Graphinex – Esmeralda Graphite Project

Environmental Impact Statement

Appendix V – Pit Void Water Quality Modelling

GRAPHINEX

TECHNICAL REPORT

Pit void water quality modelling

Graphinex Esmeralda Project

Prepared for: Graphinex Pty Ltd

MINE WASTE AND
WATER MANAGEMENT

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TECHNICAL REPORT

Pit void water quality modelling

Graphinex Esmeralda Project

Prepared for: Graphinex Pty Ltd

DOCUMENT CONTROL	
Document Number	**R01**
Project Number	**2025096**
File Location	**Z:\004_Projects\Projects 2025\2025096 (Graphinex Tailings Backfill Model)\Reporting**

DOCUMENT DISTRIBUTION			
Document Name	**Revision**	**Distributed to**	**Date distributed**
R01_2025096__Pit void water quality modelling_Rev 2_01102026	**Rev 2**	**Graphinex Pty Ltd**	**1.10.2026**

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Glossary of terms and acronyms

Acidity	A measurement of the amount of acidity in a water sample generally derived using a titration method to a set pH value (in units of mg/L $CaCO_3$ equivalent).
Alkalinity	A measurement of the amount of alkalinity in a water sample generally derived using a titration method to a set pH value (in units of mg/L $CaCO_3$ equivalent).
ABA	Acid Base Account. Evaluation of the balance between acid generation and acid neutralisation processes. Determines the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below.
AHD	Australian Height Datum used for altitude measurement in Australia.
AMD	Acid and metalliferous drainage from mine waste materials characterised by low pH, elevated metal concentrations, high sulfate concentrations and high salinity.
ANC	Acid Neutralising Capacity expressed as kg H_2SO_4 per tonne of sample. A measure of a sample's maximum potential ability to neutralise acid.
ANC:MPA	The ratio of the acid neutralising capacity to the maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
EC	Electrical Conductivity, expressed as µS/cm.
KLC	Kinetic Leach Column. Leaching setup that generates time-dependent data on the kinetics and rate of acid generation and acid neutralising reactions under laboratory controlled (or onsite conditions)
LoR	Limit of Reporting. Laboratory detection limit for the reporting of results for a particular geochemical test.
MPA	Maximum Potential Acidity. Calculated by multiplying the total sulfur or sulfide-sulfur (CRS) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acid conditions.
NAPP	Net Acid Producing Potential, expressed as kg H_2SO_4 per tonne. Calculated by subtracting the ANC from the MPA.
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
pH	A measure of hydrogen ion (H^+) concentration.
S	Sulfur.
SO_4^{2-}	Sulfate.
Static test	Procedure for characterising the geochemical nature of a sample at a single point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
TS	Total sulfur content of a sample generally measured using a 'LECO' analyser expressed as total sulfur%.
w:v	Weight to volume ratio.

1 Introduction

RGS Environmental Consultants Pty Ltd (RGS) was commissioned by AARC Environmental Solutions Pty Ltd (AARC) on behalf of Graphinex Pty Ltd (Graphinex) to develop a conceptual hydrogeochemical (water balance/water quality) model for the post closure backfilled pit for the Esmeralda graphite mining project.

This technical report presents the results of the hydrogeochemical modelling.

1.1 Background

The Esmeralda Project is a proposed open cut graphite mine, located on light grazing land approximately 70 km south of Croydon, Queensland, Australia. The Project proposes mining of the Esmeralda Granite unit and on-site concentration of graphite ore. The Project will mine up to 3.5 million tonnes per annum (Mtpa) of Run-of-Mine (ROM) ore over a mine life of approximately 53 years.

Graphinex is engaged in baseline environmental studies that are required for future impact assessment studies and Project approval. An option being considered is backfill of the open pit on mine closure. Material from above ground tailings cells will be backfilled first, followed by waste rock to reach the ground surface.

Once groundwater has saturated the backfill and reached its steady-state post-closure level, there may be groundwater quality impacts associated with solute mobilisation from the backfill. These potential groundwater quality impacts may affect receptors downstream of the pit.

1.2 Objectives

The key objectives of this study are:

- Use predictive modelling to provide an initial estimate of long-term water chemistry of water in the void.
- Considering the groundwater model findings, address potential for lateral movement of void water.
- Address the environmental risk and key environmental receivers associated with water in the backfilled void post-mining.

This assessment represents a pre-feasibility level evaluation. That is, it provides a first-order estimate of backfilled void seepage volumes and water quality based on limited site-specific data, using conservative assumptions and simplified conceptual models rather than detailed, fully parameterised simulations.

1.3 Scope of work

To achieve the objectives outlined in the previous section, RGS conducted the following scope of work:

- Information review. RGS conducted a review of available information relevant to the work, including the proposed volumes of backfill material and post-closure groundwater system. The outcomes of the review were used throughout this report and are documented in **Attachment A**.
- Develop hydrogeochemical model. To estimate pore water volumes and chemistry in the backfilled Esmeralda pit, RGS developed a hydrogeochemical model, described in Section **2** of this report. This included:
    - Conceptual model to structure and guide numerical modelling (Section **2.1**).
    - Development of source terms, quantified inputs of solutes from different sources that are expected to induce changes in geochemical conditions (Section **2.2**).
    - Development of a water balance for the pit void system (Section **2.3**).
    - Geochemical modelling to estimate pit pore water concentrations (Section **2.4**).
    - Seepage transport, to estimate groundwater quality downstream of the pit (Section **2.5**).
- Results are presented in **Section 3** with further detail in **Attachment C** and **Attachment D**.
- Conclusions and recommendations are presented in Section **4**.

2 Hydrogeochemical model

The hydrogeochemical model consisted of the following components:

- Conceptual model
- Source terms
- Water balance
- Geochemical modelling
- Seepage transport

The approach and methodology of these tasks are described in the following sections.

2.1 Conceptual model

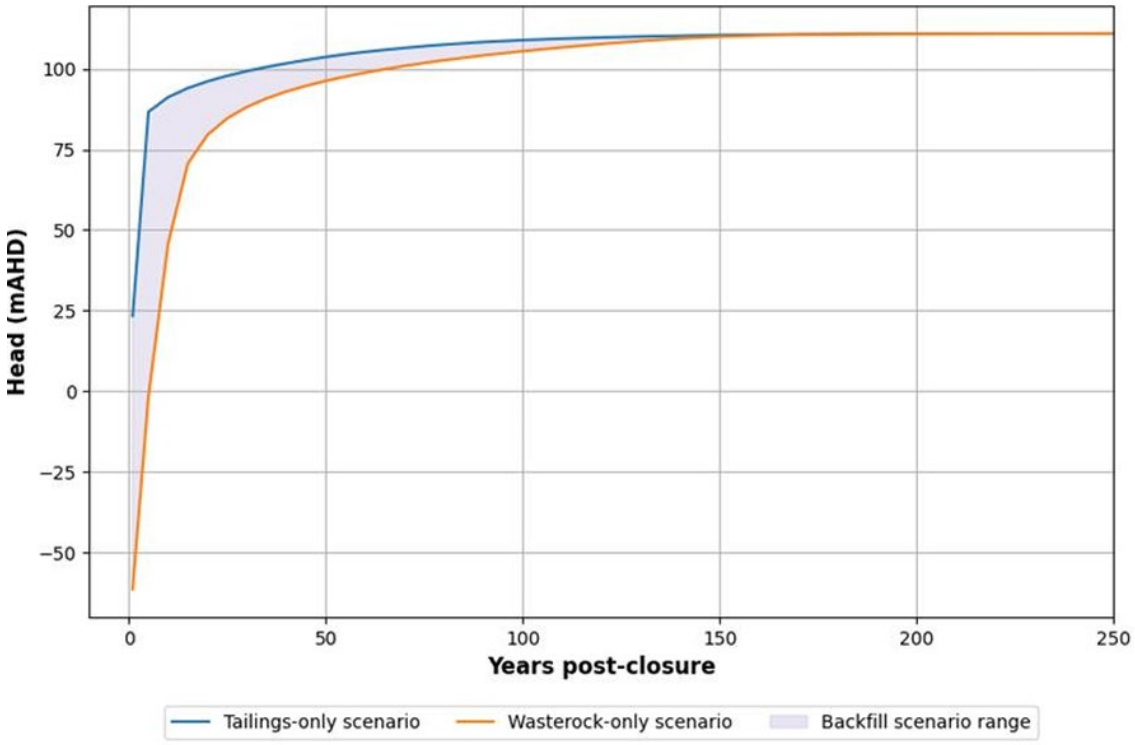
Conceptual models are the foundation for numerical models by providing a simplified representation of the key physical and chemical processes governing a real-world system. Conceptual models integrate available data, expert knowledge, and assumptions to define system boundaries, key variables, and interactions. This section describes the conceptual framework for the hydrogeochemical model of the post-closure Esmeralda pit. Information used to develop the conceptual model is summarised in **Attachment A**.

On completion of mining, groundwater levels around the pit will be depressed in response to operational phase dewatering. RGS assumes that dewatering will continue until backfilling is complete. This is because most groundwater inflow will be associated with the Gilbert River Formation aquifer that is exposed in the upper portions of the pit. Therefore, dewatering will be required to maintain operational safety until the backfill level is higher than the pre-mining groundwater level.

Based on information provided by Graphinex and AARC, backfilling will be conducted in two phases:

- Tailings from base of pit (-157 mAHD) to 42 mAHD. Tailings will be deposited dry using trucks from approximately 2061 until 2071.
- Waste rock will be placed on the tailings top surface (42 mAHD) and up to ground level (123 mAHD) from 2071 until 2077. The waste rock top surface will be shaped to facilitate surface water drainage and rehabilitation.

Groundwater level recovers to pre-mining levels about 100 to 150 years post closure (**Figure 2-1**). Active dewatering is assumed to stop about the same time as backfilling in about 2077. During recovery, groundwater cannot leave the pit as hydraulic gradients are directed inward, towards the pit. Inflowing groundwater gradually fills the pore spaces in the backfilled material (tailings and waste rock). This water mobilises solutes from the backfilled material and increases the total dissolved solids concentration of the pore water.



Source: (AARC email, 29/09/2026)

Figure 2-1: Modelled groundwater level recovery in the Esmeralda pit void

Once groundwater level has recovered, the backfilled material will be saturated and the backfill pore water can spill into the adjacent Gilbert River Formation aquifer as shown conceptually in **Figure 2-2**. The spillage of water from the backfilled pit into the Gilbert River Formation aquifer will be driven by:

- Movement of groundwater from upgradient into the east-southeast side of the pit (Flow A in **Figure 2-2**).
- Rainfall infiltrates the backfill top surface, with some lost to runoff and evapotranspiration and the remainder percolating downward (Flow B in **Figure 2-2**). This percolating water mobilises weathering products, transporting dissolved solutes from unsaturated waste rock backfill to groundwater.

The spilled void water will follow the regional groundwater gradient and leave the west-northwest side of the pit forming a plume of water affected by the pit backfill extending down hydraulic gradient (**Figure 2-2**).

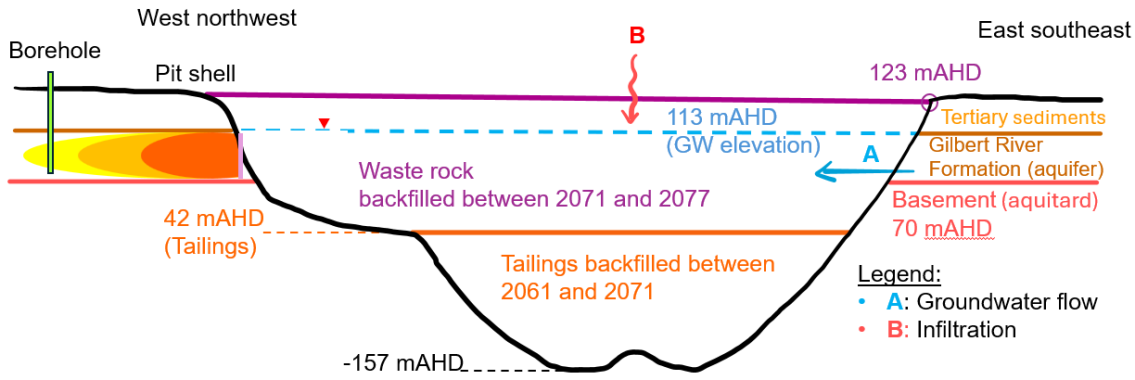
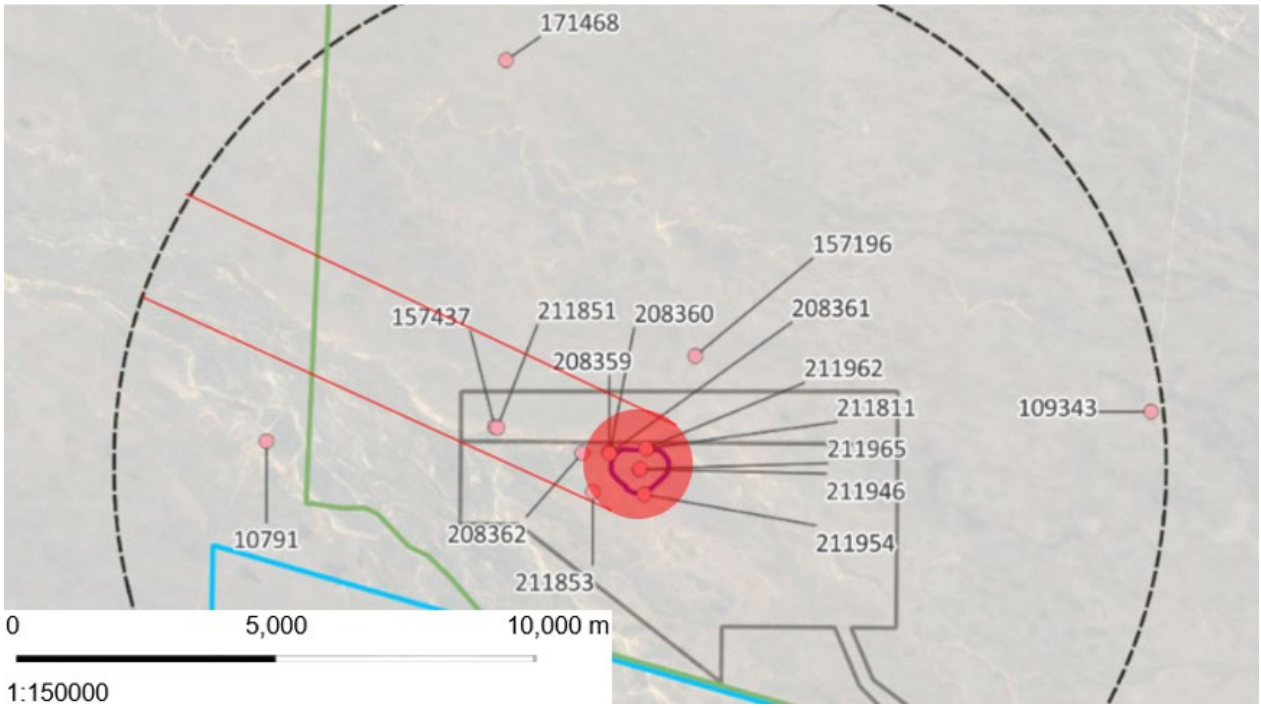


Figure 2-2: Schematic diagram of the post-closure backfilled Esmeralda pit

Inflowing groundwater (**Flow A**) and infiltrating rainwater (**Flow B**) will mix with the pore water in the backfill. This gives rise to two mixing scenarios:

- Mixing with waste rock pore water alone. Depending on the dynamics of flow through the backfill, groundwater flow across the pit may be generally limited to the waste rock backfill, leaving the tailings hydraulically isolated.
- Mixing with both waste rock and tailings pore water. Depending on the dynamics of flow through the backfill, a component of flow may extend into the tailings, adding tailings pore water into the mix that eventually spills from the pit. While complete mixing with tailings pore water is unlikely, this represents a theoretical conservative upper estimate of the potential water quality impact of the tailings.

As shown in **Figure 2-2**, void water spilled from the pit will progressively mix with regional groundwater, and a plume of pit-affected groundwater will gradually extend from the pit. The plume will potentially impact pastoral bores downgradient of the Esmeralda pit (**Figure 2-3**).



Modified from Hydrogeologist.com.au (2026)

Figure 2-3: Plan view indicating potential zone of influence downgradient of the post-closure backfilled Esmeralda pit

The following sections describe the process of modelling the pore water in the backfilled pit and movement of pit-affected groundwater downgradient.

2.2 Source terms

A source term is the quantitative representation of the mass loading of dissolved constituents entering a water system (e.g. groundwater or surface water) from defined materials or sources over time and space. For the purposes of developing a hydrogeochemical model of water in the pit backfill, the Esmeralda source terms were water qualities determined from geochemical testing of backfill (tailings and waste rock) and site measurements of groundwater quality.

The following source terms were defined:

- Unsaturated tailings (neutral pH), representing tailings prior to saturation with groundwater in the pit.

- Unsaturated tailings (low pH), representing a conservative situation in which acid generation in the tailings during transfer into the pit increases the release of dissolved constituents prior to saturation in the pit.
- Saturated tailings, representing tailings saturated in pit.
- Unsaturated waste rock, representing waste rock prior to saturation with groundwater in the pit.
- Saturated waste rock, representing waste rock saturated in pit.
- Groundwater, representing groundwater entering the pit post-dewatering and saturating the void space of the pit backfill (tailings and waste rock).
- Seepage, representing drainage from unsaturated waste rock at the top of the backfilled pit through which percolating rainfall has mobilised soluble constituents.

An important factor in the source term development is acid generation in the tailings. Kinetic testing indicated that the neutralisation capacity of the Esmeralda tailings is initially sufficient to offset acid generation and prevent acidic leachate. However, there is a lag time before acid generation starts and the tailings generate acidic leachate (RGS, 2026). This has a significant implication for transfer of the tailings from surface facilities to the backfill. In surface facilities, the tailings are assumed to be largely isolated from conditions that promote acid generation and the pore water quality in the tailings is controlled by excess neutralisation capacity. Excavating the tailings, dry trucking into the pit and exposure in the pit could facilitate acid generation and neutralisation consumption processes in the tailings. The resulting oxidation products could be mobilised into the groundwater that will fill the tailings pore spaces once dewatering stops.

Attachment B presents details of the source term development and source data. **Table 2-1** presents a summary of key source term parameters.

Table 2-1: Summary of source terms applied in this assessment

Parameters	Unsaturated tailings (neutral pH)	Unsaturated tailings (low pH)	Saturated tailings	Unsaturated waste rock	Saturated waste rock	Ground water	Seepage
pH	6.44	3.02	7.21	9.47	8.32	8.55	8.74
Acidity (mg/L as $CaCO_3$)	4	1,520	7	<1	2	-	0.5
Alkalinity (mg/L as $CaCO_3$)	8	0	71	101	76	401	110
EC (µS/cm)	1,737	3,450	490	461	228	-	289
SO_4 (mg/L)	940	2,470	186	101	30	1	44
Data source	A	A	A	A	A	B	A

Notes:
"-" signifies this parameter was not provided in the source data
A – Kinetic leach column data (RGS, 2026)
B – Baseline groundwater quality data from Esmeralda (Hydrogeologist.com.au, 2026)

The source terms are assumed to be constant for the 100-year model duration.

2.3 Water balance

A water balance is the quantitative accounting of water inflows, outflows, and changes in storage within a defined system, the Esmeralda pit void in this case, over a specified time period. A water balance assumes conservation of water mass. It may include some or all of the following components: precipitation, surface

runoff, groundwater inflow, evaporation, seepage, discharge, and operational abstractions or additions (**Eq. 2-1**).

$$Inflows - Outflows = \Delta Storage \quad \textbf{Eq. 2-1}$$

Two conditions were considered for the Esmeralda pit:

- Initial filling of the void backfill pore space with groundwater. In this condition, water does not leave the pit, but there is a progressive decrease in storage over time until groundwater recovers (**Eq. 2-2**).

$$Inflows - 0 = \Delta Storage \quad \textbf{Eq. 2-2}$$

- Spilling of pore water into the downstream aquifer after groundwater recovery. For simplicity, the long-term pit water level was assumed to be constant, that is, zero change in storage (Eq. 2-3).

$$Inflows\ (seepage, groundwater) - Outflows\ (void\ water) = 0 \quad \textbf{Eq. 2-3}$$

Inputs to the Esmeralda post-closure pit water balance included the following:

- Calculation of saturated tailings and saturated waste rock pore volume (**Table 2-2**) resulting in 2.07×10^7 m^3 and 7.57×10^6 m^3 respectively. Combined, these represent the total water storage available in the pit backfill. This is assumed constant over the 100-year model duration.
- Calculation of seepage (**Table 2-3**). Percolation of rainfall through the top surface of the pit backfill will be limited by the cover placed over the backfill. Details of the cover are in development, and this assessment has assumed long-term seepage will be 2-4% of annual rainfall. This is based on published estimates of seepage from unsaturated waste rock prior to continuum breakthrough (Williams, 2008). The median of this range (3%) has been applied in this assessment resulting in seepage of approximately 15,000 m^3/year. This seepage is assumed constant over the 100-year model duration.
- Calculation of groundwater inflow (**Table 2-4**). The Darcy flow calculation indicates groundwater inflow of approximately 550 m^3/year. This is assumed constant over the 100-year model duration.

Table 2-2: Tailings and waste rock pore volume parameters used in this assessment

Parameter	Value	Unit	Source
Volume of tailings produced	1.20×10^8	m^3	Mine schedule from Graphinex
Porosity of tailings	0.31	m^3/m^3	Estimated from density 2.65
Volume of waste rock removed from pit	1.32×10^8	m^3	Mine schedule from Graphinex
Porosity of waste rock	0.16	m^3/m^3	Estimated from density 2.65

Table 2-3: Seepage calculation parameters used in this assessment

Parameter	Value	Unit	Source
Annual rainfall	0.64	m/year	(Hydrogeologist.com.au, 2026)
Waste rock seepage as a proportion of annual rainfall	3	%	(Williams, 2008)

Parameter	Value	Unit	Source
Area of backfill top surface	0.785×10^6	m^2	Spatial data from Graphinex

Table 2-4: Groundwater inflow parameters used in this assessment

Parameter	Value	Unit	Source
Hydraulic gradient	0.001	dimensionless	(Hydrogeologist.com.au, 2026)
Gilbert River Formation aquifer thickness	50	m	(Hydrogeologist.com.au, 2026)
Gilbert River aquifer hydraulic conductivity	0.03	m/day	(Hydrogeologist.com.au, 2026)
Diameter of Esmeralda pit perpendicular to flow	1,000	m	Spatial data from Graphinex

Notes regarding the Esmeralda water balance:

- Recharge through the top surface of the backfill during backfilling operations is ignored. The impact of this recharge may change the moisture content of the backfill material, that is, moisture will occupy pore space and thus reduce the pore space to be filled by groundwater during flooding of the backfill. This may marginally reduce the time to recovery although rainfall contributions are likely to have been considered in the assessment of recovery time (refer **Figure 2-1**).
- At 3% of annual rainfall, seepage from the unsaturated backfill near surface is similar to the regional aquifer recharge to the Gilbert River Formation of 1.25% to 2.5% of annual rainfall (Hydrogeologist.com.au, 2026). Therefore, mounding of groundwater within the upper portion of the pit backfill is assumed to be insignificant and the assumption of constant long-term pit water level appears reasonable.

2.4 Geochemical modelling

Pore water chemistry was calculated in PHREEQC using the *minteq.v4.dat* thermodynamic database (Parkhurst and Appelo, 2013). Four scenarios were modelled to compare potential conditions in the post-closure Esmeralda pit void. Each scenario indicates the chemistry of water that leaves the pit and moves down the hydraulic gradient in the Gilbert River Formation aquifer.

- Scenario 1 – Simulates complete mixing of all water entering the pit backfill pore space. That is, groundwater flowing into the pit and seepage through the near surface unsaturated backfill mix with the saturated backfill pore water (tailings and waste rock).
- Scenario 2 – “flow through”. Simulates hydraulic isolation of the saturated tailings. That is, groundwater flowing into the pit and seepage through the near surface unsaturated backfill mix only with the pore water in the saturated waste rock backfill. This scenario simulates the situation in which flow within the backfill pit is limited to the waste rock “aquifer” and there is no interaction with the tailings backfill.
- Scenario 3 – Same as Scenario 1, but the initial void water quality is affected by the solute load associated with acid generation in the tailings during transfer from the above ground facilities into the pit. After backfill saturation the tailings are assumed to not produce acid due to lack of available oxygen.
- Scenario 4 – Same as Scenario 2, but the initial void water quality is affected by the solute load associated with acid generation in the tailings during transfer from the above ground facilities into the pit. After backfill saturation, the tailings are considered hydraulically isolated and the “flow through” conditions apply.

Table 2-5 summarises the source terms applied in each modelled scenario.

Table 2-5: Hydrogeochemical model scenarios and source terms

Scenario	Description	Model component	Source terms (sources of dissolved constituents)
1	Simulates complete mixing of all water entering the pit backfill pore space, i.e., both waste rock and tailings pore space.	Initial void water	Unsaturated tailings (neutral pH) Unsaturated waste rock Groundwater
		Long-term void water	Unsaturated waste rock Groundwater Saturated waste rock Saturated tailings
2	Simulates hydraulic isolation of saturated tailings, i.e., inflowing groundwater and seepage through near surface unsaturated waste rock backfill	Initial void water (same as Scenario 1)	Unsaturated tailings (neutral pH) Unsaturated waste rock Groundwater
		Long-term void water (excludes tailings)	Unsaturated waste rock Groundwater Saturated waste rock
3	Simulates acid generation in tailings and complete mixing in backfill pore space	Initial void water	Unsaturated tailings (low pH) Unsaturated waste rock Groundwater
		Long-term void water	Unsaturated tailings (neutral pH) Unsaturated waste rock Groundwater
4	Simulates acid generation in tailings and hydraulic isolation of saturated tailings	Initial void water	Unsaturated tailings (low pH) Unsaturated waste rock Groundwater
		Long-term void water	Unsaturated waste rock Groundwater Saturated waste rock

2.5 Model structure and process

Microsoft™ Excel was used to calculate the post closure water balances for each scenario.

Geochemical modelling used PHREEQC (pH-Redox-Equilibrium-Code) (Parkhurst and Appelo, 2013). It is developed, distributed and maintained by the United States Geological Survey (USGS) and is currently in Version 3. It is widely used in research and industry to perform a variety of aqueous geochemical calculations.

Various user interfaces are available. For the Esmeralda model RGS used the iPhreeqcCOM module (Charlton and Parkhurst, 2011). The module was accessed through a Microsoft Excel spreadsheet which incorporated input data, formulas, Visual Basic for Applications (VBA) and Python coding to run the PHREEQC code and process the outputs.

The outputs consisted of annual calculations of pore water chemistry in the pit void for 100 years after groundwater recovery.

The following sections present the boundary conditions and justification for the annual time step.

2.5.1 Boundary conditions

The main boundary condition was the suite of minerals allowed to precipitate from the pore water solution and specifying sorption of trace elements on iron oxyhydroxides (**Table 2-6**).

