

Simulation of water quality from North Pit, Volspruit Mine

Updated Report - FINAL

28 September 2026

Mills Water



Specialist Declaration

SPECIALIST INFORMATION

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DECLARATION BY THE SPECIALIST

I, Meris Mills, declare that –

- I act as an independent specialist;
- I will perform the work 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 Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to my client all material information in my possession that reasonably has or may have the potential of influencing –
 - any decision to be taken by the competent authority; and;
 - the objectivity of any report, plan or document to be prepared by myself for submission to a competent authority;
- All the particulars furnished by me in this form are true and correct.

Signature of the specialist

Mills Water

2026/09/25

Name of company

Date

DR MERIS MILLS

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Overview

I have more than 20 years of experience in the field of environmental geochemistry and have worked with mining clients across a range of commodities and geographies. My background in geology and environmental chemistry, combined with experience in mining and laboratory quality management, has given me a thorough understanding of water-rock interaction in the mining environment, geological controls on water movement and water quality, and the nuances of interpreting environmental geochemical testing data. I specialize in geochemical assessments for mine residue materials, geochemical modelling, environmental data interpretation, data management, environmental database design, and reporting.

Work Experience

- **Acid rock drainage and metal leaching investigations** for base metals, PGEs, coal, uranium, diamonds, graphite, iron ore, and gold.
 - **Development of geochemical models** using Phreeqci for predicting acid rock drainage and metal leaching, and calculating source terms.
 - **Review of water quality monitoring programs** for large mining facilities.
 - **Interpretation of groundwater and surface water chemistry** for large mining facilities.
 - **Development of conceptual site models** for complex sites.
 - **Due diligence audits** of mines, specialising in water-related issues.
-

Key Projects

- **2026:** Geochemical assessment of the source of ARD associated with a TSF at a copper and nickel mining operation in Zambia.
- **2023 - 2025:** Geochemical assessment and modelling of ARD and ML risks related to mine residue facilities at a copper mine in Zambia.
- **2025:** Geochemical assessment for a graphite mine in Madagascar.
- **2024:** Baseline geochemical assessment and modelling for a multi-pit uranium mine in Zambia.

- **2024:** Development of sampling plan and interpretation of data for four zinc mines in India to provide high level risk assessment in terms of ARD and ML potential.
- **2024:** Interpretation of geochemical data from tailings and waste rock from a chromium mine in South Africa to identify potential contamination risks related to mine residue management.
- **2023:** Provided geochemical insights into the process of selecting waste rock for construction of a TSF embankment at a copper mine in Zambia.
- **2022:** Long-term pit lake water quality modelling for a platinum mine in South Africa.
- **2020:** Geochemical modelling for a platinum mine pit in South Africa.

Employment

- **2015–2026:** Independent Consultant specializing in Environmental Geochemistry.
- **2006–2015:** Senior/Principal Consultant at Environmental Resources Management, Cape Town.
- **2001–2005:** Lecturer at University of Cape Town, Geology Department.
- **1997–1998:** Student Geologist, Gold Fields of South Africa.

Education

- **PhD (Geology)**, University of Cape Town, 2006.
- **MSc (Environmental Geochemistry)**, University of Cape Town, 2001.
- **BSc Honours (Geology)**, University of the Witwatersrand, 1996.
- **BSc (Geology & Advanced Earth Sciences)**, University of the Witwatersrand, 1995.

Professional Registration and Memberships

- Registered Natural Professional Scientist (PrSciNat) with the South African Council for Natural Scientific Professions (Reg. No: 400078/07).
- Member of the Ground Water Division, Geological Society of South Africa.

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List of acronyms and abbreviations

Acronym / abbreviation	Definition
ABA	Acid Base Accounting
AP	Acid potential
APHA	American Public Health Association
ARD	Acid rock drainage
As	Arsenic
bdl	Below detection limit
BH	Borehole
CBE	Charge balance error
COC	Chemical of concern
Cr(III)	Trivalent chromium
CrT	Total chromium

Cr(VI)	Hexavalent chromium
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical conductivity
IGS	Institute for Groundwater Studies
LCT	Leachable concentration threshold
MAP	Mean annual precipitation
NAG	Net acid generation
NEM:WA	National Environmental Management: Waste Act
NNP	Net neutralisation potential
NP	Neutralisation potential
NPR	Neutralisation potential ratio
PAG	Potentially acid generating
PGE	Platinum group element
Q-a	Alluvium
RLS	Rustenburg Layered Suite
RPD	Relative percentage difference
RSD	Relative standard deviation
SABS	South African Bureau of Standards
SANS	South African National Standard
TDS	Total dissolved solids
TWQR	Target water quality range
Vld1	Transvaal Supergroup Lydenburg Shale
Vme	RLS Main Zone
Vmg	Transvaal Supergroup Magaliesberg Formation
Vmn	RLS Upper Zone
Vzo	RLS Lower Zone
WHO	World Health Organization
WR	Waste rock
WULA	Water Use Licence Application
XRD	X-ray diffraction
XRF	X-ray fluorescence

1. Introduction

Mills Water was appointed by Volspruit Mining Company (Pty) Ltd to assess the potential for using groundwater inflow into an open pit of the proposed Volspruit Mine for irrigation purposes.

The Volspruit Mine is located approximately 15 km south of Mokopane in the Limpopo Province and will consist of two shallow open pits (North Pit and South Pit) targeting platinum group elements (PGEs). The current land use is farming with extensive irrigation. As part of the Water Use Licence Application (WULA), the Department of Water and Sanitation (DWS) has requested geochemical modelling be undertaken to simulate the quality of the water that would be expected in the sump of the open pit during operation, and in the backfilled pit post-closure, with the view to assessing the potential for use of the water for irrigation.

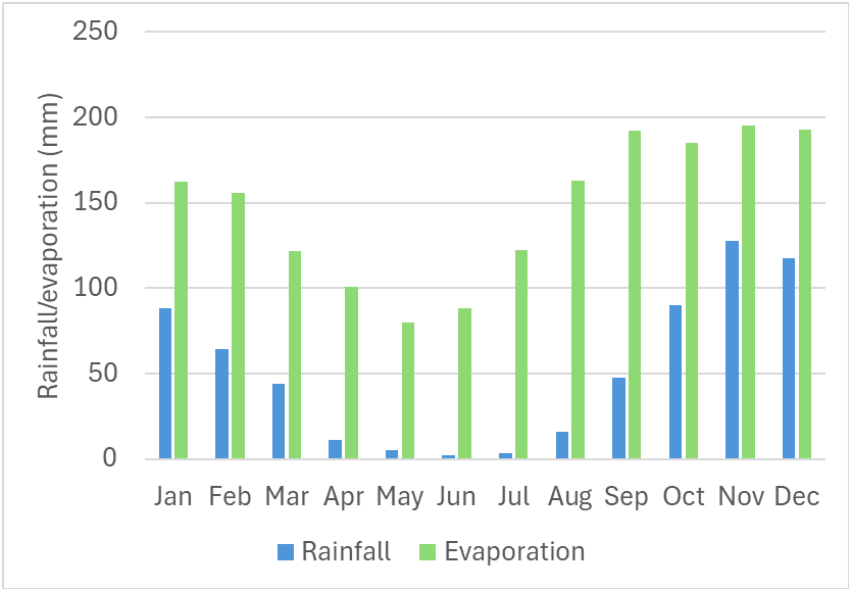
A groundwater specialist study has been completed which includes a record of groundwater use in the vicinity of the mine, conceptual and numerical models of the hydrogeological system, assessment of the impacts of mining on groundwater drawdown, and simulation of plume migration from mining related sources including the tailings storage facility (TSF), waste rock dump (WRD) and stockpiles (GPT, 2026). This report focuses exclusively on understanding the geochemical controls on baseline groundwater quality in the vicinity of the mine and simulating the geochemical evolution of water quality in the North Pit sump during operation and post-closure. The report has been updated with water quality monitoring data collected between February 2025 and August 2026.

2. Site Setting

2.1. Climate

Volspruit Mine is located in a summer rainfall area with most precipitation occurring in the form of convectional thunderstorms. Average annual rainfall calculated for the Doorndraai Dam DWS weather station over a period of 65 years is 612 mm, with almost 95% of the rain falling between October and April (GPT, 2024) (Figure 1). The mean annual precipitation (MAP) for the site was calculated as 665 mm per annum (EcoElementum, 2022). Based on NASA's MERRA-2 Modern-Era Retrospective Analysis, the average minimum temperature ranges from 6°C in June and July to 18°C between December and February, and the average maximum temperature ranges from 21°C in June and July to 29°C in January and February (Climate and Average Weather Year Round in Mokopane, 2024). Annual potential evaporation is 1740.6 mm, exceeding annual precipitation by almost three times. Potential evaporation between October and January varies from 185 to 195 mm, which is more than double the potential evaporation in May and June which is between 80 and 88 mm (EcoElementum, 2022). For a pit lake with area of 300 000 m², and typical evaporation of 0.0025 m/d, evaporation would remove 750 m³/day of water (GPT, 2024).

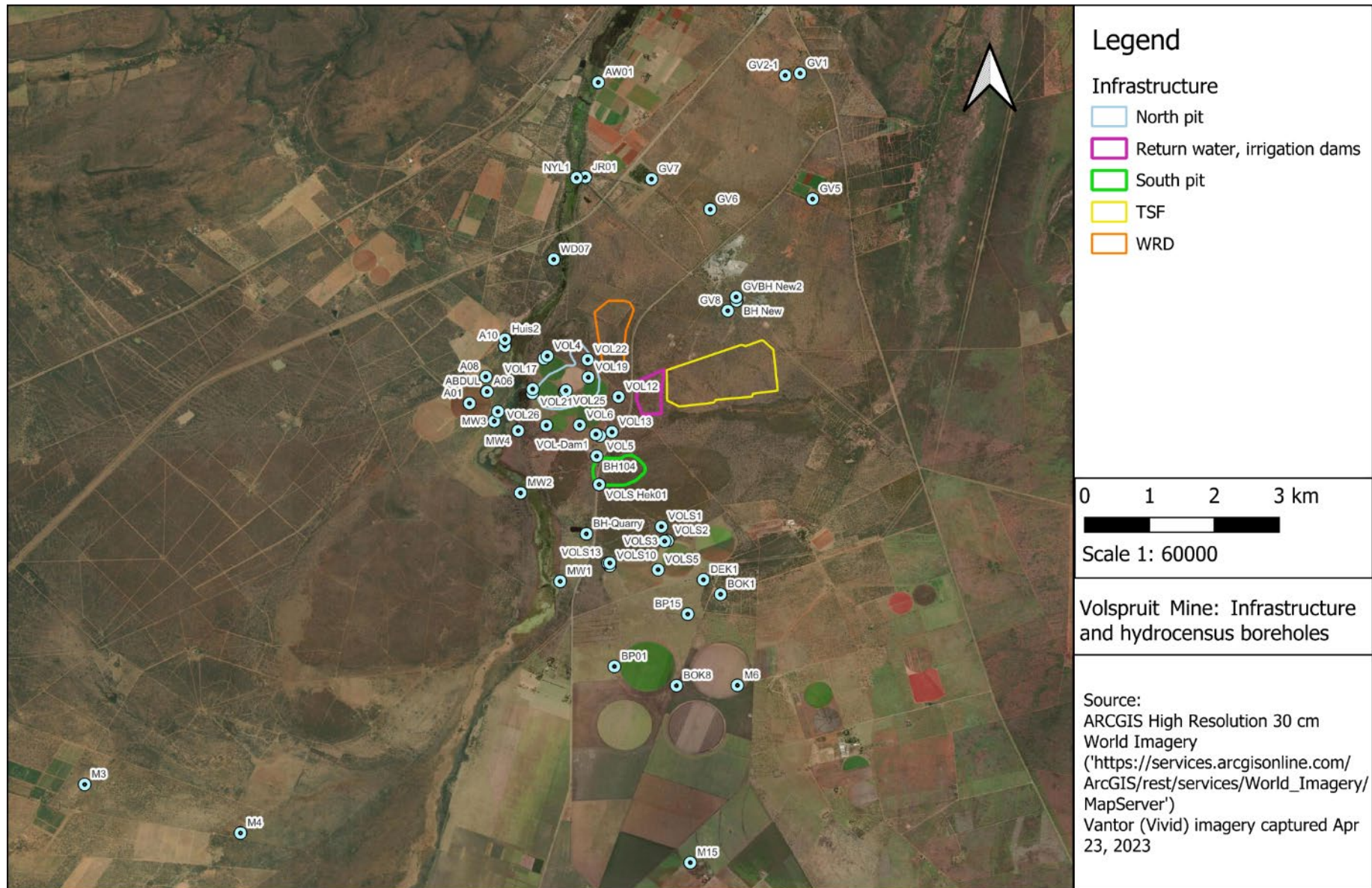
Figure 1: Average monthly rainfall and evaporation at the Doorndraai Dam weather station (EcoElementum, 2022)



2.2. Topography and Hydrology

The topography in the area of Volspruit Mine is generally flat, with a slope of 1.7° towards the Nyl River, which is located 150 m west of North Pit and 1 km west of South Pit. The Nyl River flows to the north-north-east (Figure 2).

Figure 2: Location of proposed Volspruit Mine infrastructure and hydrocensus boreholes



2.3. Geology and Mineralisation

Volspruit Mine will target PGEs and base metal sulphide mineralisation in pyroxenites of the Volspruit Pyroxenite Sub-zone of the Lower Zone of the Northern Lobe of the Rustenburg Layered Suite (RLS) of the Bushveld Complex. The surface geology of the region is shown in Figure 4.

The Lower Zone of the RLS overlies sediments of the Pretoria Group of the Transvaal Supergroup, including Magaliesberg Formation quartzites and hornfels of the Silverton Formation. These rocks form the hilly terrain approximately 5 km to the east of the mine. The Lower Zone is overlain by the Main or Critical Zone consisting of gabbro-norites and the Upper Zone, consisting of magnetite gabbros. The significant Zebedelia fault 1.5 km to the south of the South Pit has juxtaposed the RLS against basic volcanics of the Lebombo Group of the Karoo Supergroup (Council for Geoscience, 1978).

The Volspruit Pyroxenite sub-zone is overlain by the Drummondlea harzburgite-chromitite sub-zone and the Moordrift pyroxenite-harzburgite sub-zone, and is underlain by a 100 m thick zone of harzburgites. The Volspruit sub-zone is divided into numerous cycles, each one typically starting with dunites/harzburgites and followed by pyroxenites. The relatively flat-lying Volspruit PGE-Ni Reef is hosted in the pyroxenites of cyclic unit 11 and consists of fine-grained, compact, orthopyroxene and orthopyroxene-chromite with pentlandite, chalcopyrite and pyrrhotite occupying spaces between the pyroxene grains. Coarse nuggets of sulphide minerals are also present in coarse-grained to pegmatoidal feldspathic pyroxenite/norite. Fine grained disseminated and coarse-grained base metal sulphides are erratically distributed in cyclic units 10 (underlying) and 12 (overlying) (IGS, 2010). The Grasvally Chrome mine, which is located 3.5 km to the north-east of the proposed Volspruit Mine, targets chromitite layers within the upper part of the Drummondlea sub-zone.

The pyroxenites and harzburgites weather to a clayey sand residual material but this is generally <2 m thick. The weathered rocks are overlain by a thin layer of transported sandy soils (EcoElementum, 2022).

The area is heavily block faulted, with three phases of faulting being recognised. The two ore bodies (North and South) may represent fault blocks. The surrounding project area is underlain by serpentinised harzburgite. There are also intrusive acid-phase granite dykes and xenoliths of Transvaal Supergroup sediments (IGS, 2010).

2.4. Hydrogeology

Groundwater is hosted in structures associated with the various phases of faulting. The high level of fracturing of the rocks is associated with groundwater yields which regularly exceed 5 L/s. The depth of weathering and fracturing was estimated to extend to approximately 50 to 60 m bgl by GPT (2024) using information from the exploration borehole database. There appears to be a conductive zone associated with faulting at 90 to 100 m bgl, which is the depth that most irrigation boreholes target (GPT, 2024).

Groundwater is heavily utilised in the area for irrigation. A hydrocensus performed by GPT found 107 boreholes within the quaternary catchment. Water uses included pivot irrigation, potable water and livestock watering (GPT, 2024).

The depths of most of the boreholes are not known, but water levels ranged from 0.51 to 76.63 m bgl. Water levels within the proposed pit shells were between 1.6 and 13.5 m bgl with the shallowest water table closest to the Nyl River. Regional water levels indicate a relatively flat water table which is not correlated with elevation suggestive of high hydraulic conductivity (GPT, 2026).

Regional recharge is estimated at approximately 5% of mean annual rainfall. However, there is also likely to be additional recharge from irrigation and from flood events on the Nyl River. The Nyl River overlies an impermeable clay layer which prevents direct recharge from the river to groundwater. However, during flood events the Nyl River overtops its banks and fills the floodplain. The extent of the water exceeds the extent of the clay layer, and flood water is able to recharge groundwater in areas beyond the extent of the clay layer (GPT, 2026).

Groundwater flowing into the pits will need to be captured and pumped out during mining to prevent flooding of the pit. Inflowing water will be directed to a sump from where it will be pumped to surface into an irrigation dam. The amount of water estimated to require abstraction from the combined North and South pits is 3 Mm³/a at an expected rate of between 5000 and 9000 m³/day over the life of the mine (Figure 3). Most of this water is believed to originate from the upper 50 m weathered and fractured aquifer. On closure, pumping from the pits will cease. The North pit will be backfilled with waste rock, and the South Pit will remain open, ultimately forming a pit lake as groundwater levels recover. Based on the current groundwater model, surface decanting of the pits is not expected, although the water table will be close to the surface (GPT, 2024).

Figure 3: Groundwater inflow rates for the North and South Pits (Water Hunters, 2024)

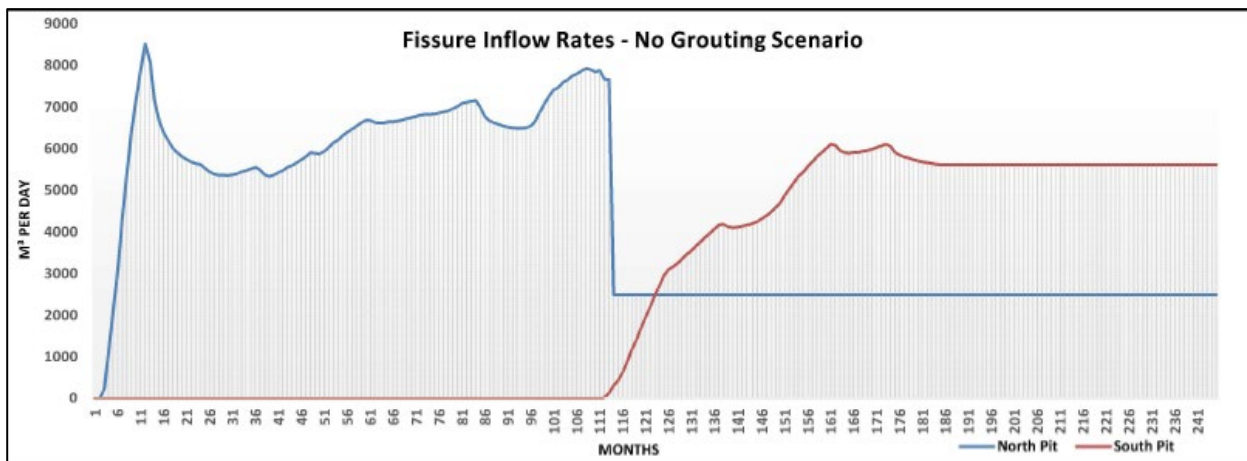
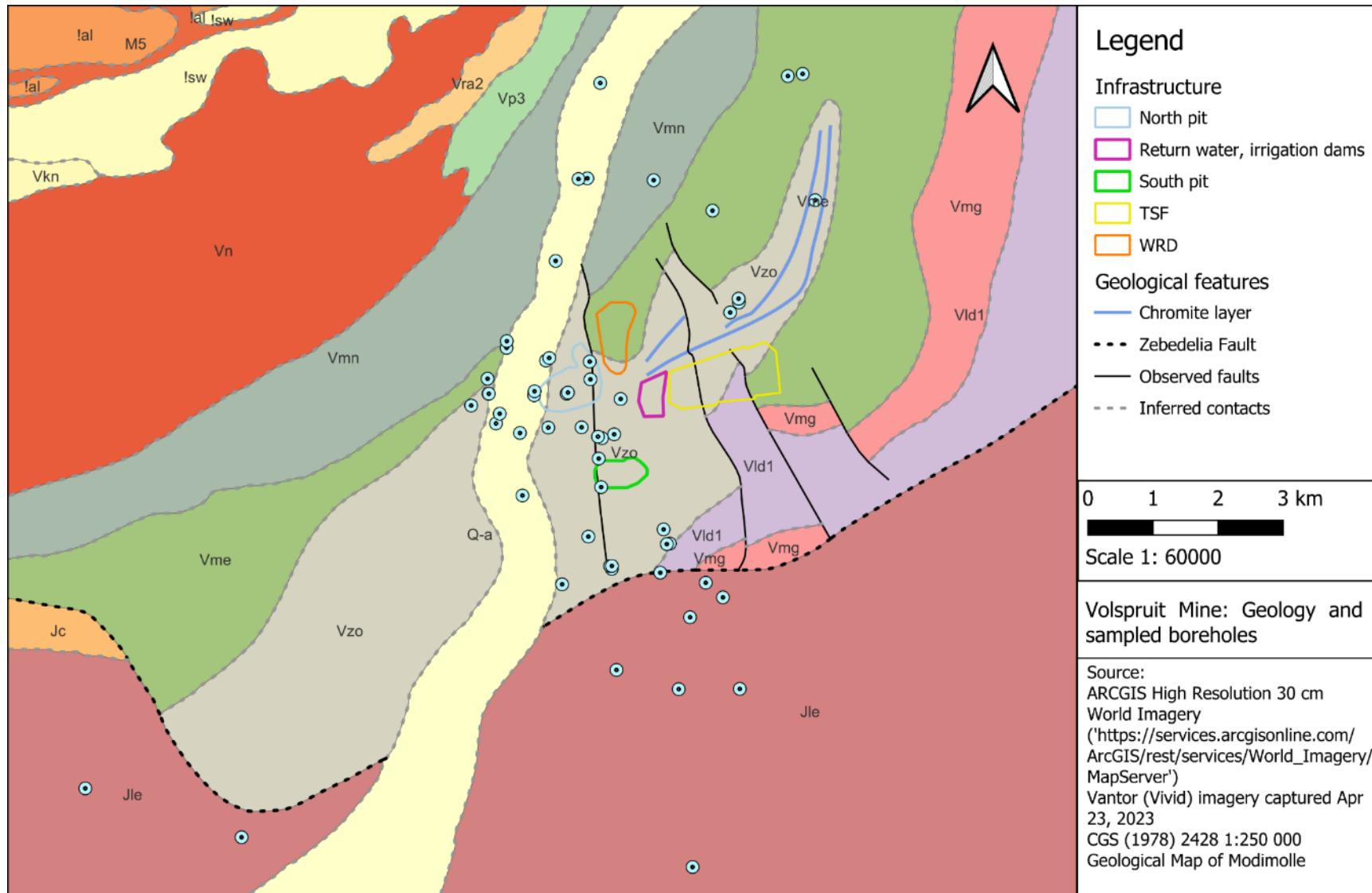


Figure 4: Location of proposed Volspruit Mine infrastructure and hydrocensus boreholes relative to regional geology. Vzo – RLS Lower Zone, Vme – RLS Main Zone, Vmn – RLS Upper Zone, Vmg – Transvaal Supergroup Magaliesberg Formation (quartzite, minor shale), Vld1 – Transvaal Supergroup Lydenburg Shale, Jle – Karoo Supergroup Letaba Formation (basic volcanic rocks), Q-a – Alluvium



3. Baseline water quality

3.1. Available data

After an initial assessment which was conducted in 2010 and 2011 (GPT, 2014), and a single sample was collected in 2020, no further water quality data were collected until GPT conducted four monitoring rounds in July 2025, November 2025, April 2026 and August 2026.

