Hydrogeochemical Pit Lake Modelling

Macraes Phase 4 Project

31 August 2026

J-NZ0498-007-R-FINAL

MINE WASTE MANAGEMENT
GREENROAD GROUP

OCEANAGOLD

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Document Number: J-NZ0498-007-R-FINAL

Document Date: 31 August 2026

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REVISION	DATE	AUTHOR	RECORD OF REVIEW
RevA	17/07/2026	EC/LN	PW
Rev0	21/08/2026	EC/LN	PW
FINAL	31/08/2026	EC	PW

EXECUTIVE SUMMARY

Introduction

OceanaGold (New Zealand) Limited (OGNZL) currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago. As part of their ongoing operations, OGNZL continually review the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project ("MP4" or "the Project") seeks to extend the life of mining at the Macraes Operation until at least 2039. The Project, which will enable ongoing gold production at a rate of approximately 130,000 ounces per annum, is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

Project Overview and Scope

To support the development of the substantive application for the Project, OGNZL has engaged Mine Waste Management (MWM) to provide an assessment of the Project's effects on surface water and groundwater quality and, to the extent required, identify any necessary management and operation measures to address any such effects.

The scope of this report is to:

- Review the existing site water quality data relevant to the MP4 Project.
- Document the methodology and procedures used to develop the hydrogeochemical models for the four pits associated with the Project.
- Present and discuss the modelling outcomes that predict the long-term evolution of pit lake water quality following mine closure.

The primary objective of this assessment is to predict the long-term, post-closure water quality of the proposed open pit lakes at Golden Bar (GB), Coronation (CO), Coronation North (CN), and Innes Mills (IM) over a 200-year period.

Hydrogeochemical Modelling Approach

The water quality modelling adopts a consistent framework designed to simulate the evolution of the pit lake chemistry, comprising four primary components:

1. Conceptual Site Model (CSM): Defines the specific model boundaries, including water sources, reactive materials, hydrological pathways, and geochemical processes.
2. Water Balance Model (WBM): Provided by GHD (2026), the WBMs supply the time-series flow rates and physical water fluxes on an annual timestep.
3. Source Term Derivation: Defines the specific chemical signature and mass release rates of the various inflows and reactive materials.

4. Model Integration and Hydrogeochemical Modelling: Pit lake water quality simulations were conducted using PHREEQC and the WATEQ4F thermodynamic database, executed via an automated Python computational framework to manage high-volume data inputs and couple the physical water volumes with the chemical mass loading

To reflect site-specific climatic and physical conditions, the models assume the following:

- The pit lakes will operate as fully mixed systems that maintain equilibrium with atmospheric oxygen and carbon dioxide.
- A constant oxidising environment (pE=10) and a water temperature of 10ºC were applied.
- All iron (Fe) in the source terms is assumed to be entirely ferric (Fe^{3+}), aligning with the oxidising environment assumption.
- Nitrogenous blasting residues (nitrate) attenuate via a bulk decay rate of 20% to 25% per annum.

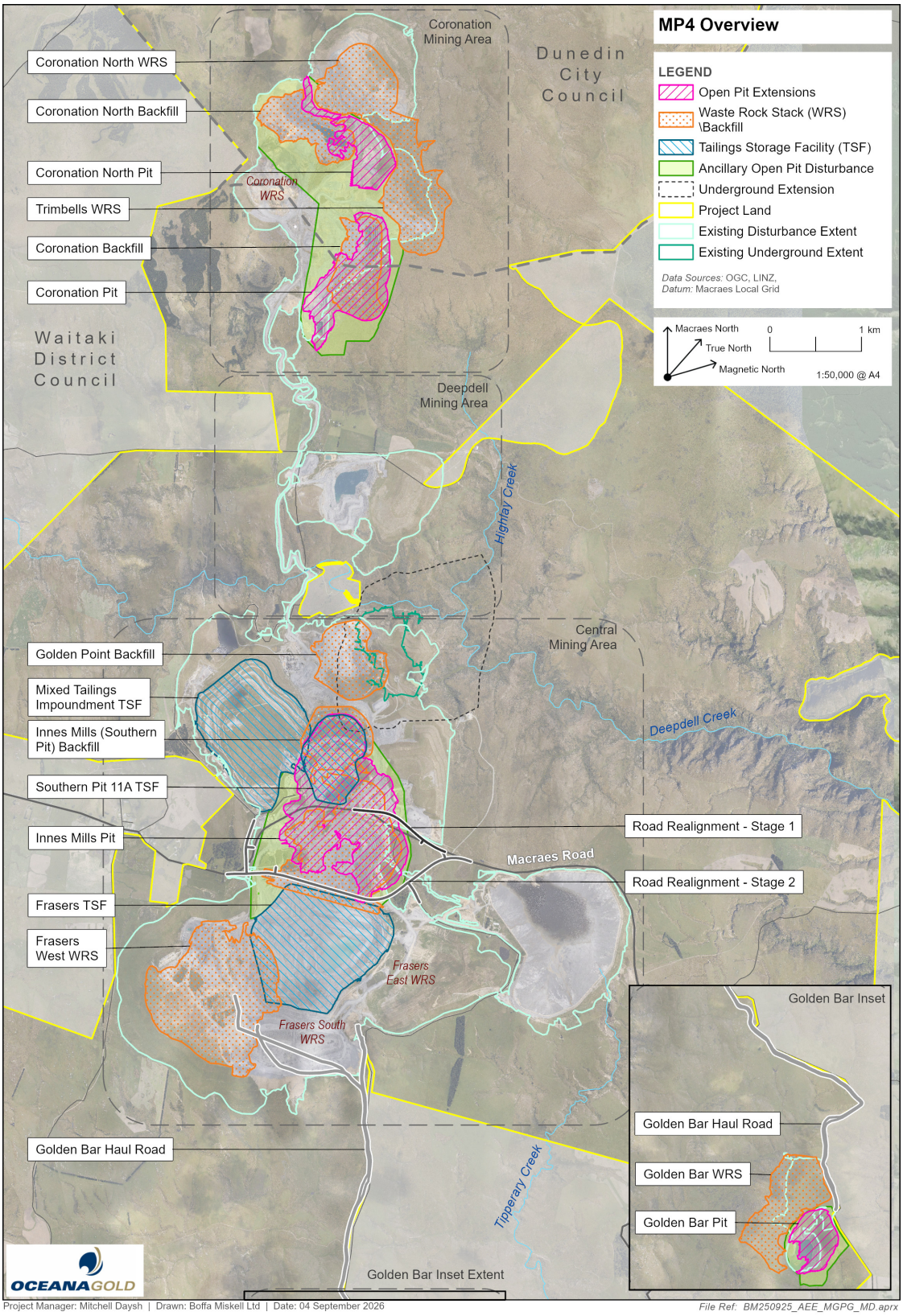

Figure ES-1: MP4 Overview Plan.

Source: OGNZL (2026).

Historical Data Review and Source Term Derivation

Site specific geochemical source terms were derived based on an extensive review of historical site water quality monitoring data and empirical modelling. The source terms represent the initial chemistry and mass flux of the various water and reactive material inputs to the pit lakes.

- Historical Data Review: OGNZL has established an extensive water quality monitoring network at Macraes Operation site. The monitoring data were categorised into groundwater, surface water, and mine water (including tailings underdrains and waste rock seepage). Monitoring datasets for sites aligned with the CSM and WB inflow components were reviewed to establish pre-mining and operational baseline and evaluate water quality evolution over time.
- Source Term Derivation: Source terms were tailored for distinct pit domains and inflow mechanism.

Summaries of the diverse source term types derived to define the pit inflows are presented in Table ES-1 to Table ES-3.

Table ES-1: Summary of source terms – groundwater and natural catchment runoff.

SOURCE TERM TYPE		GROUNDWATER				NATURAL CATCHMENT RUNOFF	
PIT DOMAIN		GB	CO & CN	IM	IM	GB	CO
MONITORING SITE		RCH2775, RCH2585, RCH3004	CP01, CP02, CP04	SPMW3, SPMW4	TTTSF IMPOUNDMENT	GB02 (PRE-2015)	DC01 (PRE-2015)
PARAMETER	UNIT	MEDIAN	MEDIAN	MEDIAN	MEDIAN	MEDIAN	MEDIAN
pH	pH units	6.65	7.3	7.4	8.1	7.5	7.7
Total Alkalinity	mg/L as $CaCO_3$	95.8	108	275	220	32.5	50
Ca	mg/L	22.4	26.5	234	640	8.15	12.7
Mg	mg/L	11.1	8.9	33.9	345	2.95	4.4
Na	mg/L	10.9	9.8	20.5	360	8.5	10.9
K	mg/L	1.06	1.31	2.25	95	0.725	1.15
SO_4	mg/L	14.3	7.8	515	3,600	6.45	5.35
Cl	mg/L	10.2	6.3	8.5	22	9.25	11
NO_3-N	mg/L	0.544	0.1132	0.01975	12	0.025	0.0175
Amm-N	mg/L	0.0075	0.0107	0.0225	13	0.0125	0.005
As	mg/L	0.0016	0.0011	0.0114	0.0125	0.00175	0.0011
Cu	mg/L	0.0043	0.00025	0.000625	0.089	0.00095	0.00025
Fe	mg/L	1.476	0.883	1.835	0.0265	0.18	0.22
Pb	mg/L	0.00465	0.00008	0.00022	0.45	0.0002	0.00005
Sb	mg/L	0.0005	-	-	0.00068	-	-
Zn	mg/L	0.0213	0.01375	0.0041	-	0.00235	-
WAD CN	mg/L	0.005	-	0.0015	0.01	-	0.0005

Table ES-2: Summary of source terms – WRS and backfill seepage.

SOURCE TERM TYPE		WRS SEEPAGE					BACKFILL SEEPAGE		
PARAMETER	UNIT	GB	CO	CN	TR	FW	COBF	CNBF	IMBF
pH	pH units	6.9	7.1	7.6	6.8	8.2	7.1	7.6	7.9
Total Alkalinity	mg/L as $CaCO_3$	267	36	891	411	1,035	36	137	517
Ca	mg/L	586	597	1,281	1,081	198	205	479	30
Mg	mg/L	725	457	892	396	1,523	141	895	1,316
Na	mg/L	101	61.9	204	85.8	106	28.6	205	94
K	mg/L	13.1	10.6	14.4	24.7	31.1	8.8	14.6	28
SO_4	mg/L	4,481	3,706	6,081	4,193	6,125	1,123	4,789	5,306
Cl	mg/L	11	8	12	6	11	8	12	11

SOURCE TERM TYPE		WRS SEEPAGE					BACKFILL SEEPAGE		
PARAMETER	UNIT	GB	CO	CN	TR	FW	COBF	CNBF	IMBF
NO_3-N	mg/L	8.05	1.1	50.7	40.6	14	1.1	7.5	14
Amm-N	mg/L	0.005	0.245	0.017	0.92	0.05	0.19	0.013	0.039
As	mg/L	0.001	0.0005	0.00075	0.0005	0.003	0.0005	0.00075	0.003
Cu	mg/L	0.0011	0.0005	0.0006	0.1347	0.0015	0.0005	0.0006	0.0015
Fe	mg/L	0.02	0.05	0.05	0.19	0.02	0.05	0.05	0.02
Pb	mg/L	0.0001	0.000075	0.00005	0.00005	0.00025	0.0008	0.00005	0.00025
Zn	mg/L	0.049	0.36	0.0028	0.36	-	0.36	0.0028	0.025

Table ES-3: Summary of source terms – runoffs from rehabilitated and unrehabilitated areas, FTSF seepage, and rainfall.

SOURCE TERM TYPE		PIT WALL AND UNREHABILITATED AREA RUNOFF	REHABILITATED AREA RUNOFF	FTSF SEEPAGE	RAINFALL
Parameter	Unit	Value	Median	Median	Value
pH	pH units	8.4	8	8.1	5.2
Total Alkalinity	mg/L as $CaCO_3$	573	119	220	0.81
Ca	mg/L	190	40	640	0.11
Mg	mg/L	186	7.9	345	0.05
Na	mg/L	32.4	12	360	0.32
K	mg/L	11.2	1.7	95	0.09
SO_4	mg/L	719	20	3,600	0.6
Cl	mg/L	15.6	8	22	0.18
NO_3-N	mg/L	0.019	0.001	12	0.0045
Amm-N	mg/L	0.038	0.005	13	-
As	mg/L	0.409	0.0039	0.0125	-
Cu	mg/L	0.001	0.001	0.089	-
Fe	mg/L	0.065	0.07	0.0265	-
Pb	mg/L	0.0003	0.00005	0.45	-
Sb	mg/L	0.008	0.0004	0.00068	-
Zn	mg/L	0.005	0.0008	-	-
WAD CN	mg/L	-	-	0.01	-

Note: Trace element values for FTSF seepage are for total concentration.

Predicted Pit Lake Water Quality

The modelling indicates that the MP4 pit lakes will operate as fully mixed systems (although seasonal stratification may occur) with the following overarching post-closure hydrogeochemical signatures:

- pH and Alkalinity: All four pit lakes are predicted to be highly buffered and circumneutral, maintaining a stable pH between 7.6 and 7.7, supported by total alkalinity concentrations consistently exceeding 140 mg/L as $CaCO_3$.
- Salinity and Major Ions: The pit lake waters will be brackish to saline and dominated by sulfate (SO_4) and magnesium (Mg). Long-term average SO_4 concentrations will range from approximately 500 mg/L in CN up to over 2,000 mg/L in IM.
- Trace Metals and Attenuation: The oxidising, circumneutral conditions will promote the rapid oxidation and precipitation of iron as amorphous ferrihydrite ($Fe(OH)_3$). This precipitate provides critical reactive surface areas that adsorb and sequester most dissolved trace metals

and metalloids (e.g., Cu, Pb) through surface complexation, maintaining generally low dissolved concentrations.

- Nitrogen Species: Nitrate and ammoniacal nitrogen loads, derived primarily from explosive residues in backfill and pit walls, will decline to negligible levels within the first 10 to 20 years post-closure.
- Predicted long-term water quality was screened against site-specific, hardness-modified ecological trigger values (TVs) established for the downstream receiving environments. As demonstrated in the summary table, despite active surface adsorption onto ferrihydrite, arsenic (As) concentrations are predicted to range between 0.2 and 0.45 mg/L across all four pit lakes, consistently exceeding the 0.013 mg/L TV. Furthermore, driven by ongoing mass loading from adjacent WRS and backfill seepage, zinc (Zn) concentrations in the CO and CN Pit Lakes are predicted to exceed the TV of 0.016 mg/L, whilst SO_4 exceeds the hardness-modified 1,000 mg/L TV in the more saline CN and IM Pit Lakes.

Management Measures

To proactively address the predicted As and Zn exceedances and manage potential compliance risks prior to surface discharge, an active in-pit treatment strategy has been proposed. This strategy utilises the controlled addition of ferric chloride ($FeCl_3$) to stimulate further ferrihydrite precipitation and enhance surface complexation of metals. Predictive inventory modelling estimates a total requirement ranging from 108 to 394 Intermediate Bulk Containers (IBCs: 1,000L) of 40% $FeCl_3$ per pit lake over the 200-year post-closure duration.

Recommendations for Future Work

To validate baseline modelling assumptions, address key hydrodynamic uncertainties, and demonstrate closure-readiness prior to decommissioning when pit voids will commence filling, the following operational-phase activities are recommended:

- Stratification and Mixing Validation: Implement a targeted monitoring programme at the GB Pit Lake prior to dewatering, collecting monthly multi-depth water samples and vertical physicochemical profiles. This high-frequency monthly sampling is required to characterise physical stratification cycles, validate seasonal vertical turnover, and resolve hydrodynamic uncertainties in the long-term predictive models.
- Source Term Refinement: Refine pit wall runoff source terms by incorporating time-decaying solute release to account for progressive mineral weathering and surface passivation. This should be supported by field pit wall wash testing on exposed wall faces of varying weathering ages (such as the historical GB wall faces) to validate the transferability of the GB analogue term across all proposed pit voids.
- Comprehensive Pit Lake Modelling: Develop an integrated, multi-dimensional pit lake model for each proposed pit void to support final closure planning (i.e., closure readiness planning). During the operational phase, these models should be upgraded to simulate physical

hydrodynamics, seasonal stratification, biogeochemical processes, and nutrient cycling, using refined geochemical source terms validated against site-specific data.

- Active Treatment and Field Validation: Conduct site-specific, bench-scale laboratory trials to verify exact $FeCl_3$ dosing requirements prior to full-scale deployment. Subsequently, undertake $FeCl_3$ dosing trials at GB Pit Lake to validate the process works in the field.

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1 PROJECT INTRODUCTION

1.1 Introduction

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1.2 Site Location and Description

OGNZL owns and operates the Macraes Operation at Macraes, approximately 30 km northwest of Palmerston in the Otago Region. The Macraes Operation is the largest gold mine in New Zealand and, since commissioning in 1990, has produced more than 6 million ounces of gold.

Macraes Flat is situated on an elevated plateau at approximately 500 m above sea level. The plateau is flanked by the Taieri Ridge to the northwest, Shag Valley and Horse Range to the east, and the coastal hills and extinct volcanic cones of Palmerston and Waikouaiti to the southeast. Macraes Road provides access to Macraes Flat and the Macraes Operation, connecting to State Highway 85 to the east and State Highway 87 (SH87, the Middlemarch–Hyde Road) to the west.

The environment within and surrounding the Macraes Operation has been shaped by historic and current mining activities. Figure 1 shows the arrangement of the major mine features at the Macraes Operation. In summary, the current components of the Macraes Operation include:

- Numerous open pits (both operational and non-operational);
- Two underground mines (Frasers, now closed, and Golden Point, which is actively mined);
- Waste rock stacks (WRSs) at various stages of operation and rehabilitation;

- A network of haul roads and general mine service tracks;
- A Processing Plant;
- Five tailings storage facilities (TSFs) (three inactive, one active but nearing capacity, and one under construction and currently receiving tailings);
- An extensive network of water management infrastructure, including diversion drains, silt ponds, sumps, pit lakes, and freshwater storage reservoirs;
- Two consented but not yet constructed water storage reservoirs (Camp Creek Dam and Coal Creek Dam); and
- Associated infrastructure supporting ongoing operations, including district roads, powerlines, workshops, offices, and associated water and amenity facilities.

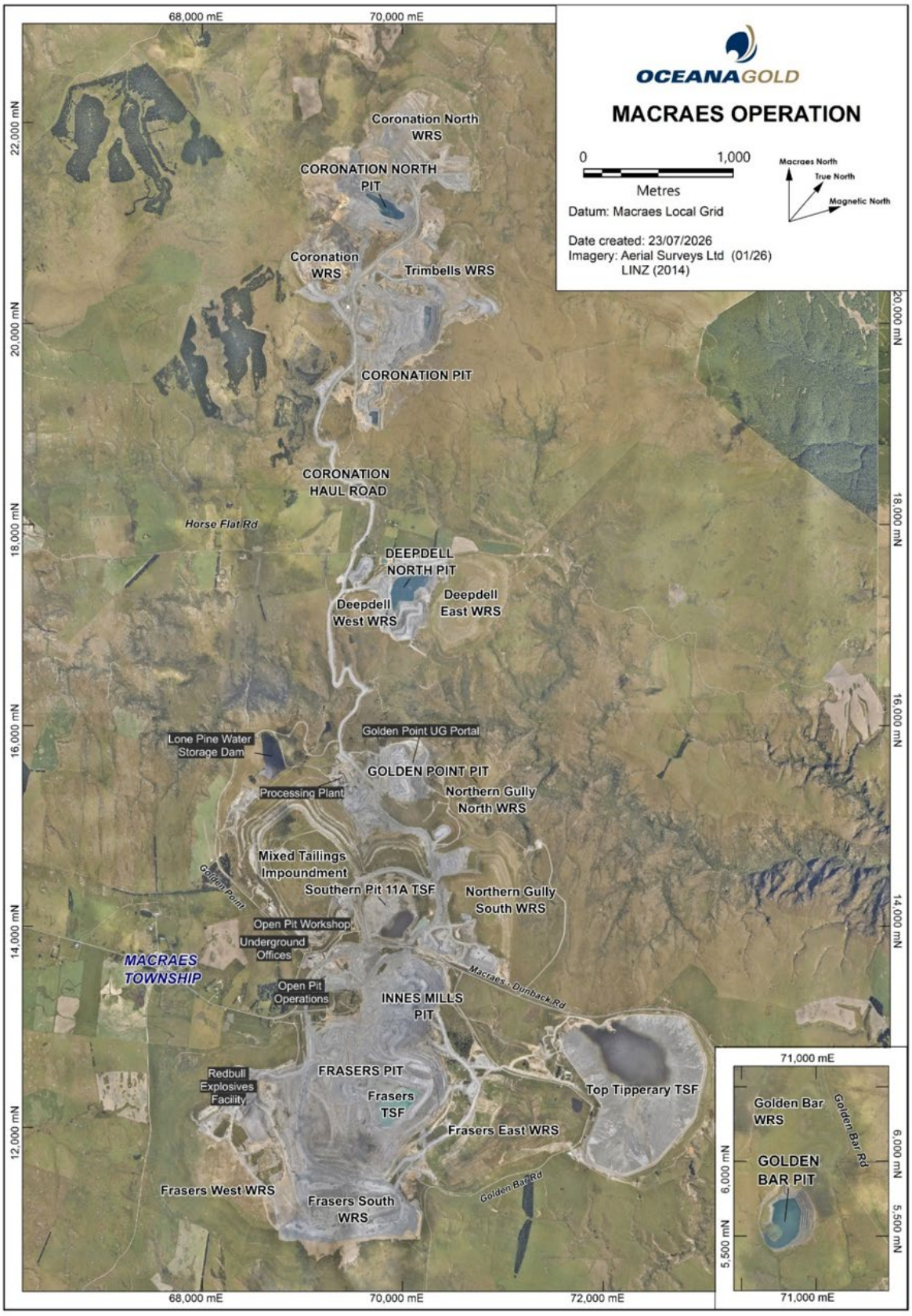

Figure 1: Existing site layout at the Macraes Operation (as of July 2026).

Source: OGNZL (2026).

1.3 Project Overview

The MP4 Project is made up of the following proposed key activities:

- Open pit extensions at Coronation (CO), Coronation North (CN), Innes Mills (IM), and Golden Bar (GB).
- Underground mine expansion through further development of the Golden Point Underground mine ("GPUG").
- Tailings management, including:
  - Construction of the Frasers Tailings Storage Facility ("FTSF") Stage 3 to accommodate a total tailings storage of up to 153 Mt; and
  - Hydraulic mining and relocation of tailings from the Mixed Tailings Impoundment ("MTI"), Southern Pit Option 10 TSF ("SP10"), and Southern Pit Option 11A TSF ("SP11") to FTSF.
- Waste rock disposal, including increased storage capacity within open pits and at existing WRSs at CO, CN, IM, GB, Golden Point (GP), and Frasers (FR).
- Water management infrastructure and operations, including:
  - Construction of Camp Creek and Coal Creek water storage dams for flow and water quality management;
  - Construction, operation and maintenance of a Water Treatment Plant; and
  - Ongoing operation and maintenance of the Mine Water Management System ("MWMS").
- Infrastructure and roading works, including:
  - Realignment of Macraes Road in two stages; and
  - Relocation of the Open Pit Mining Workshop.
- Ecological enhancements, including establishment of:
  - Murphys Ecological Enhancement Area ("MEEA") near Murphys Creek, including predator fencing, access tracks, and site facilities;
  - Mt Highlay restoration area;
  - Cranky Jims Link shrubland enhancement area;
  - Murphys Link tussock protection area; and
  - Additional compensation measures for residual ecological impacts.
- Mine closure and rehabilitation activities, including rehabilitation of mining landforms, creation of pit lakes, dry capping of tailings storage facilities, and revegetation in accordance with closure objectives.

An overview of the proposed activities which make up the Project is shown in Figure 2 below.

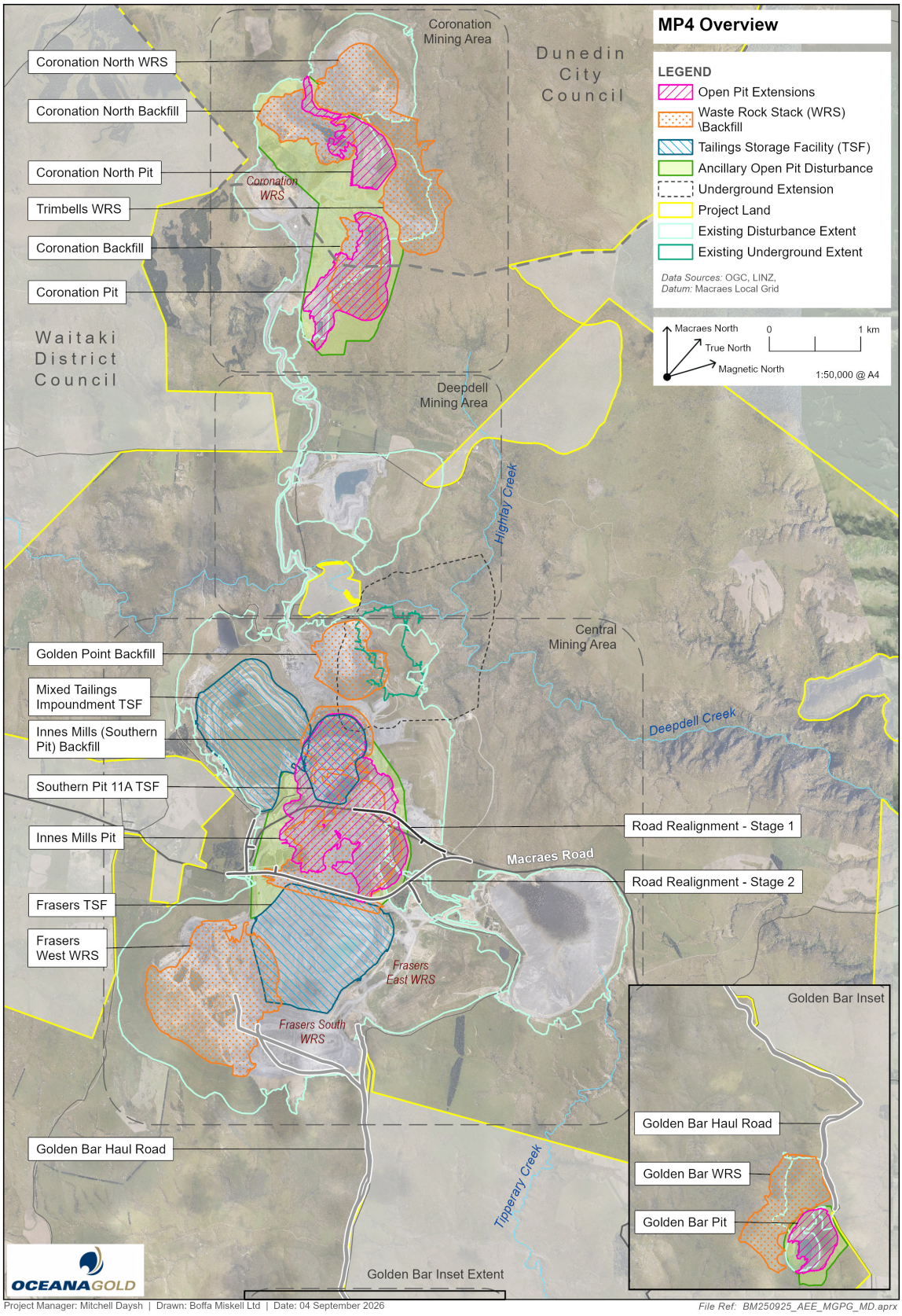

Figure 2: MP4 Overview Plan.

Source: OGNZL (2026).

1.4 Objectives and Scope of Work

The primary objective of this hydrogeochemical pit lake modelling assessment is to predict the long-term pit lake water quality at mine closure for the GB, CO, CN, and IM pits. The assessment also evaluates the potential impacts of the proposed open pit extensions on pit lake water quality and on local and downstream receiving environments over time.

To achieve this objective, the following scope of work was undertaken:

- Review geochemical characterisation data for waste rock and tailings.
- Review historical water quality monitoring data from relevant surface water, groundwater, and mine influenced water monitoring locations.
- Review previous water quality modelling completed for the Macraes Operation.
- Develop conceptual site models (CSMs) for the four mine pits associated with MP4.
- Evaluate water balance models (WBMs) provided by GHD Limited (GHD).
- Derive source terms for the hydrogeochemical models.
- Undertake hydrogeochemical modelling to predict post-closure pit lake water quality.
- Generate time-series water quality prediction datasets for integration into the site-wide probabilistic water quality model.
- Prepare this technical report to present the methodology, input data, model assumptions, and predicted outcomes.

2 MP4 PROJECT

2.1 Project Environment

2.1.1 Geology

The Macraes deposit is a structurally controlled orogenic gold deposit hosted within the metamorphic greenschist facies Otago Schist. Mineralisation is associated with the Hyde-Macraes Shear Zone (HMSZ), the principal gold-bearing structure, and the Macraes Fault, which offsets the HMSZ by approximately 250 m in a reverse sense (OGNZL, 2011). This primary deformation is accompanied by numerous subsidiary faults, both foliation-parallel and foliation-cutting, which influence local hydrogeological pathways.

Gold mineralisation formed within the brittle-ductile transition zone at temperatures of approximately 300ºC. Hydrothermal activity created a 120 m thick altered zone (Craw, 2002), comprising mineralised sheared graphitic schist and quartz veins. This zone is enriched in sulfide minerals, primarily pyrite (FeS_2) and arsenopyrite (FeAsS).

Minor fine-grained sulfide minerals include chalcopyrite ($CuFeS_2$), sphalerite (ZnS), and galena (PbS) (Golder Associates, 2011). The mineralised rocks exhibit variable enrichment in arsenic (As), gold (Au), bismuth (Bi), molybdenum (Mo), antimony (Sb), and tungsten (W) (Craw, 2002). Current resource consent conditions relate to specific mobile potential contaminants of concern (PCOCs) associated with the ore and host minerals, which includes As, copper (Cu), iron (Fe), lead (Pb), sulfate (SO_4), and zinc (Zn). Compliance monitoring is undertaken for these PCOCs to ensure management processes are appropriate and environmental effects are acceptable.

A key indicator for environmental geochemistry risk, particularly acid and metalliferous drainage (AMD), is total sulfur (S) content. The Macraes Operation maintains an extensive geochemical database comprising routine drillhole total S assays, including approximately 3,000 samples from the Coronation Pit area alone, supplemented by site-wide static acid-base accounting (ABA) testing (O'Kane Consultants, 2016). These data indicated that interburden waste rock (Au <0.15 g/t) typically exhibits higher S content than overburden materials, while low-grade ore (LGO; 0.15-0.4 g/t Au) shows S levels comparable to those of the interburden (O'Kane Consultants, 2016). Consequently, interburden materials present a relatively higher risk of AMD generation and therefore require specific management within the WRS (O'Kane, 2016). The cross-sectional distribution of these material types and their relative S risk levels is illustrated in Figure 3.

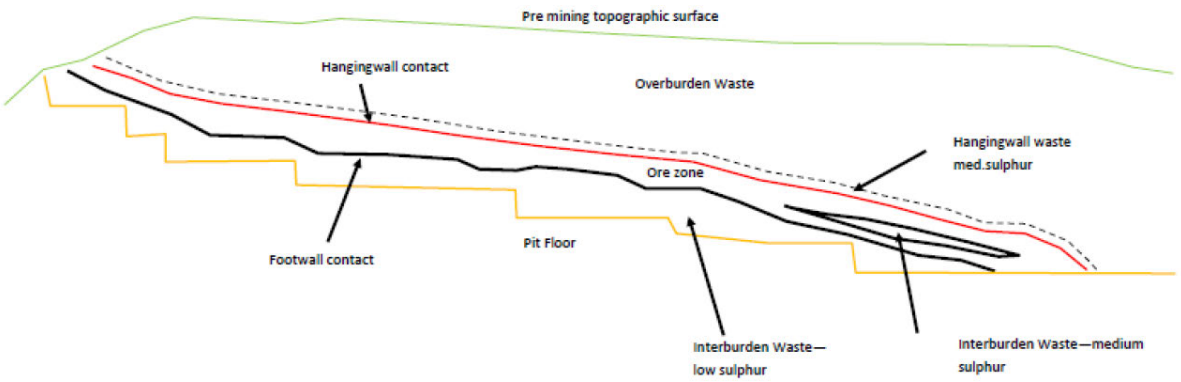

Figure 3. Stylised geological cross-section of the Coronation orebody.

Source: O'Kane Consultants (2016).

2.1.2 Climate

The MP4 Project area is characterised by a semi-arid climate, with low average annual rainfall, high wind speeds, and significant seasonal temperature variations. Local climatic conditions are strongly influenced by the Rock and Pillar Range to the west, which acts as a barrier to prevailing westerly weather systems and contributes to the relatively low level of precipitation across the area.

Climate data are collected from three weather stations: Glendale, Deepdell, and Golden Point. Evaporation data are sourced from the national weather station in Middlemarch (located approximately 30 km south-southwest at an elevation of 200 mRL), which are considered the most representative of regional conditions. Key characteristics of the historical climate dataset are summarised below:

- Mean daily temperatures range from approximately 15ºC in summer (December to February) to 5ºC in winter (June to August). Snowfall is common during the winter months.
- Average annual rainfall is approximately 650 mm. While seasonal variation is minimal, the region is susceptible to extended dry periods and droughts, particularly during summer.
- Mean annual pan evaporation is approximately 952 mm (based on the 1991-2018 dataset). This significantly exceeds annual rainfall, resulting in a negative water balance.

2.2 Proposed MP4 Mine Pit Extensions

The four mine pits associated with the MP4 Project are introduced in this section.

2.2.1 Golden Bar

The GB Pit is located approximately 10 km south of the Macraes Processing Plant. The pit was originally mined between 2004 and 2006 and has since been partially rehabilitated, forming a pit lake that currently discharges to Golden Bar Creek, a tributary of Murphys Creek.

The proposed pit extension to the GB Pit (Figure 4) will increase the pit footprint from 14 ha to 29.2 ha. The extension will involve dewatering of the existing pit, mining of the pit extension, and expansion of the GB WRS, followed by final closure and rehabilitation (OGNZL, 2026).

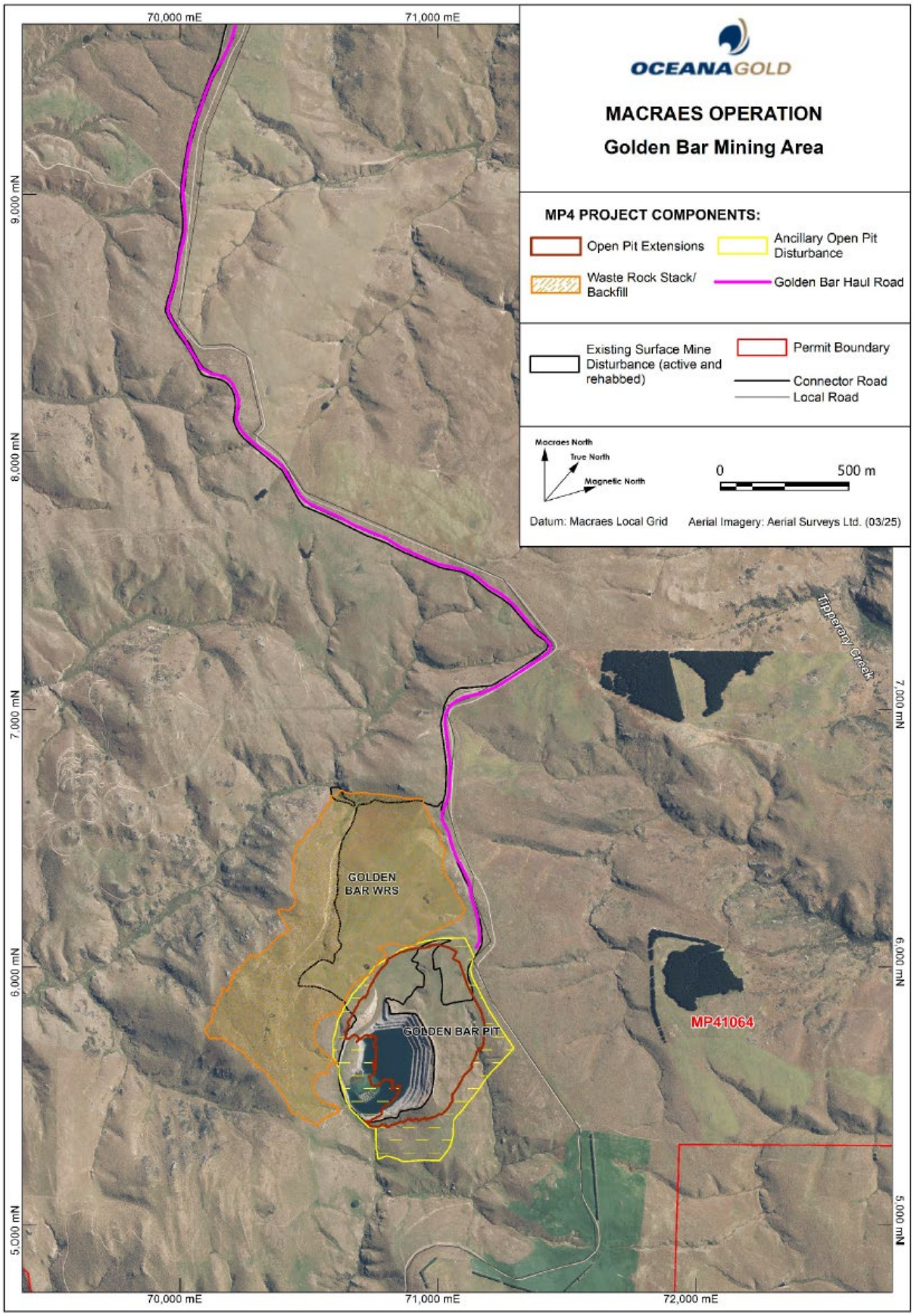

Figure 4: Golden Bar Mining Area.

Source: OGNZL (2026).

2.2.2 Coronation and Coronation North

The CO and CN Pits are located within the Coronation Mining Area, approximately 5 km north of the Macraes Processing Plant, and share waste rock disposal facilities (Figure 5). The CO Pit currently serves as a temporary water storage reservoir within the MWMS.

Coronation Pit: The proposed CO expansion (Stages 6-8) will extend the pit approximately 560 m to the southeast, increasing the footprint from 85 ha for the currently authorised CO Stage 5 Pit (CO5) to 125 ha. The Trimbells WRS (TR WRS) will be extended by 36 ha to accommodate the associated waste rock.

Coronation North Pit: The proposed CN Stage 6 expansion will extend the pit approximately 205 m to the southeast, increasing the footprint from 40 ha for the currently authorised CN Stage 5 (CN5) to approximately 57 ha.

At closure, both pits are expected to form pit lakes. Spillways cut into competent in-situ rock will be constructed for CO (625 mRL, draining to Camp Creek) and CN (562.5 mRL, draining to Coal Creek) to ensure long-term stability and prevent water impoundment against adjacent WRSs (e.g., TR WRS and Coronation North WRS [CN WRS]).

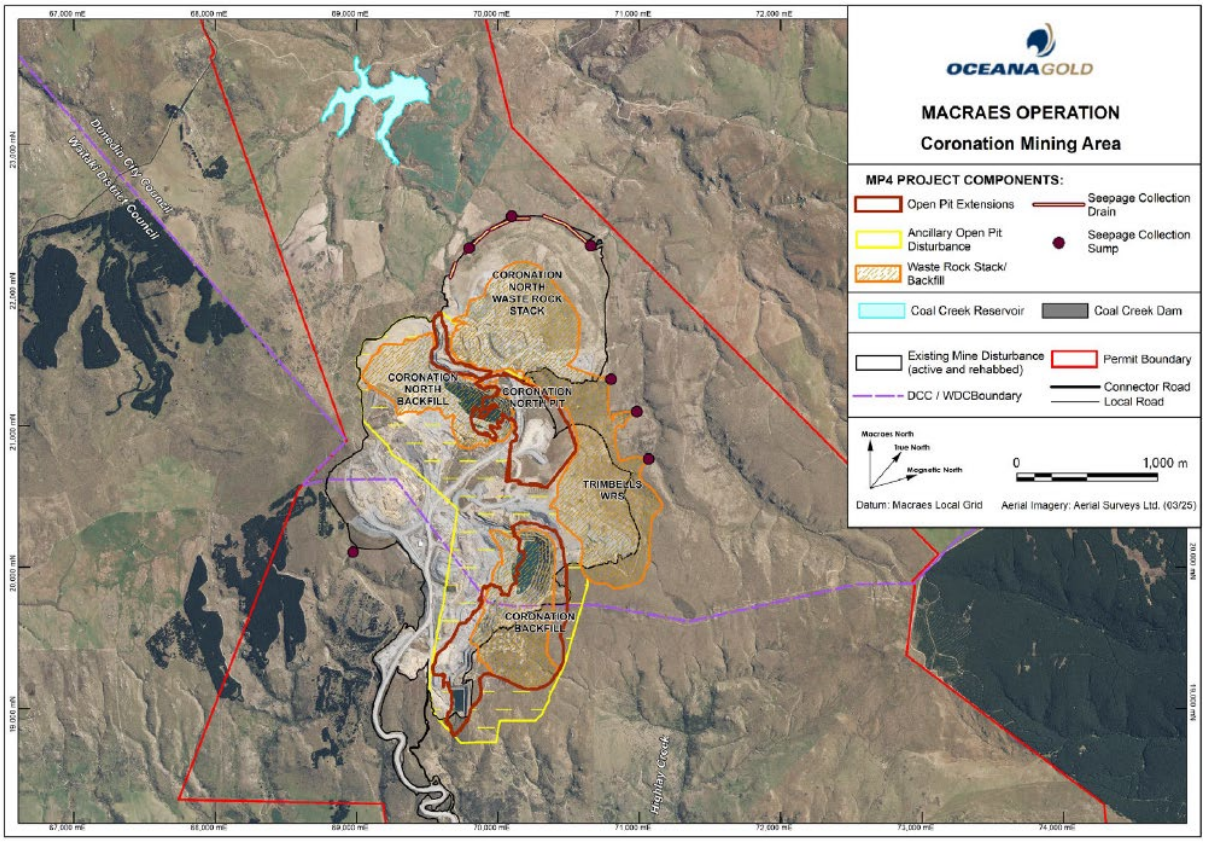

Figure 5: Coronation Mining Area.

Source: OGNZL (2026).

2.2.3 Innes Mills

The IM Pit is located in the Central Mining Area (Figure 6). The MP4 Project proposes to extend the pit to the north, east, and west into the Southern Pit area (IM11 to IM13) to facilitate the recovery of downdip

and stockwork ore. The proposed extensions will result in a total increase to the IM Pit footprint of approximately 49 ha.

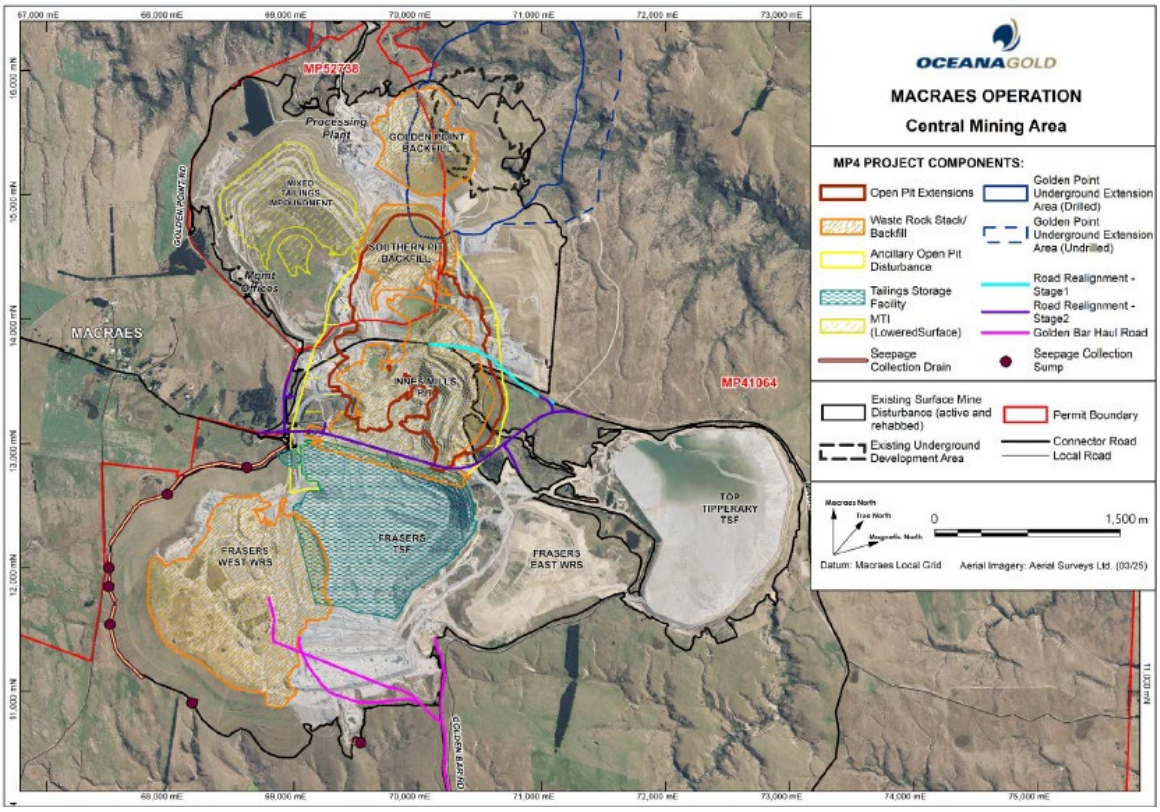

Figure 6: Central Mining Area.

Source: OGNZL (2026).

2.2.4 Summary of Mine Waste Material Movement

The proposed pit extensions will involve generation and relocation of substantial volumes of waste rock and tailings (Table 1), which may influence post-closure pit lake water quality. Key management strategies include:

- Waste Rock
  - GB: All waste rock from the pit extension will be placed within the expanded GB WRS.
  - CO and CN: Waste rock generated from the pit extensions will be used as in-pit backfill or placed within the expanded CN WRS and TR WRS (OGNZL, 2026).
  - IM: Waste rock generated from the pit extension is primarily designated for the Frasers Backfill (FRBF), with excess material distributed among Frasers South WRS (FS WRS), Innes Mills Backfill (IMBF), Southern Pit Backfill (SPBF), and Frasers West WRS (FW WRS). A portion of the IM waste rock may also be used to backfill the Golden Point Pit Backfill (GPBF).
- Tailings
  - IM: Mining of IM13 will require the relocation of approximately 59.2 Mt of tailings to the FTSF. This comprises 26 Mt of tailings from SP10 and SP11, and 33 Mt from the upper 30 m of the MTI (reducing the MTI crest height from 551 to 521 mRL).

Table 1: Summary of estimated mine waste material movement.

SITE	ORE (Mt)	WASTE (Mt)	TAILINGS (Mt)	TOTAL (Mt)
Golden Bar	2.0	32.4	-	34.4
Coronation	6.9	106.0	-	112.9
Coronation North	0.7	34.6	-	35.3
Innes Mills	36.3	276.1	59.2	371.6

Source: OGNZL (2026).

2.3 Water Quality Compliance Framework

For the MP4 Project, Viridis (2026) developed a compliance framework for assessing surface water quality in key receiving environments. This framework provides an integrated, site-specific approach to compliance assessment at the Macraes Operation, outlining the application and rationale behind the development of trigger values (TVs) and compliance criteria.

The TVs represent concentrations of constituents of concern that have been adjusted for site-specific water chemistry parameters (such as hardness, dissolved organic carbon (DOC), pH, and chloride) to account for bioavailability and associated ecological risks. The inorganic toxicant TVs are primarily based on the ANZG[1] default guideline values corresponding to a 95% species protection level.

Viridis (2026) derived TVs for both acute and chronic exposure scenarios. For reference, Table 2 presents a summary of the chronic TVs for the parameters included in the pit lake water quality modelling. For parameters whose toxicity is strongly influenced by bioavailability, the values presented in Table 2 were calculated by Viridis (2026) using representative Macraes water quality conditions (pH 7.8, DOC 4.5 mg/L, and hardness 220 mg/L as $CaCO_3$). Unless otherwise noted, the TVs for trace metals apply to the dissolved fractions; Fe is assessed against a total concentration TV.

Table 2: Proposed simplified ecological trigger values (TVs) for the MP4 Project.

PARAMETER	UNIT	PROPOSED TV	COMMENT
pH	pH units	6.5-9.0	-
SO_4	mg/L	500	when hardness <100 mg/L
		1,000	when hardness ≥ 100 mg/L
NO_3-N	mg/L	1.1	when hardness <30 mg/L
Amm-N	mg/L	0.52	Adjusted for pH 7.8 and 20ºC
As	mg/L	0.013	All compliance sites except DC08
		0.042	At DC08
B	mg/L	0.94	-
Cu	mg/L	0.004	Adjusted for DOC of 4.5 mg/L
Fe	mg/L	0.28	-
Pb	mg/L	0.045	Adjusted for hardness 220 mg/L
Zn	mg/L	0.016	Adjusted for DOC 4.5 mg/L, pH 7.8, hardness 220 mg/L
Cyanide	mg/L	0.0072	Adjusted for pH 7.8 and 20ºC

Note: All values presented in this table are chronic TVs derived from Table 3 of Viridis (2026). Further details on the derivation of TVs and the application of toxicity modifiers are provided in Viridis (2026).

[1] *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG), default guideline values for toxicants: https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search*

3 MINE PIT LAKE LIMNOLOGY AND STRATIFICATION

This section provides a detailed description of the physical, chemical, and biological processes governing hydrodynamic behaviour and water quality in mine pit lakes.

3.1 Introduction

Mine pit lakes are influenced by an integrated set of variables. Unlike natural lakes, mine pits often feature steep side slopes and high depth-to-surface-area ratios, which significantly influence their mixing regimes. Predicting their behaviour requires a comprehensive understanding of pit geometry, local climate, hydrology, biology, and geochemistry.

The foundation of pit lake water quality is its physical limnology (Figure 7), specifically the seasonal stratification and mixing cycles, which provides the essential backdrop for all subsequent geochemical reactions (Castendyk and Eary, 2009).

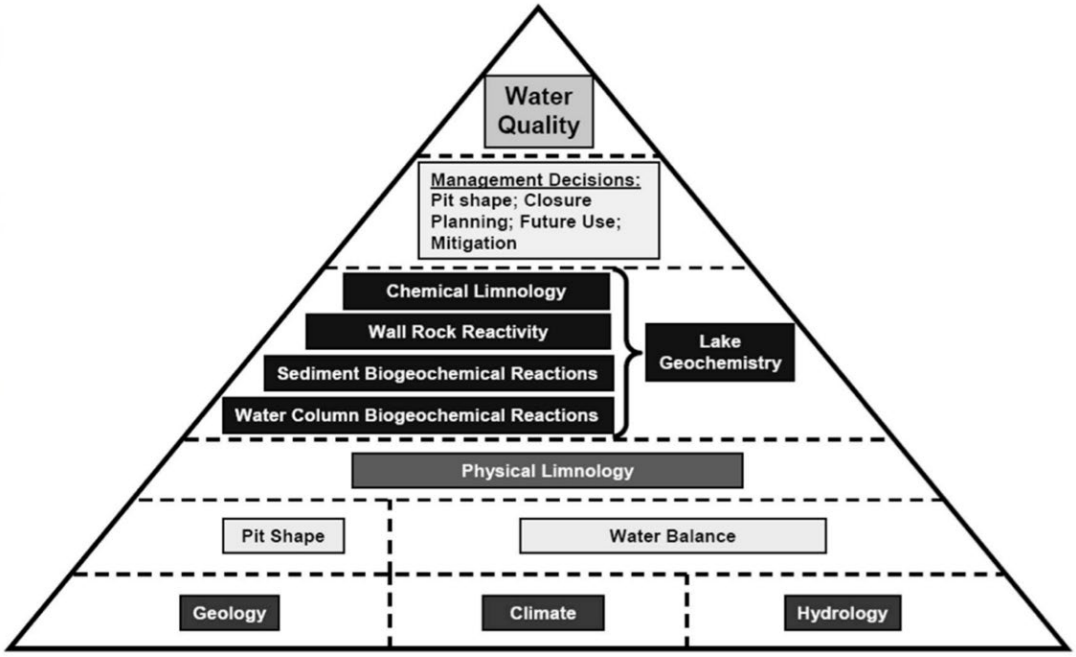

Figure 7: Conceptual relationships of pit lake components influencing water quality.
Source: Castendyk and Eary (2009).

3.2 Physicochemical Dynamics of Pit Lake Stratification

3.2.1 Stratification Classifications and Mixing Frequency

The physical behaviour of a mine pit lake is primarily governed by the vertical distribution of water density. When layers of different densities exist, the water column becomes "stratified", forming distinct horizontal layers that resist mixing and restrict the exchange of oxygen and dissolved constituents. This significantly impacts the distribution of PCOCs; in a stratified system, surface sampling is often not representative of water quality at depth.

As illustrated in Figure 8, density gradients are typically established through two primary mechanisms:

Thermal stratification in holomixis systems, driven by temperature differences. Solar radiation heats the surface layer (epilimnion), making it more buoyant than the cooler, denser water beneath (hypolimnion).

As surface temperatures decline in winter, the density of the epilimnion increases, eventually leading to a complete vertical mixing event (Figure 8a). This homogenises the water column and prevents the long-term isolation of deep waters from seasonable mixing processes. This is the dominant process observed at the Globe-Progress Mine (Reefton) and Golden Bar (Macraes) sites. Lakes that mix fully at least once a year are termed holomictic.

Chemical stratification (meromixis), driven by differences in total dissolved solids (TDS). High-salinity groundwater inflows or mineral leaching can create a dense, solute-rich bottom layer (monimolimnion) separated from the upper layer (mixolimnion) by a sharp salinity gradient called a chemocline. Unlike thermal gradients, chemical density gradients are often sufficiently robust to resist seasonal cooling, leading to long-term isolation of deep waters (Figure 8b).

For the MP4 Project, the distinction between seasonal (thermal) stratification and long-term (chemical) stratification is critical for model assumptions.

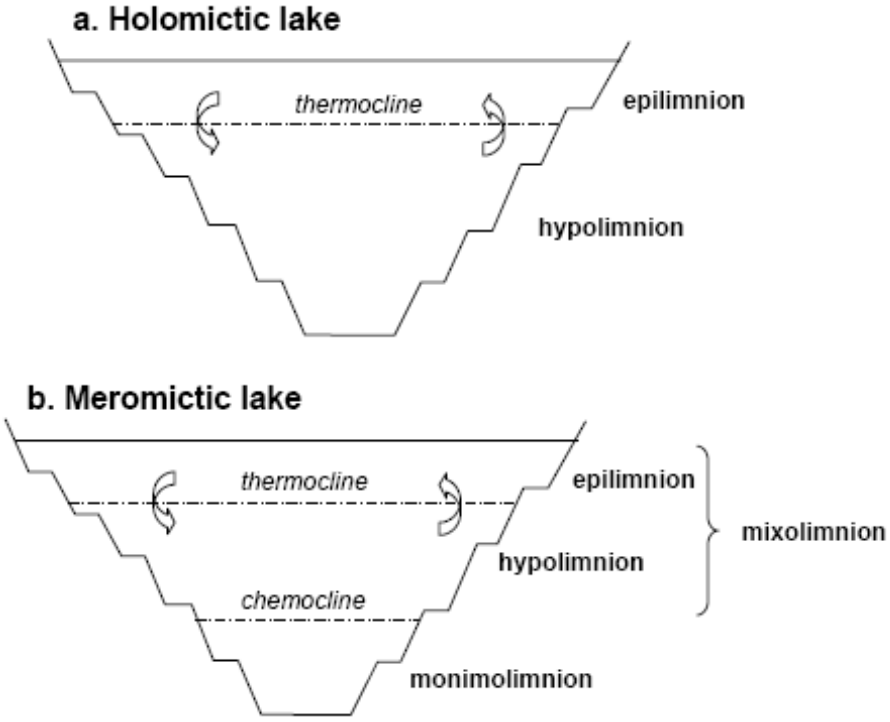

Figure 8: Limnological classifications of stratification and mixing regimes in (a) holomictic and (b) meromictic mine pit lakes.

Source: Soni et al. (2014).

3.3 Review of Previous Studies

OGNZL has undertaken several studies relating to pit lake stratification, which provide critical context for the mixing regimes expected at the Macraes Operation.

3.3.1 Waihi Gold Mine (Martha Pit)

Hydronumerics (2018) and AECOM (2018) were commissioned by OGNZL to undertake hydrodynamic and geochemical assessments of the proposed Martha Phase 4 Pit Lake at the Waihi Gold Mine.

Modelling predicted that Martha Pit Lake will not behave as a typical holomictic lake. Instead, it is expected to exhibit meromictic or oligomictic characteristics. While strong seasonal thermal stratification develops during warmer months, winter cooling is predicted to be insufficient to cause complete vertical mixing. Full-depth mixing (approximately 275 m water depth) is inhibited by a stable, deep density gradient (pycnocline) driven by high TDS groundwater inflows. This creates a persistent monimolimnion that remains isolated from seasonal mixing processes.

The physical regime directly influences the chemical evolution of the pit lake. While the epilimnion remains oxygenated, the prolonged isolation of deeper waters promotes the development of anoxic conditions and where sufficient organic carbon is present, increasingly reducing conditions within the monimolimnion. These processes have important implications for water quality:

- Redox processes: The depletion of dissolved oxygen in deep waters may lead to reducing conditions, which can facilitate the mobilisation of nutrients and trace elements from sediments and submerged pit walls through reductive dissolution and desorption processes.
- Nutrient cycling: Under reducing conditions, and where sufficient organic carbon is available, sediment-bound phosphorus (P) and nitrogen (N) may be released into the water column, resulting in the accumulation of nutrients within the deep-water reservoir.
- Mixing risks: During unusually cold winters or major storm events, mixing may extend deeper into the water column (oligomictic behaviour), entraining anoxic and solute-rich deep water into surface layers and potentially causing a rapid deterioration in surface water quality.

3.3.2 Globe Pit Lake

Previous work demonstrated thermal stratification within the Globe Pit Lake during warmer months (Hayton et al., 2020), which was associated with increased concentrations of As at depth (Figure 10). Unlike the Martha Pit, the Globe system is holomictic; full mixing of the water column occurs each winter as thermal stratification ceases (Figure 9).

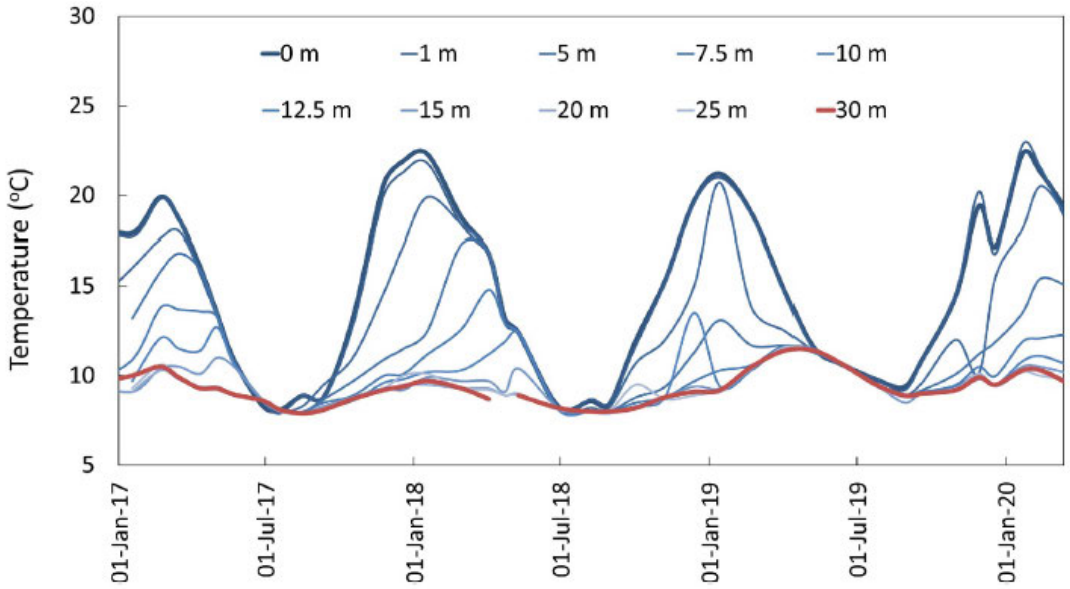

Figure 9: Globe Pit Lake temperature stratification monitoring data.

Source: Hayton et al. (2020).

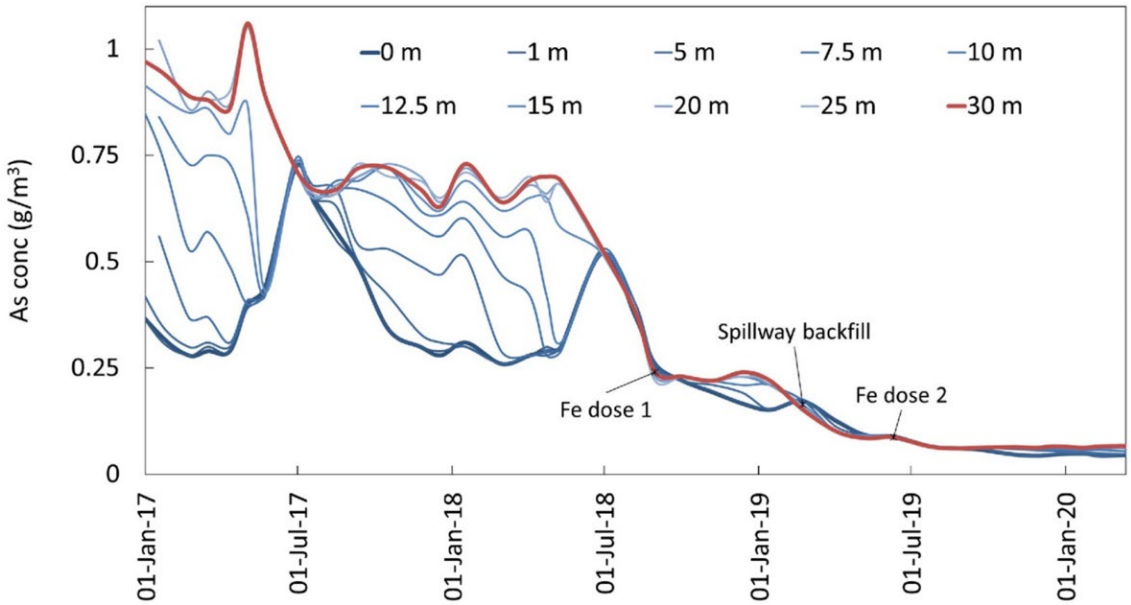

Figure 10: Monitoring data showing As concentration stratification at the Globe Pit Lake.
Source: Hayton et al. (2020).

3.3.3 Macraes Gold Mine (Golden Bar)

Two field campaigns were conducted within the 45 m deep GB Pit Lake to assess potential stratification effects (MWM, 2024b) (Figure 11). Since spilling commenced circa 2018, the lake has undergone numerous seasonal cycles.

While the sampling events occurred in October (spring) and March (late summer), they serve as proxies for the end-of-winter and end-of-summer conditions. Key results from the multi-depth profiling include:

- Thermal stratification was identified in both campaigns. The October profile (representative of post-winter conditions) showed a gradual temperature decrease with depth (11.2°C at the surface to 6.6°C at 35 m). In March (post-summer), a well-defined thermocline developed between 10 and 20 m depth (12.9°C at the surface to ~7°C at 20 m).
- pH remained relatively stable with depth in October (~8.4). In March, pH decreased at depth, correlating with the development of metalimnion.
- EC and total alkalinity were nearly uniform throughout the October profile. However, the March profile showed a distinct increase within the deeper water column (EC rising from ~880 to ~920 µS/cm; alkalinity from ~110 to ~255 mg/L), indicating chemical sequestration in the hypolimnion during periods of thermal stratification.
- Sulfate concentrations (not plotted) remained constant (260-270 mg/L) independent of depth. Dissolved As concentrations were uniform with depth in October (~0.12 mg/L) but increased to 0.17 mg/L below the thermocline in March.

The available profiling data indicate that thermal and chemical stratification can develop within the GB Pit Lake, particularly during late summer, although the magnitude and persistence of stratification remain uncertain. Given that the assessment is based on only two sampling events, additional seasonal and depth-resolved monitoring would be beneficial to better characterise annual mixing cycles and validate the conceptual understanding of pit lake stratification processes.

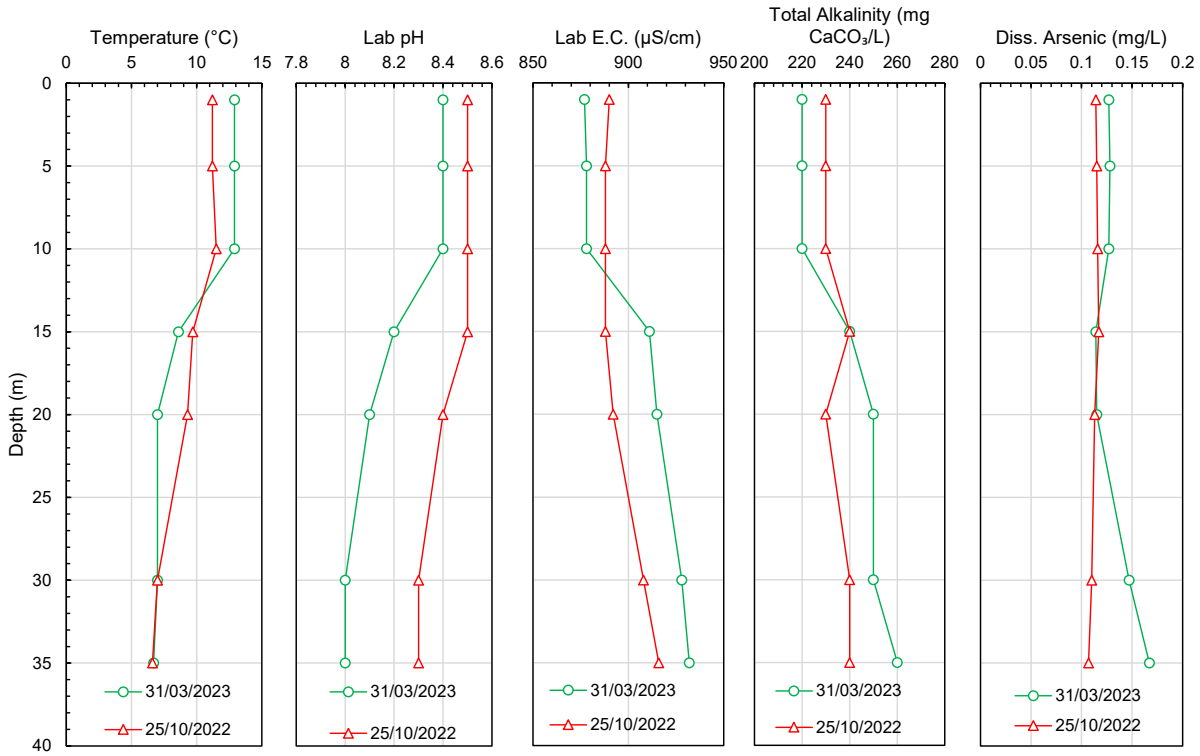

Figure 11: Results of multi-depth analysis at Golden Bar Pit Lake.

Source: MWM (2024b).

3.4 Stratification Management Options

Seasonal thermal stratification is expected to develop within the MP4 pit lakes. However, persistent density stratification resulting in meromictic conditions is not anticipated, as annual winter vertical turnover is expected to promote complete vertical mixing and limit long-term accumulation of solutes within deep waters. If pit lake stratification persists, the following management options are available to mitigate potential risks to receiving environments.

3.4.1 Aeration and Mixing

Aeration is a widely applied management technique for waters affected by suboxic or reducing conditions, particularly where elevated concentrations of Fe, As, sulfide, or ammoniacal N are present. Aeration increases dissolved oxygen (O_2) concentrations and promotes oxidation reactions within the water column.

For example, aeration facilitates the oxidation of dissolved ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+}), resulting in the formation of ferrihydrite precipitates under circumneutral pH conditions. These precipitates can subsequently remove dissolved As through adsorption and co-precipitation processes. Aeration can also promote the oxidation of dissolved sulfide (HS^-) to sulfate (SO_4^{2-}) where reducing conditions develop in deep pit waters. The following physical aeration systems are available to increase aeration:

- A trompe utilises falling water to entrain and compress air, which is subsequently released into the water column through a submerged discharge system (Leavitt et al., 2015).

- Mechanical aerators or pumping systems can be used to circulate deep water to the surface, thereby reducing stratification and promoting oxygen transfer throughout the water column (e.g., Sánchez-España et al., 2020).
- Fine-bubble diffusers generate a high air-water interfacial area by forcing air through small diffuser openings, resulting in efficient oxygen transfer and improved oxidation of reduced species such as sulfide and ammoniacal N (Dorman, 2019).

3.4.2 Ferric Chloride Addition

The addition of ferric chloride ($FeCl_3$) is an established treatment method for As-impacted waters. At Globe-Progress Pit Lake, in-pit $FeCl_3$ dosing was used to reduce As loads through adsorption onto and co-precipitation with ferrihydrite, which subsequently settles to the lakebed.

Monitoring data from the Globe-Progress Pit Lake indicate substantial reductions in As loading following $FeCl_3$ dosing events (Figure 12). Navarro-Valdivia et al. (2022) estimated that approximately 2,156 kg of As was removed following two $FeCl_3$ dosing events and a subsequent "spillway rock mixing" event, during which earthworks introduced significant quantities of rock and sediment into the pit lake.

Monitoring data presented in Figure 10 further indicate that vertical As concentration gradients were less pronounced following $FeCl_3$ dosing, suggesting that treatment may have reduced As accumulation within deeper portions of the water column.

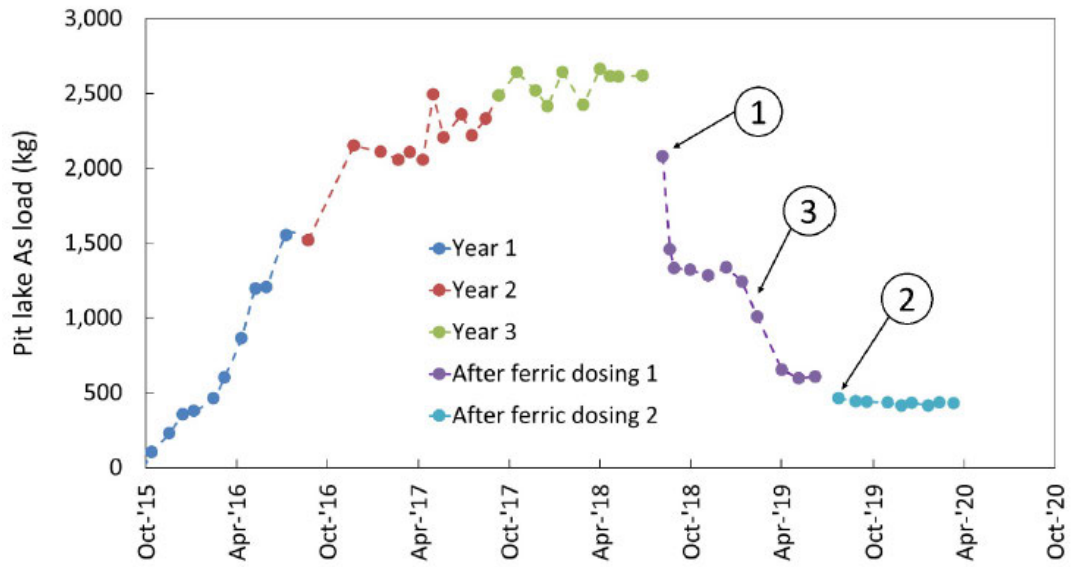

Figure 12: Globe-Progress Pit Lake As load tracking.

Note: Ferric dosing indicated by (1) and (2). Event (3) indicates a period of "spillway rock mixing" due to earthworks.

Source: Hayton et al. (2020).

3.5 Site Specific Modelling Rationale

To reflect the anticipated limnological behaviour of the MP4 pit lakes, a well-mixed (holomictic) assumption has been adopted in the hydrogeochemical modelling. This assumption is supported by:

- Observational evidence: Field monitoring at Golden Bar Pit Lake (MWM, 2024b) and Globe-Progress Pit Lake (Hayton et al., 2020) confirms full vertical turnover in pit lakes within the South Island.
- Conservative mixing: A well-mixed model assumes that solutes released from submerged pit walls, waste material, or sediments are distributed throughout the water column and therefore contribute directly to predicted surface water quality. This approach avoids reliance on the long-term sequestration of contaminants within a permanently isolated bottom-water layer.

3.6 Summary

- Annual (seasonal) thermal pit lake stratification is expected to occur within the proposed MP4 pit lakes. Based on current evidence, persistent meromictic conditions are not anticipated.
- Management options are available should elevated solute concentrations develop within pit waters. These include aeration and mixing systems to oxidise reduced species and $FeCl_3$ dosing to remove As and potentially other trace metals from the water column.

3.7 Recommendations

To validate the vertical mixing assumptions, reduce key physical and biogeochemical uncertainties, and ensure closure-readiness, the following work is recommended during operation of the Project:

- Implement a monthly monitoring program at the GB Pit Lake prior to commencement of pit dewatering. The program should:
    - Collect depth-profile measurements of temperature, dissolved oxygen (DO), pH, oxidation-reduction potential (ORP), and EC to characterise seasonal development of thermal and chemical stratification and confirm the occurrence of winter turnover.
    - Collect water samples at multiple depths (epilimnion, metalimnion, and hypolimnion) to assess vertical water quality gradients and quantify the accumulation of solutes within deep waters during stratified periods.
    - Includes analysis of pH, EC, nutrients, major cations and anions, dissolved organic carbon, and key PCOCs.
- Develop detailed hydrogeochemical pit lake models as additional monitoring data become available. Further assessments should evaluate stratification dynamics, nutrient cycling, redox sensitive constituents, and any revision to source terms to support closure planning and verify the assumptions adopted in the current assessment.

4 HISTORICAL WATER QUALITY DATA REVIEW

4.1 Overview

OGNZL maintains an extensive water quality monitoring network across the Macraes Operation. Monitoring locations are categorised into three groups:

- Groundwater
- Surface Water
- Mine Water

This review focuses on the monitoring locations considered most relevant to the MP4 hydrogeochemical modelling. As the four pits will be dewatered prior to expansion, the quality of the current standing pit water is excluded from this review, as it is not expected to influence post-closure pit lake chemistry.

4.2 Groundwater

A network of groundwater monitoring bores is distributed across the Macraes Operation to monitor groundwater quality and assess changes associated with mining activities. Representative monitoring bores were selected for each project domain (Table 3) based on the following criteria:

- Spatial relevance: Proximity to the respective pit domains to ensure the data are representative of local hydrogeological conditions.
- Baseline geochemistry: Preference for locations distal to known mine-impacted waters to ensure source terms reflect ambient groundwater quality rather than operational impacts.
- Data quality and completeness: Availability of sufficient temporal coverage and analytical completeness for the parameters required to support hydrogeochemical modelling using PHREEQC.

Table 3: Summary of groundwater monitoring bores selected for hydrogeochemical characterisation.

PROJECT DOMAIN	SELECTED MONITORING SITES
Golden Bar	RCH3004, RCH2775, RCH2585
Coronation & Coronation North[#]	CP01, CP02, CP03, CP04
Innes Mills	FDB03, SPMW3, SPMW4

Note: [#] These domains are located within the same mining area.

4.2.1 Groundwater at Golden Bar

Groundwater quality within the GB domain is monitored at bores RCH3004, RCH2775, and RCH2585 (Figure 13). Bore RCH3004, located northwest of the GB Pit, provides a continuous monitoring record since 2003. Water quality statistics are summarised in Table 4, with time-series trends for selected parameters presented in Figure 14 to Figure 16. Key observations include:

- Groundwater levels at RCH3004 typically fluctuate between 5 and 9 m below ground level (bgl).
- Groundwater is generally circumneutral (pH ~6.8) with low salinity (EC <200 µS/cm). In recent years, pH has occasionally deceased to ~6.0, while EC decreased to ~100 µS/cm.

- Sulfate concentrations decreased from ~25 mg/L during the early monitoring period and have since stabilised between approximately 5 and 15 mg/L. Chloride (Cl) concentrations have remained relatively constant at ~8 mg/L.
- Major cation concentrations are generally low. Calcium (Ca) declined from ~10 to 3 mg/L, while Mg declined from 10 to 8 mg/L with occasional recent values as low as 2 mg/L. Sodium (Na) have remained stable at ~6-8 mg/L, while K is typically <1 mg/L.
- Most trace elements remain at low concentrations, with the exception of Fe. RCH3004 exhibits elevated Fe concentrations relative to other regional monitoring location, with an average of 4.3 mg/L and a median of 5.1 mg/L.

Bores RCH2775 and RCH2585 are located closer to the GB Pit perimeter. Monitoring records at these locations are limited and are largely restricted to the period from 2003 to 2005, though monitoring at RCH2585 recommenced in 2025. Water quality data for these bores are summarised in Table 5.

Comparison of the three monitoring locations indicate a broadly similar groundwater chemistry, with two notable differences:

- EC at RCH2775 averaged 461 µS/cm (2003-2004), substantially higher than that observed at RCH3004 and RCH2585 (typically 100-200 µS/cm). The elevated EC is primarily attributed to higher alkalinity and Ca concentrations.
- Iron concentrations at the proximal bores were typically <0.6 mg/L, significantly lower than those recorded at RCH3004. This difference may reflect localised redox conditions, lithological variability, or mineralogical controls on Fe mobility.

Figure 13: Groundwater monitoring sites within Golden Bar Pit domain.

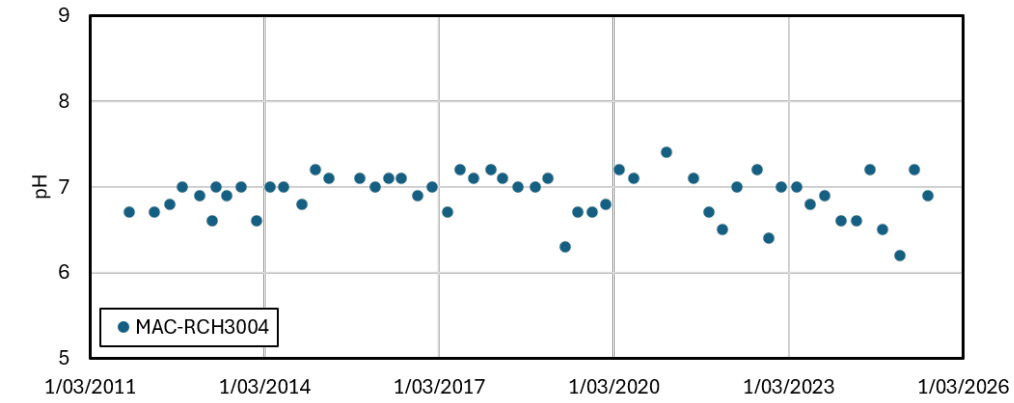

Figure 14: Time-series of pH at groundwater monitoring site RCH3004.

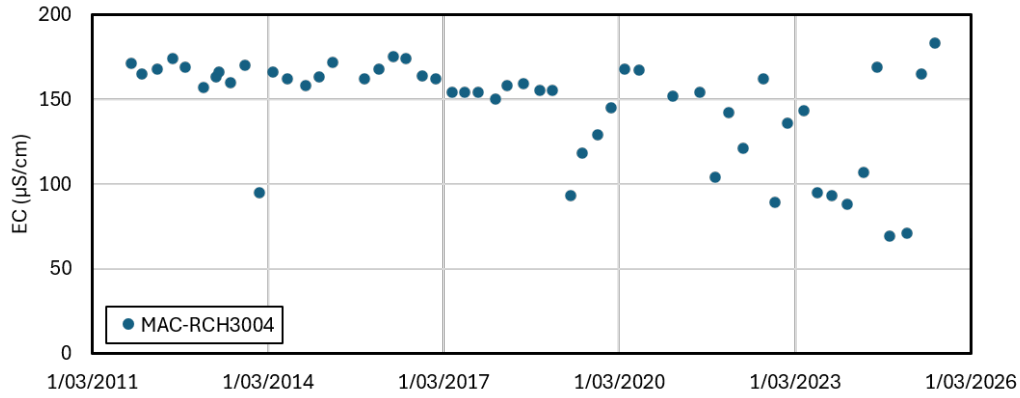

Figure 15: Time-series of EC at groundwater monitoring site RCH3004.

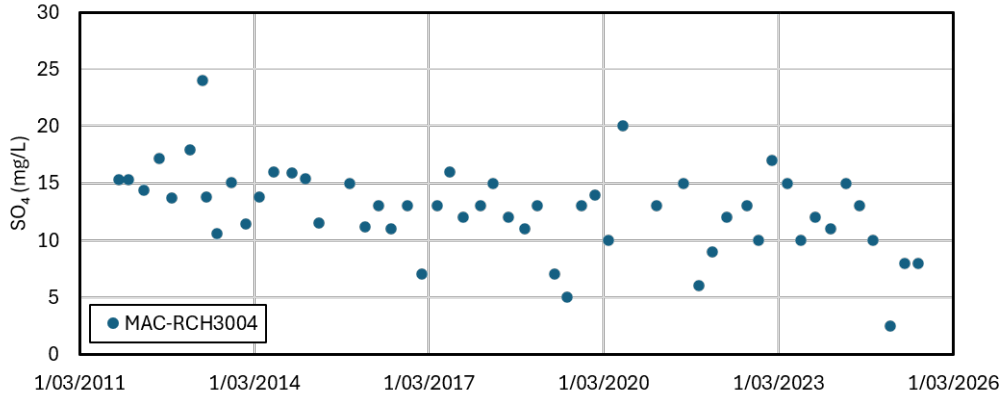

Figure 16: Time-series of SO_4 at groundwater monitoring site RCH3004.

Table 4: Statistical summary of groundwater quality data for RCH3004 (2003-2025).

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
pH	pH units	86	6.26	6.8	7.4	4.5
EC	µS/cm	86	154.5	164.5	69	200
Total Alkalinity	mg/L as $CaCO_3$	86	49.7	55	10.4	75
Total Hardness	mg/L as $CaCO_3$	68	50.3	53	15.2	69
SO_4	mg/L	86	14.4	14	2.5	26
Cl	mg/L	86	8.13	8	2.5	12
NO_3-N	mg/L	29	0.404	0.157	0.002	1.7
NO_x-N	mg/L	30	0.3972	0.137	0.002	1.73

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
NO_2-N	mg/L	28	0.0106	0.0035	0.001	0.069
NH_4-N	mg/L	32	0.034	0.01	0.005	1.73
Ca	mg/L	86	8.25	8.8	2.7	0.069
Mg	mg/L	86	7.68	8.2	2	0.32
Na	mg/L	86	9.22	9.4	5	0.14
K	mg/L	86	0.925	0.87	0.72	2
As	mg/L	82	0.00310	0.00075	0.0005	15
Cu	mg/L	34	0.00225	0.00055	0.00025	11
Fe	mg/L	85	4.33	5.1	0.01	11.5
Pb	mg/L	34	0.00013	0.00005	0.00005	2.8
Zn	mg/L	17	0.0354	0.035	0.0149	0.15025
WAD CN	mg/L	4	0.00525	0.00525	0.0005	0.0099

Note: Unless otherwise specified, all element concentrations in this and following tables represent the dissolved fraction.

Table 5: Statistical summary of groundwater quality data for RCH2775 and RCH2585.

SITE		RCH2775		RCH2585		RCH2585	
DATE		2003-2004		2003-2005		2025	
PARAMETER	UNIT	COUNT	MEDIAN	COUNT	MEDIAN	COUNT	MEDIAN
pH	pH units	3	6.6	7	6.6	3	6.5
EC	µS/cm	3	476	7	198	3	146
Total Alkalinity	mg/L as $CaCO_3$	3	216	7	79	3	33
Total Hardness	mg/L as $CaCO_3$	-	-	-	-	3	49
SO_4	mg/L	3	23	7	10	3	10
Cl	mg/L	3	9.8	7	12	3	11
NH_4-N	mg/L	-	-	-	-	3	0.005
NO_3-N	mg/L	-	-	-	-	3	0.93
NO_x-N	mg/L	-	-	-	-	3	0.94
NO_2-N	mg/L	-	-	-	-	3	0.002
Ca	mg/L	3	59	7	14	3	7.9
Mg	mg/L	3	18	7	11	3	7
Na	mg/L	3	16	7	9.8	3	8.3
K	mg/L	3	1.4	7	0.84	3	1.11
As	mg/L	3	0.0025	7	0.0025	3	0.0005
Cu	mg/L	1	0.001	2	0.014	3	0.0015
Fe	mg/L	3	0.07	7	0.514	3	0.22
Pb	mg/L	1	0.001	2	0.0175	3	0.00005
Sb	mg/L	-	-	-	-	3	0.0005
Zn	mg/L	-	-	-	-	3	0.0076

4.2.2 Groundwater at Coronation and Coronation North

Groundwater quality within the CO and CN domains is monitored at four locations: CP01, CP02, CP03, and CP04 (Figure 17). Monitoring commenced in 2015; however, data collection at CP01 and CP02 ceased in 2020 and 2019, respectively. Statistical summaries for CP01, CP02, and CP04 are provided in Table 6, with time-series trends presented in Figure 18 to Figure 20.

