-element model domain ensures an accurate incorporation of the TSF site layout, geology, and surface water features (rivers) within the regional groundwater model domain.

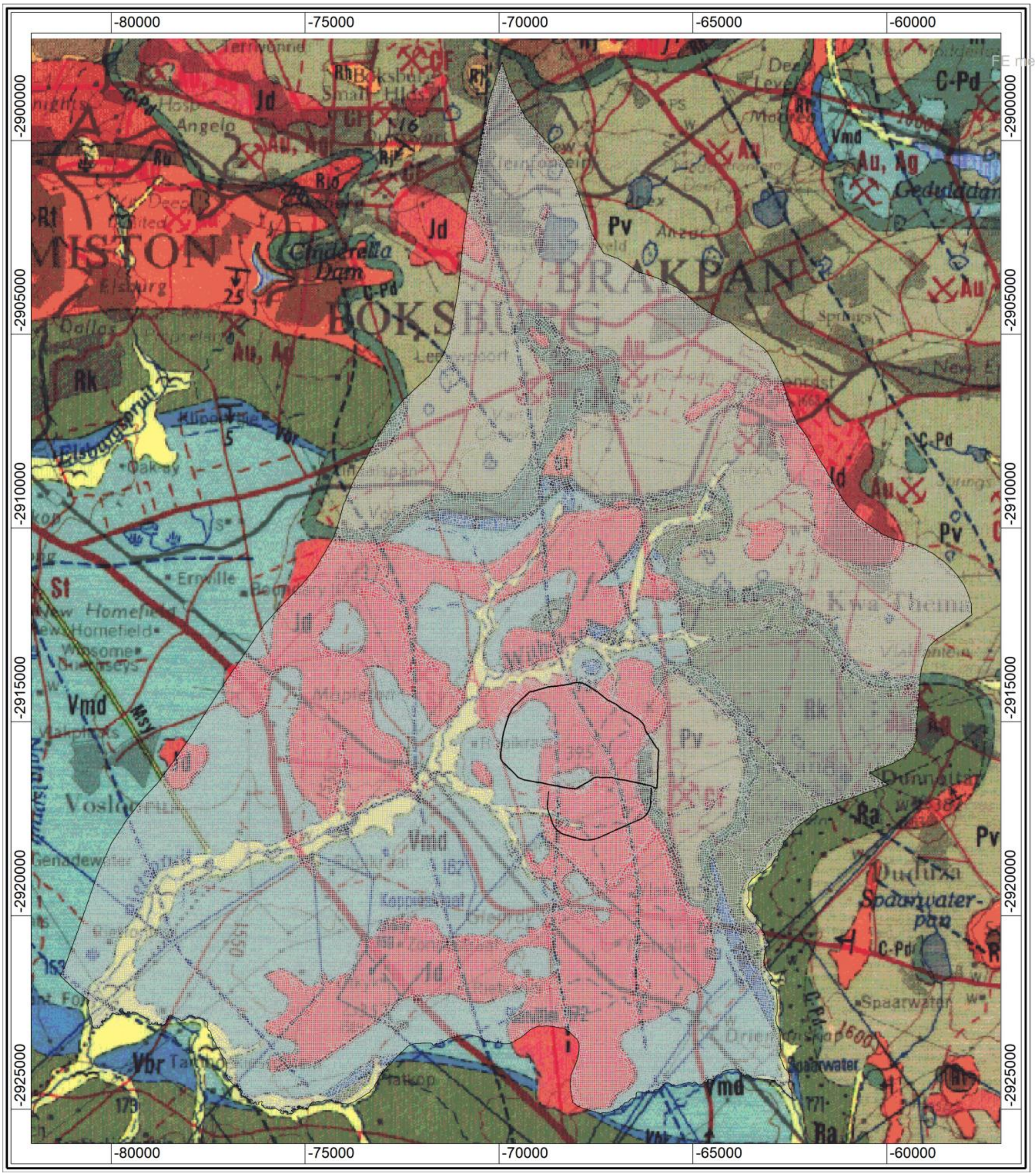

Figure 7.1: Finite element mesh of the Brakpan-Withok TSF complex groundwater model.

Element layer I, representing the soil horizon, was regionally off-set by 3 metres from surface topography, while element layer II and III, representing the weathered zone, was regionally off-set by 10 metres. The lower model layers IV to V represent the fractured aquifer up to a depth of 90 m below ground level and were split into 3 element layers, ensuring numerically stable and accurate unsaturated flow as well as transport simulations. The final depth of the model thus reaches 90m below ground elevation. Note that the final modelled depth does not suggest the general absence of groundwater flow at greater depth, especially for the dolomite aquifer, but does assume a limited contribution therefrom in the context of the study.

7.4. GROUNDWATER SOURCES AND SINKS

The main groundwater sources in the wider area of interest are

- direct rainfall recharge of the shallow primary aquifers with vertical leakage to the fractured aquifer,
- seepage from the TSF,
- potential leakage from surface water courses, and
- regional groundwater inflow.

The main groundwater sinks in the wider area of interest are

- groundwater seepage towards surface waters,
- groundwater abstractions for the dewatering of underground mines (no data available and therefore not considered),
- groundwater abstractions for potable water supply, livestock watering, or irrigation (no data available),
- regional groundwater outflow.

7.4.1. Groundwater Recharge

The main source of recharge into the shallow primary aquifers is direct rainfall recharge that infiltrates the aquifer through the overlying unsaturated zone. Recharge of the deeper fractured or karst aquifers is limited to vertical seepage from the shallow aquifer through permeable fracture systems or dissolution channels that link the two aquifers hydraulically. Due to the heterogeneous nature of systems, the hydraulic interaction is highly variable.

The seepage/recharge rate for the Brakpan and future lined Withok TSF footprints were determined using a three-dimensional seepage model (Delta H, 2024). Post closure seepage rates for the Brakpan TSF were estimated to decrease to 133 mm/a 10 years post closure and to 80 mm/a 50 years post closure, while the minimal seepage rates for the (class C) lined Withok TSF remain essentially unchanged at around 2 mm/a.

Table 7.1: Estimated recharge rates.

Unit	Life of Mine		Post-closure	
	(% of MAP)	(mm/a)	(% of MAP)	(mm/a)
Weathered Aquifer and Alluvium	6%	38	6%	38
Brakpan TSF Seepage	26%	187	20 – 11%	133 - 75
Brakpan RWD	12%	80	12%	80
Withok TSF Seepage	0.03%	2	0.03%	2

The groundwater recharge and seepage rates (Table 7.1) were assigned to the top layer of the TSF groundwater model as aerial seepage rates (2^{nd} type/Neumann or specified flux boundary condition). The recharge rates were considered fixed for the calibration of the model to arrive at a potential unique solution.

7.4.2. Groundwater Abstractions

No regional groundwater abstraction rates were available to the project team and therefore not considered in the groundwater model. While private groundwater abstractions within the larger model domain might impact the local groundwater levels around these wells or boreholes, no impact on the predicted pollution plume emanating from the TSFs are expected due to their distance.

The hydraulic containment system, i.e. the scavenger boreholes became operational in 2019 (Water Hunters 2024) and were incorporated into the model as 2^{nd} type/Neumann or specified flux (abstraction) boundary conditions on node layer 5 with the average rates given in Table 7.2. An unknown but equal head was assigned to the node layer 2 to 4 above each abstraction point to simulate the screened abstraction boreholes.

Table 7.2: Average (2019 – 2023) abstraction rates of the scavenger boreholes (Water Hunters 2024).

ID	X-Coord	Y-Coord	Q (m^3/a)
Scav1	-67789.1	-2913645	-18185.4
Scav3	-68371	-2913714	-25554.2
Scav5	-69540.1	-2914389	-38208.8
Scav7	-69965.2	-2915166	-32658.6
Scav8	-69985.8	-2915254	-21352.6
Scav9	-70003.1	-2916062	-14633.6
Scav11	-70092.4	-2915742	-7060.4
Scav12	-70085.6	-2915530	-5361.6
Scav13	-70018.6	-2915375	-2239.4
Scav 14	-67607.6	-2913492	-4704.4

7.4.3. Surface waters

Depending on the prevailing gradient between groundwater in a shallow aquifer and the surface water level in a river, groundwater might discharge into surface waters or vice versa. In this case the groundwater contribution to surface water baseflow was estimated in GRA II (DWAF, 2006) to range from 6.1 to 12.9 mm/a for quaternary catchment C22C (based on the applied model). The positive groundwater contributions to baseflow for the catchment indicates the general prevalence of gaining rivers, i.e. that groundwater is likely to discharge into surface waters and contribute to their discharges.

All surface water drainages were therefore classified as continuously gaining river courses. A river or 3rd type (Cauchy) boundary condition was assigned to the streams and river courses within the model domain whereby the leakage of groundwater into the river (or vice versa) depends on the prevailing gradient. Based on estimated baseflow rates for the catchments of interest, the streams/rivers were generally classified as potentially gaining streams/rivers and no exfiltration of surface water into the aquifer allowed. The chosen approach ensures no water losses from rivers into the model domain, while simulating potential leakage of groundwater into surface water courses (groundwater baseflow) as suggested by GRA II (Table 2.1). The streams act, therefore, only as groundwater sinks. The stage of each river node was carefully aligned with the height of the Digital Elevation Model (DEM) at that point and an incision for the hydraulically active river bottom of 5 m below topography was assumed. In the absence of site-specific data, a riverbed conductance of 1E-6 m/s was assumed for all river courses.

7.4.4. Regional Groundwater Flow

Due to the lack of data, deeper (below 60 mbgl) regional groundwater flow systems were neglected in the model. This contributes potentially to errors associated with the model calibration and predictions, but these are considered acceptable in the context of the model application. The errors affect predominantly the water balances, as water which would have otherwise left the model domain as deeper regional groundwater flow reports now to surface water courses, leading to an overestimation of groundwater baseflow, especially at the model boundaries. However, associated errors are considered negligible for the purpose of the study, as contaminant transport from the TSF occurs predominantly in the shallow weathered and uppermost parts of the fractured aquifer, with negligible groundwater flow and transport beyond these hydraulically active aquifer zones.

7.5. NUMERICAL MODEL

7.5.1. Numerical Parameters

SPRING uses an efficient preconditioned conjugate gradient (PCG) solver for the iterative solution of the flow and transport equation. The closure criterion for the solver, i.e. the convergence limit of the iteration process was set at a residual below 1e-06. The Picard iteration, used for the iterative computation of the relative permeability for each element as a function of the relative saturation and capillary pressure, used a damping factor of 0.5 and was limited to 8 iterations. The relative difference between the two computed potential heads (saturated zone) and capillary pressures (unsaturated zone) after seven iterations was generally below an acceptable 0.05 m and 0.1 m respectively.

7.5.2. Initial and Assigned Conditions

The initial conditions specified in the steady state flow model were as follows:

- Starting heads as shown in Figure 5.9.
- Horizontal hydraulic conductivities as given in Table 5.5.
- Vertical hydraulic conductivities were set at 10% of the horizontal conductivities.
- Effective porosity values were specified as 15% for the soil, 10% for the weathered aquifer, and 5% for the fractured aquifer.

7.5.3. Selection of Calibration Targets and Goals

A total of 184 groundwater levels (Table 7.3) obtained variously from the newly drilled boreholes, ongoing site monitoring, the 2015 hydrocensus by iLEH (2016), and from the National Groundwater Archive NGA within the wider area of interest (mostly dating before 1998) were used as calibration targets for the model. More emphasis was obviously placed on fitting the recent water levels monitored within the TSF area. The groundwater levels as measured in metres below ground level (mbgl) were converted within the model using the assigned digital elevation model into metres above mean sea level (mamsl) to ensure alignment with the model elevation.

Table 7.3: Groundwater levels used for the steady-state calibration of the TSF Groundwater Model.

