

NT Mining Operations Pty Ltd
Union Reefs North Underground Mine

Supplement to the Draft Environmental Impact Statement

KL | KIRKLAND LAKE GOLD

TABLE OF CONTENTS

1 Introduction 1

1.1 Overview 1

1.2 Summary of Submissions Received 2

2 Response to Submissions 3

2.1 Introduction 3

2.2 Submissions from Northern Territory Government Agencies 3

2.3 Other Submissions 45

2.4 NT EPA Site Visit and Matters to Address in the Supplement to the Draft EIS 64

3 Additional and/or Amended Information 66

3.1 Proposed Action 66

3.2 Commonwealth Approval 75

3.3 Surface Water Extraction License 76

3.4 Mine Schedule 77

3.4.1 Approvals and Permitting 77

3.4.2 Mining Activities During Each Mine Phase 78

3.4.3 Ghost Bat Management 80

3.5 Closure of OK and Prospect Adits 81

3.6 Development of Commitments Associated with 11 Actions 85

3.6.1 Contingency Actions 86

3.7 Ghost Bats – Genetic Studies 87

3.8 Ghost Bats – Significance of Union Reefs Ghost Bat Colony 88

3.9 Numerical Groundwater Model 90

3.9.1 Calibration Dataset Response 90

3.9.2 Union Reefs Area Calibration 90

3.9.3 Pine Creek Area Calibration 91

3.9.4 Shear Zone Conceptual Model 91

3.9.5 Depressurisation and the Water Act 1992 96

3.9.6 Contaminated Seepage 96

3.9.7 Model Confidence 96

3.9.8 Modelling and Discussion to Address the ToR (Section 2.2.2 – Hydrological Processes) 96

3.10 Depth of Groundwater Monitoring Bores 97

3.11 Wastewater Treatment 98

3.12 Wastewater Discharge 103

3.13 Water Quality Monitoring 104

3.14 Groundwater Dependent Ecosystems Monitoring Design 109

3.15 Project Alternatives 112

3.15.1 Alternate Portal Location in the Lady Alice Pit 112

3.15.2 Box Cut from Surface 112

3.15.3 Ghost Bat 130 m Buffer 113

4 References 117

TABLES

Table 1-1 Summary of Topic Raised in Each Submission 2
Table 2-1 NT Government Submissions 3
Table 2-2 Summarised Overflows 21
Table 2-3 Other Submissions 45
Table 2-4 NT EPA Site Visit and Matters to Address in the Supplement to the Draft EIS 64
Table 3-1 Commonwealth Legislation 75
Table 3-2 Northern Territory Legislation 76
Table 3-3 Approvals and Permitting Schedule Based on Submission of Supplementary 77
Table 3-4 MIning Activities Schedule During Each Mining Phase 78
Table 3-5 Ghost Bat Management Activities During Each Mining Phase 80
Table 3-6 Summary of Additions / Amendments to The Ghost Bat Action Plan 82
Table 3-7 Development of Ghost Bat Management Commitments 85
Table 3-8 Update to the Draft EIS Risk Register (addition of risk reference ID#12) 89
Table 3-9 Summary of Available Pumping Data, Pit Levels and Standing Water Levels (SWLs) 90
Table 3-10 Groundwater Bores and Assumed Screen Metres AHD 97
Table 3-11 Boiling Point of HCN in Degrees Kelvin 103
Table 3-12 Proposed Environment SSGVs for URSW08 106
Table 3-13 Proposed Receiving Environment SSGVs for URSW10 107
Table 3-14 Trigger Values for Conductivity 109
Table 3-15 Aquatic Ecosystems, Biological, Groundwater and Surface Water Monitoring Schedule During Each Mining Phase Based on Project Commencement Date of 01/05/2020 110

FIGURES

Figure 3-1 Proposal Components under Assessment 67
Figure 3-2 Ghost Bat Adits 68
Figure 3-3 Artificial Ghost Bat Roosts 69
Figure 3-4 Location of Groundwater Dependent Ecosystems – North 70
Figure 3-5 Location of Groundwater Dependent Ecosystems – South 71
Figure 3-6 Primary and Secondary Mine Features 72
Figure 3-7 Primary, Secondary and Tertiary Mine Features 73
Figure 3-8 Locations of Sediment Traps 74
Figure 3-9 Layer 1 Incorporating a Lineament of Higher Transmissivity 93
Figure 3-10 Layer 2 Incorporating a Lineament of Higher Transmissivity 94
Figure 3-11 Layer 3 Incorporating a Lineament of Higher Transmissivity 95
Figure 3-12 Water Treatment Plan Location and Layout 99
Figure 3-13 Cobalt Solubility VS pH 100
Figure 3-14 Cyanide Speciation VS pH 102
Figure 3-15 Alternative Box Cut Location 114
Figure 3-16 Ghost Bat Buffer Zone 115
Figure 3-17 Ghost Bat Buffer Zone (Shaded Area) Looking East 116

APPENDICES

Appendix 1 – Northern Territory Government Submissions

Appendix 2 – Other Submissions

Appendix 3 – Memo 1: Ghost Bat Activity Monitoring August 2019 – March 2020

Appendix 4 – Ghost Bat Action Plan

Appendix 5 – Ghost Bat Management Plan

Appendix 6 – Memo 2: An Analysis of Commitments to Ghost Bat Protection under the EPBC Act 1999 Environmental Offsets Policy October 2012

Appendix 7 – Memo 3: Summary of Actions at Lady Alice Adit

Appendix 8 – Memo 4: Outcomes from Action 2: Internal Investigations of Adits in the Union Reefs Project Area

Appendix 9 – Memo 5: Guide for the Thermal Modelling of Bat Roost Microclimates for Artificial Habitat Construction at Union Reefs

Appendix 10 – Memo 6: Progress Update: Artificial Ghost Bat Roost Design Project, Union Reefs

Appendix 11 – Water Management Plan

Appendix 12 – Geochemical Characterisation of Union Reefs North Drillcore Samples

Appendix 13 – Mine Closure Plan

Appendix 14 – Additional Groundwater Modelling

Appendix 15 – Crosscourse Pit Water Quality Prediction Modelling

1 INTRODUCTION

1.1 Overview

In July 2019, the Northern Territory Environment Protection Authority (NT EPA) published their decision that Northern Territory Mining Operations Pty Ltd (NTMO) proposal to develop the Union Reefs North Underground Mine required assessment under the *Northern Territory Environmental Assessment Act* at the level of an Environmental Impact Statement (EIS). NTMO prepared a Draft EIS to address the Terms of Reference (ToR) released by the NT EPA.

The Draft EIS was circulated to Northern Territory Government (NTG) agencies and made available for public comment for a period of six weeks from the 30 November 2019 to the 17 January 2020. 115 submissions were received from the NTG, non-government organisations and the general public and these are addressed in the form of this Supplementary Report to the EIS.

Pursuant with clause 12 of the Environmental Assessment Administrative Procedures, NTMO prepared this Supplementary Report to address individual submissions to the Draft EIS. This Supplement and the Draft EIS, along with their respective appendices, will collectively constitute the EIS for NTMO Union Reefs North Underground Mine (the Project).

This report provides additional and/or amended information that addresses all of the comments received on the Draft EIS. The Supplement is required to contain sufficient information to address the NTG agency comments, and comments from the public received during the exhibition period of the Draft EIS, to allow the NT EPA to make its assessment.

1.2 Summary of Submissions Received

A total of 113 submissions were received on the Draft EIS, covering 20 broad topic categories. Table 1-1 below provides a summary of the topics covered in each submission. Where a submission contains comments pertaining to more than one topic, it has been treated as a separate submission. The most common topic raised was around community and economic benefit, followed by Ghost bats and water quality. The complete and un-edited submissions from Northern Territory Government agencies are provided in Appendix 1 and other submissions are provided in Appendix 2 of this report.

TABLE 1-1 SUMMARY OF TOPIC RAISED IN EACH SUBMISSION

Topic	NT Government Submissions	Other Submissions	Total
General Proposal	x	x	**5**
Acid and Metalliferous Drainage	x		**1**
Alternatives		x	**1**
Climate Change		x	**1**
Closure	x		**1**
Approvals	x		**1**
Contingencies	x	x	**1**
Water Quality	x	x	**17**
Water Management	x		**8**
Waste Water Discharge	x		**11**
Aquatic Ecosystems	x		**2**
Environmental History	x	x	**8**
Groundwater Dependant Eco-Systems	x		**3**
Ghost Bats	x	x	**24**
Groundwater	x		**5**
Monitoring	x		**1**
Mine Closure	x		**6**
Mining Activities	x	x	**3**
Weeds	x	x	**1**
Community and Economic Benefit		x	**33**

2 RESPONSE TO SUBMISSIONS

2.1 Introduction

This section of the Supplementary report presents each submission, and provides a response. Each submission has been given a unique identification number (ID#) in the order that they were received. The response to each submission may also cross-reference additional information provided in Section 3 of this Supplement and/or the Appendices that are attached to this report.

2.2 Submissions from Northern Territory Government Agencies

Where submissions made by NTG agencies contain a number of different issues that are required to be addressed, these issues have been addressed individually within each submission.

TABLE 2-1 NT GOVERNMENT SUBMISSIONS

ID#:	1	Topic:	Proposal Description: Proposed Action	EIS Section:	Section 4
Comment					
(a) Clarify the scope of the Proposal to be assessed. Consider the cumulative effect of the current proposed actions on existing authorised activities, for example the Crosscourse pit water balance and Waste Discharge Licence (WDL) requirement, and provide additional information as required (see below). (b) In line with the requirements of the Terms of Reference (TOR), provide separate maps at the scale and resolution of Figure 4-2 of the EIS for: • Proposal components, showing the: o Location of all proposal components under assessment, including: Union Reefs North Underground Mine infrastructure, haul road, Prospect pit north and south, Crosscourse pit, Dams A, B and C, and processing operations, but not including other components covered by existing authorisations (e.g. truck workshop, fuel bay and explosive storage). o Location of Ghost bat adits remaining open during the proposal and a 130 m buffer. o Proposed locations for artificial Ghost bat roosts and a 130 m buffer. o Location of groundwater dependent ecosystems (GDE) within ML1109 and MRWET12 and MRWET13. • Primary and secondary mine features, where: o All primary mine features are depicted in one colour. o All secondary mine features depicted in a contrasting colour. • Primary, secondary and tertiary mine features, where: o Each mine feature classification is depicted in different contrasting colours. Provide updated shape files for these maps.				
Response					
(a) The scope of the Proposal to be assessed is described in detail in the Draft EIS in Section 4. There are a number of components of the URPA that are not included in the Proposal, e.g. existing authorised infrastructure in Table 4-1 in the Draft EIS. It is acknowledged that the current proposed action will affect existing authorised activities including contributing ore to the processing plant and contributing tailings and water to Crosscourse pit. The scope of the Proposal is illustrated in Figure 3-1, Figure 3-6 and Figure 3-7 in this document including: • **Primary:** Mine features primarily associated with the underground mine (closure aspects addressed in this EIS). • **Secondary:** Active and ongoing URPA mine features that interact with the project, but both pre-date and to operate beyond the period of the project (discussed in this EIS but closure aspects addressed in the broader URPA Mine Closure Plan).					

ID#:	1	Topic:	Proposal Description: Proposed Action	EIS Section:	Section 4

- **Tertiary:** URPA mine features that do not interact with the project (not discussed in this EIS but closure aspects addressed in the broader URPA Mine Closure Plan).

The cumulative effect of the current proposed actions on existing authorised activities is described in significant detail in the sections of the EIS that address inland water environmental quality, including geochemistry, and hydrological processes.

(b) Draft maps complete – refer to Section 3.1.

In line with the requirements of the Terms of Reference (TOR), provide separate maps at the scale and resolution of Figure 4 2 in the EIS for Proposal components, showing the:

- Figure 3-1 – Location of all proposal components under assessment, including: Union Reefs North Underground Mine infrastructure, haul road, Prospect pit north and south, Crosscourse pit, Dams A, B and C, and Processing operations, but not including other components covered by existing authorisations (e.g. truck workshop, fuel bay and explosive storage).
- Figure 3-2 – Location of Ghost bat adits remaining open during the proposal and a 130 m buffer.
- Figure 3-3 – Proposed locations for artificial Ghost bat roosts and a 130 m buffer.
- Figure 3-4 and Figure 3-5 – Location of Groundwater Dependent Ecosystems (GDE) within ML1109 and MRWET12 and MRWET13.

Potential groundwater dependent ecosystems within ML1109 (Figure 3-4 and Figure 3-5) include the:

- McKinlay River and Riparian Zone; and
- Assessment locations denoted by MR.

In addition, MRWET12 and MRWET13, outside of ML1109 are considered potential groundwater dependent ecosystems (Figure 3-4 and Figure 3-5).

- Figure 3-6 – Primary and secondary mine features, where:
  - All primary mine features are depicted in one colour.
  - All secondary mine features depicted in a contrasting colour.
- Figure 3-7 – Primary, secondary and tertiary mine features, where:
  - Each mine feature classification is depicted in different contrasting colours.
- Figure 3-8 – Locations of sediment traps (see comment #2 below).

ID#:	2	Topic:	Proposal Description: Operational Water infrastructure	EIS Section:	Section 4.7
Comment					
The Draft EIS discusses the use of sediment traps on site but does not show the locations in any of the figures provided. Provide locations of sediment traps on a map.					
Response					
Figure 3-8 (in Section 3.1) provides the locations of sediment traps.					

ID#	3	Topic:	Proposal Description: Mine Schedule	EIS Section:	Section 4.5
Comment					

Provide a more detailed project schedule summary, include activities and timing for:

- Approvals (specifically, include approval under the EPBC Act).
- Pre mining phase (e.g. Ghost bat management actions).
- Mine development phase (e.g. dewatering, portal construction).
- Mine operation phase (e.g. further exploration, progressive return of waste rock).
- Mine closure phase (e.g. mine closure activities).

ID#	3	Topic:	Proposal Description: Mine Schedule	EIS Section:	Section 4.5
• Post closure phase (e.g. identify individual monitoring activities and their timing). • Post closure monitoring activities.					
Response					
Detailed schedules, including activities and timing, for the following categories are provided in Section 3.4 of this Supplementary. • Approvals and permitting schedule provided in Section 3.4.1. • Mining activities during each mining phase in Section 3.4.2, Table 3-4. • Ghost bat management activities during each mining phase in Section 3.4.3, Table 3-5.					

ID#	4	Topic:	Approvals and Regulatory Framework: Commonwealth Approval Required	EIS Section:	Section 5.1.1 Table 5-1
Comment					
The Proponent has noted referral and assessment obligations, but not included the requirement for Environmental Approval under the EPBC Act. Update Table 5-1 to include the requirement of approval under the EPBC Act.					
Response					
Please see Section 3.2 of this Supplementary for an update to Table 5-1 in the Draft EIS.					

ID#	5	Topic:	Approvals and Regulatory Framework: Environmental History	EIS Section:	Section 3.4
Comment					
The Proponent has provided links to policies and planning framework that underpin its Environmental and Social Responsibility Management System, but not included a statement about whether, or not, there are any, past or existing proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against: • The person proposing to take the action; and • For an action for which a person has applied for a permit, the person making the application. For the EPBC referral matters, please include the statement and discuss how the policies and planning framework relate to EPBC matters. This information must be taken into account in EPBC Act approvals.					
Response					
There are no past or existing proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against: (a) Northern Territory Mining Operations Pty Ltd (NTMO); and (b) For an action for which NTMO has applied for a permit, or for any other actions. NTMO as the Operator, and KLG as the parent company, is committed to compliance with statutory and other requirements, including meeting or exceeding the requirements of all applicable laws and regulations relating to the environment. KLG has developed an Environmental and Social Responsibility Management System, and supporting policies that commit to compliance with environmental legislation, including the EPBC Act. KLG policy addresses the requirement for an environmental management system and further commits the Company to conduct its operations in a manner that promotes environmental performance responsibility and minimisation of environmental including social, cultural and ecological impacts.					

ID#	6	Topic:	Approvals and Regulatory Framework: Surface Water Extraction Licence is Required	EIS Section:	Section 5.1.2 Table 5-2
Comment					
Table 5-2 in the Draft EIS main report incorrectly states 'nil required' in relation to the licences, permits or approvals required under the Water Act 1992. This statement is incorrect; specifically, a surface water extraction licence is required for take of water from Dam C. Dam C is the primary clean water supply with an established pumping station; the Draft EIS indicates annual extraction from the Dam C will be 299 ML. It is not proposed to take water from Dam B; however, should any take be proposed from Dam B, this will also require a surface water extraction licence. Update Table 5-2 to include the requirement for a surface water extraction licence and note that the application for this licence should include details on the pumping station and details on its power supply (for example if it is a diesel pump then information will be required to demonstrate how hydrocarbon contamination is mitigated).					
Response					
Water Act 1992 – updated text to replace text in Table 5-2 in the Draft EIS. See Section 3.3 of this Supplementary for the updated table.					

ID#	7	Topic:	Approvals and Regulatory Framework: Water Extraction Licence Considerations	EIS Section:	Section 5.1.2 Table 5-2
Comment					
The beneficial uses gazetted for surface and groundwater in the Mary River Catchment and the McKinlay River do not include mining activity or industry. This will be a factor considered by the Controller of Water Resources when making a water extraction licence decision. The proponent's water extraction licence application must demonstrate that the activity (for example seepage from the Crosscourse pit or overflow from Dam B) does not have an adverse effect on water quality of these water sources. Update Table 5-2 to include the information provided here.					
Response					
Table updated – see Section 3.3 of this Supplementary.					

ID#	8	Topic:	Approvals and Regulatory Framework: Waste Discharge Licence	EIS Section:	Section 5.1.2 Table 5-2
Comment					
The legislation section, when referencing the Waste Management and Pollution Control Act 1998 states that a 'Waste Discharge Licence (WDL) is required for URPA passive discharge'. A WDL is issued under the Water Act 1992. Update Table 5-2 to reflect this.					
Response					
Table updated – see Section 3.3 of this Supplementary.					

ID#	9	Topic:	Terrestrial Flora and Fauna: Closure of OK and Prospect Adits	EIS Section:	Section 11.2. 1 - 11.2.3
Comment					

ID#	9	Topic:	Terrestrial Flora and Fauna: Closure of OK and Prospect Adits	EIS Section:	Section 11.2. 1 - 11.2.3

The Draft EIS identifies:

- Loss of roost sites contributing to EPBC listing of Vulnerable (Ghost bat)
- Limited roosting opportunities at critical times of the year
- Roosting limited to historical mine workings as no natural caves in the URPA
- Since 1987 disturbance and mining has caused decline in numbers and shift to alternative roost sites
- Continued occupation of sites within URPA and Pine Creek region during disturbance and mining indicates high level of importance of occupied roost
- Low Ghost bat numbers in OK adit (March to August)
- High Ghost bat numbers in Union North adit (June to November)

Provide proposed timing of adit closures and contingencies in place should significant numbers or breeding (August - November) Ghost bats be present in either OK or Prospect adits at the time of closure.

See further information request provided below at Topic Ghost bat actions – Action 1.

Response

Provisional timing of adit closures is provided in Section 3.4.3 of this Supplementary (Table 3-5 – Ghost Bat Management Schedule).

The proponent will not close the OK adit when a colony of Ghost bats is present in the structure. This was specified in the Action Plan (Appendix 2 of Appendix G in the Draft EIS):

- Action 1 stated "It will occur when bats have shifted their attention to the Union North adit." (Action Plan [p 11], under section Details of the Action).
- Step 1 of the Exclusion described in Action 1 [p 11] stated "When Ghost Bats are observed to be absent, the Exclusion Phase (Phase 2) will begin."

The Ghost bat activity monitoring conducted between October 2018 and August 2019 showed that the highest activity of Ghost bats at the OK adit was in October, and January to February, and lowest in July to August (Section 3.2.1 [p 23] and Figure 7 [p 26] in the technical report [Appendix G of the Draft EIS]). Monitoring has shown that the Prospect adit is not usually used as a diurnal roost. The Exclusion measures will also be applied simultaneously to the Prospect adit.

We attach additional information [Memo 1: Ghost bat activity monitoring August 2019 – March 2020] (Appendix 3 in this report) that provides further occupancy data for Ghost bats at the OK adit between August and March 2020. In summary it shows that:

- Bats move between the Union North adit and OK adit.
- Sometimes there are indications that only a few Ghost bats, or no Ghost bats, are present.
- Colony size (at either roost, at one time) has varied between 0 and 50 individuals.
- The long-term acoustic monitoring indicates maximum calling activity at both sites across the wet season, with peaks of activity at the Union North adit in the months October to November and at the OK adit in September to October and January.
- The Union North adit appears to be the main focus for Ghost bat roosting. Lower activity is generally observed in the OK adit around the same time of peaks at Union North, suggesting that the bats sometimes move between the two adits.
- The changing pattern of nightly activity levels across survey nights indicates that the colony may shift between the two roosts, or that it moves to other (unknown) roosts outside the Union Reefs project area.

The construction of the new mine is planned for a time as soon as possible after the project approval date – proposed for mid 2020, provided approval is granted.

While an exact date of the Exclusion cannot be specified, the combined Actions in the Action Plan, Ghost Bat Management Plan and the Ghost Bat Schedule (Section 3.4.3 of this report) do provide an explicit commitment that specifies that the Exclusion will be undertaken at a time Ghost bats are not using the structure. Therefore, there is possibly a window of between March to September 2020 when a colony of Ghost bats is unlikely to be using the OK adit, based on observations to date. But pre-Exclusion monitoring will first establish that no Ghost bats are using the OK adit before the Exclusion is implemented. If Ghost bats are found to be roosting in the OK adit during the day, the Exclusion will not go ahead. Note that the Exclusion already has contingencies for a situation where Ghost

ID#	9	Topic:	Terrestrial Flora and Fauna: Closure of OK and Prospect Adits	EIS Section:	Section 11.2. 1 - 11.2.3

bats were inside the structure without the investigators realising until the time of a dusk exodus (Action 1, Steps 2 to 8).

The additions and amendments made to the Ghost Bat Action Plan (i.e. Version 2020) in response to all Ghost bat submissions (including this one) have been summarised in Table 6 in Section 3.5 of this report.

A full updated 2020 version of the Ghost Bat Action Plan is provided at Appendix 4 of this report.

ID#	10	Topic:	Terrestrial Flora and Fauna: Ghost Bat Management Plan (GBMP)	EIS Section:	Section 11

Comment

The Draft EIS Appendix G and Ghost Bat Action Plan provide commitments associated with 11 actions. These commitments require further development in the Ghost Bat Management Plan (GBMP). The GBMP must include:

- Avoidance and mitigation measures to avoid potential impacts to the Ghost bat or its habitat caused by, but not limited to, noise and vibration, becoming entangled in barbed wire fencing, injury or mortality from vehicle and machinery movements, dust generation, lighting and fire prevention
- Mitigation and management measures in the form of specific and auditable commitments with clear timeframes and measureable outcomes
- Monitoring and review protocols
- Contingency actions
- Environmental management roles and responsibilities
- Reporting arrangements, including what will be publicly available
- Commitments should avoid the use of 'where possible', 'it is anticipated', 'as required', 'should' and 'may'
- Commitments should use the terms 'will' and 'must'
- Reference and discussion of management actions consistent with Australian Government Ghost bat Conservation Advice (TSSC 2019)
- Reference and discussion of management actions consistent with Australian Government general guidance to stakeholders preparing environmental management plans Environmental Management Plan Guidelines (2014) (Guidelines) available at **http://www.environment.gov.au/epbc/publications/environmental-management-plan-guidelines**
- An analysis about how the proposed offsets (discussed under the Actions below) meets the requirements of the EPBC Act Environmental Offsets Policy October 2012

Response

A new Ghost Bat Management Plan (Appendix 5 in this report), which will sit beneath the Action Plan, has been written to include the requested information and has been compiled based on the Australian Government Environmental Management Plan Guidelines (2014). The Ghost Bat Management Plan in Appendix 5 includes avoidance and mitigation measures, mitigation and management measures, monitoring and review protocols, roles and responsibilities, and reporting arrangement associated with each of the activities that has the potential to impact on the Ghost bats.

A separate document has been written to address the concept of offset applicability in this project: Memo 2: An analysis of commitments to Ghost bat protection under the *EPBC Act 1999* Environmental Offsets Policy October 2012 (refer to Appendix 6 in this report).

The additions and amendments made to the Ghost bat Action Plan (i.e. Version 2020) in response to all Ghost bat submissions (including this one) have been summarised in Table 3-6 in Section 3.5 of this report.

Additional detailed information has been developed on the commitments associated with the 11 actions contained in the Action Plan, and can be found in both the Ghost Bat Management Plan (included in this report at Appendix 5) and the updated Action Plan (2020) (included at Appendix 4 of this report). This information is also summarised in Section 3.6 of this Supplementary.

ID#	11	Topic:	Terrestrial Flora and Fauna: Genetic Studies	EIS Section:	Section 1.9 Table 1-5, Section 10, Table 10-7, Section 11.3.3
Comment					
The Draft EIS and GBAP state genetic studies will be conducted before mine construction. Provide results of genetic studies and future timing of Ghost bat genetic studies as they relate to: • Inform connectedness of Union Reefs Ghost bats with Pine Creek and Spring Hill colonies (Action 10) • Likelihood of Ghost bat movement to alternative roosts • Potential significance of adits within the Proposal area as important linkage roosts See further information request provided below at Topic Ghost bat actions – Action 10.					
Response					
In the Action Plan (Appendix 4 of this report), the genetic study under Action 10 was placed during Phase 1—Before new underground mine construction. The proponent has committed to beginning this work before the new mine is constructed, but no commitment is given to completing it in the pre-mining phase. There are several factors that influence the timeline of this study, including the time needed to obtain permits and animal ethics approval, the time required to capture enough Ghost bats for the study, the time needed for an external service provider to generate the genotype data from tissue samples, and the time needed for analysis and writing. To date the proponent has supported two actions designed to reduce this timeline as much as possible: 1. Put in place an agreement with Charles Darwin University to provide support for a postdoctoral researcher, who will lead this action. The researcher (Ms Nicola Hanrahan) is currently in the process of beginning this employment. 2. The researcher is in the latter stages of gaining the necessary permits and approvals for this work. While the permits might be in hand, no work that directly (i.e., capture, roost exclusions, or disturbances to roost sites during the day when Ghost bats are present) involves Ghost bats will be undertaken. Discussion on the likelihood of Ghost bat movements to alternative roosts and the potential significance of adits within the URPA as important linkages is provided in Section 3.8 of this report.					

ID#	12	Topic:	Terrestrial Flora and Fauna: Significance of Union Reefs Ghost Bat Colony	EIS Section:	Section 11
Comment					
Should the closure of the adit result in major impacts to the colony, the Draft EIS states that the loss of up to 30 individuals from the URPA represents 3% of the regional Ghost bat population. It is assumed that the proponent is inferring that a loss of 3% of the regional Ghost bat population would have a negligible effect. This is not necessarily supportable, as Ghost bat populations have been shown to be genetically distinct at both the local and regional scales. Address the concern that the risk that loss of a small number of individuals may result in a significant impact at the local and regional scale, with the extent of this risk currently uncertain.					
Response					
The Draft EIS states that the Union Reefs Local population potentially represents 2.6 % of the upper estimated regional Ghost bat population. Reference #2 in the risk register in the Draft EIS (Section 10.1.6) states that the residual risk of Action 1 is 'medium', and the likelihood is 'unlikely'. As requested we have now addressed the specific risk of a loss of a small number of individuals potentially up to 30 individuals from the URPA (population potentially represents 2.6 % of the upper estimated regional Ghost bat population) caused by Action 1. We have addressed this by adding a risk item to the risk register that includes this potential consequence (see Section 3.8 of this report).					

ID#	12	Topic:	Terrestrial Flora and Fauna: Significance of Union Reefs Ghost Bat Colony	EIS Section:	Section 11

While the specific risk of loss of individuals was not originally included in the Draft EIS (now included, refer Section 3.8 of this report), a statement on the consequence of this loss was addressed in Section 11.3.3, stating *"Given the indirect evidence that Ghost bats can readily move in and out of the URPA to sites known and possibly unknown, the impact of the closure of the OK adit is unlikely to be significant for the regional population."*

This potential loss of 2.6% of a regional population should also be placed in a population genetic context, which changes the meaning of 'loss' from one of actual numbers to one of genetic diversity. The comment states that *"Ghost Bat populations have been shown to be genetically distinct at both the local and regional scales".* The meaning of "distinct" is very relevant here. Genetic studies of the Ghost bat, both published and unpublished, have shown that regional populations are genetically different enough from one another to support a conclusion that they are isolated from each other—population subdivision at the national scale, which equates to a detectable level of 'distinctness'. But this does not imply 'distinctness' at any taxonomic level, though it does support the notion that regional populations are best considered as separate management units to maintain maximum genetic diversity in the species (Worthington Wilmer et al. 1994 Proc R Soc Lond B 257: 193–198).

The study of Worthington Wilmer et al. (1999 Evolution 53: 1582–1591) showed that colonies at Pine Creek, Nourlangie Rock and Claravale Station were part of the same genetically inter-breeding population. Thus, there is currently no published evidence of population subdivision within the Top End of the Northern Territory. Thus, in terms of the risk of significant loss of genetic diversity through the catastrophic loss of an entire colony of c. 30 individuals at Union Reefs, this would be low.

It is also important to note that a very conservative view of population extent has been used in the technical report (Appendix G of the Draft EIS) —restricted to the Daly River area, rather than the whole Top End as was demonstrated in Worthington Wilmer et al. (1999).

There is no useful concept of 'distinctness' at a local scale for Ghost bats. The studies of Worthington Wilmer et al. (1994, 1999) demonstrated high female fidelity to natal roost sites, but also that gene flow occurred among colonies within regions (mediated by males mostly). Colonies do not become distinct—if they did, they would be fully isolated and comprise their own separate 'population' (see Glossary in the Action Plan [Appendix 4 of this report] for the specific meaning of relevant terms in population genetic studies). The concern for significant loss of distinct local occurrences is therefore unfounded. However, Action 10 will further investigate the distribution of genetic diversity within the Top End, and particularly in the Daly River region, and publish relevant findings. Further discussion of genetics studies as part of Action 10 is provided in Section 3.7 of this report.

ID#	13	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions	EIS Section:	Appendix G – GBAP

Comment

For each Ghost bat action in the GBMP, clearly:

- Reference the TSSC (2016) and 2014 Guidelines (as above)
- Identify proposed commencement and timing of the action
- Identify specific auditable commitments with measureable outcomes
- Identify the person(s) undertaking the action and their research experience as it relates to cave dwelling bats

Response

The newly developed Ghost Bat Management Plan (Appendix 5 of this report) includes most of the information requested in this submission. Some of this information is presented, instead, in the Action Plan (Appendix 4 of this report) (see also Response to ID#10). E.g. The Action Plan specifically cites relevant parts of the Conservation Advice (TSSC 2019) for the Ghost bat at the top of each action under three subheadings: *"Threat factor/s addressed", "Knowledge gap addressed"*, and *"Specific priorities addressed in the Conservation Advice by this action".* The additions and amendments made to the Ghost Bat Action Plan (i.e. version 2020) relating to all Ghost bat submissions have been summarised in Table 3-6 in Section 3.5 of this report.

The Ghost bat specialist consultants mentioned in the Ghost Bat Management Plan, who will undertake the actions are Dr Kyle Armstrong of Specialised Zoological and Mr Paul Barden of Ecological Management Services. Both have

ID#	13	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions	EIS Section:	Appendix G – GBAP
extensive experience in fieldwork, and extensive experience with bat research, management and conservation (CVs can be provided). In particular, Dr Armstrong completed a PhD on the orange Leaf-nosed bat, and has continued both funded research and consultative projects on cave dwelling bats continuously since 1996, in Australia, New Guinea, Indonesia and Japan. In addition, Action 11 specifies support for a postdoctoral researcher, and this role will be filled by Ms Nicola Hanrahan who has recently submitted a PhD thesis on the acoustic ecology of the Ghost bat in the Northern Territory. Provisional timing for each activity as they relate to Ghost bat actions is provided in Section 3.4.3 in Table 3-5 – Ghost Bat Management Schedule.					

ID#	14	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 1	EIS Section:	11.3.1 and Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 1 refers to closure of the OK adit only based on carefully planned protocol. Update Action 1 to include: • Closure of Prospect adit • Timeframe for adit closure • Report with protocol for closure					
Response					
The Action Plan has been updated to specify the requests above (see also response to ID#10). The Exclusion protocol is already specified in Action 1 Step 11 of the Action Plan (Appendix 4 of this report); see also Response to ID#10. Timeframes have also been added to the Ghost Bat Management Plan (Appendix 5 of this report) and in Section 3.4.3 of this Supplementary.					

ID#	15	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 2	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 2 refers to characterisation of OK, Union North and Lady Alice adits including roost locations of Ghost bats. Update Action 2 to include: • Lady Alice adit in the title • Actions conducted to date and any proposed actions yet to be undertaken • Results for characterisation of Lady Alice adit • Results of other actions not reported in the Draft EIS (flooding potential of Union North adit) • Contingency measures should Lady Alice adit be found not suitable for Ghost bat habitat • Discussion on the merit of including a contingency offset measure • Avoid the use of terms 'could' and 'might' to reduce uncertainty about what actions are proposed					
Response					
The description of Action 2 has been updated to specify the requests in this submission. A report describing the outcomes of Action 2 is specified in the Action Plan (refer to Appendix 4 of this report), however we also attach a description of some preliminary work in Memo 3: Summary of actions at Lady Alice adit (A report describing the outcomes of Action 2 is specified in the Action Plan (refer to Appendix 4 of this report), however we also attach a description of some preliminary work in Memo 3: Summary of actions at Lady Alice adit (Appendix 7 of this report)					

ID#	15	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 2	EIS Section:	Appendix G – GBAP
and Memo 4 Outcomes from Action 2: internal investigations of adits in the Union Reefs project area (Appendix 8 of this report), which includes an assessment of the flooding potential of Union North adit. This potential risk is considered further with management controls in the Ghost Bat Management Plan (Section 8.3 at Appendix 5 of this report). Mention of *"contingency measures should Lady Alice adit be found not suitable for Ghost bat habitat"* is already addressed by Action 3. The opening of the Lady Alice adit is a contingency in itself; it does not require its own contingency, though Action 3 provides further contingency through the provision of two artificial roosts. *"Discussion on the merit of including a contingency offset measure"* was elaborated upon in the Response to ID#10 (recall the description of 4 contingencies and 2 checks provided in Section 3.6.1 of this report). In addition, we attach Memo 2: An analysis of commitments to Ghost bat protection under the EPBC Act 1999 Environmental Offsets Policy October 2012 (refer to Appendix 6 of this report).					

ID#	16	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 3	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 3 refers to creating artificial habitats as Ghost bat roosts, for both contingency and redundancy. Update Action 3 to: • Include a full description of proposed works with proposed timing, design and site selection • Include consultation undertaken with other bat experts • Include assessment of likely outcomes • Include timing and duration of ongoing monitoring • Remove vague terminology like 'it would be ideal if…'					
Response					
Action 3 has been updated to Remove vague terminology like 'it would be ideal if…'. A full description of proposed works with proposed timing, design and site selection, and a discussion of materials is provided in Memo 5: Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs and it's appended report (Memo 5 is provided at Appendix 9 of this report) and Memo 6: Progress update: artificial Ghost bat roost design project, Union Reefs (Appendix 10 of this report). Timeframes have also been added to the Ghost Bat Management Plan (Appendix 5 of this report) and in Section 3.4.3 of this Supplementary. With regard to consultation with other bat experts, there is very little experience in construction of artificial bat roosts in Australia, and virtually no information in the public domain about the success of these structures. The authoritative guide is Thomson (2002), and there are numerous publications from the USA that provide design ideas for these structures, including a seminal guide by Bat Conservation International, available at URL: https://www.batcon.org/pdfs/batsmines/batsmines_01-08.pdf Consultation was attempted with two mining proponents in the Pilbara that have recently built artificial roost structures, but no response was received. However, the photographs available online are similar to prototype designs provided to them by Dr Kyle Armstrong (letters by Specialised Zoological to proponents 2013-12-19 and 2013-01-10; available upon request), and details in online articles provided further details (see reference list for web sites). Information on artificial roosts was also written into the manuscript of (Cramer et al. 2016) by Dr Armstrong. Dr Armstrong was also involved in the construction of the first artificial bat roost in the Pilbara in 1998 by Hamersley Iron at the Tom Price mine. The designs that will be installed in the Union Reefs area will build on the information in the literature, various Pilbara experiences, and critically, the thermal microclimate modelling using Computational Fluid Dynamics that will inform design selection. The latter modelling work is underway by consultant engineers. See Memo 5: Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs (Appendix 9 of this report).					

ID#	16	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 3	EIS Section:	Appendix G – GBAP

In terms of a likely outcome, we cannot provide a guarantee that the design of the artificial roost sites will be suitable for Ghost bats, nor that Ghost bats will find and use them. Action 9, which describes the survey that will be conducted for roosts in natural caves in hilly areas surrounding the Union reefs project area (hills with mesa bluffs in particular), is designed to provide information about the potential for other roosts close to the OK adit and Union North adit that may be used when the OK adit and Prospect adit have been closed, and in the event that the Union North adit becomes unsuitable.

It should also be noted that baseline monitoring of Ghost bat usage of adits in the Union Reefs project area has demonstrated that Ghost bats freely move in and out of this area through natural processes (Memo 1: Ghost bat activity monitoring August 2019 – March 2020; provided in Appendix 3 of this report), and presumably are able to reach other suitable and known roosts within their nightly flight range.

However, there are several key aspects of the design process for the artificial roosts that we have incorporated to maximise the possibility that they will be colonised, and therefore provide the intended contingency (including but not limited to):

- Experience from the Pilbara has been sought and researched, and some of this experience was also available through one of the bat specialist consultants that prepared the present EIS (Dr Kyle Armstrong).
- Alternative designs have been investigated for their potential to maintain a suitably warm, humid microclimate by applying numerical modelling using Computational Fluid Dynamics.
- Preliminary sites for the artificial structures have been chosen (see Figure 3-3 of this report). These are on the opposite side of hills to mining activity that do not expose them to noise, vibration, dust or light. They are also directly between the Union North adit and two large steel culverts underneath the railway that were observed to be used as nocturnal feeding sites on the survey in August 2018.
- Application of various smaller features of design that impede casual entry by people.

ID#	17	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 4	EIS Section:	Appendix G – GBAP

Comment

Clarification is required for specific actions – Action 4 refers to reopen and rehabilitate Lady Alice adit so it is suitable for Ghost bat occupancy.

Update Action 4 to build upon commitments undertaken by Action 2 and actions commenced, include:

- Rename Action 4 to capture the December opening of Lady Alice adit
- Focus on rehabilitation requirements based on characterisation of Action 2
- Timing and duration of monitoring to evaluate the condition of adit climate and success of bat usage

Response

Some work has been undertaken at the Lady Alice to partially open the entrance. Further details are available in Memo 3: Summary of actions at Lady Alice adit (Appendix 7 of this report); and a full report will be available once work is complete as stated in Action 4.

The “timing and duration of monitoring to evaluate the condition of adit climate and success of bat usage” is already incorporated into Action 7 (Table 1 of Action Plan [Appendix 4 of this report]; specifically related to bat usage), and the inclusion of microclimate modelling via dataloggers will be included with mention of bat usage in all reports.

Provisional timing and duration of each aspect of Ghost bat monitoring as it relates to Action 4 (and all other relevant actions) is provided in Section 3.4.3 in Table 3-5 – Ghost Bat Management Schedule.

ID#	18	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 5	EIS Section:	Appendix G – GBAP

Comment

ID#	18	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 5	EIS Section:	Appendix G – GBAP
Clarification is required for specific actions – Action 5 refers to management of the primary Ghost bat adit within the Proposal area, Union North adit. Update Action 5 to include detailed conditions, action triggers and reporting protocol to manage Union North adit					
Response					
Action 5 specifies a requirement for notification of breaches of restrictions and follow up actions, to be included in the regular monitoring reports if such events occur. Further details are available in the Ghost Bat Management Plan (Section 8.2 of Appendix 5 in this report) and include designated exclusion zones surrounding alternative adit entrances and methods for awareness and enforcement of this strategy including roles and responsibilities of all personnel on site.					

ID#	19	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 6	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 6 refers to implementation of management measures at Pine Creek only. The Draft EIS section 11.3.1 refers to management of the Spring Hill Ghost bat colony as well as Pine Creek. Update Action 6 to: • Confirm proposed locations for all management actions • Outline detailed management measures • Include commitments for all management actions					
Response					
Action 6 will be updated to identify proposed locations for management actions when NTMO confirms acquisition of, for example, the Spring Hill lease and operations. At the present time, the proponent commits only to those locations where it operates, including: • Protecting the Kohinoor adit at Pine Creek, as described in Action 6 in the updated Action Plan (Appendix 4 of this report). NTMO recognise that protection of the colony in the Kohinoor mine requires liaison with stakeholders in the Pine Creek area, including local Government, townspeople and Traditional Owners. NTMO commitments will be dependent on the support of these groups. However, the most important ideas are detailed in Action 6, and the proponent will commit to those if it is practicable to implement them (given local support). In summary, these commitments are to explore the options for restricting access using fencing and signage and screening from view of the road; and including the Kohinoor adit in the monitoring program detailed in Action 7 to provide long term visitation data. • Providing support for a postdoctoral researcher to lead on-ground conservation work at Pine Creek, as a collaboration amongst all stakeholders, as described above in response ID#11 and in Action 11 of the updated Action Plan (refer to Appendix 4 of this report). 'On-ground' conservation actions are probably best lead by an independent researcher rather than a mining company, though the proponent has also effectively committed to funding on-ground works through Action 11.					

ID#	20	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 7	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions –Action 7 refers to long term monitoring of local and regional Ghost bat habitat. Update Action 7 in accordance with:					

ID#	20	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 7	EIS Section:	Appendix G – GBAP
• Monitoring results since submission of the Draft EIS • Information requested above with regard to Ghost Bat Management Plan • The EPBC Act Offsets Policy with regard to the value of increased knowledge and understanding of the species' spatial ecology and metapopulation genetic structure					
Response					
We provide Memo 1: Ghost bat activity monitoring August 2019 – March 2020 (Appendix 3 in this report). The data collected in this period since submission of the Draft EIS, supports the theory that Ghost bats regularly move in and out of the Union Reefs area. The Ghost Bat Management Plan (Appendix 5 in this report) provides operational detail including roles and responsibilities for the monitoring program in Action 7. The GBMP also lists reporting commitments for results of the monitoring program. Memo 2: An analysis of commitments to Ghost bat protection under the EPBC Act 1999 Environmental Offsets Policy October 2012 (Appendix 6 of this report) has been provided to address the requirement for further information about how Action 7 may be considered an environmental offset.					

ID#	21	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 8	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 8 refers to providing part of the new mine as Ghost bat habitat. Update Action 8 to: • Include a full description of proposed design and timing • Consider the EPBC Act Offsets Policy with regard to whether this action mitigates rather than offsets Ghost bat persistence					
Response					
Timing of activities relating to Action 8 (and all other actions) is provided in Section 3.4.3 in Table 3-5 – Ghost Bat Management Schedule of this report. The report of Velasco 2019 (Appendix 1 of Appendix G of the Draft EIS) shows several illustrations of the planned underground structure of the mine. Only upper portions will be retained for Ghost bats. We provide Memo 2: An analysis of commitments to Ghost bat protection under the EPBC Act 1999 Environmental Offsets Policy October 2012 (Appendix 6 of this Supplementary), to address the requirement for further information about how Action 8 qualifies as an environmental offset. Action 8 has been updated to include the requirement for a report on an evaluation of the closure and gating of the mine entrance, as well as any resulting actions that are considered to be effective in maintaining Ghost bat presence and that of other bat species at the site in the long term. Action 7 specifies the monitoring commitment.					

ID#	22	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 9	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 9 refers to field surveys for Ghost bat roost in natural caves. Update Action 9 to include: • Frequency and timing of proposed surveys • Description of how information will be compiled • Reporting of information, for example, provided to DENR, DOEE and/or made publicly available					
Response					

ID#	22	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 9	EIS Section:	Appendix G – GBAP
The first field survey is planned for May 2020. Timing and duration of each aspect of Ghost bat monitoring as it relates to Action 9 (and all other relevant actions) is provided in Section 3.4.3 in Table 3-5 of this report. Action 9 in the Action Plan (Appendix 4 of this report) has also been updated to include information on the frequency and timing of the proposed surveys. A description of how information will be compiled will be as per the methods described within reports submitted to NTG for drilling approvals by Armstrong and Barden (2018, 2019). As stated in Action 9 that *"The presence of Ghost Bats will be established from scat material accumulations at the entrance of caves, and bat detector and video recordings made at cave entrances."* The video monitoring will benefit from recent developments in the construction of an autonomous thermal video recording system based on the FLIR Boson camera. Action 9 has been updated to include this detail, as well as some details of the acoustic recording and analysis process. Mention was made in Action 9 of the intention to produce a report. This will be made available to the NT Government. Action 9 has been updated to specify this (refer to Appendix 4 in this report). An assessment will be made upon completion of the report on whether it is appropriate to release into the public domain, given the sensitivity of information on threatened species.					

ID#	23	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 10	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 10 refers to genetic studies to investigate the connectedness of regional Ghost bat colonies. Update Action 10 to include: • Frequency and timing of genetic studies • Scope and design of further genetic studies • Description of how information will be compiled • Reporting of information, for example, provided to DENR, DOEE and/or made publicly available.					
Response					
The timing of activities relating to Action 10 (and all other actions) is provided in Section 3.4.3 in Table 3-5 of this report. The genetic study will be initiated as soon as the project is approved, and subject to any timeframes required to obtain permits and land access agreement. Response to ID#10 specified the timing of the study and report—The deadline of this report will be six months from the completion of the field component, with its timing depending on the date of project approval, the timeframes required for permits, the success of field collection surveys and the timeframe required for laboratory work to be completed by an external service provider. The scope of the proponent's commitment is outlined under Action 10, and the scope of this genetic study will inform the management and assessment of Ghost bats both in the Union Reefs area and the wider Daly River region. Mention was made in Action 10 of the intention to produce a report. This could be made available to the public upon request from the time it is submitted to the NT Government, but more likely it will be released to the public domain via the peer-reviewed scientific literature. Action 10 has been updated to specify this.					

ID#	24	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 11	EIS Section:	Appendix G – GBAP
Comment					
Clarification is required for specific actions – Action 11 refers to providing support for further academic research.					

ID#	24	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 11	EIS Section:	Appendix G – GBAP

DENR's Flora and Fauna Division notes that there are uncertainties about the risks associated with the temporary closure of the OK adit and the proposed mining activities, with the potential for a significant impact on a sub-population of the Ghost bat. Within this context, the division is generally supportive of the proponent's commitment to fund additional actions that are likely have a net benefit to the regional population of the species, including through significantly increasing understanding of the species' spatial ecology and metapopulation genetic structure. If implemented as outlined in the Draft EIS, these actions may adequately compensate for any residual significant impacts from the proposal.

Update Action 11 to:

- Clarify whether funding is intended to offset this proposal or is part of a separate commitment
- Clarify reporting of information, for example, provided to DENR, DOEE and/or made publicly available
- Note that under the EPBC Act Environmental Offsets Policy no more than 10% can be applied for indirect offsets. Funding for research programs is generally considered to be an indirect offset

Response

We provide Memo 2: An analysis of commitments to Ghost bat protection under the EPBC Act 1999 Environmental Offsets Policy October 2012 (refer to Appendix 6 of this report), to address whether Action 11 could be considered as an environmental offset.

In response to the request for clarity around reporting information, the postdoctoral researcher will be required to provide regular update reports to the proponent as a courtesy, but these will represent internal documents. It will be up to the postdoctoral researcher to publish her own research in peer-reviewed scientific journals, and make any of her efforts for Ghost bat research and conservation available in the public domain as she deems appropriate.