Observations for CP01, CP02, and CP04

These monitoring locations exhibit relatively stable hydrogeochemical conditions, with variations primarily attributable to groundwater depth:

- Groundwater levels at CP01 and CP02 typically fluctuated between 15 and 22 m bgl, representing the deeper groundwater system. In contrast, CP04 recorded a shallow water table (<0.7 m bgl), reflecting a near-surface groundwater regime that is more susceptible to meteoric recharge and evapoconcentration processes.
- CP04 exhibits a more alkaline pH (median 7.9) and higher median EC (324 µS/cm) than the deeper groundwater systems at CP01 (pH 6.8, EC 209 µS/cm) and CP02 (pH 7.3, EC 178 µS/cm).
- The higher EC at CP04 is associated with higher total alkalinity (median 151 mg/L as $CaCO_3$) and Ca concentrations (median 45 mg/L).
- Sulfate concentrations remained consistently low at all three locations, with median concentrations ranging from 7 to 9 mg/L.

Observations for CP03

CP03 exhibits a hydrogeochemical signature that differs from the other three monitoring locations and indicates a localised hydrochemical change that has developed since 2017:

- Groundwater levels have shown substantial variability, ranging from 3.5 to 24 m bgl.
- Groundwater pH initially fluctuated around 6.5 before declining to approximately 5.0 (Figure 21).
- Both SO_4 and EC have exhibited increasing trends since 2017.

The large fluctuations in groundwater level, coupled with the observed deterioration in water quality, suggest that CP03 may be influenced by localised hydrogeological or mine-related factors that are not representative of ambient groundwater conditions within the broader CO/CN domain. Consequently, data from CP03 were not considered appropriate for groundwater source-term derivation and were excluded from subsequent hydrogeochemical modelling assessments.

Figure 17: Groundwater monitoring sites within the Coronation and Coronation North domains.

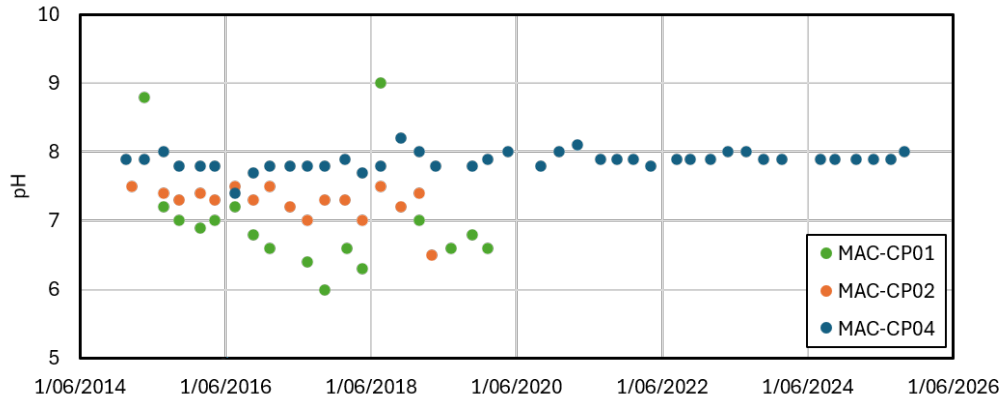

Figure 18: Time-series of pH at groundwater monitoring sites CP01, CP02, and CP04.

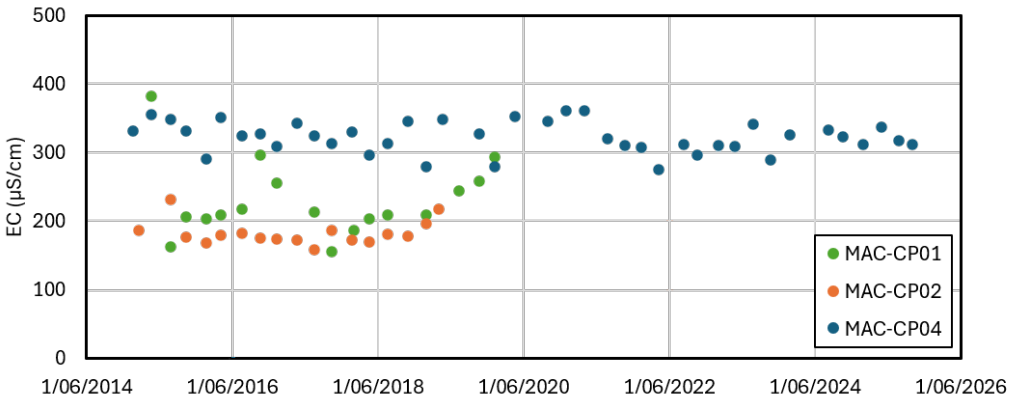

Figure 19: Time-series of EC at groundwater monitoring sites CP01, CP02, and CP04.

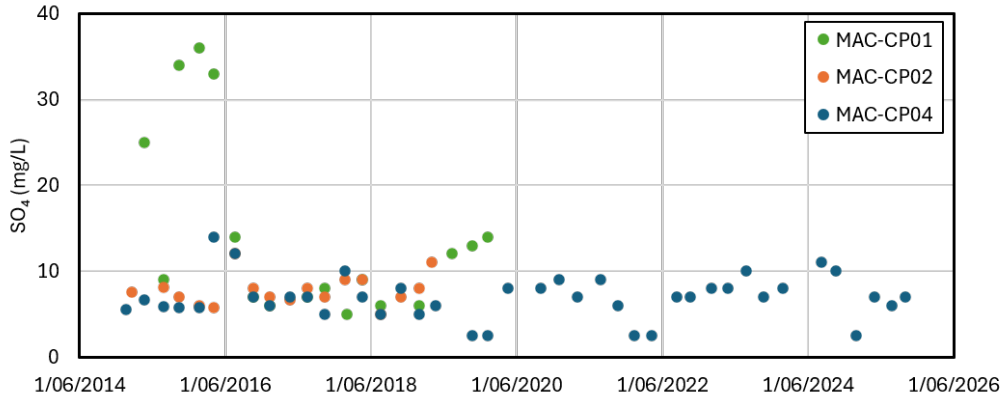

Figure 20: Time-series of SO_4 at groundwater monitoring sites CP01, CP02, and CP04.

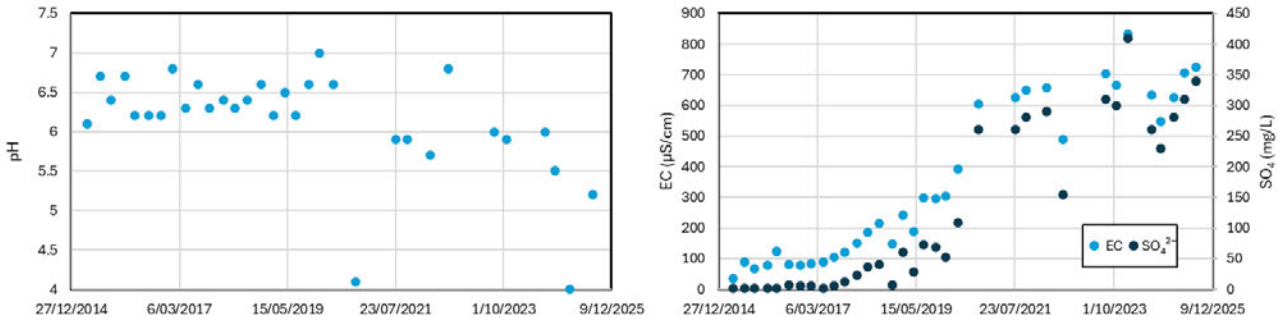

Figure 21: Time-series of pH, EC, and SO_4 at groundwater monitoring site CP03.

Table 6: Statistical summary of groundwater quality data for CP01, CP02, and CP04.

PARAMETER	UNIT	CP01			CP02			CP04		
		Count	Average	Median	Count	Average	Median	Count	Average	Median
pH	pH units	17	6.65	6.8	17	7.17	7.3	41	7.86	7.9
EC	µS/cm	17	229.9	209	17	182.9	178	41	322.6	324
Total Alkalinity	mg/L as $CaCO_3$	17	98.4	94	17	79.3	78	41	150.9	151
Total Hardness	mg/L as $CaCO_3$	17	81.2	80	17	76.9	76	41	148.0	151
Cl	mg/L	17	5.01	5	17	4.98	5	41	8.37	9
SO_4	mg/L	17	14.35	9	17	7.76	7.5	41	6.93	7

PARAMETER	UNIT	CP01			CP02			CP04		
		Count	Average	Median	Count	Average	Median	Count	Average	Median
NH_4-N	mg/L	9	0.0214	0.017	7	0.014	0.005	31	0.0113	0.005
NO_3-N	mg/L	7	0.1081	0.021	5	0.382	0.31	28	0.0419	0.0085
NO_x-N	mg/L	9	0.1111	0.022	7	0.346	0.29	31	0.0436	0.009
NO_2^--N	mg/L	7	0.001	0.001	5	0.0024	0.001	28	0.0064	0.001
Ca	mg/L	17	16.1	16.7	17	18.3	17.9	41	43.8	45
Mg	mg/L	17	10.01	10.1	17	7.54	7.2	41	9.37	9.5
Na	mg/L	17	15.19	10.90	17.00	6.88	6.50	41.00	12.11	12
K	mg/L	17	2.187	2	17	1.087	0.97	41	0.983	0.96
As	mg/L	14	0.00329	0.00215	13	0.00082	0.0005	36	0.0020	0.0015
Cu	mg/L	4	0.00085	0.0008	5	0.00118	0.0005	24	0.0003	0.00025
Fe	mg/L	14	2.50	2.35	13	0.085	0.01	36	0.265	0.28
Pb	mg/L	4	0.00005	0.00005	5	0.00005	0.00005	24	0.0001	0.00005
Sb	mg/L	-	-	-	-	-	-	14	0.0001	0.0001
Zn	mg/L	-	-	-	1	0.027	0.027	19	0.0015	0.0005

4.2.3 Groundwater at Innes Mills

Groundwater within the IM domain is characterised using data from FDB03, SPMW3, and SPMW4 (Figure 22). While FDB03 was initially considered representative of regional background groundwater quality, GHD recommended the use of SPMW3 and SPMW4 to provide a more site-specific representation of groundwater quality conditions in the vicinity of the IM Pit. Statistical summaries are presented in Table 7 and Table 8, while time-series trends are shown in Figure 23 to Figure 28.

FDB03

FDB03 is located west of the Central Mining Area and exhibits a shallow water table (typically <3.2 m bgl). The historical monitoring record indicates two distinct hydrogeochemical periods:

- Pre-2018: Water quality was relatively stable, characterised by circumneutral pH (6.4 to 7.7) and low salinity (median EC ~130 µS/cm). Average concentrations of major ions, including SO_4, Cl, Ca, Mg, Na, and K, were consistently low (<10 mg/L). Most trace elements remained near or below the limit of reporting (LOR), except for dissolved Fe, which ranged widely from 0.02 to 6.4 mg/L (average 3.71 mg/L).
- Post-2018: While pH remained circumneutral, EC frequently exceeded 1,000 µS/cm and was accompanied by episodic SO_4 concentrations of up to 700 mg/L. These changes indicate a departure from regional background groundwater conditions.

SPMW3 and SPMW4

SPMW3 and SPMW4 provide the most representative record of groundwater quality in the immediate vicinity of the IM Pit. Previous hydrogeochemical assessment undertaken by GHD identified both locations as being affected by a pre-existing groundwater plume. Monitoring commenced in 2001 with data collection continuing until 2016 at SPMW3 and 2019 at SPMW4.

- Initial conditions (2001): Both locations exhibited similar hydrochemical signatures, characterised by circumneutral pH (~7), EC of ~1000 µS/cm, and SO_4 concentrations of ~300 mg/L.
- SPMW3: Between 2005 and 2012, EC and SO_4 concentrations increased substantially, peaking at 4,500 µS/cm and 3,300 mg/L, respectively. Following this period, water quality stabilities, with EC declining ~1,800 µS/cm, SO_4 concentrations to ~800 mg/L, and pH increasing to around 7.5, by 2015-2016.
- SPMW4: Groundwater chemistry at SPMW4 remained comparatively stable throughout the monitoring period. From 2001 to 2019, pH gradually increased from ~6.8 to 7.8, while EC and SO_4 concentrations generally remained around 700 µS/cm and 200 mg/L, respectively.

Compared with the pre-2018 FDB03 dataset, groundwater at SPMW3 and SPMW4 is characterised by higher salinity and SO_4 concentrations. The data from these two sites provide a more conservative representation of the groundwater quality that will interact with post-closure inflows to the IM Pit.

For SPMW3 the 2015-2016 monitoring period was adopted for groundwater source term derivation. Although this period does not represent pre-mining groundwater conditions, it reflects a relatively stable post-disturbance groundwater chemistry following the earlier salinity peak. Adoption of this post-disturbance plateau provides a realistic and conservative representation of groundwater likely to interact with the IM Pit during the post-closure period. For SPMW4, the long-term stable water quality record was used to characterise site-specific groundwater conditions within the IM domain.

Figure 22: Groundwater monitoring sites within the Innes Mills domain.

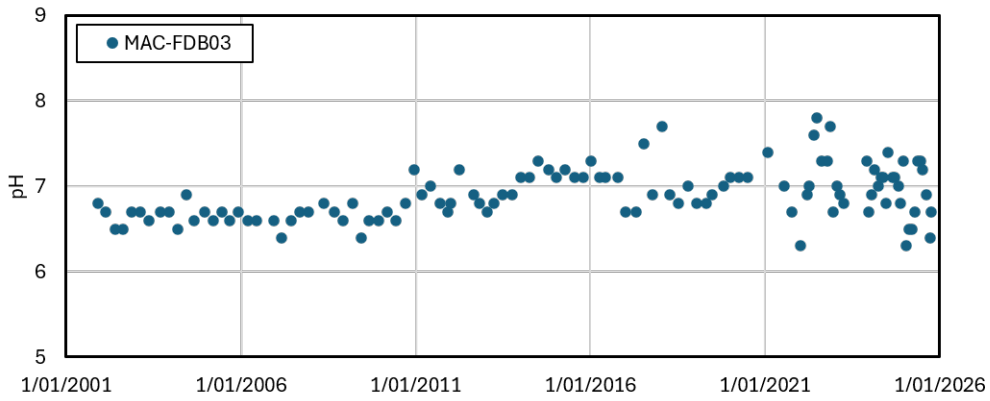

Figure 23: Time-series of pH at groundwater monitoring site FDB03.

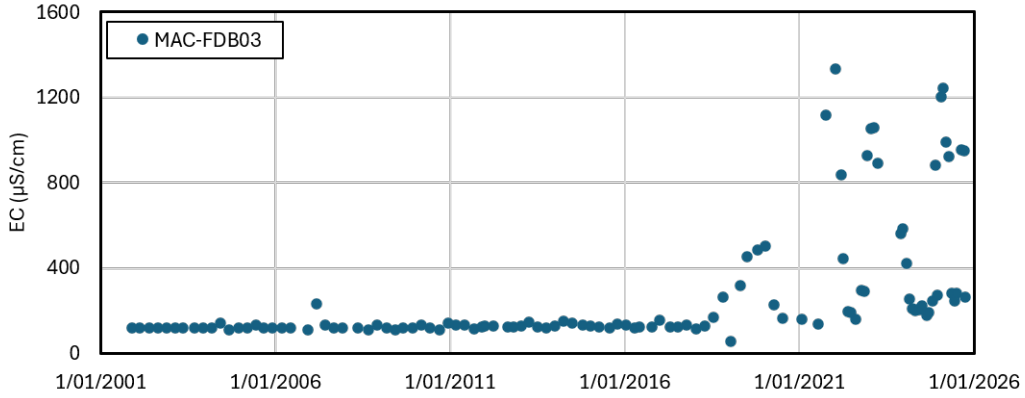

Figure 24: Time-series of EC at groundwater monitoring site FDB03.

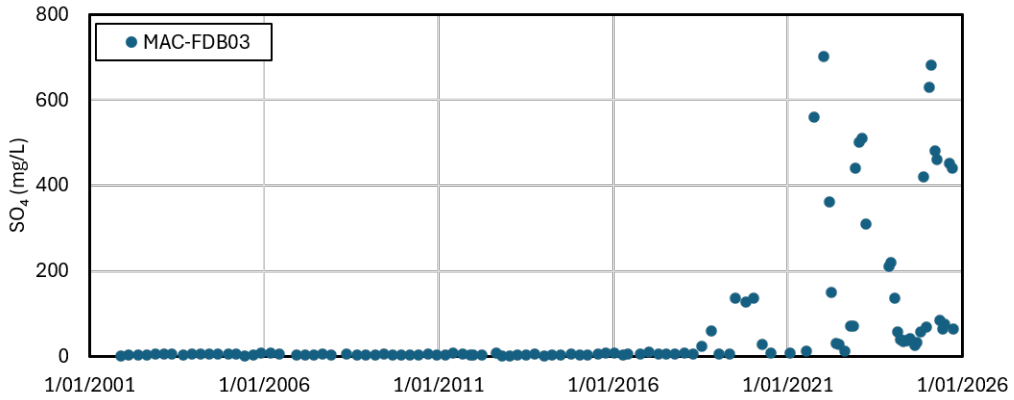

Figure 25: Time-series of SO_4 at groundwater monitoring site FDB03.

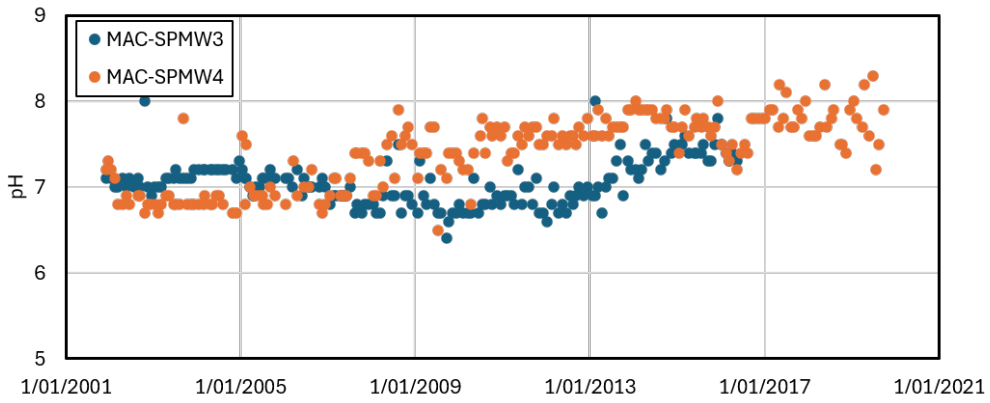

Figure 26: Time-series of pH at groundwater monitoring sites SPMW3 and SPMW4.

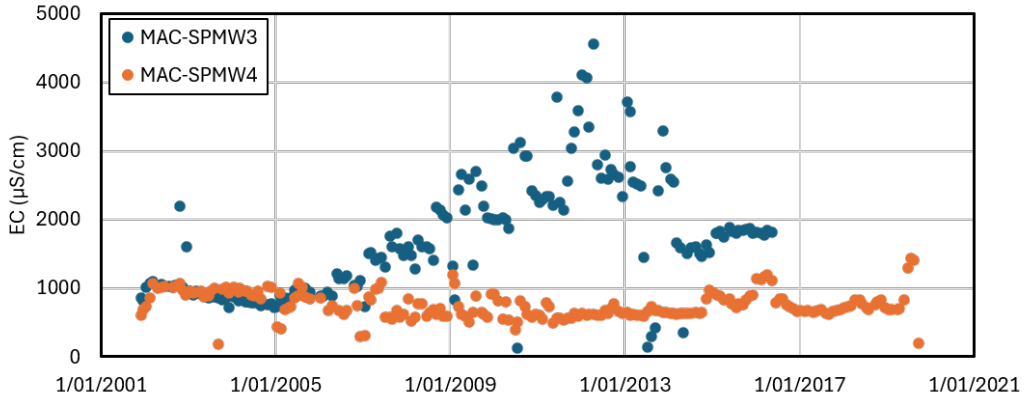

Figure 27: Time-series of EC at groundwater monitoring sites SPMW3 and SPMW4.

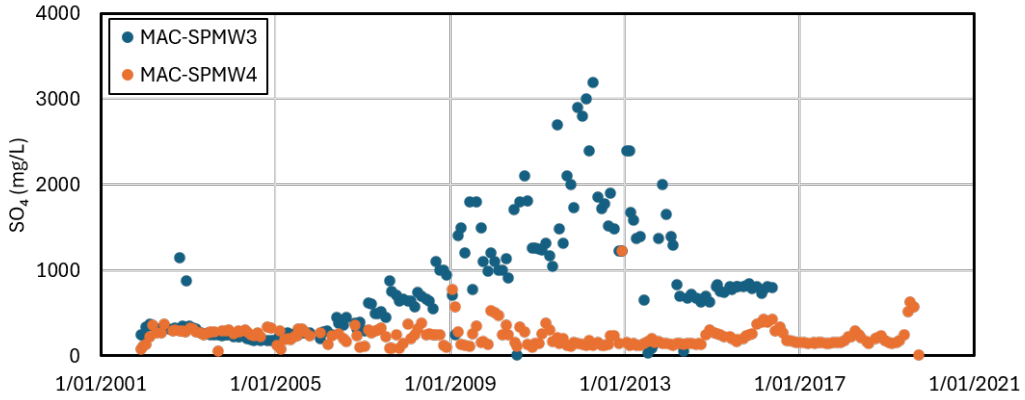

Figure 28: Time-series of SO_4 at groundwater monitoring sites SPMW3 and SPMW4.

Table 7: Statistical summary of groundwater quality data for FDB03.

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN
pH	pH units	65	6.76	6.70
EC	µS/cm	65	125.8	120
Total Alkalinity	mg/L as $CaCO_3$	65	50.6	50
Total Hardness	mg/L as $CaCO_3$	41	36.5	37
Cl	mg/L	65	5.96	5.9
SO_4	mg/L	65	4.28	4.2
NH_4-N	mg/L	4	0.230	0.159

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN
NO_3-N	mg/L	2	0.006	0.006
NO_x-N	mg/L	5	0.027	0.02
NO_2-N	mg/L	2	0.021	0.021
Ca	mg/L	65	7.30	5.3
Mg	mg/L	65	5.65	5.6
Na	mg/L	65	9.41	9.3
K	mg/L	65	1.43	1.25
As	mg/L	18	0.0021	0.0018
Cu	mg/L	18	0.0006	0.0003
Fe	mg/L	18	3.71	4.8
Pb	mg/L	18	0.0004	0.00005
WAD CN	mg/L	1	0.0005	0.0005

Note: Data from 2001 to mid-2017.

Table 8: Statistical summary of groundwater quality data for SPMW3 and SPMW4.

SITE		SPMW3			SPMW4		
		2015 - 2016			2001 - SEPTEMBER 2019		
PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	COUNT	AVERAGE	MEDIAN
pH	pH units	17	7.4	7.4	209	7.2	7.5
EC	µS/cm	17	1819	1818	210	755	712
Total Alkalinity	mg/L as $CaCO_3$	9	349	350	52	199	200
Total Hardness	mg/L as $CaCO_3$	17	1099	1110	137	354	320
Cl	mg/L	17	10.35	10	210	6.54	7
SO_4	mg/L	17	795	810	210	230	220
NH_4-N	mg/L	6	0.0065	0.005	98	0.055	0.04
NO_3-N	mg/L	4	0.0243	0.0095	97	0.374	0.03
NO_x-N	mg/L	5	0.0222	0.006	26	0.208	0.06
NO_2-N	mg/L	4	0.0025	0.0025	46	0.004	0.002
Ca	mg/L	17	358.82	360	210	120	108
Mg	mg/L	9	48.3	48	52	24.2	19.8
Na	mg/L	17	25.6	25	210	16.1	16
K	mg/L	17	2.65	2.6	210	2.86	1.9
As	mg/L	17	0.0186	0.0173	198	0.007	0.0055
Cu	mg/L	6	0.0003	0.00025	98	0.001	0.001
Fe	mg/L	8	3.925	3.5	153	0.934	0.17
Pb	mg/L	6	0.00007	0.00005	98	0.00041	0.00039
WAD CN	mg/L	6	0.0005	0.0005	96	0.0024	0.0025

4.3 Surface Water

Surface water monitoring data were reviewed to characterise the following categories of surface water:

- Natural runoff: Runoff originating from undisturbed catchments.
- Rehabilitated mine-impacted runoff: Runoff originating from mining disturbed areas (including WRS) that have been or are planned to be rehabilitated as part of mine closure.

- No-rehabilitated mine-impacted runoff: Runoff originated from mining disturbed areas that will remain exposed following closure, including pit walls and backfilled mine voids.

4.3.1 Natural Catchment Runoff at Golden Bar

Natural surface runoff within the GB domain is characterised using monitoring data from GB02, located southeast of the GB Pit (Figure 29). Monitoring commenced in 2003, providing a representative baseline dataset prior to local mining influences. A distinct hydrogeochemical shift occurred in 2015, as illustrated in the time-series plots for pH, EC, and SO_4 (Figure 30 to Figure 32), due to the overflow of the GB Pit Lake. Consequently, data collected between 2003 and 2014 were used to define the baseline (pre-mining) surface runoff quality. Statistical summaries for this period are presented in Table 9. Key observations are summarised below:

- Pre-2015 (baseline period)
    - Surface water was circumneutral, with pH ranging from 6.6 to 7.9 (median pH 7.5).
    - Salinity was consistently low, with a median EC of 112 µS/cm and an average of 153 µS/cm.
    - Major ion concentrations were generally low, with median concentrations consistently less than 10 mg/L.
    - Most trace elements were generally near or below LORs. Arsenic and Fe exhibited elevated concentrations during the 2003 sampling events, reaching up to 0.385 mg/L and 6 mg/L, respectively.
- Post-2015 (operational influence)
    - From 2015 onwards, surface water chemistry changed substantially. Water pH increased to 8.0-8.5, while EC increased to 400-900 µS/cm.
    - Concentrations of Ca, Mg, and SO_4 also increased markedly over the same period (Figure 30, Figure 31, and Figure 32).
    - The timing and natural of these changes are consistent with the commencement of the GB Pit Lake overflow into Golden Bar Creek. As a result, post-2015 water quality at GB02 is considered to represent a combination of natural runoff and pit lake discharge, rather than baseline catchment runoff conditions.

Figure 29: Surface water monitoring site (GB02) within the Golden Bar domain.

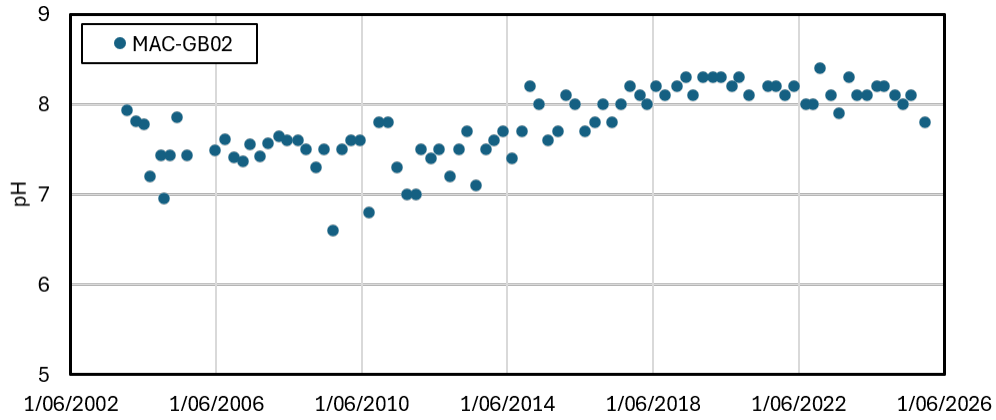

Figure 30: Time-series of pH at surface water monitoring site GB02.

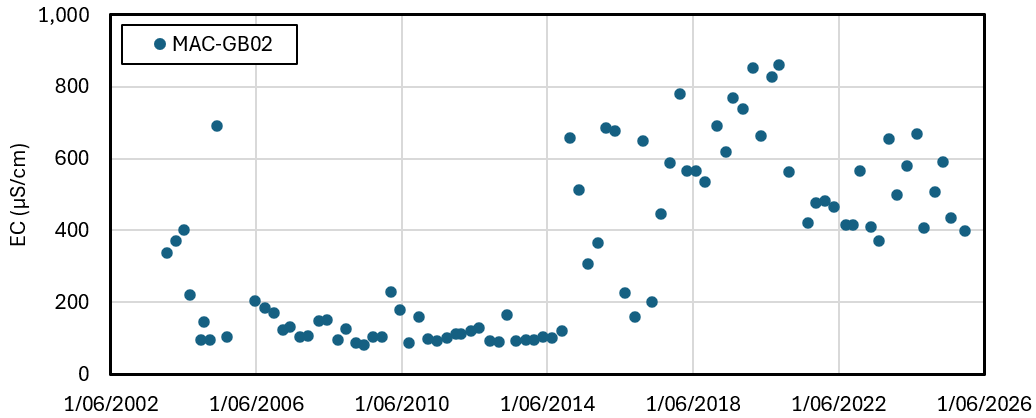

Figure 31: Time-series of EC at surface water monitoring site GB02.

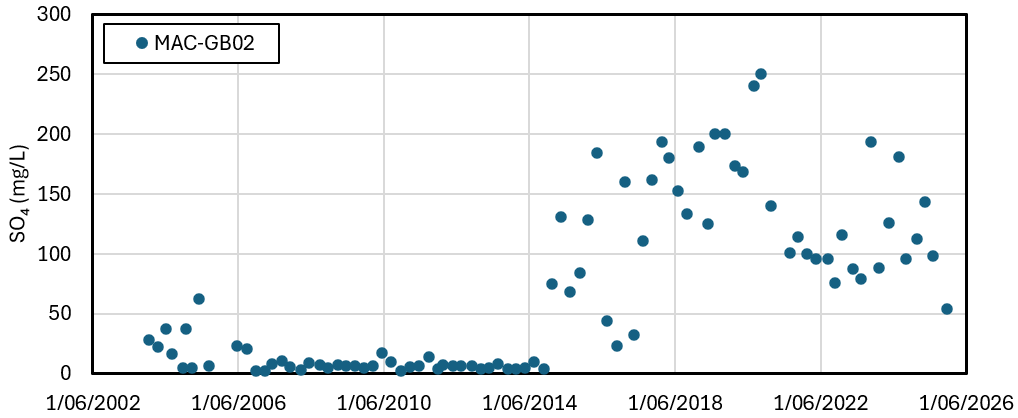

Figure 32: Time-series of SO_4 at surface water monitoring site GB02.

Table 9: Statistical summary of surface water quality data for GB02 (2003-2014).

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
pH	pH units	44	7.35	7.5	7.94	6.6
EC	µS/cm	44	153	112	81	692
Total Alkalinity	mg/L as $CaCO_3$	44	49.8	32.5	4	229
Total Hardness	mg/L as $CaCO_3$	27	35.4	29	17	93
Cl	mg/L	44	9.64	9.25	4.4	15
SO_4	mg/L	44	10.73	6.45	2	62.6
NH_4-N	mg/L	10	0.0275	0.0125	0.005	0.16
NO_3-N	mg/L	4	0.0275	0.025	0.02	0.04
NO_x-N	mg/L	2	0.008	0.008	0.005	0.011
NO_2-N	mg/L	1	0.002	0.002	0.002	0.002
Ca	mg/L	44	16.7	8.15	3.7	144
Mg	mg/L	44	4.86	2.95	1.9	26.8
Na	mg/L	44	9.20	8.5	7.6	16.7
K	mg/L	44	0.933	0.725	0.1	6.76
As	mg/L	44	0.029	0.0018	0.001	0.385
Cu	mg/L	10	0.0024	0.0010	0.0007	0.016
Fe	mg/L	43	0.438	0.18	0.02	6
Pb	mg/L	10	0.0004	0.0002	0.00005	0.001
Zn	mg/L	2	0.0024	0.0024	0.0005	0.0042

4.3.2 Natural Catchment Runoff at Coronation and Coronation North

Natural surface runoff within the CO and CN domains is characterised using monitoring data from the DC01 compliance monitoring site, located southeast of the Coronation Mining Area (Figure 33). Time-series plots for pH, EC, and SO_4 concentrations are presented in Figure 34 to Figure 36. A statistical summary of water quality during the pre-mining period (prior to 2014) is provided in Table 10.

Monitoring data collected from 2014 onwards indicate a progressive influence from mining activities. Therefore, the pre-2014 dataset was considered representative of undisturbed natural runoff conditions and was used to define baseline surface water quality for the CO/CN domain.

Key observations include:

- Surface runoff pH has remained stable, typically varying between 7.5 and 8.0.

- Prior to 2014, EC values were generally low, typically below 200 µS/cm. Since 2014, EC has exhibited greater variability and an overall increasing trend, with recent peak values exceeding 600 µS/cm. This increase is consistent with the commencement of Coronation WRS construction and the associated influence of mine-affected runoff.
- Sulfate concentrations exhibit a similar temporal trend to EC, increasing from less than 20 mg/L prior to 2014 to concentrations of up to 200 mg/L in recent years.

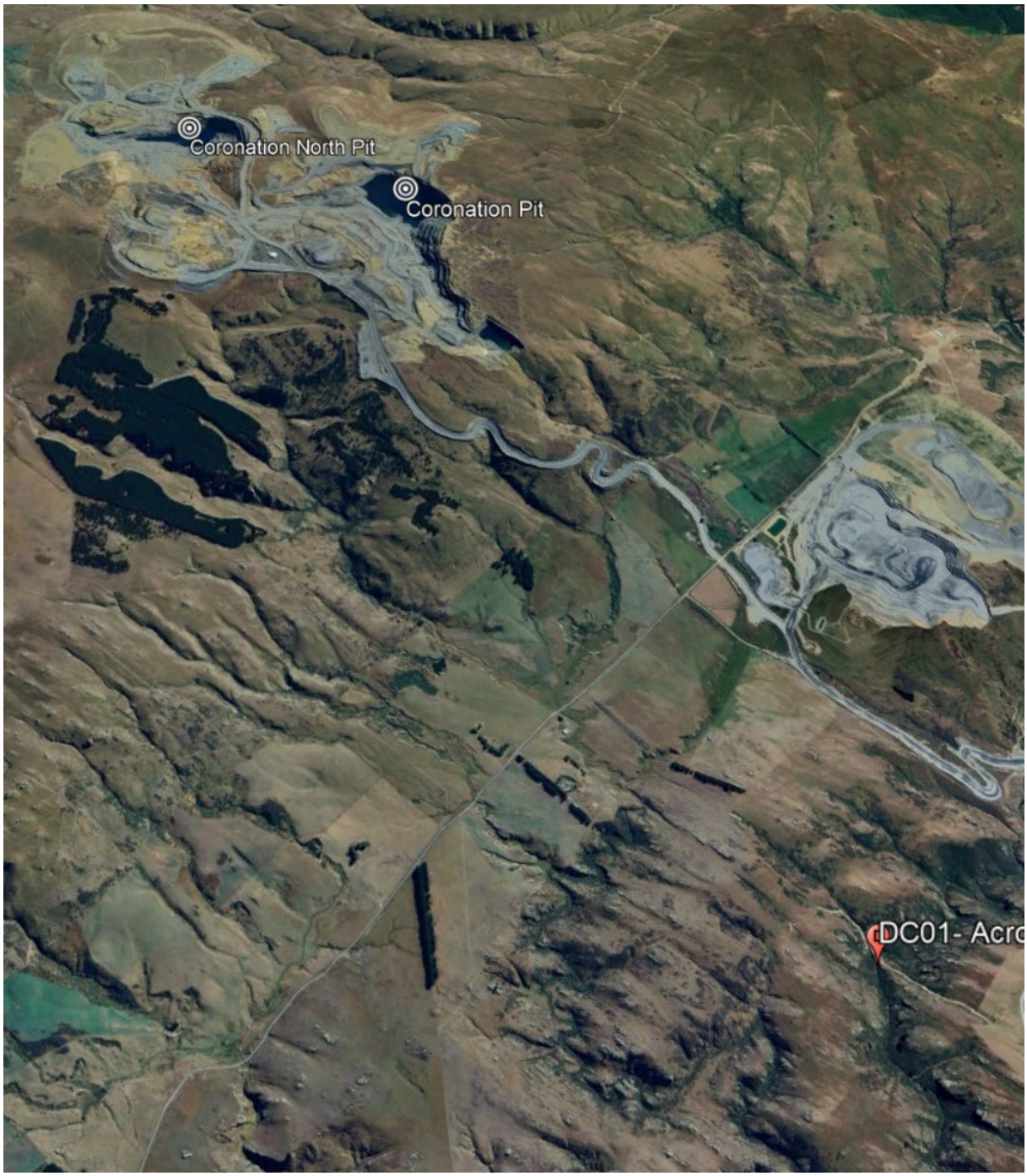

Figure 33: Location of surface runoff monitoring site DC01.

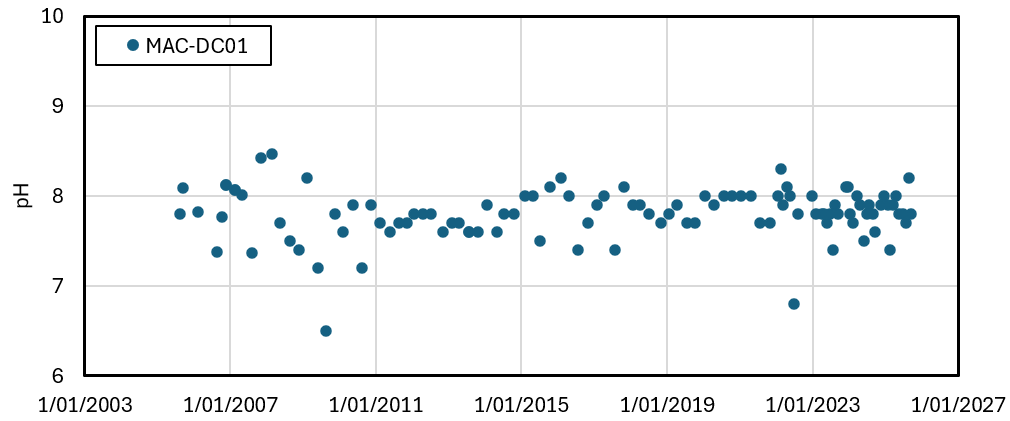

Figure 34: Time-series of pH at surface water monitoring site DC01.

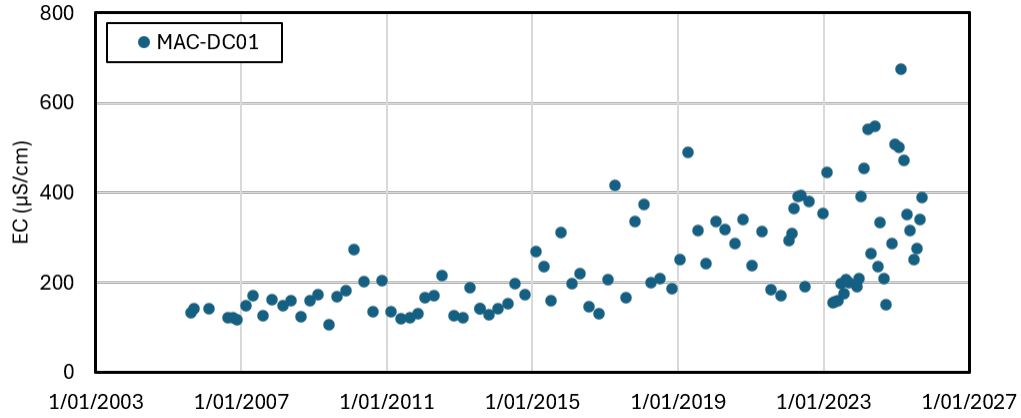

Figure 35: Time-series of EC at surface water monitoring site DC01.

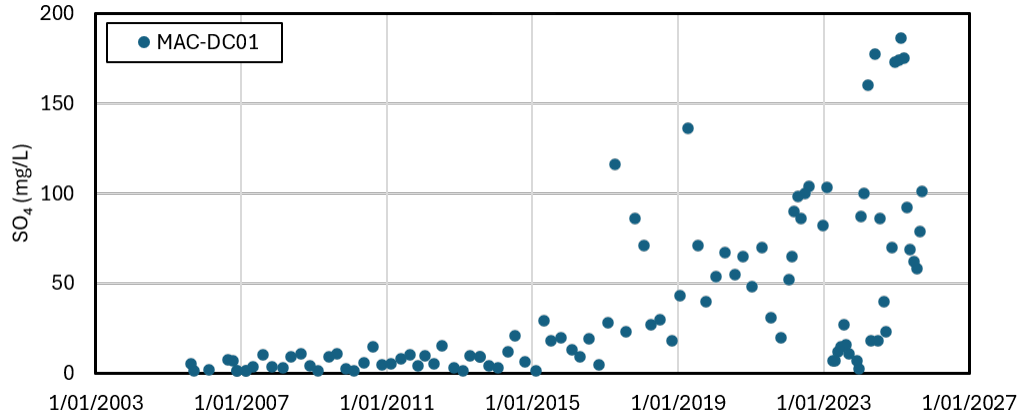

Figure 36: Time-series of SO_4 at surface water monitoring site DC01.

Table 10: Statistical summary of surface water quality data for DC01 (2005-2013).

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
pH	pH units	34	7.52	7.7	8.47	6.5
EC	µS/cm	34	153	142.5	107	273
Total Alkalinity	mg/L as $CaCO_3$	34	52.8	50	23	120
Total Hardness	mg/L as $CaCO_3$	23	52.1	51	32	81
Cl	mg/L	34	11.5	11	7.3	18
SO_4	mg/L	34	6.15	5.35	1.3	15.2

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
NH_4-N	mg/L	8	0.008	0.005	0.005	0.03
NO_3-N	mg/L	4	0.062	0.0175	0.001	0.21
NO_x-N	mg/L	1	0.21	0.21	0.21	0.21
NO_2-N	mg/L	2	0.0028	0.0028	0.0021	0.0034
Ca	mg/L	34	12.4	12.7	7.5	21
Mg	mg/L	34	4.53	4.4	3	7.1
Na	mg/L	34	11.7	10.85	9	21
K	mg/L	34	1.15	1.145	0.52	2.2
As	mg/L	30	0.0013	0.0011	0.0005	0.0025
Cu	mg/L	7	0.0007	0.00025	0.00025	0.0016
Fe	mg/L	34	0.237	0.22	0.08	0.58
Pb	mg/L	7	0.0001	0.00005	0.00005	0.0005
WAD CN	mg/L	7	0.0028	0.0005	0.0005	0.014

4.3.3 Natural Catchment Runoff at Innes Mills

Dedicated natural runoff monitoring sites have not been established within the IM domain. Consequently, regional background natural runoff water quality was characterised using the pre-2015 monitoring dataset from GB02 (Section 4.3.1).

This proxy dataset is considered representative of the IM domain due to the similar geological and hydrological settings of the two catchments. Furthermore, the pre-2015 GB02 dataset is consistent with long-term baseline surface water quality recorded at DC01 prior to mining influence (2005-2013).

4.3.4 Runoff from Rehabilitated Mine Land

The Deepdell South Silt Pond is located within the Deepdell Creek catchment and receives drainage from the Deepdell East WRS and the backfilled Deepdell Pit (Figure 37). The contributing catchment comprises approximately 50% rehabilitated mine land and 50% undisturbed natural terrain.

Water quality monitoring data from this site are considered representative of surface runoff from rehabilitated mine land. The geometry of the Deepdell South Pit backfill effectively isolates the pond from deeper WRS seepage, ensuring that the captured water reflects near-surface runoff processes.

Monitoring data collected since 2002 are summarised in Table 11, with time-series trends for pH, EC, and SO_4 presented in Figure 38 to Figure 40. Key observations include:

- Surface runoff is weakly alkaline, with pH typically ranging between 7.0 and 8.5.
- EC values generally fluctuate between 150 and 500 µS/cm, which is likely associated with meteoric dilution during wetter periods and first-flush processes, whereby salts accumulated within near-surface materials are mobilised at the onset of rainfall events.
- Sulfate concentrations range from 5 to 50 mg/L, with occasional concentrations approach 80 mg/L.
- A distinct "loading and flushing" cycle was observed between 2013 and 2016, during which SO_4 concentrations increased steadily before declining rapidly back to approximately 10 mg/L. A secondary, less pronounced increasing trend is evident from late 2021 to 2025, with recent SO_4 concentrations generally ranging between 20 and 40 mg/L.

Figure 37: Location of Deep Dell South Silt Pond.

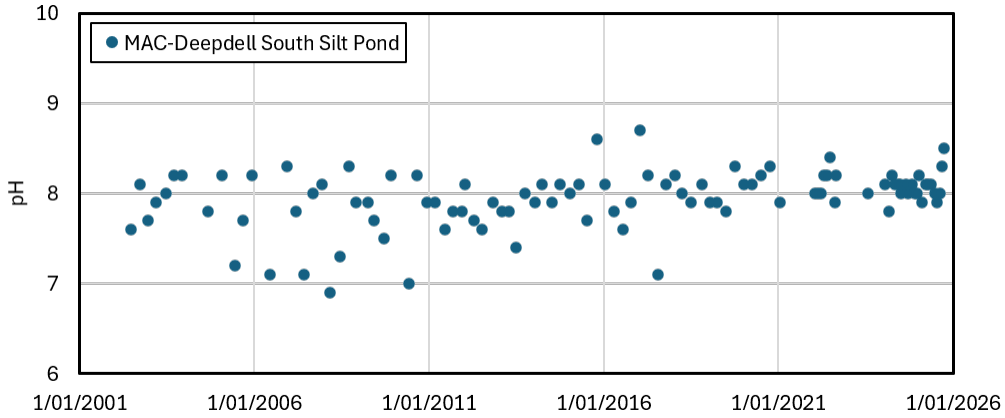

Figure 38: Time-series of pH at surface water monitoring site Deepdell South Silt Pond.

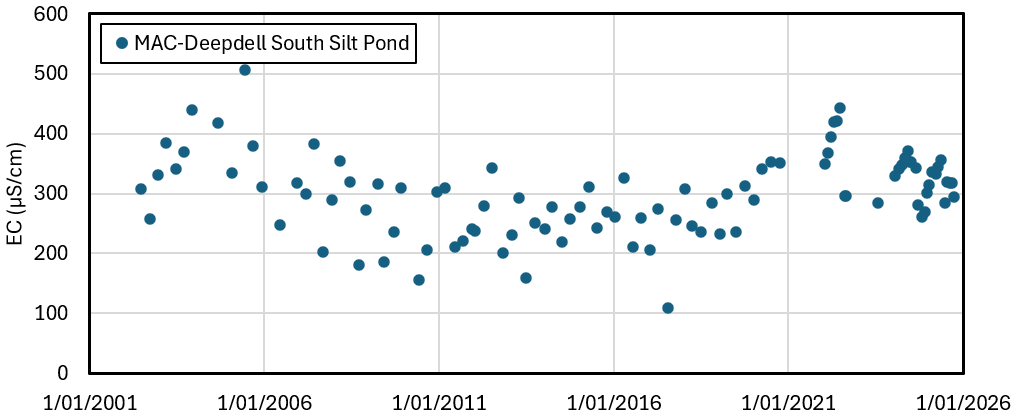

Figure 39: Time-series of EC at surface water monitoring site Deepdell South Silt Pond.

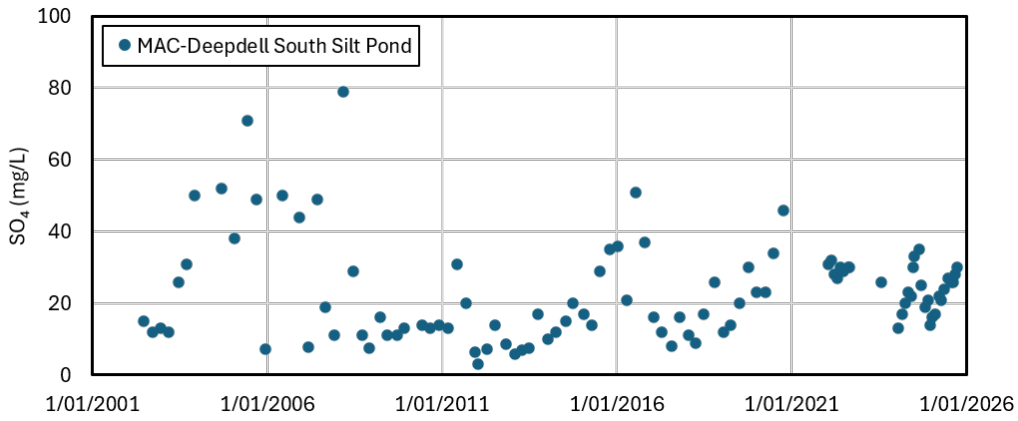

Figure 40: Time-series of SO_4 at surface water monitoring site Deepdell South Silt Pond.

Table 11: Statistical summary of surface water quality data for Deepdell South Silt Pond.

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
pH	pH units	100	7.8	8	8.7	6.9
EC	µS/cm	100	298	300.5	109	507
Total Alkalinity	mg/L as $CaCO_3$	100	119	119	28	230
Total Hardness	mg/L as $CaCO_3$	65	130	128	37	230
Cl	mg/L	100	8.08	8	2.5	18
SO_4	mg/L	100	23.0	20	3	79
NH_4-N	mg/L	56	0.0290	0.005	0.005	0.34
NO_3-N	mg/L	43	0.0719	0.001	0.001	0.73
NO_x-N	mg/L	56	0.0889	0.004	0.001	0.74
NO_2-N	mg/L	43	0.0039	0.001	0.001	0.033
Ca	mg/L	100	39.2	40	11	76
Mg	mg/L	100	8.03	7.9	2.4	17
Na	mg/L	100	12.1	12	5.8	22
K	mg/L	100	1.78	1.7	0.38	8.5
As	mg/L	56	0.00465	0.0039	0.0005	0.018
Cu	mg/L	45	0.00091	0.001	0.00025	0.0016
Fe	mg/L	57	0.2022	0.07	0.01	4.4
Pb	mg/L	44	0.00016	0.00005	0.00005	0.00085
Sb	mg/L	11	0.0004	0.0004	0.0002	0.0005
Hg	mg/L	3	0.00004	0.00004	0.00004	0.00004
Zn	mg/L	27	0.0013	0.0005	0.0005	0.006
As (total)	mg/L	13	0.0143	0.0079	0.0024	0.065
Cu (total)	mg/L	7	0.0020	0.0016	0.00027	0.0071
Fe (total)	mg/L	13	1.83	1.2	0.37	9.5
Pb (total)	mg/L	7	0.0012	0.00054	0.000055	0.0057
Sb (total)	mg/L	1	0.00057	0.00057	0.00057	0.00057
WAD CN	mg/L	12	0.00056	0.0005	0.0005	0.0012

Note: The statistical summary excludes the record for 19/1/2021, which is considered an anomaly.

4.3.5 Runoff from Unrehabilitated Mine Land

The overarching closure strategy for the Project is to ensure that the vast majority of mining-disturbed lands, including WRSs and other operational areas, is rehabilitated at closure. The only mining-

impacted features that will not be rehabilitated are those that will be permanently inundated by the post-closure pit lakes, including:

- Exposed pit walls
- In-pit waste rock backfills

As these unrehabilitated features will be submerged following closure, their geochemical contributions, including solute loads and nitrogenous blasting residues, will occur as internal pit lake inputs rather than as sources of surface runoff. Consequently, a review of runoff from unrehabilitated mine land was not undertaken, as these source terms are incorporated explicitly within the pit lake hydrogeochemical modelling framework.

4.4 Mine Water

4.4.1 Standing Pit Water

All four pits included in this hydrogeochemical modelling assessment currently contain standing pit water. The pit water will be fully discharged prior to commencement of the proposed pit extensions and therefore these waters will not impact the pit lake water quality that develops after mine closure. Consequently, the historical water quality of the existing pit waters was not considered in the development of post-closure pit lake source terms and was not reviewed as part of this assessment. (except for GB which is discussed in Section9.3).

4.4.2 WRS Seepage

WRS seepage is generated through the infiltration of rainfall into the waste rock landforms and the subsequent percolation of water through the stored material. Seepage quality has been monitored at various locations across the Macraes Operations. Historical seepage quality data for the WRSs relevant to MP4 were reviewed and used to develop estimates of post-closure WRS seepage quality for input to the hydrogeochemical modelling. A detailed review of the seepage monitoring dataset and the source-term derivation methodology is provided in MWM (2026a).

4.4.3 TTTSF Impoundment Water Quality

To characterise tailings-associated water quality, monitoring data from the TTTSF Impoundment (decant pond) were reviewed as an analogue for water in contact with deposited tailings. A statistical summary for this dataset (from 2018 onwards) is provided in Table 12, with the temporal evolution of key parameters presented in Figure 41 to Figure 43. The following observations are noted:

- During the early monitoring period (pre-2016), water pH exhibited significant variability, ranging from moderately acidic to circumneutral (pH 5.1 to 7.8). Since the second half of 2016, pH has stabilised at approximately pH 8.0. This shift coincides with an increase in total alkalinity from negligible levels to approximately 250 mg/L as $CaCO_3$, indicating enhanced buffering capacity.
- Prior to 2016, EC values consistently exceeded 6,000 µS/cm. Subsequently, EC generally fluctuated between 5,000 and 6,000 µS/cm. Recent data since 2025 indicate a further decline towards approximately 4,000 µS/cm, suggesting a gradual reduction in dissolved solid concentrations.

- Sulfate, the dominant anion in the water, exhibits a temporal trend similar to EC. Its concentrations have declined from early peaks exceeding 5,000 mg/L to a more recent range of 3,000 to 4,000 mg/L.
- The water is characterised by elevated N species, with median NO_3-N and ammoniacal N concentrations of approximately 12 to 13 mg/L.

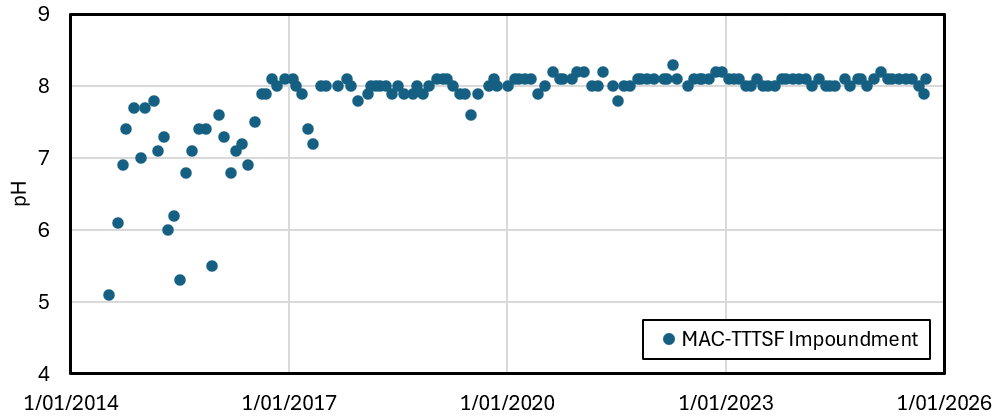

Figure 41: Time-series of pH at monitoring site TTTSF Impoundment.

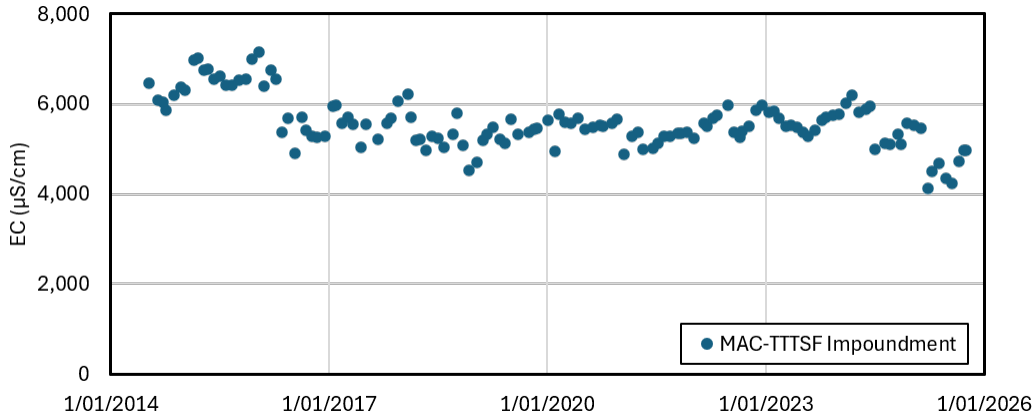

Figure 42: Time-series of EC at monitoring site TTTSF Impoundment.

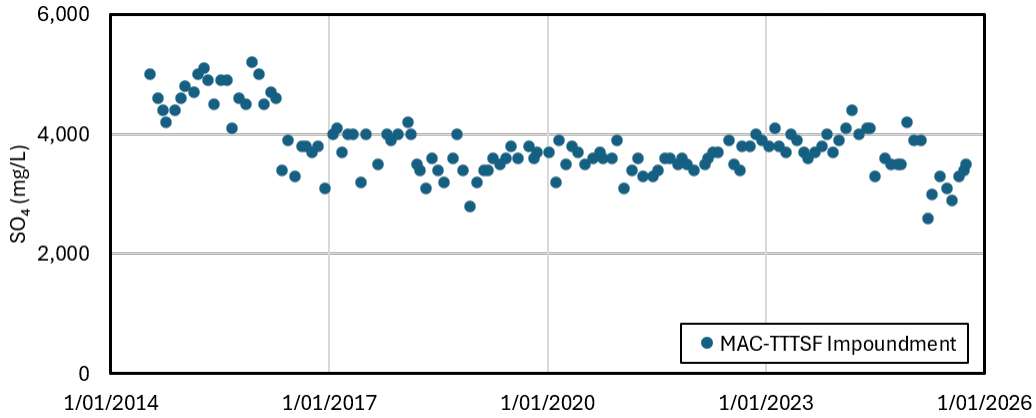

Figure 43: Time-series of SO_4 at monitoring site TTTSF Impoundment.

Table 12: Statistical summary of water quality data for TTTSF Impoundment decant pond (2018 onwards).

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN
pH	pH units	92	8.0	8.1
EC	µS/cm	92	5368	5390
Total Alkalinity	mg/L as $CaCO_3$	92	215	220
Total Hardness	mg/L as $CaCO_3$	92	2995	3000
Cl	mg/L	92	21.6	22
SO_4	mg/L	92	3610	3600
NH_4-N	mg/L	89	12.6	13
NO_3-N	mg/L	89	12.2	12
NO_x-N	mg/L	89	12.9	13
NO_2-N	mg/L	89	0.676	0.62
Ca	mg/L	92	631	640
Mg	mg/L	92	346	345
Na	mg/L	92	360	360
K	mg/L	92	94.0	95
Tl	mg/L	3	0.00015	0.00015
As (total)	mg/L	14	0.013	0.0125
Cu (total)	mg/L	92	0.1813	0.089
Fe (total)	mg/L	34	0.06	0.0265
Pb (total)	mg/L	92	2.9046	0.45
Sb (total)	mg/L	34	0.0021	0.00068
WAD CN	mg/L	92	0.0595	0.01
SCN	mg/L	91	2.51	1.6

Note: The statistical summary excludes a suspicious sample collected on 20 August 2024.

5 WATER QUALITY MODELLING APPROACH

5.1 Introduction

The water quality modelling approach for the four pits follows a consistent framework designed to simulate the long-term evolution of pit lake chemistry. This framework comprises the following key components:

- Conceptual site model (CSM) development: Defines the model boundaries, key components, and physical and chemical interactions between them.
- Water balance model (WBM) development: Quantifies the water fluxes into and out of the pit lake systems (developed by GHD).
- Source term derivation: Defines the chemical compositions of water inflows and the release of solutes from reactive materials (e.g., waste rock backfills).
- Model integration: Couples the physical water balance with the hydrogeochemical processes to generate long-term water quality predictions.

Details of each component are provided in the following sections.

5.2 Conceptual Site Model

A CSM was developed for each pit to provide a simplified representation of the physical and geochemical processes that are expected to influence pit lake water quality. The CSM is a critical precursor to numerical modelling, as it identifies and defines the following:

- Sources
    - Inflows: Identifies key water sources, including groundwater, surface runoff, direct rainfall precipitation, and seepage, and defines the initial water chemistry and flow rates (flux) for each inflow.
    - Reactive materials: Identifies the geological materials and mine wastes exposed within pit walls, backfill areas, and surrounding catchments that may contribute dissolved constituents to the pit lake.
- Pathways
    - Hydrological flow: Describes the overall water balance and hydraulic connections between the pit lake and surrounding environment.
    - Contaminant transport: Identifies the mechanisms by which dissolved constituents are transported from sources into the pit lake, and ultimately to downstream receiving environments.
- Processes
    - Geochemical reactions: Includes mineral dissolution and precipitation, acid neutralisation reactions, aqueous complexation, and sorption processes.

- Physical processes: Includes mixing, evapoconcentration, and potential pit lake stratification.

5.3 Water Balance Model

The WBM provides the quantitative basis for understanding water movement and storage within the system defined in the CSM. By applying the principle of mass conservation, the WBM accounts for all water fluxes, and changes in storage within the pit lake system. This is critical for predicting long-term water quality, as the water volumes and residence times directly influence the dilution, concentration, and transport of dissolved constituents.

The WBMs used in this assessment were developed by GHD (2026) using a daily timestep. To maintain computational efficiency for the hydrogeochemical assessment, daily outputs from the WBMs were aggregated and provided to MWM as annual average flow rates and annual changes in storage volume. These annualised outputs were then used to calculate year-to-year changes in pit lake water chemistry.

5.4 Source Terms

Source terms define the geochemical and physical characteristics of aqueous and loading inputs to the models. These inputs include the initial chemistry of various water inflows (e.g., groundwater, surface runoff, and seepage) and the mass release rates of solutes from reactive materials such as waste rock backfill. The methodology used to derive the source terms, together with the adopted source term concentrations, is presented in Section 6.

5.5 Hydrogeochemical Model Development

5.5.1 Introduction

The hydrogeochemical models were developed in accordance with the approach illustrated in Figure 44. The specific components and methodologies of this workflow are detailed in the following sections.

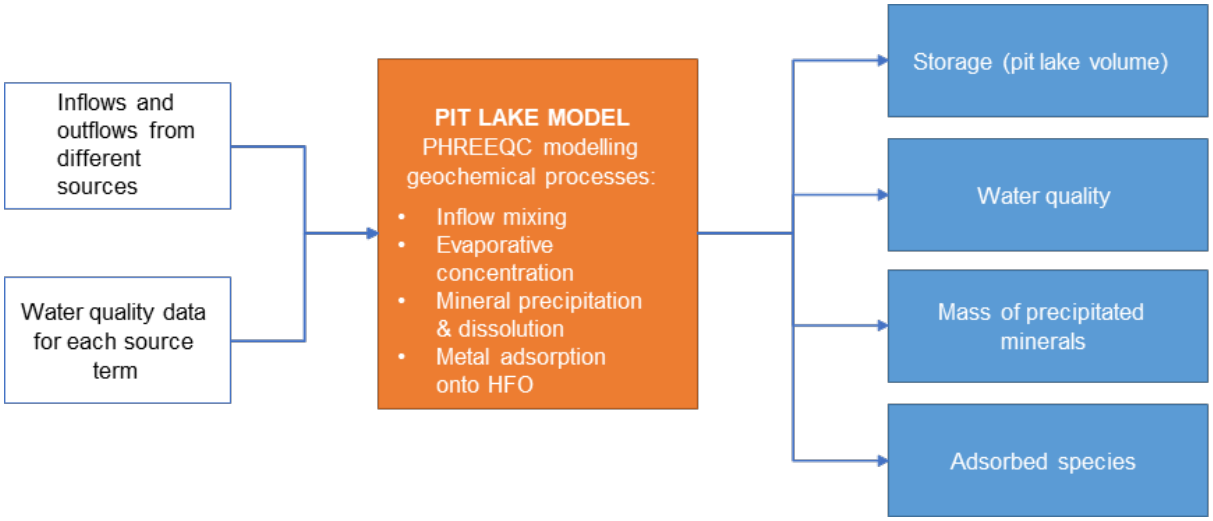

Figure 44: Process flow for the hydrogeochemical modelling.

5.5.2 Modelling Software and Computational Framework

Pit lake water quality simulations were conducted using PHREEQC (Parkhurst & Appelo, 2013) coupled with the WATEQ4F thermodynamic database (Ball & Nordstrom, 1991). PHREEQC is an industry-standard geochemical modelling code capable of simulating a diverse range of aqueous geochemical reactions in complex hydrogeological systems. Within mining and environmental applications, it is the primary tool for evaluating the long-term evolution of pit lake water quality, waste rock seepage, and tailings water interactions. When combined with site-specific source term inputs, PHREEQC calculates aqueous speciation, mineral saturation indices, precipitation and dissolution reactions, gas exchanges, and surface complexation processes, thereby quantifying key controls on constituent mobility and attenuation.

The modelling workflow was implemented within a Python[2] based computational framework. This integration facilitates an automated environment to manage the high-volume data inputs required for PHREEQC simulations, execute parallelised calculation runs, and parse extensive output files for time-series analysis. This approach ensures the efficiency, reproducibility, and scalability of the predictive results.

5.5.3 Modelling Period

The modelling period defines the temporal boundaries for the simulations. Each pit domain was simulated for a specified duration (200 years for the pit lakes proposed in MP4), with the water quality and water balance models sharing identical temporal resolution and simulation timeframes to ensure mass-balance consistency and data alignment.

5.5.4 Geochemical and Physical Processes

The predictive modelling applied a reactive transport approach to simulate the following geochemical and physical processes:

- Mixing and aqueous speciation: Simulates the mixing of different source water inputs and the resulting chemical interactions between dissolved constituents, explicitly calculating aqueous speciation, electrical charge balance, pH, and alkalinity.
- Evaporative concentration (evapoconcentration): Accounts for increasing solute concentrations resulting from net evaporative water loss from the pit lake surface.
- Atmospheric gas exchange: Maintains equilibrium with atmospheric O_2 and CO_2, which influences water pH, alkalinity, carbonate equilibria, and redox conditions.
- Mineral equilibrium: Calculates mineral saturation indices (SI) and determines the potential for mineral phases to dissolve or precipitate. This provides fundamental solubility controls for major ions and regulates the dissolved concentrations of minor and trace elements.
- Surface complexation and adsorption: Simulates the attenuation of trace metals and metalloids by surface complexation (e.g., adsorption) with ferrihydrite, where present.
- Nitrate attenuation: Accounts for reductions in nitrate concentrations through abiotic and biologically mediated denitrification pathways.

[2] *Python (version 3.12) is the programming language utilised for data processing and simulation automation.*

5.5.5 Mineral Assemblage

The mineral and gaseous phases included in the equilibrium calculation are summarised in Table 13. The selection of these phases was based on the following geochemical and thermodynamic considerations:

- Source term constraints: Mineral phases are only included if their constituent elements are present within the source term chemistry.
- Kinetic viability: The selection prioritises phases that are likely to precipitate or dissolve within the 200-year modelling period. Phases that typically form over geological timescales (e.g., highly crystalline silicates) are excluded in favour of more reactive or amorphous secondary phases (e.g., ferrihydrite, gypsum).
- Geochemical characterisation: The mineral assemblage is informed by site-specific mineralogical data to ensure it reflects the secondary minerals likely to form under the predicted pH-redox conditions.
- Primary phase controls: Key minerals identified in the mine waste that are likely to exert significant control on pore water or pit lake chemistry over time.

Table 13: Mineral assemblage for hydrogeochemical modelling.

PHASE	FORMULA	PHASE	FORMULA
Calcite	$CaCO_3$	Gypsum	$CaSO_4 \cdot 2H_2O$
Hydromagnesite	$Mg_5(CO_3)_4(OH)_2:4H_2O$	Quartz	SiO_2
$Fe(OH)_3$ (a)	$Fe(OH)_3$	Malachite	$Cu_2(CO_3)(OH)_2$
Smithsonite	$ZnCO_3$	O_2(g)	O_2
CO_2(g)	CO_2		

5.6 Model Integration

The final hydrogeochemical model integrates hydrological fluxes with the hydrogeochemical reaction implemented in PHREEQC. Within the Python-based computational environment, annual water balance outputs are coupled with site-specific source term chemistry to calculate evolving mass balance at each timestep.

This approach ensures that predicted water quality reflects both physical processes, including dilution and evapoconcentration, and geochemical processes, including aqueous speciation, mineral equilibrium, gas exchange, and constituent attenuation. By linking hydrological drivers directly with geochemical reaction pathways, the simulation provides a technically rigorous prediction of the long-term chemical evolution of the pit lake water quality.

5.7 General Assumptions and Limitations

The following assumptions and limitations apply to the hydrogeochemical modelling. Any site-specific assumptions, constraints, or deviations are described in the respective modelling memoranda.

- Lake Stratification: The models assume a fully mixed (holomictic) water column throughout the simulation period. This assumption is supported by pit lake morphometry and regional climatic conditions, which indicate a low likelihood of persistent density stratification (meromixis)

(Section 3). Consequently, the pit lakes are assumed to maintain equilibrium with atmospheric O_2 and CO_2 throughout out the modelling period.

- Redox Conditions: In the absence of site-specific redox measurements, a pE[3] value of 10 is applied to all source waters and equilibrium calculations. This value represents an oxidising environment consistent with atmospheric equilibrium.
- Temperature: Based on the site temperatures measured in the GB Pit Lake (Section 3.3.3), which ranged from 7ºC to 13ºC, a constant water temperature of 10ºC is applied to all inflows and pit lake waters. This temperature is used to calculate temperature-dependent equilibrium constants in PHREEQC.
- Iron Speciation: Consistent with the *pE* and holomictic assumptions, total Fe in the source terms is modelled as ferric iron (Fe^{3+}) upon entering the pit lake. While certain inflows (e.g., groundwater) may naturally enter with elevated reduced ferrous iron (Fe^{2+}), rapid oxidation to Fe^{3+} is assumed upon discharge into the oxic, well-mixed pit lake environment. This ensures that the primary redox-sensitive master variables are synchronised across the physical and chemical components of the model.
- Metal Attenuation: The assumed oxic pit lake environment promotes the formation of secondary Fe(III) oxyhydroxides, providing reactive surfaces for metal and metalloid attenuation via surface complexation (adsorption). While localised O_2 depletion may occur at depth, the adopted "oxic endmember" assumption provides a transparent and reproducible basis for long-term modelling.
- Blasting Residues: An initial N load of 5.35 g/m^2, representing residual ANFO[4] from blasting activities, is simulated as a staged release of NH_4NO_3 over the first four years of pit filling (MWM, 2025). The initial load and release period were estimated by dividing the total residual N mass released to the GB Pit Lake by the pit footprint area over the time period.
- Nitrate Attenuation: A nitrogen decay rate of 20% to 25% per annum is applied to nitrate concentrations. This bulk reduction accounts for biologically mediated denitrification and other attenuation processes typically observed in the Golden Bar Pit Lake (MWM, 2025).

[3] *pE is the negative logarithm of electron activity (pE = -log[e$^-$]). It serves as a master variable for redox status, analogous to pH for acidity.*

[4] *Ammonium nitrate fuel oil.*

6 SOURCE TERM DERIVATION

6.1 Introduction

Table 14 provides an overview of the inflows incorporated into the hydrogeochemical models for each pit. For each inflow, a corresponding source term was derived using site monitoring data, analogue datasets, or dedicated investigations. The source-term derivation is presented in the following sections.

Inter-pit transfers (an outflow from one pit subsequently becomes an inflow to another pit) are excluded from Table 14 as their water quality is determined dynamically by the hydrogeochemical models rather than by predefined source-term inputs.

Table 14: Summary of source terms derived for pit inflows.

SOURCE TERM	GOLDEN BAR	CORONATION	CORONATION NORTH	INNES MILLS
Rainfall water	Nichol et al. (1997)			
Background Groundwater	Yes	Yes	N/A	Yes
Runoff – pit wall	GB Analogue Model (MWM, 2025)			
Runoff – natural catchment	Yes	Yes	N/A	N/A
Runoff – rehab area (incl. WRS)	Monitoring data: Deepdell South Silt Pond			
Seepage – WRS	GB WRS	TR WRS	TR and CO WRS	N/A
Seepage – backfill	No	COBF	CNBF	IMBF
Solute released from submerged backfill	No	IBC[5] Field Trial (MWM, 2026c)	IBC Field Trial (MWM, 2026c)	IBC Field Trial (MWM, 2026c)

Note: N/A denotes not applicable.

6.2 Rainfall

The rainfall source term is based on the Lauder research station dataset (Nichol et al., 1997), collected between 1983 and 1994. This station is located approximately 70 km northeast of the Macraes Operation at an elevation of 317 mRL. As the most representative regional record available, this source term is applied to all direct precipitation inflows across the pit domains for modelling (Table 15).

Table 15: Chemical composition of the rainfall source term.

PARAMETER	UNIT	VALUE
pH	pH units	5.2
Total Alkalinity	mg/L as $CaCO_3$	0.81
Ca	mg/L	0.11
Mg	mg/L	0.05
Na	mg/L	0.32
K	mg/L	0.09
SO_4	mg/L	0.18
Cl	mg/L	0.6
NO_3-N	mg/L	0.0045

Source: Nichol et al. (1997).

[5] *Intermediate bulk container.*

6.3 Groundwater

Groundwater source terms were developed to account for spatial variability in hydrogeochemistry across the Project area. Distinct groundwater chemistries were established for each pit domain based on statistical evaluation of representative monitoring bores, as summarised in Table 16.

- Golden Bar: The groundwater source term for GB was derived by averaging the median values from RCH3004, RCH2775, and RCH2585. To account for temporal variations observed at RCH2585, the dataset was divided into two discrete periods (2003-2005 and 2025), with both periods weighted equally in the final source term derivation.
- Coronation and Coronation North: A common groundwater source term was developed for these two domains by averaging the statistical medians from CP01, CP02, and CP04 over the 2014-2025 monitoring period. This approach integrates the elevated salinity and alkalinity observed at the shallow CP04 with the deeper regional groundwater conditions characterised by CP01 and CP02.
- Innes Mills: Hydrogeological modelling indicates that groundwater inflows into the IM domain comprises two distinct components: “natural” groundwater through the schist aquifer and seepage originating from the FTSF. The schist groundwater source term was derived from the average of the medians of the SPMW3 and SPMW4 datasets, which are affected by mine impacted water. The FTSF seepage source term was derived from monitoring data collected at the TTTSF Impoundment from 2018 onwards.

Table 16: Source terms for groundwater.

PIT DOMAIN		GB	CO & CN	IM	
MONITORING SITE		RCH2775, RCH2585, RCH3004	CP01, CP02, CP04	SPMW3, SPMW4	TTTSF IMPOUNDMENT
SAMPLE COUNT		99	75	227	92
PARAMETER	UNIT	MEDIAN	MEDIAN	MEDIAN	MEDIAN
pH	pH units	6.65	7.3	7.4	8.1
Total Alkalinity	mg/L as $CaCO_3$	95.8	108	275	220
Ca	mg/L	22.4	26.5	234	640
Mg	mg/L	11.1	8.9	33.9	345
Na	mg/L	10.9	9.8	20.5	360
K	mg/L	1.06	1.31	2.25	95
SO_4	mg/L	14.3	7.8	515	3,600
Cl	mg/L	10.2	6.3	8.5	22
NO_3-N	mg/L	0.544	0.1132	0.01975	12
NH_4-N	mg/L	0.0075	0.0107	0.0225	13
As	mg/L	0.0016	0.0011	0.0114	0.0125#
Cu	mg/L	0.0043	0.00025	0.000625	0.089#
Fe	mg/L	1.476	0.883	1.835	0.0265#
Pb	mg/L	0.00465	0.00008	0.00022	0.45#
Sb	mg/L	0.0005	-	-	0.00068#
Zn	mg/L	0.0213	0.01375	0.0041	-
WAD CN	mg/L	0.005	-	0.0015	0.01

Note: Sample counts and dissolved Cu concentrations for CO & CN are derived from the CP04 dataset (Cu was excluded from the CP02 analytical suite). pH values represent the arithmetic mean of CP02 & CP04. # denotes total concentrations.

6.4 Runoff

6.4.1 Runoff from Natural Catchments

Source terms for natural catchment runoff were derived from surface water monitoring locations considered representative of baseline conditions and unaffected by mining activities during the selected monitoring periods. To ensure source terms reflect pre-impact water quality, median values from GB02 (pre-2015) and DC01 (pre-2015) were adopted to characterise natural runoff for the GB and CO domains, respectively. The source term values are summarised in Table 17.

Table 17: Source terms for natural catchment runoff.

PIT DOMAIN		GB	CO
MONITORING SITE		GB02 (PRE-2015)	DC01 (PRE-2015)
SAMPLE COUNT		44	34
PARAMETER	UNIT	MEDIAN	MEDIAN
pH	pH units	7.5	7.7
Total Alkalinity	mg/L as $CaCO_3$	32.5	50
Ca	mg/L	8.15	12.7
Mg	mg/L	2.95	4.4
Na	mg/L	8.5	10.9
K	mg/L	0.725	1.15
SO_4	mg/L	6.45	5.35
Cl	mg/L	9.25	11
NO_3-N	mg/L	0.025	0.0175
NH_4-N	mg/L	0.0125	0.005
As	mg/L	0.00175	0.0011
Cu	mg/L	0.00095	0.00025
Fe	mg/L	0.18	0.22
Pb	mg/L	0.0002	0.00005
Sb	mg/L	-	-
Zn	mg/L	0.00235	-
WAD CN	mg/L	-	0.0005

6.4.2 Runoff from Pit Walls

This source term represents meteoric runoff interacting with exposed pit wall surfaces and other unrehabilitated rock surfaces within the pit. It was derived via inverse mass-balance calibration of an empirical analogue model based on observed water quality in the GB Pit Lake (MWM, 2025). The calibration process ensured that modelled solute flux were consistent with the observed rates of constituent accumulation within the lake. The following is noted for the analogue model development:

- Water quality monitoring data from 2013 to 2022 were used. During this period, the pit lake chemistry was relatively stable with pH generally ranging between 8.2 and 8.5.
- Water balance modelling indicates that surface runoff contributes 62% of total inflows, with direct rainfall (36%) and groundwater (2%) making up the remainder. However, geochemical mass balancing indicates that pit wall runoff generates over 95% of the total constituent load.
- The GB Pit Lake contains approximately 160,000 m^3 of historical waste rock backfill. To ensure a conservative pit wall source term, solute loads from the submerged backfill were not modelled separately and were instead allocated entirely to the pit wall runoff source term.

Nitrogen is non-conservative and decays over time via microbially mediated nitrification and denitrification. To simulate the initial "flushing" of ANFO blasting residues, a specific load of 5.35 g/m^2 of N as NH_4NO_3 was applied to the exposed pit wall surface area (MWM, 2025).

PHREEQC modelling accounted for thermodynamic controls, including the precipitation of secondary minerals (e.g., calcite) and the adsorption of trace metals onto ferrihydrite to simulate natural attenuation.

The source terms derived via the GB Analogue Model are assumed to be representative of all pit walls and unrehabilitated in-pit waste rock across the MP4 Project scope for the following reasons:

- The GB Pit Lake serves as a valid analogue due to the similar geology and lithology across the Macraes Operation area.
- The model relies on long-term observed data rather than theoretical values.
- Pit walls account for 95% to 98% of the incoming constituent mass, while other hydrologic inputs (groundwater, rainfall, and catchment runoff) exert a negligible chemical control on constituent concentrations.

The calibrated pit wall runoff source term is summarised in Table 18. It is noted that this source term is conservative considering it includes a significant backfill component, flushing of fresh surfaces, and no solute decay over time.

Table 18: Source terms for pit wall runoff and runoff from unrehabilitated areas.

PARAMETER	UNIT	VALUE
pH	pH units	8.4
Total Alkalinity	mg/L as $CaCO_3$	573
Ca	mg/L	190
Mg	mg/L	186
Na	mg/L	32.4
K	mg/L	11.2
SO_4	mg/L	719
Cl	mg/L	15.6
NO_3-N	mg/L	0.019
Amm-N	mg/L	0.038
As	mg/L	0.409
Cu	mg/L	0.001
Fe	mg/L	0.065
Pb	mg/L	0.0003
Sb	mg/L	0.008
Zn	mg/L	0.008

Source: MWM (2025).

6.4.3 Runoff from Rehabilitated Areas

As introduced in Section 4.3.4, the Deepdell South Silt Pond is considered a representative field analogue for characterising surface runoff from rehabilitated land. The geochemical source term for this runoff was derived from the statistical median values of the historical monitoring dataset collected at this location, as summarised in Table 19.

Table 19: Source terms for runoff from rehabilitated mine land (incl. WRS).

MONITORING SITE		DEEPDELL SOUTH SILT POND
PARAMETER	UNIT	MEDIAN
pH	pH units	8.0
Total Alkalinity	mg/L as $CaCO_3$	119
Ca	mg/L	40
Mg	mg/L	7.9
Na	mg/L	12
K	mg/L	1.7
SO_4	mg/L	20
Cl	mg/L	8
NO_3-N	mg/L	0.001
NH_4-N	mg/L	0.005
As	mg/L	0.0039
Cu	mg/L	0.001
Fe	mg/L	0.07
Pb	mg/L	0.00005
Sb	mg/L	0.0004
Zn	mg/L	0.0005
WAD CN	mg/L	0.0005

6.5 Seepage

6.5.1 Seepage from WRS

Source terms for WRS seepage were derived using empirical relationships linking seepage SO_4 concentrations to average WRS heights, alongside associated hydrochemical parameters. The detailed development of these empirical correlations is documented in MWM (2026a). A summary of the predictive framework, calculation steps, and resulting WRS seepage source terms is presented below.

6.5.1.1 Technical Rationale

Building on previous findings that WRS height correlates directly with seepage SO_4 concentrations (Babbage, 2022) and the identification of mature WRS that are geochemically "stabilised" (MWM, 2023), Navarro-Valdivia et al. (2024) established a predictive framework for post-closure WRS seepage quality. Key aspects of this framework include:

- Establishing a direct linear relationship between average WRS height and maximum historical SO_4 concentrations using a long-term monitoring database spanning six distinct WRS sub-catchments.
- Applying this height-concentration relationship to the final consented WRS topographic design to predict peak post-closure SO_4 concentrations.
- Utilising the predicted SO_4 concentrations as an index parameter to estimate other long-term solute concentrations via established empirical correlations.

6.5.1.2 Methodology and Procedure

To determine the site-specific post-closure WRS seepage source terms for the pit lake modelling, the following procedure was followed:

- Reviewed historical seepage data to identify the maximum SO_4 concentrations for each primary WRS sub-catchment.
- Analysed topography and GIS datasets to determine current and ultimate WRS footprints, configurations, and volumes, which were used to calculate the average WRS heights (MWM, 2026h).
- Established the linear relationship between maximum SO_4 and average WRS height to calculate long-term, post-closure SO_4 concentrations using Equation 1:

  Equation 1: $$[SO_4\ (mg/L)]max = 87 \times \text{Average WRS height (m)}$$

- Derived secondary water quality parameters based on the strength of their statistical correlation with SO_4:
  - Correlated parameters (R^2 >0.5): Estimated using the site-specific linear regressions (y = ax + b, where a is the slope and b is the intercept).
  - Independent parameters (R^2 ≤0.5): Defined using the statistical median of the historical dataset during the identified quasi-stable geochemical period.

This methodology accounts for the unique geometries, source material variations, and construction methods across different sampling locations, providing a domain-specific source term input for the pit lake models.

6.5.1.3 WRS Seepage Source Terms

The observed maximum SO_4 concentrations from historical monitoring data and the average WRS heights are provided in Table 20.

Table 20: Summary of updated average WRS height, observed and predicted SO_4 concentrations.

WRS	CURRENT AVERAGE HEIGHT (SUB-CATCHMENT) (m)	MAXIMUM OBSERVED SO_4 CONCENTRATION (mg/L)	FINAL AVERAGE HEIGHT (SUB-CATCHMENT) (m)	PREDICTED POST-CLOSURE SO_4 CONCENTRATION (mg/L)
Golden Bar	29.9	2,400	51.5	4,481
Coronation	35.7	2,100	42.6	3,706
Coronation North	34.8	1,520	69.9	6,081
Trimbells	33.3	1,470	48.2	4,193
Frasers West	52.1	3,600	70.4	6,125

The estimated WRS seepage quality, including SO_4 and other primary parameters, is summarised in Table 21. These values serve as the source term inputs for the pit lake water quality modelling.

Table 21: Summary of predicted WRS seepage source terms at closure.

PARAMETER	UNIT	GB	CO	CN	TR	FW
pH	pH units	6.9	7.1	7.6	6.8	8.2
Total Alkalinity	mg/L as $CaCO_3$	267	36	891	411	1,035
Ca	mg/L	586	597	1,281	1,081	198

PARAMETER	UNIT	GB	CO	CN	TR	FW
Mg	mg/L	725	457	892	396	1,523
Na	mg/L	101	61.9	204	85.8	106
K	mg/L	13.1	10.6	14.4	24.7	31.1
SO_4	mg/L	4,481	3,706	6,081	4,193	6,125
Cl	mg/L	11	8	12	6	11
NO_x	mg/L	8.05	1.1	50.7	40.6	14
Amm-N	mg/L	0.005	0.245	0.017	0.92	0.05
As	mg/L	0.001	0.0005	0.00075	0.0005	0.003
Cu	mg/L	0.0011	0.0005	0.0006	0.1347	0.0015
Fe	mg/L	0.02	0.05	0.05	0.19	0.02
Pb	mg/L	0.0001	0.000075	0.00005	0.00005	0.00025
Zn	mg/L	0.049	0.36	0.0028	0.36	-

6.5.2 Seepage from Backfill

The derivation of source terms for backfill seepage adopted the empirical SO_4-height relationship established for WRS (Section 6.5.1). However, because the thickness of unsaturated backfill is a dynamic, time-variant parameter regulated by the recovering pit lake water level, an empirical capping framework was introduced to constrain long-term concentrations values.