Table 2-6: Geochemical modelling conditions

Condition	Value	Sources	Comment
Precipitation of minerals	Ferrihydrite Gibbsite Gypsum Barite Rhodochrosite $Cr(OH)_3(am)$	(Eary, 1999)	These are hydroxide, carbonate and sulfate minerals generally recognised as precipitating/dissolving over time scales relevant to mine drainage. The mineral starting mass was set to zero and the model calculated precipitation from solution if thermodynamic conditions were favourable.
Sorption surface	Ferrihydrite	(Parkhurst and Appelo, 2013)	Number of sites and surface area per unit amount of Ferrihydrite as defined in the PHREEQC users guide.
Scaling applied to source term concentrations	0.1	(Morin, 2013; Kirchner and Mattson, 2015; Lapakko and Olson, 2015)	Scaling is standard practice when translating test results to field-scale geochemical models, because laboratory tests are conducted under controlled and often accelerated conditions that are not representative of the field environment. Ideally, the scaling factor is calibrated against field observations. Published studies suggest factors in the range 0.01 to 0.1 may be applicable.

2.5.2 Time step

The geochemical model considered time steps over which the chemical reactions, mass transfer, and speciation calculations were considered “complete”, that is, at equilibrium by the end of the timestep. The length of the timestep was based on the estimated minimum residence time of water in the pit void based on:

- The distance across the pit in the direction of flow. This distance is around 1,000 m at its maximum length across the pit along a west southwest to east northeast direction.
- The seepage velocity, based on regional groundwater parameters of:
  - Hydraulic conductivity
  - Hydraulic gradient
  - Porosity of the medium

As a conservative approach, the groundwater parameter values used were:

- Hydraulic conductivity of 0.83 m/d, the highest measured value for the Gilbert River Formation (Hydrogeologist.com.au, 2026).
- Hydraulic gradient of 0.001 (Hydrogeologist.com.au, 2026).
- Porosity of the medium, in this case the porosity of the waste rock (estimated at 0.16 based on planned backfill volume and density).

This yielded seepage velocity of 0.005 m/d and residence time of 527 years.

Considering the above, a time step of one year was considered appropriate for the purposes of this assessment.

2.6 Seepage transport

The Domenico solution (Domenico, 1987) is a widely used analytical model for simulating the three-dimensional transport of reactive solutes in groundwater under steady-state or non-steady state conditions. Domenico’s equation is an analytical solution for transport of solutes in groundwater that can be used when

not much groundwater flow information exists. Key aspects of the model appropriate for this assessment include:

- Considers advection (transport by flowing water) and dispersion (spreading of the contaminant).
- Assumes a homogeneous aquifer, a uniform groundwater flow velocity, and a rectangular source of contamination with a fixed concentration (**Figure 2-4**).
- Geochemical degradation of contaminants is not considered.

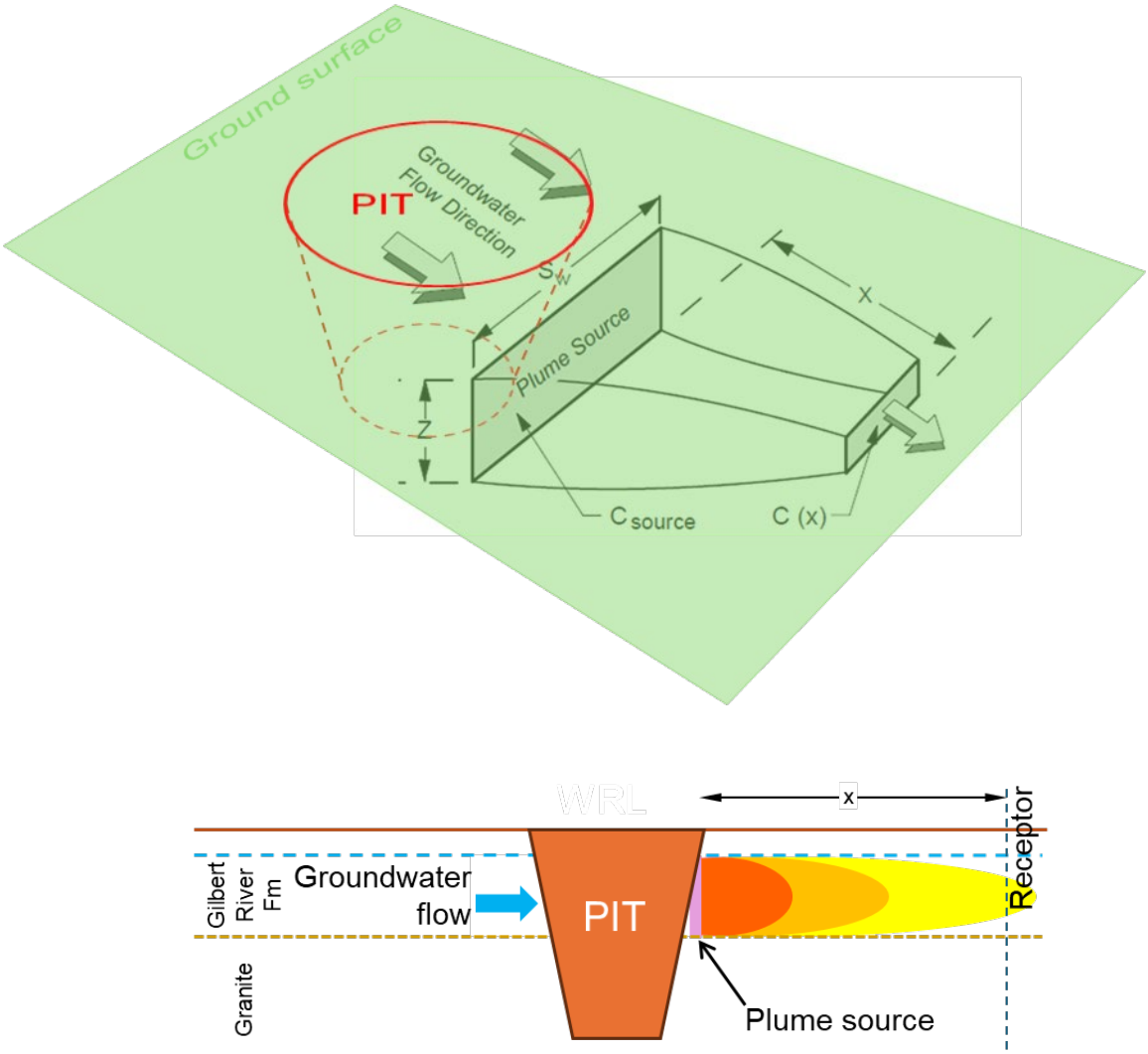


Figure 2-4: Conceptualisation of solute transport in groundwater

For this assessment, with reference to **Figure 2-4**:

- The width of the plume source (S_W) would be the effective width of the pit perpendicular to groundwater flow. For this assessment, the effective width was taken as the pit diameter, 1,000 m.
- The height of the plume source (Z) would be the thickness of the aquifer affected by seepage from the pit. For this assessment, the effective thickness was taken as 50 m.
- The concentration of the source (C_{source}) would be the concentration of the selected solute in the pit void water quality.
- The concentration at the receptor, located *x* distance from the source is $C_{(x)}$.

The Domenico solution can be programmed into a spreadsheet for ease of calculation and to compare scenarios. To calculate the mixing with groundwater along the flow path from source to receptor, a source concentration of 100 units was entered into the spreadsheet, and a groundwater background concentration of 0 units was assumed.

2.7 Model assumptions and uncertainty

All models estimate future conditions (e.g., physicochemical parameters) by reducing complex systems to a limited number of significant, often simplified, processes. Predicting the water qualities of complex systems requires many assumptions. Even a rigorous sampling and analysis programme cannot precisely determine all the physical, chemical, and geological characteristics of the system. Nor can they precisely indicate how these characteristics might change over time. Therefore, it is recognised that, although assumptions are informed by data, they include an inherent level of uncertainty (Drever, 2011). While these uncertainties are generally hard to quantify, they can be recognised. **Table 2-7** summarises the key uncertainties associated with the Esmeralda post closure hydrogeochemical model.

Table 2-7: Key uncertainties of the Esmeralda post closure hydrogeochemical model

Uncertainty source	Limitation	Uncertainty estimate
Predicting field-scale water quality from lab scale test results is an approximation.	Leaching of salts and metals at the field scale is variable in time and controlled by factors not fully applied at the lab scale. Amongst others, these factors include temperature, nature of the leaching solution, the solution to solid ratio, solution-solid contact time, particle size of the solid. This indicates that the quality of water due to interaction with waste rock as presented in this report, are informed estimates.	Laboratory solute release rates may differ from field rates by a factor of one to 100.
The compositions of input water.	The quality of water sources, such as groundwater, surface water, and rainwater, are the results of other complex systems (aquifer, catchment, atmosphere). While water composition can be determined in the laboratory with some accuracy, it requires a statistically relevant number of samples to establish inherent variability due to factors such as seasons, sediment movement, changes in gradient, etc. The required number of samples is only rarely obtained in practice.	Concentrations within 50% of “real world value”.
Source terms are constant	There is rarely sufficient data to identify how source terms may vary over time and whether the variation is systematic or random. This limitation is managed by assuming most source terms are constant. For declining source terms, this is a conservative assumption.	Solute releases may be overestimated by a factor of 1 to 100.
The geochemical database is relevant to the system being modelled.	Hydrogeochemical modelling uses the inherently uncertain laboratory results and water qualities as inputs. These are processed using thermodynamic data determined in the laboratory on ideal materials and solutions. The laboratory determined constants may not be directly applicable to the materials, solutions, and chemical context of the system being modelled.	The impact of changes in thermodynamic parameters on model results are difficult to quantify.

Uncertainty source	Limitation	Uncertainty estimate
The modelling assumes thermodynamic equilibrium in the model system.	In the field, all chemical components are subject to kinetic variation, and the system might, at best, be in a state of quasi equilibrium.	Published research shows that this assumption produces results that align with the general chemistry in the field.
Groundwater inflow rates, groundwater levels, hydrogeological parameters.	The groundwater characterisation and modelling incorporates limitations and assumptions that are propagated, at least in part, to the hydrogeochemical model.	Hydraulic characteristics may vary over several orders of magnitude.

Geochemical evaluations over the last few decades have shown that modelling, particularly the equilibrium assumption, is a powerful tool that has consistently produced results that accurately describe the general chemistry of natural and mine water. Acknowledging this, and the uncertainties outlined above, the available information is considered sufficient to provide “qualitatively correct” estimates of water chemistry, as presented in this report.

The model results are an informed estimate of future conditions derived using a limited number of fixed values for hydrogeological and geochemical parameters under defined boundary conditions. Each result represents a scenario-based prediction conditional on the adopted conceptual model and parameter set.

The model outputs do not incorporate statistical variability or quantify the probability of occurrence of a given concentration. Therefore, the deterministic concentrations modelled should be considered as comparative assessment tools and a starting point for project design decisions. The emphasis should be on the modelled trends in chemistry, rather than the precise concentrations.

3 Results

This section presents the geochemical modelling and seepage transport results separately.

3.1 Geochemical modelling

Attachment C presents tabulated results of the geochemical modelling for all four scenarios while graphs of the time series model data are presented in **Attachment D**. This section presents an overview of the model data.

The modelled pH and salinity (as represented by calculated TDS) in the Esmeralda pit void are presented graphically in **Figure 3-1**.

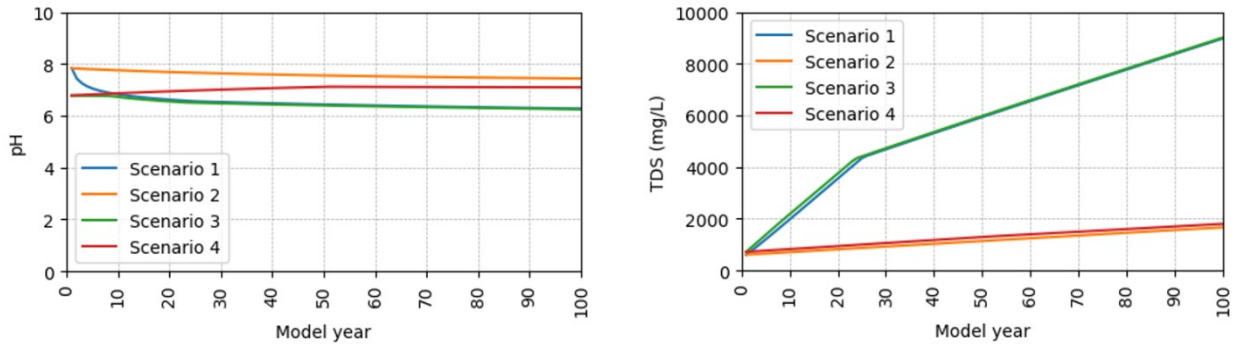


Figure 3-1: Modelled Esmeralda pit void pH (left) and TDS (right)

From **Figure 3-1**:

- Modelled pH for all scenarios is within the range pH 6-8. The acidity load from backfill tailings reduces the pH for Scenarios 1 and 3 relative to Scenarios 2 and 4. However, the modelled pH for all four scenarios is generally similar to the local groundwater range of pH 7.5-8.7 (Hydrogeologist.com.au, 2026).
- Modelled TDS is significantly higher for Scenario 1 and Scenario 3, which include solute load from backfill tailings, and reach ~9,000 mg/L TDS after 100 years. In contrast, Scenario 2 and Scenario 4, which assume the tailings are hydraulically isolated, reach ~2,000 mg/L TDS after 100 years. The latter is within the local groundwater range of 492-2,050 mg/L TDS. However, modelled TDS in the pit prior to spilling is close to the local median of 682 mg/L TDS and increases from there. This is because the pore space in the backfill is filled with groundwater and the groundwater source term was based on the median of the available groundwater quality data (Hydrogeologist.com.au, 2026).

Figure 3-2 compares the modelled ranges of selected trace elements with default guideline values (DGV) for 95% species protection in freshwater aquatic ecosystems (ANZG, 2018) and the measured range of local groundwater concentrations, “Local GW” (Hydrogeologist.com.au, 2026). The hardness category of the modelled results is generally “moderate” or harder and DGVs for cadmium, chromium(III), lead, nickel and zinc have been adjusted as indicated in ANZG (2018).

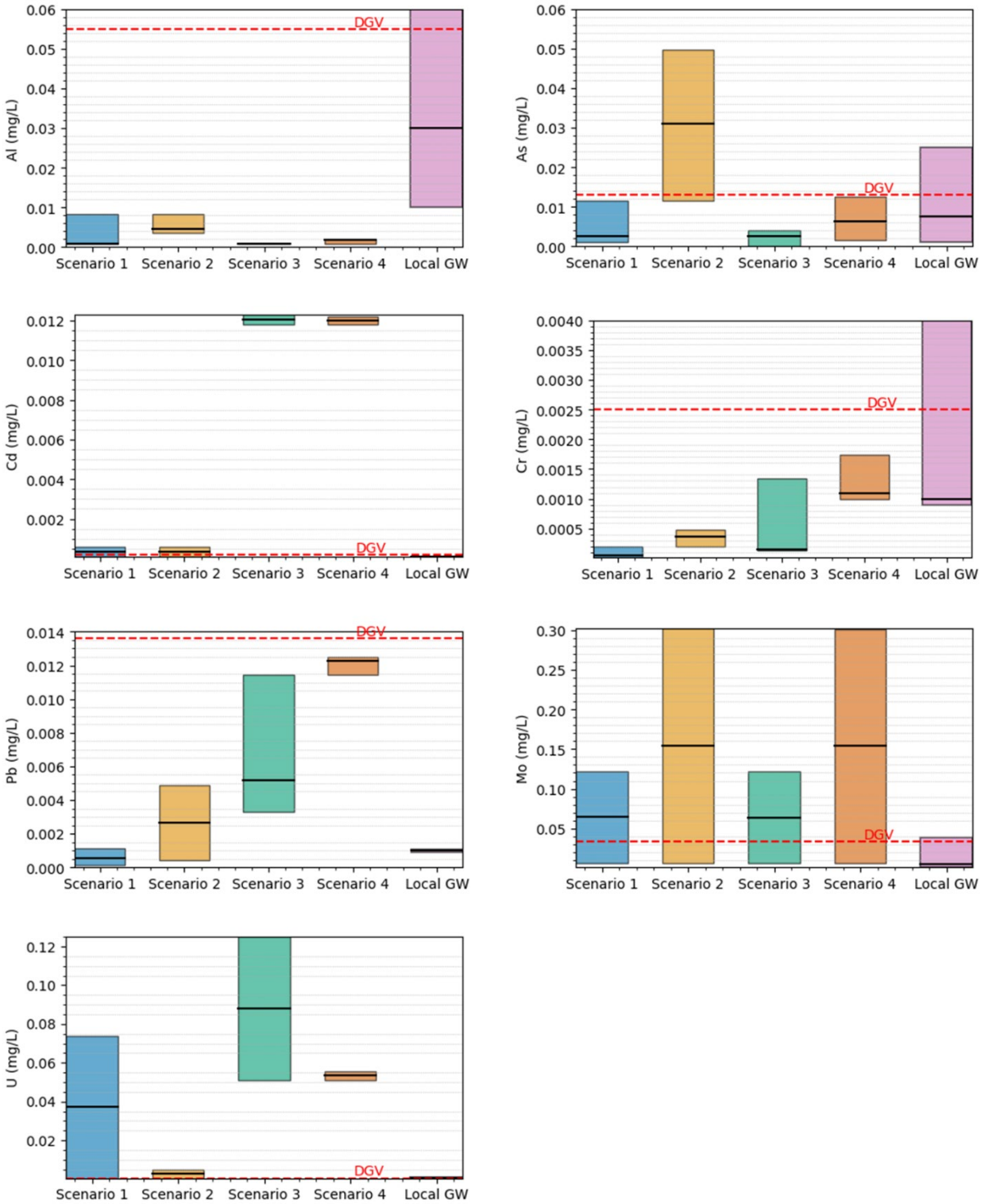


Figure 3-2: Modelled Esmeralda pit void min-max-median concentrations of selected trace elements

From **Figure 3-2**:

- Modelled aluminium (Al) concentrations are below DGV and local groundwater.
- Modelled arsenic (As) concentrations are generally below DGV and comparable with local GW except for Scenario 2, where higher pH and alkalinity relative to other scenarios, makes sorption of arsenic on iron oxyhydroxides (as represented by Ferrihydrite in the model) less effective.
- Modelled cadmium (Cd) concentrations for Scenarios 1 and 2 are comparable to DGV and local GW. However, Scenarios 3 and 4 are significantly higher due to the assumed acid generation in the tailings. The unsaturated tailings (low pH) source term has about 400 times more cadmium than neutral tailings. This indicates the need to limit tailings oxidation during transfer from the above ground facilities into the pit. A similar outcome is evident in the data for cobalt, copper, nickel and zinc.
- Modelled median chromium (Cr) concentrations are below DGV and local GW. The chromium concentration ranges increase from Scenario 1 through Scenario 4 as a result of:
    - Higher chromium in the tailings (low pH) source term used in Scenarios 3 and 4
    - Less pore volume for dilution with tailings hydraulically isolated in Scenarios 2 and 4
- Modelled lead (Pb) concentrations are below hardness-adjusted DGV but are generally higher than the local GW.
- Modelled molybdenum (Mo) concentrations are generally higher than DGV and local GW due to elevated source terms. A similar outcome is evident in the data for selenium (Se) and vanadium (V).
- Modelled uranium (U) concentrations show a wide range for Scenarios 1 and 3, which reflects the higher contribution of uranium from tailings. In contrast, Scenarios 2 and 4, which exclude the tailings source have smaller ranges.

3.2 Seepage transport

Figure 3-3 presents the calculated concentration experienced at a receptor located 1,000 m downstream of the Esmeralda pit. This shows a lag period of more than 500 years after pit spillage into the aquifer starts before an increase in background concentrations is experienced at the receptor. Thereafter, concentrations increase to 100% of the source concentration over a period >2,000 years.

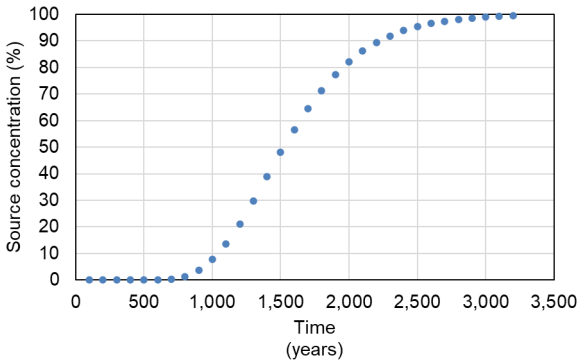


Figure 3-3: Calculated percentage of source concentration at a receptor 1,000 m downstream

This estimate does not account for groundwater mounding (if any) within the pit backfill.

4 Conclusions

This assessment for the Esmeralda Project provides a first-order prediction of post-closure water quality within the backfilled pit void and the potential for downstream groundwater quality impacts.

Conceptually, groundwater will progressively refill the backfilled pit following cessation of dewatering, with recovery to near pre-mining levels expected 100 to 150 years after closure. During the refilling period, inflowing groundwater and rainfall percolating into the top surface of the backfill will mobilise solutes from the tailings and waste rock materials, generating pore water of elevated salinity relative to background groundwater. Long-term pore water chemistry is strongly influenced by whether the saturated tailings remain hydraulically connected to the advective flow pathway.

Four scenarios were modelled:

- Scenario 1 – complete mixing of water within backfill tailings and waste rock
- Scenario 2 – hydraulic isolation of tailings
- Scenario 3 – Scenario 1 assuming acidification of tailings during backfilling
- Scenario 4 – Scenario 2 assuming acidification of tailings during backfilling

Across the four modelled scenarios, modelled void water pH remains circumneutral (pH 6–8), comparable to local groundwater conditions. Salinity varies markedly between scenarios:

- Scenarios assuming full hydraulic mixing between groundwater, waste rock and saturated tailings (Scenarios 1 and 3) result in significantly higher long-term TDS (~9,000 mg/L)
- Scenarios assuming hydraulic isolation of saturated tailings (Scenarios 2 and 4) indicate lower salinity (~2,000 mg/L)

For aluminium, arsenic, chromium and lead, modelled long-term concentrations are comparable with or below guideline values for protection of moderately disturbed freshwater aquatic ecosystems. Exceptions include molybdenum, selenium, and vanadium, due to elevated source term concentrations.

The influence of acid generation during tailings transfer is evident in trace element concentrations exceeding guideline values. Scenarios 3 and 4 show significant exceedances of cadmium, cobalt, nickel and zinc associated with the low-pH tailings, while Scenarios 1 and 2 show markedly lower exceedances.

Preliminary seepage transport calculations indicate a delay of more than 500 years before detectable changes occur at receptors located approximately 100 m downgradient of the pit. This reflects the slow advective velocity and dispersion within the Gilbert River Formation aquifer.

The model outcomes show that Scenario 2 results in lowest element concentrations. This highlights:

- The importance of minimising tailings oxidation during transfer from surface facilities to the pit.
- The significance of placing tailings at the base of the pit to minimise interaction with groundwater at higher levels in the backfill.

5 References

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6 Attachments

Attachment A Information review

The following section presents selected information relevant to this assessment obtained from documents provided by AARC.

General

The Esmeralda Project is a proposed open cut graphite mine, located on light grazing land approximately 70 km south of Croydon, Queensland, Australia. The Project proposes mining of the Esmeralda Granite unit and on-site concentration of graphite ore. The Project will mine up to 3.5 million tonnes per annum (Mtpa) of Run-of-Mine (ROM) ore over a mine life of approximately 50 years. Extracted graphite ore (~ 6% total graphite) will be trucked to the mineral processing plant for stockpiling and concentration via conventional flotation methods. Concentrate will then be trucked to a separate facility in Townsville for refinement and distribution. Graphinex plans to commence construction of the Project in 2027 – subject to relevant approvals being granted.

The graphite mineralisation at the project is hosted in predominantly hydrothermally altered light grey, fine to medium-grained porphyritic biotite granite

The Project proposes to construct and operate an open cut graphite mine, producing up to 3.5 million tonnes per annum (Mtpa) of Run-of-Mine (ROM) ore over a mine life of approximately 50 years. Mining is proposed via conventional truck and excavator methods, to a depth of 280 m below ground level

Excavated overburden and non-ore-bearing material will be deposited in out-of-pit waste dumps located adjacent to the mining void. The majority of waste movement will occur within the first 18 years of the mine life, with a total of 143.8 Mt estimated to be moved over the entire 50-year production life of the Project.

Flotation tailings produced from the mineral processing circuit will be transferred to one of three purpose designed storage facilities, to be constructed in stages over the production life of the mine.

Table A-1 presents overall project timeframes.

Table A-1: Project timeframes

Approximate Timeframe	Project Phase
2024–2026	Mine planning, technical studies and approvals
2027	Construction (pre-strip, topsoil stockpiling, infrastructure and road development, waste/overburden removal)
2028–2070	Mining and processing (ramping up to full production by 2030 – 3.5 Mtpa)
2070–2076	Mid-grade ore stockpile reclaim (plant feed from stockpiles after pit depletion)
2076–2086	Final site rehabilitation and monitoring (estimated 10-year post-mining period)

With regards to this assessment, the timeframe of interest is 2076-2086. Should backfilling of the pit be selected as a closure alternative, backfilling would take place during this period. Therefore, the modelling conducted for this assessment estimates conditions after approximately 2086.

For the purposes of this assessment, the pit will be backfilled to natural ground. The watercourse diversion around the northern extent of the pit will remain. The only area draining to the backfilled pit extent post closure will be its direct catchment. Levees around the northern and eastern extent of the backfilled pit will be re-profiled to allow the area to drain. Flooding will occur primarily from water in the diversion around the northern extent and will occur very infrequently (10% of years for a duration less than 24 hours each occurrence)[1].

[1] Email from Engeny hydrologist dated 20/02/2026

Backfilling will consist of:

- Tailings trucked to the pit and placed to 42 mAHD
- Waste rock to 123 mAHD

Geology

The entire Esmeralda project area is concealed under Cainozoic and Mesozoic cover sequences. These Cainozoic sediments are underlain by the Mesozoic sediments of the Carpentaria Basin consisting of sandstone, siltstones, and shales of the Gilbert River Formation.

A major unconformity exists between the Mesozoic sediments and Proterozoic basement. The Carpentaria Basin is comprised of Early Cretaceous to Middle Jurassic age, fluvial to shallow marine dominated sediments. The basement is currently mapped as “unknown basement” and is interpreted to be the Esmeralda Supersuite granites.

Previous drilling in the area suggests that the cover sequence consists of flat laying laminated and cross bedded siltstone, claystone, and coarse sandstones. Logging of drill core has stated these sediments had alternating porous and non-porous horizons and differing strengths. According to historic drill holes, this sequence is approximately 50 – 70 m thick across the project area.

Water

Surface water

The Project is located within the Norman Drainage Basin. The Norman River is joined by three major tributaries, the Carron, Clara and Yappar Rivers. The Project is situated between the Clara and Yappar Rivers, approximately 7 km north of the Clara River and 8 km south-west of the Yappar River, at its closest point. The Yappar and Clara Rivers are declared high ecological value waters, as the biological integrity of the water in these systems is effectively unmodified or highly valued.

The proposed pit location is intersected by an unnamed watercourse of stream order 3. This watercourse is proposed to be permanently diverted around the pit as part of Project development and retained post-closure and supported by a flood levee.

Groundwater

Gilbert River Formation is generally regarded as a moderate to high permeability formation and a regional aquifer. The Gilbert River Formation aquifer supports numerous pastoral users for livestock (beef cattle) watering. The observed groundwater elevation within the Gilbert River Formation is approximately 113 mAHD.

The basement rocks are typically intersected at a depth of 50 mbgl or an elevation of approximately 70 mAHD. Hydrogeologically, the basement rock would be expected to behave as an aquiclude or aquitard. Fracturing (due to faulting or structural controls) may locally increase permeability and porosity of the basement rocks.