For clarity around the use of the term *"spatial ecology"* mentioned in Submission ID#'s 20 and 24, the proponent will not be conducting or funding direct research on spatial ecology. The use of genetic markers under Action 10 is simply as a means to be able to infer the connectedness of colonies in the region and beyond. Metapopulation structure requires a separate and multi-disciplinary investigation (this is a whole subsection of population biology), though the population genetic study may be able to speculate on whether the population might behave as a metapopulation. The scope of the postdoctoral researcher might extend to investigating aspects of population structure as they relate to a metapopulation, but this is up to the independent consideration of the postdoctoral researcher.

ID#	25	Topic:	Hydrological Processes: Mine Water Use	EIS Section:	Section 8

Comment

The site water balance indicates that the site is hydrologically in water excess. Provide details of any operational water sourcing hierarchy established for the site and whether there are water reuse and recycling measures in place to minimise the volume of imported water and the generation of mine affected water that would potentially require discharge to the receiving environment.

Response

Dam C was created at a time when the site operations were in water deficit. Processing operations depended on water inputs from the newly created Dam C. since then the site has accumulated significant quantities of water and much of the water requirement for processing operations has shifted to recycle water i.e. from Crosscourse pit. Required Dam C water i.e. Low EC and neutral pH includes the following:

- Elution circuit
- Wash down
- Cleaning processing tank
- Flushing

The site operations sourced 250 - 300 ML annually from Dam C during the period 2015 - 2017 before processing operations were shut down. The reopened processing operations intent, initially to use the same amount of Dam C water. In the longer term, KLG have committed to constructing and operating an RO water treatment plant to achieve a suitable water quality to allow reuse of more water from Crosscourse pit for processing, in place of use of

ID#	25	Topic:	Hydrological Processes: Mine Water Use	EIS Section:	Section 8
raw water from Dam C. i.e. Water would recycled from Crosscourse pit for processing instead of use of raw water from Dam C. There will still be a requirement for some discharge to the environment from Crosscourse pit.					

ID#	26	Topic:	Hydrological Processes: Numerical Groundwater Model	EIS Section:	Appendix H
Comment					
The Department of Industry and Primary Resources (DPIR) and DENR's Water Resources and Environmental Authorisation divisions identify the following limitations of the numerical groundwater model described in Appendix H: • The flow model is based on input data from analytical models and a very limited dataset for calibration and validation. At best this is a regional scale model and not appropriate as a predictive tool for meaningful impact assessment of contaminated seepage especially post closure. Refinement should aim to improve the predictive capability of the models is insufficient in its present form to support the claim that there will be no impact on the Pine Creek town water supply borefield. • The model does not currently incorporate a key component of the area's conceptual model, which is that the aquifer transmissivity is very likely to be enhanced along the shear zone and this feature may facilitate increased directional drawdown towards the borefield. • The model calibration has also only focused on recharge and has not included an adequate incorporation of the previous dewatering water level data that exists for the area (specifically for the period 1990 through to present). • Further modelling is required to understand the extent of the predicted drawdown and to increase confidence in the modelled outputs. • It is likely the groundwater model has underestimated the predicted drawdown. Further to information provided in the Draft EIS: • Update the commitment for monitoring and reporting (Draft EIS 12.5) to include results from further refinement of the conceptual model and subsequent modelling. • Provide modelling and discussion to address the TOR (Section 2.2.2 – Hydrological Processes), specifically that there will be no impact the Pine Creek water supply. Include consideration of transmissivity along the shear zone. • Consider the impacts of depressurisation are a relevant consideration under the Water Act 1992 in relation to impacts on existing water users (e.g. town water supply, stock and domestic users).					
Response					
The response to this submission is presented in Section 3.9.					

ID#	27	Topic:	Hydrological Processes: Mine Water Management	EIS Section:	Section 8
Comment					
Table 8-1 does not seem to reflect the possible 18 L/s groundwater inflow and suggests peak ingress is 221 ML in 2022 and 2023. This is important for understanding the adequacy of water storage and the likelihood of any unplanned discharge. Clarify the site water balance with regard to taking into account worst case groundwater ingress scenarios.					
Response					
Table 8-1 (operational site water balance) in the EIS shows that the groundwater ingress adopted for the site water balance is equivalent to about 7 L/s, i.e. the lower bound. This has been adopted as the most likely scenario for the site water balance under average conditions. In the unlikely case that the worst case groundwater ingress scenario					

ID#	27	Topic:	Hydrological Processes: Mine Water Management	EIS Section:	Section 8

eventuated, i.e. 18 L/s groundwater ingress, up to an additional 347 ML/year would contribute to the site water balance, i.e. the groundwater ingress would increase from 221 L/s to 568 L/s under the worst case scenario.

- Average discharge under WDL (from Table 8-1 in EIS) is 1,734 ML
- Average discharge under WDL plus maximum groundwater flow is 2,081 ML
- Wet year discharge under WDL (from Table 8-2 in EIS) 2,358 ML

This corresponds to an additional 20% of forecast average discharges under a WDL, which is considered minor and within the potential year to year variation with rainfall.

ID#	28	Topic:	Hydrological Processes: Mine Water Management	EIS Section:	Section 8

Comment

Clarify the method of dewatering of mine water ingress during the operational phase of the project.

Response

Underground waste water and groundwater ingress will be pumped by sump pump into Prospect north pit. Prospect north pit water storage pond will be dewatered regularly into Crosscourse pit. Water will be pumped via a 200 to 300 mm diameter pipeline connect to Crosscourse pit. Pumping will be via a diesel pump. A dewatering schematic is included in the Water Management Plan in Appendix 11 of this report.

ID#	29	Topic:	Hydrological Processes: Groundwater Drawdown – Dewatering Pits and Underground Void	EIS Section:	Section 12

Comment

Confidence around predicted drawdown is important to fully understand the likely extent of drawdown and potential impact on existing water users (including stock and domestic) in context of declared beneficial uses of the receiving environment. Outputs from additional modelling will be required to inform the water management plan and corresponding monitoring program.

Provide the Water Management Plan as part of the Supplement submission. It is recommended that the water management plan is developed in consultation with DENR's Water Resources Division.

Response

Increase in model confidence is addressed above in Submission ID#26 (i.e. Section 3.9 in this document). The outputs (but not the documentation) were available when the elements of the Water Abstraction Management Plan and corresponding monitoring program were devised.

The Water Abstraction Management Plan is provided as Appendix C of Appendix 11 of this report.

ID#	30	Topic:	Hydrological Processes: Water Balance	EIS Section:	Section 8

Comment

The Draft EIS states that 'the net balance of direct rainfall, catchment runoff and evaporation is estimated to be 455 ML on average, indicating that the site is hydrologically in water excess'.

Provide detail in terms of water storage capacity on site and any points of uncontrolled discharge or overflow.

Response

ID#	30	Topic:	Hydrological Processes: Water Balance	EIS Section:	Section 8

The estimated surface water excess presented in the EIS Section 8.1.1 simply demonstrates the fundamental surface water hydrology of the site, which is but a component of the overall site water balance described in the EIS Section 8. The water storage capacity and discharge information is provided in Section 8.1.6.

Overflow points include the following:

- Dam B overflow to Sediment Trap 3
- Sediment Trap 3 overflow to McKinlay River
- Sediment Trap 4A overflow to McKinlay River
- Dam C overflow to Dam A
- Dam A overflow to Wellington Creek
- Decant pond to McKinlay River
- Sediment Trap 5B overflow to Esmeralda Creek

Section 5.1.5 and Section 8, Figures 8-1 and 8-2 in the Water Management Plan (refer to Appendix 11 of this report) describe water flow during average and wet rainfall seasons. No uncontrolled discharge via overflow points are expected (i.e. associated with the Project areas), in part due to the mitigation measures of the WDL described in Section 8.1.6 in the Draft EIS. Overflow paths at the URPA are described in the Water Management plan in Section 5.1.5.

ID#	31	Topic:	Hydrological Processes: Water Balance	EIS Section:	Section 8

Comment

The water balance has been drafted considering typical rainfall characterised by historical rainfall conditions. In the event of rare or extreme rainfall events and considering the water level in Crosscourse pit is close to the spill level, detail should be provided on the flow path in the event of an overflow of the pit. Further, provide detail on how a rare or extreme rainfall event would impact on the water balance of other water holding structures on site.

Response

It is appropriate to assess the effect of an extreme rainfall event on the site water balance, but the probability of coincidental occurrence of very wet seasonal conditions (which the EIS does present) and an extreme flood event (which the EIS does not present) is highly unlikely. The sensitivity of site water balance to rare wet seasonal conditions (i.e. an extreme wet season) is included in Section 8.1.7 and an assessment of potential impacts of extreme flood events are included in Section 8.2.2.

With the proposed mitigation measures, overflow from Crosscourse pit is not expected to occur during operations.

Section 8, Figures 8-1 and 8-2 in the Water Management Plan (refer to Appendix 11 in this report) describe water flow during average and wet rainfall seasons. Overflow paths are described in comment # 30 above, and do not include Crosscourse pit.

For site operational purposes, analysis of 100, 500, 1,000 years average return interval flood events have been presented for Prospect pit and Crosscourse pit. Please refer to Water Management plan, Section 6.3, Section 7.2 and Appendix A, in Appendix 11 of this report.

The water balance will be analysed annually to provide comprehensive study of the full seepage, runoff and evaporation cycle.

ID#	32	Topic:	Hydrological Processes: Stormwater	EIS Section:	Section 8.3

Comment

Where it is stated that runoff from Dam C is expected to be in the order of 1,500 ML/year, confirm whether this means that 1,500 ML/year would be passively discharged to the receiving environment every year.

Response

ID#	32	Topic:	Hydrological Processes: Stormwater	EIS Section:	Section 8.3

Dam C is a clean water storage and receives runoff from upslope catchment unaffected by mining. Overflows from Dam C would not be considered a "discharge" to the receiving environment in the same way as discharges from mine affected water storages at the site. Therefore it is not appropriate to characterise overflows from Dam C as "passive discharge", as Dam C simply impounds a tributary of Wellington Creek.

Overflows are described in detail in the water management plan and have been summarised below.

TABLE 2-2 SUMMARISED OVERFLOWS

	1,380 mm Average Rainfall Surface Runoff Volume (ML)	2,000 mm High Rainfall Surface Runoff Volume (ML)
Dam B overflow to Sediment Trap 3	309	646
Sediment Trap 3 overflow to McKinlay River	278	631
Sediment Trap 4A overflow to McKinlay River	191	318
Dam C overflow to Dam A	0	300
Dam A overflow to Wellington Creek	368	1,050
Decant Pond to McKinlay River	475	723
Sediment Trap 5B overflow to Esmeralda Creek	251	419

ID#	33	Topic:	Hydrological Processes: Groundwater	EIS Section:	Section 12

Comment

Figure 12-1, relating to the regional groundwater study area, shows a Discharge Boundary and a No Flow Boundary. Detail should be provided on these boundaries and their purpose.

Response

Not all details are discussed in the main body of the EIS and it is not intended to be read without the Appendices. Figure 12-1 in the EIS is analogous to Figure 18 in the groundwater study (Appendix H of the Draft EIS). It is here that the boundaries are discussed, i.e.:

"*In summary the groundwater study area is bounded by granites with very low permeability which are considered no-flow boundaries. In some cases these are co-incident with or adjacent-to topography/surface water divides. The exceptions to this are:*

- The narrow northwards exit for the groundwater system (Figure 18); and
- A gap in the north east extreme of the groundwater study area which is considered to be a no-flow groundwater boundary, as although it does not have a change in geology, it has a minor local topography/surface water divide, which is also a likely groundwater divide (Figure 18)."

The discharge boundary allows water out of model replicating streamflow along a tributary of the McKinlay Creek. The no flow does not allow flow in or out of the model and this is considered appropriate:

- Where granite bounds the aquifer; and
- In the north east extreme area of the model where there is a subtle topography divide and highly likely a groundwater divide.

ID#	34	Topic:	Hydrological Processes: Groundwater	EIS Section:	Section 12
Comment					
There is potential for groundwater drawdown to impact on base flows of the McKinlay River i.e. increased loss of water from the McKinlay River to the alluvium during and post mining. Provide detail of the proposed trigger values for groundwater drawdown levels and include in the Water Management Plan, along with a monitoring program to allow early detection of any drawdown that could impact on water availability or yield for other users or receptors					
Response					
Modelled groundwater levels do not change at the McKinlay River. Dealing with the second part of the comment first, there is no indication there will be any increase in water loss to the aquifer from McKinlay River to the alluvium during and post mining. This contrasts the conceptual model where the McKinlay River is always a discharge location. It is recognised that this is likely reverse in the immediate area adjacent to the McKinlay River channel when the river is full of surface water but that this 'source' mode for the McKinlay River is highly likely to be short-lived due to the incised geometries of the bed and banks in the landscape. This short-lived and localised mechanism is not considered warranted to be included in the groundwater modelling. Dealing with the first part of the comment, baseflows in the McKinlay River are the recession component of streamflow which occur following rainfall that is large enough to result in surface water flow. These baseflows are groundwater, but are associated with the rainfall associated change in the areas immediately adjacent to McKinlay River which explains why they are ephemeral and short-lived. The mechanisms for their formation and the magnitude of these baseflows is not likely to be materially changed by the aquifer drawdowns modelled as the aquifer geometry is not materially changed. The Water Abstraction Management Plan is provided as Appendix C of Appendix 11 of this report.					

ID#	35	Topic:	Hydrological Processes: Groundwater Drawdown – Potential Impacts	EIS Section:	Section 12
Comment					
Drawdown losses were not considered likely to result in the drying of permanent pools in the McKinlay River, but it was acknowledged that this may lead to reduced volume, especially towards the end of the dry season when evaporation is high. In years of low rainfall, isolated permanent pools are especially important as they provide refuge for aquatic flora and fauna that propagate the river during the wet season. Provide updated hydrogeological modelling results to provide improved certainty on the potential significance of drawdown on surface water and permanent pools.					
Response					
Increase in model confidence is addressed in Submission ID#26 and Section 3.9. The models presented here (Appendix 14) report outcomes based on a series of additional changes to model parameters. The modelling presented in this report does not change the material outcomes of the modelling previously performed in the Draft EIS Appendix H. Model outputs from this report increase the confidence of the previous models. Following on from this report we consider the results presented in the Draft EIS Appendix H to be conservative in nature and reasonable for inclusion in the Environmental Impact Statement.					

ID#	36	Topic:	Hydrological Processes: Surface Water Flows	EIS Section:	Section 12
Comment					
Treated mine-affected water is proposed to be discharged to the McKinlay River under a WDL. The Proponent should provide certainty that it has adequate baseline flow data to determine the conditions under which release of water could occur without having a significant impact on the surface water quality and flow regime. Releases of water to the McKinlay River should be monitored and managed to avoid any significant changes to the timing, rate,					

ID#	36	Topic:	Hydrological Processes: Surface Water Flows	EIS Section:	Section 12
frequency and duration of seasonal surface water flows. Provide details of how this would be addressed in the Water Management Plan.					
Response					
KLG has produced a Water Management Plan (WMP) and will produce a WDL application to address this comment further. Section 5 of the WMP (refer to Appendix 11 in this report) Active Crosscourse Pit Dewatering Concept Plan of the WDL provides the background information for these works.					

ID#	37	Topic:	Inland Water Environmental Quality: Wastewater Treatment	EIS Section:	Section 8
Comment					
It is noted that NTMO treats water at different sites across its lease areas to manage contaminant levels prior to discharge to the receiving environment and that primary treatment using caustic soda, limestone or lime is carried out to stabilise pH. Apart from Crosscourse pit. Detail should be provided on where this treatment takes place and at what frequency. Further treatment with Ferrous Chloride (FeCl2) is then required to reduce concentrations of contaminants, specifically metals, to obtain a suitable water quality for discharge. Detail should be provided on where this treatment is carried out, what the desirable water quality is prior to treatment, and whether treatment with FeCl2 would result in elevated concentrations of iron or other contaminants in the receiving waters. It is understood that cyanide has been detected in the tailings discharge to Crosscourse pit; detail should be provided on whether the processing operations allow for cyanide destruction to prevent downstream impacts.					
Response					
The treatment method proposed is a two-stage in-pipe dose system using a Caustic50 treatment first to raise the pH to 9.0. This targets the heavy metals which precipitate out as insoluble hydroxides. This is then followed, further down the pipe, with a Ferric Chloride dose to remove the Arsenic and reduce the pH to the desired 8.0. The dose quantities are kept to the minimum required to achieve the target water quality with the current dose rates being approximately 0.05 g/l of C50 and 0.08 g/l of FeCl3. Information about the proposed waste water treatment, water quality parameters and cyanide destruction is detailed in Section 3.11 below.					

ID#	38	Topic:	Inland Water Environmental Quality: Water Treatment	EIS Section:	Section 8
Comment					
Where it is proposed to treat and discharge out of Crosscourse pit, detail should be provided on the infrastructure and capacity onsite for treatment and discharge. Confirmation should be provided on whether treated water would be pumped into Dam B and discharged via the proposed authorised discharge point.					
Response					
The tailings water will be treated into Dam B with a control release algorithm to McKinlay River. Details are provided in the Water Management Plan (Section 5, Active Crosscourse Pit Dewatering Concept Plan of Appendix 11 of this report).					

ID#	39	Topic:	Inland Water Environmental Quality: Water Storage Capacity	EIS Section:	Section 8
Comment					
Provide details of the overall capacity of Crosscourse pit, the capacity that remains available, the rate and volume of tailings and water generated by current mill processing of material from Cosmo Howley and projected volumes through the life of the Proposal. Demonstrate that the Crosscourse pit has adequate capacity to receive the projected volumes of tailings and water. If it is proposed to use water from Crosscourse pit to manage water levels, identify what the water would be used for and demonstrate that the water quality is suitable for the intended use.					
Response					
The overall capacity of Crosscourse pit is described in the Water Management Plan (refer to Appendix 11 of this report). The total capacity of Crosscourse pit is estimated 29,282 ML, of which 10,190 is occupied by tailings, 12,605 ML is occupied by water, leaving 6,487 ML of freeboard to the overflow level a 234 m AHD. The rate and volume of water displaced by tailings throughout the Project is detailed in Table 8.1 in the EIS, which shows that a total of 2,051 ML of water is forecast to be displaced by tailings throughout the Project. This volume is small (11%) of the remaining tailing storage capacity in Crosscourse pit. As described in Section 8.1.6 in the EIS, water from Crosscourse pit would be treated and discharged under a WDL to maintain the current freeboard to minimise passive seepage out of Crosscourse pit. KLG have also committed to constructing and operating a RO water treatment plant to achieve a suitable water quality to allow reuse of water from Crosscourse pit for mining and processing in place of use of raw water from Dam C. Additional details are provided in the Water Management Plan (Appendix 11 of this report), Table 11 Crosscourse Life Cycle Analysis Average Rainfall April 2020-April 2024 without Discharge and Table 13 Crosscourse Life Cycle Analysis Four Consecutive Years Wet Rainfall April 2020-April 2024 without Discharge.					

ID#	40	Topic:	Inland Water Environmental Quality: Water Quality – Crosscourse Pit Outflows	EIS Section:	Section 8
Comment					
Crosscourse pit is anticipated to become a groundwater source at 173 to 176 m AHD. Provide detail on how outflows from Crosscourse pit would potentially affect the surrounding aquifer water quality and how such impacts would be managed and mitigated during operations and post mining.					
Response					
Initial groundwater outflows would be expected to flow towards Dam B due to the geometry of the system. Groundwater quality of outflow is highly likely to reflect that of the quality of the Crosscourse pit. A groundwater monitoring network involving three bores (two before Dam B and 1 adjacent to Dam B) are proposed. In addition, Dam B will be monitored. More detail is provided in the Water Quality Management Plan (Refer to Appendix D of Appendix 11 in this report). Crosscourse pit levels are intended to be controlled using the mitigation measure of a WDL.					

ID#	41	Topic:	Inland Water Environmental Quality: Prospect Pit Backfill	EIS Section:	Appendix H – Section 4.3.5 page 56
Comment					
Section 4.3.5 of Appendix H states that *"The post underground mining groundwater regime at the other pits is highly likely to mimic the pre-underground mining groundwater regime. The exception to this is the Prospect pit itself which will be dewatered and infilled to above water table during mining."* Confirm that the Proposal includes backfilling the Prospect pit South only and that waste rock will be maintained to above the water table during mining.					

ID#	41	Topic:	Inland Water Environmental Quality: Prospect Pit Backfill	EIS Section:	Appendix H – Section 4.3.5 page 56
Discuss whether infilling to above the water table is proposed for the Prospect pit North, Prospect pit South or both.					
Response					
KLG confirms that the Proposal includes partially backfilling the Prospect pit South. This is a staging point for progressively underground backfill. Traditionally underground mining does not produce the volumes of waste that are generated in open pit mining. Traditionally, waste material is used to backfill underground development and stoping to ensure the mine remains stable for the life-of-mine. The pit will be dewatered prior to backfill. Backfill in the pit 291,000 t will be returned underground during mining (other than a small amount of inter material required at the portal). Waste rock will be maintained to above the current water table (1175 mRL) during mining by active sump pumping when and if required. During operations, these waste rock materials will be variously saturated and unsaturated, during rain events. Saturated fresh rock will not oxidise, and hence will not be a source of Acid Rock Drainage (ARD) or Neutral Mine Drainage (NMD). Unsaturated fresh and transition waste rock will be exposed to oxidation and water leaching, but geochemical testing (see Appendix 12 in this report) shows that these materials will be dominantly Non-Acid Forming (NAF), with Potentially Acid Forming (PAF) materials making up an estimated 5%. The NAF materials have excess acid buffering potential, and when mixed with PAF are expected to control any significant acid generation, and the generation of AMD/NMD is expected to be insignificant during operations. This will be monitored as part of water management (see Appendix 11 in this report). Geochemical testing also shows that oxide waste rock is inert and hence suitable for permanent surface storage above the water table if required. Prospect pit North will be a temporary storage pond for underground water and levels are intended to be maintained below current water table (1175 mRL) at either less than 1168.5 or 1173.5 mRL depending on portal levels. Water levels in Prospect pit North are also likely to influence water tables in Prospect pit South. The water table is anticipated to rebound to the pre mining level in both the Prospect pit North and South post closure.					

ID#	42	Topic:	Inland Water Environmental Quality: Water Use	EIS Section:	Section 8
Comment					
It is proposed that good quality water from Dam C will be predominantly used in processing activities with some input from water in Crosscourse pit. This process would potentially result in the generation of poor quality water and reflects minimal recycling on site. It is preferable that good quality water, i.e. the water from Dam C, be discharged from site to create capacity in the water holding structures onsite to enable the treatment and/or recycling of poorer quality water, i.e. from Crosscourse pit, to be used in processing operations. NTMO should provide detail on whether this option had been considered and investigated.					
Response					
KLG have committed to constructing and operating a RO water treatment plant to achieve a suitable water quality to allow reuse of water from Crosscourse pit for mining and processing in place of use of raw water from Dam C. Water would recycled from Crosscourse pit for mining and processing instead of use of raw water from Dam C.					

ID#	43	Topic:	Inland Water Environmental Quality: Water Discharge	EIS Section:	Section 13
Comment					
It is understood that passive discharges occur from a number of sources onsite:					

ID#	43	Topic:	Inland Water Environmental Quality: Water Discharge	EIS Section:	Section 13

- From the former TSF Decant Pond which passively discharges via a spillway into the McKinlay River
- From Dam C, which receives seepage from the East Waste Dump and passively discharges via a weir and spillway into Dam A and then into Wellington Creek
- From Sediment trap 4A which received runoff from the West WRD

Provide confirmation of whether these locations comprise the full extent of the passive discharge points and whether there other known or likely sources of passive discharge. Provide detail on whether the water quality of passive discharges is monitored to assess the impacts on the receiving environment.

Response

Passive discharge points are described in detail in the Water Management Plan (refer to Appendix 11 of this report) and described in Submission ID#32 above. All likely sources of discharge that are expected to have an influence on water quality downstream have been discussed in detail in the Draft EIS Appendix I, Section 2.3.2, as have the results of passive discharge monitoring points.

ID#	44	Topic:	Inland Water Environmental Quality: Wastewater Discharge	EIS Section:	Section 13

Comment

The Draft EIS suggests discharge of treated wastewater from Dam B to the McKinlay River via a creek. It is proposed that URSW04 will be the authorised discharge point and that URSW08 will be the compliance point. An authorised discharge point is typically the end of pipe/outfall of the source, in this case Dam B. URSW04 is approximately 1 km downstream of Dam B. A compliance point is typically just a few kilometres from the source. URSW08 is approximately 13 km downstream from Dam B, this is considered quite an extensive mixing zone.

The purpose of a mixing zone is to manage the controlled discharge of soluble non-bioaccumulatory toxicants whose impacts on local biota are primarily related to their concentration.

The water quality objective of the Beneficial Use Declaration (BUD) for the McKinlay River relating to aquatic ecosystem protection applies to the area of the McKinlay River NTMO propose to discharge waste water; it starts upstream of the mine site and continues downstream for just over 20 km. In accordance with the current Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) (the water quality guidelines), where mixing zones are to be applied, they should be as small as practicable.

Water quality management should ensure that the agreed and designated community values and management goals of the broader waterway outside the mixing zone are not compromised.

The Draft EIS suggests that the discharge location has been determined based on 'appropriate length for the mixing zone prior to compliance point monitoring at URSW08'. The length of the proposed mixing zone is over 12 km and over half the length of the BUD.

Justify and provide the method for determining the location of discharge and compliance points in relation to length of mixing zone and BUD with consideration of the water quality guidelines (ANZG 2018).

Provide alternative discharge and compliance points and details of resultant mixing zone as determined in accordance with the water quality guidelines.

Consider the BUD's in the receiving environment as well as the quantity and quality of the discharge water.

Response

See response in Section 3.12 below.

ID#	45	Topic:	Inland Water Environmental Quality: Water Quality Monitoring	EIS Section:	Section 8

Comment

ID#	45	Topic:	Inland Water Environmental Quality: Water Quality Monitoring	EIS Section:	Section 8

NTMO should describe the approach and methodology that will be used to develop site specific trigger values (SSTVs) to ensure appropriate discharge activity and early detection of any impacts to the receiving environment. This should be informed by a review of the water quality monitoring program and analysis of relevant water quality data with respect to seasonal variation and rainfall events. NTMO should clearly identify the triggers, actions and responses that would be undertaken if impacts on the receiving environment are identified or indicated through the review of monitoring data.

It is noted that proposed SSTVs, which were determined based on water quality at the upstream monitoring point, URSW09, are included at Table 8-5.

- This Draft EIS proposes a trigger value for Electrical Conductivity (EC) of 700 to 1,000 µs/cm. The most recent annual monitoring report proposed a trigger value for of 250 µs/cm and showed that EC at URSW09, is on average between 17 and 120 µs/cm. This is consistent with the ANZECC default values for conductivity which are set at 20 to 250 µs/cm.
- The Draft EIS explains that the 'proposed SSTV for EC of 700 to 1000 µs/cm is based on site data that indicates EC within the water stream is generally related to sulphate concentrations rather than toxicants such as heavy metals'. However in discussing surface water in the downstream environment of the McKinlay River the Draft EIS states that 'during nine seasons of monitoring, Electrical Conductivity (EC) has been within the Guideline Values (GV), demonstrating that the impact has been slight'. This conflicting information does not support the proposed higher trigger value for EC at the compliance point. NTMO should explain further and provide supporting evidence to demonstrate why the higher value is representative of the receiving environment.
- The Draft EIS states that 'NTMO has adopted the 95 % ecosystem protection values for environmental protection at surface water monitoring point URSW08, i.e. downstream at the end of the mixing zone. This is with the exception of aluminium and zinc, which have derived site specific trigger values (SSTVs) using ANZECC & ARMCANZ (2000) guidelines being the 80th percentile of the historic dataset'.
- This is not reflected in Table 8-5 which shows that:
  - 95 % ecosystem protection values are applied to pH, dissolved oxygen (DO) (upper percentile), turbidity, Arsenic, Cobalt, Iron, Lead, Manganese, Nickel, Selenium and Zinc.
  - 80th percentile of the historic dataset are applied to DO (lower percentile), TSS, Aluminium, Cadmium, Chromium, and Copper.

Response

See response in Section 3.13 below.

ID#	46	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 13

Comment

The Draft EIS states that 'the surface water use changes to livestock drinking water approximately 4 km downstream of monitoring point URSW08, with Pastoral Stations being the main downstream users' and 'livestock drinking water guidelines (SWG) are also considered given the downstream declared beneficial use'. The BUD for this section of the McKinlay River relates to aquatic ecosystem protection. Describe how the proposed ANZECC livestock drinking water guideline values will maintain protection of this BUD. NTMO should explain further and provide supporting evidence to demonstrate that this is the case.

Response

Aquatic ecosystem protection levels will be used. Stock watering guidelines were also referenced due to the change in usage downstream, i.e. for completeness. It is not presented as an alternative guideline, it is included for comparison.

ID#	46	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 13
The proposed guideline values (see response to Submission #45 for an updated version of Table 8.5 of the Draft EIS) support the BUD in the McKinlay River. These guideline values will be used to measure compliance at both URSW08 (95 % DGVs) and URSW10 (80 % SSTVs/DGVs). Adoption of the ANZG guidelines values is supported by the beneficial use declaration of the McKinlay River. The McKinlay River was gazetted in 1998, declaration gazette number G9, and the level of protection applied references the ANZECC 1992 aquatic ecosystem protection guidelines as the standard to which the water quality must be maintained. These guidelines have been superseded by the ANZG 2018 revision. The default guideline values used in ANZECC 1992 are not directly comparable to the values in ANZG 2018 as ANZECC 1992 DGVs are for total concentrations while ANZG are 0.45 micrometre filtered. It is appropriate to adopt the most recent guidelines for reference.					

ID#	47	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Appendix I – Geochemical Water Quality Modelling
Comment					
Section 2.3 of Appendix I of the Draft EIS states that Cosmo ore processing commenced at the URPA in 2011 and ceased in 2017 and concludes that neutral mine drainage observed in the McKinlay River through the water quality monitoring program is not related to Cosmo ore processing. However during a site visit on 29 November 2019 it was noted that the mill was processing Cosmo Ore and had been for some time. Provide details of when ore from Cosmo has been processed at the URPA and any recorded impacts to Crosscourse pit water quality or McKinlay River downstream water quality from this activity.					
Response					
The mill was turned on in late October 2019. It had not been operating ‘for some time’ during the site visit in late November, and was only operating at 50% capacity. Appendix I, Section 2.3.3 in the Draft EIS contains detailed information relating to water quality in Crosscourse pit, both during processing 2010 to 2017 and in the period since the mill was turned off i.e. post 2017. Cosmo ore has been processed since 2011, and trends show clearly that for most parameters, the Cosmo Tailings slurry quality had no effect on the water quality of Crosscourse pit. The only exceptions are Co and Cu, which have dropped since processing ceased. Comparison of water quality at upstream (URSW09) and downstream (URSW08) sites on McKinley River in Section 2.3.1 of Appendix I of the Draft EIS, covering the same period show a lack of impact from metal concentration increases.					

ID#	48	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 8
Comment					
The Draft EIS also states that 'Since the completion of mining in Crosscourse pit, it has so far been a groundwater sink, with inflows estimated to be 85 ML/year in early 2019, however if the water level in Crosscourse pit rises, the pit has the potential to become a groundwater source'. Detail should be provided on potential groundwater quality impacts considering Crosscourse pit receives mine tailings.					
Response					
Crosscourse pit has received tailings in the past and the effects have been observed in the monitoring record as increased concentration of certain metal (oids), i.e. EIS Appendix I, Section 2.3.3. The modelling shows that the groundwater impacts are dependent on the pit lake elevation since below ~173 mAHD the pit is a net groundwater sink. Above this, and the Crosscourse pit water is expected to migrate into groundwater with the main downstream receptor being the McKinlay River. The concentrations of metals/metalloids (As, Co, Cu, and Zn) have exceeded GV on many occasions in Crosscourse pit historically (Draft EIS Appendix I, Section 2.3.3) and depending on the available dilution in the river, has potential to exceed guideline values. Mitigations that have been presented in the EIS include water treatment and controlled discharge to maintain low pit lake elevations in Crosscourse and reduce the likelihood of impact on receptors.					

ID#	49	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 8
Comment					
Due to hydrological connectivity, detail should be provided on what the potential impacts of water quality in Crosscourse pit could have on the quality of water in Prospect pit, or vice versa.					
Response					
During mining Prospect pit will be dewatered. Post mining, water levels in Crosscourse pit are anticipated to be maintained lower than Prospect pit using the mitigation measure of a WDL. At higher water levels, connectivity within the Prospect pit could result in Crosscourse pit waters influencing Prospect pit. If Crosscourse pit lake water levels rise such that Crosscourse is a net source of groundwater up gradient of Prospect, then there is potential for higher salinity and metal (oid) loads to reach Prospect pit. Water treatment and controlled discharge are predicted to mitigate this. It should be noted that this is not a result of the underground operations as there is only a relatively minor effect on overall Crosscourse lake water quality compared to the historical record.					

ID#	50	Topic:	Inland Water Environmental Quality: Cumulative Impacts to Water Quality	EIS Section:	Section 1.5 – Mine Water Management
Comment					
The NTMO Union Reefs Underground Mine Terms of Reference (TOR) requires a draft Water Management Plan that includes, among other things, the proposed water management measures to avoid cumulative impact from poor water quality. Further under Closure objectives, information was required to assess the cumulative impacts of the proposal on the interactions between previous activities and impacts, and the new proposal. The Draft EIS recognises that the McKinlay River has been impacted by neutral mine drainage from the URPA, and infers that this may be due to seepage from waste rock dumps and an historic tailings facility, but does not adequately describe the potential cumulative impacts of the Proposal to downstream surface water quality, with consideration of these existing impacts.					

ID#	50	Topic:	Inland Water Environmental Quality: Cumulative Impacts to Water Quality	EIS Section:	Section 1.5 – Mine Water Management
• Provide detail of how potential cumulative impacts to surface water quality have been considered and what management measures are proposed to avoid impacting the water quality objectives and beneficial uses of the McKinlay River. • Provide detail on how the effectiveness of any management measures implemented to avoid degradation of groundwater quality in aquifers and surface water quality downstream would be monitored, measured and reported.					
Response					
Cumulative impacts in the Prospect pits are not expected during operations, as water will be managed through pumping into Crosscourse pit. Once the water table rebounds after mining, the main potential sources of ARD/NMD in the Prospect pits will be largely covered with water, and effects on water quality minimised. Historical monitoring of the Prospect pit water indicates relatively good quality water, and this is expected to be representative of the water quality at closure since the water table will recover to similar levels. Crosscourse pit water will be managed during operations by controlled discharge and hence cumulative impacts are not expected. A Water Quality Management Plan (WQMP) is presented for the project in Appendix D of Appendix 11 of this report, which describes how water quality monitoring will be implemented, measured and reported and for further detail on modelled predicted water quality see Appendix 15.					

ID#	51	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 13. Appendix I – Geochemical Water Quality Modelling
Comment					
A baseline water quality study has been conducted recognising there are limitations in the number and reliability of the available data, and is presented as preliminary and only indicative (Phase I). NTMO has committed to do more work as part of Phase 2 which will include predictive water quality modelling to produce estimates of water quality and flow during operations, and into closure. Note that geochemical test work is still being conducted and were not available for this Draft EIS. The geochemical test work will provide the input data for the predictive water quality modelling. It has been identified that the URPA has impacted the quality of the McKinlay River (based on 2 sample points) consistent with neutral mine drainage inputs to the river. As part of the proposed development of the new mine, NTMO is to further evaluate the risks to the environment (i.e. Identify the source, pathway, sinks) and implement a robust monitoring program and strategy to address the risks especially towards closure and post closure, where the water level in pits and dams are expected to be at their highest levels. A predictive water quality model is proposed by NTMO as Phase 2 to be submitted as part of the Supplement. • Provide the geochemical characterisation results and an updated Geochemical Water Quality Modelling report that contains the inputs, components, boundaries, limitations assumptions and results of the predictive modelling (Phase 2) following upgrade from the conceptual (Phase 1) model results provided in Appendix I of the Draft EIS. • Provide detail on the proposed timing and frequency of model recalibration and updates using monitoring data collected during operations and post mining.					
Response					
This report includes an updated geochemical characterisation report in Appendix 12 of this report and the predictive water quality modelling report with details requested in Appendix 15. A water quality modelling update (i.e. recalibration) will be prepared within 1 year of operations as additional data, including surface water and ground water data and leach column testing results, are obtained. Updates thereafter					

ID#	51	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 13. Appendix I – Geochemical Water Quality Modelling
will be carried out as required, in response to additional key information or where there are key changes in mine operations and water management.					

ID#	52	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 13
Comment					
Ongoing monitoring of both surface and groundwater will be required to determine the impact to groundwater quality due to the Proposal. Section 3.4.1 of the Draft EIS commits to monitoring As, Cu, Ni, Pb, Zn and Fe in groundwater. Clarify whether additional metals, metalloids and/or inorganic substances would be monitored during operations and post mining, with consideration of those listed in Draft EIS Table 8-6 for metals including (in addition to those above) Al, Cd, Co, Cr, HCN and sulfate.					
Response					
A Water Quality Management Plan is now provided in Appendix D of Appendix 11 in this report which addresses this response.					

ID#	53	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 8
Comment					
Dam C is raw water and therefore relatively clean compared with Crosscourse pit water. Provide additional detail and justification for using water from Dam C for processing rather than water from Crosscourse pit, including consideration of water quality and why (if relevant) water quality precludes use. Describe how a water source hierarchy has been developed and implemented for the site to determine which of the potential sources of water the mine will use.					
Response					
Dam C historically has been used as a clean water source for processing. KLG is aware that the use of Dam C water does not adhere to the principles inherent in the water source hierarchy, i.e. reduce, reuse, recycle and commits to constructing and operating a RO water treatment plant to achieve a suitable water quality to allow reuse of water from Crosscourse pit for mining and processing in place of use of raw water from Dam C. Water would recycled from Crosscourse pit for mining and processing instead of use of raw water from Dam C.					

ID#	54	Topic:	Inland Water Environmental Quality: Acid and Metalliferous Drainage	EIS Section:	Section 4
Comment					
The Draft EIS describes several uncertainties that limit understanding of the extent and specific nature of the potential Acid and Metalliferous Drainage (AMD) issues that may be encountered during the mine life, and under long-term management arrangements. These uncertainties could allow for unexpected issues with the quality and quantity of contaminated water that may be discharged from the mining lease, and the potential impact of such discharges on the McKinlay River. The national guideline Preventing Acid and Metalliferous drainage: Leading Practice Sustainable Development Program for the Mining Industry (available at **https://www.industry.gov.au/data-and-publications/leading-**					

ID#	54	Topic:	Inland Water Environmental Quality: Acid and Metalliferous Drainage	EIS Section:	Section 4

practice-handbook-preventing-acid-and-metalliferous-drainage) emphasises the importance of developing AMD management strategies for site operations and closure during the feasibility phase. At the feasibility stage, a sufficient level of technical rigour is needed to avoid an AMD problem that escalates during operations to an extent that there may not be an economically viable solution.

The AMD minimisation strategies should be developed to a sufficient level of detail to allow realistic costings and management plans to be made.

The EIS should include information that:

- Provides a sufficient overview of water treatment methodologies for each source of contaminated water on the site, and the treatment performance associated with the relevant methodologies;
- Demonstrates that the potential financial burden of the measures required to prevent environmental harm can be met within the project constraints, during the operational life of the mine, and beyond;
- Demonstrates that all reasonable and practicable measures will be taken to prevent the discharge of any contaminated water from the premises; and
- Includes appropriate modelling to conservatively predict the quantity and quality of water that cannot reasonably be contained, and must be released from the mining lease.

Response

The Supplementary EIS (this report) includes an updated geochemical characterisation report in Appendix 12 and the predictive water quality modelling report with details requested in Appendix 15.

Combined, these two reports resolve the key uncertainties, and confirm an overall low risk of ARD/NMD from project development. The planned management strategies involving backfilling surface placed development waste rock back underground, water management and treatment as required, controlled water discharge, and monitoring of surface water and groundwater to confirm modelling predictions during operations and at closure. This will be sufficient to minimise potential impacts. Monitoring results will be assessed for early signs of any unforeseen effects to allow flexibility to modify management actions as required. The option of increasing water treatment is a key contingency.

The geochemical investigations completed for the Supplementary EIS are of appropriate rigor for the stage of the project, and are consistent with the national guideline "Preventing Acid and Metalliferous Drainage" referred to.

ID#	55	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 14

Comment

Aquatic ecosystem protection applies. Wastewater discharges and groundwater seepage may impact the McKinlay River. It is proposed that surface water discharge quality will be managed by electrical conductivity and will be released via siphon discharge to the McKinlay River.

Nutrients, especially nitrate and ammonia, have potential to enter the aquatic ecosystem via groundwater seeps – the impact of release of nutrients to the environment, beyond the boundary of the premises, must be determined e.g. nitrogen in terms of loads and concentrations and assessment of the chemical forms that are readily bioavailable.

Use of a dilution algorithm and electrical conductivity as operational controls of the quality of the waste water discharge should be justified.

Change in ionic composition and ionic strength may be a stressor to the receiving environment. It is recommended that the proponent carry out the necessary investigations to demonstrate that waste water with different salt composition and concentration to the receiving environment will not cause environmental harm.

If change in ionic concentration is to be used as an indicator of the corresponding composition of bioavailable metals that have potential to be toxic to aquatic organisms (contaminants of concern), the proponent should demonstrate that the proposed measure of change in electrical conductivity has sufficient resolution and quality control to provide appropriate early warning of change in the concentration of the contaminants of concern.

ID#	55	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Section 14
If the waste water is to be discharged by siphoning, detail should be provided on how discharge flow rates and volumes will be controlled, measured/metered, recorded and stopped if required.					
Response					
There are multiple questions in Submission #55, and these have been dot pointed for ease of reference and have been addressed individually below: • Nutrients, including nitrate and ammonia are unlikely to be a significant issue. Ammonia toxicity is primarily a function of pH, with ammonium (generally considered to be benign) representing over 90% of the ammonia-ammonium equilibrium at approximately pH 8 or lower. Guideline values for total nitrogen and total phosphorous will be included in the WDL. In accordance with ANZG 2018 total nitrogen will be compared as a first pass against filtered (or bioavailable) values. When total concentrations, accounting for any speciation effects, do not exceed guideline values, no further action will be required. Further testing will be undertaken to determine the concentration of bioavailable forms when exceedances are noted. Source identification and management measures will be carried out to delineate sources and mitigate any impacts identified. • The information associated with the discharge of water will be submitted to DENR for comment and review as part of the WDL application process. Using real-time data to determine dilution requirements allows for constantly variable water chemistry. Alternative methods, including measurements of metal concentrations that require laboratory analysis inevitably require a delay between collection and adjustment of procedures. By using pH, EC and other physicochemical measurements, greater certainty in the actual instream water quality can be achieved. The effect that various ionic compositions, and consequently differing ECs in discharge water will have on the receiving environment has been detailed in the context of SSGV derivation, provided in response to comment # 45. The SSGV derivation includes consideration of toxicity, stressors and other potential environmental impacts. • Determining the relationship between physical parameters and other toxicant values is not considered necessary because physical parameters will be used to determine discharge requirements, in addition to metal concentrations obtained from laboratory analysis. The Water Management Plan, to be submitted as part of the WDL application, will include detail of how physicochemical parameters and metal concentrations will be used in conjunction with one another to ensure environmental protection. • The potential for automated operation of syphons is being reviewed to determine the potential environmental and financial benefits this could offer. All operational procedures will be based on existing knowledge and will consider stream flow, water quality (upstream/downstream/discharge), the relationship between stream flow and rainfall, discharge flow rates, emergency management requirements, staffing availability, treatment rates, storage capacity and other environmental conditions. It is also noted that additional water treatment trials are planned. All information and available results will be included in the Water Management Plan, provided along with the WDL application. As demonstrated in the Draft EIS and the information contained within this Supplementary response, results obtained indicate that receiving environment values can be adequately protected.					

ID#	56	Topic:	Aquatic Ecosystems: Groundwater Dependent Ecosystems	EIS Section:	Section 14 and Appendix J
Comment					
Groundwater dependent ecosystems (GDEs) are present as permanent pools supporting aquatic ecosystems. Potential for significant impact exists through groundwater drawdown and altered water quality through surface and groundwater pathways. The Draft EIS identifies groundwater modelling will assist with understanding any potential impacts to GDEs. Provide an updated assessment of GDEs based on improved modelling of hydrological processes (including drawdown) and water quality to demonstrate whether significant residual impact remains.					
Response					

ID#	56	Topic:	Aquatic Ecosystems: Groundwater Dependent Ecosystems	EIS Section:	Section 14 and Appendix J
Additional groundwater modelling has been undertaken by GHD (2019b) i.e. Appendix 14 in this report, to add further certainty to the results of original groundwater flow models. This included adding relevant data not available during the initial modelling, as well as testing the model to ensure it was robust in its determination of impacts on groundwater availability to the McKinlay River during the life of the project and beyond. The results of updated modelling showed that the material outcomes of the original model were very similar, and the work was able to increase certainty around groundwater drawdown impacts in respect to on site water management and the McKinlay River. GHD (2019b) note that modelling undertaken previously (GHD 2019a, i.e. EIS Appendix H) was conservative in its predictions, and therefore any conclusions made in regards to impacts on GDEs as a result of the Project have been adequately covered during the EIS. Ongoing modelling is committed to in the Water Abstraction Management Plan (Appendix C of Appendix 11 in this report).					

ID#	57	Topic:	Aquatic Ecosystems: GDE Monitoring Design	EIS Section:	Section 14.6
Comment					
The Draft EIS expects no significant changes to the assemblages of aquatic biota in the upper McKinlay River, primarily because the: • Remnant waterbodies are not substantial features of the aquatic landscape, and • Aquatic fauna is adapted to rapid re-colonisation of temporary habitat. DENR's Water Resources Division note that there is room for improvement in the practice of biological monitoring of mining operations in the Northern Territory. Assessments based on macroinvertebrates mostly rely on family level identifications and use coarse-scale summaries of community composition for tests of impact. AUSRIVAS modelling as frequently deployed, is rarely suitable for the task of assessment in temporary streams. Future biological monitoring would benefit from: • Improvement to study design including data from pre-impact and multiple spatial control sites • Adoption of finer taxonomic resolution (ultimately species-level) • Adoption of new technologies including underwater video for fish and eDNA • A clear statement of the aims and objectives of the monitoring. Provide details of an aquatic ecosystems monitoring plan that: • Demonstrates whether changes in pool water volume are linked to de-watering activities • Demonstrates whether changes in biological attributes are due to mining effects, or are simply reflective of regional changes in similar habitat • Includes monitoring locations, timing, methods, statistical analysis, reporting, contingency actions and a trigger response framework to increase certainty that any potential impacts would be effectively avoided or mitigated.					
Response					
<u>Aquatic Ecology Monitoring</u> A mitigation and management action set out in Section 14.4 of the EIS document states: • Whilst it is not considered that the project will impact significantly on aquatic ecosystems, it is acknowledged that interactions between surface and groundwater are complex, and prevailing climate conditions cannot be confidently predicted. Therefore, ongoing monitoring will be an effective tool to track the extent of groundwater drawdown, and the impact on surface and groundwater flows, and any corresponding impact on the aquatic ecosystems during the life of the mine and the recovery period. A monitoring plan will be a component of the URPA Water Management Plan. As a component of the Water Management Plan (WMP), KLG has committed to an aquatic ecology monitoring program (AEMP). The program will monitor whether dewatering activities are resulting in changes to GDE pool volumes, and whether those changes are impacting on aquatic ecosystem health. The monitoring program will					

ID#	57	Topic:	Aquatic Ecosystems: GDE Monitoring Design	EIS Section:	Section 14.6

achieve this through a number of key tasks, detailed in the monitoring program framework provided in Appendix B of Appendix 11 in this report.