6.5.2.1 Technical Rationale

Unsaturated backfill located above the recovering pit lake level generates seepage through rainfall infiltration. Once the rising pit lake submerges the material, seepage ceases. Consequently, the volume of unsaturated waste rock available to contribute to top-down seepage decreases over time as the pit lake fills. These physical processes have been incorporated into the model.

Babbage (2022) developed a relationship (Equation 2) to predict SO_4 concentrations as a function of WRS age and average height (volume / area).

Equation 2: $\text{Median } SO_4(\text{mg/L}) = 96.1 + 1.22 \times \text{Average Height (m)} \times (4 \times \text{Age1(year)} + \text{Age2(year)})$

Where Age1 is the duration the WRS remains in full operation (not capped) and Age2 is the duration the WRS is under partial operation (partially capped).

While this linear model effectively captures early-stage kinetic leaching, it lacks a limit or concentrations ceiling. Applying this function to long-term period (e.g., 100 years) will yield anomalously high solute concentrations, which are unrealistic and unsupported by historical site monitoring data.

To determine the maximum concentration of solutes, a site-specific empirical concentration cap is established, which correlates the maximum SO_4 concentration to the remaining unsaturated thickness of the backfill. The minimum value between Equation 1 and Equation 2 is used as the input SO_4 concentration. Secondary solute concentrations are subsequently calculated via the established empirical correlation relative to the SO_4 concentration (Section 6.5.1).

As the pit lake level recovers, the backfill material becomes progressively saturated from the base upward. This dynamic process results in the following:

- Increasing concentrations of solutes at the beginning of the model, when concentrations are governed by Equation 2 (below the cap).

- Peak concentrations: The peak concentration results from the intersection between Equation 1 (increasing trend) and Equation 2 (decreasing cap).
- Declining unsaturated thickness: The "effective height", defined as the vertical distance between the backfill surface and the rising pit lake level, decreases the cap concentration over time as the level rises
- Saturated Material: Once backfill material becomes permanently submerged, it ceases to contribute to vertical seepage. Solute release from this saturated material is instead governed by submerged loading rates (detailed in Section 6.5.3).

6.5.2.2 Methodology and Procedure

Because the backfill source terms are coupled to the fluctuating water table, they are calculated dynamically within the Python-based hydrogeochemical model at each time step using the following procedure:

- Iterative height tracking: At each annual time step, the model calculates the current thickness of unsaturated backfill by subtracting the predicted pit lake elevation from the backfill surface elevation.
- Dynamic source term update: The empirical SO_4-height relationship derived for the WRS (Equation 1) is applied to the updated unsaturated backfill thickness. Subsequent parameter values are determined using specific correlations relative to SO_4 at each iteration. This ensures that as the "effective height" of the backfill decreases, the seepage concentrations are adjusted proportionally.
- PHREEQC integration: These time-variant source terms are fed directly into the PHREEQC model to simulate the evolving equilibrium chemistry at the backfill seepage for adding solubility controls and speciation which then feeds into the general PHREEQC pit lake model.

6.5.2.3 Backfill Seepage Source Terms

The evolution of SO_4 concentrations from the backfill seepage governed by Equation 1 and Equation 2 is shown in Figure 45, and the peak values for all parameters are provided in Table 22.

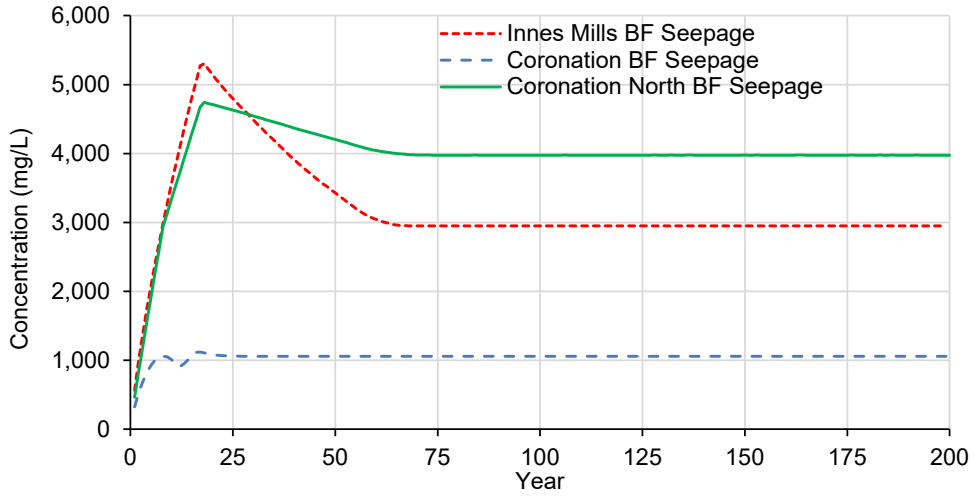

Figure 45: Estimated sulfate concentration for backfill seepage.

Table 22: Predicted peak values for backfill seepage.

PARAMETER	UNIT	COBF	CNBF	IMBF
pH	pH units	7.1	7.6	7.9
Total Alkalinity	mg/L as $CaCO_3$	36	137	517
Ca	mg/L	205	479	30
Mg	mg/L	141	895	1,316
Na	mg/L	28.6	205	94
K	mg/L	8.8	14.6	28
SO_4	mg/L	1,123	4,789	5,306
Cl	mg/L	8	12	11
NOx	mg/L	1.1	7.5	14
Amm-N	mg/L	0.19	0.013	0.039
As	mg/L	0.0005	0.00075	0.003
Cu	mg/L	0.0005	0.0006	0.0015
Fe	mg/L	0.05	0.05	0.02
Pb	mg/L	0.0008	0.00005	0.00025
Zn	mg/L	0.36	0.0028	0.025

6.5.3 Frasers TSF Seepage

FTSF seepage is expected to enter the IM Pit Lake as a component of the groundwater inflow. The source terms for the FTSF seepage were derived from the TTTSF impoundment (decant pond) data and are summarised in Table 23.

Table 23: Source terms for FTSF seepage.

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN
pH	pH units	92	8.0	8.1
Total Alkalinity	mg/L as $CaCO_3$	92	215	220
Ca	mg/L	92	631	640
Mg	mg/L	92	346	345
Na	mg/L	92	360	360
K	mg/L	92	94.0	95
SO_4	mg/L	92	3,610	3,600
Cl	mg/L	92	21.6	22
NO_3-N	mg/L	89	12.2	12
NH_4-N	mg/L	89	12.6	13
As (total)	mg/L	14	0.013	0.0125
Cu (total)	mg/L	92	0.1813	0.089
Fe (total)	mg/L	34	0.06	0.0265
Pb (total)	mg/L	92	2.9046	0.45
Sb (total)	mg/L	34	0.0021	0.00068
WAD CN	mg/L	92	0.0595	0.01
SCN	mg/L	91	2.51	1.6

Note: Concentrations for As, Cu, Fe, Pb, Sb represent total analytical fractions.

6.6 Load Released from Submerged Waste Rock

As pit lake water levels rise and inundate backfilled waste rock, solutes are released from the material. The release rates, expressed as a specific mass load (mg/kg), were derived from the IBC field trial assessment results (MWM, 2026c). This is provided as Appendix A.

6.6.1 Technical Background

Saturated field leach trials (MWM, 2026c) were conducted using IBCs to quantify the solute load released from submerged waste rock backfill within the proposed MP4 pit lakes. This approach accounts for the "saturated material" described in Section 6.5.2, where material moves from the unsaturated seepage zone to the saturated pit lake environment.

Conventionally, source terms for submerged backfill are derived using laboratory tests, such as shake flask extractions on crushed samples. However, laboratory methods often overestimate solute release because the high reactive surface areas of crushed samples do not reflect actual field conditions or the particle size distribution of run-of-mine material.

The IBC field trials were designed to simulate the saturated "as-blasted" waste rock under site-specific environmental conditions. This provides a more realistic and scientifically defensible basis for calculating the "first-flush" loading from the saturated backfill compared to standard laboratory extractions.

6.6.2 Methodology and Procedure

The field trials utilised six 1,000 L IBCs to test two primary waste rock types: three IBCs contained overburden (OB) sourced from the CN Pit, and three contained interburden (IB) sourced from the IM Pit. The procedure involved the following steps:

- Material preparation: Freshly blasted waste rock was processed through a 200 mm grizzly screen to remove extreme oversize material. The rock was loaded into the IBCs at an oversize-to-undersize ratio of 1:3 to maintain a representative particle size distribution of the blasted rock.
- Saturation: The loaded IBCs were weighed and filled with a known volume of potable water to achieve complete saturation. They were left uncovered to expose the system to ambient site conditions (temperature, rainfall, and evaporation).
- Sampling and analysis: Water samples were collected on a designed schedule and analysed for major ions, alkalinity, nitrogen species, and trace metals.
- Total mass calculation: The total mass of each solute was calculated by multiplying the background-corrected concentration by the initial volume of water added to the IBC. Although water levels declined during the trials due to evaporation and leakage, using the initial water volume establishes a conservative basis for the model.
- Specific load derivation: The total solute mass was then divided by the measured dry weight of the waste rock in each IBC to calculate the specific solute load in mg/kg.
- Final source term selection: To define the conservative source term for the pit lake modelling, the maximum solute load observed at the point of relative chemical equilibrium was selected between the OB and IB trial results.

6.6.3 Load Release Rates

The detailed calculations for the solute loads mobilised from the saturated waste rock are provided in MWM (2026c). The results selected as the source terms are summarised in Table 24.

Table 24: Summary of solute load release rates.

PARAMETER	UNIT	VALUE
Total Alkalinity	mg/kg as $CaCO_3$	37.24
Ca	mg/kg	10.93
Mg	mg/kg	5.13
Na	mg/kg	3.19
K	mg/kg	3.94
SO_4	mg/kg	22.74
Cl	mg/kg	1.30
NO_3-N	mg/kg	0.189
Amm-N	mg/kg	0.225
As	mg/kg	0.068
Cu	mg/kg	0.0001
Fe	mg/kg	0.701
Pb	mg/kg	0.00002
Zn	mg/kg	0.0002
Sb	mg/kg	0.23

6.7 GPUG Source Terms

The monitoring data is available from 2022 for GPUG at the monitoring site MAC-GUPG Discharge. The source terms for GPUG were derived from the 2023-2025 period and are provided in Table 25. The source terms were provided to GHD for their groundwater and surface water modelling and are not used for the pit lake water quality modelling of MWM.

Table 25: Source terms for GPUG.

PARAMETER	UNIT	COUNT	AVERAGE	MEDIAN	MIN	MAX
pH	pH units	29	8.32	8.3	10	7.9
Total Alkalinity	mg/L as $CaCO_3$	29	236	152	40	2100
Ca	mg/L	29	294	280	147	440
Mg	mg/L	29	77.5	75	1.6	199
Na	mg/L	29	129	124	78	177
K	mg/L	29	25.69	24	17	36
SO_4	mg/L	29	1110	1140	570	1560
Cl	mg/L	29	22.7	21	15	59
NO_3-N	mg/L	29	39.4	32	12	168
Amm-N	mg/L	29	20.6	15	1.1	157
As (total)	mg/L	28	3.36	1.05	0.048	27
Cu (total)	mg/L	27	0.152	0.047	0.0028	1.2
Fe (total)	mg/L	27	172	54	2.2	1280
Pb (total)	mg/L	27	0.106	0.034	0.0022	0.67
Zn (total)	mg/L	27	0.741	0.27	0.035	4.7
Sb (total)	mg/L	27	0.030	0.024	0.014	0.082

Note: Statistical summary is based on the data period of 2023-2025.

7 PIT LAKE WATER QUALITY MODELLING

7.1 Overview

Hydrogeochemical modelling was conducted for the four pit domains following the methodology introduced in Section 5. The subsequent sections provide a summary of the key procedures and predictive model outputs for each pit. Complete model configurations and full simulation results are provided in the respective technical memoranda (Appendix B to Appendix E).

7.2 Golden Bar

This section summarises the detailed modelling process that is contained in Appendix B (MWM, 2026b).

7.2.1 Conceptual Site Model and Water Balance

The post-closure hydrological regime for the GB Pit was characterised in the CSM (Figure 46) supported by a 200-year WBM (GHD, 2026). The predicted proportions of cumulative water inflows, outflows, and the equilibrium status are summarised in Table 26. The respective stacked annual inflows and outflows are presented in Figure 47 and Figure 48. The long-term hydrological behaviour of the pit lake is primarily driven by direct precipitation and surface runoff, with evaporation serving as the dominant outflow pathway throughout the filling and equilibrium phase.

Table 26: Summary of Golden Bar Pit Lake hydrological components.

MODEL FEATURE	CUMULATIVE PROPORTION	DESCRIPTION
Inflow		
Rainfall	53%	Direct precipitation onto the pit lake surface.
Groundwater	5.4%	Inflow from the surrounding pit walls and through the pit base.
Runoff from pit walls	27%	Runoff from exposed pit wall surfaces generated by rainfall.
Runoff from rehabilitated areas	5.6%	Runoff from the mining impacted areas (including WRS) that will be fully rehabilitated.
Runoff from natural catchment	4.3%	Runoff from the natural catchment (unimpacted by mining activities) to the pit.
Seepage from WRS	4.5%	Seepage from the GB WRS. Seepage is driven by net percolation of meteoric water through the WRS that migrates into the pit.
Outflow		
Evaporation	65.6%	Loss of pure water from the pit lake surface due to evaporation, causing evapoconcentration of solutes.
Groundwater	0.02%	Outflow from the pit as groundwater into the surrounding aquifer.
Overflow	34.4%	Surface discharge from the pit to Golden Bar Creek once the spill point is reached.
Equilibrium		
Equilibrium Level	500 mRL	Predicted long-term, steady-state hydraulic head.
Equilibrium Volume	5.8 Mm^3	Inclusive of backfill pore volume (where applicable).

Source: Data derived from the water balance provided by GHD (2026).

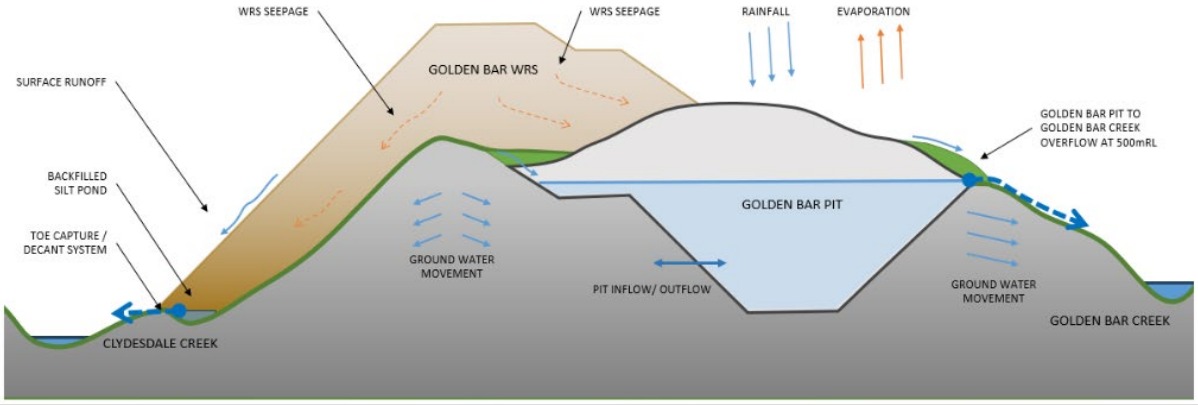

Figure 46: Conceptual site model for Golden Bar Pit.

Source: GHD (2026).

Note: Image is not to scale.

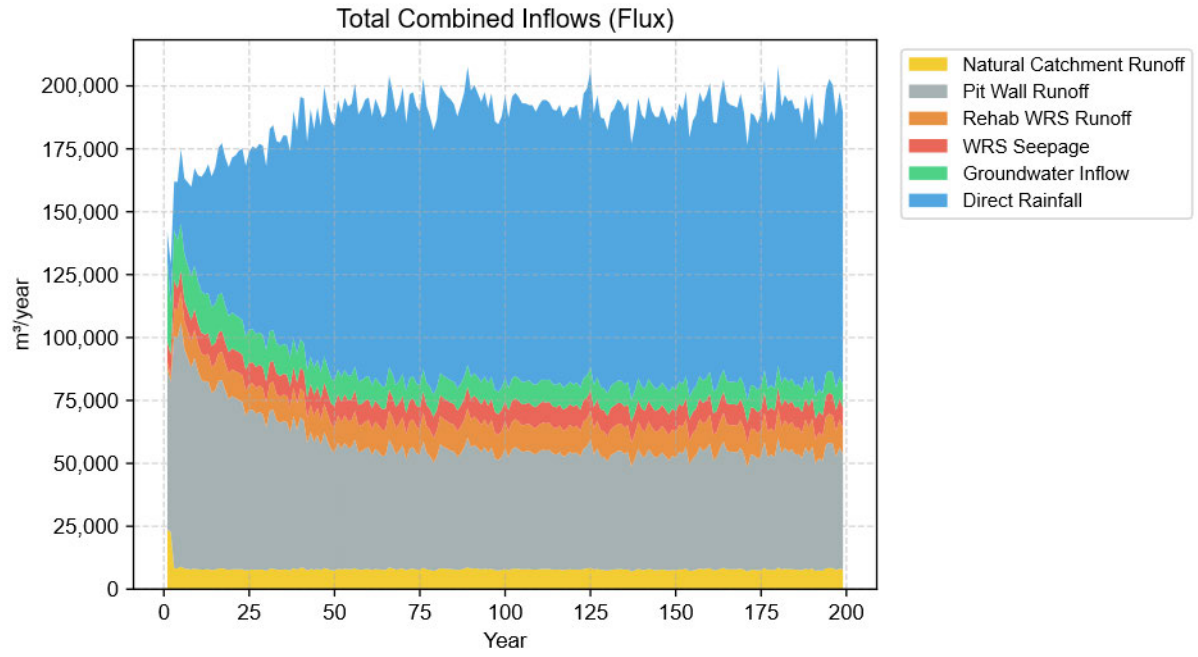

Figure 47: Stacked water balance of annual inflow to Golden Bar Pit Lake.

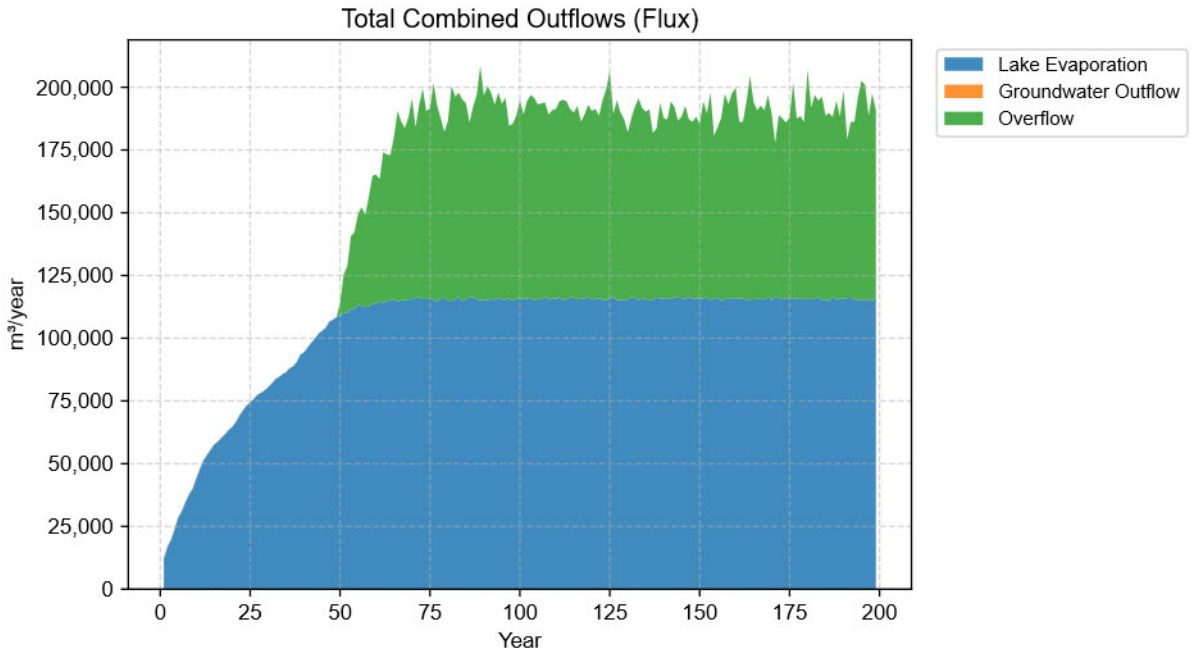

Figure 48: Stacked water balance of annual outflows from Golden Bar Pit Lake.

7.2.2 Water Quality Prediction Results

The predicted long-term water quality for the GB Pit Lake is summarised in Table 27. Annual mass loads for the majority of chemical species modelled peak during the initial infilling phase driven primarily by surface runoff from the exposed pit walls. These loads subsequently decline over the first 70 years post-closure, eventually stabilising as the pit lake achieves a long-term hydrogeochemical steady stage.

The performance of the GB Pit Lake is characterised by the following findings:

- The GB Pit Lake is predicted to remain circumneutral throughout the simulation, maintaining a stable pH of approximately 7.7 supported by a predicted total alkalinity of approximately 190 mg/L (as $CaCO_3$) with the precipitation of approximately 3,489 tonnes (t) of secondary calcite.
- The pit lake is predicted to reach a TDS concentration of approximately 1,100 mg/L. The hydrogeochemical profile will be dominated by SO_4 (612 mg/L) and Mg (140 mg/L).
- Long-term secondary mineral formation is characterised by the precipitation of approximately 7,912 kg of amorphous ferrihydrite and 3,489 t of calcite. The precipitation of ferrihydrite provides critical reactive surfaces for the adsorption and sequestration of trace metals and metalloids.
- Due to the buffered circumneutral pH and active adsorption onto ferrihydrite surfaces, the mobility of most modelled trace elements remains limited, with dissolved concentrations predicted to remain low.

Nitrogenous loads are predicted to attenuate within the first 10 to 20 years. Nitrate-nitrogen (NO_3-N) is predicted to decrease from 4.16 mg/L to 0.1 mg/L, while ammoniacal nitrogen (NH_4-N) falls from 0.376 mg/L to negligible levels.

- Annual mass loads for the majority of chemical species modelled peak during the initial infilling phase driven primarily by surface runoff from the exposed pit walls. These loads subsequently

decline over the first 70 years post-closure, eventually stabilising as the pit lake achieves a long-term hydrogeochemical steady state.

Table 27: Predicted Golden Bar Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 49	YEAR 70	YEAR 100	YEAR 200
Pit Lake Level	mRL	426.6	473.3	495.2	500	500	500
Pit Lake Volume	Mm^3	0.13	2.41	5.12	5.78	5.79	5.78
pH	pH units	7.71	7.74	7.73	7.73	7.73	7.73
TDS	mg/L	936	1,084	1,096	1,100	1,106	1,126
Total Alkalinity	mg/L as $CaCO_3$	180	194	192	191	190	189
Ca	mg/L	64.0	60.8	62.1	63.0	63.9	65.4
Mg	mg/L	111	139	141	141	141	144
Na	mg/L	23.2	27.3	27.7	27.9	28.1	28.9
K	mg/L	6.3	8.0	8.1	8.0	8.0	8.1
SO_4	mg/L	457	574	585	589	595	612
Cl	mg/L	12.0	13.0	13.2	13.2	13.3	13.6
NO_3-N	mg/L	4.16	0.10	0.04	0.04	0.04	0.04
Amm-N	mg/L	0.37560	0.00015	0.00005	0.00004	0.00004	0.00004
As	mg/L	0.180	0.247	0.245	0.243	0.240	0.239
Cu	mg/L	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011
Fe	mg/L	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018
Pb	mg/L	0.00018	0.00017	0.00017	0.00017	0.00017	0.00017
Zn	mg/L	0.0118	0.0114	0.0117	0.0118	0.0120	0.0125

Note: Pit lake starts overflow in Year 49 and reaches long-term stable level in Year 70.

7.3 Coronation and Coronation North

This section summarises the detailed modelling process that is contained in Appendix C (MWM, 2026d) and Appendix D (MWM, 2026e).

7.3.1 Conceptual Site Model and Water Balance

The post-closure hydrological regime for the CO and CN pits is characterised in the CSM (Figure 49), supported by a 200-year WBM developed (GHD, 2026). The predicted proportions of cumulative water inflows, outflows, and the equilibrium status are summarised in Table 28. The respective stacked annual inflows and outflows are presented in Figure 50 to Figure 53. The long-term hydrological behaviour of both pit lakes is primarily driven by direct precipitation and surface runoff, with evaporation serving as the dominant outflow pathway throughout the filling and equilibrium phases.

Table 28: Summary of Coronation and Coronation North Pit Lake hydrological components.

MODEL FEATURE	CO	CN	DESCRIPTION
Inflows			
Direct Rainfall	50.1%	41.2%	Primary inflow; scales with expanding lake surface area.
Groundwater	3.6%	10.6%	For CN, this is essentially the groundwater outflow from the CO Pit.
Runoff from pit walls	30.4%	20.4%	Generated from exposed pit wall surfaces.
Runoff from rehabilitated areas	6.2%	17.5%	Runoff from mining impacted areas (including WRS) that will be fully rehabilitated.
Runoff from natural catchment	1.0%	-	For CO Pit Lake only.

MODEL FEATURE	CO	CN	DESCRIPTION
Seepage from backfill	7.1%	3.8%	Include seepage from unsaturated COBF (for CO) and CNBF (for CN) material above the respective pit lake level.
Seepage from WRS	1.7%	6.5%	Include seepage from TR WRS (for CO), and seepage from CO and TR WRS (for CN).
Outflows			
Evaporation	56.0%	53.5%	Principal outflow, leading to evapoconcentration of solutes.
Groundwater	0.7%	1.5%	Outflow from the pit as groundwater into the surrounding aquifer.
Overflow	43.4%	45.0%	Surface discharge to Camp Creek (from CO) or Coal Creek (from CN) upon reaching the respective spill point.
Equilibrium			
Equilibrium Level	625 mRL	562.5 mRL	Predicted steady-state hydraulic head.
Equilibrium Volume	5.5 Mm^3	15.3 Mm^3	Inclusive of backfill pore volume (where applicable).

Source: Data derived from the water balance provided by GHD (2026).

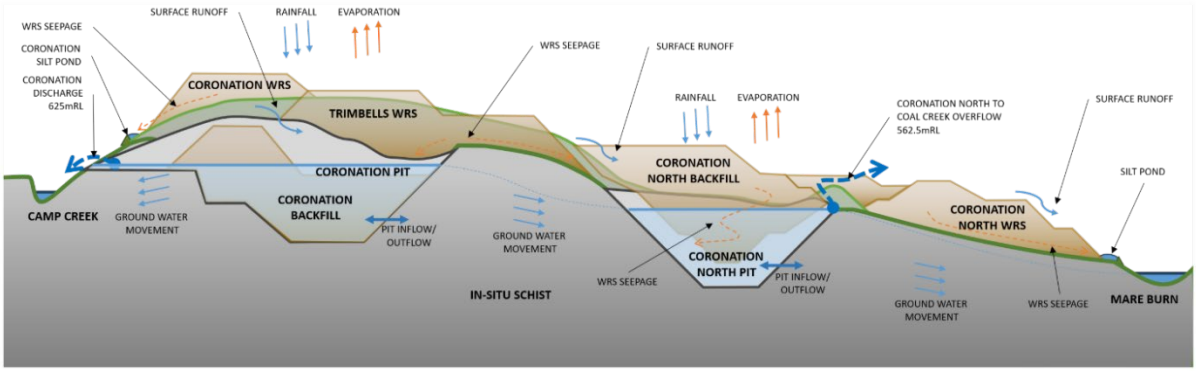

Figure 49: Conceptual site model for Coronation and Coronation North pits.

Source: GHD (2026).

Note: Image is not to scale.

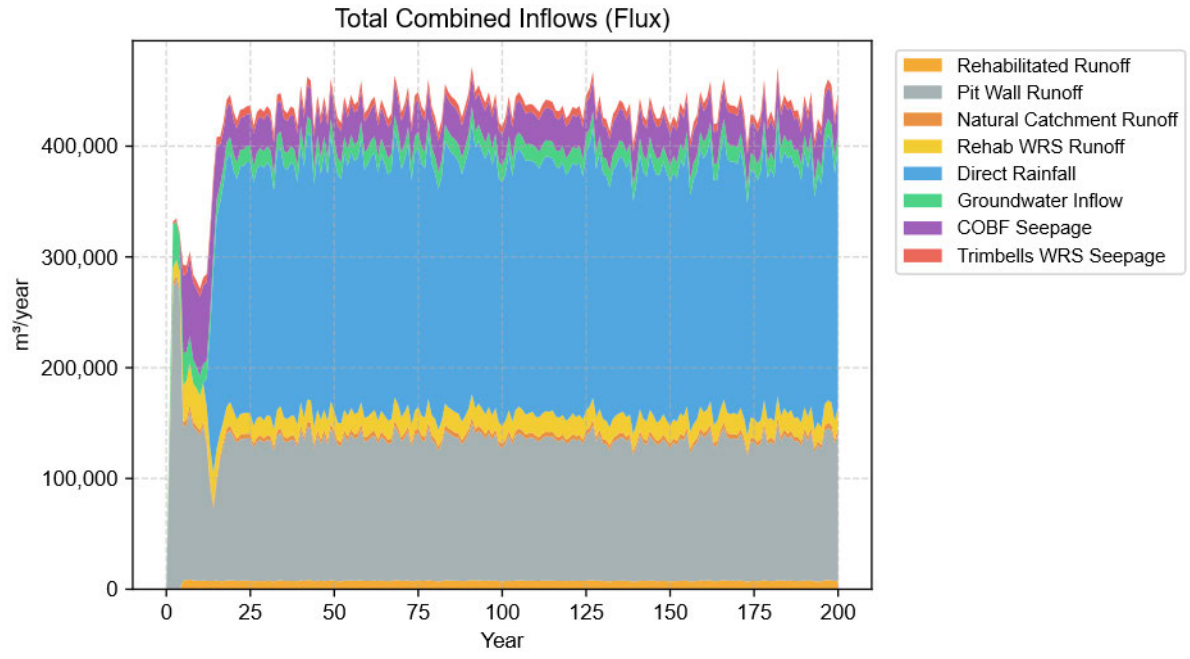

Figure 50: Stacked water balance of annual inflows to Coronation Pit Lake.

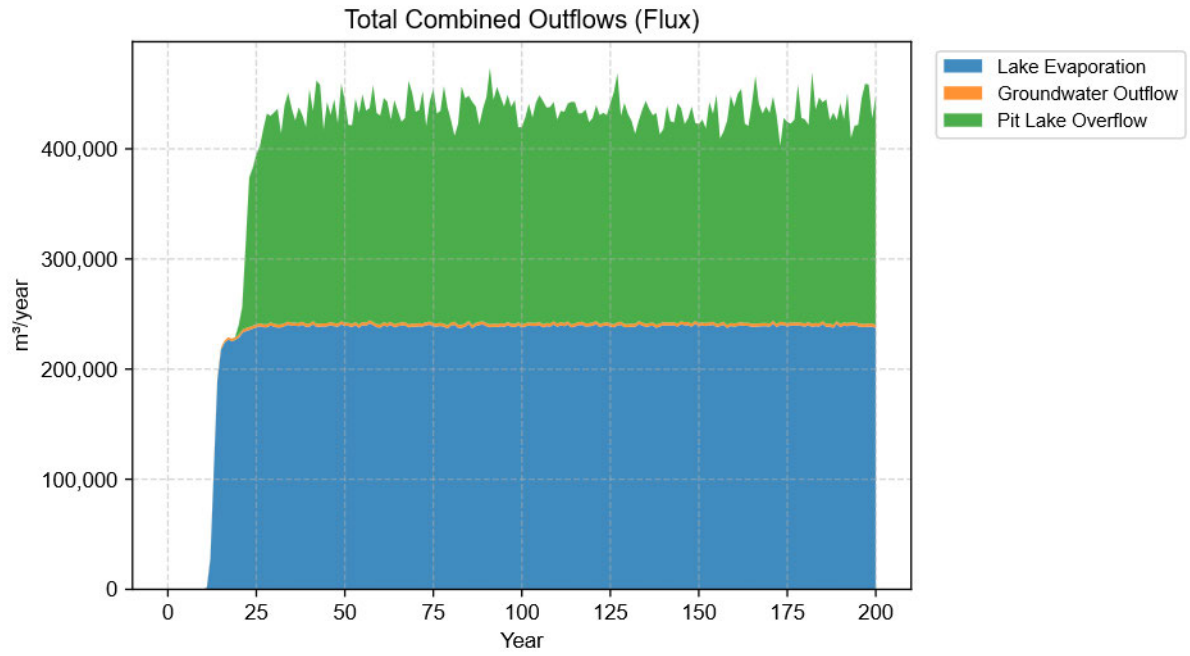

Figure 51: Stacked water balance of annual outflows from Coronation Pit Lake.

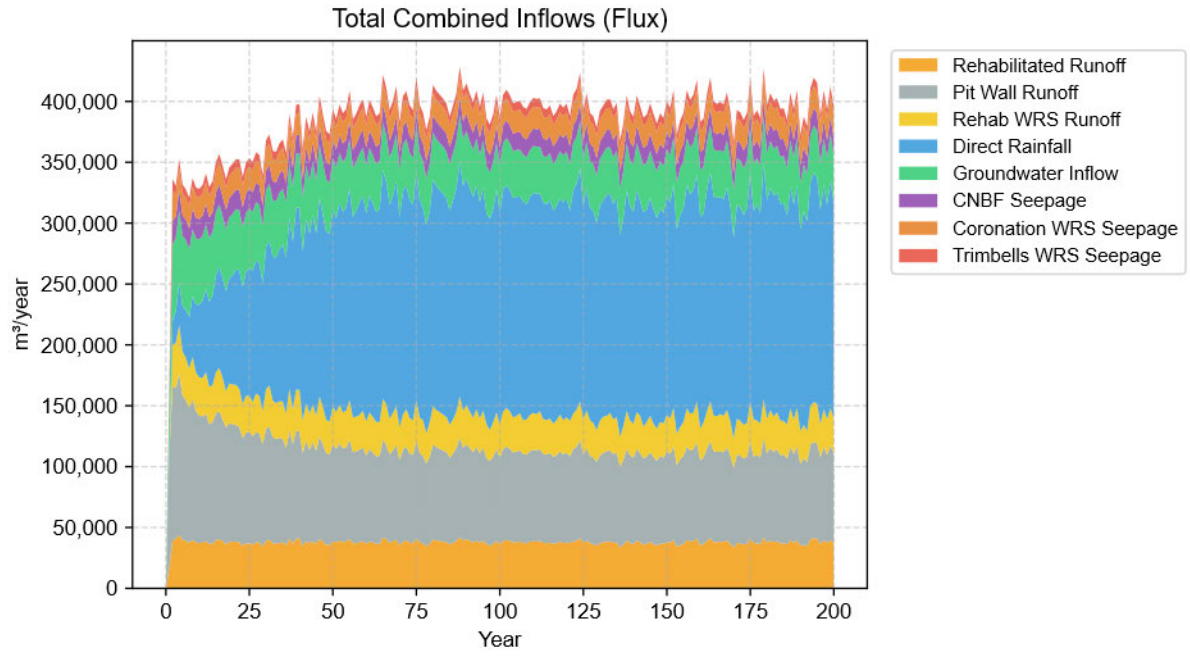

Figure 52: Stacked water balance of annual inflows to Coronation North Pit Lake.

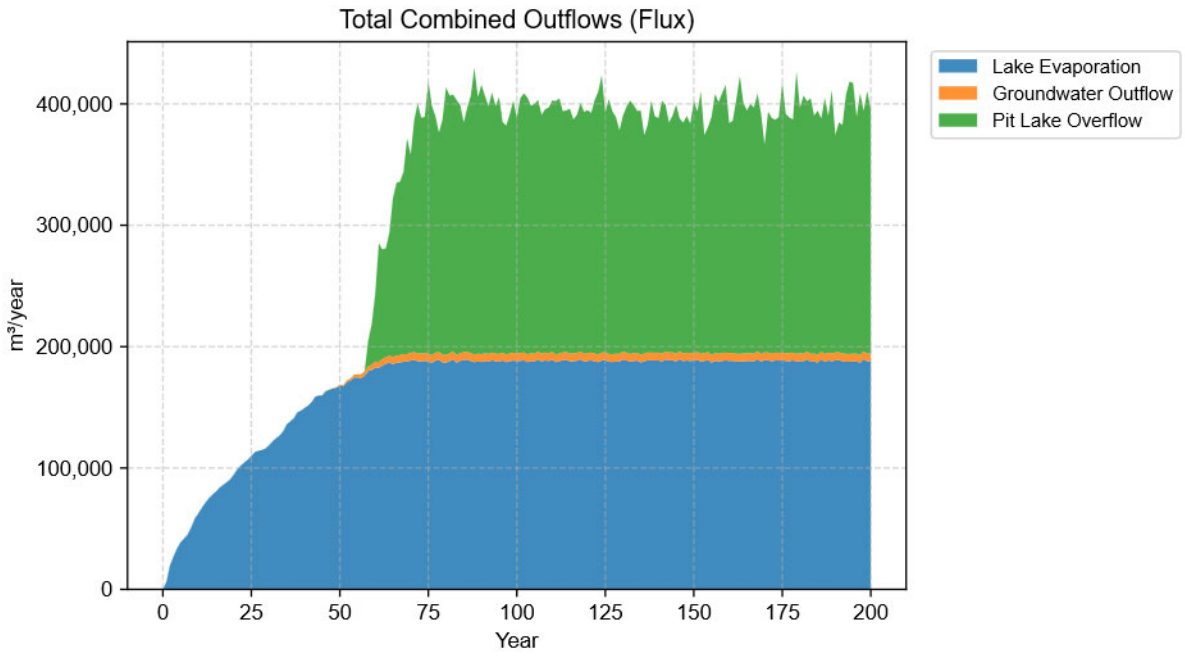

Figure 53: Stacked water balance of annual outflows from Coronation North Pit Lake.

7.3.2 Water Quality Prediction Results

The predicted water quality for both pit lakes is summarised in Table 29 and Table 30, respectively. The long-term geochemical performance of the pit lakes is characterised by the following key findings:

- Both pit lakes are predicted to remain circumneutral (maintaining a pH of approximately 7.7 and 7.6, respectively) throughout the 200-year simulation. This stability is supported by high residual alkalinity (exceeding 140 mg/L), providing robust buffering capacity.
- The pit lake waters are predicted to be brackish, with long-term TDS concentrations stabilising at 1,385 mg/L in CO and 1,770 mg/L in CN. The bulk hydrogeochemical profiles of both lakes will be dominated by SO_4 and Mg, with long-term SO_4 concentrations of approximately 835 mg/L in CO and 1,151 mg/L in CN, and Mg concentrations of 168 mg/L and 202 mg/L, respectively. Dissolved Ca concentrations are constrained by calcite solubility.
- Dissolved trace metals and metalloid (As, Cu, Pb, Zn) are effectively mitigated via coprecipitation and surface complexation onto amorphous ferrihydrite precipitates. The models predict the precipitation of approximately 59.6 t of ferrihydrite in the CO Pit Lake and 36.9 t in the CN Pit Lake over the 200-year period. This precipitation is primarily driven by continuous mass loads of dissolved Fe released from in-pit backfill material during the early filling phase. Notably, despite this attenuation, dissolved concentrations of Cu and Zn are predicted to gradually increase over the modelling period in both pit lakes. This prediction is conservative, as source term concentrations (e.g., pit wall runoff) were held constant throughout the simulation rather than accounting for natural attenuation and passivation of mineral surfaces over time.
- Nitrate and ammoniacal N loads, primarily derived from residual ANFO, are predicted to attenuate rapidly. Due to biologically mediated denitrification and dilution, long-term

concentrations of NO_3-N decay to approximately 0.16 mg/L, while Amm-N falls to negligible levels (below 0.05 mg/L) in both pits.

- Mass loading for the majority of modelled chemical species is driven predominantly by in-pit backfill solute release during the early post-closure phase. Following the complete submersion of the backfill, annual loads of these species decline significantly; long-term mass flux becomes governed by pit wall runoff and WRS seepage at lower levels.

Table 29: Predicted Coronation Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 19	YEAR 27	YEAR 50	YEAR 100	YEAR 200
Pit Lake Level	mRL	556.1	623.3	625.0	625.0	625.0	625.0
Pit Lake Volume	Mm^3	0.16	4.80	5.46	5.46	5.46	5.46
pH	pH	7.74	7.71	7.70	7.68	7.66	7.66
TDS	mg/L	1,271	1,621	1,566	1,459	1,383	1,385
Total Alkalinity	mg/L as $CaCO_3$	198	188	182	172	165	164
Ca	mg/L	62.1	80.3	84.5	91.5	95.8	97.6
Mg	mg/L	170	197	191	177	168	168
Na	mg/L	31.0	56.8	51.0	40.7	33.7	32.9
K	mg/L	10.5	41.9	34.2	20.6	11.7	10.1
SO_4	mg/L	696	959	931	874	831	835
Cl	mg/L	14.7	24.0	21.8	17.7	15.0	14.6
NO_3-N	mg/L	4.271	0.310	0.177	0.158	0.158	0.158
Amm-N	mg/L	0.4124	0.0014	0.0005	0.0004	0.0004	0.0004
As	mg/L	0.355	0.494	0.446	0.359	0.297	0.285
Cu	mg/L	0.0019	0.0006	0.0007	0.0011	0.0019	0.0031
Fe	mg/L	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018
Pb	mg/L	0.00011	0.00001	0.00001	0.00001	0.00002	0.00003
Zn	mg/L	0.0129	0.0532	0.0567	0.0629	0.0685	0.0724

Note: Pit lake starts overflow in Year 19 and reaches long-term stable level in Year 27.

Table 30: Predicted Coronation North Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 57	YEAR 71	YEAR 100	YEAR 200
Pit Lake Level	mRL	458.2	521.0	558.2	562.5	562.5	562.5
Pit Lake Volume	Mm^3	0.17	5.39	13.92	15.24	15.26	15.26
pH	pH	7.69	7.63	7.62	7.62	7.61	7.59
TDS	mg/L	1,510	1,690	1,781	1,781	1,770	1,770
Total Alkalinity	mg/L as $CaCO_3$	180	158	154	152	149	144
Ca	mg/L	83.8	117	128	131	136	146
Mg	mg/L	189	199	209	208	205	202
Na	mg/L	41.0	46.9	48.4	47.6	45.4	42.3
K	mg/L	21.0	21.6	19.7	18.5	15.5	10.8
SO_4	mg/L	871	1,064	1,142	1,145	1,142	1,151
Cl	mg/L	17.8	16.8	16.2	15.8	14.9	13.5
NO_3-N	mg/L	8.48	0.65	0.22	0.17	0.16	0.16
Amm-N	mg/L	0.4853	0.0021	0.0008	0.0002	0.0001	0.0001
As	mg/L	0.396	0.314	0.289	0.278	0.252	0.211
Cu	mg/L	0.0008	0.0016	0.0017	0.0018	0.0022	0.0033

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 57	YEAR 71	YEAR 100	YEAR 200
Fe	mg/L	0.00018	0.00019	0.00019	0.00019	0.00019	0.00019
Pb	mg/L	0.00001	0.00001	0.00001	0.00001	0.00002	0.00003
Zn	mg/L	0.0216	0.0389	0.0448	0.0465	0.0497	0.0560

Note: Pit lake starts overflow in Year 57 and reaches long-term stable level in Year 71.

7.4 Innes Mills

This section summarises the detailed modelling process that is contained in Appendix E (MWM, 2026f).

7.4.1 Conceptual Site Model and Water Balance

The post-closure hydrological regime for the IM Pit was characterised through the CSM (Figure 54) supported by a 200-year WBM developed by GHD (2026). The predicted proportions of cumulative water inflows, outflows, and equilibrium status are summarised in Table 31. The respective stacked annual inflows and outflows are presented in Figure 55 and Figure 56. The hydrological behaviour of the pit lake is primarily driven by direct precipitation and mixed groundwater inflow, with evaporation serving as the dominant outflow mechanism during the filling phase.

Table 31: Summary of Innes Mills Pit Lake hydrological components.

MODEL FEATURE	CUMULATIVE PROPORTION	NOTE
Inflow		
Rainfall	35.8%	Direct precipitation onto the pit lake surface.
Groundwater	17.1%	Mixture of groundwater from schist (8.1%) and FTSF seepage (9.0%).
Runoff from pit walls	22.8%	Runoff from exposed pit wall surfaces generated by rainfall.
Runoff from rehabilitated mining areas	8.6%	Runoff from the mining impacted areas (including WRS) that will be fully rehabilitated.
Seepage from backfill	15.6%	Seepage from the Innes Mills Backfill (IMBF).
Outflow		
Evaporation	48.1%	Loss of pure water from the pit lake surface due to evaporation, causing evapoconcentration of solutes.
Groundwater	4.3%	Outflow from the pit as groundwater into surrounding aquifer.
Overflow	47.6%	Surface discharge from the pit to Deepdell Creek once the spill point is reached.
Equilibrium		
Equilibrium Level	473.1 mRL	Predicted steady-state hydraulic head.
Equilibrium Volume	25.8 Mm^3	Inclusive of backfill pore volume (where applicable).

Source: Data derived from the water balance provided by GHD (2026).

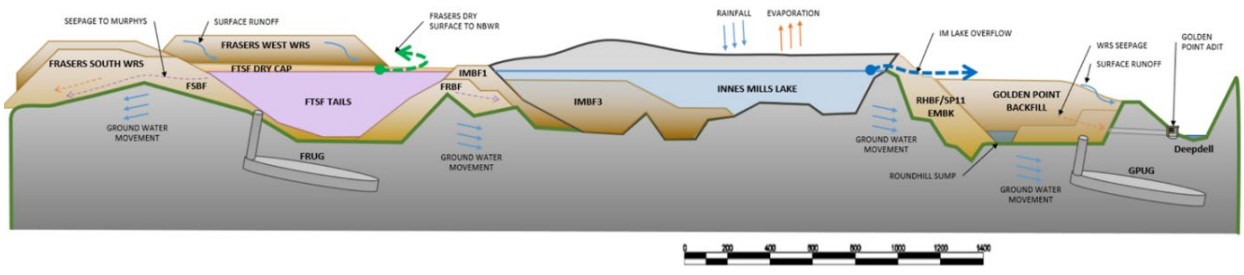

Figure 54: Conceptual site model for the Innes Mills Pit.

Source: GHD (2026).

Note: Image is not to scale.

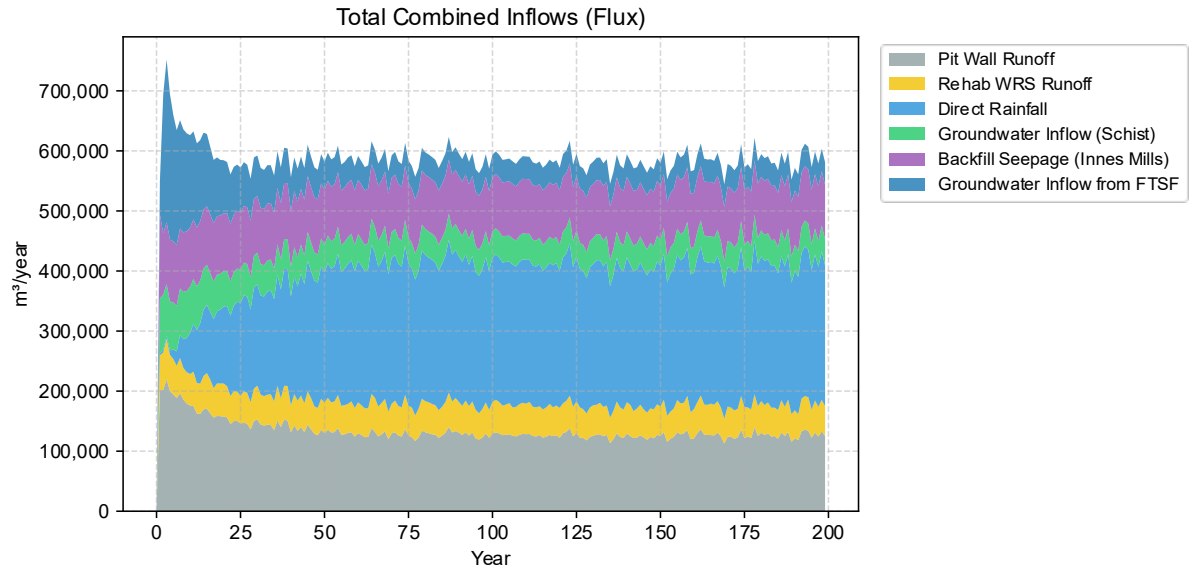

Figure 55: Stacked water balance of annual inflows to Innes Mills Pit Lake.

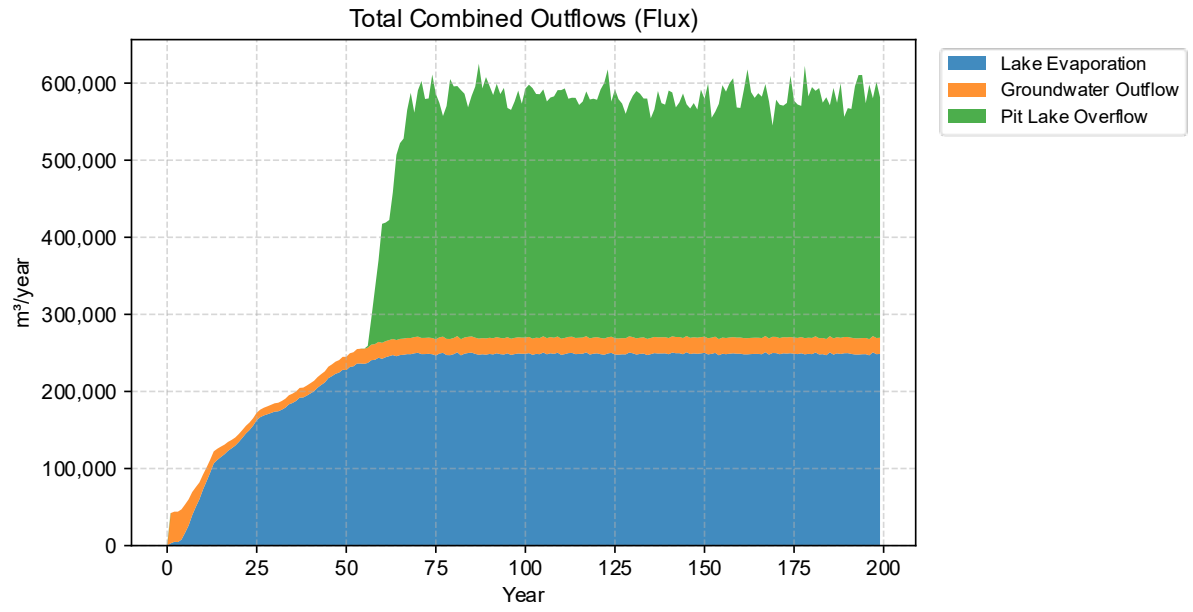

Figure 56: Stacked water balance of annual outflows from Innes Mills Pit Lake.

7.4.2 Water Quality Prediction Results

The predicted post-closure water quality for the IM Pit Lake is summarised in Table 32. The long-term geochemical performance of the pit lake is characterised by the following findings:

- The IM Pit Lake is predicted to remain circumneutral throughout the simulation. A long-term pH of approximately 7.7 is maintained by a predicted total alkalinity exceeding 170 mg/L (as $CaCO_3$), supported by the precipitation of approximately 22,000 t of secondary calcite.

- The pit lake will be brackish, with a long-term TDS concentration stabilising at approximately 2,400 mg/L. The hydrogeochemical profile will be dominated by SO_4 (approximately 1,600 mg/L) and Mg (320 mg/L).

Initial nitrogenous loads are predicted to attenuate within the early stages of filling. Nitrate-N is predicted to decrease from 6.16 mg/L to 0.23 mg/L, while Amm-N falls from 0.9 mg/L to 0.003 mg/L, by Year 200.

- Approximately 298 t of amorphous ferrihydrite is predicted to precipitate, providing critical reactive surface areas for the adsorption and sequestration of trace metals and metalloids. Consequently, concentrations of trace metals, such as Pb, will remain consistently low, and As concentrations are predicted to decline from 0.94 mg/L to 0.187 mg/L by Year 200. Despite the attenuation, Zn and Cu concentrations will increase to 0.009 mg/L and 0.0015 mg/L, respectively.
- Modelled WAD CN concentrations remain below 0.003 mg/L. These values reflect the conservative assignment of half-LOR (0.01 mg/L) to historical groundwater non-detects; actual post-closure concentrations are expected to decrease to zero.
- Mass loading for the majority of modelled chemical species, primarily major ions and dissolved metals and metalloids, is driven by backfill solute release and groundwater inflow from the FTSF during the first 10 to 15 years. Beyond Year 20, annual loads of these species decline significantly and are governed primarily by the IMBF seepage, with the FTSF seepage serving as a minor contributor.

Table 32: Predicted Innes Mills Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 56	YEAR 68	YEAR 100	YEAR 200
Pit Lake Level	mRL	350.2	434	469.5	473.1	473.1	473.1
Pit Lake Volume	Mm^3	0.12	10.37	23.88	25.83	25.82	25.78
pH	pH units	8.01	7.61	7.65	7.66	7.66	7.67
TDS	mg/L	1,850	3,143	3,021	2,929	2,716	2,435
Total Alkalinity	mg/L as $CaCO_3$	311	157	174	175	176	178
Ca	mg/L	15.5	168.6	136.7	132.3	124.9	115.1
Mg	mg/L	195	359	380	371	350	322
Na	mg/L	122.3	157.1	127.7	120.6	104.4	82.2
K	mg/L	151	73.8	56.3	52.1	41.3	26.2
SO_4	mg/L	871	2,118	2,046	1,980	1,827	1,626
Cl	mg/L	49.9	28.2	23.6	22.6	19.6	15.6
NO_3-N	mg/L	6.16	1.31	0.32	0.24	0.23	0.23
Amm-N	mg/L	0.909	0.024	0.005	0.003	0.003	0.003
As	mg/L	0.939	0.428	0.341	0.322	0.266	0.187
Cu	mg/L	0.0002	0.0008	0.0009	0.001	0.0011	0.0015
Fe	mg/L	0.00143	0.0002	0.00019	0.00019	0.00019	0.00018
Pb	mg/L	0.000002	0.000006	0.000006	0.000007	0.000008	0.000011
Zn	mg/L	0.0016	0.0064	0.0072	0.0074	0.008	0.0091
WAD CN	mg/L	0	0.003	0.002	0.002	0.002	0.001

Note: Pit lake starts overflow in Year 56 and reaches long-term stable level in Year 68.

8 PIT LAKE WATER QUALITY SUMMARY AND DISCUSSION

8.1 Predicted Water Quality Comparison with Trigger Values

A summary of the TVs developed by Viridis (2026) based on the "standard" Macraes operation receiving water conditions determined by Viridis (pH 7.8, Cl 9.1 mg/L, dissolved organic carbon (DOC) 4.5 mg/L, hardness 220 mg/L as $CaCO_3$, and temperature 20ºC) is provided in Section 2.3 (Table 2). However, several TVs are subject to the modifier values adopted; therefore, these TVs were updated using the predicted equilibrium water quality of the four pit lakes.

Table 33 presents these site-specific, modifier-adjusted TVs with the predicted pit lake water quality predicted for the years when stable lake levels are reached. These values are applied as a conservative screening guide to assess long-term water quality prior to the discharge into the downstream catchments (Camp Creek, Coal Creek, and Golden Bar Creek). Time series trends tracking selected water quality parameters against the respective TVs over the 200-year modelling period are presented in Figure 57. The following should be noted:

- Total hardness was calculated for each pit lake using the predicted Ca and Mg concentrations following: Total Hardness (mg/L as $CaCO_3$) = 2.497 x Ca (mg/L) + 4.118 x Mg (mg/L). In accordance with guidelines, the TV for Pb was capped at a maximum hardness of 400 mg/L as $CaCO_3$ (ANZG, 2018) and Zn was capped at 440 mg/L as $CaCO_3$ (ANZG, 2024).
- To maintain thermodynamic consistency with the hydrogeochemical models, a temperature of 10ºC was applied where required as a modifier.
- In the absence of historical site monitoring data for DOC at Macraes, the concentration of 4.5 mg/L used by Viridis was retained for all four domains.
- Model predicted pH and Cl concentrations were used to determine the TVs, where required.
- These TVs serve as a screening tool rather than compliance thresholds to provide context on water quality. Parameters that are elevated are shown in red text.

Table 33: Comparison of predicted pit lake quality with derived TVs.

PARAMETER	UNIT	GB (YEAR 70)	CO (YEAR 27)	CN (YEAR 71)	IM (YEAR 68)	TV	MODIFIER
Pit Lake Level	mRL	500	625.0	562.5	473.1	-	-
Pit Lake Volume	Mm^3	5.78	5.46	15.24	25.83	-	-
pH	pH units	7.73	7.70	7.62	7.66	6.5-9.0	-
TDS	mg/L	1,100	1,566	1,781	2,929	-	-
Total Alkalinity	mg/L as $CaCO_3$	191	182	152	175	-	-
Ca	mg/L	63.0	84.5	131	132.3	-	-
Mg	mg/L	141	191	208	371	-	-
Na	mg/L	27.9	51.0	47.6	120.6	-	-
K	mg/L	8.0	34.2	18.5	52.1	-	-
SO_4	mg/L	589	931	1,145	1,980	1,000	hardness ≥100 mg/L
Cl	mg/L	13.2	21.8	15.8	22.6	-	-

PARAMETER	UNIT	GB (YEAR 70)	CO (YEAR 27)	CN (YEAR 71)	IM (YEAR 68)	TV	MODIFIER
NO_3-N	mg/L	0.04	0.177	0.17	0.24	2.6	hardness ≥100 mg/L with Cl <30 mg/L
Amm-N	mg/L	0.00004	0.0005	0.0002	0.003	0.94	pH 7.8, temp 10ºC (modelled condition)
As	mg/L	0.243	0.446	0.278	0.322	0.013	-
Cu	mg/L	0.0011	0.0007	0.0018	0.001	0.004	assumed DOC 4.5 mg/L
Fe	mg/L	0.00018	0.00018	0.00019	0.00019	0.28	-
Pb	mg/L	0.00017	0.00001	0.00001	0.000007	0.091	hardness 400 mg/L
Zn	mg/L	0.0118	0.0567	0.0465	0.0074	0.019	hardness 440 mg/L, assumed DOC 4.5 mg/L, pH 7.8
Hardness (calculated)	mg/L as $CaCO_3$	738	997.5	1,184	1,858	-	-

Note: Predicted pit lake water quality provided in the table corresponds to the timeframe when long-term hydraulic equilibrium and stable overflow to surface catchments occurs for each respective pit lake.

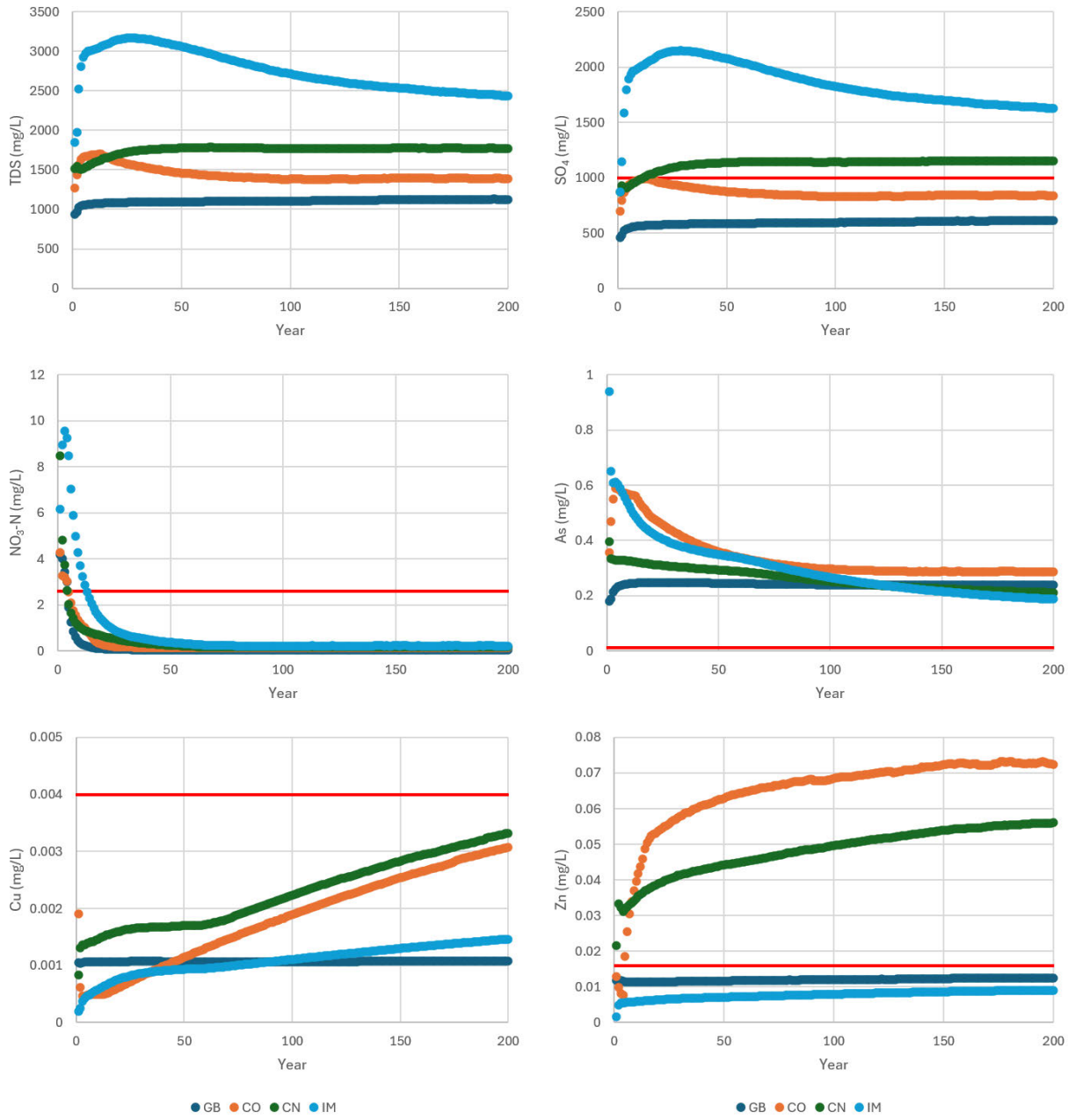

Figure 57: Time series of selected parameter for all four pits.

Note: Red lines indicate the corresponding TVs for each respective parameter panel – noting these are not adjusted for any toxicity modifying parameters.

8.2 Overall Pit Lake Prediction

The overall comparison of the predicted pit lake water quality is summarised as follows:

- All four pit lakes will be circumneutral with a pH around 7.7 and an alkalinity exceeding 140 mg/L as $CaCO_3$ over the modelling period.
- The pit lake water will be SO_4 dominated, with its average concentrations ranging from approximately 500 mg/L in the CN Pit Lake up to over 2,000 mg/L in the IM Pit Lake. Consequently, the TDS shows a similar trend to SO_4 for these pits. Magnesium and Ca are the primary cations, with Ca concentrations generally lower due to the constraint of formation of

calcite. Based on the hardness calculated using Ca and Mg concentrations, SO_4 in the CN and IM Pit Lakes are expected to exceed the TV of 1,000 mg/L.

- For the pits which will be partially backfilled (CO, CN, and IM), a substantial load of Fe will be released before the backfill is submerged. For GB and the other pits after the submergence of the backfill, groundwater usually provides a consistent low Fe mass flux. This released Fe, under oxidising circumneutral conditions, precipitates as amorphous ferrihydrite, resulting in low dissolved Fe concentrations in the pit lake water and providing surface area for adsorption and sequestration of trace metals and metalloids.
- Due to surface adsorption and circumneutral pH conditions, concentrations of most modelled trace elements are predicted to remain low.
    - Arsenic concentrations either remain stable between approximately 0.2 and 0.3 mg/L (e.g., GB and CN) or decline from higher initial concentrations to a similar range (e.g., CO and IM). Across all four pit lakes, As concentrations will remain above the TV of 0.013 mg/L, requiring management measures (Section 9). This prediction is conservative, as the primary long-term As load originates from pit wall runoff, which does not consider progressive mineral weathering and surface passivation of sulfide minerals.
    - Concentrations of Cu are predicted to remain low at around 0.001 mg/L for GB and IM over the modelling period. Conversely, CO and CN exhibit consistently increasing Cu concentrations, which are predicted to exceed 0.003 mg/L by Year 200, though remaining below the Cu TV of 0.004 mg/L.
    - Similarly, Zn concentrations in the GB and IM Pit Lakes are predicted to remain consistently below the TV of 0.016 mg/L. In contrast, Zn concentrations in the CO and CN Pit Lakes are predicted to exceed the TV (unmodified) and have an increasing concentration with time. This trend in CO and CN is driven by assumption of continuous mass loading from backfill seepage and pit wall runoff exceeding the attenuation capacity of secondary Fe-mineral precipitation.
    - Lead concentrations remain negligible across all four pit lakes over the modelling period.

Both nitrogenous species (nitrate and Amm-N) are predicted to decline from relatively high initial concentrations within 10-20 years post-closure, and stabilising at concentrations below the respective TVs.

8.3 Water Quality Discussion

8.3.1 Ferrihydrite Formation and Adsorption

As introduced in the previous sections, ferrihydrite precipitates are the primary controller of the concentrations of trace element concentrations in water. Therefore, further detailed discussion regarding several key technical details is provided here.

8.3.1.1 Oxidising Water Environment

Two forms of iron exist under natural conditions: ferric iron (Fe^{3+}) and ferrous iron (Fe^{2+}). Under oxidising conditions, Fe^{3+} is the dominant Fe form and will form ferrihydrite precipitates.

Based on the review of previous lake stratification studies and the observation at GB Pit Lake (Section 3.3), it is expected that the four pit lakes to be formed post-closure will not establish long-term stratified layers; seasonal full mixing is expected to occur, which will result in gas exchange of the pit water with atmosphere gases. Therefore, it is reasonable to assume that the pit lake water is oxidising, although temporary localised reducing environments may form at depths.

8.3.1.2 Iron Release and Ferrihydrite Formation

Load analysis shows that the solute load released from backfill material is the predominant Fe source at CO, CN, and IM. This release generally ceases after submergence by recovered pit lake water within several decades, with groundwater providing a more consistent but much lower flux thereafter.

8.3.2 Prediction of As Concentrations

While As concentration decline is predicted to occur for CO and IM, long-term As concentrations in all four pit lakes are predicted to range between approximately 0.2 and 0.3 mg/L by Year 200. Surface water modelling by GHD (2026), based on these source concentrations, shows that As concentrations may exceed compliance limits, which represents a primary driver for implementing management measures (Section 10).

Attenuation of As concentrations (within the predicted concentration ranges) in the pit lakes is mainly attributed to the surface adsorption by ferrihydrite under the predicted circumneutral pH conditions and dilution (if favoured by pit lake inflow and outflow water flux balance). The hydrogeochemical modelling shows that although As occupies a large proportion of the available sorption sites provided by the ferrihydrite precipitates, the mass flux of Fe is still insufficient to further reduce the As concentrations, without external addition. Therefore, treatment of As by $FeCl_3$ was investigated (MWM, 2026g), which is discussed in Section9.2. Further details are provided in Appendix F.

8.3.3 Prediction of Cu and Zn Concentrations

Concentrations of Cu and Zn are predicted to increase over time in the CO and CN Pit Lakes. Load analysis indicates that seepage from the CO and TR WRS is the primary source for these two elements, providing a consistent and stable annual mass loads throughout the modelling period.

8.3.4 Prediction of Cyanide

Cyanide is included in the model prediction for the IM Pit Lake as this chemical is expected to be released from the FTSF seepage to the pit lake as one of the groundwater inflows. The modelling results indicate WAD CN concentrations (no higher than 0.003 mg/L) will be consistently below its TV.

8.3.5 Solute Release from Waste Rock

As demonstrated in the mass load analysis for the pits that will be backfilled, solute release from backfill waste rock significantly influences final pit lake water quality as it is flooded:

- The adopted solute release rates (mg/kg) were derived from the IBC field trials for submerged backfill material (Table 9 of MWM, 2026c). The backfilled waste rock needs to be managed to prevent oxidation. If the backfilled waste rock is subject to ongoing oxidation, then the pit lake hydrogeochemical modelling should be re-evaluated using the higher solute release rates outlined in MWM (2026c).

- Backfilled waste rock also has a seepage component where the water quality is a function of the backfill height. This source term is based on a WRS that has limited management of oxygen. If the backfilled WRS is built to reduce oxidation of sulfide minerals then this source term would be conservative.

9 MANAGEMENT MEASURES

9.1 Introduction

Macraes is a mature operation with over 30 years of operational history. The environmental geochemistry risks are generally well understood. For the MP4 Project, predictive models have been developed to forecast the long-term, post-closure water quality of the proposed pit lakes. As detailed in Section 8, the model results indicate that proactive management (active treatment) will be required to manage potentially elevated trace element concentrations, specifically, As and Zn, prior to surface discharge.

Furthermore, as all four existing pit voids will be completely dewatered prior to the commencement of the pit extensions, the management and fate of the standing pit water must be addressed. This section outlines the management strategies for both the long-term, post-closure pit lakes and the short-term operational dewatering of the GB Pit Lake.

9.2 In-Pit Ferric Chloride Dosing Strategy for Arsenic and Zinc Treatment

The foundational geochemical mechanism and empirical derivation of the active treatment strategy are detailed in MWM (2026g) and include the addition of ferric chloride to the pit lake to remove As and other trace metals. This memorandum is provided in Appendix F.

9.2.1 Water Quality Objectives and Compliance Targets

The primary objective of the in-pit active treatment strategy is to proactively manage trace element concentrations within the pit lakes prior to their eventual discharge to the downstream receiving environment. Specifically, the $FeCl_3$ dosing strategy targets the reduction of dissolved As, which is predicted to exceed the Viridis (2026) TV across all four MP4 pit lakes.

Concurrently, the plan should also address elevated Zn concentrations. GHD (2026) surface water modelling indicates that dissolved Zn is predicted to exceed TVs at downstream compliance sites if left unmanaged. This risk is primarily localised to the CO Pit Lake, driven by Zn loading from the TR WRS and COBF seepage (MWM, 2026d).

9.2.2 Treatment Mechanism and PHREEQC Calibration

The treatment mechanism relies on the controlled addition of $FeCl_3$ to the pit lakes. Under circumneutral, oxidising conditions of the Macraes pit lakes, the dosed Fe rapidly hydrolyses and precipitates as amorphous ferrihydrite. This precipitate provides highly reactive surface areas that scavenge dissolved trace elements, including As, Zn, and other metals through surface complexation and co-precipitation (MWM, 2026g).

To evaluate the chemical ratios required to meet the compliance targets, geochemical equilibrium simulations were performed using PHREEQC and the WATEQ4F thermodynamic database, applying the generalised two-layer surface complexation model of Dzombak and Morel (1990). The PHREEQC model was calibrated using an empirical algorithm derived from field data at the Reefton Restoration Project (MWM, 2026g), which demonstrated that an optimal Fe:As dosing mass ratio of 10:1 achieves approximately 90% As removal. To replicate this empirical removal efficiency within the thermodynamic model, the ferrihydrite surface site density was calibrated to 0.014 mol of strong sites and 0.33 mol of weak sites per mol of Fe, with a specific surface area of 600 m^2/g. The calibration results for individual samples are presented in Figure 58.

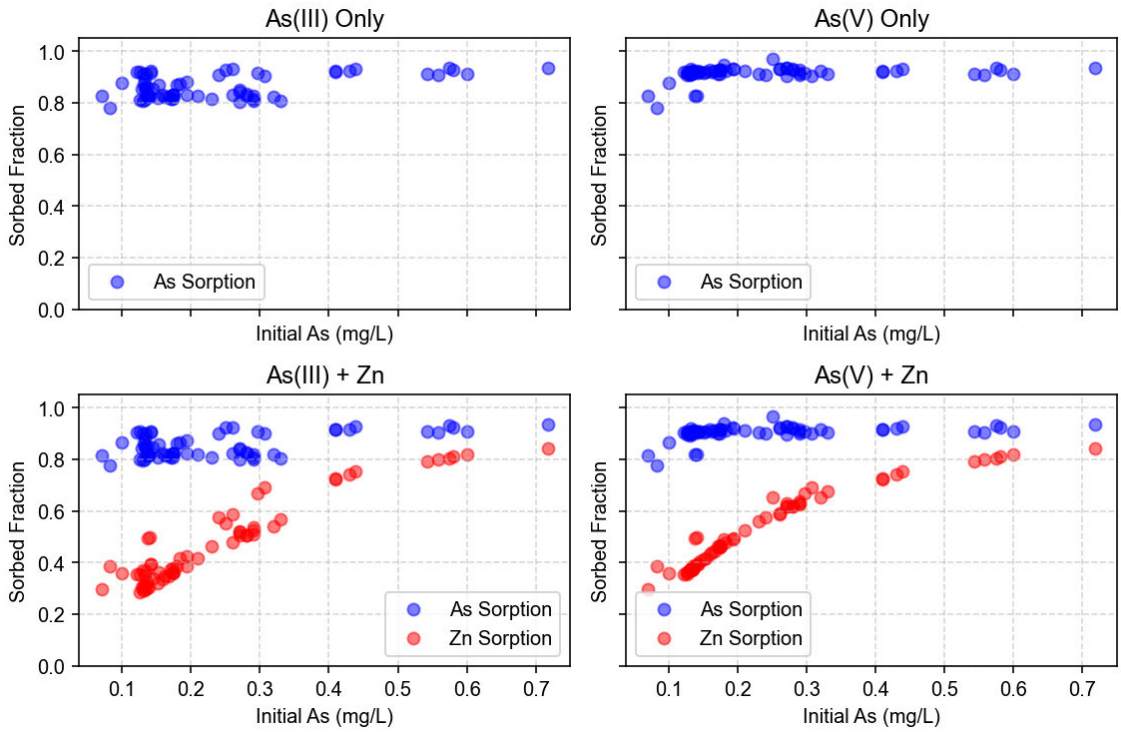

Figure 58: Sorbed fraction of As and Zn for the Golden Bar Pit Lake water samples at an Fe:As ratio of 10:1.

Note: The initial concentration of Zn is fixed at 0.5 mg/L for all solutions at an Fe:As ratio of 10:1. The plots show the sorbed fractions of As and Zn as a function of varying initial As concentrations.

9.2.3 Sorption Sensitivity and Competitive Adsorption Effects

As the historical analogue water quality dataset did not include Zn concentrations, the calibrated PHREEQC model was essential to investigate the effects of competitive adsorption between trace metals on the ferrihydrite surface.

To vary the dosing plan under varying hydrogeochemical conditions, sensitivity analyses were executed using the historical GB water sample dataset over a range of Fe:As dosing mass ratios. The following effects on dosing performance were investigated by the modelling:

- Competitive adsorption by Zn: The sensitivity analysis applied an assumed initial Zn concentration of 0.05 mg/L (based on the predicted long-term post-closure value for the CO Pit Lake). The PHREEQC simulation indicates that co-adsorption of Zn reduces the net As sorption by less than 1%, confirming that competitive surface interference from Zn will not compromise the As remediation objective (Figure 59).

Mass-action Co-extraction: Conversely, Zn removal efficiency improves at higher initial As concentrations. Because the dosing plan maintains a constant Fe:As mass ratio, elevated initial As concentrations trigger a larger mass addition of $FeCl_3$, which increases the total ferrihydrite precipitate volume and generates a higher abundance of sorption sites available to capture aqueous Zn.

- Arsenic speciation control: Simulations demonstrate that As(V) has a higher sorption affinity for the ferrihydrite surface than As(III) under typical pit lake pH conditions. Consequently, if the

post-closure water bodies become As(III)-dominant, a higher ferric dose will be required to achieve the target compliance limits (Figure 60).

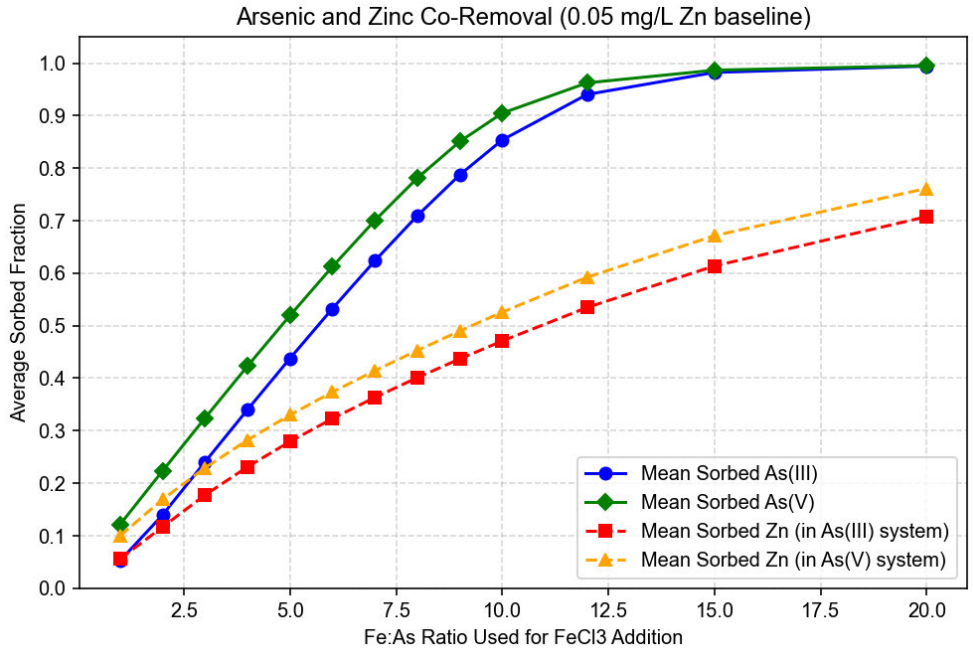

Figure 59: Average As sorption as a function of Fe:As dosing ratio (with 0.05 mg/L Zn).

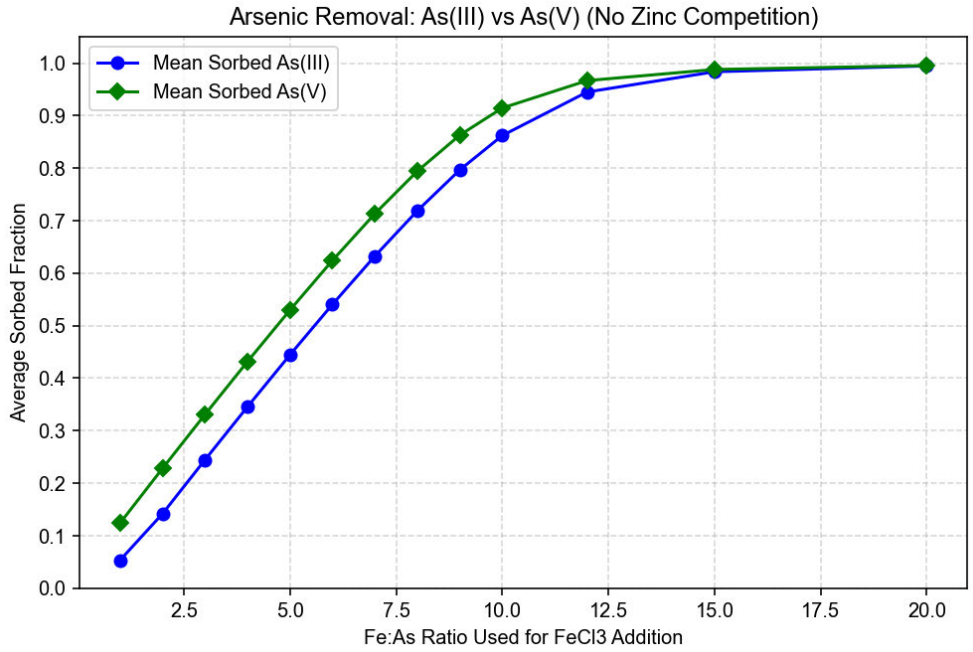

Figure 60: Average As sorption as a function of Fe:As dosing ratio (without Zn).

9.2.4 Operational Dosing Strategy and Inventory Requirements

As the geochemical evolution, initial water volumes, and hydrological filling rates are unique to each pit lake, the predictive dosing schedule was iteratively optimised over the 200-year post-closure duration. To effectively manage the evolving water chemistry and maintain dissolved trace metals consistently below the compliance targets, a targeted, two-stage adaptive dosing strategy is required:

- Initial phase: A relatively high initial chemical dose is applied during the first few years of treatment to rapidly reduce the accumulated dissolved metal concentrations within the existing pit lake water body.
- Steady-state maintenance phase: Following drawdown, operational transition to a lower-intensity, continuous maintenance dosing plan designed to attenuate the ongoing, low-volume mass inflows of As and Zn introduced via groundwater seepage and surface runoff.

Time-series concentration profiles demonstrating the effectiveness of this optimised two-stage dosing strategy for each pit lake are provided in Figure 61 to Figure 64.

The commencement year for dosing in each pit lake is triggered dynamically by its local hydrogeological timeline, starting prior to the earlier of either groundwater outflow initiation or pit lake spilling. Consequently, treatment for the GB and IM Pit Lakes commences immediately at Year 1, whereas CO and CN commence in Year 9 and Year 40, respectively. Operationally, dosing is recommended during unstratified periods (e.g., winter) to optimise reagent dispersion throughout the water column.

Total dosing mass demands vary across the four pits due to these site-specific treatment timelines, initial concentrations, and backfill interactions. The optimised 200-year total dosing inventories for each pit lake are compiled in Table 34. The calculated total amounts of $FeCl_3$ required, ranging from 108 to 394 IBCs of 40% $FeCl_3$ per pit lake over the 200-year period, align well with empirical operational metrics from the Globe Progress Pit Lake analogue site, which deployed approximately 100 IBCs under similar geoenvironmental conditions.

Table 34: Predicted $FeCl_3$ dosing schedules and requirements over a 200-year post-closure period.

PIT LAKE	NOMINAL PIT LAKE VOLUME (Mm^3)	TOTAL Fe REQUIRED (kg)	NUMBER OF IBC EQUIVALENT ($FeCl_3$ at 40% BY WEIGHT)	DOSING COMMENCEMENT YEAR
Golden Bar	~5.8	60,506	108	1
Coronation	~5.5	220,792	394	9
Coronation North	~15.0	168,447	301	40
Innes Mills	~25.0	160,523	287	1

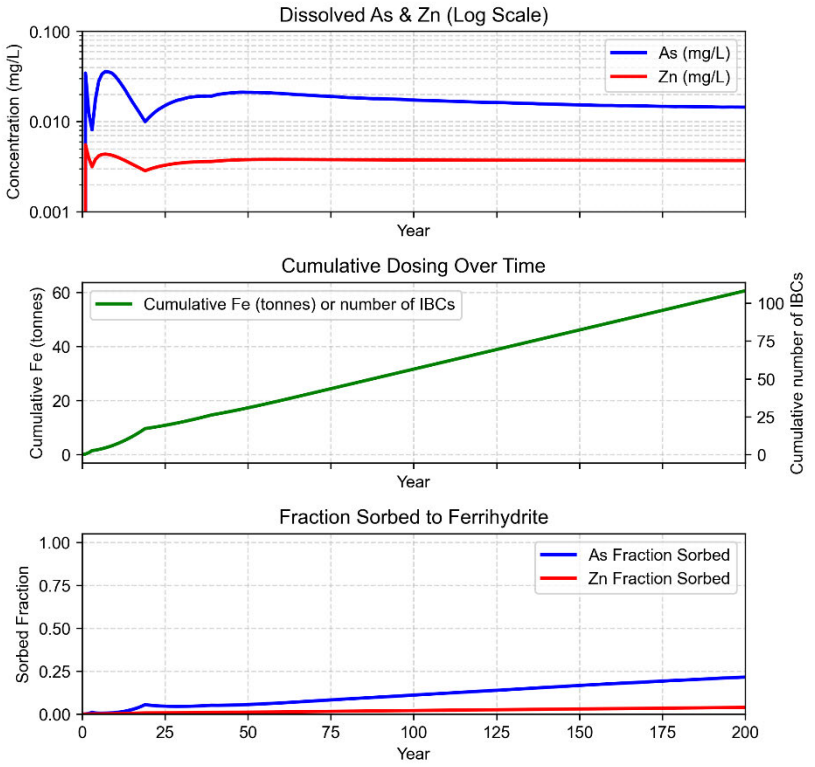

Figure 61: Predicted As and Zn concentrations under optimised $FeCl_3$ dosing for Golden Bar Pit Lake.