Data from the 2010/2011 surveys had the following limitations:

- Several potential contaminants of concern, including copper, nickel and chromium, were not analysed in most of the samples.
- Total alkalinity was not reported for many of the samples.

To improve the available data, the samples collected in the 2025 and 2026 monitoring rounds were analysed for the following:

- pH, electrical conductivity (EC)
- Major cations (Ca, Mg, Na, K, NH₄) and major anions (Cl, SO₄, total alkalinity, NO₃, NO₂, F)
- Trace elements (Fe, Mn, Al, As, B, Ba, Cd, Co, Cr, CrVI, Cu, Ni, Pb, Se, Si, V, Zn and Sn)

The monitoring rounds are summarised in Table 1.

Table 1: Summary of available water quality monitoring data

Monitoring round	Number of locations sampled	Analytical suite	Quality control samples
May 2010	14	pH, EC, TDS, Ca, Mg, Na, K, Cl, SO ₄ , total alkalinity, NO ₃ , Fe, Mn	1 duplicate
June 2010	6	pH, EC, TDS, Ca, Mg, Na, K, Cl, SO ₄ , total alkalinity, NO ₃ , Fe, Mn	-
July 2011	10	pH, EC, TDS, NO ₃ , NO ₂ , SO ₄ , F, Cl, Na, Zn, Sb, As, Ba, B, Cd, Cu, Cr, Fe, Pb, Mn, Hg, Ni, Se, U, Al, Sn	-
June 2020 (GPT, 2020)	1	pH, EC, TDS, NO ₃ , NO ₂ , SO ₄ , F, Cl, Na, Ca, Mg, K, Zn, Sb, As, Ba, B, Cd, Cu, Cr, Fe, Pb, Mn, Hg, Ni, Se, U, Al	-
July 2025	16	pH, EC, Ca, Mg, Na, K, NH ₄ , Cl, SO ₄ , total alkalinity, NO ₃ , NO ₂ , F, Fe, Mn, Al, As, B, Ba, Cd, Co, Cr, CrVI, Cu, Ni, Pb, Se, Si, V, Zn and Sn	1 duplicate, 3 interlaboratory comparisons
November 2025	8	pH, EC, Ca, Mg, Na, K, NH ₄ , Cl, SO ₄ , total alkalinity, NO ₃ , NO ₂ , F, Fe, Mn, Al, As, B, Ba, Cd, Co, Cr, CrVI, Cu, Ni, Pb, Se, Si, V, Zn and Sn	-
April 2026	19		
June 2026	8		
August 2026	24		

To facilitate interpretation of the water quality data, each location was assigned to a lithology based on the following information:

- The Modimolle geological map (Council for Geoscience, 1978).
- Available borehole logs for BH104, VOL17, VOL19, VOL20 and VOL21.

- The geological map presented on page 28 of the IGS geological report which shows the extent of pyroxenite and harzburgite in the Lower Zone (IGS, 2010). The extent of the pyroxenite is largely defined by the North and South pit shells.
- Major ion chemistry.

The following groups were defined and used in colour coding on graphs:

- Basic volcanics (from the Lebombo Formation of the Karoo Supergroup)
- Magnetite gabbro (from the RLS Upper zone (Vmn))
- Gabbro norite (from the RLS Main Zone (Vme))
- Harzburgite (from the RLS Lower Zone (Vzo))
- Pyroxenite (from the RLS Lower Zone (Vzo))
- Pyroxenite / harzburgite (from the RLS Lower Zone (Vzo) where no information was available to identify specific lithology)
- Harzburgite / basic volcanics – defined by water chemistry for a group of boreholes near to the Zebedelia fault that may be drawing mixed water from the fault zone or be affected by irrigation of Karoo water onto the RLS lithologies.

3.2. Data quality assessment

The quality of the available water quality data was assessed following methods outlined in Standard Methods (APHA, 1999), including:

- Comparison of measured TDS to calculated TDS:
 - acceptable range of 1.0 – 1.2
- Comparison of calculated TDS to measured EC:
 - acceptable range of 5.5 – 7.0
- Calculation of the charge balance error (CBE):
 - acceptable range of -10% to 10%
- Comparison of duplicates using relative percentage difference (RPD) or relative standard deviation (RSD):
 - If measurement is within same order of magnitude as detection limit, acceptable range is | 100% |
 - If measurement is one order of magnitude higher than detection limit, acceptable range | 50% |
 - If measurements is more than order of magnitude above the detection limit, acceptable range is | 10% |

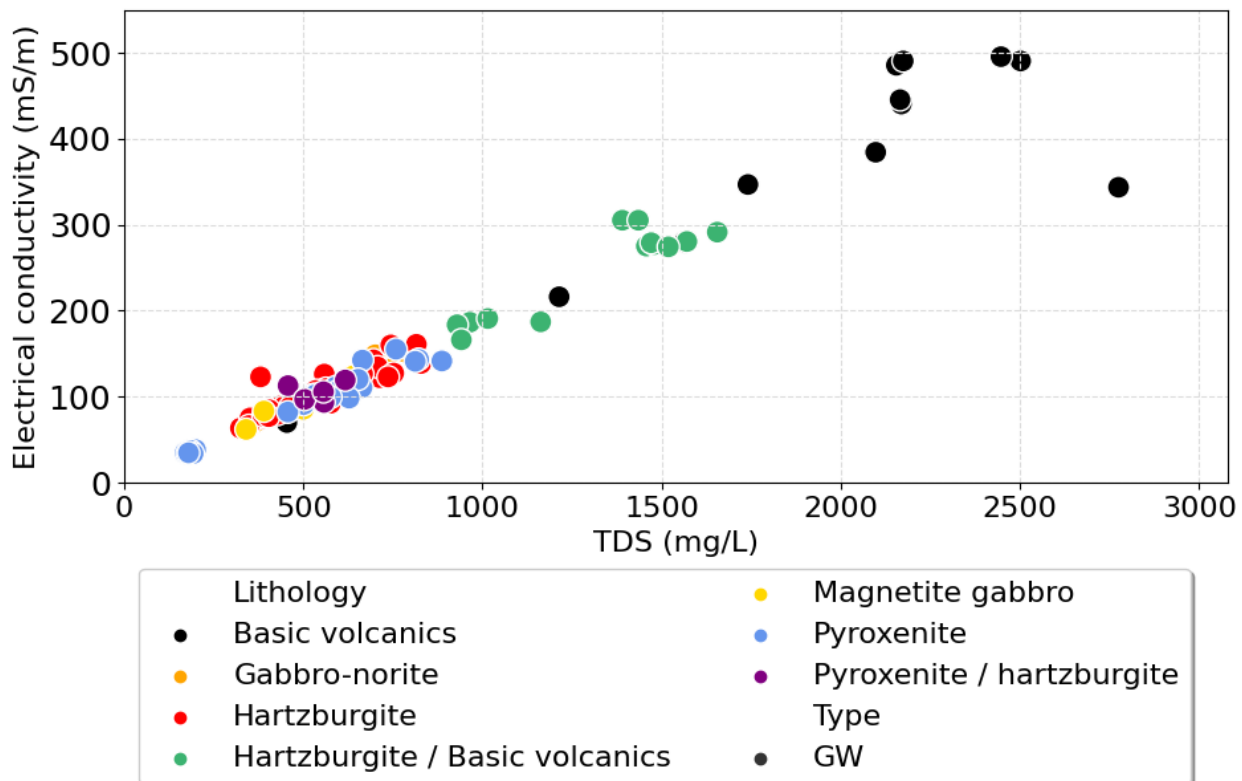
The relative percentage difference (RPD) was calculated for the duplicate sample from 2010. Most repeat analyses had an acceptable RPD, except for sulphate (20.3%), calcium (12.9%) and magnesium (13.8%). However, within the scale of variation of these parameters in water quality from the groundwater quality dataset, the difference should not affect interpretation. Samples BH New, BH-Quarry and GVBH New2 were analysed in duplicate in 2025, with the duplicate sent to a different laboratory. The RPDs of these inter-laboratory comparison samples were generally acceptable for EC, pH, total alkalinity, calcium and magnesium. Chloride RPDs were exceeded in all three samples and sulphate in two of the three samples. The RPDs for nitrogen, iron and manganese commonly exceeded the acceptable ranges. These elements can change speciation subsequent to sampling and the holding time can affect the

degree to which this happens. The data for these analytes therefore have a higher uncertainty and this will be considered during data interpretation. RPDs could not be calculated for trace elements because one or both of the measurements were below the quantification limits. It should be noted that the Waterlab quantification limits were generally lower than the EPL detection limits, often allowing reporting of measurable concentrations of analytes by Waterlab that were not quantified by EPL.

In terms of data quality assessment:

- The ratio of measured to calculated TDS was not assessed because some of the laboratory reported TDS were not measured but were calculated from the EC.
- The ratio of calculated TDS to measured EC ranged from 2.4 to 8.1. The ratio in 36 of the 108 samples was in the range 5.5 to 7.0 with most samples having a ratio of <5.5. This does not necessarily mean the data are unreliable. The ratio is dependent on the ionic composition of the sample because some ions are less conductive than others. A plot of EC against calculated TDS indicates a strong correlation (Figure 5) between EC and TDS and the data are therefore considered acceptable except for sample CG Huis which plots off the main trend. The sulphate and calcium concentrations in this sample are anomalously high, and the sample has been excluded from the dataset.
- Of the 103 samples with sufficient data to calculate the charge balance error (CBE), 101 have CBE with $|10\%|$. The two samples with $CBE < -10\%$ indicate a slight anion excess. At BH New in July 2025, the chloride concentration is elevated, but this could still be within natural variation, therefore the value is retained. The cations measured at BH104 in July 2025 are lower than on other occasions, but this could again be due to natural variation.

Figure 5: Plot of measured EC against calculated TDS



3.3. Water quality in terms of drinking water standards

Because groundwater is commonly used for domestic supply, the water quality was compared to the SANS241:2025 standards (SABS, 2025). All samples collected complied with SANS risk defined limits for pH, nitrite, zinc, barium, boron, cadmium, copper, lead, nickel and selenium. The percentage of samples exceeding the risk-defined limits for other parameters is shown in Figure 6 for macro-parameters and Figure 7 for micro-parameters.

Figure 6: Percentage of samples exceeding SANS risk defined limits (SABS, 2025) for macro-parameters by lithology

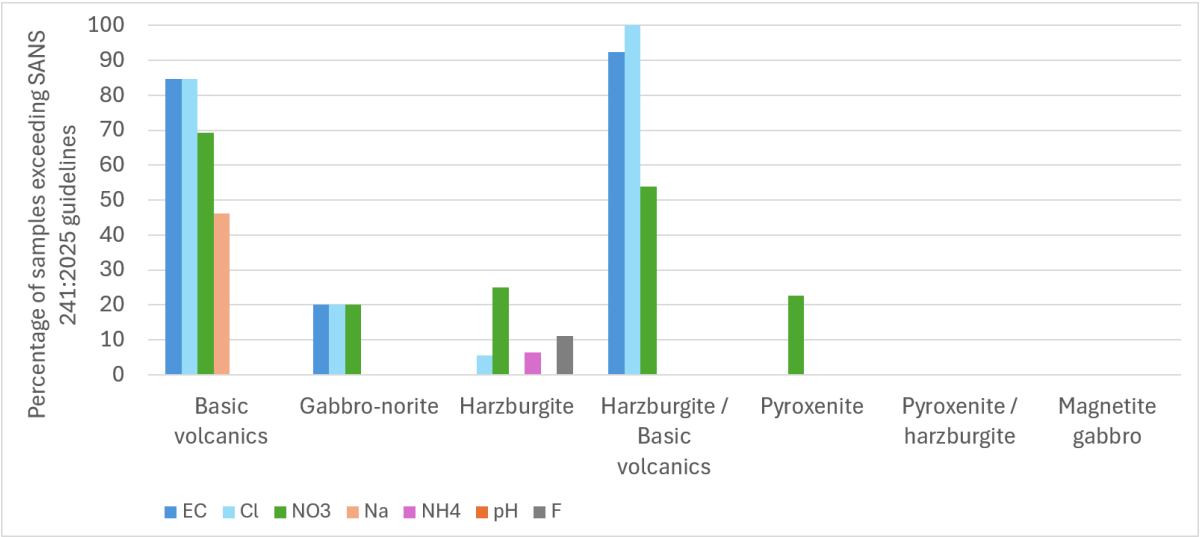
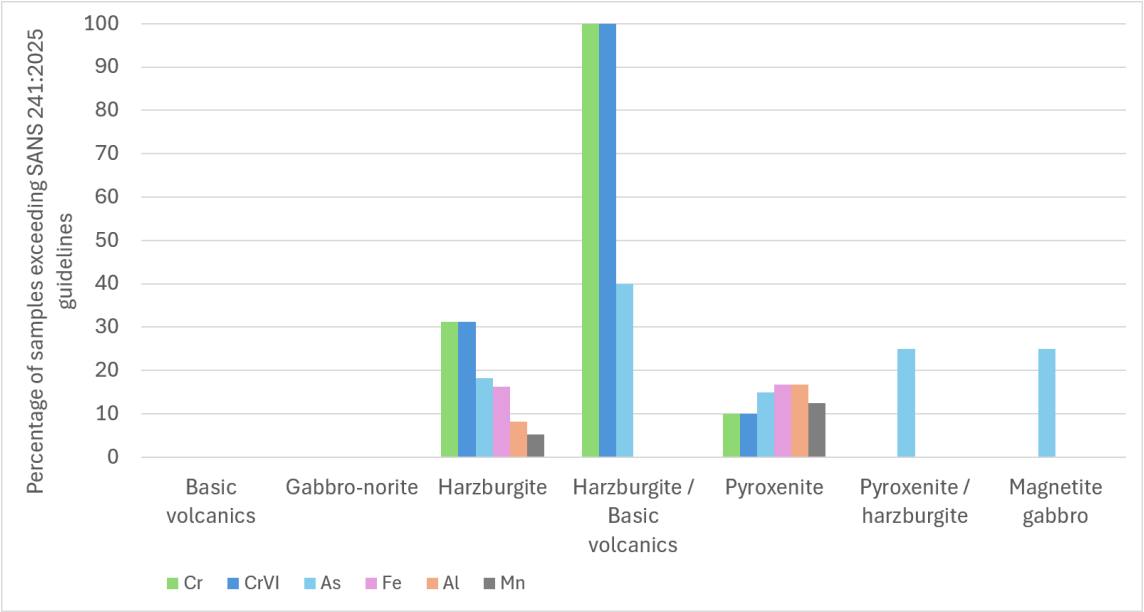


Figure 7: Percentage of samples exceeding SANS risk defined limits (SABS, 2025) for micro-parameters by lithology



Of note are the following:

- In samples associated with the basic volcanics (Lebombo Formation of the Karoo), EC, chloride and nitrate exceed the SANS limits in more than 50% of the samples.
- Nitrate exceeds the limits across the most different lithologies i.e. basic volcanics, gabbro-norite, harzburgite, mixed harzburgite/basic volcanics and pyroxenite.
- Sodium concentrations exceed the SANS limits in samples associated with basic volcanics only.
- Ammonium and fluoride exceed the limits in 10% or fewer samples from harzburgite lithologies.
- SANS limits for micro-parameters are exceeded for Cr(VI), arsenic, iron, aluminium and manganese.
- Samples associated with basic volcanic, pyroxenite/harzburgite and magnetite/gabbro lithologies exceed limits for iron and/or arsenic in <30% of the samples.
- Limits for more micro-parameters are exceeded in samples associated with harzburgite and pyroxenite compared to other lithologies.

Exceedance of SANS limits for EC, ammonium, chloride, sodium, aluminium, iron and manganese are related to aesthetic effects on water quality i.e. the water may look or taste sub-optimal, but these parameters are not associated with health effects. However, nitrate, Cr(VI) and arsenic exceedances may indicate a potential health risk. Nitrate can pose an acute health risk, especially to bottle-fed infants, at concentrations exceeding 11 mg/L as N. Hexavalent chromium (CrVI) and arsenic are carcinogens which may pose a chronic health risk. Exposure to concentrations of these elements in drinking water at levels above the SANS guideline for an extended period of time should be avoided to limit the potential for development of certain cancers (World Health Organisation, 2022). The geochemistry of these elements will be assessed in more detail in the following sections.

3.4. Water quality in terms of irrigation standards

Groundwater is used extensively across the area for crop irrigation. The water quality was compared to the DWAF irrigation target water quality range (TWQR) limits. The percentage of samples which exceed the TWQR from each of the lithologies is summarised in Figure 8 for selected macro-parameters and Figure 9 for selected microparameters.

The baseline salinity of the water, as measured by EC, is above the TWQR in almost all the samples across the sampled lithologies. In the Karoo basic volcanics influenced water, the higher EC is driven by elevated sodium and chloride, hence the chloride and sodium concentrations exceed the TWQR limits in a greater percentage of samples from those lithologies. Nitrate exceeds the TWQR limit of 5 mg/L in most lithologies. pH is above the TWQR of 8.4 on some samples from the RLS lithologies, and fluoride exceeds the TWQR in two samples from MW1.

For micro-elements, Cr(VI) exceeds the TWQR in all the samples from the mixed harzburgites/Karoo volcanics, and in 10-22% of those from harzburgite and pyroxenites, but there are no exceedances from other lithologies. Manganese exceeds the TWQR in

less than 25% of samples from basic volcanics, harzburgites and pyroxenites, and boron exceeds the TWQR in less than 10% of samples from harzburgites and pyroxenites.

Figure 8: Percentage of samples exceeding DWAF irrigation TWQR limits (Department of Water Affairs and Forestry, 1996a) for macro-parameters by lithology

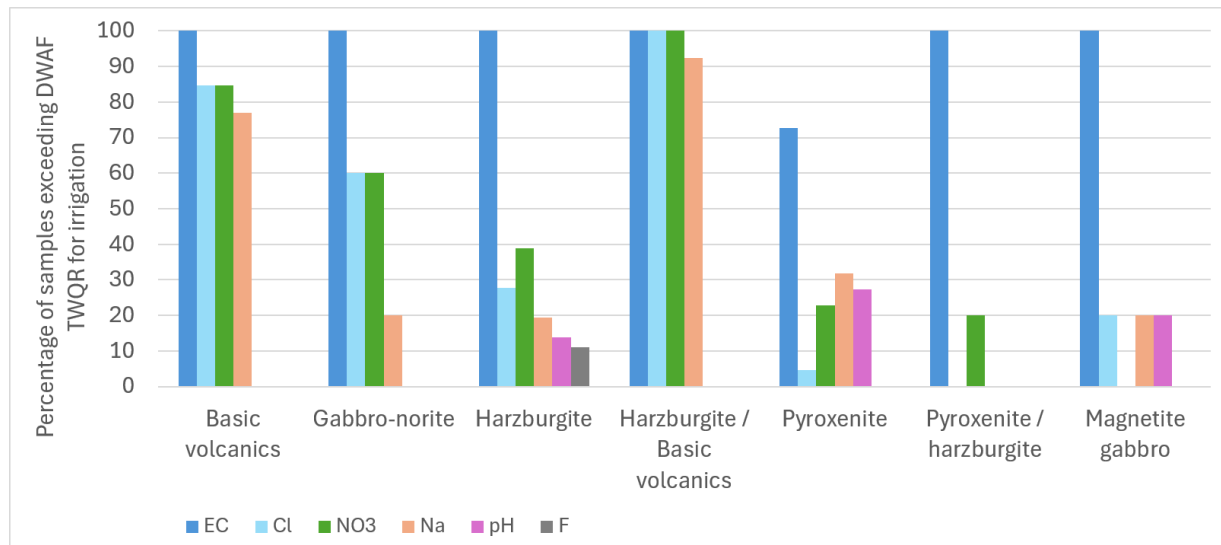
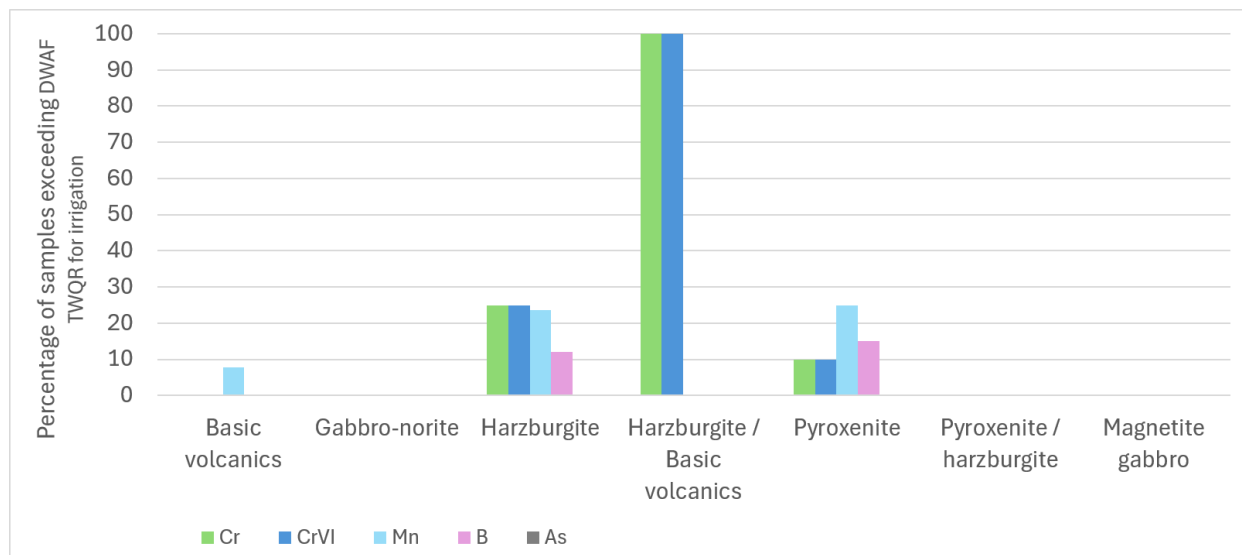


Figure 9: Percentage of samples exceeding DWAF irrigation TWQR limits (Department of Water Affairs and Forestry, 1996a) for micro-parameters by lithology



The TWQR defines ideal water quality, but water outside of this range may still be acceptable depending on the soil type and/or crop. The DWAF has also defined maximum guideline limits above which most crops will not thrive (Department of Water Affairs and Forestry, 1996a). The maximum limit for chloride is exceeded in 77% of the samples from the Karoo volcanics. Nitrate concentrations exceeding the irrigation water maximum limit of 30 mg/L were measured in samples from Karoo volcanics (23% of samples), pyroxenites (21% of samples), harzburgite/volcanics (15% of samples) and harzburgites (10% of samples). pH above 8.4 was measured in 25% of samples from pyroxenites, 20% of samples from magnetite gabbro and 13% of samples from harzburgites. Iron and boron exceeded maximum limits in three and one samples respectively. Chromium and arsenic did not exceed the maximum limits. High levels of

nitrogen in groundwater are likely to affect most crops and pose an increasingly serious risk of contaminating groundwater. Chloride concentrations exceeding 700 mg/L can result in accumulation of toxic levels of chloride through both root and foliar absorption, thus resulting in foliar injury and decreases in yield (Department of Water Affairs and Forestry, 1996a).