Additional aquatic ecology monitoring is likely to be requested by the Regulator as part of a Waste Discharge Licence. Additional monitoring components will be appended to the existing AEMP and be conducted in line with aquatic ecology monitoring conducted historically at the URPA.

A monitoring commitment was made in the EIS Document (Section 14.5.2) which incorporated regionally relevant control sites that were not modelled to be impacted by the project:

- The sparse distribution of permanent surface water on the upper McKinlay River for 20 km downstream of the URPA denotes that there are not likely to have been reference locations included in this survey (pending results of groundwater modelling). Baseline monitoring of permanent pools outside of the modelled impact area will be used, in combination with those in close proximity to the project, to quantify impacts of groundwater drawdown (if required). Reference locations may include the billabong (MRBILL01), which is not predicted to experience any change in groundwater availability, and provides a regionally appropriate control point.

As part of the AEMP, a control site will be sought that is outside of the McKinlay River catchment, to allow for an adequate assessment of external environmental influences (e.g. climate) on surface water availability.

Trigger Response Framework

A trigger response framework will be developed utilising baseline data that will be collected in 2020. Triggers will be based principally on groundwater levels in monitoring bores, and is outlined in the Water Abstraction Management Plan (refer to Appendix C in Appendix 11 of this report). Additionally, water level data collected at each GDE pool is included in the assessment of trigger values. As baseline data collection is currently being undertaken for aquatic ecosystems and riparian vegetation, there are not yet formal triggers to assess the impact of water management on site on aquatic ecosystems. Ecological data gathered over the life of the project will be utilised when required, to investigate the impact of reduced volume in GDE pools. This will occur using trend analysis, and comparisons to control sites, climate data and previous wet season flow records. Responses to triggers may include but are not limited to:

- Investigation of changes in groundwater levels or quality at monitoring bores against model predictions
- Analysis of water level monitoring at each GDE pool during both the wet and dry seasons during different stages of the Project
- Comparisons of aquatic ecology monitoring data collected prior to and during different stages of The Project (or magnitudes of measured drawdown)
- Investigation into how climate may have impacted groundwater availability using control site data
- Revision of water management on site, including the WMP
- Pending the results of water quality analysis, irrigation of GDE pools with water stored on site from dams

A schedule including provisional timing and duration of the proposed aquatic ecosystems monitoring plan is found in Section 3.14, Table 3-15.

ID#	58	Topic:	Aquatic Ecosystems: GDE Monitoring – Site Selection	EIS Section:	Section 14

Comment

The Draft EIS proposes to use two permanent waterholes, located downstream (within 250 m and 750 m respectively) of URSW10, as a focus for assessment of aquatic ecosystem impacts during mining activities.

Discuss whether these sites are suitable for AUSRIVAS monitoring, including sediment and biological monitoring. Discuss the relevance of comparison between habitat at these locations and the upstream location

Response

In the EIS document, Section 14.5 discusses the use of sampling techniques for GDE pools:

Macroinvertebrate and fish sampling programs in the late dry season as per NT AusRivAS sampling protocols carry significant safety risks, given the presence of estuarine crocodiles. Deployment of 'artificial substrates' into

permanent pools significantly reduces the risks. Using standardised, replicated artificial substrates in all permanent pools will enable baseline macroinvertebrate data to be collected annually, to characterise macroinvertebrate communities spatially and temporally, in permanent pools along the McKinlay River. This methodology has been used successfully to characterise macroinvertebrate communities in waterbodies across Australia, including tropical intermittent waterways. This will be an important tool in monitoring impacts to surface water ecosystems, particularly prior to the peak of groundwater drawdown at the end of mining.

The late dry season aquatic ecosystem monitoring at permanent surface water sites will be in addition to the continuation of the current, annual, early dry season macroinvertebrate monitoring program using NT AusRivAS.

It is not expected that further information, beyond the framework presented in Appendix B of Appendix 11 in this report is required.

ID#	59	Topic:	Aquatic Ecosystems: Macroinvertebrate Monitoring	EIS Section:	Section 14
Comment					
The Draft EIS suggests that in regards to Biological Monitoring, that the upstream macroinvertebrate community is different to the downstream macroinvertebrate community. Provide detail on whether NTMO has considered determining a more appropriate upstream monitoring site to ensure comparison of like for like.					
Response					
During a survey for the EIS, an aquatic ecologist walked large sections of the McKinlay River both upstream and downstream of the mine, noting differences in habitat availability based on location in the catchment. Historical macroinvertebrate monitoring sites are located upstream and downstream of potential impacts of mining activities. As the URPA is located in the Headwaters of the McKinlay River, changes in attributes such as channel width and incision, sediment composition and habitat availability are expected at sites moving in a downstream direction. The attributes of the channel remain uniform upstream of the URPA, but change downstream of a weir and railway crossing constructed near the URPA operations. Like for like is not possible in terms of habitat availability, but continued standardised sampling will be used at each creek site. The use of genus level identifications may assist in further understanding of the differences between sites upstream and downstream of the mine, which will be explored in the 2020 monitoring. In terms of GDE pools, creating like for like scenarios is also difficult, as the attributes of each pool are different. Regionally relevant control sites will allow for investigation of changes in the biological communities of the GDE pools over time, to understand any environmental factors are influencing ecosystem health.					

ID#	60	Topic:	Social, Cultural and Economic Surroundings: Impact of Poor Water Quality on Mary River National Park Values	EIS Section:	Section 13
Comment					
The Proposal lies within the Mary River catchment, with the McKinlay River as the main drainage sub-catchment. Parks, Wildlife and Heritage (PWH) Division of the Department of Tourism, Sport and Culture seeks to highlight that Mary River National Park is one of the Northern Territory's most important National Parks and protects values that are nationally and internationally significant. The McKinlay River is less than 1 km from the Union Reef Project Area, flowing during the wet season northwards to the Mary River. While there are no National Parks or Reserves directly within the proposed area, the Mary River National Park includes the lower and middle sections of the Mary River Catchment. There are potential impacts on the values protected by Mary River National Park, particularly from the release of contaminated discharge water. The Draft EIS outlines intentions to discharge treated contaminated water into the Mary River Catchment through a Water Discharge Licence, however an adequate treatment process has not been outlined in the Draft EIS.					

ID#	60	Topic:	Social, Cultural and Economic Surroundings: Impact of Poor Water Quality on Mary River National Park Values	EIS Section:	Section 13
Given the close proximity of the mine to the McKinlay River and the Mary River National Park it is requested that the Park be specifically acknowledged through the identification and treatment of potential impacts on the Park's biodiversity, cultural and visitor (recreational and economic) values.					
Response					
The Mary river National Park encompasses the middle and lower parts of the Mary River catchment. The headwaters of the Mary River are located near Douglas Springs, approximately 60 km to the east of Pine Creek. The river flows generally north-west, until it meets the McKinlay River, 85 km downstream from the Proposal area. It is here that the Mary River National park southernmost boundary is located. The rugged granite hills of the Project area are in the southernmost part of the Mary River catchment. Erosion and weathering of the rugged plateau have produced the foothills of the middle parts of the catchment. The Mary River crossing at the Arnhem Highway is a convenient delineation between the upper (southern) catchment and the floodplains of the lower (northern) catchment. Further downstream, and north of the McKinley River junction and the Arnhem Highway, the seasonally inundated alluvial floodplains are characterised by broad, shallow, largely unchannelled flow during the wet season. This is the Mary River Coastal Floodplain, unusual in the Top End in lacking a single major river channel through the floodplain to the ocean. The floodplain is poorly drained and the inflow channel diffuses into vast seasonal swamps before reaching the sea through a number of tidal channels. Compared to other coastal floodplains in the Northern Territory, this feature results in greater areas of wetland habitats flooded over extended periods and an extremely complex and productive system (NRETAS 2015). The coastal floodplain is recognised as an area of national or international significance for biodiversity conservation, and is listed as a wetland of national significance in the Directory of Important Wetlands in Australia. It is the most significant and reliable breeding site for Magpie Goose in the Northern Territory, and a major breeding area for many fish species, notably Barramundi (NRETAS 2015). NTMO acknowledge the significant conservation values described above. The Project area lies approximately 85 km upstream of the southern boundary of the National Park. NTMO also takes its environmental duty of care responsibilities seriously, and actively manages the water inventory at the URPA to maintain at very low, the risk of a very large quantity of mine affected water entering the McKinlay river in an uncontrolled event.					

ID#	61	Topic:	Mine Closure and Rehabilitation: Mine Closure Plan and TSF	EIS Section:	Section 9
Comment					
The Draft EIS does not meet the Terms of Reference with regard to providing sufficient detail and an integrated MCP incorporating relevant Proposal components. Given the short life of mine and that commencement is proposed as soon as possible, more detail is required to assess closure aspects and a detailed MCP is necessary for environmental impact assessment. It is noted that the Draft EIS commits to updating an integrated MCP for the Union Reefs Project Area (URPA) but does not describe how this will occur. The tertiary features of the URPA and any interactions with primary and secondary features should be addressed in the MCP. In particular, the fate of Crosscourse pit (as a tailings repository) at the end of mine life (less than 5 years) and the capacity of Crosscourse pit (maximum tailings and water levels) has not been adequately addressed. While it is recognised that there is complexity in relation to use of existing mine features and potential for cumulative and significant impacts, further information is required to provide context and discussion on how closure of the Proposal relates to, and should be considered in, the updated MCP. Provide an integrated Mine Closure Plan that demonstrates how closure objectives would be met for all mine features related to the Proposal, including: • Primary mine features (underground mine and associated infrastructure)					

ID#	61	Topic:	Mine Closure and Rehabilitation: Mine Closure Plan and TSF	EIS Section:	Section 9

- Secondary mine features (haul road, Dams A, B and C, Crosscourse pit tailings dam, Prospect north and south pits and the processing areas)
- Tertiary mine features (where existing features are affected by or interact with the Proposal)
- Timing, commitments and completion criteria for all mine closure activities

Response

A draft Mine Closure Plan for the Union Reefs North Underground Mine is now provided in Appendix 13 of this report.

NTMO commits to update the broader Union Reef Project Area Mine Closure Plan in 2020.

The WMP (refer to Appendix 11 in this report) includes the water balance as tables and diagrams not previously included in the EIS water management section. Please refer to WMP Section 4.3 Predicted Crosscourse Life Cycle 2019-2022. Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17 and Table 18. Figure 27, Figure 28, Figure 29, Figure 30, Figure 31, Figure 32, Figure 33 and Figure 34. Consideration of all these tables and figures is important to understand the scenarios and outcomes considered in the Crosscourse water balance.

Mining activities throughout the closure phase are also detailed in the schedule provided in Table 3-4 in Section 3.4.2.

ID#	62	Topic:	Mine Closure and Rehabilitation: Post Closure Crosscourse Pit	EIS Section:	Section 9

Comment

There is limited information for the post closure final tailings level and water level in Crosscourse pit. The management of the likely positive water balance of the Crosscourse pit needs to be addressed for mine closure. The likelihood of Crosscourse pit to fill and remain near to the spill level is a risk to the long term use of Crosscourse pit as a tailings storage facility.

The Draft EIS indicates water cover and ongoing maintenance as the closure option. Provide detail on how this would be achieved and the final maximum level that would enable a water cover to be maintained into the long term post mining, including freeboard requirements and any maintenance and management actions that would need to be undertaken.

Include the improved water quality modelling results for water quality of Crosscourse pit in the MCP.

Response

A draft Mine Closure Plan for the Union Reefs North Underground Mine is now provided in Appendix 13 of this report.

The Water Management Plan now provided at Appendix 11 in this report has the projected water and tailings levels (combined).

KLG commit to update the broader Union Reef Project Area Mine Closure Plan in 2020.

Only considering the Union Reefs North Underground Mine, the current plan for the Crosscourse pit tailings storage facility is to prepare for closure after mining. The strategy to achieve this is active discharge via a WDL.

Continued discharging and dewatering Crosscourse entirely could result in an active tailings storage facility in the Crosscourse pit lasting until 2036 at which time the tailings reach capacity in the pit. Given the Crosscourse pit and tailings storage facility water balance is positive, a long term water cover is considered a major risk. Capping is the most likely mitigation and management approach to address this risk at closure. KLG is considering the options of both "*Hardpan*" and conventional backfill capping methodologies. KLG is currently working with University Queensland on developing the "*Hardpan*" capping technology for this application.

ID#	63	Topic:	Mine Closure and Rehabilitation: Mine Closure Plan	EIS Section:	Appendix E
Comment					
All surface infrastructure associated with the underground mine will be decommissioned, removed and the areas rehabilitated. Confirm whether all pumps, water tanks and other facilities will be removed.					
Response					
NTMO commits that all pumps, water tanks and other facilities will be removed from the project area within 3 months of mining being completed. This will need to be completed prior to final abandonment binding being placed around the open pit. All equipment will be reassigned to other operations, sold or scrapped on removal from the Union Reefs North underground project depending on site requirements at the time.					

ID#	64	Topic:	Mine Closure and Rehabilitation: Mine Closure	EIS Section:	Section 9
Comment					
Confirm timing of Prospect pit bund construction post mining.					
Response					
NTMO commits that the construction of the final safety bund around the Prospect pit will be completed within 12 months of final mining of the underground mine being completed. The final bund will be constructed with a main access gate left open so that the site is accessible for Ghost bat and water quality monitoring. Access will be completely closed off when the monitoring program is no longer required. The Prospect pit bund construction timing is included in the provisional schedule provided in Table 3-4 in Section 3.4.2.					

ID#	65	Topic:	Mine Closure and Rehabilitation: Mine Closure	EIS Section:	Section 9
Comment					
Provide detail on the standards that would be used to assess, monitor and measure rehabilitation success in areas that will be revegetated.					
Response					
These are outlined in the draft Mine Closure Plan for the Union Reefs North Underground Mine in Appendix 13 in this report.					

ID#	66	Topic:	Mine Closure and Rehabilitation: Pit Lake Water Quality	EIS Section:	Section 8
Comment					
Provide details and results of further geochemical waste characterisation undertaken since the Draft EIS was published and how these results have been used to progress the conceptual water quality model to a predictive water quality model. Provide the inputs data, assumptions and limitations of the model. Provide further assessment of the long term pit lake water quality post mining and how this would change over time. Include consideration of effects of evapoconcentration on long term water quality.					
Response					

ID#	66	Topic:	Mine Closure and Rehabilitation: Pit Lake Water Quality	EIS Section:	Section 8
This report includes an updated geochemical characterisation report in Appendix 12 of this report and the predictive water quality modelling report with details requested in Appendix 15. Combined, these two reports resolve the key uncertainties, and confirm an overall low risk of ARD/NMD from project development. Once the water table rebounds in the Prospect pit after mining, the main potential sources of ARD/NMD will be largely covered with water (waste rock and to a lesser extent the pit walls), and any negative effects on water quality reduced. Historic monitoring of the Prospect pit water indicates relatively good quality water, and this is expected to be representative of the water quality long term after closure, since the water table will recover to similar levels, the waste rock will be submerged and the vast majority has been identified as NAF. Crosscourse pit at closure is currently expected to have approximately similar water quality to what has been observed in the historical monitoring record. Because this pit has a positive water balance, evapoconcentration is not expected to be relevant. Prospect pit will have a bunded wall constructed at the perimeter of the Prospect pit. This will decrease the current catchment from 15.7 ha to approx. 8.5 ha. The pit will be recharged by groundwater ingress and runoff during the first wet season post mining and eventually reach groundwater aquifer level. The pit water level will continue fluctuating between 1170-1180 RL, subject to different wet season rainfall and following its historical trend. The spillway height is 1195RL, providing 15 m freeboard. This bund will be maintained at mine closure as an abandonment bund for safety and security.					

ID#	67	Topic:	Mine Closure and Rehabilitation: Mine Closure	EIS Section:	Section 9
Comment					
Identify any residual liabilities relating to the final post mining land use and include whether this has been agreed to by key stakeholders.					
Response					
Confirmed in the draft Mine Closure Plan for the Union Reefs North Underground Mine which is now provided at Appendix 13 in this report.					

ID#	68	Topic:	Approvals and Regulatory Framework: Water Extraction Licence Considerations	EIS Section:	Section 5.1.2 Table 5-2
Comment					
Groundwater inflows into the workings are predicted to be 18 L/s at a worst case scenario, with dewatering being required to facilitate mining. If dewatering is undertaken via sump pumps no groundwater extraction licence will be required.					
Response					
Yes, dewatering is undertaken via sump pumps. Figure 20 – Prospect pit mining water management schematic in the Water Management Plan (refer to Appendix 11 in this report) provides further details.					

ID#	69	Topic:	Approvals and Regulatory Framework: Waste Discharge Licence	EIS Section:	Section 5.1.2 Table 5-2
Comment					
It is unlikely the Controller of Water Resources will grant a WDL for a discharge where the quality and quantity of the discharge are out of the control of the licensee.					

ID#	69	Topic:	Approvals and Regulatory Framework: Waste Discharge Licence	EIS Section:	Section 5.1.2 Table 5-2
Response					
Noted. Submission ID# 37, 44, 45, 55 and 78 address proposed waste discharge management strategies.					

ID#	70	Topic:	Approvals and Regulatory Framework: Waste Discharge Licence	EIS Section:	Section 5
Comment					
As this is considered a new activity, a new WDL is required. Should NTMO wish to have a WDL in place for the 2020/21 Wet season, it should ensure a WDL application and all supporting documentation, as per the above advice, is submitted to the Administering Agency no later than 30 July 2020 to allow adequate time for assessment, site visits and consultation meetings.					
Response					
Noted.					

ID#	71	Topic:	Approvals and Regulatory Framework: Waste Discharge Licence	EIS Section:	Section 5
Comment					
The MMP states that 'The URPA passive discharge was licensed under a WDL between 2011 and 2016. In 2017, the DENR advised NTMO that it no longer requires a WDL for the URPA passive discharges'. Note this statement is incorrect –the WDL was under assessment when NTMO personnel advised the Administering Agency that it no longer required a WDL as there was no discharge from the site.					
Response					
NTMO acknowledge that the statement on the historic WDL for Union Reefs was incorrect, and that NTMO notified DENR that a WDL was not required.					

ID#	72	Topic:	Approvals and Regulatory Framework: Waste Management and Pollution Control Act 1998 (WMPC Act)	EIS Section:	Section 5.1.2 Table 5-2
Comment					
The proponent should be advised that the *Waste Management and Pollution Control Act 1998* (WMPC Act) applies in relation to a contaminant or waste (as defined in the WMPC Act) that results from, directly or indirectly, the carrying out of a mining activity by a person on land on which the activity is authorised by or under the *Mining Management Act 2001*, where the contaminant or waste is not confined within the land on which the activity is being carried out. If a contaminant or waste is emitted or discharged from land on which an extractive mineral permit exists, it will be considered an incident as defined by the WMPC Act if it threatens or may threaten to cause pollution resulting in material or serious environmental harm. Where an incident causes, or threatens to cause, pollution resulting in material environmental harm or serious environmental harm, the person conducting the activity must notify the Northern Territory Environment Protection Authority in accordance with Section 14 of the WMPC Act.					
Response					
Noted.					

ID#	73	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions	EIS Section:	Appendix G – GBAP
Comment					
Note that under the EPBC Act the commencement of the referred action may only occur once an approval is given.					
Response					
Noted.					

ID#	74	Topic:	Terrestrial Flora and Fauna: Ghost Bat Actions – Action 8	EIS Section:	Appendix G – GBAP
Comment					
Note this action is to be used as an offset, noting it will only be achieved after the mining is completed e.g. 2 years. The EPBC Act Offsets Policy indicates that offsets must be effective and timely, that is, offsets are usually required to be in place prior to the action commencing and endure for at least the period of impact. This offset can only be achieved after the mining ceases, therefore there is uncertainty as to whether this approach can actually be described as an offset compatible with the EPBC Act Offsets policy. It may be that such an action is mitigative in effect. The Draft EIS may wish to consider this issue in more detail and potentially consider a different offsetting arrangement in addition to that proposed.				
Response					
A separate document has been written to address the concept of offset applicability in this project: Memo 2: An analysis of commitments to Ghost bat protection under the *EPBC Act 1999* Environmental Offsets Policy October 2012 (refer to Appendix 6 in this report).					

ID#	75	Topic:	Terrestrial Flora and Fauna: Weeds Management Act 2001	EIS Section:	Sections 5 and 9
Comment					
The Proponent should be aware that significant weed species are present on the proposed mine site, access roads and surrounds. Some of these weed species, including gamba grass, are listed in the Draft EIS under section 7.8 (Introduced Species). DENR's Weed Management Branch seeks clarification from the Proponent on weed management matters and request consultation and review of the Weed Management Plan, either as part of a Mine Management Plan or standalone document, that addresses control methods and the spread mitigation procedures the proponent will undertake to minimise impact of weeds on land affected under this proposal. In section 5.1.2 Northern Territory Legislation of the Draft EIS the statutory obligations under the *Weeds Management Act 2001* are referenced and it is written 'Weed management, including Weeds of National Significance (WoNS) is addressed in the URPA MMP'. However, there is no MMP submitted for review with the Draft EIS. The Notice of Intent also referenced a Weed Management Plan (WMP), without providing a copy for review. Sections 9.1.1, 9.1.3 and 9.1.4 of the Draft EIS, state that Kirkland Gold will 'establish a WMP' in the event of a temporary closure. This contradicts earlier statements that a WMP will be part of the MMP.				
Response					
NTMO will provide the Union Reefs Project Area weed management plan as a stand-alone document for review and comment to DENR's weed management branch during the mine management planning process.					

ID#	76	Topic:	Inland Water Environmental Quality: Water Quality	EIS Section:	Sections 8
Comment					
The focus is primarily on water entering the receiving environment and there a number of key concerns requiring consideration: • Capacity to manage existing wastewater onsite (pre-operational) • Seepage (i.e. uncontrolled and untreated discharges from site) • Proposed wastewater management, including: o Likely increase in capacity as a result of operations o Treatment options and treatment rates • Discharge, including: o Waste water quality – site specific trigger values (SSTVs) o Monitoring downstream impacts on the environment o Sources of discharges from all sources on site				
Response					
Each of these matters has been addressed in response to submissions (above and below) in which a question is posed. The water management plan is also included in this Supplementary report in Appendix 11. • Capacity to manage existing wastewater onsite (pre-operational) – addressed in the water management pan at Appendix 11 • Seepage (i.e. uncontrolled and untreated discharges from site) – see comment #32, #43 and Section 3.9.6 • Proposed wastewater management, including: o Likely increase in capacity as a result of operations –addressed in the Water management plan o Treatment options and treatment rates. – see Section 3.11 to 3.13 • Discharge, including: o Waste water quality – site specific trigger values (SSTVs) – see Section 3.13 o Monitoring downstream impacts on the environment – see submission relating to Aquatic Ecology and the aquatic ecology monitoring framework (AEMP) in Appendix B in Appendix 11 in this report				

ID#	77	Topic:	Inland Water Environmental Quality: Mine Water Management	EIS Section:	Sections 8
Comment					
The scenarios presented in the Draft EIS provide limited options: • Maintain the water level in Crosscourse pit by discharging under a WDL; or • Do not manage the water level in Crosscourse pit, but continue to dewater into it resulting in the water level increasing. It is unclear whether any other options or scenarios were considered by NTMO, such as reuse or recycling of water in Crosscourse pit or dewatering to another pit.					
Response					
See response to this submission in ID#25.					

ID#	78	Topic:	Inland Water Environmental Quality: Wastewater Treatment	EIS Section:	Appendix E
Comment					
As per commitment in Appendix E, NTMO plan on treating water from Crosscourse pit prior to discharge. The treatment method is to dose it (with NaOH, CaCO3, or CaO) which is the method currently applied at Cosmo. Due					

ID#	78	Topic:	Inland Water Environmental Quality: Wastewater Treatment	EIS Section:	Appendix E
to the specific nature of Crosscourse pit being utilised as a tailings storage facility likely to contain elevated arsenic, cobalt, zinc and copper and cyanide there will be a requirement to develop new effective strategies to improve water treatment to reduce arsenic levels.					
Response					
Wastewater treatment of Crosscourse pit water is detailed in Section 8 of the Draft EIS. This shows the results from treatment trials using ferrous chloride ($FeCl_2$). This treatment is designed to form stable iron-arsenic complexes (i.e. ferric arsenate), and other metal iron oxyhydroxide complexes. The results of water treatment trials have shown that concentrations of arsenic, iron, zinc and copper can be reduced to below 80% SSGVs at the end of pipe and prior to discharge and instream dilution. Cobalt, which remains elevated in post treated water, can be reduced though alterations of the treatment processes. This can be achieved through precipitation by initial pH adjustment to approximately 9.5. The subsequent treatment processes will reduce the pH back to neutral so that all alkaline soluble metals do not remobilise. Further treatment trials will be provided as part of the WDL application process. Free cyanide concentrations are expected to be minimal due to the volatility of the protonated compound, as detailed above in Comment # 37. WAD-cyanide concentrations are expected to remain negligible, as observed during previous processing regimes. This is demonstrated in the WAD-CN results shown in Appendix I, Figure 2-12 of the Draft EIS.					

2.3 Other Submissions

TABLE 2-3 OTHER SUBMISSIONS

ID#	79	Topic:	Public Comment: Fluid Power	EIS Section:	General
Comment					
My business Fluid Power Darwin is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs (12) of people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	80	Topic:	Public Comment: Slingshot Haulage	EIS Section:	General
Comment					
My business (Slingshot Haulage) is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs (15) of people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	81	Topic:	Public Comment: Hosepower	EIS Section:	General
Comment					
Our business Hosepower is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have reviewed the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. Our business employs 28 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS. We have had dealings with the mine for many years and have found them to be focused on their HSE policies and procedures.					
Response					
Noted.					

ID#	82	Topic:	Public Comment: Territory Steel	EIS Section:	General
Comment					
Territory Steel is a direct supplier and supporter to the operations of NTMO. We understand that they have an EIS for review to extend their operations. We have reviewed the web link for the EIS, and we support the proposed operations at Unions Reef and surrounding area going ahead as soon as practicable.					

ID#	82	Topic:	Public Comment: Territory Steel	EIS Section:	General
Territory Steel currently employs 8 people and we are sure that with expeditious approval by the EPA, ongoing employment will be supported from what we believe to be the responsible environmental activities of this mining operation as reflected in the EIS.					
Response					
Noted.					

ID#	83	Topic:	Public Comment: MG Electrical	EIS Section:	General
Comment					
MG Electrical Services Pty Ltd specialises in electrical distribution services and has been operation in the Northern Territory for 38 years. My business is a direct supplier and supporter to the operations of NTMO. We understand that they have an EIS for review to extend their operations. We have reviewed the web link for the EIS to gain an understanding of the environmental scope covering land and water management. I have confidence in the capacity of NTMO to manage the environmental impacts of the works and would be pleased to support the proposed operations at Unions Reef and surrounds. My business employs 27 residents of the Northern Territory and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	84	Topic:	Public Comment: RED Appointments	EIS Section:	General
Comment					
Red Appointments NT Pty Ltd is a Darwin based recruitment and labour hire business. In the NT, we employ between 60 and 100 casual employees with approximately 1/3 of our workforce identifying as Aboriginal or Torres Strait Islander. Providing NT Mining Operations Pty Ltd meet the environmental impact requirements of NTEPA, we as a business support the expansion of their operations. Whilst not an expert in the field, I have read their EIS and it appears to be very comprehensive. As a local business, the approval of their expansion plans would bring some much needed economic stimulus, not only to Red Appointments, but to the community as a whole. We are hopeful the approval for their proposed expansion plans will be approved very soon.					
Response					
Noted.					

ID#	85	Topic:	Public Comment: Stephen Hallam	EIS Section:	General
Comment					
My name is Stephen Hallam I work for NT Mining Operations as Project Lead for Prospect Mine I am looking at moving to the NT I have been tasked with building Bat habitats as stated in the EIS I have spent 34 yrs in the underground mining industry I'm very excited at the prospect of building bat habitats that could potentially be a long term solution for the roosting of bats. In the time I have been employed with NTMO it is apparent to me that they are a very committed company that does what they say they will do The significance and seriousness that NTMO are inputting to monitoring the Flora, Fauna and ground water should not be understated and would a travesty if for whatever reason did not get off the					

ID#	85	Topic:	Public Comment: Stephen Hallam	EIS Section:	General
ground My research shows that only two bat habitats have been built worldwide and this would be a huge opportunity to gather scientific information surrounding Ghost bats whilst trying to be on the forefront protecting with potentially bat roosts that could be built relatively cheap at any mining location.					
Response					
Noted.					

ID#	86	Topic:	Public Comment: PolyFabrications Australia	EIS Section:	General
Comment					
My business Polyfabrications Australia is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 6 fulltime staff and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	87	Topic:	Public Comment: Rhino Industrial Pty Ltd	EIS Section:	General
Comment					
My business Rhino Industrial is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 10 full time staff and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	88	Topic:	Public Comment: Think Water Winnellie	EIS Section:	General
Comment					
Our businesses Think Water Winnellie / Virginia (Darwin) & Pump 365 is a direct supporter to the operations of NTMO and we understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. Our businesses employs 22 people directly & supports a further 7 local sub-contractors on a daily & weekly basis. I am sure that with expeditious approval by the EPA, Think Water Darwin, Pump 365 & our sub-contractors will be provided with additional commercial opportunities from NTMO that will not only support but grow our current employment position in the Northern Territory, from what we believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	89	Topic:	Public Comment: AJ Couriers and Haulage Pty Ltd	EIS Section:	General
Comment					
Our business, AJ Couriers and Haulage Pty Ltd, is a locally owned and operated business in the Northern Territory that is a direct supporter to the operations and proposed expansion of NT Mining Operations. I understand they have an EIS for review to commence an underground operation at the Union Reef site just outside of Pine Creek. I have had a chance to review the EIS online and I fully support the commencement of the expansion. I have confidence in the capacity of NTMO to manage the environmental aspects of the essential elements with minimal impact to the environment as outlined in the EIS. The operations of NTMO are a large contributor to our small business which has 25 employees and with approval from EPA, I am confident this expansion will support ongoing employment.					
Response					
Noted.					

ID#	90	Topic:	Public Comment: Cory Camps	EIS Section:	General
Comment					
I would recommend the proposed underground mine by Kirkland Lake Gold at the Union Reef site. I am an employee at their nearby Cosmo mine and am impressed with their environmental management. I previously worked at the Cosmo site under previous ownership and can see a vast improvement in environmental conditions and attitudes. The company is genuine in maintaining the natural beauty of the Northern Territory. There has been great investment towards the infrastructure to the sites and camps. There is a great number of locals employed where skill sets are suited. Of the employees that reside interstate, a number of them pay for their own flights to and from Darwin. They also use part of their time off to stay in the Territory to support the tourism industry and not to mention benefit to the local areas of Pine Creek, Adelaide River and Douglas Daily to mention a few of the locations that are utilised for regularly. I understand the Ghost Bat population is in the vicinity of Union Reef, however Kirkland Lake is taking all due diligence to ensure their preservation. My belief is the bats are not originally from the Union Reef Site and are from a nearby colony. They should be if not already attempted, relocated to this colony. In closing the approval of the Union Reef underground should be granted as there is a strong responsibility and commitment from Kirkland Lake to the environment. It is being undertaken at a previously mined area that was far greater damaging to the environment as it was open pit. An underground mine will leave very little any environmental footprint. The company shows a great commitment to even further investment to the Northern Territory and local areas and people.					
Response					
Noted.					

ID#	91	Topic:	Public Comment: Caitlin Brown	EIS Section:	General
Comment					
I am writing in regards to the KLG NT Operations EIS submission for permission to mine underground at the Union Reefs site. I have been an employee at the Union Reefs site for 6 months now, relocating from the Victorian KLG operations for an exploration geologist role based at UR. Since moving here I have been thoroughly impressed at the diligence and attentiveness that the environmental team shows towards the community and the environment. As a team we see the environmental team, albeit a small one, frequently monitoring and innovating environmental strategy across both sites, from testing dams and our drinking water, collecting weather information, monitoring movement of the bats, tracking and rescuing wildlife and even keeping us updated on croc sightings. They show great passion for their jobs and go above and					

ID#	91	Topic:	Public Comment: Caitlin Brown	EIS Section:	General
beyond with integrity to ensure the bats are protected and monitored, even if it means us changing our drilling plans to protect them. Part of moving to UR operations was the opening of the Pine Creek camp facility. We were blown away at the amount of work that went into fixing up such a dilapidated site. It feels like a tropical sanctuary now and it really is a home away from home. The best part about moving into the camp is living in a local town. We all enjoy the luxury of having a destination to explore, go on runs, and visit the local pubs and sometimes to just see other people outside work! Quite a few of my team have been employed from Pine Creek and it has been a pleasure to have local experience and support the community we live in. The potential development of the underground mine at UR will go a long way to secure our team's future and help it expand further. I have no doubt that KLG will, as ever, operate under a high social and environmental standard to ensure the mark it leaves is only a positive one. The current operation has made a positive impact on many lives and I hope to stay in the Northern Territory and work with KLG for many years to come.					
Response					
Noted.					

ID#	92	Topic:	Public Comment: A & K Fencing	EIS Section:	General
Comment					
My business A & K Fencing ABN 80 208 206 602 is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 3 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	93	Topic:	Public Comment: URPA Maintenance Team (Mark Solari)	EIS Section:	General
Comment					
Being a Northern Territory resident, local business owner and employee of Kirkland Lake Gold Northern Territory Mining Operations at the Union Reefs processing plant, I feel that I should give my honest opinion in relation to the NT mining operations submission of environmental impact statement regarding the proposal to extend mining operations at Union Reefs and surrounds. Having said that, I have been employed by numerous mining companies both in Australia and abroad in my 20+ years working in the mining industry, and in that time I have experienced many different approaches by companies in regards to following and adhering to their own environmental policies. After experiencing firsthand the steps that Kirkland Lake Resources and the commitment that their employees are constantly taking to minimize if not eliminate the risk of damaging native flora, fauna and natural water courses, I would have to say that this company is at the forefront of environmental policy compared to what I have experienced previously. They have a dedicated environmental team and dedicated employees which is what is not only needed but also required when working in this specific area of the Northern Territory. From my stand point the continuous monitoring of water quality and the important research that has been achieved regarding the protection of native species and an enforced environmental policy shows that this company is not only dedicated but also committed to creating a project that generates much needed local employment, that is also focused on minimal impact as possible to the surrounding environment and native species therein. The second point I would like to discuss is the importance of local employment and job opportunities for the NT as a whole, both individual and business. It is my understanding that Northern Territory Mining Operations currently					

ID#	93	Topic:	Public Comment: URPA Maintenance Team (Mark Solari)	EIS Section:	General
employ approximately 150+ personnel across their NT operations and are looking to expand to approximately 300 in Union Reefs area alone. This will not only provide a substantial impact on local employment but also the ability to create more opportunities for training and development of local employees not to mention the impact it would have on local businesses in the NT, examples of businesses that would benefit from having another mining operation in the area are as follows. Logistics and Transport, Hospitality and Catering, Structural Engineering, Civil Engineering, Consultancy, Spare Parts and Consumables, Protective Coatings and Blasting, Industrial Gas Supplies, Electrical and Refrigeration, Crane, Rigging and Scaffolding, Building Contractors, Laboratory analysis and Non Destructive Testing. So as you can see this is by no means a comprehensive list of businesses there are many more that go towards supplying services to the mining industry and thus creating a flow on effect contributing towards the NT economy. As most Territorians are aware that in recent times it has become more difficult to find gainful employment in the NT particularly in a full time capacity. Statistics show that unemployment rates in the NT have risen from 2.7% in December 2010 to 5.1% in June 2019 (statistics taken from economy.id.com.au) but I suspect the figures currently are much higher now, considering that the large scale Inpex project was also completed in June 2019 creating a mass exodus of workers and closure of many Darwin businesses. In conclusion. As you can see this project is important to numerous people and businesses in Pine Creek and the Northern Territory community as a whole and I'm sure many people would be grateful if this project were to go ahead.					
Response					
Noted.					

ID#	94	Topic:	Public Comment: J & T Auto Electrics	EIS Section:	General
Comment					
Our Company, J & T Auto Electrics & Air Conditioning is a direct supporter to the operation of NT Mining Operations (NTMO). We are a local family run business, established in 2010, providing Automotive Electrical and Air Conditioning services. We have conducted business with NTMO since 2017 as their preferred local Auto Electricians and suppliers of Automotive parts and accessories. We understand they had an Environmental Impact Statement (EIS) for review to extend their operations. Our Company is aware of the EIS and have viewed the web link and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. We have confidence in the capacity of NTMO to manage the environmental aspects of the essential elements of minimal impact to the environment. Our Company employs seven people, including Directors, with the capacity and workload to employ more. We are sure that with expeditious approval by the Environmental Protection Authority, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS. If you require further information, please don't hesitate to contact our office on 8967 1637 or email admin@jtae.com.au					
Response					
Noted.					

ID#	95	Topic:	Public Comment: Greg Bicknell (NT Chamber of Commerce)	EIS Section:	General
Comment					
The Northern Territory Chamber of Commerce and Industry (Chamber) welcomes the opportunity to make a submission in support of the EIS provided by NTMO regarding the expansion of the Gold mine at Union Reefs in the Northern Territory of Australia.					

ID#	95	Topic:	Public Comment: Greg Bicknell (NT Chamber of Commerce)	EIS Section:	General

Established in 1957, the Chamber is the largest employer association in the Northern Territory (NT), representing over 1,200 businesses. The Chamber is an independent, not-for-profit and non-government body – our membership and offices span the Territory.

The Chamber provides members and the Northern Territory business community an effective platform for lobbying on the issues that impact upon business, whilst providing services and support in a number of key areas including industrial relations, training, employment, education and training advice, networking and premier business events.

Importance of the Resources Sector to the Territory

The development of Union Reefs is important for the future development of the Northern Territory – noting that the resources sector is the largest sector of the NT economy and that currently our overall economy continues to be in a precarious state – with a fiscal balance deficit of $1.1 billion and a total net debt of $6.2 billion in 2019/2020, fuelled in part by a contracting economy, including a 14% drop in Royalties from the preceding year:-

- Minerals and energy accounts for 13% to 20% of NT GSP, compared to national average of 8%. It is the largest private economic sector in the NT and as a percentage of GSP is exceeded only by WA.
- Mining employment tends to be regional and not the greatest employer, gauged by employee numbers (3.1% of NT workforce).
- NT minerals exploration of $111.8m in 2017/18 is down from $250m in 2012, but up from $100.8m in 2015/16. 33% of 2017/18 minerals exploration was on base metals, 24% on gold 10% on rare earths and 9% on Lithium.
- In 2010 60% of the NT land mass was subject to mineral exploration licences, at the start of 2019 13% of the NT was subject to mineral exploration licences.
- Although the Territory is more reliant on Commonwealth funding than other Australian jurisdictions, the Territory's Own Source Revenue forms an important component of total revenue. In 2018/2019 Territory taxes and royalties contributed $1.06 billion of Territory Own Source Revenue, 17% of the NT's total revenue (confirm NT revenue).
- In 2018/2019 Royalties made up 40% of Territory Own Source Revenue.

Our Economy needs Union Reefs to Proceed Now

The Chamber of Commerce is currently conducting its annual NT Business Confidence Survey which closes at the end of January 2020. Interim results, based on responses from some 335 companies, indicate that 30% of those businesses expect to reduce their staffing levels this year and over 50% currently have a dim view regarding their future outlook for the NT Economy (refer to data charts/tables provided below). Hence the speedy development of Union Reefs would be warmly welcomed by the Territory Business Community – noting the company will have a large regional & local workforce and they have a strong commitment to local procurement.

Environmental Sustainability / Business Engagement

The Chamber has looked at the web link for the EIS and are confident that NTMO are committed to developing the mine in an environmentally sustainable manner. We are aware that the company has engaged specialist environmental expertise and are committed to minimising any environmental impacts regarding Groundwater, waste discharge etc.

The company is a valuable member of our Chamber and utilises our networks and services to engage with and brief our NT Business Community. In fact, the Company has already committed to hosting our next Business at Sunset event at the end of January 2020 – where they can directly brief our local business community about upcoming local business opportunities as well to share with them the environmental strategies to be utilised. This is evidence of solid social responsibility by NTMO.

Summary

The Chamber is pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. We are sure that with expeditious approval by the EPA, ongoing employment and desperately needed economic stimulus for our local economy will be supported from what we believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Response

ID#	95	Topic:	Public Comment: Greg Bicknell (NT Chamber of Commerce)	EIS Section:	General
Noted.					

ID#	96	Topic:	Public Comment: Andrew Swanson	EIS Section:	General
Comment					
Hi my name is Andrew Swanson I am an employee of KLG giving them a permit would be good for the local economy. And employed more local workers as well as boosting the local economy. Cheers					
Response					
Noted.					

ID#	97	Topic:	Public Comment: Sandra Heard	EIS Section:	General
Comment					
I am commenting on the Draft EIS submitted for public comment to support the project as it provides great benefit the Pine Creek community. Since resuming work in the Kirkland Lake Gold Northern Territory operations ("NTMO") I have been impressed with the level of investment the company has made into the area. I was last there in mid-2015 and since returning have noticed lots of construction at the Cosmo Mine site, Cosmo camp and Pine Creek camp which would amount to several millions dollars' worth and well over $100M worth of mine and exploration investment; a company generally doesn't make this investment unless they are committed to be in the area long-term. NTMO is a good employer, providing good quality living and working facilities and remuneration. This project will ensure my ongoing employment and also provide opportunities for others to gain quality employment through company growth. Kirkland Lake Gold is a significant gold mining company and responsible operator, the same investment that has been placed in the current operations (which includes significant environmental management from a team of at around 10 environmental scientists and technicians) will be placed in the proposed project. KLG has the money and ability to commit to mitigating the possible affects the proposed project might have on the Ghost Bat population- who better than a mining company to develop an alternative roosting site for the Ghost Bats. This project going ahead is of great economic benefit as it safeguards KLG's ongoing investment into the area.					
Response					
Noted.					

ID#	98	Topic:	Public Comment: Al Patounas	EIS Section:	General
Comment					
I am a Darwin resident, member of the ADF (reserves) and employee of KLG. I moved to Darwin in January of 2019 to support my partner with her employment in the education sector. Shortly after moving to Darwin I was fortunate enough to find employment with KLG, which favour local people to employ and I am sure my new home had a great influence on my employment with them. KLG make significant investments into the local economy and are a great asset to the NT and Australia having recently donated 1 million dollars to bush fire assistance funds. NT Operations have a very capable and passionate environmental team monitoring and researching the local Flora, Fauna and ground water and take any impacts and our responsibility very seriously. The opening of the underground mine at Union Reef would be of great importance to extending operations in the NT as ore is still needed to run the mills and keep them going and by keeping them going they will keep jobs going and money					

ID#	98	Topic:	Public Comment: Al Patounas	EIS Section:	General
flowing into the local economy. Environmental impacts are of extremely high importance to the company and any negative impacts are stringently mitigated by the team.					
Response					
Noted.					

ID#	99	Topic:	Public Comment: Aquatreat NT	EIS Section:	General
Comment					
My business Aquatreat NT is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 8 personnel, 2 are indigenous who are being trained on the wastewater systems on the mine, and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	100	Topic:	Public Comment: Andrew Upfill	EIS Section:	General
Comment					
I am the HR Manager with NTMO and immediately recognise the juxtaposition of being (un)biased in a public submission to the EIS that has been published by NTMO. I can speak from first hand as to the incredible amount of work that has gone into establishing a commercially viable operation – we have recruited over 278 personnel to the operation from this time last year and have a prospect of establishing a 'mining region' in the footprint of the surrounds of Union Reef and Pine Creek. Our employees now total over 300 with an additional headcount of over 150 contractors per month. We are contributing significant upside to an economy which is struggling post INPEX boom, something which is difficult to manage for any government in the cycles of large infrastructure projects. The past historical mining activity has ironically created ideal environmental conditions for species such as Ghost bats which are poorly understood by the general population – it is curious to consider that where Ghost bats were once prolific in the Kakadu region they appear less so now, however this region has no mining as a cause for the diminishing of numbers. It would appear that Mining is good for this particular species. In the Union Reef and Pine Creek area where there has been mining – hand dug mining adits (tunnels) are now providing habitat for Ghost bats to not only survive but also by all accounts flourish. The irony of these colonies of bats now being a reason for progress toward economic and commercial activity to be sustained due to being in old mining workings is not lost on me! **<u>The Scope of Building Artificial Habitats</u>** The environmental considerations for the project to progress are taken very seriously, the adherence to regulations is warranted based upon the cowboy tactics of rape and pillage as past miners were in to exploit the 'easy' mining of open pits which have left quite a legacy which we are rightfully striving to better manage, contain and wherever possible eradicate. We have has some significant inroads with backfilling a small open pit at Cosmo Howley (Chinese 2) which has been significant to witness. This project employed a team of indigenous operators who were from the local area, it has been significant in providing local employment as well as healing the scars of the landscape which have been troublesome and expensive to manage in the past.					

ID#	100	Topic:	Public Comment: Andrew Upfill	EIS Section:	General

We have a range of experts who have been engaged in the EIS. In addition to this we have some incredibly dedicated and passionate personnel on site who deliver the day in day out operations.

Of note are the following: (However there are many others):

- Trevor Edwards – Superintendent Projects: He has been instrumental in the water balance of the Cosmo Howley streak and had the vision and articulation behind the infill of the Chinese 2 pit.
- Emer McGowan – Environmental Officer: She has been pivotal with overseeing the Ghost bat monitoring program on the ground and is a most passionate advocate of wildlife and fauna awareness and protection.
- Sally Horsnell – Environment Manager: Dedicated with years of local knowledge, Sally has a strong chemistry skill set and also appreciates what can be the protracted pieces of governance for the regulation with environment mitigation activity. The Adaptive Management Strategy for water balance management is a great example of what has been delivered in private public partnership.

The Public Private Partnership related to the Extension of Mining activity proposed at Union Reef is a great example of how the economy of the Territory can be delivered sustainably in light of innovation.

NTMO has a MoU with Charles Darwin University and have a range of proposed programs that will run on triennial funding, specifics of these programs are very close to contract and include:

- Ghost bats
- Wellness programs and
- Chemistry Research

In effect the triple bottom line of Environment, Social and Economic responsibility is being met by NTMO. It would be significant to have the EIS approved in the shortest possible timeframe to ensure the establishment of these programs can be well felt for many years.

The human capital in the existing workforce which is more than 60% locally based from Darwin and surrounds, is one that is providing an essential pillar in skills and capability development for a scale up in both industrial and mining activity – added to this are the numerous other jobs that support the operations – from catering to suppliers and beyond.

The Territory has a bright future – the Union Reefs proposed mining activity is one which is tied to the wellbeing of the environment. Kirkland Lake Gold the parent company of NTMO has demonstrated its commitment to the prospect of the region being a flourishing mining centre for more than the next 10 years. Imagine if there is another Tanami just waiting to be found which could responsibly sustain the region for the next 50 years?

If you would like any further clarification or comment please do not hesitate to contact me on 0419 715 425.

Response

Noted.

ID#	101	Topic:	Public Comment: Go Wise Real Estate	EIS Section:	General

Comment

Our business Go Wise Real Estate is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. Our business employs 4 people and support a range of trades such as plumbers electricians and the list goes on. I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

We have had the pleasure of working with NTMO now for 3 years, through this time have built a strong relationship and believe their vision for the Territory's future is detrimental in our current economic climate for job and population growth.

Feel free to contact me on 0407 003 008 if you would like to discuss further.

Response

ID#	101	Topic:	Public Comment: Go Wise Real Estate	EIS Section:	General
Noted.					