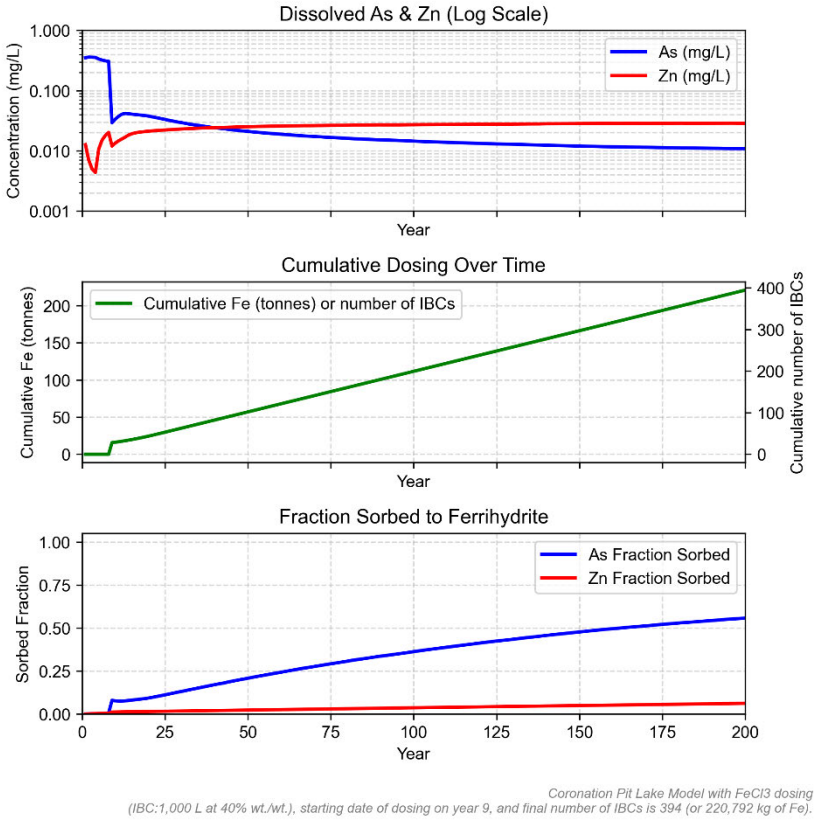

Figure 62: Predicted As and Zn concentrations under optimised $FeCl_3$ dosing for Coronation Pit Lake.

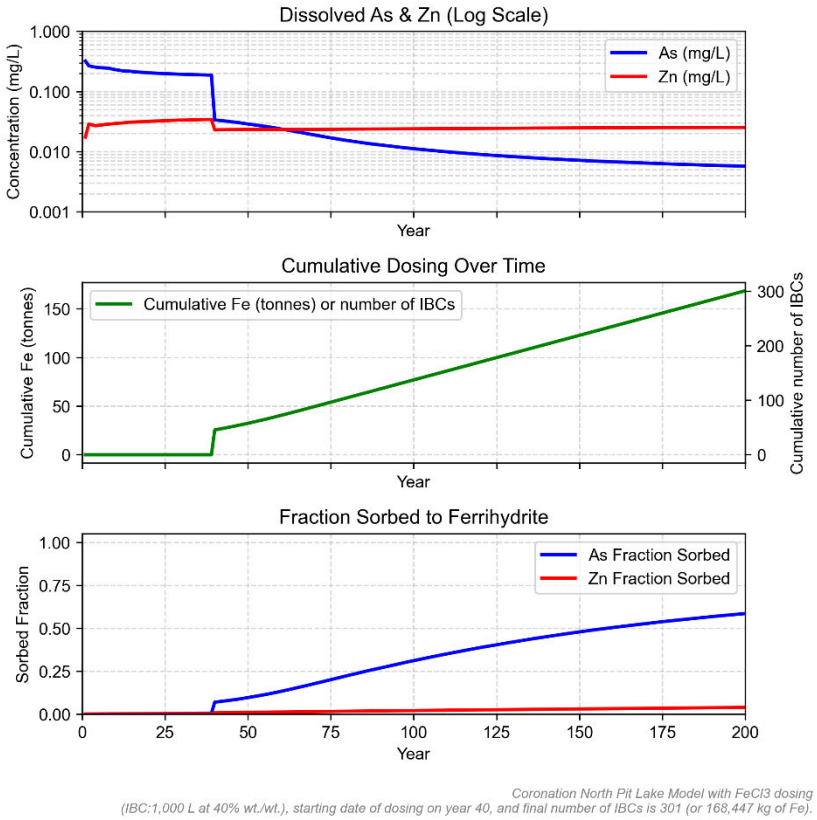

Figure 63: Predicted As and Zn concentrations under optimised $FeCl_3$ dosing for Coronation North Pit Lake.

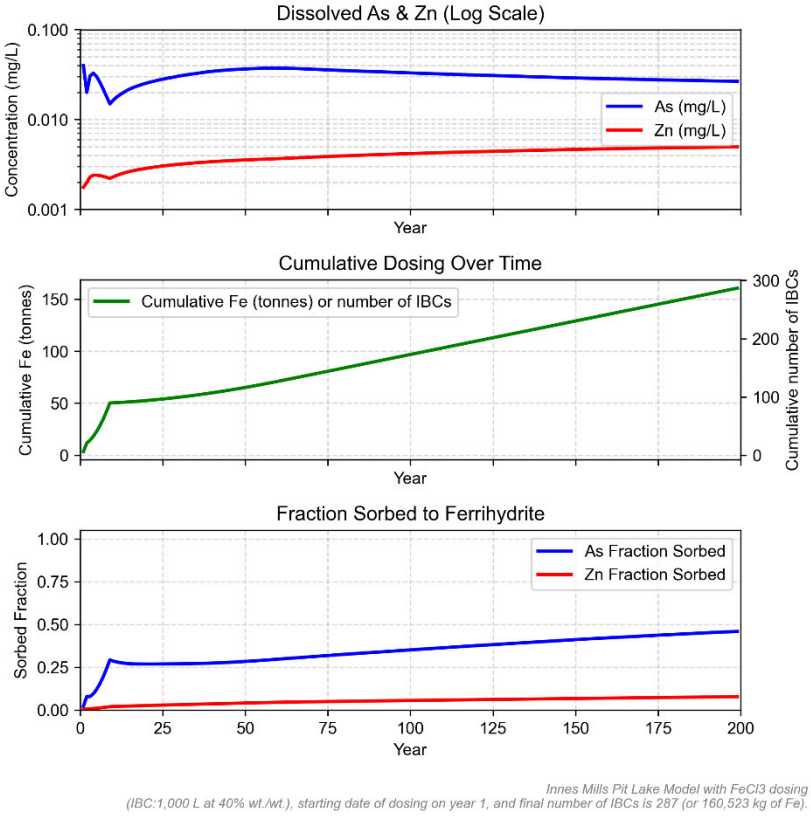

Figure 64: Predicted As and Zn concentrations under optimised $FeCl_3$ dosing for Innes Mills Pit Lake.

9.2.5 Engineering Delivery Strategy

To address practical implementation in the field and mitigate potential challenges associated with stratified boundary layer, the delivery of the $FeCl_3$ inventory will utilise specific delivery mechanisms based on analogue operational experience:

- Application mechanism: Delivery of the 40% (by weight) $FeCl_3$ solution will be achieved using a floating, high-volume farm effluent sprinkler system deployed directly on the pit lake surface to maximize initial lateral distribution.
- Mechanical mixing: Active mechanical turnover or deep mixing of the entire water body is not anticipated to be required. Empirical field evidence from the Globe Progress Pit Lake demonstrates that successful As attenuation can be achieved via surface dosing without active mechanical agitation. Dosing of the pit lake when it is not stratified could be advantageous.
- Aeration and oxidation: To ensure rapid oxidation of the dosed Fe and prevent localised anoxia (which could inhibit ferrihydrite precipitation), the application infrastructure will be supported by targeted aeration systems. This will involve the use of either localised trompes or bubble diffusers within the active dosing zone.

9.3 Golden Bar Pit Lake Water Treatment

The GB Pit is currently filled to capacity and passively discharges to Golden Bar Creek. Dewatering of this pit is required approximately two years prior to the commencement of the GB pit extension. As per OGNZL[6], water removed from the pit will be retained onsite for hydro mining, and OGNZL is currently working through the requirements and water storage. The primary management option indicated in OGNZL (2026) is to pump the water to Frasers Pit via a temporary pipeline installed adjacent to the Golden Bar haul road for reuse within the MWMS without treatment.

While direct reuse without treatment of the water is under consideration, comprehensive geochemical characterisation and the evaluation of the potential treatment strategies remain critical.

9.3.1 Golden Bar Water Quality Review

To inform the operational dewatering lifecycle, infrastructure risk management, and contingency treatment strategies, historical water quality monitoring data from the GB Pit Lake were reviewed. Water quality within the pit has been monitored since 2004, and this assessment incorporates the most up-to-date data available, extending to the end of 2025.

Temporal trends for pH, SO_4 and dissolved As concentrations are illustrated in Figure 65 to Figure 67. Key observations of the historical water quality data are summarised below:

- The pit water is slightly alkaline, stabilising at approximately pH 8.3 over the monitoring period.
- EC increased progressively from an initial value of approximately 450 µS/cm to a peak exceeding 900 µS/cm in 2015, followed by a gradual decline in recent years.

[6] *Via personal communication with* [redacted] *dated 13/7/2026.*

- Sulfate is the dominant anion in the pit water. Concentrations increased from approximately 50 mg/L to over 300 mg/L during the early monitoring phases, followed by a progressive decline from 2018 onwards.
- Calcium and Mg are the dominant cations. Concentrations of Ca stabilised at approximately 80 mg/L by 2017 before declining slightly in recent years. In contrast, Mg concentrations increased from approximately 15 mg/L to 80 mg/L by 2018 and have since remained stable around this level. The other two major cations, Na and K, have remained stable throughout the monitoring period at approximately 12 mg/L and 4 mg/L.
- Dissolved As concentrations show a decline trend, falling from over 0.7 mg/L during early monitoring to approximately 0.2 mg/L in 2012. In recent years, concentrations have fluctuated around 0.1 mg/L, with a trajectory toward even lower concentrations.
- Other trace elements, including Cu and Zn, remain consistently low, with concentrations typically near or below the LOR.

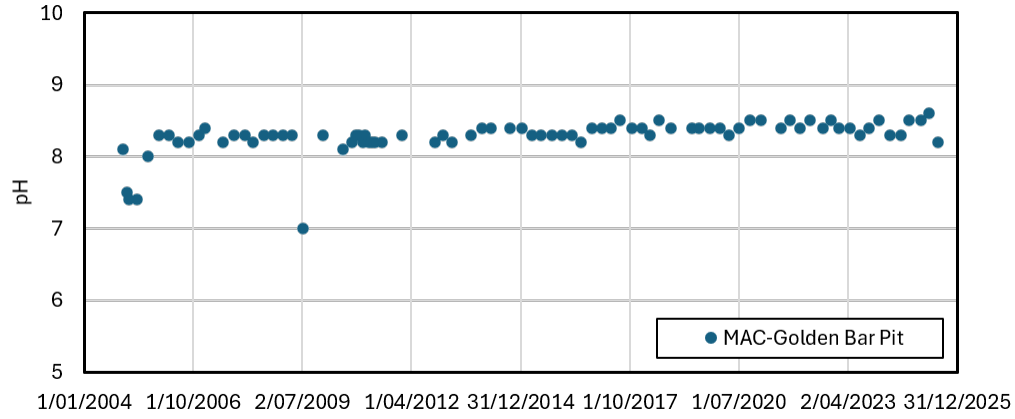

Figure 65: Time-series of pH for Golden Bar Pit water.

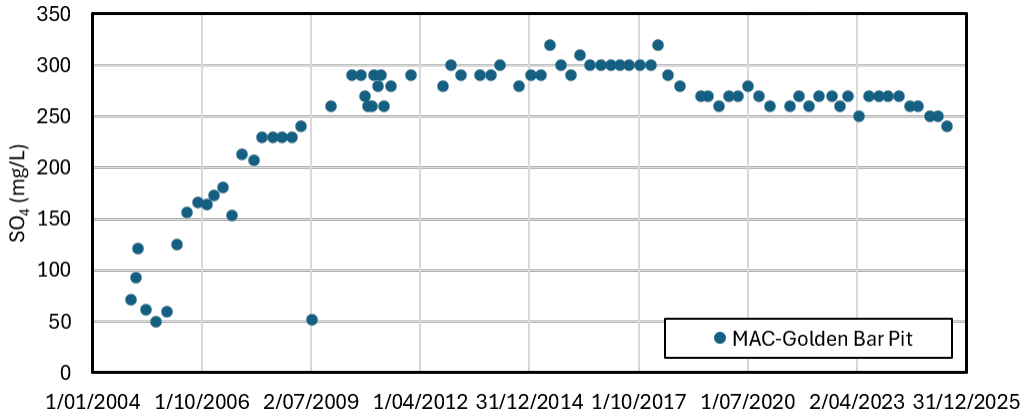

Figure 66: Time-series of SO_4 for Golden Bar Pit water.

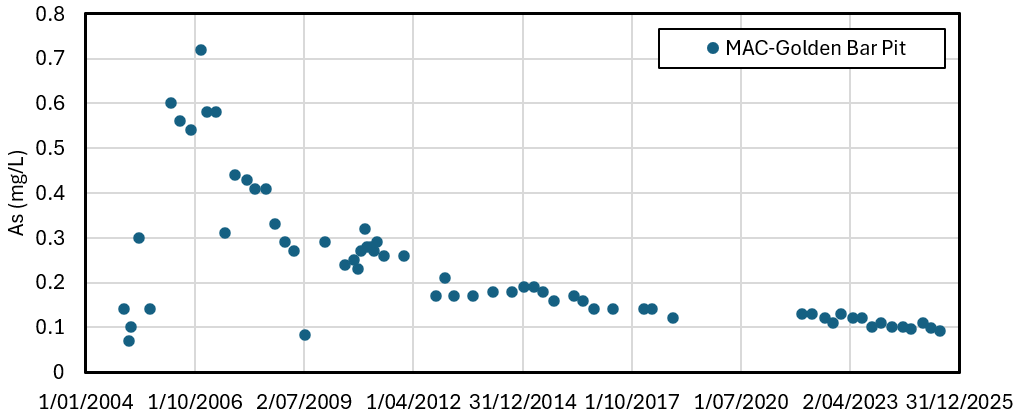

Figure 67: Time-series of As for Golden Bar Pit water.

The long-term SO_4 and As trends indicate that the chemical composition of the GB pit water has generally stabilised since 2012, though a slight decreasing trend is apparent. Consequently, the statistical water quality summary compiled in Table 35 represents this stable period from 2013 onward. Notably, the As concentration within the standing water body consistently exceed the proposed downstream ecological TV.

Table 35: Statistical summary of key parameters of Golden Bar Pit water

PARAMETER	UNIT	COUNT	MEDIAN	AVERAGE	MIN	MAX
pH	pH units	47	8.4	8.39	8.2	8.6
EC	µS/cm	47	900	899	834	970
Alk (Total)	mg/L as $CaCO_3$	47	230	227	194	250
Ca	mg/L	47	73	71.7	55	88
Mg	mg/L	47	75	75.6	60	89
Na	mg/L	47	13	13.0	11	15
K	mg/L	47	4.3	4.34	3.7	5.9
SO_4	mg/L	47	270	280	240	320
Cl^-	mg/L	47	6.4	6.04	2.5	9
NH_4-N	mg/L	44	0.005	0.008	0.005	0.05
NO_3-N	mg/L	28	0.004	0.006	0.001	0.023
NO_x-N	mg/L	43	0.008	0.013	0.001	0.12
As	mg/L	31	0.13	0.139	0.093	0.21
Cu	mg/L	31	0.00025	0.00037	0.00025	0.0009
Fe	mg/L	31	0.01	0.016	0.01	0.12
Pb	mg/L	31	0.00005	0.00006	0.00005	0.00023
Sb	mg/L	10	0.00225	0.0022	0.0018	0.003
Zn	mg/L	13	0.0005	0.0008	0.0005	0.002
As (total)	mg/L	31	0.13	0.128	0.094	0.17
Cu (total)	mg/L	31	0.000265	0.000455	0.000265	0.002
Fe (total)	mg/L	31	0.04	0.1491	0.0105	1.9
Pb (total)	mg/L	31	0.000055	0.000138	0.000055	0.0015
Sb (total)	mg/L	14	0.00215	0.0022	0.0017	0.0028
Zn (total)	mg/L	16	0.00055	0.00132	0.00055	0.0065
WAD CN	mg/L	15	0.01	0.01	0.01	0.05

9.3.2 Water Treatment Recommendations

Water quality within the current GB Pit is affected by mine-impacted waters. Particularly As concentrations have ranged between 0.09 and 0.17 mg/L, which requires active management prior to water discharge.

To enable the controlled discharge of the GB Pit Lake to the receiving environment and to validate the long-term predictive models that utilise in-pit treatment, it is recommended that the GB Pit Lake is treated with $FeCl_3$ prior to the commencement of dewatering to the MWMS to:

- Provide site-specific operational experience with the treatment of standing pit lake water to remove dissolved metals such as As, Cu, and Zn. These field datasets will be used to calibrate and optimise the dosing program for the long-term, post-closure pit lake treatment.
- Mitigate immediate environmental risk and minimise downstream compliance risks, providing an opportunity to safely discharge the treated GB Pit Lake waters to the receiving environment without exceeding downstream ecological TVs.

10 SUMMARY AND RECOMMENDATIONS

10.1 MP4 Pit Lake Post-Closure Water Quality Summary

The hydrogeochemical modelling provides a 200-year prediction of the post-closure water quality for the GB, CO, CN, and IM. A comprehensive summary of the predicted water quality for each pit lake at the point of surface spilling is provided in Table 33. The key results are provided in the following sections.

10.1.1 General Water Quality Signature

The overall hydrogeochemical signature of the four pit lakes is characterised by the following long-term trends:

- pH and alkalinity: All four pit lakes will be circumneutral and highly buffered, maintaining a stable pH of approximately 7.6 to 7.7. This is supported by total alkalinity concentrations consistently exceeding 140 mg/L as $CaCO_3$.
- Salinity and major ions: The pit lake waters will be brackish to saline and dominated by SO_4 and Mg. Average SO_4 concentrations will range from approximately 500 mg/L in CN up to over 2,000 mg/L in IM. Calcium concentrations will remain comparatively lower, constrained by the secondary precipitation of calcite.
- Trace metals: The oxidising, circumneutral conditions will promote the rapid oxidation and precipitation of iron as amorphous ferrihydrite. This precipitate provides critical reactive surface areas that adsorb and sequester most dissolved trace metals and metalloids (e.g., Cu, Pb) through surface complexation, maintaining generally low dissolved concentrations.
- Nitrogenous species: Nitrate and ammoniacal N loads, derived primarily from ANFO in the backfill and pit walls, will decline to negligible levels within the first 10 to 20 years post-closure.

10.1.2 Comparison against Viridis Trigger Values

While the overall pit lake water quality remains relatively stable over the long-term, comparisons against the conservative Viridis (2026) ecological TVs highlight specific parameters of concern that will require downstream dilution or active management prior to reaching compliance sites:

- Sulfate: Driven by high overall salinity, SO_4 concentrations in the CN and IM Pit Lakes are predicted to exceed the hardness-modified TV of 1,000 mg/L.
- Arsenic: Despite active surface adsorption onto ferrihydrite, As concentrations will stabilise between 0.2 and 0.3 mg/L across all four pit lakes, consistently exceeding the TV of 0.013 mg/L without active treatment.
- Zinc: Zn concentrations are predicted to exceed the TV of 0.016 mg/L in the CO and CN Pit Lakes. Unlike other trace metals, Zn is expected to continue on a rising trajectory in these pits due to ongoing, decoupled mass loading from adjacent WRS and backfill seepage.

Compliant Parameters: All other modelled parameters, including Cu, Pb, cyanide, and nitrogen species, are predicted to remain below their respective TVs in all pits.

- Treatment of pit lakes is required using $FeCl_3$.

10.2 Recommendations for Further Work

Further work is required to support adaptive management of final pit lakes. This includes:

10.2.1 Pit Lake Monitoring and Modelling

- Stratification and Mixing Validation: Implement a targeted monitoring programme at the GB Pit Lake prior to dewatering, collecting monthly multi-depth water samples and vertical physicochemical profiles. This high-frequency monthly sampling is required to characterise physical stratification cycles, validate seasonal vertical turnover, and resolve hydrodynamic uncertainties in the long-term predictive models.
- Source Term Refinement: Refine pit wall runoff source terms by incorporating time-decaying solute release to account for progressive mineral weathering and surface passivation. This should be supported by field pit wall wash testing on exposed wall faces of varying weathering ages (such as the historical GB wall faces) to validate the transferability of the GB analogue term across all proposed pit voids.
- Comprehensive Pit Lake Modelling: Develop an integrated, multi-dimensional pit lake model for each proposed pit void to support final closure planning (i.e., closure readiness planning). During the operational phase, these models should be upgraded to simulate physical hydrodynamics, seasonal stratification, biogeochemical processes, and nutrient cycling, using refined geochemical source terms validated against site-specific data.

10.2.2 Pit Lake Treatment Trials

- Active Treatment and Field Validation: Conduct site-specific, bench-scale laboratory trials to verify exact $FeCl_3$ dosing requirements prior to full-scale deployment. Subsequently, undertake $FeCl_3$ dosing trials at GB Pit Lake to validate the process works in the field.

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12 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix G of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A SOLUTE RELEASE RATES FROM IBC FIELD TRIALS

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MEMORANDUM

Recipient:	OceanaGold (New Zealand) Limited c/- [redacted]
From:	Paul Weber – Mine Waste Management Limited (MWM)
Date:	31 August 2026
Cc:	[redacted] – OceanaGold Raimundo Brahm – MWM; Eric Chen – MWM
Document Number:	J-NZ0498-010-M-FINAL
Document Title:	Solute Release Rates: IBC Field Trials
Disclaimer:	This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

Mine Waste Management Limited (MWM) has been engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess environmental geochemistry hazards and potential effects for the proposed Macraes Phase Four Project (MP4 or the Project). This assessment supports the application as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

To support this assessment, saturated field leach trials using IBC[1] (IBC trials) were undertaken on representative waste rock materials. These trials were designed to evaluate the potential constituents of concern (PCOC) and associated solute loads that may be mobilised upon submergence of waste rock (e.g., within a future pit lake).

This memorandum presents a comprehensive evaluation of the IBC trial dataset, providing field-scale estimates of solute load release that offer greater site-specificity than conventional laboratory-based tests (e.g., SFE[2]/SPLP[3]). These estimates will inform predictive water quality modelling of Coronation Pit, Coronation North Pit, and Innes Mills Pits following backfilling and saturation.

OBJECTIVES

This memorandum documents the IBC trials undertaken and addresses the following objectives:

- Quantification of solute release from the IBC trials to derive a representative source term for saturated waste rock solute load.
- Evaluation of the IBC trial source terms compared to source terms derived from laboratory-based leach tests.

[1] *Intermediate bulk container (1 m^3)*
[2] *Shake flask extraction*
[3] *Synthetic Precipitation Leaching Procedure*

BACKGROUND

During mine closure, a pit can be backfilled with various materials, such as waste rock and tailings. While the storage of waste rock as backfill benefits the long-term geochemical stability of the submerged materials, it may introduce PCOCs to an evolving pit lake through three mechanisms:

- Surface runoff from the backfill due to rainfall when the material sits above the lake water level.
- Seepage through the backfill due to rainfall infiltrating the material when it sits above the lake water level.
- Release of soluble PCOCs from the backfill as the materials are saturated by rising pit lake water levels.

Conventional laboratory tests (e.g., SFE/SPLP) on crushed, sub-2 mm material are often used as a conservative approach to derive source terms for solute loads and to inform long-term water quality predictions for pit lakes. However, this approach can result in overly conservative estimates that do not reflect site-specific conditions (e.g., field materials have larger particle sizes and smaller surface areas per unit mass compared to laboratory samples).

The IBC trials are intended to simulate field conditions of saturated waste rock by using 'as blasted' materials', providing a representative understanding of the PCOC loads released upon submergence.

METHODOLOGY

Materials

The study consists of six saturated leach trials using 1,000 L IBCs and two types of freshly blasted waste rock materials (Figure 1):

- Three IBCs contained overburden (OB) materials from the Coronation North Pit.
- Three IBCs representative of interburden (IB) materials (shear zone materials) sourced from the Innes Mills Pit.

Trial Establishment

Waste rock was passed through a 200 mm grizzly screen to segregate oversize and undersize fractions (Figure 1). Due to the schistose nature of the material (which fractures along foliation planes), the large oversized tabular fragments were generally ~500 mm by < 100 mm and could be used in the IBC trials. The IBC tops were removed, and the material was loaded by excavator at a visually estimated oversize-to-undersize ratio of 1:3 to maintain a grain size distribution representative of a backfill pile.

Multiple grab samples (approximately five samples per IBC[4]) were collected during loading. These samples were combined to form a single composite sample for each IBC and dispatched to SGS Laboratory for geochemical characterisation.

[4] *Grab sample grain size of <100 mm due to constraints of sample bags.*

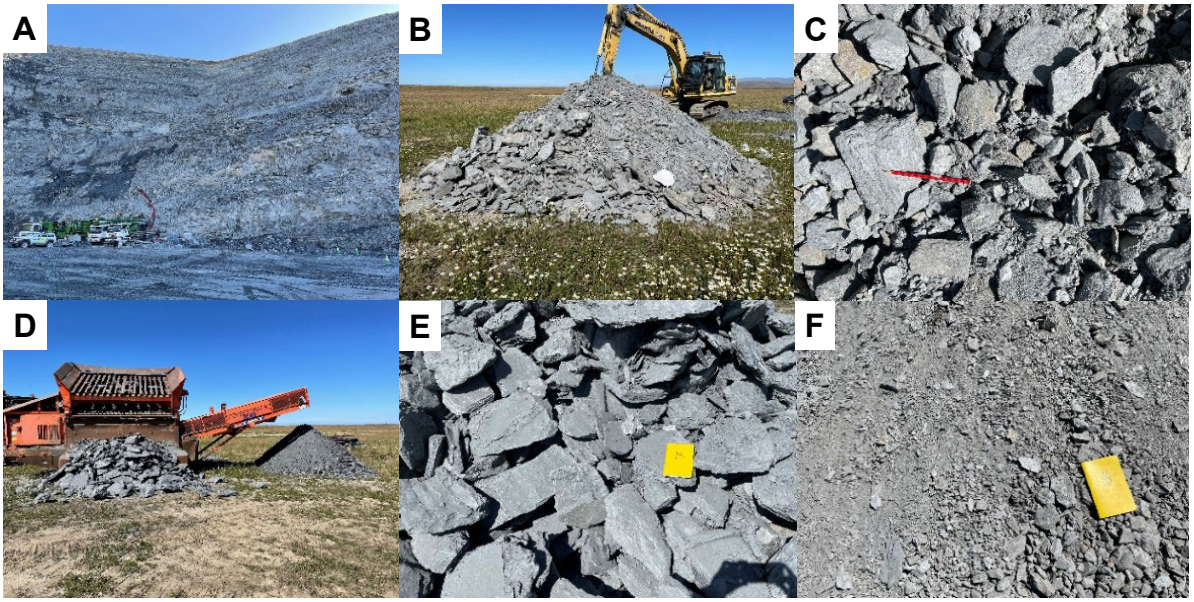

Figure 1: Photos of selected waste rock samples and the size splitting process.

(A) IB material at source location (Innes Mills Pit).
(B) OB pile used in IBC trials.
(C) OB pile close-up (before size splitting).
(D) Size splitting of IB pile through 200 mm grizzly screen.
(E and F) Resulting coarse IB and fine OB materials, respectively.

Waste Rock Saturation

Potable water (Palmerston township supply) was added to the waste rock filled IBCs to establish saturated conditions (Figure 2). The IBCs were weighed before and after the water addition, and the total quantity of water was estimated by the weight difference (Table 1). The IBCs were left uncovered, allowing exposure to ambient conditions (e.g., temperature, evaporation, precipitation).

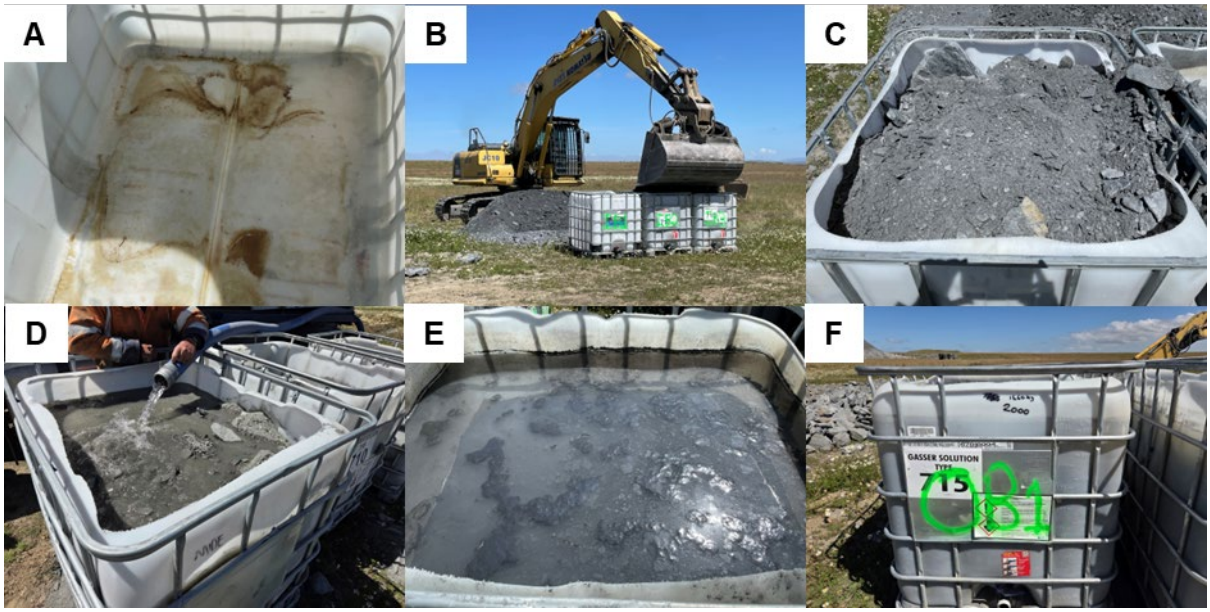

Figure 2: IBC trial system.

(A) Empty IBC container; (B) IBCs being filled with IB material; (C) IB1 trial filled with dry rock; (D) Filling IBC with water; (E) Saturated IB2; and (F) Full setup of OB1.

Table 1: Measured and calculated parameters.

	UNITS	OB1	OB2	OB3	IB1	IB2	IB3
Dry rock weight	kg	1,595	1,335	1,535	1,555	1,415	1,455
Saturated weight	kg	1,935	1,795	1,935	2,035	1,785	1,885
Water weight (volume[1])	kg (L)	340	460	400	480	370	430
Saturated volume	L	950	900	930	990	970	940
Bulk density[2]	kg/L	2.6	3.0	2.9	3.0	2.4	2.9
Porosity[3]	vol%	23	41	32	39	26	35

[1] Assuming a density of 1 kg/L.

[2] Calculated as: Dry rock weight / (Saturated volume – Water volume).

*[3] Calculated as: 100 * (Water volume - dV) / (Saturated volume - dV), where dV is the volume of water above the surface of the rock material, estimated as 0.15 m^3 from the measured height of the water column in the IBCs (~125 mm; measured from photographs of the rock and water surface levels).*

Sample Collection and Analysis

Four rounds of sampling have been completed by OGNZL staff. The first round was conducted one day after the initial IBC establishment (5/02/2026), with subsequent rounds at day 8, 23, and 37. Samples were collected as a composite of approximately 50% water from the bottom valve and 50% surface water (where available).

All samples were sent to R J Hill Laboratories Limited for analysis. A sample was also collected from the potable water supply for analysis. The composition of the potable water sample was subtracted from the IBC water samples to account for the solute contribution from the water supply.

Water samples were analysed for major anions (Cl^-[5], SO_4[6]) and cations, total alkalinity, nitrogen species, and trace total/dissolved metal(loid)s (Attachment A).

Solute concentrations (mg/L) are directly measured from samples collected from the IBCs and reflect how much of a given solute is present in the trial water. To allow for scaling of these concentrations to larger or variable rock masses, solute loads (mg/kg) are calculated from these measured concentrations and represent the mass of solute released per kg of waste rock. These mass normalised solute loads then allow porewater concentrations to be estimated for any backfill volume by applying the load to the total rock mass and the anticipated volume of porewater.

The solute loads were calculated from the dissolved concentrations using the following equations:

Equation 1: $$\mathrm{L_C(mg)} = \left([\mathrm{C}]_{\mathrm{sample}}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) - [\mathrm{C}]_{\mathrm{PW}}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right)\right) \cdot \mathrm{V_w(L)}$$

Equation 2: $$\mathrm{SL_C}\left(\frac{\mathrm{mg}}{\mathrm{kg}}\right) = \frac{\mathrm{TL_C(mg)}}{\mathrm{W_r\ (kg)}} \frac{\mathrm{L_C(mg)}}{\mathrm{W_r\ (kg)}}$$

Where L_C is the total load of solute C released in the IBC trial, $[C]_{sample}$ and $[C]_{PW}$ are the measured solute concentrations in the leach sample and potable water, respectively. V_w is the initial water volume added to the IBC, SL_C is the mass-normalised specific solute load, and W_r is the dry weight of the rock material.

Water levels declined at variable rates during the trial:

[5] Chloride.

[6] Sulfate.

- OB1 remained fully submerged with 50 mm above the rock surface, OB2 and IB2 were partially exposed, and OB3 and IB3 had water levels ~250 mm below the rock surface.
- During the third sampling round (27/02/2026), it was noted that the IB1 IBC was dry due to leakage from a crack in the IBC. As a result, there are only two porewater samples available for IB1 (05/02 and 12/02).
- Due to this variable loss in water across trials, solute load calculations were based on the initial water volume. This approach results in an overestimate (i.e., a conservative estimate) of the solute load, as the measured concentrations are applied to a water volume greater than that present in the IBC at the time of measurement.

Acid Base Accounting (ABA) and SFE Tests

Samples from each IBC trial (four per IBC) were collected for ABA and SFE testing:

- ABA analysis was completed on samples obtained from the trial materials and included total sulfur (S wt%) and carbon (C wt%) determination by LECO, ANC[7], paste pH (1:2) and NAG[8] testing using standard SGS laboratory methods. The reported MPA[9] are calculated assuming all S is pyritic.
- SFE tests were performed on samples crushed to ≤ 2 mm, using a 1:10 solid-to-water ratio (20 g sample to 200 mL deionised water), agitated for 18 hours. The leachate was analysed for major anions (Cl, SO_4) and cations, total alkalinity, nitrogen species, and trace total/dissolved metal(loid)s.

RESULTS

ABA Analysis

All samples are classified as NAF[10]. Key geochemical data are provided in Table 2 and Figure 3.

Table 2: Results from ABA analyses.

	UNITS	OB1	OB2	OB3	IB1	IB2	IB3
Total S	wt%	0.128	0.118	0.155	0.225	0.318	0.291
Total C	wt%	0.36	0.35	0.37	0.92	0.94	0.98
Paste pH	pH Units	8.7	8.6	9.0	9.0	9.0	9.0
ANC	kg H_2SO_4/t	23	24	23	51	56	61
MPA	kg H_2SO_4/t	3.9	3.6	4.7	6.9	9.7	8.9
NAPP	kg H_2SO_4/t	-19	-20	-19	-44	-46	-52
NAG pH	pH Units	5.4	5.2	4.9	6.6	6.6	6.6
NAG to pH 7.0	kg H_2SO_4/t	13	18	21	3	2	2

[7] *Acid Neutralisation Capacity.*
[8] *Net Acid Generation.*
[9] *Maximum Potential Acidity.*
[10] *Non-Acid Forming.*

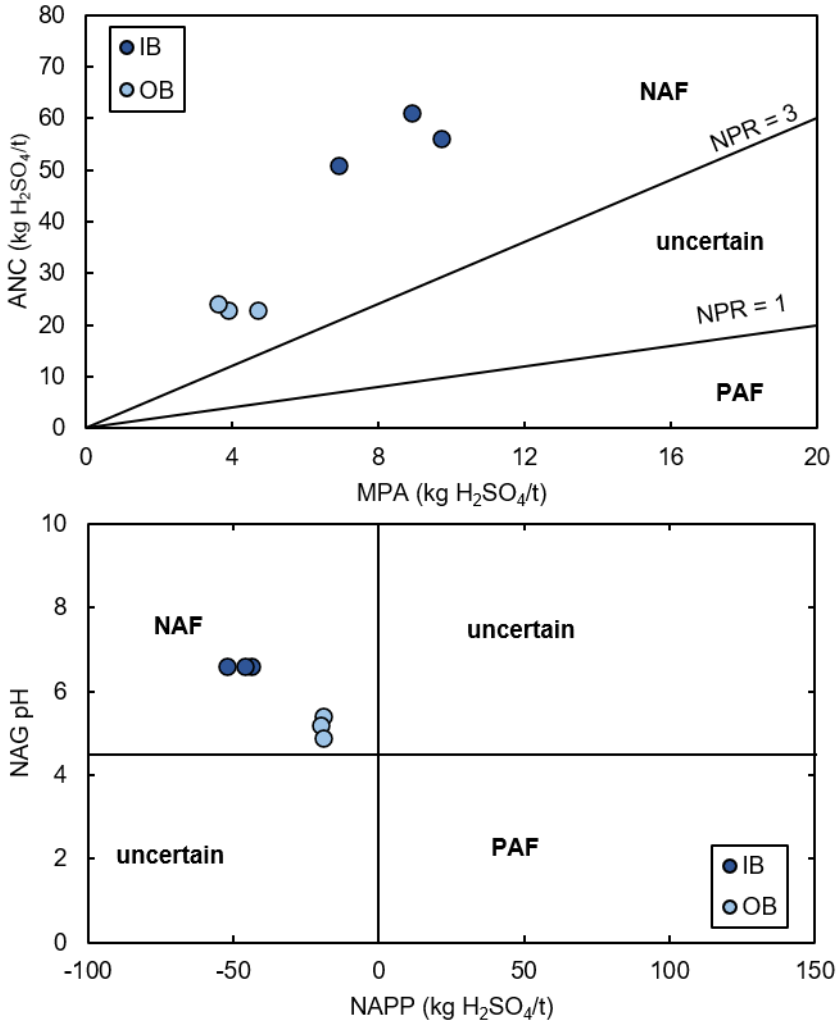

Figure 3: ABA plots for IB and OB rock types.

Top: Price (2009) classification based on NPR[11] = ANC / MPA (incorporating a site-specific threshold of NPR = 3).
Bottom: AMIRA (2002) classification based on NAPP[12] = MPA – ANC.

IBC Trial Solute Loads

The results of laboratory analyses for the IBC porewater and potable water samples are provided in Table 3 and Table 4. The charge balance error for all samples was within the acceptable threshold (±10%), indicating good agreement between major cations and anions and supporting the reliability of the analytical results.

The calculated solute loads are provided in Table 5 and Table 6. Negative results indicate where solutes in potable water were reported as higher concentrations than in the porewater. No dissolved concentration data are available for the final sampling round (13/03); the total concentrations of Na, K, Ca, Mg, and Sr were used as a proxy for dissolved concentrations in the solute load calculations, which is considered a conservative approach.

[11] *Neutralisation Potential Ratio.*
[12] *Net Acid Production Potential.*

Table 3: Geochemical composition of potable water and porewater from IBC field trials for IB material.

	UNITS	POTABLE WATER	IB1-1	IB1-2	IB2-1	IB2-2	IB2-3	IB2-4	IB3-1	IB3-2	IB3-3	IB3-4
Date	day/month	5/02	5/02	12/02	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03
pH	pH unit	7.7	7.9	7.9	7.8	8.0	8.0	8.2	8.0	8.0	8.0	8.2
EC	µS/cm	247	394	587	358	528	583	665	350	551	586	645
						DISSOLVED CONCENTRATIONS						
Alk_{Tot}	mg/L $CaCO_3$	69	106	200	100	167	200	220	94	176	195	220
SO_4	mg/L	22	50	64	41	62	69	85	41	65	72	83
Cl	mg/L	15	17	19	17	18	19	21	16	19	19	19
Ammonia-N	mg/L	<0.010	1.010	0.860	0.390	0.760	0.450	0.049	0.660	0.870	0.124	<0.010
NO_3-N	mg/L	0.480	1.940	0.053	1.510	0.700	0.450	0.840	2.100	0.390	1.120	0.420
NO_2-N	mg/L	<0.002	0.109	0.010	0.185	0.240	0.032	0.012	0.115	0.174	0.068	0.003
Na	mg/L	16.2	21.0	27.0	20.0	26.0	26.0	--	21.0	27.0	27.0	--
K	mg/L	1.56	13.50	18.30	9.40	15.60	16.30	--	10.80	16.50	14.90	--
Mg	mg/L	7.3	11.4	17.2	10.6	16.5	19.3	--	10.0	17.3	19.9	--
Ca	mg/L	27	37	62	36	55	61	--	34	57	64	--
Sr	mg/L	0.145	0.450	0.840	0.370	0.720	0.810	--	0.390	0.760	0.830	--
Fe	mg/L	<0.02	0.03	<0.02	<0.02	<0.02	0.18	--	<0.02	<0.02	<0.02	--
Mn	mg/L	<0.0005	0.0118	0.0830	0.0220	0.1480	0.2700	--	0.0159	0.0290	0.0058	--
Al	mg/L	<0.003	0.056	0.009	0.015	0.008	0.004	--	0.018	0.009	0.008	--
As	mg/L	<0.0010	0.0500	0.1330	0.0420	0.1040	0.2600	--	0.0510	0.0660	0.0920	--
Mo	mg/L	<0.0002	0.0091	0.0178	0.0061	0.0164	0.0200	--	0.0072	0.0157	0.0240	--
U	mg/L	0.00004	0.00700	0.01950	0.00550	0.01620	0.02400	--	0.00640	0.02200	0.03100	--
Co	mg/L	<0.0002	0.0016	0.0037	0.0014	0.0031	0.0029	--	0.0014	0.0033	0.0048	--
Ni	mg/L	<0.0005	0.0094	0.0189	0.0068	0.0176	0.0179	--	0.0088	0.0220	0.0290	--
V	mg/L	<0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	--	0.0010	0.0011	<0.0010	--
Cu	mg/L	0.0064	0.0006	<0.0005	0.0009	<0.0005	<0.0005	--	<0.0005	<0.0005	<0.0005	--
Zn	mg/L	0.0106	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	--	<0.0010	<0.0010	<0.0010	--
						TOTAL CONCENTRATIONS						
Na	mg/L	--	--	--	--	--	--	32	--	--	--	30

	UNITS	POTABLE WATER	IB1-1	IB1-2	IB2-1	IB2-2	IB2-3	IB2-4	IB3-1	IB3-2	IB3-3	IB3-4
Date	day/month	5/02	5/02	12/02	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03
K	mg/L	--	--	--	--	--	--	19	--	--	--	17
Mg	mg/L	--	--	--	--	--	--	23	--	--	--	26
Ca	mg/L	--	--	--	--	--	--	68	--	--	--	74
Sr	mg/L	0.146	0.500	0.840	0.460	0.700	0.820	0.980	0.450	0.760	0.830	1.010
Fe	mg/L	0.02	23.00	0.80	15.80	0.41	1.16	--	16.70	1.69	1.58	0.00
Mn	mg/L	<0.00053	0.28	0.10	0.36	0.15	0.28	0.09	0.22	0.05	0.03	0.25
Al	mg/L	<0.0032	8.00	0.29	4.50	0.14	0.35	0.92	5.50	0.53	0.57	6.90
As	mg/L	<0.0011	0.085	0.139	0.117	0.105	0.300	0.210	0.080	0.075	0.099	0.195
Mo	mg/L	<0.00021	0.01140	0.01930	0.00570	0.01780	0.02200	0.04800	0.00930	0.01880	0.02700	0.06100
U	mg/L	0.00004	0.00900	0.02100	0.00700	0.01710	0.02300	0.03500	0.00790	0.02300	0.03200	0.04000
Co	mg/L	<0.00021	0.0123	0.0040	0.0146	0.0032	0.0033	0.0056	0.0102	0.0045	0.0054	0.0280
Ni	mg/L	<0.00053	0.0300	0.0190	0.0280	0.0173	0.0187	0.0270	0.0250	0.0230	0.0310	0.0590
V	mg/L	<0.0011	0.0167	0.0014	0.0124	0.0012	0.0014	0.0029	0.0125	0.0021	0.0021	0.0145
Cu	mg/L	0.0068	0.0072	<0.00053	0.0080	<0.00053	<0.00053	0.0015	0.0046	<0.00053	0.0006	0.0066
Zn	mg/L	0.0197	0.0500	0.0027	0.0410	0.0012	0.0028	0.0062	0.0360	0.0058	0.0041	0.0450

EC: Electrical conductivity; Alk_{Tot}: Total alkalinity; Ammonia-N: Total ammoniacal-N; NO_2-N: Nitrite-N; NO_3-N: Nitrate-N; SO_4: Sulfate.

Table 4: Geochemical composition of IBC field trials for OB material.

	Units	OB1-1	OB1-2	OB1-3	OB1-4	OB2-1	OB2-2	OB2-3	OB2-4	OB3-1	OB3-2	OB3-3	OB3-4
Date	day/month	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03
pH	pH unit	7.4	7.4	7.4	7.7	7.4	7.5	7.5	7.6	7.5	7.4	7.4	7.4
EC	µS/cm	381	519	513	571	325	421	426	472	390	511	523	587
		DISSOLVED CONCENTRATIONS											
Alk_{Tot}	mg/L $CaCO_3$	76	135	130	112	68	95	85	70	70	116	126	134
SO_4	mg/L	61	87	93	128	43	72	88	115	63	96	99	115
Cl	mg/L	16	18	19	22	16	18	18	20	16	19	20	23
Ammonia-N	mg/L	1.100	1.120	0.650	0.350	1.070	1.050	0.570	0.250	1.610	1.470	0.870	1.330
NO_3-N	mg/L	3.300	0.210	0.053	0.090	3.300	0.410	0.061	0.320	5.100	0.135	0.116	0.004
NO_2-N	mg/L	0.510	0.059	0.019	0.011	0.200	0.141	0.004	0.017	0.210	0.043	0.012	<0.002
Na	mg/L	22.0	24.0	23.0	--	16.7	21.0	20.0	--	18.2	22.0	22.0	--
K	mg/L	8.60	11.80	11.40	--	6.90	10.70	10.60	--	10.60	13.40	12.90	--
Mg	mg/L	16.8	24.0	26.0	--	13.5	18.6	21.0	--	18.6	24.0	27.0	--
Ca	mg/L	25	34	35	--	19	24	26	--	24	29	33	--
Sr	mg/L	0.180	0.260	0.250	--	0.125	0.165	0.172	--	0.142	0.210	0.210	--
Fe	mg/L	<0.02	0.90	2.30	--	<0.02	<0.02	0.17	--	<0.02	<0.02	2.70	--
Mn	mg/L	2.3000	5.0000	3.6000	--	2.1000	3.5000	2.8000	--	3.1000	4.6000	4.3000	--
Al	mg/L	0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	--	<0.003	<0.003	<0.003	--
As	mg/L	0.0013	0.0950	0.1510	--	<0.0010	0.0017	0.0036	--	<0.0010	0.0025	0.0290	--
Mo	mg/L	0.0007	0.0012	0.0013	--	0.0006	0.0009	0.0006	--	0.0007	0.0009	0.0014	--
U	mg/L	0.00013	0.00022	0.00024	--	0.00007	0.00010	0.00008	--	0.00007	0.00012	0.00011	--
Cr	mg/L	0.0006	<0.0005	0.0006	--	0.0006	<0.0005	<0.0005	--	<0.0005	<0.0005	<0.0005	--
Co	mg/L	0.0190	0.0280	0.0151	--	0.0181	0.0270	0.0181	--	0.0240	0.0310	0.0190	--
Ni	mg/L	0.0210	0.0370	0.0270	--	0.0200	0.0370	0.0410	--	0.0270	0.0370	0.0240	--
V	mg/L	<0.0010	<0.0010	<0.0010	--	<0.0010	<0.0010	<0.0010	--	<0.0010	<0.0010	<0.0010	--
Cu	mg/L	0.0013	<0.0005	<0.0005	--	0.0010	<0.0005	0.0005	--	0.0007	<0.0005	<0.0005	--
Zn	mg/L	0.0019	0.0020	0.0014	--	0.0014	0.0018	0.0029	--	0.0010	0.0018	0.0020	--
		TOTAL CONCENTRATIONS											
Na	mg/L	--	--	--	28	--	--	--	23	--	--	--	26

	Units	OB1-1	OB1-2	OB1-3	OB1-4	OB2-1	OB2-2	OB2-3	OB2-4	OB3-1	OB3-2	OB3-3	OB3-4
Date	day/month	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03
K	mg/L	--	--	--	12	--	--	--	11	--	--	--	14
Mg	mg/L	--	--	--	30	--	--	--	23	--	--	--	33
Ca	mg/L	--	--	--	36	--	--	--	28	--	--	--	37
Sr	mg/L	0.182	0.260	0.250	0.270	0.136	0.163	0.163	0.189	0.156	0.210	0.220	0.260
Fe	mg/L	9.80	5.10	5.60	--	17.20	2.50	1.69	--	15.20	1.45	3.80	--
Mn	mg/L	2.50	5.10	3.50	1.96	2.60	3.60	2.70	1.20	3.40	4.60	4.20	6.50
Al	mg/L	3.00	1.41	0.91	1.33	5.60	0.82	0.48	0.77	4.60	0.48	0.37	5.90
As	mg/L	0.022	0.107	0.170	0.110	0.013	0.004	0.005	0.005	0.014	0.004	0.032	0.053
Mo	mg/L	0.00054	0.00105	0.00128	0.00088	0.00071	0.00088	0.00073	0.00052	0.00070	0.00083	0.00148	0.00129
U	mg/L	0.00083	0.00046	0.00044	0.00051	0.00088	0.00022	0.00017	0.00017	0.00094	0.00021	0.00019	0.00094
Co	mg/L	0.0290	0.0310	0.0177	0.0104	0.0320	0.0310	0.0195	0.0091	0.0390	0.0340	0.0199	0.0380
Ni	mg/L	0.0310	0.0390	0.0310	0.0270	0.0380	0.0400	0.0430	0.0440	0.0460	0.0380	0.0250	0.0440
V	mg/L	0.0060	0.0027	0.0019	0.0027	0.0101	0.0015	<0.0011	0.0013	0.0093	<0.0011	<0.0011	0.0103
Cu	mg/L	0.0076	0.0024	0.0020	0.0030	0.0088	0.0015	0.0013	0.0024	0.0096	0.0010	0.0010	0.0096
Zn	mg/L	0.0270	0.0118	0.0083	0.0124	0.0330	0.0077	0.0044	0.0072	0.0350	0.0052	0.0040	0.0350

EC: Electrical conductivity; Alk_{Tot}: Total alkalinity; Ammonia-N: Total ammoniacal-N; NO_2-N: Nitrite-N; NO_3-N: Nitrate-N; SO_4: Sulfate.

Table 5: Solute loads of IB material from IBC trials.

	UNITS	IB1-1	IB1-2	IB2-1	IB2-2	IB2-3	IB2-4	IB3-1	IB3-2	IB3-3	IB3-4
Date	day/month	5/02	12/02	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03
Alk_{Tot}	mg/kg $CaCO_3$	11.42	40.44	8.11	25.63	34.25	39.48	7.39	31.62	**37.24**	44.63
SO_4	mg/kg	8.64	12.96	4.97	10.46	12.29	16.47	5.62	12.71	**14.78**	18.03
Cl	mg/kg	0.62	1.23	0.52	0.78	1.05	1.57	0.30	1.18	**1.18**	1.18
Na	mg/kg	1.48	3.33	0.99	2.56	2.56	4.13^{Tot}	1.42	3.19	**3.19**	4.08^{Tot}
K	mg/kg	3.69	5.17	2.05	3.67	3.85	4.46^{Tot}	2.73	4.42	**3.94**	4.56^{Tot}
Mg	mg/kg	1.27	3.06	0.86	2.41	3.14	4.11^{Tot}	0.80	2.96	**3.72**	5.53^{Tot}
Ca	mg/kg	3.09	10.80	2.35	7.32	8.89	10.72^{Tot}	2.07	8.87	**10.93**	13.89^{Tot}
Sr	mg/kg	0.094	0.215	0.059	0.150	0.174	0.218^{Tot}	0.072	0.182	**0.202**	0.255^{Tot}
Fe*	mg/kg	0.006	<0.006	<0.005	<0.005	**0.044**	--	<0.006	<0.006	<0.006	--
Mn*	mg/kg	0.004	0.026	0.006	0.039	**0.071**	--	0.005	0.008	0.002	--
Al*	mg/kg	0.0168	0.0023	0.0035	0.0017	0.0007	--	0.0049	0.0022	**0.0019**	--
Ammonia-N*	mg/kg	0.31	0.26	0.10	0.20	**0.12**	0.01	0.19	0.26	0.04	<0.003
NO_3-N	mg/kg	0.45	-0.13	0.27	0.06	-0.01	0.09	0.48	-0.03	**0.19**	-0.02
NO_2-N*	mg/kg	0.0333	0.0028	0.0481	0.0625	0.0081	0.0029	0.0337	0.0511	**0.0198**	0.0006
As*	mg/kg	0.0153	0.0409	0.0109	0.0271	**0.0679**	--	0.0149	0.0194	0.0270	--
Mo*	mg/kg	0.0028	0.0055	0.0016	0.0043	0.0052	--	0.0021	0.0046	**0.0071**	--
U	mg/kg	0.0021	0.0060	0.0014	0.0042	0.0063	--	0.0019	0.0065	**0.0091**	--
Co*	mg/kg	0.0005	0.0011	0.0003	0.0008	0.0007	--	0.0004	0.0009	**0.0014**	--
Ni*	mg/kg	0.0028	0.0058	0.0017	0.0045	0.0046	--	0.0025	0.0064	**0.0085**	--
B*	mg/kg	<0.015	<0.015	<0.013	<0.013	**<0.013**	--	<0.015	<0.015	<0.015	--
V*	mg/kg	0.0002	<0.0003	<0.0003	<0.0003	**<0.0003**	--	0.0001	0.0002	<0.0003	--
Cu	mg/kg	-0.0018	<0.0002	-0.0014	<0.0001	**<0.0001**	--	<0.0001	<0.0001	<0.0001	--
Zn	mg/kg	<0.0003	-0.0028	<0.0003	<0.0003	**<0.0003**	--	<0.0003	<0.0003	<0.0003	--

Loads represent potable water supply-subtracted IBC porewater concentrations.

The LOR values were obtained by propagating the LOR of the concentrations, using Equation 1, with the potable water concentration set to zero.

** Where value was below LOR in potable water sample, but the above LOR in the porewater sample, half detection limit was used for the subtraction of the potable water load in Equation 1.*

^{Tot} Solute load was calculated from total concentration (all other solutes represent the dissolved fraction).

Negative values occur where potable water composition has higher concentration than the porewater sample.

*Values in **bold** are the ones selected for comparison with SFE tests and source term definition; --: No data available.*

Table 6: Solute loads of OB material from IBC trials.

	UNITS	OB1-1	OB1-2	OB1-3	OB1-4	OB2-1	OB2-2	OB2-3	OB2-4	OB3-1	OB3-2	OB3-3	OB3-4
Date	day/ month	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03	5/02	12/02	27/02	13/03
Alk_{Tot}	mg/kg $CaCO_3$	1.49	14.07	13.00	9.17	-0.34	8.96	5.51	0.34	0.26	12.25	**14.85**	16.94
SO_4	mg/kg	8.31	13.86	15.13	22.60	7.24	17.23	**22.74**	32.04	10.68	19.28	20.07	24.23
Cl	mg/kg	0.21	0.64	0.85	1.49	0.34	1.03	1.03	1.72	0.26	1.04	**1.30**	2.08
Na	mg/kg	1.24	1.66	1.45	2.52^{Tot}	0.17	1.65	1.31	2.34^{Tot}	0.52	1.51	**1.51**	2.55^{Tot}
K	mg/kg	1.50	2.18	2.10	2.31^{Tot}	1.84	3.15	**3.11**	3.39^{Tot}	2.36	3.09	2.96	3.22^{Tot}
Mg	mg/kg	2.03	3.56	3.99	4.84^{Tot}	2.14	3.89	4.72	5.41^{Tot}	2.94	4.35	**5.13**	6.70^{Tot}
Ca	mg/kg	-0.43	1.49	**1.71**	1.92^{Tot}	-2.62	-1.03	-0.34	0.34^{Tot}	-0.78	0.52	1.56	2.61^{Tot}
Sr	mg/kg	0.007	0.025	**0.022**	0.026^{Tot}	-0.007	0.007	0.009	0.015^{Tot}	-0.0008	0.017	0.017	0.030^{Tot}
Fe*	mg/kg	<0.004	0.190	0.488	--	<0.007	<0.007	0.055	--	<0.005	<0.005	**0.701**	--
Mn*	mg/kg	0.49	1.07	0.77	--	0.72	1.21	0.96	--	0.81	1.20	**1.12**	--
Al*	mg/kg	0.0003	<0.0006	**<0.0006**	--	<0.001	<0.001	<0.001	--	<0.0008	<0.0008	<0.0008	--
Ammonia-N*	mg/kg	0.23	0.24	0.14	0.07	0.37	0.36	0.19	0.08	0.42	0.38	**0.23**	0.35
NO_3-N	mg/kg	0.60	-0.06	-0.09	-0.08	0.97	-0.02	-0.14	-0.06	1.20	-0.09	**-0.09**	-0.12
NO_2-N*	mg/kg	0.109	0.012	**0.004**	0.002	0.069	0.048	0.001	0.006	0.054	0.011	0.003	<0.0005
As*	mg/kg	0.00017	0.0201	**0.0321**	--	<0.0003	0.0004	0.0011	--	<0.0003	0.0005	0.0074	--
Mo*	mg/kg	0.0001	0.0002	0.0003	--	0.0002	0.0003	0.0002	--	0.0002	0.0002	**0.0003**	--
U	mg/kg	0.00002	0.00004	**0.00004**	--	0.00001	0.00002	0.00001	--	0.00001	0.00002	0.00002	--
Co*	mg/kg	0.0040	0.0059	0.0032	--	0.0062	0.0093	**0.0062**	--	0.0062	0.0081	0.0049	--
Ni*	mg/kg	0.0044	0.0078	0.0057	--	0.0068	0.0127	**0.0140**	--	0.0070	0.0096	0.0062	--
B*	mg/kg	<0.011	<0.011	**<0.011**	--	<0.017	<0.017	<0.017	--	<0.013	<0.013	<0.013	--
V*	mg/kg	<0.0002	<0.0002	**<0.0002**	--	<0.0003	<0.0003	<0.0003	--	<0.0003	<0.0003	<0.0003	--
Cu	mg/kg	-0.0011	<0.0001	**<0.0001**	--	-0.0019	<0.0002	-0.0020	--	-0.0015	<0.0001	<0.0001	--
Zn	mg/kg	-0.0019	-0.0018	-0.0020	--	-0.0032	-0.0030	**-0.0027**	--	-0.0025	-0.0023	-0.0022	--

See footnotes of Table 5 for further details on data management and presentation.

Temporal Evolution of Solute Loads

To evaluate the temporal evolution of the solute loads, the average values for each material type (OB and IB) per sampling round were calculated and were plotted against the sample collection date (Figure 4 and Figure 5).

The calculated solute loads are affected by the water volume loss with time, as the same initial value of water volume is used for the calculation of all samples. This results in progressive overestimation of solute loads with time generating a conservative estimate that is used for modelling purposes.

The loads of the most soluble constituents (SO_4, Cl, Na, K, Ca, Mg, and Sr) exhibited similar temporal behaviour for both OB and IB. An initial increase was observed between the first sampling round (5/02) and the second round (12/02) (by a factor of ~1.5 to ~5.0). The solute loads were maintained approximately constant by 27/02, before rising again at the last sampling round (13/03).

The Cl load has the highest increase, with a factor of ~6.5 between the first and last sampling rounds of OB. Taking Cl as representative of a conservative element in solution, the approximately steady state between 12/02 and 27/02 indicates that concentration of most constituents stabilise by this point and overestimation of solute loads by water volume loss is relatively low. The high increase at 13/03 is likely related to water loss during the IBC trials.

In addition, the decrease in Alk_{Tot} for OB between 12/02 and 13/03 is associated with a greater increase in SO_4 concentration relative to IB. This trend is likely attributed to sulfide oxidation, increasing the sulfate release and consuming alkalinity.

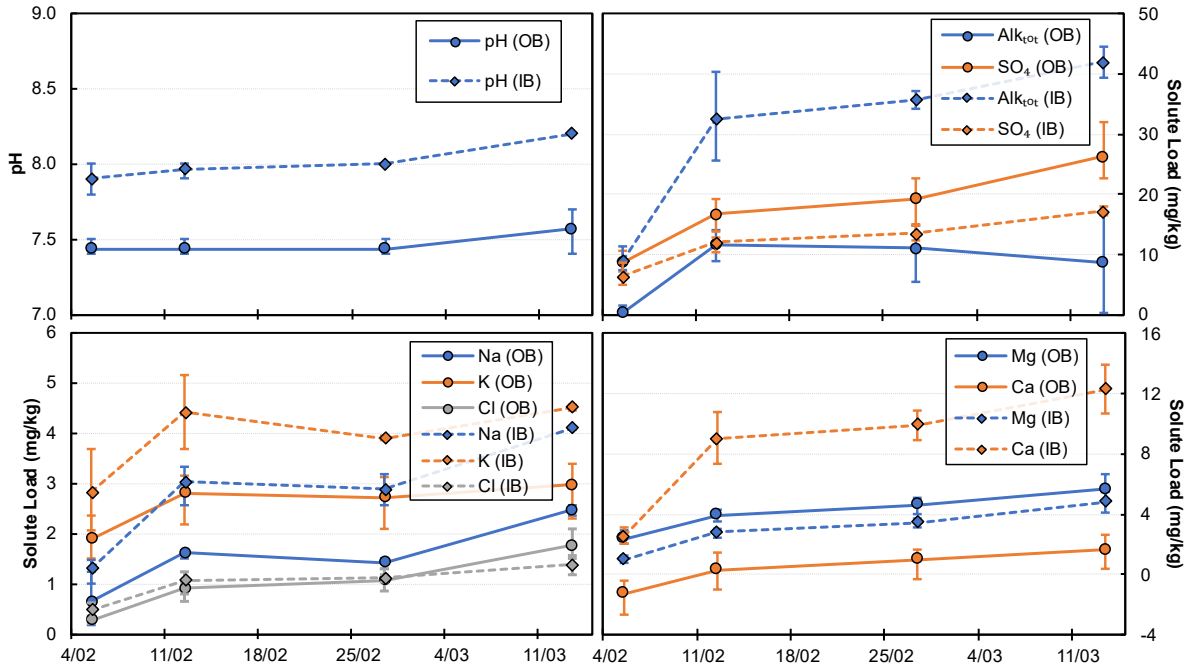

Figure 4: Time series plot of average pH and selected average solute loads from the IBC trials.

Error bars correspond to the minimum and maximum solute loads for each group.
Sample size n = 3 for all averages, except for IB on 27/02/2026 and 13/03/2026 (n = 2).

The loads of nitrogenous compounds (Ammonia-N, NO_3-N and NO_2-N) decrease over the sampling period. Nitrate-N loads declined to near-zero by 12/02, with negative values for OB material and low values for IB material (<0.07 mg/kg) in all subsequent sampling rounds. The NO_2-N and Ammonia-N loads demonstrate slower decay throughout the sampling period.

Over the trial period, As, Mo, and Fe loads increased progressively for both OB and IB materials, with Fe loads notably higher in OB (average ~0.4 mg/kg at 27/02) than IB (~0.02 mg/kg). In contrast, Al, Mn, Co, and Ni loads declined over time, with Al in OB material remaining below LOR throughout.

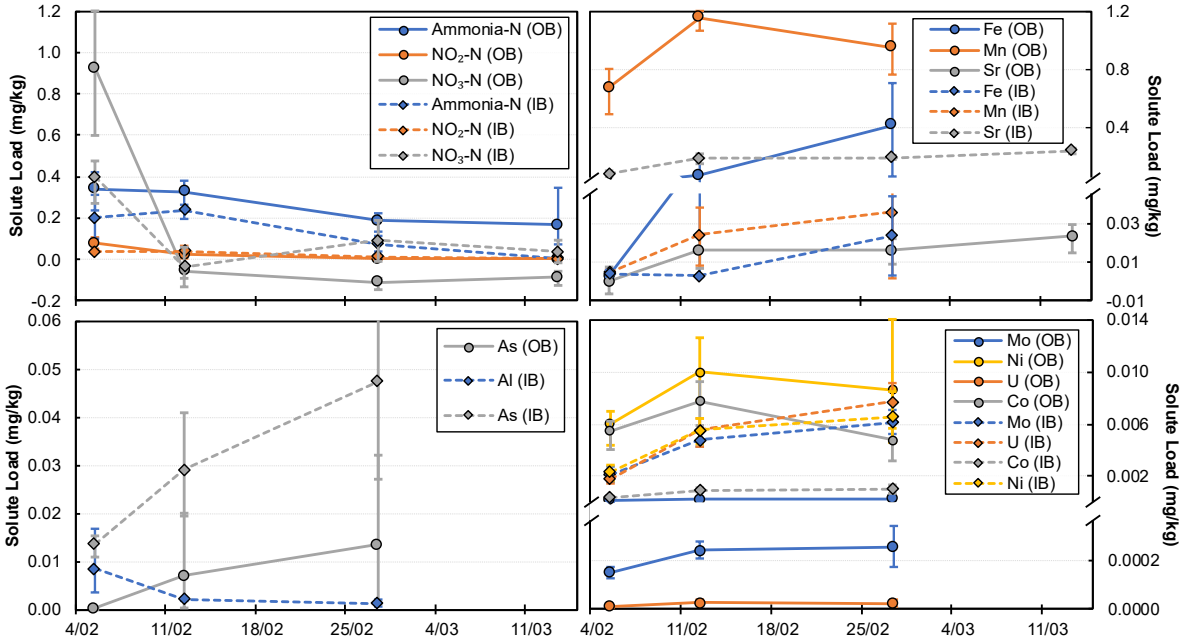

Figure 5: Time series plot of selected solute loads from the IBC trials porewater.

Negative values occur where potable water composition has higher concentration than the porewater sample.

Comparison of IBC and SFE Porewater

The OB and IB loads for the 27/02/2026 sampling round were selected as the most representative baseline for comparison for the following reasons:

- Most solute loads appear to have stabilised by this date.
- Data do not demonstrate oxidation effects that were observed on 13/03/2026 (high SO_4 and decrease in Alk_{Tot}).
- There was less porewater volume loss on 27/02/2026 than on 13/03/2026, reducing the risk of further overestimation of solute loads.

IBC data are compared with solute loads from the SFE tests to evaluate differences between the two testing procedures (Table 7). As the SFE solid:liquid weight ratio is 1:10 and water density is ~1 kg/L, the solute load (SL_C^{SFE}) is calculated as in Equation 3.

Equation 3: $$SL_C^{SFE}\left(\frac{mg\ water}{kg\ sample}\right) = [C]_{leachate}\left(\frac{mg\ water}{kg\ sample}\right) = [C]_{leachate}\left(\frac{mg\ solute}{L\ water}\right) \cdot 10\left(\frac{L\ water}{kg\ sample}\right)$$

For all solutes and rock types, the maximum measured load was selected for the analysis (for IBC trials and SFE tests), with the exception of Cl in SFE tests for IB materials. Two of the three SFE tests for IB

produce Cl loads that are 1 to 2 orders of magnitude higher than the other IB and all OB SFE tests (up to 120 mg/kg in IB3). These extremely high Cl loads are not reflected in the difference between IB and OB Cl loads in the IBC porewater samples. A likely source of the high Cl loads in SFE test is saline fluid inclusions in quartz, which can be broken up during crushing. The lowest Cl load from IB1 (2.7 mg/kg) was selected for the comparison with the IBC trials maximum solute loads.

Solute loads from the IBC trials are compared to solute loads from the SFE tests in Table 7 and Figure 7. The SFE tests produce leachates with higher pH than the IBC trials for the same rock type:

- SFE leachates of OB have an average pH of ~8.1, whereas the porewater of the IBC trials have an average pH of ~7.5.
- SFE leachates of IB have an average pH of ~9.1, whereas the porewater of the IBC trials have an average pH of ~8.0.

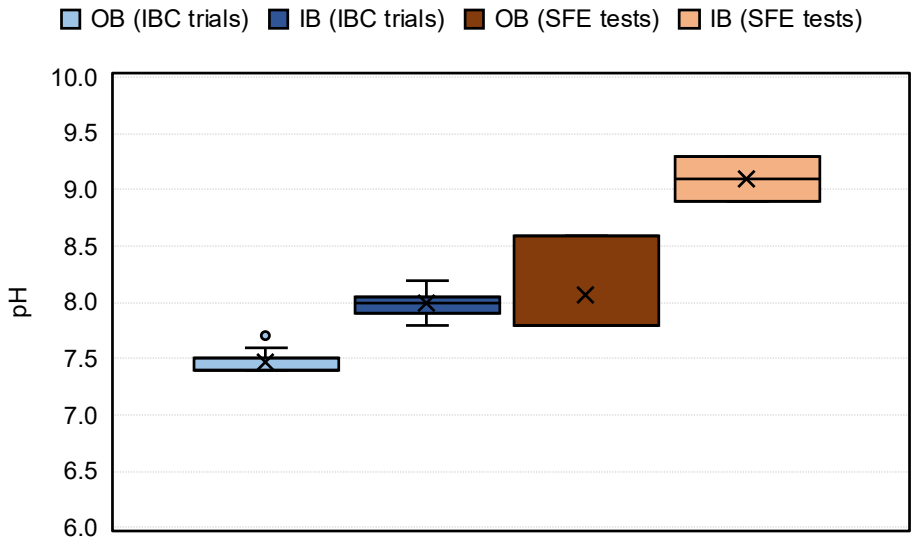

Figure 6: Boxplot of the pH values from each set of tests.

IBC trials: OB (n = 12) and IB (n = 10).
SFE: OB (n = 3) and IB (n = 3).

Most solutes exhibited significantly lower loads in the IBC trials than in the SFE tests, typically by ~50% to ~99%. Key comparative observations include:

- Alk_{Tot} loads for the IBC trials (~15 mg/kg for OB and ~37 mg/kg for IB) are ~90% lower than the loads of the SFE tests for both rock types (150 mg/kg for OB and 400 mg/kg for IB).
- SO_4 loads for the IBC trials (~15 mg/kg for IB and ~23 mg/kg for OB) are 77% and 70% lower than the loads of the SFE tests (64 mg/kg for IB and 76 mg/kg for OB).
- Cl loads for the IBC trails (1.3 mg/kg for OB and 1.2 mg/kg for IB) are 56% and 35% lower than the SFE tests (2.0 mg/kg for OB and 2.7 mg/kg for IB).
- K loads for the IBC trials are ~93% lower than the SFE tests, with ~3.1 mg/kg and 43 mg/kg for OB, and ~3.9 mg/kg and 63 mg/kg for IB. The loads of Na, Ca, Mg, and Sr in the IBC trials are proportionally lower than the SFE for IB (65% to 89%) than OB (78% to 95%).
- The OB trials have:

  - Solute loads of ~1.5 mg/kg Na, ~1.7 mg/kg Ca, ~5.1 mg/kg Mg and ~0.02 mg/kg Sr in the IBC trials.
  - Solute loads of 9 mg/kg Na, 33 mg/kg Ca, ~24 mg/kg Mg and ~0.2 mg/kg Sr in the SFE tests.
- The IB trials have:
  - Solute loads of ~3.2 mg/kg Na, ~10.9 mg/kg Ca, ~3.7 mg/kg Mg and ~0.2 mg/kg Sr in the IBC trials.
  - Solute loads of 10 mg/kg Na, 97 mg/kg Ca, ~11 mg/kg Mg and ~1 mg/kg Sr in the SFE tests.
- The higher Fe load in OB (~0.7 mg/kg) than IB (~0.04 mg/kg) is reflected in both the IBC trials and SFE tests. However, the Fe load of OB in the SFE test is considerably higher (~7 mg/kg), resulting in the IBC trials load being 91% lower. The Fe load of IB is 51% lower than SFE test (0.09 mg/kg).
- The Mn load is approximately the same in the IBC trials and SFE tests for OB (~1.1 mg/kg) but is approximately twice as high in the IBC trial relative to the SFE test for the IB material (0.07 mg/kg vs 0.03 mg/kg).
- Al is below the LOR in the IBC trials porewater of OB and has low loads in IB (0.0019 mg/kg). On the contrary, the Al loads are high in the SFE tests (7.9 and 5.8 mg/kg, respectively), resulting in the Al loads of IB being ~99.98% lower in the IBC trials than the SFE test load. Al solubility is amphoteric, exhibiting a minimum at pH around 6-7 and increasing rapidly with pH increase. The higher pH of the SFE leachates (Figure 6) is likely the cause of the difference in solute loads between both experiments.
- Total-N [13] loads are ~95% lower than the loads from the SFE tests for both materials (~0.2 – 0.3 mg/kg in the IBC trials and 4.7 – 6.0 mg/kg in the SFE tests). This is the result of the rapid decay of NO_3-N during the first month of the IBC trials, as the initial solute loads (sampling round 05/02/2026: ~0.5 to 1.2 mg/kg) were only ~50% to ~75% lower than the SFE tests (1.3 – 2.6 mg/kg).
- The comparison of As load between the IBC trials and SFE tests shows:
  - The highest As load in the IBC trials of OB (~0.03 mg/kg) is an order of magnitude higher than the other IBC trials of the same rock material (~0.001 – 0.007 mg/kg).
  - The highest As load from the IBC trials of OB represents a ~50% increase from the SFE tests (0.02 mg/kg), whereas the other IBC trials represent a ~99% decrease.
  - The inconsistency between trials of OB is probably caused by the sensitivity of As adsorption to small pH variations or different proportions of Fe oxidation.
  - The As load in the IBC trials from IB (~0.07 mg/kg) shows a decrease of ~88% with respect to the SFE tests (0.56 mg/kg).

[13] *Total nitrogen from nitrogen compounds (Ammonia-N + NO_3-N + NO_2-N).*

- Mo loads for the IBCs (0.0003 mg/kg for OB and ~0.007 mg/kg for IB) are 99% and 65% lower than the loads from the SFE tests (0.03 mg/kg for OB and 0.02 mg/kg for IB), respectively.
- Co and Ni loads for the OB IBCs (~0.006 mg/kg Co and ~0.01 mg/kg Ni) are 69% and 53% lower than the SFE tests (0.02 mg/kg Co and 0.03 mg/kg Ni), respectively. Co and Ni concentrations in the IB SFE leachate are below the LOR (<0.005 mg/kg Co and <0.005 mg/kg Ni), meaning the SFE loads are constrained by detection limits rather than representing actual loads. The IBC trial loads (~0.001 mg/kg Co and ~0.009 mg/kg Ni) are close to the LOR-derived SFE loads, indicating that the apparent difference between the two test methods is an artefact of the SFE detection limits rather than a genuine difference in release.
- Zn loads were negative in all but one IBC trial (0.0002 mg/kg in IB). This value is 99.9% lower than the load calculated from the SFE tests (0.06 mg/kg in IB).

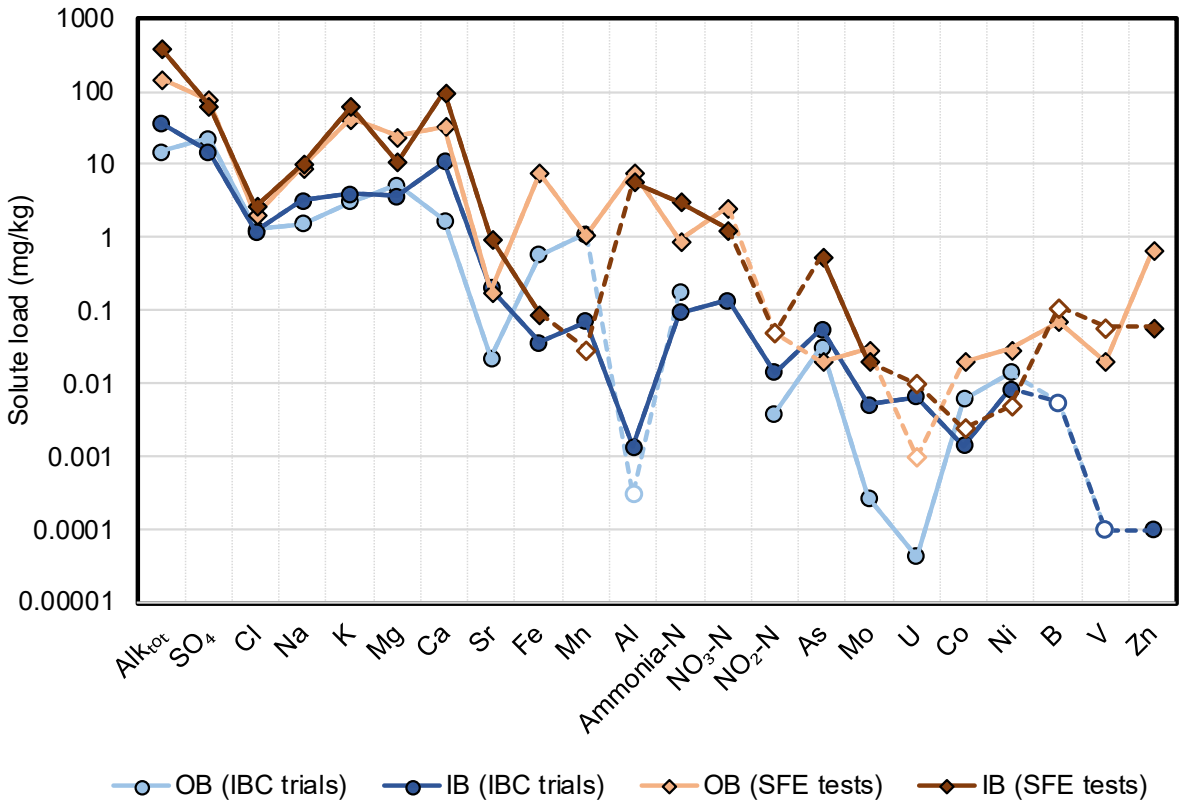

Figure 7: Solute load plot (log scale) for selected dissolved solutes in IBC trials and SFE tests.

Symbols with no fill and a dashed lines indicate values below or near the LOR.

Values below the LOR are replaced with half LOR values.

Missing data points represent either unavailable data or negative solute loads resulting from the potable water baseline subtraction.

Table 7: SFE leachate solute concentrations and solute loads.

	SOLUTE CONCENTRATIONS							SOLUTE LOADS					
	UNITS	OB1	OB2	OB3	IB1	IB2	IB3	UNITS	OB1	OB2	OB3	IB1	IB2	IB3
pH	pH unit	7.8	7.8	8.6	8.9	9.1	9.3	--	--	--	--	--	--	--
Alk_{Tot}	mg/L $CaCO_3$	15	14	14	37	40	40	mg/kg $CaCO_3$	**150**	140	140	370	**400**	400
SO_4	mg/L	7.6	5.5	6.9	6.4	4.2	2.0	mg/kg	**76**	55	69	**64**	42	20
Cl	mg/L	0.16	0.20	0.15	0.27	12.00	2.00	mg/kg	1.6	**2.0**	1.5	**2.7**	120.0	20.0
F	mg/L	0.16	0.16	0.18	0.07	0.08	0.07	mg/kg	1.6	1.6	**1.8**	0.7	**0.8**	0.7
Na	mg/L	0.8	0.9	0.8	1.0	0.9	1.0	mg/kg	8	**9**	8	**10**	9	1
K	mg/L	4.1	4.3	4.2	6.1	6.	6.3	mg/kg	41	**43**	42	61	60	**63**
Mg	mg/L	2.39	2.06	2.14	1.08	0.93	0.9	mg/kg	**23.9**	20.6	21.4	**10.8**	9.3	9.0
Ca	mg/L	3.3	2.7	2.7	9.7	7.7	7.6	mg/kg	**33**	27	27	**97**	77	76
Sr	mg/L	0.018	0.015	0.014	0.099	0.077	0.073	mg/kg	**0.18**	0.15	0.14	**0.99**	0.77	0.73
Fe	mg/L	0.185	0.762	0.348	0.007	0.009	0.009	mg/kg	1.85	**7.62**	3.48	0.07	**0.09**	0.09
Mn	mg/L	0.097	0.110	0.102	0.003	<0.001	<0.001	mg/kg	0.97	**1.10**	1.02	**0.03**	<0.01	<0.01
Al	mg/L	0.299	0.787	0.455	0.332	0.515	0.575	mg/kg	2.99	**7.87**	4.55	3.32	5.15	**5.75**
Ammonia N	mg/L	0.09	0.04	0.06	0.29	0.30	0.31	mg/kg	**0.9**	0.4	0.6	2.9	3.0	**3.1**
Total N	mg/L	0.45	0.60	0.54	0.47	0.34	0.28	mg/kg	4.5	**6.0**	5.4	**4.7**	3.4	2.8
NO_3-N	mg/L	0.260	0.230	0.260	0.130	0.110	0.093	mg/kg	**2.60**	2.30	2.60	**1.30**	1.10	0.93
NO_2-N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sb	mg/L	0.001	0.001	0.002	0.023	0.022	0.021	mg/kg	0.01	0.01	**0.02**	**0.23**	0.22	0.21
As	mg/L	0.002	0.002	0.002	0.046	0.056	0.052	mg/kg	**0.02**	0.02	0.02	0.46	**0.56**	0.52
Mo	mg/L	0.003	0.003	0.003	0.002	0.002	0.002	mg/kg	**0.03**	0.03	0.03	**0.02**	0.02	0.02
U	mg/L	<0.0002	<0.0002	<0.0002	0.001	<0.001	<0.001	mg/kg	<0.002	<0.002	<0.002	**0.01**	<0.01	<0.01
Co	mg/L	<0.001	0.002	0.001	<0.0005	<0.0005	<0.0005	mg/kg	<0.01	**0.02**	0.01	<0.005	<0.005	<0.005
Ni	mg/L	0.002	0.003	0.002	<0.001	<0.0005	<0.0005	mg/kg	0.02	**0.03**	0.02	<0.01	<0.005	<0.005
B	mg/L	0.007	0.007	0.007	0.009	0.01	0.011	mg/kg	**0.07**	0.07	0.07	0.09	0.10	**0.11**
Ba	mg/L	0.007	0.011	0.008	0.005	0.004	0.004	mg/kg	0.07	**0.11**	0.08	**0.05**	0.04	0.04
V	mg/L	<0.001	0.002	0.001	0.004	0.006	0.006	mg/kg	<0.01	**0.02**	0.01	0.04	**0.06**	0.06
Cu	mg/L	<0.001	0.001	<0.001	<0.001	<0.0005	<0.0005	mg/kg	<0.01	**0.01**	<0.01	<0.01	<0.005	<0.005
Zn	mg/L	0.009	0.067	0.006	0.006	<0.005	<0.002	mg/kg	0.09	**0.67**	0.06	**0.06**	<0.05	<0.02

	SOLUTE CONCENTRATIONS							SOLUTE LOADS					
	UNITS	OB1	OB2	OB3	IB1	IB2	IB3	UNITS	OB1	OB2	OB3	IB1	IB2	IB3
W	mg/L	<0.001	<0.001	<0.001	0.008	0.007	0.007	mg/kg	<0.01	<0.01	<0.01	**0.08**	0.07	0.07

Red numbers are very high Cl values that are excluded from the interpretation.

***Bold text** indicates the selected values (maximum load of each rock type, except for Cl in IB) used in the comparison with IBC trial results.*

Source Terms

Data from the IBC trials were used to develop a representative source term for the saturated waste rock solute load (Table 8). The following is noted:

- For most solutes, the maximum IBC trial solute loads for the 27/02/2026 sampling round were selected.
- The maximum solute loads from the SFE tests were used for solutes not measured in the porewater samples of the IBC trials (e.g., F, Sb).
- If all analyses were below the LOR for a solute, the load was calculated using the LOR value.
- Solutes with negative loads were set to zero.
- If the weight proportions of the OB and IB rock types destined for backfill are known, a source term can be derived from both the OB and IB datasets. However, without these data, a "conservative" source term was defined by assigning the maximum value measured for the OB and IB materials for each solute (Table 8).

The source term demonstrates that most of the solute loads derived from the IBC trials (except for Mn) are lower than those derived from the SFE trials. Notable differences include:

- The conservative source term loads for Al, Cu, Zn, Cd, and Cr are > 99% lower relative to the maximum solute loads from the SFE.
- The conservative source term loads for Alk_{Tot}, K, Fe, Total-N, and B are 90% to 94% lower than the maximum solute loads from the SFE tests.
- The SO_4, Na, Mg, Ca, Sr, As, Mo, and Co solute loads of the conservative source term are 68% to 88% lower than the solute loads from the SFE tests.
- The Cl and Ni solute loads of the conservative source term are ~52% lower than the SFE tests.
- Mn is an exception, showing near-equivalent mass loads between the conservative source term and the SFE tests.