From an irrigation water quality perspective, nitrate concentrations above 30 mg/L and chloride concentrations above 700 mg/L are most likely to affect crop growth.

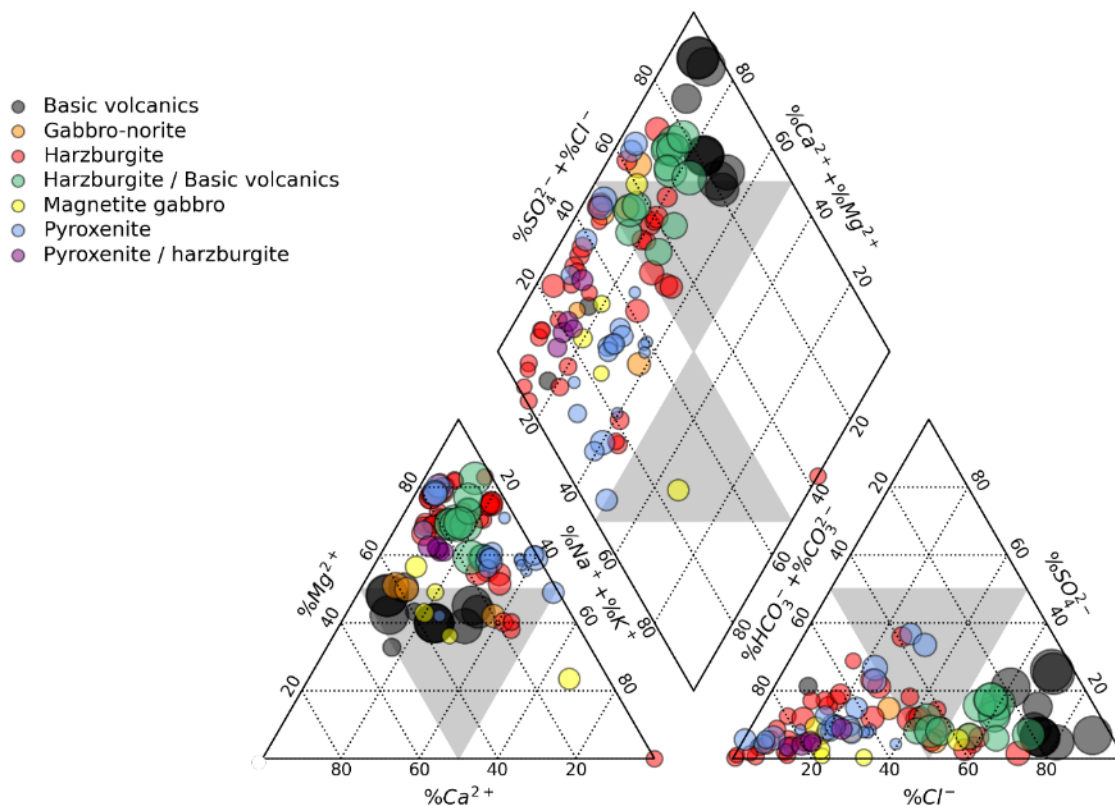
3.5. Major ion chemistry

The major ion chemistry of groundwater can be used to assess aspects such as geological controls on water quality and mixing of different waters.

The data are plotted on a Piper diagram in Figure 10, colour coded by surface lithology. The major ion chemistry is strongly affected by the lithological composition of the aquifer. Water from the Karoo basic volcanics (grey circles) has the highest TDS and is dominated by chloride, with cations comprised of a mixture of calcium and magnesium with some sodium. In contrast, water in the Lower Zone units comprised of harzburgite (red) and pyroxenite (blue) is magnesium-bicarbonate dominated with some samples having higher proportions of sodium, chloride and sulphate. Samples labelled as harzburgite / basic volcanics are located close to the Zebedelia Fault and show elevated TDS, a mixed anion signature between the chloride-dominated basic volcanics and alkalinity dominated Lower Zone lithologies, but a cation signature most similar to the harzburgites and pyroxenites. The surface geology of these locations indicates Lower Zone units, but the chemistry suggests that water from the Karoo volcanics is being drawn into the boreholes, or that there is recharge of Karoo volcanic type water which is irrigated at surface. Samples from the Upper and Main Zones (magnetite gabbro and gabbro-norite) have a mixed chloride-alkalinity anion signature and a mixed calcium-magnesium-sodium cation signature, but with lower TDS than the Karoo volcanics.

The major ion chemistry indicates that the aquifer lithology affects the chemistry, but that mixing has occurred in some areas due to the highly fractured nature of the geology or related to irrigation. These distinct geological signatures may aid in understanding the source of nitrate, arsenic and hexavalent chromium.

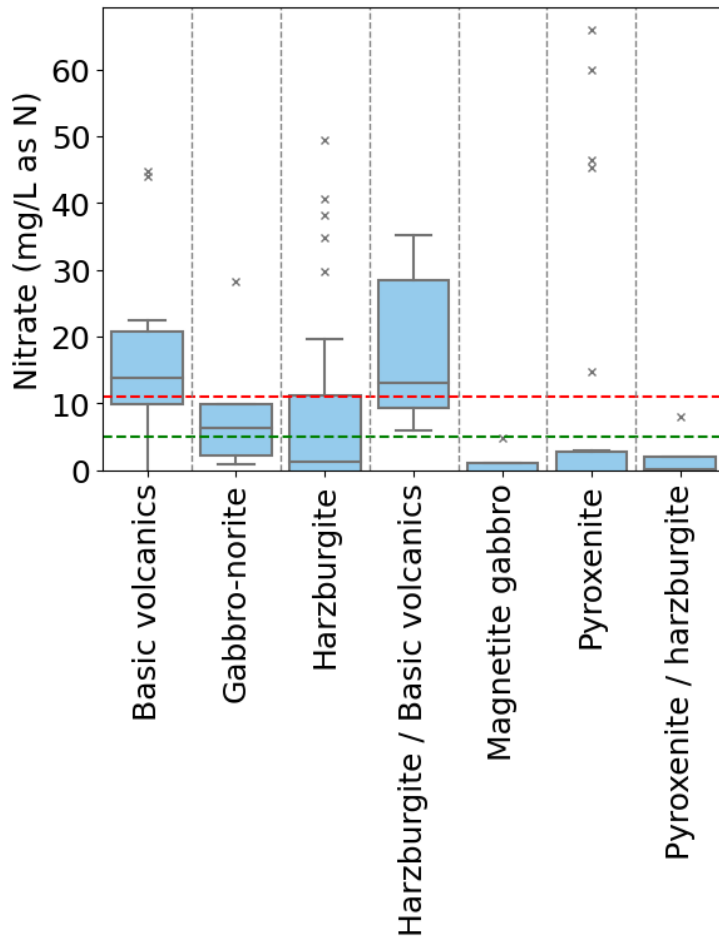
Figure 10: Piper diagram colour-coded by lithology. Symbol size is proportional to TDS



3.6. Nitrate

Baseline nitrate concentrations range from <0.5 mg/L to 65.9 mg/L as N with 44% of locations exceeding the SANS241 drinking water standard and 17% of locations exceeding the irrigation maximum limit. The range and median nitrate concentrations in the different lithologies are shown in Figure 11, and the spatial distribution is shown in Figure 13. Elevated (>11 mg/L) nitrate concentrations are observed in most lithologies except magnetite gabbro (Upper Zone) and pyroxenite/harzburgite (Figure 12). The highest nitrate concentrations are observed in clusters in the vicinity of the proposed North Pit shell (VOL4, VOL12, VOL19, VOL21, and VOL22) in the RLS Lower Zone and close to the Zebedelia Fault in the RLS Lower Zone (VOLS2, VOLS3, VOLS5) although high concentrations are also observed in the Karoo volcanics at BOK8 and M6 and in gabbro-norite of the Main Zone at GV2-1 (Figure 13). Most of these locations are close to a centre pivot irrigation system. The baseline nitrate likely originates from fertilizers used in farming, although blasting residues related to Grasvally Mine could also be a source.

Figure 11: Box-and-whisker plot of nitrate concentrations in different lithologies. The red dashed line indicates the SANS241 drinking water limit and the green dashed line indicates the target water quality range (TWQR) for irrigation water.



A plot of nitrate against TDS (Figure 12) indicates the following:

- Positive correlations are observed between nitrate and TDS in some samples from Lower Zone aquifers (Harzburgites and pyroxenites) and in most samples from Karoo (Basic volcanics) affected aquifers, but the correlations are not the same. This may be due to the higher initial TDS of groundwater in the Karoo aquifers.
- Not all samples from the Lower Zone and other RLS aquifers indicate a correlation between nitrate and TDS, suggesting that the nitrate does not originate from the aquifer material.
- The observed correlations between nitrate and TDS suggest evaporative concentration which is likely to occur during irrigation.

The nitrate is therefore most likely to originate from fertilizers, with higher concentrations due to evaporative concentration through irrigation and in the soil zone.

Nitrate can be difficult to remove from water with conventional water treatment methods (coagulation, sedimentation, filtration and chlorination), but ion exchange, reverse osmosis, biological denitrification and electrodialysis methods are effective (Department of Water Affairs & Forestry, 1996b; World Health Organisation, 2022).

Figure 12: Scatterplot of nitrate against TDS colour-coded by lithology

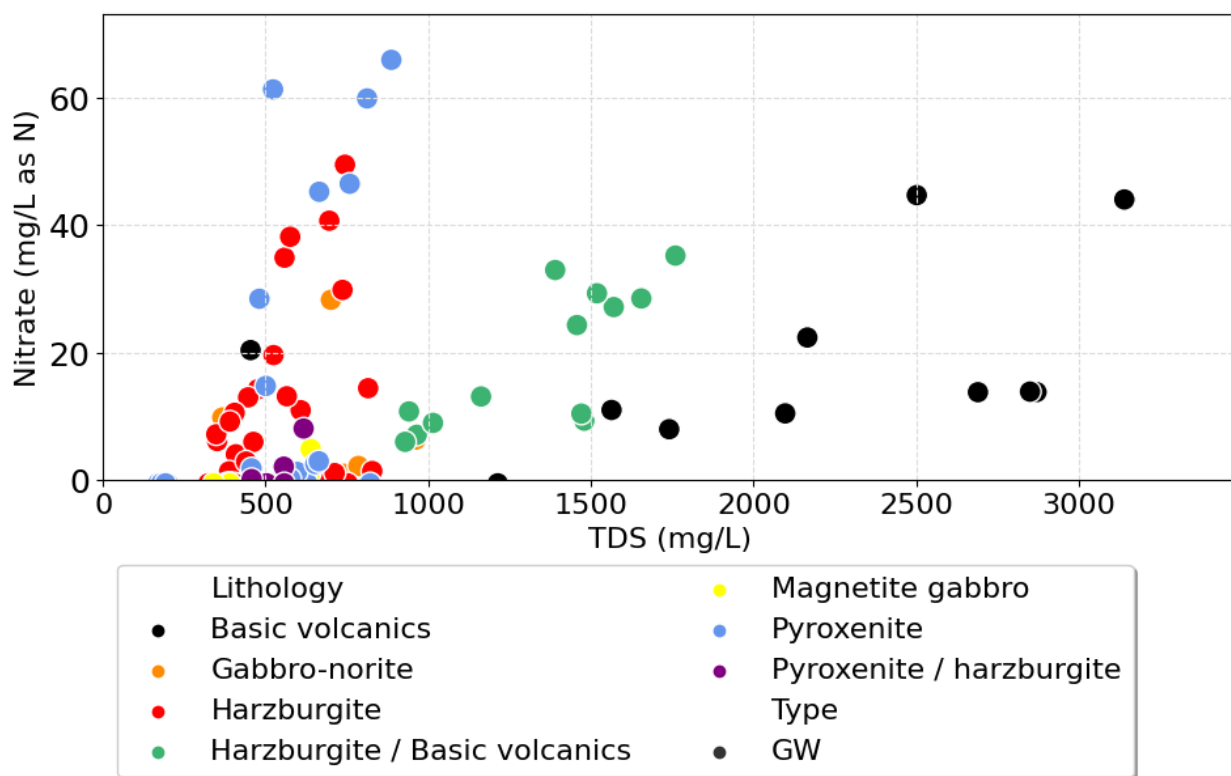
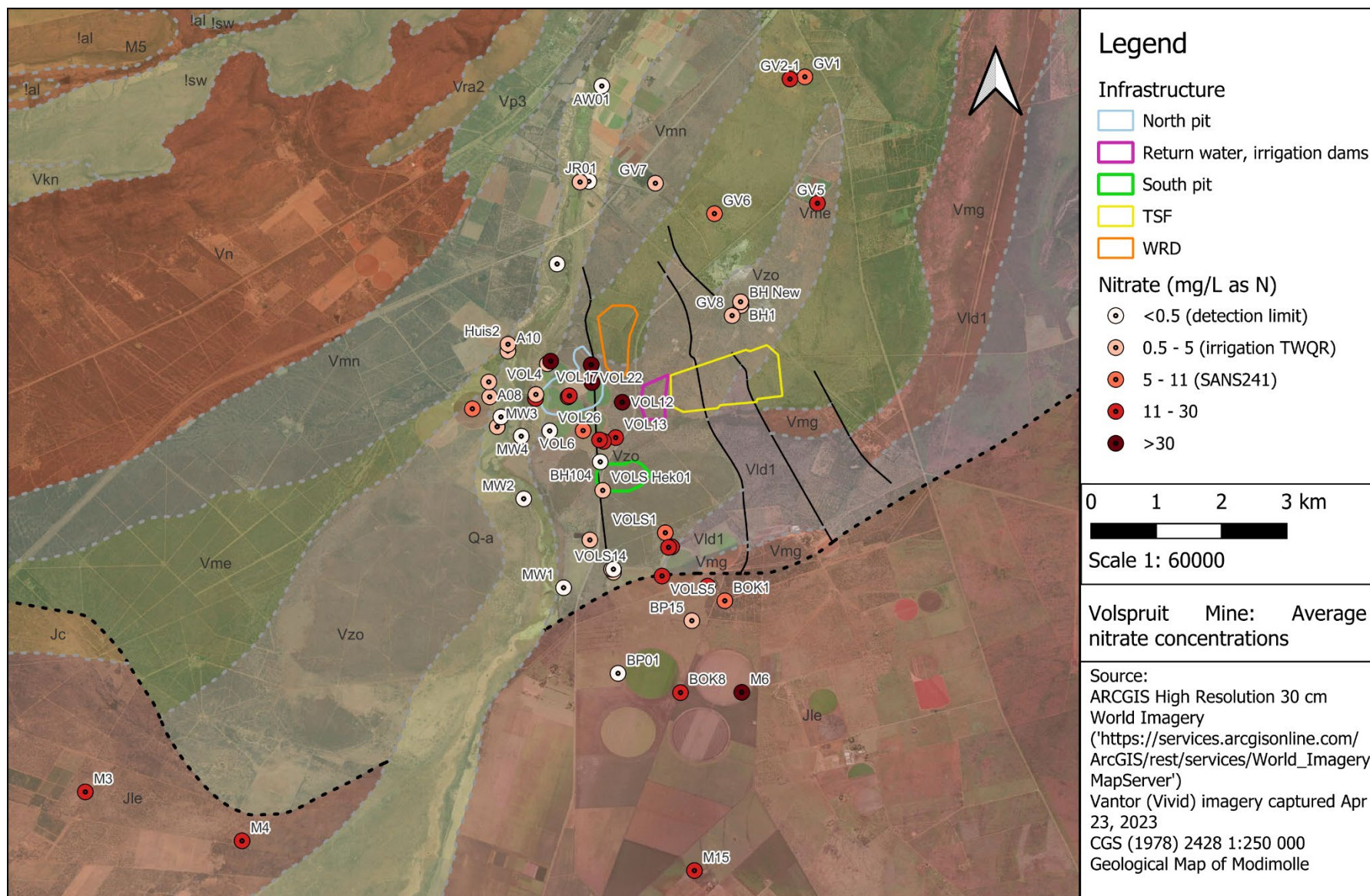


Figure 13: Spatial distribution of average nitrate concentrations



3.7. Arsenic

Prolonged (>5 years) ingestion of water containing arsenic can lead to the development of arsenicism which is associated with dermal lesions, peripheral neuropathy, skin cancer, bladder and lung cancer and peripheral vascular disease. However, there is uncertainty as to the risks at low concentrations, and the DWAF drinking water standard suggests that concentrations between 0.01 and 0.2 mg/L are tolerable with a low risk of skin cancer in highly sensitive individuals over the long term (Department of Water Affairs & Forestry, 1996b). The WHO has developed a provisional guideline of 0.010 mg/L based on limits on measuring low concentrations of arsenic and difficulties of removing arsenic from water to levels below 0.010 mg/L (World Health Organisation, 2022).

Arsenic was detected in 25 out of 88 samples with concentrations ranging from <0.01 to 0.028 mg/L, although it must be noted that 14 of the 53 non-detects have quantification limits of 0.05 mg/L or more, and arsenic may therefore be present but not reported due to the higher quantification limits in these analyses. The drinking water limit of 0.01 mg/L is exceeded at 27% of sampled locations. The arsenic concentrations are not correlated with any other parameter, but concentrations exceeding 0.01 mg/L appear to be associated with the RLS lithologies with the highest concentrations to the south of the proposed South Pit shell, mostly close to the Zebedelia Fault (Figure 14, Figure 15).

Arsenic is unlikely to originate through irrigation because it tends to be strongly adsorbed to soil, especially soils with high clay contents (Department of Water Affairs and Forestry, 1996a). Arsenic can become mobile under reducing conditions. Currently there are insufficient data to understand the origin and geochemical behaviour of arsenic, but it does appear to be associated with the RLS lithologies. Arsenic concentrations exceeding the SANS241 drinking water limit of 0.010 mg/L have been identified at VOLS14 (0.028 mg/L), VOLS10 (0.024 mg/L), VOLS1 (0.021 mg/L), VOLS Hek01 (0.021 mg/L), VOLS5 (0.021 mg/L), JR01 (0.021 mg/L), MW3 (0.021 mg/L), VOL6 (0.017 mg/L), A06 (0.017 mg/L), Abdul Dam (0.014 mg/L), VOL12 (0.013 mg/L), VOLS2 (0.013 mg/L), VOL20 (0.011 mg/L) and BH-Quarry (0.011 mg/L).

Treatment of water to remove arsenic can be done by oxidizing dissolved arsenic to the pentavalent form using chloride or potassium permanganate, coagulation and flocculation of precipitated arsenic minerals using aluminium sulphate or lime, and then settlement and filtration (Department of Water Affairs & Forestry, 1996b; World Health Organisation, 2022).

Figure 14: Box-and-whisker plot of arsenic concentrations in different lithologies. The red dashed line indicates the SANS241 drinking water limit and the green dashed line indicates the target water quality range (TWQR) for irrigation water.