ID#	102	Topic:	Public Comment: Bogdan Dlugogorski	EIS Section:	General
Comment					
To Whom It May Concern Kirkland Lake Gold (KLG) will fund two major research projects at Charles Darwin University (CDU) with further research projects being developed for funding under the KLG-CDU collaboration agreement. KLG is funding a three-year biodiversity research project on the ecology of the threatened Ghost bat at CDU's Research Institute for the Environment and Livelihoods (RIEL). This project has a direct cash value of approximately $1,000,000 to the university and will support a NT-based early career research scientist. The research project will also bring flow-on financial benefits to the university through opportunities for recruitment of PhD and Honours students. CDU's research performance will be positively influenced by the scientific publication outputs arising from this project in addition to attracting increased research funding and new students. Being a proactive environmental management project, this biodiversity research program will take the lead in demonstrating new approaches for better conservation of species in the context of mining development. It will also directly fund the mapping of the distribution of a poorly known threatened species, the Ghost bat and provide publicly available data for assessing effects of current and future mining activities on the status of said species. This species and other bats in the NT are not very well known as a threatened species. The funding of a large-scale research project on the ecology of bats across the 'Top End' of the NT, well beyond the footprint of the relevant mining leases, will help to make a substantial contribution to the knowledge base on this aspect of NT's biodiversity assets. The project will enable CDU to develop a close working relationship with the NT Government's Department of Environment and Natural Resources to develop capacity and conduct strategic research in the NT resulting in better conservation outcomes associated with current and future mining proposals. KLG has enabled CDU to adopt a very broad scope to this project, conducting both applied and basic research beyond the specific needs relating to the Union Reefs North Underground Mine proposal. The project provides an excellent model and framework for industry-funded research which will facilitate better environmental management and decision making. In addition to the above, CDU will support KLG to be a responsive and supportive employer by delivering appropriate wellness and engagement activities to its staff population. KLG has commissioned the Wellness Centre based at the College of Health and Human Sciences (CHHS) at CDU to support the Kirkland Mining staff community throughout 2020. This support will be provided by CDU's academic staff who have relevant expertise and experience with support from students enrolled in appropriate degree programs. Through this initiative, KLG is demonstrating its commitment to maintaining a healthy and focussed workforce who are able to bring their best every day.					
Response					
Noted.					

ID#	103	Topic:	Public Comment: Oolloo Investments	EIS Section:	General
Comment					
My business is Oolloo Investments is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Unions Reefs and Surrounds going ahead as soon as practicable. My business employs 5 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	104	Topic:	Public Comment: Trevor Edwards	EIS Section:	General
Comment					
I wish to begin by declaring that I am an Employee of Kirkland Lake Gold at Their Northern Territory Operations. The purpose of this letter is to voice my support of the EIS submitted for the extension of Mining at the Union Reefs Site. I am Familiar with the EIS and believe KLG have given due consideration to all Aspects of the expansion. I have been working For KLG for a bit over two years and am pleased to be working back closer to home after ten years of Fly in Fly out and interstate work. I have had previous experience in the Union Reef and Cosmo area. A standout difference to me form other mining operations that I have worked for is Kirkland Lake Gold's Dedication to maintaining their social licence to operate and the level of commitment they have to Applying Best Practice and transparency in all that they do. Some examples of best Practice that I have observed are: • Full grouting to surface when completing Exploration Drill Holes (not a requirement although it should be) • Pit less drilling techniques for exploration drilling • Timely and first rate rehabilitation of drill pads and exploration track • Rehabilitation of legacy mining sites and waste Dumps I would encourage anyone who has concerns about KLG's level of commitment to Environmental Issues to organise a site Visit to the Cosmo Mine site and see firsthand the work and Financial Commitment they have made to Rehabilitation in the past few years. I hope we are looking at the future of Responsible and Sustainable Mining in the Northern Territory overall and not just one operators efforts. Social License Extends beyond Environmental Responsibilities and I would like to bring attention to another benefit of operations. • Buy local policy supporting many small to medium businesses in the NT • Strong emphasis on local employment, More than 70% and looking to increase • Relocation Assistance to bring People and their families to the NT A point that deserves more than a bullet is the Training and upskilling of local employees that have struggled to find work in the current economic climate. This is a win win situation as in time these employees can progress from entry level positions to fill some of the skill shortages that the Industry has in the NT. My personal Favourite of the NT Operations Core Values is "plan and do what we say we will". KLG has demonstrated the commitment to this in addition to the above mentioned by the recent upgrades of the U/R mill and Pine Creek and Cosmo Camps. This has been a significant investment and welcome work to local contractors who have done an excellent job and reinforces the fact that the NT business can get it done if given the opportunities. The time is here for External Stakeholders to give timely and thoughtful consideration to the proposals before them and allow the project to come to fruition.					
Response					
Noted.					

ID#	105	Topic:	Public Comment: Fawcett Cattle Company	EIS Section:	General
Comment					
My business Fawcett Cattle Company is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 15 people (9 of these 15 employees are Indigenous Locals from within the region our business is located) and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS. NTMO have always been supporters of our business and we strongly support NTMO in their endeavours. Not only because for our business but this will support many businesses in our region and many local businesses at that.					
Response					
Noted.					

ID#	106	Topic:	Public Comment: MMC Australia Pty Ltd	EIS Section:	General
Comment					
To whom it may concern: Relating to the Union Reefs North Underground Mine EIS for review I have looked at the Draft environmental Impact statement at the following link: https://ntepa.nt.gov.au/__data/assets/pdf_file/0009/760923/draft_eis_union_reefs_north_underground_mine_main_report.pdf. I would like to inform MMC is a NT business owned by the Pike family who all reside in the NT, invest all profit in the NT and employs more than 150 local employees. MMC fully support NT Mining in the Mining operations at Union Reef. MMC is a current service provider to NT Mining and I have full confidence in them being responsible from environmental perspective. Furthermore MMC has been involved in the operations of the Union Reef plant with its many operators in its history and we have directly seen the benefit the operations has had for the regional area of Pine Creek but also the NT. We look forward to a quick approval of the EIS and we will see the benefit to the economy quickly as NT Mining execute as per the EIS. Feel free to contact me for any further input.					
Response					
Noted.					

ID#	107	Topic:	Public Comment: Environment Centre NT	EIS Section:	General
Comment					
ECNT welcome this opportunity to provide comment on NTMO's proposal. While the rationale for restricting scope of assessment strictly to the new underground mining proposal is clear, it is disappointing that the opportunity was not taken to satisfy the public that altered parameters of the directly related Union Reefs plant have and will pursue an appropriate standard of environmental management. Our ability to meaningfully consider the impacts of this proposal are further hampered by the lack of detail on water quality objectives. While we do not accept that the draft is adequate basis for approval, we are able to share the following comments.					
Response					
Noted.					

ID#	108	Topic:	Climate Change: Environment Centre NT	EIS Section:	General

Comment

Climate Change

It is imperative that the assessment process pursues a higher standard of detail and planning around issues related to climate change than has been accepted in the past. We welcome the itemisation of estimated annual greenhouse gas emissions, however the value seems low against industry averages for gold production, and itemisation might assist. It could be assumed that this figure does not include the carbon burden of milling at URPA, and no detail is offered as to how the climate impact of this existing operation is accounted for or considered within the scope of existing authorisations. It would not be exactly scandalous to find that the authorisation from over 25 years ago neglected this now prominent parameter.

And yet merely acknowledging this burden is inadequate. The proponent should be required to consider offsets for anticipated greenhouse gas emissions and other related carbon burden. The Draft acknowledges the NTEPA's Guidelines on Environmental Offsets and Associated Approval Conditions, which does not specify carbon emissions, but could be read as relevant with respect to related impacts on biodiversity. More useful is the Draft NT Offsets Policy, which was released for consultation last year, and does specify carbon emissions. ECNT recommend that no new mining approval should be granted in absence of any consideration of options for offsetting carbon debt. So too, ECNT considers that any mining proposal should incorporate solar power. This is an obvious configuration option that the Draft does not discuss. In this instance, we would further encourage exploration of refit of the power for the plant at URPA. While the planned project duration does not demand consideration of further destabilisation of climate related systems, reference to average annual rainfall invites consideration of data skewed to account for advancing climate change, as other operations have learnt to their detriment.

Response

The Draft EIS has been developed seeking approval for the development of an underground portal within the Union Reefs Project Area. The overall footprint of this project is relatively small which highlights the small greenhouse gas emissions reported in the Draft EIS. The Union Reefs processing facility is currently authorised for use, and sources ore from other mining areas (Cosmo Howley project Area). Therefore the greenhouse gas emissions from that ore would be related to the Cosmo and Union Reefs processing plant authorisations.

NTMO and Kirkland Lake Gold are constantly looking at ways to reduce the environmental impact of operations. Kirkland Lake Gold's Macassa Mine in Canada was one of the first major mines to use battery-operated mining equipment underground, and worked closely with Artisan (now part of Sandvik) in developing this equipment. NTMO is working closely with EPIROC to investigate the use of their battery operated equipment, and will consider these for long term use at Union Reefs as not only is the technology better for the environment, it is also cheaper to run as fuel costs are lower and the requirements for air and ventilation underground are reduced compared to underground mining using diesel equipment.

NTMO is also investigating is the use of alternate electricity supplies for the processing plant and mines. NTMO has entered into a MoU with Charles Darwin University to specifically investigate alternative energy supplies. Currently NTMO uses power from the NT Government owned power grid that runs close to all mines and plants, however the use of solar or wind has not been discounted at this stage, although more work is required to understand if this can support the demands of our operations for either peak or base load. Charles Darwin University will assist with understanding these requirements and what technology could be used to fulfil our requirements both at the Union Reefs Underground mine and the whole of operations.

ID#	109	Topic:	Alternatives: Environment Centre NT	EIS Section:	General

Comment

Alternatives

The Draft does a poor job of considering alternative configurations. It should be a matter of course for any project to detail the no-go alternative, and discuss pros and cons of not proceeding. Of particular interest would be the comparative implications for closure and rehabilitation. Beyond the fore-mentioned interest in considering solar or

ID#	109	Topic:	Alternatives: Environment Centre NT	EIS Section:	General
other clean energy options, this draft could have discussed the potential of cyanide-free processing with a thiosulphate refit.					
Response					
The Draft EIS does address the no-go option. The project context in EIS Section 4.4 describes the Life of Mine plan for NTMO mining operations in the Northern Territory. Without the Union Reefs North underground mine, NTMO cannot continue to operate an economically sustainable business in the Northern Territory. The no-go option would therefore put the URPA, and potentially all of NTMOs other sites into care and maintenance mode. The Union Reefs processing plant was commissioned in 1994 and operates using an industry standard CIL process. The plant has safely operated since commissioning was completed. The new technology that has been developed by CSIRO and is now marketed by Clean Mining has only been shown to work on smaller scaled projects and it is not well understood if this technology would work on the scale of the Union Reefs plant. More work would be required to understand if it would operate at the current mill scale and what retrofitting would be required (including capital costs) to use this new technology in the Northern Territory. While the technology is still in the early stages of commercialisation (only one small plant has been built to date). It would be a financial risk for NTMO to move to this type of processing at this time. However, the fact that it has "the potential to eliminate tailings dams" (Clean Mining, 2019) means it would be a technology that Kirkland Lake Gold should investigate for future use as both the environmental and financial benefits warrant a further investigation.					

ID#	110	Topic:	Contingencies: Environment Centre NT	EIS Section:	4.10.2
Comment					
<u>Contingencies</u> We are assured (section 4.10.2, Material Characterisation) that: Preliminary results from recent geochemical testwork indicate that the majority of materials to be extracted from the Union Reefs North Underground Mine development will be NAF and the risk assessment of seepage from surface storage of waste rock is gauged as Low, on the basis: While no kinetic geochemical test work has been done, static test work indicates that most (≈90%) of the material to be stored is NAF with very low levels of leachable metals/metalloids. However the NT has a regrettable recent history of unintended environmental harm due to overly optimistic mis-characterisation of waste rock. It would be prudent to discuss contingency planning for the eventuality of that case in this project.					
Response					
The planned management strategies to minimise potential impacts: • Backfilling surface placed development waste rock back underground • Water management (pumped to Crosscourse pit during operations) • Post operations allowing the pit to refill and submerge the waste rock • Monitoring of surface water and groundwater during operations and at closure Monitoring results will be assessed for early signs of any unforeseen effects to allow flexibility to modify management strategies as required. The option of increasing water treatment is a key contingency as well as reducing the water levels in Crosscourse pit.					

ID#	111	Topic:	Water Quality: Environment Centre NT	EIS Section:	4.10.2
Comment					
<u>Water Quality</u> We are told, in 4.10.2, that: geochemical water quality prediction modelling [is] to be carried out as a part of additional work and further, in 13.3.2; Geochemical modelling will be undertaken (to be included in a Supplementary report) that will address quantitatively, the level of water quality impact and again, from the					

ID#	111	Topic:	Water Quality: Environment Centre NT	EIS Section:	4.10.2

appendix: Phase 2 will be conducted when the geochemical test data is available, and will consist of a predictive water quality model, which is expected to contribute to a Supplementary EIS at a later date. This is grossly inadequate. It is not sufficient for this significant detail to be relegated to the supplement, thereby denying the benefit of public consideration. This may compound the risk of impacts on water quality from dewatering, and potentially impacts the contingency of intentional discharges into the river (subject to aquatic ecosystem beneficial use).

Although we are informed: The water quality monitoring program conducted by NTMO at the URPA includes sampling locations on the McKinlay River, a control upstream from the site (URSW09) and one which serves as a compliance point downstream from the site (URSW08). Comparison of results from analysis of water sampled at these two 2 sites allows assessment of the impact of the URPA on the quality of water in the McKinlay River downstream of the site over the past ten wet seasons, i.e. 2010 to 2019. We are offered no such data, and there is no discussion of the impact of this proposal on water quality at URPA.

Response

The Supplementary EIS includes an updated geochemical characterisation report in Appendix 12 in this report and the predictive water quality modelling report with details requested in Appendix 15. Combined, these two reports resolve the key uncertainties, and confirm an overall low risk of ARD/NMD from project development. The updated modelling results confirm conclusions from the preliminary modelling indicating relatively minor changes to the Crosscourse pit water quality compared to the monitoring record, and that Crosscourse pit water flows to the McKinlay River will depend on the pit lake water level, rather than the project operations.

Upstream and downstream McKinlay River sites were compared in the preliminary Water Quality modelling report in EIS Appendix I, Section 2.3.1.

ID#	112	Topic:	Rehabilitation: Environment Centre NT	EIS Section:	General

Comment

Rehabilitation

The closure criteria and rehabilitated landform objectives appear appropriate for a proposal of this scope. It is however disappointing that the opportunity has not been recognised to reaffirm plans for closure of those domains which may remain operational beyond end of mine, as part of the URPA. We are assured the considerations of closure of the Crosscourse Pit and Processing Operations are addressed in the URPA closure plan. But this detail evades public scrutiny. It is noteworthy that the public were granted zero visibility of the implications for these closure plans in the context of Cosmo. Now, we are presented with further input to the URPA project area, with absolutely no idea of how the additional risk and impact might be managed there. ECNT recommend that this EIA should have been recognised as an opportunity to assert the adequacy of rehabilitation and early-closure planning so far, and to assure the public of the standard that will apply to this intimately related authorisation in the context of the additional proposal. Section 9.3 reminds us, with: NTMO will redevelop the broader URPA Mine Closure Plan (MCP) 2015 in accordance with the Western Australian Guidelines for Preparing Mine Closure Plans that the NT has no such standards or guidelines.

With: The structure and information in the URPA MCP 2015 will need to be reconfigured and reassessed to meet new guideline requirements, and the revised URPA MCP is likely to be substantially different to previously submitted versions. The proponent acknowledges that this proposal represents a waypoint at which closure planning at URPA will be significantly upgraded, but then: NTMO will work with the DPIR to agree on a realistic submission date for the redeveloped URPA MCP tells us that parties to this assessment expect approval to be independent of this significant feature.

In this way, appropriate consideration of significant risks fall through the cracks of piecemeal assessment. The compounded rehabilitation challenged to the URPA presented by the North Underground proposal has not only been explicitly ruled out of scope of this assessment. Although we are assured that these direct impacts of this proposal will be addressed in the URPA's existing authorisation, there is no evidence of where the URPA closure plan sits now; how it has been influenced already by Cosmo; nor how it might accommodate the additional impact North Underground represents. 3 ECNT recommend that all parties to assessment should recognise subsequent

ID#	112	Topic:	Rehabilitation: Environment Centre NT	EIS Section:	General
approvals as an opportunity to reassert, or if necessary reconsider, the adequacy of opaque management plans, in the public domain. The secrecy surrounding MMPs has long been challenged, and successive NT governments have pledged to open these instruments to public scrutiny. This process is an opportunity to demonstrate the value of transparency, which includes strengthening public license by assuring high standards, and we remain interested in its progress.					
Response					
Noted.					

ID#	113	Topic:	Public Comment: Rick Erkelens Earth Moving	EIS Section:	General
Comment					
I have been working for Kirkland Lake Gold at Cosmo for past year. I have several Bulldozers and do work on contract for the Company on various jobs, including rehabilitation. Kirkland Lake is a very go ahead motivated Company with a deep commitment to the environment and rehab of mined areas. I am a local, based at Batchelor. Kirkland Lake offers hope for my company as they are committed to looking after local business. Union Reef going ahead would be a lifesaver for us and many others in the area. Kirkland Lake – Spends Money! Kirkland Lake – is committed to protect and rehabilitate the environment. Kirkland Lake is Win – Win for the territory! Let the Mine at Union Reef go ahead!					
Response					
Noted.					

ID#	114	Topic:	Public Comment: Rhinos Diesel	EIS Section:	General
Comment					
Rhinos Diesel Services is a direct supporter to the operations of NTMO. I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. Rhinos Diesel Services employ 26 people most of which are directly involved with Cosmo and Union Reef operations Subject to approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS. NTMO is a very valuable customer to many local businesses not just ours. They have a very good reputation, for supporting local businesses and meeting the promises they make If Darwin had more operations like this the economy would be much better.					
Response					
Noted.					

ID#	115	Topic:	Public Comment: Aaron Banderson	EIS Section:	General
Comment					
My name is Aaron Banderson and I am descendent of the Wagiman people. I am a TO and my grandmother, Teresa Banderson (Muyuway) is a senior TO and resident of Pine Creek. The Wagiman people were granted Native Title in 2019. I grew up in Pine Creek and still have a lot of family and friends residing there.					

ID#	115	Topic:	Public Comment: Aaron Banderson	EIS Section:	General
I am a full council member for the NLC, a Director of Tjuwaliyn Wagiman Corporation (Pine Creek Region) and the Managing Director of Djundjakan Pty Ltd; a 100% Indigenous owned and run company. I am currently employed by KLG in a supervisory and mentoring capacity for Indigenous employees, on the Chinese 2 Rehabilitation Project. I appreciate that KLG is making an active effort to mitigate environmental issues caused by previous operators, and support local remote job seekers. From my point of view, KLG is directly influencing mining culture from an environmental perspective by managing rehabilitation and water quality values in the area. I have a vested interest in this project and the region, particularly regarding the local economy and job interests for Indigenous people in the area. I support the EIS going forward and supporting local job growth for the Pine Creek community. KLG should work with the senior TOs to encourage job opportunities for remote Indigenous job seekers. I am also interested in the cultural significance of Ghost bats and the connection they have with the Wagiman people. The name of the bat is jinminmin. There is a cultural belief that the Ghost bats are present in Union Reefs because of the Rainbow Serpent. Disturbing the bats or moving them from the Union Reefs site will disturb the connection with the Rainbow Serpent. Ghost bats should be left at Union Reefs and can be relocated around site, but not to Pine Creek or another colony. It would be beneficial for KLG to consult with Senior TOs of the Wagiman language group who are based in Pine Creek to help work with the Ghost bats, to meet the EIS goals in managing and relocating Ghost bats. This should happen before a decision is made about the final location of Ghost bats at Union Reefs.					
Response					
Noted.					

ID#	117	Topic:	Public Comment: Shaun Wilson Wilton Homes and Constructions	EIS Section:	General
Comment					
My business is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business directly employs 20 local people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS. You would be aware of the current construction down-turn in the NT and without NTMO future carefully managed projects I would not be able to keep my current workers employed. NTMO stipulates in my contracts that I only use local workers and I support the smaller local suppliers through this. I have witnessed through the previous 12 months on site an extremely well managed and regulated company in regards to all their policies and procedures, especially to flora, fauna, land and water management.					
Response					
Noted.					

ID#	118	Topic:	Public Comment: Alan Bennett Totalweld Sales & Service	EIS Section:	General
Comment					
Totalweld Sales & Service who is a NT owned and operated local business is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 10 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

ID#	119	Topic:	Public Comment: Gordon Hounslow Triple A Hoses	EIS Section:	General
Comment					
My business is Triple A Hoses it is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 16 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.					
Response					
Noted.					

2.4 NT EPA Site Visit and Matters to Address in the Supplement to the Draft EIS

TABLE 2-4 NT EPA SITE VISIT AND MATTERS TO ADDRESS IN THE SUPPLEMENT TO THE DRAFT EIS

ID#	116	Topic:	NT EPA site visit	EIS Section:	General

Comment

The NT EPA requires Ghost bat count numbers to enable understanding of the usage of both adits as well as contributing to making informed decisions with respect to their management. To fully address the related items on page [8] (Ghost bat Actions 7 and 9) of the NTG agency comments (sent to NTMO 31 January 2020), include in the Supplement, the exact:

- Dates counts were conducted
- Locations at which the counts were conducted
- Methodologies used for each of the counts
- Number of bats that were counted at each location and on each occasion

Response

We have prepared Memo 1: Ghost bat activity monitoring August 2019 – March 2020 (Appendix 3 of this report) to provide further details from our long-term monitoring programme. These results were not available at the time of EIS submission. The latest results add considerable clarity to our understanding of how Ghost bats use the Union North adit and OK adit. A quick summary is as follows:

- Data is now available from two breeding periods.
- Union North adit appears to be the main focus for the Ghost bat.
- Lower activity is observed in the OK adit around the same time of peaks, suggesting that the bats sometimes move between the two structures.
- The highest levels of activity are around the time when Ghost bats give birth, so there is evidence that the colony spends some part of the breeding cycle in the Union Reefs project area.
- There are long periods when Ghost Bats are absent, or there are very low levels of activity.
- Video recordings (thermal or infrared) helped to give reliable counts of colony size, which varied at each site. Colony size varied between c. 10 to 50 individuals.
- There is adequate evidence from the combined acoustic and video recordings that individuals move in and out of the Union Reefs project area as part of natural processes.

Comment

The NT EPA notes that the Draft EIS provides only one alternative for the portal (page 55 in the Draft EIS) and does not discuss whether other options are available for avoiding closing the OK adit. To inform the NT EPA's assessment and address the requirements of Environment Protection and Biodiversity Conservation Regulation 6.03(c) (d), it is recommended that the Supplement include further discussion of alternatives that would avoid disturbance (both above and underground) within 130 m of known Ghost bat adits. The Supplement should discuss any feasible mitigation measures, changes to the action or procedures to prevent or reduce impacts to the species.

Response

Project alternatives are discussed in Section 4.11 of the Draft EIS. Two alternatives are described. Additional information regarding these alternatives, and the relationship between the Ghost bat adits and mineralised zones is contained in Section 3.15 of this report.

Comment

With regard to water matters, as mentioned during the site visit, please include information in the Supplement with respect to the following points discussed:

(a) A 12 km mixing zone in the McKinlay River – in the absence of relevant information justifying this length, this is considered an unreasonably long/large mixing zone. While it may have been the existing zone for a previous waste discharge licence (WDL), it may not be considered acceptable for this Proposal. Ensure you fully address the related item on page 15 of the NTG agency comments (sent to NTMO 31 January 2020).

ID#	116	Topic:	NT EPA site visit	EIS Section:	General

(b) Clarify under which Act or instrument there are 'compliance points', e.g. under the mining authorisation or previous WDL (include reference numbers).

(c) Crosscourse pit water:

- What was the level (mAHD) of the lake at the end of the dry Season, 30 September 2019?
- What was the level (mAHD) of the water at the time of the site visit?
- What is the maximum operational level (mAHD) before water starts leaving the pit (via the gravels)?
- What is the maximum depth of the Crosscourse pit (mAHD)?
- What is the depth of groundwater monitoring bores and their screen intervals (mAHD) around and down gradient of the Crosscourse pit?

Response

(a) With regard to the 12 km mixing zone in the McKinlay River – this issue has been addressed in Section 3.12 below in response to Submission #44.

(b) There is no requirement for 'compliance points' under the previous WDL (WDL-138-03).
There is no requirement for 'compliance points' under the Mine Management Act. URSW08 is not contained within the ML and therefore not controlled under the Mine Management Act.
Under the (most recent) WDL-138-03 SSTVs listed in the WDL for Zn, Se, Cl, TSS and Turbidity was only applied at URSW08. SSTV's were not applied to any other monitoring point or authorised discharge point. URSW01 and URSW10 were the only authorised discharge points, albeit with related to uncontrolled discharge.

(c) Crosscourse pit water

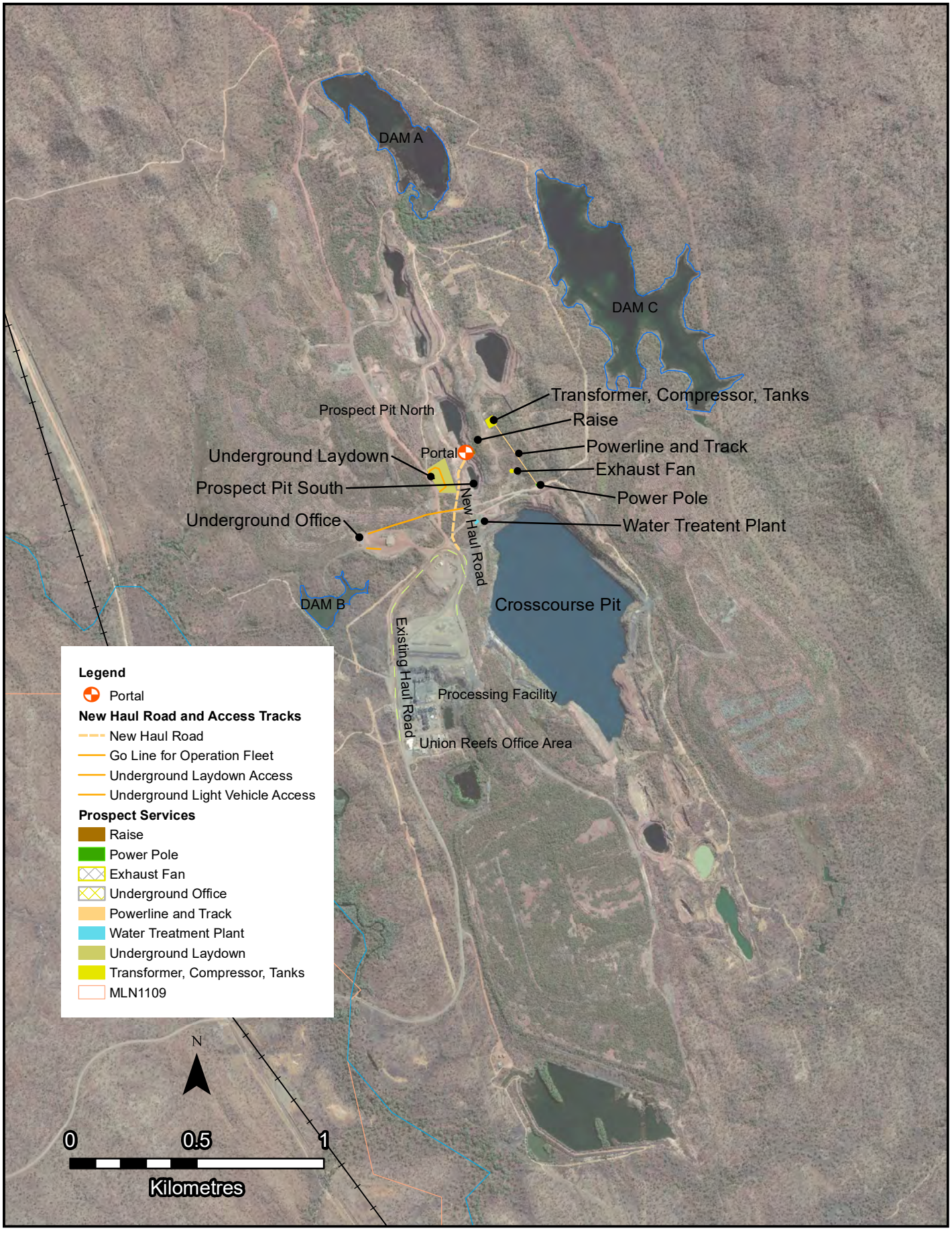
- What was the level (mAHD) of the lake at the end of the dry Season, 30 September 2019? **173.25 mAHD**
- What was the level (mAHD) of the water at the time of the site visit? **174.3 mAHD**
- What is the maximum operational level (mAHD) before water starts leaving the pit (via the gravels)? **189.22 mAHD**
- What is the maximum depth of the Crosscourse pit (mAHD)? **81.9 m**
- What is the depth of groundwater monitoring bores and their screen intervals (mAHD) around and down gradient of the Crosscourse pit? – This has been addressed at **Section 3.10.**

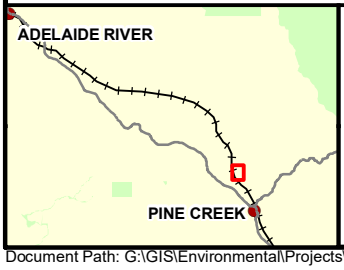
3 Additional and/or Amended Information

3.1 Proposed Action

In line with the requirements of Submission #1, this Supplementary report contains updated maps at the scale and resolution of Figure 4-2 in the EIS for Proposal components, including:

- Figure 3-1 – Location of all proposal components under assessment, including: Union Reefs North Underground Mine infrastructure, haul road, Prospect pit north and south, Crosscourse pit, Dams A, B and C, and Processing operations, but not including other components covered by existing authorisations, (e.g. truck workshop, fuel bay and explosive storage).
- Figure 3-2 – Location of Ghost bat adits remaining open during the proposal and a 130 m buffer.
- Figure 3-3 – Proposed locations for artificial Ghost bat roosts and a 130 m buffer. This figure includes the location of Ghost bat adits relative to the mineralised zones at the URPA. This is discussed in more detail in Submission ID#16 and Appendix 9 of this report.
- Figure 3-4 – Location of groundwater dependent ecosystems (north) and Figure 3-5 (south).
- Figure 3-6 – Primary and secondary mine features.
- Figure 3-7 – Primary, secondary and tertiary mine features.
- Figure 3-8 – Locations of sediment traps (see Submission ID#2).





Union Reefs Project Area
Proposal Components and Infrastructure

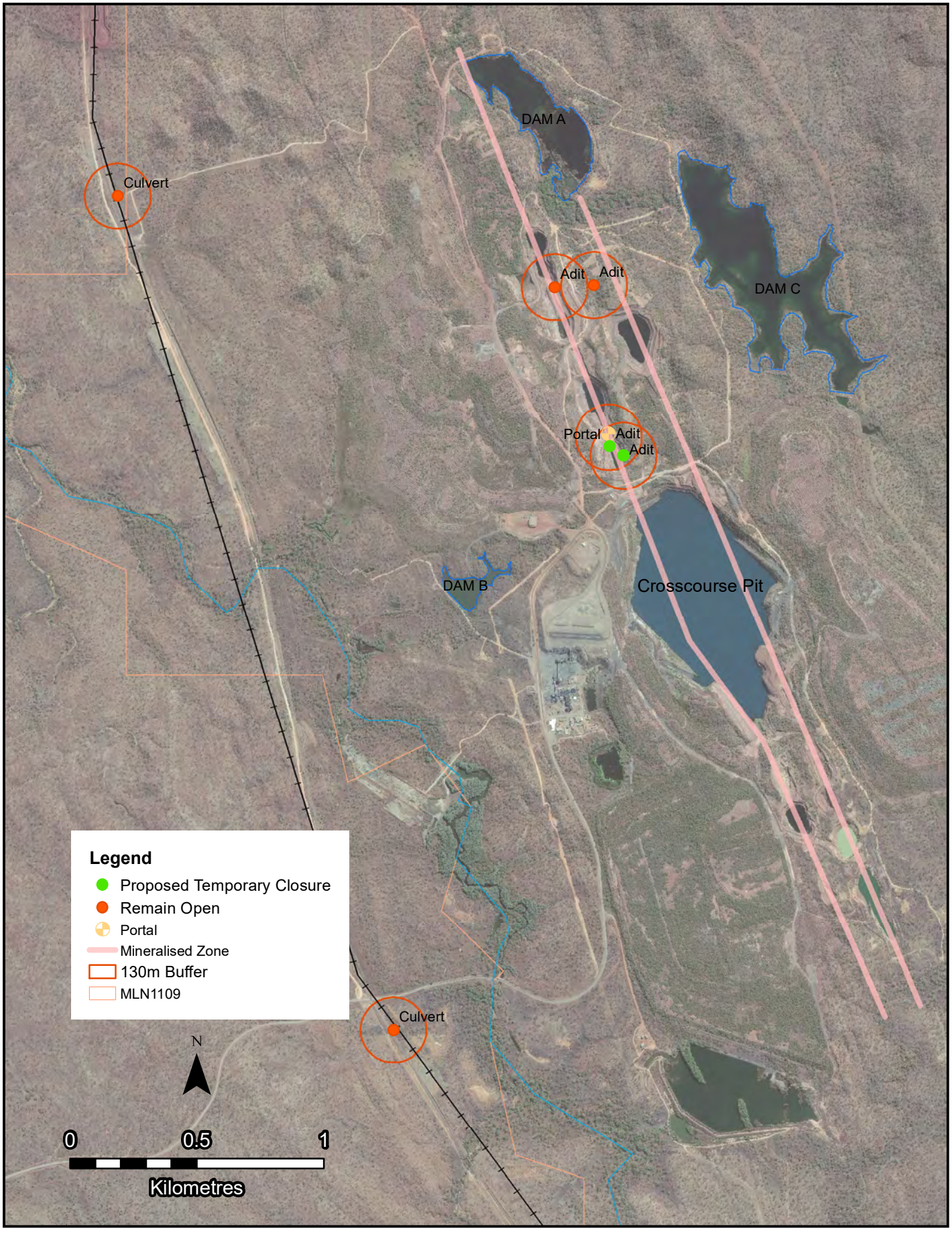
FIGURE 3-1 PROPOSAL COMPONENTS UNDER ASSESSMENT

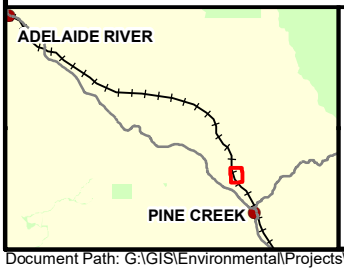
KIRKLAND LAKE GOLD

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Union Reefs Project Area
Terrestrial Fauna Management

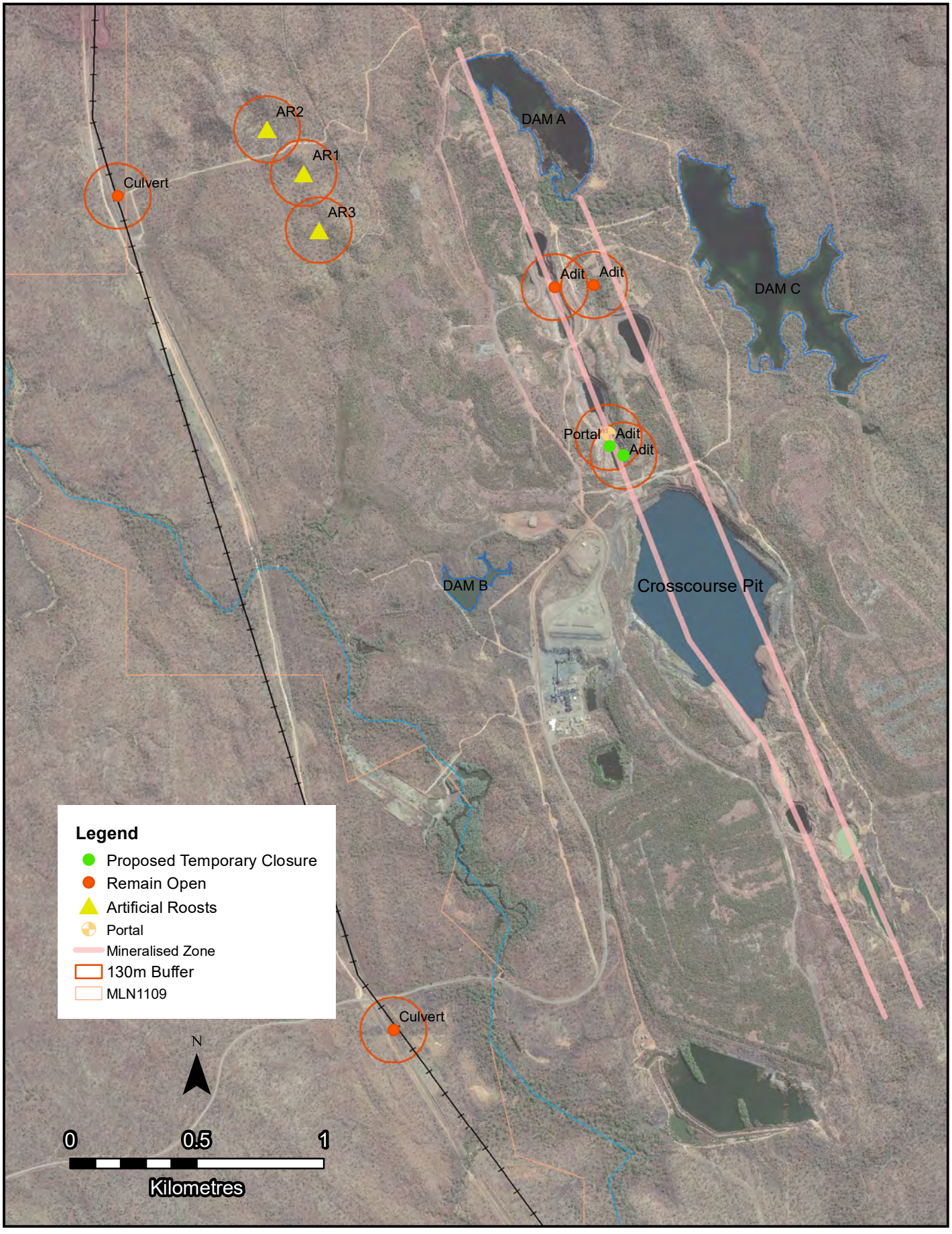
FIGURE 3-2 GHOST BAT ADITS

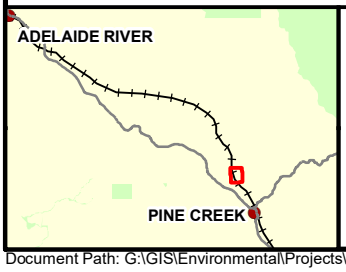
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Union Reefs Project Area Habitats to Remain Open, 130m Buffer and Preliminary Artificial Roosts

FIGURE 3-3 ARTIFICIAL GHOST BAT ROOSTS

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MRWET07
MRWET09
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MRWET05
MRWEIR
MRBILL01
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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

Potential Groundwater Dependant Ecosystems

- Assessment locations
- McKinlay River & Riparian Zone
- Ponds
- Dams
- Pits
- MLN 1109

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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

Kirkland Lake Gold
Union Reef EIS

Job Number 12512776
Revision D
Date 12 Feb 2020

Potential Groundwater Ecosystems - North

Figure 3-4 LOCATION OF GROUNDWATER DEPENDENT ECOSYSTEMS – NORTH

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:drockliff

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

Potential Groundwater Dependant Ecosystems

- Assessment locations
- McKinlay River & Riparian Zone
- Ponds
- Dams
- Pits
- MLN 1109

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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

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Kirkland Lake Gold
Union Reef EIS

Job Number 12512776
Revision D
Date 12 Feb 2020

Potential Groundwater Ecosystems - South

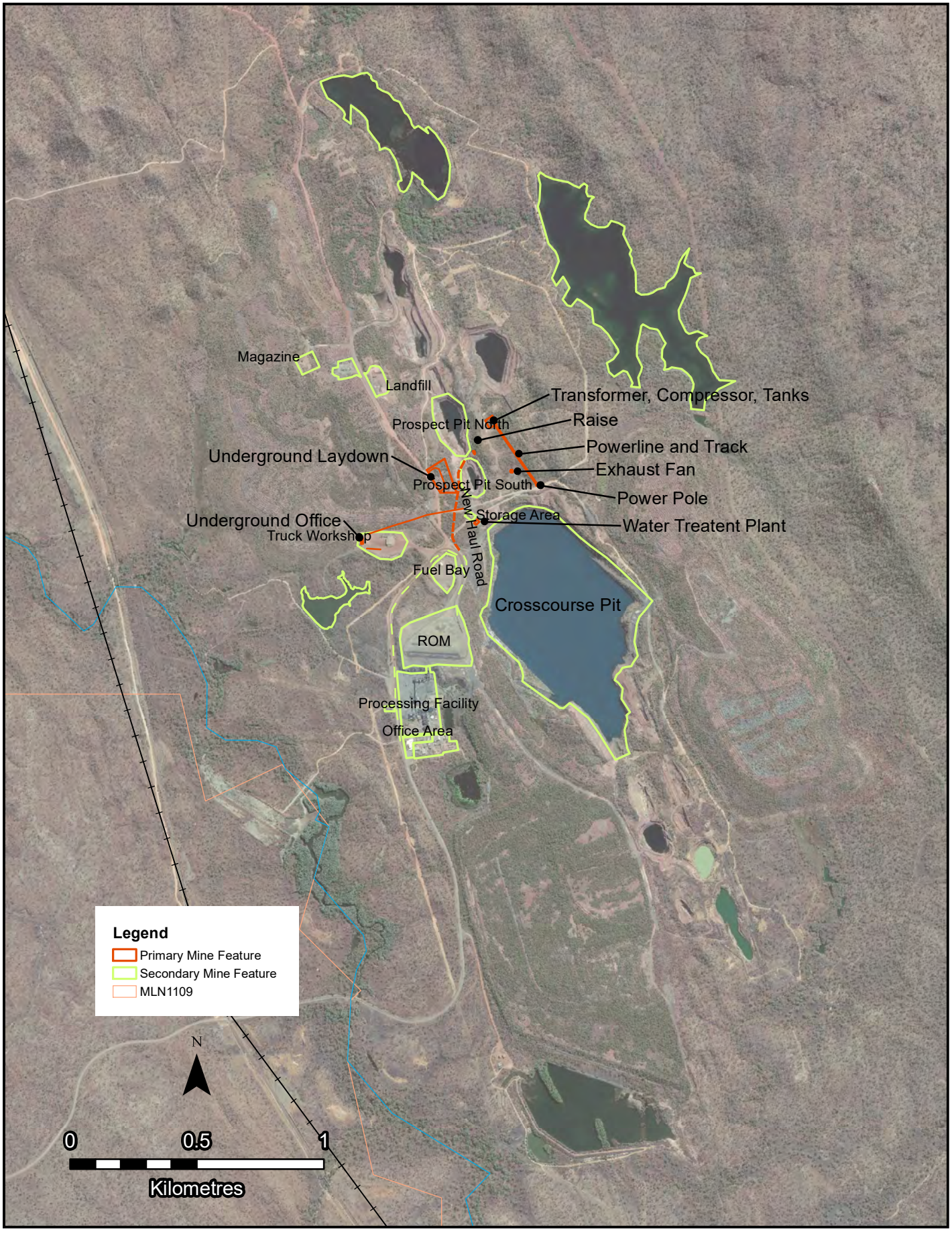
FIGURE 3-5 LOCATION OF GROUNDWATER DEPENDENT ECOSYSTEMS – SOUTH

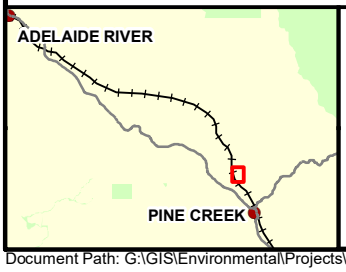
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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:drockliff





Union Reefs Project Area
Primary and Secondary Mine Features

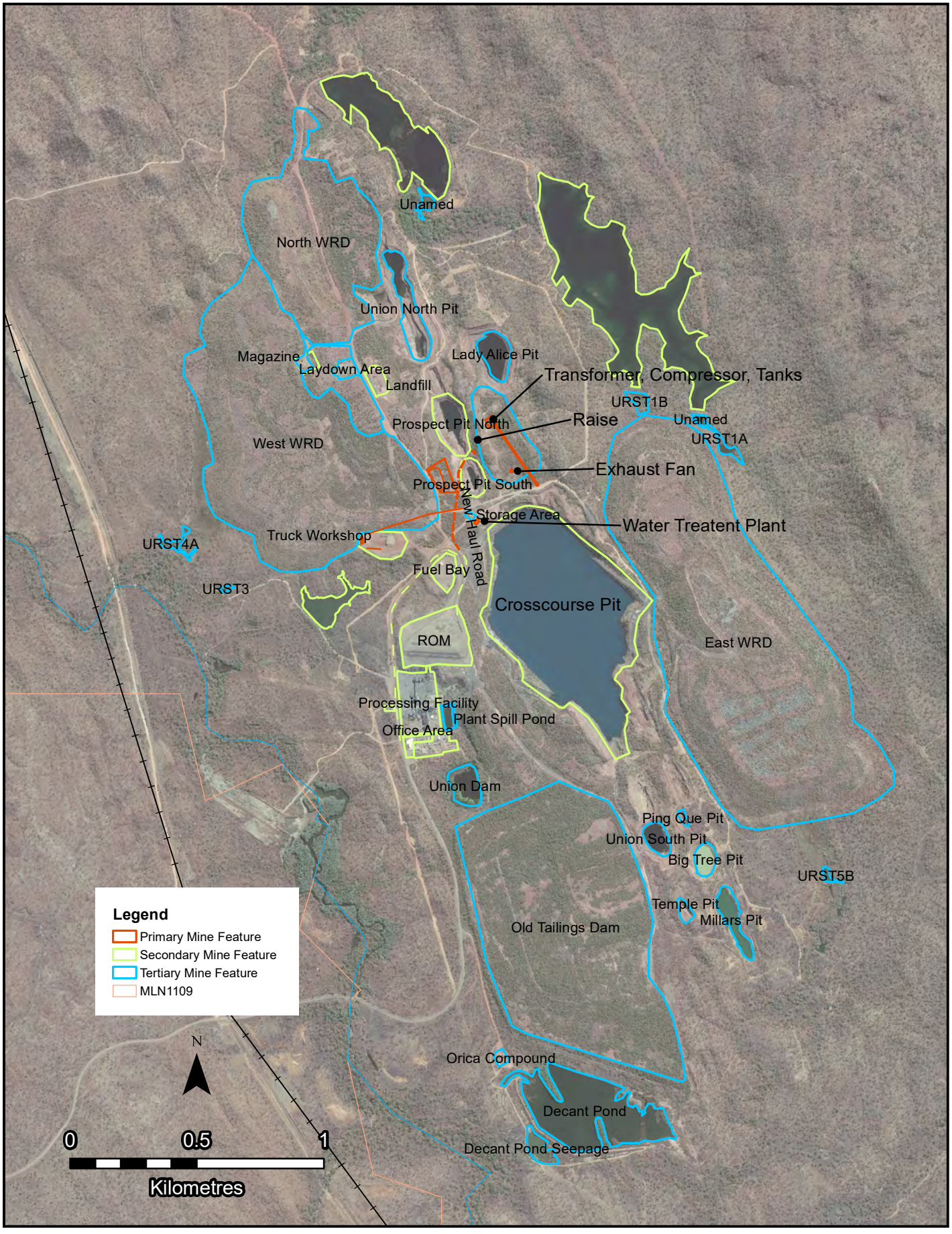
FIGURE 3-6 PRIMARY AND SECONDARY MINE FEATURES

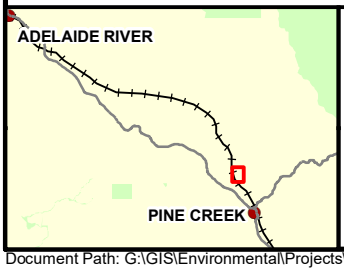
KIRKLAND LAKE GOLD

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Union Reefs Project Area

Primary Secondary and Tertiary Mine Features

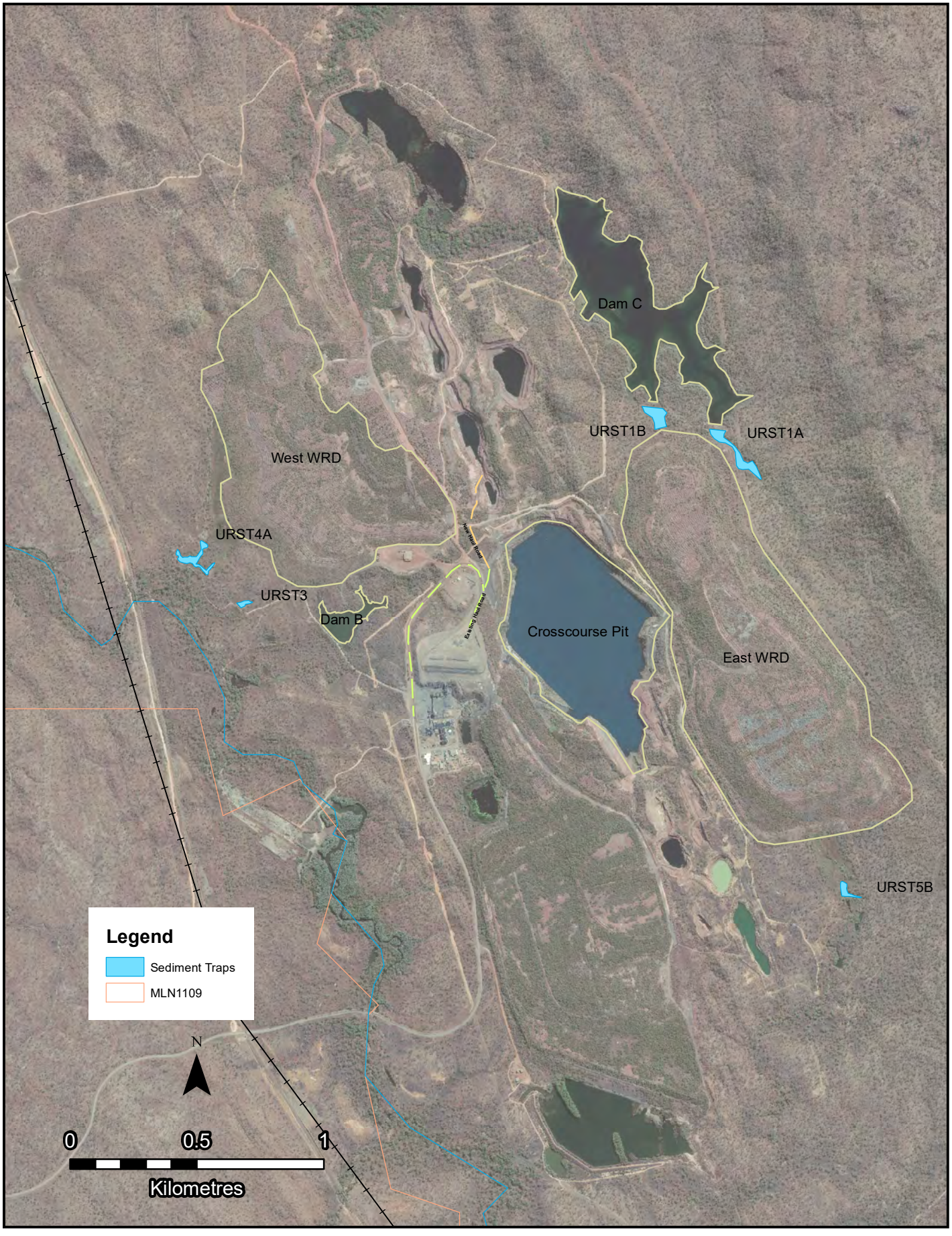
FIGURE 3-7 PRIMARY, SECONDARY AND TERTIARY MINE FEATURES

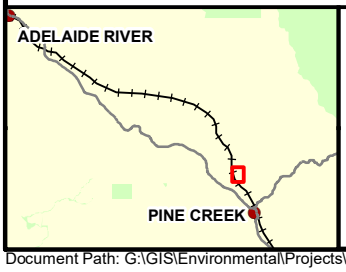
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Union Reefs Project Area
Sediment Traps

FIGURE 3-8 LOCATIONS OF SEDIMENT TRAPS

KIRKLAND LAKE GOLD

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17 February 2020

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3.2 Commonwealth Approval

Table 3-1 below addresses Submission ID# 4, calling for the inclusion of the requirement of environmental approval under the EPBC Act in Table 5-1 in the Draft EIS.