Preliminary groundwater inflow rates have been estimated at approximately 3 ML to 3.5 ML per day. The majority of this inflow is associated with the Gilbert River Formation. The basement strata (which hosts the ore body) is not expected to contribute significantly to these groundwater inflow rates.

Groundwater impacts relevant to this assessment include:

- Groundwater supply bore(s) are expected to be installed within or adjacent to the open-cut pit footprint. These would serve to provide water supply and advance dewatering prior to mining development.
- Development of the open-cut pit during operations to a depth of approximately 280 m below ground level will intersect the groundwater table and the Gilber River Formation. Groundwater inflow to the pit (and any out-of-pit dewatering) will result in a drawdown cone that will radially extend from the mine development.
- Dewatering pumping is likely to cease during backfilling operations. This will allow groundwater levels to recover, flooding the backfill placed in the pit.

Land use and receptors

The Project area is located within the Gulf Savannah natural resource management (NRM) region. The Project area is located within an existing pastoral property. Land within and surrounding Project is designated as 'Rural' zone under the Croydon Shire Planning Scheme 2019.

The land in the study area is currently used for low-intensity cattle grazing of native vegetation. No historical mining has occurred in the underlying or surrounding Project area. Exploration drilling has been conducted as part of resource definition and for the development of groundwater monitoring bores.

There are no protected areas near the Project. The Tagalaka National Park (also listed as Littleton Resources Reserve), the Rungulla National Park and several Nature Refuges (state protected areas established under the NC Act) are located within 100 km of the Project. The Esmeralda Nature Refuge is located approximately 40 km to the east of the Project.

There are 12 registered bores within 10 km of the project mining area with all bores drilled and constructed to take groundwater from the Gilbert River Formation.

Database searches indicate the possible presence of terrestrial groundwater dependant ecosystems (GDEs) around the proposed mining area and further afield. These potential GDEs are generally linked to riverine / floodplain ecosystems. While government mapping generally indicates watercourse vegetation to have potential as GDEs, this is not considered to be an indication of actual groundwater dependency.

The nearest publicly mapped spring is located more than 30 km from the project mining area. There are no surface expressions of groundwater within or near the Project.

Geochemistry

RGS Environmental Consultants Pty Ltd (RGS) was requested by AARC Environmental Solutions Pty Ltd (AARC) to complete a geochemistry assessment of mine materials and tailings for the Esmeralda flagship project on behalf of Graphinex Pty Ltd. The results presented in this technical report (RGS, 2026) are highlighted in the following sections.

Based on total sulfur values, the results indicate that 55 % of all of the mine material samples are classified as NAF-Barren (53 %) or NAF (2 %). A small proportion of the samples may have insufficient ANC to fully neutralise any acid produced and are classified as Uncertain (2 %). Some of the mine material samples are classified as PAF-LC (2 %) or PAF (39 %). The geochemical classification for mine materials is presented in **Figure A-1**. Most materials (soil, overburden, waste rock, and low grade ore) are largely classified as NAF-Barren. However, most of the tailings are classified as PAF or Uncertain.

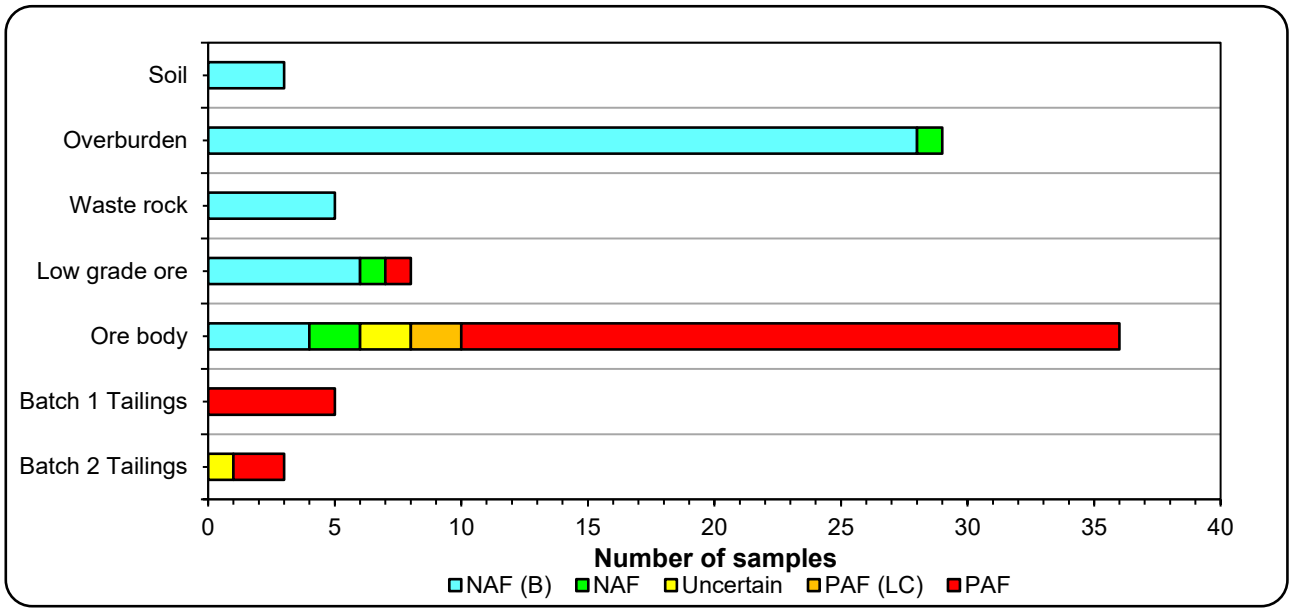


Figure A-1: Geochemical classification for mine materials.

Waste rock

Waste rock materials are alkaline and have negligible total sulfur. Acid neutralising capacity is generally higher than overburden materials and is typically moderate. The samples classify as NAF-Barren and can initially produce slightly elevated concentration of fluoride, aluminium, and copper that dimmish over time.

Long term leaching in KLCs indicate waste rock does not add acidity to leachate water which remains in the neutral range.

Tailings

The tailings are slightly alkaline with low salinity, and low acid neutralising capacity. The majority of tailings samples are classified as PAF.

Low neutralising capacity is consistent across all the tailings samples. ABCC test results for a tailings sample (2024006_001) are shown in **Figure A-2**. These results show that pH drops almost immediately as acid is progressively added which indicates limited buffering capacity in the tailings.

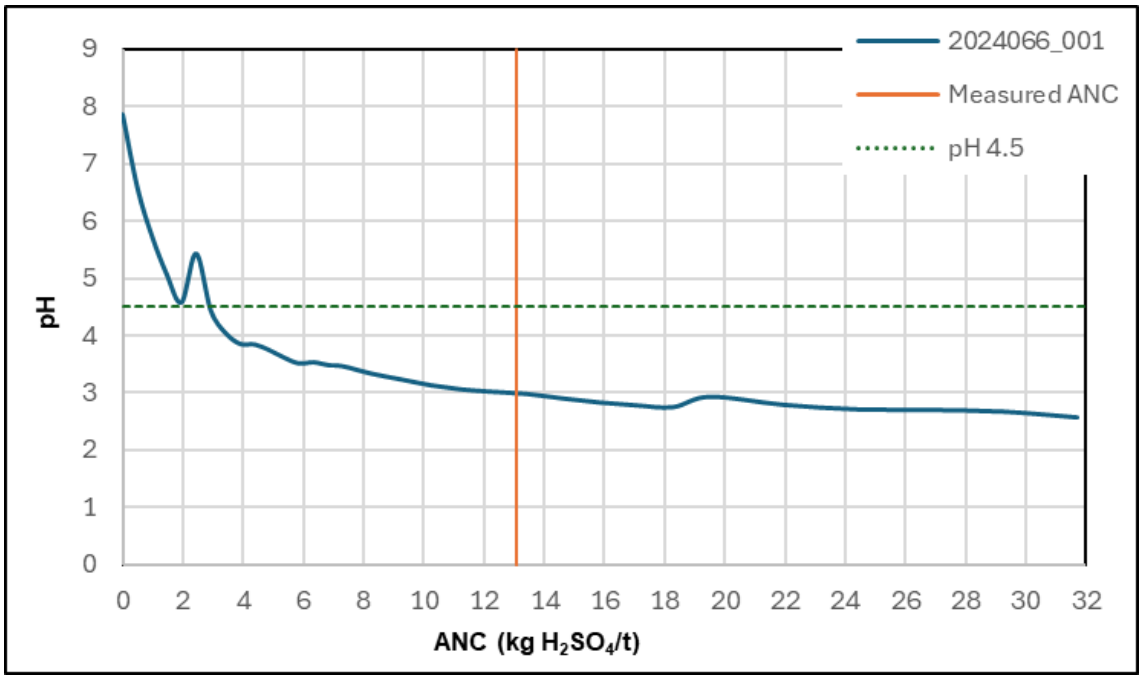


Figure A-2: Tailings acid buffering characteristic curve

KLC 6 (RGS, 2026) leachate data show pH started at 6.28 (17 April 2025), then decreased to 4.90 (7 August 2025), and steadily continued to decrease to pH 3.07 (18 February 2026). This pH decrease is related to an increase in acidity and a decrease in alkalinity (**Figure A-3**). Alkalinity starts to decline at close to two pore flushes, and acidity begins to increase at three pore flushes.

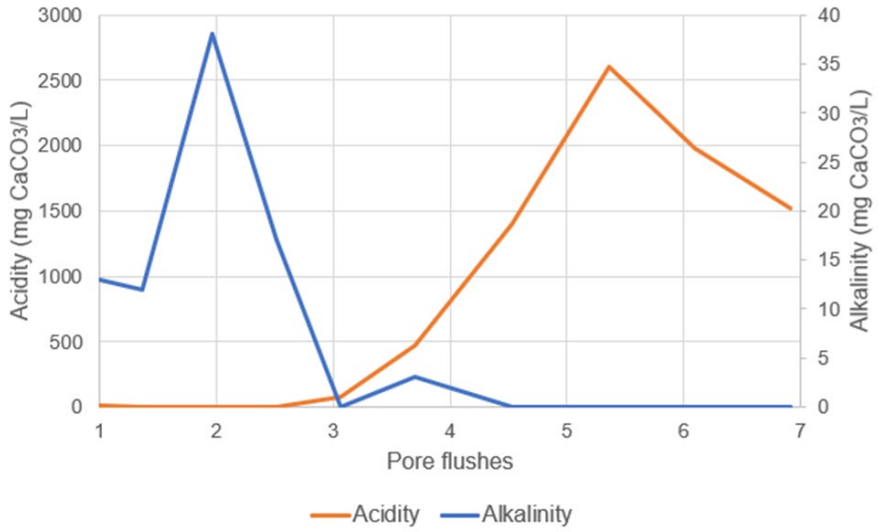


Figure A-3: Unsaturated tailings acidity and alkalinity in KLC 6

Leachate data from KLC 7 (saturated tailings) suggests that there is limited potential for acid formation in the long term (**Figure A-4**).

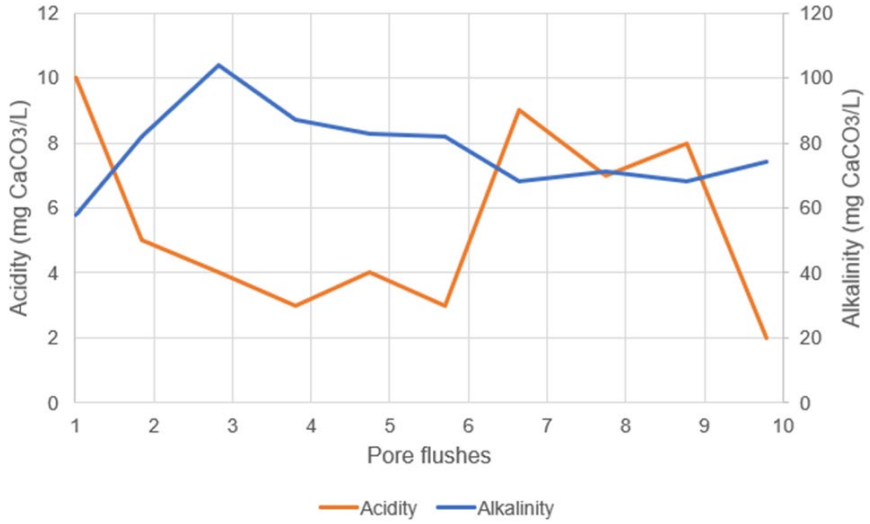


Figure A-4: Saturated tailings acidity and alkalinity in KLC 7

Based on the initial alkaline pH values for tailings, it is likely that some of the inherent sulfide sulfur is slow to react, or less reactive than those typically associated with pyrite minerals. Mineralogy testing and interpretation determined that the sulfur is in the form of pyrrhotite and elemental sulfur. There are two batches of analysed tailings, which all initially produce a neutral pH and are classified as PAF. Seepage is moderately saline, which is typical for tailings. The newer tailings are slightly more saline and have higher ANC. Initial contact water may contain slightly elevated concentrations of aluminium, although all other metal/metalloid concentrations are expected to be low.

If the tailings are left unmanaged and allowed to oxidise, several metals/metalloids, including aluminium, boron, cadmium, copper, lead, manganese, nickel, and zinc can mobilise into pore water under weakly acidic conditions. Leachate produced under saturated (anoxic) conditions maintains a neutral pH and lower concentrations of metal/metalloids.

Long term leaching in KLCs indicates tailings under oxidising conditions add acidity to leachate water which develops a decreasing pH trend over time. However, under anoxic conditions, tailings leachate maintains a steady pH.

Under oxidising conditions long term leaching produces increasing salt concentrations dominated by sodium, chloride and sulfate.

Geochemistry of pyrrhotite

The presence of sulfide within the ore body and tailing materials may result in a slower than predicted rate of acid generation potential/capacity as currently calculated through standard static geochemical test techniques. Geochemical and mineralogical testing show that the sulfur in these materials is present as pyrrhotite and elemental sulfur, rather than pyrite.

Pyrrhotite has two possible reaction pathways, one of which generates sulfuric acid (Eq. A-1), the other elemental sulfur (Eq. A-2). The reaction kinetics were tested in the laboratory, and it was confirmed that slow acid generation can occur from ore body materials under freely oxidising conditions.

$$Fe_{(1-x)}S + \frac{3(3-x)}{4}O_2 + \frac{3-x}{2}H_2O \rightarrow (1-x)FeOOH + H_2SO_4 \qquad \text{Eq. A-1}$$

$$Fe_{(1-x)}S + \frac{3(1-x)}{4}O_2 + \frac{(1-x)}{2}H_2O \rightarrow (1-x)FeOOH + S^0 \qquad \text{Eq. A-2}$$

Attachment B Source terms

Source terms are water qualities determined from geochemical testing of backfill (tailings and waste rock) and site measurements of groundwater quality. The source terms were developed from datasets of water quality results: KLC leachates (RGS, 2026) and groundwater (Hydrogeologist.com.au, 2026). The datasets were processed as follows to obtain a single water chemistry:

- Replace all values below the detection limit (DL) with half of the DL value.
- Define the median value for each parameter for the number of samples considered applicable for the source term.
- Scale the parameter concentration by a factor of 0.1. This is standard practice when translating results to field-scale geochemical models, because laboratory tests are conducted under controlled and often accelerated conditions that are not representative of the field environment. Ideally, the scaling factor is calibrated against field observations. In the absence of site-specific data, published ranges from 0.01 to 0.1 are applied (Morin, 2013; Kirchner and Mattson, 2015; Lapakko and Olson, 2015).

Table B-1 Source terms developed for this assessment.

Source term	Representing	Development
Unsaturated tailings (neutral pH)	Tailings prior to saturation with groundwater in the pit	The unsaturated tailings (neutral pH) source term was defined using the first three leaches from free-draining KLC 6 (RGS, 2026). Groundwater saturation would involve a limited volume of water passing through the tailings. Therefore, only the first three leaches were used to define this source term (17 April 2025, 15 May 2025, and 11 June 2025).
Unsaturated tailings (low pH)	A conservative situation in which acid generation in the tailings during transfer into the pit increases the release of dissolved constituents prior to saturation in the pit	The unsaturated tailings (low pH) source term was defined using the last three leaches from free-draining KLC 6 (RGS, 2026) which indicated acid conditions in later leachates. The last three leaches were used to define this source term (17 December 2025, 21 January 2026, and 18 February 2026).
Saturated tailings	Tailings saturated in pit	The saturated tailings source term was defined using the last three leaches from saturated KLC 7 (RGS, 2026). Only the last three leaches were used to define this source term (17 December 2025, 21 January 2026, and 18 February 2026).
Unsaturated waste rock	Waste rock prior to saturation with groundwater in the pit	The unsaturated waste rock source term was defined using the first three leaches from KLC3 (RGS, 2026). Only the first three leaches were used to define this source term (17 April 2025, 15 May 2025, and 11 June 2025).
Saturated waste rock	Waste rock saturated in pit	Long-term solute loads were considered best defined using the last three KLC3 (RGS, 2026) leaches (17 December 2025, 21 January 2026, and 18 February 2026).
Groundwater	Groundwater saturating the void space of the pit backfill (tailings and waste rock)	This dataset includes 14 boreholes in the vicinity of the Esmeralda deposit. The samples were collected between 14 September 2024 and 19 November 2025.
Seepage	Drainage from unsaturated waste rock at the top of the backfilled pit through which percolating rainfall has mobilised soluble constituents	Dataset consisted of all available leachates from KLC3 (RGS, 2026)

Table B-2: Source term concentrations

Parameters	Unsaturated tailings (neutral pH)	Unsaturated tailings (low pH)	Saturated tailings	Unsaturated waste rock	Saturated waste rock	Groundwater	Seepage
pH	6.44	3.02	7.21	9.47	8.32	8.55	8.74
Alkalinity (mg $CaCO_3$/L)	8	0	71	100.5	76	401	109.5
Al (mg/L)	0.13	195	0.04	0.6	0.14	0.02	0.2
As (mg/L)	0.003	0.05	0.002	0.012	0.005	0.012	0.015
B (mg/L)	0.73	0.48	0.27	0.06	0.33	0.18	0.13
Ba (mg/L)	0.101	0.02	0.057	0.004	0.003	0	0.001
Be (mg/L)	0.0005	0.133	0.0005	0.0005	0.0005	0	0.0005
Ca (mg/L)	330	419	94	2	5	1	2
Cd (mg/L)	0.0004	0.16	0.00005	0.00005	0.00005	0.00005	0.00005
Cl (mg/L)	16	115	2	8	0.5	89	0.5
Co (mg/L)	0.013	6.35	0.0005	0.005	0.0005	0.0005	0.0005
Cr (mg/L)	0.0005	0.014	0.0005	0.0005	0.0005	0.0005	0.0005
Cu (mg/L)	0.03	3.84	0.0005	0.003	0.003	0.0005	0.002
Fe (mg/L)	0.025	54.1	0.3	0.15	0.025	0.025	0.025
Hg (mg/L)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K (mg/L)	22	24	14	4	4	5	3
Mg (mg/L)	27	61	5	0.5	1	1	0.5
Mn (mg/L)	2.13	30.3	0.523	0.004	0.004	0.015	0.0005
Mo (mg/L)	0.003	0.0005	0.012	0.081	0.03	0.004	0.028
Na (mg/L)	18	9	7	92	41	234	64
Ni (mg/L)	0.024	15.6	0.0005	0.005	0.0005	0.0005	0.0005
Pb (mg/L)	0.0005	0.152	0.0005	0.001	0.0005	0.0005	0.0005
Sb (mg/L)	0.0005	0.0005	0.0005	0.047	0.049	0	0.078
Se (mg/L)	0.005	0.063	0.002	0.005	0.002	0.005	0.005
SO_4 (mg/L)	940	2470	186	101	30	1	44

Parameters	Unsaturated tailings (neutral pH)	Unsaturated tailings (low pH)	Saturated tailings	Unsaturated waste rock	Saturated waste rock	Groundwater	Seepage
Th (mg/L)	0.0005	0.014	0.0005	0.0005	0.0005	0	0.0005
U (mg/L)	0.002	0.697	0.002	0.001	0.0005	0	0.001
V (mg/L)	0.005	0.005	0.005	0.01	0.005	0.005	0.005
Zn (mg/L)	0.112	42.4	0.0025	0.0025	0.0025	0.011	0.0025

Attachment C Tabulated results of modelled pit void water quality

Esmeralda pit void water quality model results:
Scenario 1
Base case - complete mixing in backfill pore volume

Scenario 1	Esmeralda groundwater (median, dissolved)	Note	Modelled void water	Modelled void water	Modelled void water
Parameter	Hydrogeologist.com.au (2026)		Minimum	Median	Maximum
pH	8.55		6.27	6.43	7.83
Al (mg/L)	0.02		0.0007	0.0007	0.0082
Alkalinity (as mg/L $CaCO_3$)	401		244	302	383
As (mg/L)	0.012		0.0011	0.0026	0.0116
B (mg/L)	0.18		0.2353	3.32	6.41
Ba (mg/L)	0	na	0.0075	0.0117	0.0192
Be (mg/L)	0	na	<0.0001	<0.0001	<0.0001
Ca (mg/L)	1.0		14.1	995	1,294
Cd (mg/L)	0.00005		<0.0001	0.0003	0.0006
Cl (mg/L)	89		90.5	1,971	3,851
Co (mg/L)	0.0005		0.0016	0.0095	0.0174
Cr (mg/L)	0.0005		<0.0001	<0.0001	0.0002
Cu (mg/L)	0.0005		0.0025	0.0172	0.0321
Fe (mg/L)	0.025		0.0001	2.43	4.88
Hg (mg/L)	0.00005		<0.0001	0.0003	0.0006
K (mg/L)	5.0		6.72	197	387
Mg (mg/L)	1.0		2.99	266	528
Mn (mg/L)	0.015		0.1601	15.4	30.0
Mo (mg/L)	0.004		0.0064	0.0642	0.1215
Na (mg/L)	234		238	514	790
Ni (mg/L)	0.0005		0.0024	0.032	0.0617
Pb (mg/L)	0.0005		0.0001	0.0006	0.0011
SO4 (mg/L)	1		73	1,826	1,861
Sb (mg/L)	0	na	0.0013	0.0701	0.1389
Se (mg/L)	0.005		0.0055	0.0239	0.0406
Sn (mg/L)	_		<0.0001	<0.0001	<0.0001
Sr (mg/L)	_		<0.0001	<0.0001	<0.0001
Tl (mg/L)	_		<0.0001	<0.0001	<0.0001
U (mg/L)	0	na	0.0002	0.0371	0.0741
V (mg/L)	0.005		0.0055	0.0303	0.0551
Zn (mg/L)	0.011		0.019	0.1624	0.3064
TDS (mg/L, calculated)			607	5,966	8,976
Charge balance (%)	_	1	-0.54	-0.03	6.32
Ionic strength	_	2	0.01	0.12	0.19

NOTES

1	Charge balance error in the range +/-25 is considered suitable for this assessment
2	The PHREEQC ion association model is generally valid for ionic strength less than ~0.5
_	Not applicable.

Esmeralda pit void water quality model results:
Scenario 2
No mixing with backfill tailings

Scenario 2	Esmeralda groundwater (median, dissolved)	Note	Modelled void water	Modelled void water	Modelled void water
Parameter	Hydrogeologist.com.au (2026)		Minimum	Median	Maximum
pH	8.55		7.43	7.55	7.83
Al (mg/L)	0.02		0.0036	0.0045	0.0082
Alkalinity (as mg/L $CaCO_3$)	401		304	558	803
As (mg/L)	0.012		0.0116	0.0309	0.0498
B (mg/L)	0.18		0.2353	1.86	3.48
Ba (mg/L)	0	na	0.0075	0.0184	0.0228
Be (mg/L)	0	na	<0.0001	0.0002	0.0003
Ca (mg/L)	1.0		14.1	19	21
Cd (mg/L)	0.00005		<0.0001	0.0003	0.0006
Cl (mg/L)	89		90.5	93	95
Co (mg/L)	0.0005		0.0016	0.004	0.0065
Cr (mg/L)	0.0005		0.0002	0.0004	0.0005
Cu (mg/L)	0.0005		0.0025	0.0166	0.0306
Fe (mg/L)	0.025		0.0001	0.00	0.00
Hg (mg/L)	0.00005		<0.0001	0.0003	0.0005
K (mg/L)	5.0		6.72	26	46
Mg (mg/L)	1.0		2.99	8	13
Mn (mg/L)	0.015		0.1601	0.2	0.2
Mo (mg/L)	0.004		0.0064	0.1546	0.3016
Na (mg/L)	234		238	441	642
Ni (mg/L)	0.0005		0.0024	0.0048	0.0073
Pb (mg/L)	0.0005		0.0005	0.0027	0.0049
SO4 (mg/L)	1		73	221	367
Sb (mg/L)	0	na	0.0013	0.2437	0.4842
Se (mg/L)	0.005		0.0055	0.0154	0.0252
Sn (mg/L)	_		<0.0001	<0.0001	<0.0001
Sr (mg/L)	_		<0.0001	<0.0001	<0.0001
Tl (mg/L)	_		<0.0001	<0.0001	<0.0001
U (mg/L)	0	na	0.0002	0.0026	0.0051
V (mg/L)	0.005		0.0055	0.0291	0.0524
Zn (mg/L)	0.011		0.019	0.0311	0.0432
TDS (mg/L, calculated)			607	1,143	1,666
Charge balance (%)	_	1	6.32	7.89	8.55
Ionic strength	_	2	0.01	0.02	0.03

NOTES

1	Charge balance error in the range +/-25 is considered suitable for this assessment
2	The PHREEQC ion association model is generally valid for ionic strength less than ~0.5
_	Not applicable.

Esmeralda pit void water quality model results:
Scenario 3
Base case with acid generation in tailings during transfer to backfill

Scenario 3	Esmeralda groundwater (median, dissolved)	Note	Modelled void water	Modelled void water	Modelled void water
Parameter	Hydrogeologist.com.au (2026)		Minimum	Median	Maximum
pH	8.55		6.25	6.39	6.78
Al (mg/L)	0.02		0.0007	0.0007	0.0009
Alkalinity (as mg/L $CaCO_3$)	401		244	326	405
As (mg/L)	0.012		<0.0001	0.0025	0.0041
B (mg/L)	0.18		0.217	3.30	6.39
Ba (mg/L)	0	na	0.0016	0.0116	0.0153
Be (mg/L)	0	na	<0.0001	<0.0001	0.0034
Ca (mg/L)	1.0		31.8	1,002	1,300
Cd (mg/L)	0.00005		0.0118	0.012	0.0123
Cl (mg/L)	89		97.7	1,978	3,858
Co (mg/L)	0.0005		0.467	0.4745	0.4823
Cr (mg/L)	0.0005		0.0001	0.0002	0.0013
Cu (mg/L)	0.0005		0.2826	0.2969	0.3115
Fe (mg/L)	0.025		3.72	6.20	8.65
Hg (mg/L)	0.00005		<0.0001	0.0003	0.0006
K (mg/L)	5.0		6.87	197	388
Mg (mg/L)	1.0		5.49	268	531
Mn (mg/L)	0.015		2.24	16.8	30.2
Mo (mg/L)	0.004		0.0062	0.064	0.1213
Na (mg/L)	234		237	513	789
Ni (mg/L)	0.0005		1.15	1.17	1.20
Pb (mg/L)	0.0005		0.0033	0.0052	0.0115
SO4 (mg/L)	1		185	1,828	1,862
Sb (mg/L)	0	na	0.0013	0.0701	0.1389
Se (mg/L)	0.005		0.0098	0.028	0.0443
Sn (mg/L)	_		<0.0001	<0.0001	<0.0001
Sr (mg/L)	_		<0.0001	<0.0001	<0.0001
Tl (mg/L)	_		<0.0001	<0.0001	<0.0001
U (mg/L)	0	na	0.0512	0.0881	0.1251
V (mg/L)	0.005		0.0056	0.0304	0.0552
Zn (mg/L)	0.011		3.12	3.25	3.39
TDS (mg/L, calculated)			717	6,005	9,009
Charge balance (%)	_	1	-0.51	0.01	6.04
Ionic strength	_	2	0.01	0.12	0.19

NOTES

1	Charge balance error in the range +/-25 is considered suitable for this assessment
2	The PHREEQC ion association model is generally valid for ionic strength less than ~0.5
_	Not applicable.