X	Y	Wl (mamsl)	X	Y	Wl (mamsl)	X	Y	Wl (mamsl)
-66074	-2916779	1578.68	-62771.1	-2911547	1595.872	-75855.7	-2917711	1524.896
-65700	-2917161	1577.29	-62431.6	-2911947	1590.239	-75912.5	-2917557	1524.52
-66284	-2917339	1578.68	-63130.3	-2912009	1584.066	-76169.7	-2916266	1534.801
-69842	-2916299	1553.04	-63379.2	-2911950	1595.811	-76103.1	-2913341	1570.953
-69958.7	-2916230	1552.142	-69177.6	-2922259	1572.497	-72430.7	-2910489	1582.093
-69998	-2915048	1553.336	-69293.8	-2921244	1580.599	-76024.4	-2917373	1523.439
-69959	-2914926	1553.65	-70632.9	-2909402	1588.557	-76366.3	-2915775	1536.306
-69965.2	-2915166	1555.766	-70445.2	-2908292	1596.143	-76478.6	-2915529	1538.809
-62655	-2908430	1621.874	-71012.8	-2911158	1558.046	-76603.8	-2917807	1523.512
-62721	-2908255	1616.974	-71039.3	-2911250	1556.19	-77072.9	-2918149	1522.153
-62618	-2908648	1624.424	-62759	-2907971	1622.334	-66608.5	-2909842	1588.661
-66694.1	-2914736	1580.923	-63041	-2907694	1617.707	-72298.7	-2909258	1576.637
-66603	-2910920	1572.736	-70374	-2913887	1543.369	-66547	-2918387	1575.56
-70003.1	-2916062	1552.353	-71042	-2917013	1548.087	-64514.1	-2912447	1584.197
-70003.1	-2916062	1552.353	-70429	-2914729	1546.594	-70726.7	-2917619	1542.55
-70093	-2916079	1553.669	-69994	-2914692	1549.911	-69678	-2917151	1551.763
-69485.5	-2921614	1568.929	-70018.7	-2915375	1554.638	-69468	-2917128	1551.93
-64281.5	-2910239	1594.327	-70276	-2915404	1552.21	-69836	-2917879	1551.43
-66874	-2911998	1565.422	-69680	-2913041	1542.91	-70014	-2918011	1553.84
-66990	-2914391	1573.173	-68158.1	-2910497	1566.365	-65998	-2917328	1580.73
-66989.8	-2914391	1573.173	-68188.5	-2910035	1568.754	-65569.3	-2923102	1554.226
-69940.4	-2914873	1555.276	-69540.1	-2914389	1560.537	-65252	-2920145	1580.504
-69885.7	-2914925	1555.63	-70085.6	-2915531	1553.374	-65290.4	-2923592	1551.843
-68371	-2913714	1557.345	-68782.9	-2913780	1560.749	-65067.8	-2923622	1551.451
-67428.6	-2914122	1568.92	-67768.6	-2913921	1568.153	-64955.9	-2923837	1551.069
-68085.5	-2913850	1557.719	-67148.6	-2914267	1570.184	-63962	-2920393	1560.9
-68372	-2913931	1563.04	-67789.1	-2913645	1566.113	-63584.1	-2921029	1569.788
-69985.8	-2915254	1555.355	-66342.6	-2914863	1585.162	-63863.9	-2920538	1569.928
-69583.7	-2914642	1555.901	-67607.6	-2913492	1563.893	-63809	-2920538	1568.387
-69344	-2914114	1563.07	-66587.1	-2913998	1575.703	-63692.9	-2921615	1561.967
-67295.8	-2914424	1579.175	-62783.8	-2914685	1620.297	-69195.3	-2918966	1558.964
-68970	-2916849	1555.23	-74483.6	-2915241	1555.177	-72805.4	-2917878	1530.899

X	Y	Wl (mamsl)	X	Y	Wl (mamsl)	X	Y	Wl (mamsl)
-68996.9	-2916882	1556.365	-74621.6	-2915365	1555.154	-75794.7	-2918756	1524.998
-69094.7	-2916873	1555.299	-74651	-2915119	1554.728	-75905.5	-2918757	1525.094
-69471	-2916563	1556.94	-74569.9	-2914810	1558.727	-76424.8	-2924577	1526.71
-64455.7	-2924111	1547.061	-74432.6	-2914564	1560.585	-76621.7	-2924178	1526.347
-65786	-2913386	1575.865	-74098.9	-2914592	1560.427	-73241.8	-2923974	1549.166
-66743.4	-2910613	1575.858	-68861.6	-2919025	1563.02	-72663.2	-2918492	1535.422
-75853.4	-2922851	1530.287	-74609.7	-2917426	1527.415	-66338	-2918209	1584.463
-75238.5	-2923739	1535.758	-74931.2	-2914658	1554.899	-69811.5	-2914712	1558.947
-66239.6	-2922150	1559.296	-74211.8	-2914407	1565.011	-70092.4	-2915742	1554.252
-66017.4	-2922303	1560.165	-74749.3	-2917273	1525.091	-68587	-2922370	1580
-66391.7	-2919566	1590.97	-74806.6	-2917028	1534.483	-73211.6	-2908739	1592.99
-66662	-2917821	1582.344	-74834.5	-2916874	1537.361	-64302	-2921741	1561.784
-77898.6	-2919262	1518.246	-75146.9	-2915676	1552.216	-64247.8	-2921402	1561.089
-74326	-2923334	1537.878	-74969.5	-2917520	1527.502	-64490.8	-2922695	1555.205
-71611.6	-2913039	1559.118	-75112	-2916875	1536.698	-64546	-2922820	1554.522
-65786.1	-2924211	1558.619	-68770	-2917479	1557.75	-74573.2	-2918903	1528.731
-65508.6	-2924240	1555.512	-75221	-2917184	1531.56	-76706.9	-2919101	1522.72
-65065.1	-2924145	1550.416	-75591.8	-2915401	1546.984	-63995.9	-2921893	1558.349
-67845.3	-2922498	1572.17	-75705.8	-2915032	1550.835	-64381.9	-2922326	1555.302
-68207.1	-2922008	1574.873	-75681.3	-2914447	1554.168	-73031.2	-2921881	1561.802
-68541.7	-2921947	1575.979	-75816.6	-2915033	1549.089	-78935.8	-2921822	1508.562
-68354	-2918308	1565.74	-75333.8	-2916846	1538.762	-76455.7	-2919376	1521.09
-70257	-2923107	1566.329	-75785.6	-2915555	1537.483	-67772	-2917241	1560.62
-77044.1	-2922950	1518.721	-75806.8	-2916694	1535.799	-67772	-2917226	1559.09
-77016.8	-2923011	1518.426	-75863	-2916480	1535.313	-75361.6	-2912076	1593.929
-74091.1	-2911269	1589.274	-74633.7	-2913272	1578.236	-71064.6	-2906635	1606.108
-71305.8	-2913253	1539.739	-75978.9	-2913919	1560.799	-72168.5	-2907718	1591.994
-71645.5	-2911962	1552.23	-75608.2	-2917370	1526.354	-63277.2	-2921552	1557.514
-62428.9	-2910865	1597.018	-75978.3	-2915710	1537.445			
-62750.8	-2910161	1608.483	-75774	-2917525	1523.957			

Furthermore, the median 2023 to January 2024 sulphate concentrations from the site monitoring programme as well as the newly drilled scavenger boreholes, were used as calibration targets for the transport model (Table 7.4).

Table 7.4: Sulphate concentrations used for the calibration of the TSF Groundwater Transport Model.

ID	X-Coord	Y-Coord	2023/24 Median SO_4 (mg/L)
WITBH2	-68354	-2918308	
WITBH4	-68770	-2917479	163
WITBH6	-68372	-2913931	2839
B2-BT8	-68970	-2916849	2236
B7-BT10	-69998	-2915048	360
B8	-69959	-2914926	823
B15	-70374	-2913887	553
B23-BT6	-67090	-2913681	2155
BT9	-69794	-2916290	590
BT11	-69845.2	-2914750	1058
BW3	-67852.3	-2913659	717
BW5	-67091.4	-2913478	29
BW6	-70125.3	-2915564	1143
BW7	-67537.2	-2913578	10
P-1	-67664.5	-2916531	2742
P-4	-67425.1	-2916497	1480
P-5	-67394.5	-2916619	734
P-6	-67535.2	-2916442	2691

ID	X-Coord	Y-Coord	2023/24 Median SO_4 (mg/L)
P-7	-67744.1	-2916587	2910
DDP-01	-66174	-2915205	1864
DDP-02	-66123.3	-2915360	2860
Scav1	-67789.1	-2913645	2270
Scav3	-68371	-2913714	2340
Scav5	-69540.1	-2914389	2690
Scav7	-69965.2	-2915166	2270
Scav8	-69985.8	-2915254	2635
Scav9	-70003.1	-2916062	1787
Scav11	-70092.4	-2915742	3056
Scav12	-70085.6	-2915530	1842
Scav 14	-67607.6	-2913492	814

7.5.4. Boundary Conditions

An overview of the physical features and assigned boundary conditions used in the Brakpan-Withok TSF complex groundwater flow model are given in Table 7.5 below.

Table 7.5: Boundary conditions assigned in the groundwater model.

Boundary	Natural feature	Assigned boundary condition
Top	Land surface	Rainfall recharge, seepage
Top	Rivers	River lines, no losses allowed
Perimeter (SE and SW)	Rivers	River lines, no losses allowed
Perimeter	Topographic high	No-flow
Bottom	Vertical limit of active groundwater flow system	No-Flow

7.5.1. Steady State Calibration of Flow Model

The groundwater levels (in metres above mean sea level) measured in 184 boreholes monitored within the model domain (Table 7.3) were used as targets for the steady-state model calibration. Since the modelled groundwater levels are directly related to the assigned recharge rates and hydraulic conductivities, an independent estimate of one or other of these parameters is required to arrive at a potentially unique solution of the model. The estimated recharge rates (Table 7.1) were therefore considered fixed during the calibration and only hydraulic conductivities varied. The original model was run with the initial conditions and the conductivities adjusted within sensible boundaries until a best fit between measured and computed heads (Figure 7.2) was achieved. No attempt was made to change hydraulic conductivity values within different hydro-stratigraphic units to achieve representative uniform parameters for these.

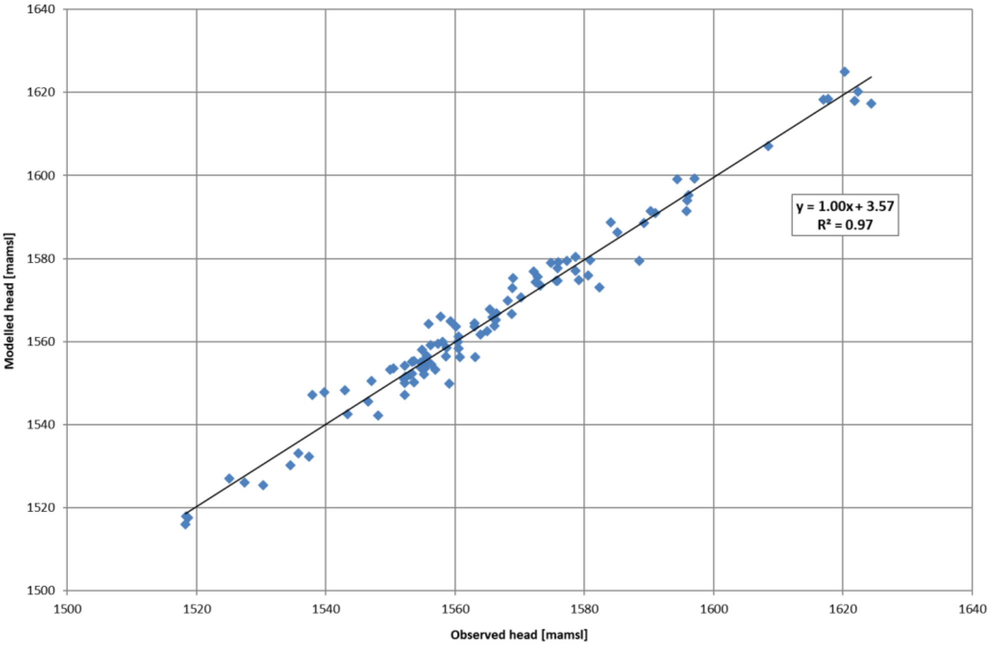

Figure 7.2: Steady-state calibration of the Brakpan-Withok TSF complex groundwater flow model.

The root mean square error (RMSE) and the normalised root mean square error (NRMSE) were used as quantitative indicators for the adequacy of the fit between the 184 (=*n*) observed (h_{obs}) and simulated (h_{sim}) water levels:

$$RMSE = \sqrt{\frac{\sum(h_{obs} - h_{sim})^2}{n}}$$

$$NRMSE = \frac{RMSE}{h_{max} - h_{min}}$$

The normalised root mean square error scales the error value to the overall range of observed heads within a model domain (here approximately $h_{max} - h_{min}$ =1624.4 mamsl – 1508.6 mamsl = 158.8 m), where NRMSE values lower than 10% are generally considered acceptable.

Despite the intended constraint of uniform hydraulic conductivity values for the different geological units, a good correlation between observed and modelled water levels (R^2 = 0.97 or 97% correlation, Figure 7.2) with a unit slope and no obvious bias towards too high or low modelled heads was achieved for the steady-state calibration. The corresponding root mean square error of RMSE = **3.62%** and normalised root mean square error of NRMSE = **3.12%** of the steady-state calibration of the groundwater flow model are more than adequate for the purpose of the study.

The calibrated hydraulic conductivity values are given in Table 7.6 and the simulated heads (Figure 7.3) were subsequently used as starting heads for the predictive model scenarios.

Table 7.6: Final hydraulic conductivities of the Brakpan-Withok TSF complex groundwater model.