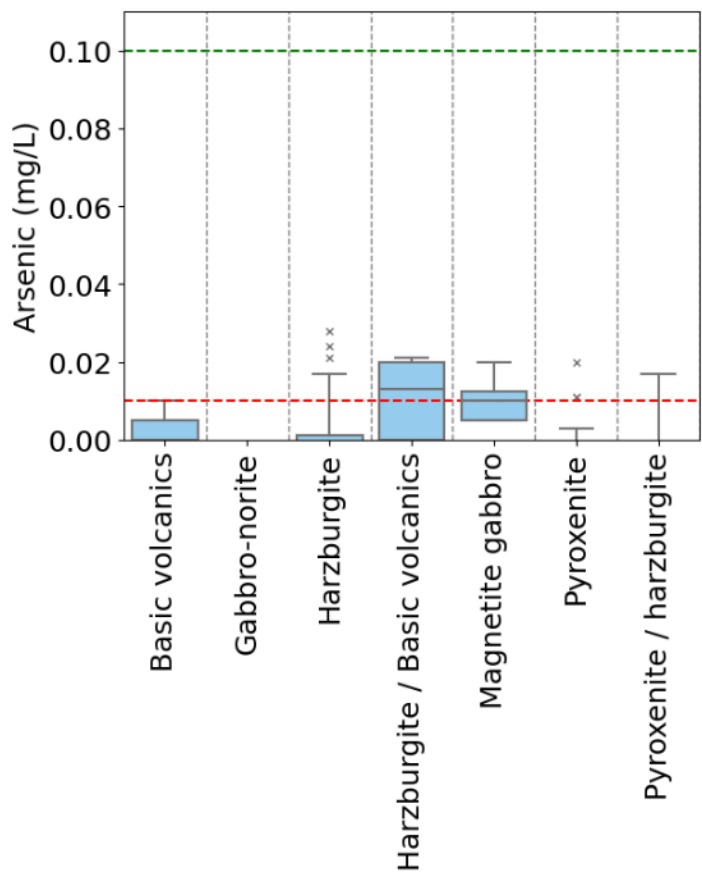
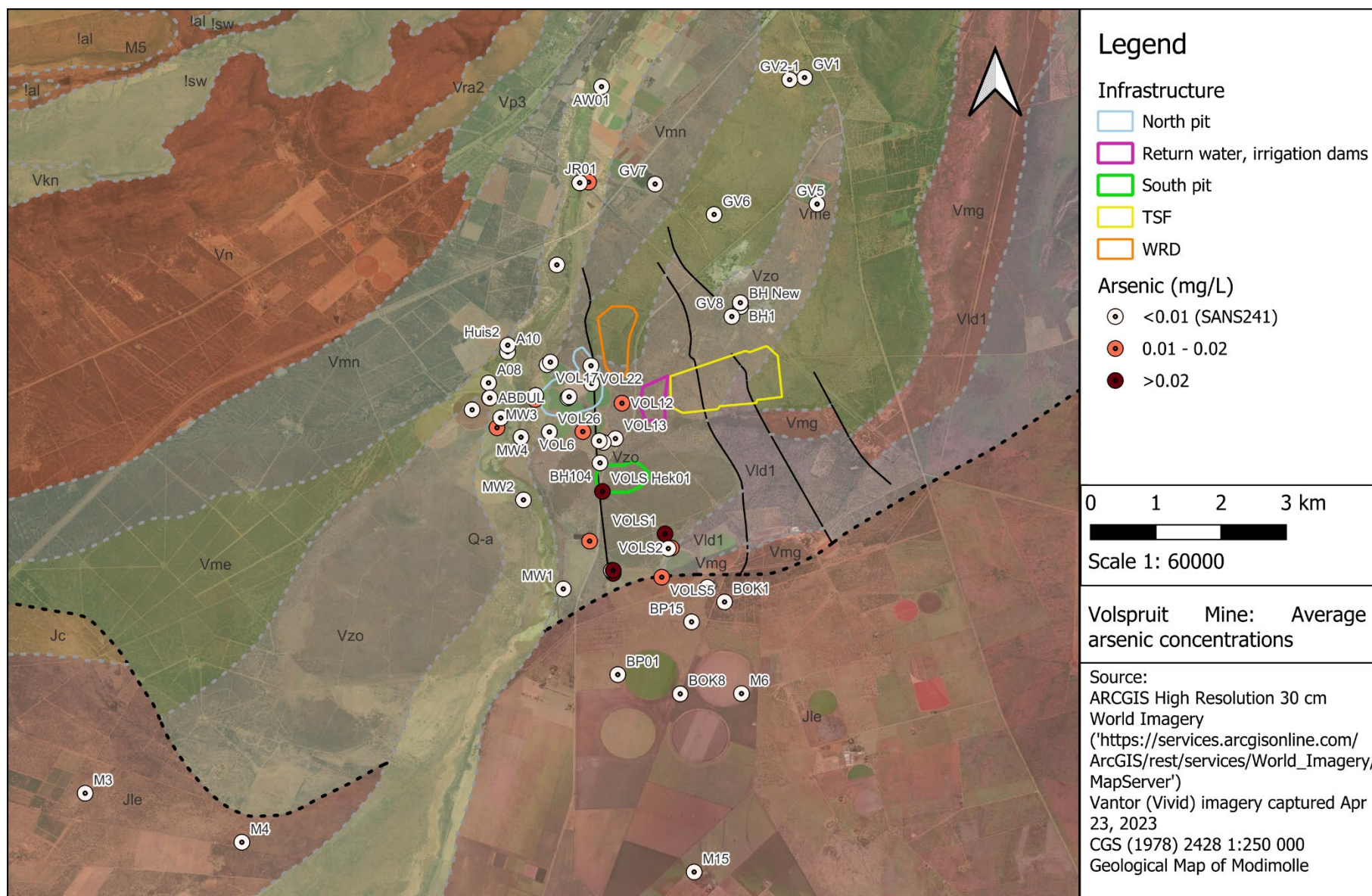


Figure 15: Spatial distribution of average arsenic concentrations



3.8. Hexavalent chromium

Hexavalent chromium (Cr(VI)) is more toxic and mobile than trivalent chromium (Cr(III)). Inhalation of Cr(VI) can lead to the development of cancer, but there is limited available data to assess the potential for Cr(VI) to cause cancer via ingestion through drinking water. Environmental concentrations of Cr(VI) are generally orders of magnitude lower than concentrations which have been found to cause tumours in rats and mice and a Cr(VI) concentration of 0.05 mg/L is considered to be adequately protective of human health (World Health Organisation, 2022).

Chromium was reported in 24 of 77 samples. Speciation analysis confirmed that most of the chromium is present in the hexavalent form. The drinking water standard was exceeded in 21 of the 77 samples representing 32% of sampled locations with concentrations ranging from 0.01 to 0.70 mg/L. It should be noted that for most of the samples, the quantification limit was 0.05 mg/L, therefore it is possible that Cr(VI) is present at concentrations below the drinking water standard in these samples.

Detections of Cr(VI) are associated almost exclusively with the harzburgite and harzburgite/basic volcanics lithological groups, indicating a geological control (Figure 16). The harzburgites host the chromite layers that are mined at Grasvally and therefore represent an obvious potential source. However, not all samples from harzburgite lithologies have elevated Cr(VI). The Cr(VI) detections are spatially clustered into two areas, one in the vicinity of and to the south of the North pit shell, and the second to the north of the Zebedelia Fault (Figure 18). Both clusters are close to centre pivot irrigation systems. There does appear to be a correlation between most of the chromium detections and nitrate (Figure 17), with samples from VOLS2 and VOLS3 close to the Zebedelia Fault plotting above the correlation line and samples from VOL12 and VOL19 close to the North pit shell plotting below the correlation line.

Cr(VI) in groundwater can originate from anthropogenic sources through industrial use and waste disposal, or through natural geochemical processes which can mobilise Cr(VI) from rocks into water. Anthropogenic sources include wastewater and sludges from the leather industry and slags and tailings from chromium processing (Zhigalenok, et al., 2025). Grasvally chrome mine represents an obvious potential source, however Cr(VI) was detected in only one of the boreholes close to the Grasvally operation, namely BH1 at 0.033 mg/L, and the highest Cr(VI) concentrations were detected more than 4 km to the south of the mining operations.

Concentrations of naturally occurring Cr(VI) are generally <0.01 mg/L, but concentrations of up to 0.3 mg/L have been observed in China and Cyprus associated with ultramafic aquifers (Rasool, et al., 2026). Chromium is mobilised from geological sources by initial slow weathering of primary chromium-containing minerals to release Cr(III) and then oxidation of Cr(III) to Cr(VI) (Zhigalenok, et al., 2025). This process occurs in well-aerated, alkaline conditions in ultramafic terrains in the presence of manganese oxide minerals (Rasool, et al., 2026). Intensive irrigation can leach natural Cr(VI) which has accumulated in the soil zone and transport it to groundwater. Nitrate-driven redox shift and anion competition also aid in mobilizing Cr(VI) in agricultural areas. Pumping of groundwater and lowering of water levels can also expose more material to oxygen or oxygenated groundwater, increasing the potential for oxidation of Cr(III) to Cr(VI) (Zhigalenok, et al., 2025; Rasool, et al., 2026). The enhancement of Cr(VI) leaching by

pumping and irrigation may explain the observed correlation between Cr(VI) and nitrate, with nitrate being a tracer for high levels of irrigation.

Based on available information, it seems most likely that Cr(VI) originates from the natural geology in the area, but mobilisation may be enhanced by extensive groundwater pumping and irrigation of centre pivot systems. Planned dewatering for open pit mining may lead to further mobilisation of Cr(VI) due to exposure of more chromium bearing minerals to an oxidizing environment and Cr(VI) concentrations will require routine monitoring and management in dewatering water.

Treatment options for removing Cr(VI) from water include (Department of Water Affairs & Forestry, 1996b; World Health Organisation, 2022):

- Reduction to Cr(III) by addition of ferrous sulphate with precipitation and flocculation of Cr(III) hydroxide with lime and alum followed by settlement and filtration;
- Adsorption by iron oxides; or
- Removal with reverse osmosis or ion exchange.

Figure 16: Box-and-whisker plot of Cr(VI) concentrations in different lithologies. The red dashed line indicates the SANS241 drinking water limit and the green dashed line indicates the target water quality range (TWQR) for irrigation water.

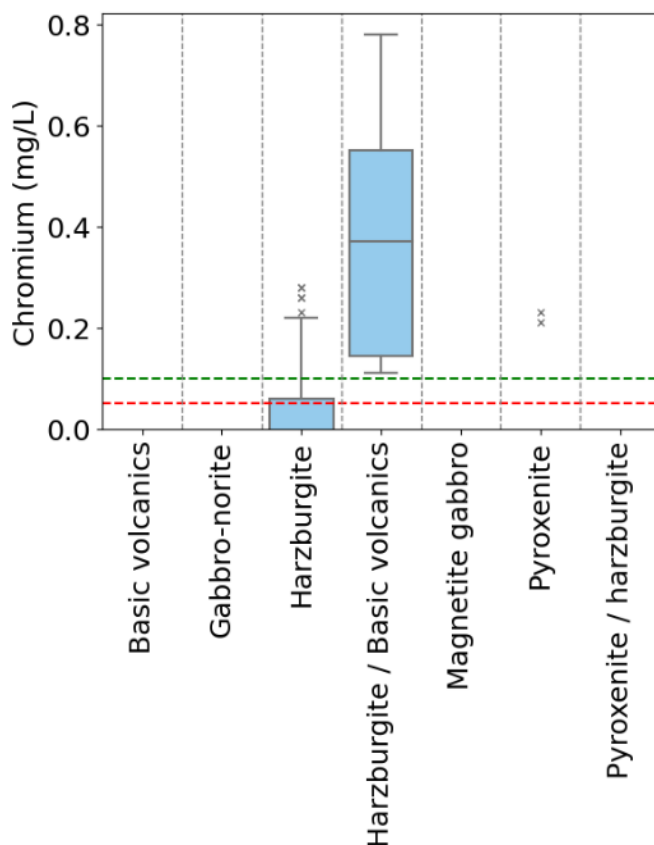


Figure 17: Scatterplot of Cr(VI) against nitrate colour-coded by lithology

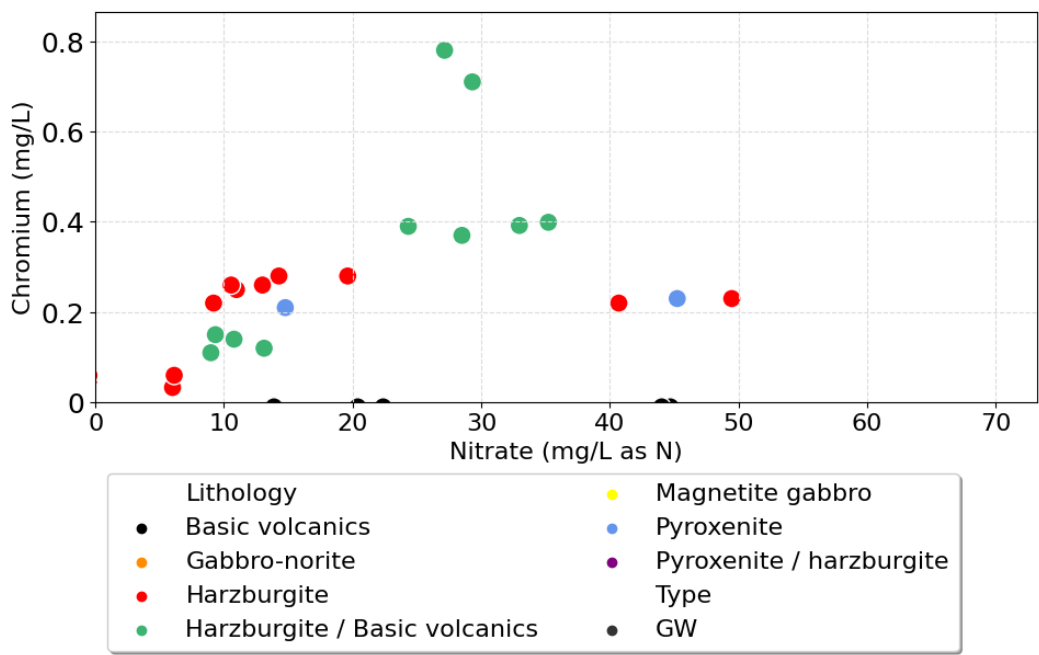
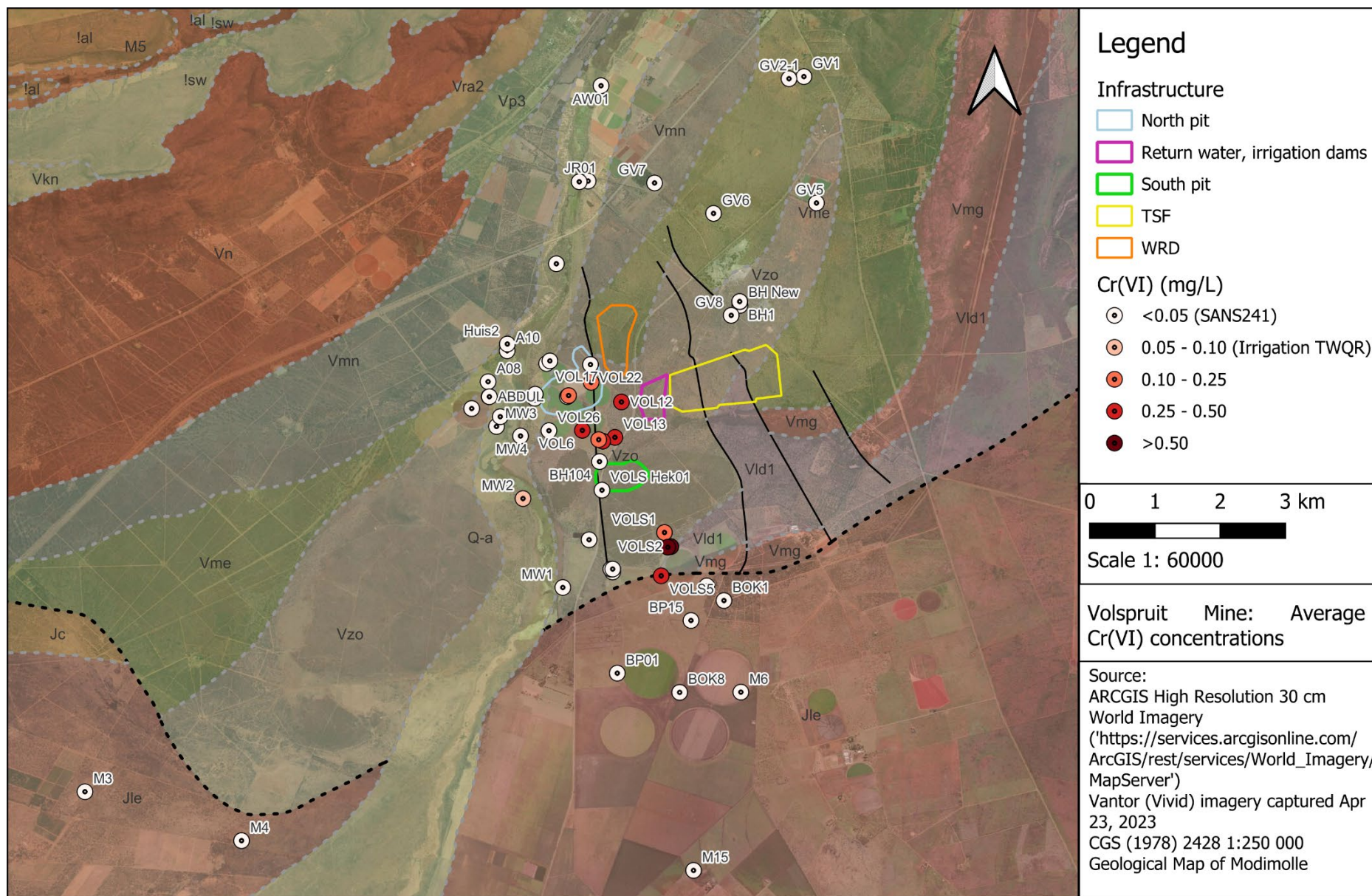


Figure 18: Spatial distribution of average Cr(VI) concentrations



3.9. Summary of nitrate, arsenic and Cr(VI) geochemistry

The information relating to nitrate, arsenic and Cr(VI) geochemistry based on currently available data is summarised in Table 2.

Table 2: Summary of geochemistry of nitrate, arsenic and Cr(VI)

	Nitrate	Arsenic	Cr(VI)
Possible sources	- Fertilizer (most likely) - Blast residues	RLS Lower Zone lithologies	RLS Lower Zone lithologies
Factors which may affect mobilisation	- Extensive irrigation - Extensive groundwater use - Highly fractured aquifer	Currently uncertain.	- Irrigation - Lowered water table due to extensive groundwater use. - Cr(VI) is present in samples from boreholes within RLS Lower Zone lithologies, particularly where harzburgite is suspected.
Evidence	- Elevated concentrations are not associated with a particular lithology. - Concentrations are highest close to center pivot irrigated fields. - Concentrations close to Grasvally Mine are lower than closer to irrigated areas.	Concentrations exceeding quantification limits are measured in samples from boreholes in the RLS Lower Zone units.	- Most Cr(VI) concentrations are correlated with nitrate - Highest Cr(VI) concentrations are located near to center pivot irrigated fields. - Cr(VI) concentrations close to the Grasvally Mine are lower than those close to centre pivot irrigated fields.

4. Geochemistry

4.1. Available data

Geochemical studies have been undertaken on the mine residue materials expected to be generated by the proposed Volspruit Mine. GPT (2024) reported that Acid Base Accounting (ABA) analysis of waste rock and tailings completed by EScience Associates in 2012 found virtually no potential for acid rock drainage (ARD) formation. The following geochemical testing has previously been completed (Table 3):

- Three core samples of ore material were collected in 2010 and analysed for ABA and a 1:4 solid:liquid ratio distilled water leach test.
- Fifteen composite core samples of waste rock from the North Pit were collected in 2011 and analysed for ABA and a 1:20 distilled water leach test.
- Four composite core samples of waste rock from the South Pit were collected in 2011 and analysed for ABA, net acid generation (NAG), mineralogy by x-ray diffraction (XRD), whole rock chemistry by x-ray fluorescence (XRF) and a 1:20 solid:liquid acid rain leach test.

Table 3: Details of waste rock and ore samples

	Ore	North pit waste rock	South pit waste rock
Year	2010	2011	2011
No. samples	3	15	4
Samples	GVN 132M -A (12.23 – 12.35 m) GVN 132M – B (51.66 – 51.95 m) GVN 132M – C (76.77 – 76.9 m)	NO901 – NO915	Composite 1: 0 – 47 m Composite 2: 23 – 80 m Composite 3: 33 – 91 m Composite 4: 50 - 101 m (immediately above reef)
Analyses	ABA, 1:4 distilled water leach test	ABA, 1:20 distilled water leach test	ABA, NAG, XRD, XRF (majors and trace), 1:20 acid rain leach test

4.2. ABA

ABA results for waste rock and ore are given in Table 4. The waste rock composite samples have low total or sulphide sulphur concentrations (<0.2 wt%) and sufficient neutralising potential (NP) to neutralise acidity generated by oxidation of sulphide minerals, assuming that the sulphur is all present as pyrite. The NAG pH of Composite 1 is less than the screening level for potentially acid generating (PAG) rock, but the low pH is unlikely to be due to sulphide oxidation because no sulphur was detected in this sample. The risk of ARD developing from waste rock is therefore considered to be negligible.

Two of the three ore samples are considered to be PAG because they have total sulphur concentrations that would be capable of generating more acidity than could be neutralised by the available NP assuming the total sulphur is present as pyrite. There may therefore be some risk of ARD generation associated with ore stockpiles. However, tailings material is reported to have virtually no risk for acid generation (GPT, 2024), presumably because sulphides report to the product.

Table 4: ABA results for waste rock and ore composites. Values exceeding screening levels are highlighted in blue bold.

Analyte	Material type	Paste pH	Total S	Sulphide S	NP	AP ⁺	NNP	NPR	NAG pH	NAG 4.5	Type
Units			wt% S	wt% S	kg CaCO ₃ /t	kg CaCO ₃ /t	kg CaCO ₃ /t	kg CaCO ₃ /t		kg H ₂ SO ₄ /t	
Screening level (Price, 2009)		5.5	0.3	0.2			High risk: <0	High risk: <1, Low risk: 1-2	PAG*: <4.5		
GVN 132 M-A	Ore	7.3	0.01		4.5	0.3	4.1	14.2			III
GVN 132 M-B	Ore	9.3	2.04		9.9	63.8	-53.9	0.2			I
GVN 132 M-C	Ore	9.7	0.75		5.5	23.4	-18	0.2			I
NO 901	North pit WR			0.01	110	0.3	110	352			III
NO 902	North pit WR			0.03	160	0.9	159	171			III
NO 903	North pit WR			<0.01	140	<0.3	140	>467			III
NO 904	North pit WR			0.04	61	1.3	60	49			III
NO 905	North pit WR			0.03	79	0.9	78	84			III
NO 906	North pit WR			0.01	190	0.3	190	608			III
NO 907	North pit WR			0.07	270	2.2	268	123			III
NO 908	North pit WR			<0.01	240	<0.3	240	>800			III
NO 909	North pit WR			0.07	140	2.2	138	64			III
NO 910	North pit WR			0.03	81	0.9	80	86			III
NO 911	North pit WR			<0.01	110	<0.3	110	>367			III
NO 912	North pit WR			<0.01	45	<0.3	45	>150			III
NO 913	North pit WR			0.01	39	0.3	39	125			III
NO 914	North pit WR			<0.01	54	<0.3	54	>180			III
NO 915	North pit WR			<0.01	70	<0.3	70	>233			III
Composite 1	South pit WR	6.7	<0.01		4.2	<0.3	4.5	13.4	4.4	0.2	III
Composite 2	South pit WR	8.7	0.09		7.1	2.8	4.3	2.5	6.2	<0.01	III
Composite 3	South pit WR	8.9	0.09		8.1	2.8	5.3	2.9	6.6	<0.01	III
Composite 4	South pit WR	8.8	0.19		21.2	5.9	15.3	3.6	7.3	<0.01	III

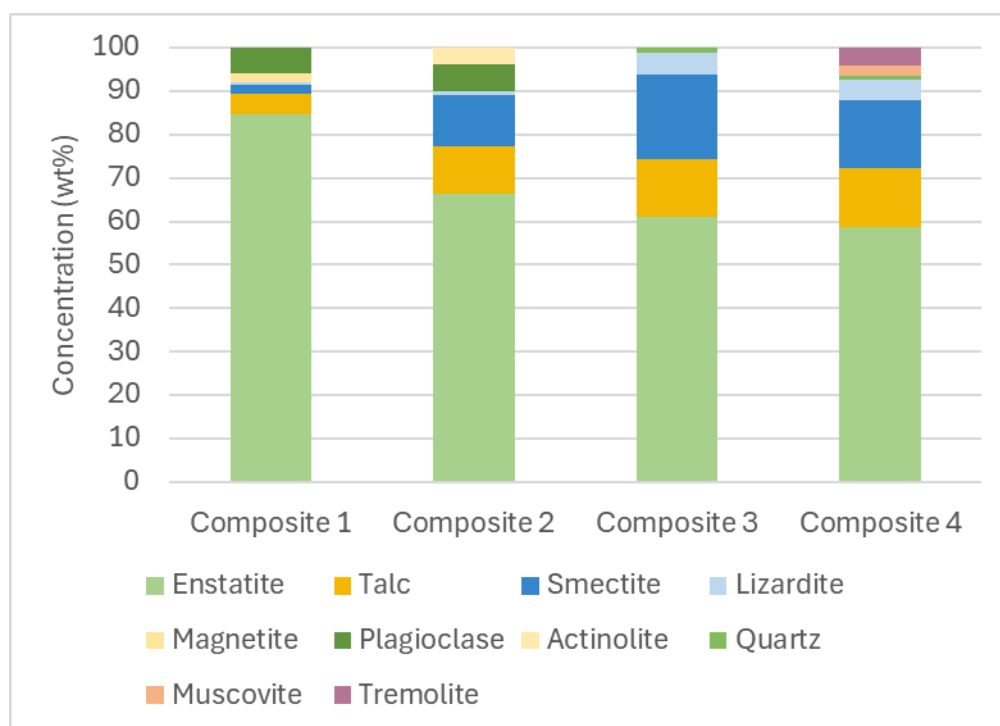
*Potentially acid generating, + - calculated from either total sulphur or sulphide sulphur

4.3. Mineralogy

The waste rock from the South Pit, which is assumed to be largely similar to the waste rock from the North Pit, consists of more than 59% enstatite, a magnesium orthopyroxene. The bulk of the rest of Composite 2, 3 and 4 is made up of talc (5 – 13%) and smectite (2 – 20%), which are alteration products of primary minerals. Composites 1 and 2 contain plagioclase (~6%) and Composites 3 and 4 contain lizardite (~5%), a magnesium serpentine mineral. Other minerals identified in the samples in minor quantities (<5%) include muscovite, tremolite, magnetite and quartz. No sulphide minerals were identified by XRD, but it should be noted that the XRD may not detect trace amounts of minerals.