TABLE 3-1 COMMONWEALTH LEGISLATION

Legislation	Licensing and Approvals	Context
Environment Protection and Biodiversity Conservation Act 1999	Formal referral , assessment and approval of the project under the EPBC Act is required, given the proposed impact on *Macroderma gigas* (Ghost bat) habitat (temporary adit closure) – this species is Listed as vulnerable under the EPBC Act.	An Act relating to the protection of the environment and the conservation of biodiversity, threatened species and related purposes. The project has been declared a controlled action under the EPBC Act, with regard to listed, threatened species (Chapter 11 and Appendix G of the Draft EIS) and will be assessed under the bilateral agreement between the Northern territory and Australian Government. Approval of the project is not included in the bilateral agreement.

3.3 Surface Water Extraction License

Table 3-2 below addresses Submission ID# 6, calling for the inclusion of the requirement for the licences, permits or approvals required under the Water Act 1992 into Table 5-2 in the Draft EIS.

TABLE 3-2 NORTHERN TERRITORY LEGISLATION

Legislation	License, Approval or Permit	Context
Water Act 1992	Water extraction licence	In December 2018, the Water Act was amended to include mining and petroleum activities. The amended Act includes transitional provisions that established a process for mining and petroleum activities to become integrated into the water extraction licensing regime as the associated environment management plan or mine management plan expires, or is renewed or amended. The Controller of Water Resources can grant a licence to take surface water or groundwater under sections 45 and 60 of the Act, respectively. NTMO has a previously authorised water entitlement (water extraction from Dam C) under mining authorisation # 0539-03. Water is taken for mining activities pursuant to a mine management plan approved under the Mining Management Act 2001 before 30 June 2019. The proposed water extraction for the Project is no greater than the previously authorised water entitlement. I.e. water extraction from Dam C for use in the processing. Previous years Dam C water usage: • 2015 to 2016 280 ML • 2016 to 2017 300 ML Proposed water usage approx. 300 ML NTMO will submit an application for a water extraction licence and will include details on the pumping station and its power supply. The proponent's water extraction licence application will also demonstrate that the activity does not have an adverse effect on water quality of these water sources. I.e. The beneficial uses gazetted for surface and groundwater in the Mary River Catchment and the McKinlay River do not include mining activity or industry. This will be a factor considered by the Controller of Water Resources when making a water extraction licence decision. The proponent's water extraction licence application must demonstrate that the activity (for example extraction from Dam C) does not have an adverse effect on water quality of other water sources.
Water Act 1992	Waste discharge licence	A waste discharge licence for controlled discharge of waste water is issued under this Act, and is subject to the conditions of the licence.

3.4 Mine Schedule

Table 3-3 to Table 3-5 in the following sections provide provisional scheduling and timing for activities required in Submission ID #3.

3.4.1 APPROVALS AND PERMITTING

TABLE 3-3 APPROVALS AND PERMITTING SCHEDULE BASED ON SUBMISSION OF SUPPLEMENTARY

Activity	Mining Phase	Start	End	Duration (days)	Frequency	Comments
Submission of Supplementary report to NT EPA	Development /construction	-	Submit on 06/03/2020	-	Once	-
Submission of water extraction licence	Development /construction	-	Submit by 07/03/2020	Deadline	Once	-
Submission of MMP amendment to DPIR	Development /construction	-	Submit by 12/03/2020	-	Once	-
Submission of closure plan to DPIR	Development /construction	-	Submit by 06/2020	-	Once	-
NT EPA assessment report released	Development /construction	-	24/04/2020	-	Once	Date based on 35 business days from Supplementary submission if information is adequate
EPBC approval	Development /construction	-	15/06/2020	-	Once	Date based on 35 business days from NT EPA Assessment Report if information is adequate
Submission of WDL application	Development /construction	-	30/06/2020	-	Once	-
Submission of annual WDL report	All mining phases	01/08/2021	01/08/2026	Minimum 6 years	Annual	Annual WDL reporting will be continued without interruption
Application for approval to store and transport explosives (NT Worksafe)	Development /construction	-	Submit by 06/2020	-	Once	Permit gained prior to obtaining explosives
Application under the TPWC Act for Ghost bat management (Action 10)	Development /construction	-	Submit by 05/2020	-	Once	Permit gained prior to conducting Action 10

3.4.2 MINING ACTIVITIES DURING EACH MINE PHASE

TABLE 3-4 MINING ACTIVITIES SCHEDULE DURING EACH MINING PHASE

Activity	Start	End	Duration (days)	Frequency	Comments
Development / Construction Phase					
Installation of surface mine ventilation system	04/03/2021	03/05/2021	60	Once	-
Explosives bunker upgrade	01/04/2020	01/06/2020	61	Once	
Prospect pit ramp upgrade	01/05/2020	05/05/2020	4	Once	
Haul road construction	01/05/2020	15/05/2020	15	Once	
Infrastructure area (substation, etc.)	01/05/2020	05/06/2020	35	Once	
Extend north bench	-	05/05/2020	1	Once	
Extend south bench	-	06/05/2020	1	Once	
Install pump and pump line into southern and northern pits	05/05/2020	07/05/2020	2	Once	End linked to start Prospect pit dewatering
Preparation of portal bench area	05/05/2020	07/05/2020	2	Once	Same as extend north / south bench
Prospect pit north and south dewatering	07/05/2020	17/05/2020	10	Once	All assumes May 1 approval of EIS and MMP
Develop access to ore	01/06/2020	30/09/2020	121	On-going	Up until the first ore produced from the mine
Exploration platform construction	30/06/2020	29/08/2020	60	Once	May need additional platforms based on success
Production / Operation Phase					
Mining ore	30/09/2020	19/12/2022	810	On-going during production	Based on reserves only
Tailings deposition	05/10/2020	24/03/2023	900	On-going during production	Assumes ore milled after completion of mining
Waste rock deposition	01/06/2020	22/05/2022	720	On-going during production	Backfill will be larger than waste produced at end of mining sequence

Activity	Start	End	Duration (days)	Frequency	Comments
Processing ore	05/10/2020	24/03/2023	900	On-going during production	Same as tailings deposition as producing makes tailings
Backfilling of stopes with waste rock	04/03/2020	24/03/2023	750	On-going during production	Backfill stopes after mining is completed
Closure Phase					
Remove temporary surface waste rock piles to underground	01/09/2021	24/03/2023	569	On-going during closure	This is when we start backfilling stopes underground using waste from surface
De-sludge sumps	24/03/2023	3/04/2023	10	Once	-
Cease pumping underground inflows	-	24/03/2023	-	Once	-
Remove air management infrastructure from surface	24/03/2023	22/06/2023	90	Once	-
Remove tanks / power / compressor / raise area infrastructure	24/03/2023	21/08/2023	150	Once	-
Allow underground network to flood	24/03/2023		Natural recharge rates	On-going	
Construct final portal geometry to preclude public access but allow Ghost bat access	30/09/2023	30/10/2023	30	Once	-
Alter portal ramp geometry to final required landform	01/01/2024	16/01/2024	15	Once	-
Bund prospect pit to prevent access	16/01/2024	01/03/2024	45	Once	-
Site landform and drainage reconstruction	16/01/2024	16/03/2024	60	Once	-
Rehabilitation and revegetation	16/01/2024	01/03/2024	45	Once	-
Remove and spread soil stockpiles	16/01/2024	01/03/2024	45	Once	-
Post Closure Phase					
Rehabilitation and revegetation	16/03/2024	16/03/2026	730	On-going	Assuming 2 years monitoring

3.4.3 GHOST BAT MANAGEMENT

TABLE 3-5 GHOST BAT MANAGEMENT ACTIVITIES DURING EACH MINING PHASE

Activity	Start	End	Duration (days)	Frequency	Comments
Development / Construction Phase					
Monitoring – OK adit and Prospect adit (acoustic)	01/10/2018	Until adit closure	-	Continuous	
Monitoring – OK adit and Prospect adit (thermal video)	01/10/2018	Until adit closure	-	2 consecutive nights every 2 weeks	
Action 1 – Closure of OK adit and Prospect adit	Within the low/no occupancy opportunity window	Prior to mine production phase	Minimum 3	Once	
Action 4 – Re-open Lady Alice adit	01/12/2019	01/12/2020	1	Once	This action was completed in December 2019
Action 6 – Implement management at Kohinoor adit	01/05/2020	-	-	Continuous	
Action 5 – Manage disturbance to Union North	01/10/2018	-	-	Continuous	
Action 9 – Survey for unknown cave roost sites in areas surrounding URPA.	01/05/2020	01/12/2021	1 day/ survey	Several field surveys	
Ghost bat management Action 2 – Characterise OK adit and Union North adit	01/12/2019	01/12/2019	1	Once	This action was completed in December 2019
Action 3 – Construct artificial roosts	01/04/2020	Prior to commencement of Action 1	5	Once	At least 2 structures built
All Mine Phases					
Union North adit (acoustic monitoring)	01/10/2018	Until post closure	-	Continuous	
Union North adit (thermal video monitoring)	01/10/2018	Until post closure	-	2 consecutive nights every 2 weeks	
Lady Alice adit (acoustic monitoring)	01/10/2018	Until post closure	-	Continuous	
Lady Alice adit (thermal video monitoring)	01/10/2018	Until post closure	-	2 consecutive nights every 2 weeks	
Kohinoor adit (acoustic monitoring)	01/05/2020	Until post closure	-	Continuous	
Kohinoor adit (thermal video monitoring)	01/05/2020	Until post closure	-	2 consecutive nights every 2 weeks	

Activity	Start	End	Duration (days)	Frequency	Comments
Spring Hill roosts (acoustic monitoring)	01/01/2020	Until post closure	-	Continuous	
Spring Hill roosts (thermal video monitoring)	01/01/2020	Until post closure	-	2 consecutive nights every 2 weeks	
Natural Caves surrounding URPA (acoustic monitoring)	Immediately following discovery	Until post closure			
Natural Caves surrounding URPA (thermal video monitoring)	Immediately following discovery	Until post closure			
Artificial Roosts (acoustic monitoring)	Immediately following construction	Until post closure	-	Continuous	
Artificial Roosts (thermal video monitoring)	Immediately following construction	Until post closure	-	2 consecutive nights every 2 weeks	
Action 10 – Study of colony connectedness using genetic markers	01/03/2020	01/12/2021	-	Continuous	
Action 11 – Provide support for university research project on general ecology	01/03/2020	01/03/2023	Duration of program	Continuous	
Closure and Post Closure Phase					
Action 8 – Convert underground mine for Ghost bat habitat	01/05/2023	01/05/2023	1	Once	
Action 8 – Underground mine (acoustic monitoring)	01/05/2023	01/11/2023	186	Continuous for 6 months	

3.5 Closure of OK and Prospect Adits

The following information is in response to Submission ID#9. The table below summarised in one place, all the additions and amendments made to the Ghost Bat Action Plan (i.e. version 2020) relating to all Ghost bat submissions The Ghost Bat Action Plan is provided as Appendix 4 of this report.

TABLE 3-6 SUMMARY OF ADDITIONS / AMENDMENTS TO THE GHOST BAT ACTION PLAN

Action Description	Section of Action Plan	Summary of Amendments/Additions Included in Version 2020
N/A	Background	Reference to the newly created Ghost Bat Management Plan to be used in conjunction with the Action Plan as part of KLG Environmental Management System.
N/A	Strategy of this Action Plan	Newly created section detailing strategies surrounding triggers and contingencies and the general methodology for the design of the Action Plan.
N/A	Phased timing of the actions	Clarification on which actions are continued / commenced during each phase.
N/A	Whole Action Plan	The language in the Action Plan has been checked to ensure that the terms 'where possible', 'it is anticipated', 'as required', 'should' and 'may' are absent, and that the terms 'will' and 'must' are used. No ambiguity around the proponent's responsibility for Ghost bat management was detected.
N/A	Each action	The Action Plan specifically cites relevant parts of the Conservation Advice (TSSC 2019) for the Ghost bat at the top of each action under three subheadings: • "Threat factor/s addressed". • "Knowledge gap addressed". • "Specific priorities addressed in the Conservation Advice by this action". • These have been combined under a new heading: • "Conservation Advice considerations".
Action 1 – OK Adit Exclusion Exclude the Ghost bat from the OK adit based on a planned methodology and timing. [Avoidance and mitigation / minimisation]	Title; Details of the action	• Specific mention of the Prospect adit. • Statement that the same method will be used for Prospect adit to make certain that Ghost bats are not using the structure during the day before the entrance is sealed to bats. • Update to methodology for Exclusion and closure timeframe. • Mention of a report deadline of one month after the completion of the Exclusion (following step 10).
Action 2 – Survey of Internal Adit Structures Characterise the internal dimensions of the OK adit and Union North adit, and the position of Ghost bat roost areas within. [Research to support minimisation]	Details of the action	• The specified report to document results of action will be forwarded within 6 months of the project approval date. • Reference to methodology document which details methodology for adit characterisation.

Action Description	Section of Action Plan	Summary of Amendments/Additions Included in Version 2020
Action 3 – Construct Artificial Habitats Create several artificial roosting habitats in the URPA, for both contingencies and additional capacity, and evaluate their success. [Both mitigation / minimisation and offset]	Details of the action	• Updated to specify the need for a report on the modelling and construction process (in the Action Plan and Ghost Bat Management Plan), to be submitted within 3 months of the completion of construction of the structures. • Statement about how Action 3 provides a contingency.
Action 4 – Re-open Lady Alice Adit Re-open and rehabilitate the Lady Alice adit so that it is suitable for Ghost bat occupancy. [Mitigation / minimisation and offset]	Details of the action	• A more explicit statement included that describes how the details of Action 4 will be included in reporting for Actions 2, 3, and 7. • Details about which aspects of the action have already been completed.
Action 5 – Manage Union North Adit Manage the Union North adit during the period of mining to exclude visitation from mining personnel. [Mitigation / minimisation]	Item 7-12 in Details of the action	• Updated to include mention of the risk of lighting, dust, the movement of machinery, fires, entanglement in barbed wire fences, and noise and vibration.
Action 6 – Manage Pine Creek and Spring Hill Ghost Bat Sites Implement management measures at the Koohinoor adit, Pine Creek, to protect the Ghost bat roost. [Mitigation / minimisation]	Details of the action	• Updated to include a report deadline of two years from the date of project approval.
Action 7 – Monitoring Program Continued monitoring of Ghost bat presence, activity levels and colony size at Union North adit, potentially Lady Alice adit, new artificial roost habitats, and other key regional sites (Pine Creek; Spring Hill; any newly discovered caves of significance surrounding the URPA). [Mitigation / minimisation]	Table 1; 4. The best indicator of usage comes from counts of colony size; 6. Triggers	• Updated to mention the inclusion of data derived from noise and vibration dataloggers in the regular reporting summarised in Table 1. • The monitoring of bats for six months post-mining in the decommissioned mine described as part of Action 8 included in Table 1. • Update of monitoring instrumentation. • Update to remove the discussion around trigger in the context of acoustic ad video monitoring.
Action 8 – Facilitate Post-Mining Occupation of Mine Workings by Ghost Bats Provide a portion of the new mine for Ghost bat occupancy once mining has been completed and evaluate its success. [Rehabilitation or offset]	Details of the action	The monitoring of bats for six months post-mining in the decommissioned mine described as part of Action 8 included in Table 1 under Action 7.
Action 9 – Cave and Mine Roost Survey	Details of the action	• Updated to include a reporting deadline three months after the surveys have been completed.

Action Description	Section of Action Plan	Summary of Amendments/Additions Included in Version 2020
Conduct field surveys for Ghost bat diurnal roosts in natural caves in the hills surrounding the URPA. [Research to support minimisation]		• Update of information on monitoring equipment and survey methodology.
Action 10 – Genetic Study Investigate the connectedness of Ghost bat colonies in the region using an advanced genetic method based on genome-scale DNA sequencing. [Research to support minimisation]	Details of the action	• Updated to specify that the deadline of the report will be six months from the completion of the field component. • Information provided as to where the reports will be submitted and if they will be made publicly available.
Action 11 – Support Ghost Bat Research Provide support for further academic research. This would include coordinating the development of a Recovery Plan, which is required under the EPBC Act 1999, but has not yet been developed. [Research to support overall management]		

3.6 Development of Commitments Associated with 11 Actions

The following information is provided in addition to the response to comment ID#10. It details the further development of NTMO commitments in Ghost bat management.

TABLE 3-7 DEVELOPMENT OF GHOST BAT MANAGEMENT COMMITMENTS

Aspect / Action	Information Already Provided	Further Development Provided
Noise and vibration	The modelling study conducted by Velasco (2019; Appendix 1 of Appendix G of the Draft EIS) found negligible levels in the closest roosts used by the Ghost bats (Union North adit, and potentially the Lady Alice adit).	• Ghost Bat Management Plan (Appendix 5 in this report) includes extra detail around noise and vibration monitoring that will be undertaken at these two sites, and also triggers and contingencies. • Baseline monitoring has already begun in the Union North adit and Lady Alice Adit (see Memo 3: Summary of actions at Lady Alice adit)(Appendix 7 in this report).
Action 1 (the exclusion of all bats from the OK adit, and the Prospect adit)	• Designed to remove bats from the close proximity of underground blast effects, as well as light and the movement of machinery at the entrance portal of these structures. • Further protection for the colony present in the Union Reefs project area was specified under Action 5 (managing the Union North adit during the period of mining to exclude visitation from mining personnel).	• The Ghost Bat Management Plan (Appendix 5 in this report) expands on the measures specified in Action 5 according to the request.
Action 2 (characterising the internal dimensions of the OK adit and Union North adit)	Details of the Action specified the requirement for a report documenting the results.	Memo 4 is provided — Outcomes from Action 2: internal investigations of adits in the Union Reefs project area] (Appendix 8 of this report).
Action 4 (re-open and rehabilitate the Lady Alice adit)	Details of the proposed action.	Memo 3 is provided — Summary of actions at Lady Alice adit (Appendix 7 of this report). This Memo describes work already conducted at Lady Alice adit between December 2019 and February 2020.
Action 5 (manage the Union North Adit during the period of mining)	Details of the action specify a requirement for notification of breaches of restrictions and follow up actions, to be included in the regular monitoring reports if such events occur.	The Ghost Bat Management Plan (Appendix 5 in this report) expands upon these requirements and details the commitments of NTMO during all phases of the mine to control and avoid risks to Ghost bat using Union North adit. The commitments are measurable and auditable with roles and responsibilities specified.

Aspect / Action	Information Already Provided	Further Development Provided
Action 7	Description of the acoustic and video monitoring timeframes and reporting frequency is summarised and stated explicitly in Table 1 under Action 7 (Appendix 4 of this report).	• Inclusion of data derived from noise and vibration dataloggers and further detail on timing and methodology in the Ghost Bat Management Plan (Appendix 5 in this report). • The monitoring programme provides information on Ghost bat activity levels, movements and occupancy levels that will allow assessments to be made on whether these variables have changed after the commencement of mining, and will form the basis for triggers and contingency actions, and the evaluation of success of artificial roosts.
Reporting Commitments	Mention of the commitment for supplying reports.	Each Action in the Action plan and each aspect within the Ghost Bat Management Plan where reporting has been committed to is expanded upon to provide details of timing, frequency and entities who the report will be made available to for each report.

3.6.1 CONTINGENCY ACTIONS

Contingency actions are an important part of the strategy for the protection of Ghost bats during the period of mining and beyond. In the first instance, the exclusion of bats from the OK adit will mean that only one of two sites will be available for roosting within the Union Reefs area. If for some reason the Union North adit becomes unsuitable for roosting for at least part of the year, then the Action Plan describes four contingencies and two investigations ('checks') to ensure that alternative sites are available:

Contingency 1

Action 3 will provide more than one artificial roost within the Union Reefs project area. Maximum potential for their success will be ensured by checking several designs for their ability to hold an appropriate microclimate using Computational Fluid Dynamics (CFD) modelling [Memo 5: Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs] (Appendix 9 of this report). This will give bats more choice within the Union Reefs area than they have presently. This contingency will be extended by building two designs / structures, in case bats do not choose one structure as an alternative roost.

Contingency 2

Action 4 describes the reopening of the Lady Alice adit to provide an additional contingency site very close to the Union North adit [Memo 3: Summary of actions at Lady Alice adit] (Appendix 7 of this report).

Contingency 3

Action 6 will implement management measures at the Kohinoor adit at Pine Creek to ensure that this site remains accessible and suitable for Ghost bats that might be moving amongst roost sites, as part of natural movements or in response to disturbance at another site.

Contingency 4

In the longer term, Action 8 specifies that the underground mine will be given over to usage for bats. Therefore, if the Union Reefs area has reduced potential to support Ghost bats during mining, then an even larger and more stable resource will be available when it has finished. This site will also serve as a contingency if a catastrophic event occurs at the Kohinoor adit, which is at constant risk of disturbance from casual visitation.

Check 1

Action 9 investigates whether there is additional roosting opportunity in caves adjacent to the Union Reefs area, which could be used readily by Ghost bats given the relatively short distance of hill features to the Union Reefs area. The Action includes those that might be discovered in the regular monitoring programme (Action 7), and is planned for the cooler months as soon as possible upon project approval.

Check 2

Action 10 will use genetic markers to determine whether bats are connected amongst known roost sites in the region (Daly River area; among the Pine Creek, Union Reefs and Spring Hill sites).

3.7 Ghost Bats – Genetic Studies

The below discussion is in response to Submission ID#11 and provides further consideration of the likelihood of Ghost bat movements to alternative roosts and the potential significance of adits within the URPA as important linkages.

The sum of observations made to date support a view that Ghost bats already move in and out of the Union Reefs area, and are thus connected with other colonies nearby. Until the genetics studies have validated this view, we rely on two concepts:

1. Contingencies to ensure that the closure of the OK adit does not result in Ghost bats leaving the Union Reefs area. Two actions, the provision of two artificial roosts plus the re-opening of the Lady Alice adit, effectively replace the OK adit with three roosting alternatives relatively close by. In addition to continuing to provide protection for bats using the Union North adit, this is the core of the strategy to provide roost redundancy for the Union Reefs bats.
   The proponent has committed to providing these two contingency artificial roosts, investigate existing roosts to inform modelling studies for artificial roost design, and reopening the Lady Alice adit before the commencement of mining [Memo 3: Summary of actions at Lady Alice adit; Memo 4: Outcomes from Action 2: internal investigations of adits in the Union Reefs project are; Memo 5: Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs] (Appendix 7, Appendix 8 and Appendix 9 respectively in this report).
   Given that no guarantee can be given that Ghost bats will use either the artificial roosts or Lady Alice adit, as a third contingency, the proponent has committed to beginning targeted field surveys for cave roosts in the mesa hills surrounding the Union Reefs area (Action 9 in the Action Plan). A tentative timing of May 2020 has been proposed for this.
   Note also that two extra adits approximately halfway between Union Reefs and Spring Hill ('Teachers adits') have been observed to contain accumulated feeding remains and scats, and 1 to 2 individuals; and
2. Information from baseline monitoring as a basis for inferring that Ghost bats move in and out of the Union Reefs area. In Appendix G of the Draft EIS (Barden and Armstrong 2019), the acoustics-based activity monitoring showed marked variation across the study period (Figure 7, p 26). Throughout much of the time, the activity of Ghost bats at both roosts was very. In addition, the size of the colony has been shown to change (Memo 1: Ghost bat activity monitoring August 2019 – January 2020 and its appended report) (Appendix 3 of this Supplementary report). Both these observations are evidence that Ghost bats move in and out of the Union Reefs area.
   Furthermore, we gave an opinion that Ghost bat movement to alternative roosts outside the Union Reefs area was very likely given that the distance between Union Reefs and Spring Hill, and between Union Reefs and Pine Creek, was within c. 15 km in both cases (Appendix G of the Draft EIS – Section 3.1.1; Section 4.1.3; Section 4.2). We cited scientific literature that gave values suggesting significant flight capacity in a single night in support of this opinion (Appendix G of the Draft EIS Section 2.3; Section 3.2.2; Section 4.1.3). The genetic study represents an empirical approach to validation of that opinion.

The Action Plan recognises that the adits in the Union Reefs area might function as a means to link colonies within the region (see sections mentioned in the above paragraph), and specifically the strongholds in Spring Hill and Pine Creek—this is also stated in Specific Objective 3 of the Action Plan. In addition, Figure 2.2 of the Action Plan (Appendix 4 of this report) illustrates that records of the Ghost bat have been documented at other sites nearby at Francis Creek, and further north of Spring Hill and further south from Pine Creek. Together with the potential findings of Action 9 (searches for cave roosts in areas adjacent to the Union Reefs area), there is certainly potential for other roosts to function as links between major strongholds—it is very unlikely that the OK adit provides the only potential for linking between Pine Creek and Spring Hill.

It is relevant to highlight again that the acoustics-based and video-based baseline monitoring has shown that the number of Ghost bats in both the Union North adit and OK adit has varied since October 2018 (Hanrahan et al. 2019; Memo 1)(Appendix 3 of this report). This is clear evidence that bats are moving in and out of the Union Reefs area, highlighting that bats readily relocate to other known roosts nearby as a natural process; and that Union Reefs links other roost sites. It is not known how critical the Union Reefs adits are for linking amongst roost sites.

3.8 Ghost Bats – Significance of Union Reefs Ghost Bat Colony

Table 3-8 is an update to the Draft EIS risk register and has been created in response to Submission ID#12. The additional risk provide further consideration of the significance of the Union Reefs Ghost bat Colony and the consequences of its loss.

TABLE 3-8 UPDATE TO THE DRAFT EIS RISK REGISTER (ADDITION OF RISK REFERENCE ID#12)

Ref.	Impact Pathway			Planned Controls to Manage Risk (As per Project Description, and elements of Standards / Codes of Practice)	Initial Risk			Level of Certainty	Additional Controls Recommended to Reduce Risk	Residual Risk			Level of Certainty	Comment	Applicable Technical Report / EIS chapter
	Potential Event (How the Project interacts with assets, values, uses and location. Include clear description of the cause)	**Environmental Factor / Receptor**	**Description of Consequences** (Clearly understand what is the final impact. Describe whether it is construction, operation or decommissioning)		Consequence	Likelihood	Risk Rating			Consequence	Likelihood	Risk Rating			
ID#12	Temporary closure OK adit during mine development and mine operations.	Terrestrial flora and fauna	Loss of up to 30 individuals from the URPA (population potentially represents 2.6 % of the upper estimated regional Ghost bat population).	As a contingency action, redundancy of roosting opportunity will be created within the URPA through the provision of artificial roost habitats and the modification of the Lady Alice adit to be more suitable for the Ghost bat (Actions 3 and 4). Concurrent novel and collaborative management of stronghold sites at Pine Creek and Spring Hill also increases security of alternative roost sites (Action 6). The security of the colony using Union North adit will be maintained through education of personnel and restricting access (Action 5). Closure of the OK adit will be timed to avoid the presence of breeding individuals in the OK adit, particularly those with young (Action 1). Conduct a programme of continuous monitoring of Ghost bat presence, activity levels and colony size at all known (Union North adit) and potential (Lady Alice adit, newly created artificial roost habitats) roosts within the project area (Action 7).	*Major*	*Possible*	*High*	Medium Level	Undertake Field surveys for Ghost bat diurnal roosts in caves surrounding the Union Reefs project area (Action 9). Undertake a genetic study to determine whether the colony in the Union reefs project area is connected to those at Pine Creek and Spring Hill (Action 10). Given fluctuations in colony size observed in the Union Reefs project area since August 2018, it is expected that genetic markers will confirm the connectedness of regional colonies - and therefore that Pine Creek and Spring Hill are alternative roost sites. The colonies at Pine Creek and Spring Hill are both within 15 km from the Union Reefs adits, and Ghost bats are likely to be able to fly this distance in a single night. Conduct a programme of continuous monitoring of Ghost bat presence, activity levels and colony size at all known and potential roosts within the project area (Action 7). Working with PC Gold on Ghost bat monitoring at Spring Hill.	*Major*	*Unlikely*	*Medium*	Medium Level	Loss of up to 30 individuals from the URPA (population potentially represents 2.6 % of the upper estimated regional Ghost bat population or approx. 1.5% of the Top End population). Loss of up to 30 individuals in a population genetic context is of unknown consequence, however there is currently no published evidence of population subdivision within the Top End of the Northern Territory i.e. low risk of loss of genetic diversity.	Appendix G and Chapter 11.3.3 of Draft EIS

3.9 Numerical Groundwater Model

(Response to Submission ID#26).

GHD support the premise that additional modelling would be considered a reasonable request from the EPA. This justifies the works presented in GHD (2019B), Appendix 14 in this report which presents additional groundwater modelling conducted immediately following the modelling works presented in the groundwater study in the EIS Appendix H (GHD, 2019A). This Supplementary report also includes a Water Abstraction Management Plan provided as Appendix C of Appendix 11 of this report.

3.9.1 CALIBRATION DATASET RESPONSE

GHD recognise that an ideal calibration dataset would include simultaneous water level data and pumping data from both Union Reefs area (and the Pine Creek area). Unfortunately these data were not all available for the period 1990 through to present as indicated in the EPA response. The following is intended to provide justification for the approached taken and present a summary of the available data. Where additional data does exist the project and future modelling could benefit from it.

TABLE 3-9 SUMMARY OF AVAILABLE PUMPING DATA, PIT LEVELS AND STANDING WATER LEVELS (SWLS)

	Cross-course Pit Levels	Other Pit Levels	URMB25 Pumping	URMB25 SWLs	TR1-6 SWLs	URDB1-6 SWLs	URDB7, URDB9 & URMB26 SWLs	Pine Creek SWLs	Pine Creek Pumping
Late 1980s								Yes	
Early 1990s								Yes	
Late 1990s	Yes			Yes					
Early 2000s					Yes	Yes			
Late 2000s						Yes			
Early 2010s	Yes	Yes				Yes	Yes	Yes	
Late 2010s	Yes	Yes				Yes	Yes	Yes	Yes

3.9.2 UNION REEFS AREA CALIBRATION

Previous dewatering water level data from the 1990s that exists for the area were provided in Appendix H of the Draft EIS (GHD, 2019A) but this was limited to 1 bore URMB25. URMB25 is immediately north and adjacent to the Crosscourse pit and as it was a known pumping bore (with unknown pumping regime and rates), it was not considered suitable for model calibration purposes especially in isolation. During this period the level of the Crosscourse pit was tracked. Groundwater pumping rate data for the Crosscourse pit was limited to a single reference (URS, 2002). No other groundwater bore pumping rates were available to GHD for the Union Reefs area.

From the early 2000s, there is data from the TSF bores and those immediately south and adjacent to the Decant pond. These facilities were relatively static water level bodies and therefore bores immediately adjacent to them were not considered of high value for model calibration purposes. Pit water level rebounds for the 2000s were not available.

From 2010 additional groundwater level data from bores (URDB7, URDB9 and URDB26) and simultaneous pit water monitoring level was available. This presented (and still presents) an opportunity for calibration, but could not be justified as a priority for the calibration effort due to the complications of other unknown site influences. The priority calibration target was replicating the observed dry season peak Crosscourse pit groundwater inflow during mining.

3.9.3 PINE CREEK AREA CALIBRATION

Groundwater level data for eight key bores in the Pine Creek area are presented in the Draft EIS Appendix H (GHD, 2019A). These data were available for two distinct campaigns (mid-1980s to mid-1990s and covering the 2010s). The additional modelling (GHD, 2019B; Appendix 14 of this report) did benefit from additional pumping data at Pine Creek provide by Power and Water Corporation (PWC, 2019). Groundwater bore pumping rates were not provided for the Pine Creek area before 2006 but it is recognised that these data may be available.

Whilst there is an opportunity for additional transient model calibration in the Pine Creek area, it is not considered likely, based on the modelling in the EIS and in this report i.e. GHD (2019A and 2019B), that this will change the magnitude of the predicted dewatering impact to be at a scale that it could measureable. Perhaps more importantly is consideration that an increase in confidence in the model at Pine Creek does not directly translate to an increase the confidence in the dewatering assessment at Union Reefs.

The Pine Creek borefield is a complex pumping network and it was considered well beyond KLG's remit in this EIS to provide a model designed for assessment of the Pine Creek borefield operation. Rather, the model was designed to provide an impact assessment on the Pine Creek borefield at a regional scale which is considered reasonable for this Draft EIS.

Pine Creek borefield impact is also considered in the context of the Crosscourse pit (active dewatering and passive refilling during rebound from the 1990s to now). There is no indication in the Pine Creek water level data in the EIS Appendix H (GHD, 2019A) that this significantly larger stress on the aquifer (than that proposed from the significantly smaller and shorter underground mining), resulted in a measureable impact on the Pine Creek borefield.

Considering the additional modelling in this report (GHD, 2019B; Appendix 14) and in the Draft EIS GHD (2019A), we believe that the predictive capability of the models is insufficient in its present form to support the claim that there will be no impact on the Pine Creek town water supply borefield.

3.9.4 SHEAR ZONE CONCEPTUAL MODEL

Numerous attempts were made to delineate a regional shear zone and validate the concept that:

- The aquifer transmissivity was enhanced along a shear zone
- That this shear zone connectivity was extensive enough to interact with the Pine Creek borefield

This included a GHD site visit to discuss the delineation of shear zones with KLG geologists and a literature review including:

- KLG geological mapping
- NTG hydrogeological mapping McGowan (1989b) as well as geological mapping from NTG (1985), Hollis and Glass (2011) and NRMAPS (2019)

Reports and papers including but not limited to Port (1981), Prowse (1982) McGowan (1989a), Turner (1990) and Ahmad and Hollis, (2013).

Following on from this, the GHD (2019A) approach presented the whole of aquifer as the 'shear zone' analogous to the broad Pine Creek Shear Zone presented in McGowan (1989a). The lower transmissivity material in this conceptual model were broadly analogous to the cordierite zones presented in Turner (1990) and the granites which in this case were considered to have low enough transmissivity that they were not modelled.

A 'shear zone' or lineament of higher transmissivity was also included in the GHD (2019B) model set. Data to validate or delineate the area of higher transmissivity was sparse and as such the following principles were applied, the lineament must intersect the known:

- Mineralised areas in the Lady Alice line and Union line
- Pine Creek mineralisation
- Successfully yielding Pine Creek borefield bores
- Any other bores with higher yielding airlifts at time drilling

The layer materials are presented in Figure 3-9, Figure 3-10 and Figure 3-11. This material geometry was applied to the models discussed in GHD (2019B, Appendix 14).

Whilst it is recognised that the aquifer is highly unlikely to be homogenous, there appears very little evidence for a regional individual lineament of higher transmissivity. Rather, we hypothesise that what little transmissivity exists in the aquifer, occurs associated to the combined network of fractured rock, associated with shear zones, along fold hinges and more importantly unloading of shallow rock mass.

With the application of material properties that resulted in reasonable matches to historical data, this feature did not facilitate increased directional drawdown towards the borefield.

Applying a higher transmissivity to a shear zone (and the required lower transmissivity elsewhere) to the model, limits the modelled impact off strike. This does not result in a measureable impact at the Pine Creek borefield, but it does result in a lower impact to McKinlay Creek.

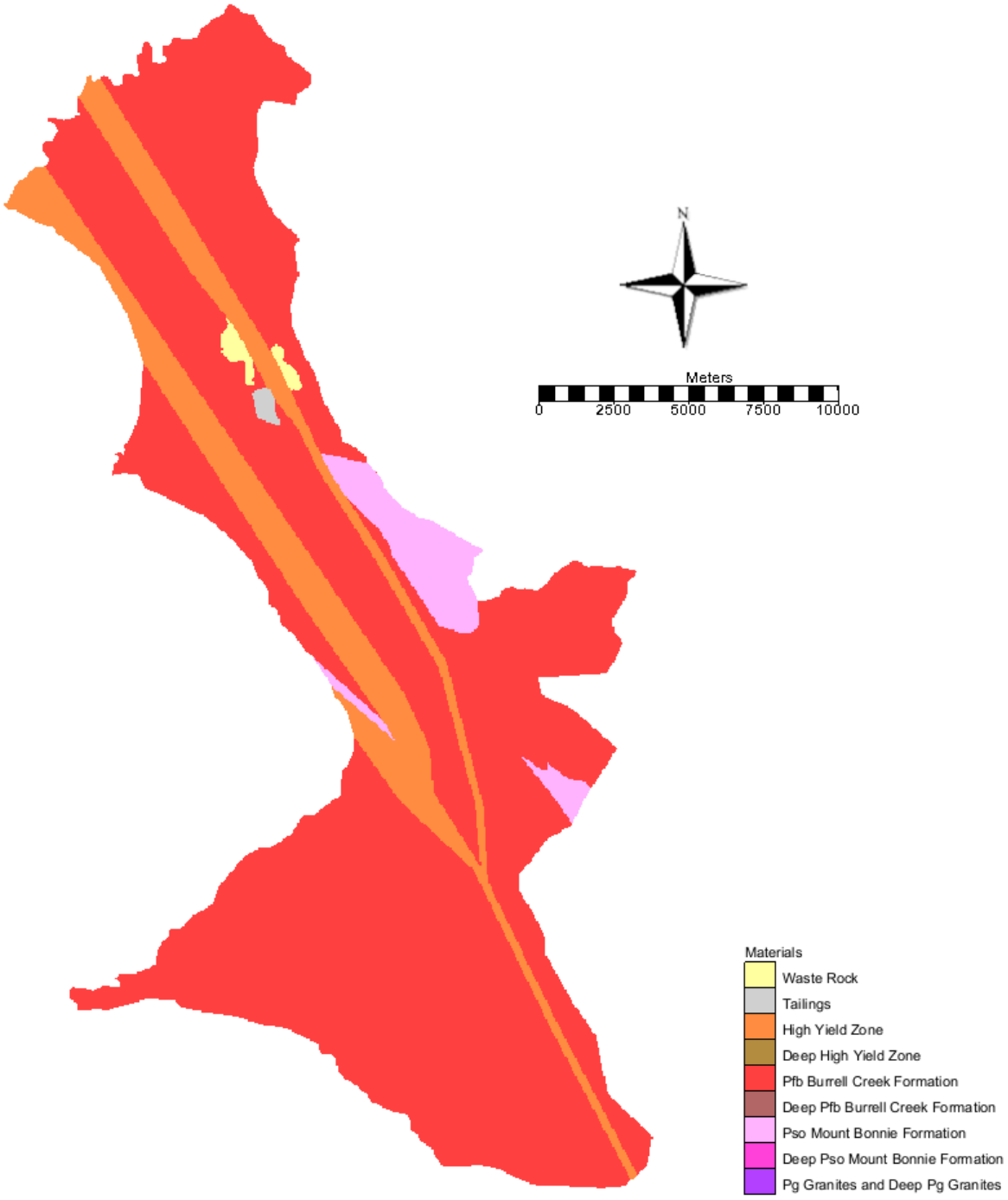


FIGURE 3-9 LAYER 1 INCORPORATING A LINEAMENT OF HIGHER TRANSMISSIVITY

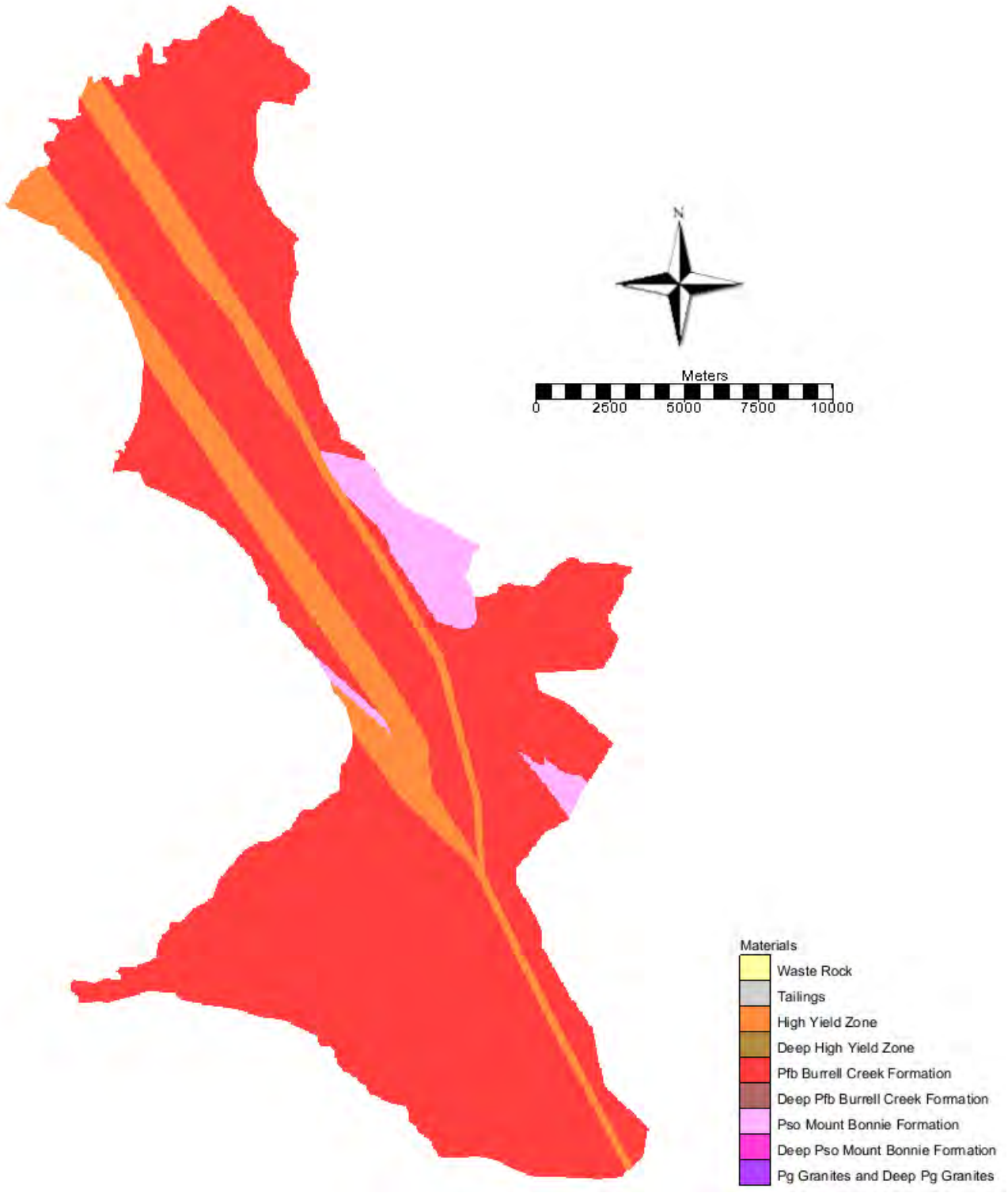


FIGURE 3-10 LAYER 2 INCORPORATING A LINEAMENT OF HIGHER TRANSMISSIVITY

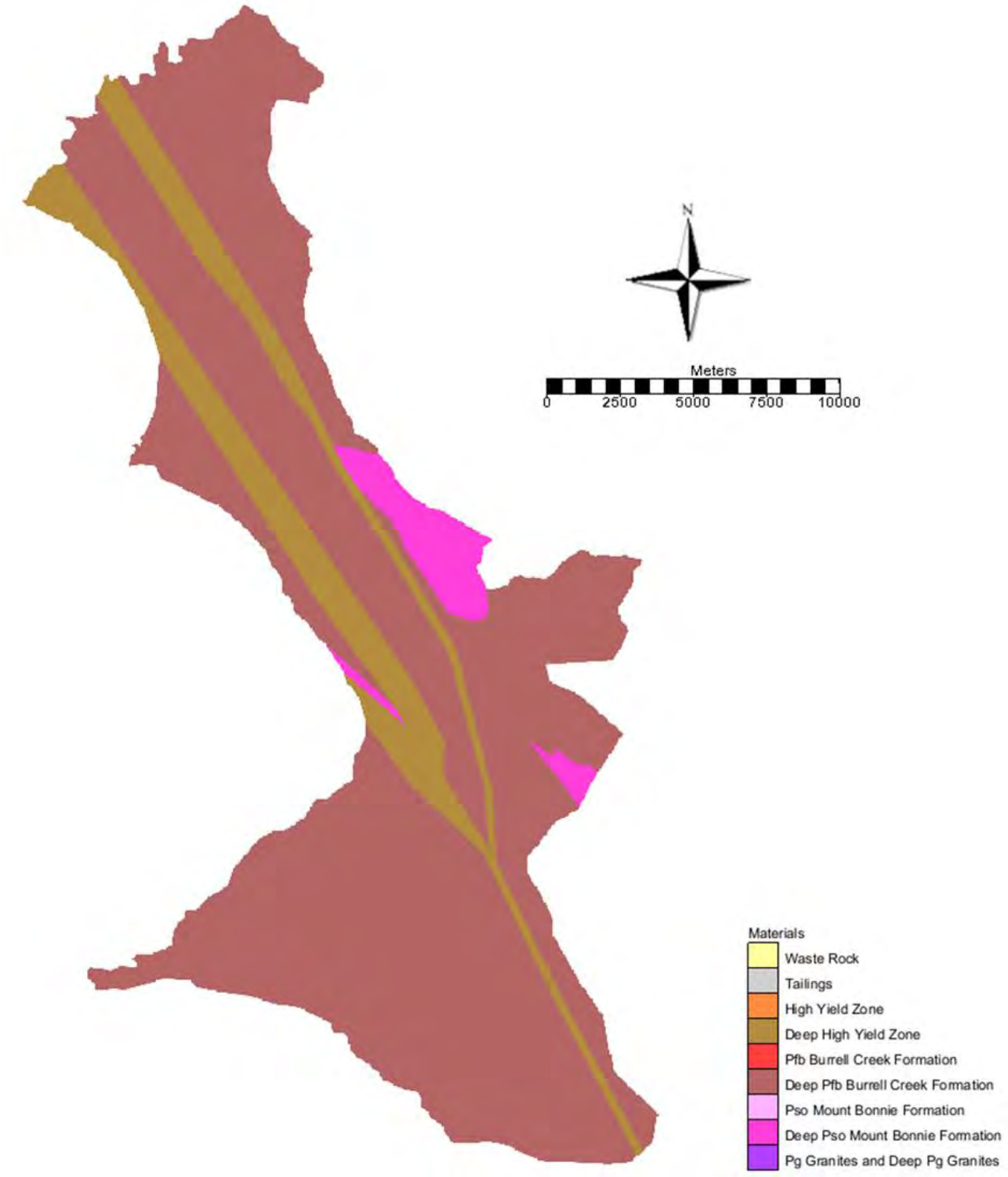


FIGURE 3-11 LAYER 3 INCORPORATING A LINEAMENT OF HIGHER TRANSMISSIVITY

3.9.5 DEPRESSURISATION AND THE WATER ACT 1992

Depressurisation of the adjacent bores has been considered and presented in the Draft EIS in Appendix E of Appendix H, notably:

- Figure E-6 RN036105 (Territory Iron Bore) Modelled groundwater
- Figure E-7 RN025785 (Pine Creek Borefield) Modelled groundwater
- Figure E-8 RN022577 (Pine Creek Borefield) Modelled groundwater

The EIS states that "The closest potential groundwater user is considered to be the currently unused Territory Iron bore (RN036105), used for dust suppression at the rail siding and haul road adjacent to the URPA mine. The modelled underground mine drawdown impacts this bore peaking at 0.08 m 3 years after mining. This minor change should not measurably impact groundwater availability to this bore. No stock or domestic groundwater bores have been identified within the zone of groundwater drawdown."