Aquifer	Hydraulic conductivity (m/s)
Alluvium	3E-05
Weathered Dolomite	1E-05
Dolomite	2E-06
Dolerite	4E-07 - 2E-06
Weathered Karoo	4E-06
Karoo	6E-07

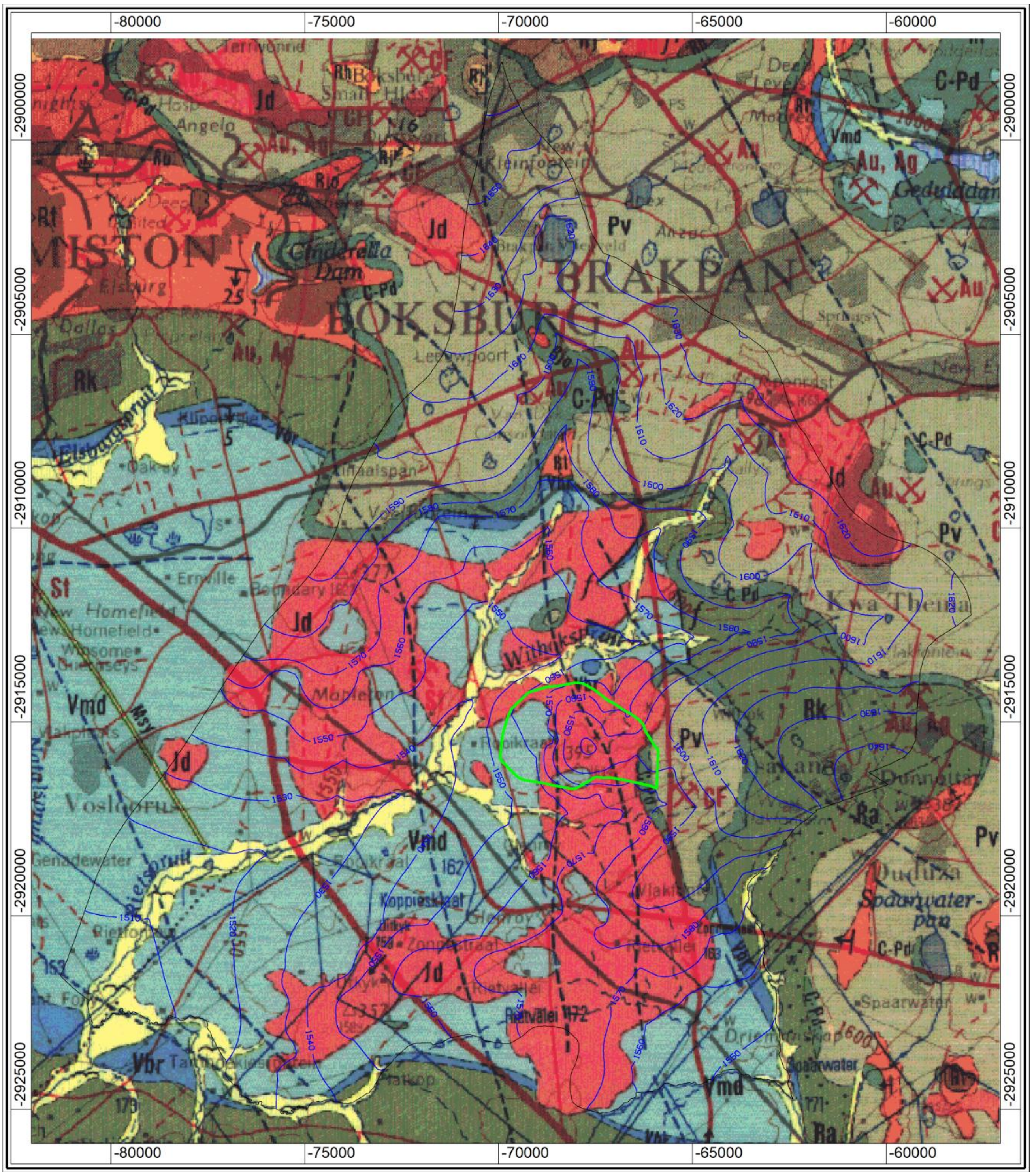

Figure 7.3: Simulated steady-state heads (free water table) for the Brakpan-Withok TSF Complex (green outlines) Groundwater Model.

7.5.2. Calibration of Transport Model

The solution of the calibrated steady-state groundwater flow model was used as the basis for the transport model calibration. The model mesh was sufficiently refined to simulate the solute transport in the unsaturated and saturated zones accurately and to comply with applicable numerical stability criteria:

Courant criteria: $C_r = \left|\frac{v\Delta t}{L}\right| \leq 1$

Peclet criteria: $L < 2\alpha_l$ and $\Delta t < \frac{L}{v}$

v Flow velocity
Δt Discrete time step
L Longest dimension of an element in the direction of flow
α_l Longitudinal dispersion coefficient

Following the precautionary principle, only advective-dispersive transport of the constituents of concern, without any retardation or transformation, was simulated. The simulated impact of a seepage plume emanating from the TSF on the ambient groundwater quality is therefore a likely overestimation. In the absence of site-specific data, literature values of dispersivity were assigned to the aquifer, namely a uniform longitudinal dispersion length of 50 m and a transversal dispersion length of 10% thereof, or 5 m.

A uniform constant sulphate source concentration of 3 200 mg/L was assigned to the seepage from the TSF and since no element specific retardation or transformation was simulated, concentrations for other elements of concern can be derived by multiplying with the respective source concentration for any element.

Since deposition onto the Brakpan TSF started in 1985, the model was run for 38 years (to simulate the 2023 sulphate plume concentrations) in transient state with a time step width of three days. No changes in the seepage rates or concentrations were adopted during this period. The Phase 1 scavenger boreholes (Scav1 to Scav9) were activated in the model in 2019 with the rates given in Table 7.2.

The simulated versus observed 2023 sulphate concentrations are shown in Figure 7.4. A very good correlation (R^2 = 0.98 or 98%) between simulated and observed sulphate concentrations was achieved in the model. As for the flow model, the root mean square error (RMSE) and normalised root mean square error (NRMSE) were used as quantitative indicators for the adequacy of the fit between the 26 (=*n*) observed (c_{obs}) and simulated (c_{sim}) sulphate concentrations.

The corresponding root mean square error of RMSE = **227** and normalised root mean square error of NRMSE = **7.44%** of the groundwater transport model are very satisfactory.

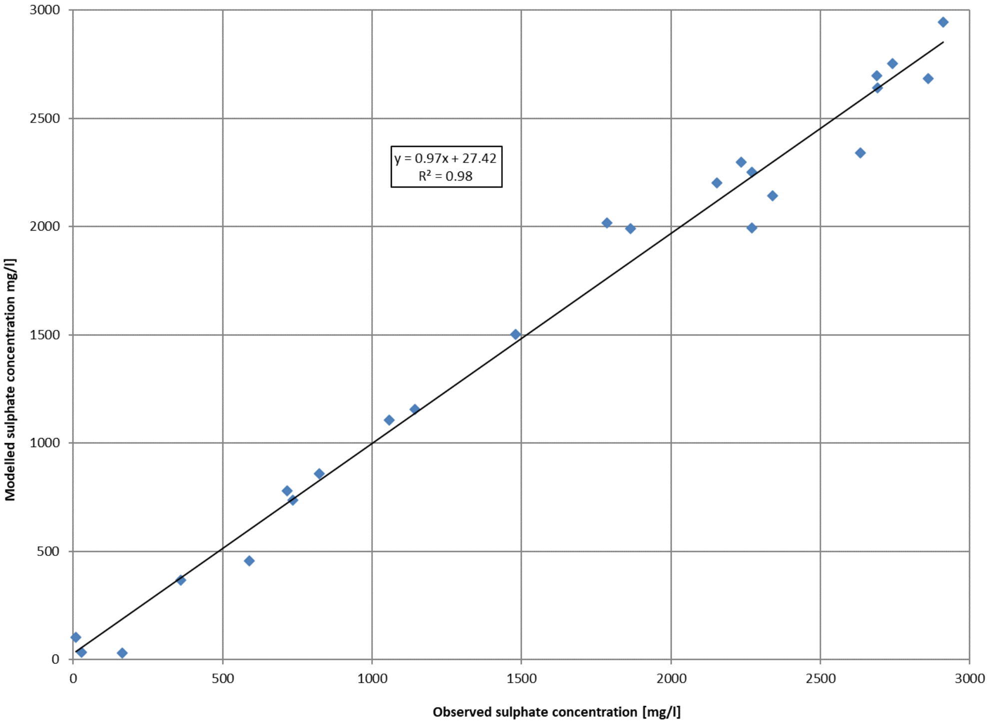

Figure 7.4: Calibration of the Brakpan-Withok Groundwater Transport Model.

The subsequently simulated 2023 sulphate plume along with observed median sulphate concentrations are shown in Figure 7.5.

Based on the model simulations, the seepage plume has reached the Withokspruit north of the TSF and is likely to contribute as groundwater baseflow to the discharge in the spruit with sulphate concentrations of up to 900 mg/L. The western lobe of the seepage plume extends for a cutoff value of 250 mg/L sulphate approximately 520m towards the Rietspruit.

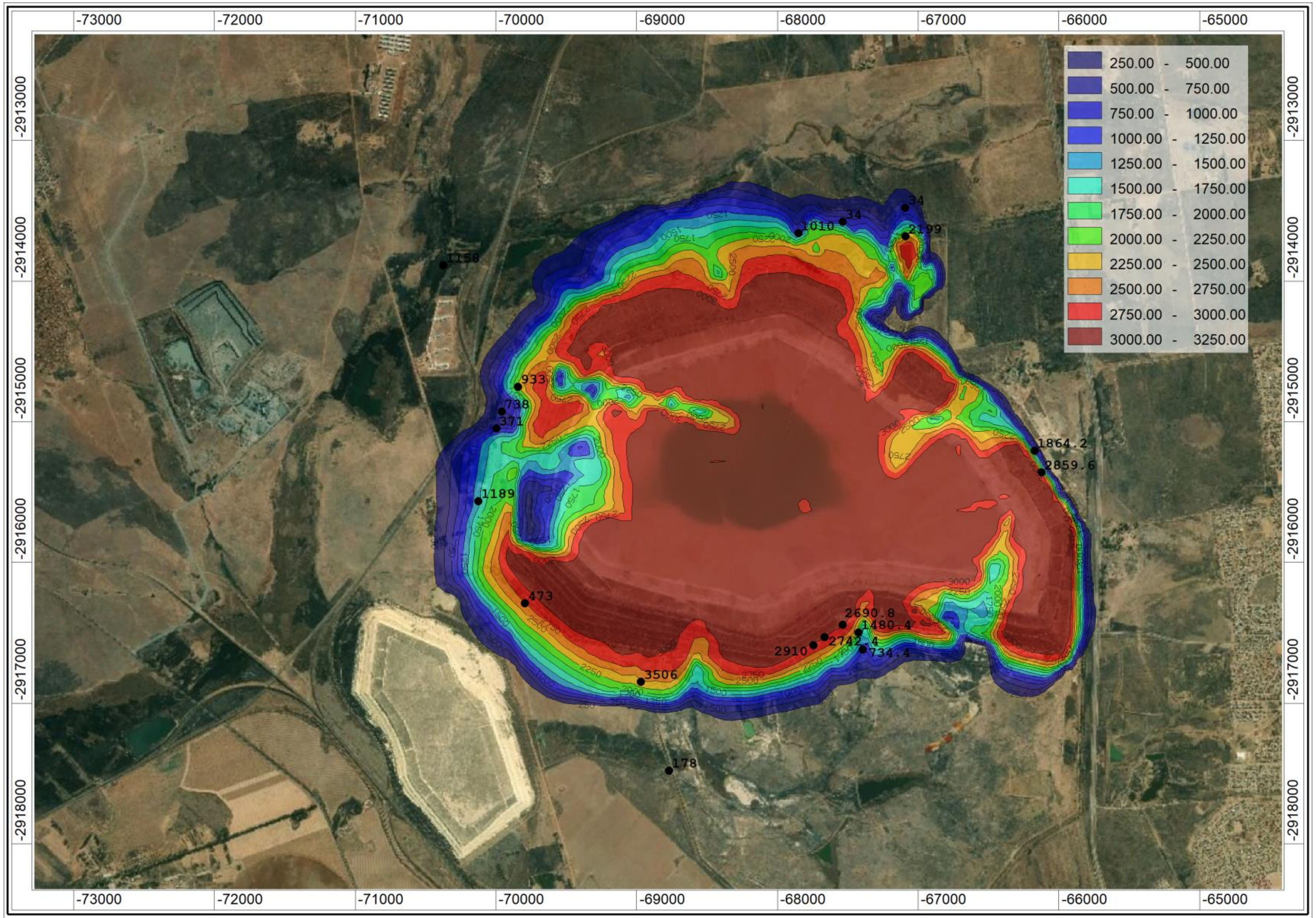

Figure 7.5: Simulated 2023 sulphate plume and observed concentrations for the Brakpan TSF.

A cross-plot of observed and simulated 2020 sulphate concentrations shows a very good correlation (R^2 = 0.96 or 96% correlation, Figure 7.6) with an almost unit slope (1.01). As for the calibration of the water levels, the corresponding root mean square error of RMSE = **196.6%** translates to a normalised root mean square error of NRMSE = **7.10%**, which is considered more than acceptable for the calibration of the transport model.

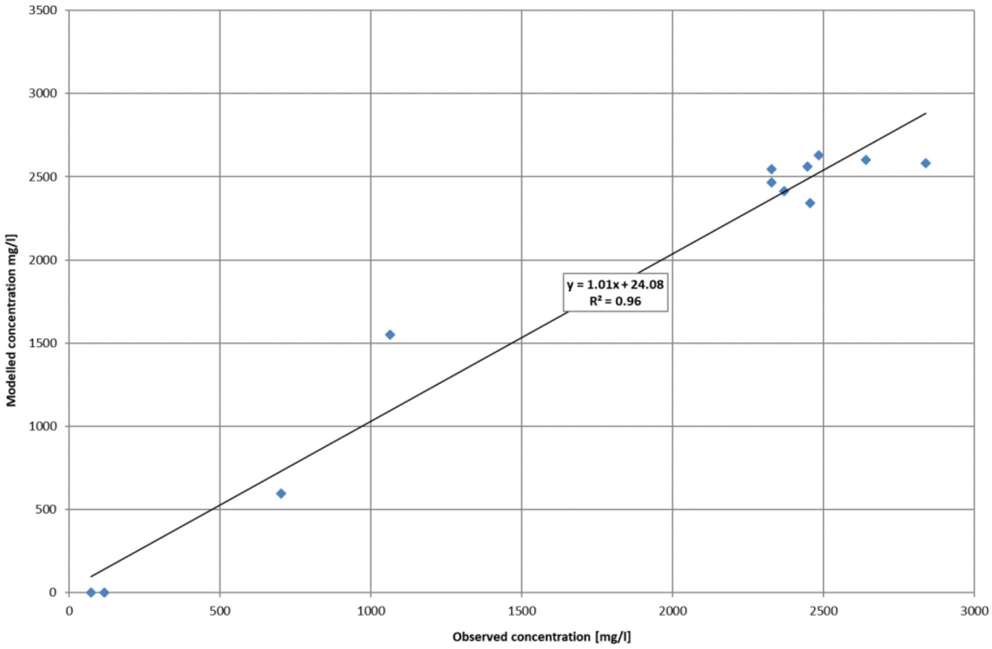

Figure 7.6: Simulated and observed 2020 sulphate concentrations around the Brakpan TSF.