Enstatite, talc and lizardite are magnesium containing minerals. Weathering of these minerals may be the reason for the dominance of magnesium in groundwater from the RLS.

Figure 19: Mineralogical composition of waste rock samples



4.4. Total chemistry

Waste rock from the South Pit is composed predominantly of silica (23 – 25 wt%) and magnesium (30 – 32 wt%) with lesser amounts of iron (3.4 – 3.6 wt%) and calcium (0.7 – 2.1 wt%) (Figure 20). The most abundant minor elements are chromium (0.4 – 0.8 wt%), manganese (0.11 – 0.13 wt%) and nickel (0.07 – 0.13 wt%). The whole rock major element chemistry shows little variation between the samples.

Trace element concentrations which exceed 10 mg/kg in waste rock samples are shown in Figure 21. The concentrations of most trace elements are similar between the samples, but Composite 4 has higher concentrations of copper and strontium than the other samples. Copper is used as an indicator element of PGE mineralisation (IGS, 2010)

and the higher concentrations probably indicate the proximity of the ore zone as this sample was collected immediately above the reef.

Figure 20: Major and minor element composition of South Pit waste rock samples

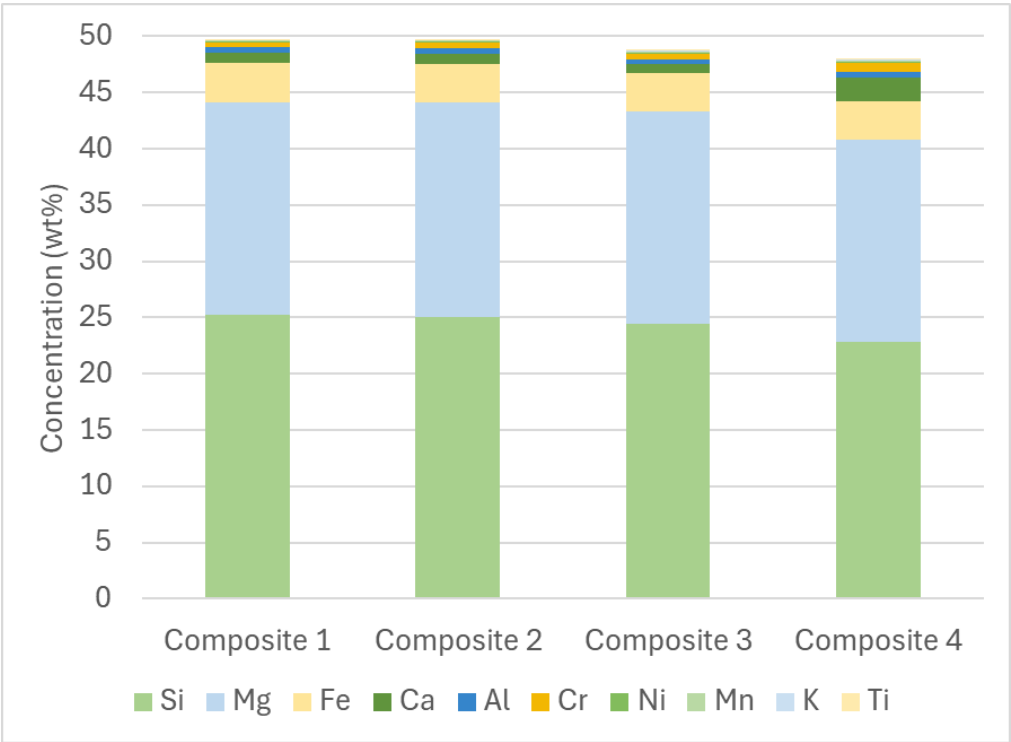
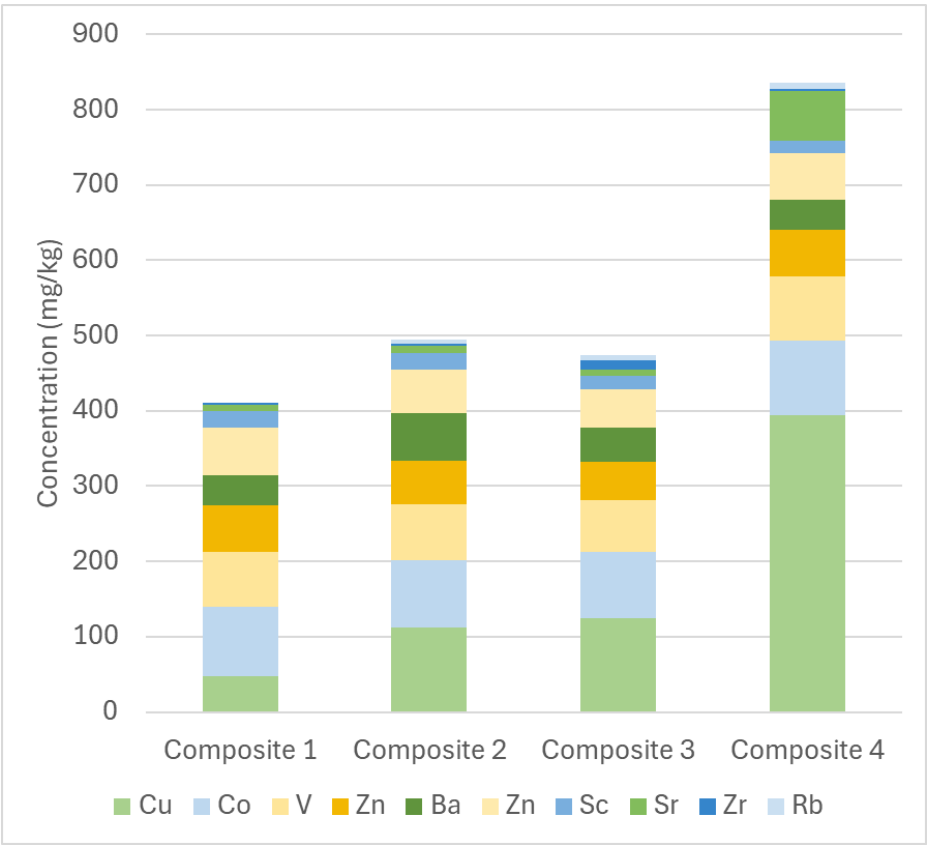


Figure 21: Trace element composition of South Pit waste rock samples



4.5. Leachable chemistry

Leachate tests were conducted on ore and waste materials to assess the potential for mobilisation of metals into water. Because three different leach tests were conducted on the three sets of samples, comparison of the results is challenging. The four waste rock composite samples from the South Pit were subjected to a 1:4 solid:liquid ratio acid rain leach, which involves leaching with a dilute solution of carbonic and nitric acid at pH between 3.6 and 3.8 to mimic the effects of acidic rainfall interacting with the material. Following leaching, the pHs of the leachates were between 6.2 and 7.0 indicating that the waste rock was able to neutralise the acidity in the acid rain leachate. The ore samples were leached with distilled water at a 1:4 solid:liquid ratio. The North Pit samples were leached with distilled water at a solid:liquid ratio of 1:20. The results of the three leach tests were normalised to the 1:20 ratio and compared to the leachable concentration thresholds (LCT0) in the *National Norms and Standards for the Assessment of Waste for Landfill Disposal* (R635 of 2013: NEM:WA (59/2008)) in Table 5 for the purposes of identifying potential chemicals of concern (COCs). However, it should be noted that the pH of the leachates is affected by the leaching fluid, and this is likely to affect the leachate concentrations.

The ionic make-up of the waste rock acid-rain and distilled water leachates is shown in Figure 22. Bicarbonate dominates the anions, although there is a small contribution from sulphate in several samples. The cations are dominated by magnesium in most samples, but sodium dominates in four of the nineteen samples (NO 905, NO 910, NO 914 and NO 915). There is insufficient information about the source and composition of the samples to understand why these samples differ. The magnesium-alkalinity signature of most of the samples mirrors the groundwater quality observed in Lower Zone lithologies. The TDS is highest in Composite 4 and lowest in Composite 1, which suggests lower concentrations of leachable ions in the weathered zone and higher concentrations of leachable ions closer to the ore zone.

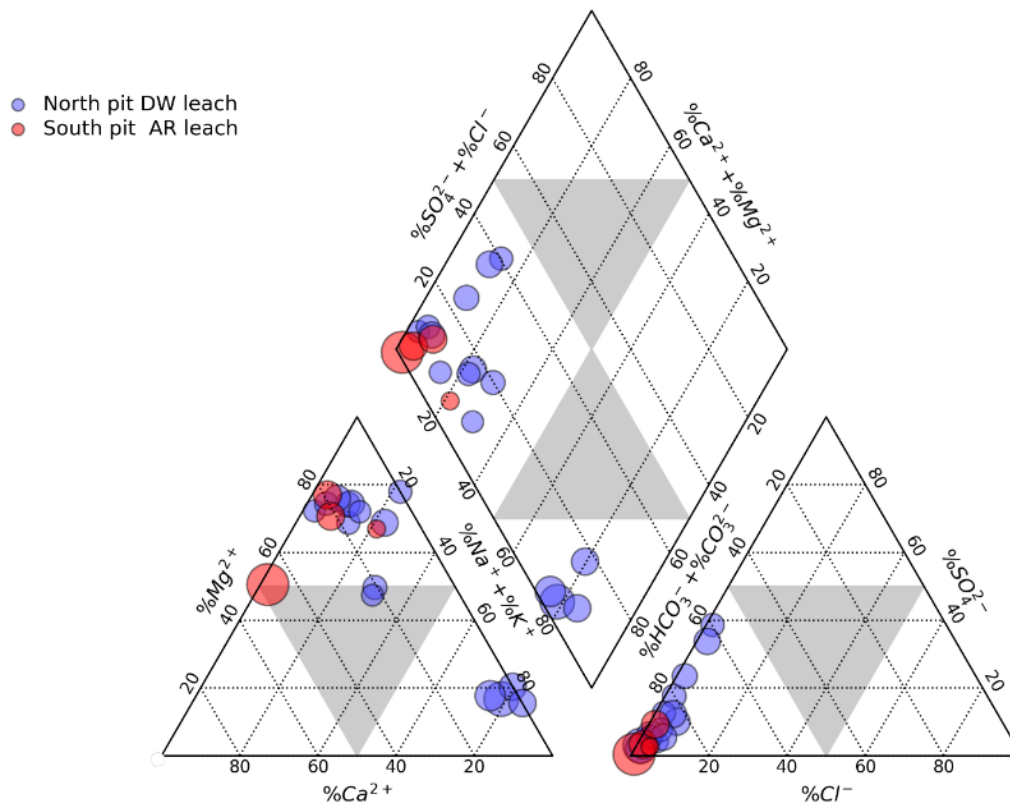
Nitrate concentrations in the leachates are well below the LCT0 of 11 mg/L as N. Nitrate in groundwater is therefore unlikely to originate by leaching from the rock materials and is most likely to originate from fertilisation.

Table 5: Comparison of 1:20 leachate results to leachable concentration thresholds (LCTs)

Sample ID	Source	Cl	SO4	NO3	F	As	B	Ba	Cd	Co	CrT	Cr(VI)	Cu	Hg	Mn	Mo	Ni	Pb	Sb	Se	V	Zn
LCT0		300	250	11	1.5	0.01	0.5	0.7	0.003	0.5	0.1	0.05	2	0.006	0.5	0.07	0.07	0.01	0.02	0.01	0.2	5.0
LCT1		15000	12500	550	75	0.5	25	35	0.15	25	5	2.5	100	0.3	25	3.5	3.5	0.5	1	0.5	10	250
NO 901	N pit	0.81	1.1	0.43	bdl	0.026	0.01	0.023	bdl	0.140	0.004	bdl	0.004	bdl	24.000	0.014	0.077	bdl	bdl	0.011	0.011	bdl
NO 902	N pit	0.42	1.2	0.11	bdl	bdl	bdl	0.011	bdl	bdl	0.003	bdl	bdl	bdl	0.007	bdl	bdl	bdl	bdl	bdl	0.004	bdl
NO 903	N pit	0.22	0.77	bdl	0.1	bdl	bdl	0.013	bdl	bdl	bdl	bdl	bdl	bdl	0.004	bdl	bdl	bdl	bdl	bdl	0.003	bdl
NO 904	N pit	0.43	0.52	bdl	0.21	bdl	bdl	0.017	bdl	bdl	0.003	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.004	bdl
NO 905	N pit	0.23	0.49	bdl	bdl	bdl	bdl	0.073	bdl	0.006	0.017	0.017	0.010	bdl	0.024	bdl	0.019	bdl	bdl	bdl	0.009	bdl
NO 906	N pit	0.98	2	0.76	0.08	bdl	bdl	0.04	bdl	0.008	0.010	bdl	0.022	0.002	0.060	bdl	0.030	bdl	bdl	bdl	0.004	bdl
NO 907	N pit	0.36	6.4	0.27	0.06	bdl	bdl	0.029	bdl	0.005	0.005	bdl	0.008	0.001	0.004	bdl	bdl	bdl	bdl	bdl	0.003	bdl
NO 908	N pit	0.25	4.1	bdl	0.24	bdl	bdl	0.033	bdl	0.004	0.008	bdl	0.007	bdl	0.003	bdl	0.007	bdl	bdl	bdl	bdl	bdl
NO 909	N pit	0.23	1.9	bdl	0.08	bdl	bdl	0.044	bdl	0.005	0.012	0.013	0.009	0.003	0.023	bdl	0.019	0.007	bdl	bdl	0.005	bdl
NO 910	N pit	0.19	0.88	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.001	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
NO 911	N pit	0.22	0.81	0.23	0.09	bdl	bdl	0.034	bdl	0.007	0.006	bdl	0.013	bdl	0.006	bdl	0.008	bdl	bdl	bdl	bdl	bdl
NO 912	N pit	0.16	5.5	bdl	bdl	bdl	bdl	0.026	bdl	bdl	0.004	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.003	bdl
NO 913	N pit	0.25	2.6	0.12	bdl	bdl	bdl	0.048	bdl	0.004	0.010	0.010	0.008	0.001	0.013	bdl	bdl	bdl	bdl	bdl	0.004	bdl
NO 914	N pit	0.6	2.2	0.28	bdl	bdl	bdl	0.029	bdl	0.010	0.015	0.015	0.022	bdl	0.025	bdl	bdl	bdl	bdl	bdl	0.009	bdl
NO 915	N pit	0.25	1.1	0.15	0.1	bdl	bdl	0.007	bdl	0.076	0.076	0.036	0.100	bdl	0.045	bdl	0.010	bdl	bdl	bdl	0.008	bdl
Composite 1	S pit	<5	<5	<0.2	<0.2	0.005	0.170	0.586	<0.005	0.016	0.042	<0.005	0.019	ND	0.206	<0.005	0.067	<0.005	<0.005	<0.005	<0.005	0.285
Composite 2	S pit	<5	20	<0.2	<0.2	<0.005	0.140	0.434	<0.005	0.042	<0.005	<0.005	<0.005	ND	0.384	<0.005	2.300	<0.005	<0.005	<0.005	<0.005	0.230
Composite 3	S pit	<5	8	<0.2	<0.2	<0.005	<0.005	0.060	<0.005	0.020	<0.005	<0.005	<0.005	ND	0.247	<0.005	1.260	<0.005	<0.005	<0.005	<0.005	<0.005
Composite 4	S pit	<5	<5	<0.2	<0.2	<0.005	<0.005	0.099	<0.005	0.015	<0.005	<0.005	<0.005	ND	0.289	<0.005	0.229	<0.005	<0.005	<0.005	<0.005	<0.005
GVN 132 M<A	Ore	ND	ND	ND	ND	<0.002	<0.005	0.145	<0.005	0.055	0.128	ND	0.073	ND	0.598	<0.005	1.140	0.006	<0.002	<0.004	<0.005	0.007
GVN 132 M<B	Ore	ND	ND	ND	ND	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	ND	<0.005	ND	<0.005	<0.005	0.013	<0.005	<0.002	<0.004	<0.005	<0.005
GVN 132 M<C	Ore	ND	ND	ND	ND	<0.002	0.010	0.462	<0.005	0.015	0.566	ND	0.254	ND	1.096	<0.005	1.490	0.031	<0.002	<0.004	0.056	0.031

Bdl – below quantification limits, ND – analysis not done, blue filled cells exceed LCT0.

Figure 22: Piper diagram showing major ion composition of North and South pit waste rock samples with the size of the symbol proportional to the TDS



Trace elements that were detected in one or more of the waste rock leachates include aluminium, arsenic, boron, barium, cobalt, copper, chromium, chromium VI, mercury, iron, manganese, molybdenum, nickel, rubidium, scandium, selenium, strontium, titanium, vanadium and zinc. Of the trace elements for which there are LCTs, manganese is detected in 82% of the samples, although concentrations exceed the LCT0 in only one waste sample from the North Pit and one ore sample. Chromium and cobalt are detected in 73% of samples, but only chromium exceeds the LCT0 in one waste sample from the North Pit, and two ore samples. However, Cr(VI) does not exceed the LCT0 in any of the samples. Between 50 and 70% of samples have detections of nickel, copper, aluminium and vanadium, but only nickel exceeds the LCT0 in one waste sample from the North Pit, two waste samples from the South Pit and two samples of ore. Zinc, lead, arsenic and selenium are detected in leachates from fewer than 15% of samples. One sample from the North Pit exceeds the arsenic and selenium LCT0 and one ore sample exceeds the lead LCT0. No LCT1 threshold values were exceeded. These results indicate that some materials have the potential to leach low concentrations of arsenic, chromium, manganese, nickel, lead and selenium. Arsenic and chromium have been observed in background groundwater at concentrations above the SANS 241 drinking water standard, indicating that there is potential for mobilisation of these trace elements from waste and ore materials under the right geochemical conditions.

Conclusions that can be reached from the leach tests are as follows:

- Nitrate present in groundwater does not originate from the waste rock or ore. It is more likely related to fertilization of fields;

- Arsenic, chromium, manganese, nickel, lead and selenium have the potential to be mobilised from waste rock dumps, tailings facilities or ore stockpiles. The detection of Cr(VI) and arsenic above drinking water standards in boreholes in the vicinity of the mine suggests that these processes are already occurring in the unmined geology, possibly, in the case of chromium, exacerbated by extensive irrigation practices.

5. Modelling Approach

5.1. Conceptual hydrological models

The conceptual hydrological models are based on the completed pit and do not consider the changes in relative water inflow volumes and waste rock versus ore rock exposure that occur as the pit develops. Two models are considered, namely the unflooded pit during operation from which irrigation water is pumped from a sump, and the backfilled flooded pit post-closure.

The water that collects in the North pit will be a mixture of the various water sources entering the pit which has been modified by reaction with the pit wall rocks and by evaporation. Water sources that will contribute to the water in the pit will include:

- Surface water run-off from the catchment surrounding the pit. Engineering controls on surface water flow should be set up to divert as much run-off away from the pit as possible, therefore this is not expected to be a large volume of water.
- Rainfall directly into the pit.
- Groundwater inflow into the pit. Water can enter the pit from the shallower highly fractured aquifer or the deeper less fractured aquifer, although most water (~80%) is expected to originate from the highly fractured aquifer.
- Once the water table has recovered, the backfilled pit will contain a mixture of surface water runoff, rainfall and groundwater inflow.

Water is removed from the pit by:

- Pumping for irrigation – this should not affect the water quality because the quality of the water pumped out is the same as the water quality in the sump. The volume pumped for irrigation during operation is assumed to equal the amount required to be removed to prevent the pit from flooding. However, post closure, the volume of water removed for irrigation is reportedly reduced to 103 068 m³/month (Water Hunters, 2024) to allow recovery of the water table.
- Evaporation – evaporation removes pure water and leaves behind dissolved ions. This means that the concentrations of ions in the remaining water increase in proportion to the amount of water evaporated. The volume of water evaporated is expected to be negligible once the pit is backfilled.