Table 8: Source terms of solute loads from saturated backfill.

	OB			IB			CONSERVATIVE		
	SOURCE TERM	DEFINED FROM	RELATIVE DIFFERENCE	SOURCE TERM	DEFINED FROM	RELATIVE DIFFERENCE	SOURCE TERM	DEFINED FROM	RELATIVE DIFFERENCE
Units	mg/kg		%	mg/kg	--	%	mg/kg	--	%
Alk_{Tot}	14.9	IBC max	90.1%	37.2	IBC max	90.7%	37.2	IB (IBC max)	90.7%
SO_4	22.7	IBC max	70.1%	14.8	IBC max	76.9%	22.7	OB (IBC max)	70.1%
Cl	1.3	IBC max	34.9%	1.2	IBC max	56.2%	1.3	OB (IBC max)	51.7%
F	1.80	SFE max	--	0.80	SFE max	--	1.80	OB (SFE max)	--
Na	1.51	IBC max	83.2%	3.19	IBC max	68.1%	3.19	IB (IBC max)	68.1%
K	3.11	IBC max	92.8%	3.94	IBC max	93.7%	3.94	IB (IBC max)	93.7%
Mg	5.13	IBC max	78.5%	3.72	IBC max	65.5%	5.13	OB (IBC max)	78.5%
Ca	1.71	IBC max	94.8%	10.93	IBC max	88.7%	10.93	IB (IBC max)	88.7%
Sr	0.022	IBC max	87.6%	0.202	IBC max	79.6%	0.202	IB (IBC max)	79.6%
Fe	0.70	IBC max	90.8%	0.04	IBC max	59.7%	0.70	OB (IBC max)	90.8%
Mn	1.12	IBC max	-1.9%	0.07	IBC max	-135.1%	1.12	OB (IBC max)	-1.9%
Al	0.0005	IBC max	99.99%	0.0019	IBC max	99.97%	0.0019	IB (IBC max)	99.98%
Ammonia-N	0.23	IBC max	25.0%	0.12	IBC max	96.2%	0.23	OB (IBC max)	97.1%
NO_3-N	0.00	IBC max (-)	100.0%	0.19	IBC max	96.0%	0.19	IB (IBC max)	93.9%
NO_2-N	0.004	IBC max	99.9%	0.020	IBC max	98.5%	0.020	IB (IBC max)	99.7%
Total-N	0.23	--	93.5%	0.33	--	92.6%	0.43	--	92.4%
Sb	0.02	SFE max	--	0.23	SFE max	--	0.23	IB (SFE max)	--
As	0.032	IBC max	-60.4%	0.068	IBC max	87.9%	0.068	IB (IBC max)	87.9%
Pb	0.00002	IBC LOR	--	0.00002	IBC LOR	--	0.00002	IBC LOR	--
Mo	0.00034	IBC max	98.9%	0.0071	IBC max	64.7%	0.0071	IB (IBC max)	76.5%
U	0.00004	IBC max	--	0.0091	IBC max	8.5%	0.0091	IB (IBC max)	8.5%
Cr	0.00011	IBC LOR	98.9%	0.00011	IBC LOR	--	0.00011	IBC LOR	98.9%
Co	0.0062	IBC max	69.0%	0.0014	IBC max	--	0.0062	OB (IBC max)	69.0%
Ni	0.014	IBC max	53.2%	0.0085	IBC max	--	0.014	OB (IBC max)	53.2%
B	0.011	IBC LOR	84.3%	0.011	IBC LOR	90.0%	0.011	IBC LOR	90.0%

	OB			IB			CONSERVATIVE		
	SOURCE TERM	DEFINED FROM	RELATIVE DIFFERENCE	SOURCE TERM	DEFINED FROM	RELATIVE DIFFERENCE	SOURCE TERM	DEFINED FROM	RELATIVE DIFFERENCE
Units	mg/kg		%	mg/kg	--	%	mg/kg	--	%
Ba	0.11	SFE max	--	0.05	SFE max	--	0.11	OB (SFE max)	--
V	0.0002	IBC LOR	99.0%	0.0002	IBC LOR	99.7%	0.0002	IBC LOR	99.7%
Cu	0.0000	IBC max (-)	100.0%	0.0001	IBC LOR	--	0.0001	IBC LOR	99.0%
Zn	0.0000	IBC max (-)	100.0%	0.0002	IBC LOR	99.7%	0.0002	IBC LOR	99.97%
Cd	0.00001	IBC LOR	--	0.00001	IBC LOR	--	0.00001	IBC LOR	--
Hg	0.00002	IBC LOR	--	0.00002	IBC LOR	--	0.00002	IBC LOR	--
W	0.01	SFE LOR	--	0.08	SFE max	--	0.08	IB (SFE max)	--
Ag	0.005	SFE LOR	--	0.005	SFE LOR	--	0.005	SFE LOR	--
Tl	0.005	SFE LOR	--	0.005	SFE LOR	--	0.005	SFE LOR	--
Sn	0.01	SFE LOR	--	0.01	SFE LOR	--	0.01	SFE LOR	--
Se	0.05	SFE LOR	--	0.05	SFE LOR	--	0.05	SFE LOR	--

Total-N: Ammonia-N + NO_3-N + NO_2-N.

Conservative: Represent maximum of OB and IB.

IBC max: Source term defined as the maximum solute load from 27/02 samples of IBC trials.

IBC max (-): Source term set to zero, because the maximum solute load is negative.

SFE max: Source term defined as the maximum solute load from SFE tests.

IBC LOR and SFE LOR: Source term defined as the solute load calculated with the LOR value, as all analyses are below LOR.

*Relative difference: the percent difference between the assigned source term and the maximum SFE value of the respective rock type, with respect to the latter. For the conservative source term, the SFE value is the maximum between both rock types. Calculated as 100 * (1 Source Term / SFE max). Missing values were not calculated because SFE data was below LOR, data were missing, or the SFE solute load was used to define the source term.*

CONCLUSIONS AND RECOMMENDATIONS

IBC trials were completed for the Project to simulate the field conditions of saturated waste rock materials and provide an understanding of the solute loads that will be released from waste rock upon submergence. The derived solute loads from these IBC trials are used to define a source term to be applied in the modelling of load release from the saturated portion of waste rock in backfilled pits (Table 9).

Table 9: Source term for saturated backfilled pits.

SOLUTE	UNITS	VALUE
Alk_{Tot}	mg/kg $CaCO_3$	37.24
SO_4	mg/kg	22.74
Cl	mg/kg	1.30
F	mg/kg	1.80
Na	mg/kg	3.19
K	mg/kg	3.94
Mg	mg/kg	5.13
Ca	mg/kg	10.93
Sr	mg/kg	0.202
Fe	mg/kg	0.701
Mn	mg/kg	1.12
Al	mg/kg	0.0019
Ammonia-N	mg/kg	0.225
NO_3-N	mg/kg	0.189
NO_2-N	mg/kg	0.020
Sb	mg/kg	0.23
As	mg/kg	0.068
Pb	mg/kg	0.00002
Mo	mg/kg	0.0071
U	mg/kg	0.0091
Cr	mg/kg	0.00011
Co	mg/kg	0.0062
Ni	mg/kg	0.014
B	mg/kg	0.011
Ba	mg/kg	0.11
V	mg/kg	0.0002
Cu	mg/kg	0.0001
Zn	mg/kg	0.0002
Cd	mg/kg	0.00001
Hg	mg/kg	0.00002
W	mg/kg	0.08
Ag	mg/kg	0.005
Tl	mg/kg	0.005
Sn	mg/kg	0.01
Se	mg/kg	0.05

The results of this study demonstrate that:

- Most solute loads derived from the IBC trials are 50% to 99% lower than estimates derived from SFE tests. Notably:
  - Common PCOCs, such as SO_4 and As, have solute load estimates ~70% and ~90% lower than estimates from SFE tests, respectively.
  - Nitrogen residues from blasting decayed considerably within a month during the IBC trials, resulting in loads ~95% lower than the SFE tests.
  - Metals (Al, Cr, V, Cu, Zn) show a reduction of ~99% in solute loading compared to the SFE tests.
- IBC trials provide a more realistic representation of solute load compared to laboratory-based SFE tests. These data will be used as source terms for recently blasted backfilled rocks in pit lake models.
- The application of these data to the development of pit lake models assumes that no ongoing oxidation occurs within the materials after placement. To evaluate the risk to water quality associated with ongoing oxidation, the SFE data from the IBC trials was compared to historical SFE backfill data obtained from WRS materials (MWM, 2024). These data suggest that mass loads could be higher by a factor of 5 (Table 10) if the samples continue to oxidise. If backfill waste rock is not managed to mitigate oxidation or if a long delay (e.g., > 1 year) occurs before the rock is saturated, this adjustment factor will be included in the models (i.e., increasing the loads shown in Table 9 by a factor of 5).

Table 10: SFE SO_4 solute loads (mg/kg).

	PREVIOUS STUDIES (MWM, 2024)		THIS STUDY
	BACKFILL	INSITU (DRILLCORE)	OB + IB
n	12	6	6
Average	**306**	**157**	**54**
Median	295	82	60
Std	107	135	21
Min	150	57	20
Max	570	350	76

CLOSING REMARKS

Please do not hesitate to contact Paul Weber at [redacted] or [redacted] should you wish to discuss this memorandum in greater detail.

Attachments: Attachment A – Laboratory Results.

REFERENCES

AMIRA, 2002. ARD Test Handbook. AMIRA International, Melbourne, Australia.

Mine Waste Management (MWM), 2024. Macraes Mine Phase 4.3: Environmental Geochemistry Assessment. MWM Document No. J-NZ0229-004-R-Rev0.

Price, W.A., 2009. Prediction Manual for Drainage Chemistry from Sulphidic Carapace Materials. MEND Report 1.20.1, CANMET, Ottawa, Canada.

ATTACHMENT A – LABORATORY RESULTS

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Certificate of Analysis

Client:	Oceana Gold (New Zealand) Limited	**Lab No:**	4092643	SPv1
Contact:	[redacted]	**Date Received:**	07-Feb-2026	
	C/- Oceana Gold (New Zealand) Limited	**Date Reported:**	13-Feb-2026	
	PO Box 5442	**Quote No:**	142110	
	Moray Place	**Order No:**	545256	
	Dunedin 9058	**Client Reference:**	IBC Leach Trial	
		Submitted By:	[redacted]	

Sample Type: Aqueous

Sample Name:		Std	OB1-1	OB2-1	OB3-1	IB1-1
Lab Number:		4092643.1	4092643.2	4092643.3	4092643.4	4092643.5
Sum of Anions	meq/L	2.3	3.5	3.0	3.5	3.8
Sum of Cations	meq/L	2.7	3.9	3.1	3.9	4.1
% Difference in Ion Balance	%	7.2	4.8	1.74	4.9	4.4
pH	pH Units	7.7	7.4	7.4	7.5	7.9
Total Alkalinity	g/m³ as $CaCO_3$	69	76	68	70	106
Carbonate Alkalinity	g/m³ as $CaCO_3$	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bicarbonate Alkalinity	g/m³ as $CaCO_3$	69	76	68	70	105
Total Hardness	g/m³ as $CaCO_3$	96	133	104	137	138
Electrical Conductivity (EC)	mS/m	24.7	38.1	32.5	39.0	39.4
Electrical Conductivity (EC)	µS/cm	247	381	325	390	394
Total Arsenic	g/m³	< 0.0011	0.022	0.0129	0.0142	0.085
Total Boron	g/m³	< 0.053	< 0.053	< 0.053	< 0.053	< 0.053
Dissolved Calcium	g/m³	27	25	19.4	24	37
Total Iron	g/m³	0.021	9.8	17.2	15.2	23
Dissolved Magnesium	g/m³	7.3	16.8	13.5	18.6	11.4
Dissolved Potassium	g/m³	1.56	8.6	6.9	10.6	13.5
Dissolved Sodium	g/m³	16.2	22	16.7	18.2	21
Chloride	g/m³	15	16	16	16	17
Total Inorganic Nitrogen	g/m³	0.49	4.9	4.5	6.9	3.1
Total Ammoniacal-N	g/m³	< 0.010	1.10	1.07	1.61	1.01
Nitrite-N	g/m³	< 0.002	0.51	0.20	0.21	0.109
Nitrate-N	g/m³	0.48	3.3	3.3	5.1	1.94
Nitrate-N + Nitrite-N	g/m³	0.48	3.8	3.5	5.3	2.1
Sulphate	g/m³	22	61	43	63	50

Sample Name:		IB2-1	IB3-1
Lab Number:		4092643.6	4092643.7
Sum of Anions	meq/L	3.4	3.4
Sum of Cations	meq/L	3.8	3.7
% Difference in Ion Balance	%	5.0	5.1
pH	pH Units	7.8	8.0
Total Alkalinity	g/m³ as $CaCO_3$	100	94
Carbonate Alkalinity	g/m³ as $CaCO_3$	< 1.0	< 1.0
Bicarbonate Alkalinity	g/m³ as $CaCO_3$	99	93
Total Hardness	g/m³ as $CaCO_3$	133	125
Electrical Conductivity (EC)	mS/m	35.8	35.0
Electrical Conductivity (EC)	µS/cm	358	350
Total Arsenic	g/m³	0.117	0.080
Total Boron	g/m³	< 0.053	< 0.053
Dissolved Calcium	g/m³	36	34

Sample Type: Aqueous			
	Sample Name:	IB2-1	IB3-1
	Lab Number:	4092643.6	4092643.7
Total Iron	g/m³	15.8	16.7
Dissolved Magnesium	g/m³	10.6	10.0
Dissolved Potassium	g/m³	9.4	10.8
Dissolved Sodium	g/m³	20	21
Chloride	g/m³	17	16
Total Inorganic Nitrogen	g/m³	2.1	2.8
Total Ammoniacal-N	g/m³	0.39	0.66
Nitrite-N	g/m³	0.185	0.115
Nitrate-N	g/m³	1.51	2.1
Nitrate-N + Nitrite-N	g/m³	1.70	2.2
Sulphate	g/m³	41	41

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved	Sample filtration through 0.45 µm membrane filter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch.	-	1-7
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-7
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1-7
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1-7
% Difference in Ion Balance	Calculation from Sum of Anions and Cations. Please note: The result reported for the '% Difference in Ion Balance' is an absolute difference between the 'Sum of Anions' and 'Sum of Cations' based on the formula taken from APHA. This does not indicate whether the 'Sum of Anions' or the 'Sum of Cations' produced a higher value. APHA 1030 E : Online Edition.	0.10 %	1-7
pH	pH meter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-7
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m³ as $CaCO_3$	1-7
Carbonate Alkalinity	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m³ as $CaCO_3$	1-7
Bicarbonate Alkalinity	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m³ as $CaCO_3$	1-7
Total Hardness	Calculation from Dissolved Calcium and Dissolved Magnesium. APHA 2340 B : Online Edition.	1.0 g/m³ as $CaCO_3$	1-7
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2510 B : Online Edition.	0.1 mS/m	1-7
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	1 µS/cm	1-7
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0011 g/m³	1-7

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m³	1-7
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m³	1-7
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.021 g/m³	1-7
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m³	1-7
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m³	1-7
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m³	1-7
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	1-7
Total Inorganic Nitrogen	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.010 g/m³	1-7
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m³	1-7
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-7
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m³	1-7
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-7
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	1-7

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 07-Feb-2026 and 13-Feb-2026. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Oceana Gold (New Zealand) Limited	**Lab No:**	4092643	SPv2
Contact:	[redacted]	**Date Received:**	07-Feb-2026	
	C/- Oceana Gold (New Zealand) Limited	**Date Reported:**	23-Feb-2026	**(Amended)**
	PO Box 5442	**Quote No:**	142110	
	Moray Place	**Order No:**	545256	
	Dunedin 9058	**Client Reference:**	IBC Leach Trial	
		Submitted By:	[redacted]	

Sample Type: Aqueous

Sample Name:		Std	OB1-1	OB2-1	OB3-1	IB1-1
Lab Number:		4092643.1	4092643.2	4092643.3	4092643.4	4092643.5
Individual Tests						
Sum of Anions	meq/L	2.3	3.5	3.0	3.5	3.8
Sum of Cations	meq/L	2.7	4.0	3.1	4.0	4.1
% Difference in Ion Balance	%	7.2	5.9	3.0	6.3	4.5
pH	pH Units	7.7	7.4	7.4	7.5	7.9
Total Alkalinity	g/m³ as $CaCO_3$	69	76	68	70	106
Carbonate Alkalinity	g/m³ as $CaCO_3$	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bicarbonate Alkalinity	g/m³ as $CaCO_3$	69	76	68	70	105
Total Hardness	g/m³ as $CaCO_3$	96	133	104	137	138
Electrical Conductivity (EC)	mS/m	24.7	38.1	32.5	39.0	39.4
Electrical Conductivity (EC)	µS/cm	247	381	325	390	394
Total Dissolved Solids (TDS)	g/m³	147	220	210	270	240
Dissolved Aluminium	g/m³	< 0.003	0.003	< 0.003	< 0.003	0.056
Total Aluminium	g/m³	< 0.0032	3.0	5.6	4.6	8.0
Dissolved Boron	g/m³	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total Boron	g/m³	< 0.053	< 0.053	< 0.053	< 0.053	< 0.053
Dissolved Calcium	g/m³	27	25	19.4	24	37
Dissolved Cobalt	g/m³	< 0.0002	0.0190	0.0181	0.024	0.0016
Total Cobalt	g/m³	< 0.00021	0.029	0.032	0.039	0.0123
Dissolved Iron	g/m³	< 0.02	< 0.02	< 0.02	< 0.02	0.03
Total Iron	g/m³	0.021	9.8	17.2	15.2	23
Dissolved Magnesium	g/m³	7.3	16.8	13.5	18.6	11.4
Dissolved Manganese	g/m³	< 0.0005	2.3	2.1	3.1	0.0118
Total Manganese	g/m³	< 0.00053	2.5	2.6	3.4	0.28
Dissolved Mercury	g/m³	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Total Mercury	g/m³	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011
Dissolved Molybdenum	g/m³	< 0.0002	0.0007 #1	0.0006	0.0007 #1	0.0091
Total Molybdenum	g/m³	< 0.00021	0.00054 #1	0.00071	0.00070 #1	0.0114
Dissolved Potassium	g/m³	1.56	8.6	6.9	10.6	13.5
Dissolved Sodium	g/m³	16.2	22	16.7	18.2	21
Dissolved Strontium	g/m³	0.145	0.180	0.125	0.142	0.45
Total Strontium	g/m³	0.146	0.182	0.136	0.156	0.50
Dissolved Uranium	g/m³	0.00004 #1	0.00013	0.00007	0.00007	0.0070
Total Uranium	g/m³	0.000036 #1	0.00083	0.00088	0.00094	0.0090
Dissolved Vanadium	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0011
Total Vanadium	g/m³	< 0.0011	0.0060	0.0101	0.0093	0.0167
Chloride	g/m³	15	16	16	16	17
Total Inorganic Nitrogen	g/m³	0.49	4.9	4.5	6.9	3.1
Total Ammoniacal-N	g/m³	< 0.010	1.10	1.07	1.61	1.01

Sample Type: Aqueous						
Sample Name:		Std	OB1-1	OB2-1	OB3-1	IB1-1
Lab Number:		4092643.1	4092643.2	4092643.3	4092643.4	4092643.5
Individual Tests						
Nitrite-N	g/m³	< 0.002	0.51	0.20	0.21	0.109
Nitrate-N	g/m³	0.48	3.3	3.3	5.1	1.94
Nitrate-N + Nitrite-N	g/m³	0.48	3.8	3.5	5.3	2.1
Sulphate	g/m³	22	61	43	63	50
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	< 0.0010	0.0013	< 0.0010	< 0.0010	0.050
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	0.0006	0.0006	< 0.0005	< 0.0005
Dissolved Copper	g/m³	0.0064	0.0013	0.0010	0.0007	0.0006
Dissolved Lead	g/m³	0.00022	< 0.00010	< 0.00010	< 0.00010	0.00010
Dissolved Nickel	g/m³	< 0.0005	0.021	0.020	0.027	0.0094
Dissolved Zinc	g/m³	0.0106	0.0019	0.0014	0.0010	< 0.0010
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	< 0.0011	0.022	0.0129	0.0142	0.085
Total Cadmium	g/m³	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053
Total Chromium	g/m³	< 0.00053	0.0049	0.0095	0.0082	0.0103
Total Copper	g/m³	0.0068	0.0076	0.0088	0.0096	0.0072
Total Lead	g/m³	0.00081	0.0120	0.0120	0.0189	0.0104
Total Nickel	g/m³	< 0.00053	0.031	0.038	0.046	0.030
Total Zinc	g/m³	0.0197	0.027	0.033	0.035	0.050

Sample Name:		IB2-1	IB3-1
Lab Number:		4092643.6	4092643.7
Individual Tests			
Sum of Anions	meq/L	3.4	3.4
Sum of Cations	meq/L	3.8	3.7
% Difference in Ion Balance	%	5.0	5.1
pH	pH Units	7.8	8.0
Total Alkalinity	g/m³ as $CaCO_3$	100	94
Carbonate Alkalinity	g/m³ as $CaCO_3$	< 1.0	< 1.0
Bicarbonate Alkalinity	g/m³ as $CaCO_3$	99	93
Total Hardness	g/m³ as $CaCO_3$	133	125
Electrical Conductivity (EC)	mS/m	35.8	35.0
Electrical Conductivity (EC)	µS/cm	358	350
Total Dissolved Solids (TDS)	g/m³	220	230
Dissolved Aluminium	g/m³	0.015	0.018
Total Aluminium	g/m³	4.5	5.5
Dissolved Boron	g/m³	< 0.05	< 0.05
Total Boron	g/m³	< 0.053	< 0.053
Dissolved Calcium	g/m³	36	34
Dissolved Cobalt	g/m³	0.0014	0.0014
Total Cobalt	g/m³	0.0146	0.0102
Dissolved Iron	g/m³	< 0.02	< 0.02
Total Iron	g/m³	15.8	16.7
Dissolved Magnesium	g/m³	10.6	10.0
Dissolved Manganese	g/m³	0.022	0.0159
Total Manganese	g/m³	0.36	0.22
Dissolved Mercury	g/m³	< 0.00010	< 0.00010
Total Mercury	g/m³	< 0.00011	< 0.00011
Dissolved Molybdenum	g/m³	0.0061 #1	0.0072
Total Molybdenum	g/m³	0.0057 #1	0.0093
Dissolved Potassium	g/m³	9.4	10.8
Dissolved Sodium	g/m³	20	21
Dissolved Strontium	g/m³	0.37	0.39
Total Strontium	g/m³	0.46	0.45
Dissolved Uranium	g/m³	0.0055	0.0064

Sample Type: Aqueous			
Sample Name:		IB2-1	IB3-1
Lab Number:		4092643.6	4092643.7
Individual Tests			
Total Uranium	g/m³	0.0070	0.0079
Dissolved Vanadium	g/m³	< 0.0010	0.0010
Total Vanadium	g/m³	0.0124	0.0125
Chloride	g/m³	17	16
Total Inorganic Nitrogen	g/m³	2.1	2.8
Total Ammoniacal-N	g/m³	0.39	0.66
Nitrite-N	g/m³	0.185	0.115
Nitrate-N	g/m³	1.51	2.1
Nitrate-N + Nitrite-N	g/m³	1.70	2.2
Sulphate	g/m³	41	41
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn			
Dissolved Arsenic	g/m³	0.042	0.051
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005
Dissolved Copper	g/m³	0.0009	< 0.0005
Dissolved Lead	g/m³	< 0.00010	< 0.00010
Dissolved Nickel	g/m³	0.0068	0.0088
Dissolved Zinc	g/m³	< 0.0010	< 0.0010
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn			
Total Arsenic	g/m³	0.117	0.080
Total Cadmium	g/m³	< 0.000053	< 0.000053
Total Chromium	g/m³	0.0067	0.0072
Total Copper	g/m³	0.0080	0.0046
Total Lead	g/m³	0.0167	0.0094
Total Nickel	g/m³	0.028	0.025
Total Zinc	g/m³	0.041	0.036

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

Amended Report: This certificate of analysis replaces report '4092643-SPv1' issued on 13-Feb-2026 at 4:37 pm. Reason for amendment: Additional testing added.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m³	1-7
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000053 - 0.0011 g/m³	1-7
Filtration, Unpreserved	Sample filtration through 0.45 µm membrane filter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch.	-	1-7
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-7
Total Digestion with HCl	Nitric/hydrochloric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-7
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1-7
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1-7

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
% Difference in Ion Balance	Calculation from Sum of Anions and Cations. Please note: The result reported for the '% Difference in Ion Balance' is an absolute difference between the 'Sum of Anions' and 'Sum of Cations' based on the formula taken from APHA. This does not indicate whether the 'Sum of Anions' or the 'Sum of Cations' produced a higher value. APHA 1030 E : Online Edition.	0.10 %	1-7
pH	pH meter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-7
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-7
Carbonate Alkalinity	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-7
Bicarbonate Alkalinity	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-7
Total Hardness	Calculation from Dissolved Calcium and Dissolved Magnesium. APHA 2340 B : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-7
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2510 B : Online Edition.	0.1 mS/m	1-7
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	1 µS/cm	1-7
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	1-7
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m^3	1-7
Total Aluminium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0032 g/m^3	1-7
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-7
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m^3	1-7
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-7
Dissolved Cobalt	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0002 g/m^3	1-7
Total Cobalt	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	1-7
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-7
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.021 g/m^3	1-7
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-7
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	1-7
Total Manganese	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m^3	1-7
Dissolved Mercury	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00010 g/m^3	1-7
Total Mercury	Acid digestion, ICP-MS, screen level. APHA 3125 B : Online Edition.	0.00011 g/m^3	1-7
Dissolved Molybdenum	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0002 g/m^3	1-7
Total Molybdenum	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	1-7
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-7

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m³	1-7
Dissolved Strontium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m³	1-7
Total Strontium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m³	1-7
Dissolved Uranium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00002 g/m³	1-7
Total Uranium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000021 g/m³	1-7
Dissolved Vanadium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0010 g/m³	1-7
Total Vanadium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0011 g/m³	1-7
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	1-7
Total Inorganic Nitrogen	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.010 g/m³	1-7
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m³	1-7
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-7
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m³	1-7
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-7
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	1-7

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 07-Feb-2026 and 21-Feb-2026. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

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Certificate of Analysis

Client:	Oceana Gold (New Zealand) Limited	**Lab No:**	4100657 SPv1
Contact:	Rachel Skews	**Date Received:**	14-Feb-2026
	C/- Verum Group Limited	**Date Reported:**	05-Mar-2026
	PO Box 29415	**Quote No:**	140473
	Riccarton	**Order No:**	512224
	Christchurch 8440	**Client Reference:**	Macraes EPTS Dissolved Sulphur
		Submitted By:	Jessie Callaghan

Sample Type: Aqueous

Sample Name:		Pre-NRB(dosed) field filtered 12-Feb-2026	Pre-SRB(dosed) field filtered 12-Feb-2026	Post-SRB field filtered 12-Feb-2026	"Post-SOB-P field filtered 12-Feb-2026	OB1 12-Feb-2026
Lab Number:		4100657.1	4100657.2	4100657.3	4100657.4	4100657.5
Individual Tests						
Sum of Anions	meq/L	-	-	-	-	5.0
Sum of Cations	meq/L	-	-	-	-	5.3
% Difference in Ion Balance	%	-	-	-	-	2.6
pH	pH Units	-	-	-	-	7.4
Total Alkalinity	g/m³ as $CaCO_3$	-	-	-	-	135
Carbonate Alkalinity	g/m³ as $CaCO_3$	-	-	-	-	< 1.0
Bicarbonate Alkalinity	g/m³ as $CaCO_3$	-	-	-	-	135
Total Hardness	g/m³ as $CaCO_3$	-	-	-	-	183
Electrical Conductivity (EC)	mS/m	-	-	-	-	51.9
Electrical Conductivity (EC)	µS/cm	-	-	-	-	519
Total Dissolved Solids (TDS)	g/m³	-	-	-	-	340
Dissolved Aluminium	g/m³	-	-	-	-	< 0.003
Total Aluminium	g/m³	-	-	-	-	1.41
Dissolved Boron	g/m³	-	-	-	-	< 0.05
Total Boron	g/m³	-	-	-	-	< 0.053
Dissolved Calcium	g/m³	-	-	-	-	34
Dissolved Cobalt	g/m³	-	-	-	-	0.028
Total Cobalt	g/m³	-	-	-	-	0.031
Dissolved Iron	g/m³	-	-	-	-	0.90
Total Iron	g/m³	-	-	-	-	5.1
Dissolved Magnesium	g/m³	-	-	-	-	24
Dissolved Manganese	g/m³	-	-	-	-	5.0
Total Manganese	g/m³	-	-	-	-	5.1
Dissolved Mercury	g/m³	-	-	-	-	< 0.00010
Total Mercury	g/m³	-	-	-	-	< 0.00011
Dissolved Molybdenum	g/m³	-	-	-	-	0.0012 #1
Total Molybdenum	g/m³	-	-	-	-	0.00105 #1
Dissolved Potassium	g/m³	-	-	-	-	11.8
Dissolved Sodium	g/m³	-	-	-	-	24
Dissolved Strontium	g/m³	-	-	-	-	0.26
Total Strontium	g/m³	-	-	-	-	0.26
Total Sulphur	g/m³	490	460	420	510	-
Dissolved Uranium	g/m³	-	-	-	-	0.00022
Total Uranium	g/m³	-	-	-	-	0.00046
Dissolved Vanadium	g/m³	-	-	-	-	< 0.0010
Total Vanadium	g/m³	-	-	-	-	0.0027
Chloride	g/m³	-	-	-	-	18

Sample Type: Aqueous						
Sample Name:		Pre-NRB(dosed) field filtered 12-Feb-2026	Pre-SRB(dosed) field filtered 12-Feb-2026	Post-SRB field filtered 12-Feb-2026	"Post-SOB-P field filtered 12-Feb-2026	OB1 12-Feb-2026
Lab Number:		4100657.1	4100657.2	4100657.3	4100657.4	4100657.5
Individual Tests						
Total Inorganic Nitrogen	g/m³	-	-	-	-	1.38
Total Ammoniacal-N	g/m³	-	-	-	-	1.12
Nitrite-N	g/m³	-	-	-	-	0.059
Nitrate-N	g/m³	-	-	-	-	0.21
Nitrate-N + Nitrite-N	g/m³	-	-	-	-	0.26
Sulphate	g/m³	-	-	-	-	87
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	-	-	-	-	0.095
Dissolved Cadmium	g/m³	-	-	-	-	< 0.00005
Dissolved Chromium	g/m³	-	-	-	-	< 0.0005
Dissolved Copper	g/m³	-	-	-	-	< 0.0005
Dissolved Lead	g/m³	-	-	-	-	< 0.00010
Dissolved Nickel	g/m³	-	-	-	-	0.037
Dissolved Zinc	g/m³	-	-	-	-	0.0020
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	-	-	-	-	0.107
Total Cadmium	g/m³	-	-	-	-	< 0.000053
Total Chromium	g/m³	-	-	-	-	0.0023
Total Copper	g/m³	-	-	-	-	0.0024
Total Lead	g/m³	-	-	-	-	0.0032
Total Nickel	g/m³	-	-	-	-	0.039
Total Zinc	g/m³	-	-	-	-	0.0118

Sample Name:		OB2 12-Feb-2026	OB3 12-Feb-2026	IB1 12-Feb-2026	IB2 12-Feb-2026	IB3 12-Feb-2026
Lab Number:		4100657.6	4100657.7	4100657.8	4100657.9	4100657.10
Individual Tests						
Sum of Anions	meq/L	3.9	4.9	5.9	5.2	5.5
Sum of Cations	meq/L	4.1	5.0	6.3	5.7	5.9
% Difference in Ion Balance	%	1.84	1.47	3.1	4.3	4.1
pH	pH Units	7.5	7.4	7.9	8.0	8.0
Total Alkalinity	g/m³ as $CaCO_3$	95	116	200	167	176
Carbonate Alkalinity	g/m³ as $CaCO_3$	< 1.0	< 1.0	1.4	1.5	1.8
Bicarbonate Alkalinity	g/m³ as $CaCO_3$	95	116	199	166	175
Total Hardness	g/m³ as $CaCO_3$	136	171	230	200	210
Electrical Conductivity (EC)	mS/m	42.1	51.1	58.7	52.8	55.1
Electrical Conductivity (EC)	µS/cm	421	511	587	528	551
Total Dissolved Solids (TDS)	g/m³	270	330	350	280	320
Dissolved Aluminium	g/m³	< 0.003	< 0.003	0.009	0.008	0.009
Total Aluminium	g/m³	0.82	0.48	0.29	0.139	0.53
Dissolved Boron	g/m³	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total Boron	g/m³	< 0.053	< 0.053	< 0.053	< 0.053	< 0.053
Dissolved Calcium	g/m³	24	29	62	55	57
Dissolved Cobalt	g/m³	0.027	0.031	0.0037	0.0031	0.0033
Total Cobalt	g/m³	0.031	0.034	0.0040	0.0032	0.0045
Dissolved Iron	g/m³	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Total Iron	g/m³	2.5	1.45	0.80	0.41	1.69
Dissolved Magnesium	g/m³	18.6	24	17.2	16.5	17.3
Dissolved Manganese	g/m³	3.5	4.6	0.083	0.148	0.029
Total Manganese	g/m³	3.6	4.6	0.097	0.153	0.053
Dissolved Mercury	g/m³	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Total Mercury	g/m³	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011
Dissolved Molybdenum	g/m³	0.0009 #1	0.0009 #1	0.0178	0.0164	0.0157
Total Molybdenum	g/m³	0.00088 #1	0.00083 #1	0.0193	0.0178	0.0188
Dissolved Potassium	g/m³	10.7	13.4	18.3	15.6	16.5

Sample Type: Aqueous						
Sample Name:		OB2 12-Feb-2026	OB3 12-Feb-2026	IB1 12-Feb-2026	IB2 12-Feb-2026	IB3 12-Feb-2026
Lab Number:		4100657.6	4100657.7	4100657.8	4100657.9	4100657.10
Individual Tests						
Dissolved Sodium	g/m³	21	22	27	26	27
Dissolved Strontium	g/m³	0.165 #1	0.21	0.84	0.72 #1	0.76 #1
Total Strontium	g/m³	0.163 #1	0.21	0.84	0.70 #1	0.76 #1
Dissolved Uranium	g/m³	0.00010	0.00012	0.0195	0.0162	0.022
Total Uranium	g/m³	0.00022	0.00021	0.021	0.0171	0.023
Dissolved Vanadium	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0011
Total Vanadium	g/m³	0.0015	< 0.0011	0.0014	0.0012	0.0021
Chloride	g/m³	18	19	19	18	19
Total Inorganic Nitrogen	g/m³	1.61	1.65	0.93	1.70	1.43
Total Ammoniacal-N	g/m³	1.05	1.47	0.86	0.76	0.87
Nitrite-N	g/m³	0.141	0.043	0.010	0.24	0.174
Nitrate-N	g/m³	0.41	0.135	0.053	0.70	0.39
Nitrate-N + Nitrite-N	g/m³	0.55	0.178	0.062	0.94	0.57
Sulphate	g/m³	72	96	64	62	65
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	0.0017	0.0025	0.133	0.104	0.066
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Lead	g/m³	< 0.00010	< 0.00010	0.00015	0.00011	0.00015
Dissolved Nickel	g/m³	0.037	0.037	0.0189	0.0176 #1	0.022
Dissolved Zinc	g/m³	0.0018	0.0018	0.0014	< 0.0010	< 0.0010
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	0.0044	0.0044	0.139	0.105	0.075
Total Cadmium	g/m³	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053
Total Chromium	g/m³	0.00153	0.00110	0.00061	< 0.00053	0.00112
Total Copper	g/m³	0.00149	0.00099	< 0.00053	< 0.00053	< 0.00053
Total Lead	g/m³	0.00198	0.00129	0.00066	0.00063	0.00136
Total Nickel	g/m³	0.040	0.038	0.0190	0.0173 #1	0.023
Total Zinc	g/m³	0.0077	0.0052	0.0027	0.0012	0.0058

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m³	5-10
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000053 - 0.0011 g/m³	5-10
Filtration, Unpreserved	Sample filtration through 0.45 µm membrane filter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch.	-	5-10
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) : Online Edition.	-	5-10
Total Digestion	Boiling nitric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-4
Total Digestion with HCl	Nitric/hydrochloric acid digestion. APHA 3030 E (modified) : Online Edition.	-	5-10
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	5-10

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	5-10
% Difference in Ion Balance	Calculation from Sum of Anions and Cations. Please note: The result reported for the '% Difference in Ion Balance' is an absolute difference between the 'Sum of Anions' and 'Sum of Cations' based on the formula taken from APHA. This does not indicate whether the 'Sum of Anions' or the 'Sum of Cations' produced a higher value. APHA 1030 E : Online Edition.	0.10 %	5-10
pH	pH meter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	5-10
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m^3 as $CaCO_3$	5-10
Carbonate Alkalinity	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 as $CaCO_3$	5-10
Bicarbonate Alkalinity	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 as $CaCO_3$	5-10
Total Hardness	Calculation from Dissolved Calcium and Dissolved Magnesium. APHA 2340 B : Online Edition.	1.0 g/m^3 as $CaCO_3$	5-10
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2510 B : Online Edition.	0.1 mS/m	5-10
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	1 µS/cm	5-10
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	5-10
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m^3	5-10
Total Aluminium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0032 g/m^3	5-10
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	5-10
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m^3	5-10
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	5-10
Dissolved Cobalt	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0002 g/m^3	5-10
Total Cobalt	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	5-10
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	5-10
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.021 g/m^3	5-10
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	5-10
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	5-10
Total Manganese	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m^3	5-10
Dissolved Mercury	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00010 g/m^3	5-10
Total Mercury	Acid digestion, ICP-MS, screen level. APHA 3125 B : Online Edition.	0.00011 g/m^3	5-10
Dissolved Molybdenum	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0002 g/m^3	5-10

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Molybdenum	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m³	5-10
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m³	5-10
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m³	5-10
Dissolved Strontium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m³	5-10
Total Strontium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m³	5-10
Total Sulphur	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B : Online Edition.	0.5 g/m³	1-4
Dissolved Uranium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00002 g/m³	5-10
Total Uranium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000021 g/m³	5-10
Dissolved Vanadium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0010 g/m³	5-10
Total Vanadium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0011 g/m³	5-10
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	5-10
Total Inorganic Nitrogen	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.010 g/m³	5-10
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m³	5-10
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	5-10
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m³	5-10
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	5-10
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m³	5-10

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 14-Feb-2026 and 04-Mar-2026. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Yu-Hsuan (Coco) Hsueh BSc (Tech)
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Oceana Gold (New Zealand) Limited	**Lab No:**	4114895 SPv1
Contact:	[redacted]	**Date Received:**	28-Feb-2026
	C/- Oceana Gold (New Zealand) Limited	**Date Reported:**	10-Mar-2026
	PO Box 5442	**Quote No:**	
	Moray Place	**Order No:**	545256
	Dunedin 9058	**Client Reference:**	IBC Saturation Trial
		Submitted By:	[redacted]

Sample Type: Aqueous

Sample Name:		IB2- 2 27-Feb-2026	IB3- 2 27-Feb-2026	OB1- 2 27-Feb-2026	OB2- 2 27-Feb-2026	OB3- 2 27-Feb-2026
Lab Number:		4114895.1	4114895.2	4114895.3	4114895.4	4114895.5
Individual Tests						
Sum of Anions	meq/L	6.0	6.0	5.1	4.0	5.2
Sum of Cations	meq/L	6.2	6.4	5.4	4.3	5.5
pH	pH Units	8.0	8.0	7.4	7.5	7.4
Total Alkalinity	g/m³ as $CaCO_3$	200	195	130	85	126
Bicarbonate	g/m³ at 25°C	240	240	158	103	153
Total Hardness	g/m³ as $CaCO_3$	230	240	194	150	196
Electrical Conductivity (EC)	mS/m	58.3	58.6	51.3	42.6	52.3
Total Dissolved Solids (TDS)	g/m³	350	360	320	290	350
Dissolved Aluminium	g/m³	0.004	0.008	< 0.003	< 0.003	< 0.003
Total Aluminium	g/m³	0.35	0.57	0.91	0.48	0.37
Dissolved Boron	g/m³	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total Boron	g/m³	< 0.053	< 0.053	< 0.053	< 0.053	< 0.053
Dissolved Calcium	g/m³	61	64	35	26	33
Dissolved Cobalt	g/m³	0.0029	0.0048	0.0151	0.0181	0.0190
Total Cobalt	g/m³	0.0033	0.0054	0.0177	0.0195	0.0199
Dissolved Iron	g/m³	0.18	< 0.02	2.3	0.17	2.7
Total Iron	g/m³	1.16	1.58	5.6	1.69	3.8
Dissolved Magnesium	g/m³	19.3	19.9	26	21	27
Dissolved Manganese	g/m³	0.27	0.0058	3.6 #1	2.8 #1	4.3 #1
Total Manganese	g/m³	0.28	0.026	3.5 #1	2.7 #1	4.2 #1
Dissolved Mercury	g/m³	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Total Mercury	g/m³	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011
Dissolved Molybdenum	g/m³	0.020	0.024	0.0013 #1	0.0006	0.0014
Total Molybdenum	g/m³	0.022	0.027	0.00128 #1	0.00073	0.00148
Dissolved Potassium	g/m³	16.3	14.9	11.4	10.6	12.9
Dissolved Sodium	g/m³	26	27	23	20	22
Dissolved Strontium	g/m³	0.81	0.83 #1	0.25	0.172 #1	0.21
Total Strontium	g/m³	0.82	0.83 #1	0.25	0.163 #1	0.22
Dissolved Uranium	g/m³	0.024 #1	0.031	0.00024	0.00008	0.00011
Total Uranium	g/m³	0.023 #1	0.032	0.00044	0.000171	0.000191
Dissolved Vanadium	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total Vanadium	g/m³	0.0014	0.0021	0.0019	< 0.0011	< 0.0011
Chloride	g/m³	19	19	19	18	20
Total Ammoniacal-N	g/m³	0.45	0.124	0.65	0.57	0.87
Nitrite-N	g/m³	0.032	0.068	0.019	0.004	0.012
Nitrate-N	g/m³	0.45	1.12	0.053	0.061	0.116
Nitrate-N + Nitrite-N	g/m³	0.48	1.18	0.072	0.065	0.128
Total Kjeldahl Nitrogen (TKN)	g/m³	0.62	0.26	1.06	0.84	1.12

Sample Type: Aqueous						
Sample Name:		IB2- 2 27-Feb-2026	IB3- 2 27-Feb-2026	OB1- 2 27-Feb-2026	OB2- 2 27-Feb-2026	OB3- 2 27-Feb-2026
Lab Number:		4114895.1	4114895.2	4114895.3	4114895.4	4114895.5
Individual Tests						
Total Phosphorus	g/m³	0.071	0.034	0.27	0.153	0.092
Sulphate	g/m³	69	72	93	88	99
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	0.26	0.092	0.151	0.0036	0.029
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005	0.0006	< 0.0005	< 0.0005
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	0.0005	< 0.0005
Dissolved Lead	g/m³	0.00016	0.00024	< 0.00010	< 0.00010	< 0.00010
Dissolved Nickel	g/m³	0.0179	0.029	0.027	0.041	0.024
Dissolved Zinc	g/m³	< 0.0010	< 0.0010	0.0014	0.0029	0.0020
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	0.30	0.099	0.170	0.0052	0.032
Total Cadmium	g/m³	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053
Total Chromium	g/m³	0.00057	0.00080	0.0021	0.00124	0.00126
Total Copper	g/m³	< 0.00053	0.00055	0.0020	0.00130	0.00098
Total Lead	g/m³	0.00103	0.00111	0.0034	0.0021	0.00154
Total Nickel	g/m³	0.0187	0.031	0.031	0.043	0.025
Total Zinc	g/m³	0.0028	0.0041	0.0083	0.0044	0.0040

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00005 - 0.0010 g/m³	1-5
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000053 - 0.0011 g/m³	1-5
Filtration, Unpreserved	Sample filtration through 0.45 µm membrane filter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch.	-	1-5
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-5
Total Digestion with HCl	Nitric/hydrochloric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E : Online Edition.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E : Online Edition.	0.05 meq/L	1-5
pH	pH meter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m³ as $CaCO_3$	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D : Online Edition.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Dissolved Calcium and Dissolved Magnesium. APHA 2340 B : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2510 B : Online Edition.	0.1 mS/m	1-5
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	1-5
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.003 g/m^3	1-5
Total Aluminium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0032 g/m^3	1-5
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-5
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-5
Dissolved Cobalt	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0002 g/m^3	1-5
Total Cobalt	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-5
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.021 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	1-5
Total Manganese	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m^3	1-5
Dissolved Mercury	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00010 g/m^3	1-5
Total Mercury	Acid digestion, ICP-MS, screen level. APHA 3125 B : Online Edition.	0.00011 g/m^3	1-5
Dissolved Molybdenum	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0002 g/m^3	1-5
Total Molybdenum	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.02 g/m^3	1-5
Dissolved Strontium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0005 g/m^3	1-5
Total Strontium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m^3	1-5
Dissolved Uranium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00002 g/m^3	1-5
Total Uranium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000021 g/m^3	1-5
Dissolved Vanadium	Filtered sample, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0010 g/m^3	1-5
Total Vanadium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0011 g/m^3	1-5
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-5
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m^3	1-5
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-5
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, automated phenol/hypochlorite colorimetry. APHA 4500-N_{org} D (modified): Online Edition.	0.10 g/m^3	1-5
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) : Online Edition.	0.002 g/m^3	1-5
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 03-Mar-2026 and 09-Mar-2026. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Yu-Hsuan (Coco) Hsueh BSc (Tech)
Client Services Manager - Environmental

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis

Client:	Oceana Gold (New Zealand) Limited	**Lab No:**	4138595 SPv1
Contact:	[redacted]	**Date Received:**	17-Mar-2026
	C/- Oceana Gold (New Zealand) Limited	**Date Reported:**	26-Mar-2026
	PO Box 5442	**Quote No:**	32948
	Moray Place	**Order No:**	545256
	Dunedin 9058	**Client Reference:**	IBC Leach Trial
		Submitted By:	[redacted]

Sample Type: Aqueous

Sample Name:		IB2 13-Mar-2026	IB3 13-Mar-2026	OB1 13-Mar-2026	OB2 13-Mar-2026	OB3 13-Mar-2026
Lab Number:		4138595.1	4138595.2	4138595.3	4138595.4	4138595.5
Individual Tests						
pH	pH Units	8.2	8.2	7.7	7.6	7.4
Total Alkalinity	g/m³ as $CaCO_3$	220	220	112	70	134
Electrical Conductivity (EC)	mS/m	66.5	64.5	57.1	47.2	58.7
Total Dissolved Solids (TDS)	g/m³	390	390	340	290	340
Total Aluminium	g/m³	0.92	6.9	1.33	0.77	5.9
Total Boron	g/m³	< 0.053	< 0.053	< 0.053	< 0.053	< 0.053
Total Calcium	g/m³	68	74	36	28	37
Total Cobalt	g/m³	0.0056	0.028	0.0104	0.0091	0.038
Total Magnesium	g/m³	23	26	30	23	33
Total Manganese	g/m³	0.093	0.25	1.96	1.20	6.5
Total Mercury	g/m³	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011
Total Molybdenum	g/m³	0.048	0.061	0.00088	0.00052	0.00129
Total Potassium	g/m³	18.6	17.0	12.4	11.4	13.9
Total Sodium	g/m³	32	30	28	23	26
Total Strontium	g/m³	0.98	1.01	0.27	0.189	0.26
Total Uranium	g/m³	0.035	0.040	0.00051	0.000169	0.00094
Total Vanadium	g/m³	0.0029	0.0145	0.0027	0.0013	0.0103
Chloride	g/m³	21	19	22	20	23
Total Ammoniacal-N	g/m³	0.049	< 0.010	0.35	0.25	1.33
Nitrite-N	g/m³	0.012	0.003	0.011	0.017	< 0.002
Nitrate-N	g/m³	0.84	0.42	0.090	0.32	0.004
Nitrate-N + Nitrite-N	g/m³	0.85	0.43	0.101	0.34	0.005
Total Kjeldahl Nitrogen (TKN)	g/m³	0.23	0.40	0.78	0.54	2.0
Total Phosphorus	g/m³	0.143	0.36	0.22	0.132	1.93
Sulphate	g/m³	85	83	128	115	115
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	0.21	0.195	0.110	0.0046	0.053
Total Cadmium	g/m³	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053
Total Chromium	g/m³	0.00137	0.0080	0.0024	0.00123	0.0093
Total Copper	g/m³	0.00145	0.0066	0.0030	0.0024	0.0096
Total Lead	g/m³	0.0022	0.0156	0.0043	0.0024	0.0147
Total Nickel	g/m³	0.027	0.059	0.027	0.044	0.044
Total Zinc	g/m³	0.0062	0.045	0.0124	0.0072	0.035

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000053 - 0.0011 g/m^3	1-5
Filtration, Unpreserved	Sample filtration through 0.45 µm membrane filter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch.	-	1-5
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-5
Total Digestion with HCl	Nitric/hydrochloric acid digestion. APHA 3030 E (modified) : Online Edition.	-	1-5
pH	pH meter. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2320 B (modified for Alkalinity <20) : Online Edition.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2510 B : Online Edition.	0.1 mS/m	1-5
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. Analysed at Hill Laboratories - Chemistry; Unit 1, 17 Print Place, Middleton, Christchurch. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) : Online Edition.	10 g/m^3	1-5
Total Aluminium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0032 g/m^3	1-5
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m^3	1-5
Total Calcium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m^3	1-5
Total Cobalt	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	1-5
Total Magnesium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.021 g/m^3	1-5
Total Manganese	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m^3	1-5
Total Mercury	Acid digestion, ICP-MS, screen level. APHA 3125 B : Online Edition.	0.00011 g/m^3	1-5
Total Molybdenum	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00021 g/m^3	1-5
Total Potassium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.053 g/m^3	1-5
Total Sodium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.021 g/m^3	1-5
Total Strontium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.00053 g/m^3	1-5
Total Uranium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.000021 g/m^3	1-5
Total Vanadium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B : Online Edition.	0.0011 g/m^3	1-5
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-5
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m^3	1-5
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m^3	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, automated phenol/hypochlorite colorimetry. APHA 4500-N_{org} D (modified): Online Edition.	0.10 g/m^3	1-5
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) : Online Edition.	0.002 g/m^3	1-5
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) : Online Edition.	0.5 g/m^3	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 18-Mar-2026 and 26-Mar-2026. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

ANALYSIS REPORT

WP26-16713

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 04-Mar-2026
Completed: 17/04/2026
Job Number: WP26-16713
Report Number: 0000033627
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	ESO_CSA06V S % LOR 0.01	ESO_CSA06V C* % LOR 0.01	ESO_NEPM103_1_2 pH 1:2 aged* pH unit LOR 2.00	ESO_NEPM103_1_2 Cond (1:2) aged* µS/cm LOR 2.00
CX91300	WP26-16713.001	0.375	0.18	-	-
CX94000	WP26-16713.002	0.128	0.36	8.7	250
CX91200	WP26-16713.003	0.118	0.35	8.6	250
CX91220	WP26-16713.004	0.155	0.37	9.0	340
CX91240	WP26-16713.005	0.225	0.92	9.0	370
CX91260	WP26-16713.006	0.318	0.94	9.0	320
CX91280	WP26-16713.007	0.291	0.98	9.0	340

ANALYSIS REPORT

WP26-16713

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 04-Mar-2026
Completed: 17/04/2026
Job Number: WP26-16713
Report Number: 0000033627
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	ESO_CLA48V ANC H2SO4* KGH2SO4/T LOR -1,000.00	ESO_CLA48V ANC CaCO3* % LOR -100.00	ESO_CLA48V TAP* KGH2SO4/T LOR 0.15	ESO_CLA48V NAPP* KGH2SO4/T LOR -1,000.00
CX91300	WP26-16713.001	-	-	-	-
CX94000	WP26-16713.002	23	2.4	3.9	-19
CX91200	WP26-16713.003	24	2.4	3.6	-20
CX91220	WP26-16713.004	23	2.4	4.7	-19
CX91240	WP26-16713.005	51	5.2	6.9	-44
CX91260	WP26-16713.006	56	5.7	9.7	-46
CX91280	WP26-16713.007	61	6.2	8.9	-52

ANALYSIS REPORT

WP26-16713

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 04-Mar-2026
Completed: 17/04/2026
Job Number: WP26-16713
Report Number: 0000033627
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	ESO_CLA49V NAG pH* pH unit LOR 2.00	ESO_CLA49V NAG to pH 4.5* KGH2SO4/T	ESO_CLA49V NAG* KGH2SO4/T
CX91300	WP26-16713.001	-	-	-
CX94000	WP26-16713.002	5.4	0	13
CX91200	WP26-16713.003	5.2	0	18
CX91220	WP26-16713.004	4.9	0	21
CX91240	WP26-16713.005	6.6	0	3
CX91260	WP26-16713.006	6.6	0	2
CX91280	WP26-16713.007	6.6	0	2

Date Start/End Analysis (3/4/2026 - 17/4/2026)

* - Denotes non accredited tests

REMARKS:
Blank NAG Ph=4.93

ANALYSIS REPORT

WP26-16713

Client:	MINE WASTE MANAGEMENT LIMITED PO Box 8040, Riccarton Christchurch 8440 NEW ZEALAND Attention:	**Received:** **Completed:** **Job Number:** **Report Number:** **Order Reference:**	04-Mar-2026 17/04/2026 WP26-16713 0000033627 J-NZ0498 ST

APPLIED METHODS:

ESO_CSA06V: Total sulphur/carbon, LECO Method: SGS Global method

ESO_CLA49V: Net Acid Generation Test: SGS Global method

ESO_NEPM103_1_2: Paste pH in soil: NEPM103 1:2 extraction

ESO_CLA48V: Determination of ANC, TAP and NAPP of Soils/Rocks: SGS inhouse method

Signed and dated on 17-Apr-2026

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EWAEC_APHA2510 Conductivity µS/cm LOR 2.00	EWAPH_APHA4500H PH pH unit LOR 2.00	EWA_APHA2310 Acidity pH4 mg/l LOR 5.00	EWA_APHA2310 Acidity pH5 mg/l LOR 5.00
CX94000	WP26-16795.001	51	7.8	-	-
CX91200	WP26-16795.002	45	7.8	-	-
CX91220	WP26-16795.003	44	8.6	-	-
CX91240	WP26-16795.004	65	8.9	-	-
CX91260	WP26-16795.005	66	9.1	-	-
CX91280	WP26-16795.006	65	9.3	-	-

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EWA_APHA2310 Acidity pH7 mg/l LOR 5.00	EWA_APHA2320 AlkbicarHCO3 mg/l LOR 5.00	EWA_APHA2320 AlkcarCO3 mg/l LOR 5.00	EWA_APHA2320 AlkhydOH mg/l LOR 5.00
CX94000	WP26-16795.001	-	18	<5	<5
CX91200	WP26-16795.002	-	17	<5	<5
CX91220	WP26-16795.003	-	17	<5	<5
CX91240	WP26-16795.004	-	45	<5	<5
CX91260	WP26-16795.005	-	49	<5	<5
CX91280	WP26-16795.006	-	49	<5	<5

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EWA_APHA2320 AlkPHN* mg/l LOR 5.00	EWA_APHA2320 AlkTOT mg/l CaCO3 LOR 5.00	EWASC_APHA4500NH3H NH3-N g/m3 LOR 0.01	EWAIC_APHA4110B_ELS F g/m3 LOR 0.02
CX94000	WP26-16795.001	<5	15	0.09	0.16
CX91200	WP26-16795.002	<5	14	0.04	0.16
CX91220	WP26-16795.003	<5	14	0.06	0.18
CX91240	WP26-16795.004	<5	37	0.29	0.07
CX91260	WP26-16795.005	<5	40	0.30	0.08
CX91280	WP26-16795.006	<5	40	0.31	0.07

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EWASC_APHA4500_NO3_I Total N g/m3 LOR 0.05	EW_APHA3125_DIS_ELS Al* g/m3 LOR 0.01	EW_APHA3125_DIS_ELS Sb* g/m3	EW_APHA3125_DIS_ELS As* g/m3
CX94000	WP26-16795.001	0.45	0.299	0.001	0.002
CX91200	WP26-16795.002	0.60	0.787	0.001	0.002
CX91220	WP26-16795.003	0.54	0.455	0.002	0.002
CX91240	WP26-16795.004	0.47	0.332	0.023	0.046
CX91260	WP26-16795.005	0.34	0.515	0.022	0.056
CX91280	WP26-16795.006	0.28	0.575	0.021	0.052

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EW_APHA3125_DIS_ELS Ba* g/m3	EW_APHA3125_DIS_ELS B* g/m3 LOR 0.01	EW_APHA3125_DIS_ELS Cd* g/m3	EW_APHA3125_DIS_ELS Ca* g/m3 LOR 0.10
CX94000	WP26-16795.001	0.007	0.007	<0.0002	3.3
CX91200	WP26-16795.002	0.011	0.007	<0.0002	2.7
CX91220	WP26-16795.003	0.008	0.007	<0.0002	2.7
CX91240	WP26-16795.004	0.005	0.009	<0.0002	9.7
CX91260	WP26-16795.005	0.004	0.010	<0.0002	7.7
CX91280	WP26-16795.006	0.004	0.011	<0.0002	7.6

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EW_APHA3125_DIS_ELS Cr* g/m3	EW_APHA3125_DIS_ELS Co* g/m3	EW_APHA3125_DIS_ELS Cu* g/m3	EW_APHA3125_DIS_ELS Fe* g/m3 LOR 0.01
CX94000	WP26-16795.001	<0.001	<0.001	<0.001	0.185
CX91200	WP26-16795.002	0.001	0.002	0.001	0.762
CX91220	WP26-16795.003	<0.001	0.001	<0.001	0.348
CX91240	WP26-16795.004	<0.001	<0.0005	<0.001	0.007
CX91260	WP26-16795.005	<0.001	<0.0005	<0.0005	0.009
CX91280	WP26-16795.006	<0.001	<0.0005	<0.0005	0.009

ANALYSIS REPORT

WP26-16795

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PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EW_APHA3125_DIS_ELS Pb* g/m3	EW_APHA3125_DIS_ELS Mg* g/m3 LOR 0.02	EW_APHA3125_DIS_ELS Mn* g/m3	EW_APHA3125_DIS_ELS Mo* g/m3
CX94000	WP26-16795.001	<0.0005	2.39	0.097	0.003
CX91200	WP26-16795.002	<0.001	2.06	0.110	0.003
CX91220	WP26-16795.003	<0.001	2.14	0.102	0.003
CX91240	WP26-16795.004	<0.0005	1.08	0.003	0.002
CX91260	WP26-16795.005	<0.0005	0.93	<0.001	0.002
CX91280	WP26-16795.006	<0.0005	0.90	<0.001	0.002

ANALYSIS REPORT

WP26-16795

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Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EW_APHA3125_DIS_ELS Ni* g/m3	EW_APHA3125_DIS_ELS K* g/m3 LOR 0.10	EW_APHA3125_DIS_ELS Se* g/m3	EW_APHA3125_DIS_ELS Ag* g/m3
CX94000	WP26-16795.001	0.002	4.1	<0.005	<0.0005
CX91200	WP26-16795.002	0.003	4.3	<0.005	<0.0005
CX91220	WP26-16795.003	0.002	4.2	<0.005	<0.0005
CX91240	WP26-16795.004	<0.001	6.1	<0.005	<0.0005
CX91260	WP26-16795.005	<0.0005	6.0	<0.005	<0.0005
CX91280	WP26-16795.006	<0.0005	6.3	<0.005	<0.0005

ANALYSIS REPORT

WP26-16795

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PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EW_APHA3125_DIS_ELS Na* g/m3 LOR 0.50	EW_APHA3125_DIS_ELS Sr* g/m3	EW_APHA3125_DIS_ELS Tl* g/m3	EW_APHA3125_DIS_ELS Sn* g/m3
CX94000	WP26-16795.001	0.8	0.018	<0.0005	<0.001
CX91200	WP26-16795.002	0.9	0.015	<0.0005	<0.0005
CX91220	WP26-16795.003	0.8	0.014	<0.0005	<0.001
CX91240	WP26-16795.004	1.0	0.099	<0.0005	<0.0005
CX91260	WP26-16795.005	0.9	0.077	<0.0005	<0.0005
CX91280	WP26-16795.006	1.0	0.073	<0.0005	<0.0005

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
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Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EW_APHA3125_DIS_ELS U* g/m3	EW_APHA3125_DIS_ELS V* g/m3	EW_APHA3125_DIS_ELS W* g/m3	EW_APHA3125_DIS_ELS Zn* g/m3 LOR 0.01
CX94000	WP26-16795.001	<0.0002	<0.001	<0.001	0.009
CX91200	WP26-16795.002	<0.0002	0.002	<0.001	0.067
CX91220	WP26-16795.003	<0.0002	0.001	<0.001	0.006
CX91240	WP26-16795.004	0.001	0.004	0.008	0.006
CX91260	WP26-16795.005	<0.001	0.006	0.007	<0.005
CX91280	WP26-16795.006	<0.001	0.006	0.007	<0.002

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EWAIC_APHA4110B CL* g/m3 LOR 0.02	EWAIC_APHA4110B Nitrate-N* g/m3 LOR 0.01	EWAIC_APHA4110B Nitrite-N* g/m3 LOR 0.01	EWAIC_APHA4110B SO4* g/m3 LOR 0.10
CX94000	WP26-16795.001	0.16	0.26	<0.01	7.6
CX91200	WP26-16795.002	0.20	0.23	<0.01	5.5
CX91220	WP26-16795.003	0.15	0.26	<0.01	6.9
CX91240	WP26-16795.004	0.27	0.13	<0.01	6.4
CX91260	WP26-16795.005	12	0.11	<0.01	4.2
CX91280	WP26-16795.006	2.0	0.093	<0.01	2.0

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

Sampled By:

Sample ID	Laboratory ID	EWASC_APHA4500_P_G Total P g/m3 LOR 0.01
CX94000	WP26-16795.001	6.020
CX91200	WP26-16795.002	1.790
CX91220	WP26-16795.003	1.280
CX91240	WP26-16795.004	1.130
CX91260	WP26-16795.005	1.100
CX91280	WP26-16795.006	0.840

Date Start/End Analysis (26/3/2026 - 15/4/2026)

* - Denotes non accredited tests

REMARKS:
Analysis of ,Ammonia Nitrogen/Total N, Total P/Flouride and Dissolved Metals is subcontracted to Eurofins Els, 85 Port Road, Seaview, Lower Hutt, Wellington NZ-5010 NEW ZEALAND.
Report # AR-26-NW-033650-01
Nitrite-N < DL

ANALYSIS REPORT

WP26-16795

Client: MINE WASTE MANAGEMENT LIMITED
PO Box 8040, Riccarton

Christchurch 8440 NEW ZEALAND
Attention:

Received: 26-Mar-2026
Completed: 15/04/2026
Job Number: WP26-16795
Report Number: 0000033599
Order Reference: J-NZ0498 ST

APPLIED METHODS:

EWAEC_APHA2510: Conductivity and TDS by Calculation - Water: APHA 2510 SGS Westport

EWA_APHA2320: Alkalinity: APHA 2320B

EWASC_APHA4500_NO3_I: Total nitrogen APHA4500-NO3 I following persulphate digest APHA4500N C: APHA 4500-NO3 I Subcontracted ELS

EWAPRP_APHA3030B_IC: Filtration water 45 µm: APHA 3030B

EWAPH_APHA4500H: pH in water by APHA4500H: APHA 4500 H SGS Westport

EWASC_APHA4500NH3H: Ammonia nitrogen by CFA/FIA: APHA 4500 NH3 H online edition subcontracted ELS

EWAPRP_APHA3030B: Filtration water 45 µm: APHA 3030B

EWAIC_APHA4110B: Anions by Ion Chromatography in Water: APHA 4110 B

EWA_APHA2310: Acidity includes Free CO2: APHA 2310

EWAIC_APHA4110B_ELS: Anions by Ion Chromatography in Water: APHA 4110 B subcontracted ELS

EW_APHA3125_DIS_ELS: Trace metals (dissolved) in water by APHA3125 (modified): APHA 3125 subcontracted ELS

EWASC_APHA4500_P_G: Dissolved reactive and total phosphorus: APHA 4500-P G subcontracted ELS

Signed and dated on 15-Apr-2026

Zahida ZIA
Environmental Supervisor

APPENDIX B GOLDEN BAR PIT LAKE WATER QUALITY MODEL

MINE WASTE MANAGEMENT
GREENROAD GROUP

5 Sir William Pickering Drive, Burnside,
Christchurch 8053, New Zealand

T. +64 3 242 0221
E. admin@minewaste.com.au

MEMORANDUM

Recipient:	OceanaGold (New Zealand) Limited c/- [redacted]
From:	Paul Weber – Mine Waste Management Limited (MWM)
Date:	31 August 2026
Cc:	[redacted] – OceanaGold Eric Chen – MWM; Leo Navarro – MWM
Document Number:	J-NZ0498-008-M-FINAL
Document Title:	Golden Bar Pit Lake Water Quality Model
Disclaimer:	This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

Mine Waste Management Limited (MWM) has been engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess environmental geochemistry hazards and potential effects for the proposed Macraes Phase Four Project (MP4 or the Project). This assessment supports the application as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

As part of the broader geoenvironmental hazard assessment, this memorandum provides a quantitative prediction of the long-term pit lake water quality for the Golden Bar (GB) Pit Lake, incorporating the proposed Stage 2 and Stage 3 extensions. It documents the hydrogeochemical modelling approach, derived source terms, and resulting pit lake water quality predictions. These predictions are used by GHD (2026a) to estimate effects on surface water and groundwater.

BACKGROUND

The GB Pit, part of the Macraes Operation, is located approximately 10 km south of the Macraes Mine Processing Plant. It was originally mined from 2004 to 2006 and has been partially rehabilitated to form a pit lake that is currently spilling water to a tributary of Murphys Creek, locally known as Golden Bar Creek (Figure 1).

The current GB Pit, partially rehabilitated in 2012, has a footprint of 14 ha. The proposed pit extension will increase the footprint by approximately 15.2 ha, resulting in a total pit footprint of approximately 29.2 ha. Additionally, the existing rehabilitated GB waste rock stack (WRS) will be expanded to approximately 55 ha. To facilitate mining of the proposed extension, the pit will be dewatered.

OBJECTIVES AND SCOPE OF WORK

The primary objective of this study is to develop a post-closure hydrogeochemical model to predict the GB Pit Lake water quality for a period of 200 years. The quantitative prediction of the long-term water quality will support GHD's assessment of environmental effects of the proposed Stage 2 and Stage 3 pit extensions on receiving waters for the Project (GHD, 2026a).

The scope of work includes:

- Developing a conceptual site model (CSM) to identify the inflows, outflows, model components, and the key geochemical and physical processes that will influence the pit lake after the proposed extensions.
- Deriving source terms (chemical composition) for pit lake inflows, utilising site-specific data where possible.
- Predicting the GB Pit Lake water quality quantitatively, based on the integration of the derived source terms with the water balance model (WBM) provided by GHD (2026b).

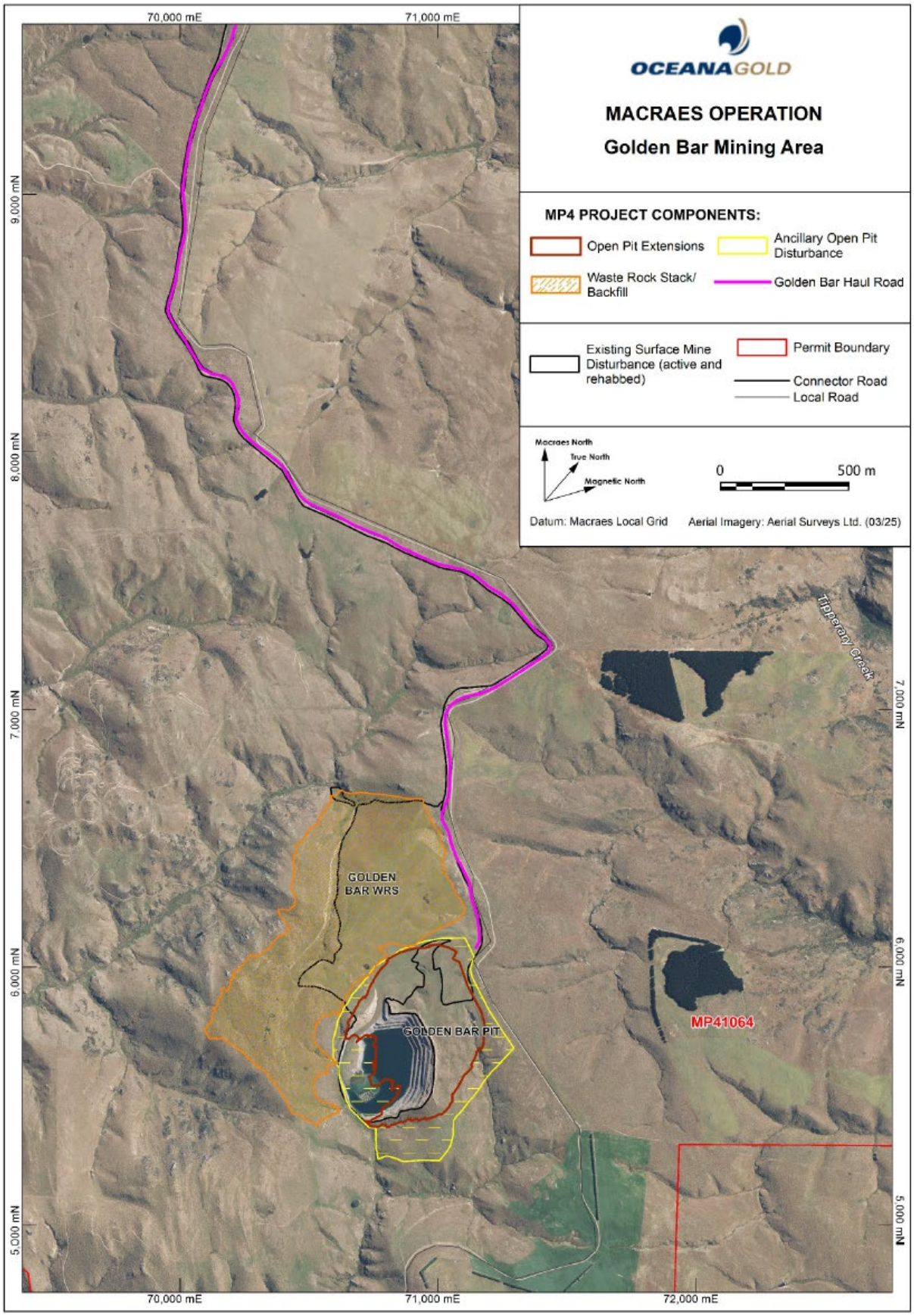

Figure 1: Golden Bar Mining Area.

Source: OGNZL (2026).

CONCEPTUAL SITE MODEL

A CSM was developed to facilitate the hydrogeochemical modelling of the GB Pit Lake (Figure 2). The inflows and outflows for the GB Pit Lake, which align with the WBM developed by GHD (introduced in the subsequent section), are summarised in Table 1. The following key points are noted:

- No backfilling is proposed for this pit extension; the geochemical contribution from the small scale backfill placed during the 2012 partial rehabilitation has been aggregated into the pit wall solute load calculation (MWM, 2025).
- The CSM accounts for six types of inflow and three types of outflow.
- A portion of the seepage from the expanded GB WRS will report to the pit.
- Groundwater outflow from the GB Pit Lake is negligible as determined by GHD (2026b).
- Upon reaching the spill elevation, the pit lake will discharge via surface overflow to Golden Bar Creek.
- The existing pit will be completely dewatered to facilitate pit expansion, leaving no residual water at the commencement of pit lake filling.

Table 1: Summary of water balance components for Golden Bar Pit Lake CSM.

MODEL FEATURE	NOTE
Inflow	
Rainfall	Direct precipitation onto the pit lake surface.
Groundwater	Inflow from the surrounding pit walls and through the pit base.
Runoff from pit walls	Runoff from exposed pit wall surfaces generated by rainfall.
Runoff from rehabilitated areas	Runoff from the mining impacted areas (including WRS) that will be fully rehabilitated.
Runoff from natural catchment	Runoff from the natural catchment (unimpacted by mining activities) to the pit.
Seepage from WRS	Seepage from the GB WRS. Seepage is driven by net percolation of meteoric water through the WRS that migrates into the pit.
Outflow	
Evaporation	Loss of pure water from the pit lake surface due to evaporation, causing evapoconcentration of solutes.
Groundwater	Outflow from the pit as groundwater into the surrounding aquifer.
Overflow	Surface discharge from the GB Pit Lake to Golden Bar Creek once the spill point is reached.

Note: All water flow rates are based on the water balance provided by GHD (2026b).

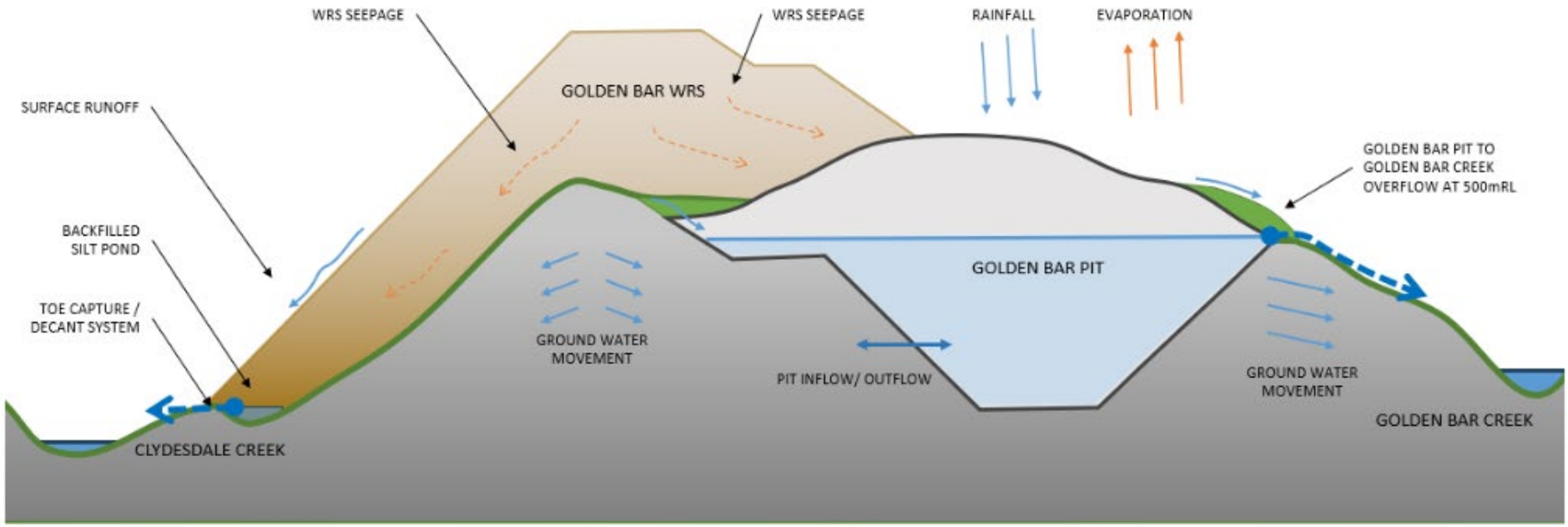

Figure 2: Conceptual site model for Golden Bar Pit.

Source: GHD (2026a).

Note: Image is not to scale.

WATER BALANCE MODEL

The WBM was developed by GHD (2026b) to provide the hydrologic basis for the pit lake water quality modelling. The key findings and model summary are as follows:

- Modelling period – The WBM covers a 200-year post-closure period (2033 to 2233) utilising an annual timestep.
- Inflow components – Six inflow sources are accounted for over the 200-year period (Figure 3), fluctuating dynamically in response to the rising pit lake water level:
    - Direct rainfall onto the pit lake surface contributes approximately 53% of the total inflow volume over the modelling period.
    - Pit wall runoff contributes over 27% of the total inflow volume.
    - Other inflows, including groundwater inflow (5.4%), seepage from the GB WRS (4.5%), natural catchment runoff (4.3%), and rehabilitated WRS runoff (5.6%), constitute the remaining volume.
- Outflow components – Three outflow pathways are accounted for over the 200-year period (Figure 4):
    - Evaporation accounts for approximately 65.6% of the total outflow volume.
    - Surface overflow accounts for approximately 34.4% of the total outflow volume.
    - Groundwater outflow is negligible at 0.02%.
- Spill dynamics and equilibrium:
    - Year 49: Short-term hydrologic fluctuations (e.g., episodic high rainfall) cause the water level to temporarily reach the spill point, initiating intermittent overflow to Golden Bar Creek.
    - Year 70: The system achieves a long-term, hydrodynamic steady-state equilibrium at 500 mRL (the spill point; Figure 5).
    - At equilibrium, the pit lake depth is predicted to reach 89.5 m based on a pit floor base level of 410.5 mRL, with a total pit lake volume of approximately 5.8 Mm^3.

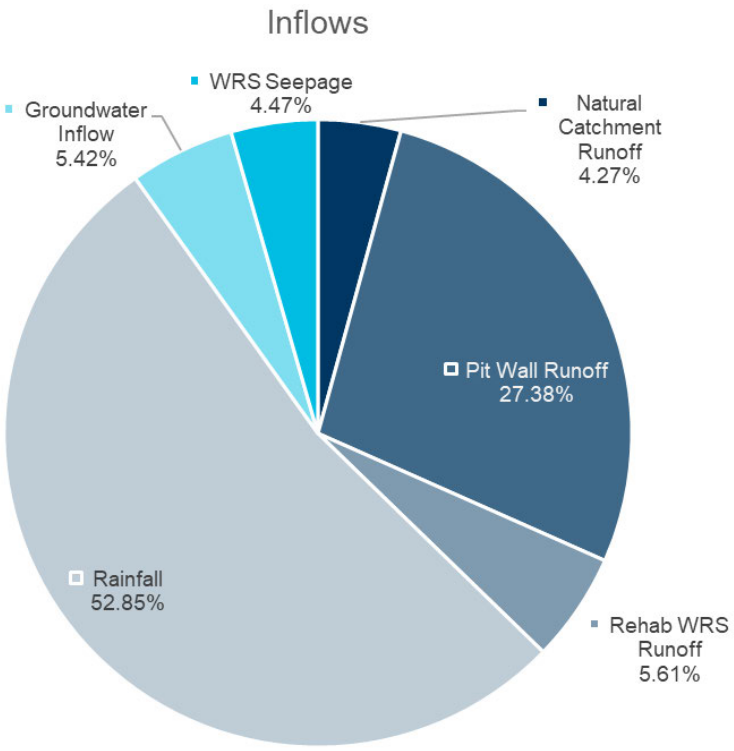

Figure 3: Predicted proportions of cumulative water inflows to Golden Bar Pit Lake (200-year period).

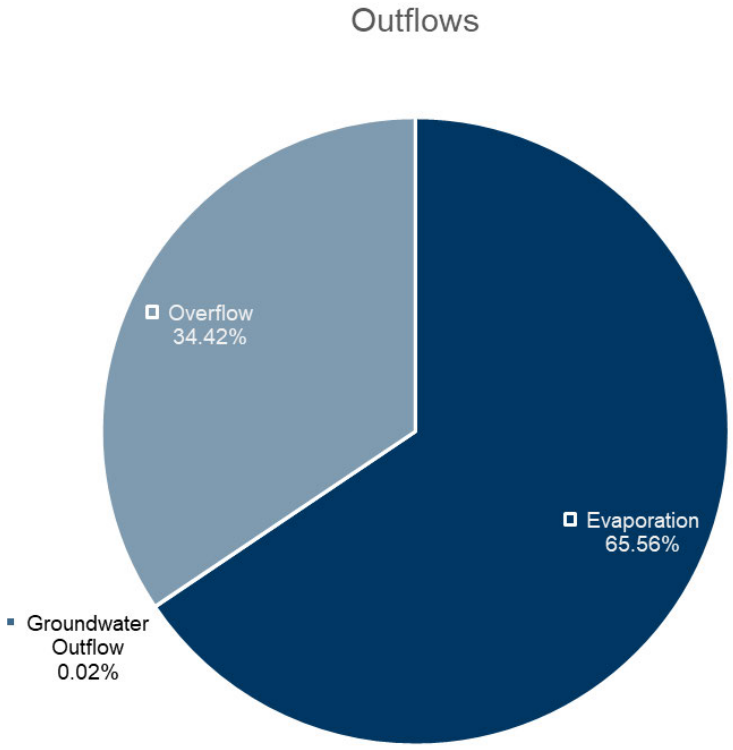

Figure 4: Predicted proportions of cumulative water outflows from Golden Bar Pit Lake (200-year period).

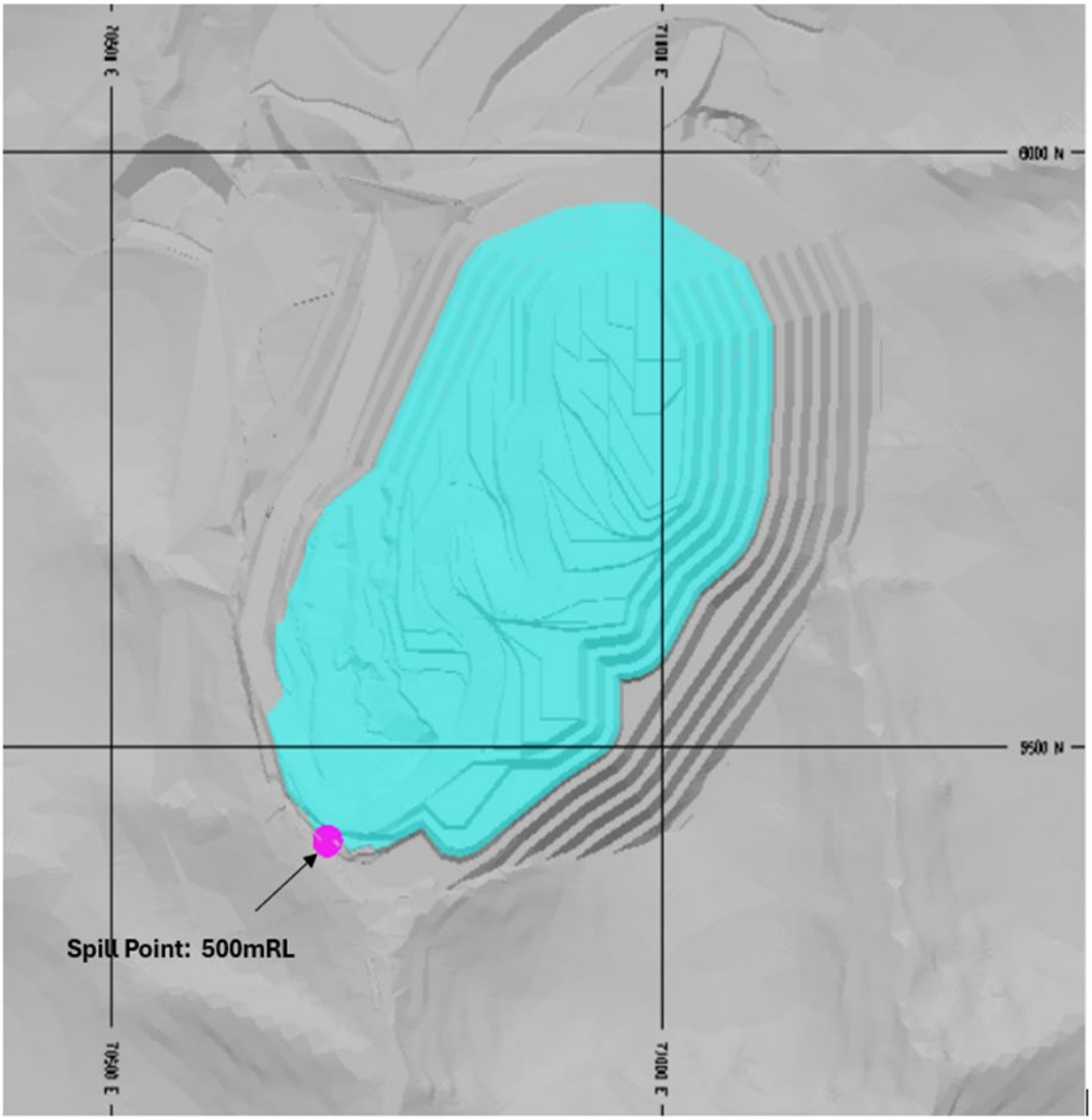

Figure 5: Golden Bar Pit Lake with spill point at 500 mRL.

Source: GHD (2026b).

SOURCE TERMS

Water quality source terms for the various inflows were derived from relevant geochemical and environmental monitoring datasets (Table 2). The derivation methodology is detailed in the hydrogeochemical modelling report (MWM, 2026b), with the resulting source terms summarised in Table 3.