7.6. PREDICTIVE MODEL SCENARIOS

7.6.1. Life of Facility - Unmitigated

The future development of the Brakpan-Withok TSF complex entails the continuing deposition of tailings slurry at a rate of 0.5 Mtpm onto the Brakpan TSF until its final crest elevation of 1750 mamsl is reached, as well as the deposition of tailings slurry at a rate of 1.3 Mtpm onto the fully lined Withok TSF until it reaches its final crest elevation of 1660 mamsl. It is currently planned that the tailings deposition onto the Brakpan-Withok TSF complex ends after 24.5 years.

The calibrated model was therefore run with unchanged seepage rates and concentrations for another 24.5 years (using a time step width of one day) to predict the groundwater elevations and sulphate concentrations in 2049, which subsequently served as initial heads and concentrations for the post closure scenarios.

It is obvious from Figure 7.7 that tailings deposition onto the lined Withok extension of the Brakpan TSF contributes only marginally to the seepage plume, with elevated sulphate concentrations underneath the extension being driven by the continuous spreading of the Brakpan seepage plume. The lined Withok expansion reduces the recharge over its footprint, which leads to less dilution of the existing Brakpan seepage plume and thereby an apparent increase in concentrations underneath.

The 250 mg/L sulphate isoline of the Brakpan TSF seepage plume is predicted to migrate until 2049 a further 250m in a north and north-westerly direction and around 220m in a westerly direction. The maximum sulphate concentrations of groundwater baseflow reporting to the Withokspruit are likely to increase to 1600 mg/L sulphate.

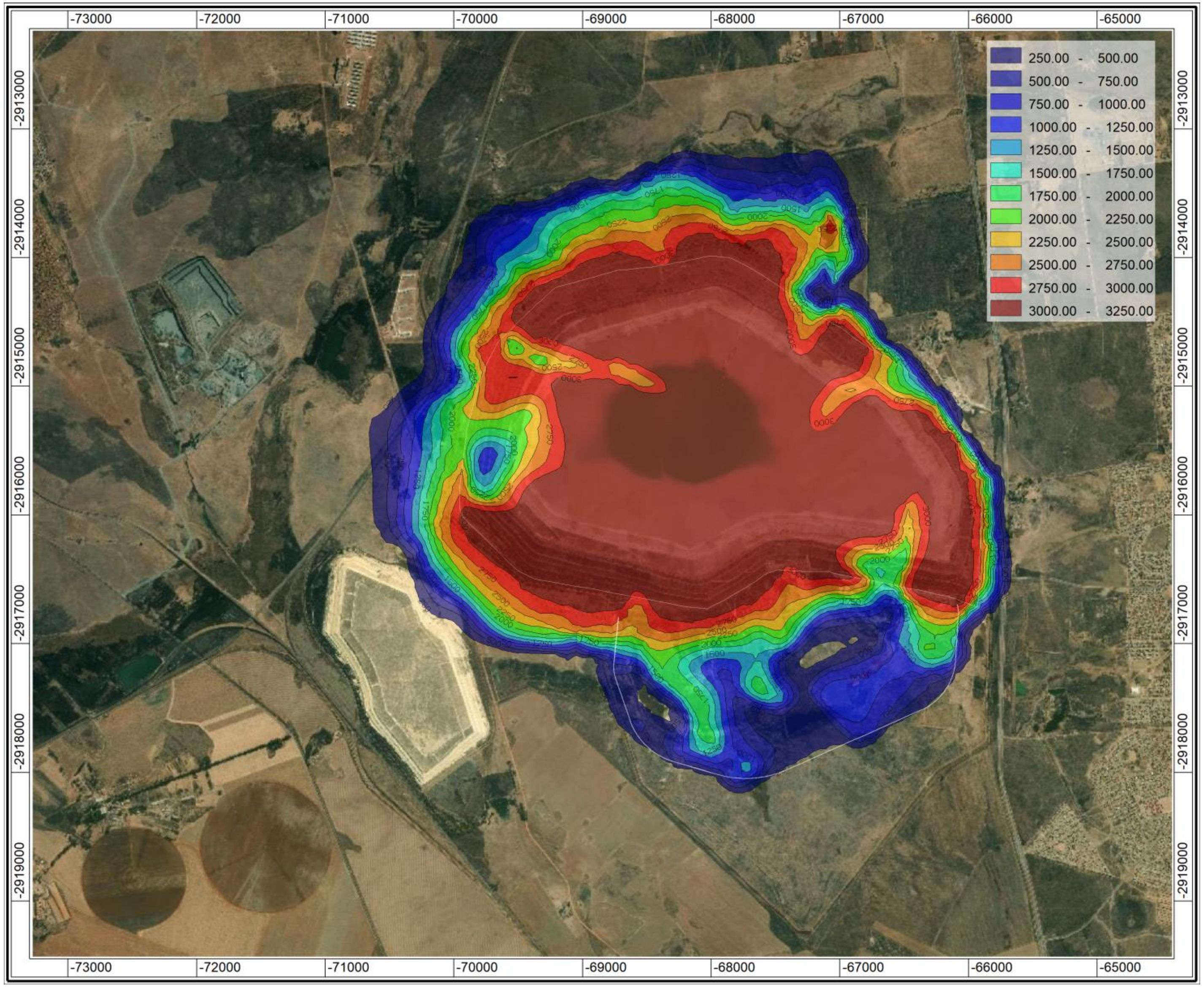

Figure 7.7: Simulated sulphate concentrations (unmitigated) in the shallow aquifer at the end of active deposition onto the Brakpan-Withok TSF complex (2049).

7.6.2. Life of Facility - Mitigated

While the lined Withok expansion of the Brakpan TSF does not require additional mitigation measures beyond the liner, the current and future impacts of seepage from the unlined Brakpan TSF on the underlying aquifer and surface water courses require mitigation. The installation of a hydraulic plume containment system (scavenger wells) was therefore initiated by the client between 2019 and 2024 (Table 7.2). The aim of these scavenger wells was to intercept the dominant plume migration within the weathered aquifer towards the surface drainages.

The mitigated model scenario assesses the efficiency of the scavenger wells in the containment of the seepage plume during the remaining life of the TSF. All scavenger wells were incorporated in the model scenario with sustainable yields recommended by Water Hunters (Table 7.7). As for the unmitigated scenario, the 2023 sulphate concentrations of the calibrated transport model (Figure 7.5) were used as initial concentrations for the mitigated operational simulations, assuming continuous operation of the scavenger well system for the remaining life of the facility. No other changes from the model set-up for the unmitigated scenario were done.

Table 7.7: Sustainable yields of the scavenger boreholes (Water Hunters 2024).

ID	X-Coord	Y-Coord	Q (m^3/a)
Scav1	-67789.1	-2913645	94608
Scav3	-68371	-2913714	66226
Scav5	-69540.1	-2914389	94608
Scav7	-69965.2	-2915166	94608
Scav8	-69985.8	-2915254	94608
Scav9	-70003.1	-2916062	72533
Scav11	-70092.4	-2915742	50458
Scav12	-70085.6	-2915530	40997
Scav13	-70018.6	-2915375	50458
Scav 14	-67607.6	-2913492	40997

The simulated sulphate seepage plume at the end of active deposition onto the TSF complex is shown in Figure 7.8. The installed scavenger well system manages to contain the plume or “pull back” the 250 mg/L sulphate isoline by around 400m in the west and up to 275m in the north as well as bringing about a reduction in plume concentrations (beyond the TSF footprint itself) in comparison to the unmitigated scenario.

Furthermore, maximum sulphate concentrations within the baseflow towards the Withokspruit are predicted to reduce to 800 mg/L.

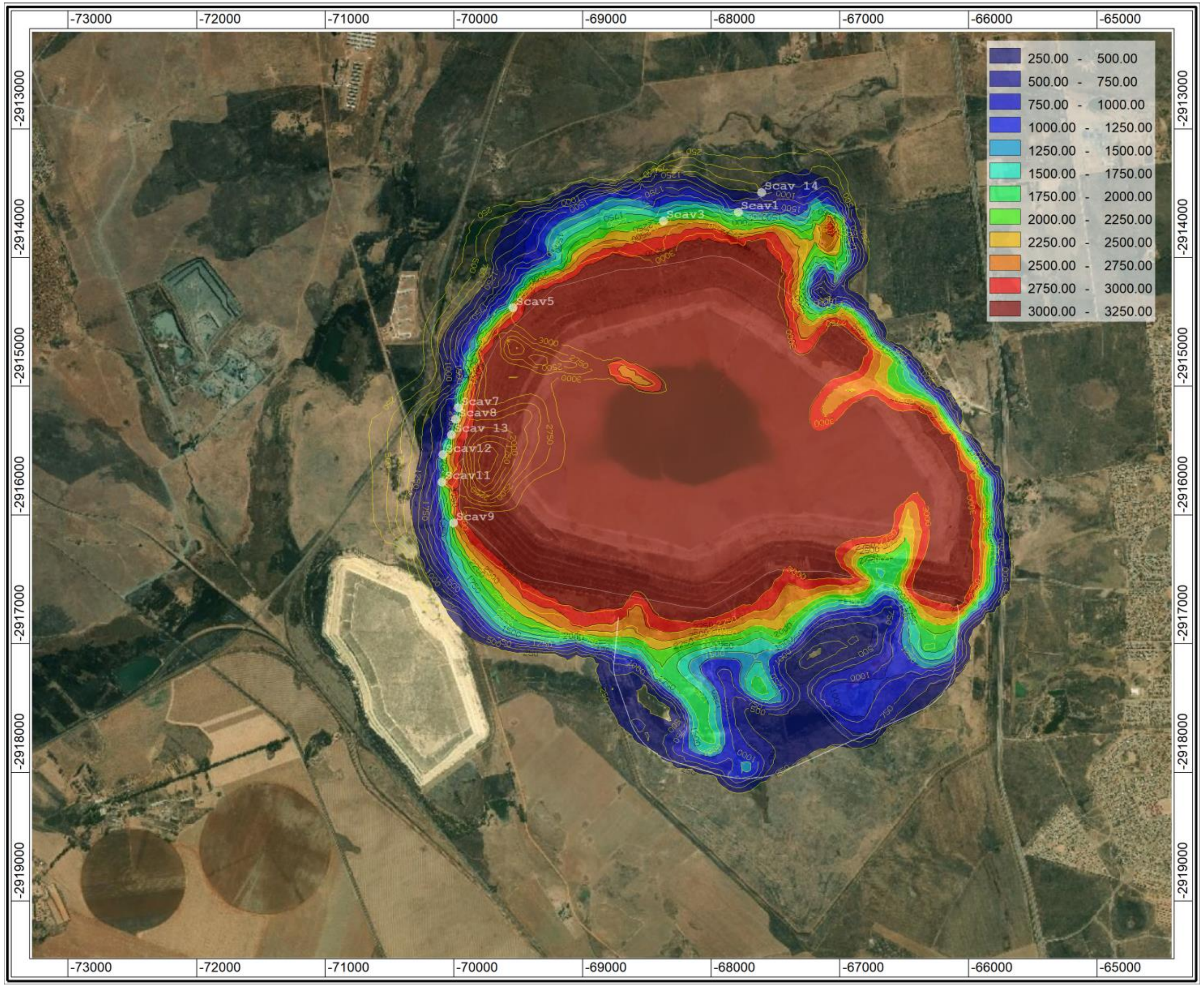

Figure 7.8: Simulated sulphate concentrations in the shallow aquifer at the end of active deposition onto the Brakpan-Withok TSF complex (2049) for the mitigated scenario (unmitigated 2049 concentrations indicated by yellow contour lines).

7.6.3. Post Closure - Unmitigated

The unmitigated closure scenario considers only the cessation of tailings slurry deposition onto the Brakpan-Withok TSF complex in 2049 and no further rehabilitation to reduce rainwater ingress. A separate seepage model (Delta H 2024) has predicted a reduction in seepage losses for the unlined Brakpan TSF from 133 mm/a (after 10 years) to 80 mm/a (after 50 years) due to the slow draining of the overflow core, while no significant reduction of the anyway minor seepage losses is expected for the lined Withok extension (Table 7.1).

These rates were assigned to the different footprints in the post closure scenario using a simplified linear interpolation over time, for the next 50 years. Following the precautionary principle, no reduction in the source concentration (3 200 mg/L sulphate) was assumed for the post closure simulations. With no mitigation measures or any retardation and degradation processes considered, the simulation represents a worst-case scenario of up to 50 years (Figure 7.9) of seepage plume migration post closure.

The predicted 50-year post closure seepage plume within the shallow weathered aquifer (Figure 7-9) shows a continuous plume migration towards the Withokspruit (around 250m) in the north and the Rietspruit (around 350m) in the west, while the eastern and southern plume extents start to recede. Sulphate concentrations in groundwater seeping into the Withokspruit are predicted to increase up to 2 300 mg/L.