The volume of water in (V_{in}) and out (V_{out}) of the pit are expected to be equal at steady state:

$$V_{in} = V_{out}$$

The inflowing water is a mixture of run-off from the area surrounding the pit (V_{RO}), rainwater directly into the pit (V_{rain}), shallow groundwater (V_{GWS}) and deep groundwater (V_{GWD}):

$$V_{in} = V_{RO} + V_{rain} + V_{GWS} + V_{GWD}$$

The volume of water leaving the pit will be the sum of water evaporated (V_{EV}) and water pumped out for irrigation (V_{IRR}):

$$V_{out} = V_{EV} + V_{IRR}$$

Combining the various inflows and outflows gives:

$$V_{RO} + V_{rain} + V_{GWS} + V_{GWD} = V_{EV} + V_{IRR}$$

5.2. Conceptual geochemical model

The expected chemistry of the water in the pit at steady state can be estimated using a salt balance to estimate the quality of the irrigation water assuming other inputs are known. The salt balance calculates the amount of salt entering and leaving the pit by multiplying the volume of each water source (in L) with its quality (in mg/L). The initial volume (V_i) and quality (Q_i) of water in the pit must also be considered. In an unflooded pit, this term would represent the water in the sump. It is likely to be very small relative to the other water sources and is ignored. However, in the backfilled pit, the volume of water already in the pit will be large relative to the inflowing water, and so must be included in the salt balance. Reactants added ($Reactants_{in}$) or removed ($Reactants_{out}$) from the system by reaction of the water mixture with the wall and floor rock, and evaporative concentration must also be considered:

$$(V_i \times Q_i) + (V_{RO} \times Q_{RO}) + (V_{rain} \times Q_{rain}) + (V_{GWS} \times Q_{GWS}) + (V_{GWD} \times Q_{GWD}) + Reactants_{in} = (V_{EV} \times Q_{EV}) + (V_{IRR} \times Q_{IRR}) + Reactants_{out}$$

The various inputs and outputs are shown as conceptual models for operation and closure in Figure 23 and Figure 24.

Figure 23: Conceptual site model for North Pit operation

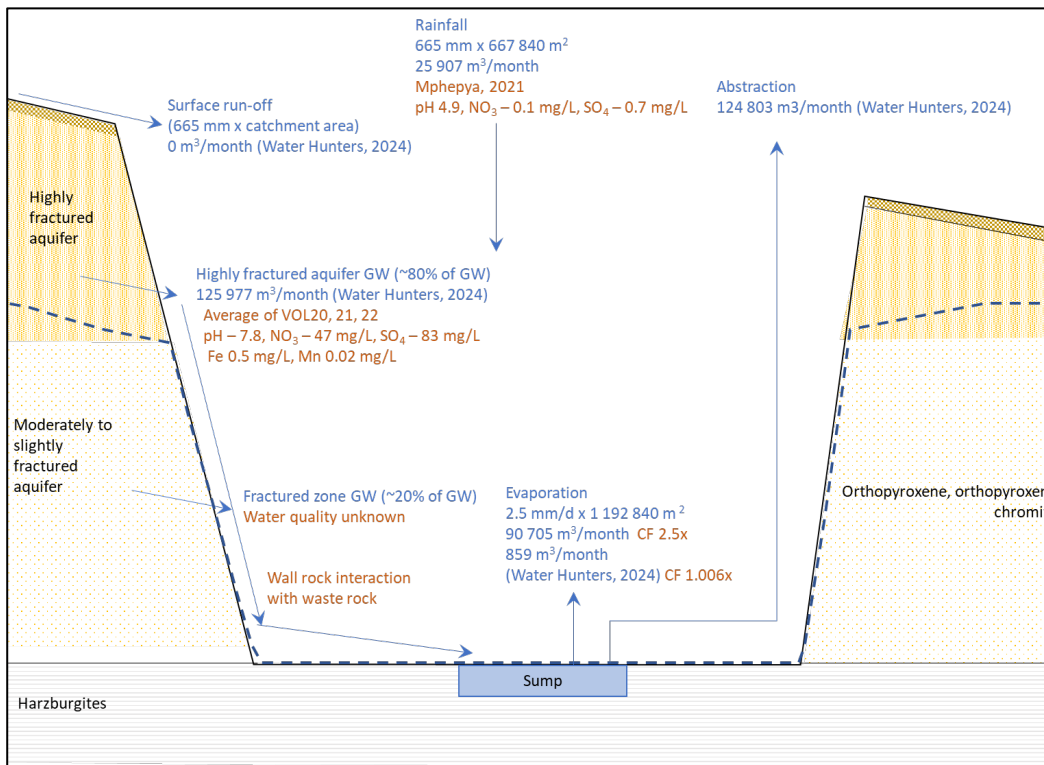
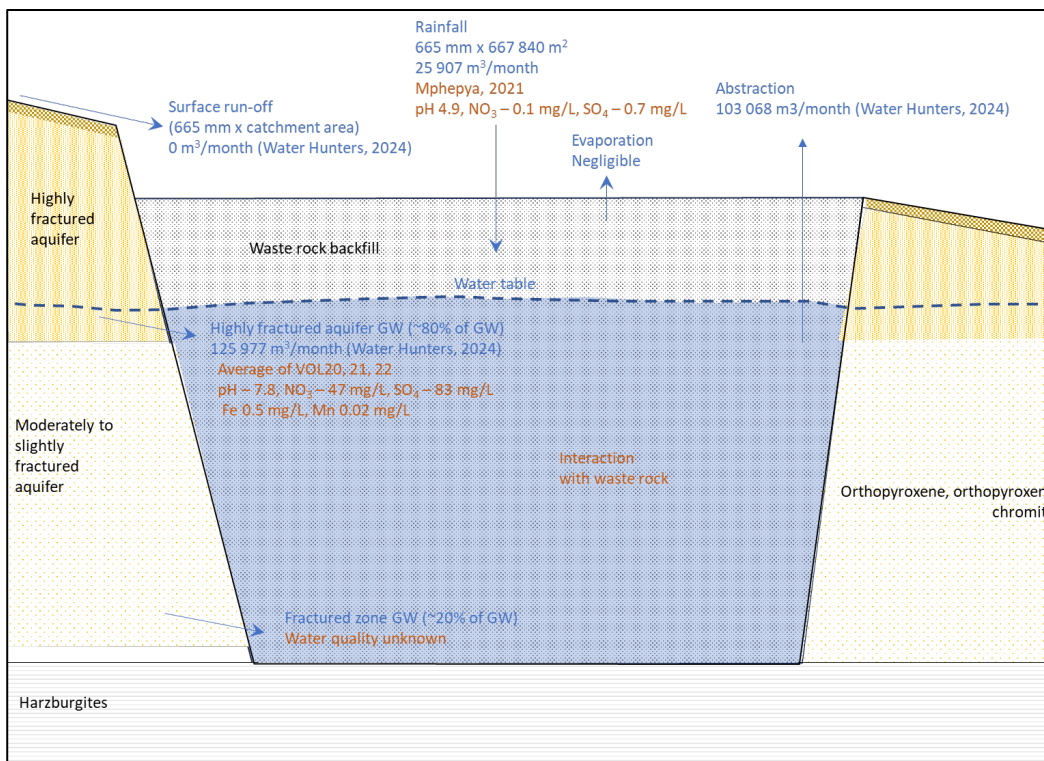


Figure 24: Conceptual site model for North Pit closure



Geochemical modelling is used to estimate the inputs and outputs of chemical constituents from reactions of water with exposed minerals on the pit walls or along the pit floor. Groundwater would be expected to already be largely in equilibrium with the aquifer minerals, such as enstatite, smectite and talc. Incongruent weathering of

enstatite and talc would be expected to form smectite and release some magnesium into groundwater. These minerals would also be present in the walls and floor of the pit as well as the backfilled waste rock. However, the system is slightly different in the pit compared to in the aquifer, as follows:

- During operation, wall and floor rocks in the unflooded pit are exposed to atmospheric partial pressures of oxygen and carbon dioxide. Oxygen can oxidize minerals such as sulphides.
- Blasting of the rocks can generate material of finer grain size than in the aquifer, increasing the reactive surface area and exposing fresh surfaces to weathering.
- The concentration of trace elements may be higher in ore rocks and rocks close to the ore zone.

Based on leach tests and groundwater quality, potential contaminants of concern include chloride, nitrate, nickel, Cr(VI), iron, manganese, copper and aluminium.

Chloride behaves conservatively and would be concentrated by evaporation. The chloride concentration in rainfall run-off is likely to be low compared to the chloride concentration in groundwater, and concentration of the chloride in groundwater is likely to be the main source of chloride in the pit.

Groundwater in the North Pit footprint has background concentrations of nitrate above agricultural guidelines, most likely due to fertilization and irrigation. Nitrate is highly soluble in water and nitrate concentrations are not likely to be limited by mineral precipitation. Nitrogen is a redox-controlled element which cycles through the environment and its behaviour is closely tied to biological activity. Under the oxidizing conditions that would be expected in the presence of oxygen, such as in recently recharged groundwater or the pit walls and floor, nitrate is stable. Nitrate can be assimilated into plant matter, for example algae that may grow in a dam, with nitrogen gas being released on decomposition of the organic matter. However, under oxidizing conditions with no organic carbon, nitrate concentrations would increase through evaporation (Soni, Mishra, & Singh, 2014; Gammons, Harris, Castro, Cott, & Hanna, 2009). Denitrification may occur in the backfilled pit, but it is not included in the geochemical model due to the number of unknowns in terms of future water quality, particularly with respect to the presence of organic carbon.

Nickel can be present in pentlandite, a nickel sulphide mineral in which the PGEs are hosted ($(\text{Fe,Ni})_9\text{S}_8$), or as a constituent of enstatite (Deer, Howie, & Zussman, 1970). Assuming all sulphur in the waste rock is present as pentlandite, there is less than 0.6 wt% of pentlandite present in the waste rocks. Oxidation of pentlandite under the oxidizing conditions present within the pit can release elements such as nickel. However, nickel mobility is limited at $\text{pH} > 7$ by adsorption to smectite and iron oxide minerals (Appelo, 2005; McBride, 1994). Nickel can also precipitate as an oxide or hydroxide mineral in oxidizing conditions above pH 7 to 8. At $\text{pH} < 7$, nickel mobility is increased, as observed in the acid rain leachates of the waste rock. Oxidation of sulphide minerals also mobilises sulphate. Sulphate solubility is limited by gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) precipitation (Eary, 1999).

Iron and manganese are ubiquitous in groundwater. At $\text{pH} > 7$ under oxidizing conditions, solubility of both iron and manganese is expected to be limited by

precipitation of hydroxide and carbonate minerals, and by adsorption to organic matter, oxides and silicates. However, measured concentrations in water often exceed concentrations that would be expected if concentrations were thermodynamically limited by mineral precipitation (McBride, 1994). This disequilibrium could be due to:

- Solid particles being included in the dissolved phase either because the sample was not filtered, or because the particles are small enough to pass through a 0.45 micron filter; or
- Redox disequilibrium.

Accurate projection of the long-term manganese and iron concentrations in the irrigation water can therefore be difficult. Based on a study of 24 pit lakes at former hard rock mines, Eary (1999) found that at neutral pH, iron concentrations exceeded solubility limits for iron hydroxide minerals, but considering the generally low concentrations observed at neutral pH, ferrihydrite ($\text{Fe}(\text{OH})_3$) was still considered an acceptable solubility control to use in a geochemical model. For manganese, manganite is a possible control, but at neutral pH, manganese concentrations often exceed concentrations which would be expected if minerals such as manganite (MnOOH) controlled the solubility. Rhodochrosite (MnCO_3) could control solubility at alkaline pH (Eary, 1999).

Aluminium solubility in water is lowest between pH 6 and 7 and increases under more acid or alkaline conditions. Aluminium concentrations in the distilled water leach test from the ore samples were up to 71 mg/L due to the alkaline nature of the leach (pH 9.7). Based on a study of 24 pit lakes at former hard rock mines, Eary (1999) found that at neutral pH, amorphous aluminium hydroxide ($\text{Al}(\text{OH})_3$) provides a reasonable upper limit for aluminium concentrations, and this is used in the model.

Copper mobility tends to be limited at near neutral pH due to sorption to organic matter, clays and oxides, but it can be mobilized as the Cu^{2+} ion at acidic pH and by the formation of hydroxy or carbonate complexes at alkaline pH (McBride, 1994). This is observed in the alkaline (pH 9.7) distilled water leach test from the ore which has a copper concentration of 1.3 mg/L.

Cr(VI) has been included in the model but is assumed to originate only from groundwater i.e. not through leaching from exposed rocks, and to behave conservatively i.e. it is not removed from solution by any reactions. Further investigation of the distribution of Cr(VI) and the mechanism of mobilisation will be needed to refine the geochemical model.

5.3. Numerical Model

Geochemical modelling was undertaken using the PHREEQC modelling program (Parkhurst, 2013) version 3.7.3.15968. PHREEQC allows modelling of low-temperature aqueous geochemical reactions and can be used to model speciation, saturation indices, kinetics, mixing, inverse modelling and one-dimensional transport.

The conceptual model is converted to a quantitative geochemical model as follows:

- Step 1: Calculate the quality of the mixture using a Phreeqc mixing model:

$$Q_{\text{mix}} = ((V_{\text{RO}} \times Q_{\text{RO}}) + (V_{\text{Rain}} \times Q_{\text{Rain}}) + (V_{\text{GWS}} \times Q_{\text{GWS}}) + (V_{\text{GWD}} \times Q_{\text{GWD}}) + (V_i \times Q_i)) / V_{\text{IRR}}$$

- Step 2: Adjust the quality of the mixture for evaporation by modelling a reaction in Phreeqc that removes pure water.
- Step 3: Allow the system to chemically equilibrate by dissolving and precipitating minerals and allowing adsorption onto precipitated ferric hydroxide.

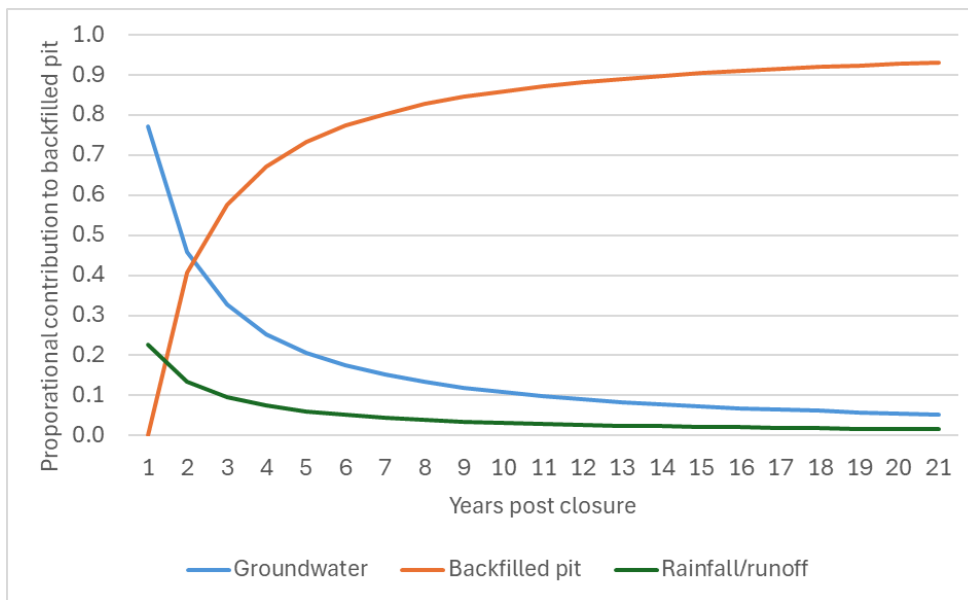
Input data were sourced from previous reports and literature. Water volumes were sourced or calculated as follows (Table 7):

- V_{RO} and V_{Rain} were combined and calculated as a single parameter. This is because there was no information about the size of the catchment outside of the pit, but the catchment is assumed to be small relative to the size of the pit. The pit surface area was provided in the water balance report (Water Hunters, 2024). The site water balance (Water Hunters, 2024) does not include rainfall or surface water run-off into the North pit. The $V_{RO+Rain}$ was calculated by multiplying the pit surface area with the annual rainfall of 665 mm as specified in Water Hunters (2024). For the operational model, the runoff was adjusted using a runoff coefficient of 0.7 (Table 4; Water Hunters, 2024). No runoff coefficient was included in the post-closure model assuming that the amount of infiltration would be high. This value was then divided by 12 to obtain an average monthly rainfall + runoff amount.
- Several estimates of the total volume of groundwater ($V_{GWS} + V_{GWD}$) entering the pit were available. Water Hunters (2024) include fissure water in the water balance (125 977 m³/month), and GPT (2024; Table 14) estimate inflows into both pits of between 152 000 and 273 750 m³/month. The GPT (2024) values were halved to obtain inflows into the North Pit only. Of these inflows, 80% is estimated to originate from the upper (<50 m bgl) highly fractured aquifer (V_{GWS}) and 20% from deeper less fractured rock (V_{GWD}) (Giep du Toit, pers.comm.)
- The volume of water removed from the pit (V_{IRR}) was provided in Water Hunters (2024). This value was taken as the volume of water pumped from the pit to the irrigation dam.
- The amount of evaporation during operation was sourced from the water balance report (Water Hunters, 2024) or was calculated based on the pit floor and wall surface area and an evaporation rate given in GPT (2024). In the model this is implemented as a concentration factor calculated as the total volume before evaporation divided by the total volume after evaporation. Concentration factors during operation varied from 1.006 in the base case to 9.1 for the low recharge scenario (Scenario 4). Evaporation was not included in the closure model because no surface water body is expected.

During operation, the system is modelled as being at steady state i.e. the amount of water entering the pit is equal to the amount leaving the pit. However, post-closure, the water level in the pit is assumed to recover because the amount of water removed from the pit is less than the amount of water entering the pit. While the water table recovers, the proportional contribution of groundwater inflow and rainfall to the water quality decrease relative to the influence of water already in the pit because of the increasing volume of water in the pit. Simplistic calculations were completed to

demonstrate this effect which is illustrated in Figure 25. Once the water level has recovered, it is expected that the water table in the backfilled pit may be slightly mounded due to increased recharge into the backfill. The increased contribution of recharge may also result in fresher water quality within the backfilled pit than in the adjacent aquifer. The water within the backfill is assumed to mix completely, although it is more likely that the recharge effect will be greater at shallower depths, i.e. shallower groundwater will be fresher. The closure model is run per year over 20 years with the initial water quality for each year being the output of the model for the previous year.

Figure 25: Relative contributions of groundwater, rainfall/runoff and water already in the pit to the backfilled pit over time



Water quality inputs to the geochemical model include:

- Literature data from Mphepya et al (2004) was used for Q_{Rain} .
- The quality of shallow groundwater (Q_{GWS}) is taken as the average of the quality of VOL19, VOL20, VOL21, VOL22, VOL25 and VOL27 (GPT, 2024). These six boreholes are within or immediately adjacent to the proposed pit shell boundary. No definitive information on the quality of deep groundwater (Q_{GWD}) was found, although the review of water quality in Section 3 suggests there are different populations of water. For the current model, the groundwater quality used for Q_{GWS} is assumed to be representative of both shallow and deep groundwater.

Input water quality is given in Table 6.

Weathering of rock-forming minerals enstatite and talc to montmorillonite (smectite) is likely to occur with time, but the process is slow. Enstatite was therefore included as a kinetic reactant using kinetic data from Palandri and Kharaka (2004). The backfilled pit was assumed to be a closed system because the majority of the water will not be in contact with the atmosphere. Oxygen and carbon dioxide are contributed by rainfall/runoff. Reducing conditions may develop in the pit through consumption of oxygen by decomposition of organic matter and oxidation reactions.

An equilibrium phase mineral assemblage was included in the model which consisted of:

- Talc was included in the model based on the amount measured by XRD. Precipitation was not allowed because talc is unlikely to form under the conditions present in the open pit.
- Weathering products magnesium montmorillonite (smectite), gibbsite, ferric hydroxide, nickel hydroxide, manganite and magnesite. Some smectite was included in the initial model, but no amount of the other minerals was included in the initial model. These minerals were allowed to precipitate and dissolve.
- As no thermodynamic data for pentlandite could be sourced, the mineral millerite was used to represent nickel sulphide. A small amount of millerite was added to allow the solution to reach a nickel concentration equivalent to the acid rain leach. Sinks for nickel in the model include nickel hydroxide and sorption to iron hydroxide and clay minerals. Sorption to smectite was included in the model using data from Bradbury & Baeyens (1995),
- Oxygen and carbon dioxide were not included as equilibrium reactants in the model as the backfilled pit was assumed to be a closed system. Oxygen can enter the system in runoff/rainfall water, and carbon dioxide is generated by rock weathering.

Trace element cations and anions that were present in solution were allowed to sorb onto ferric hydroxides that precipitated during the simulation. Sorption data for nickel were sourced from Olin & Lehtikoinen (1997).

The quality of water within the pit will not be constant and is expected to vary based on a number of factors including:

- The amount of rainfall and evaporation which can vary seasonally and over longer term cycles;
- The amount and quality of inflowing shallow groundwater; and
- The amount and quality of inflowing deep groundwater.

Because some of these factors are expected to vary with time, a scenario modelling approach was taken to model pit water quality under a variety of conditions. The scenarios were modelled by using input parameters from different reports and by considering seasonal variation in rainfall and evaporation. The scenarios and input values for each scenario are summarised in Table 7 and include:

- Base case – based on water balance conducted by Water Hunters (2024) which excludes evaporation and is therefore likely to be a best-case scenario.
- Scenario 1 – the base case with evaporation included, and therefore more realistic than the base case.
- Scenario 2 and 3 – the same rainfall and evaporation as Scenario 1 but using low (Scenario 2) and high (Scenario 3) groundwater inflow values from GPT (2024) to assess the effect that groundwater inflow volumes will have on water quality. Scenario 2 would represent the worst case scenario in terms of evaporative concentration.
- Scenario 4 and 5 – the same groundwater inflows as Scenario 1 but with evaporation and rainfall rates modified for summer (higher rainfall and higher

evaporation -Scenario 4) and winter (lower rainfall and lower evaporation – Scenario 5) conditions.

- Scenario 6 – representing the backfilled pit as closure, this uses the same input values as the base case but with increased rainfall infiltration.