Esmeralda pit void water quality model results:
Scenario 4
Acid generation during tailings transfer to backfill and subsequent hydraulic isolation at base of void

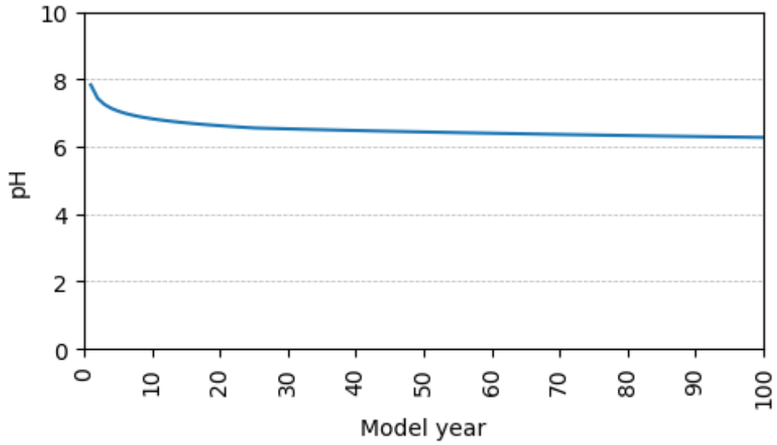
Scenario 4	Esmeralda groundwater (median, dissolved)	Note	Modelled void water	Modelled void water	Modelled void water
Parameter	Hydrogeologist.com.au (2026)		Minimum	Median	Maximum
pH	8.55		6.78	7.10	7.12
Al (mg/L)	0.02		0.0009	0.0017	0.0018
Alkalinity (as mg/L $CaCO_3$)	401		244	545	769
As (mg/L)	0.012		0.0015	0.0063	0.0126
B (mg/L)	0.18		0.217	1.85	3.46
Ba (mg/L)	0	na	0.0016	0.0145	0.0171
Be (mg/L)	0	na	<0.0001	<0.0001	0.0034
Ca (mg/L)	1.0		31.8	51.2	56.7
Cd (mg/L)	0.00005		0.0118	0.012	0.0122
Cl (mg/L)	89		97.7	100	103
Co (mg/L)	0.0005		0.467	0.4675	0.4679
Cr (mg/L)	0.0005		0.001	0.0011	0.0017
Cu (mg/L)	0.0005		0.2826	0.2961	0.3094
Fe (mg/L)	0.025		3.07	3.38	3.72
Hg (mg/L)	0.00005		<0.0001	0.0003	0.0005
K (mg/L)	5.0		6.87	26.6	46.2
Mg (mg/L)	1.0		5.49	10.4	15.3
Mn (mg/L)	0.015		0.6051	0.6803	2.24
Mo (mg/L)	0.004		0.0062	0.1543	0.3012
Na (mg/L)	234		237	440	641
Ni (mg/L)	0.0005		1.14	1.14	1.15
Pb (mg/L)	0.0005		0.0115	0.0122	0.0125
SO4 (mg/L)	1		185	333	479
Sb (mg/L)	0	na	0.0013	0.2437	0.4842
Se (mg/L)	0.005		0.0098	0.0197	0.0295
Sn (mg/L)	_		<0.0001	<0.0001	<0.0001
Sr (mg/L)	_		<0.0001	<0.0001	<0.0001
Tl (mg/L)	_		<0.0001	<0.0001	<0.0001
U (mg/L)	0	na	0.0512	0.0535	0.0558
V (mg/L)	0.005		0.0056	0.0303	0.0548
Zn (mg/L)	0.011		3.10	3.11	3.12
TDS (mg/L, calculated)			717	1,297	1,799
Charge balance (%)	_	1	6.04	7.41	8.28
Ionic strength	_	2	0.01	0.03	0.04

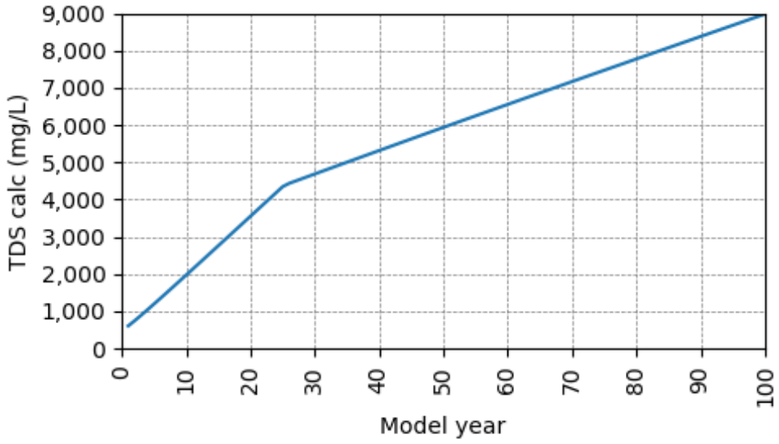
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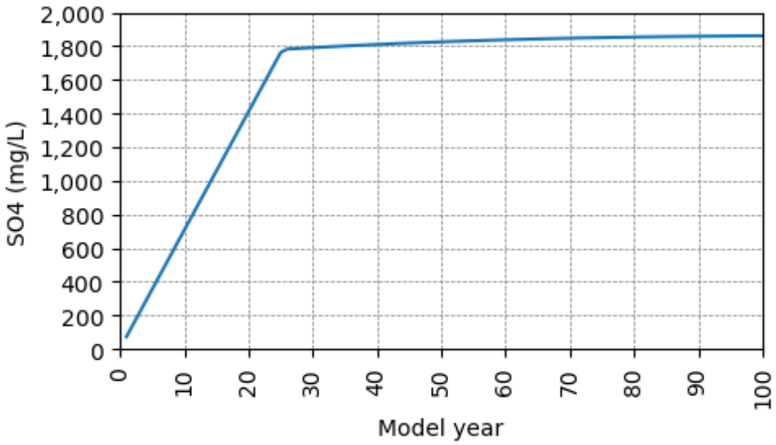
1	Charge balance error in the range +/-25 is considered suitable for this assessment
2	The PHREEQC ion association model is generally valid for ionic strength less than ~0.5
_	Not applicable.

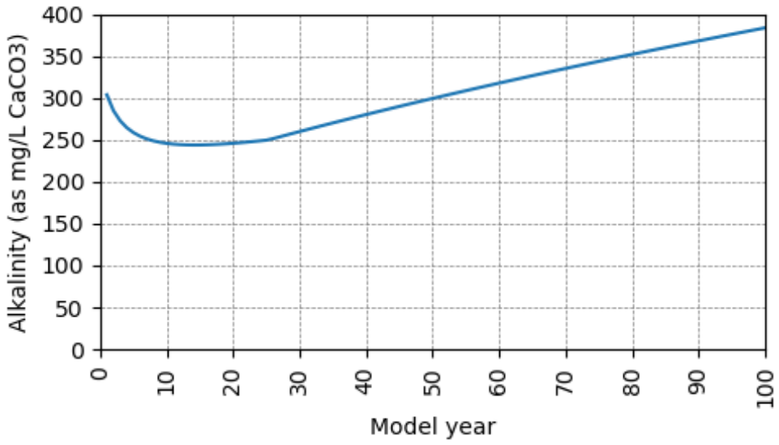
Attachment D Graphical results of modelled pit void water quality

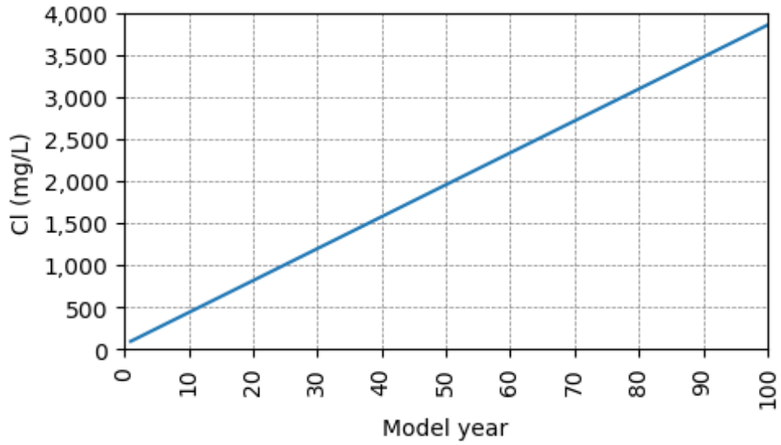
Esmeralda - WB/WQ model results:
Scenario 1
Base case - complete mixing in backfill pore volume

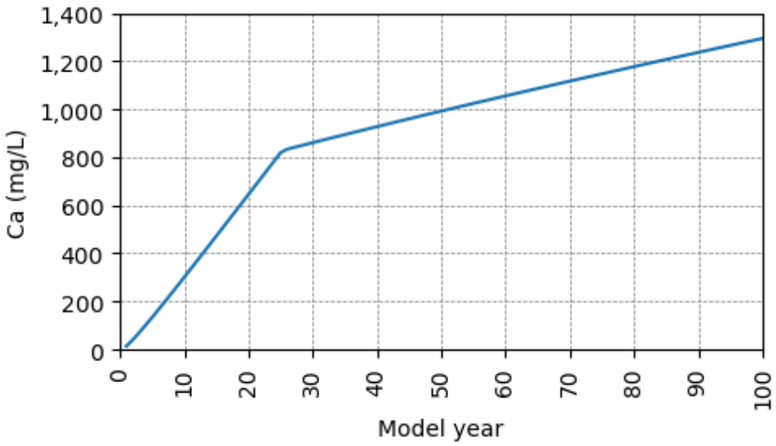


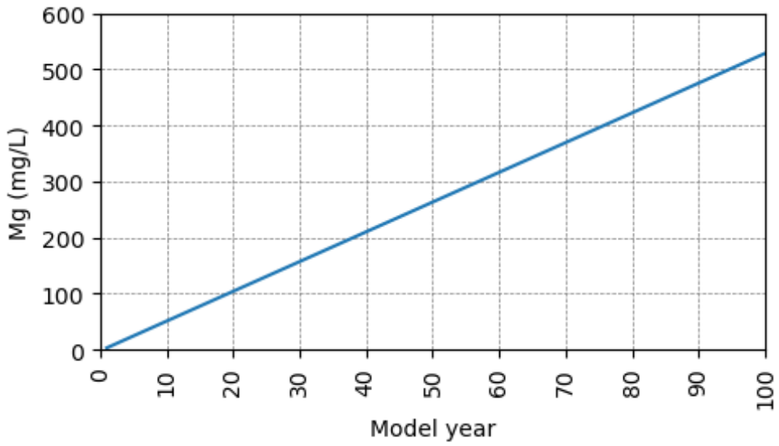


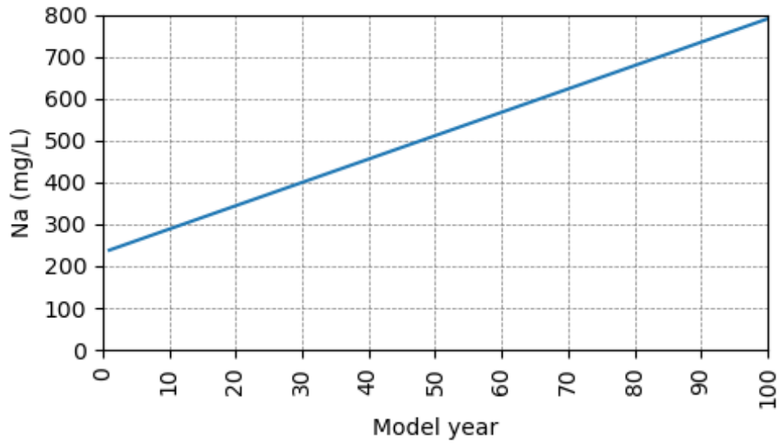




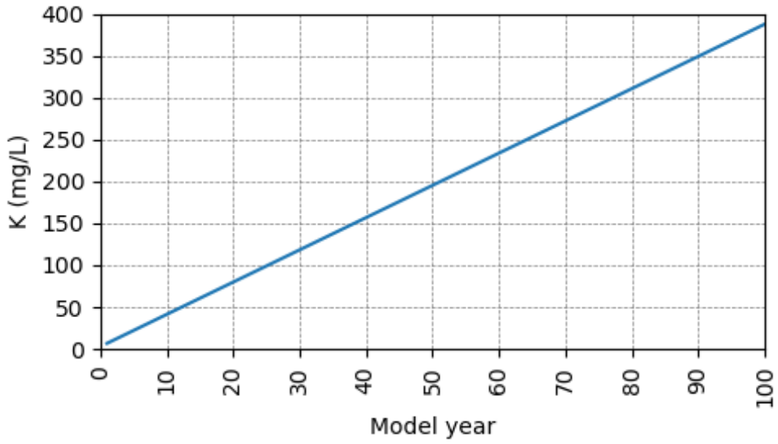


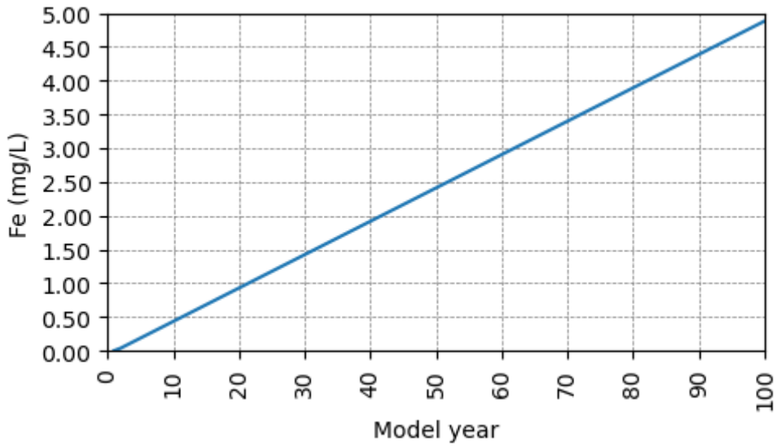


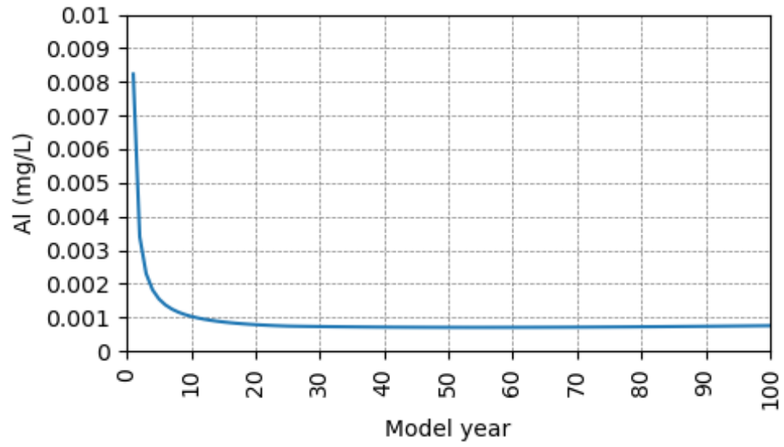


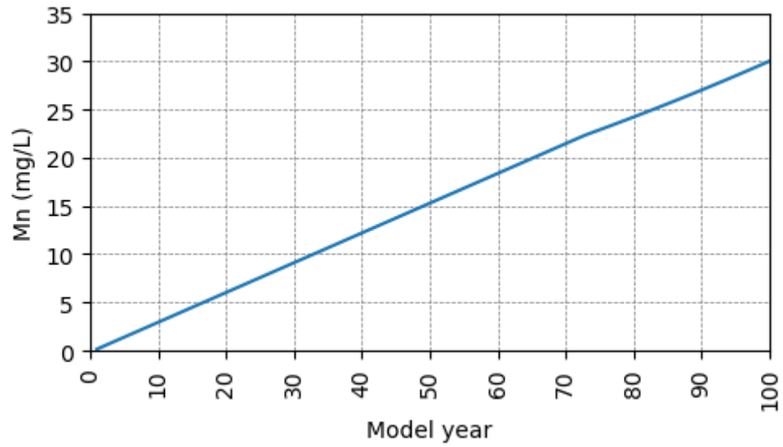


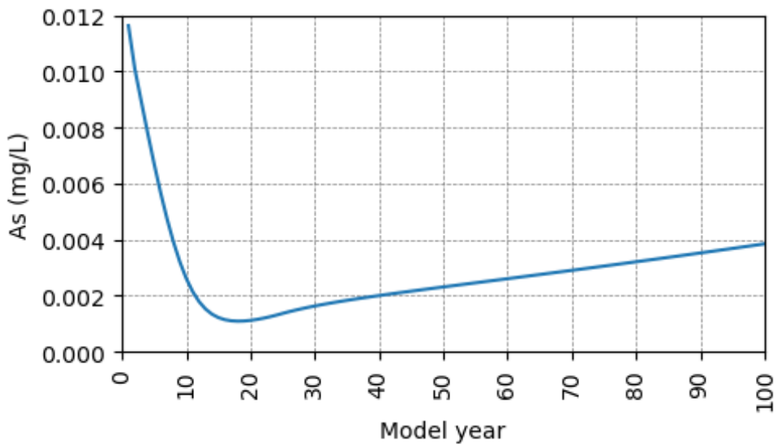
Esmeralda - WB/WQ model results:
Scenario 1
Base case - complete mixing in backfill pore volume

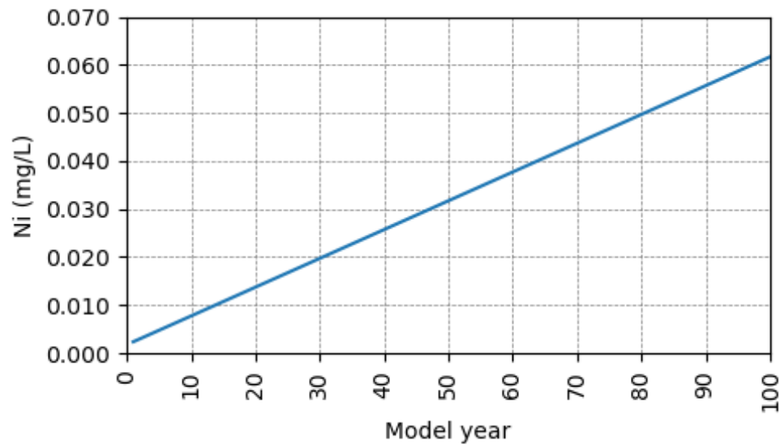


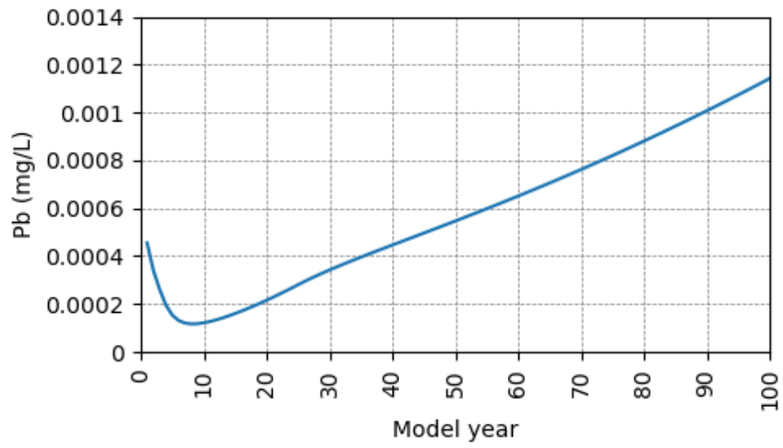




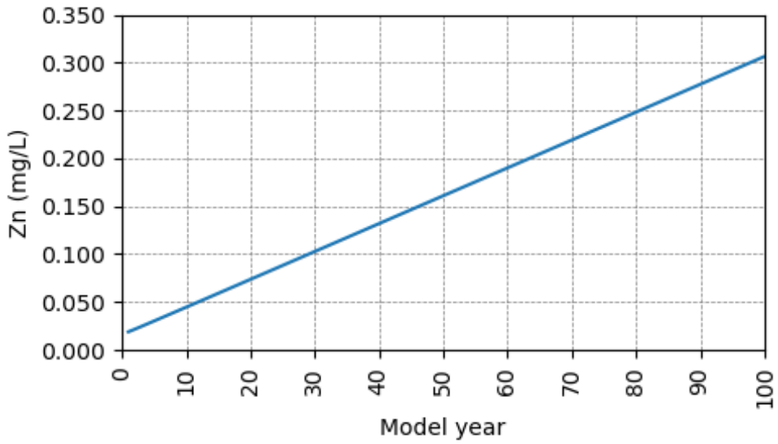


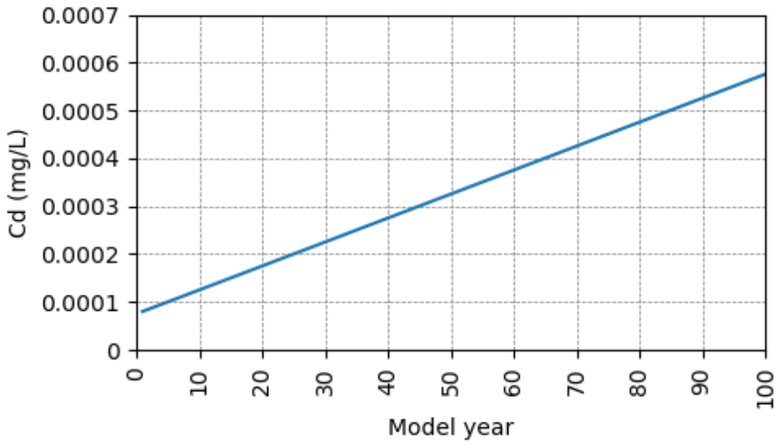


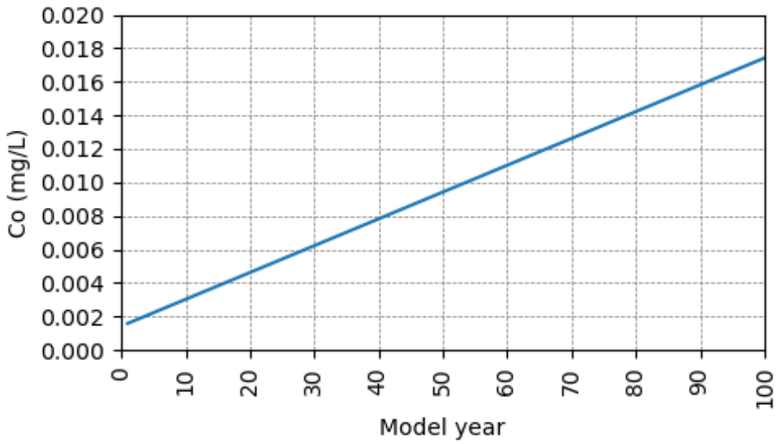


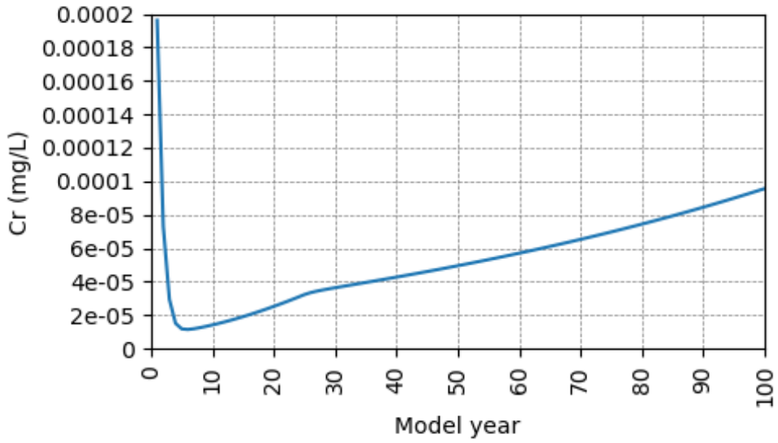


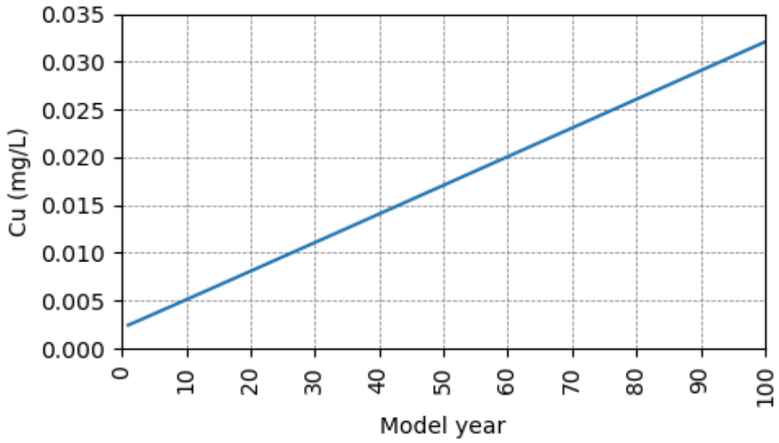
Esmeralda - WB/WQ model results:
Scenario 1
Base case - complete mixing in backfill pore volume