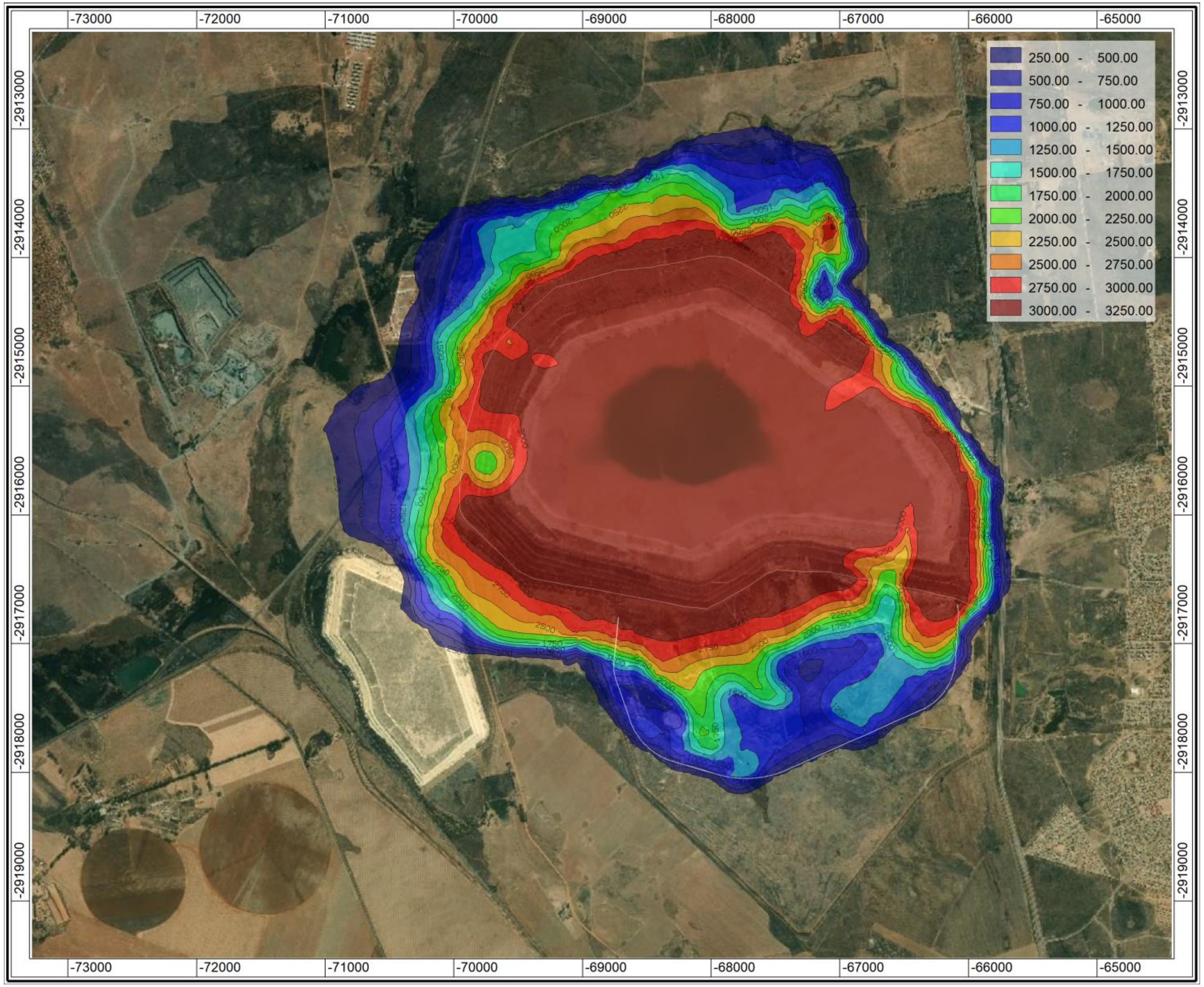

Figure 7.9: Simulated sulphate concentrations in the shallow aquifer 50 years post closure.

7.6.4. Post Closure - Mitigated

As for the mitigated life of facility scenario, the mitigated post closure scenario assumes the continuous operation of the hydraulic plume containment (scavenger well) system installed by Water Hunters (Table 7.7) until measured concentrations recede below acceptable limits to allow natural attenuation of the plume. Containment is likely to be required beyond the current simulation time frame of 50 years.

As for the unmitigated scenario, a constant source concentration of 3 200 mg/L sulphate (with no retardation or transformation of sulphate simulated) was precautionarily assumed to prevail and a reduction of net seepage losses assumed for the Brakpan TSF only (Table 7.1). The predicted mitigated concentrations at the end of the life of the TSF complex (Figure 7-8) were used as initial concentrations for the mitigated post closure simulations and the model subsequently run over 50 years (with a time step width of 1 day).

The mitigated 50-year post closure seepage plume is shown in Figure 7.10. The scavenger well system achieves a further minor reduction in the northern and western plume extent and concentrations in comparison to the life of facility extent (Figure 7.8), but a significant reduction (up to 900m) in comparison to the unmitigated scenario (Figure 7.9).

The installed hydraulic containment system (i.e., the current scavenger wells) appears to be feasible and effective but should be augmented by additional scavenger wells at the north-west edge of the Brakpan TSF to achieve a more comprehensive plume containment within 50 years.

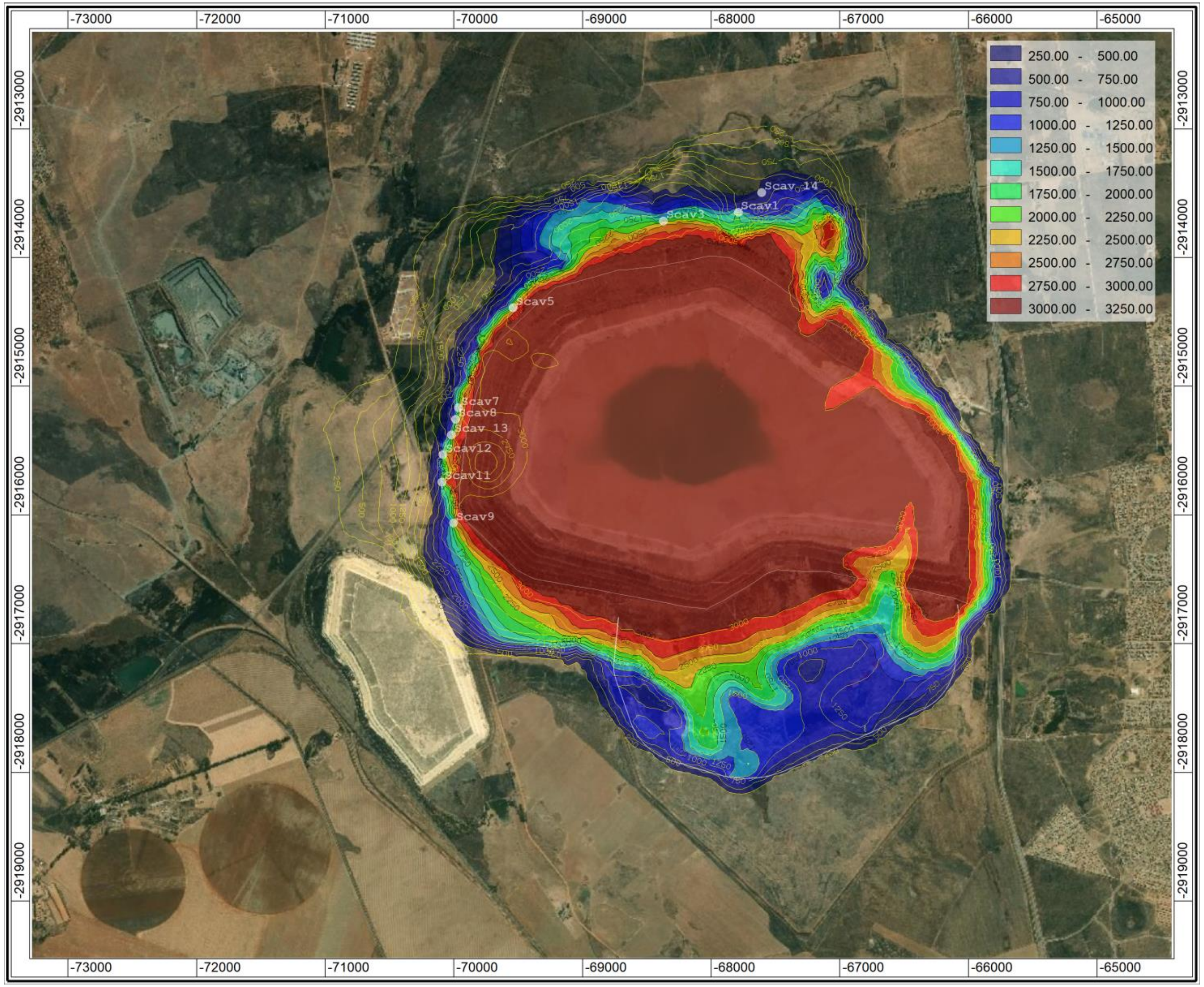

Figure 7.10: Simulated sulphate concentrations in the shallow aquifer 50 years post closure for the mitigated scenario (unmitigated concentrations indicated by yellow contour lines).

7.7. CONFIDENCE IN MODEL PREDICTIONS

Preamble drawn from the (Australian Groundwater Modelling Guidelines, Barnett et al. 2012, see Appendix C)

"A decision often must address the fact that something bad may happen. We may be willing to pay a price to reduce the likelihood of its occurrence. How much we are prepared to pay depends on the cost of its occurrence and the amount by which its likelihood can be reduced through pre-emptive management. The role of modelling in this process is to assess likelihood. This must not be confused with predicting the future.".

Delta H shares this view, specifically for long-term predictions beyond the model calibration timeframe.

7.7.1. Methodology

In the absence of other internationally accepted standard, Delta H follows the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) to distinguish confidence levels (Class 1, Class 2 or Class 3 in order of increasing confidence) of a model. The factors used for the classification (see Appendix A) depend foremost on:

- the available data, including spatial and temporal coverage to fully characterise the aquifer and the historic groundwater behaviour,
- the calibration procedures, including types and quality of data used as calibration targets,
- the consistency between the calibration and predictive analysis, e.g. a steady state calibration is bound to produce transient predictions of low confidence and a transient prediction is expected to have a high level of confidence if the time frame of the predictive model is less or similar to that of the calibration model (e.g. a 25 year transient calibration period would be required for a high confidence prediction over 25 years), and
- the level of stresses applied in predictive model in relation to the stresses included in the calibration (e.g. if a model was calibrated without major abstractions, simulations of significant abstractions or mine inflows will be of low confidence).

While a model may fall into different classes for the various criteria (data, calibration, and prediction), it should be classified as Class 1 if any of the criteria fall into a Class 1 classification irrespective of all other ratings. A Class 1 (low confidence) model is often used for an initial assessment of a project if insufficient data are available to support a full conceptualisation of the aquifer(s). This can then subsequently be improved to higher confidence classes as additional data from e.g. an associated monitoring programme, become available.

7.7.2. Classification

In accordance with the guideline, Delta H provides a classification for each of these criteria as well as an overall model classification that reflects their importance with regard to the model objectives (Table 7.8).

Table 7.8: Criteria specific and overall model confidence level classification.

Criteria	Confidence level classification	Key indicators
Data	2	Sufficient aquifer data available in the area of interest. Little or no useful data on river flows and stage elevations.
Calibration	1	Calibration statistics for water levels and current concentrations are generally good. No transient calibration performed due to lack of historical data.
Prediction	1	Transient predictions are made when calibration is in steady state only.
Overall	1	Two criteria fall inevitably into Class 1, model to be updated once data become available for the TSF

While the model must be classified as a class 1 model, a low model confidence does not mean that the model is not fit for purpose. According to Barnett et al. (2012) a class 1 (low confidence) model is, for example, sufficient for:

- Predicting long-term impacts of proposed developments in low-value aquifers.
- Understanding groundwater flow processes under various hypothetical conditions.
- As a starting point on which to develop higher class models as more data is collected and used.

7.7.3. Recommendations to improve Model Confidence

To increase the formal classification of the model confidence from Class 1 to Class 2, the following steps should be undertaken:

- Biennial model updates as monitoring data (water levels and concentrations) during the operation of the scavenger well system become available.
- Updated source concentrations based on additional water quality data from the tailings liquor and TSF drains.

8. GEOHYDROLOGICAL IMPACTS

8.1. IMPACT ASSESSMENT METHODOLOGY

The impact significance rating system is presented in Table 8-1, 8-2 and 8-3 and involves three parts:

Part A: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale/ population and duration (Table 8.1).

Part B: Use the matrix (Table 8.2) to determine a rating for impact consequence based on the definitions identified in Part A; and

Part C: Use the matrix (Table 8.3) to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence.

Table 8.1: Consequence Rating Methodology.

Impact characteristics	Definition	Criteria
Magnitude	Major -	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate -	Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor -	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded
	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
Spatial scale or population	Site or local	Site specific or confined to the immediate project area
	Regional	May be defined in various ways, e.g. cadastral, catchment, topographic
	National/ International	Nationally or beyond
Duration	Short term	Up to 18 months.
	Medium term	18 months to 5 years
	Long term	Longer than 5 years

Table 8.2: Consequence Rating Methodology 2.

			Spatial scale/ Population		
			Site or Local	Regional	National/ International
MAGNITUDE					
Minor	DURATION	Long term	Medium	Medium	High
		Medium term	Low	Low	Medium
		Short term	Low	Low	Medium
Moderate	DURATION	Long term	Medium	High	High
		Medium term	Medium	Medium	High
		Short term	Low	Medium	Medium
Major	DURATION	Long term	High	High	High
		Medium term	Medium	Medium	High
		Short term	Medium	Medium	High

Table 8.3: Significance Rating Methodology.

Probability (of Exposure to Impacts)	Consequence Negative			Consequence Positive		
	Low	Medium	High	Low	Medium	High
Definite	Medium	Medium	High	Medium	Medium	High
Possible	Low	Medium	High	Low	Medium	High
Unlikely	Low	Low	Medium	Low	Low	Medium

8.2. Overview of Impacts

The Brakpan TSF is an existing unlined facility, while the Withok extension will be a (class C) lined facility. The seepage plume emanating from the TSF complex is therefore primarily associated with the Brakpan TSF. The lined Withok expansion reduces essentially the recharge over its footprint, which leads to less dilution of the existing Brakpan seepage plume and thereby an increase in concentrations. The seepage contributions from the Withok TSF extension are on the other hand negligible.