Table 6: Input water qualities for geochemical model

Borehole	Units	Inflowing groundwater	Rainfall (Mphepya, Pienaar, Galy-Lacaux, Held, & Turner, 2004)
EC	mS/m	110	-
TDS	mg/L	588	3.3
pH		7.8	4.9
Total alkalinity	mg/L as CaCO ₃	311	0.7
NO₃	mg/L as N	33	0.3
SO₄	mg/L	88	0.7
F	mg/L	0.30	na
Cl	mg/L	56	0.4
Na	mg/L	18	0.2
Ca	mg/L	43	0.2
Mg	mg/L	115	0.5
K	mg/L	4.6	0.2
Fe	mg/L	0.1	na
Mn	mg/L	0.002	na
Al	mg/L	bdl	na
Cr(VI)	mg/L	0.22	na

bdl – below detection limits

na - not analysed

Table 7: Input volumes for model scenarios

Scenario	Units	Base case (Water balance)	Scenario 1 (Water balance + eva- poration)	Scenario 2 (GPT low)	Scenario 3 (GPT high)	Scenario 4 (Summer)	Scenario 5 (Winter)	Scenario 6 (Closure)
Total ground- water	m ³ /month	125977	125977	76042	212917	125977	125977	125977
Shallow ground- water	m ³ /month	100782	100782	60833	170333	100782	100782	100782
Deep ground- water	m ³ /month	25195	25195	15208	42583	25195	25195	25195
Rainfall + Runoff	m ³ /month	25907	25907	25907	25907	49223	2591	37009
Total	m³/month	151884	151884	101948	238823	175200	128568	162986
Evapora tion	m ³ /month	859	90706	90706	90706	123360	61680	0
Total - eva- poration	m³/month	151025	61178	11243	148118	51840	66888	162986
Ground- water	Proportion	0.83	0.83	0.75	0.89	0.72	0.98	Varies with time, see Figure 25
Rainfall + runoff	Proportion	0.17	0.17	0.25	0.11	0.28	0.02	
Evapora tive con- centra tion	Factor	1.006	2.5	9.1	1.6	3.4	1.9	
Com- ment		From water balance (Water Hunters, 2024)	Inflow from water balance with evaporati on calculate d from pit floor and walls surface area x 2.5 mm/day	Inflow from low value in GPT (2024) with evaporati on calculate d from pit floor and walls surface area x 2.5 mm/day	Inflow from high value in GPT (2024) with evaporati on calculate d from pit floor and walls surface area x 2.5 mm/day	Inflow from water balance. 95% of rainfall falling in 6 months. Eva- poration double in summer than winter.	Inflow from water balance . 5% of rainfall falling in 6 months. Eva- poration double in summer than winter.	Inflow from water balance with increased rainfall infiltration and no eva- poration

6. Modelling Results

6.1. During operation (Scenario 1 to 5)

The modelled irrigation water quality results for Scenarios 1 to 5 are given in Table 8. The pH of the irrigation water in each of the models is near neutral to slightly alkaline, between 7.4 and 7.8. The TDS of the water in Scenarios 1 to 5 is more than five times higher than background groundwater, with the highest TDS (3157 mg/L) expected to occur if water inflow volumes are low (Scenario 2; GPT low) and in summer months when evaporation is greatest (Scenario 4). In the base case and the Scenario 3 (GPT high), the TDS in the sump may end up lower than the TDS of background groundwater. In the base case this is because groundwater is diluted by rainwater and there is no evaporation to cause further concentration of ions. In Scenario 3, it is because of the incongruent weathering of enstatite in the wall rocks, which releases magnesium which can react with alkalinity to precipitate magnesite, removing dissolved solids from the water. However, the rate and extent to which this reaction would occur is uncertain, and no reliance should be placed on the modelled lower TDS.

Most of the simulated element concentrations are within the irrigation TWQRs but the following elements exceed the TWQRs:

- EC in all the modelled scenarios. According to DWAF (1996), at the simulated EC levels (except for Scenario 2), a relative yield of more than 80% can still be achieved for moderately salt-tolerant crops. However, a leaching fraction of up to 0.2 would be required to prevent soil and groundwater salinization i.e. enough water would need to be irrigated to ensure that 20% of the applied water would drain through the soil below the level of evapotranspiration.
- Nitrate in all the modelled scenarios. Nitrate is believed to originate from fertilization of fields which currently occupy the surface footprint of the North pit. With the commencement of mining, soils overlying the proposed pit shell will be removed. Nearby farming will stop, and nitrogen stored in the soils will gradually be leached out. The amount of nitrogen stored in the soils is not known and the amount of time taken for the nitrate in groundwater to return to background levels is not known. Nitrogen may also originate from areas upgradient of the mine footprint and be transported in groundwater, in which case the nitrogen concentrations may not decrease once mining has started. Irrigation with water with inorganic nitrogen concentrations exceeding 30 mg/L as N can affect yield and quality of crops. In addition, it can continue to contaminate groundwater, especially at the higher leaching fractions which may be required to prevent soil salinisation. The amount of nitrate used in crop fertilization can be reduced by an amount equivalent to that added in irrigation water to maintain the same amount of fertilisation while minimising the risks to groundwater (Department of Water Affairs and Forestry, 1996a).
- Chloride concentrations are above the TWQR for the GPT Low (Scenario 2) and the summer (Scenario 4) scenarios. Chloride concentrations of between 140 and 700 mg/L can cause foliar injury and yield decreases in sensitive crops when crop foliage is wetted, and may cause slight problems with chloride toxicity when water is applied to the soil surface.

The model indicates that nickel concentrations will be limited to <0.007 mg/L by sorption to montmorillonite Table 8. This is largely supported by measured baseline nickel concentrations which are below detection limits in groundwater in the vicinity of the North Pit shell, although nickel is detected at concentrations up to 0.064 mg/L at Grasvally. Measured and modelled nickel concentration are within the TWQR for irrigation (Department of Water Affairs and Forestry, 1996a). Modelled Cr(VI) concentrations range from 0.008 to 0.066 mg/L, with water quality in Scenario 2 predicted to exceed drinking water standards but remain within the irrigation TWQR. Measured groundwater Cr(VI) concentrations do not exceed the drinking water standard or irrigation TWQR in the vicinity of the North Pit, although Cr(VI) was detected at low concentrations (<0.031 mg/L) nearby to the North Pit. The model does not account for generation of additional Cr(VI) due to oxidation of exposed rocks in the walls of the open pit or leaching from TSF and or WRDs. Cr(VI) concentrations will need to be closely monitored in the irrigation water.

The modelled results for irrigation water indicate that the sump water quality is not ideal for irrigation and use may require management in terms of finding appropriate crops, ensuring a sufficient leaching fraction, adjusting fertilization amounts, and monitoring of groundwater quality to ensure the baseline quality does not deteriorate. The water quality is also likely to vary seasonally due to varying amounts of rainfall and evaporation, with worst qualities expected in the summer months. The aspects of the water quality that make it less suitable for irrigation are salinity and nitrate, which already exceed the DWAF irrigation TWQR concentrations in the background groundwater. These concentrations are increased by evaporation within the pit. Sulphate concentrations may increase due to oxidation of sulphide minerals, contributing to the salinity of the irrigation water.

Table 8: Modelling results compared to South African irrigation guideline values (Department of Water Affairs and Forestry, 1996a).

Borehole	EC ^E	TDS	pH	NO ₃	SO ₄	Total alkalinity	F	Cl	Na	Ca	Mg	K	Ni	Fe	Mn	Al	Cr(VI)
Units	mS/m	mg/L		mg/L as N	mg/L	mg/L as CaCO ₃	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
TWQR^A	<40		6.5 - 8.4	<5^B			<2	<140	<70				<0.2	<5	<0.02	<5	<0.1
Crop/soil specific^C	40 - 540		<6.5, >8.4	5 - 30			2-15	140-700	70-460				0.2 - 2.0	5 - 20	0.02 - 10	5 - 20	0.1 - 1
Short term^D	>540			>30				>700	>460				>2.0	>20	>10	>20	>1
Base case (water balance)	81	403	7.8	39	71	20	0.42	51	10	36	45	4	0.001	0.026	<0.001	0.001	0.008
Scenario 1 (water balance + evap)	194	971	7.6	97	175	15	1.04	127	25	94	101	10	0.002	0.026	<0.001	0.001	0.020
Scenario 2 (GPT low)	631	3157	7.4	316	569	10	3.40	416	82	322	329	34	0.007	0.027	<0.001	0.001	0.066
Scenario 3 (GPT high)	134	671	7.7	67	120	17	0.71	87	17	63	71	7	0.002	0.026	<0.001	0.001	0.014
Scenario 4 (summer)	229	1144	7.6	114	206	14	1.22	150	30	112	119	12	0.003	0.026	<0.001	0.001	0.024
Scenario 5 (winter)	174	872	7.7	87	157	16	0.93	114	22	84	91	9	0.002	0.026	<0.001	0.001	0.018

A – TWQR = target water quality range – the range of concentrations which have no effect on crop growth

B – guideline is for total inorganic nitrogen of which nitrate is expected to comprise a large proportion

C – Range within which crop growth may be affected under certain circumstances, particularly in coarser, acidic soils.

D – Generally acceptable only for irrigation over a short term on a site-specific basis.

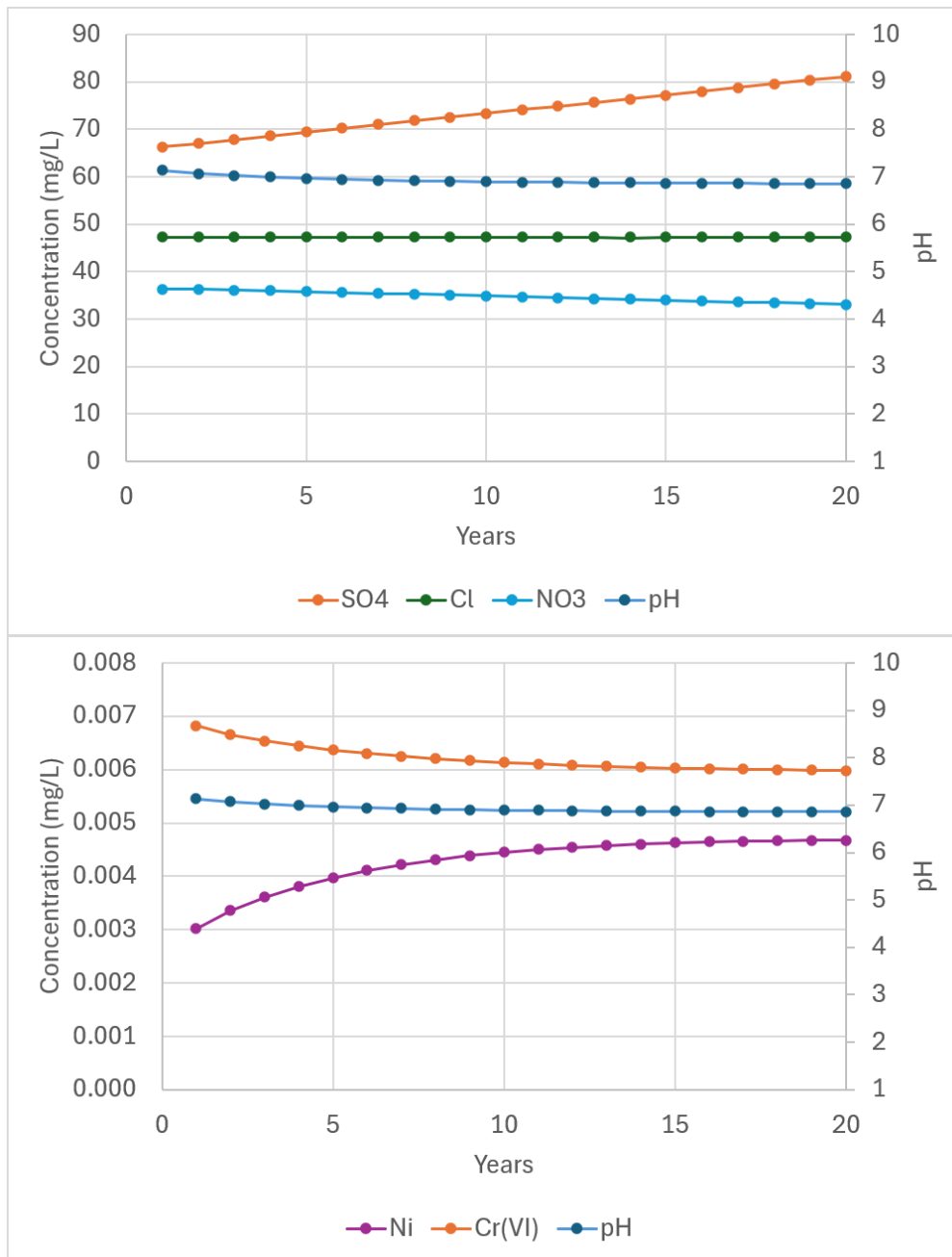
E – EC was calculated from TDS using a factor calculated from the correlation between EC and TDS in groundwater.

6.2. Post closure (Scenario 6)

The results showing the simulated evolution of water quality in the backfilled North Pit based on simplistic calculations for the water balance are shown in Figure 26. The water quality initially has lower concentrations for most parameters compared to background groundwater due to dilution by increased rainfall recharge into the backfilled material. Concentrations of conservative parameters which do not originate from reaction with backfilled material (e.g. chloride) remain stable for the duration of the model because of the slightly increased recharge expected over the backfill and the lack of evaporation. Nitrate concentrations decrease slightly with time as the system becomes less oxidizing due to rainwater inflow being smaller, and oxygen being consumed by sulphide oxidation. Sulphate concentrations increase slightly with time due to ongoing contribution by oxidation of nickel sulphide minerals. Nickel is also generated by these reactions but is immobilised by adsorption to smectite minerals. EC and nitrate exceed the TWQR for irrigation water. The following should be noted:

- The results are dependent on the relative amounts of water entering and leaving the pit. These parameters are currently estimated at a high level.
- The model assumes oxygen is contributed by rainwater and additional nickel sulphide is available each year. The presence of organic carbon in the backfilled material may induce more reducing conditions, under which further nickel sulphide oxidation would be limited, and denitrification could occur, limiting sulphate concentrations and potentially reducing nitrate concentrations.

Figure 26: Evolution of major ions (top) and trace elements (bottom) in backfilled water quality as the water table recovers post closure.



7. Assumptions and limitations

The report focuses only on geochemical controls and geochemical modelling for the North Pit sump and post-closure backfilled pit water quality. Groundwater drawdown and plume migration impacts are covered in GPT (2026).

7.1. Water quality interpretation

- The baseline water quality dataset has historical limitations:

- Several potential contaminants of concern, including copper, nickel and chromium, were not analysed in 2010 samples.
 - Total alkalinity was not reported for many older samples.
 - Laboratory quantification limits for arsenic and chromium were at or above SANS 241 drinking water standards in several samples.
 - Arsenic may be present in some samples but not reported where
- Lithological classification of monitoring locations is partly interpretive and based on available geological maps, limited borehole logs, published geological interpretation and major ion chemistry.

7.2. Geochemical data interpretation

- XRD mineralogical analysis may not detect trace mineral phases, including trace sulphide minerals.
- The South Pit and North Pit waste rock geochemistry are assumed to be broadly similar such that the geochemical results from samples from the South Pit are considered representative of North Pit waste rock geochemistry.
- Comparisons between leachate tests are limited because different leach methods and solid-to-liquid ratios were used for different samples. In addition, leachate pH is affected by the leaching fluid used, which may influence metal mobility.

7.3. Geochemical modelling

- The conceptual hydrological models are based on the completed pit and do not consider the changes in relative water inflow volumes and waste rock versus ore rock exposure that occur as the pit develops.
- Geochemical modelling depends on assumptions about:
 - input water qualities;
 - pit water volumes;
 - groundwater inflow;
 - rainfall/runoff contributions;
 - backfilling of the North Pit;
 - recovery of the water table after closure.
- The model assumes that wall and floor rocks in the unflooded pit are exposed to atmospheric partial pressures of oxygen and carbon dioxide.
- Chloride and Cr(VI) are assumed to behave conservatively. Specifically, the model does not account for potential generation of additional Cr(VI) due to oxidation of exposed rocks in the walls of the open pit or leaching from TSF and or WRDs.
- Nitrate is modelled to behave conservatively i.e. the model does not consider degradation of nitrate through denitrification reactions.
- Gypsum, manganite, amorphous aluminium hydroxide, ferrihydrite, rhodochrosite are included in the model as equilibrium minerals limiting solubility of sulphate, manganese, aluminium and iron.
- The model predicts the incongruent dissolution of enstatite and formation of magnesite. However, the rate and extent of these reactions is uncertain, and no reliance should be placed on the modelled lower TDS.
- Solubility of copper and nickel is assumed to be controlled by sorption to clay minerals and iron oxide minerals.
- The results are dependent on the relative amounts of water entering and leaving the pit. These parameters are currently estimated at a high level.

- The model assumes oxygen is contributed by rainwater and additional nickel sulphide is available each year.
- The model assumes that waste rock has negligible ARD potential, while ore may pose some ARD risk because two ore samples were classified as potentially acid generating.
- Modelled water quality predictions should be treated as scenario-based estimates rather than exact future concentrations, because of uncertainty in hydrological inputs, mineral-water reactions and long-term field conditions.
- Routine monitoring is recommended for constituents of concern, especially Cr(VI), nitrate, arsenic and salinity-related parameters, because dewatering and irrigation use may affect concentrations over time.

8. Summary and Recommendations

A geochemical model was developed to estimate the quality of water reporting to the sump of the North Pit of the proposed Volspruit Mine during operation and in the backfilled pit post closure and to assess whether the water would be suitable for use for irrigation. A detailed assessment of baseline groundwater quality was undertaken in support of the model development to understand likely groundwater inflow quality once mining has commenced.

Several rounds of groundwater monitoring were undertaken in 2010/2011 and 2025/2026 in the broader region surrounding the proposed Volspruit mine. Groundwater quality is affected by the lithology of the aquifer, with clear differences in quality for water originating from different units of the RLS and the nearby Karoo volcanics. Comparison of the water quality to drinking water and irrigation standards identified several parameters with concentrations that could pose a potential health risk to domestic users of groundwater or could affect crops through irrigation, including:

- Nitrate concentrations were above SANS241 drinking water standards and the irrigation TWQR at 44% of sampled locations. The spatial distribution of nitrate did not show a lithological control, but high nitrate concentrations were commonly associated with centre pivot irrigation systems. Nitrate is likely to have originated through farming operations.
- Arsenic concentrations were above SANS241 drinking water standards at 27% of sampled locations. Currently no geochemical controls on arsenic mobility have been identified.
- Cr(VI) concentrations were above SANS241 drinking water standards at 32% of sampled locations and above the TWQR at 25% of sample locations. These locations are limited to the RLS Lower Zone, but predominantly in harzburgite units. However, not all harzburgite locations had elevated Cr(VI), and the highest Cr(VI) concentrations also had elevated nitrate, suggesting that irrigation plays a role in mobilising Cr(VI).

The quality of sump water generated during operation is determined by evaporation of a mixture of rainwater and groundwater, modified by reactions occurring on the pit walls. Data from GPT (2024) and Water Hunters (2024) were used to develop a salt balance for the system, which was then used to calculate the water quality in the sump. Groundwater was estimated to contribute between 72% and 98% of the water in the sump, with the remainder originating as rainfall. Evaporation occurs as the inflowing

water runs down the walls and floor of the pit, concentrating the sump water by 1.006 to 9.1 times. Geochemical reactions were also incorporated into the model, including weathering of rock forming minerals, including trace levels of nickel sulphides, precipitation of minerals which have reached saturation in solution, and adsorption of chemical elements to iron oxide and clay minerals. Six different scenarios were modelled to incorporate the variation in the inflow and evaporation volume estimates from different sources and methods, and to assess the effect of seasonal variation in rainfall and evaporation.

The sump water in all modelled scenarios was found to exceed the TWQR for irrigation for EC and nitrate. EC and nitrate already exceed the TWQR in the background groundwater, and the evaporation in the pit results in an increase in the EC by up to 4 times compared to background. Worse water quality would be expected if there are low inflows and in the summer months due to increased evaporation. Use of the sump water for irrigation would therefore require treatment, or special management in terms of finding appropriate crops, ensuring a sufficient leaching fraction, adjusting fertilization amounts, and monitoring of groundwater quality, to ensure the baseline quality does not deteriorate. Intercepting the water via scavenger boreholes around the edge of the pit rather than pumping from the sump is another approach to manage water quality which would reduce the degree of evaporation, thus improving water quality. Although the model does not currently predict Cr(VI) concentrations above irrigation guidelines, it also does not incorporate geochemical reactions which may generate Cr(VI) within the pit.

The quality of water in the backfilled pit post closure becomes slightly fresher than surrounding groundwater due to the increased recharge expected into the backfill. Backfilling is expected to prevent evaporation and limit ingress of atmospheric gases, and the pumped-out water quality would be expected to be better than during operation. A slight increase in concentration with time might occur for EC and sulphate assuming that some nickel sulphide oxidation occurs. Nickel mobility is limited by adsorption to iron oxide and smectite weathering products. The model also does not currently include Cr(VI) generation reactions which may occur within the backfill. Although a slight improvement in quality is expected in the backfilled pit, the post-closure water quality does not meet the TWQR for irrigation water for EC and nitrate because of the concentrations of these parameters in the background groundwater. The model does not account for reactions which may remove nitrates from the system if there is organic carbon present, and presents a worst case scenario for the set of input parameters. Development of reducing conditions within the backfilled pit is likely to lead to denitrification, resulting in decreasing nitrate concentrations in irrigation water, and will also limit sulphide oxidation. Reducing conditions would also remove any Cr(VI) from the water.

The models that have been developed have several limitations, namely:

- The model during operation is developed based on the final pit dimensions and does not consider changes in water quality with time as the pit expands during mining.
- The model does not account for changes in the background groundwater quality which may occur due to seepage from mine infrastructure, such as the TSF or return water dams, or changes in groundwater flow direction due to dewatering.

- The models do not include trace element concentrations other than iron, manganese, aluminium, nickel and Cr(VI).
- The post-closure model is based on simplistic calculations which do not take into account the likely decrease in groundwater inflows with time.

The following recommendations are made for further work to improve the confidence in the model:

- Continue to conduct quarterly groundwater monitoring to improve the understanding of the behaviour of arsenic and Cr(VI);
- Once the distribution and geochemical controls on arsenic and Cr(VI) are better understood, update the geochemical models with these parameters;
- Improve estimates of inflows and outflows for the models as the water quality is sensitive to these changes.

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CERTIFICATE OF ANALYSES**TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS**

Date received: 2010 -05 -18
Project number: 123

Date completed: 2010 -07 -09
Report number: 26903

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Telephone: 012 804 8120 Fax:012 804 8140

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Analyses	Sample Identification	
	GVN 132 M-A	GVN 132 M-B
Sample Number	5138	5139
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Distilled Water	Distilled Water
Mass Used (g) (dry)	100	100
Volume Used (mℓ)	400	400
ICP – OES Scan	See Attached Spreadsheet	See Attached Spreadsheet

Analyses	Sample Identification	
	GVN 132 M-C	
Sample Number	5140	
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Distilled Water	
Mass Used (g) (dry)	100	
Volume Used (mℓ)	400	
ICP – OES Scan	See Attached Spreadsheet	

Technical Signatory: E. Nkabinde

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CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2010 - 05 -18
Project number: 123

Report number: 26903

Date completed: 2010 -
Order number:

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Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification		
	GVN 132 M-A	GVN 132 M-B	GVN 132 M-C
Sample Number	5138	5139	5140
Paste pH	7.3	9.3	9.7
Total Sulphur (%) (LECO)	0.01	2.04	0.75
Acid Potential (AP) (kg/t)	0.313	63.75	23.44
Neutralization Potential (NP)	4.45	9.90	5.45
Nett Neutralization Potential (NNP)	4.15	0.00	0.00
Neutralising Potential Ratio (NPR) (NP : AP)	14	0.155	0.232
Rock Type	II	I	I

- Negative NP values are obtained when the volume of NaOH (0.1N) titrated (pH:8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 – 2.5 Any negative NP values are corrected to 0.00.