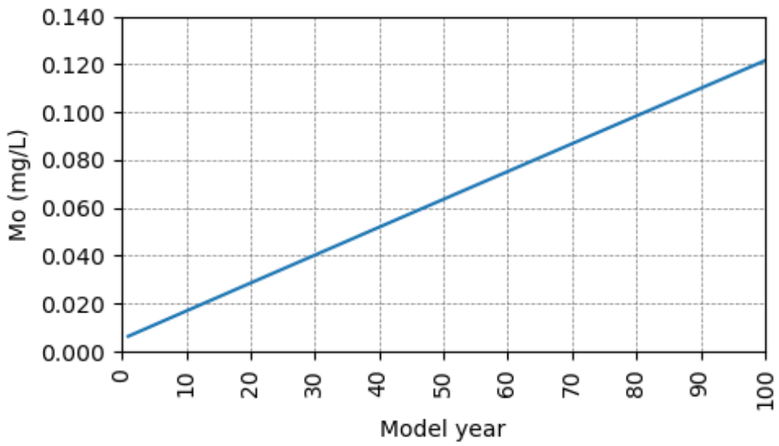


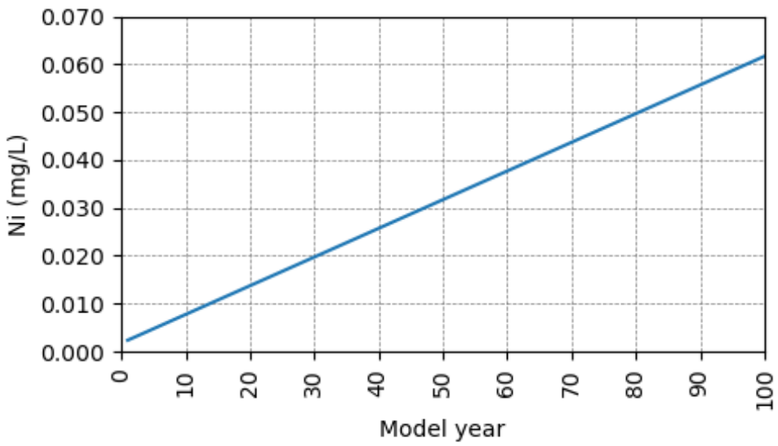




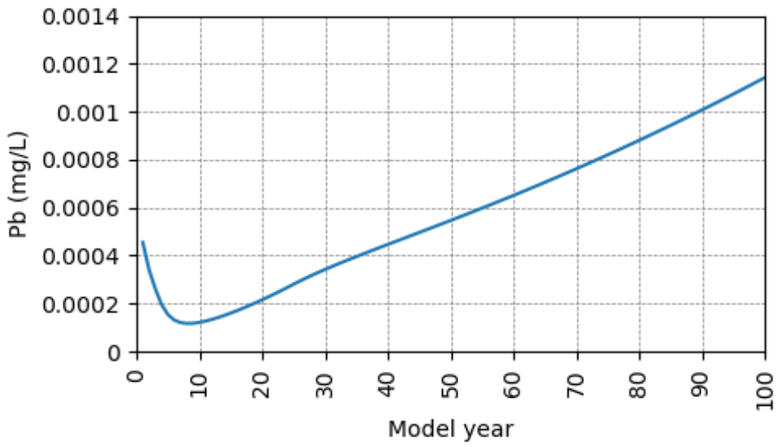


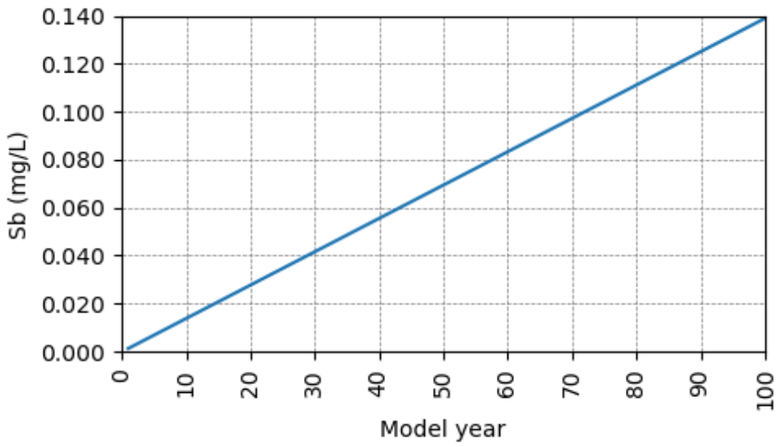


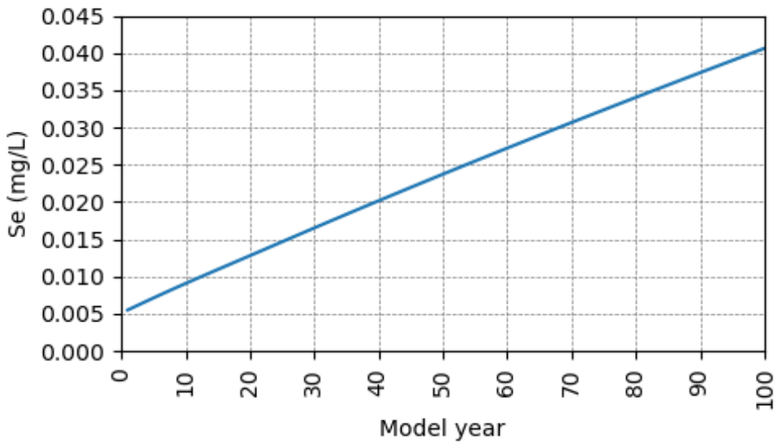


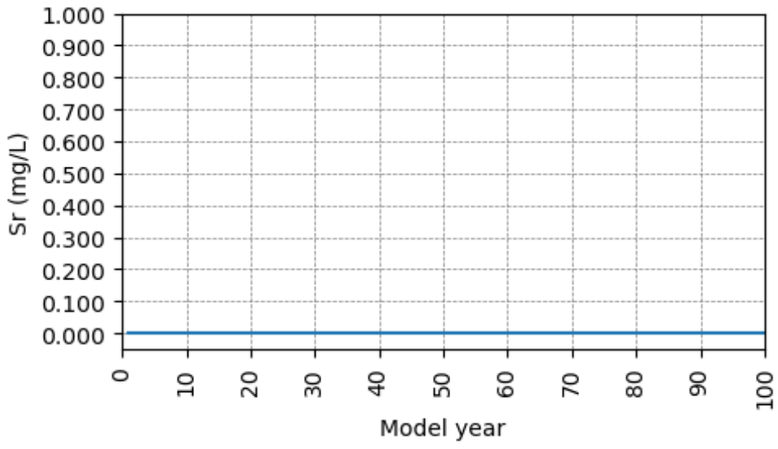


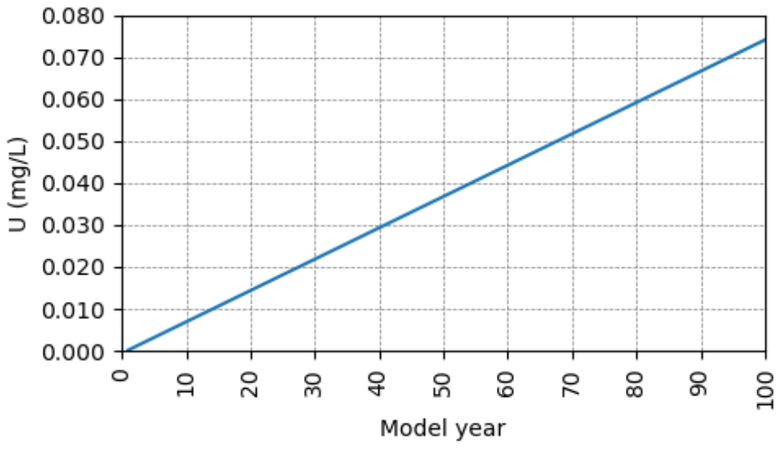
Esmeralda - WB/WQ model results:
Scenario 1
Base case - complete mixing in backfill pore volume

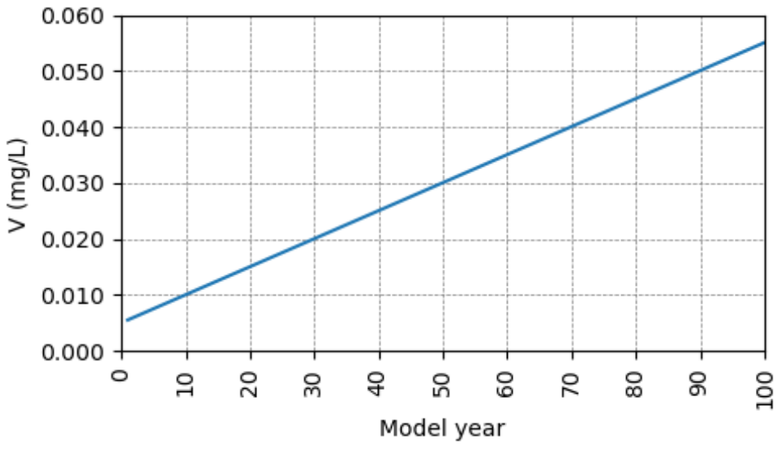


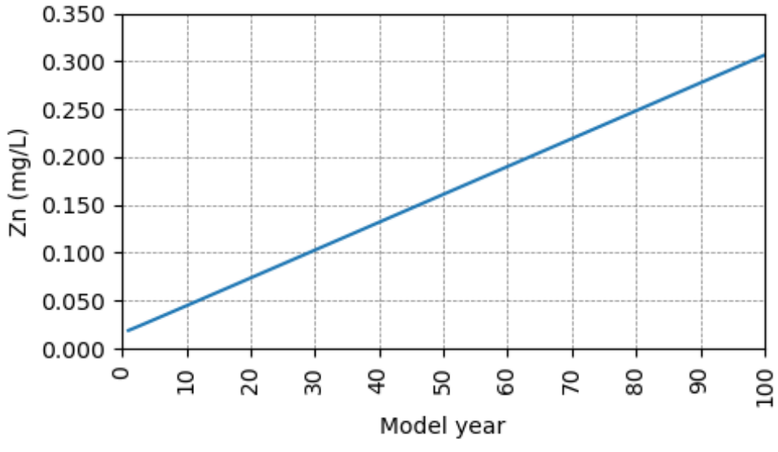


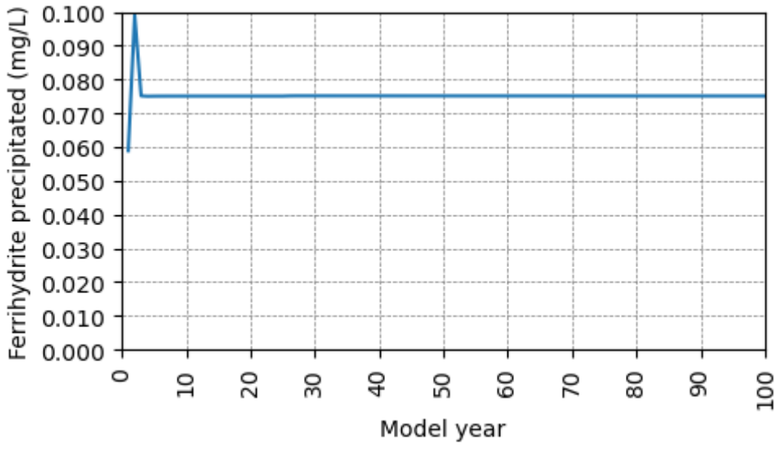




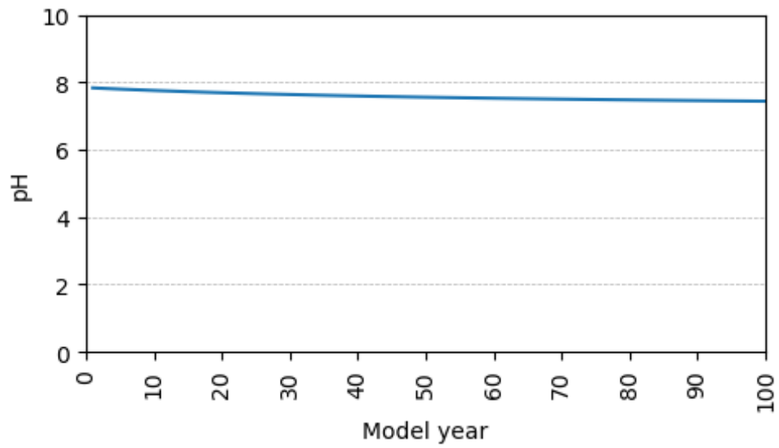


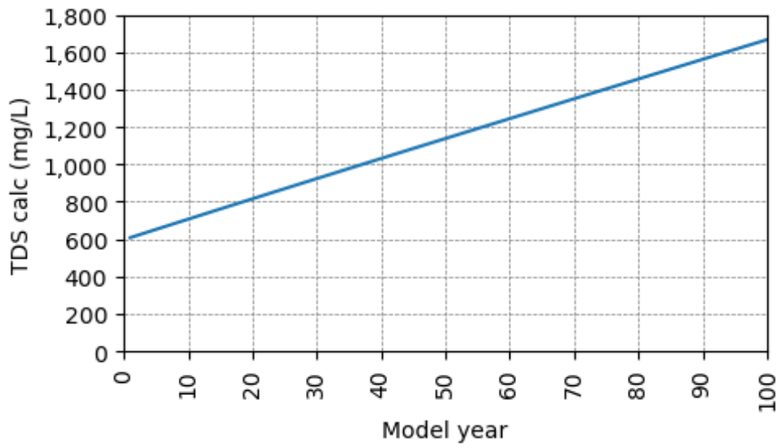


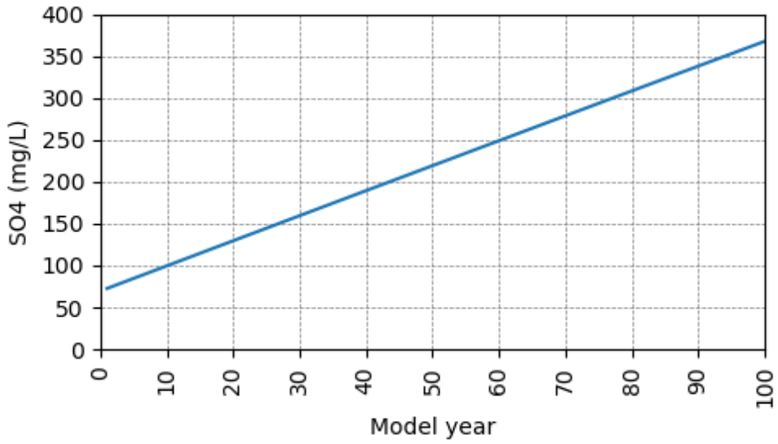


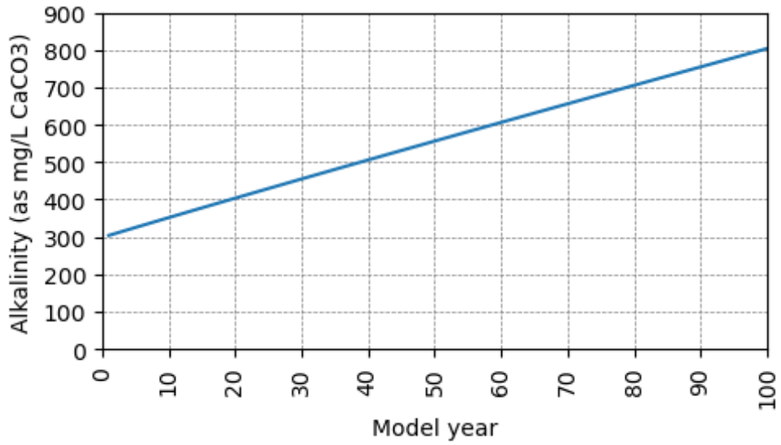


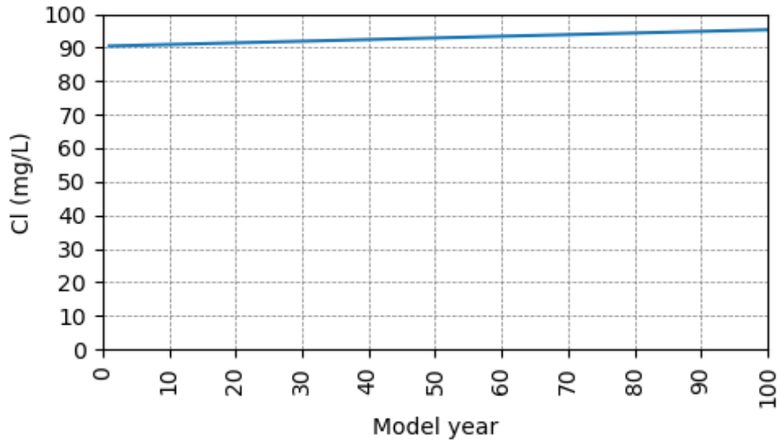
Esmeralda - WB/WQ model results:
Scenario 2
No mixing with backfill tailings

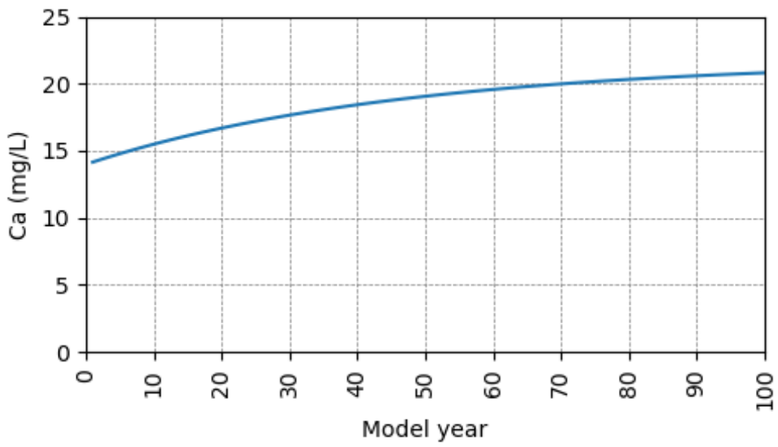


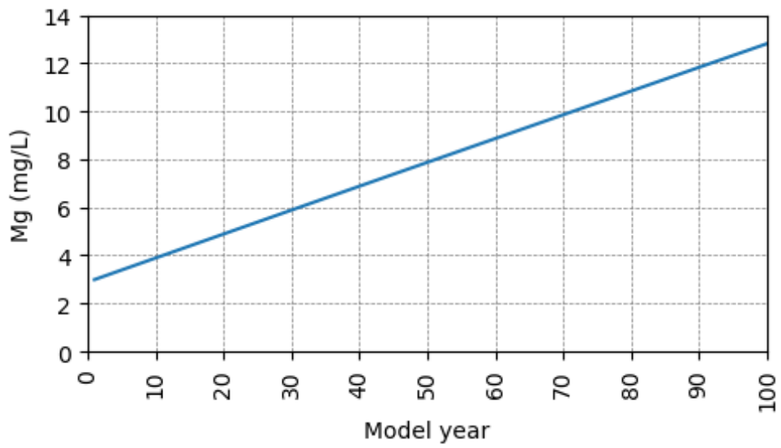


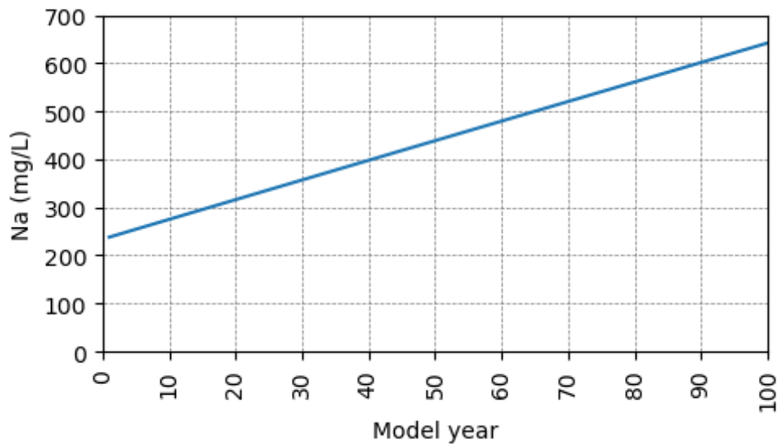




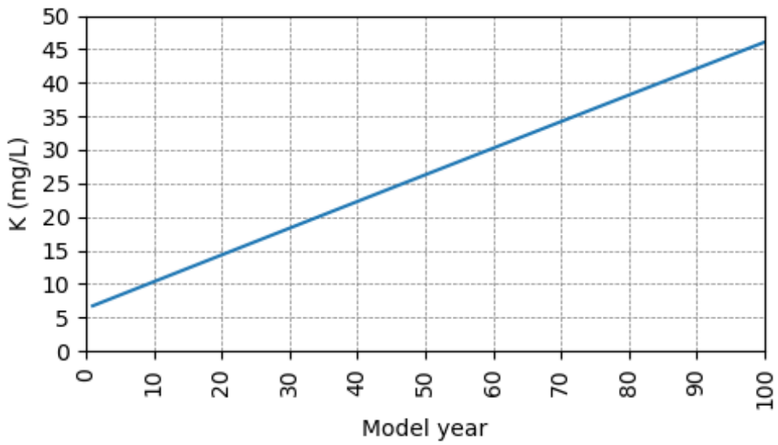


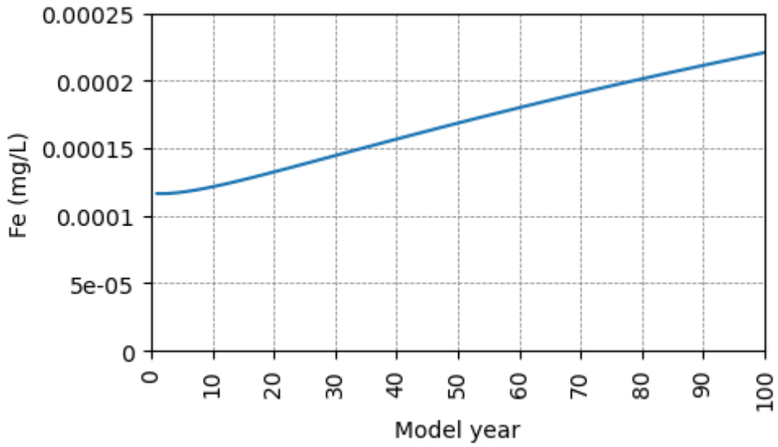


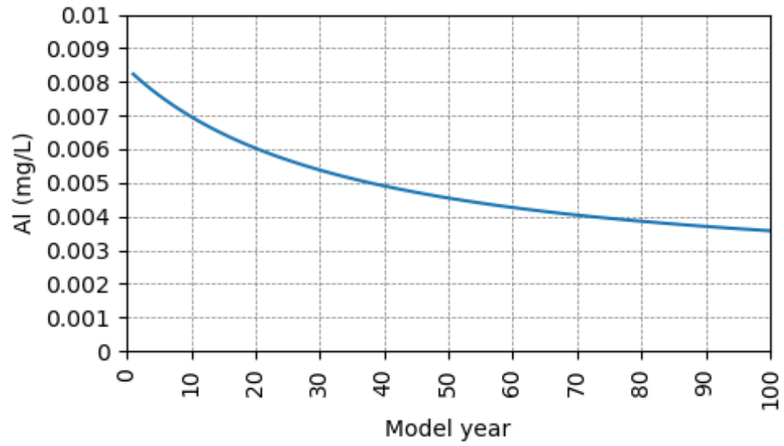


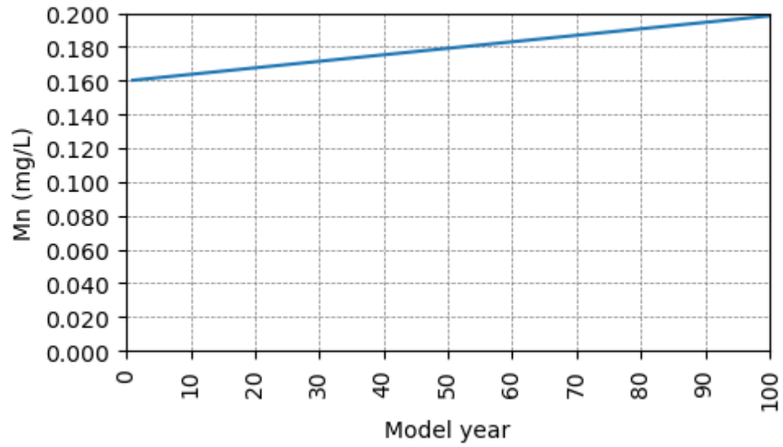


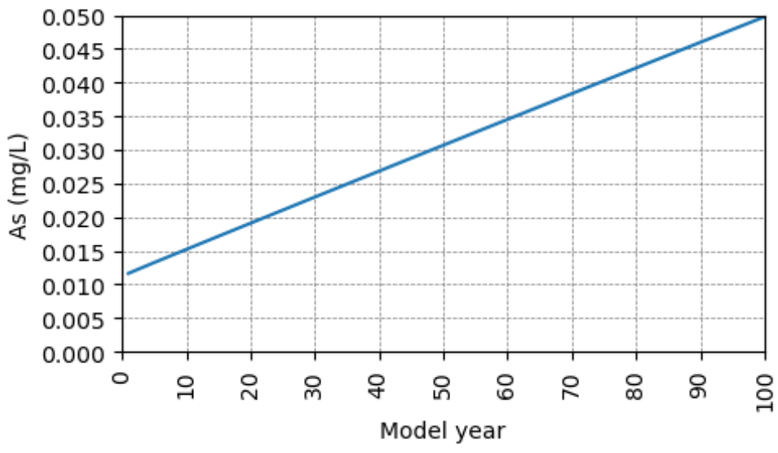
Esmeralda - WB/WQ model results:
Scenario 2
No mixing with backfill tailings