The most significant groundwater impacts that could potentially arise from the proposed activities, i.e. the continuing deposition of tailings onto the unlined Brakpan TSF and the lined Withok TSF, are as follows:

- Construction
    - With no construction required for the raising of the Brakpan TSF, construction activities are only associated with the preparation of the ground for the lined Withok extension.
    - Potential contamination of shallow groundwater resources due to accidental hydrocarbon or other chemical spillages from vehicles and operational activities might occur. Spillages are commonly minor and localised.
- Operational
    - Continuing deposition of tailings on the Brakpan TSF will maintain higher seepage rates over the TSF footprint area with a subsequent local mounding of the water table.
    - Deposition of tailings on the lined Withok TSF will reduce the currently prevailing recharge rate with a subsequent local, insignificant lowering of the water table.
    - If hydraulic containment of the Brakpan TSF seepage plume is continued, the groundwater abstractions will result in local cones of dewatering around the scavenger wells. These will be offset by the enhanced recharge rate and water table mounding over the Brakpan TSF footprint area. No scavenger (plume control) boreholes are required for the lined Withok TSF.
    - Influences on the groundwater quality during the life of the TSF complex are associated with poor quality tailings liquor (process water) and the exposure of minerals, including sulphide bearing minerals, to the atmosphere, along with the subsequent leaching of elements and acid mine drainage. Both processes result in poor quality seepage water infiltrating into the underlying shallow weathered aquifer. The impacts are primarily linked to the existing, unlined Brakpan TSF with marginal contributions from the lined Withok TSF.
- Closure/Post Closure
    - Groundwater quality within the TSF complex footprint area is expected to deteriorate due to continuous seepage of poor-quality water from the Brakpan TSF and to a minor extent the Withok TSF into the underlying aquifer. The resulting groundwater pollution plume will continue to migrate post closure (as the TSFs drain down over time).

8.3. Construction Phase

Deposition onto the Brakpan TSF started in 1985 and will continue with no further construction required for the remaining life of the facility. The construction of the Withok TSF extension will on the other hand entail ground clearing and earth works for the liner installation.

8.3.1. Impacts on Groundwater Quality

Potential contamination of shallow groundwater resources due to accidental hydrocarbon or other chemical spillages from vehicles and operational activities might occur. Spillages are commonly minor and localised (Table 8.4).

8.3.2. Groundwater Management

The site should develop and maintain a Standard Operating Procedure to contain and remediate any accidental hydrocarbon or other chemical spillages. Such containment can be achieved by utilisation of spill kits and/or excavation of affected soil with subsequent disposal at an accredited disposal site. Staff should be trained in the appropriate usage of spill kits and excavation of affected soils. Any excavation of affected soils should be supervised by the Environmental Site Officer.

Table 8.4: Groundwater quality impacts during the construction phase.

NATURE OF THE IMPACT: ***Accidental hydrocarbon or other chemical spillages from construction vehicles. Localised impacts on ambient groundwater quality due to accidental spillages***		
	Impact Rating Without Mitigation	**Impact Rating With Mitigation**
Extent *(Local, Regional, International)*	Local	Local
Duration *(Short term, Medium term, Long term)*	Medium term	Short term
Magnitude *(Major, Moderate, Minor)*	Moderate	Minor
Probability *(Definite, Possible, Unlikely)*	Possible	Possible
Calculated Significance Rating (Low, Medium, High)	**Low**	**Low**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	No	
Residual impacts ❖ None		
Mitigation measures ❖ Develop and maintain a Standard Operating Procedure to contain and remediate any accidental hydrocarbon or other chemical spillages. ❖ Contain spillage using spill kits, excavate and dispose of contaminated material/soil at accredited disposal site.		

8.4. Operational Phase

8.4.1. Impacts on Groundwater Quality

The seepage plume emanating from the Brakpan TSF has and will continue to predominantly impact on the groundwater quality of the underlying and surrounding weathered aquifer (Figure 7.7), karst aquifer and, to a lesser degree, on the lower permeability fractured aquifer. Considering the elevated sulphate (amongst other constituents) concentrations of the seepage water, major impacts on the ambient groundwater quality are evident (chapter 5.6.3). If not contained, the seepage plume emanating from the Brakpan TSF will continue to impact on the Withokspruit and potentially on the Rietspruit, triggering the risk of off-site migration beyond site boundaries and impacts on potential downstream water users.

Due to the low seepage rate of the lined Withok TSF extension (2 mm/a), its direct seepage impacts are on the other hand marginal. Indirect impacts include a reduced dilution of the Brakpan seepage plume due to reduced recharge/seepage over its footprint area.

The significance rating of impacts of the seepage plume emanating from the Brakpan-Withok TSF complex on the groundwater quality during the operational phase of the facility is provided in Table 8.5. They should be seen as related to the existing Brakpan TSF with no significant contributions of the lined Withok TSF extension.

It is important to note that hydraulic containment of the existing seepage plume is recommended to continue as a management measure and will improve observed plume concentrations significantly. The hydraulic plume containment will have to continue beyond the life of the facility until acceptable source and plume concentrations allow for monitored natural attenuation.

Table 8.5: Groundwater quality impacts during the operational phase.

NATURE OF THE IMPACT: ***Continuing deposition of tailings material onto the existing unlined Brakpan TSF and the lined Withok extension with subsequent seepage from the unlined TSF.***		
	Impact Rating Without Mitigation	**Impact Rating With Mitigation**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Long term	Long term
Magnitude *(Major, Moderate, Minor)*	Major	Major
Probability *(Definite, Possible, Unlikely)*	Definite	Possible
Calculated Significance Rating (Low, Medium, High)	**High**	**High**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	No	
Residual impacts ❖ Deterioration of groundwater quality underneath the unlined Brakpan TSF.		
Mitigation measures ❖ Continuous monitoring of source concentrations (i.e. within drains and scavenger boreholes) concentrations and downstream plume migration using proposed monitoring network. ❖ Hydraulic plume containment using proposed scavenger boreholes until acceptable plume concentrations allow for monitored natural attenuation.		

8.4.2. Impacts on Groundwater Quantity and Flow Regime

Seepage from the Brakpan TSF has changed, and will continue to change, the volume of groundwater in storage locally due to mounding of water table within the TSF and its surrounds. On the other hand, a localised lowering of the water table around the scavenger boreholes themselves is expected. Similarly, the lined Withok TSF extension will lead to reduced recharge underneath its footprint.

Table 8.6: Groundwater quantity impacts during the operational phase.

NATURE OF THE IMPACT: Local changes of water table and associated local groundwater flow direction ***due to seepage from the unlined Brakpan TSF, hydraulic plume containment with scavenger boreholes and minor leakage from the lined Withok TSF extension.***		
	Impact Rating Without Mitigation	**Impact Rating With Mitigation**
Extent *(Local, Regional, International)*	Local	Local
Duration *(Short term, Medium term, Long term)*	Long term	Long term
Magnitude *(Major, Moderate, Minor)*	Minor	Minor
Probability *(Definite, Possible, Unlikely)*	Possible	Unlikely
Calculated Significance Rating (Low, Medium, High)	**Medium**	**Low**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	No	
Residual impacts ❖ None.		
Mitigation measures ❖ Continuous monitoring of water levels within the TSFs and monitoring boreholes. ❖ Continuous operation of the existing scavenger well system.		

8.4.3. Groundwater Management

Groundwater monitoring as well as hydraulic plume containment should continue for the remaining operational life of the facility and post closure.

8.5. Post Closure Phase

8.5.1. Impacts on Groundwater Quality

Seepage from the Brakpan TSF and to a minor extent the Withok TSF extension will continue to impact on the ambient groundwater quality post closure. While lower seepage rates are expected once active deposition onto the TSFs ends, post closure seepage concentrations will have a significant impact on the ambient groundwater quality for several decades as the TSF complex drains down and the tailings material is leached out. The predicted extent of the post closure seepage plumes are given in chapter 7.6, while the significance rating of post closure groundwater quality impacts is provided in Table 8.7.

Table 8.7: Groundwater quality impacts during the post closure phase.

NATURE OF THE IMPACT: ***Continuing deposition of tailings material onto the existing unlined Brakpan TSF and the lined Withok extension with subsequent seepage from the unlined TSF.***		
	Impact Rating Without Mitigation	**Impact Rating With Mitigation**
Extent *(Local, Regional, International)*	Regional	Local
Duration *(Short term, Medium term, Long term)*	Long term	Long term
Magnitude *(Major, Moderate, Minor)*	Major	Moderate
Probability *(Definite, Possible, Unlikely)*	Definite	Possible
Calculated Significance Rating (Low, Medium, High)	**High**	**Medium**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	No	
Residual impacts ❖ Deterioration of groundwater quality underneath the unlined Brakpan TSF.		
Mitigation measures ❖ Continuous monitoring of source concentrations (i.e. within drains and scavenger boreholes) concentrations and downstream plume migration using proposed monitoring network. ❖ Hydraulic plume containment using proposed scavenger boreholes until acceptable plume concentrations allow for monitored natural attenuation.		

8.5.2. Impacts on Groundwater Quantity and Flow Regime

Operational impacts on the groundwater quantity and flow regime are expected to persist post closure, although seepage rates from the Brakpan TSF will recede once tailings deposition end and water levels drop within the TSF. The minor leakage rates of the lined Withok extension are predicted to persist post closure. As for the operational phase, the plume control borehole system will reduce the localised mounding and the groundwater baseflow towards the Withokspruit and Rietspruit due to seepage from the unlined Brakpan TSF.

The significance rating of the post closure groundwater quantity impacts assessment is given in Table 8.8.

Table 8.8: Groundwater quantity impacts during the post closure phase.

NATURE OF THE IMPACT: Local changes of water table and associated local groundwater flow direction due to seepage from the unlined Brakpan TSF, hydraulic plume containment with scavenger boreholes and minor leakage from the lined Withok TSF extension.		
	Impact Rating Without Mitigation	**Impact Rating With Mitigation**
Extent *(Local, Regional, International)*	Local	Local
Duration *(Short term, Medium term, Long term)*	Long term	Long term
Magnitude *(Major, Moderate, Minor)*	Minor	Minor
Probability *(Definite, Possible, Unlikely)*	Possible	Unlikely
Calculated Significance Rating (Low, Medium, High)	**Medium**	**Low**
Impact Status: (positive or negative)	Negative	Negative
Reversibility: (Reversible or Irreversible)	Reversible	
Irreplaceable loss of resources: (Yes or No)	No	
Can impacts be enhanced: (Yes or No)	No	
Residual impacts ❖ None.		
Mitigation measures ❖ Continuous monitoring of water levels within the TSFs and monitoring boreholes. ❖ Continuous operation of the existing scavenger well system.		

8.5.3. Groundwater Management

Hydraulic plume containment will have to continue for several decades post closure until the source is sufficiently depleted (to be monitored in the water quality of the drains) and downstream plume concentrations reduced (to be monitored in the scavenger wells and monitoring boreholes) to allow for natural attenuation of the remaining plume. Abstraction rates of the plume control boreholes might have to be adapted in the long term to account for the declining seepage rate of the Brakpan TSF based on observed drawdowns.

The effectiveness of the hydraulic plume containment must be assessed through continuous groundwater monitoring within the plume control boreholes and downstream monitoring boreholes as already recommended for the operational phase. Should the plume control borehole system prove to be insufficient (based on downstream monitoring data), additional boreholes would need to be installed to ensure adequate hydraulic plume containment.

9. GROUNDWATER MONITORING SYSTEM

9.1. GROUNDWATER MONITORING NETWORK

Delta H proposes the drilling of 5 additional monitoring boreholes (NN1 to NN5) to better delineate the existing Brakpan TSF seepage plume, especially towards the Withokspruit. Based on observed concentrations, the monitoring boreholes should potentially be converted into scavenger wells (Figure 9.1 and Table 9.2).

Figure 9.1: Existing (black) and proposed (white) groundwater monitoring boreholes.

9.2. MONITORING FREQUENCY

The following monitoring frequencies are recommended for the scavenger wells throughout the life of the TSF:

- Continuous real time monitoring of water levels, providing input to a digital algorithm to control abstraction rates
- Weekly calibration of abstraction rates with key indicator water quality measurements
- Monthly full spectrum analysis (Table 9.1).

The following independent confirmatory monitoring frequencies are recommended for the monitoring boreholes during the construction and life of the TSF:

- Water levels: Monthly
- Water qualities: Quarterly

The following monitoring frequencies are recommended post closure:

- Water levels: Quarterly
- Water qualities: Quarterly

- The monitoring frequency should be reviewed every 5 years post closure.

9.3. MONITORING PARAMETERS

A list of groundwater parameters to be monitored is given in Table 9.1.

Table 9.1: List of groundwater monitoring parameters.

Description	Parameter	Comments
Potential heads	Static groundwater levels	Measured in metres below ground level (mbgl) and converted into metres above mean seal level (mamsl). Collar elevations of the boreholes need to be considered.
Physico-chemical parameters, field	pH, Electrical Conductivity (EC), Temperature, Redox-Potential (mV), colour and smell (if any)	Parameters to be measured during sampling in the field, should stabilize before sample is retrieved
Physico-chemical parameters, laboratory	pH, Electrical Conductivity (EC), Temperature, Redox-Potential (mV)	To assess deviations from field measurements
Major elements	Ca, Mg, Na, K, Total Alkalinity, SO_4, NO_3, NH_3, Total N, Cl, Total Dissolved Solids (TDS), CN (total and free)	Normal suite of parameter, NH_3 and total N included due to redox sensitivity
Trace elements	Al, As, B, Ba, Cd, Co, Cr, Cu, F, Fe, Mn, Mo, Ni, Pb, U, Zn	Samples to be filtered and acidified on-site.