Likewise, no impact is predicted at the Pine Creek Borefield.

We would not anticipate that this would be considered a breach of any section of the Water Act 1992 in relation to impacts on existing water users (e.g. town water supply, stock and domestic users).

3.9.6 CONTAMINATED SEEPAGE

The numerical groundwater flow model was not designed nor intended as a contaminant transport model, nor has it been documented in the EIS that it has.

The numerical model is capable of, with the modification documented in GHD (2019c) and GHD (2019B; Appendix 14), providing meaningful assessment of the risk of seepage occurring from the Crosscourse pit. Likewise, the numerical model is capable of providing an assessment of the magnitude of that seepage under the documented conditions and material properties.

3.9.7 MODEL CONFIDENCE

GHD shared the concern about model confidence and proceeded with the works documented in GHD (2019B; Appendix 14) to address this gap. Whilst the groundwater study of the EIS (GHD, 2019A) benefited from knowing the modelling outcomes of these, the GHD (2019B) document was not anticipated to be completed and incorporated within the original EIS. As a result of the GHD (2019B; Appendix 14) work there is an increased confidence in the outcomes of the modelling.

3.9.8 MODELLING AND DISCUSSION TO ADDRESS THE TOR (SECTION 2.2.2 – HYDROLOGICAL PROCESSES)

The modelling and discussion to address the ToR (Section 2.2.2 - Hydrological Processes) is documented within the groundwater study of the EIS Appendix H (GHD, 2019A) and the executive summary outlines and cross references where each element can be found with that document:

"The groundwater study report characterises the current hydrological regime of the Union Reefs area and receiving waterways, in particular McKinlay River (Section 2.5.2). Maps and/or schematic diagrams of flow directions and long term monitoring data are used to describe:

- Groundwater aquifers (Figure 19, Figure 20, Figure 21, Figure 22, and Figure 23) and hydrological properties (Table 4, Table 5 and Table 8);
- Depth to aquifers (Table 2 and Table 3), including temporal variation (Table 2, Table 3 and Appendix B)
- Groundwater contours (Figure 25) and flow direction (i.e. Figure 18 and Figure 25), volumes (Table 12) and yields (Table 4);
- Hydrological connectivity is assumed between groundwater aquifers, existing pits, ponds and dams (Section 2.3);
- Hydrological connectivity is assumed between the Pine Creek bore field (town water supply) and the Union Reefs area and zone of influence (Figure 29, Figure 30 and Figure 31), however, due to the distances involved, material properties and that they are in different catchments there is unlikely to be any interaction (Appendix E);

- Surface connections via likely discharge locations, notably the McKinlay River and specifically at MRBILL01, MRWET12 and MRWET13 (Figure 3) or recharge zones, notably existing open pits (Table 1 and Figure 10); and
- Beneficial uses (Section 2.1 and Appendix A), specifically groundwater extraction, notably at Pine Creek borefield and nearest bore RN036105 (Figure 15)."

Updated Commitments

The Water Abstraction Management Plan (attached as Appendix C in Appendix 11 in this report) includes updated commitments for monitoring and reporting to include results from further refinement of the conceptual model and subsequent modelling.

3.10 Depth of Groundwater Monitoring Bores

TABLE 3-10 GROUNDWATER BORES AND ASSUMED SCREEN METRES AHD

Type	Location	Easting	Northing	Assumed Screen Top mAHD	Assumed Screen Base mAHD	Recommendation
Existing	URDB1	801950.2	8480027.1	145.50	133.50	Camera survey or provide log
Existing	URDB2	801953.7	8480007.2	150.44	138.44	Camera survey or provide log
Existing	URDB3	801800.7	8480005.8	146.50	134.50	Camera survey or provide log
Existing	URDB4	801804.1	8479985	147.00	135.00	Camera survey or provide log
Existing	URDB5	801700.1	8479992	150.93	138.93	Camera survey or provide log
Existing	URDB6	801703.1	8479967.5	153.03	141.03	Camera survey or provide log
Existing	URDB7	801275	8483594	150.48	138.48	Camera survey or provide log
Existing	URDB9	801485	8483779	108.00	96.00	Camera survey or provide log
Existing	URMB25	801485	8482576	156.17	86.17	Camera survey or provide log
Existing	URMB26	802131	8482107	161.50	91.50	Camera survey or provide log
Existing	RN036105	799463	8485209	129.50	126.00	None, log on NRMaps
Proposed	MRWET12	798830	8483118	152.00	151.00	Provide log and survey once installed
Proposed	MRWET13	798622	8483238	150.92	149.92	Provide log and survey once installed
Proposed	MRBILL01	800935	8480923	160.92	159.92	Provide log and survey once installed
Proposed	MRBILL02	800214	8482438	156.78	155.78	Provide log and survey once installed
Proposed	11	802152	8479317	146.50	140.50	Provide log and survey once installed

Type	Location	Easting	Northing	Assumed Screen Top mAHD	Assumed Screen Base mAHD	Recommendation
Proposed	10	802940	8479931	151.50	145.50	Provide log and survey once installed
Proposed	4	799759	8483122	141.97	135.97	Provide log and survey once installed
Proposed	4 deep	799755	8483120	121.83	115.83	Provide log and survey once installed
Proposed	1	800409	8486001	131.00	125.00	Provide log and survey once installed
Proposed	5	801198	8482419	159.00	153.00	Provide log and survey once installed
Proposed	6	801396	8482409	164.83	158.83	Provide log and survey once installed
Proposed	8	801579	8481683	167.20	161.20	Provide log and survey once installed
Proposed	3	800425	8484281	146.05	140.05	Provide log and survey once installed
Proposed	3 deep	800420	8484280	126.16	120.16	Provide log and survey once installed
Proposed	2	799860	8485579	128.50	122.50	Provide log and survey once installed
Proposed	7	800939	8481993	152.53	146.53	Provide log and survey once installed
Proposed	9	800879	8480964	137.68	131.68	Provide log and survey once installed

3.11 Wastewater Treatment

Water treatment for the Project will occur within a water treatment facility, located as shown in Figure 3-12 below. Treatment will occur primarily throughout the wet season to enable discharge when the McKinlay River is flowing, however treatment and storage in Dam B may occur throughout the year when sufficient freeboard is available in Dam B.

During mine operations the water treatment plant will operate in accordance with the site Water Management Plan, which will be provided as part of the Water Discharge Licence (WDL) application.

800000E
800500E
801000E
801500E
8482500N
8482000N
N
PROSPECT CLAIM PIT
NORTH WEST WASTE DUMP
Treatment Facility Location
URST4A
Settling Pond
URSW04
URST3
CROSSCOURSE PIT
DAM B
Siphon
Discharge Outlet-Rock Energy Dissipator
McKinlay River
RoM Pad
URPSP
URRD
UNION DAM
0
100
200 m
Legend
Monitoring Location
Surface
URPA Surface Monitoring Waypoints Point
Infra
URPA
MGA_200214_dam_sh_mga entities LineString
Discharge Outlet
Treatment Facility Location
Settling Pond
Siphon
URPA Dams
URPA Spillway
URPA RoM
Ponds
Pits
McKinlay River
Waste Rock Dump
Raster Map
Google Satellite

FIGURE 3-12 WATER TREATMENT PLAN LOCATION AND LAYOUT

The water treatment proposed for the Project is detailed within Section 8.5.3 of the Draft EIS.

The treatment method proposed is a two-stage in-pipe dose system using a Caustic50 treatment first to raise the pH to 9.0. This targets the heavy metals which precipitate out as insoluble hydroxides. This is then followed further down the pipe with a Ferric Chloride dose to remove the Arsenic and reduce the pH to the desired 8.0. The dose quantities are kept to the minimum required to achieve the target water quality with the current dose rates being approximately 0.05 g/l of C50 and 0.08 g/l of FeCl3. Strict control will be maintained throughout the dosing process to ensure the supernatant water is not contaminated with the dose chemicals.

Tests of the treated water have, to date, shown this method delivers the water quality to meet target levels. Table 8-6 in the EIS shows the results of initial water treatment work carried out. The results were compared to Australian & New Zealand Guidelines for Fresh and Marine Water Quality 2018 (ANZG 2018) default species protection guideline values (DGVs) for fresh water, detailed below:

- Post treatment aluminium concentrations are below 99 % DGVs
- Post treatment arsenic concentrations are on average below 95 % DGVs for As(IV)
- Post treatment cadmium concentrations are the same as 95 % DGVs
- Post treatment copper and zinc on average are below the 80 % DGVs
- Post treatment cobalt concentrations exceed the 80 % DGVs
- Post treatment iron concentrations are over four times lower than the ANZG 2018 recommended interim indicative working value, posing no risk to the receiving environment
- Weak acid dissociable cyanide concentrations remained near or below detection limits in Crosscourse pit, including depositional periods
- Free cyanide concentrations in CC pit are on average below 95 % DGVs

The results obtained from the water treatment of Crosscourse pit indicate that cobalt is currently the primary contaminant of concern, however this does not suggest there is any environmental risk posed by the release of the treated water. Based on known cobalt solubility characteristics, i.e. Figure 3-13 below taken from Katsiapi *et al* (2010), the inclusion of hydroxide treatment methods will enable the precipitation of cobalt such that the concentrations in the discharge water will not be of significant concern.

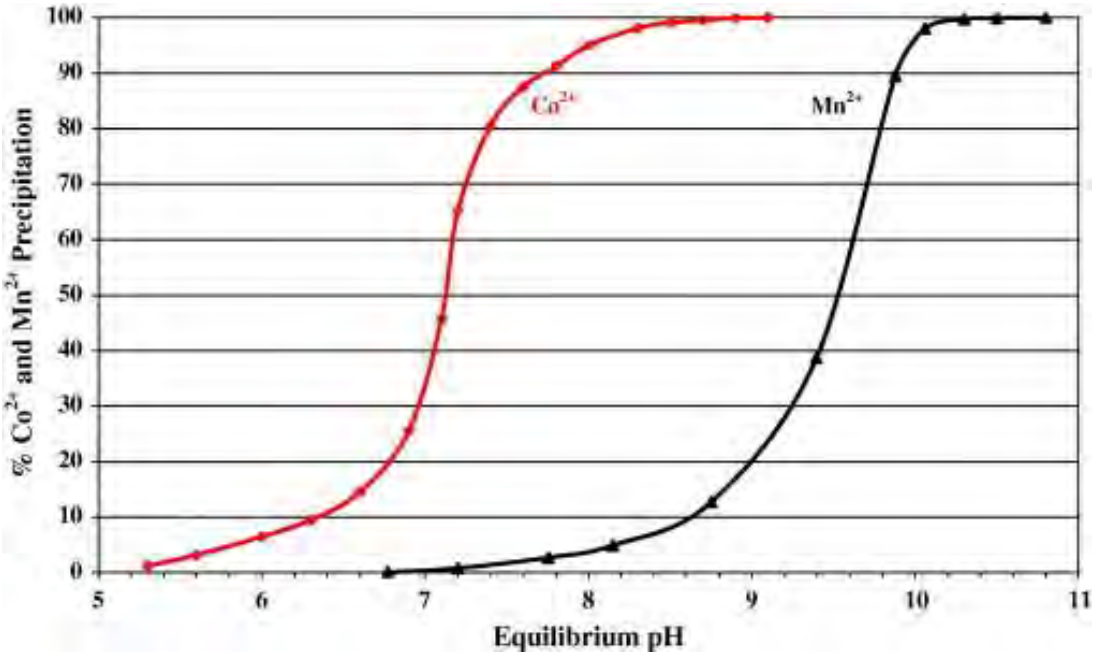


FIGURE 3-13 COBALT SOLUBILITY VS PH

NTMO are investigating multiple options to mitigate against potential impacts associated with the primary contaminants of concern are minimised. These options include:

- Reviewing the McKinlay River stream hydrology and developing conservative discharge models.
- Conducting further water treatment trials to ensure that the concentrations of potential toxicants are further reduced.

The results of further testing will be provided along with the WDL application as supporting evidence that water will be adequately managed. The test results thus far indicate there is the potential for slight short-term environmental impacts associated with the elevated Cobalt concentrations observed. Impacts, if they do occur, are likely to be associated with the most cobalt sensitive species, freshwater algae, with concentrations in Crosscourse pit treated water being between the EC50 (197µg/L) for growth and the NOEC/EC10 (66.9µg/L) (ECHA 2020), with other species sensitivities being tens or even hundreds of times higher. Exposure times used to derive these concentrations were 72 h. Given the observed values associated with Crosscourse pit treated water (Table 8-6 in the Draft EIS) and comparisons to the concentrations and exposure times referenced above, the potential for any impact is low and any impacts are likely to be either insignificant and/or short lived. Additional water treatment controls, such as increasing the initial pH to 9.5, are expected to reduce the potential for environmental impact even further by reducing the observed cobalt concentrations in the Crosscourse pit treated water even further.

Iron poses a negligible risk to the receiving environment, as demonstrated in the results provided in Table 8-6 in the Draft EIS, with concentrations in treated water four times lower than the ANZG 2018 recommended interim indicative working value.

The potential for free cyanide concentrations within Crosscourse pit to rise during operations is not considered to be a risk. This is due to the volatility of HCN (protonated CN-), Tboil 299.0 ± 0.5 K (see Figure 3-14 below), which will volatilise once neutralised. Approximately 95 % of the free cyanide will be in the protonated form once deposited into Crosscourse pit, see Figure 3-14 taken from Estay et al (2013), and any remaining free cyanide will be protonated during treatment and volatilise in Dam B. WAD-cyanide concentrations are expected to remain negligible, as observed during previous processing regimes. This is demonstrated in the Crosscourse pit WAD-CN results shown in Appendix I, Figure 2-12 of the Draft EIS. As such no cyanide destruction is proposed.

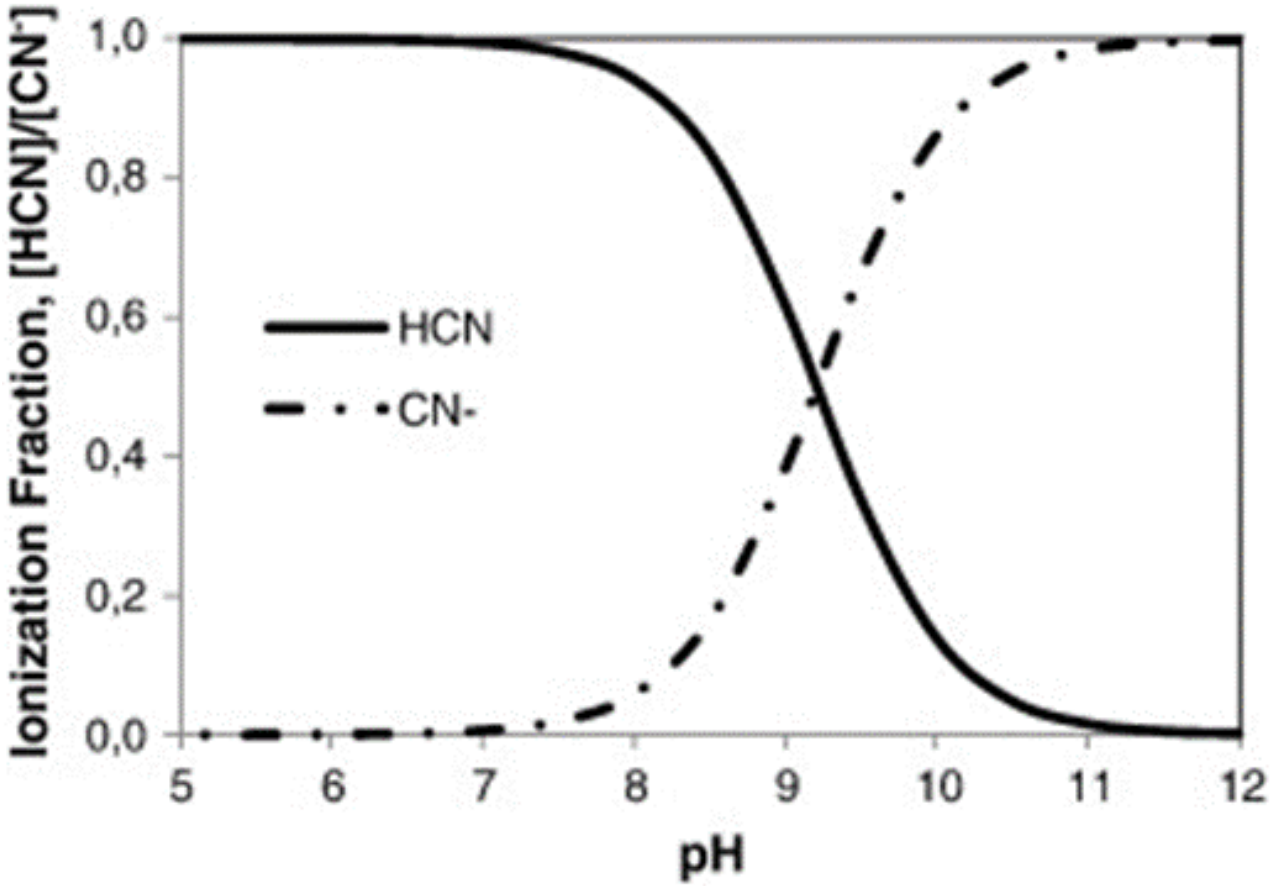


FIGURE 3-14 CYANIDE SPECIATION VS PH

Based on the current treatment results, it is evident that through procedural and operational controls the receiving environment can be adequately protected. The results also indicate that CC pit water quality is currently adequate to achieve the required quality for discharge. During processing CC pit cyanide concentrations are not expected to substantially change during processing, as demonstrated above for free cyanide and shown in Appendix I, Figure 2-12 of the Draft EIS report for WAD-cyanide. Minor changes to metal concentrations can be managed through the proposed water treatment methods. The information provided, and any additional information obtained, will be reviewed through the WDL application process before approval.

TABLE 3-11 BOILING POINT OF HCN IN DEGREES KELVIN

T_{boil} (K)	Reference	Comment
298.9	Cole, 1955	Uncertainty assigned by TRC = 0.5 K; TRC
298.9	Coates and Davies, 1950	Uncertainty assigned by TRC = 0.4 K; TRC
299.0	Benson, 1948	Uncertainty assigned by TRC = 0.4 K; TRC
299.0	Rabinovitch and Winkler, 1942	Uncertainty assigned by TRC = 1.5 K; TRC
298.9	Coates and Taylor, 1936	Uncertainty assigned by TRC = 0.5 K; TRC
299.08	Smyth and McAlpine, 1934	Uncertainty assigned by TRC = 0.4 K; TRC
298.9	Carlisle, 1933	Uncertainty assigned by TRC = 0.5 K; TRC
298.8	Buchanan, 1932	Uncertainty assigned by TRC = 0.5 K; TRC
298.90	Lowry and Henderson, 1932	Uncertainty assigned by TRC = 0.3 K; TRC
298.9	Coates, Hinkel, et al., 1928	Uncertainty assigned by TRC = 0.4 K; TRC
299.5	Enklaar, 1927	Uncertainty assigned by TRC = 1. K; TRC
298.9	Manjiro and Shirado, 1927	Uncertainty assigned by TRC = 1. K; TRC
299.7	Walker and Marvin, 1926	Uncertainty assigned by TRC = 0.5 K; TRC
298.9	Hara and Sinozaki, 1923	Uncertainty assigned by TRC = 0.5 K; TRC
299.4	Harker, 1921	Uncertainty assigned by TRC = 0.6 K; TRC

3.12 Wastewater Discharge

The proposed mixing zone was determined primarily based on historical precedence and logistical constraints. The comments made by the Northern Territory Government highlights the necessity to review the proposed discharge point, compliance location and mixing zone proposed. The issues raised are expected to be covered during the WDL application process.

Upon reviewing the proposed compliance, mixing and discharge points, an alternative assessment approach has been developed. The new approach would retain the URSW08 monitoring point to ensure that any passive or uncontrolled discharge is captured in the monitoring. The proposed guideline values (see response to Submission # 45 for an updated version of Table 8.5 of the Draft EIS) will be used to measure compliance at both URSW08 (95 % DGVs) and URSW10 (80 % SSTVs/DGVs). This is consistent with the multiple lines of evidence approach recommended by ANZG 2018.

Adoption of the ANZG guidelines values is supported by the beneficial use declaration of the McKinlay River. The McKinlay River was gazetted in 1998, declaration gazette number G9, and the level of protection applied references the ANZECC 1992 aquatic ecosystem protection guidelines as the standard to which the water quality must be

maintained. These guidelines have been superseded by the ANZG 2018 revision. The default guideline values used in ANZECC 1992 are not directly comparable to the values in ANZG 2018 as ANZECC 1992 DGVs are for total concentrations while ANZG are 0.45 micrometre filtered. It is appropriate to adopt the most recent guidelines for reference.

The proposed guideline values have been determined because URSW10 is located on the mining lease boundary, downstream of which could reasonably be considered a moderately to highly disturbed ecosystem. ANZG 2018 states:

"The philosophy applied to degraded aquatic ecosystems is that they still retain — or after rehabilitation may have — ecological or conservation values but for practical reasons it may not be feasible to return them to a slightly to moderately disturbed condition. At least in the short to medium term."

While it is NTMO's intention to release the highest quality water practicable, dewatering Crosscourse pit to ensure mine safety is the primary objective, and for practical reasons it is not feasible to return the ecosystem to a slightly disturbed condition while operating. Adhering to the ANZG 2018 80 % DGVs at URSW10 and ANZG 95 % DGVs at URSW08 will enable minimal impact on the growth and/or reproduction of a selection of species and only if concentrations remain elevated for a prolonged period. The proposed approach will respect the beneficial use declaration conditions in the McKinlay River, such that the aquatic ecosystem functions will remain protected.

Discharge will occur from syphons installed at Dam B, this is considered the end of pipe or discharge points and the mixing zone will stretch approximately 2.7 km downstream to URSW10. The proposed level of species protection at URSW10, a mixture of 80 % Default Guideline Values (DGVs) and Site Specific Guideline Values (SSGVs) was determined based on the practical constraints associated with dewatering Crosscourse pit, and the area adjacent a significant mining operations would reasonably be considered comparable to an ecosystem of lower ecological value (for example urban stream receiving stormwater runoff). The practical constraints faced by NTMO relate to ensuring safe operation of the open cut pit, which cannot be compromised.

3.13 Water Quality Monitoring

The Australian and New Zealand water quality guidelines provide guidance on the derivation of SSGVs for application to a downstream site. The below information includes the theory behind the derivation of SSGVs, and the methodology to meet the ANZG 2018 requirements.

Physicochemical Stressors

A trigger for further investigation of the test water body will be deemed to have occurred when the median concentration of a particular measurement parameter in *n* independent samples taken at the test water body exceeds the 80th percentile (or is below the 20th percentile if 'less is worse') of the same measurement parameter at the reference site.

A minimum of two years of consecutive monthly data at the reference site is required before a valid SSGV can be established based on that site's percentiles. If this requirement has not been satisfied, then the median of the data values measured at the test site should be compared to the appropriate DGVs identified in the Australian and New Zealand Water Quality Guidelines.

This rule is statistically based and acknowledges natural background variation by comparison to a reference site. Its robustness derives from the fact that it accommodates site-specific anomalies and uses a robust statistical measure as the basis for triggering. No assumptions are required to be made about the distributional properties of the data obtained from either the test or reference sites. The computational requirements of the approach are minimal and can be performed without the need for statistical tables, formulas or computer software.

"Exceedances of the guideline values are intended as an 'early warning' mechanism to alert managers of a potential problem. They are not intended to be an instrument to assess 'compliance' and should not be used in this capacity."

Suitable reference sites need to be identified and data obtained to characterise that site. The protocol recommends that two years of continuous monthly data at the reference site is required before a valid guideline value can be established. If not available, comparison of the test site median should be made with reference to the DGVs".

Toxicants

Some natural surface waters will contain concentrations of toxicants that may exceed the DGVs. If this is the case, then new values should be based on background (or baseline) data. (In this case, 'background' refers to natural toxicant concentrations that are unrelated to human disturbance.) As a matter of course, gathering background data is always recommended, at least in the initial stages of a water quality management program, to establish whether or not concentrations of toxicants are naturally high.

Toxicant concentrations may vary seasonally. Because of this and the need to be confident about the best estimate of background concentrations, we recommend that background data be gathered on a monthly basis for at least two years. Until this minimum data requirement has been established, comparison of the test-site median should be made with reference to the DGVs.

For those months, seasons or flow periods that constitute logical time intervals or events to consider and derive background data, the 80th percentile of background data (from a minimum of 10 observations) should be compared with the DGV. This 80th percentile value is used as the new guideline value for this period if it exceeds the DGVs. Compare test data with the new guideline values using the same principles outlined for PC stressors.

Methodology to Derive SSGVs for Union Reefs

The SSGVs to be derived for McKinlay River have been derived on the basis of the ANZG 2018 requirements using URSW09 as the upstream reference site. The process is to calculate a series of different percentiles for different parameters as follows:

- For physicochemical parameters: 20th and/or 80th percentile of upstream.
- For nutrients and non-toxic compounds: 80th percentile of upstream.
- For metals: 80th percentile of upstream.

The value is calculated and then compared to the DGV for freshwater ecosystems and toxicants in freshwaters. The highest value is selected as the SSGV, i.e. if the background conditions are equal to or higher than the published DGV or when no DGV exists, then the 80th percentile of the data set will be adopted as the SSGV value, see Table 3-12 and Table 3-13.

TABLE 3-12 PROPOSED ENVIRONMENT SSGVS FOR URSW08

Analyte	80th Percentile URSW09	ANZG 2018 95% DGVs	SSGV URSW08
pH	7.0	8.0	8.0
pH (20th %ile)	6.2	6.0	6.0
EC (µS/cm)	56	250	750
DO (%)	117	120	120
DO (20th %ile)	40	90	40
Turbidity (NTU)	14	15	15
TSS (mg/L)	30	20	30
Cyanide (µg/L)	-	7.0	7.0
Total Nitrogen (µg/L)	-	300	300
Total Phosphorous (µg/L)	-	10	10
Dissolved Metals (µg/L)			
Aluminium	120	55	120
Arsenic (III)*	-	24	24
Arsenic (V)*	-	13	13
Cadmium	1.0	0.2	1.0
Chromium	2.6	1.0	2.6
Cobalt	<1.0	1.4	1.8
Copper	4.4	1.4	4.4
Iron	270	300	300
Lead	<1.0	3.4	3.4
Manganese	37	1,900	1,900
Nickel	<1.0	11	11
Selenium	<1.0**	11	11
Zinc	30	8.0	30

*Historical results are for total arsenic only. The DGVs will be applied until sufficient background data is obtained to calculate SSGVs.

**No data available for dissolved selenium.

Default Guideline Values and Species Protection

A good understanding of the ambient water quality and its seasonal variations is a critical part of any environmental assessment study. The background data collected has included each chemical that may be present in the discharge water and may enter the environment. This is of particular importance when natural background concentrations of these chemicals are high as may be the case in mineralised mining environments.

For developing SSGVs for the McKinlay River at the Union Reef site, in order to not contribute to the disturbed nature of the system and to work towards continual improvement of the system, the species protection level has been set at 95% for slightly to moderately disturbed ecosystems to be met at URSW08. See Table 3-13.

TABLE 3-13 PROPOSED RECEIVING ENVIRONMENT SSGVS FOR URSW10

Analyte	80th Percentile URSW09	ANZG 2018 80% DGVs	SSGV URSW10
pH	7.0	8.0	8.0
pH (20th %ile)	6.2	6.0	6.0
EC (µS/cm)	56	250	1000
DO (%)	117	120	120
DO (20th %ile)	40	90	40
Turbidity (NTU)	14	15	15
TSS (mg/L)	30	20	30
Cyanide (mµ/L)	-	18	18
Total Nitrogen (µg/L)	-	300	300
Total Phosphorous (µg/L)	-	10	10
Dissolved Metals (µg/L)			
Aluminium	120	150	150
Arsenic (III)*	-	360	360
Arsenic (V)*	-	140	140
Cadmium	1.0	0.8	1.0
Chromium	2.6	40	40
Cobalt	<1.0		14
Copper	4.4	2.5	4.4
Iron	270	300	300
Lead	<1.0	9.4	9.4
Manganese	37	3,600	3,600
Nickel	<1.0	17	17
Selenium (Total)**	<1.0	34	34
Zinc	30	31	31

Hardness Modified Guideline Values

The guideline values for several metals can be corrected for hardness to account for the hardness of the local water as an increase in hardness will reduce the toxicity of a metal. The metals which fall into this category are cadmium, chromium (iii), lead, nickel and zinc. The SSGV will be modified for hardness using the hardness at URSW10 and URSW08 on the day of sampling.

SSGV Exceedance

For parameters that exceed the SSGVs at the downstream monitoring locations, URSW10 and URSW08, the actions described in NTMO's Trigger Action Response Plan (TARP) will be implemented for physicochemical stressors and for toxicants. Following the ANZG's requirements, the options physicochemical stressors exceedances should be triggered where the median of the test site data exceeds the SSGV. For toxicants, the options should be triggered where the 90th percentile of the test site data exceeds the SSGV.

The options are:

- Further site-specific investigations to determine the biological effects of the elevated parameters;
- Implementation of remedial actions to improve discharge water quality;
- Further site specific investigations may include direct toxicity assessment (DTA), which is a common method of determining biological effects in the downstream ecosystem; or
- As per NTMO TARP – this is currently being updated to include consideration of water treatment results and will be provided with the WDL application.

Electrical Conductivity (EC)

Most freshwater macroinvertebrates have internal ionic concentrations of 1,560 to 23,440 µS/cm (Hart et al. 1991). These organisms maintain constant internal ionic concentrations in freshwater via passive mechanisms (James et al. 2003) and conductivities similar to the internal ionic concentrations result in less ionic stress on the organism. Toxicity data for Australian macroinvertebrates shows LC50 values ranging from 5,500 to 52,000 µS/cm (median 17,500) (Kefford et al. 2003). This is in contrast to fish species which actively maintain their blood salt concentration at 10,900 – 20,300 µS/cm, however, EC above the internal salinity can stress the fishes' osmoregulatory system (James et al. 2003). Toxicity data for early life stages of Australian fish species with LC50 values ranging from 2,200 to 51,500 µS/cm (median 12,100 µS/cm) (Clunie et al. 2002). However, there is concern that aquatic organisms, algae, aquatic plants and microinvertebrates appear to be less tolerant than macroinvertebrates and fish as these species seem to be restricted to conductivities below 4,690 µS/cm (Nielsen et al. 2003).

Mann *et al* (2014) has calculated species protection values for conductivity based on two waters with different ionic constituents representing coal mine discharge in Queensland. Mann et al. (2014) calculated the species protection values based on chronic EC50 data and the 80% species protection values range from 5,190 to 6,600 µS/cm. To convert these values to meet the methodology to derive ANZG guidelines an application factor of 5 must be applied to the EC50 data (Warne 2018). Therefore, the 80% species protection values derived using NATA accredited bioassays with Australian species representative of tropical northern Australia by Mann et al. (2014) ranges between 1,040 to 1,320 µS/cm.

Using a larger database of toxicity data derived from Dunlop *et al* (2005) with toxicity results from Australian species a revised 80% species protection value has been calculated. LC50 and EC50 data has been converted to EC10 data according to the methodology described in Warne et al (2018) and justified by Batley et al. (2018). This methodology is that currently used to derive the revised ANZG (2018), a table of electrical conductivity species protection values has been provided in Table 3-14.

TABLE 3-14 TRIGGER VALUES FOR CONDUCTIVITY

% Species Protection	Conductivity (µS/cm) (95 % Confidence Limits)
99	670 (507 - 1,278)
95	820 (620 - 1,430)
90	930 (700 - 1,560)
80	1,100 (830 - 1,780)

Based on the guideline values shown above, an EC of 750 µS/cm will be protective of 95 % of the species at URSW08 and a value of 1,000 µS/cm will be protective of 80 % of the species at URSW08. Please note that species protection levels are based on impacts of a 10 % reduction in reproduction or growth in the stated percentage of species, e.g. a 95 % species protection value will protect 95 % of the species from a 10 % decrease in growth or reproduction.

Cyanide

The cyanide SSGV is calculated as unionised HCN measured as CN.

In waters of low ionic strength and low organic matter, total cyanide, WAD-CN and HCN will often be similar. However, in water with high content of complexing ions such as metals, it is likely that total cyanide > WAD-CN > HCN. Hence WAD-CN may overestimate the available cyanide concentration. The potential for elevated concentrations of WAD and free cyanide to impact on the McKinlay River is discussed in detail in comment ID # 37.

Cobalt

The value published in the 2018 ANZG is the one published in ANZECC (2000) as a low reliability DGV and has subsequently been recalculated by the Canadian Government (ATSDR) in 2017, using the same methodology as used to derive the Australian DGVs. The value for 95 % species protection at elevated hardness expected at URSW08 is 1.8 µS/cm. The 80% species protection value as presented in the Canadian guidelines is 14 µS/cm at hardness 400 mg/L. The potential for elevated concentrations of cobalt to impact on the McKinlay River is discussed in detail in item ID 37.

3.14 Groundwater Dependent Ecosystems Monitoring Design

This forms part of the response to comment ID#57.

Table 3-15 provides the provisional timing and duration of all biological monitoring and aquatic ecosystems management activities.

TABLE 3-15 AQUATIC ECOSYSTEMS, BIOLOGICAL, GROUNDWATER AND SURFACE WATER MONITORING SCHEDULE DURING EACH MINING PHASE BASED ON PROJECT COMMENCEMENT DATE OF 01/05/2020

Activity	Start	End	Duration (days)	Frequency	Comments
Development / Construction Phase					
Installation of flow gauge on upper McKinlay River	01/03/2020	05/03/2020	5	Once	Gauging work already commenced.
Installation of additional groundwater monitoring bores	03/03/2020	10/04/2020	48	Once	
Surface water quality data collection	01/04/2020	01/12/2020	1	Monthly	Assumes end of dry season sometime in December.
Sediment quality data collection	01/04/2020	01/06/2020	1	Once	
Active fish survey	01/04/2020	30/04/2020	3	Once	
Groundwater quality data collection	01/04/2020	01/09/2020	2	Quarterly	Assumes installation of bores in March/April.
Post-wet season macroinvertebrate monitoring	01/04/2020	01/06/2020	5	Once	
Groundwater level data collection	14/04/2020	01/09/2020	1	Daily	Assumes installation of bores in March, data collected monthly, recorded daily.
Post-wet season fauna monitoring	15/04/2020	15/07/2020	90	Once	
Establishment of regionally relevant GDE reference location	01/05/2020	03/05/2020	3	Once	Assumes end of wet season by April.
Riparian vegetation survey	01/06/2020	01/07/2020	5	Once	
Passive fish survey	01/08/2020	01/09/2020	2	Once	
Baseline aquatic ecology reporting	01/09/2020	31/12/2020	10	Once	
Baseline water and sediment quality reporting	01/09/2020	31/12/2020	5	Once	
Dry season macroinvertebrate monitoring	01/10/2019	15/08/2020	60	Annually	
Development of site specific values for groundwater drawdown	TBC				
All Mining Phases					
Wet season surface water quality sampling	01/12/2020	01/04/2027	1	Fortnightly / monthly	Only during wet season months (normally December - April).
Post-wet season sediment sampling	01/03/2021	01/06/2027	1	Annually	Includes total period of groundwater availability loss.

Activity	Start	End	Duration (days)	Frequency	Comments
Dry season surface water quality sampling	01/04/2021	01/12/2027	1	Monthly	
Surface water quality reporting	30/09/2020	31/12/2027		Various	Commencement of mining, 3, 6, 12 and 24 months into mining, 1 and 5 years post mining.
Pit water quality and volume monitoring	30/09/2020	31/12/2027			Refer to Water Quality Management Plan (refer to 11.D in Appendix 11) and Water Abstraction Management Plan (refer to 11.C in Appendix 11) of this report.
Treatment studies	TBC				
Rebounded mine water quality at outflow or in prospect pit at closure					Refer to Water Quality Management Plan (Section 11.D of Appendix 11 of this report).
Post-wet season macroinvertebrate monitoring	01/04/2021	01/06/2027	5	Annual	
Active fish survey	01/04/2021	01/06/2027	2	Annual	
Post-wet season fauna monitoring	01/05/2021	01/09/2027	90	Annual	
Riparian vegetation monitoring	01/06/2023	01/06/2027	3	Triennial	
Dry season macroinvertebrate monitoring	01/07/2021	01/09/2027	30	Annual	
Passive fish survey	01/08/2021	01/09/2027	2	Annual	
Biological and sediment reporting	01/09/2021	31/12/2027	10	Annual	
Groundwater quality monitoring					Refer to Water Quality Management Plan (Section 11.D in Appendix 11 in this report).
Groundwater quality reporting					Refer to Water Quality Management Plan (Section 11.D in Appendix 11 in this report).

Activity	Start	End	Duration (days)	Frequency	Comments
Groundwater level monitoring					Refer to Water Abstraction Management Plan (section 11.C in Appendix 11 in this report).
Groundwater level reporting					Refer to Water Abstraction Management Plan (section 11.C in Appendix 11 in this report).

3.15 Project Alternatives

3.15.1 ALTERNATE PORTAL LOCATION IN THE LADY ALICE PIT

This alternative was considered and dismissed. The eastern wall of the pit is geotechnically unstable and therefore is unsuitable for a portal. The southern wall is in mineralization which is also not suitable for a portal. North and eastern walls are topographically higher than the areas surrounding the pit meaning a portal couldn't be built in these areas. The volume of water to be discharged prior to mining is much larger. Access to this pit is close to the Union North pit, and further from the processing plant which would increase costs of mining. Waste material would still need to be stored temporarily in prospect pit, were the portal to be constructed in Lady Alice.

3.15.2 BOX CUT FROM SURFACE

Due to the orientation of the mineralization i.e. dipping to the east, the location of the box-cut would be required to be from the east and drifting to the west (see Figure 3-15). To account for topography and the location of the Lady Alice mineralised zone, the location of the box cut would be around 350 m to the east of the planned underground development in Prospect pit. The current budgeted costs for development are $6,500/m, resulting in an additional $1.2M cost to project. Additional cost requirements to build the box-cut in this location include:

- Mining requirements:
  - Additional 70,000 m3 material mined at a cost of around $500,000 (@ $7.101/m3).
  - Waste rock dump required to store material, this cost has not been estimated for this purpose.
  - A further $100,000 budgeted to build box-cut for shotcrete, pumping and piping infrastructure.
- 700 m of additional haul road:
  - +$250,000 of establishment costs for haul road, due to cut and fill required over hill and to avoid exclusion zones to south of Prospect.
  - +$100,000 on-going additional costs to haul ore further, this includes road maintenance and additional fuel requirements.
  - 185 metres of additional access development to access reserve ramp at same location as current Prospect Portal (i.e. 350 m box-cut ramp access vs 165 m from Prospect pit portal).

3.15.3 GHOST BAT 130 M BUFFER

If we assume that a 130 m buffer applies to the project, both above and underground, and one of the above alternative decline locations is chosen, and therefore the Proposal is able to avoid disturbance of the OK adit within Prospect pit, the outcome for the project is a significant reduction in revenue. That is because the mineral reserves located underground and within the 130m buffer (Figure 3-16) amount to:

- Approximately 60,000 tonnes @ 7.8 g/t Au, or 15,000 ounces.
- Assuming a gold price of $2,000 and 95 % mill recovery this is around $27.1 M of lost revenue.
- Assuming a spot price (4/3/2020) of $2,485 and 95 % mill recovery this is around $33.6M of lost revenue.
- Lost NT Government royalty from this reduced production would range from between $0.68 M and $0.84 M, based on 2.5 % royalty.

Both of the alternative locations would allow the OK adit to remain open, and the 130 m buffer requirements would have a significant impact on the project viability regardless of which alternative was chosen. Either alternative, in association with a buffer zone within the mineralization, would reduce the project mineral resource by approximately 27 %. The impact of this reduction is so significant as to render the project unsuitable, unless the OK adit is also closed and the requirement for a buffer removed.