It is noted that the seepage source term for the GB WRS was derived based on a height of 18 m. This height corresponds to the portion of the WRS catchment that contributes seepage to the GB Pit Lake.

Table 2: Data sources for source term derivation.

MODEL FEATURE	SOURCE TERM DATA SOURCE
Rainfall	Rainfall quality data from Nichol et al. (1997), collected between 1983 and 1994 at the Lauder collection site (~70 km NE from Macraes Operation).
Groundwater	Average of the median groundwater quality monitoring data from compliance monitoring wells MAC-RCH3004, 2775, and 2585.
Pit wall runoff	Source term derived for the Golden Bar Analogue Model (MWM, 2025).
Natural catchment runoff	Median water quality monitoring data from compliance monitoring site GB02 (pre-2015).
Runoff from rehabilitated areas (incl. WRS)	Median water quality monitoring data from the monitoring point at Deepdell South Silt Pond (MWM, 2026b), as recommended by GHD (2026a).
WRS seepage (GB WRS)	This source term represents the portion of the waste rock that drains into the pit lake. It is based on the GB WRS seepage assessment (MWM, 2026a) with necessary modifications, using the correlations from MWM (2026a) and assuming an average height of 18 m for the WRS basal sub-catchment.

Table 3: Summary of source terms derived for Golden Bar Pit.

TYPE		RAINFALL	GROUND WATER	PIT WALL RUNOFF	NATURAL CATCHMENT RUNOFF	REHAB AREA RUNOFF	WRS SEEPAGE (GB)
Data Source	Unit	Nichol et al. (1997)	Monitoring data: RCH3004, RCH2775, RCH2585	GB Analogue Model (MWM, 2025)	Monitoring data: GB02	Monitoring data: Deepdell South Silt Pond	WRS Seepage Assessment (MWM, 2026a)
pH	pH units	5.2	6.7	8.4	7.5	8.0	6.8
Total alkalinity	mg/L as $CaCO_3$	0.81	95.8	573	32.5	119	128
Ca	mg/L	0.11	22.4	190	8.15	40	229
Mg	mg/L	0.05	11.1	186	2.95	7.9	254
Na	mg/L	0.32	10.9	32.4	8.5	12	46
K	mg/L	0.09	1.06	11.2	0.725	1.7	6.8
SO_4	mg/L	0.18	14.3	719	6.45	20	1,566
Cl	mg/L	0.6	10.2	15.6	9.25	8	11
NO_3-N	mg/L	0.0045	0.544	0.019	0.025	0.001	8
Amm-N	mg/L	-	0.0075	0.038	0.0125	0.005	0.005
As	mg/L	-	0.00156	0.409	0.00175	0.0039	0.001
Cu	mg/L	-	0.00426	0.001	0.00095	0.001	0.0011
Fe	mg/L	-	1.48	0.065	0.18	0.07	0.02
Pb	mg/L	-	0.00465	0.0003	0.0002	0.00005	0.0001
Zn	mg/L	-	0.0213	0.008	0.00235	0.0005	0.049

Note: Amm-N refers to ammoniacal N. Values for trace elements were derived for the dissolved fractions.

WATER QUALITY MODEL

Model Development

The pit lake water quality model was developed using PHREEQC software (Parkhurst & Appelo, 2013) with the WATEQ4F thermodynamic database (Ball & Nordstrom, 1991). The model simulated the following geochemical and physical processes:

- Mixing: Integration of multiple inflow streams.
- Evapoconcentration: Concentration of solutes due to pit lake surface evaporation.
- Gas exchange: Equilibration of water with atmospheric O_2 and CO_2.
- Mineral saturation: Thermodynamic control via mineral dissolution and precipitation.
- Surface complexation: Adsorption of trace elements onto hydrous ferric oxides (HFO), such as amorphous ferrihydrite $Fe(OH)_3$ (a), where present.
- Nitrogen attenuation: Degradation and removal of nitrogenous species.

The mineral assemblage, which includes the mineral phases selected for the calculation of mineral saturation, is provided in Table 4.

Table 4: Mineral assemblage used in the PHREEQC model.

PHASE	FORMULA	PHASE	FORMULA
Calcite	$CaCO_3$	Gypsum	$CaSO_4 \cdot 2H_2O$
Hydromagnesite	$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$	Quartz	SiO_2
$Fe(OH)_3$ (a)	$Fe(OH)_3$	Malachite	$Cu_2(CO_3)(OH)_2$
Smithsonite	$ZnCO_3$	O_2(g)	O_2
CO_2(g)	CO_2		

Assumptions and Limitations

The key assumptions and limitations of the model include:

- The model assumes a fully mixed (holomictic) water column throughout the modelling period. The assumption is based on the expectation of a low risk of persistent multi-year stratification of pit lakes (MWM, 2026b). Hence, this well-mixed configuration defines the redox environment for the PHREEQC simulation. While localised oxygen depletion may occur at depth, the adopted approach provides a consistent basis for predicting long-term water quality trends and mineral stability.
- In the absence of site-specific redox data, a pE[1] of 10, representing oxidising conditions, was adopted for all source terms and equilibrium phases.
- Measured site data indicates that the GB Pit Lake ranges in temperature from approximately 7°C to 13°C (MWM, 2026b); hence, a constant water temperature of 10ºC was applied to all inflows and the pit lake body, which is considered reasonable for modelling purposes.
- Iron (Fe) in all source terms was assumed to be entirely ferric iron (Fe^{3+}), consistent with the assumed oxidising environment (pE = 10). It is noted that the relatively high Fe concentration (1.48 mg/L) in groundwater may report to the lake as ferrous iron (Fe^{2+}), which is nevertheless expected to rapidly oxidise to Fe^{3+} under circumneutral conditions with negligible or low O_2 consumption.

[1] pE is the negative logarithm of electron activity (pE = -log[e^-]). It serves as a master variable for redox status, analogous to pH for acidity.

- An initial nitrogen load of 5.35 g/m^2, representing residual ANFO[2] from blasting, was simulated as a staged release of NH_4NO_3 over the first four years of pit filling (MWM, 2025). Based on a calculated plan area of approximately 497,300 m^2 for the new pit design, the total nitrogen load available for release is calculated at 2,660 kg (5.35 g/m^2 x 497,300 m^2).
- A nitrogen decay rate based on observations from the GB Pit Lake (MWM, 2025) was implemented. The model assumes a 20-25% annual reduction in nitrate load, attributed to biologically mediated denitrification or other attenuation processes.

MODEL PREDICTION

Water Volume Variation

Annual volumetric variability for each water balance component is illustrated in Figure 6. The comprehensive water balance for the GB Pit Lake is presented as stacked charts for inflow (Figure 7) and outflow (Figure 8), based on data provided by GHD (2026b). These plots demonstrate that while several inflows peak during the initial pit filling phase, direct rainfall steadily increases until approximately Year 70. Among the outflows, lake evaporation remains the predominant pathway, with surface overflow contributing the remainder of the balance once the lake reaches equilibrium. Groundwater outflow remains negligible at this scale (Figure 8).

[2] *Ammonium nitrate fuel oil.*

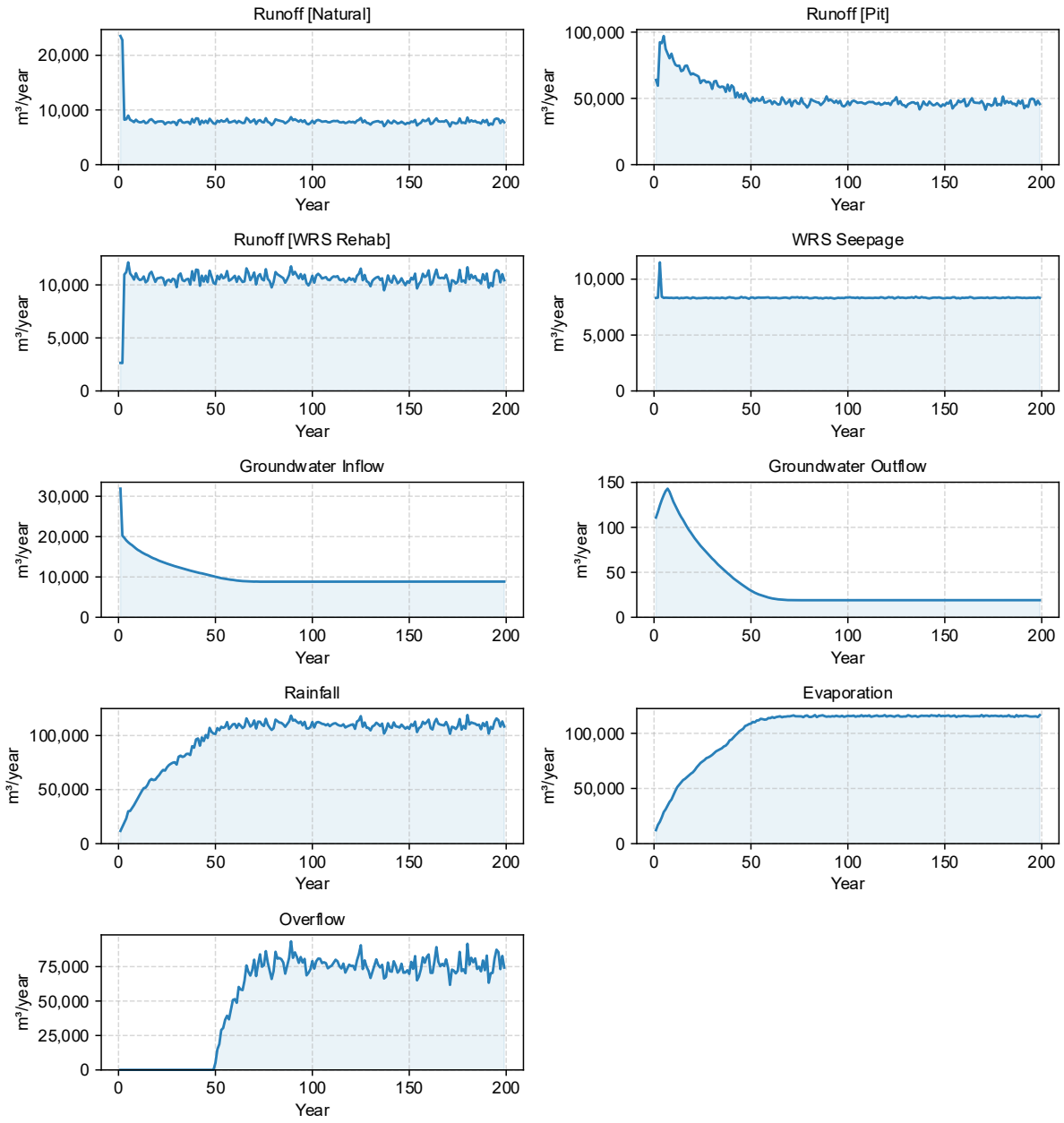

Figure 6: Annual water balance fluxes for Golden Bar Pit Lake.

Source: GHD (2026b).

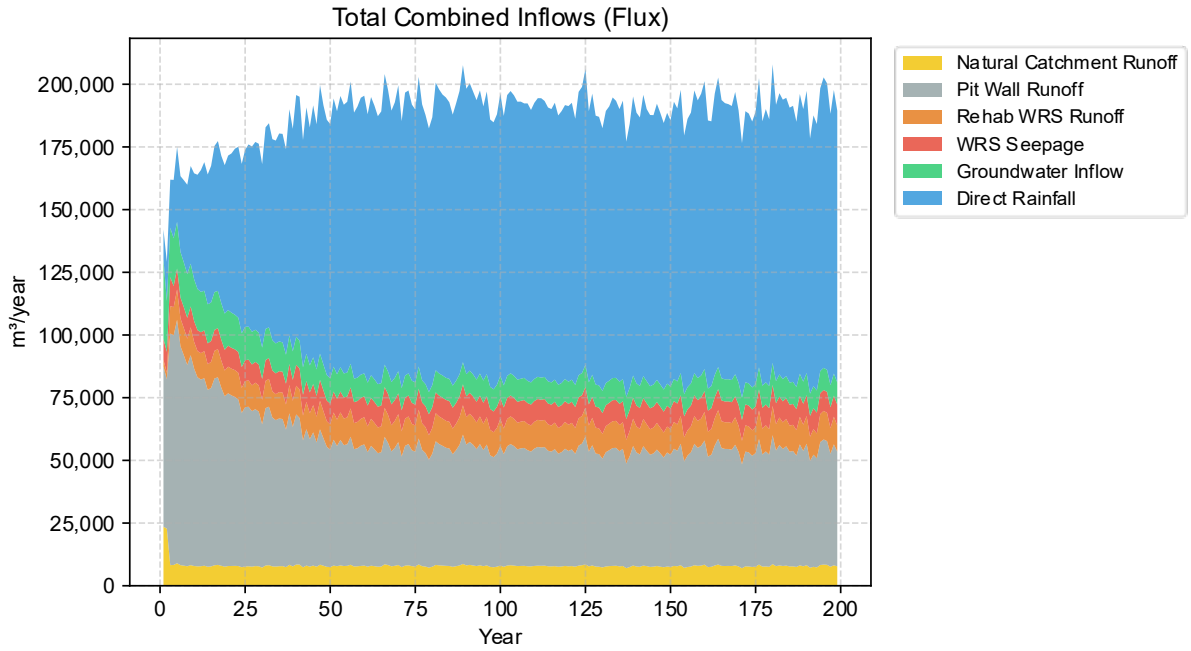

Figure 7: Stacked water balance of annual inflows to Golden Bar Pit Lake.

Source: GHD (2026b).

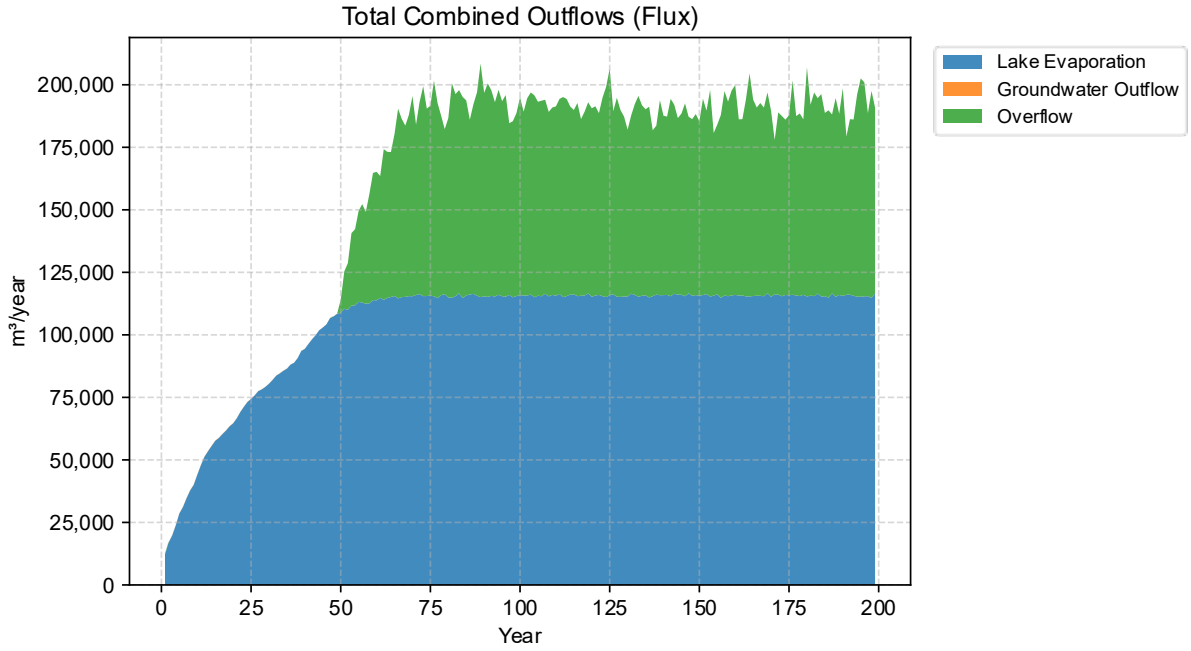

Figure 8: Stacked water balance of annual outflows from Golden Bar Pit Lake.

Groundwater outflow (generally ~20m³/year) represents <0.03% of the maximum y-axis value (200,000 m³/year) and is therefore negligible at this scale.

Source: GHD (2026b).

Water Quality Prediction

The predicted long-term water quality for the GB Pit Lake is summarised in Table 5. The temporal evolution of key parameters over the 200-year modelling period is illustrated in Figure 9 and Figure 10. The following observations are noted:

- **pH and alkalinity:** The GB Pit Lake is predicted to remain circumneutral, with pH stabilising at approximately 7.7. Total alkalinity is predicted to be steady at approximately 190 mg $CaCO_3$/L, driven by equilibrium with calcite.
- **Salinity:** The long-term total dissolved solids (TDS) concentration is predicted to exceed 1,100 mg/L. This value represents the net mass remaining in solution, after accounting for both evapoconcentration and solute removal via secondary mineral precipitation.
- **Major ions:**
    - Magnesium (Mg) is the dominant major cation, with a predicted concentration of approximately 140 mg/L, higher than other major cations including Ca (65 mg/L), Na (29 mg/L), and K (8 mg/L).
    - Sulfate (SO_4) concentrations are predicted to increase gradually post closure from 457 mg/L to 612 mg/L over the 200-year modelling period. Chloride (Cl) concentrations are expected to remain stable at approximately 13 mg/L.
- **Trace elements and mineral precipitation:**
    - Dissolved Fe concentrations are predicted to remain low at 0.00018 mg/L, which is controlled by the solubility of amorphous $Fe(OH)_3$.
    - Approximately 20 kg of Fe enters the pit lake annually, primarily via groundwater inflows. Over the 200-year modelling period, this cumulative mass influx yields approximately 7,912 kg of precipitated amorphous $Fe(OH)_3$, which provide specific surface areas for the adsorption and sequestration of trace metals and metalloids (e.g., arsenic).
    - Arsenic (As) concentrations are predicted to stabilise at approximately 0.24 mg/L from Year 20 onwards.
    - Initial concentrations of other trace elements (Cu, Pb, and Zn) are low. Copper and Pb are predicted to maintain steady concentrations of 0.0011 and 0.00017 mg/L, respectively, across the modelling period. Zinc concentrations are predicted to increase marginally from 0.0118 mg/L to 0.0125 mg/L.
    - Approximately 3,489 tonnes (t) of secondary calcite is predicted to precipitate over the 200-year period, providing the primary geochemical buffering mechanism maintaining the lake's circumneutral pH.
- **Nitrogenous compounds:**
    - Nitrate-nitrogen (NO_3-N) is predicted to decrease from 4.16 mg/L to 0.1 mg/L within the first 20 years, eventually stabilising at 0.04 mg/L.

- Ammoniacal nitrogen (Amm-N) follows a similar trend, decreasing from an initial 0.3756 mg/L to negligible concentrations within 10 years.

Table 5: Predicted Golden Bar Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 49	YEAR 70	YEAR 100	YEAR 200
Pit lake level	mRL	426.6	473.3	495.2	500	500	500
Pit lake volume	Mm^3	0.13	2.41	5.12	5.78	5.79	5.78
pH	pH units	7.71	7.74	7.73	7.73	7.73	7.73
TDS	mg/L	936	1,084	1,096	1,100	1,106	1,126
Total alkalinity	mg/L as $CaCO_3$	180	194	192	191	190	189
Ca	mg/L	64.0	60.8	62.1	63.0	63.9	65.4
Mg	mg/L	111	139	141	141	141	144
Na	mg/L	23.2	27.3	27.7	27.9	28.1	28.9
K	mg/L	6.3	8.0	8.1	8.0	8.0	8.1
SO_4	mg/L	457	574	585	589	595	612
Cl	mg/L	12.0	13.0	13.2	13.2	13.3	13.6
NO_3-N	mg/L	4.16	0.10	0.04	0.04	0.04	0.04
Amm-N	mg/L	0.3756	0.00015	0.00005	0.00004	0.00004	0.00004
As	mg/L	0.180	0.247	0.245	0.243	0.240	0.239
Cu	mg/L	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011
Fe	mg/L	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018
Pb	mg/L	0.00018	0.00017	0.00017	0.00017	0.00017	0.00017
Zn	mg/L	0.0118	0.0114	0.0117	0.0118	0.0120	0.0125

Note: The GB Pit Lake starts overflow in Year 49 and reaches long-term stable level in Year 70.

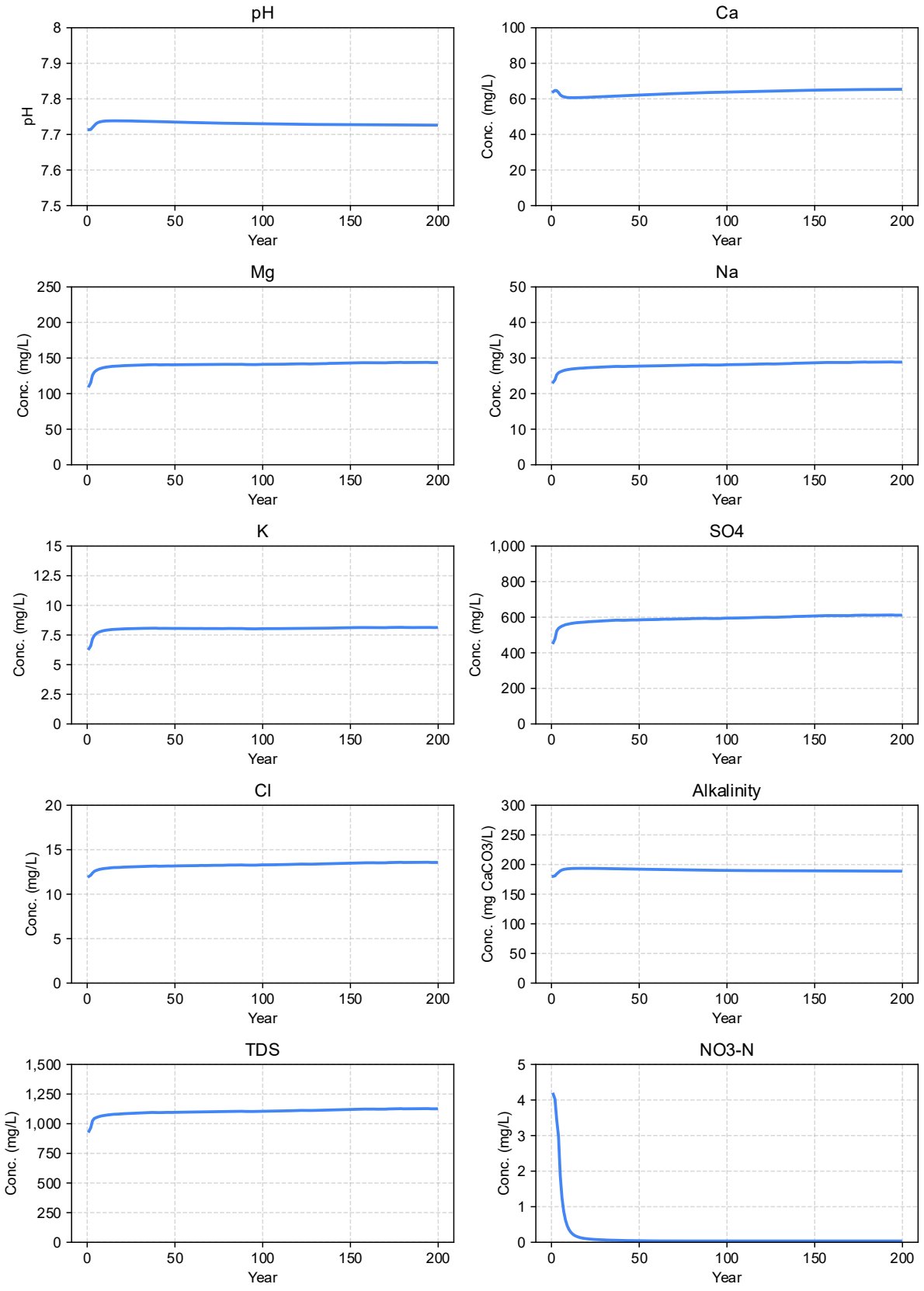

Figure 9: Predicted temporal evolution of primary water quality parameters in Golden Bar Pit Lake.

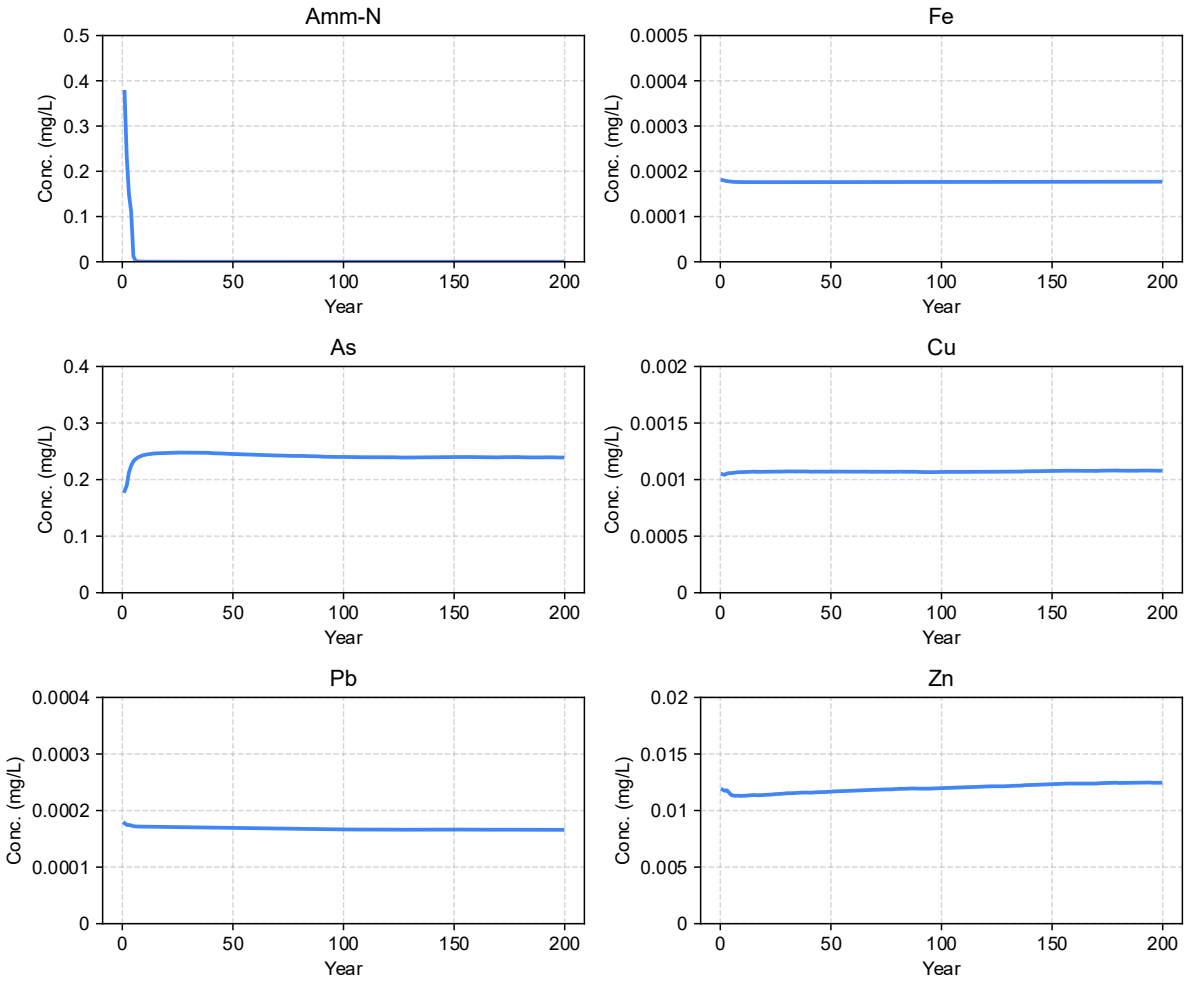

Figure 10: Predicted temporal evolution of primary water quality parameters in Golden Bar Pit Lake. (continued).

Mass Loading Prediction

The mass loading of selected chemical species entering the pit lake, categorised by inflow source, is presented in Figure 11 and Figure 12. Key observations include:

- Most chemical species exhibit an initial peak in annual loading, and the loads progressively decline as the pit lake approaches a long-term hydrogeochemical steady state by Year 70.
- Surface runoff from the exposed pit walls is the primary mass contributor during the initial infilling phases for the majority of species, including major ions, alkalinity, and As.
- WRS seepage is a significant secondary source of SO_4 and major cations to the pit lake over the modelling period.
- Groundwater mass loading contributes a substantial portion of long-term flux for trace metals and metalloids, including Fe, Cu, Pb, and Zn.
- Nitrate loading is dominated by WRS seepage and remains steady throughout the simulation. This trend is driven by a substantially higher NO_3-N concentration (8 mg/L) derived for the GB WRS seepage, relative to other sources, combined with a stable annual seepage flux.

- Amm-N loading is primarily driven by pit wall runoff and attenuates after the initial filling phase.
- The model integrates an additional 2,660 kg of nitrogen (as NH_4NO_3) released from the pit walls over the first four years. While this initial mass is omitted from the annual mass flux plots (to preserve chart legibility and prevent extreme y-axis scaling distortion), it is the primary contributor to the NO_3-N and Amm-N concentrations predicted during the early post-closure phase.

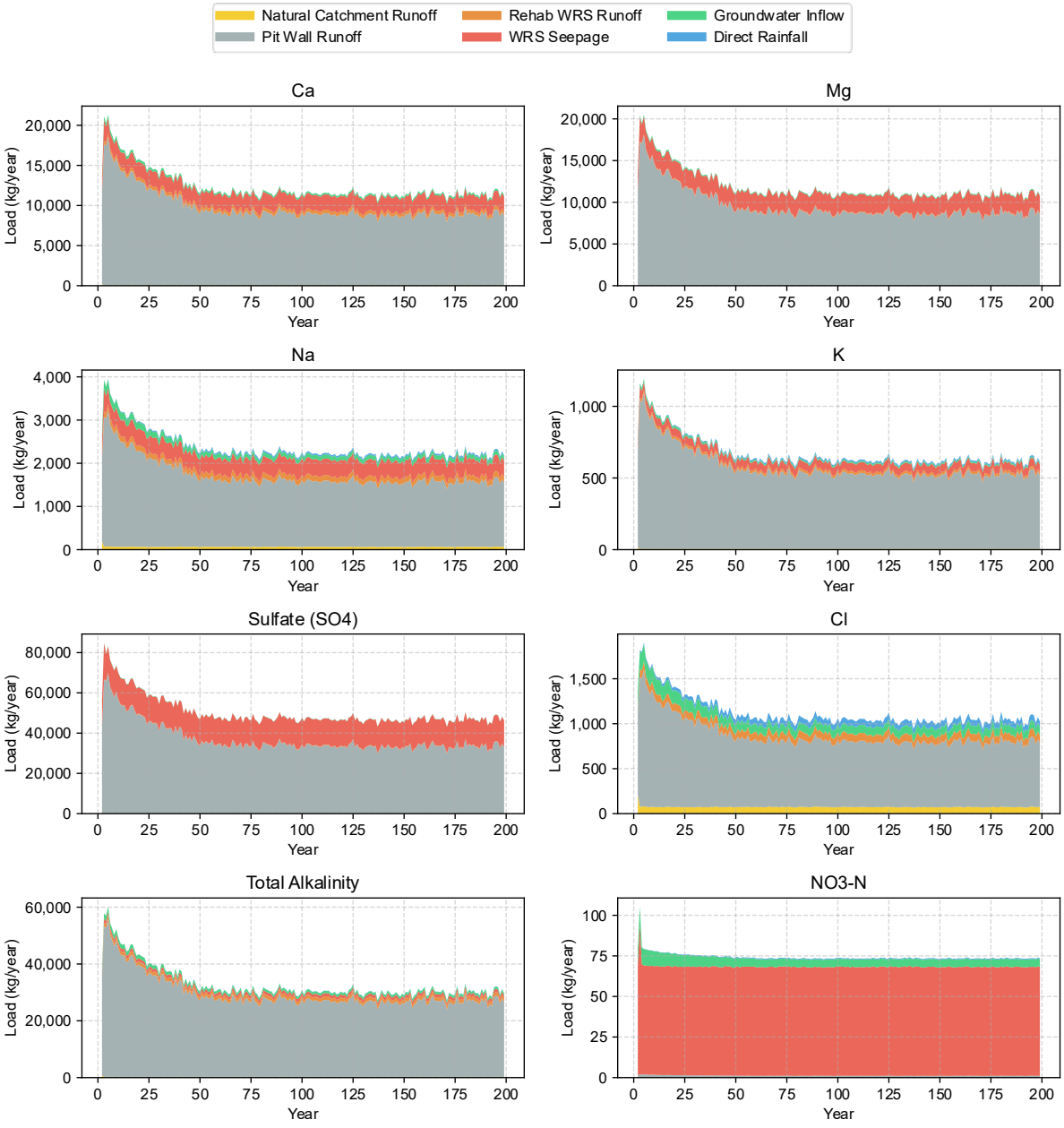

Figure 11: Predicted annual mass loading for Golden Bar Pit Lake by water balance component.

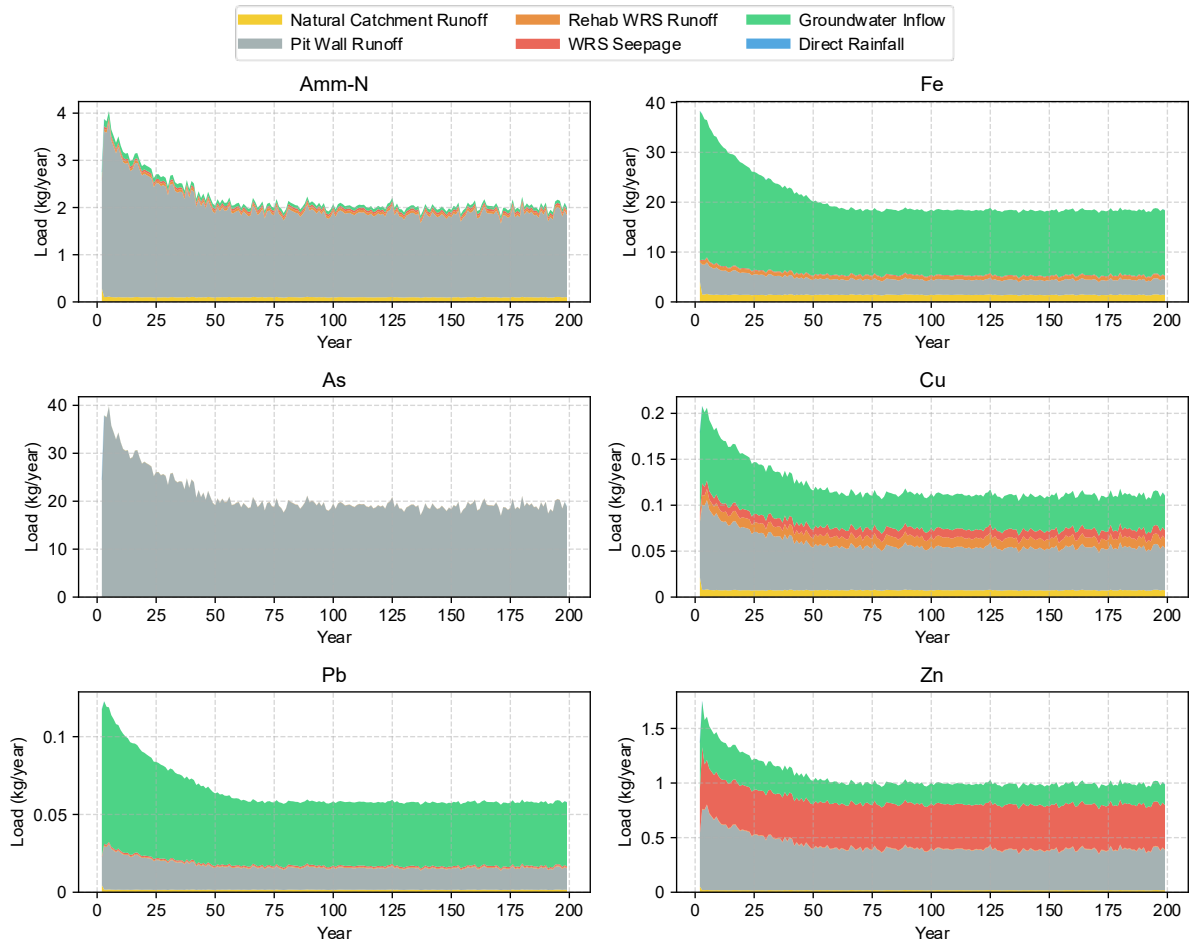

Figure 12: Predicted annual mass loading for Golden Bar Pit Lake by water balance component (continued).

SUMMARY

The long-term water quality of the GB Pit Lake was modelled to assess the post-closure geochemical evolution and potential environmental impacts of the proposed Project. The predictive simulations indicate the following key outcomes:

- The pit lake is predicted to remain circumneutral throughout both the infilling and spilling phases, maintaining a stable pH of ~7.7 supported by a sustained acid buffering capacity (predicted total alkalinity of ~190 mg $CaCO_3$/L).
- At hydraulic equilibrium (post Year 70), the pit lake is predicted to reach a TDS concentration of approximately 1,100 mg/L. Following the initial refilling phase, the hydrogeochemical profile becomes dominated by SO_4 (~612 mg/L) and Mg (~140 mg/L). The pit lake will remain unsaturated with respect to gypsum.
- Long-term secondary mineral formation is characterised by the precipitation of approximately 7,912 kg of amorphous $Fe(OH)_3$ and 3,489 t of calcite. The precipitation of amorphous $Fe(OH)_3$ provides critical reactive surfaces for the adsorption and sequestration of trace metals and metalloids.

- Due to the buffered circumneutral pH and active adsorption onto $Fe(OH)_3$ surfaces, the mobility of most modelled trace elements remains limited, with dissolved concentrations predicted to remain low.
- Nitrate and ammoniacal N concentrations are predicted to attenuate rapidly within the first 10 to 20 years post-closure, eventually stabilising at 0.04 mg/L and 0.00004 mg/L, respectively. This attenuation occurs prior to the predicted pit lake overflow in Year 49.
- Annual mass loads for the majority of chemical species modelled peak during the initial infilling phase driven primarily by surface runoff from the exposed pit walls. These loads subsequently decline over the first 70 years post-closure, eventually stabilising as the pit lake achieves a long-term hydrogeochemical steady state.

Full water quality data are provided as a Microsoft Excel file (Attachment A).

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ATTACHMENT A: GOLDEN BAR PIT LAKE DIGITAL OUTPUT MODEL RESULTS [MICROSOFT EXCEL FILE]

APPENDIX C CORONATION PIT LAKE WATER QUALITY MODEL

MINE WASTE MANAGEMENT
GREENROAD GROUP

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MEMORANDUM

Recipient:	OceanaGold (New Zealand) Limited c/- [redacted]
From:	Paul Weber – Mine Waste Management Limited (MWM)
Date:	31 August 2026
Cc:	[redacted] – OceanaGold Eric Chen – MWM; Leo Navarro – MWM
Document Number:	J-NZ0498-012-M-FINAL
Document Title:	Coronation Pit Lake Water Quality Model
Disclaimer:	This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

Mine Waste Management Limited (MWM) has been engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess environmental geochemistry hazards and potential effects for the proposed Macraes Phase Four Project (MP4 or the Project). This assessment supports the application as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

As part of the broader geoenvironmental hazard assessment, this memorandum provides a quantitative prediction of the long-term pit lake water quality for the Coronation (CO) Pit Lake, incorporating the proposed Stages 6 to 8 extensions and proposed waste rock backfills. It documents the hydrogeochemical modelling approach, derived source terms, and resulting water quality predictions. These predictions are used by GHD (2026a) to estimate effects on surface water and groundwater.

BACKGROUND

The CO Pit, part of the Macraes Operation, is located approximately 5 km north of the Macraes Mine Processing Plant. It was previously mined from 2013 to 2019 and is currently used as a temporary water storage reservoir as part of the Mine Water Management System (MWMS).

The proposed CO Stage 6-8 Pit (CO6, CO7, and CO8) consists of an approximately 560 m expansion of the existing pit toward the southeast (Figure 1). The currently authorised CO Stage 5 (CO5) Pit has a footprint of 85 ha. The proposed extension will increase the total pit footprint to approximately 125 ha. The Trimbells waste rock stack (TR WRS) will be extended by approximately 36 ha. The pit will be dewatered for the mining of the pit extension and partially backfilled at mine closure.

OBJECTIVES AND SCOPE OF WORK

The primary objective of this study is to develop a post-closure hydrogeochemical model to predict the CO Pit Lake water quality for a period of 200 years. The quantitative prediction of the long-term water quality will support GHD's assessment of environmental effects of the proposed CO6 to CO8 extensions on receiving waters for MP4 (GHD, 2026a).

The scope of work includes:

- Developing a conceptual site model (CSM) to identify the inflows, outflows, model components, and the key geochemical and physical processes that will influence the pit lake after the proposed extensions.
- Deriving source terms (chemical composition) for pit lake inflows, utilising site-specific data where possible.
- Predicting the CO Pit Lake water quality quantitatively, based on the integration of the derived source terms with the water balance model (WBM) provided by GHD (2026b).

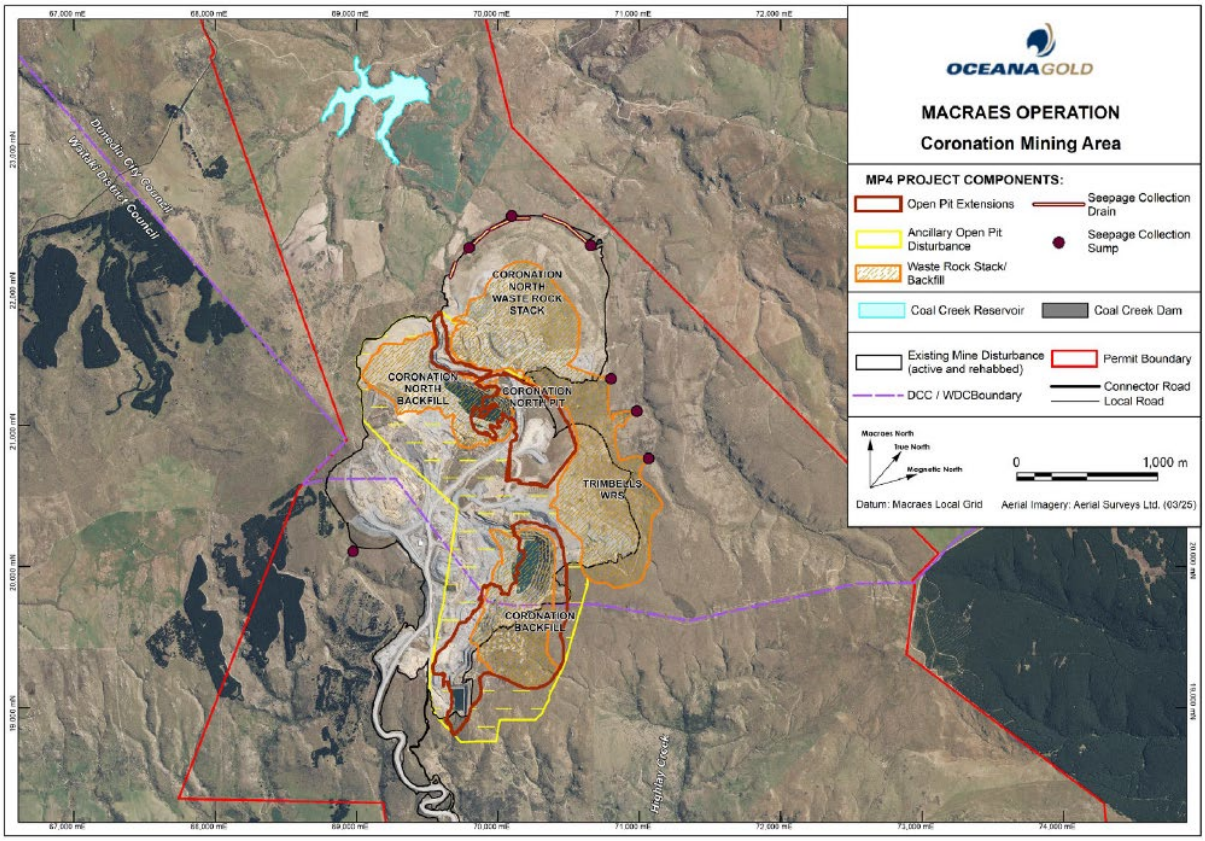

Figure 1: Coronation Mining Area showing the location of Coronation Pit extension.

Source: OGNZL (2026).

CONCEPTUAL SITE MODEL

A CSM was developed to facilitate the hydrogeochemical modelling of the CO Pit Lake (Figure 2). The inflows and outflows for the CO Pit Lake, which align with the WBM developed by GHD (introduced in the subsequent section), are summarised in Table 1. The following key points are noted:

- The pit will be partially backfilled with 24.6 Mm^3 of waste rock. Approximately 5.9 Mm^3 of this material will be above the final pit lake overflow level. Waste rock material from previous stages is included in this total volume and represented as one consolidated backfill unit in the model.
- The CSM accounts for seven types of inflow and three types of outflow.

- Seepage from the CO Backfill (COBF) and a portion of the seepage from TR WRS will report to the pit.
- Groundwater outflow from the CO Pit Lake will be limited.
- Upon reaching the spill elevation, the pit lake will discharge via surface overflow to Camp Creek in the upper catchment of Deepdell Creek.
- The existing pit will be completely dewatered to facilitate pit expansion, leaving no residual water at the commencement of pit lake filling.

Table 1: Summary of water balance components for Coronation Pit Lake CSM.

MODEL FEATURE	NOTE
Inflow	
Rainfall	Direct precipitation onto the pit lake surface.
Groundwater	Inflow from the surrounding pit walls and through the pit base.
Runoff from pit walls	Runoff from exposed pit wall surfaces generated by rainfall.
Runoff from rehabilitated areas	Runoff from the mining impacted areas (including WRS) that will be fully rehabilitated.
Runoff from natural catchment	Runoff from the natural catchment (unimpacted by mining activities) to the pit.
Seepage from WRS	Seepage from the TR WRS. Seepage is driven by net percolation of meteoric water through the WRS that migrates into the pit.
Seepage from backfill	Seepage from the unsaturated COBF material above the pit lake level that drains to the pit lake.
Outflow	
Evaporation	Loss of pure water from the pit lake surface due to evaporation, causing evapoconcentration of solutes.
Groundwater	Outflow from the pit as groundwater into the surrounding aquifer.
Overflow	Surface discharge from the CO Pit Lake to Camp Creek once the spill point is reached.

Note: All water flow rates are based on the water balance provided by GHD (2026b).

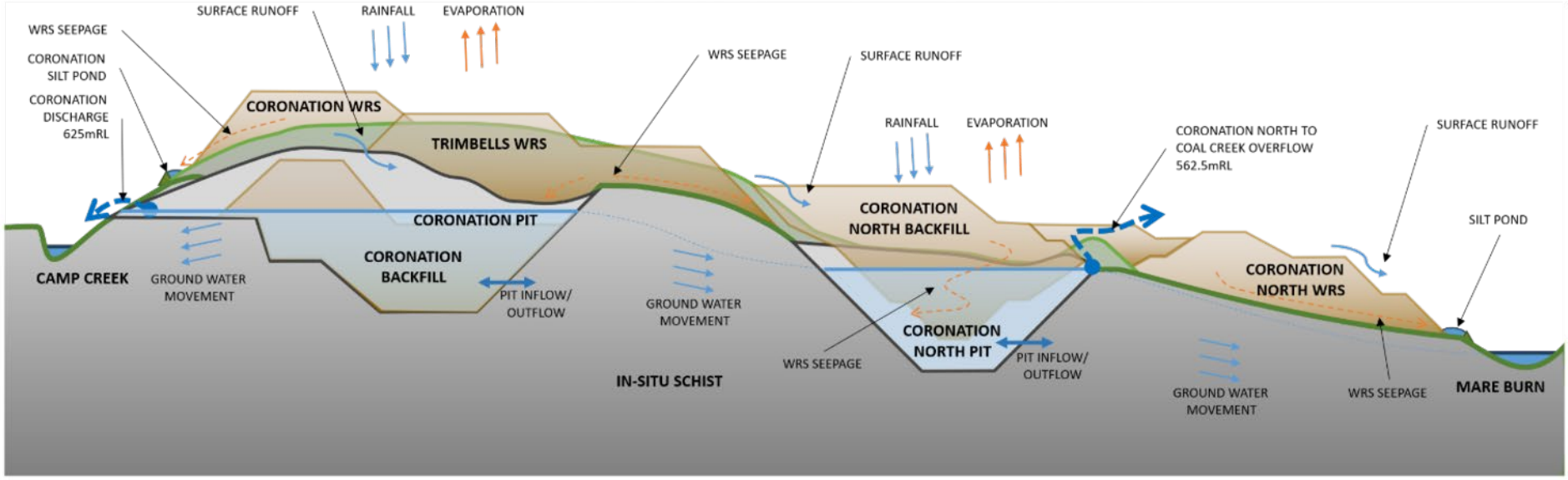

Figure 2: Conceptual site model for Coronation (and Coronation North) Pit.

Source: GHD (2026a).

Note: Image is not to scale.

WATER BALANCE MODEL

The WBM was developed by GHD (2026b) to provide the hydrologic basis for the pit lake water quality modelling. The key findings and model summary are as follows:

- Modelling period – The WBM covers a 200-year post-closure period (2033 to 2233) utilising an annual timestep.
- Inflow components – Eight inflow sources are accounted for over the 200-year model period (Figure 3), fluctuating dynamically in response to the rising pit lake water level:
    - Direct rainfall onto the pit lake surface contributes approximately 50% of the total inflow volume.
    - Pit wall runoff contributes over 30% of the total inflow volume.
    - Other inflows, including groundwater inflow (3.6%), seepage from COBF and the TR WRS (8.8% combined), natural catchment runoff (<1%), and rehabilitated area (including WRS) runoff (6.2% combined), constitute the remaining volume.
- Outflow components – Three outflow pathways are identified over the 200-year model period (Figure 4):
    - Evaporation accounts for approximately 56% of the total outflow volume.
    - Surface overflow accounts for over 43% of the total outflow volume.
    - Groundwater outflow is negligible at less than 1%.
- Spill dynamics and equilibrium:
    - Year 19: Short-term hydrologic fluctuations (e.g., episodic high rainfall) cause the water level to temporarily reach the spill point, initiating intermittent overflow to Camp Creek
    - Year 27: The system achieves a long-term, hydrodynamic steady-state equilibrium at 625 mRL (the spill point).
    - At equilibrium, the water column is predicted to reach 92.2 m based on a pit floor level of 532.8 mRL that includes the saturated backfill, with a total water volume of approximately 5.5 Mm^3 (inclusive of the backfill pore volume). The pit lake above the backfill is 5 m deep on average and has a total volume of 1.75 Mm^3.

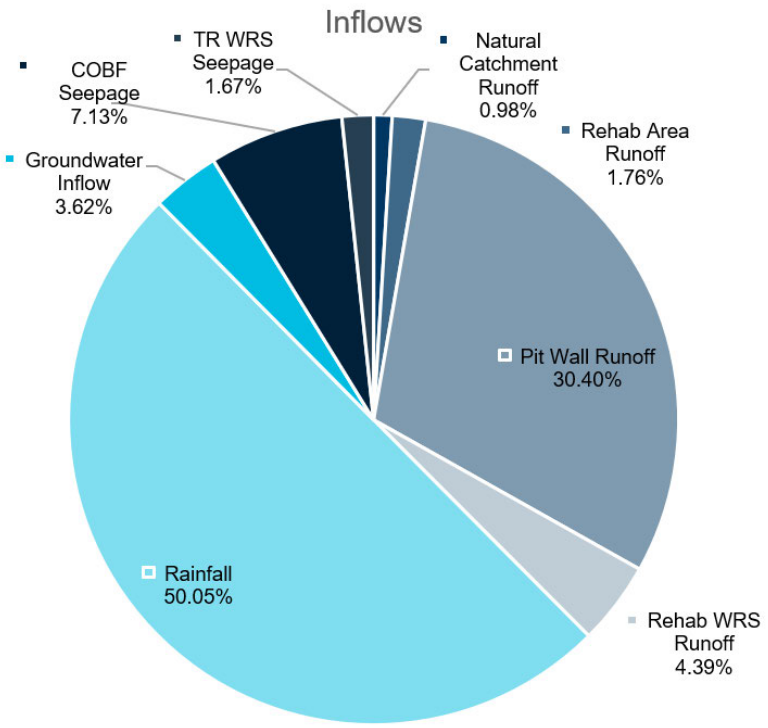

Figure 3: Predicted proportions of cumulative water inflows to Coronation Pit Lake (200-year period).

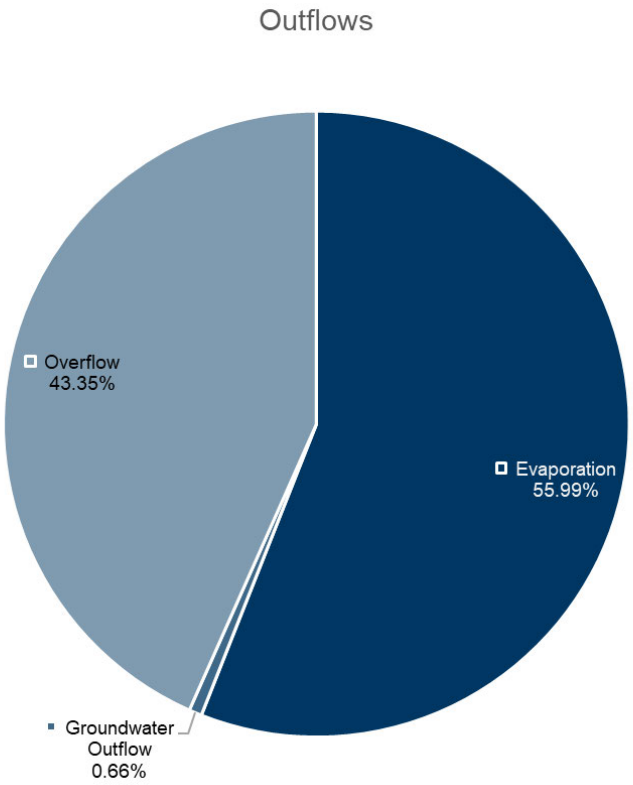

Figure 4: Predicted proportions of cumulative water outflows from Coronation Pit Lake (200-year period).

SOURCE TERMS

Water quality source terms for the various inflows were derived from relevant geochemical and environmental monitoring datasets (Table 2). The derivation methodology is detailed in the hydrogeochemical modelling report (MWM, 2026b), with the resulting source terms summarised in Table 3.

It should be noted that the chemical composition of the COBF seepage is time-variant; Table 3 presents the peak concentrations of this source term to represent the most conservative water quality profile. The detailed derivation approach is documented in MWM (2026b).

Table 2: Data sources for source term derivation.

MODEL FEATURE	SOURCE TERM DATA SOURCE
Rainfall	Rainfall quality data from Nichol et al. (1997), collected between 1983 and 1994 at the Lauder collection site (~70 km NE from Macraes).
Groundwater	Median groundwater quality monitoring data from compliance monitoring wells CP01, CP02, and CP4, covering the period 2014-2025.
Pit wall runoff	Source term derived for the Golden Bar Analogue Model (MWM, 2025).
Natural catchment runoff	Median water quality monitoring data from compliance monitoring site DC01 (pre-2015).
Runoff from rehabilitated areas (incl. WRS)	Median water quality monitoring data from the monitoring point at Deepdell South Silt Pond (MWM, 2026b), as recommended by GHD (2026a).
WRS seepage (Trimbells)	WRS seepage assessment (MWM, 2026a) for TR WRS.
Backfill seepage (COBF)	Backfill seepage quality for COBF, modelled as a variable source term to account for the declining unsaturated thickness of the backfill as the pit lake fills (MWM, 2026a).
Solute load released from submerged backfill	IBC[1] field trial assessment (MWM, 2026c).

[1] *Intermediate bulk container.*

Table 3: Summary of source terms derived for Coronation Pit.

TYPE		RAINFALL	GROUNDWATER	PIT WALL RUNOFF	REHAB AREA RUNOFF	NATURAL CATCHMENT RUNOFF	WRS SEEPAGE (TR)	BACKFILL SEEPAGE (COBF)	SOLUTE LOAD RELEASED FROM BACKFILL*
Data Source	Unit	Nichol et al. (1997)	Monitoring data: CP01, CP02, and CP04	GB Analogue Model (MWM, 2025)	Monitoring data: Deepdell South Silt Pond	Monitoring data: DC01	WRS Seepage Assessment (MWM, 2026a)	Calculated by the model^	IBC Field Trial Assessment (MWM, 2026c)
pH	pH units	5.2	7.3	8.4	8.0	7.7	6.8	7.1	-
Total alkalinity	mg/L as $CaCO_3$	0.81	108	573	119	50	411	36	37.2
Ca	mg/L	0.11	26.5	190	40	12.7	1,081	205	10.9
Mg	mg/L	0.05	8.9	186	7.9	4.4	396	141	5.13
Na	mg/L	0.32	9.8	32.4	12	10.9	85.8	28.6	3.19
K	mg/L	0.09	1.31	11.2	1.7	1.15	24.7	8.8	3.94
SO_4	mg/L	0.18	7.8	719	20	5.35	4,193	1,123	22.7
Cl	mg/L	0.6	6.3	15.6	8	11	6	8	1.30
NO_3-N	mg/L	0.0045	0.1132	0.019	0.001	0.0175	40.6	1.1	0.189
Amm-N	mg/L	-	0.0107	0.038	0.005	0.005	0.92	0.19	0.225
As	mg/L	-	0.00108	0.409	0.0039	0.0011	0.0005	0.0005	0.068
Cu	mg/L	-	0.00025	0.001	0.001	0.00025	0.1347	0.0005	0.0001
Fe	mg/L	-	0.883	0.065	0.07	0.22	0.19	0.05	0.7
Pb	mg/L	-	0.00008	0.0003	0.00005	0.00005	0.00005	0.00008	0.00002
Zn	mg/L	-	0.01375	0.008	0.0005	-	0.36	0.36	0.0002

Note:

Amm-N refers to ammoniacal N.

** All values for the solute load released from backfill are expressed in mg/kg.*

^ COBF seepage source term represents peak values (in Year 17) from a variable source term model.

WATER QUALITY MODEL

Model Development

The pit lake water quality model was developed using PHREEQC software (Parkhurst & Appelo, 2013) with the WATEQ4F thermodynamic database (Ball & Nordstrom, 1991). The model simulated the following geochemical and physical processes:

- Mixing: Integration of multiple inflow streams.
- Evapoconcentration: Concentration of solutes due to pit lake surface evaporation.
- Gas exchange: Equilibration of water with atmospheric O_2 and CO_2.
- Mineral saturation: Thermodynamic control via mineral dissolution and precipitation.
- Surface complexation: Adsorption of trace elements onto hydrous ferric oxides (HFO), such as amorphous ferrihydrite $Fe(OH)_3$ (a), where present.
- Nitrogen attenuation: Degradation and removal of nitrogenous species.

The mineral assemblage, which includes the mineral phases selected for the calculation of mineral saturation, is provided in Table 4.

Table 4: Mineral assemblage used in the PHREEQC model.

PHASE	FORMULA	PHASE	FORMULA
Calcite	$CaCO_3$	Gypsum	$CaSO_4 \cdot 2H_2O$
Hydromagnesite	$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$	Quartz	SiO_2
$Fe(OH)_3$ (a)	$Fe(OH)_3$	Malachite	$Cu_2(CO_3)(OH)_2$
Smithsonite	$ZnCO_3$	O_2(g)	O_2
CO_2(g)	CO_2		

Assumptions and Limitations

The key assumptions and limitations of the model include:

- The model assumes a fully mixed water column (holomictic) throughout the modelling period. This assumption is based on the expectation of a low risk of persistent multi-year stratification of pit lakes (MWM, 2026b). Hence, this well-mixed configuration defines the redox environment for the PHREEQC simulations. While localised oxygen depletion at depth may occur, the adopted approach provides a consistent basis for predicting long-term water quality trends and mineral stability.
- In the absence of site-specific redox data, a pE[2] of 10, representing oxidising conditions, was adopted for all source terms and equilibrium phases.

[2] pE is the negative logarithm of electron activity (pE = -log[e^-]). It serves as a master variable for redox status, analogous to pH for acidity.

- Measured site data indicates that the Golden Bar (GB) Pit Lake ranges in temperature from approximately 7°C to 13°C (MWM, 2026b); hence, a constant water temperature of 10°C was applied to all inflows and the pit lake body, which is considered reasonable for modelling purposes.
- Iron (Fe) in all source terms was assumed to be entirely ferric iron (Fe^{3+}), consistent with the assumed oxidising environment (pE = 10). While the groundwater Fe concentration is 0.883 mg/L, its contribution to the total lake water balance is low (3.6% of total inflow). It is expected that any ferrous iron (Fe^{2+}) entering the pit will rapidly oxidise to Fe^{3+} under circumneutral conditions with negligible or low O_2 consumption.
- Solute release rates for backfill saturation are derived from the IBC field trials (MWM, 2026c). These data provide a more representative estimation of field conditions compared to the static shake flask extraction data used in previous pit lake water quality assessments (e.g., MWM, 2024).
- An initial nitrogen load of 5.35 g/m^2, representing residual ANFO[3] from blasting, was simulated as a staged release of NH_4NO_3 over the first four years of pit filling (MWM, 2025). While the ultimate disturbed footprint of the entire pit (including original and extended boundaries) is 125 ha (OGNZL, 2026), analysis identifies that the area affected by blasting during the next mining phases is only 68 ha. It is assumed only the recently blasted areas will generate elevated nitrogen in pit wall runoff, with previous surfaces being flushed by rainfall. Hence, the total nitrogen load available for release is calculated at 3,638 kg (5.35 g/m^2 x 680,000 m^2).
- A nitrogen decay rate based on observations from the GB Pit Lake (MWM, 2025) was implemented. The model assumes a 20-25% annual reduction in nitrate load, attributed to biologically mediated denitrification or other attenuation processes.

MODEL PREDICTION

Water Volume Variation

Annual volumetric variability for each water balance component is illustrated in Figure 6. The comprehensive water balance for the CO Pit Lake is presented as stacked charts for inflows (Figure 7) and outflows (Figure 8), based on data provided by GHD (2026b). These plots demonstrate that several inflows, including pit wall runoff, rehab WRS runoff, groundwater inflow and seepage from COBF and WRS, peak during the initial backfill submersion and pit refilling phase. Among the outflows, lake evaporation and surface overflow remain the predominant pathways after the lake reaches equilibrium water level.

It is noted that the water level in the pit for the first ~10 years following closure is completely within the backfill, with no open water at the surface. Hence there is no direct rainfall to the pit lake and any outflow during that period (Figure 6).

[3] *Ammonium nitrate fuel oil.*

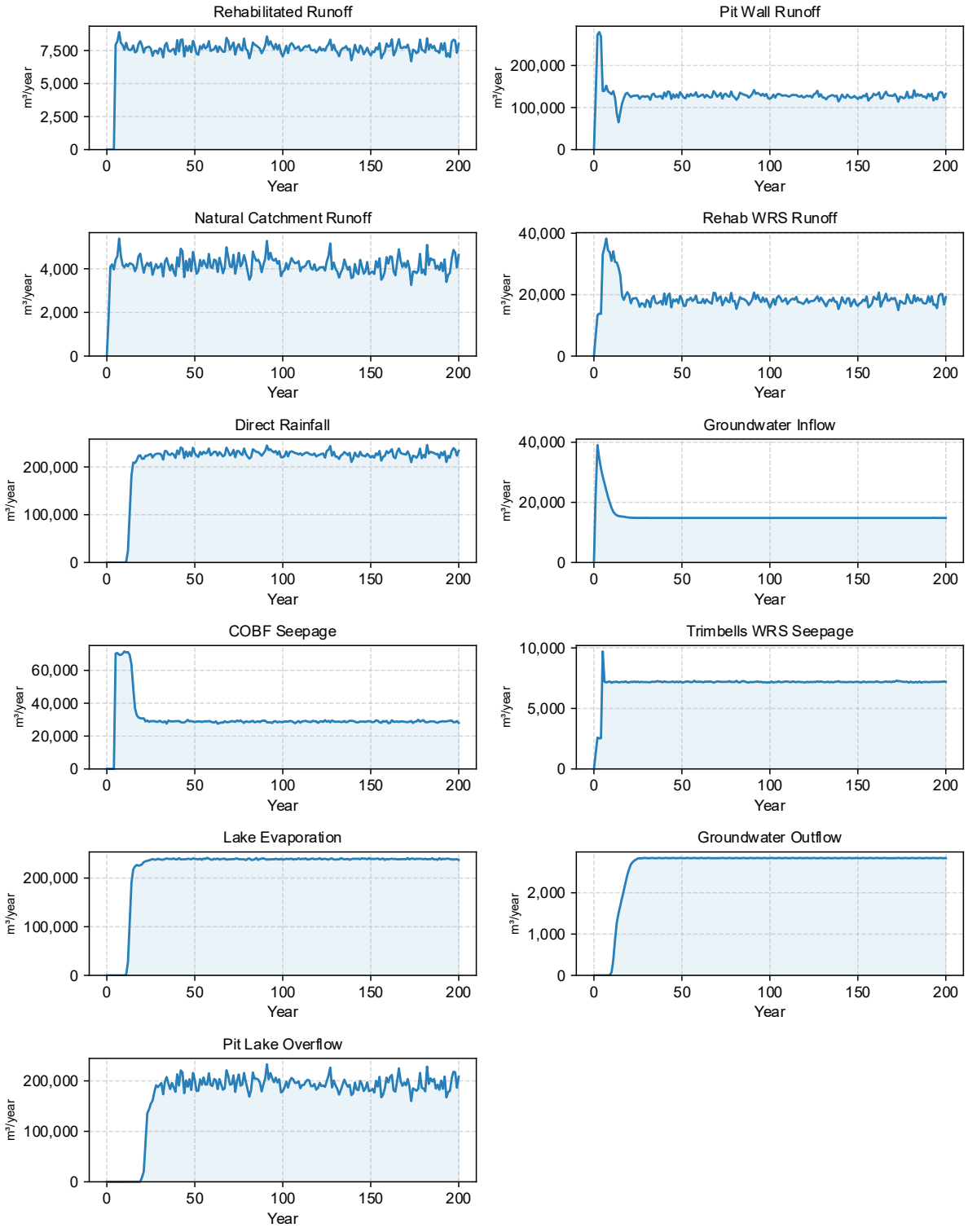

Figure 5: Annual water balance fluxes for Coronation Pit Lake.

Source: GHD (2026b).

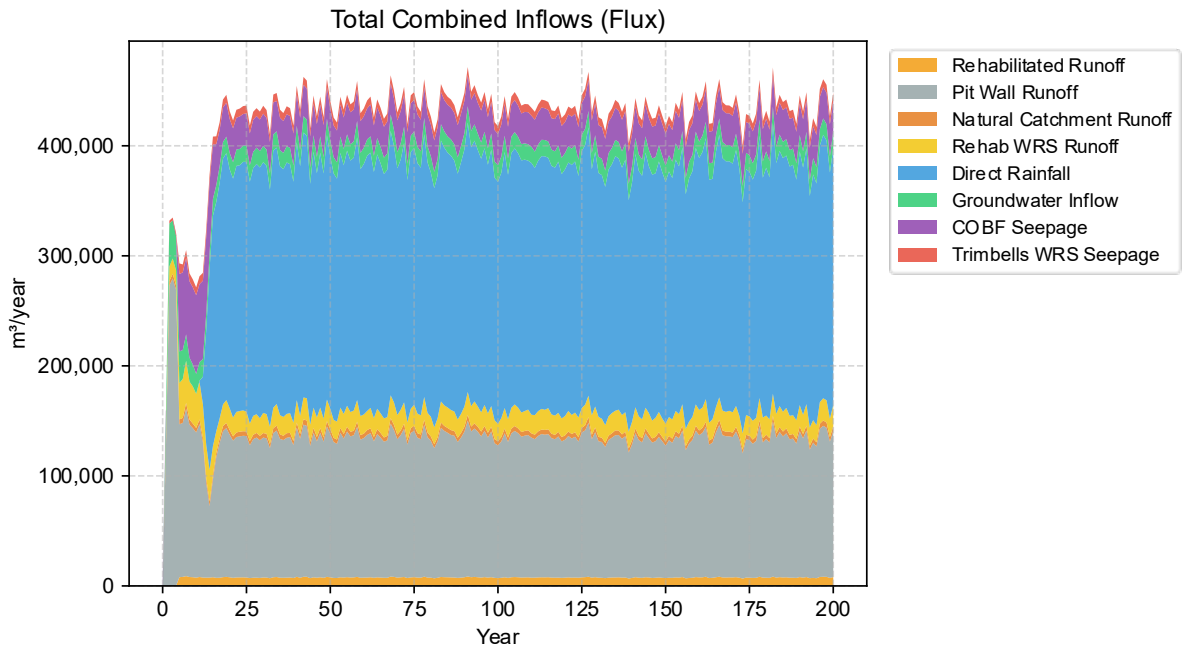

Figure 6: Stacked water balance of annual inflows to Coronation Pit Lake.

Source: GHD (2026b).

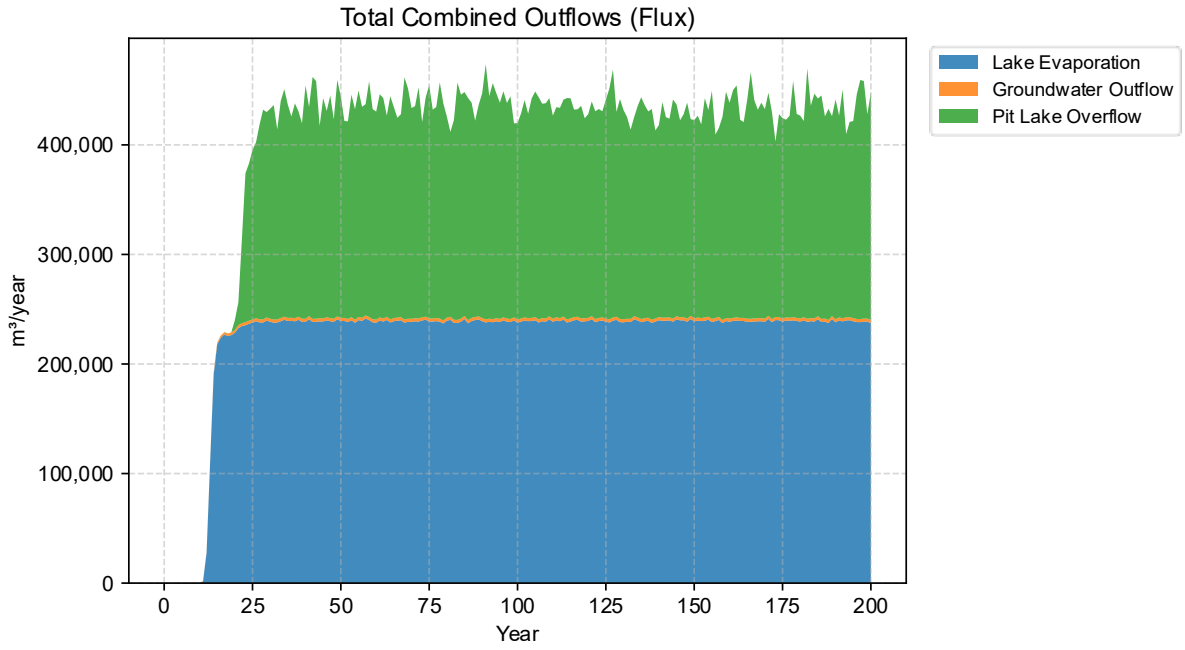

Figure 7: Stacked water balance of annual outflows from Coronation Pit Lake.

Source: GHD (2026b).

Water Quality Prediction

The predicted long-term water quality for the CO Pit Lake is summarised in Table 5. The temporal evolution of key parameters over the 200-year modelling period is illustrated in Figure 9 and Figure 10. The following observations are noted:

- **pH and alkalinity:** The CO Pit Lake is predicted to remain circumneutral, with pH stabilising at approximately 7.7. The long-term total alkalinity is predicted to be above 160 mg $CaCO_3$/L over the modelling period, providing significant buffering capacity against potential acidifying processes.
- **Salinity:** The long-term total dissolved solids (TDS) concentration is predicted to stabilise at 1,385 mg/L after reaching 1,621 mg/L in Year 19 at the onset of intermittent overflow. This value represents the net mass remaining in solution, after accounting for both evapoconcentration and solute removal via secondary mineral precipitation.
- **Major ions:**
    - Magnesium (Mg) is the dominant major cation, with a predicted concentration of 197 mg/L in Year 19, before gradually declining to a long-term concentration of 168 mg/L. Conversely, the concentrations of Ca are predicted to increase from approximately 62 to 98 mg/L over the modelling period.
    - Sodium (Na) and K are predicted to be 57 mg/L and 42 mg/L, respectively, in Year 19 at the onset of intermittent overflow, before stabilising at 33 mg/L and 10 mg/L in the long term.
    - Similarly, following an initial peak driven by the backfill submergence phase, sulfate (SO_4) concentrations are predicted to be 959 mg/L when intermittent overflow starts in Year 19, eventually stabilising at approximately 835 mg/L in the long term. The concentrations of Cl rise to 24 mg/L in Year 19 followed by a decline to approximately 15 mg/L.
- **Trace elements and mineral precipitation:**
    - Dissolved concentrations of Fe are predicted to be 0.00018 mg/L, which is controlled by the solubility of amorphous $Fe(OH)_3$.
    - Approximately 59.6 tonnes (t) of amorphous $Fe(OH)_3$ are predicted to precipitate over the 200-year modelling period, providing specific surface areas for adsorption and sequestration of trace metals and metalloids. However, a significant proportion of this mass is directly driven by the continuous influx of dissolved Fe released from backfill material over the first 25 years.
    - Following initial fluctuations during the early filling phase, arsenic (As) concentrations are predicted to increase from 0.355 mg/L to 0.494 mg/L when intermittent overflow starts before gradually declining to 0.285 mg/L.
    - The initial concentrations of Cu and Zn are relatively low but gradually increase to 0.003 mg/L and 0.072 mg/L respectively. Lead (Pb) will remain negligible at below 0.00005 mg/L after Year 1.
    - Approximately 11,828 t of secondary calcite is predicted to precipitate over the modelling period, providing the primary geochemical buffering mechanism maintaining the lake's circumneutral pH.
- **Nitrogenous compounds:**

- Nitrate-nitrogen (NO_3-N) is predicted to rapidly decrease from approximately 4.27 mg/L to 0.310 mg/L by the time intermittent overflow starts, eventually stabilising at 0.158 mg/L.
- Ammoniacal nitrogen (Amm-N) follows a similar trend, decreasing from an initial 0.412 mg/L to 0.0014 mg/L when overflow begins, before stabilising at 0.0004 mg/L.

Table 5: Predicted Coronation Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 19	YEAR 27	YEAR 50	YEAR 100	YEAR 200
Pit lake level	mRL	556.1	623.3	625.0	625.0	625.0	625.0
Pit lake volume	Mm^3	0.16	4.80	5.46	5.46	5.46	5.46
pH	pH units	7.74	7.71	7.70	7.68	7.66	7.66
TDS	mg/L	1,271	1,621	1,566	1,459	1,383	1,385
Total alkalinity	mg/L as $CaCO_3$	198	188	182	172	165	164
Ca	mg/L	62.1	80.3	84.5	91.5	95.8	97.6
Mg	mg/L	170	197	191	177	168	168
Na	mg/L	31.0	56.8	51.0	40.7	33.7	32.9
K	mg/L	10.5	41.9	34.2	20.6	11.7	10.1
SO_4	mg/L	696	959	931	874	831	835
Cl	mg/L	14.7	24.0	21.8	17.7	15.0	14.6
NO_3-N	mg/L	4.271	0.310	0.177	0.158	0.158	0.158
Amm-N	mg/L	0.4124	0.0014	0.0005	0.0004	0.0004	0.0004
As	mg/L	0.355	0.494	0.446	0.359	0.297	0.285
Cu	mg/L	0.0019	0.0006	0.0007	0.0011	0.0019	0.0031
Fe	mg/L	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018
Pb	mg/L	0.00011	0.00001	0.00001	0.00001	0.00002	0.00003
Zn	mg/L	0.0129	0.0532	0.0567	0.0629	0.0685	0.0724

Note: Pit lake starts overflow in Year 19 and reaches long-term stable level in Year 27.

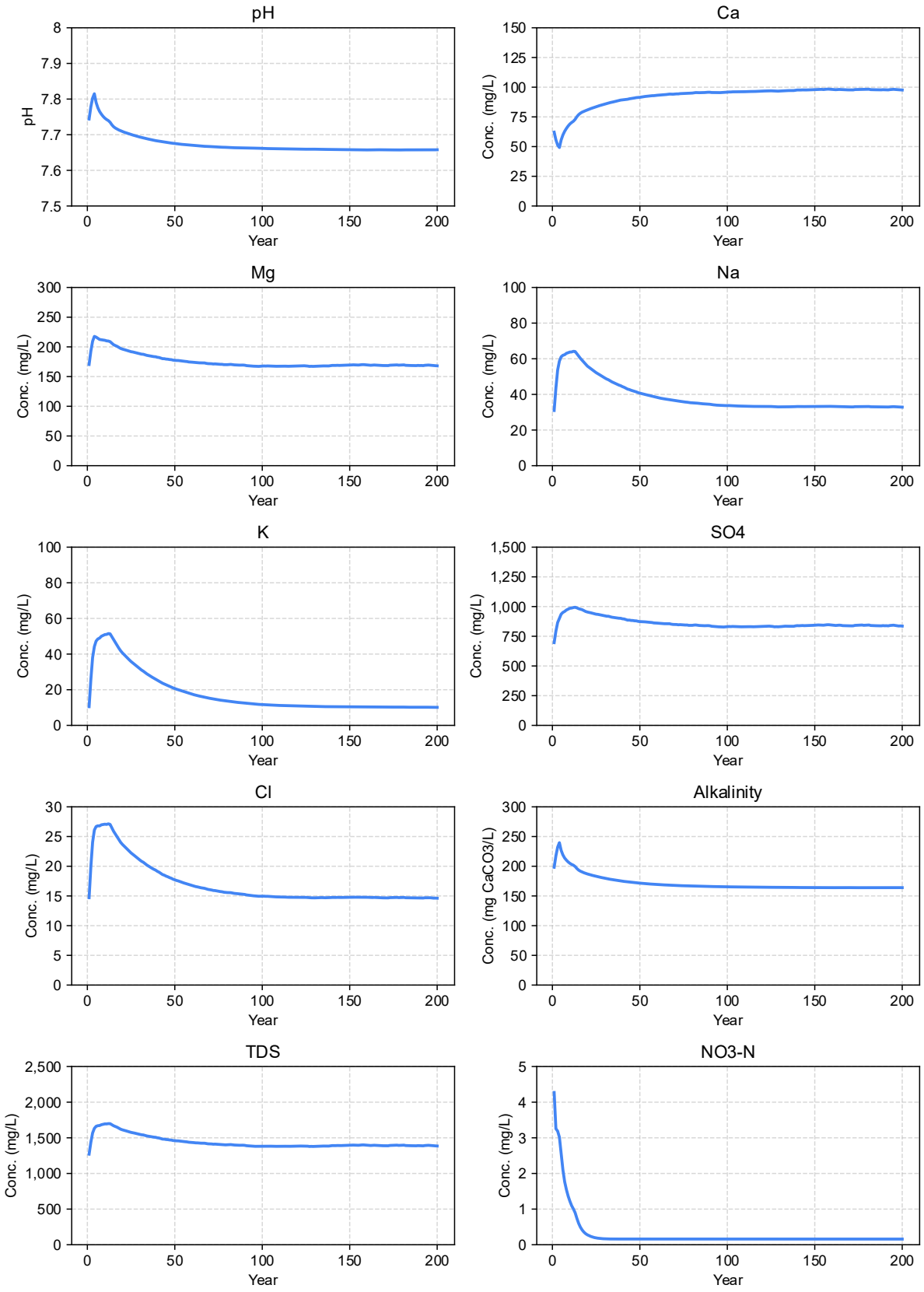

Figure 8: Predicted temporal evolution of primary water quality parameters in Coronation Pit Lake.

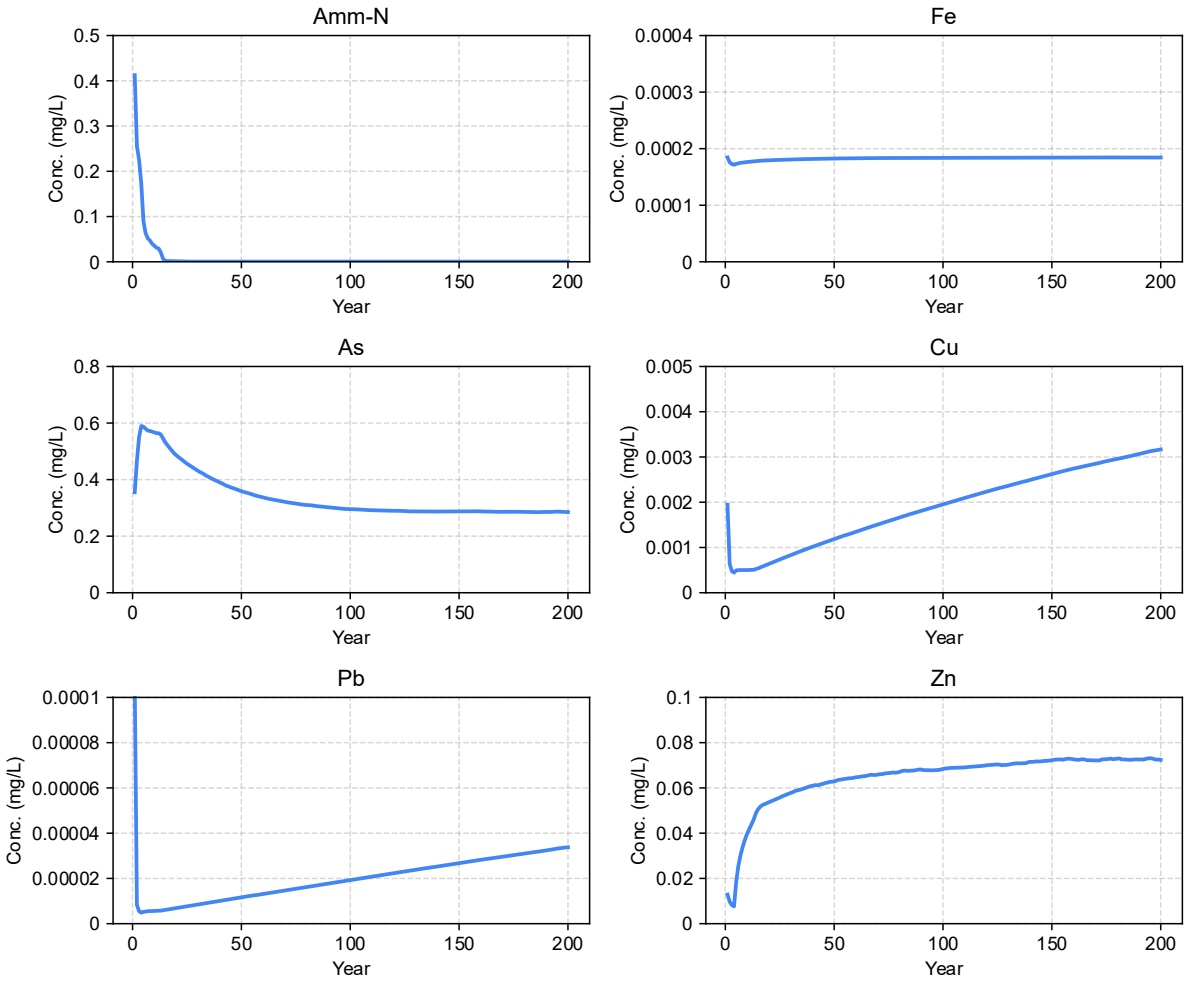

Figure 9: Predicted temporal evolution of primary water quality parameters in Coronation Pit Lake. (continued).

Mass Loading Prediction

The mass loading of selected chemical species entering the pit lake, categorised by inflow source, is presented in Figure 11 and Figure 12. Key observations include:

- Backfill solute release is the dominant mass contributor for nearly all modelled chemical species (except for Zn) during the early post-closure phase. This loading ceases in approximately Year 13 once the backfill is completely submerged by the rising pit lake water level.
- Apart from the backfill release, pit wall runoff represents the primary driver for major ions, alkalinity, and trace elements (including As and Pb).
- Seepage from the TR WRS and COBF acts as a secondary source, contributing moderate loads of Ca and SO_4 to the pit lake over the modelling period.
- Following the submersion and subsequent cessation of mass released from backfill, Fe and Amm-N annual loads decrease to negligible levels.
- Nitrate and Cu loading are primarily driven by the TR WRS seepage, whereas the COBF seepage dominates the long-term mass flux of Zn.