The following recommendations apply to the monitoring protocol for the TSF:

- The static groundwater levels should be measured in the boreholes without any preceding abstractions (obviously not applicable for scavenger wells).
- The boreholes should be purged (replacing approximately three times the stagnant water within the borehole) until the physico-chemical parameters stabilize and are determined. Samples for analysis should be retrieved after stabilization of the field parameters.
- Scavenger wells do obviously not need to be purged and can be sampled directly.
- Suitable sample containers should be utilised for the sample collection, i.e. plastic or glass containers for major elements and plastic or boron-glass containers for minor and trace elements.
- Samples for trace element analysis should be filtered and acidified (HNO_3, $pH < 2$) on-site.
- Sample collection including determined physico-chemical parameters should be documented in a sample protocol for each site and signed off by the sampling personnel as part of the chain of custody.
- The samples should be delivered to an accredited laboratory as soon as possible for analysis of the above parameters.

1.1. MONITORING BOREHOLES

The approximate locations of the proposed monitoring boreholes are given in Table 9.2. It must be emphasised that the locations of these new monitoring boreholes are only approximate locations based on predicted flow and transport directions, and that they will need to be refined based on ground geophysics and other infrastructure or safety concerns.. The exact location of each monitoring borehole will require ground truthing and should be aided by geophysical methods to detect potential preferential flow paths.

Table 9.2: Approximate coordinates of proposed additional Brakpan TSF monitoring boreholes.

X	Y	ID
-69060	-2913970	NN1
-68775	-2913690	NN2
-69100	-2913670	NN3
-69400	-2916600	NN4
-65825	-2916420	NN5

The monitoring boreholes should:

- be drilled at the approximate (!) locations indicated in Figure 9.1 and given in Table 9.2.
- be accurately sited based on ground geophysics.
- be drilled to a depth of 40 m or the bottom of the weathered zone (plus 5 m into un-weathered rocks).
- be drilled with a final completion diameter (uPVC) of at least 165 mm (to allow for pumping equipment)
- be designed so that they can be equipped with a pump (i.e. suitable gravel pack, slotted casing and secure surface layout)

The recommendations above enable the monitoring boreholes to be transformed into abstraction/scavenger boreholes should environmentally critical concentration thresholds be breached in the future. It goes without saying that any proposed abstraction must be preceded by an application to the Department of Water and Sanitation for the required permissions.

10. CONCLUSION AND RECOMMENDATIONS

Delta H (Delta-H Water System Modelling Pty Ltd) was appointed by Water Hunters CC, in turn appointed by Ergo Mining Pty Ltd, a subsidiary of DRDGOLD Limited,, to develop a three-dimensional numerical groundwater flow and transport model for the Brakpan-Withok Tailings Storage Facility (TSF) complex, in order to assesses its impacts on the ambient groundwater environment.

Deposition onto the unlined existing Brakpan TSF, partially underlain by dolomitic rocks, started in 1985 and, due to highly concentrated tailings liquor, an extensive seepage plume developed. The seepage plume has already reached the nearby Withokspruit stream, with a high likelihood of off-site migration via the surface drainages. To manage the impact, DRD Gold installed a scavenger well system for hydraulic plume containment on the downstream side of the Brakpan TSF.

A three-dimensional numerical groundwater flow and transport model was developed to quantify the impacts of the current and future seepage plume emanating from the unlined Brakpan TSF and the (class C) lined Withok TSF extension on the underlying aquifer during the life of the facility (approximately 24.5 years) and 50 years post closure. The model was also used to evaluate the efficiency of the currently installed scavenger well system in the mitigation of impacts.

The seepage plume emanating from the Brakpan-Withok TSF complex is primarily associated with the Brakpan TSF. The lined Withok expansion reduces essentially the recharge over its footprint, which leads to less dilution of the existing Brakpan seepage plume and thereby an increase in its concentrations. The seepage contributions from the Withok TSF extension are on the other hand negligible.

While the scavenger well system is predicted to achieve a significant reduction in plume extent and concentrations during the life of the facility and post closure, the wide spacing of scavenger wells at the northern edge of the Brakpan TSF allows parts of the seepage plume to bypass the hydraulic containment system and continue to impact onto the Withokspruit. The drilling of three additional monitoring boreholes at this edge of the existing Brakpan TSF as well as one on its south-western and south-eastern edges is recommended. Depending on encountered concentrations, the monitoring boreholes should be converted into scavenger wells.

The model predictions were formally classified as class 1 or low confidence. To increase the confidence level, the model predictions should be updated biennially as monitoring data (water level and qualities) during the operation of the scavenger well system becomes available.

11. REFERENCES

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12. DECLARATION BY THE SPECIALIST

I, Kai Thorsten Witthueser, declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. "the Protocols") and in Government Notice No. 1150 of 30 October 2020.
- I performed 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 the specialist report relevant to this application (see CV in Appendix B), 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 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;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of section 24F of the NEMA Act.

Delta-H Water System Modelling Pty Ltd (Delta H)

29 Nov 2024

13. DISCLAIMER

Delta-H Water System Modelling Pty Ltd (Delta H) has executed this study along professional and thorough guideline, within their scope of work. The specialist report has been compiled by an experienced, fully qualified, and duly registered Professional Natural Scientist.

No representation or warranty with respect to the information, forecasts, opinions contained in either this report nor the documents and information provided to Delta H is given or implied. Delta H does not accept any liability whatsoever for any loss or damage, however arising, which may directly or indirectly result from its use. This report is intended for confidential usage of the client. It may be used for any lawful purpose but cannot be reproduced, excerpted or quoted except with prior written approval of Delta H.

APPENDIX A – Model Confidence Classification (Barnett et al. 2012)

Confidence level classification	*Data*	*Calibration*	*Prediction*	*Key indicator*	*Examples of specific uses*
Class 3	• Spatial and temporal distribution of groundwater head observations adequately define groundwater behaviour, especially in areas of greatest interest and where outcomes are to be reported. • Spatial distribution of bore logs and associated stratigraphic interpretations clearly define aquifer geometry. • Reliable metered groundwater extraction and injection data is available. • Rainfall and evaporation data is available. • Aquifer-testing data to define key parameters. • Streamflow and stage measurements are available with reliable baseflow estimates at a number of points. • Reliable land-use and soil-mapping data available. • Reliable irrigation application data (where relevant) is available. • Good quality and adequate spatial coverage of digital elevation model to define ground surface elevation.	• Adequate validation* is demonstrated. • Scaled RMS error (refer Chapter 5) or other calibration statistics are acceptable. • Long-term trends are adequately replicated where these are important. • Seasonal fluctuations are adequately replicated where these are important. • Transient calibration is current, i.e. uses recent data. • Model is calibrated to heads and fluxes. • Observations of the key modelling outcomes dataset is used in calibration.	• Length of predictive model is not excessive compared to length of calibration period. • Temporal discretisation used in the predictive model is consistent with the transient calibration. • Level and type of stresses included in the predictive model are within the range of those used in the transient calibration. • Model validation* suggests calibration is appropriate for locations and/or times outside the calibration model. • Steady-state predictions used when the model is calibrated in steady-state only.	• Key calibration statistics are acceptable and meet agreed targets. • Model predictive time frame is less than 3 times the duration of transient calibration. • Stresses are not more than 2 times greater than those included in calibration. • Temporal discretisation in predictive model is the same as that used in calibration. • Mass balance closure error is less than 0.5% of total. • Model parameters consistent with conceptualisation. • Appropriate computational methods used with appropriate spatial discretisation to model the problem. • The model has been reviewed and deemed fit for purpose by an experienced, independent hydrogeologist with modelling experience.	• Suitable for predicting groundwater responses to arbitrary changes in applied stress or hydrological conditions anywhere within the model domain. • Provide information for sustainable yield assessments for high-value regional aquifer systems. • Evaluation and management of potentially high-risk impacts. • Can be used to design complex mine-dewatering schemes, salt-interception schemes or water-allocation plans. • Simulating the interaction between groundwater and surface water bodies to a level of reliability required for dynamic linkage to surface water models. • Assessment of complex, large-scale solute transport processes.
Class 2	• Groundwater head observations and bore logs are available but may not provide adequate coverage throughout the model	• Validation* is either not undertaken or is not demonstrated for the full model domain.	• Transient calibration over a short time frame compared to that of prediction.	• Key calibration statistics suggest poor calibration in parts of the model domain. • Model predictive time frame is between 3 and 10 times the duration of transient	• Prediction of impacts of proposed developments in medium value aquifers. • Evaluation and management of

Confidence level classification	*Data*	*Calibration*	*Prediction*	*Key indicator*	*Examples of specific uses*
	domain. • Metered groundwater-extraction data may be available but spatial and temporal coverage may not be extensive. • Streamflow data and baseflow estimates available at a few points. • Reliable irrigation-application data available in part of the area or for part of the model duration.	• Calibration statistics are generally reasonable but may suggest significant errors in parts of the model domain(s). • Long-term trends not replicated in all parts of the model domain. • Transient calibration to historic data but not extending to the present day. • Seasonal fluctuations not adequately replicated in all parts of the model domain. • Observations of the key modelling outcome data set are not used in calibration.	• Temporal discretisation used in the predictive model is different from that used in transient calibration. • Level and type of stresses included in the predictive model are outside the range of those used in the transient calibration. • Validation* suggests relatively poor match to observations when calibration data is extended in time and/or space.	calibration. • Stresses are between 2 and 5 times greater than those included in calibration. • Temporal discretisation in predictive model is not the same as that used in calibration. • Mass balance closure error is less than 1% of total. • Not all model parameters consistent with conceptualisation. • Spatial refinement too coarse in key parts of the model domain. • The model has been reviewed and deemed fit for purpose by an independent hydrogeologist.	medium risk impacts. • Providing estimates of dewatering requirements for mines and excavations and the associated impacts. • Designing groundwater management schemes such as managed aquifer recharge, salinity management schemes and infiltration basins. • Estimating distance of travel of contamination through particle-tracking methods. Defining water source protection zones.
Class 1	• Few or poorly distributed existing wells from which to obtain reliable groundwater and geological information. • Observations and measurements unavailable or sparsely distributed in areas of greatest interest. • No available records of metered groundwater extraction or injection. • Climate data only available from relatively remote locations. • Little or no useful data on land-use, soils or river flows and stage elevations.	• No calibration is possible. • Calibration illustrates unacceptable levels of error especially in key areas. • Calibration is based on an inadequate distribution of data. • Calibration only to datasets other than that required for prediction.	• Predictive model time frame far exceeds that of calibration. • Temporal discretisation is different to that of calibration. • Transient predictions are made when calibration is in steady state only. • Model validation* suggests unacceptable errors when calibration dataset is extended in time and/or space.	• Model is uncalibrated or key calibration statistics do not meet agreed targets. • Model predictive time frame is more than 10 times longer than transient calibration period. • Stresses in predictions are more than 5 times higher than those in calibration. • Stress period or calculation interval is different from that used in calibration. • Transient predictions made but calibration in steady state only. • Cumulative mass-balance closure error exceeds 1% or exceeds 5% at any given calculation time. • Model parameters outside the range expected by the conceptualisation with no further justification. • Unsuitable spatial or temporal discretisation. • The model has not been reviewed.	• Design observation bore array for pumping tests. • Predicting long-term impacts of proposed developments in low-value aquifers. • Estimating impacts of low-risk developments. • Understanding groundwater flow processes under various hypothetical conditions. • Provide first-pass estimates of extraction volumes and rates required for mine dewatering. • Developing coarse relationships between groundwater extraction locations and rates and associated impacts. • As a starting point on which to develop higher class models as more data is collected and used.

APPENDIX B – CV OF SPECIALIST

Dr Kai Thorsten Witthüser

Director, Affiliated Professor (UFS)

Qualifications

Diplom-Geograph (M.Sc. equiv.)	1996	Ruhr-University of Bochum (Germany)
Dr. rer. nat. Hydrogeology (summa cum laude)	2001	University of Karlsruhe (Germany)

Areas of Expertise

Hydrogeological modelling	Finite-Difference(MODFLOW) and Finite-Element (SPRING) modelling of groundwater flow and contaminant transport
Geochemical modelling	Reactive transport modelling using PhreeqC, MT3DMS and SPRING
Environmental impact assessments	Groundwater related specialist input to EIA processes
ARD assessment	Assessment of acid rock drainage potential and development of ARD management strategies and plans
Fractured and Karst aquifers	Hydrogeological and hydrochemical characterisation of complex aquifer systems

Summary of Experience and Capability

Prof Dr Kai Witthüser has more than 24 years of experience in hydrogeology, specialising in mining related environmental impact assessments, hydrogeological and geochemical modelling. Kai lectured at the University of Bonn (Germany, 3 years) and Pretoria (South Africa, 5 years), before joining Water Geosciences Consulting as a director and groundwater specialist in 2006 (the company merged later with Metago and SLR Africa) and starting Delta h Water Systems Modelling in 2012. He is Affiliated Professor at the Institute for Groundwater Studies, University of the Free State since 2009. Countries of work experience include Austria, Benin, Botswana, Democratic Republic of Congo, Denmark, Germany, Ghana, India, Israel, Morocco, Namibia, Slovenia, South Africa, Tanzania and Zimbabwe.