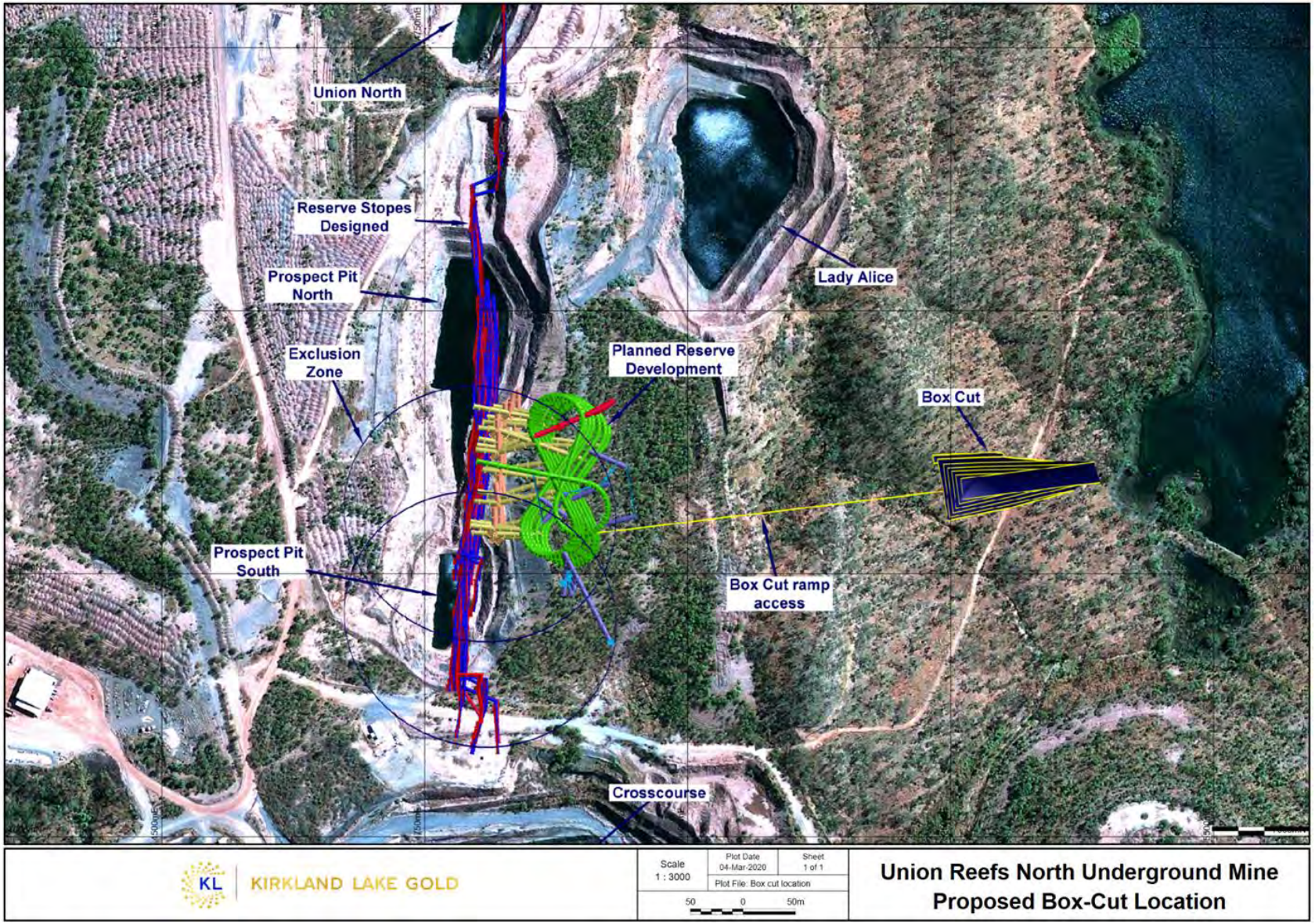


FIGURE 3-15 ALTERNATIVE BOX CUT LOCATION

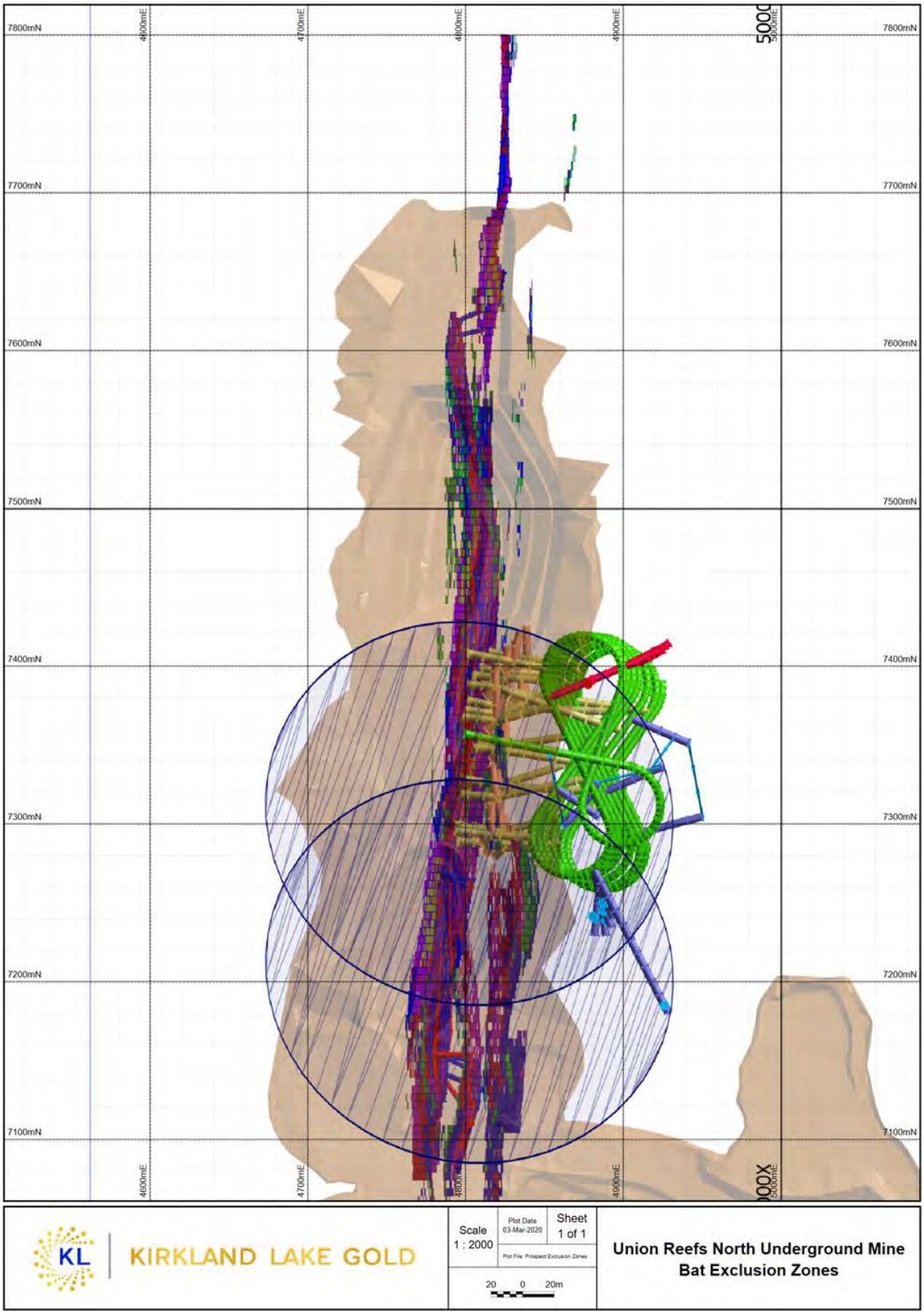


FIGURE 3-16 GHOST BAT BUFFER ZONE

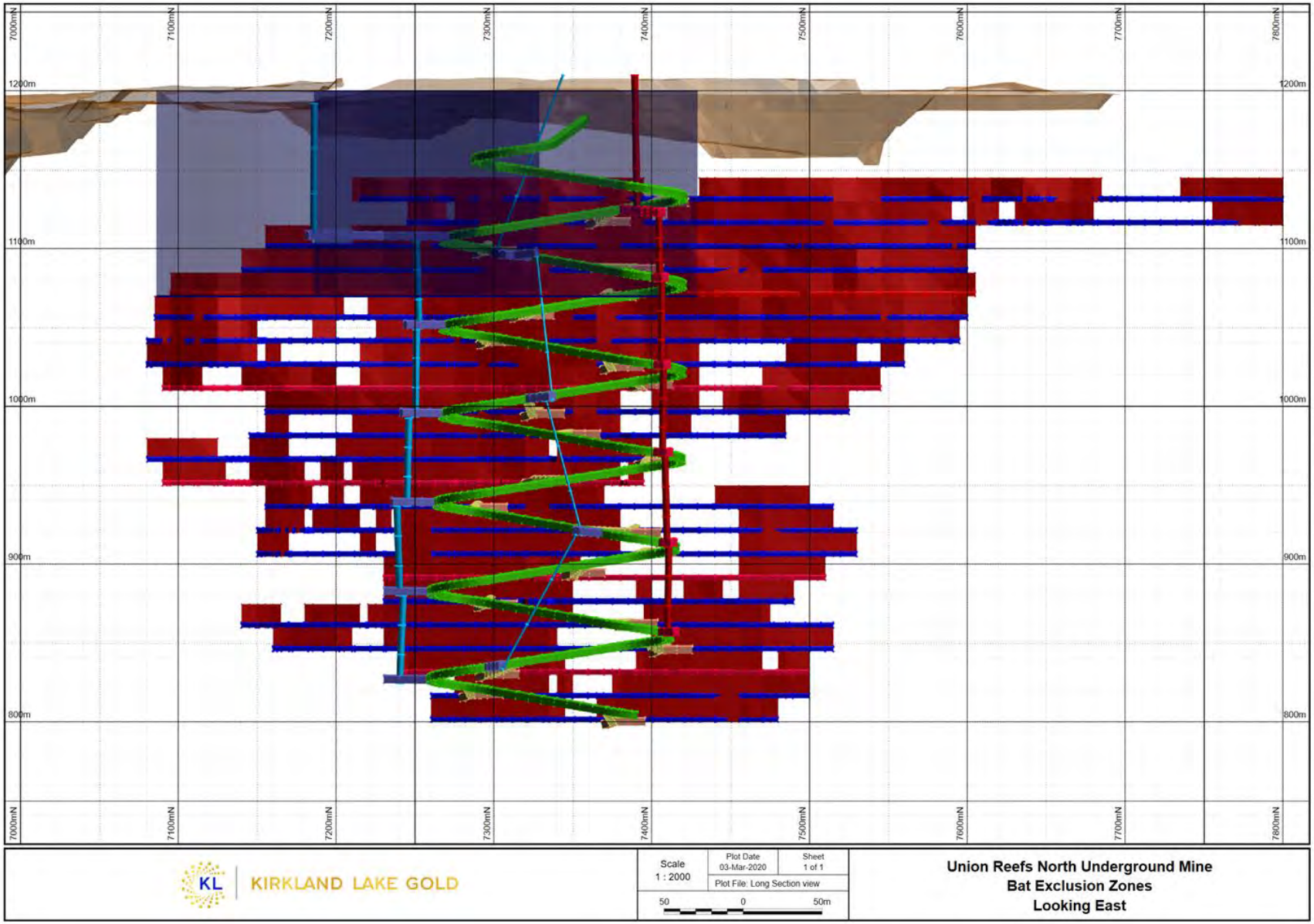


FIGURE 3-17 GHOST BAT BUFFER ZONE (SHADED AREA) LOOKING EAST

4 REFERENCES

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APPENDICES

Appendix 1 – Northern Territory Government Submissions

Appendix 2 – Other Submissions

Appendix 3 – Memo 1: Ghost Bat Activity Monitoring August 2019 – March 2020

Appendix 4 – Ghost Bat Action Plan

Appendix 5 – Ghost Bat Management Plan

Appendix 6 – Memo 2: An Analysis of Commitments to Ghost Bat Protection under the EPBC Act 1999 Environmental Offsets Policy October 2012

Appendix 7 – Memo 3: Summary of Actions at Lady Alice Adit

Appendix 8 – Memo 4: Outcomes from Action 2: Internal Investigations of Adits in the Union Reefs Project Area

Appendix 9 – Memo 5: Guide for the Thermal Modelling of Bat Roost Microclimates for Artificial Habitat Construction at Union Reefs

Appendix 10 – Memo 6: Progress Update: Artificial Ghost Bat Roost Design Project, Union Reefs

Appendix 11 – Water Management Plan

Appendix 12 – Geochemical Characterisation of Union Reefs North Drillcore Samples

Appendix 13 – Mine Closure Plan

Appendix 14 – Additional Groundwater Modelling

Appendix 15 – Crosscourse Pit Water Quality Prediction Modelling


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APPENDICES

Appendix 1 – Northern Territory Government Submissions

NORTHERN TERRITORY GOVERNMENT

ATTACHMENT A

TABLE 1: NTG COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT TO ADDRESS IN THE SUPPLEMENT

NT MINING OPERATIONS PTY LTD – UNION REEFS UNDERGROUND MINE

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Proposal Description		
Proposed action	Section 4	Clarify the scope of the Proposal to be assessed. Consider the cumulative effect of the current proposed actions on existing authorised activities, for example the Crosscourse Pit water balance and Waste Discharge Licence (WDL) requirement, and provide additional information as required (see below). In line with the requirements of the Terms of Reference (TOR), provide separate maps at the scale and resolution of Figure 4-2 for: • Proposal components, showing the: o location of all proposal components under assessment, including: Union Reefs North Underground Mine infrastructure, haul road, Prospect Pit north and south, Crosscourse Pit, Dams A, B and C, and Processing operations, but not including other components covered by existing authorisations (e.g. truck workshop, fuel bay and explosive storage) o location of ghost bat adits remaining open during the proposal and a 130 m buffer o proposed locations for artificial ghost bat roosts and a 130 m buffer o location of groundwater dependent ecosystems (GDE) within ML1109 and MRWET12 and MRWET13. • Primary and secondary mine features, where: o all primary mine features are depicted in one colour o all secondary mine features depicted in a contrasting colour • Primary, secondary and tertiary mine features, where: o each mine feature classification is depicted in different contrasting colours Provide updated shape files for these maps.
Operational water infrastructure	Section 4.7	The Draft EIS discusses the use of sediment traps on site but does not show the locations in any of the figures provided.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		Provide locations of sediment traps on a map.
Mine Schedule	Section 4.5	Provide a more detailed project schedule summary, include activities and timing for: • approvals (specifically, include approval under the EPBC Act) • pre mining phase (e.g. ghost bat management actions) • mine development phase (e.g. dewatering, portal construction) • mine operation phase (e.g. further exploration, progressive return of waste rock) • mine closure phase (e.g. mine closure activities) • post closure phase (e.g. identify individual monitoring activities and their timing) • post closure monitoring activities.
Approvals and regulatory framework		
Commonwealth approval required	Section 5.1.1 Table 5-1	The Proponent has noted referral and assessment obligations, but not included the requirement for Environmental Approval under the EPBC Act. Update Table 5-1 to include the requirement of approval under the EPBC Act.
Environmental History	Section 3.4	The Proponent has provided links to policies and planning framework that underpin its Environmental and Social Responsibility Management System, but not included a statement about whether, or not, there are any, past or existing proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against: a. the person proposing to take the action; and b. for an action for which a person has applied for a permit, the person making the application. For the EPBC referral matters, please include the statement and discuss how the policies and planning framework relate to EPBC matters. This information must be taken into account in EPBC Act approvals.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Surface water extraction licence is required	Section 5.1.2 Table 5-2	Table 5-2 in the Draft EIS main report incorrectly states 'nil required' in relation to the licences, permits or approvals required under the *Water Act 1992*. This statement is incorrect; specifically, a surface water extraction licence is required for take of water from Dam C. Dam C is the primary clean water supply with an established pumping station; the Draft EIS indicates annual extraction from the Dam C will be 299 ML. It is not proposed to take water from Dam B; however, should any take be proposed from Dam B, this will also require a surface water extraction licence. Update Table 5-2 to include the requirement for a surface water extraction licence and note that the application for this licence should include details on the pumping station and details on its power supply (for example if it is a diesel pump then information will be required to demonstrate how hydrocarbon contamination is mitigated).
Water extraction licence considerations	Section 5.1.2 Table 5-2	The beneficial uses gazetted for surface and groundwater in the Mary River Catchment and the McKinlay River do not include mining activity or industry. This will be a factor considered by the Controller of Water Resources when making a water extraction licence decision. The proponent's water extraction licence application must demonstrate that the activity (for example seepage from the Crosscourse Pit or overflow from Dam B) does not have an adverse effect on water quality of these water sources. Update Table 5-2 to include the information provided here.
Waste Discharge Licence	Section 5.1.2 Table 5-2	The legislation section, when referencing the *Waste Management and Pollution Control Act 1998* states that a 'Waste Discharge Licence (WDL) is required for URPA passive discharge'. • a WDL is issued under the *Water Act 1992* Update Table 5-2 to reflect this.
Terrestrial flora and fauna		

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Closure of OK and Prospect adits	Section 11.2.1-3	The Draft EIS identifies: • loss of roost sites contributing to EPBC listing of Vulnerable (Ghost bat) • limited roosting opportunities at critical times of the year • roosting limited to historical mine workings as no natural caves in the URPA • since 1987 disturbance and mining has caused decline in numbers and shift to alternative roost sites • continued occupation of sites within URPA and Pine Creek region during disturbance and mining indicates high level of importance of occupied roost • low ghost bat numbers in OK Adit (March to August) • high ghost bat numbers in Union North Adit (June to November) Provide proposed timing of adit closures and contingencies in place should significant numbers or breeding (August - November) ghost bats be present in either OK or Prospect adits at the time of closure. See further information request provided below at Topic Ghost bat actions – Action 1
Ghost Bat Management Plan (GBMP)	Section 11	The Draft EIS and Ghost Bat Action Plan provide commitments associated with 11 actions. These commitments require further development in the Ghost Bat Management Plan (GBMP). The GBMP must include: • avoidance and mitigation measures to avoid potential impacts to the ghost bat or its habitat caused by, but not limited to, noise and vibration, becoming entangled in barbed wire fencing, injury or mortality from vehicle and machinery movements, dust generation, lighting and fire prevention • mitigation and management measures in the form of specific and auditable commitments with clear timeframes and measureable outcomes • monitoring and review protocols • contingency actions • environmental management roles and responsibilities • reporting arrangements, including what will be publicly available

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		• commitments should avoid the use of 'where possible', 'it is anticipated', 'as required', 'should' and 'may' • commitments should use the terms 'will' and 'must' • reference and discussion of management actions consistent with Australian Government ghost bat Conservation Advice (TSSC 2019) • reference and discussion of management actions consistent with Australian Government general guidance to stakeholders preparing environmental management plans *Environmental Management Plan Guidelines (2014)* (Guidelines) available at http://www.environment.gov.au/epbc/publications/environmental-management-plan-guidelines • an analysis about how the proposed offsets (discussed under the Actions below) meets the requirements of the *EPBC Act Environmental Offsets Policy October 2012*.
Genetic studies	Sections 1.9 Table 1-5 10 Table 10-7 11.3.3	The Draft EIS and GBAP state genetic studies will be conducted before mine construction. Provide results of genetic studies and future timing of ghost bat genetic studies as they relate to: • inform connectedness of Union Reefs ghost bats with Pine Creek and Spring Hill colonies (Action 10) • likelihood of ghost bat movement to alternative roosts • potential significance of adits within the Proposal area as important linkage roosts See further information request provided below at Topic Ghost bat actions – Action 10
Significance of Union Reefs ghost bat colony	Section 11	Should the closure of the adit result in major impacts to the colony, the Draft EIS states that the loss of up to 30 individuals from the URPA represents 3% of the regional Ghost Bat population. It is assumed that the proponent is inferring that a loss of 3% of the regional Ghost Bat population would have a negligible effect. This is not necessarily supportable, as Ghost Bat populations have been shown to be genetically distinct at both the local and regional scales. Address the concern that the risk that loss of a small number of individuals may result in a significant impact at the local and regional scale, with the extent of this risk currently uncertain.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Ghost bat actions	Appendix G - GBAP	For each ghost bat action in the GBMP, clearly: • reference the TSSC (2016) and 2014 Guidelines (as above) • identify proposed commencement and timing of the action • identify specific auditable commitments with measureable outcomes • identify the person(s) undertaking the action and their research experience as it relates to cave dwelling bats.
Ghost bat actions – Action 1	11.3.1 and Appendix G - GBAP	Clarification is required for specific actions - Action 1 refers to closure of the OK Adit only based on carefully planned protocol. Update Action 1 to include: • closure of Prospect Adit • timeframe for adit closure • report with protocol for closure.
Ghost bat actions – Action 2	Appendix G - GBAP	Clarification is required for specific actions - Action 2 refers to characterisation of OK, Union North and Lady Alice adits including roost locations of ghost bats. Update Action 2 to include: • Lady Alice Adit in the title • actions conducted to date and any proposed actions yet to be undertaken • results for characterisation of Lady Alice Adit • results of other actions not reported in the Draft EIS (flooding potential of Union North Adit) • contingency measures should Lady Alice Adit be found not suitable for ghost bat habitat • discussion on the merit of including a contingency offset measure • avoid the use of terms ‘could’ and ‘might’ to reduce uncertainty about what actions are proposed.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Ghost bat actions – Action 3	Appendix G - GBAP	Clarification is required for specific actions - Action 3 refers to creating artificial habitats as ghost bat roosts, for both contingency and redundancy. Update Action 3 to: • include a full description of proposed works with proposed timing, design and site selection • include consultation undertaken with other bat experts • include assessment of likely outcomes • include timing and duration of ongoing monitoring • remove vague terminology like 'it would be ideal if…'
Ghost bat actions – Action 4	Appendix G - GBAP	Clarification is required for specific actions - Action 4 refers to reopen and rehabilitate Lady Alice Adit so it is suitable for ghost bat occupancy. Update Action 4 to build upon commitments undertaken by Action 2 and actions commenced, include: • rename Action 4 to capture the December opening of Lady Alice Adit • focus on rehabilitation requirements based on characterisation of Action 2 • timing and duration of monitoring to evaluate the condition of adit climate and success of bat usage
Ghost bat actions – Action 5	Appendix G - GBAP	Clarification is required for specific actions - Action 5 refers to management of the primary ghost bat adit within the Proposal area, Union North Adit. Update Action 5 to include: • detailed conditions, action triggers and reporting protocol to manage Union North Adit.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Ghost bat actions – Action 6	Appendix G - GBAP	Clarification is required for specific actions - Action 6 refers to implementation of management measures at Pine Creek only. The Draft EIS section 11.3.1 refers to management of the Spring Hill ghost bat colony as well as Pine Creek. Update Action 6 to: • confirm proposed locations for all management actions • outline detailed management measures • include commitments for all management actions.
Ghost bat actions – Action 7	Appendix G - GBAP	Clarification is required for specific actions - Action 7 refers to long term monitoring of local and regional ghost bat habitat. Update Action 7 in accordance with: • monitoring results since submission of the Draft EIS • information requested above with regard to Ghost Bat Management Plan • the EPBC Act Offsets Policy with regard to the value of increased knowledge and understanding of the species' spatial ecology and metapopulation genetic structure.
Ghost bat actions – Action 8	Appendix G - GBAP	Clarification is required for specific actions - Action 8 refers to providing part of the new mine as ghost bat habitat. Update Action 8 to: • include a full description of proposed design and timing • consider the EPBC Act Offsets Policy with regard to whether this action mitigates rather than offsets ghost bat persistence.
Ghost bat actions – Action 9	Appendix G - GBAP	Clarification is required for specific actions - Action 9 refers to field surveys for ghost bat roost in natural caves.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		Update Action 9 to include: • frequency and timing of proposed surveys • description of how information will be compiled • reporting of information, for example, provided to DENR, DOEE and/or made publicly available.
Ghost bat actions – Action 10	Appendix G - GBAP	Clarification is required for specific actions - Action 10 refers to genetic studies to investigate the connectedness of regional ghost bat colonies. Update Action 10 to include: • frequency and timing of genetic studies • scope and design of further genetic studies • description of how information will be compiled • reporting of information, for example, provided to DENR, DOEE and/or made publicly available.
Ghost bat actions – Action 11	Appendix G - GBAP	Clarification is required for specific actions - Action 11 refers to providing support for further academic research. DENR's Flora and Fauna Division notes that there are uncertainties about the risks associated with the temporary closure of the OK Adit and the proposed mining activities, with the potential for a significant impact on a sub-population of the ghost bat. Within this context, the division is generally supportive of the proponent's commitment to fund additional actions that are likely have a net benefit to the regional population of the species, including through significantly increasing understanding of the species' spatial ecology and metapopulation genetic structure. If implemented as outlined in the Draft EIS, these actions may adequately compensate for any residual significant impacts from the proposal. Update Action 11 to: • clarify whether funding is intended to offset this proposal or is part of a separate commitment • clarify reporting of information, for example, provided to DENR, DOEE and/or made publicly available

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		• note that under the EPBC Act Environmental Offsets Policy no more than 10% can be applied for indirect offsets. Funding for research programs is generally considered to be an indirect offset.
Hydrological processes		
Mine water use	Section 8	The site water balance indicates that the site is hydrologically in water excess. Provide details of any operational water sourcing hierarchy established for the site and whether there are water reuse and recycling measures in place to minimise the volume of imported water and the generation of mine affected water that would potentially require discharge to the receiving environment.
Numerical groundwater model	Appendix H	The Department of Industry and Primary Resources (DPIR) and DENR's Water Resources and Environmental Authorisation divisions identify the following limitations of the numerical groundwater model described in Appendix H: • the flow model is based on input data from analytical models and a very limited dataset for calibration and validation. At best this is a regional scale model and not appropriate as a predictive tool for meaningful impact assessment of contaminated seepage especially post closure. Refinement should aim to improve the predictive capability of the models is insufficient in its present form to support the claim that there will be no impact on the Pine Creek town water supply borefield • the model does not currently incorporate a key component of the area's conceptual model, which is that the aquifer transmissivity is very likely to be enhanced along the shear zone and this feature may facilitate increased directional drawdown towards the borefield • the model calibration has also only focused on recharge and has not included an adequate incorporation of the previous dewatering water level data that exists for the area (specifically for the period 1990 through to present) • further modelling is required to understand the extent of the predicted drawdown and to increase confidence in the modelled outputs • it is likely the groundwater model has underestimated the predicted drawdown.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		Further to information provided in the Draft EIS: • update the commitment for monitoring and reporting (Draft EIS 12.5) to include results from further refinement of the conceptual model and subsequent modelling. • provide modelling and discussion to address the TOR (Section 2.2.2 - Hydrological Processes), specifically that there will be no impact the Pine Creek water supply. Include consideration of transmissivity along the shear zone • consider the impacts of depressurisation are a relevant consideration under the *Water Act 1992* in relation to impacts on existing water users (e.g. town water supply, stock and domestic users)
Mine Water Management	Section 8	Table 8-1 does not seem to reflect the possible 18 L/s groundwater inflow and suggests peak ingress is 221 ML in 2022 and 2023. This is important for understanding the adequacy of water storage and the likelihood of any unplanned discharge. Clarify the site water balance with regard to taking into account worst case groundwater ingress scenarios.
Mine Water Management	Section 8	Clarify the method of dewatering of mine water ingress during the operational phase of the project.
Groundwater drawdown – dewatering pits and underground void	Section 12	Confidence around predicted drawdown is important to fully understand the likely extent of drawdown and potential impact on existing water users (including stock and domestic) in context of declared beneficial uses of the receiving environment. Outputs from additional modelling will be required to inform the water management plan and corresponding monitoring program. Provide the Water Management Plan as part of the Supplement submission. It is recommended that the water management plan is developed in consultation with DENR's Water Resources Division.
Water balance	Section 8	The Draft EIS states that 'the net balance of direct rainfall, catchment runoff and evaporation is estimated to be 455 ML on average, indicating that the site is hydrologically in water excess'.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		Provide detail in terms of water storage capacity on site and any points of uncontrolled discharge or overflow.
Water balance	Section 8	The water balance has been drafted considering typical rainfall characterised by historical rainfall conditions. In the event of rare or extreme rainfall events and considering the water level in Crosscourse Pit is close to the spill level, detail should be provided on the flow path in the event of an overflow of the pit. Further, provide detail on how a rare or extreme rainfall event would impact on the water balance of other water holding structures on site.
Stormwater	Section 8.3	Where it is stated that runoff from Dam C is expected to be in the order of 1,500 ML/year, confirm whether this means that 1,500 ML/year would be passively discharged to the receiving environment every year.
Groundwater	Section 12	Figure 12-1, relating to the regional groundwater study area, shows a Discharge Boundary and a No Flow Boundary. Detail should be provided on these boundaries and their purpose.
Groundwater	Section 12	There is potential for groundwater drawdown to impact on base flows of the McKinlay River i.e. increased loss of water from the McKinlay River to the alluvium during and post mining. Provide detail of the proposed trigger values for groundwater drawdown levels and include in the Water Management Plan, along with a monitoring program to allow early detection of any drawdown that could impact on water availability or yield for other users or receptors
Groundwater drawdown – potential impacts	Section 12	Drawdown losses were not considered likely to result in the drying of permanent pools in the McKinlay River, but it was acknowledged that this may lead to reduced volume, especially towards the end of the dry season when evaporation is high. In years of low rainfall, isolated permanent pools are especially important as they provide refuge for aquatic flora and fauna that propagate the river during the wet season. Provide updated hydrogeological modelling results to provide improved certainty on the potential significance of drawdown on surface water and permanent pools.
Surface water flows	Section 12	Treated mine-affected water is proposed to be discharged to the McKinlay River under a WDL. The Proponent should provide certainty that it has adequate baseline flow data to determine the conditions under which release of water could occur without having a significant impact on the surface water quality and flow regime. Releases of water to the McKinlay River should be monitored and managed to avoid any significant changes to the timing, rate, frequency and

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		duration of seasonal surface water flows. Provide details of how this would be addressed in the Water Management Plan.
Inland water environmental quality		
Wastewater treatment	Section 8	It is noted that NTMO treats water at different sites across its lease areas to manage contaminant levels prior to discharge to the receiving environment and that primary treatment using caustic soda, limestone or lime is carried out to stabilise pH. Apart from Crosscourse Pit. Detail should be provided on where this treatment takes place and at what frequency. Further treatment with Ferrous Chloride ($FeCl_2$) is then required to reduce concentrations of contaminants, specifically metals, to obtain a suitable water quality for discharge. Detail should be provided on where this treatment is carried out, what the desirable water quality is prior to treatment, and whether treatment with $FeCl_2$ would result in elevated concentrations of Iron or other contaminants in the receiving waters. It is understood that cyanide has been detected in the tailings discharge to Crosscourse Pit; detail should be provided on whether the processing operations allow for cyanide destruction to prevent downstream impacts.
Water treatment	Section 8	Where it is proposed to treat and discharge out of Crosscourse Pit, detail should be provided on the infrastructure and capacity onsite for treatment and discharge. Confirmation should be provided on whether treated water would be pumped into Dam B and discharged via the proposed authorised discharge point.
Water storage capacity	Section 8	Provide details of the overall capacity of Crosscourse Pit, the capacity that remains available, the rate and volume of tailings and water generated by current mill processing of material from Cosmo Howley and projected volumes through the life of the Proposal. Demonstrate that the Crosscourse Pit has adequate capacity to receive the projected volumes of tailings and water. If it is proposed to use water from Crosscourse Pit to manage water levels, identify what the water would be used for and demonstrate that the water quality is suitable for the intended use.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Water quality – Crosscourse Pit outflows	Section 8	Crosscourse Pit is anticipated to become a groundwater source at 173-176 m AHD. Provide detail on how outflows from Crosscourse Pit would potentially affect the surrounding aquifer water quality and how such impacts would be managed and mitigated during operations and post mining.
Prospect Pit backfill	Appendix H - Section 4.3.5 page 56	Section 4.3.5 of Appendix H states that *"The post underground mining groundwater regime at the other pits is highly likely to mimic the pre-underground mining groundwater regime. The exception to this is the Prospect Pit itself which will be dewatered and infilled to above water table during mining."* Confirm that the Proposal includes backfilling the Prospect Pit South only and that waste rock will be maintained to above the water table during mining. Discuss whether infilling to above the water table is proposed for the Prospect Pit North, Prospect Pit South or both.
Water use	Section 8	It is proposed that good quality water from Dam C will be predominantly used in processing activities with some input from water in Crosscourse Pit. This process would potentially result in the generation of poor quality water and reflects minimal recycling on site. It is preferable that good quality water, i.e. the water from Dam C, be discharged from site to create capacity in the water holding structures onsite to enable the treatment and/or recycling of poorer quality water, i.e. from Crosscourse Pit, to be used in processing operations. NTMO should provide detail on whether this option had been considered and investigated.
Water discharge	Section 13	It is understood that passive discharges occur from a number of sources onsite: • from the former TSF Decant Pond which passively discharges via a spillway into the McKinlay River • from Dam C, which receives seepage from the East Waste Dump and passively discharges via a weir and spillway into Dam A and then into Wellington Creek • from Sediment trap 4A which received runoff from the West WRD. Provide confirmation of whether these locations comprise the full extent of the passive discharge points and whether there other known or likely sources of passive discharge. Provide detail on whether the water quality of passive discharges is monitored to assess the impacts on the receiving environment.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Wastewater discharge	Section 13	The Draft EIS suggests discharge of treated wastewater from Dam B to the McKinlay River via a creek. It is proposed that URSW04 will be the authorised discharge point and that URSW08 will be the compliance point. An authorised discharge point is typically the end of pipe/outfall of the source, in this case Dam B. URSW04 is approximately 1 km downstream of Dam B. A compliance point is typically just a few kilometres from the source. URSW08 is approximately 13 km downstream from Dam B, this is considered quite an extensive mixing zone. The purpose of a mixing zone is to manage the controlled discharge of soluble non-bioaccumulatory toxicants whose impacts on local biota are primarily related to their concentration. The water quality objective of the Beneficial Use Declaration (BUD) for the McKinlay River relating to aquatic ecosystem protection applies to the area of the McKinlay River NTMO propose to discharge waste water; it starts upstream of the mine site and continues downstream for just over 20 km. In accordance with the current Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) (the water quality guidelines), where mixing zones are to be applied, they should be as small as practicable. Water quality management should ensure that the agreed and designated community values and management goals of the broader waterway outside the mixing zone are not compromised. The Draft EIS suggests that the discharge location has been determined based on 'appropriate length for the mixing zone prior to compliance point monitoring at URSW08'. The length of the proposed mixing zone is over 12 km and over half the length of the BUD. Justify and provide the method for determining the location of discharge and compliance points in relation to length of mixing zone and BUD with consideration of the water quality guidelines (ANZG 2018). Provide alternative discharge and compliance points and details of resultant mixing zone as determined in accordance with the water quality guidelines. Consider the BUD's in the receiving environment as well as the quantity and quality of the discharge water.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Water quality monitoring	Section 8	NTMO should describe the approach and methodology that will be used to develop site specific trigger values (SSTVs) to ensure appropriate discharge activity and early detection of any impacts to the receiving environment. This should be informed by a review of the water quality monitoring program and analysis of relevant water quality data with respect to seasonal variation and rainfall events. NTMO should clearly identify the triggers, actions and responses that would be undertaken if impacts on the receiving environment are identified or indicated through the review of monitoring data. It is noted that proposed SSTVs, which were determined based on water quality at the upstream monitoring point, URSW09, are included at Table 8-5. • This Draft EIS proposes a trigger value for Electrical Conductivity (EC) of 700 to 1,000 µs/cm. The most recent annual monitoring report proposed a trigger value for of 250 µs/cm and showed that EC at URSW09, is on average between 17 and 120 µs/cm. This is consistent with the ANZECC default values for conductivity which are set at 20 to 250 µs/cm. • The Draft EIS explains that the 'proposed SSTV for EC of 700 to 1000 µs/cm is based on site data that indicates EC within the water stream is generally related to sulphate concentrations rather than toxicants such as heavy metals'. However in discussing surface water in the downstream environment of the McKinlay River the Draft EIS states that 'during nine seasons of monitoring, Electrical Conductivity (EC) has been within the Guideline Values (GV), demonstrating that the impact has been slight'. This conflicting information does not support the proposed higher trigger value for EC at the compliance point. NTMO should explain further and provide supporting evidence to demonstrate why the higher value is representative of the receiving environment. • The Draft EIS states that 'NTMO has adopted the 95% ecosystem protection values for environmental protection at surface water monitoring point URSW08, i.e. downstream at the end of the mixing zone. This is with the exception of aluminium and zinc, which have derived site specific trigger values (SSTVs) using ANZECC & ARMCANZ (2000) guidelines being the 80th percentile of the historic dataset'. This is not reflected in Table 8-5 which shows that: o 95% ecosystem protection values are applied to pH, dissolved oxygen (DO) (upper percentile), turbidity, Arsenic, Cobalt, Iron, Lead, Manganese, Nickel, Selenium and Zinc. o 80th percentile of the historic dataset are applied to DO (lower percentile), TSS, Aluminium, Cadmium, Chromium, and Copper.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Water quality	Section 13	The Draft EIS states that 'the surface water use changes to livestock drinking water approximately 4 km downstream of monitoring point URSW08, with Pastoral Stations being the main downstream users' and 'livestock drinking water guidelines (SWG) are also considered given the downstream declared beneficial use'. The BUD for this section of the McKinlay River relates to aquatic ecosystem protection. Describe how the proposed ANZECC livestock drinking water guideline values will maintain protection of this BUD. NTMO should explain further and provide supporting evidence to demonstrate that this is the case.
Water quality	Appendix I – Geochemical water quality modelling	Section 2.3 of Appendix I of the Draft EIS states that Cosmo ore processing commenced at the URPA in 2011 and ceased in 2017 and concludes that neutral mine drainage observed in the McKinlay River through the water quality monitoring program is not related to Cosmo ore processing. However during a site visit on 29 November 2019 it was noted that the mill was processing Cosmo Ore and had been for some time. Provide details of when ore from Cosmo has been processed at the URPA and any recorded impacts to Crosscourse Pit water quality or McKinlay River downstream water quality from this activity.
Water quality	Section 8	The Draft EIS also states that 'Since the completion of mining in Crosscourse Pit, it has so far been a groundwater sink, with inflows estimated to be 85 ML/year in early 2019, however if the water level in Crosscourse Pit rises, the pit has the potential to become a groundwater source'. Detail should be provided on potential groundwater quality impacts considering Crosscourse Pit receives mine tailings.
Water quality	Section 8	Due to hydrological connectivity, detail should be provided on what the potential impacts of water quality in Crosscourse Pit could have on the quality of water in Prospect Pit, or vice versa.
Cumulative impacts to water quality	Section 1.5 Mine water management	The NTMO Union Reefs Underground Mine Terms of Reference (TOR) requires a draft Water Management Plan that includes, among other things, the proposed water management measures to avoid cumulative impact from poor water quality. Further under Closure objectives, information was required to assess the cumulative impacts of the proposal on the interactions between previous activities and impacts, and the new proposal.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		The Draft EIS recognises that the McKinlay River has been impacted by neutral mine drainage from the URPA, and infers that this may be due to seepage from waste rock dumps and an historic tailings facility, but does not adequately describe the potential cumulative impacts of the Proposal to downstream surface water quality, with consideration of these existing impacts. Provide detail of how potential cumulative impacts to surface water quality have been considered and what management measures are proposed to avoid impacting the water quality objectives and beneficial uses of the McKinlay River. Provide detail on how the effectiveness of any management measures implemented to avoid degradation of groundwater quality in aquifers and surface water quality downstream would be monitored, measured and reported.
Water quality	Section 13. Appendix I – Geochemical water quality modelling	A baseline water quality study has been conducted recognising there are limitations in the number and reliability of the available data, and is presented as preliminary and only indicative (Phase I). NTMO has committed to do more work as part of Phase 2 which will include predictive water quality modelling to produce estimates of water quality and flow during operations, and into closure. Note that geochemical test work is still being conducted and were not available for this Draft EIS. The geochemical test work will provide the input data for the predictive water quality modelling. It has been identified that the URPA has impacted the quality of the McKinlay River (based on 2 sample points) consistent with neutral mine drainage inputs to the river. As part of the proposed development of the new mine, NTMO is to further evaluate the risks to the environment (i.e. Identify the source, pathway, sinks), and implement a robust monitoring program and strategy to address the risks especially towards closure and post closure, where the water level in pits and dams are expected to be at their highest levels. A predictive water quality model is proposed by NTMO as Phase 2 to be submitted as part of the Supplement. Provide the geochemical characterisation results and an updated Geochemical Water Quality Modelling report that contains the inputs, components, boundaries, limitations assumptions and results of the predictive modelling (Phase 2) following upgrade from the conceptual (Phase 1) model results provided in Appendix I of the Draft EIS. Provide detail on the

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		proposed timing and frequency of model recalibration and updates using monitoring data collected during operations and post mining.
Water quality	Section 13	Ongoing monitoring of both surface and groundwater will be required to determine the impact to groundwater quality due to the Proposal. Section 3.4.1 of the Draft EIS commits to monitoring As, Cu, Ni, Pb, Zn and Fe in groundwater. Clarify whether additional metals, metalloids and/or inorganic substances would be monitored during operations and post mining, with consideration of those listed in Draft EIS Table 8-6 for metals including (in addition to those above) Al, Cd, Co, Cr, HCN and sulfate.
Water use	Section 8	Dam C is raw water and therefore relatively clean compared with Crosscourse Pit water. Provide additional detail and justification for using water from Dam C for processing rather than water from Crosscourse Pit, including consideration of water quality and why (if relevant) water quality precludes use. Describe how a water source hierarchy has been developed and implemented for the site to determine which of the potential sources of water the mine will use.
Acid and metalliferous drainage	Section 4	The Draft EIS describes several uncertainties that limit understanding of the extent and specific nature of the potential acid and metalliferous drainage (AMD) issues that may be encountered during the mine life, and under long-term management arrangements. These uncertainties could allow for unexpected issues with the quality and quantity of contaminated water that may be discharged from the mining lease, and the potential impact of such discharges on the McKinlay River. The national guideline Preventing Acid and Metalliferous drainage: Leading Practice Sustainable Development Program for the Mining Industry (available at https://www.industry.gov.au/data-and-publications/leading-practice-handbook-preventing-acid-and-metalliferous-drainage) emphasises the importance of developing AMD management strategies for site operations and closure during the feasibility phase. At the feasibility stage, a sufficient level of technical rigour is needed to avoid an AMD problem that escalates during operations to an extent that there may not be an economically viable solution.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		The AMD minimisation strategies should be developed to a sufficient level of detail to allow realistic costings and management plans to be made. The EIS should include information that: • Provides a sufficient overview of water treatment methodologies for each source of contaminated water on the site, and the treatment performance associated with the relevant methodologies; • Demonstrates that the potential financial burden of the measures required to prevent environmental harm can be met within the project constraints, during the operational life of the mine, and beyond; • Demonstrates that all reasonable and practicable measures will be taken to prevent the discharge of any contaminated water from the premises; and • Includes appropriate modelling to conservatively predict the quantity and quality of water that cannot reasonably be contained, and must be released from the mining lease.
Water quality	Section 14	Aquatic ecosystem protection applies. Wastewater discharges and groundwater seepage may impact the McKinlay River. It is proposed that surface water discharge quality will be managed by electrical conductivity and will be released via siphon discharge to the McKinlay River: • Nutrients, especially nitrate and ammonia, have potential to enter the aquatic ecosystem via groundwater seeps - the impact of release of nutrients to the environment, beyond the boundary of the premises, must be determined e.g. nitrogen in terms of loads and concentrations and assessment of the chemical forms that are readily bioavailable. • Use of a dilution algorithm and electrical conductivity as operational controls of the quality of the waste water discharge should be justified. • Change in ionic composition and ionic strength may be a stressor to the receiving environment. It is recommended that the proponent carry out the necessary investigations to demonstrate that waste water with different salt composition and concentration to the receiving environment will not cause environmental harm. • If change in ionic concentration is to be used as an indicator of the corresponding composition of bioavailable metals that have potential to be toxic to aquatic organisms (contaminants of concern), the proponent should demonstrate that the proposed measure of change in electrical conductivity has sufficient

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		resolution and quality control to provide appropriate early warning of change in the concentration of the contaminants of concern. If the waste water is to be discharged by siphoning, detail should be provided on how discharge flow rates and volumes will be controlled, measured/metered, recorded and stopped if required.
Aquatic ecosystems		
Groundwater dependent ecosystems	Section 14. and Appendix J	Groundwater dependent ecosystems (GDEs) are present as permanent pools supporting aquatic ecosystems. Potential for significant impact exists through groundwater drawdown and altered water quality through surface and groundwater pathways. The Draft EIS identifies groundwater modelling will assist with understanding any potential impacts to GDEs. Provide an updated assessment of GDEs based on improved modelling of hydrological processes (including drawdown) and water quality to demonstrate whether significant residual impact remains.
GDE monitoring design	Section 14.6	The Draft EIS expects no significant changes to the assemblages of aquatic biota in the upper McKinlay river, primarily because the: • remnant waterbodies are not substantial features of the aquatic landscape • aquatic fauna is adapted to rapid re-colonisation of temporary habitat. DENR's Water Resources Division note that there is room for improvement in the practice of biological monitoring of mining operations in the Northern Territory. Assessments based on macroinvertebrates mostly rely on family level identifications and use coarse-scale summaries of community composition for tests of impact. AUSRIVAS modelling as frequently deployed, is rarely suitable for the task of assessment in temporary streams. Future biological monitoring would benefit from: • improvement to study design including data from pre-impact and multiple spatial control sites • adoption of finer taxonomic resolution (ultimately species-level) • adoption of new technologies including underwater video for fish and eDNA • a clear statement of the aims and objectives of the monitoring. Provide details of an aquatic ecosystems monitoring plan that:

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		• demonstrates whether changes in pool water volume are linked to de-watering activities • demonstrates whether changes in biological attributes are due to mining effects, or are simply reflective of regional changes in similar habitat • includes monitoring locations, timing, methods, statistical analysis, reporting, contingency actions and a trigger response framework to increase certainty that any potential impacts would be effectively avoided or mitigated.
GDE monitoring - site selection	Section 14	The Draft EIS proposes to use two permanent waterholes, located downstream (within 250 m and 750 m respectively) of URSW10, as a focus for assessment of aquatic ecosystem impacts during mining activities. Discuss whether these sites are suitable for AUSRIVAS monitoring, including sediment and biological monitoring. Discuss the relevance of comparison between habitat at these locations and the upstream location
Macroinvertebrate monitoring	Section 14	The Draft EIS suggests that in regards to Biological Monitoring, that the upstream macroinvertebrate community is different to the downstream macroinvertebrate community. Provide detail on whether NTMO has considered determining a more appropriate upstream monitoring site to ensure comparison of like for like.
Social, Cultural and Economic Surroundings		
Impact of poor water quality on Mary River National Park values	Section 13	The Proposal lies within the Mary River catchment, with the McKinlay River as the main drainage sub-catchment. Parks, Wildlife and Heritage (PWH) Division of the Department of Tourism, Sport and Culture seeks to highlight that Mary River National Park is one of the Northern Territory's most important National Parks and protects values that are nationally and internationally significant. The McKinlay River is less than 1 km from the Union Reef Project Area, flowing during the wet season northwards to the Mary River. While there are no National Parks or Reserves directly within the proposed area, the Mary River National Park includes the lower and middle sections of the Mary River Catchment. There are potential impacts on the values protected by Mary River National Park, particularly from the release of contaminated discharge water. The Draft EIS

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		outlines intentions to discharge treated contaminated water into the Mary River Catchment through a Water Discharge Licence, however an adequate treatment process has not been outlined in the Draft EIS. Given the close proximity of the mine to the McKinlay River and the Mary River National Park it is requested that the Park be specifically acknowledged through the identification and treatment of potential impacts on the Park's biodiversity, cultural and visitor (recreational and economic) values.
Mine closure and rehabilitation		
Mine Closure Plan and TSF	Section 9	The Draft EIS does not meet the Terms of Reference with regard to providing sufficient detail and an integrated MCP incorporating relevant Proposal components. Given the short life of mine and that commencement is proposed as soon as possible, more detail is required to assess closure aspects and a detailed MCP is necessary for environmental impact assessment. It is noted that the Draft EIS commits to updating an integrated MCP for the Union Reefs Project Area (URPA) but does not describe how this will occur. The tertiary features of the URPA and any interactions with primary and secondary features should be addressed in the MCP. In particular, the fate of Crosscourse Pit (as a tailings repository) at the end of mine life (less than 5 years) and the capacity of Crosscourse Pit (maximum tailings and water levels) has not been adequately addressed. While it is recognised that there is complexity in relation to use of existing mine features and potential for cumulative and significant impacts, further information is required to provide context and discussion on how closure of the Proposal relates to, and should be considered in, the updated MCP. Provide an integrated Mine Closure Plan that demonstrates how closure objectives would be met for all mine features related to the Proposal, including: • primary mine features (underground mine and associated infrastructure) • secondary mine features (haul road, Dams A, B and C, Crosscourse Pit tailings dam, Prospect north and south pits and the processing areas)

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
		• tertiary mine features (where existing features are affected by or interact with the Proposal) • timing, commitments and completion criteria for all mine closure activities.
Post Closure Crosscourse Pit	Section 9	There is limited information for the post closure final tailings level and water level in Crosscourse Pit. The management of the likely positive water balance of the Crosscourse Pit needs to be addressed for mine closure. The likelihood of Crosscourse Pit to fill and remain near to the spill level is a major risk to the long term use of Crosscourse Pit as a tailings storage facility. The Draft EIS indicates water cover and ongoing maintenance as the closure option. Provide detail on how this would be achieved and the final maximum level that would enable a water cover to be maintained into the long term post mining, including freeboard requirements and any maintenance and management actions that would need to be undertaken. Include the improved water quality modelling results for water quality of Crosscourse Pit in the MCP.
Mine Closure Plan	Appendix E	All surface infrastructure associated with the underground mine will be decommissioned, removed and the areas rehabilitated. Confirm whether all pumps, water tanks and other facilities will be removed.
Mine Closure	Section 9	Confirm timing of Prospect Pit bund construction post mining
Mine Closure	Section 9	Provide detail on the standards that would be used to assess, monitor and measure rehabilitation success in areas that will be revegetated.

Topic	Draft EIS ref.	Request for information to be provided in the Supplement
Pit lake water quality	Section 8	Provide details and results of further geochemical waste characterisation undertaken since the Draft EIS was published and how these results have been used to progress the conceptual water quality model to a predictive water quality model. Provide the inputs data, assumptions and limitations of the model. Provide further assessment of the long term pit lake water quality post mining and how this would change over time. Include consideration of effects of evapoconcentration on long term water quality.
Mine closure	Section 9	Identify any residual liabilities relating to the final post mining land use and include whether this has been agreed to by key stakeholders.

TABLE 2: NTG ADVICE ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

NT MINING OPERATIONS PTY LTD – UNION REEFS UNDERGROUND MINE

Topic	Draft EIS ref.	NT Agency comments and advice (no response required)
Approvals and regulatory framework		
Water extraction licence considerations	Section 5.1.2 Table 5-2	Groundwater inflows into the workings are predicted to be 18L/s at a worst case scenario, with dewatering being required to facilitate mining. If dewatering is undertaken via sump pumps no groundwater extraction licence will be required.