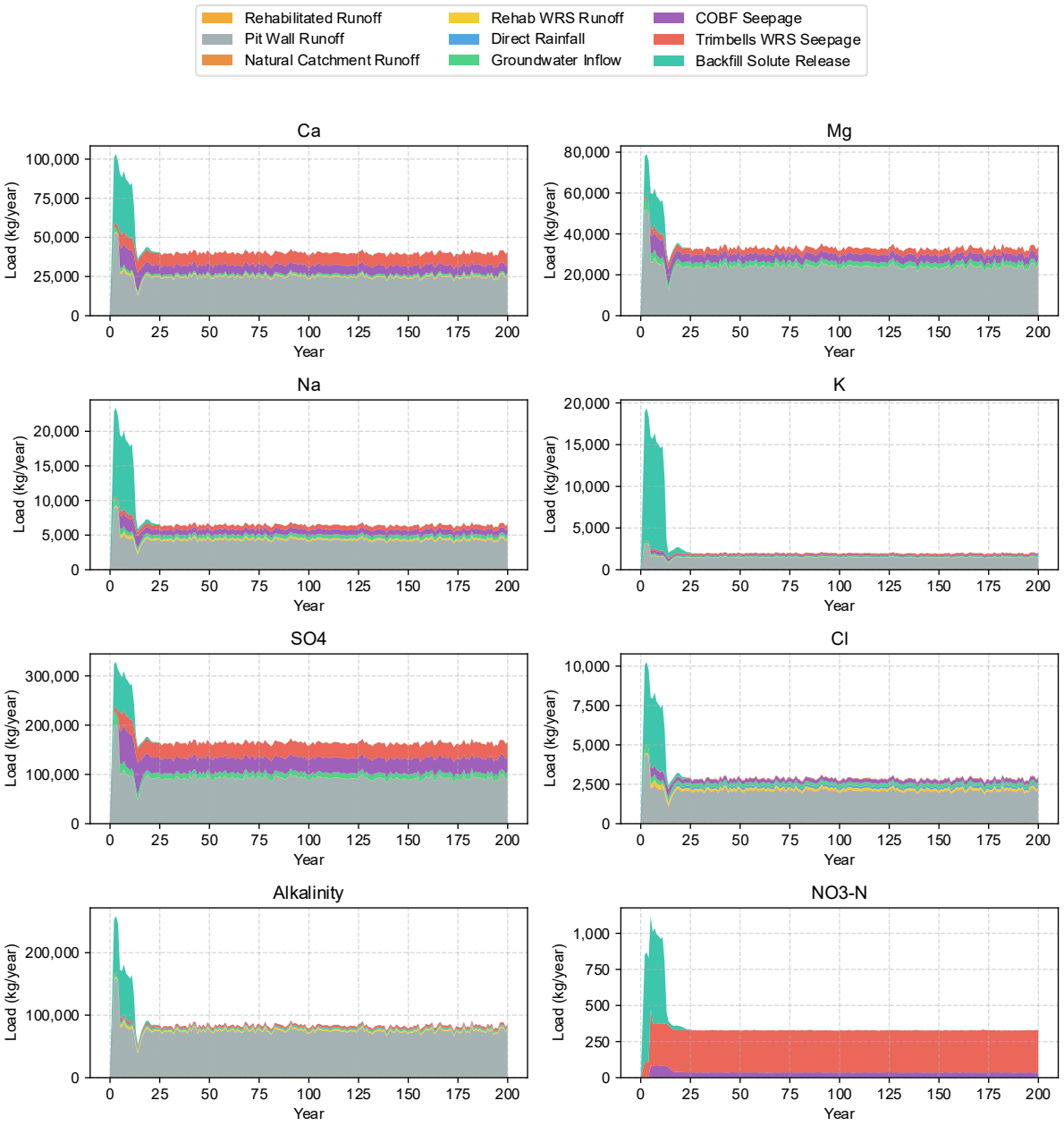

Figure 10: Predicted annual mass loading for Coronation Pit Lake by water balance component.

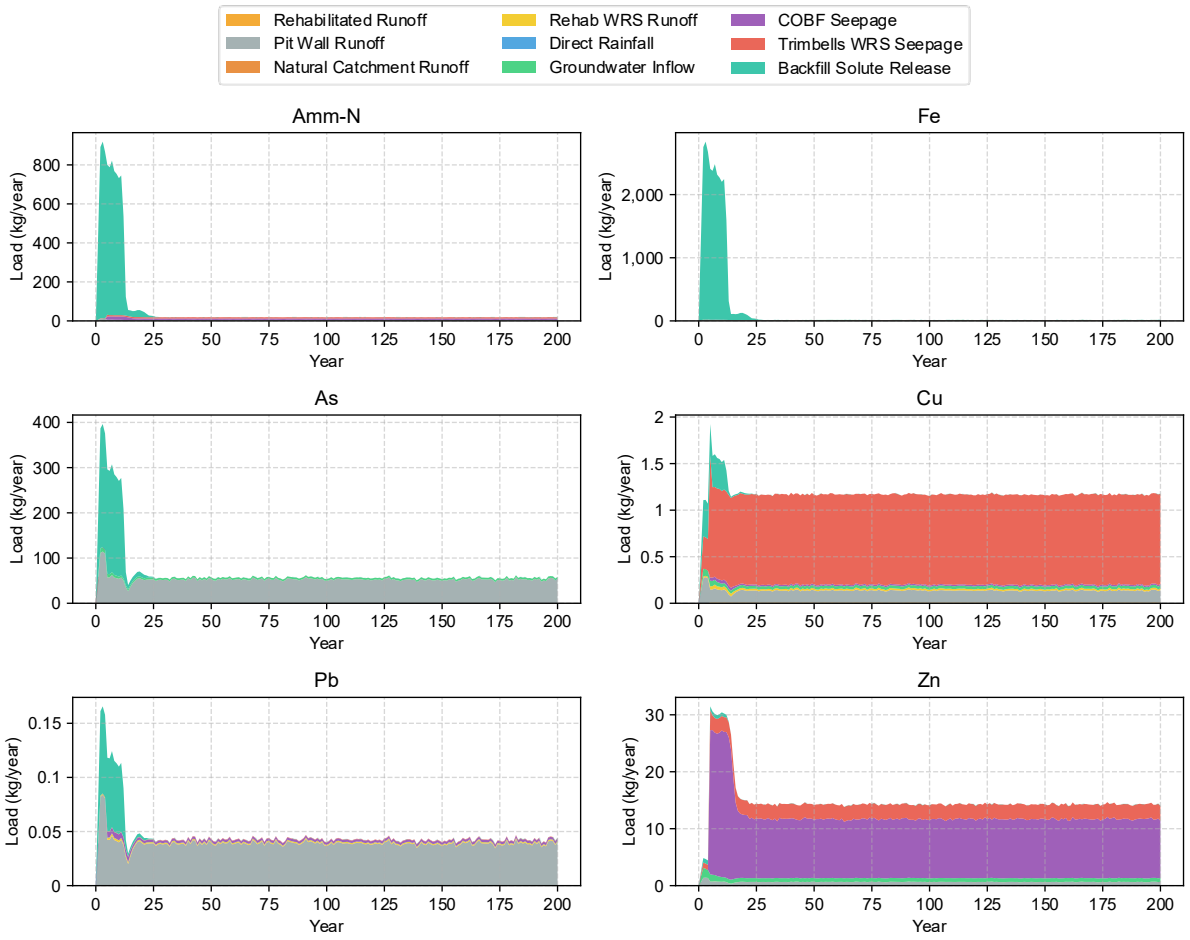

Figure 11: Predicted annual mass loading for Coronation Pit Lake by water balance component (continued).

SUMMARY

The long-term water quality of the CO Pit Lake was modelled to assess the geochemical impact of the proposed Project activities post-closure. The modelling results indicate the following:

- The pit lake is predicted to remain circumneutral throughout both the infilling and spilling phases. A stable pH of approximately 7.7 is maintained by a sustained acid buffering capacity, with long-term total alkalinity predicted to exceed 160 mg $CaCO_3$/L. This buffering is primarily derived from the dissolution of carbonate minerals (such as calcite) present in the backfill and pit wall rock, which sustained the predicted alkalinity levels.
- At hydraulic equilibrium by Year 27, the pit lake is predicted to reach a TDS concentration of approximately 1,566 mg/L. Following the initial refilling phase, the hydrogeochemical profile is expected to be sulfate-dominant (835 mg/L in Year 200) with Mg concentrations of approximately 168 mg/L (in Year 200).
- Concentrations of Fe will remain low as nearly 60 t of amorphous $Fe(OH)_3$ are predicted to precipitate, which provides the specific adsorption surface for trace metals and metalloids. Consequently, the concentrations of trace metals will remain negligible; however, Cu and Zn are predicted to gradually increase to 0.003 mg/L and 0.072 mg/L, respectively, within the 200-

year modelling period. Following the initial refilling phase, concentrations of As are predicted to gradually decline over the long term, reaching 0.285 mg/L by the end of modelling period.

- The initial concentrations of NO_3-N and Amm-N are expected to be approximately 4.27 mg/L and 0.412 mg/L, respectively, which will quickly decline and eventually stabilise at 0.158 mg/L and 0.0004 mg/L.
- Mass loading for the majority of modelled chemical species peaks sharply during the early post-closure phase, driven predominantly by backfill solute release. Following the complete submersion of the backfill in approximately 13 years, annual loads for most species, particularly Fe and ammoniacal N, decline significantly or stabilise as long-term fluxes become governed by pit wall runoff and WRS seepage.

Full water quality data are provided as a Microsoft Excel file (Attachment A).

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ATTACHMENT A: CORONATION PIT LAKE DIGITAL OUTPUT [MICROSOFT EXCEL FILE]

APPENDIX D CORONATION NORTH PIT LAKE WATER QUALITY MODEL

MINE WASTE MANAGEMENT
GREENROAD GROUP

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MEMORANDUM

Recipient:	OceanaGold (New Zealand) Limited c/- [redacted]
From:	Paul Weber – Mine Waste Management Limited (MWM)
Date:	31 August 2026
Cc:	[redacted] – OceanaGold Eric Chen – MWM; Leo Navarro – MWM
Document Number:	J-NZ0498-013-M-FINAL
Document Title:	Coronation North Pit Lake Water Quality Model
Disclaimer:	This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

Mine Waste Management Limited (MWM) has been engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess environmental geochemistry hazards and potential effects for the proposed Macraes Phase Four Project (MP4 or the Project). This assessment supports the application as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

As part of the broader geoenvironmental hazard assessment, this memorandum provides a quantitative prediction of the long-term pit lake water quality for the Coronation North (CN) Pit Lake, incorporating the proposed Stage 6 extension and proposed waste rock backfills. It documents the hydrogeochemical modelling approach, derived source terms, and resulting water quality predictions. These predictions are used by GHD (2026a) to estimate effects on surface water and groundwater.

BACKGROUND

The CN Pit, part of the Macraes Operation, is located within the area of mining permit MP41064, approximately 5 km north of the Macraes Mine Processing Plant (Figure 1).

The proposed CN Stage 6 (CN6) Pit extension involves an approximately 205 m expansion to the southeast over predominantly tussockland and the Trimbells waste rock stack (TR WRS). The currently authorised CN Stage 5 (CN5) Pit has a footprint of 40 ha. The proposed extension will increase the total pit footprint to approximately 57 ha. The pit will be dewatered for the mining of the pit extension and partially backfilled at mine closure.

OBJECTIVES AND SCOPE OF WORK

The primary objective of this study is to develop a post-closure hydrogeochemical model to predict the CN Pit Lake water quality for a period of 200 years. The quantitative prediction of the long-term water quality will support GHD's assessment of environmental effects of the proposed CN6 extension on receiving waters for the Project (GHD, 2026a).

The scope of work includes:

- Developing a conceptual site model (CSM) to identify the inflows, outflows, model components, and the key geochemical and physical processes that will influence the pit lake after the proposed extensions.
- Deriving source terms (chemical composition) for pit lake inflows, utilising site-specific data where possible.
- Predicting the CN Pit Lake water quality quantitatively, based on the integration of the derived source terms with the water balance model (WBM) provided by GHD (2026b).

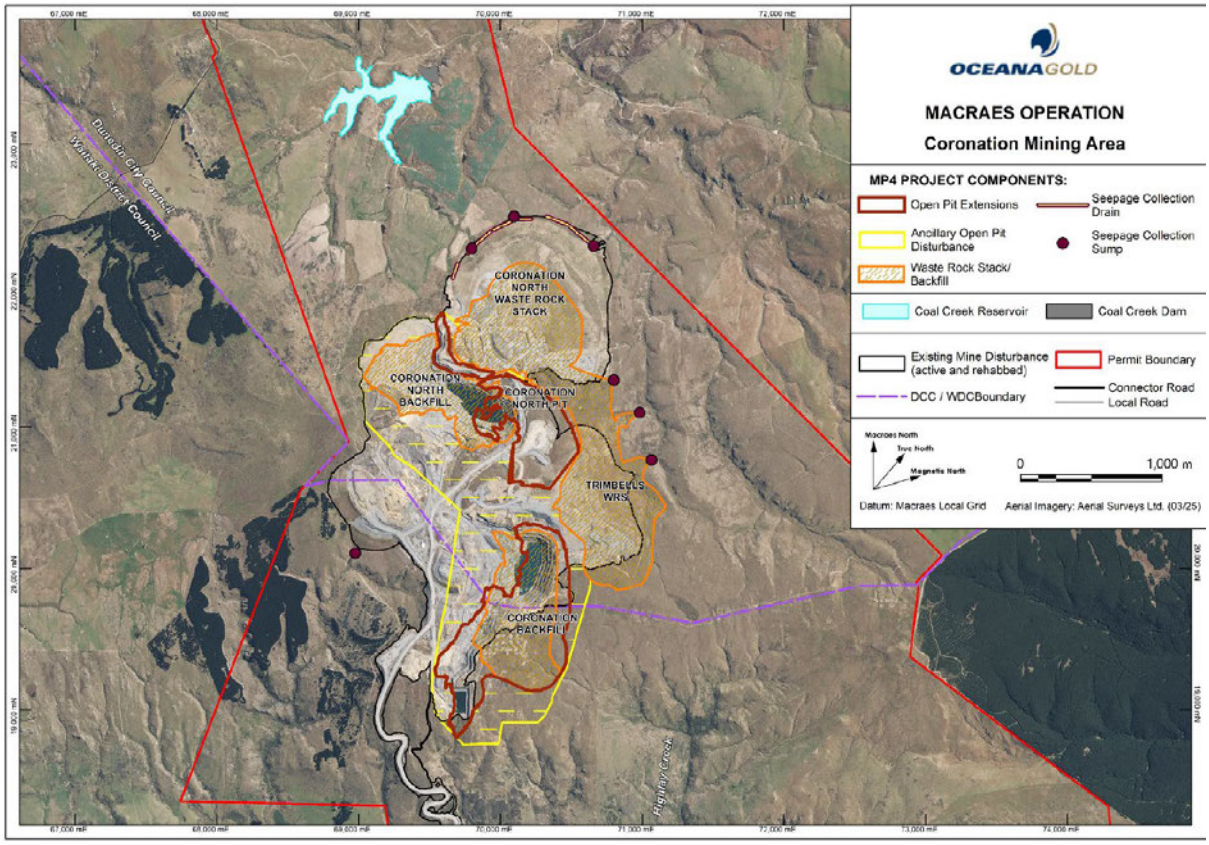

Figure 1: Coronation Mining Area showing the location of Coronation North Pit extension.

Source: OGNZL (2026).

CONCEPTUAL SITE MODEL

A CSM was developed to facilitate the hydrogeochemical modelling of the CN Pit Lake (Figure 2). The inflows and outflows for the CN Pit Lake, which align with the WBM developed by GHD (introduced in the subsequent section), are summarised in Table 1. The following key points are noted:

- The pit will be partially backfilled with 38 Mm^3 of waste rock. Approximately 27.3 Mm^3 of this material will be above the final overflow level.
- The CSM accounts for six types of inflow and three types of outflow.
- Seepage from the Coronation (CO) WRS, TR WRS, and CN Backfill (CNBF) will report to the pit.

- Upon reaching the spill elevation, the pit lake will discharge via surface overflow to Coal Creek.
- The existing pit will be completely dewatered to facilitate pit expansion, leaving no residual water at the commencement of pit lake filling.

Table 1: Summary of water balance components for Coronation North Pit Lake CSM.

MODEL FEATURE	NOTE
Inflow	
Rainfall	Direct precipitation onto the pit lake surface.
Groundwater	Inflow from the surrounding pit walls and through the pit base.
Runoff from pit walls	Runoff from exposed pit wall surfaces generated by rainfall.
Runoff from rehabilitated areas	Runoff from the mining impacted areas (including WRS) that will be fully rehabilitated.
Seepage from WRS	Seepage from the CO WRS and TR WRS. Seepage is driven by net percolation of meteoric water through the WRS that migrates into the pit.
Seepage from backfill	Seepage from the unsaturated CNBF material above the pit lake level that drains to the pit lake.
Outflow	
Evaporation	Loss of pure water from the pit lake surface due to evaporation, causing evapoconcentration of solutes.
Groundwater	Outflow from the pit as groundwater into the surrounding aquifer.
Overflow	Surface discharge from the CN Pit Lake to Coal Creek once the spill point is reached.

Note: All water flow rates are based on the water balance provided by GHD (2026b).

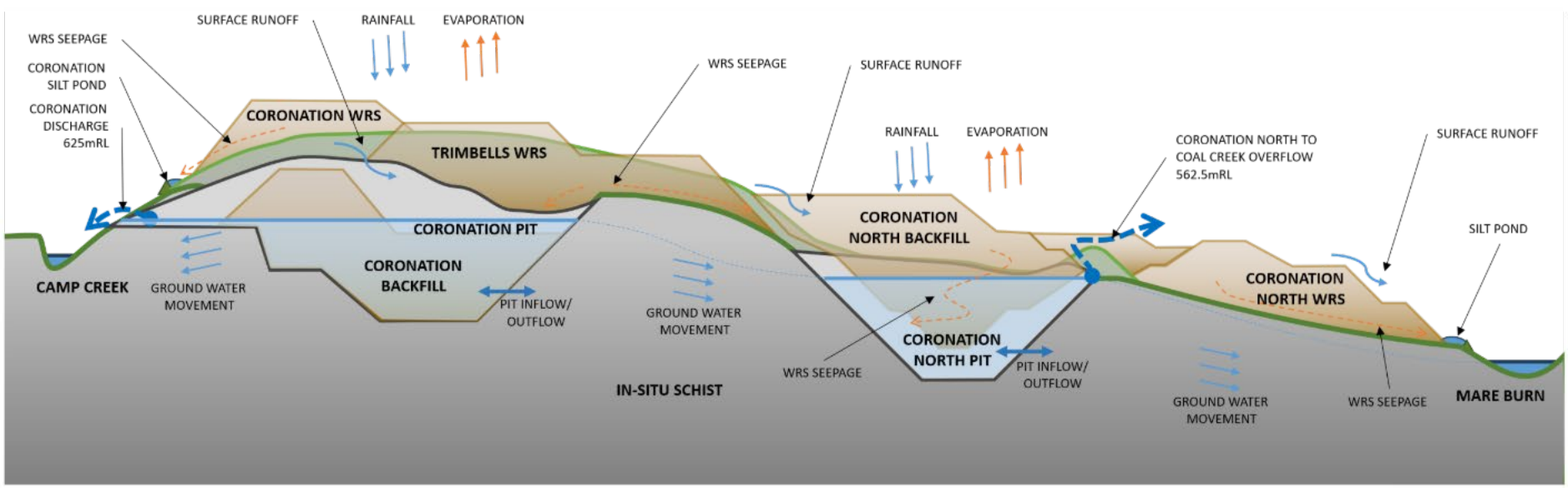

Figure 2: Conceptual site model for Coronation North (and Coronation) Pit.

Source: GHD (2026a).

Note: Image is not to scale.

WATER BALANCE MODEL

The WBM was developed by GHD (2026b) to provide the hydrologic basis for the pit lake water quality modelling. The key findings and model summary are as follows:

- Modelling period: The WBM covers a 200-year post-closure period (2033 to 2233) utilising an annual timestep.
- Inflow components: Nine inflow sources are accounted for over the 200-year model period (Figure 3), fluctuating dynamically in response to the rising pit lake water level:
    - Direct rainfall onto the pit lake surface contributes over 41% of the total inflow volume over the model period.
    - Pit wall runoff contributes over 20% of the total inflow volume.
    - Other inflows constitute the remaining volume, including groundwater inflow (10.6%), seepage from CNBF, CO WRS, and TR WRS (10.3% combined), rehabilitated area (including WRS) runoff (17.5% combined), and a minor runoff contribution from non-rehab WRS areas (0.01%).
- Outflow components: Three outflow pathways are identified over the 200-year model period (Figure 4):
    - Evaporation accounts for approximately 53.5% of the total outflow volume.
    - Surface overflow accounts for approximately 45% of the total outflow volume.
    - Groundwater outflow is low at 1.5%.
- Spill dynamics and equilibrium:
    - Year 57: Short-term hydrologic fluctuations (e.g., episodic high rainfall) cause the water level to temporarily reach the spill point, initiating intermittent overflow to Coal Creek.
    - Year 71: The system achieves a long-term, hydrodynamic steady-state equilibrium at 562.5 mRL (the spill point).
    - At equilibrium, the pit lake depth is predicted to reach 119.6 m based on a pit floor base level of 442.9 mRL, with a total pit lake volume of approximately 15.3 Mm^3 (inclusive of the backfill pore volume).

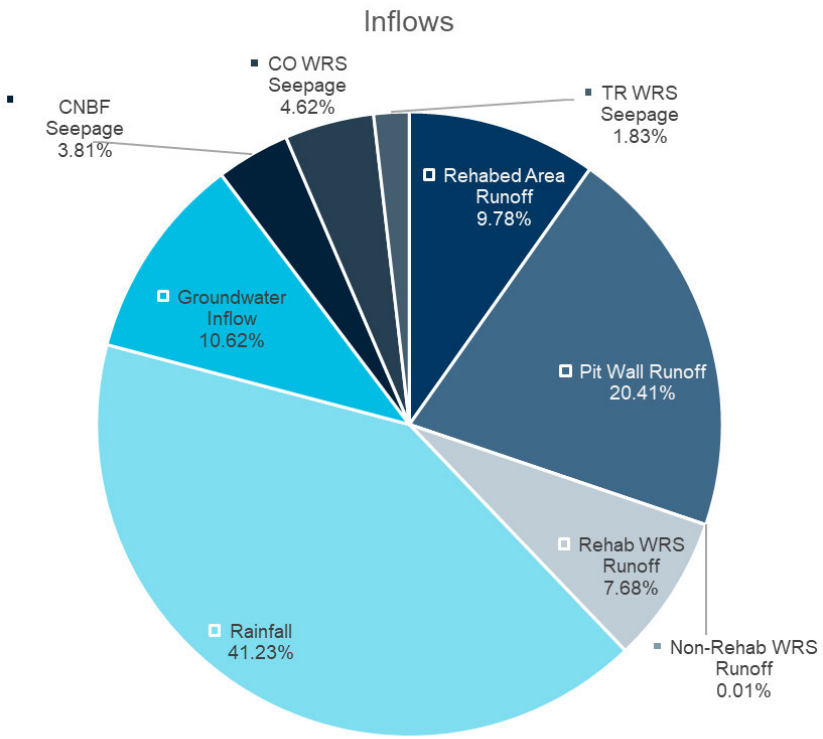

Figure 3: Predicted proportions of cumulative water inflows to Coronation North Pit Lake (200-year period).

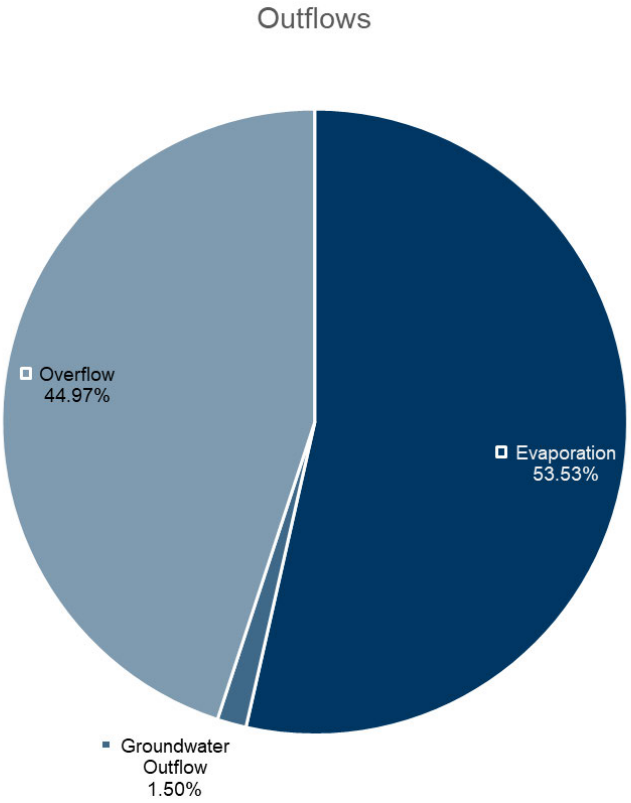

Figure 4: Predicted proportions of cumulative water outflows from Coronation North Pit Lake (200-year period).

SOURCE TERMS

Water quality source terms for the various inflows were derived from relevant geochemical and environmental monitoring datasets or numerical modelling (Table 2). The derivation methodology is detailed in the hydrogeochemical modelling report (MWM, 2026b), with the resulting source terms summarised in Table 3.

The following should be noted:

- Runoff from rehabilitated areas and the rehabilitated WRS utilises an identical source term; consequently, these flows were combined into a single input for the model.
- The chemical composition of the CNBF seepage is time-variant and governed by the declining unsaturated thickness of the backfill above the rising pit lake level (decreasing from an initial 100 m to 74 m at overflow). To provide an upper-bounding reference for the worse case water quality, Table 3 displays the peak predicted concentrations. The detailed derivation approach is documented in MWM (2026b).
- Groundwater inflow to the CN Pit is assumed to consist entirely of groundwater outflow from the CO Pit. This approach is conservative as it ignores dilution from unimpacted regional groundwater inputs and omits the physical lag period required for the CO Pit plume to migrate to the CN Pit, as well as any potential natural attenuation processes (e.g., adsorption of arsenic onto minerals within the rock mass). Because the CO Pit Lake water quality is time-variant, Table 3 presents the predicted Year 13 composition to reflect the peak concentrations, providing a worst-case snapshot for reference.

Table 2: Data sources for source term derivation.

MODEL FEATURE	SOURCE TERM DATA SOURCE
Rainfall	Rainfall quality data from Nichol et al. (1997), collected between 1983 and 1994 at the Lauder collection site (~70 km NE from Macraes).
Groundwater	Predicted CO Pit Lake water quality (MWM, 2026d).
Pit wall runoff	Source term developed for the Golden Bar Analogue Model (MWM, 2025).
Runoff from rehabilitated areas (incl. WRS)	Median water quality monitoring data from the monitoring point at Deepdell South Silt Pond (MWM, 2026b), as recommended by GHD (2026a).
WRS seepage (CO and TR)	WRS seepage assessment (MWM, 2026a) for CO WRS and TR WRS.
Backfill seepage (CNBF)	Backfill seepage quality for CNBF, modelled as a variable source term to account for the declining unsaturated thickness of the backfill as the pit lake fills (MWM, 2026a).
Solute load released from submerged backfill	IBC[1] field trial assessment (MWM, 2026c).

[1] *Intermediate bulk container.*

Table 3: Summary of source terms derived for Coronation North Pit.

TYPE		RAINFALL	GROUNDWATER[#]	PIT WALL RUNOFF	REHAB AREA RUNOFF	WRS SEEPAGE (TR)	WRS SEEPAGE (CO)	BACKFILL SEEPAGE (CNBF)	SOLUTE LOAD RELEASED FROM BACKFILL*
Data Source	Unit	Nichol et al. (1997)	Predicted CO Pit Lake quality (MWM, 2026d)	GB Analogue Model (MWM, 2025)	Monitoring data: Deepdell South Silt Pond	WRS Seepage Assessment (MWM, 2026a)	WRS Seepage Assessment (MWM, 2026a)	Calculated by the model^	IBC Field Trial Assessment (MWM, 2026c)
pH	pH units	5.2	7.7	8.4	8.0	6.8	7.1	7.6	-
Total alkalinity	mg/L as $CaCO_3$	0.81	200	573	119	411	36	137	37.2
Ca	mg/L	0.11	73	190	40	1,081	597	479	10.9
Mg	mg/L	0.05	209	186	7.9	396	457	895	5.13
Na	mg/L	0.32	64	32.4	12	85.8	61.9	205	3.19
K	mg/L	0.09	51	11.2	1.7	24.7	10.6	14.6	3.94
SO_4	mg/L	0.18	994	719	20	4,193	3,706	4,789	22.7
Cl	mg/L	0.6	27	15.6	8	6	8	12	1.30
NO_3-N	mg/L	0.0045	0.898	0.019	0.001	40.6	1.1	7.5	0.189
Amm-N	mg/L	-	0.021	0.038	0.005	0.92	0.245	0.013	0.225
As	mg/L	-	0.559	0.409	0.0039	0.0005	0.0005	0.00075	0.068
Cu	mg/L	-	0.0005	0.001	0.001	0.1347	0.0005	0.0006	0.0001
Fe	mg/L	-	0.0002	0.065	0.07	0.19	0.05	0.05	0.7
Pb	mg/L	-	0.000006	0.0003	0.00005	0.00005	0.000075	0.00005	0.00002
Zn	mg/L	-	0.0459	0.008	0.0005	0.36	0.36	0.0028	0.0002

Note:

Amm-N refers to ammoniacal N.

** All values for the solute load released from backfill are expressed in mg/kg.*

[#] Groundwater source term is the predicted CO Pit Lake water quality. Peak values in Year 13 are shown in the table.

^ CNBF seepage source term represents peak values (at Year 18) from a variable source term model.

WATER QUALITY MODEL

Model Development

The pit lake water quality model was developed using PHREEQC software (Parkhurst & Appelo, 2013) with the WATEQ4F thermodynamic database (Ball & Nordstrom, 1991). The model simulated the following geochemical and physical processes:

- Mixing: Integration of multiple inflow streams.
- Evapoconcentration: Concentration of solutes due to pit lake surface evaporation.
- Gas exchange: Equilibration of water with atmospheric O_2 and CO_2.
- Mineral solubility: Thermodynamic control via mineral dissolution and precipitation.
- Surface complexation: Adsorption of trace elements onto hydrous ferric oxides (HFO), such as amorphous ferrihydrite $Fe(OH)_3$ (a), where present.
- Nitrogen attenuation: Degradation and removal of nitrogenous species.

The mineral assemblage, which includes the mineral phases selected for the calculation of mineral saturation, is provided in Table 4.

Table 4: Mineral assemblage used in the PHREEQC model.

PHASE	FORMULA	PHASE	FORMULA
Calcite	$CaCO_3$	Gypsum	$CaSO_4 \cdot 2H_2O$
Hydromagnesite	$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$	Quartz	SiO_2
$Fe(OH)_3$ (a)	$Fe(OH)_3$	Malachite	$Cu_2(CO_3)(OH)_2$
Smithsonite	$ZnCO_3$	O_2(g)	O_2
CO_2(g)	CO_2		

Assumptions and Limitations

The key assumptions and limitations of the model include:

- The model assumes a fully mixed water column (holomictic) throughout the modelling period. This assumption is based on the expectation of a low risk of persistent multi-year stratification of pit lakes (MWM, 2026b). Hence, this well-mixed configuration defines the redox environment for the PHREEQC simulations. While localised oxygen depletion at depth may occur, the adopted approach provides a consistent basis for predicting long-term water quality trends and mineral stability.
- In the absence of site-specific redox data, a pE[2] of 10, representing oxidising conditions, was adopted for all source terms and equilibrium phases.

[2] pE is the negative logarithm of electron activity (pE = -log[e^-]). It serves as a master variable for redox status, analogous to pH for acidity.

- Measured site data indicates that the Golden Bar (GB) Pit Lake ranges in temperature from approximately 7°C to 13°C (MWM, 2026b); hence, a constant water temperature of 10°C was applied to all inflows and the pit lake body, which is considered reasonable for model purposes.
- Iron (Fe) in all source terms was assumed to be entirely ferric iron (Fe^{3+}), consistent with the assumed oxidising environment (pE = 10). It is expected that any ferrous iron (Fe^{2+}) entering the pit will rapidly oxidise to Fe^{3+} under circumneutral conditions with negligible or low O_2 consumption.
- Solute release rates from submerged backfill seepage were derived from the IBC field trials (MWM, 2026c). These data provide a more representative estimation of field conditions compared to the static shake flask extraction data used in previous pit lake water quality assessments (e.g., MWM, 2025).
- An initial nitrogen load of 5.35 g/m^2, representing residual ANFO[3] from blasting, was simulated as a staged release of NH_4NO_3 over the first four years of pit filling (MWM, 2025). The assumed area affected by blasting is approximately 57 ha. Hence, the total nitrogen load available for release is calculated at 3,050 kg (5.35 g/m^2 x 570,000 m^2).
- A nitrogen decay rate based on observations from the GB Pit Lake (MWM, 2025) was implemented. The model assumes a 20-25% annual reduction in nitrate load, attributed to biologically mediated denitrification or other attenuation processes.

MODEL PREDICTION

Water Volume Variation

The annual volumetric variability for each water balance component is illustrated in Figure 5. The comprehensive water balance for the CN Pit Lake is presented as stacked charts for inflows (Figure 6) and outflows (Figure 7), based on data provided by GHD (2026b). These plots demonstrate that total inflows gradually increase as the pit lake surface area expands, driven primarily by direct rainfall to the pit lake, until the lake reaches equilibrium. Among the outflows, lake evaporation and surface overflow are the primary pathways, with groundwater outflow remaining negligible at this scale.

[3] *Ammonium nitrate fuel oil.*

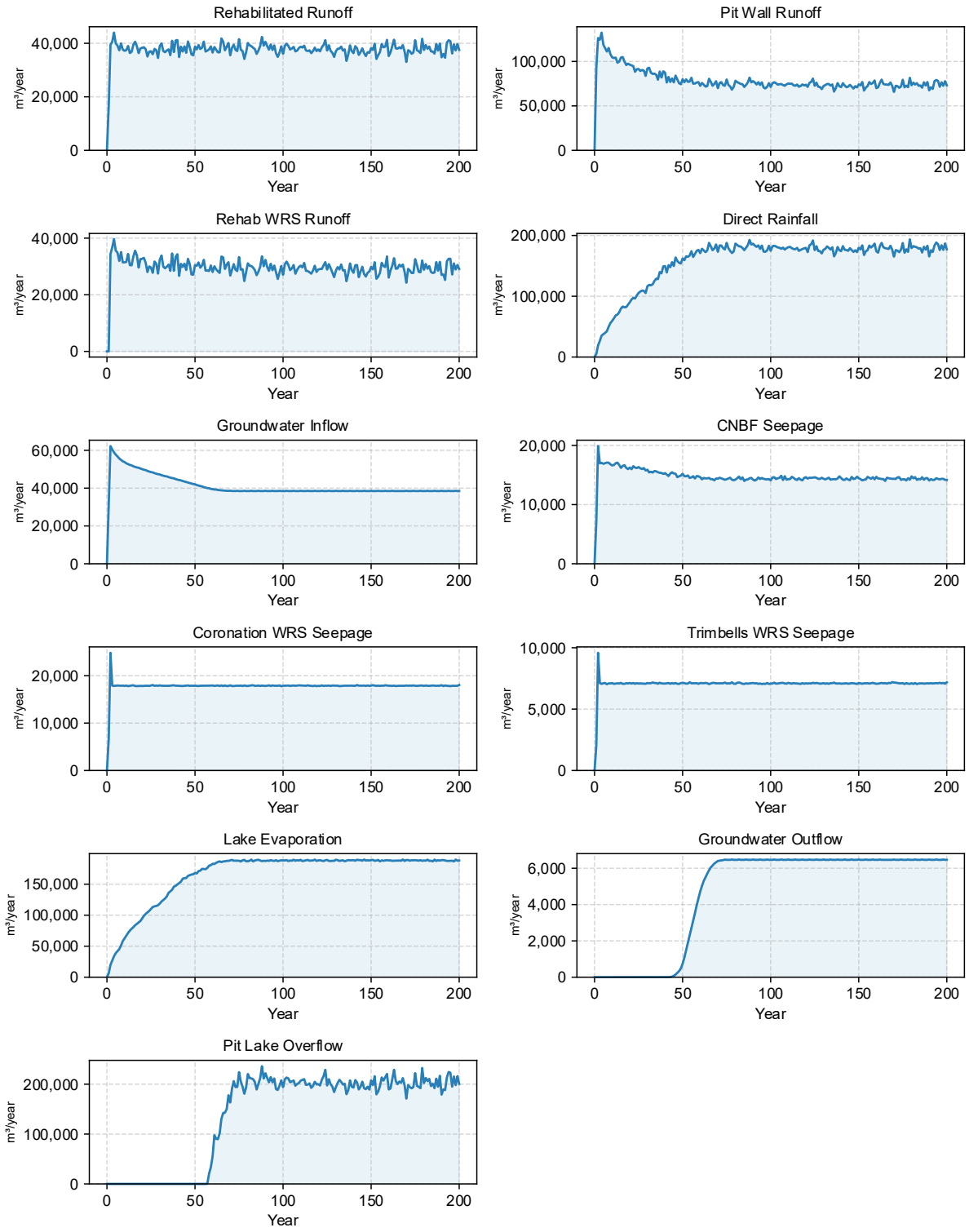

Figure 5: Annual water balance fluxes for Coronation North Pit Lake.

Source: GHD (2026b).

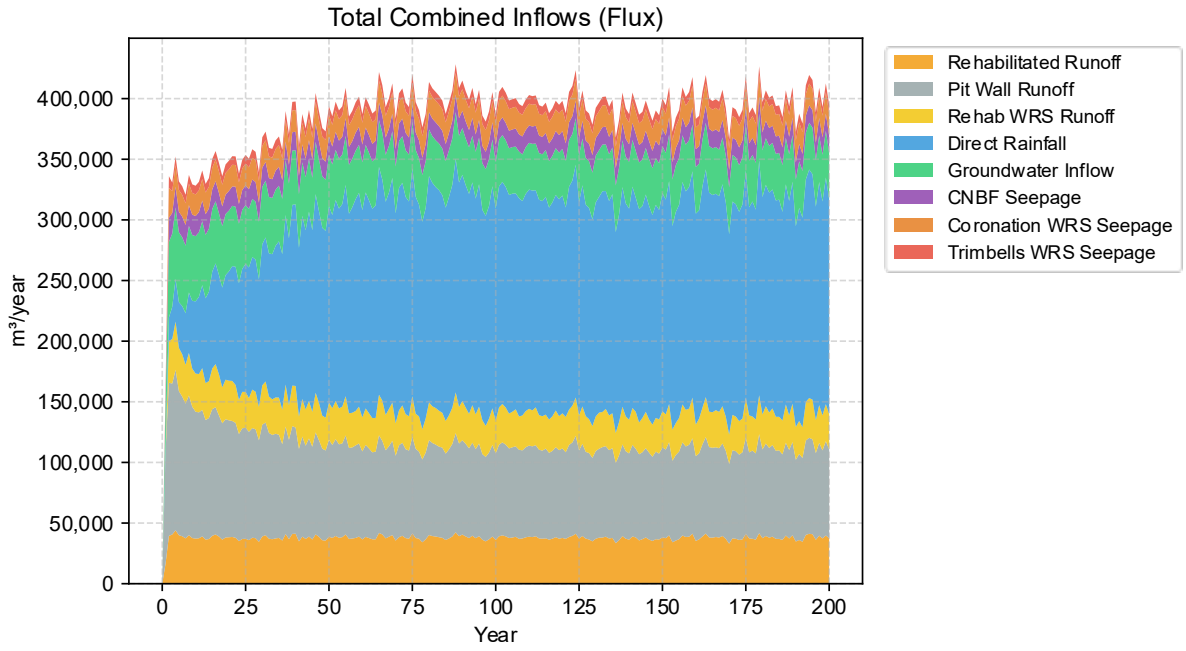

Figure 6: Stacked water balance of annual inflows to Coronation North Pit Lake.

Source: GHD (2026b).

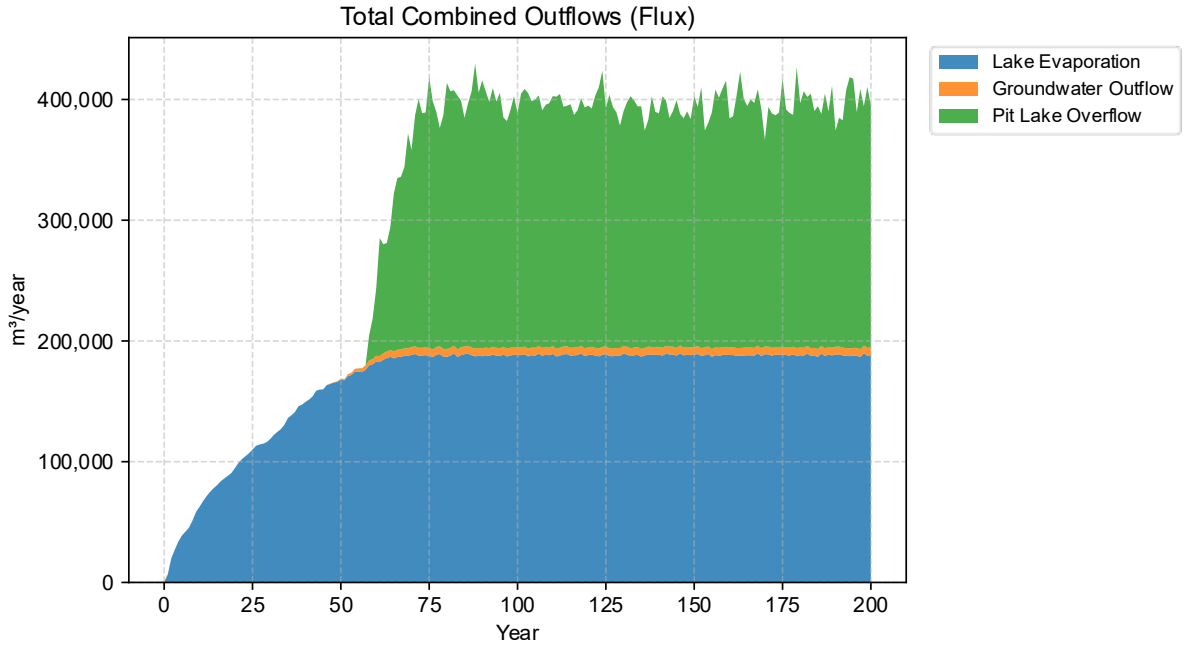

Figure 7: Stacked water balance of annual outflows from Coronation North Pit Lake.

Source: GHD (2026b).

Water Quality Prediction

The predicted long-term water quality for the CN Pit Lake is summarised in Table 5. The temporal evolution of key parameters over the 200-year modelling period is illustrated in Figure 8 and Figure 9. The following observations are noted:

- **pH and alkalinity:** The CN Pit Lake is predicted to remain circumneutral, with the pH stabilising at approximately 7.6. Total alkalinity is predicted to remain over 140 mg $CaCO_3$/L throughout the simulation, providing significant buffering capacity against potential acidifying processes.
- **Salinity:** The total dissolved solids (TDS) concentration is predicted to increase from an initial 1,510 mg/L to a stable 1,770 mg/L. This value represents the net solute mass remaining in solution after accounting for both evapoconcentration and solute removal via secondary mineral precipitation.
- **Major ions:**
    - Concentrations of Ca and Mg are predicted to increase from initial values to 117 mg/L and 199 mg/L, respectively, during the first 20 years. Calcium is predicted to rise further to approximately 146 mg/L, while Mg stabilises above 200 mg/L, by the end of the modelling period.
    - Sodium concentrations remain above 40 mg/L, while K is predicted to decline from approximately 21 mg/L to 11 mg/L.
    - Sulfate concentrations are predicted to increase from 871 mg/L to 1,142 mg/L when intermittent overflow starts (Year 57), stabilising around 1,151 mg/L. The concentrations of Cl decline slightly from 17.8 mg/L to 13.5 mg/L.
- **Trace elements and mineral precipitation:**
    - Dissolved Fe concentrations are predicted to remain below 0.0002 mg/L due to solubility control by amorphous $Fe(OH)_3$.
    - Approximately 36.9 tonnes (t) of amorphous $Fe(OH)_3$ are predicted to precipitate over the 200-year modelling period, providing specific surface areas for adsorption and sequestration of trace metals and metalloids. Notably, the influx of dissolved Fe is predominantly provided by the solute released from backfill material over the first 75 years.
    - Arsenic (As) concentrations are predicted to decline from 0.396 mg/L to 0.211 mg/L over the modelling period.
    - Dissolved Cu and Zn are predicted to increase from the initial 0.0008 mg/L and 0.0216 mg/L to 0.0033 mg/L and 0.056 mg/L, respectively, over the 200-year modelling period. Concentrations of Pb will remain negligible (up to 0.00003 mg/L).
    - Approximately 8,300 t of secondary calcite is predicted to precipitate over the modelling period, providing the primary geochemical buffering mechanism maintaining the lake's circumneutral pH.
- **Nitrogenous compounds:**
    - Nitrate-nitrogen (NO_3-N) is predicted to rapidly decrease from 8.48 mg/L to 0.65 mg/L within the first 20 years, eventually stabilising at 0.16 mg/L.

- Ammoniacal nitrogen (Amm-N) follows a similar trend, decreasing from 0.485 mg/L to 0.0021 mg/L within the first 20 years, with long-term concentrations falling to 0.0001 mg/L.

Table 5: Predicted Coronation North Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 57	YEAR 71	YEAR 100	YEAR 200
Pit lake level	mRL	458.2	521.0	558.2	562.5	562.5	562.5
Pit lake volume	Mm^3	0.17	5.39	13.92	15.24	15.26	15.26
pH	pH units	7.69	7.63	7.62	7.62	7.61	7.59
TDS	mg/L	1,510	1,690	1,781	1,781	1,770	1,770
Total alkalinity	mg/L as $CaCO_3$	180	158	154	152	149	144
Ca	mg/L	83.8	117	128	131	136	146
Mg	mg/L	189	199	209	208	205	202
Na	mg/L	41.0	46.9	48.4	47.6	45.4	42.3
K	mg/L	21.0	21.6	19.7	18.5	15.5	10.8
SO_4	mg/L	871	1,064	1,142	1,145	1,142	1,151
Cl	mg/L	17.8	16.8	16.2	15.8	14.9	13.5
NO_3-N	mg/L	8.48	0.65	0.22	0.17	0.16	0.16
Amm-N	mg/L	0.4853	0.0021	0.0008	0.0002	0.0001	0.0001
As	mg/L	0.396	0.314	0.289	0.278	0.252	0.211
Cu	mg/L	0.0008	0.0016	0.0017	0.0018	0.0022	0.0033
Fe	mg/L	0.00018	0.00019	0.00019	0.00019	0.00019	0.00019
Pb	mg/L	0.00001	0.00001	0.00001	0.00001	0.00002	0.00003
Zn	mg/L	0.0216	0.0389	0.0448	0.0465	0.0497	0.0560

Note: Pit lake starts overflow in Year 57 and reaches long-term stable level in Year 71.

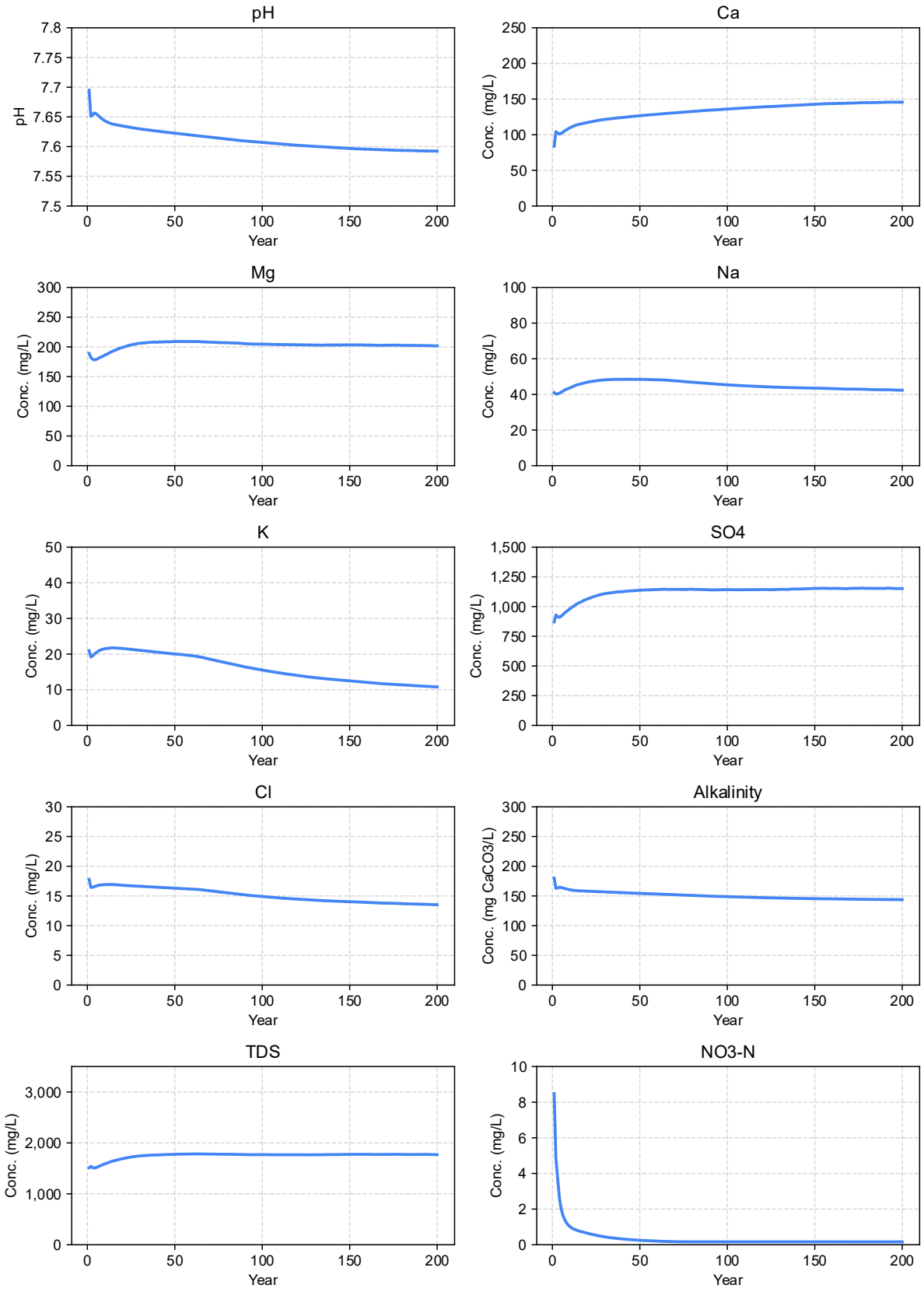

Figure 8: Predicted temporal evolution of primary water quality parameters in Coronation North Pit Lake.

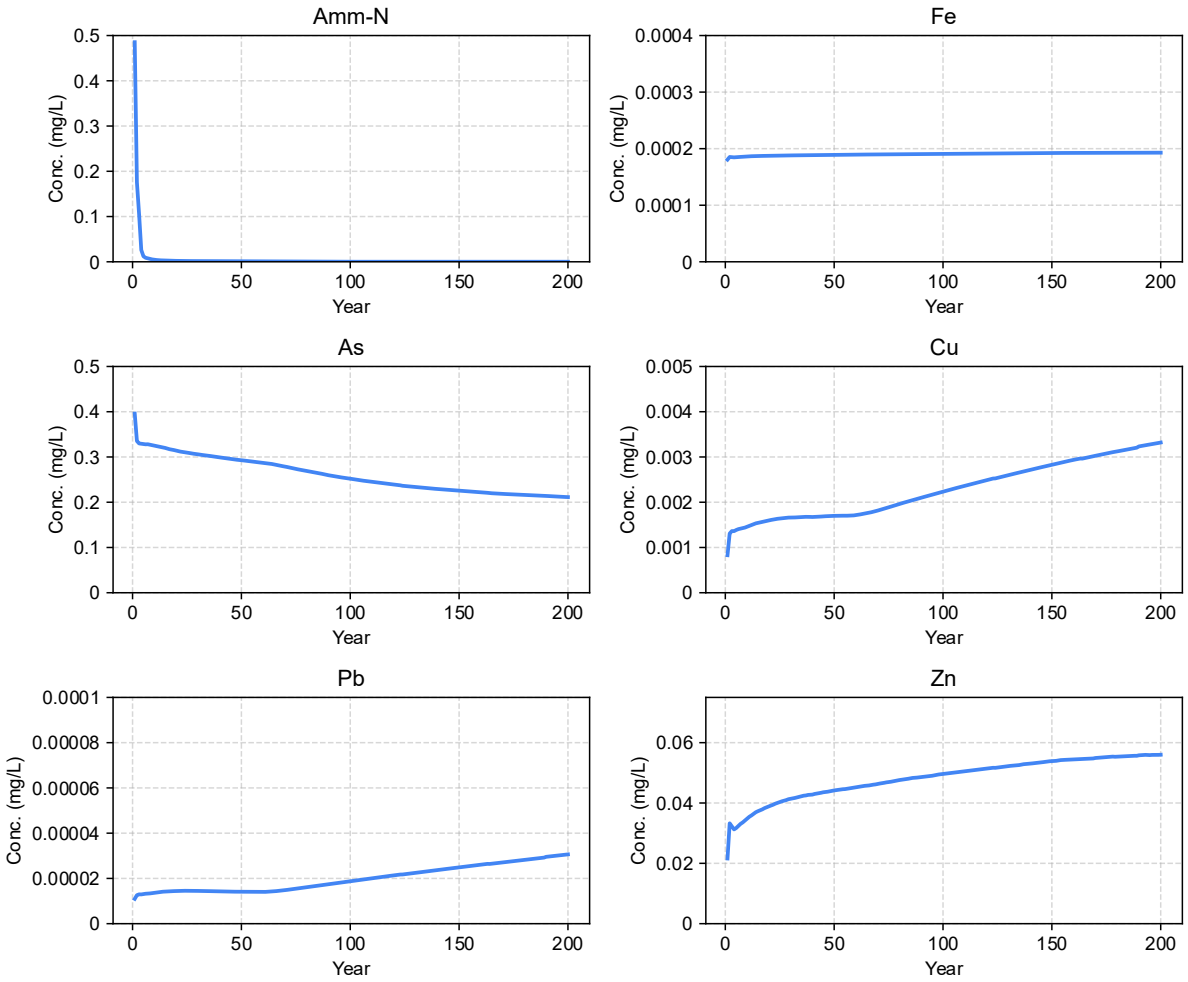

Figure 9: Predicted temporal evolution of primary water quality parameters in Coronation North Pit Lake (continued).

Mass Loading Prediction

The mass loading of selected chemical species entering the pit lake, categorised by inflow source, is presented in Figure 10 and Figure 11. Key observations include:

- Pit wall runoff is the dominant long-term mass contributor for alkalinity, Cl, As, and Pb, while remaining a primary contributor for all other major ions across the 200-year modelling period.
- Total annual loads for Ca, Mg, Na, and SO_4 are predicted to peak at approximately Year 20 before gradually declining and stabilising by Year 75. This trend is driven by an initial increase in mass load from CNBF seepage, combined with the subsequent attenuation of loads from pit wall runoff and the cessation of backfill solute release.
- Seepage from the CNBF and CO WRS constitutes the primary secondary mass inputs for the major ions (Ca, Mg, Na, and SO_4), maintaining high and stable fluxes over the modelling period.
- Backfill solute release serves as the primary driver for K, Amm-N, and Fe loadings during the early post-closure phase. Following the cessation of the backfill solute source term at Year 75, Fe and Amm-N annual loads drop to negligible levels, whereas K loads drop by more than half with pit wall runoff as the primary long-term source.

- Nitrate loading is dominated by waste rock seepage from CNBF and the TR WRS. A minor, early stage NO_3 contribution from the backfill solute release also ceases after Year 75.
- Copper loads are predominantly driven by the TR WRS seepage throughout the entire modelling period.
- Approximately half of the annual Zn flux is sourced from the CO WRS seepage, while the remaining mass is supplied by groundwater and the TR WRS seepage.
- Groundwater inflow provides a minor but stable long-term mass flux for As.

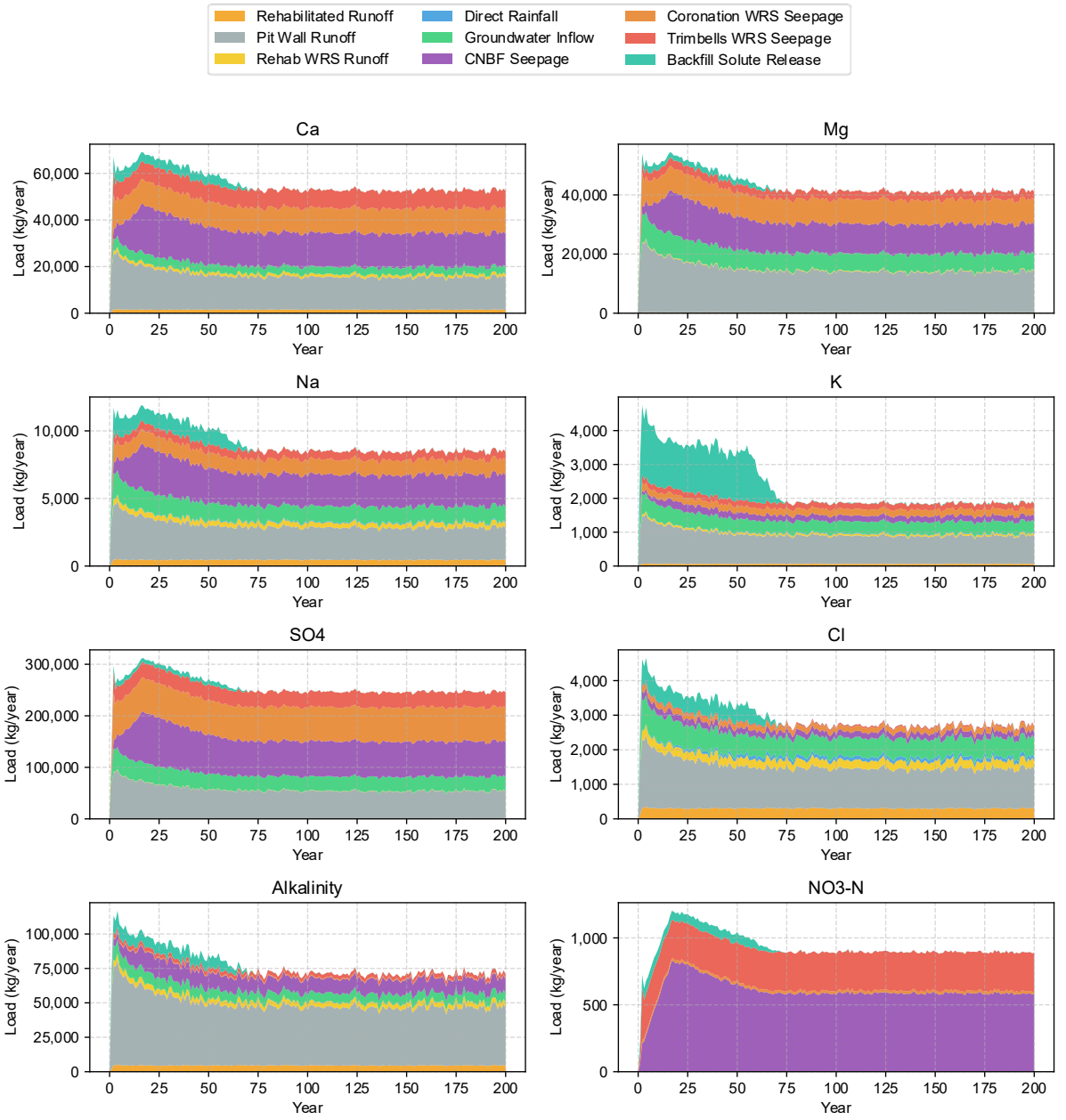

Figure 10: Predicted annual mass loading for Coronation North Pit Lake by water balance component.

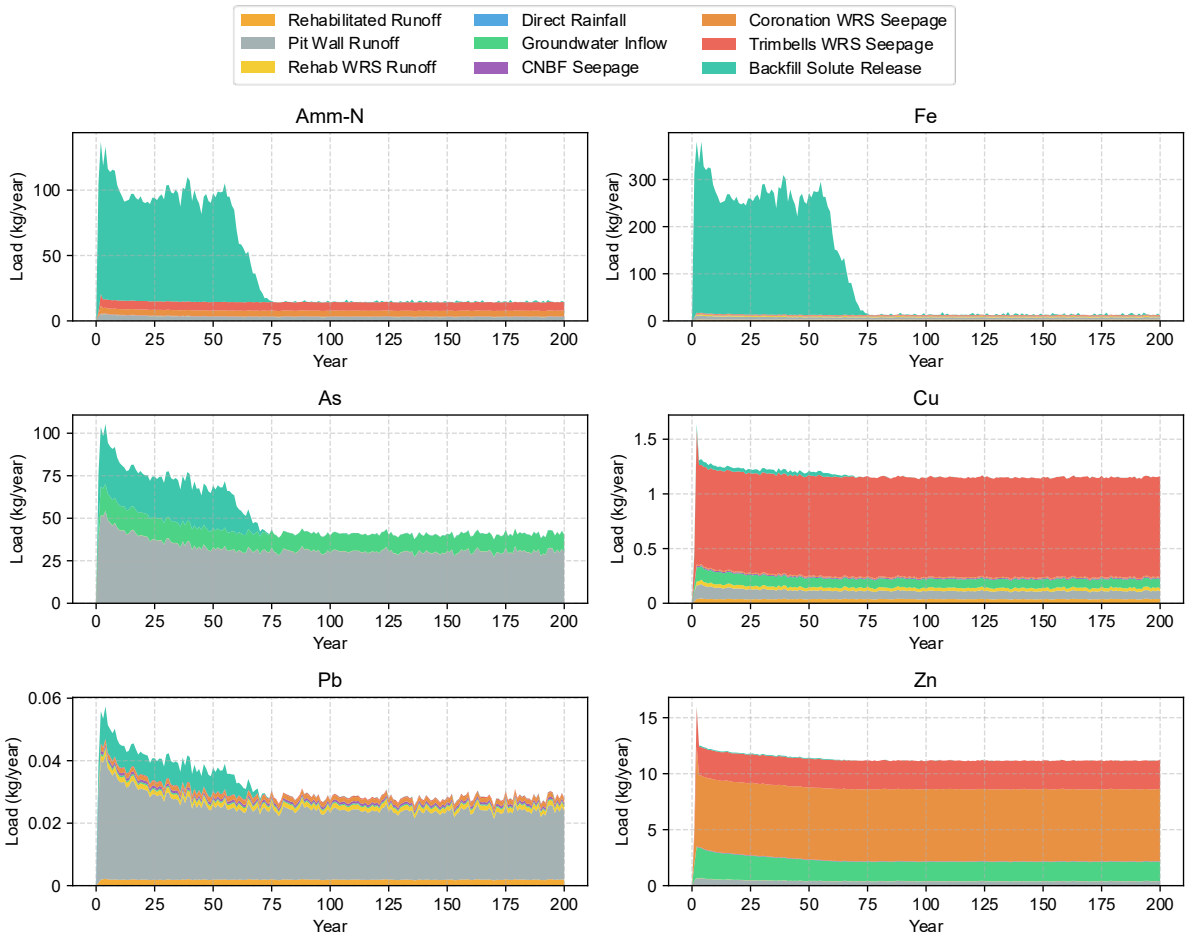

Figure 11: Predicted annual mass loading for Coronation North Pit Lake by water balance component (continued).

SUMMARY

The long-term water quality of the CN Pit Lake was modelled to assess the geochemical impact of the proposed Project activities post-closure. The modelling results indicate the following:

- The pit lake is predicted to remain circumneutral throughout both the infilling and spilling phases. A stable pH of approximately 7.6 is maintained by a sustained acid buffering capacity, with long-term total alkalinity predicted to exceed 140 mg $CaCO_3$/L.
- At hydraulic equilibrium by Year 71, the pit lake is predicted to reach a TDS concentration of approximately 1,770 mg/L. Following the initial refilling phase, the hydrogeochemical profile of the pit lake is expected to be SO_4 dominant (>1,100 mg/L) with Mg concentrations exceeding 200 mg/L.
- Approximately 37 t of amorphous $Fe(OH)_3$ is predicted to precipitate which provides critical reactive surface areas for the adsorption and sequestration of trace metals and metalloids. Consequently, the concentrations of trace metals will remain low (e.g., Pb). However, Cu and Zn are predicted to increase gradually to 0.0033 mg/L and 0.056 mg/L, respectively. Concentrations of As are predicted to decline from 0.396 mg/L to 0.211 mg/L.

- Nitrate (NO_3-N) and ammoniacal nitrogen (Amm-N) are predicted to attenuate rapidly from their initial concentrations of 8.48 mg/L and 0.485 mg/L to 0.65 mg/L and 0.0021 mg/L, respectively, within the first 20 years, eventually stabilising at approximately 0.16 mg/L and 0.0001 mg/L.
- Annual mass loads for the majority of modelled chemical species are predicted to peak at approximately Year 20, driven by an initial increase in the volumes of CNBF seepage alongside pit wall runoff. Following the cessation of the backfill solute release at Year 75, annual loads for key species, particularly Fe, Amm-N, and K, decline sharply or drop to negligible levels, eventually stabilising as long-term fluxes become governed by pit wall runoff and waste rock seepage.

Full water quality data are provided as a Microsoft Excel file (Attachment A).

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ATTACHMENT A: CORONATION NORTH PIT LAKE DIGITAL OUTPUT [MICROSOFT EXCEL FILE]

APPENDIX E INNES MILLS PIT LAKE WATER QUALITY MODEL

MINE WASTE MANAGEMENT
GREENROAD GROUP

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MEMORANDUM

Recipient:	OceanaGold (New Zealand) Limited c/- [redacted]
From:	Paul Weber – Mine Waste Management Limited (MWM)
Date:	31 August 2026
Cc:	[redacted] – OceanaGold Eric Chen – MWM; Leo Navarro – MWM
Document Number:	J-NZ0498-017-M-FINAL
Document Title:	Innes Mills Pit Lake Water Quality Model
Disclaimer:	This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

Mine Waste Management Limited (MWM) has been engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess environmental geochemistry hazards and potential effects for the proposed Macraes Phase Four Project (MP4 or the Project). This assessment supports the application as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

As part of the broader geoenvironmental hazard assessment, this memorandum provides a quantitative prediction of the long-term pit lake water quality for the Innes Mills (IM) Pit Lake, incorporating the proposed Stages 11 to 13 extensions (IM11 to IM13) and proposed waste rock backfill. It documents the hydrogeochemical modelling approach, derived source terms, and resulting pit lake water quality predictions. These predictions are used by GHD (2026a) to estimate effects on surface and groundwaters.

BACKGROUND

The IM Pit, part of the Macraes Operation, is located in the centre of the Central Mining Area, within the boundary of mining permit MP41064 (Figure 1).

MP4 proposes a further extension of the IM Pit to the north, east, and west (IM11 to IM13) into the Southern Pit area to enable the recovery of downdip ore and stockwork ore. The proposed extensions will result in an overall increase of approximately 49 ha to the current pit footprint. The full mining of IM13 will require the relocation of all SP10 and SP11 tailings, as well as a reduction of up to 30 m in the existing height of tailings from the top of the Mixed Tailings Impoundment (MTI) (OGNZL, 2026).

OBJECTIVES AND SCOPE OF WORK

The primary objective of this study is to develop a post-closure hydrogeochemical model to predict the IM Pit Lake water quality for a period of 200 years. The quantitative prediction of the long-term water quality will support GHD's assessment of environmental effects of the proposed IM extensions on receiving waters for MP4 (GHD, 2026a).

The scope of work includes:

- Developing a conceptual site model (CSM) to identify the inflows, outflows, model components, and the key geochemical and physical processes that will influence the pit lake after the proposed extension.
- Deriving source terms (chemical composition) for pit lake inflows, utilising site-specific data where possible.
- Predicting the IM Pit Lake water quality quantitatively, based on the integration of the derived source terms with the water balance model (WBM) provided by GHD (2026b).

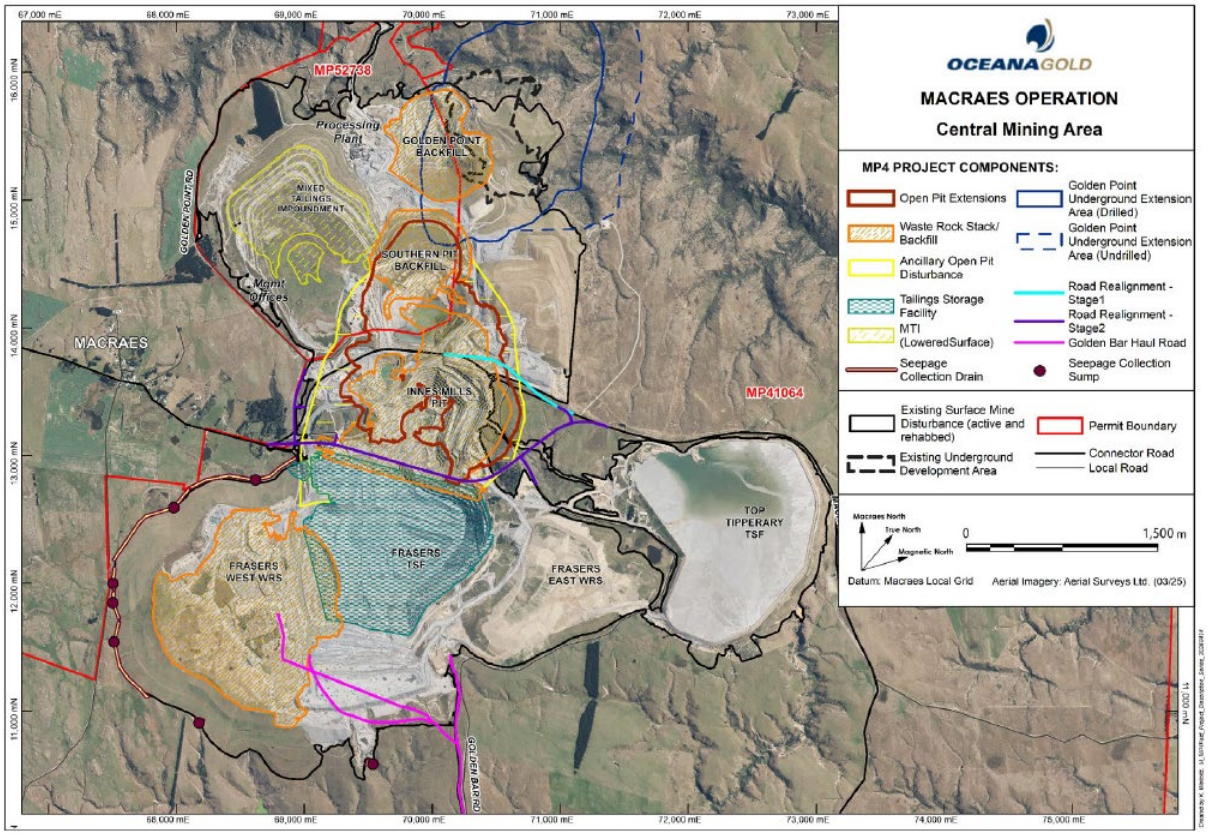

Figure 1: Central Mining Area.

Source: OGNZL (2026).

CONCEPTUAL SITE MODEL

A CSM was developed to facilitate the hydrogeochemical modelling of the IM Pit Lake (Figure 2). The inflows and outflows for the IM Pit Lake, which align with the WBM developed by GHD (introduced in the subsequent section), are summarised in Table 1. The following key points are noted:

- The pit will be partially backfilled with waste rock. The total backfill volume is estimated to be 128.5 Mm^3, which includes IMBF1, IMBF3, and FRBF. Of this, 85 Mm^3 will be saturated, with the remaining 43 Mm^3 situated above the pit lake level and therefore unsaturated.
- The CSM accounts for five types of inflow (groundwater inflow comprising two sources) and three types of outflow.

- Seepage from the Innes Mills Backfill (IMBF) will report to the pit.
- Groundwater inflow is defined as a mixture of the natural ambient groundwater and seepage from the Frasers TSF (FTSF).
- Upon reaching the spill elevation, the pit lake will discharge via surface overflow over the Golden Point Backfill into Deepdell Creek.
- The existing pit will be completely dewatered to facilitate pit expansion, leaving no residual water at the commencement of pit lake filling.

Table 1: Summary of water balance components for Innes Mills Pit Lake CSM.

MODEL FEATURE	NOTE
Inflow	
Rainfall	Direct precipitation onto the pit lake surface.
Groundwater	Mixture of groundwater and FTSF seepage.
Runoff from pit walls	Runoff from exposed pit wall surfaces generated by rainfall.
Runoff from rehabilitated areas	Runoff from the mining impacted areas (including WRS) that will be fully rehabilitated.
Seepage from backfill	Seepage from the unsaturated IMBF material above the pit lake level that drains to the pit lake.
Outflow	
Evaporation	Loss of pure water from the pit lake surface due to evaporation, causing evapoconcentration of solutes.
Groundwater	Outflow from the pit as groundwater into the surrounding aquifer.
Overflow	Surface discharge from the IM Pit Lake to Deepdell Creek once the spill point is reached.

Note: All water flow rates are based on the water balance provided by GHD (2026b).

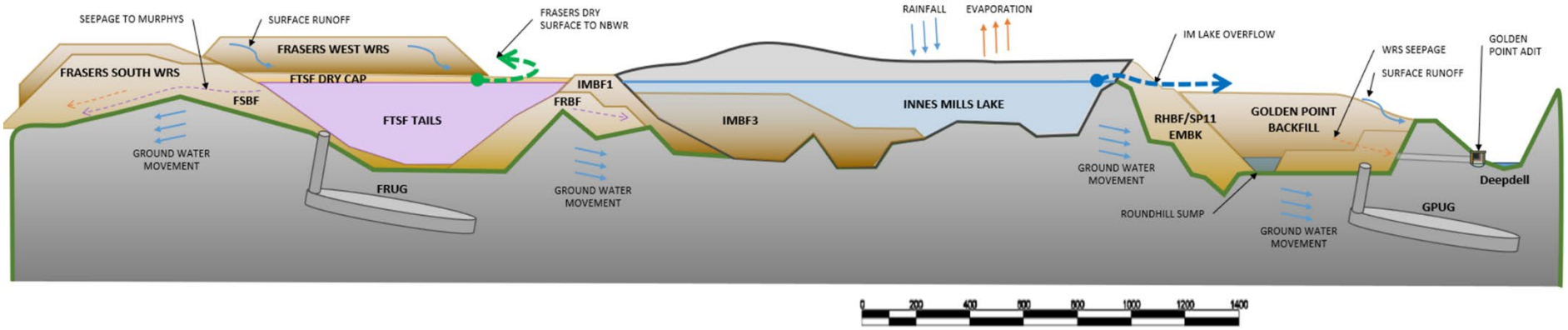

Figure 2: Conceptual site model for Innes Mills Pit.

Source: GHD (2026a).

Note: Image is not to scale.

WATER BALANCE MODEL

The WBM was developed by GHD (2026b) to provide the hydrologic basis for the pit lake water quality modelling. The key findings and model summary are:

- Model period – The WBM covers a 200-year post-closure period (2033 to 2233) utilising an annual timestep.
- Inflow components – Six inflow sources are accounted for over the 200-year model period (Figure 3), fluctuating dynamically in response to the rising pit lake water level:
    - Direct rainfall onto the pit lake surface contributes 35.8% of the total inflow volume over the model period.
    - Pit wall runoff contributes 22.8% of the total inflow volume.
    - Other inflows, including groundwater inflows (8.1% from schist aquifers and 9.0% as FTSF seepage), seepage from IMBF (15.6%), and rehabilitated WRS runoff (8.6%), constitute the remaining volume.
- Outflow components – Three outflow pathways are identified over the 200-year model period (Figure 4):
    - Evaporation accounts for over 48% of the total outflow volume.
    - Surface overflow also accounts for nearly 48% of the total outflow volume.
    - Groundwater outflow is low at 4.3%.
- Spill dynamics and equilibrium:
    - Year 56: Short-term hydrologic fluctuations (e.g., episodic high rainfall) cause the water level to temporarily reach the spill point, initiating intermittent overflow to Deepdell Creek.
    - Year 68: The system achieves a long-term, hydrodynamic steady-state equilibrium at 473.1 mRL (the spill point).
    - At equilibrium, the pit lake depth is predicted to reach 143.1 m based on a pit floor base level of 330 mRL, with a total pit lake volume of approximately 25.8 Mm^3 (inclusive of the backfill pore volume).

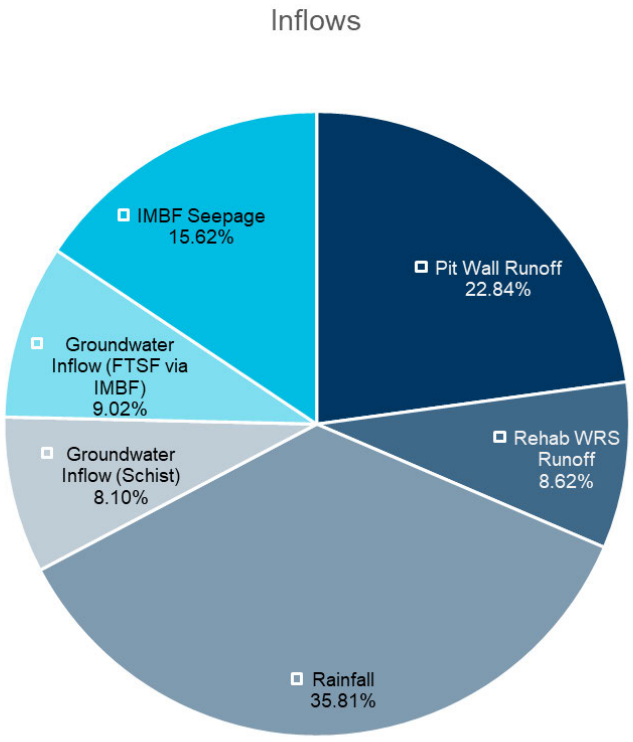

Figure 3: Predicted proportions of cumulative water inflows to Innes Mills Pit Lake (200-year period).

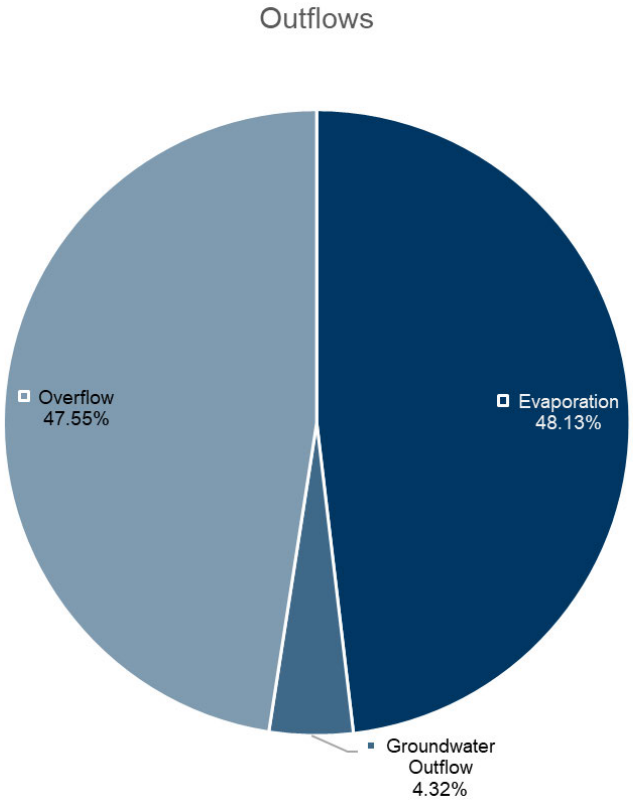

Figure 4: Predicted proportions of cumulative water outflows from Innes Mills Pit Lake (200-year period).

SOURCE TERMS

Water quality source terms for the various inflows were derived from relevant geochemical and environmental monitoring datasets (Table 2). The derivation methodology is detailed in the hydrogeochemical modelling report (MWM, 2026b), with the resulting source terms summarised in Table 3.

The following should be noted:

- Two source terms were derived for the groundwater inflow to represent distinct water types; the final groundwater source term is defined using a flow-weighted average concentration derived from these two inflow components.
- The chemical composition of the IMBF seepage varies over time; Table 3 presents peak concentrations for this source term to represent the most conservative water quality profile. The detailed derivation approach is documented in MWM (2026b).

Table 2: Data sources for source term derivation.

MODEL FEATURE	SOURCE TERM DATA SOURCE
Rainfall	Rainfall quality data from Nichol et al. (1997), collected between 1983 and 1994 at the Lauder collection site (~70 km NE from Macraes).
Groundwater from FTSF	FTSF seepage, derived from the TTTSF[1] Impoundment monitoring dataset (from 2018).
Groundwater from Schist	Schist groundwater data from the SPMW3 and SPMW4 datasets.
Pit wall runoff	Source term derived for the Golden Bar Analogue Model (MWM, 2025).
Runoff from rehabilitated areas (incl. WRS)	Median water quality monitoring data from the monitoring point at Deepdell South Silt Pond (MWM, 2026b), as recommended by GHD (2026a).
Backfill seepage (IMBF)	Backfill seepage quality for IMBF, modelled as a variable source term to account for the declining unsaturated thickness of the backfill as the pit lake fills (MWM, 2026a).
Solute load released from submerged backfill	IBC[2] field trial assessment (MWM, 2026c).

[1] *Top Tipperary TSF.*

[2] *Intermediate bulk container.*

Table 3: Summary of source terms derived for Innes Mills Pit.

TYPE		RAINFALL	GROUNDWATER (FTSF SEEPAGE)**	GROUNDWATER (SCHIST GROUNDWATER)	PIT WALL RUNOFF	REHAB AREA RUNOFF	BACKFILL SEEPAGE (IMBF)	SOLUTE LOAD RELEASED FROM BACKFILL*
Data Source	Unit	Nichol et al. (1997)	Monitoring data: TTTSF Impoundment	Monitoring data: SPMW3 and SPMW4	GB Analogue Model (MWM, 2025)	Monitoring data: Deepdell South Silt Pond	Calculated by the model ^	IBC Field Trial Assessment (MWM, 2026c)
pH	pH units	5.2	8.1	7.4	8.4	8.0	7.9	-
Total alkalinity	mg/L as $CaCO_3$	0.81	220	275	573	119	517	37.2
Ca	mg/L	0.11	640	234	190	40	30	10.9
Mg	mg/L	0.05	345	33.9	186	7.9	1,316	5.13
Na	mg/L	0.32	360	20.5	32.4	12	94	3.19
K	mg/L	0.09	95	2.25	11.2	1.7	28	3.94
SO_4	mg/L	0.18	3,600	515	719	20	5,306	22.7
Cl	mg/L	0.6	22	8.5	15.6	8	11	1.30
NO_3-N	mg/L	0.0045	12	0.01975	0.019	0.001	14	0.19
Amm-N	mg/L	-	13	0.0225	0.038	0.005	0.039	0.23
As	mg/L	-	0.0125	0.0114	0.409	0.0039	0.003	0.068
Cu	mg/L	-	0.089	0.000625	0.001	0.001	0.0015	0.0001
Fe	mg/L	-	0.0265	1.835	0.065	0.07	0.02	0.7
Pb	mg/L	-	0.45	0.00022	0.0003	0.00005	0.00025	0.00002
Zn	mg/L	-	-	0.0041	0.008	0.0005	0.025 #	0.0002
WAD CN	mg/L	-	0.01	0.0015	0.005	-	-	-
SCN	mg/L	-	1.6	-	-	-	-	-

Note:

Amm-N refers to ammoniacal N; WAD CN refers to weak acid dissociable cyanide; SCN refers to thiocyanate.

** All values for the solute load released from backfill are expressed in mg/kg.*

^ IMBF parameters represent peak source term values (at Year 18) derived from a time-variant model based on Frasers West WRS seepage data. The calculated parameter values increase initially before declining as the pit lake level further rises.

 # Zn concentration for IMBF seepage source term was not available; therefore, the source term uses median concentration from the Northern Gully East and West dataset.

*** Groundwater (FTSF seepage) source term uses total concentrations for the trace elements.*

WATER QUALITY MODEL

Model Development

The pit lake water quality model was developed using PHREEQC software (Parkhurst & Appelo, 2013) with the WATEQ4F thermodynamic database (Ball & Nordstrom, 1991). The model simulated the following geochemical and physical processes:

- Mixing: Integration of multiple inflow streams.
- Evapoconcentration: Concentration of solutes due to pit lake surface evaporation.
- Gas exchange: Equilibration of water with atmospheric O_2 and CO_2.
- Mineral saturation: Thermodynamic control via mineral dissolution and precipitation.
- Surface complexation: Adsorption of trace elements onto hydrous ferric oxides (HFO), such as amorphous ferrihydrite $Fe(OH)_3$ (a), where present.
- Nitrogen (N) attenuation: Degradation and removal of nitrogenous species.

The mineral assemblage, which includes the mineral phases selected for the calculation of mineral saturation, is provided in Table 4.

Table 4: Mineral assemblage used in the PHREEQC model.