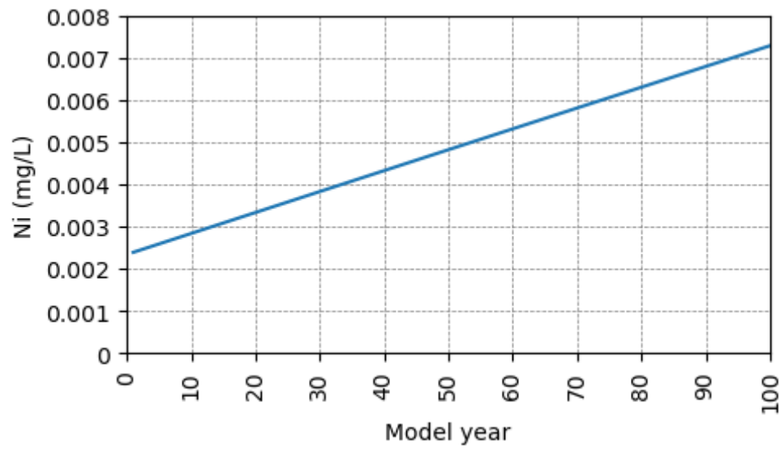


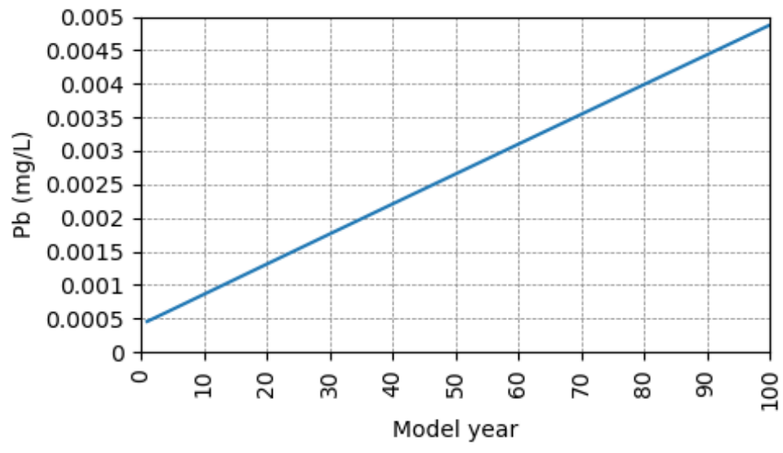




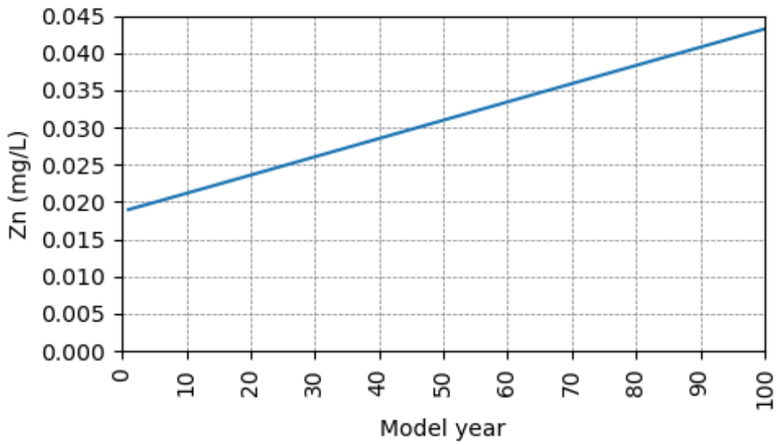


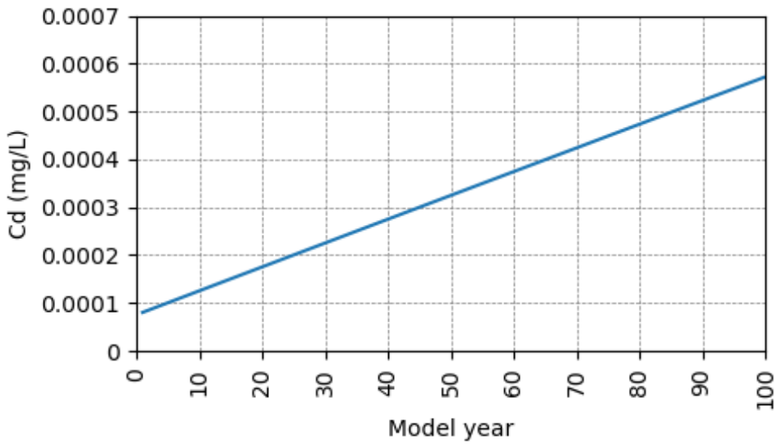


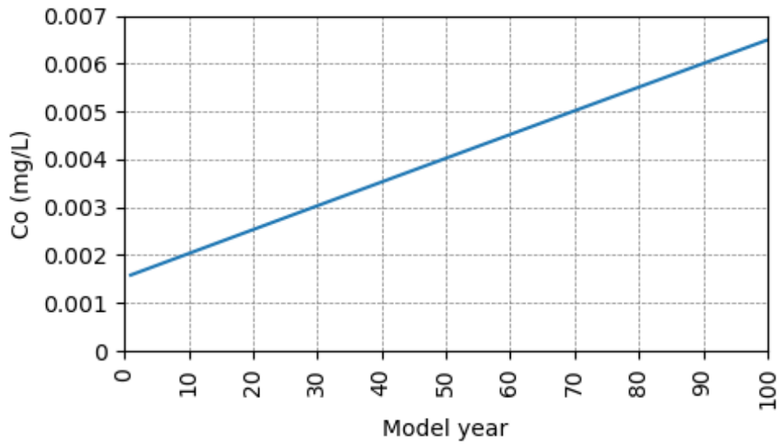


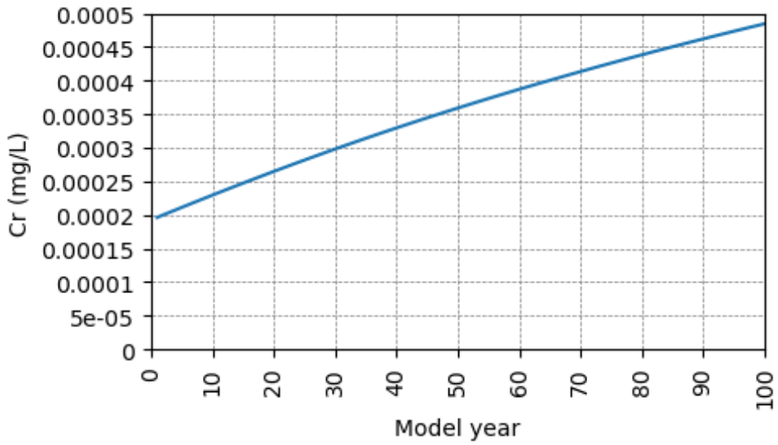


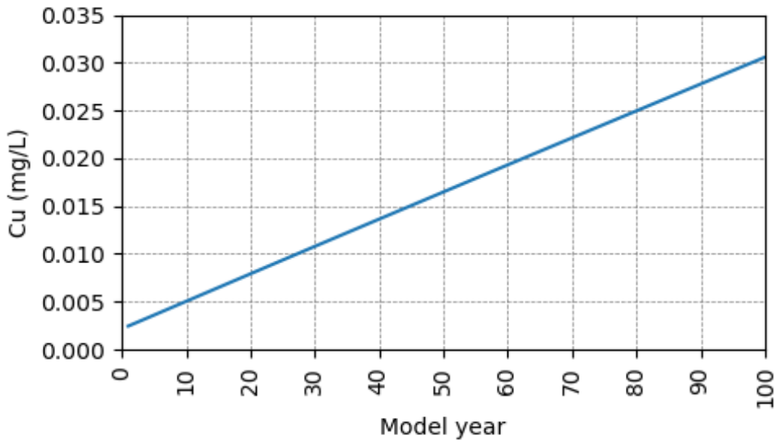
Esmeralda - WB/WQ model results:
Scenario 2
No mixing with backfill tailings

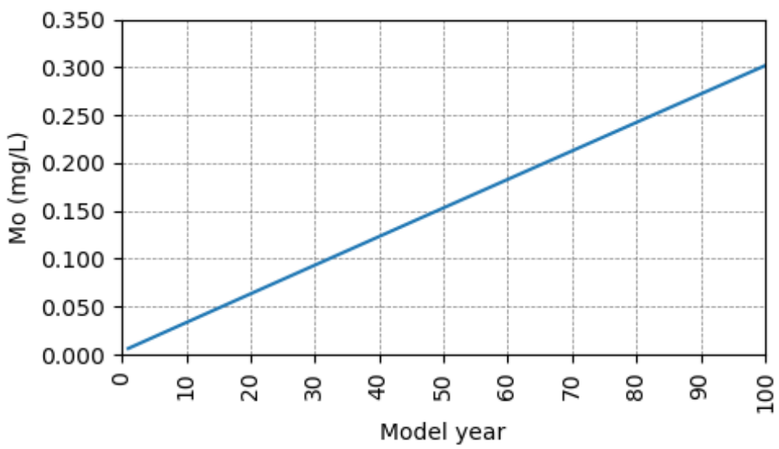


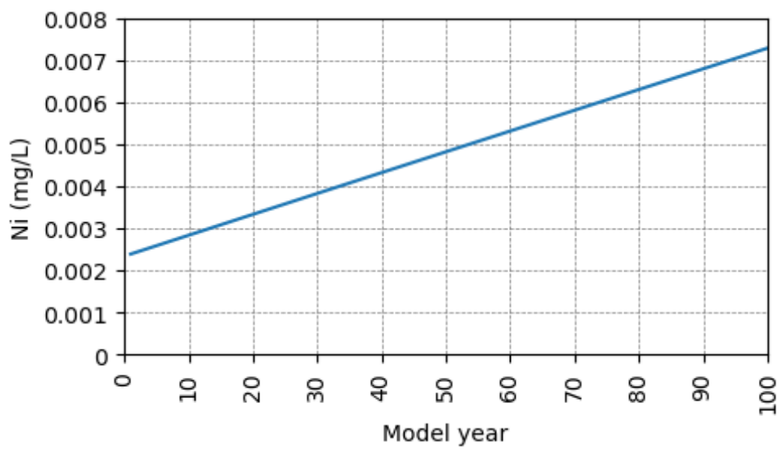




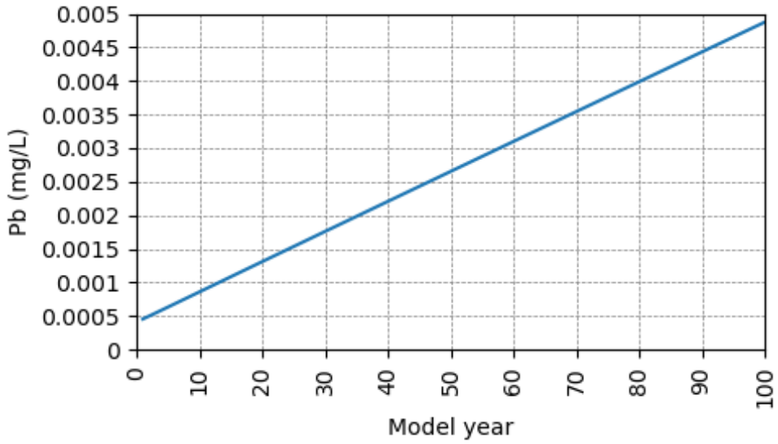


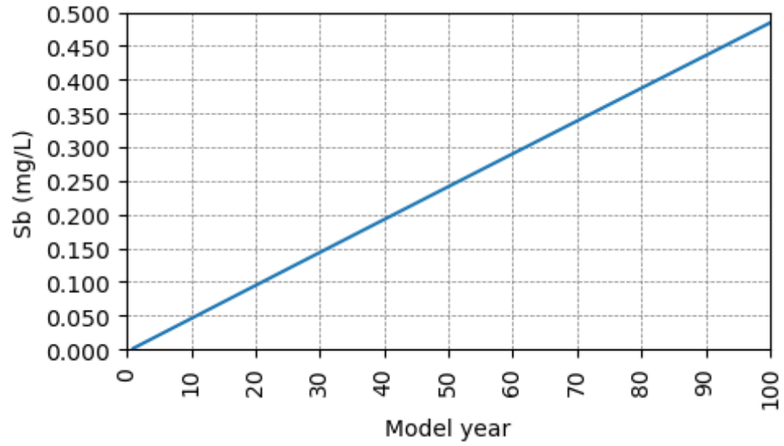


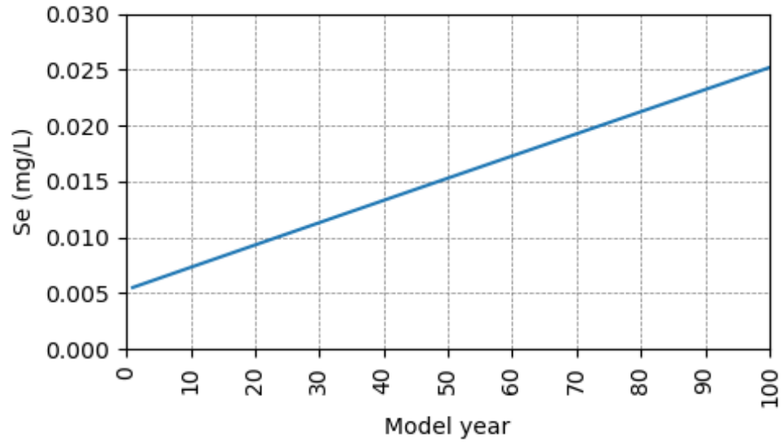


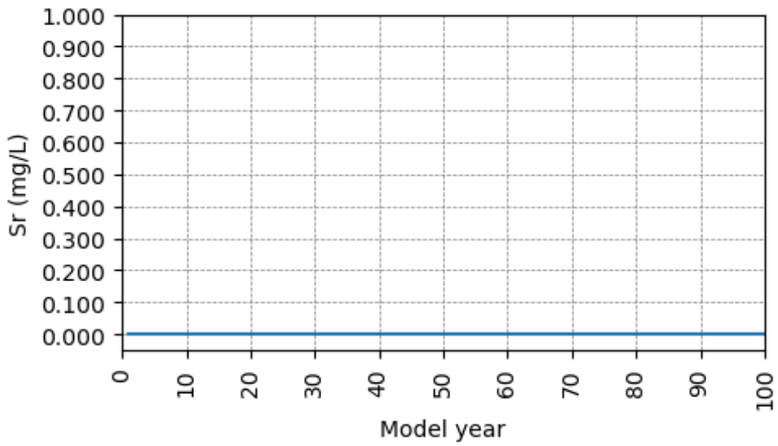


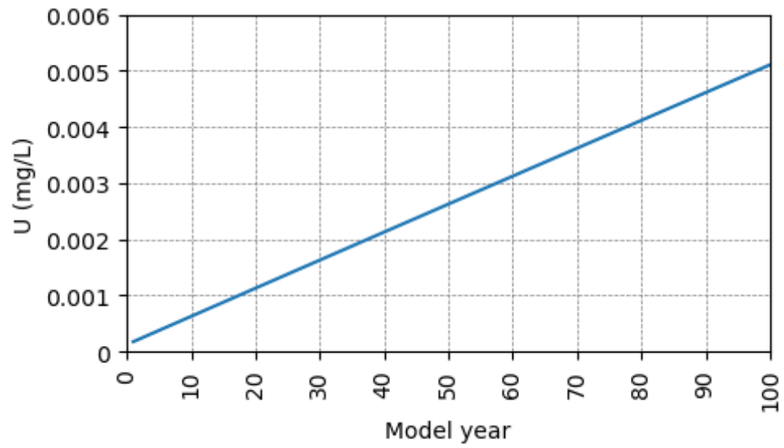
Esmeralda - WB/WQ model results:
Scenario 2
No mixing with backfill tailings

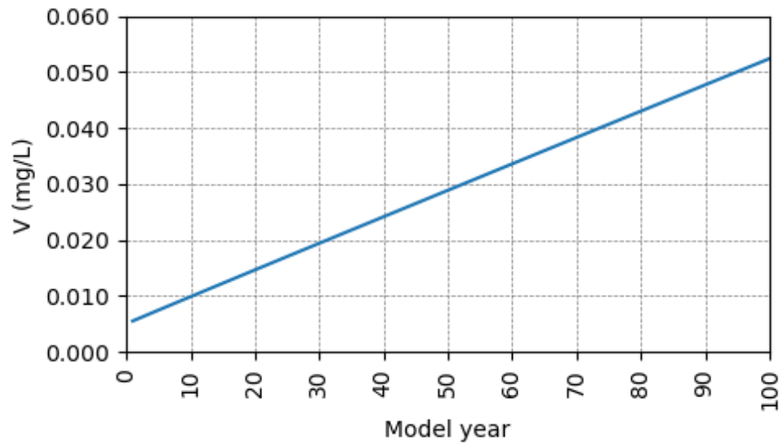


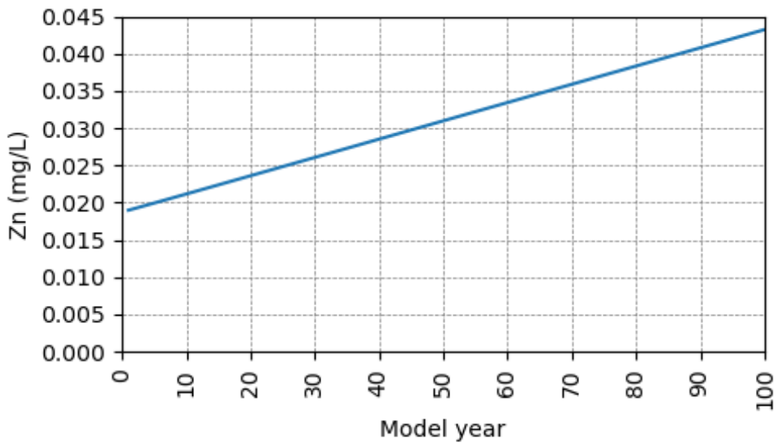


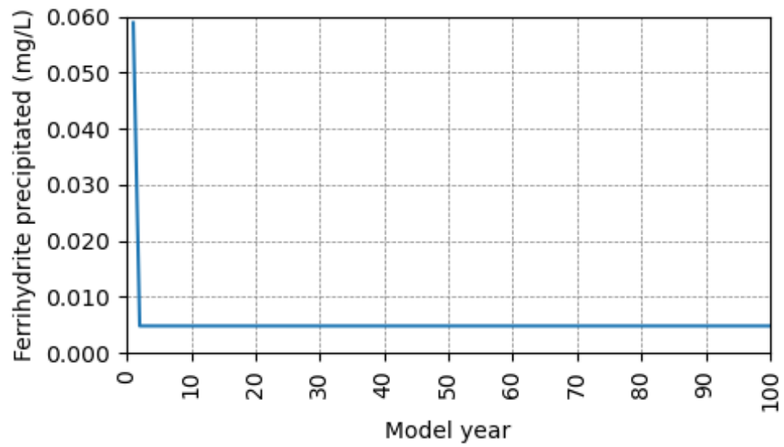




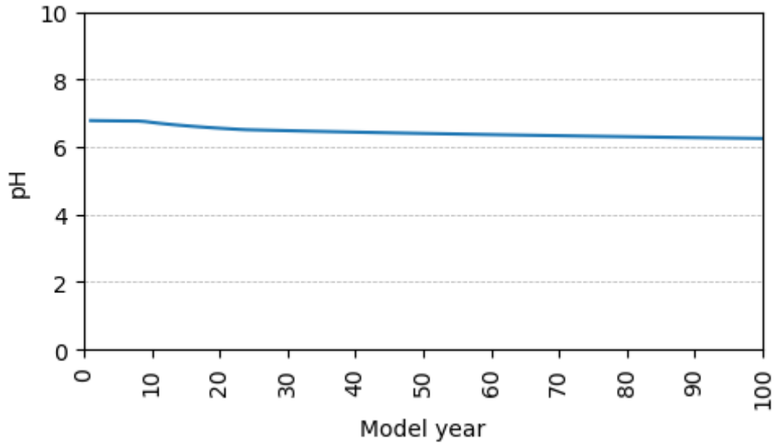


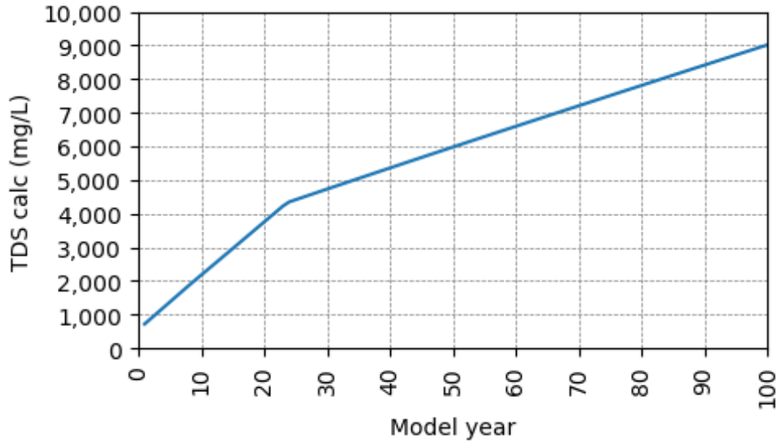


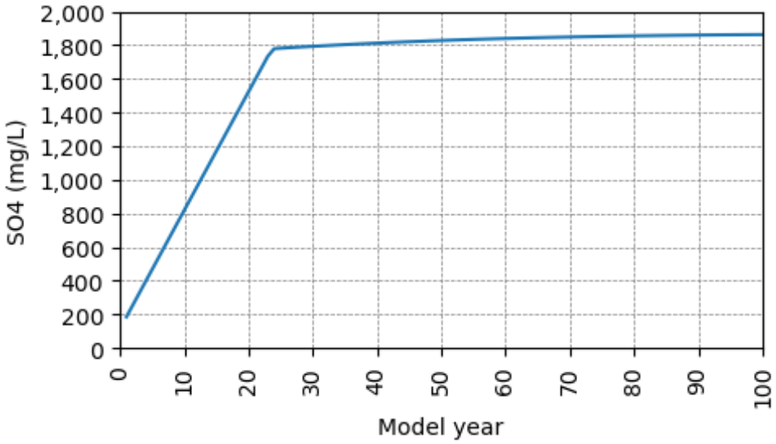


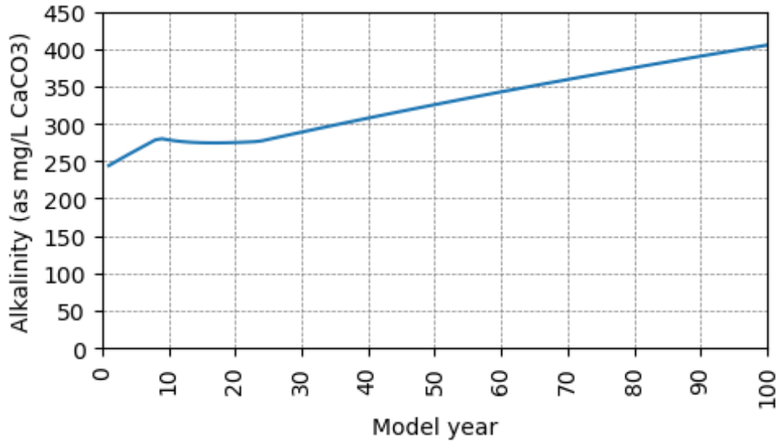


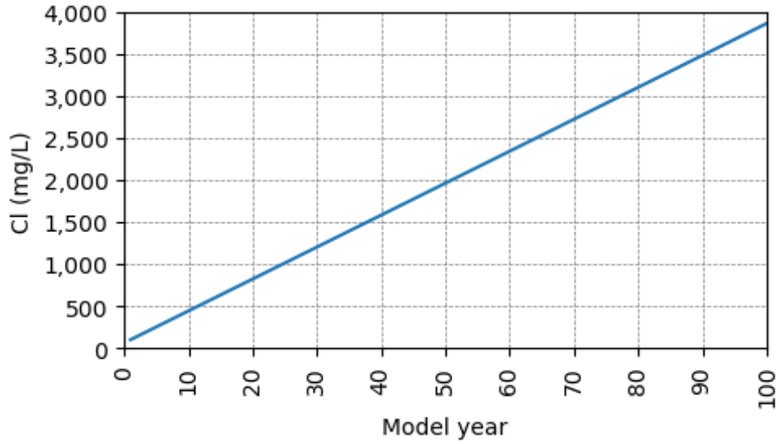
Esmeralda - WB/WQ model results:
Scenario 3
Base case with acid generation in tailings during transfer to backfill

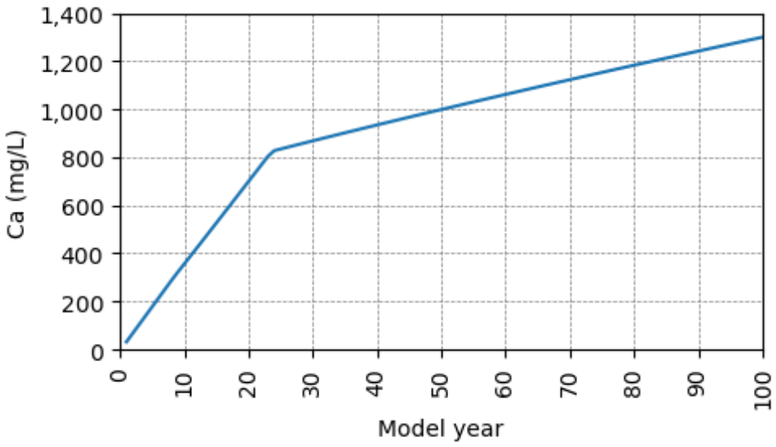


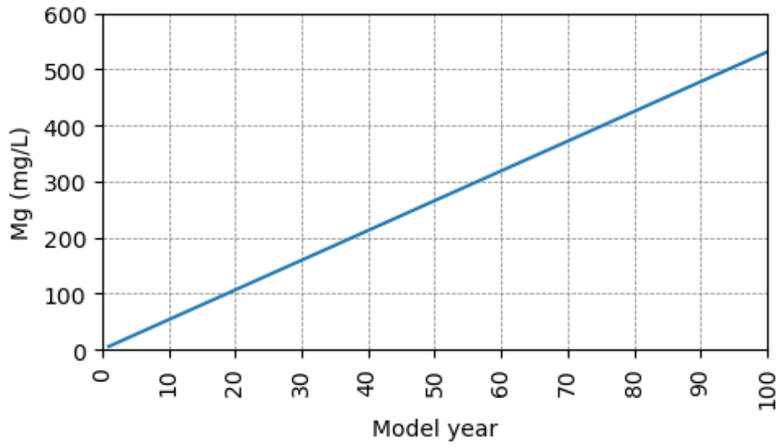


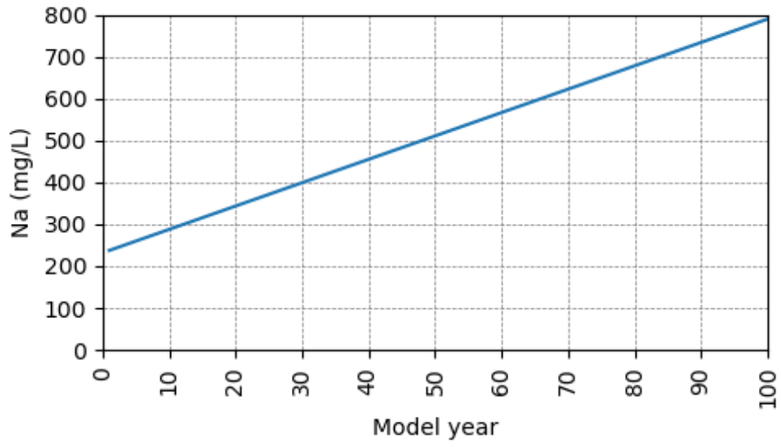




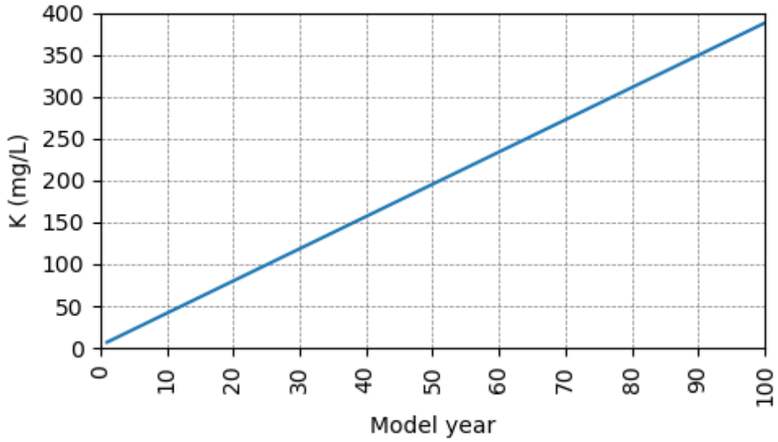


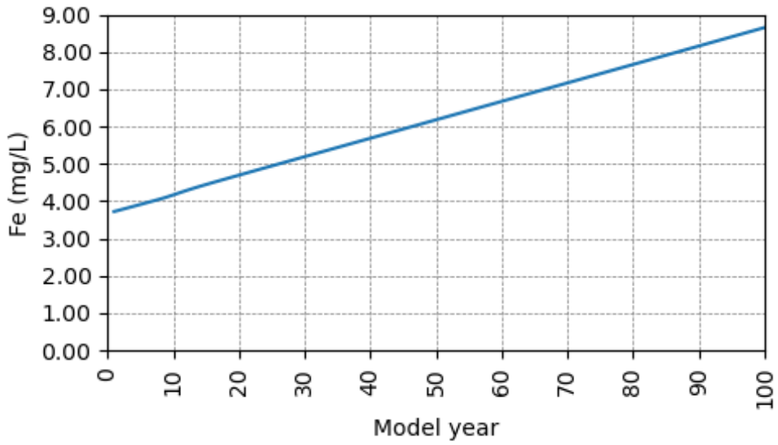


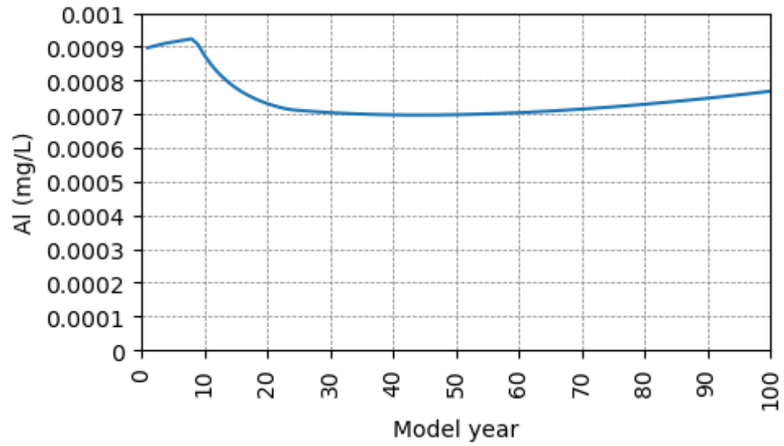


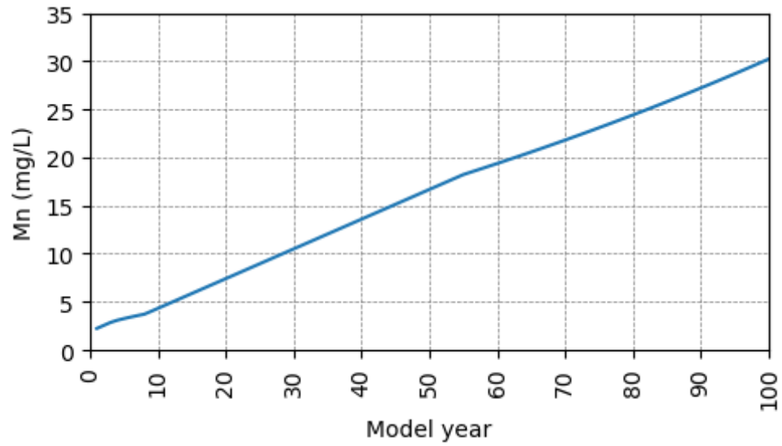


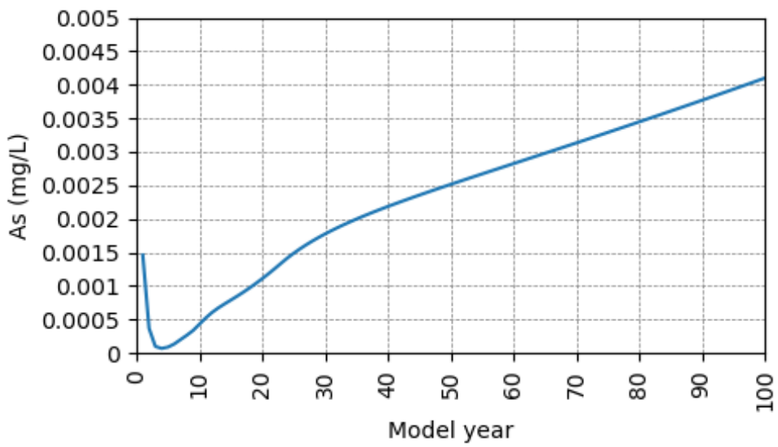
Esmeralda - WB/WQ model results:
Scenario 3
Base case with acid generation in tailings during transfer to backfill