Please refer to Appendix (p.2) for a Terminology of terms and guidelines for rock classification

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APPENDIX : TERMINOLOGY AND ROCK CLASSIFICATION

TERMINOLOGY (SYNONYMS)

- Acid Potential (AP) ; *Synonyms*: Maximum Potential Acidity (MPA)
Method: Total S(%) (Leco Analyzer) x 31.25
- Neutralization Potential (NP) ; *Synonyms*: Gross Neutralization Potential (GNP) ; *Syn*: Acid Neutralization Capacity (ANC) (The capacity of a sample to consume acid)
Method: Fizz Test ; Acid-Base Titration (Sobek & Modified Sobek (Lawrence) Methods)
- Nett Neutralization Potential (NNP) ; *Synonyms*: Nett Acid Production Potential (NAPP)
Calculation: $NNP = NP - AP$; $NAPP = ANC - MPA$
- Neutralising Potential Ratio (NPR)
Calculation: $NPR = NP : AP$

CLASSIFICATION ACCORDING TO NETT NEUTRALISING POTENTIAL (NNP)

If $NNP (NP - AP) < 0$, the sample has the potential to generate acid

If $NNP (NP - AP) > 0$, the sample has the potential to neutralise acid produced

Any sample with $NNP < 20$ is potentially acid-generating, and any sample with $NNP > -20$ might not generate acid (Usher *et al.*, 2003)

ROCK CLASSIFICATION

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

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ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD**

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Client name: Geo Pollution Technologies Address: PO Box 38384 Garsfontein East 0060 Telephone: 012 804 8120	Facsimile: 012 804 8140	Contact person: B. Bredenkamp Email: brendon@gptglobal.com Cell: 082 821 4841

CLASSIFICATION ACCORDING TO NEUTRALISING POTENTIAL RATIO (NPR)

Guidelines for screening criteria based on ABA (Price *et al.*, 1997 ; Usher *et al.*, 2003)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	< 1:1	Likely AMD generating
Possibly	1:1 – 2:1	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	2:1 – 4:1	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	>4:1	No further AMD testing required unless materials are to be used as a source of alkalinity

CLASSIFICATION ACCORDING TO SULPHUR CONTENT (%S) AND NEUTRALISING POTENTIAL RATIO (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity but it is likely to be only of short-term significance. From these facts, and using the NPR values, a number of rules can be derived:

- 1) Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidisable Sulphide-S to sustain acid generation.
- 2) NPR ratios of >4:1 are considered to have enough neutralising capacity.
- 3) NPR ratios of 3:1 to 1:1 are considered inconclusive.
- 4) NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating. (Soregaroli & Lawrence, 1998 ; Usher *et al.*, 2003)

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Technical Signatory

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CERTIFICATE OF ANALYSES ACID – BASE ACCOUNTING EPA-600 MODIFIED SOBEK METHOD

Date received: 2010 - 05 -18
Project number: 123

Report number: 26903

Date completed: 2010 -
Order number:

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PRICE, W.A., MORIN, K. & HUTT, N. 1997. **Guidelines for the prediction of Acid Rock Drainage and Metal leaching for mines in British Columbia** : Part 11. Recommended procedures for static and kinetic testing. In: Proceedings of the Fourth International Conference on Acid Rock Drainage. Vol 1. May 31 – June 6. Vancouver, BC., pp. 15 – 30.

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WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES
ICP-OES - SCAN (31 ELEMENTS)

Date received: 2010/05/18
Project number: 123

Date Completed: 2010/07/09
Report number: 26903

Client name: Geo pollution Technologies
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Extract	Sample Dry Mass	Volume	Mass (g/l)	Factor
DIST WATER	100	400	250	4

Sample Id	Sample number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<0.100	<0.400	<0.010	<0.040
GVN 132 M-A	5138	0.108	0.432	5.73	23	<0.010	<0.040
GVN 132 M-B	5139	<0.025	<0.100	<0.100	<0.400	<0.010	<0.040
GVN 132 M-C	5140	0.371	1.48	71	284	<0.010	<0.040

Sample Id	Sample number	B	B	Ba	Ba	Be	Be
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-A	5138	<0.025	<0.100	0.726	2.90	<0.025	<0.100
GVN 132 M-B	5139	<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-C	5140	0.051	0.204	2.31	9.24	<0.025	<0.100

Sample Id	Sample number	Bi	Bi	Ca	Ca	Cd	Cd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<2	<10	<0.005	<0.020
GVN 132 M-A	5138	<0.025	<0.100	12	48	<0.005	<0.020
GVN 132 M-B	5139	<0.025	<0.100	5.00	20	<0.005	<0.020
GVN 132 M-C	5140	<0.025	<0.100	80	320	<0.005	<0.020

Sample Id	Sample number	Co	Co	Cr	Cr	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-A	5138	0.276	1.10	0.640	2.56	0.364	1.46
GVN 132 M-B	5139	<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-C	5140	0.076	0.304	2.83	11	1.27	5.08

Sample Id	Sample number	Fe	Fe	K	K	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<1.00	<4.00	<0.025	<0.100
GVN 132 M-A	5138	40.00	160.000	4.50	18.000	<0.025	<0.100
GVN 132 M-B	5139	0.7	2.840	18	72.000	<0.025	<0.100
GVN 132 M-C	5140	216.00	864.000	27.00	108.000	<0.025	<0.100

Sample Id	Sample number	Mg	Mg	Mn	Mn	Mo	Mo
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<8	<0.025	<0.100	<0.025	<0.100
GVN 132 M-A	5138	82	328	2.99	12	<0.025	<0.100
GVN 132 M-B	5139	4.00	16	<0.025	<0.100	<0.025	<0.100
GVN 132 M-C	5140	252	1008	5.48	22	<0.025	<0.100

Sample Id	Sample number	Na	Na	Ni	Ni	P	P
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<2	<8	<0.025	<0.100	<0.025	<0.100
GVN 132 M-A	5138	7.00	28	1.14	4.56	0.177	0.708
GVN 132 M-B	5139	29	116	<0.025	<0.100	<0.025	<0.100
GVN 132 M-C	5140	110	440	1.49	5.96	0.543	2.17

Sample Id	Sample number	Pb	Pb			Sb	Sb
		mg/l	mg/kg			mg/l	mg/kg
Det Limit		<0.020	<0.100			<0.010	<0.040
GVN 132 M-A	5138	0.032	0.128			<0.010	<0.040
GVN 132 M-B	5139	<0.025	<0.100			<0.010	<0.040
GVN 132 M-C	5140	0.157	0.628			<0.010	<0.040

Sample Id	Sample number	Se	Se	Si	Si	Sn	Sn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.020	<0.080	<0.200	<1.00	<0.025	<0.100
GVN 132 M-A	5138	<0.020	<0.080	49	196	7.64	31
GVN 132 M-B	5139	<0.020	<0.080	16	64	0.137	0.548
GVN 132 M-C	5140	<0.020	<0.080	72	288	44	176

Sample Id	Sample number	Sr	Sr	Ti	Ti	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-A	5138	0.253	1.01	<0.025	<0.100	<0.025	<0.100
GVN 132 M-B	5139	0.054	0.216	<0.025	<0.100	<0.025	<0.100
GVN 132 M-C	5140	2.58	10	0.340	1.36	0.281	1.12

Sample Id	Sample number	W	W	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-A	5138	<0.025	<0.100	0.033	0.132	<0.025	<0.100
GVN 132 M-B	5139	<0.025	<0.100	<0.025	<0.100	<0.025	<0.100
GVN 132 M-C	5140	<0.025	<0.100	0.153	0.612	<0.025	<0.100

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES
ICP-MS SEMI-QUANTITATIVE ANALYSIS [s]

Date received: 2012/02/08
Project number: 123

Date Completed: 2012/03/08
Report number: 34030

Client name: GEO POLLUTION TECHNOLOGIES
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Telephone: 012 804 8120

Contact person: Altus Huisamen
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Cell: 083 352 0223

Extract	Sample Dry Mass (g)	Volume (ml)	Factor
Acid Rain	50	1000	20

[s]= Results obtained form subcontracted laboratory

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	0.207	4.14	<0.01	<0.20
Composite 2	2462	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	0.170	3.39	0.586	12
Composite 2	2462	<0.01	<0.20	0.140	2.79	0.434	8.68
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	0.060	1.21
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	0.099	1.98

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	<0.01	<0.20	2	40
Composite 2	2462	<0.01	<0.20	<0.01	<0.20	9	180
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	9	180
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	45	900

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	<0.01	<0.20	0.016	0.315
Composite 2	2462	<0.01	<0.20	<0.01	<0.20	0.042	0.835
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	0.020	0.409
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	0.015	0.301

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	0.042	0.848	<0.01	<0.20	0.019	0.377
Composite 2	2462	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 2	2462	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	0.726	15	<0.01	<0.20	<0.01	<0.20
Composite 2	2462	0.014	0.275	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	0.025	0.507	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	0.014	0.283	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 2	2462	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	Ho	Ho	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	<0.01	<0.20
Composite 2	2462	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	0.4	7.5	<0.01	<0.20	<0.01	<0.20
Composite 2	2462	3.0	60	<0.01	<0.20	<0.01	<0.20
Composite 3	2463	3.6	71	<0.01	<0.20	<0.01	<0.20
Composite 4	2464	3.5	70	<0.01	<0.20	<0.01	<0.20

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Composite 1	2461	<0.01	<0.20	7	140	0.206	4.13
Composite 2	2462	<0.01	<0.20	18	360	0.384	7.67

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2012-02-08
Project number: 123

Report number: 34030

Date completed: 2012-03-13
Order number: Volspruit EAV-11-053

Client name: GEO POLLUTION TECHNOLOGIES
Address: P O Box 38384, Garsfontein East, 0060
Telephone: 012 804 8120 Fax: 012 804 8140

Contact person: Altus Huisamen
Email: altus@gptglobal.com
Cell: 083 352 0223

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification				
	Composite 1	Composite 2	Composite 3	Composite 4	Composite 4
Sample Number	2461	2462	2463	2464	2464D
Paste pH	6.7	8.7	8.9	8.7	8.9
Total Sulphur (%) (LECO)	<0.01	0.09	0.09	0.19	0.19
Acid Potential (AP) (kg/t)	0.31	2.81	2.81	5.94	5.94
Neutralization Potential (NP)	4.18	7.12	8.10	21.48	20.99
Nett Neutralization Potential (NNP)	3.86	4.30	5.28	15.54	15.05
Neutralizing Potential Ratio (NP : AP)	13.36	2.53	2.88	3.62	3.53
Rock Type	III	III	III	III	III

- Negative NP values are obtained when the volume of NaOH (0.1N) titrated (pH:8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 – 2.5 Any negative NP values are corrected to 0.00.

Please refer to Appendix (p.2) for a Terminology of terms and guidelines for rock classification

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2012-02-08
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APPENDIX : TERMINOLOGY AND ROCK CLASSIFICATION

TERMINOLOGY (SYNONYMS)

- Acid Potential (AP) ; *Synonyms*: Maximum Potential Acidity (MPA)
Method: Total S(%) (Leco Analyzer) x 31.25
- Neutralization Potential (NP) ; *Synonyms*: Gross Neutralization Potential (GNP) ; *Syn*: Acid Neutralization Capacity (ANC) (The capacity of a sample to consume acid)
Method: Fizz Test ; Acid-Base Titration (Sobek & Modified Sobek (Lawrence) Methods)
- Nett Neutralization Potential (NNP) ; *Synonyms*: Nett Acid Production Potential (NAPP)
Calculation: $NNP = NP - AP$; $NAPP = ANC - MPA$
- Neutralising Potential Ratio (NPR)
Calculation: $NPR = NP : AP$

CLASSIFICATION ACCORDING TO NETT NEUTRALISING POTENTIAL (NNP)

If $NNP (NP - AP) < 0$, the sample has the potential to generate acid

If $NNP (NP - AP) > 0$, the sample has the potential to neutralise acid produced

Any sample with $NNP < 20$ is potentially acid-generating, and any sample with $NNP > -20$ might not generate acid (Usher *et al.*, 2003)

ROCK CLASSIFICATION

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2012-02-08
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CLASSIFICATION ACCORDING TO NEUTRALISING POTENTIAL RATIO (NPR)

Guidelines for screening criteria based on ABA (Price *et al.*, 1997 ; Usher *et al.*, 2003)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	< 1:1	Likely AMD generating
Possibly	1:1 – 2:1	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	2:1 – 4:1	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	>4:1	No further AMD testing required unless materials are to be used as a source of alkalinity

CLASSIFICATION ACCORDING TO SULPHUR CONTENT (%S) AND NEUTRALISING POTENTIAL RATIO (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity but it is likely to be only of short-term significance. From these facts, and using the NPR values, a number of rules can be derived:

- 1) Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidisable Sulphide-S to sustain acid generation.
- 2) NPR ratios of >4:1 are considered to have enough neutralising capacity.
- 3) NPR ratios of 3:1 to 1:1 are considered inconclusive.
- 4) NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating. (Soregaroli & Lawrence, 1998 ; Usher *et al.*, 2003)



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CERTIFICATE OF ANALYSES ACID – BASE ACCOUNTING EPA-600 MODIFIED SOBEK METHOD

Date received: 2012-02-08
Project number: 123

Report number: 34030

Date completed: 2012-03-13
Order number: Volspruit EAV-11-053

Client name: GEO POLLUTION TECHNOLOGIES
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REFERENCES

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PRELIM CERTIFICATE OF ANALYSES
TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-02-08
Project number: 123

Report number: 34030

Date completed: 2012-03-02
Order number: Volspruit EAV-11-053

Client name: GEO POLLUTION TECHNOLOGIES
Address: P O Box 38384, Garsfontein East, 0060
Telephone: 012 804 8120 Fax: 012 804 8140

Contact person: Altus Huisamen
Email: altus@gptglobal.com
Cell: 083 352 0223

Analyses	Sample Identification			
	Composite 1		Composite 2	
Sample number	2461		2462	
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Acid Rain		Acid Rain	
Dry Mass Used (g)	50		50	
Volume Used (mℓ)	1000		1000	
pH Value at 25°C	6.2		6.7	
Electrical Conductivity in mS/m at 25°C	6.5		23.0	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Alkalinity as CaCO ₃	56	1 120	120	2 400
Chloride as Cl	<5	<100	<5	<100
Sulphate as SO ₄	<5	<100	20	400
Nitrate as N	<0.2	<4.0	<0.2	<4.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0
ICP-MS Scan [s]	See attached report 34030 ICP MS		See attached report 34030 ICP MS	
Acid Base Accounting	To follow		To follow	
Net Acid Generation	See attached report 34030 NAG		See attached report 34030 NAG	
Sulphur Speciation	To follow		To follow	
X-ray Diffraction	See attached report 34030 XRD		See attached report 34030 XRD	
X-ray Fluorescence	To follow		To follow	

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Analyses	Sample Identification			
	Composite 3		Composite 4	
Sample number	2463		2464	
TCLP / Acid Rain / Distilled Water / H ₂ O ₂	Acid Rain		Acid Rain	
Dry Mass Used (g)	50		50	
Volume Used (mℓ)	1000		1000	
pH Value at 25°C	6.6		7.0	
Electrical Conductivity in mS/m at 25°C	26.2		52.5	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Alkalinity as CaCO ₃	140	2 800	340	6 800
Chloride as Cl	<5	<100	<5	<100
Sulphate as SO ₄	8	160	<5	<100
Nitrate as N	<0.2	<4.0	<0.2	<4.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0
ICP-MS Scan [s]	See attached report 34030 ICP MS		See attached report 34030 ICP MS	
Acid Base Accounting	To follow		To follow	
Net Acid Generation	See attached report 34030 NAG		See attached report 34030 NAG	
Sulphur Speciation	To follow		To follow	
X-ray Diffraction	See attached report 34030 XRD		See attached report 34030 XRD	
X-ray Fluorescence	To follow		To follow	

CERTIFICATE OF ANALYSES
NETT ACID GENERATION

Date received: 2012-02-08
Project number: 123

Report number: 34030

Date completed: 2012-03-01
Order number: Volspruit EAV-11-053

Client name: GEO POLLUTION TECHNOLOGIES
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Nett Acid Generation	Sample Identification				
	Composite 1	Composite 2	Composite 3	Composite 4	Composite 4
Sample Number	2461	2462	2463	2464 D	2464
NAG pH: (H ₂ O ₂)	4.4	6.2	6.6	7.2	7.3
Titration with NaOH	0.10	<0.01	<0.01	<0.01	<0.01
Final pH: (H ₂ O ₂)	4.5	6.2	6.6	7.2	7.3
NAG (kg H ₂ SO ₄ / t)	0.20	<0.01	<0.01	<0.01	<0.01

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CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2012-02-08
Project number: 123

Report number: 34030

Date completed: 2012-03-01
Order number: Volspruit EAV-11-053

Client name: GEO POLLUTION TECHNOLOGIES
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Contact person: Altus Huisamen
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Cell: 083 352 0223

Composition (%) [s]					
Composite 1			Composite 2		
2461			2462		
Mineral	Amount (weight %)	Error	Mineral	Amount (weight %)	Error
Enstatite	84.74	1.98	Actinolite	3.86	0.72
Lizardite	0.56	0.57	Enstatite	66.3	1.86
Magnetite	2.08	0.36	Lizardite	1.14	0.57
Plagioclase	5.83	1.47	Plagioclase	6.06	1.35
Smectite	2.07	1.8	Smectite	11.52	1.65
Talc	4.72	1.05	Talc	11.12	0.9

Composition (%) [s]					
Composite 3			Composite 4		
2463			2464		
Mineral	Amount (weight %)	Error	Mineral	Amount (weight %)	Error
Actinolite	trace		Enstatite	58.82	1.71
Enstatite	61.04	1.74	Lizardite	4.72	0.51
Lizardite	4.92	0.54	Muscovite	2.53	0.84
Muscovite	0	0	Quartz	0.82	0.23
Quartz	1.16	0.23	Smectite	15.71	2.49
Smectite	19.48	2.37	Talc	13.4	1.02
Talc	13.4	1.05	Tremolite	3.99	0.93

[s] Results obtained from sub-contracted laboratory

CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2012-02-08
Project number: 123

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Notes:

The samples were prepared for XRD analysis using a back loading preparation method. They were analysed with a PANalytical X'Pert Pro powder diffractometer with X'Celerator detector and variable divergence- and fixed receiving slits with Fe filtered Co-K_α radiation. The phases were identified using X'Pert Highscore plus software. The relative phase amounts (weight %) were estimated using the Rietveld method (Autoquan program). Errors are on the 3 sigma level in the column to the right of the amount (in weight per cent).

Comment:

- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group (i.e "Actinolite" and "Tremolite" would represent the mineral group "Amphibole").
- Errors reported for phases occurring in minor amounts are sometimes larger than that of the quantity reported, indicating the possible absence of those phases.
- Due to preferred orientation effects results may not be as accurate as shown in the table.
- Smectite amounts may have larger errors than shown and smectite may be overestimated in samples 2162-2164

Amorphous phases, if present, were not taken into account in the quantification.

Ideal Mineral compositions:

Actinolite $\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})$
Enstatite MgSiO_3
Lizardite $\text{Mg,Fe}_3\text{Si}_2\text{O}_5(\text{OH})_4$
Magnetite Fe_3O_4
Muscovite $\text{K Al}_2 ((\text{OH})_2 \text{ Al Si}_3 \text{ O}_{10})$
Plagioclase $(\text{Na,Ca})(\text{Si,Al})_4\text{O}_8$
Quartz SiO_2
Smectite $\text{CaMg}_2\text{AlSi}_4(\text{OH})_2 \cdot \text{H}_2\text{O}$
Talc $\text{Mg}_3(\text{Si}_2\text{O}_5)_2(\text{OH})_2$
Tremolite $\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$

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CERTIFICATE OF ANALYSES
X-RAY FLUORESCENCE

Date received: 2012-02-08
Project number: 123

Report number: 34030

Date completed: 2012-03-16
Order number: Volspruit EAV-11-053

Client name: GEO POLLUTION TECHNOLOGIES
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Contact person: Altus Huisamen
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Major Elements	Major Element Concentration (wt %)[s]			
	Composite 1	Composite 2	Composite 3	Composite 4
	2461	2462	2463	2464
SiO ₂	54.01	53.45	52.32	48.72
TiO ₂	0.08	0.07	0.07	0.06
Al ₂ O ₃	1.89	1.85	1.73	1.70
Fe ₂ O ₃ (t)	10.14	9.73	9.97	9.83
MnO	0.173	0.160	0.144	0.144
MgO	31.24	31.79	31.20	29.89
CaO	1.22	1.26	1.01	2.98
Na ₂ O	<0.01	<0.01	<0.01	<0.01
K ₂ O	0.028	0.074	0.106	0.104
P ₂ O ₅	0.000	0.002	0.002	0.003
Cr ₂ O ₃	0.59	0.59	0.79	2.06
L.O.I	0.23	0.66	1.98	3.80
Total	99.60	99.61	99.28	99.25
H ₂ O ⁻	0.44	0.49	0.66	0.66

[s] =Results obtained from sub-contracted laboratory

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Trace Elements	Trace Element Concentration (ppm) [s]			
	Composite 1	Composite 2	Composite 3	Composite 4
	2461	2462	2463	2464
As	<4	<4	<4	<4
Ba	41	64	46	40
Bi	<3	<3	<3	<3
Br	<2	<2	<2	<2
Ce	<10	<10	<10	<10
Co	92	90	87	99
Cr	4 405	4 340	5 107	7 660
Cs	<5	<5	<5	<5
Cu	48	112	125	394
Ga	2.1	2	2.2	2.2
Ge	1.3	1.6	<1	1.6
Hf	<3	<3	<3	<3
La	<10	<10	<10	<10
Mo	<2	<2	<2	<2
Nb	1.6	1.9	1.7	1.5
Nd	<10	<10	<10	<10
Ni	653	1 052	1 110	1 322
Pb	<2	2.6	2.8	3.7
Rb	<2	5.5	6.1	8.2
Sc	23	22	18	16
Se	1.2	<1	<1	1.4
Sm	<10	<10	<10	<10
Sr	8.4	10	7.6	67
Ta	<2	<2	<2	<2
Th	<3	<3	<3	<3
Tl	<3	<3	4.1	3.3
U	<2	<2	<2	<2
V	72	74	69	85
W	<3	<3	<3	<3
Y	1.7	1.8	2	1.1
Yb	3.9	4.5	5.4	7
Zn	62	57	51	62
Zr	2.8	3.7	13	2.1

[s] =Results obtained from sub-contracted laboratory

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