PHASE	FORMULA	PHASE	FORMULA
Calcite	$CaCO_3$	Gypsum	$CaSO_4 \cdot 2H_2O$
Hydromagnesite	$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$	Quartz	SiO_2
$Fe(OH)_3$ (a)	$Fe(OH)_3$	Malachite	$Cu_2(CO_3)(OH)_2$
Smithsonite	$ZnCO_3$	O_2(g)	O_2
CO_2(g)	CO_2		

Assumptions and Limitations

The key assumptions and limitations of the model include:

- The model assumes a fully mixed water column (holomictic) throughout the modelling period. This assumption is based on the expectation of a low risk of persistent multi-year stratification of pit lakes (MWM, 2026b). Hence, this well-mixed configuration defines the redox environment for the PHREEQC simulations. While localised oxygen depletion at depth may occur, the adopted approach provides a consistent basis for predicting long-term water quality trends and mineral stability.
- In the absence of site-specific redox data, a pE[3] of 10, representing oxidising conditions, was adopted for all source terms and equilibrium phases.

[3] *pE is the negative logarithm of electron activity (pE = -log[e^-]). It serves as a master variable for redox status, analogous to pH for acidity.*

- Measured site data indicates that the Golden Bar (GB) Pit Lake ranges in temperature from approximately 7˚C to 13˚C (MWM, 2026b); hence, a constant water temperature of 10˚C was applied to all inflows and the pit lake body, which is considered reasonable for modelling purposes.
- Iron (Fe) in all source terms was assumed to be entirely ferric iron (Fe^{3+}), consistent with the assumed oxidising environment (pE = 10). It is expected that any ferrous iron (Fe^{2+}) entering the pit will rapidly oxidise to Fe^{3+} under circumneutral conditions with negligible or low O_2 consumption.
- Solute release rates for backfill seepage are derived from the IBC field trials (MWM, 2026c). These data provide a more representative estimation of field conditions compared to the static shake flask extraction data used in previous pit lake water quality assessments (e.g., MWM, 2024).
- An initial nitrogen load of 5.35 g/m^2, representing residual ANFO[4] from blasting, was simulated as a staged release of NH_4NO_3 over the first four years of pit filling (MWM, 2025). Based on a calculated plan area of approximately 1,650,000 m^2 for the new pit design footprint, the total nitrogen load available for release is calculated at approximately 8,850 kg.
- A nitrogen decay rate based on observations at the GB Pit Lake (MWM, 2025) was implemented. The model assumes a 20-25% annual reduction in nitrate load, attributed to biologically mediated denitrification and other attenuation processes.
- Attenuation and degradation for cyanide were not simulated within the PHREEQC model. Cyanide concentration changes are driven by volumetric dilution, representing a conservative, upper-bound estimate of potential downstream impacts.

MODEL PREDICTION

Water Volume Variation

Annual volumetric variability for each water balance component is illustrated in Figure 5. The comprehensive water balance for the IM Pit Lake is presented as stacked charts for inflows (Figure 6) and outflows (Figure 7), based on data provided by GHD (2026b).

These plots demonstrate that total inflows peak early during the initial filling phase, driven by elevated runoff components. As the pit lake level rises, pit wall runoff progressively declines, and direct rainfall becomes the dominant inflow. Among the outflows, lake evaporation dominates during the first 50 years; however, once the pit lake fills to capacity around Year 60, surface overflow occurs and becomes another primary outflow pathway alongside evaporation, while groundwater outflow remains a minor component.

[4] *Ammonium nitrate fuel oil.*

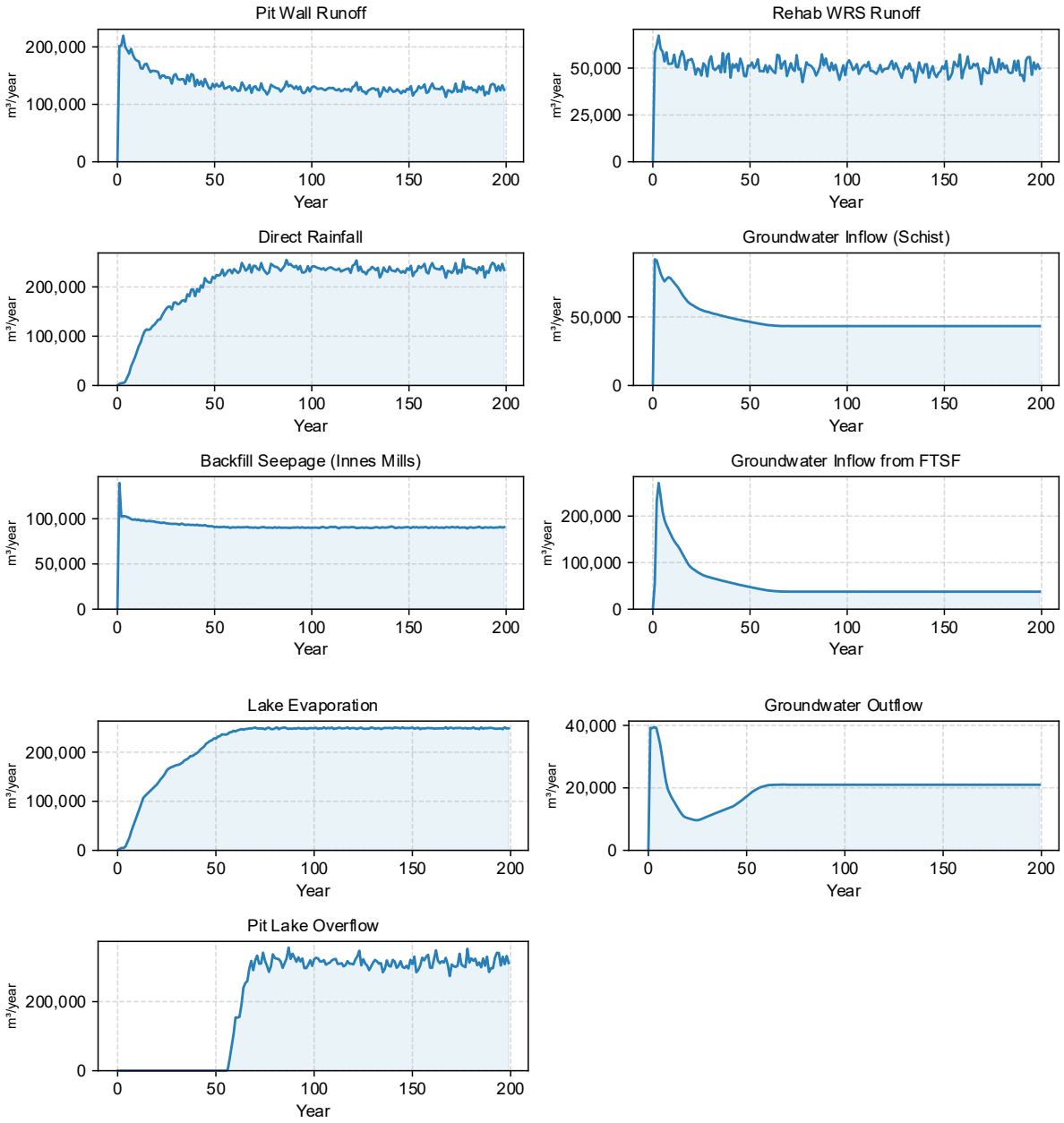

Figure 5: Annual water balance fluxes for Innes Mills Pit Lake.

Source: GHD (2026b).

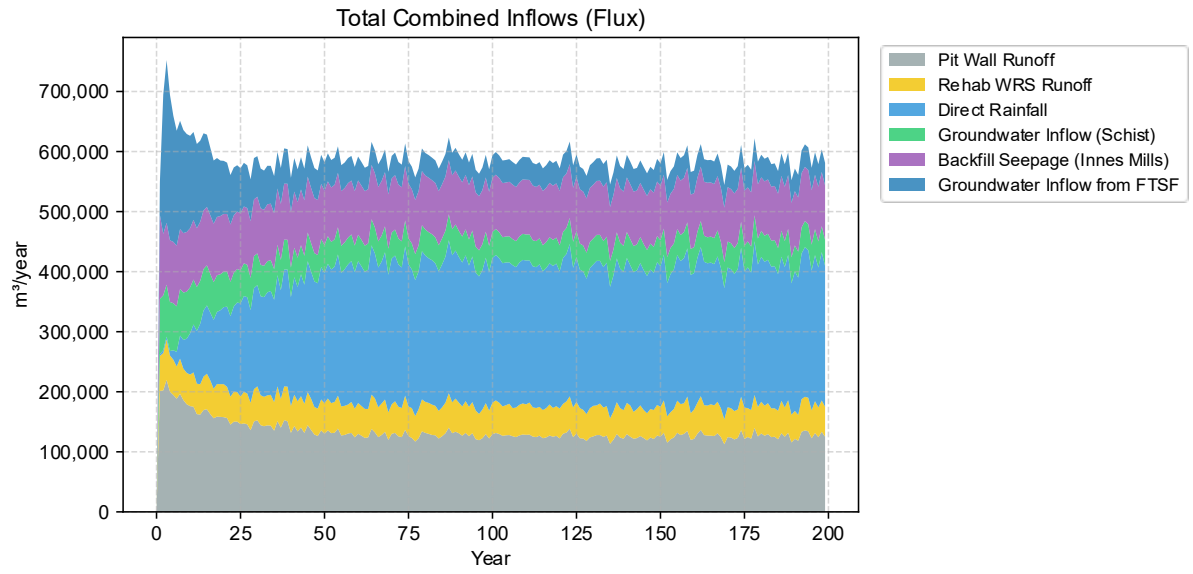

Figure 6: Stacked water balance of annual inflows to Innes Mills Pit Lake.

Source: GHD (2026b).

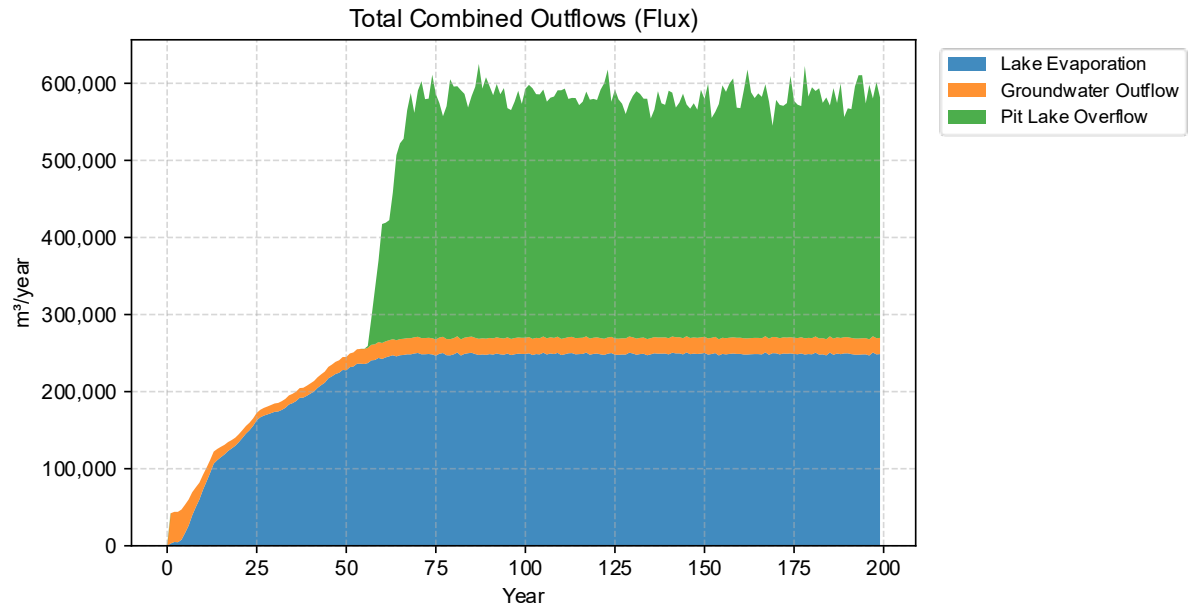

Figure 7: Stacked water balance of annual outflows from Innes Mills Pit Lake.

Source: GHD (2026b).

Water Quality Prediction

The predicted long-term water quality for the IM Pit Lake is summarised in Table 5. The temporal evolution of key parameters over the 200-year modelling period is illustrated in Figure 8 and Figure 9. The following observations are noted:

- **pH and alkalinity:** The IM Pit Lake is predicted to remain circumneutral, with the pH stabilising at 7.7, supported by an alkalinity of over 170 mg $CaCO_3$/L.
- **Salinity:** The initial total dissolved solids (TDS) concentration is predicted at 1,850 mg/L in Year 1, which increases to 3,143 mg/L within the first 20 years and subsequently declines to below

2,500 mg/L. This value represents the net mass remaining in solution, after accounting for both evapoconcentration and solute removal via secondary mineral precipitation.

- **Major ions:**
    - Calcium concentrations are predicted to increase from an initial 15.5 mg/L to 169 mg/L by Year 20, followed by a gradual decline to 115 mg/L by Year 200.
    - Magnesium increases from an initial 195 mg/L to 380 mg/L in Year 56 at the onset of intermittent overflow, before declining to 322 mg/L by Year 200.
    - Sodium follows a similar trend to Mg, declining to 82 mg/L in Year 200 after exceeding 150 mg/L around Year 20, while K consistently declines from the initial 151 mg/L to 26 mg/L over the 200-year modelling period.
    - Sulfate concentrations increase from an initial 871 mg/L to 2,118 mg/L by Year 20, eventually declining to 1,626 mg/L. Chloride declines from an initial 50 mg/L to 15.6 mg/L over the 200-year modelling period.
- **Trace elements and mineral precipitation:**
    - Dissolved Fe concentrations are predicted to start at 0.00143 mg/L, quickly stabilising at 0.0002 mg/L. Approximately 298 tonnes (t) of amorphous $Fe(OH)_3$ is predicted to precipitate over the modelling period, providing specific adsorption surfaces for trace metals and metalloids. Notably, the influx of dissolved Fe is predominantly driven by solute release from the backfill material over the first 70 years.
    - Arsenic (As) concentrations are predicted to decline rapidly from 0.94 mg/L to 0.428 mg/L in the first 20 years, eventually falling to 0.187 mg/L by Year 200. This trend is attributed to a combination of dilution via pit lake flushing and adsorption onto the predicted amorphous $Fe(OH)_3$ precipitates.
    - Dissolved Zn and Cu concentrations are predicted to continuously increase over the modelling period, from initial 0.0016 mg/L and 0.0002 mg/L, respectively to 0.0091 mg/L and 0.0015 mg/L by Year 200.
    - Concentrations of Pb remain negligible throughout the simulation, with the long-term value predicted at 0.00001 mg/L.
    - WAD CN remains at low concentrations, consistently below 0.003 mg/L.
    - Approximately 22,000 t of secondary calcite is predicted to precipitate over the modelling period, providing the primary geochemical buffering mechanism maintaining the lake's circumneutral pH.
- **Nitrogenous compounds:**
    - Nitrate-nitrogen (NO_3-N) is predicted to rapidly decline from approximately 6.16 mg/L to 1.31 mg/L within the first 20 years, followed by a continuous decrease to 0.23 mg/L by Year 200.

- Ammoniacal nitrogen (Amm-N) is predicted to decline from an initial 0.909 mg/L to 0.024 mg/L within the first 20 years, eventually stabilising at 0.003 mg/L.

Table 5: Predicted Innes Mills Pit Lake water quality for selected years.

PARAMETER	UNIT	YEAR 1	YEAR 20	YEAR 56	YEAR 68	YEAR 100	YEAR 200
Pit lake level	mRL	350.2	434	469.5	473.1	473.1	473.1
Pit lake volume	Mm^3	0.12	10.37	23.88	25.83	25.82	25.78
pH	pH units	8.01	7.61	7.65	7.66	7.66	7.67
TDS	mg/L	1,850	3,143	3,021	2,929	2,716	2,435
Total alkalinity	mg/L as $CaCO_3$	311	157	174	175	176	178
Ca	mg/L	15.5	168.6	136.7	132.3	124.9	115.1
Mg	mg/L	195	359	380	371	350	322
Na	mg/L	122.3	157.1	127.7	120.6	104.4	82.2
K	mg/L	151	73.8	56.3	52.1	41.3	26.2
SO_4	mg/L	871	2,118	2,046	1,980	1,827	1,626
Cl	mg/L	49.9	28.2	23.6	22.6	19.6	15.6
NO_3-N	mg/L	6.16	1.31	0.32	0.24	0.23	0.23
Amm-N	mg/L	0.909	0.024	0.005	0.003	0.003	0.003
As	mg/L	0.939	0.428	0.341	0.322	0.266	0.187
Cu	mg/L	0.0002	0.0008	0.0009	0.001	0.0011	0.0015
Fe	mg/L	0.00143	0.0002	0.00019	0.00019	0.00019	0.00018
Pb	mg/L	0.000002	0.000006	0.000006	0.000007	0.000008	0.000011
Zn	mg/L	0.0016	0.0064	0.0072	0.0074	0.008	0.0091
WAD CN	mg/L	0	0.003	0.002	0.002	0.002	0.001

Note: Pit lake starts overflow in Year 56 and reaches long-term stable level in Year 68.

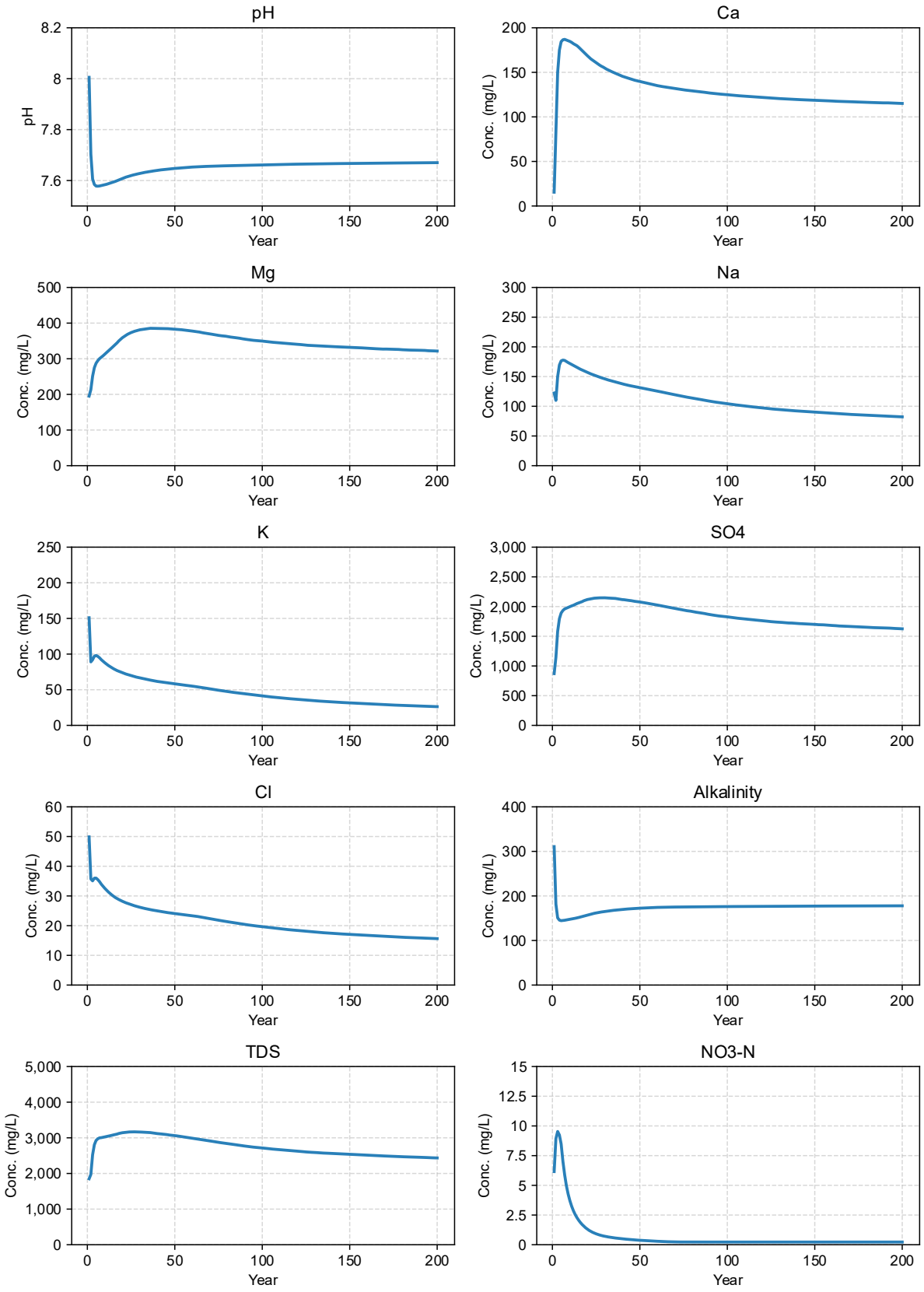

Figure 8: Predicted temporal evolution of primary water quality parameters in Innes Mills Pit Lake.

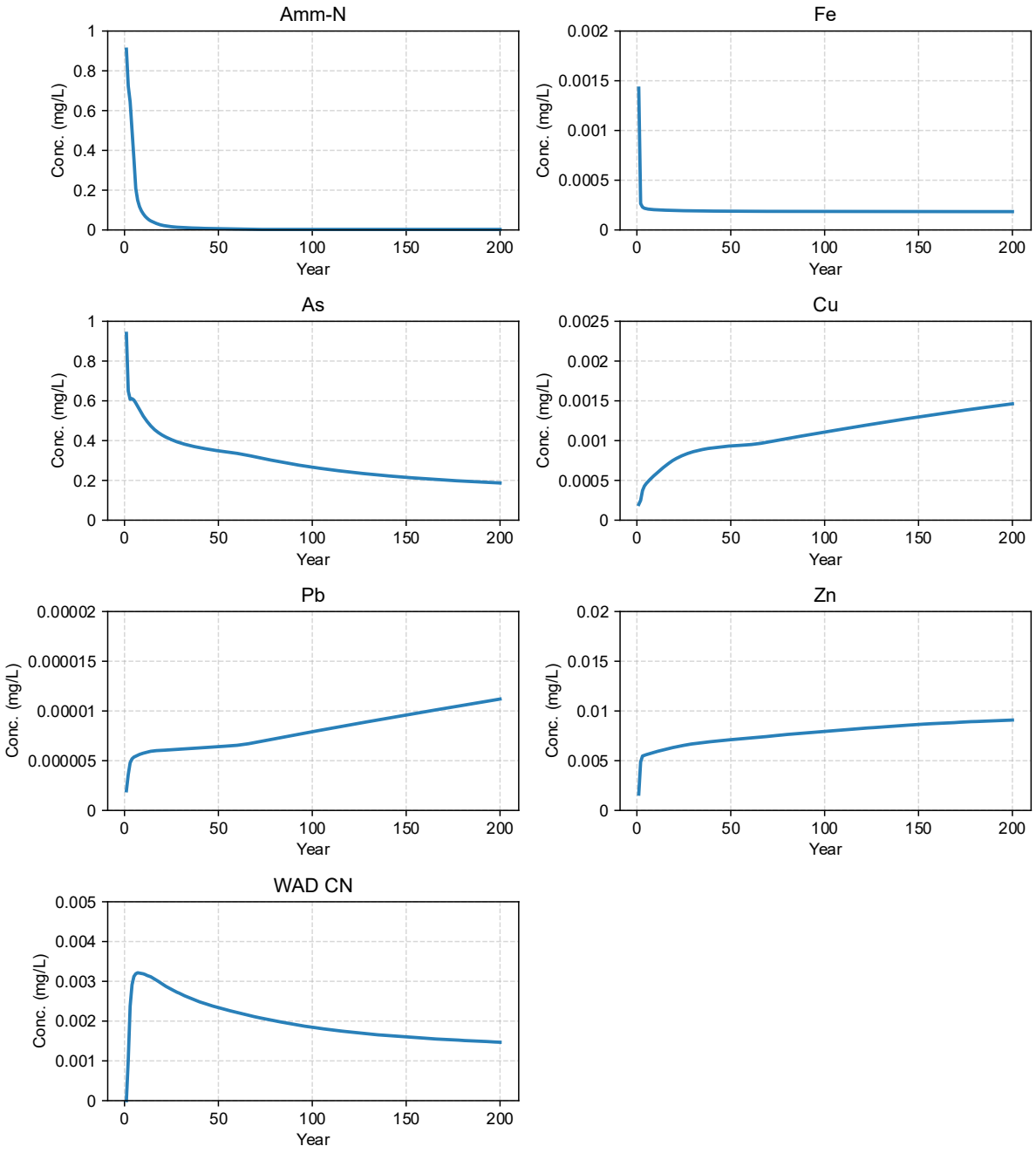

Figure 9: Predicted temporal evolution of primary water quality parameters in Innes Mills Pit Lake (continued).

Mass Loading Prediction

The mass loading of selected chemical species entering the pit lake, categorised by inflow source, is presented in Figure 10 and Figure 11. Key observations include:

- Backfill solute release is the predominant driver for mass loading of chemical species including major ions (K and Cl), alkalinity, and trace elements (Fe and As), during the early infilling stage. This is driven by the large portion of the backfill (IMBF) placed below the pit base level. These mass fluxes diminish after approximately 70 years as the backfill is progressively submerged by the rising lake level.

- The annual mass load from the IMBF seepage increases over the first 20 years, becoming the predominant contributor to the mass loading of Ca, Mg, Na, SO_4 and Zn over the remainder of the 200-year modelling period.
- Mass loading from groundwater inflow from the FTSF is more prominent in the early stages before declining to a stable, relatively low-level output around Year 70 for most modelled species. However, this source remains the dominant contributor to nitrogenous compounds and Cu loading throughout the entire modelling period, and it also dominates the WAD CN load (noting that WAD CN source concentrations are only defined for three source terms).
- Pit wall runoff provides a constant and steady alkalinity load to the pit lake, along with minor to moderate loads for major ions, As and Pb.
- The loading contributions from other inflow sources, including direct rainfall, rehabilitated WRS runoff, and groundwater inflow (schist), are negligible across all modelled chemical species.

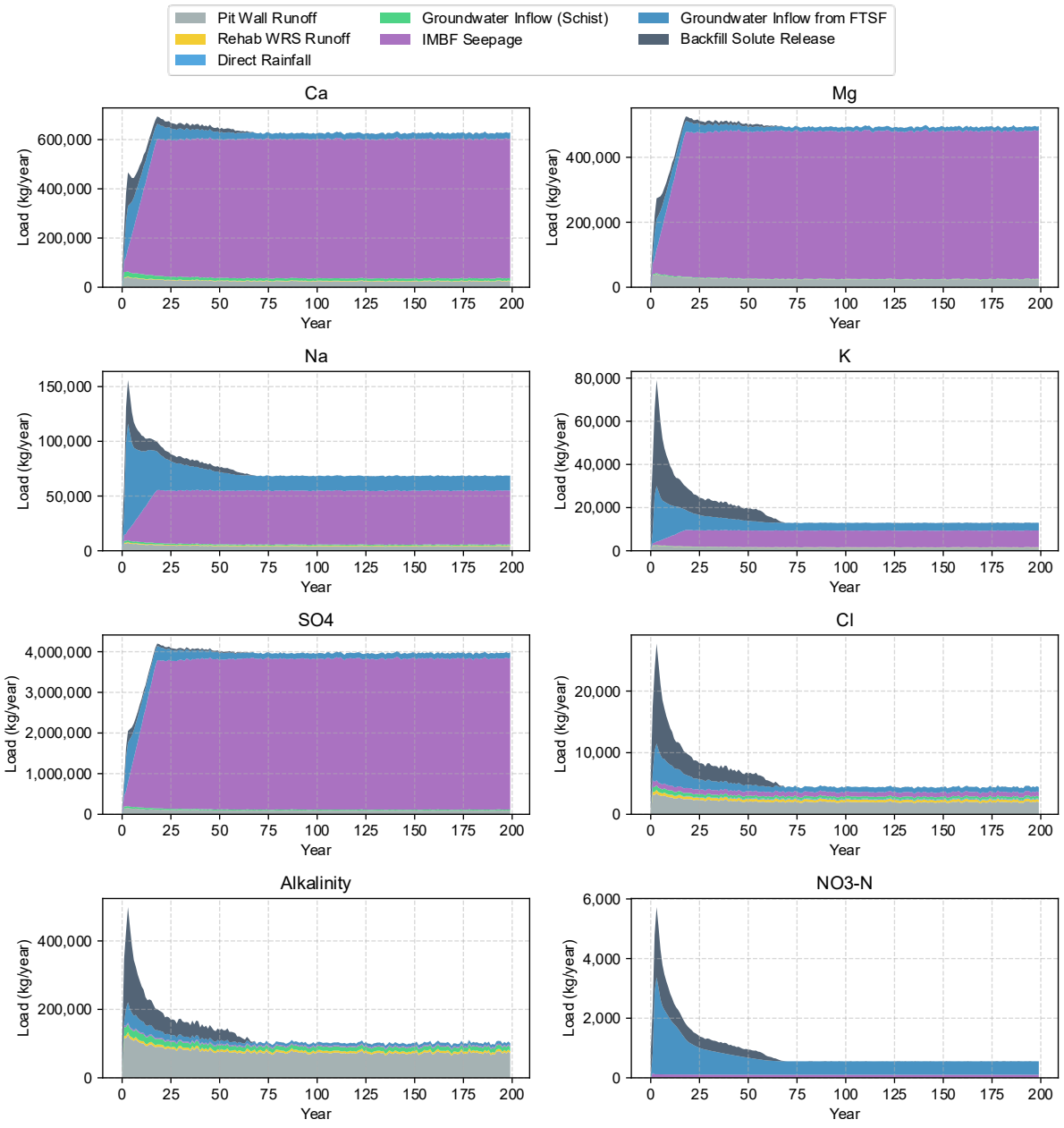

Figure 10: Predicted annual mass loading for Innes Mills Pit Lake by water balance component.

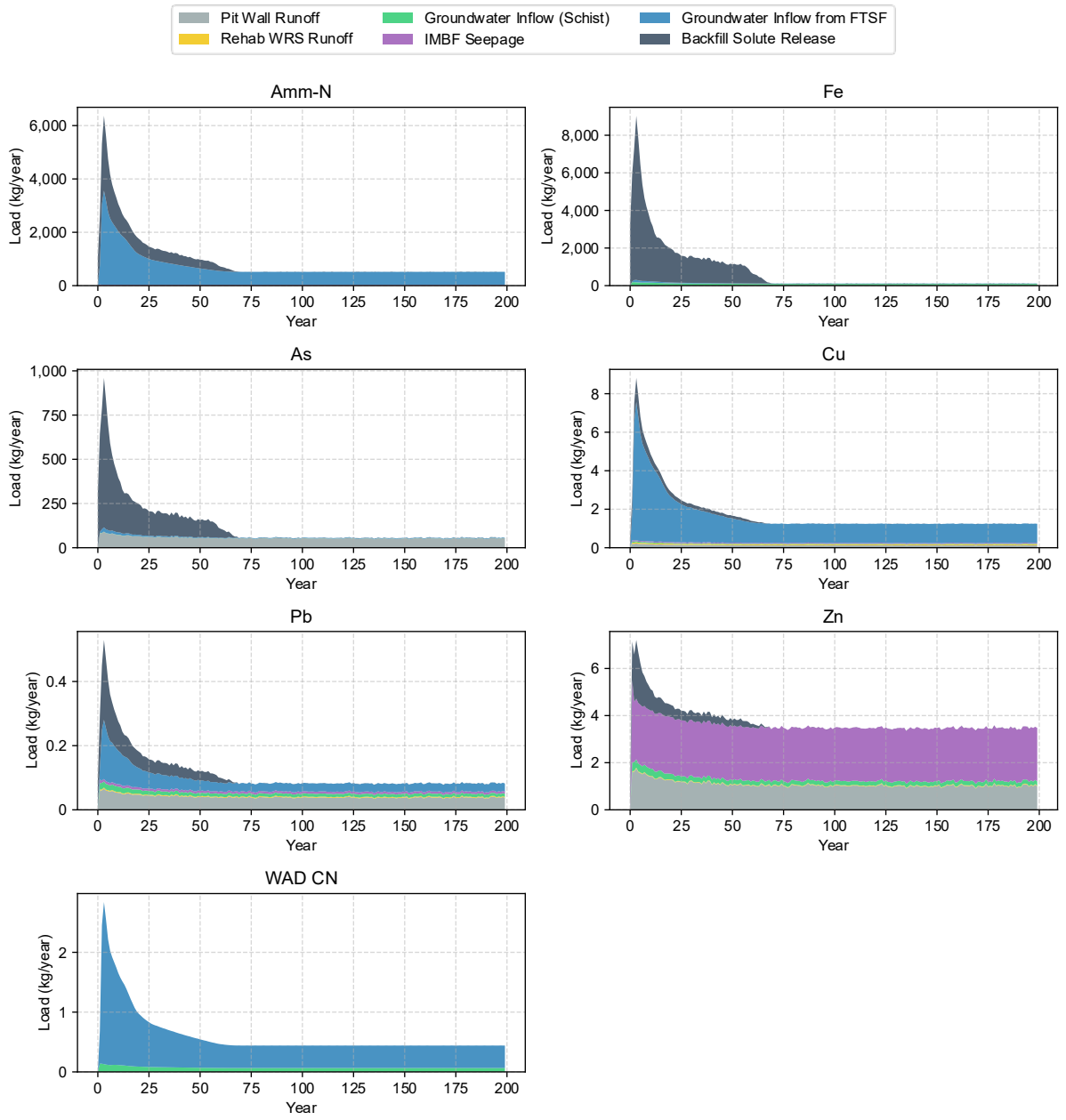

Figure 11: Predicted annual mass loading for Innes Mills Pit Lake by water balance component (continued).

SUMMARY

The long-term water quality of the IM Pit Lake was modelled to assess the geochemical impact of the proposed Project activities post-closure. The modelling results indicate the following:

- The pit lake is predicted to remain circumneutral throughout both the infilling and spilling phases. A stable pH of approximately 7.7 is maintained by sustained acid buffering capacity, with long-term total alkalinity predicted to exceed 170 mg $CaCO_3$/L. The model predicts over 22,000 t of secondary calcite will precipitate over the 200-year modelling period.
- Driven by solute release from the substantial backfill, major ion concentrations during the early filling stage are expected to be elevated compared to other pit lakes modelled for MP4. This

results in a TDS that is predicted to increase to exceed 3,000 mg/L, before gradually declining to approximately 2,400 mg/L by the end of the 200-year modelling period. The long-term hydrogeochemical profile of the pit lake will be dominated by SO_4 (approximately 1,600 mg/L) and Mg (322 mg/L).

- Approximately 298 t of amorphous $Fe(OH)_3$ is predicted to precipitate, providing critical reactive surface areas for the adsorption and sequestration of trace metals and metalloids. Consequently, concentrations of trace metals, such as Pb, will remain consistently low. Arsenic concentrations are predicted to decline from an initial 0.94 mg/L to 0.341 mg/L by Year 56 when overflow commences, before reaching 0.187 mg/L by Year 200. Zinc and Cu concentrations remain low, increasing slightly to 0.009 mg/L and 0.0015 mg/L, respectively, by the end of the simulation.
- Nitrate (NO_3-N) and ammoniacal nitrogen (Amm-N) are predicted to attenuate rapidly from initial concentrations of 6.16 mg/L and 0.909 mg/L, respectively, down to 1.31 mg/L and 0.024 mg/L within the first 20 years, before ultimately stabilising at 0.23 mg/L and 0.003 mg/L.
- WAD CN concentrations remain negligible throughout the simulation at below 0.003 mg/L. Noting that WAD CN concentrations are modelled conservatively (i.e., no degradation with time).
- Mass loading analysis indicates that backfill solute release and groundwater inflow from the FTSF are the dominant drivers for most chemical species during the first 10 to 15 years. Beyond Year 20, IMBF seepage becomes the predominant contributor to the mass loads of major ions and Zn, while the FTSF seepage serves as a minor to moderate loading contributor over the remainer of the modelling period.

Full water quality data are provided as a Microsoft Excel file (Attachment A).

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ATTACHMENT A: INNES MILLS PIT LAKE DIGITAL OUTPUT [MICROSOFT EXCEL FILE]

APPENDIX F ARSENIC REMOVAL BY FERRIC CHLORIDE DOSING

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MEMORANDUM

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Date:	31 August 2026
Cc:	[redacted] – OceanaGold Raimundo Brahm – MWM; Leonardo Navarro – MWM; Eric Chen – MWM
Document Number:	J-NZ0498-018-M-FINAL
Document Title:	Arsenic Removal by Ferric Chloride Dosing of Pit Lakes
Disclaimer:	This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

Mine Waste Management Limited (MWM) has been engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess environmental geochemistry hazards and potential effects for the proposed Macraes Phase Four Project (MP4 or the Project). This assessment supports the application as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

As part of the broader geoenvironmental hazard assessment, this memorandum provides an empirical model for the prediction of arsenic (As) removal from a pit lake via ferric chloride ($FeCl_3$) dosing. The model predicts that optimal dosing results in the effective removal of at least 88% of the As load from a pit lake operating within a pH range of 7 to 9 and with initial As concentrations >0.1 mg/L. Dosing of pit lakes with $FeCl_3$ is part of the suite of adaptive management options available for the Project and may be used to reduce As concentrations prior to pit lakes discharging to receiving waters (e.g., Golden Bar Pit Lake (MWM, 2026)).

OBJECTIVES AND SCOPE OF WORK

The primary objective of this memorandum is to develop an empirical model for MP4 to predict As removal efficiency by $FeCl_3$ dosing, utilising historical operational data from the Reefton Restoration Project (RRP) that is managed by OGNZL.

The scope of work included:

- Undertaking a technical assessment of the RRP datasets related to the removal of As from mine-impacted waters.
- Developing an empirical model for MP4 to quantify As removal efficiency by $FeCl_3$ based on the RRP data.
- Assessing additional geochemical controls on As removal efficiency that are not explicitly captured within the empirical model.

BACKGROUND

The following section provides a technical overview of As removal via adsorption onto ferric hydroxide precipitates that form from $FeCl_3$ addition to pit lakes, Empirical data from the RRP is used, and the processes and learnings are applied to MP4.

Arsenic Sorption

Arsenic removal from solution is primarily driven by surface complexation onto ferric hydroxide precipitates (e.g., ferrihydrite). The efficiency of this process is dependent on As speciation: As(V) (arsenate) typically adsorbs more strongly than the more mobile As(III) (arsenite) (Inam et al., 2021). Additional geochemical controls on the sorption efficiency include pH, redox potential (Eh), competing anions, and the specific surface area of the precipitating iron minerals.

In neutral metalliferous drainage (NMD), which is characteristic of the Project, dissolved iron (Fe) is typically present as ferrous iron (Fe^{2+}) due to the low solubility of Fe^{3+} at circumneutral pH. The oxidation of Fe^{2+} to Fe^{3+} triggers the precipitation of ferric hydroxides (e.g., $Fe(OH)_3$), which removes As from the aqueous phase via surface complexation (adsorption and co-precipitation). In solutions with high dissolved As relative to the available Fe, the external addition of Fe^{3+}, typically via $FeCl_3$ dosing, is required to generate the necessary hydroxide surface area for effective As attenuation.

Reefton Restoration Project

OGNZL implemented pit lake $FeCl_3$ dosing to the Globe-Progress Pit Lake (GPL) at the RRP during the closure of the Globe Progress Mine. Empirical data regarding As removal efficiencies were derived from three RRP studies:

- Vertical flow reactor (VFR) trials (Verum Group and MWM, 2020).
- Mixing trials (OKC, 2018).
- $FeCl_3$ dosing of the GPL (Hayton et al., 2020; MWM, 2022).

Vertical Flow Reactor

VFR trials targeted As removal in NMD waters (pH 6.9 - 9.4) via Fe oxidation and precipitation. These trials treated water with high concentrations of Fe (up to ~50 mg/L) and As (up to ~4 mg/L). Water quality analyses were conducted on the drainage flowing in and out of two reactors: the Under-drain VFR (UVFR) and the Saddle VFR (SDVFR) (Attachment A).

Key calculated values used to quantify As removal efficiency include:

- Fe:As ratio: The mass ratio between precipitated Fe and initial As, calculated as the difference in dissolved Fe before and after treatment divided by the initial dissolved As.
- As removal (%): The percentage of removed As, calculated as the difference in dissolved As before and after treatment relative to the initial dissolved As before treatment.

Mixing Trials

Two sets of mixing trials were performed using the RRP site water:

1. Devils Creek Mixing Trials (DMT): Large-scale (120 L) drum trials where two water samples with differing Fe concentrations were mixed at various proportions. The two water samples were sourced from:
    a. GPL: low dissolved Fe (< 0.02 mg/L).
    b. Devils Waste Rock Drain (RDRN; Verum and MWM, 2020): high dissolved Fe (7.9 mg/L).

    After mixing, the water was left for 24 hours in settling columns prior to sampling. The initial pH ranged between 7.9 and 8.7.
2. Saddle Embankment Mixing Trials (SMT): Small-scale (1 L) laboratory trials, using water sourced from:
    a. Saddle Embankment Seepage Bund (SESB): high dissolved Fe (8.55 mg/L) and As (1.82 mg/L).
    b. Saddle Embankment Chimney Drain (SECD): low dissolved Fe (0.58 mg/L) and As (0.081 mg/L).

    Four mixing trials were performed using a 72:28 mixing proportion and dosed with varying amounts of Fe. Samples were collected at settling intervals of 4 hours and 24 hours.

The Fe:As ratios and As removal (%) for both mixing trials were calculated using the methodology established for the VFR trials (Attachment B).

Pit Lake $FeCl_3$ Dosing

The RRP conducted two major $FeCl_3$ dosing events at the GPL (1st dose and 2nd dose), achieving a cumulative reduction in the As load of approximately 80%. Dosing was necessary due to negligible dissolved Fe concentrations (< 0.02 mg/L) in the lake.

Mass balance calculations, using average As concentrations of the GPL (~0.5 mg/L at the time of the 1st dose) and lake volume, provided estimates of As loads before and after dosing (Table 1). Between these dosing events, the measured pH at different depths ranged from 8.3 to 9.3. During this same period, a “spillway rock mixing” (SR mix) event occurred when a significant volume of waste rock from an infill ramp was pushed from the pit wall into the pit lake. This event triggered further As removal. While the exact geochemical mechanism of this removal is unclear, it is likely attributed to the physical remobilisation of settled ferric hydroxides and the enhanced mixing of the pit lake, facilitating additional As adsorption and potentially adsorption to rock/clay particles.

Table 1: Arsenic removal efficiencies at GPL.

PARAMETER	1ST DOSE	SPILLWAY (SR MIX)	1ST DOSE + SR MIX	2ND DOSE	1ST DOSE + 2ND DOSE	ALL COMBINED
Date (month/year)	06/2018	01/2019		06/2019		
As initial concentration (mg/L)	0.51	0.23	0.51	0.09	0.51	0.51
As initial load (kg)	2,619	1,243	2,619	608	2,619	2,619
Added Fe (kg) [1]	13,303	0	13,303	6,170	19,473	19,473
Fe:As ratio (kg/kg) [1]	5.1	0.0	5.1	10.1	7.4	7.4
As final concentration (mg/L)	0.23	0.09	0.09	0.07	--	0.07
As final load (kg)	1,243	608	608	463	1098	463
As removal (%)	52.5	51.1	76.8	23.8	58.1	82.3

Source: Hayton et al. (2020).

[1] The estimated Fe loads and Fe:As ratios differ from the source document (Hayton et al., 2020) as previous calculations did not account for the increased density of the $FeCl_3$ solution at 40% (~1.4 kg/L).

Figure 1 shows the calculated efficiencies of As removal by adsorption to ferric hydroxide precipitates across all trials. For the VFR and mixing trials, the precipitated amount of Fe mass used in the Fe:As ratio corresponds to the change in dissolved Fe before and after treatment. For the GPL dosing, the precipitated Fe was conservatively assumed to be the total load of Fe added from the $FeCl_3$ dose. For all cases, the As component in the Fe:As ratio corresponds to the As load before treatment.

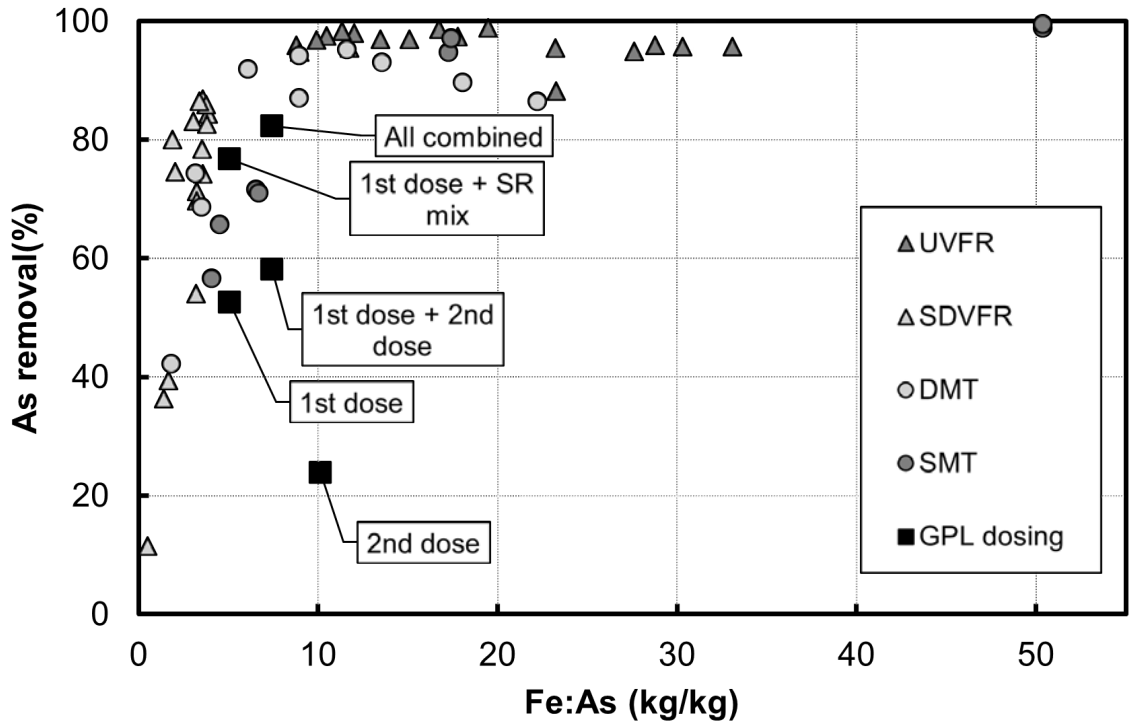

Figure 1: Complete dataset of As removal efficiency from the RRP.

Note: The dataset includes the VFR trials, mixing trials, and pit lake dosing events. The labels indicate the different stages of the GPL dosing (as shown in Table 1).

Comparison with MP4 Water Quality

The Globe Progress mine and the Macraes Operation are mesothermal orogenic gold systems characterised by refractory gold within sulfide minerals and an abundance of carbonate minerals. Consequently, the mine water from both locations shares fundamental geochemical characteristics that drive similar As removal behaviours via adsorption:

- High sulfate (SO_4) concentrations derived from the oxidation and leaching of sulfide minerals.
- Circumneutral to weakly alkaline pH drainage resulting from the neutralisation of sulfide weathering by abundant carbonate minerals.
- Elevated As concentrations leaching from oxidised arsenopyrite.

The empirical model developed in this memorandum is specifically designed to predict the treatment requirements for the Golden Bar Pit Lake. The predicted long-term pH and SO_4 for Golden Bar fall within the range of the RRP dataset, while As concentrations align with the lower values of the RRP range (Table 2). The model can also be applied to other pits at MP4, but data needs to be assessed to confirm applicability.

Table 2: Water quality comparison of selected parameters.

LOCATION	GOLDEN BAR MODEL (MP4) [1]		GLOBE PROGRESS (RRP)		
SOURCE	YEAR 20	YEAR 100	VFR TRIALS	MIXING TRIALS	GPL
pH (pH units)	7.7	7.7	6.9 – 9.4	7.9 – 8.7	8.3 – 9.3 [2]
SO_4 (mg/L)	574	595	110 – 650	220 – 470	150 – 230 [2]
As (mg/L)	0.25	0.24	0.5 – 3.7	0.22 – 1.34	0.28 – 0.73 [3]

[1] *Source: MWM (2026).*

[2] *Measured range from all depths of the lake pit during the dosing period.*

[3] *Measured range from all depths for the year before dosing (dosing occurred at ~0.53 mg/L As when the lake was homogeneous).*

RESULTS

In this section, a regression model for MP4 is defined using the RRP dataset to predict As removal efficiency as a function of Fe^{3+} addition.

Data Filtering

VFR Data

Data clusters of two or more points exist for the VFR trials (Figure 1), representing effectively the same conditions. To prevent regression bias towards these clusters, each cluster was replaced by its arithmetic mean prior to building the model. A total of 25 data points were condensed to define 10 average values (6 for UVFR and 4 for SDVFR), as detailed in Table 3 and Attachment A.

Mixing Trial Data

Arsenic removal (%) from the short settling times (4 hours) in the SMT is consistently lower than the long settling times (24 hours). This indicates that the adsorption process was incomplete at 4 hours; therefore, these data points were excluded from the regression calculations.

Pit Lake Dosing Data

The individual As removal efficiencies for the 1st dose and 2nd doses are lower than the trend defined by the filtered VFR and mixing trial data. During VFR and mixing trials, the water is mixed, facilitating the sorption of As by the ferric hydroxide particles in suspension. The "1st + SR mix" and the "All combined" data points were selected as the most representative of the true As removal capacity of $FeCl_3$ dosing and are the only ones used in the regression model.

Table 3: Filtered dataset used for regression modelling.

DATASET	NAME	Fe:As (kg/kg)	As REMOVAL (%)
UVFR	Average 1	28.90	95.46
	4/03/2019	33.06	95.73
	19/03/2019	23.22	95.42
	Average 2	17.26	97.98
	23/04/2019	19.45	98.83
	Average 3	14.27	96.93
	Average 4	10.18	97.17
	Average 5	11.69	97.20
	Average 6	8.86	95.32
	22/01/2020	23.25	88.21
SDVFR	Average 7	1.52	37.86
	13/12/2018	0.50	11.54
	Average 8	3.58	84.89
	Average 9	3.57	76.34
	22/01/2020	2.03	74.57
	10/02/2020	3.19	54.09
	Average 10	3.25	70.47
DMT	Trial 1	22.23	86.36
	Trial 2	8.96	94.12
	Trial 3	18.09	89.57
	Trial 4	6.11	91.85
	Trial 5	13.58	93.00
	Trial 6	3.21	74.29
	Trial 7	11.64	95.08
	Trial 8	1.86	42.14
	Trial 9	8.96	86.92
	Trial 10	3.54	68.57
SMT	Control long	4.56	65.60
	10:1 long	6.74	70.90
	20:1 long	17.45	97.02
	50:1 long	50.42	99.48
GPL dosing	All combined	7.44	82.32
	1st + SR mix	5.08	76.79

Model Definition

The filtered dataset (Table 3) indicates that the As removal efficiency from $FeCl_3$ dosing aligns with the efficiencies observed during the oxidation of NMD (VFR and mixing trials). Consequently, these data

for As removal by oxidation of Fe can be used to predict the effectiveness of $FeCl_3$ dosing in solutions with similar pH and As concentrations.

The correlation between the Fe:As ratio and As removal (%) follows the exponential saturation function:

Equation 1: $$y = a \cdot \left(1 - e^{-k(x-x_0)}\right)$$

This function responds with a steep increase in y (As removal (%)) at small x values (Fe:As) and flattens progressively as it approaches the asymptote defined by a. The parameter a represents the theoretical maximum As removal possible (≤ 100%). The parameter k controls the shape of the curve, with high k values resulting on a steeper initial increase and faster flattening of the curve. The parameter x_0 defines the horizontal offset of the curve. This value is expected to be near 0, as there should be no As adsorption in the absence of ferric hydroxide precipitation.

A regression curve was calculated using Equation 1 to determine the best fit for parameters a, k, and x_0, using the filtered dataset. Figure 2 shows the resulting curve. In addition, a "conservative model" was defined using the three data points that define the lowest efficiency curve.

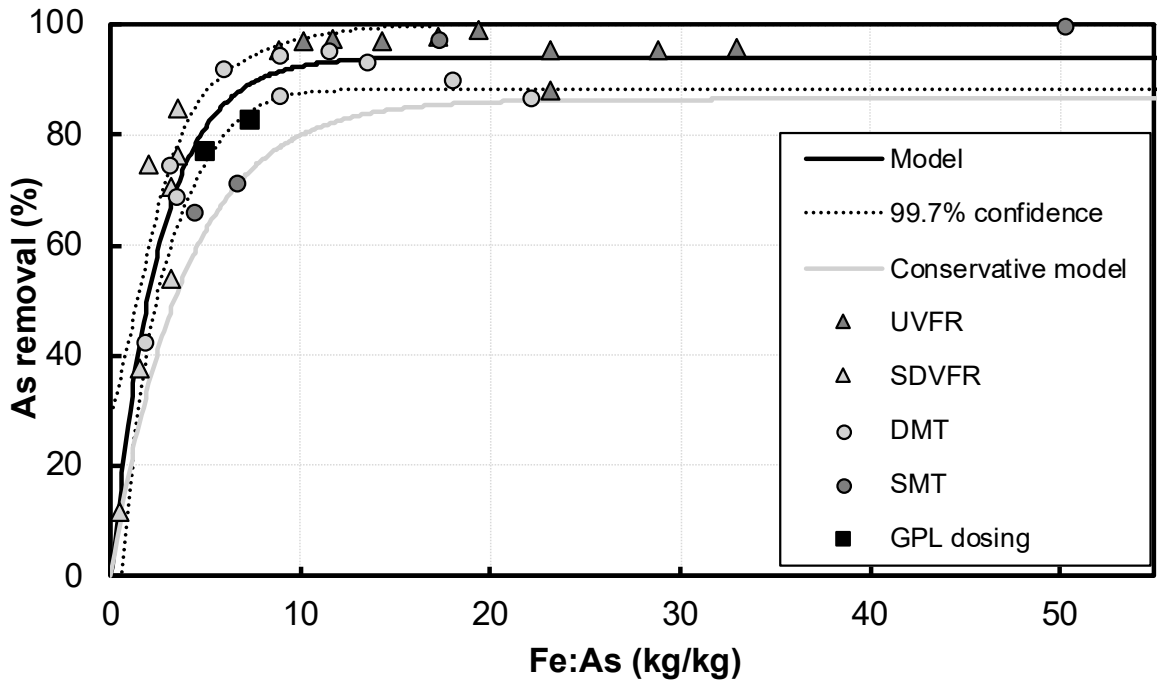

Figure 2: Empirical model of As removal efficiency.

The parameters of both models shown in Figure 2 and the parameter uncertainty measures (standard deviations, correlation coefficients, and covariance matrix) are provided in Table 4.

Table 4: Parameters of regression models (Equation 1).

	MODEL				CONSERVATIVE MODEL
Parameter	Value	Std. dev.	Correlation coeff.	Covariance matrix	Value
a	94.08	1.99	$\rho(a,k)$ = -0.535	$\begin{bmatrix} 3.963 & -0.061 & -0.113 \\ -0.061 & 0.003 & 0.012 \\ -0.113 & 0.012 & 0.067 \end{bmatrix}$	86.43
k	0.4057	0.0571	$\rho(k,x_0)$ = 0.778		0.2586
x_0	0.06	0.26	$\rho(a,x_0)$ = -0.219		0.00

Detailed guidelines for implementing this model for pit lake dosing are provided in Attachment C. A dosing calculator is also included as a digital file (Attachment D). The following comments are provided:

- The model indicates that optimal dosage (the minimum dosage required to reach maximum removal) occurs at an approximate Fe:As ratio of 10, resulting in a minimum As removal of ~88% (at a confidence level of 99.7%).
- The conservative model reaches its maximum removal (~86%) at a higher dosage (Fe:As of ~20 kg/kg).
- This model can also predict the As removal potential during oxidation of high-Fe NMD. The dissolved Fe load can be defined as equivalent to the Fe^{3+} added from dosage.

DISCUSSION

This section discusses physical and geochemical parameters that affect the efficiency of As removal.

Mixing Efficiency and Particle Residence Time

The VFR and mixing trial datasets are derived from small-scale, well-mixed scenarios; therefore, the model does not inherently account for the hydraulic limitations encountered in larger water bodies.

To facilitate distribution during the GPL dosing, the $FeCl_3$ solution was discharged into runoff streams during heavy rain that drained into the pit lake While multi-point sampling confirmed that these inflows provided excellent initial mixing throughout the pit lake, the initial efficiency of the 1st dose remained below the modelled values. Performance only reached expected ranges following the physical remobilisation of the water and precipitate mass.

This suggests that simple mixing may be insufficient to promote adequate As removal. Increasing the residence time of ferric hydroxide precipitates in the water column before settling to the bottom of the pit lake may improve As treatment performance. This could include agitation and aeration of the pit lake (sprinklers, bubble diffusers, etc.) and remobilisation of the precipitated ferric hydroxide precipitate.

Impact of Initial As Concentration

VFR trials of RDRN at RRP (Hayton, 2020; not included in this empirical model) showed consistently lower As removal efficiencies compared to the UVFR trials, despite the Fe:As ratios of the VFR trials falling within the ideal range for maximum As removal (> 11 kg/kg; Figure 3).

The main difference between the trials were the initial As concentrations. The middle plot of Figure 3 shows a positive correlation between the initial As concentration and its maximum removal efficiency. Some samples with an initial As concentration < 0.11 mg/L show lower As removal efficiencies than predicted by the model. However, this decrease in efficiency does not mean the treatment failed to lower the absolute concentrations. As shown in the bottom plot of Figure 3, all samples with an initial As concentration < 0.5 mg/L achieved a final As concentration < 0.04 mg/L.

To incorporate this observation into the model, a conservative prediction has been defined: the model applies a fixed final concentration of 0.04 mg/L for any solution with an initial As concentration < 0.11 mg/L, when treated at an Fe:As ratio > 10 kg/kg.

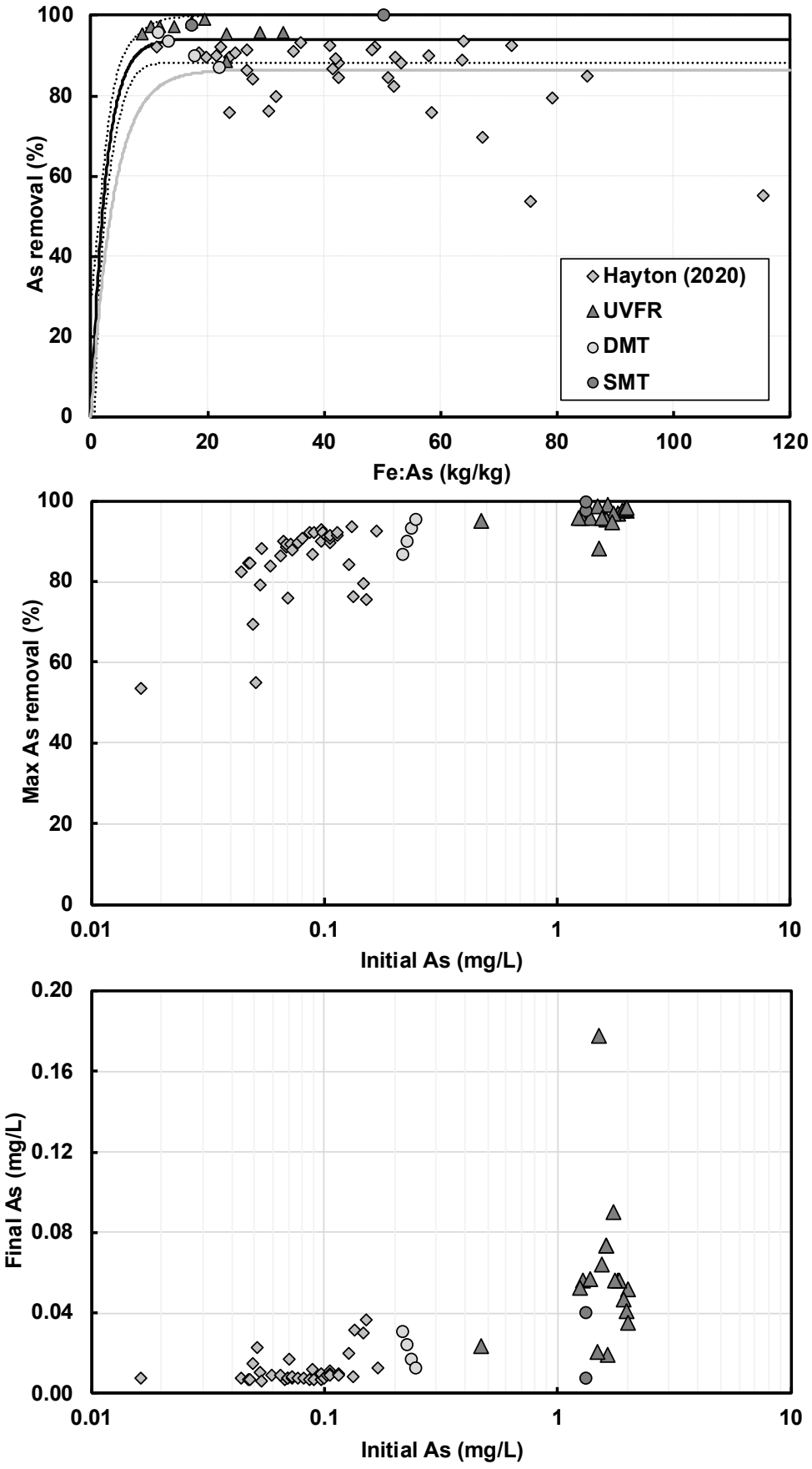

Figure 3: Comparison of VFR trials from Hayton (2020), and VFR and mixing trials used in the model.

Arsenic Speciation and pH

Experimental data of As adsorption (Inam et al., 2021) shows the influence of pH on the adsorption efficiency of both As species (As(III) and As(V)) (Figure 4). At an Fe:As ratio of ~5.5 kg/kg, optimal removal occurs at pH 6-7 for As(V) (~99%) and at pH ~8 for As(III) (~80%). The effect of As(V) removal at pH >7 cannot be derived from these experiments as ferric hydroxide precipitation was inhibited, resulting in low Fe:As ratios.

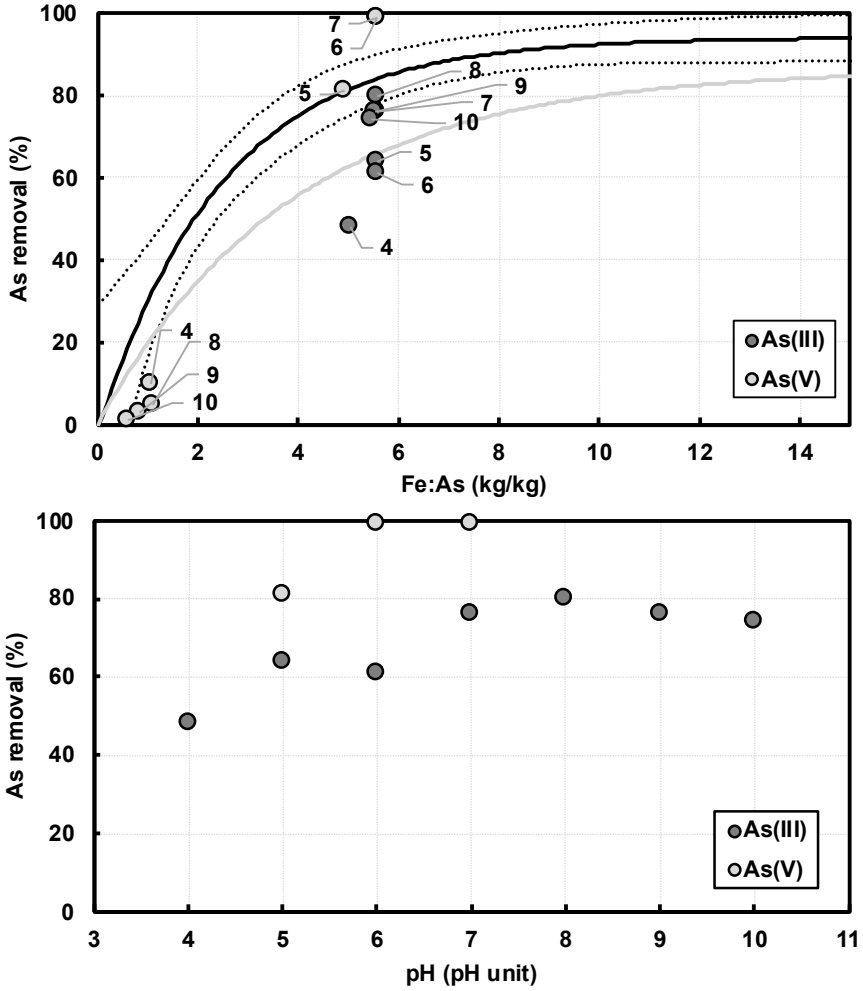

Figure 4: Effect of pH and Fe: As ratio on As adsorption efficiency.

Source: Inam et al. (2021). Experimental conditions: Initial As = 1 mg/L, Temp = 25 °C
Top plot: Data labels are pH values of the experiments.
Bottom plot: Only experiments with Fe:As ≥ ~5 kg/kg

Because the model predicts further increases in As removal (%) at higher Fe:As ratios, optimal As adsorption is expected to reach ~100% for As(V) and >80% for As(III) within the pH 7-8 range. Consequently, the maximum As removal efficiency in the model at this pH range (defined by parameter a in Equation 1) is intrinsically linked to the relative proportions of As(V) and As(III).

While As speciation data at RRP is limited (Verum and MWM, 2020; Hayton, 2020), the following is noted:

- Arsenic in seepage water before VFR treatment is predominantly As(III), though the degree of subsequent oxidation during treatment remains unknown.

- Arsenic in the GPL is expected to be predominantly As(V), provided the pit lake does not become sub-oxic.

The Devils Creek Mixing Trials (DMT) provide further insight into the effect of As speciation, which was assessed for the study (Figure 1 and Attachment B):

- After reaching a maximum As removal of ~95% in Trial 4, there is a steady decrease toward ~86% in Trial 1 as the Fe:As ratio increases (within a pH range of 7.9 to 8.3).
- Assuming the seepage water endmember from Devils Waste Rock Drain is 100% As(III) and the GPL endmember is 100% As(V) (Verum and MWM, 2020; Hayton, 2020), and that no extra As oxidation occurred during the trials, a correlation between As speciation and maximum As removal (%) can be derived (Figure 5).
- This correlation can be extended to the optimal values for the As(III) and As(V) endmembers from the experimental work of Inam et al. (2021).
- The relationship is likely described by a sigmoidal curve, though further studies are required to confirm this behaviour.

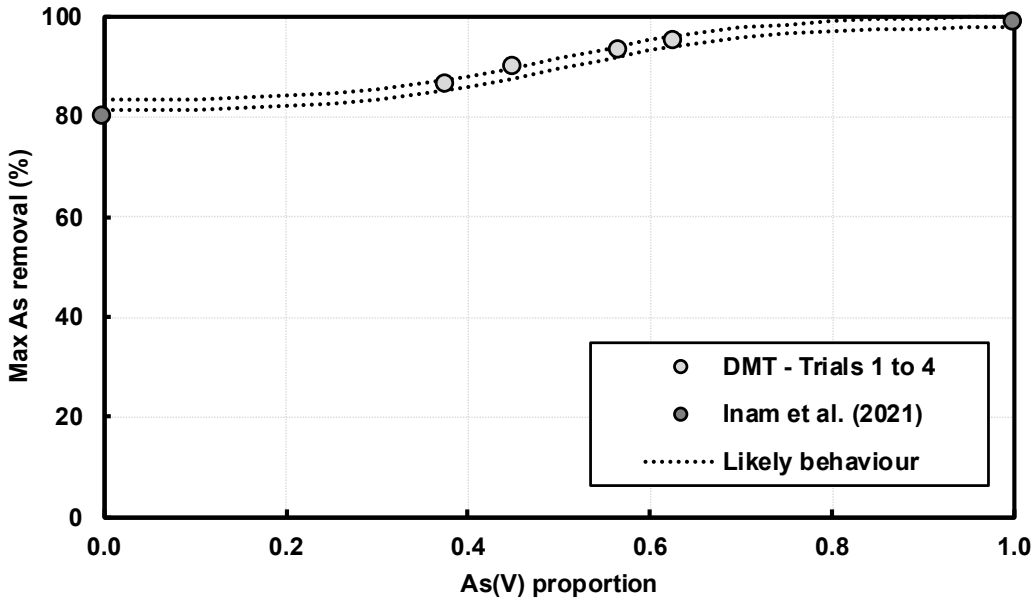

Figure 5: Correlation of As speciation with maximum As removal from the data.

As(V) proportion = As(V) / (As(V) + As(III))

This correlation could be mathematically implemented by defining parameter α (from Equation 1) as a function of As speciation at pH 7–8. This refinement would be useful if the As speciation of the target solution is known (e.g., Golden Bar Pit Lake). In the current model, these As speciation effects could be approximated by using different percentiles depending on As speciation (e.g., ~5% confidence for 100% As(V) and ~99% confidence for 60% As(V)).

GPL Dosing

The As removal efficiency of the 2nd dose at GPL was lower than the 1st dose, achieving only 24% removal (final concentration of 0.07 mg/ L As; Table 1). The lower performance of this dose was likely due to the combined effects of three factors:

- The low initial As concentration (0.09 mg/L) reduced the thermodynamic driving force of adsorption compared to the 1st dose.
- It is expected that the 1st dose and the spillway rock mixing event preferentially removed As(V), leaving the residual load enriched in the more mobile, less efficiently adsorbed As(III) species.
- Unlike small-scale, well-mixed trials, the larger volume of the pit lake limited reagent dispersion and reduced the residence time of the ferric hydroxide precipitates in suspension.

ASSUMPTIONS

The following was assumed in the development of the empirical model:

- The model is based on empirical data from a single site (the former Globe Progress Mine) and calibrates the dependency of As removal on the Fe:As ratio. The influence of other geochemical properties (e.g., pH, temperature, ionic strength, As speciation) may create some variance in model reults.
- The model assumes the inclusion of a management process that promotes active mixing in the pit lake to encourage oxidising conditions and increase the residence time of ferric hydroxide precipitates in suspension.
- Based on the available data, low initial As concentrations (< 0.1 mg/L) can affect removal efficiencies, but are expected to produce final As concentrations of < 0.04 mg/L.
- The model is intended for application to analogous water types (pH 6.5-9.5, As concentrations of ~0.1 mg/L to ~4.0 mg/L). The water quality model for the Golden Bar Pit Lake predicts a steady pH of ~7.7 and As concentration of ~0.24 mg/L from Year 20 (MWM, 2026).

RECOMMENDATIONS

Overall geochemical review and empirical data indicate that pit lake dosing using $FeCl_3$ is an effective method for removing As. To ensure success at MP4, the following actions are recommended:

- Complete bench-scale trials prior to full-scale dosing to confirm site-specific Fe:As ratios.
- Undertake $FeCl_3$ dosing incrementally to promote efficient As adsorption and to identify the specific geochemical response of the pit lake relative to the model predictions. These trials should be undertaken on the Golden Bar Pit Lake prior to dewatering to confirm the methodology works under field conditions.
- Implement a management process that promotes active mixing in the pit lake to encourage oxidising conditions and increase the particle residence time.

CLOSING REMARKS

Please do not hesitate to contact Paul Weber at [redacted] or [redacted] should you wish to discuss this memorandum in greater detail.

Attachments:
Attachment A – VFR Trial Dataset
Attachment B – Mixing Trial Dataset
Attachment C – Model Implementation
Attachment D – Microsoft Digital File – Treatment Algorithm

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ATTACHMENT A – VFR TRIAL DATASET

Table A1: UVFR trial data.

	INITIAL DISSOLVED CONCENTRATIONS			FINAL SOLUTION PROPERTIES AND DISSOLVED CONCENTRATIONS						REMOVAL EFFICIENCIES	
Trial	As (mg/L)	Fe (mg/L)	SO_4 (mg/L)	pH	EC (µS/cm)	DO (%)	As (mg/L)	Fe (mg/L)	SO_4 (mg/L)	Fe:As (kg/kg)	As removal (%)
8/01/2019 [1]	0.47	13	420	7.83	1,415	41.3	0.02	0.02	420	27.62	94.89
11/02/2019 [1]	1.28	41		7.54	1,303	33.5	0.06	2.20	380	30.31	95.63
18/02/2019 [1]	1.38	43	350	7.61	1,298	41.3	0.06	3.30	370	28.77	95.87
4/03/2019	1.24	48	360	7.76	1,279	34.8	0.05	7.00	360	33.06	95.73
19/03/2019	1.62	44		7.57	1,330	31.6	0.07	6.00	400	23.22	95.42
3/04/2019 [2]	1.99	39	390				0.05	3.60	440	17.79	97.39
23/04/2019	1.64	34	460	7.53	1,362	60.8	0.02	2.10	460	19.45	98.83
6/05/2019 [3]	1.82	29	460	7.57	1,370	61.2	0.06	4.50	450	13.46	96.92
21/05/2019 [3]	1.83	31	420				0.06	3.40	440	15.08	96.94
5/06/2019 [4]	1.91	23	480	7.85	1,385	46.6	0.05	3.00	440	10.47	97.54
17/06/2019 [5]	1.97	25	650	7.78	1,393	46.3	0.04	1.37	690	11.99	97.92
2/07/2019 [2]	1.48	26	450				0.02	1.25	450	16.72	98.58
23/07/2019 [5]	2.00	24	400	8.44	1,276	52.6	0.04	1.33	400	11.34	98.25
20/08/2019 [4]	1.75	19	380	8.01	1,262	44.7	0.06	1.79	390	9.89	96.80
11/09/2019 [5]	1.62	24	360	8.89	1,240	46.0	0.07	5.00	360	11.73	95.43
17/10/2019 [6]	1.55	21	340				0.06	7.40	340	8.77	95.87
18/11/2019 [6]	1.72	23	330	6.91	1,161	55.6	0.09	7.60	330	8.95	94.77
22/01/2020	1.51	41	270	8.13	1,120	37.4	0.18	5.90	280	23.25	88.21

SO_4 = sulfate, EC = electrical conductivity, DO = dissolved oxygen.

Source: Verum Group and MWM (2020).

Note: Numbered superscripts indicate data point is part of the cluster replace by the respective average value.

Table A2: SDVFR trial data.

	INITIAL DISSOLVED CONCENTRATIONS			FINAL SOLUTION PROPERTIES AND DISSOLVED CONCENTRATIONS						REMOVAL EFFICIENCIES	
Trial	As (mg/L)	Fe (mg/L)	SO_4 (mg/L)	pH	EC (µS/cm)	DO (%)	As (mg/L)	Fe (mg/L)	SO_4 (mg/L)	Fe:As (kg/kg)	As removal (%)
24/10/2018 [7]	3.10	12.0	122	8.11	876	12.9	1.88	6.90	122	1.65	39.35
23/11/2018 [7]	3.30	13.2	118	8.13	872	18.0	2.10	8.60	119	1.39	36.36
13/12/2018	2.60	10.7	119	8.01	881	15.1	2.30	9.40	118	0.50	11.54
8/01/2019 [8]	3.20	12.9	120	8.12	853	19.0	0.42	1.44	121	3.58	86.88
15/02/2019 [8]	3.20	12.0	113	8.57	853	12.0	0.54	2.20	108	3.06	83.13
12/03/2019	3.70	8.6	153				0.74	1.64	150	1.88	80.00
16/05/2019 [8]	3.00	13.2	121	7.95	863	23.3	0.47	1.57	116	3.88	84.33
11/06/2019 [8]	2.70	12.2	127	8.36	869	25.5	0.47	1.95	128	3.80	82.59
23/07/2019 [8]	3.20	13.7	130	7.84	878	22.7	0.45	1.68	133	3.76	85.94
20/08/2019 [8]	3.10	12.2	138	7.83	871	32.0	0.42	1.66	139	3.40	86.45
11/09/2019 [9]	0.56	2.4	128	8.10	870	25.1	0.14	0.39	131	3.59	74.29
18/11/2019 [9]	3.10	14.5	133	7.17	862	32.8	0.67	3.50	134	3.55	78.39
22/01/2020	3.50	9.2	155	8.30	869	42.0	0.89	2.10	154	2.03	74.57
10/02/2020	1.59	7.0	119	8.06	849	34.4	0.73	1.92	119	3.19	54.09
5/03/2020 [10]	3.20	13.2	124	9.35	857	19.0	0.92	2.80	125	3.25	71.25
10/06/2020 [10]	3.30	14.2	119	8.33	855	21.0	1.00	3.50	121	3.24	69.70

SO_4 = sulfate, EC = electrical conductivity, DO = dissolved oxygen.

Source: Verum Group and MWM (2020).

Note: Numbered superscripts indicate data point is part of the cluster replace by the respective average value.

ATTACHMENT B – MIXING TRIAL DATASET

Table B1: Devils Creek mixing trials results.

	INITIAL DISSOLVED CONCENTRATIONS			FINAL SOLUTION PROPERTIES AND DISSOLVED CONCENTRATIONS						REMOVAL EFFICIENCIES	
Trial	As (mg/L)	Fe (mg/L)	SO_4 (mg/L)	pH	EC (µS/cm)	DO (%)	As (mg/L)	Fe (mg/L)	SO_4 (mg/L)	Fe:As (kg/kg)	As removal (%)
Trial 1 (75L RDRN, 45L GPL)	0.22	4.92	465	7.87	1,450	81.0	0.030	0.03	470	22.23	86.36
Trial 5 (36L RDRN, 84L GPL)	0.26	2.35	323	8.27	1,146	90.6	0.015	0.02	340	8.96	94.12
Trail 2 (66L RDRN, 54L GPL)	0.23	4.23	439	8.09	1,384	81.4	0.024	0.07	460	18.09	89.57
Trial 6 (26L RDRN, 94L GPL)	0.27	1.67	290	8.18	1,078	92.9	0.022	0.02	290	6.11	91.85
Trail 3 (52L RDRN, 68L GPL)	0.24	3.32	375	7.96	1,281	81.0	0.017	0.06	420	13.58	93.00
Trial 7 (15L RDRN, 105L GPL)	0.28	0.96	246	8.28	968	94.2	0.072	0.06	240	3.21	74.29
Trial 4 (45L RDRN, 75L GPL)	0.25	2.94	354	8.26	1,221	83.8	0.012	0.03	340	11.64	95.08
Trial 8 (8L RDRN, 112L GPL)	0.28	0.54	222	8.49	907	95.8	0.162	0.02	240	1.86	42.14
Trial 9 (36L RDRN, 84L GPL)	0.26	2.35	318	8.58	1,135	94.0	0.034	0.02	300	8.96	86.92
Trial 10 (15L RDRN, 105L GPL)	0.28	1.01	246	8.65	967	93.8	0.088	0.02	250	3.54	68.57

SO_4 = sulfate, EC = electrical conductivity, DO = dissolved oxygen.

Table B2: Saddle Embankment trials results.

		INITIAL DISSOLVED CONCENTRATIONS		FINAL DISSOLVED CONCENTRATIONS		REMOVAL EFFICIENCIES	
Trial	Settling time	As (mg/L)	Fe (mg/L)	As (mg/L)	Fe (mg/L)	Fe:As (kg/kg)	As removal (%)
Control short	4 hr	1.34	6.35	0.58	0.87	4.09	56.57
10:1 short	4 hr	1.34	9.35	0.38	0.54	6.57	71.49
20:1 short	4 hr	1.34	23.95	0.07	0.75	17.31	94.63
50:1 short	4 hr	1.34	67.75	0.02	0.23	50.39	98.73
Control long	24 hr	1.34	6.35	0.46	0.24	4.56	65.60
10:1 long	24 hr	1.34	9.35	0.39	0.32	6.74	70.90
20:1 long	24 hr	1.34	23.95	0.04	0.56	17.45	97.02
50:1 long	24 hr	1.34	67.75	0.01	0.19	50.42	99.48

Source: OKC (2018).

ATTACHMENT C – MODEL IMPLEMENTATION

Ferric Chloride Dosing Estimation

Initial Fe and As Loads

Pit lakes are often stratified. To calculate the total As load (L^i_{As}), multiple measurements taken at different depths must be integrated with their respective water volumes. If the pit lake is vertically homogeneous, or if an average As concentration (C^i_{As}) has already been estimated, the total As load can be calculated as:

Equation C1: $$L^i_{As}\,[kg] = V_{pit}\,[m^3] \cdot C^i_{As}\,\left[\frac{g}{m^3}\right] \cdot 0.001\,\left[\frac{kg}{g}\right]$$

Where V_{pit} is the total volume of the pit lake. The initial load of Fe (L^i_{Fe}) is approximated as the total mass of Fe added via the $FeCl_3$ dose. The concentration of commercial $FeCl_3$ solutions (C_{FeCl_3}) is usually 40% (by weight) and has a density (ρ_{FeCl_3}) of ~1.4 kg/L at 25°C. The Fe load is calculated as:

Equation C2: $$L^i_{Fe}[kg] = V_{FeCl_3}[m^3] \cdot \rho_{FeCl_3}\left[\frac{kg}{L}\right] \cdot 1000\left[\frac{L}{m^3}\right] \cdot \frac{C_{FeCl_3}\,[\%]}{100\,[\%]} \cdot \frac{MW_{Fe}\left[\frac{g}{mol}\right]}{MW_{Fe}\left[\frac{g}{mol}\right] + 3 \cdot MW_{Cl}\left[\frac{g}{mol}\right]}$$

Where V_{FeCl_3} is the total volume of $FeCl_3$ solution used in the dosing process, and MW_{Fe} and MW_{Cl} are the molar weights of Fe (55.85 g/mol) and Cl (35.45 g/mol), respectively. The resulting dosing ratio can be calculated using both loads:

Equation C3: $$Fe{:}\,As = \frac{L^i_{Fe}\,[kg]}{L^i_{As}\,[kg]}$$

Regression Model

The Fe:As ratio can be used to calculate the estimated As removal (%) using the models defined in this document. To obtain an acceptable conservative estimate, the lower band of a chosen confidence interval can be used. Alternatively, the “conservative model” can also be used.

To obtain a conservative estimate from a confidence interval, the base As removal (%) (y in the model equation) is first calculated using Equation 1 and the fitted parameters from Table 4. Then, the partial derivatives of Equation 1 with respect to the three parameters are calculated:

Equation C4: $$\frac{dy}{da} = 1 - e^{-k(x-x_0)}$$

Equation C5: $$\frac{dy}{dk} = a \cdot (x - x_0) \cdot e^{-k(x-x_0)}$$

Equation C6: $$\frac{dy}{dx_0} = -a \cdot k \cdot e^{-k(x-x_0)}$$

Using these derivatives and the covariance matrix from Table 4, the residual variance is calculated using:

Equation C7: $$\sigma^2 = \sum_{i=1}^{n=3}\sum_{j=1}^{n=3} Cov(i,j) \cdot \frac{dy}{dp_i} \cdot \frac{dy}{dp_j}$$

Where σ is the standard deviation, and the derivatives $\frac{dy}{dp_1}$, $\frac{dy}{dp_2}$, and $\frac{dy}{dp_3}$ correspond to $\frac{dy}{da}$, $\frac{dy}{dk}$, and $\frac{dy}{dx_0}$, respectively. The lower band of the chosen confidence interval ($\bar{y_{\%conf}}$) is given by:

Equation C8: $$\bar{y_{\%conf}} = y - \Delta y_{\%conf} = y - F \cdot \sigma$$

Equation C9: $$F = \Phi^{-1}\left(\left(1 + \frac{\%conf}{100}\right)/2\right)$$

Where is the confidence interval as a percentage (e.g., 95% confidence), F is the multiplier factor applied to σ, and Φ^{-1} is the inverse of the standard normal cumulative distribution function. Example confidence intervals and their respective F factors are shown in Table C1.

Table C1: Example of equivalent F factors for different confidence intervals.

CONFIDENCE INTERVALS (%)	F FACTOR
99.73	3.00
95.45	2.00
95.00	1.96
90.00	1.64
68.27	1.00

Alternatively, the conservative model can be applied simply using Equation 1 and the parameters from Table 4.

Final As Load and Concentration

The value of $y_{\%conf}^{-}$ corresponds to the estimated As removal (%) (As_{rem}). This value is used in Equations C10 and C11 to estimate the final As mass load (L_{As}^{f}) and the final pit lake concentration (C_{As}^{f}):

Equation C10: $$L_{As}^{f}\,[kg] = L_{As}^{i}\,[kg] \cdot \left(1 - \frac{As_{rem}\,[\%]}{100\,[\%]}\right)$$

Equation C11: $$C_{As}^{f}\,\left[\frac{g}{m^3}\right] = \frac{L_{As}^{f}\,[kg] \cdot 1000\left[\frac{g}{kg}\right]}{V_{pit}\,[m^3] + V_{FeCl_3}\,[m^3]}$$

Because $V_{pit} \gg V_{FeCl_3}$, the added volume of the dosing solution (V_{FeCl_3}) can generally be neglected, allowing the total volume in the denominator to be approximated simply as V_{pit}.

ATTACHMENT D – MICROSOFT DIGITAL FILE – TREATMENT ALGORITHM

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