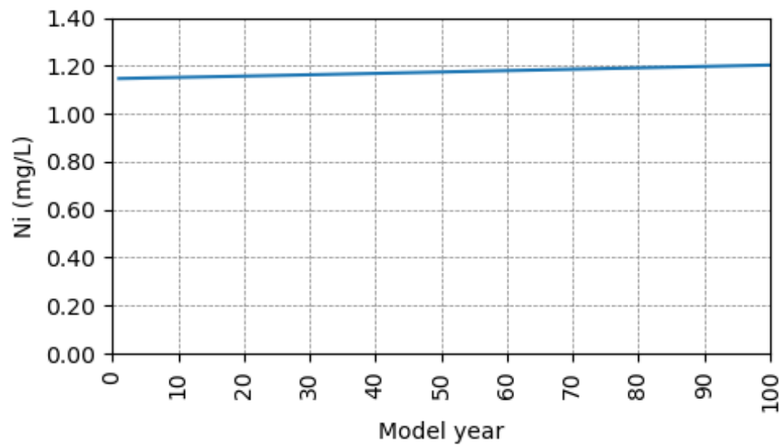


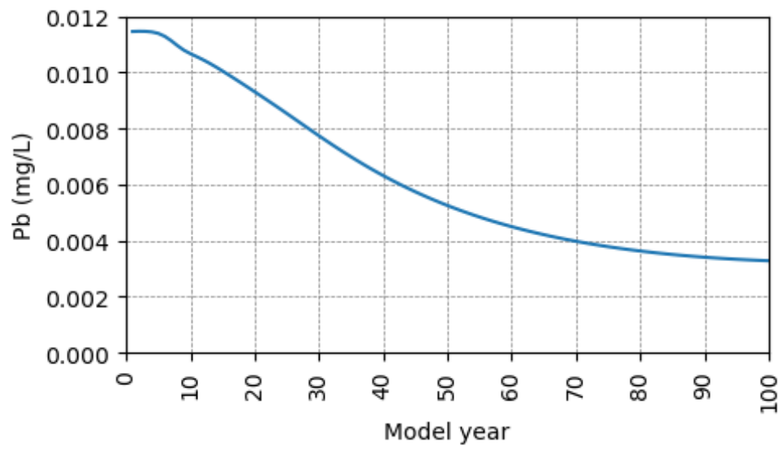




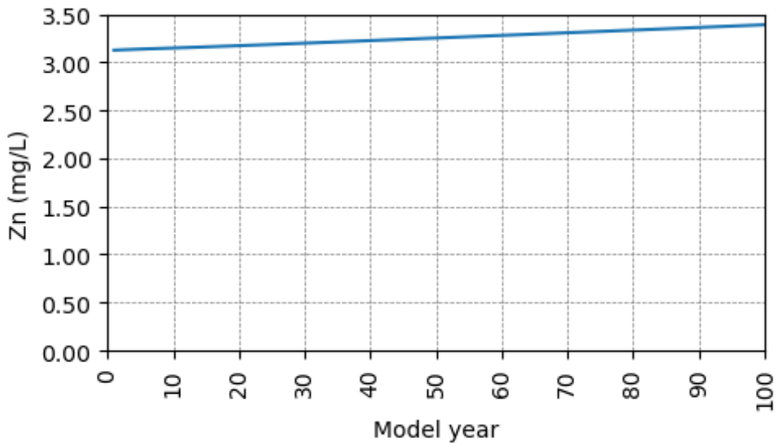


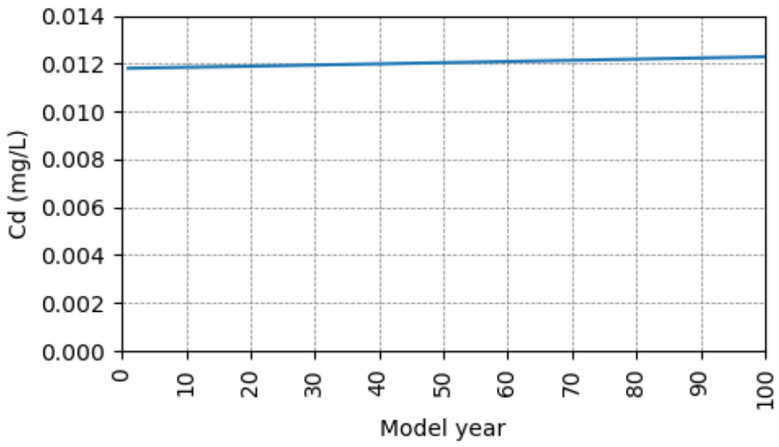


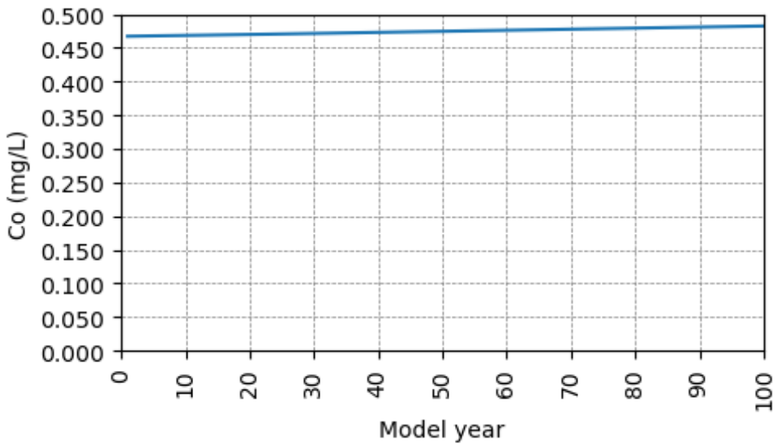


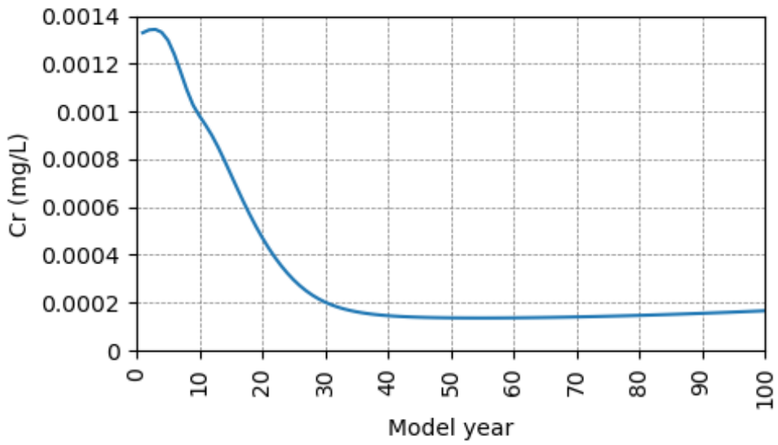


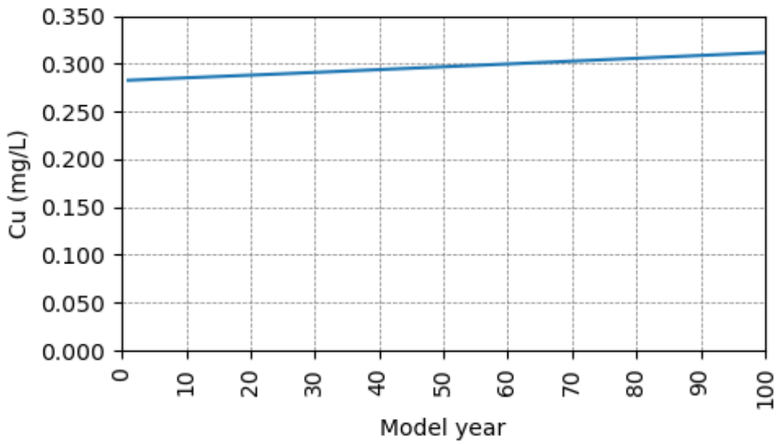
Esmeralda - WB/WQ model results:
Scenario 3
Base case with acid generation in tailings during transfer to backfill

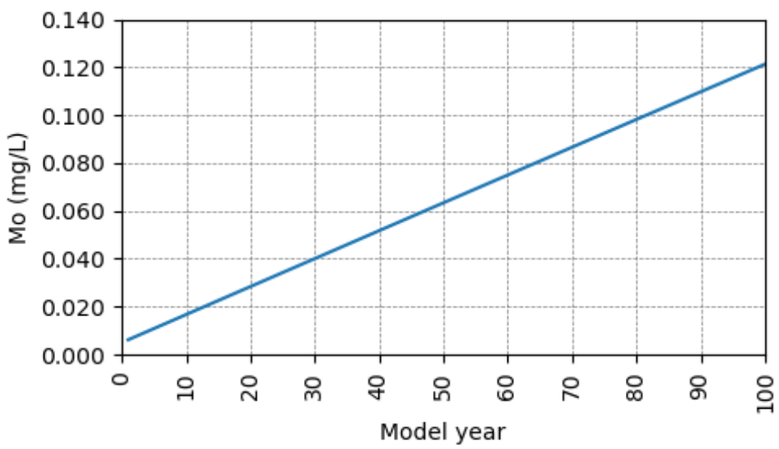


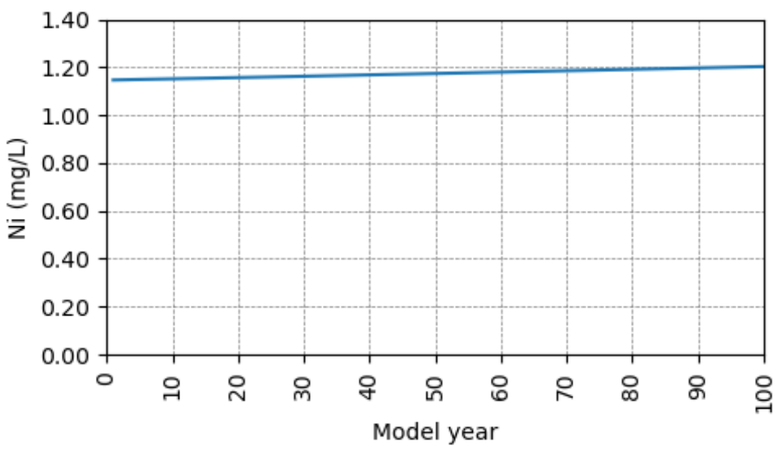




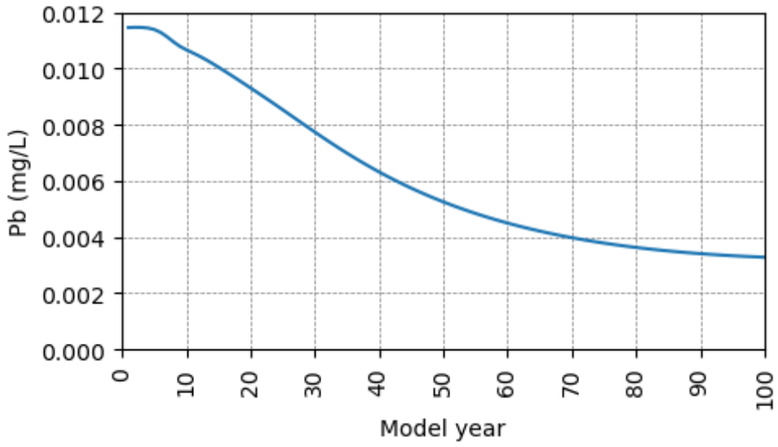


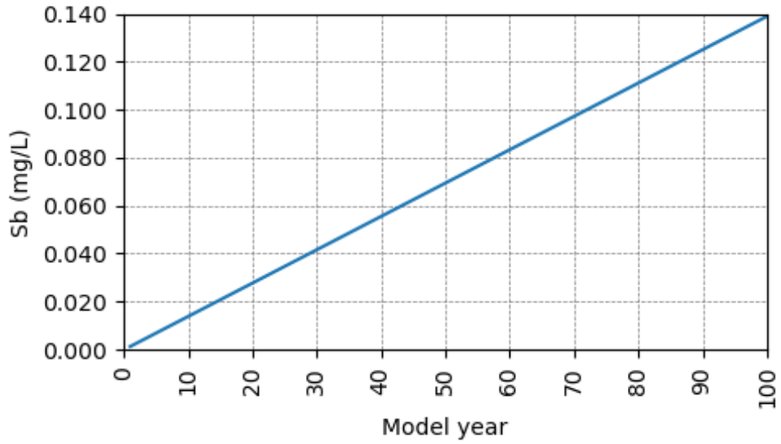


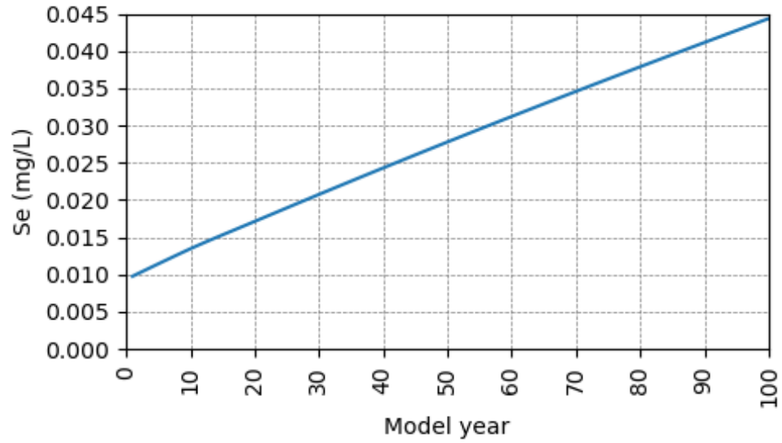


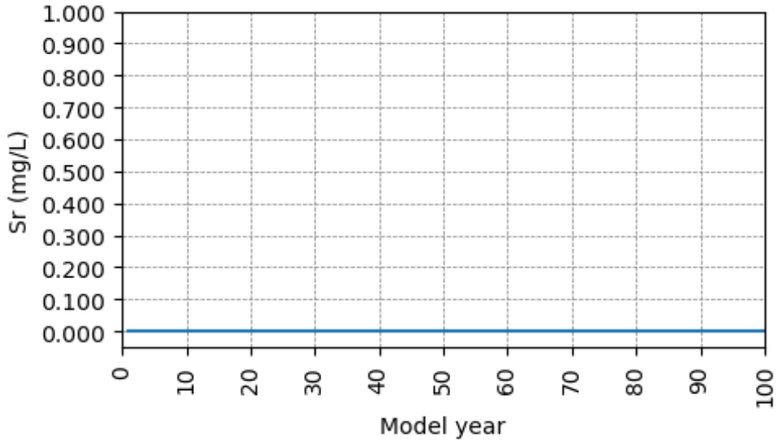


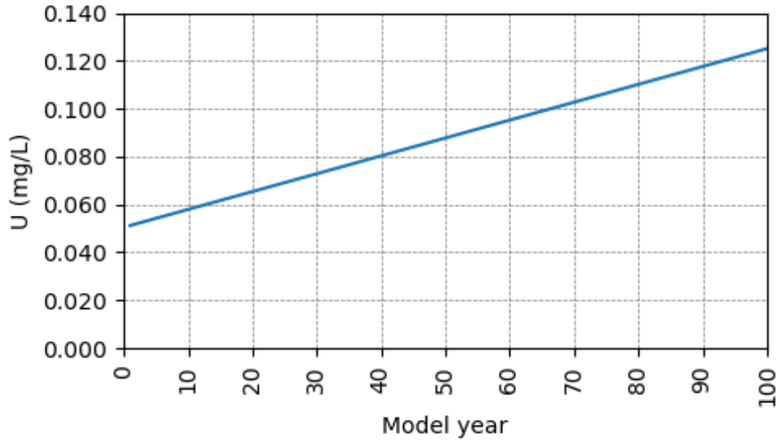
Esmeralda - WB/WQ model results:
Scenario 3
Base case with acid generation in tailings during transfer to backfill

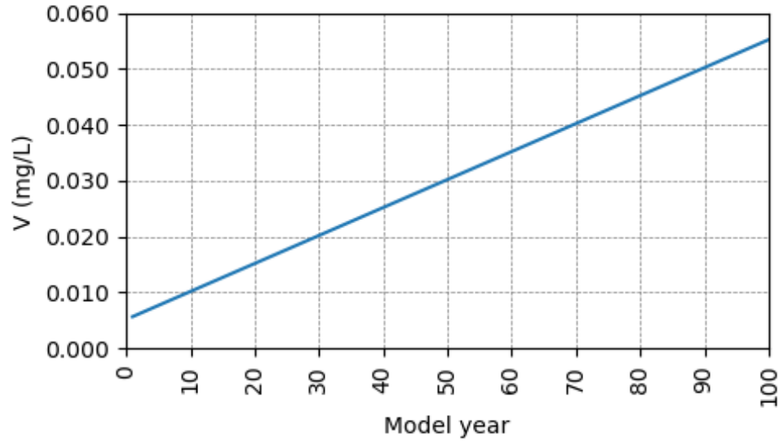


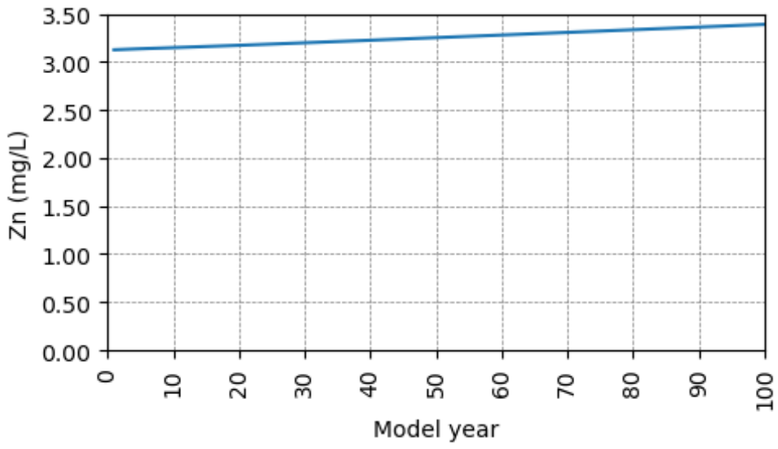


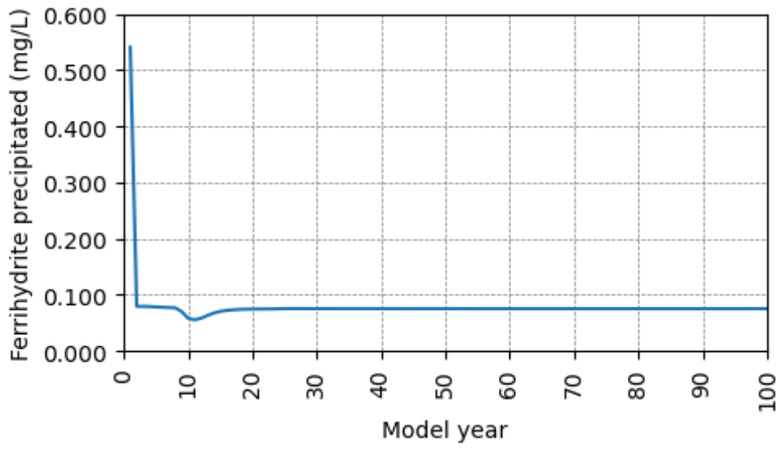




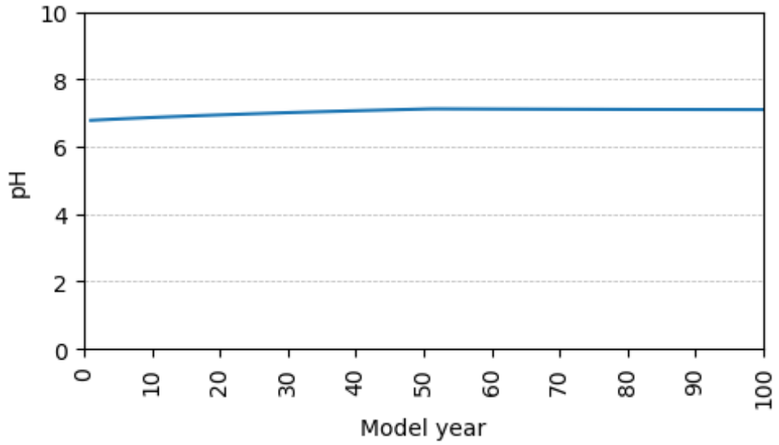


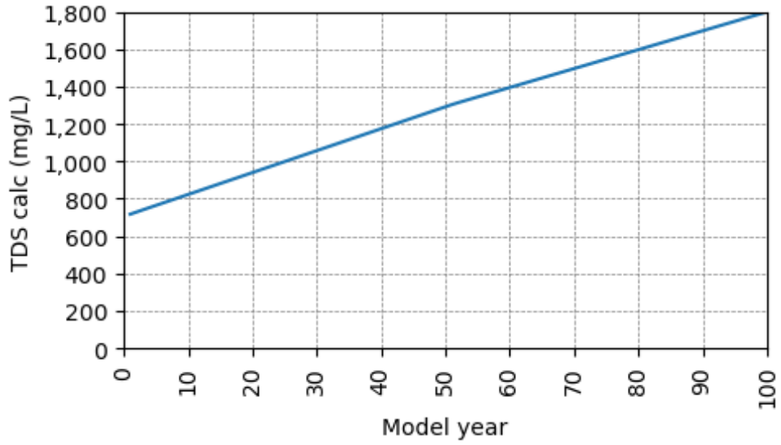


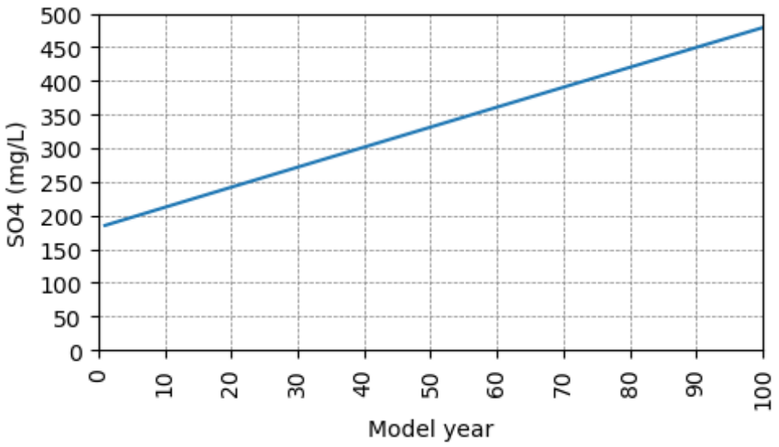


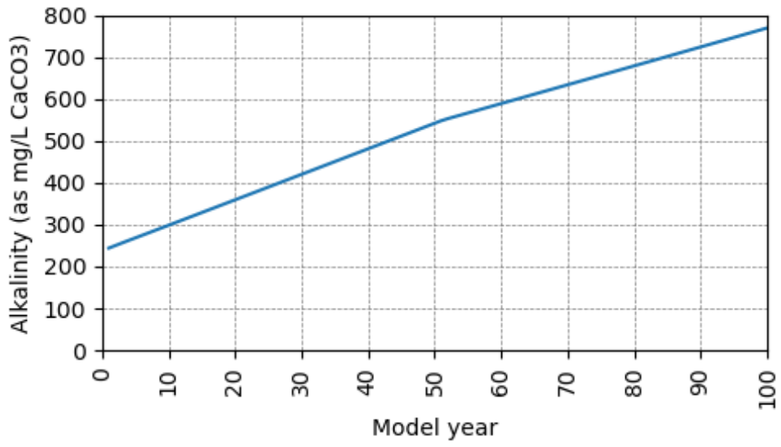


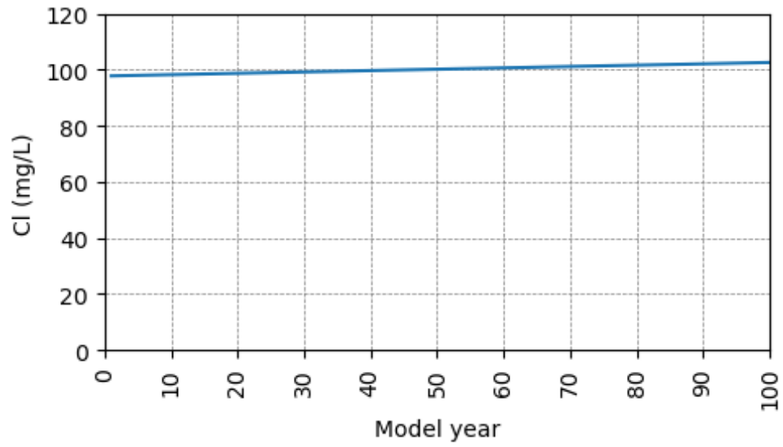
Esmeralda - WB/WQ model results:
Scenario 4
Acid generation during tailings transfer to backfill and subsequent hydraulic isolation at base of void