Professional Registrations and Affiliations

Professional Registered Scientist (SACNASP) PrSciNat Reg Nr. 400184/07 Geological Science
Member of the International Mine Water Association
Member of the Geological Society of South Africa
Member of the Groundwater Division of South Africa

Recent Project Experience

Project	Date	Task
Various Platinum Mines in the Bushveld Igneous Complex	2006 - Ongoing	Groundwater flow (mine inflows) and contaminant transport modelling, ARD assessment, Impact assessment
Evander Goldfields	2010 -2013	ARD assessment, groundwater flow (mine dewatering and flooding) and contaminant transport modelling (TSF), Impact assessment
Various Projects (Gold and copper mines) in the DRC	2009 -2013	ARD assessment and management plan, groundwater flow (pit inflow) and contaminant transport modelling (TSF), Impact assessment
Mkuju River Project (Uranium mine,	2009 -2012	ARD assessment, Groundwater flow (pit inflows, water supply) and

Project	Date	Task
Tanzania)		contaminant transport modelling (TSF, leach pads), Impact assessment
Sebata Institute (Pty) Ltd	2012	Review of technical reports
SLR Consulting (Canada) Ltd	2011 - 2012	External adequacy reviews of groundwater components of mining applications to the Yukon Department of Environment
Impala Rustenburg	2011 -2014	Geochemical assessment, Groundwater flow (underground mine inflows) and contaminant transport modelling (TSF), closure scenarios, Cumulative impact assessment, specialist input for water use licence
Impala Rustenburg	2014 - 2022	Compilation of quarterly surface water and annual groundwater monitoring reports
Palla Road Well Field Model (Botswana)	2012 -2012	Groundwater flow (well field) model, staff training
Golden Star Prestea Project, Gold (Ghana)	2012	Environmental Impact assessment (sub-contracted by Golder Associates Africa)
Gautrain Water Ingress Dispute	2012 -2013	Expert witness for Norton Rose / Bombela Concession Company (Pty) Ltd
New Largo Mine	2013 -2014	Groundwater flow model to assess mining related impacts on groundwater dependent wetlands
Yzermyn Coal Mine	2013 -2014	Groundwater flow (underground mine inflows) and contaminant transport modelling, ARD assessment, Impact assessment
Der Brochen Mine	2013 -2014	Groundwater flow (underground mine) and contaminant transport (TSF) modelling, ARD assessment, Impact assessment
Kalumbila Minerals	2013 -2017	ARD assessments for several mining projects
Inkomati Water Management Area	2014 -2015	Determination of water resource classes and quality objectives
Shondoni Mine	2014 -2015	Contaminant transport model (TSF) and AMD treatment options
Balgray Coal Mine	2014 -2015	Groundwater flow and contaminant transport modelling, ARD assessment, Impact assessment
New Vaal Colliery	2014 -2015	Groundwater modelling and water management plan
Moropule Coal Mine (Botswana)	2014 -2017	Groundwater flow and contaminant transport modelling, ARD assessment, Impact assessment
Sustainability Indicators and Decision Framework for Sustainable Groundwater Use	2014 - 2017	Developing a framework for the management of groundwater resources
Mafube Coal Mine	2015	Groundwater and geochemical modelling for closure scenarios
Wafi-Golpu – Pre-Feasibility Study	2015	Hydrogeological review, groundwater flow and transport model for LoM and post-closure, geothermal model.
Koeberg Nuclear Power Station	2015 -2016	Groundwater flow and transport model to optimise groundwater monitoring network
Water Sensitive Urban Design Scenario Planning for Cape Town	2015 - 2016	Groundwater flow and hydrological model for urban area to assess impacts of WSUD
Upper Vaal Catchment	2015 - 2016	Groundwater and surface water interaction model for the protection of the water resource in the Upper Vaal Catchment
SACE Complex	2016 - 2017	Groundwater and geochemical modelling for closure scenarios
Goedehoop Colliery	2016- 2017	Post closure groundwater and geochemical modelling
Strategic Water Source Areas of South Africa Lesotho and Swaziland for both Surface Runoff and Groundwater	2015 - 2017	Identification, delineation and description of Strategic Groundwater Source Areas (sub-contacted by CSIR)
Tutuka Power Station	2017 - 2018	Source-Pathway-Receptor Study for Eskom's Tutuka Power Station,
Unki Mine	2017 - 2018, 2020	Groundwater and geochemical modelling for impact assessment
Urban groundwater development and management	2017 - 2019	Research project to assess the state of urban groundwater management, development of high-level innovative technical solutions for groundwater use in urban settings
Twickenham Platinum Mine	2018	Groundwater modelling for the prediction of life of mine inflows, abstraction scenarios and post closure water table rebound
Grootgeluk Colliery	2018 -2019	Geochemical assessment and modelling of mine water qualities
New Denmark Colliery	2018	Groundwater and geochemical modelling for the prediction of life of mine and post closure decant and water qualities
SACE Lifex	2019 - 2021	Groundwater modelling for the prediction of life of mine and post closure decant, including updates
Elders Colliery	2019 -	Groundwater and geochemical modelling for the prediction of life of mine

Project	Date	Task
	2020	and post closure decant and water qualities
Arnot Colliery	2019	Geochemical modelling of mine water qualities
Feasibility study for managed aquifer recharge at Palla Road Wellfield	2019 - 2022	Groundwater modelling, geochemical assessment
Far West Rand Tailings Retreatment Project	2019 - 2022	Groundwater flow and transport model, geochemical assessment
Far West Rand Regional Tailings Facility	2019 - 2022	3D Seepage model
Doha Port Diving Pool	2019 - 2020	Dewatering model
Damac Golf Course Dubai	2019 - 2020	Groundwater flow and dewatering model
Mafube Colliery Mine Residue Project	2019 - 2024	Groundwater flow and transport model, geochemical model
Landau 3 Mine Residue Deposit	2020	Groundwater transport model for dump reclamation
Greenside Mine Residue Deposit	2020 - 2021	Groundwater transport model for dump reclamation and rehabilitation
Araren Pit Toka project, Indonesia	2020 - ongoing	Groundwater dewatering model with consideration of discrete fractures
Bokgoni Colliery	2021	Groundwater flow and transport model
Elandsfontein Phosphate Mine	2022 - ongoing	Groundwater flow model
Elders Colliery	2023	Groundwater flow and transport model to evaluate irrigation with mine water
Goldfields Irrigation Study	2022 - ongoing	Regional groundwater flow and transport model to evaluate large-scale irrigation with mine waters
Natal Anthracite Coal	2022 - ongoing	Conceptual and numerical groundwater and geochemical model for mine closure
Ncojane Wellfield	2022 - 2024	Groundwater flow model for wellfield management
Booysendal TSF	2023 - 2024	3D seepage model, groundwater flow and transport model, geochemical assessment
Vryheid Coronation Colliery	2023-2024	Conceptual and numerical groundwater and geochemical model for mine closure
Far West Rand Regional Tailings Storage Facility	2019 - 2024	3D seepage model, groundwater flow and transport model, geochemical assessment

Earlier Project Experience

During his employment with Water Geosciences Consulting (the company merged later with Metago and SLR Africa), Kai was involved in numerous other modelling and/or geochemical assessment projects:

- African Barrick Gold, groundwater flow and contaminant transport model, ARD assessment Golden Ridge Mine (TZ)
- African Barrick Gold, groundwater flow and contaminant transport model, ARD assessment Tulawaka Mine (TZ)
- African Barrick Gold, audit of monitoring and sampling practice at North Mara Mine, Tanzania (TZ)
- Zimplats, ARD assessment Ngezi Mine (ZW)
- Swakopmund Uranium, Geochemistry assessment, Langer Heinrich Mine (NAM)
- Extract Resources, ARD assessment, Husab Mine (NAM)
- Gold Fields Ghana, groundwater flow and contaminant transport model, Tarkwa Mine (GH)
- Banro, groundwater flow and contaminant transport model, ARD assessment, Development of an ARD management plan, Twangiza Mine (DRC)
- Metorex, ARD assessment Kinsenda Copper Mine (DRC)
- Angloplat, Amandelbult, integrated groundwater management (ZA)
- Elands, groundwater flow and contaminant transport model, Tharisa Mine (ZA)

- EastPlats, regional groundwater model for the Brits area (ZA)
- La Repose Resort Development, groundwater flow (salt water intrusion) model, (ZA)
- Heineken, groundwater flow and contaminant transport model, Meyerton brewery (ZA)
- Eastern Platinum, groundwater flow and contaminant transport model, Spitskop Mine (ZA)
- NCMC, groundwater flow and contaminant transport model, Ntsimbintle Mine (ZA)
- EastPlats, groundwater flow model Crocette Mine (ZA)
- Aquarius Platinum, groundwater flow and contaminant transport model Everest Mine (ZA)

Publications (Books and peer reviewed journals only)

Hötzl, H. & Witthüser, K. (1999): *Methoden für die Beschreibung der Grundwasserbeschaffenheit*. DVWK Schriften 125; Bonn (Wirtschafts- und Verl.-Ges. Gas und Wasser), Germany.

Witthüser, K. & Cencur Curk, B. (2000): Groundwater pollution by contaminant transport from soil to fractured rock. *Acta Carsologica* 29/1 (13): 173 – 181.

Witthüser, K., Reichert, B. & Hötzl, H. (2002): Contaminant transport in fractured chalk: Laboratory and field experiments. *Ground Water* 41 (6): 806 – 815.

Witthüser, K. (2002): *Untersuchungen zum Stofftransport in geklüfteten Festgesteinen unter besonderer Berücksichtigung der Matrixdiffusion*. Schr. Angew. Geol. Karlsruhe 64: 145 pages; Karlsruhe, Germany.

Witthüser K, Weede M, Thüringer C & Hötzl H, Dietrich P, Helmig R, Sauter M, Köngeter J & Teutsch G (2005): Characterization of the Rock- Matrix and Fracture-System in flow and transport in fractured porous media. In: Dietrich P, Helmig R, Sauter M, Hötzl H, Köngeter J, Teutsch G (Eds) - *Flow and Transport in Fractured Porous Media*, 223-235, Springer, Berlin, Heidelberg, New York.

Witthüser, K., Arnepalli, D. & Singh, D.N. (2006): Investigations on diffusion characteristics of granite and chalk rock mass. Geotechnical and Geological Engineering 24(2): 325 – 334.

Leyland, R.C. & Witthüser, K.T. (2008): *Regional description of the groundwater chemistry of the Kruger National Park*. WRC Report No. KV 211/08, Water Research Commission, Pretoria.

Van Rooy, J.L. & Witthüser, K.T., (2008). Vulnerability and risk in Karst terrains. Problem Soils in South Africa. Geotechnical Division SAICE & SAIEG. 3 – 4 November. Pretoria. South Africa.

Holland, M. & Witthüser, K.T. (2009). Geochemical characterization of karst groundwater in the Cradle of Humankind World Heritage Site. *Environmental Geology* 57 (3), pp.513

Dippenaar, M.A., Witthüser, K.T. & Van Rooy, J.L. (2009): Groundwater occurrence in Basement aquifers in Limpopo Province, South Africa: model-setting-scenario approach. *Environmental Earth Science* 59 (2): 459 – 464.

Witthüser, K.T, Leyland, R.C. & Holland, M (2010). Vulnerability of dolomite aquifers in South Africa. In: Xu, Y and Braune, E. *Sustainable groundwater resources in Africa. Water supply and sanitation environment*. UNESCO. CRC Press, France.

Van Wyk, Y. & Witthüser, K.T (2011): A Forced-Gradient tracer test on the Hansrivier Dyke: Beaufort West, South Africa. *Water SA* 37 (4): 437 – 444.

Witthüser K.T.; Holland M.; Rossouw T.G.; Rambau E.; Bumby A.J.; Petzer K.J.; Dennis I.; Beekman H.; van Rooy J.L.; Dippenaar M.A. & de Wet L.M. (2011). Hydrogeology of Basement aquifers in the Limpopo Province. Water Research Commission, Report No.1693/1/10, Pretoria.

Holland, M. & Witthüser, K.T. (2011). Evaluation of geologic and geomorphologic influences on borehole productivity in crystalline bedrock aquifers of Limpopo Province, South Africa. Hydrogeology Journal, 19: 1065 – 1083.

Abdalla, F.A., Reichert, B. & Witthueser, K. (2011). Anthropogenic contaminants as tracers in fractured chalk aquifer: Transport mechanisms and analytical modeling. Arabian Journal of Geosciences 4(5): 755 – 762.

Dennis, I., Witthueser, K., Vivier, K., Dennis, R. & Mavurayi, A. (2012). *Groundwater Resource Directed Measures*. Water Research Commission Report No. TT506/12, Pretoria.

Witthüser K.T. & König, C.M. (2013). Numerical modelling techniques for fractured aquifers and flooding of mines. In: Cobbing et al. *Assessing and Managing Groundwater in Different Environments*. IAH Selected Papers 19. CRC Press, London.

Witthüser K.T., Holland M., Seidel T. & König, C.M. (2015). Numerical Modelling of Mine Dewatering and Flooding in the Evander Gold Basin, South Africa. South African Journal of Geology, Vol. 118.1:71 – 83 (http://dx.doi.org/10.2113/gssajg.118.1.71).

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Seiler, H., Bollaert, M. & Witthüser, K. (2016). Regional Water Sensitive Design Scenario Planning for Cape Town using an Urban (Geo)hydrology Model. Water Research Commission Report No. TT 708/16, Pretoria.

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Seyler, H., Witthüser, K. Sunaitis, M. (2019). Urban Groundwater Development and Management. Water Research Commission Report No. 2741/1/19, ISBN: 978-0-6392-0089-7, Pretoria.

Seyler, H., Gibson, K., Kanyama, Y., Witthueser, K. (2020). Machine Learning Models for Groundwater Availability – Incorporating a Framework for a Sustainable Groundwater Strategy. Prepared by Delta-h Groundwater Systems for the Water Research Commission. WRC Project K5/2879.