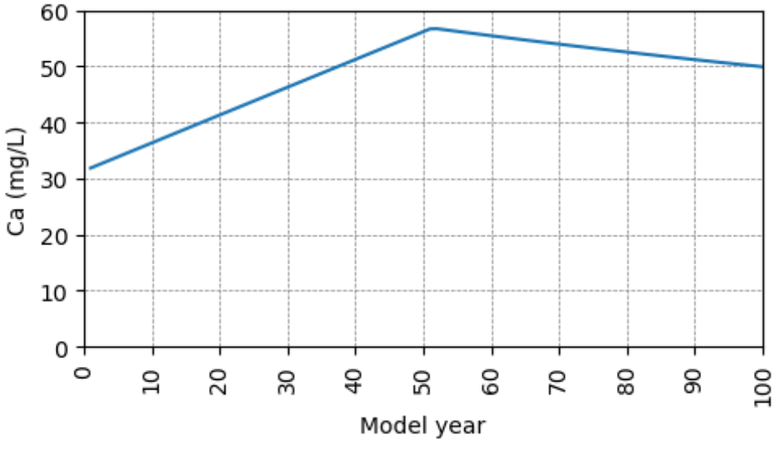


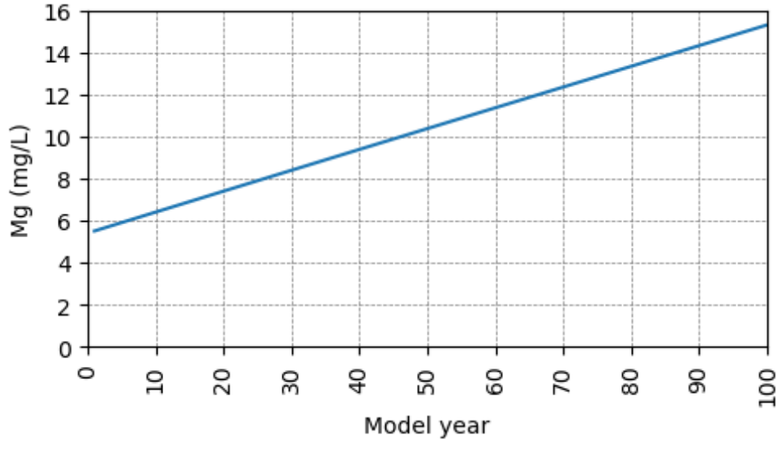


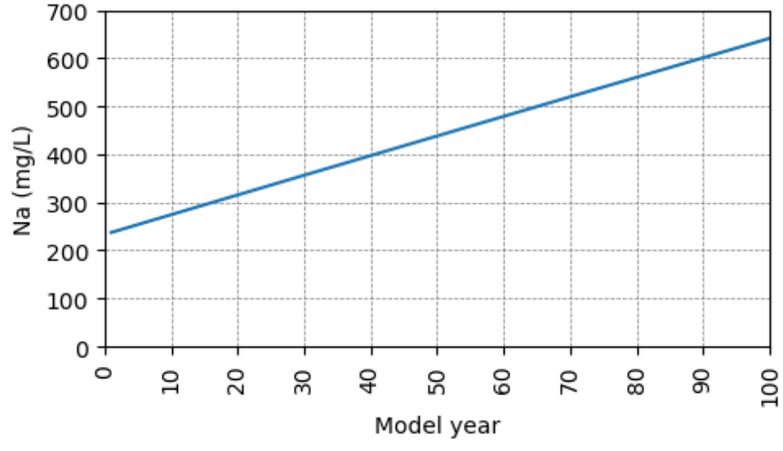




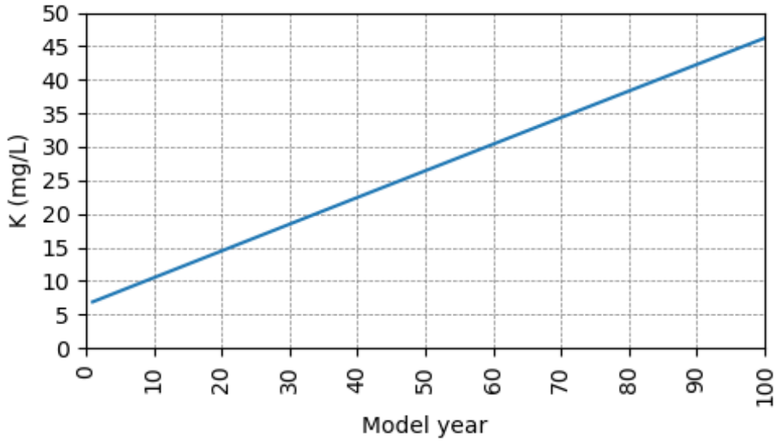


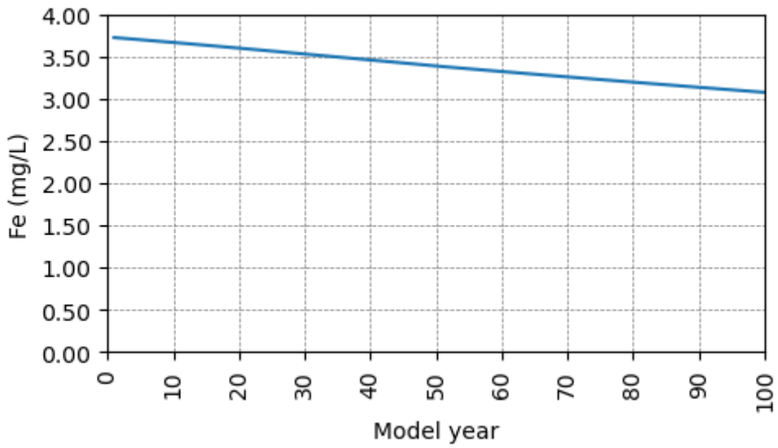


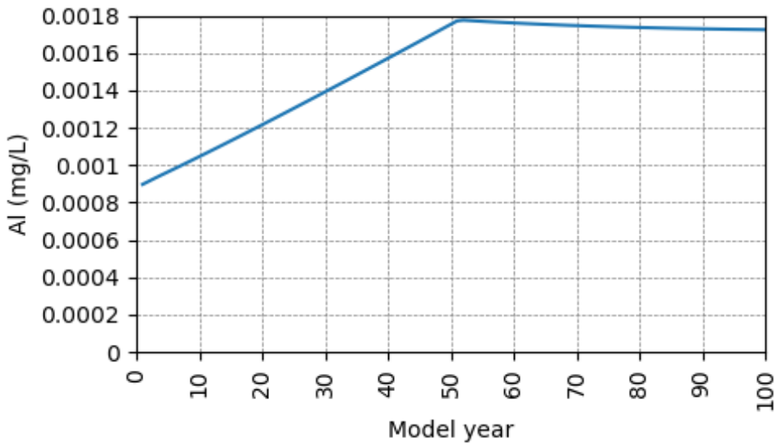


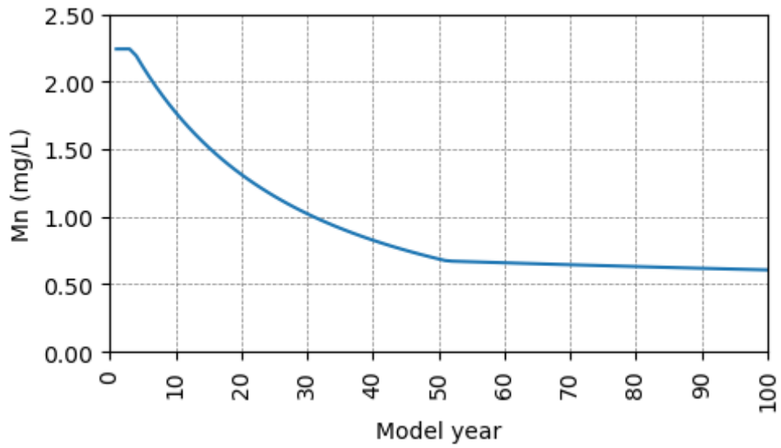


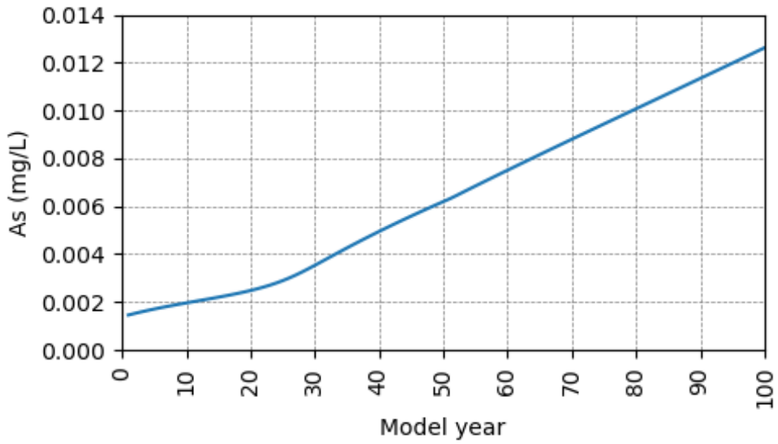
Esmeralda - WB/WQ model results:
Scenario 4
Acid generation during tailings transfer to backfill and subsequent hydraulic isolation at base of void

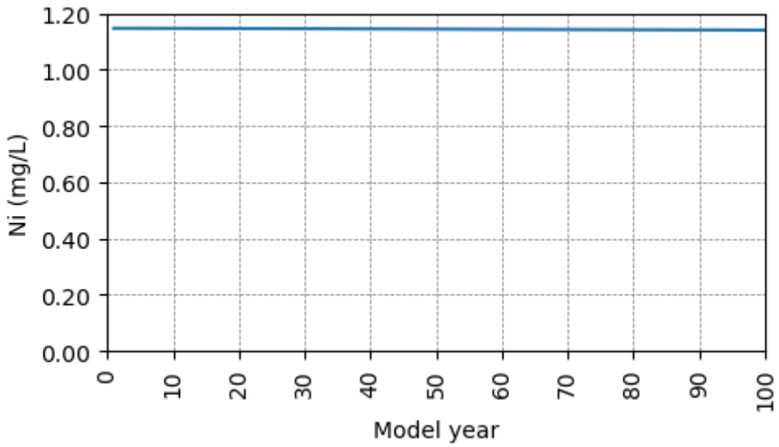


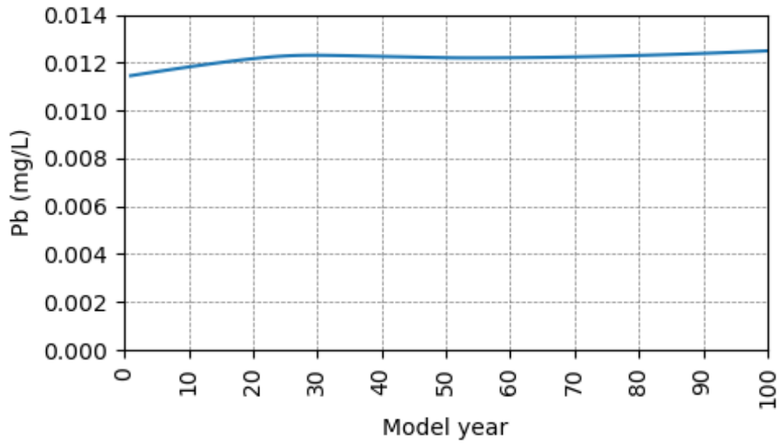




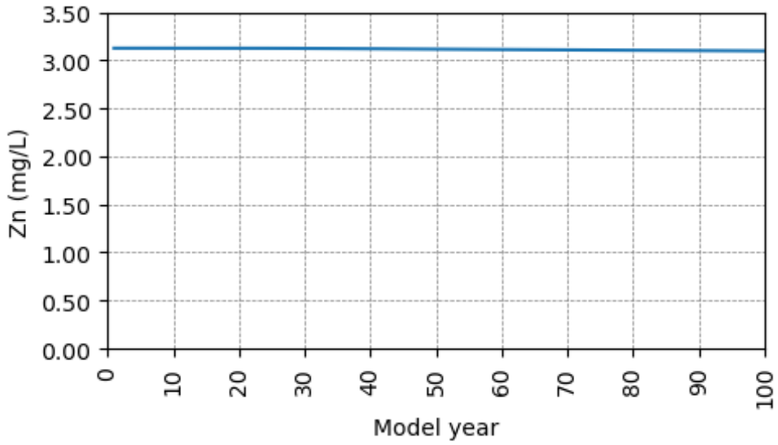


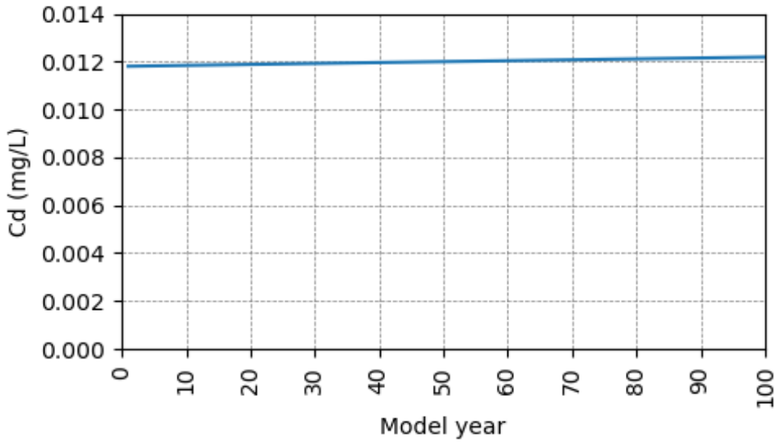


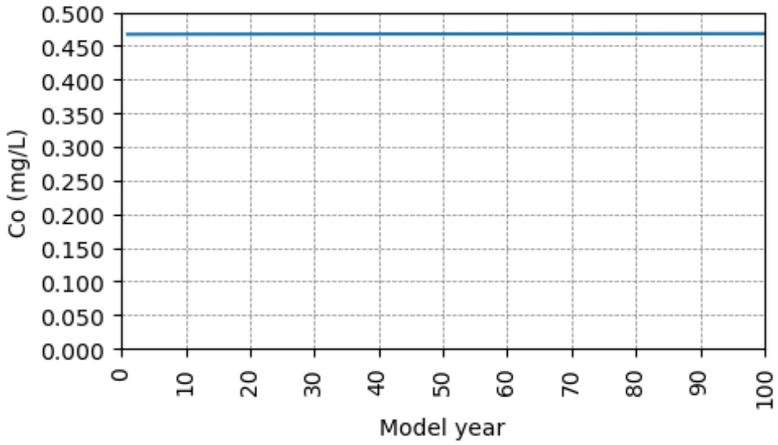


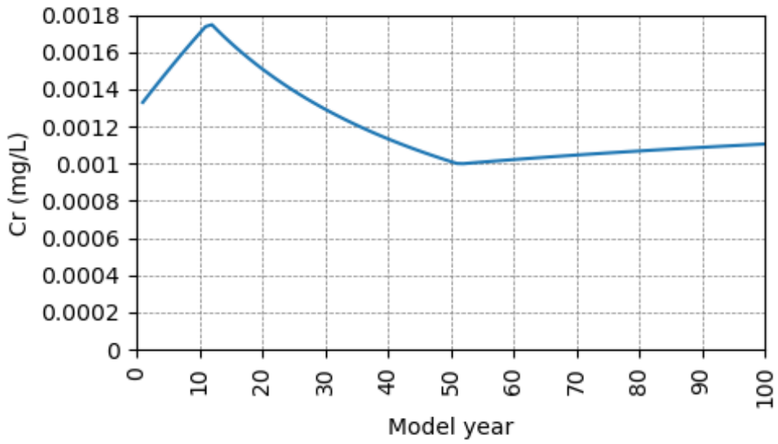


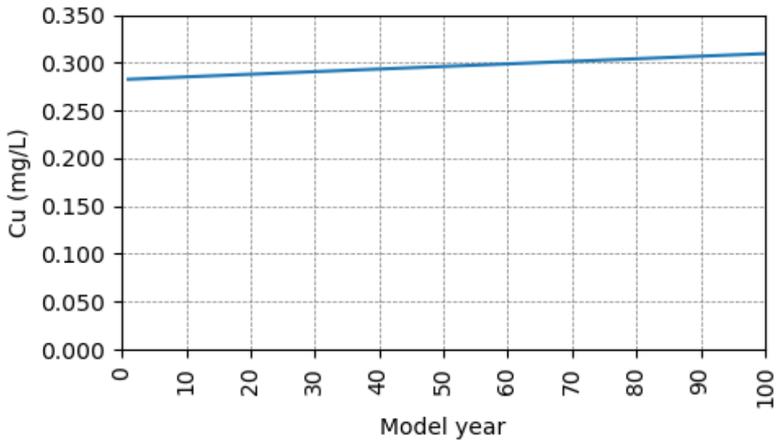
Esmeralda - WB/WQ model results:
Scenario 4
Acid generation during tailings transfer to backfill and subsequent hydraulic isolation at base of void

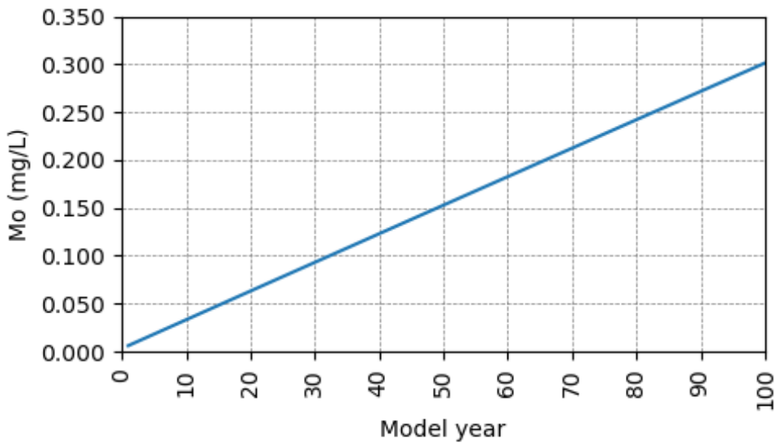


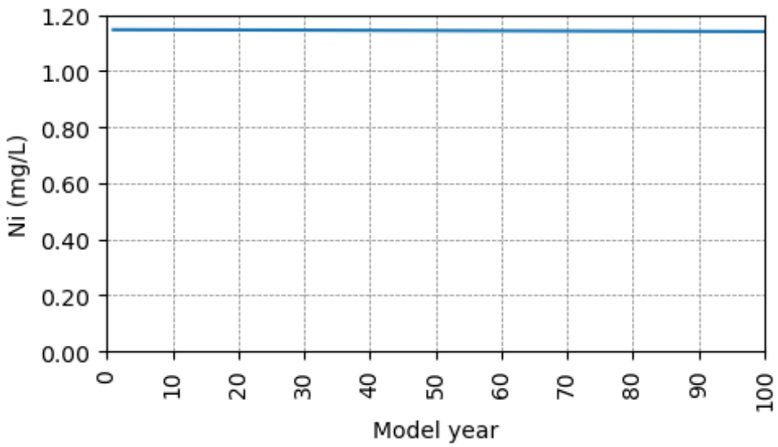




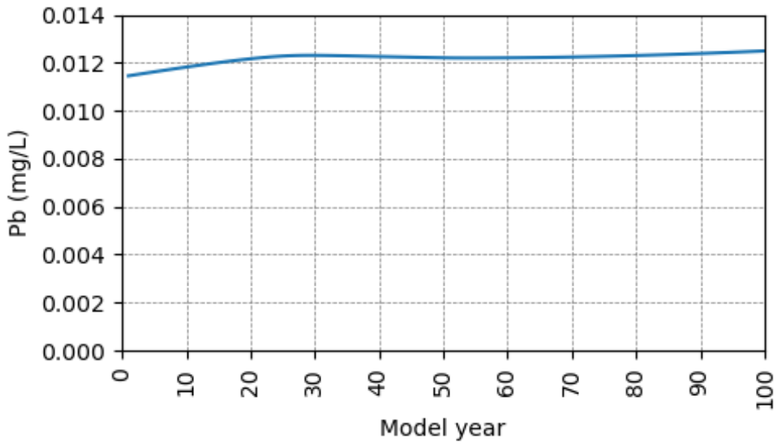


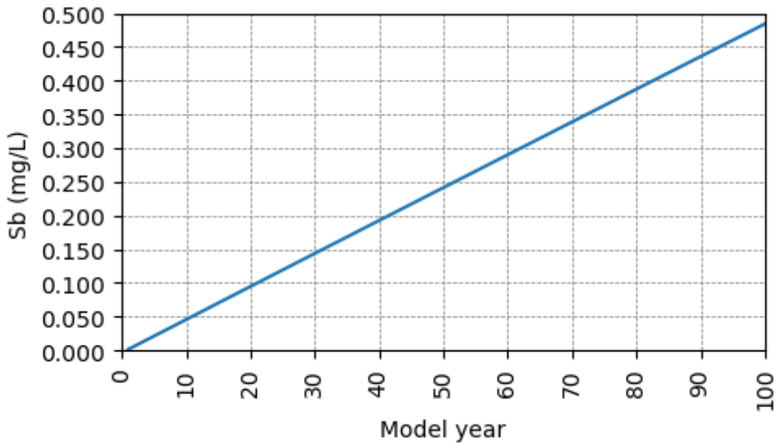


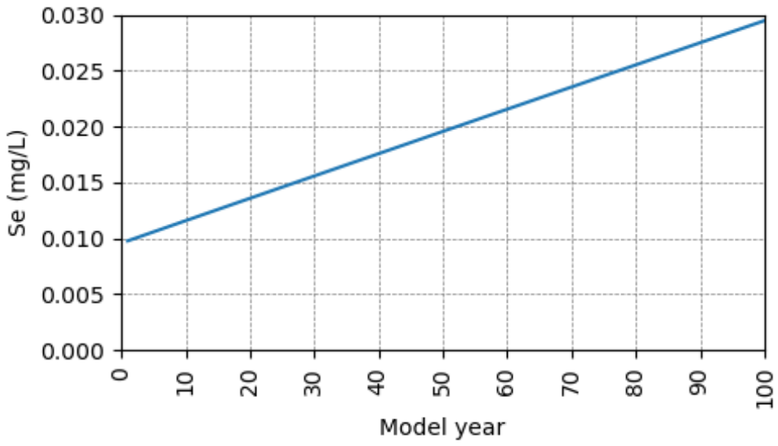


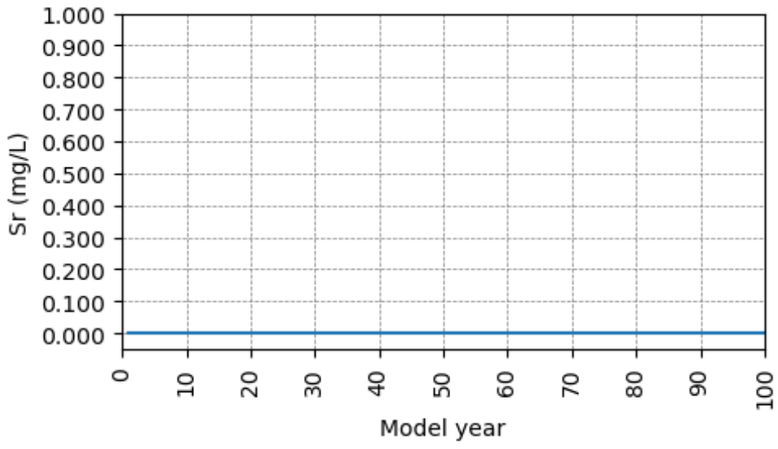


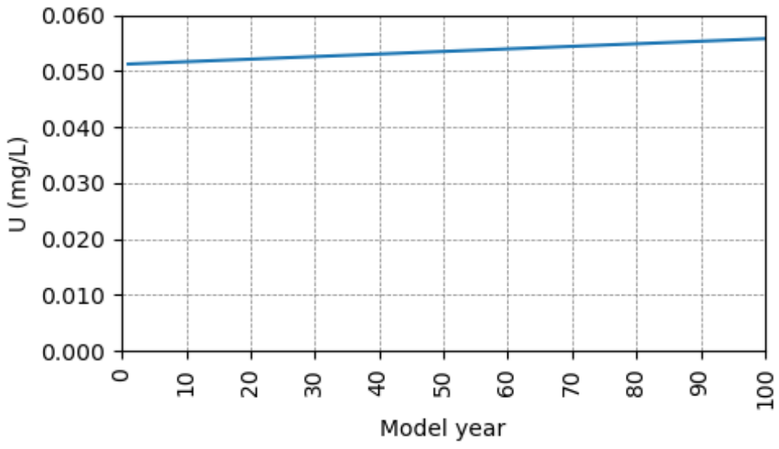
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Scenario 4
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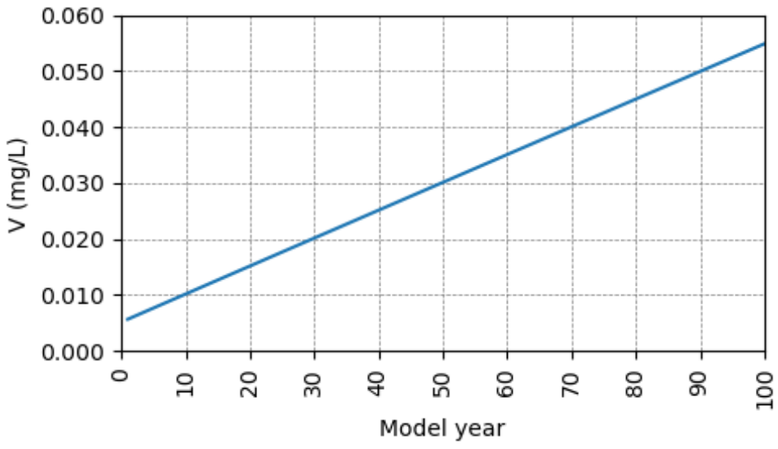


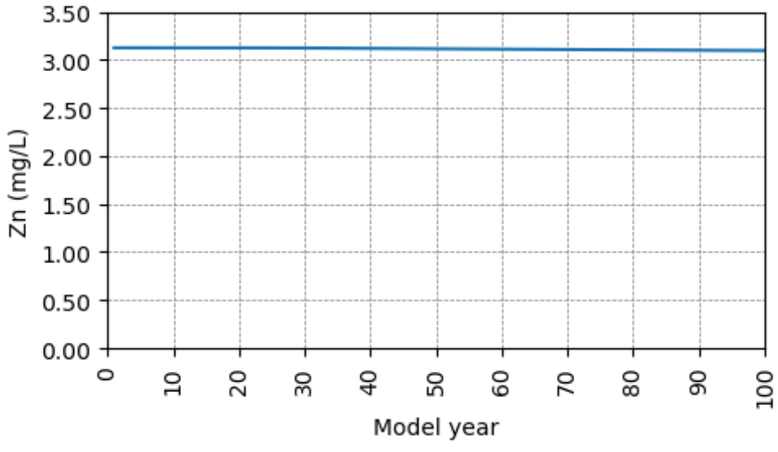


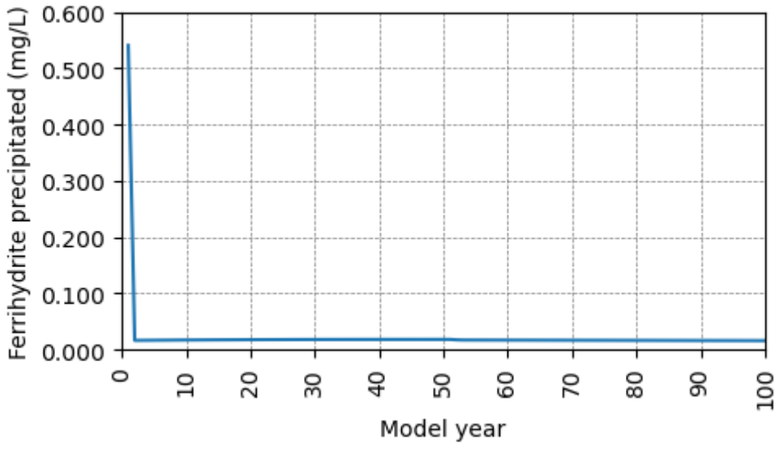














MINE WASTE AND
WATER MANAGEMENT