Topic	Draft EIS ref.	NT Agency comments and advice (no response required)
Waste Discharge Licence	Section 5.1.2 Table 5-2	It is unlikely the Controller of Water Resources will grant a WDL for a discharge where the quality and quantity of the discharge are out of the control of the licensee.
Waste Discharge Licence	Section 5	As this is considered a new activity, a new WDL is required. Should NTMO wish to have a WDL in place for the 2020/21 Wet season, it should ensure a WDL application and all supporting documentation, as per the above advice, is submitted to the Administering Agency no later than 30 July 2020 to allow adequate time for assessment, site visits and consultation meetings.
Waste Discharge Licence	Section 5	The MMP states that 'The URPA passive discharge was licensed under a WDL between 2011 and 2016. In 2017, the DENR advised NTMO that it no longer requires a WDL for the URPA passive discharges'. Note this statement is incorrect –the WDL was under assessment when NTMO personnel advised the Administering Agency that it no longer required a WDL as there was no discharge from the site.
Waste Management and Pollution Control Act 1998 (WMPC Act)	Section 5.1.2 Table 5-2	The proponent should be advised that the *Waste Management and Pollution Control Act 1998* (WMPC Act) applies in relation to a contaminant or waste (as defined in the WMCP Act) that results from, directly or indirectly, the carrying out of a mining activity by a person on land on which the activity is authorised by or under the *Mining Management Act 2001*, where the contaminant or waste is not confined within the land on which the activity is being carried out. If a contaminant or waste is emitted or discharged from land on which an extractive mineral permit exists, it will be considered an incident as defined by the WMPC Act if it threatens or may threaten to cause pollution resulting in material or serious environmental harm. Where an incident causes, or threatens to cause, pollution resulting in material environmental harm or serious environmental harm, the person conducting the activity must notify the Northern Territory Environment Protection Authority in accordance with section 14 of the WMPC Act.
Terrestrial Flora and Fauna		

Topic	Draft EIS ref.	NT Agency comments and advice (no response required)
Ghost bat actions	Appendix G - GBAP	Note that under the EPBC Act the commencement of the referred action may only occur once an approval is given.
Ghost bat actions – Action 8	Appendix G - GBAP	Note this action is to be used as an offset, noting it will only be achieved after the mining is completed e.g. 2 years. The EPBC Act Offsets Policy indicates that offsets must be effective and timely, that is, offsets are usually required to be in place prior to the action commencing and endure for at least the period of impact. This offset can only be achieved after the mining ceases, therefore there is uncertainty as to whether this approach can actually be described as an offset compatible with the EPBC Act Offsets policy. It may be that such an action is mitigative in effect. The Draft EIS may wish to consider this issue in more detail and potentially consider a different offsetting arrangement in addition to that proposed.
Weeds Management Act 2001	Sections 5 and 9	The Proponent should be aware that significant weed species are present on the proposed mine site, access roads and surrounds. Some of these weed species, including gamba grass, are listed in the Draft EIS under section 7.8 (Introduced Species). DENR's Weed Management Branch seeks clarification from the Proponent on weed management matters and request consultation and review of the Weed Management Plan, either as part of a Mine Management Plan or standalone document, that addresses control methods and the spread mitigation procedures the proponent will undertake to minimise impact of weeds on land affected under this proposal. In section 5.1.2 Northern Territory Legislation of the Draft EIS the statutory obligations under the *Weeds Management Act 2001* are referenced and it is written 'Weed management, including Weeds of National Significance (WoNS) is addressed in the URPA MMP'. However, there is no MMP submitted for review with the Draft EIS. The Notice of Intent also referenced a Weed Management Plan (WMP), without providing a copy for review. Sections 9.1.1, 9.1.3 and 9.1.4 of the Draft EIS, state that Kirkland Gold will 'establish a WMP' in the event of a temporary closure. This contradicts earlier statements that a WMP will be part of the MMP.

Topic	Draft EIS ref.	NT Agency comments and advice (no response required)
Inland Water Environmental Quality		
Water quality	Section 8	The focus is primarily on water entering the receiving environment and there a number of key concerns requiring consideration: • capacity to manage existing wastewater onsite (pre-operational) • seepage (i.e. uncontrolled and untreated discharges from site) • proposed wastewater management, including: o Likely increase in capacity as a result of operations o Treatment options and treatment rates. • discharge, including: o Waste water quality – site specific trigger values (SSTVs) o Monitoring downstream impacts on the environment o Sources of discharges from all sources on site.
Mine water management	Section 8	The scenarios presented in the Draft EIS provide limited options: • maintain the water level in Crosscourse Pit by discharging under a WDL; or • do not manage the water level in Crosscourse Pit, but continue to dewater into it resulting in the water level increasing. It is unclear whether any other options or scenarios were considered by NTMO, such as reuse or recycling of water in Crosscourse Pit or dewatering to another pit.
Wastewater treatment	Appendix E	As per commitment in Appendix E, NTMO plan on treating water from Crosscourse Pit prior to discharge. The treatment method is to dose it (with NaOH, $CaCO_3$, or CaO) which is the method currently applied at Cosmo. Due to the specific nature of Crosscourse Pit being utilised as a tailings storage facility likely to contain elevated arsenic, cobalt, zinc and

Topic	Draft EIS ref.	NT Agency comments and advice (no response required)
		copper and cyanide there will be a requirement to develop new effective strategies to improve water treatment to reduce arsenic levels.

Appendix 2 – Other Submissions

TERRITORY STEEL

Strengthening the Top End

Monday, January 13, 2020

To Whom it may concern:

Territory Steel is a direct supplier and supporter to the operations of NTMO. We understand that they have an EIS for review to extend their operations. We have reviewed the web link for the EIS, and we support the proposed operations at Union Reef and surrounding area going ahead as soon as practicable.

Territory Steel currently employs 8 people and we are sure that with expeditious approval by the EPA, ongoing employment will be supported from what we believe to be the responsible environmental activities of this mining operation as reflected in the EIS.

Best Regards

P.Tedesco
M.D Territory Steel

Darwin Steel Supplies Pty Ltd *TIA* Territory Steel
ABN: 23 109 503 326 ACN: 109 503 326
11 Toupein Road, Yarrawonga NT, 0830 T: (08) 89310044 F: (08) 89311044
, PO Box 117, Berrimah NT, 0828

From: Katharina Hymon <Katharina.Hymon@fluidpowerau.com>
Sent: Monday, 13 January 2020 1:50 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: NTMO - Union Reefs site - support

To whom it may concern:

My business Fluid Power Darwin is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs (12) of people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Yours sincerely,

Kind Regards
Kady

08 8921 8654
0414 973 149

Katharina.Hymon@fluidpowerAu.com
Darwin.Accounts@fluidpowerAU.com
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4 Andrews Street,
PO Box 200,
Berrimah NT 0828

PALL Pall Corporation

FLUID POWER DARWIN

From: Slingshot Haulage <slingshothaulage@bigpond.com>
Sent: Monday, 13 January 2020 2:18 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject:

To whom it may concern:

My business (Slingshot Haulage) is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs (15) of people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.
Yours sincerely,

Regards,

Chad Dehne
Slingshot Haulage Pty Ltd
ABN 42 086 882 644
123 Victoria Hwy
PO Box 583
Katherine NT 0851
Ph: 08 8971 1788
Fax: 08 8971 1044
Accts: 08 8971 0974



From: David O'Callaghan <davidoc@redappointments.com>
Sent: Monday, 13 January 2020 3:05 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: suppport for expansion of Union Reefs Mine

TO WHOM IT MAY CONCERN

Red Appointments NT Pty Ltd is a Darwin based recruitment and labour hire business. In the NT, we employ between 60 and 100 casual employees with approximately 1/3 of our workforce identifying as Aboriginal or Torres Straight Islander. Providing NT Mining Operations Pty Ltd meet the environmental impact requirements of NTEPA, we as a business support the expansion of their operations. Whilst not an expert in the field, I have read their EIS and it appears to be very comprehensive. As a local business, the approval of their expansion plans would bring some much needed economic stimulus, not only to Red Appointments, but to the community as a whole. We are hopeful the approval for their proposed expansion plans will be approved very soon.

Yours sincerely,

David O'Callaghan

Managing Director (NT)

RED Appointments
complete · people · solutions

P 08 8947 0443 F 08 8947 0570 M 0400 294 953
E davidoc@redappointments.com W www.redappointments.com
A 33/119 Reichardt Road Winnellie NT 0820 (entrance off Hickman Street)
PO Box 39828 Winnellie NT 0821

RED Appointments
Indigenous Employment

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Find us on Facebook



Red Appointments has built a reputation in the marketplace for providing exceptional service to our clients and candidates. We appreciate referrals from our clients, partners and friends to continue to grow and develop our business. It would be our pleasure to assist anyone you recommend who may benefit from our services. Speak to one of our consultants to make your referral today!.

From: Sales Manager <sales.manager@hosepower.com.au>
Sent: Monday, 13 January 2020 3:26 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: Union Reef Gold Mine Expansion

To whom it may concern:

Our business Hosepower is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations. I have reviewed the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable.

Our business employs 28 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS. We have had dealings with the mine for many years and have found them to be focused on their HSE policies and procedures.

Kind regards,

Keith Howland
Business Manager

Hosepower

7 Verrinder Road, Berrimah, DARWIN NT 0828
T: (08) 8984 3828 M: 0498 843 827 F: (08) 8984 3992 E: sales.manager@hosepower.com.au
www.hosepower.com.au

MG Electrical Services Pty Ltd
ABN: 13 009 625 496
93 McKinnon Road, Pinelands NT 0829
PO Box 3106, Palmerston NT 0831
Telephone: 08 8931 4177
Fax: 08 8931 4188
Email: mgelectrical@mgelectrical.com.au

13th January, 2020

Northern Territory Environment
Protection Authority Level 1,
Arnhemica House, 16 Parap Rd, Parap,
Darwin eia.ntepa@nt.gov.au

Re: NT Mining Operations - Union Reefs North Underground Mine - Notice of Intent

To whom it may conce rn:

MG Electrical Services Pty Ltd specialises in electrical distribution services and has been operating in the Northern Territory for 38 years.

My business is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have reviewed the web link for the EIS to gain an understanding of the environmental scope covering land and water management. I have confidence in the capacity of NTMO to manage the environmental impacts of the works and would be pleased to support the proposed operations at Union Reef and surrounds.

My business employs 27 residents of the Northern Territory and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Yours sincerely,



Mick Goold Director
MG Electrical Services Pty Ltd
M: 0419 825 675

From: Adam Stockwell <adam.stockwell@thinkwater.com.au>
Sent: Tuesday, 14 January 2020 1:36 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: RE: NTMO EIS - Support email.

To whom it may concern:

Our businesses Think Water Winnellie / Virginia (Darwin) & Pump 365 is a direct supporter to the operations of NTMO and we understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. Our businesses employs 22 people directly & supports a further 7 local sub-contractors on a daily & weekly basis.

I am sure that with expeditious approval by the EPA, Think Water Darwin, Pump 365 & our sub-contractors will be provided with additional commercial opportunities from NTMO that will not only support but grow our current employment position in the Northern Territory, from what we believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Kind Regards

Adam Stockwell
Managing Director

Think Water Winnellie & Virginia
59 Coonawarra Road, Winnellie NT 0834
PO Box 38319, Winnellie NT 0821
P 08 8983 3232 | **F** 08 8983 3243 | **M** 0408 835 797
E adam.stockwell@thinkwater.com.au | **W**





From: Bedros Garske <bedros@rhinoindustrial.com.au>
Sent: Tuesday, 14 January 2020 2:22 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: KL Gold

To whom it may concern:

My business Rhino Industrial is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 10 full time staff and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Regards

Bedros

Bedros Garske
Rhino Industrial Pty Ltd
88 Pruen Road, Berrimah 0828
Po Box 36765, Winnellie 0820
Ph 08 8947 3400
Mobile 0488 573 402
Fax 08 8947 3656
Email - bedros@rhinoindustrial.com.au

From: stephen hallam <stephenhallam1@icloud.com>
Sent: Tuesday, 14 January 2020 11:11 AM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: NT Mining Operations - Stephen Hallam b

To whom it may concern

My name is Stephen Hallam I work for NT Mining Operations as Project Lead for Prospect Mine I am looking at moving to the NT I have been tasked with building Bat habitats as stated in the EIS I have spent 34 yrs in the underground mining industry I'm very excited at the prospect of building bat habitats that could potentially be a long term solution for the roosting of bats
In the time I have been employed with NTMO it is apparent to me that they are a very committed company that does what they say they will do The significance and seriousness that NTMO are inputting to monitoring the Flora, Fauna and ground water should not be understated and would a travesty if for whatever reason did not get off the ground My research shows that only two bat habitats have been built world wide and this would be a huge opportunity to gather scientific information surrounding ghost bats whilst trying to be on the forefront protecting with potentially bat roosts that could be built relatively cheap at any mining location

Regards
Stephen Hallam

From: Poly Fabrication Admin <admin@polyfabrication.net.au>
Sent: Tuesday, 14 January 2020 2:21 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: Kirkland Lake Gold

To whom it may concern:

My business Polyfabrications Australia is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 6 fulltime staff and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Regards

Bedros

Bedros Garkse
82 Pruen Road, Berrimah 0828
Po Box 36765, Winnellie 0820
Mobile 0488 573 402
Fax 08 8947 3656
Email - admin@polyfabrication.net.au

polyfabrications AUSTRALIA

From: AJ Couriers & Haulage <ajchaulage4@bigpond.com>
Sent: Tuesday, 14 January 2020 4:06 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: Support NTMO EIS

To whom it may concern

Our business, AJ Couriers and Haulage Pty Ltd, is a locally owned and operated business in the Northern Territory that is a direct supporter to the operations and proposed expansion of NT Mining Operations. I understand they have an EIS for review to commence an underground operation at the Union Reef site just outside of Pine Creek. I have had a chance to review the EIS online and I fully support the commencement of the expansion. I have confidence in the capacity of NTMO to manage the environmental aspects of the essential elements with minimal impact to the environment as outlined in the EIS. The operations of NTMO are a large contributor to our small business which has 25 employees and with approval from EPA, I am confident this expansion will support ongoing employment.

Yours sincerely,

Regards,
Jeff Stevens

AJ Couriers & Haulage Pty Ltd
9 Angliss Road, Berrimah, NT 0828
Ph: 08 8931 4922

From: Cory camps <cory_camps@hotmail.com>
Sent: Tuesday, 14 January 2020 3:45:41 PM
To: eia.ntpa@nt.gov.au <eia.ntpa@nt.gov.au>
Subject: Union Reef Underground

To whom it may concern,

I would recommend the propsed underground mine by Kirklans Lake Gold at the Union Reef site. I am an employee at their nearby Cosmo mine and am impressed with their environmental management.

I previously worked at the Cosmo site under previous ownership and can see a vast improvement in environmental conditions and attitudes. The company is genuine in maintaining the natural beauty of the Northern Territory.
There has been great investment towards the infrastructure to the sites and camps. There is a great number of locals employed where skill sets are suited. Of the employees that reside interstate, a number of them pay for their own flights to and from Darwin. They also use part of their time off to stay in the Territory to support the tourism industry and not to mention benefit to the local areas of Pine Creek, Adelaide River and Douglas Daily to mention a few of the locations that are utilised for regularly.

I understand the Ghost Bat population is in the vicinity of Union Reef, however Kirkland Lake is taking all due diligence to ensure their preservation. My belief is the bats are not originally from the Union Reef Site and are from a nearby colony. They should be if not already attempted, relocated to this colony.

In closing the approval of the Union Reef underground should be granted as the their is a strong resposibility and commitment from Kirkland Lake to the environment. It is being undertaken at a previoulsy mined area that was far greater damaging to the environment as it was open pit. An underground mine will leave very little any environmental footprint. The company shows a great commitment to even further investment to the Northern Territory and local areas and people.

Regards
Cory Camps
Underground Operator Cosmo Deeps

Chamber of Commerce
NORTHERN TERRITORY

P: +61 8 8982 8100
F: +61 8 8981 1405
E: darwin@chambernt.com.au

Suite 5/4 Shepherd Street
Darwin, Northern Territory
0800 Australia

GPO Box 1825
Darwin, Northern Territory
0801 Australia

ABN 36 160 572 513

www.chambernt.com.au

15 January 2019

To Whom it may concern,

The Northern Territory Chamber of Commerce and Industry (**Chamber**) welcomes the opportunity to make a submission in support of the EIS provided by NTMO regarding the expansion of the Gold mine at Union Reefs in the Northern Territory of Australia.

Established in 1957, the Chamber is the largest employer association in the Northern Territory (NT), representing over 1,200 businesses. The Chamber is an independent, not-for-profit and non-government body - our membership and offices span the Territory.

The Chamber provides members and the Northern Territory business community an effective platform for lobbying on the issues that impact upon business, whilst providing services and support in a number of key areas including industrial relations, training, employment, education and training advice, networking and premier business events.

Importance of the Resources Sector to the Territory

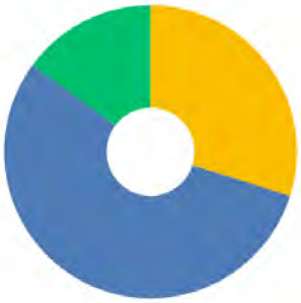
The development of Union Reefs is important for the future development of the Northern Territory – noting that the resources sector is the largest sector of the NT economy and that currently our overall economy continues to be in a precarious state - with a fiscal balance deficit of $1.1 billion and a total net debt of $6.2 billion in 2019/2020, fuelled in part by a contracting economy, including a 14% drop in Royalties from the preceding year:-

- Minerals and energy accounts for 13% to 20% of NT GSP, compared to national average of 8%. It is the largest private economic sector in the NT and as a percentage of GSP is exceeded only by WA.
- Mining employment tends to be regional and not the greatest employer, gauged by employee numbers (3.1% of NT workforce).
- NT minerals exploration of $111.8m in 2017/18 is down from $250m in 2012, but up from $100.8m in 2015/16. 33% of 2017/18 minerals exploration was on base metals, 24% on gold 10% on rare earths and 9% on Lithium.
- In 2010 60% of the NT land mass was subject to mineral exploration licences, at the start of 2019 13% of the NT was subject to mineral exploration licences.
- Although the Territory is more reliant on Commonwealth funding than other Australian jurisdictions, the Territory's Own Source Revenue forms an important component of total revenue. In 2018/2019 Territory taxes and royalties contributed $1.06 billion of Territory Own Source Revenue, 17% of the NT's total revenue (confirm NT revenue).
- In 2018/2019 Royalties made up 40% of Territory Own Source Revenue.

Our Economy needs Union Reefs to proceed now

The Chamber of Commerce is currently conducting its annual NT Business Confidence Survey which closes at the end of January 2020. Interim results, based on responses from some 335 companies, indicate that 30% of those businesses expect to reduce their staffing levels this year and over 50% currently have a dim view regarding their future outlook for the NT Economy (refer to data charts/tables provided below). Hence the speedy development of Union Reefs would be warmly welcomed by the Territory Business Community – noting the company will have a large regional & local workforce and they have a strong commitment to local procurement.

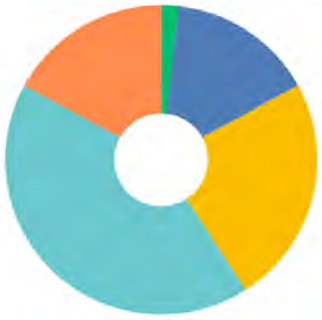
What are your expectations for your employment business levels during 2020 compared to current levels?



Skipped: 0 Answered: 335

Expect to increase number of Employees	15%	50
Retain the same number of Employees	55%	185
Expect to reduce number of Employees	30%	100

How confident do you feel for the future of NT In general?



Skipped: 0 Answered: 335

Very positive	2%	6
Positive	15%	51
Neutral	24%	80
Negative	42%	141
Very negative	17%	57

Environmental Sustainability/Business Engagement

The Chamber has looked at the web link for the EIS and are confident that NTMO are committed to developing the mine in an environmentally sustainable manner. We are aware that the company has engaged specialist environmental expertise and are committed to minimising any environmental impacts regarding Groundwater, waste discharge etc.

The company is a valuable member of our Chamber and utilises our networks and services to engage with and brief our NT Business Community. In fact, the Company has already committed to hosting our next Business at Sunset event at the end of January 2020 – where they can directly brief our local business community about upcoming local business opportunities as well to share with them the environmental strategies to be utilised. This is evidence of solid social responsibility by NTMO.

Summary

The Chamber is pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. We are sure that with expeditious approval by the EPA, ongoing employment and desperately needed economic stimulus for our local economy will be supported from what we believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Yours sincerely,

Greg Bicknell
CEO

Phone: (08) 8976 0887
Mobile: 0427 760 888
Fax: (08) 8976 0897
Email: cheryl.erkelens@bigpond.com
PO Box 34, Batchelor NT 0845
ABN: 54 121 981 137

RICK ERKELENS EARTHMOVING
FOR ALL CIVIL AND MINING EARTHWORKS

To Whom It May Concern,

I have been working for Kirkland Lake Gold at Cosmo for past year.

I have several Bulldozers and do work on contract for the Company on various jobs, including rehabilitation.

Kirkland Lake is a very go ahead motivated Company with a deep commitment to the environment and rehab of mined areas.

I am a local, based at Batchelor.
Kirkland Lake offers hope for my company as they are committed to looking after local business.

Union Reef going ahead would be a lifesaver for us and many others in the area.

Kirkland Lake – Spends Money !

Kirkland Lake – is committed to protect and rehabilitate the environment.

Kirkland Lake is Win – Win for the territory !

Let the Mine at Union Reef go ahead !

Thank You

Yours,

Rick Erkelens.

From: Caitlin Brown <CBrown@klgold.com.au>
Sent: Wednesday, 15 January 2020 5:28 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: UR EIS Draft comments.

To whom it may concern,

I am writing in regards to the KLG NT Operations EIS submission for permission to mine underground at the Union Reefs site.

I have been an employee at the Union Reefs site for 6 months now, relocating from the Victorian KLG operations for an exploration geologist role based at UR.

Since moving here I have been thoroughly impressed at the dillegence and attentiveness that the environmental team shows towards the community and the environment. As a team we see the environmental team, albeit a small one, frequently monitoring and innovating environmental strategy across both sites, from testing dams and our drinking water, collecting weather information, monitoring movement of the bats, tracking and rescuing wildlife and even keeping us updated on croc sightings. They show great passion for their jobs and go above and beyond with integrity to ensure the bats are protected and monitored, even if it means us changing our drilling plans to protect them.

Part of moving to UR operations was the opening of the Pine Creek camp facility. We were blown away at the amount of work that went into fixing up such a dilapidated site. It feels like a tropical sanctuary now and it really is a home away from home. The best part about moving into the camp is living in a local town. We all enjoy the luxury of having a destination to explore, go on runs, visit the local pubs and sometimes to just see other people outside work! Quite a few of my team have been employed from Pine Creek and it has been a pleasure to have local experience and support the community we live in.

The potential development of the underground mine at UR will go a long way to secure our team's future and help it expand further. I have no doubt that KLG will, as ever, operate under a high social and environmental standard to ensure the mark it leaves is only a positive one. The current operation has made a positive impact on many lives and I hope to stay in the Northern Territory and work with KLG for many years to come.

Thank you.

Caitlin Brown
Project Exploration Geologist

KL | KIRKLAND LAKE GOLD

Kirkland Lake Gold Ltd. (TSX: KL,NYSE:KL,ASX:KLA)
Dorat Rd
Hayes Creek, NT, 0822
Australia

O: (08) 8982 4444 | M: 0458 105 452
E: CBrown@klgold.com.au | W: www.klgold.com

From: A & K Fencing <akfencing@bigpond.com>
Sent: Thursday, 16 January 2020 12:29 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: NTMO

To whom it may concern:

My business A & K Fencing ABN 80 208 206 602 is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 3 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Yours sincerely,

Andrew Dahlitz and Kathryn Thomas
A & K Fencing
Mobile: 0412 145 787
Email: akfencing@bigpond.com

From: Mark Solari <mark.solari1@gmail.com>
Sent: Thursday, 16 January 2020 1:44 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: KLG NT mining operations EIS public comment

To whom it may concern,

Being a Northern Territory resident, local business owner and employee of Kirkland Lake Gold Northern Territory Mining Operations at the Union Reefs processing plant, I feel that I should give my honest opinion in relation to the NT mining operations submission of environmental impact statement regarding the proposal to extend mining operations at Union Reefs and surrounds. Having said that, I have been employed by numerous mining companies both in Australia and abroad in my 20+ years working in the mining industry, and in that time I have experienced many different approaches by companies in regards to following and adhering to their own environmental policies. After experiencing first hand the steps that Kirkland Lake Resources and the commitment that their employees are constantly taking to minimize if not eliminate the risk of damaging native flora, fauna and natural water courses, I would have to say that this company is at the forefront of environmental policy compared to what I have experienced previously. They have a dedicated environmental team and dedicated employees which is what is not only needed but also required when working in this specific area of the Northern Territory . From my stand point the continuous monitoring of water quality and the important research that has been achieved regarding the protection of native species and an enforced environmental policy shows that this company is not only dedicated but also committed to creating a project that generates much needed local employment, that is also focused on minimal impact as possible to the surrounding environment and native species therein.

The second point I would like to discuss is the importance of local employment and job opportunities for the NT as a whole, both individual and business. It is my understanding that Northern Territory Mining Operations currently employ approximately 150+ personnel across their NT operations and are looking to expand to approximately 300 in Union Reefs area alone. This will not only provide a substantial impact on local employment but also the ability to create more opportunities for training and development of local employees not to mention the impact it would have on local businesses in the NT, examples of businesses that would benefit from having another mining operation in the area are as follows. Logistics and Transport, Hospitality and Catering, Structural Engineering, Civil Engineering, Consultancy, Spare Parts and Consumables, Protective Coatings and Blasting, Industrial Gas Supplies, Electrical and Refrigeration, Crane, Rigging and Scaffolding, Building Contractors, Laboratory analysis and Non Destructive Testing. So as you can see this is by no means a comprehensive list of businesses there are many more that go towards supplying services to the mining industry and thus creating a flow on effect contributing towards the NT economy. As most territorians are aware that in recent times it has become more difficult to find gainful employment in the NT particularly in a full time capacity. Statistics show that unemployment rates in the NT have risen from 2.7% in December 2010 to 5.1% in June 2019 (statistics taken from economy.id.com.au) but I suspect the figures currently are much higher now, considering that the large scale Inpex project was also completed in June 2019 creating a mass exodus of workers and closure of many Darwin businesses.

In conclusion. As you can see this project is important to numerous people and businesses in Pine Creek and the Northern Territory community as a whole and I'm sure many people would be grateful if this project were to go ahead.

Kind Regards from the maintenance team at Union Reefs,
Mark Solari
Anthony Holben

Colin Williams
From: J & T Auto Electrics & Air Conditioning <admin@jtae.com.au>
Sent: Thursday, 16 January 2020 4:09 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: Support Environmental Impact Statement - NT Mining Operations

To whom it may concern,

Our Company, J & T Auto Electrics & Air Conditioning is a direct supporter to the operation of NT Mining Operations (NTMO). We are a local family run business, established in 2010, providing Automotive Electrical and Air Conditioning services. We have conducted business with NTMO since 2017 as their preferred local Auto Electricians and suppliers of Automotive parts and accessories.

We understand they had an Environmental Impact Statement (EIS) for review to extend their operations. Our Company is aware of the EIS and have viewed the web link and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. We have confidence in the capacity of NTMO to manage the environmental aspects of the essential elements of minimal impact to the environment.

Our Company employs seven people, including Directors, with the capacity and workload to employ more. We are sure that with expeditious approval by the Environmental Protection Authority, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

If you require further information, please don't hesitate to contact our office on 8967 1637 or email admin@jtae.com.au

Yours sincerely,

Joel & Teegan Thring

Owner / Directors
J & T Auto Electrics & Air Conditioning

2/1 Marlow Road, Berrimah NT 0828 |
Ph: 8967 1637 | M: 0439 391 763
Email: admin@jtae.com.au
W: www.jtae.com.au
ARCTick AU32815

From: Andrew Swanson <aswanson670@gmail.com>
Sent: Thursday, 16 January 2020 4:26 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject:

Hi my name is Andrew Swanson I am an employee of KLG giving them a permit would be good for the local economy .And employed more local workers as well as boosting the local economy. Cheers

From: Sarah Heard <s.e.heard@gmail.com>
Sent: Thursday, 16 January 2020 5:22 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: EIS Union Reef underground mine public comment

I am commenting on the draft EIS submitted for public comment to support the project as it provides great benefit the Pine Creek community.

Since resuming work in the Kirkland Lake Gold Northern Territory operations ("NTMO") I have been impressed with the level of investment the company has made into the area. I was last there in mid-2015 and since returning have noticed lots of construction at the Cosmo Mine site, Cosmo camp and Pine Creek camp which would amount to several millions dollars' worth and well over $100M worth of mine and exploration investment; a company generally doesn't make this investment unless they are committed to be in the area long-term.

NTMO is a good employer, providing good quality living and working facilities and remuneration. This project will ensure my ongoing employment and also provide opportunities for others to gain quality employment through company growth.

Kirkland Lake Gold is a significant gold mining company and responsible operator, the same investment that has been placed in the current operations (which includes significant environmental management from a team of at around 10 environmental scientists and technicians) will be placed in the proposed project. KLG has the money and ability to commit to mitigating the possible affects the proposed project might have on the Ghost Bat population-who better than a mining company to develop an alternative roosting site for the Ghost Bats.

This project going ahead is of great economic benefit as it safeguards KLG's ongoing investment into the area.

Kind regards,

Sarah

From: Alketas Patounas <patounas.al@gmail.com>
Sent: Friday, 17 January 2020 8:07 AM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: KLG NT Operations - EIS

Good morning,

I am a Darwin resident, member of the ADF (reserves) and employee of KLG. I moved to Darwin in January of 2019 to support my partner with her employment in the education sector. Shortly after moving to Darwin I was fortunate enough to find employment with KLG, which favor local people to employ and I am sure my new home had a great influence on my employment with them. KLG make significant investments into the local economy and are a great asset to the NT and Australia having recently donated 1 million dollars to bush fire assistance funds.

NT Operations have a very capable and passionate environmental team monitoring and researching the local Flora, Fauna and ground water and take any impacts and our responsibility very seriously. The opening of the underground mine at Union Reef would be of great importance to extending operations in the NT as ore is still needed to run the mills and keep them going and by keeping them going they will keep jobs going and money flowing into the local economy. Environmental impacts are of extremely high importance to the company and any negative impacts are stringently mitigated by the team.

Kind Regards,

Al Patounas
Graduate Geologist
Mob:0424976891

Oolloo Investments Pty Ltd
ABN: 60 887 484 204
164 Finlay Road
Adelaide River NT 0846
Ph 08 89767099 Fax 08 89767161
Email: TRE22@bigpond.com

17th January 2020

To whom it may concern:

My business Oolloo Investments is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 5 of people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Yours sincerely,

Ian Rixon
Director
Oolloo Investments

From: Andrew Upfill <AUpfill@klgold.com.au>
Sent: Friday, 17 January 2020 10:09 AM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: NTMO Union Reef Mining extension

To who it concerns:

I am the HR Manager with NTMO and immediately recognise the justaposition of being (un)biased in a public submission to the EIS that has been published by NTMO.

I can speak from first hand as to the incredible amount of work that has gone into establishing a commercially viable operation – we have recruited over 278 personnel to the operation from this time last year and have a prospect of establishing a 'mining region' in the footprint of the surrounds of Union Reef and Pine Creek. Our employees now total over 300 with an additional headcount of over 150 contractors per month. We are contributing significant upside to an economy which is struggling post INPEX boom, something which is difficult to manage for any government in the cycles of large infrastructure projects.

The past historical mining activity has ironically created ideal environmental conditions for species such as ghost bats which are poorly understood by the general population – it is curious to consider that where Ghost bats were once prolific in the Kakadu region they appear less so now, however this region has no mining as a cause for the diminishing of numbers. It would appear that Mining is good for this particular species.

In the Union Reef and Pine Creek area where there has been Mining – hand dug mining adits (tunnels) are now providing habitat for Ghost bats to not only survive but also by all accounts flourish. The irony of these colonies of bats now being a reason for progress toward economic and commercial activity to be sustained due to being in old mining workings is not lost on me!
The scope of building artificial habitats

The environmental considerations for the project to progress are taken very seriously, the adherence to regulations is warranted based upon the cowboy tactics of rape and pillage as past miners were in to exploit the 'easy' mining of open pits which have left quite a legacy which we are rightfully striving to better manage, contain and wherever possible eradicate.

We have has some significant inroads with backfilling a small open pit at Cosmo Howley (Chinese 2) which has been significant to witness. This project employed a team of indigenous operators who were from the local area, it has been significant in providing local employment as well as healing the scars of the landscape which have been troublesome and expensive to manage in the past.

We have a range of experts who have been engaged in the EIS. In addition to this we have some incredibly dedicated and passionate personnel on site who deliver the day in day out operations

Of note are the following: (However there are many others)

- **Trevor Edwards** – Superintendent Projects: He has been instrumental in the water balance of the Cosmo Howley streak and had the vision and articulation behind the infill of the Chinese 2 pit

- **Emer McGowan** – Environmental Officer: She has been pivotal with overseeing the Ghost Bat monitoring program on the ground and is a most passionate advocate of wildlife and fauna awareness & protection
- **Sally Horsnell** – Environment Manager: Dedicated with years of local knowledge, Sally has a strong chemistry skill set and also appreciates what can be the protracted pieces of governance for the regulation with environment mitigation activity. The Adaptive Management Strategy for water balance management is a great example of what has been delivered in private public partnership.

The Public Private Partnership related to the Extension of Mining activity proposed at Union Reef is a great example of how the economy of the Territory can be delivered sustainably in light of innovation.

NTMO has a MoU with Charles Darwin University and have a range of proposed programs that will run on triennial funding, specifics of these programs are very close to contract and include:

- Ghost Bats
- Wellness programs and
- Chemistry Research

In effect the triple bottom line of Environment, Social and Economic responsibility is being met by NTMO. It would be significant to have the EIS approved in the shortest possible timeframe to ensure the establishment of these programs can be well felt for many years.

The human capital in the existing workforce which is more than 60% locally based from Darwin and surrounds, is one that is providing an essential pillar in skills and capability development for a scale up in both industrial and mining activity – added to this are the numerous other jobs that support the operations – from catering to suppliers and beyond.

The Territory has a bright future – the Union Reefs proposed mining activity is one which is tied to the wellbeing of the environment. Kirkland Lake Gold the parent company of NTMO has demonstrated its commitment to the prospect of the region being a flourishing mining centre for more than the next 10 years. Imagine if there is another Tanami just waiting to be found which could responsibly sustain the region for the next 50 years?
If you would like any further clarification or comment please do not hesitate to contact me on 0419 715 425.

Sincerely

Andrew Upfill
HR Manager

KL | KIRKLAND LAKE GOLD

Kirkland Lake Gold Ltd. (TSX: KL,NYSE:KL,ASX:KLA)
2/14 Shepherd Street
Darwin, NT, 0800
Australia

O: 08 8982 4423 | M: 0419 715 425
E: AUpfill@klgold.com.au | W: www.klgold.com

From: Michael McElwee <michael@aquatreat.com.au>
Sent: Friday, 17 January 2020 10:31 AM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: letter of support NTMO

To whom it may concern:

My business Aquatreat NT is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations.

I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable.
My business employs 8 personnel, 2 are indigenous who are being trained on the wastewater systems on the mine, and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.
Yours sincerely,

Michael Mc Elwee

Director



Union Reefs Underground EIS Comment

Good morning,

My name is Aaron Banderson and I am descendent of the Wagiman people. I am a TO and my grandmother, Teresa Banderson (Muyuway) is a senior TO and resident of Pine Creek. The Wagiman people were granted Native Title in 2019. I grew up in Pine Creek and still have a lot of family and friends residing there.

I am a full council member for the NLC, a Director of Tjuwaliyn Wagiman Corporation (Pine Creek Region) and the Managing Director of Djundjakan Pty Ltd; a 100% Indigenous owned and run company. I am currently employed by KLG in a supervisory and mentoring capacity for Indigenous employees, on the Chinese 2 Rehabilitation Project. I appreciate that KLG is making an active effort to mitigate environmental issues caused by previous operators, and support local remote job seekers.

From my point of view, KLG is directly influencing mining culture from an environmental perspective by managing rehabilitation and water quality values in the area.
I have a vested interest in this project and the region, particularly regarding the local economy and job interests for Indigenous people in the area.
I support the EIS going forward and supporting local job growth for the Pine Creek community. KLG should work with the senior TOs to encourage job opportunities for remote Indigenous job seekers.
I am also interested in the cultural significance of ghost bats and the connection they have with the Wagiman people.

The name of the bat is jinminmin. There is a cultural belief that the ghost bats are present in Union Reefs because of the Rainbow Serpent. Disturbing the bats or moving them from the Union Reefs site will disturb the connection with the Rainbow Serpent. Ghost bats should be left at Union Reefs and can be relocated around site, but not to Pine Creek or another colony.

It would be beneficial for KLG to consult with senior TOs of the Wagiman language group who are based in Pine Creek to help work with the ghost bats, to meet the EIS goals in managing and relocating ghost bats. This should happen before a decision is made about the final location of ghost bats at Union Reefs.

From: Jade Blazely <jade@gowise.com.au>
Sent: Friday, 17 January 2020 1:40 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: Re NTMO

To whom it may concern:

Our business Go Wise Real Estate is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations . I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. Our business employs 4 people and support a range of trades such as plumbers electricians and the list goes on. I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

We have had the pleasure of working with NTMO now for 3 years, through this time have built a strong relationship and believe their vision for the Territory's future is detrimental in our current economic climate for job and population growth.

Feel free to contact me on 0407 003 008 if you would like to discuss further.

Yours sincerely,

Jade Blazely
0407 003 008
jade@gowise.com.au
Sales and Leasing Agent

GO WISE real estate

Research and Innovation

P 08 8946 7704 **E** bogdan.dlugogorski@cdu.edu.au

17 January 2020

To Whom It May Concern

Kirkland Lake Gold (KLG) will fund two major research projects at Charles Darwin University (CDU) with further research projects being developed for funding under the KLG-CDU collaboration agreement.

KLG is funding a three-year biodiversity research project on the ecology of the threatened ghost bat at CDU's Research Institute for the Environment and Livelihoods (RIEL). This project has a direct cash value of approximately $1,000,000 to the university and will support a NT-based early career research scientist. The research project will also bring flow-on financial benefits to the university through opportunities for recruitment of PhD and Honours students. CDU's research performance will be positively influenced by the scientific publication outputs arising from this project in addition to attracting increased research funding and new students.

Being a proactive environmental management project, this biodiversity research program will take the lead in demonstrating new approaches for better conservation of species in the context of mining development. It will also directly fund the mapping of the distribution of a poorly known threatened species, the ghost bat and provide publicly available data for assessing effects of current and future mining activities on the status of said species. This species and other bats in the NT are not very well known as a threatened species. The funding of a large-scale research project on the ecology of bats across the 'Top End' of the NT, well beyond the footprint of the relevant mining leases, will help to make a substantial contribution to the knowledge base on this aspect of NT's biodiversity assets. The project will enable CDU to develop a close working relationship with the NT Government's Department of Environment and Natural Resources to develop capacity and conduct strategic research in the NT resulting in better conservation outcomes associated with current and future mining proposals.

KLG has enabled CDU to adopt a very broad scope to this project, conducting both applied and basic research beyond the specific needs relating to the Union Reefs North Underground Mine proposal. The project provides an excellent model and framework for industry-funded research which will facilitate better environmental management and decision making.

In addition to the above, CDU will support KLG to be a responsive and supportive employer by delivering appropriate wellness and engagement activities to its staff population. KLG has commissioned the Wellness Centre based at the College of Health and Human Sciences (CHHS) at CDU to support the Kirkland Mining staff community throughout 2020. This support will be provided by CDU's academic staff who have relevant expertise and experience with support from students enrolled in appropriate degree programs. Through this initiative, KLG is demonstrating its commitment to maintaining a healthy and focussed workforce who are able to bring their best every day.

Yours sincerely

Bogdan Dlugogorski
DVC and VP Research and Innovation

Environment Centre NT
protecting nature | living sustainably | creating a climate for change

ATTENTION: NT EPA

Re: NT Mining Operations Pty Ltd's draft EIS for Union Reefs North Underground Mine

ECNT welcome this opportunity to provide comment on NTMO's proposal.

While the rationale for restricting scope of assessment strictly to the new underground mining proposal is clear, it is disappointing that the opportunity was not taken to satisfy the public that altered parameters of the directly related Union Reefs plant have and will pursue an appropriate standard of environmental management. Our ability to meaningfully consider the impacts of this proposal are further hampered by the lack of detail on water quality objectives.

While we do not accept that the draft is adequate basis for approval, we are able to share the following comments.

Climate Change

It is imperative that the assessment process pursues a higher standard of detail and planning around issues related to climate change than has been accepted in the past. We welcome the itemisation of estimated annual greenhouse gas emissions, however the value seems low against industry averages for gold production, and itemisation might assist. It could be assumed that this figure does not include the carbon burden of milling at URPA, and no detail is offered as to how the climate impact of this existing operation is accounted for or considered within the scope of existing authorisations. It would not be exactly scandalous to find that the authorisation from over 25 years ago neglected this now prominent parameter.

And yet merely acknowledging this burden is inadequate. The proponent should be required to consider offsets for anticipated greenhouse gas emissions and other related carbon burden. The Draft acknowledges the NTEPA's Guidelines on Environmental Offsets and Associated Approval Conditions, which does not specify carbon emissions, but could be read as relevant with respect to related impacts on biodiversity. More useful is the Draft NT Offsets Policy, which was released for consultation last year, and does specify carbon emissions. ECNT recommend that no new mining approval should be granted in absence of any consideration of options for offsetting carbon debt.

So too, ECNT considers that any mining proposal should incorporate solar power. This is an obvious configuration option that the Draft does not discuss. In this instance, we would further encourage exploration of refit of the power for the plant at URPA.

While the planned project duration does not demand consideration of further destabilisation of climate related systems, reference to average annual rainfall invites consideration of data skewed to account for advancing climate change, as other operations have learnt to their detriment.

Alternatives

The Draft does a poor job of considering alternative configurations. It should be a matter of course for any project to detail the no-go alternative, and discuss pros and cons of not proceeding. Of particular interest would be the comparative implications for closure and rehabilitation.

Beyond the fore-mentioned interest in considering solar or other clean energy options, this draft could have discussed the potential of cyanide-free processing with a thiosulphate refit.

Contingencies

We are assured (section 4.10.2, Material Characterisation) that:

> *Preliminary results from recent geochemical testwork indicate that the majority of materials to be extracted from the Union Reefs North Underground Mine development will be NAF*

and the risk assessment of seepage from surface storage of waste rock is gauged as Low, on the basis:

> *While no kinetic geochemical test work has been done, static test work indicates that most (≈90%) of the material to be stored is NAF with very low levels of leachable metals/metalloids.*

However the NT has a regrettable recent history of unintended environmental harm due to overly optimistic mis-charactersiation of waste rock. It would be prudent to discuss contingency planning for the eventuality of that case in this project.

Water quality

We are told, in 4.10.2, that:

> *geochemical water quality prediction modelling [is] to be carried out as a part of additional work*

and further, in 13.3.2;

> *Geochemical modelling will be undertaken (to be included in a Supplementary report) that will address quantitatively, the level of water quality impact*

and again, from the appendix:

> *Phase 2 will be conducted when the geochemical test data is available, and will consist of a predictive water quality model, which is expected to contribute to a supplementary EIS at a later date.*

This is grossly inadequate. It is not sufficient for this significant detail to be relegated to the supplement, thereby denying the benefit of public consideration. This may compound the risk of impacts on water quality from dewatering, and potentially impacts the contingency of intentional discharges into the river (subject to aquatic ecosystem beneficial use).

Although we are informed:

> *The water quality monitoring program conducted by NTMO at the URPA includes sampling locations on the McKinlay River, a control upstream from the site (URSW09) and one which serves as a compliance point downstream from the site (URSW08). Comparison of results from analysis of water sampled at these two*

> *sites allows assessment of the impact of the URPA on the quality of water in the McKinlay River downstream of the site over the past ten wet seasons, i.e. 2010 to 2019.*

we are offered no such data, and there is no discussion of the impact of this proposal on water quality at URPA.

Rehabilitation

The closure criteria and rehabilitated landform objectives appear appropriate for a proposal of this scope. It is however disappointing that the opportunity has not been recognised to reaffirm plans for closure of those domains which may remain operational beyond end of mine, as part of the URPA. We are assured the considerations of closure of the Crosscourse Pit and Processing Operations are addressed in the URPA closure plan. But this detail evades public scrutiny. It is noteworthy that the public were granted zero visibility of the implications for these closure plans in the context of Cosmo. Now, we are presented with further input to the URPA project area, with absolutely no idea of how the additional risk and impact might be managed there.

ECNT recommend that this EIA should have been recognised as an opportunity to assert the adequacy of rehabilitation and early-closure planning so far, and to assure the public of the standard that will apply to this intimately related authorisation in the context of the additional proposal.

Section 9.3 reminds us, with:

> *NTMO will redevelop the broader URPA Mine Closure Plan (MCP) 2015 in accordance with the Western Australian Guidelines for Preparing Mine Closure Plans*

that the NT has no such standards or guidelines.

With:

> *The structure and information in the URPA MCP 2015 will need to be reconfigured and reassessed to meet new guideline requirements, and the revised URPA MCP is likely to be substantially different to previously submitted versions.*

the proponent acknowledges that this proposal represents a waypoint at which closure planning at URPA will be significantly upgraded, but then:

> *NTMO will work with the DPIR to agree on a realistic submission date for the redeveloped URPA MCP.*

tells us that parties to this assessment expect approval to be independent of this significant feature.

In this way, appropriate consideration of significant risks fall through the cracks of piecemeal assessment. The compounded rehabilitation challenged to the URPA presented by the North Underground proposal has not only been explicitly ruled out of scope of this assessment. Although we are assured that these direct impacts of this proposal will be addressed in the URPA's existing authorisation, there is no evidence of where the URPA closure plan sits now; how it has been influenced already by Cosmo; nor how it might accommodate the additional impact North Underground represents.

ECNT recommend that all parties to assessment should recognise subsequent approvals as an opportunity to reassert, or if necessary reconsider, the adequacy of opaque management plans, in the public domain. The secrecy surrounding MMPs has long been challenged, and successive NT governments have pledged to open these instruments to public scrutiny. This process is an opportunity to demonstrate the value of transparency, which includes strengthening public license by assuring high standards, and we remain interested in its progress.

Contact:

Justin Tutty

member, Environment Centre (NT)
justin@darwin.email
0424-028-741

To Whom it may Concern,

I wish to begin by declaring that I am an Employee of Kirkland Lake Gold at Their Northern Territory Operations.

The purpose of this letter is to voice my support of the EIS submitted for the extension of Mining at the Union Reefs Site.

I am Familiar with the EIS and believe KLG have given due consideration to all Aspects of the expansion.

I have been working For KLG for a bit over two years and am pleased to be working back closer to home after ten years of Fly in Fly out and interstate work. I have had previous experience in the Union Reef and Cosmo area. A standout difference to me form other mining operations that I have worked for is Kirkland Lake Gold's Dedication to maintaining their social licence to operate and the level of commitment they have to Applying Best Practice and transparency in all that they do.

Some examples of best Practice that I have observed are

- Full grouting to surface when completing Exploration Drill Holes (not a requirement although it should be)
- Pit less drilling techniques for exploration drilling
- Timely and first rate rehabilitation of drill pads and exploration tracks
- Rehabilitation of legacy mining sites and waste Dumps

I would encourage anyone who has concerns about KLG's level of commitment to Environmental Issues to organise a site Visit to the Cosmo Mine site and see firsthand the work and Financial Commitment they have made to Rehabilitation in the past few years. I hope we are looking at the future of Responsible and Sustainable Mining in the Northern Territory overall and not just one operators efforts.

Social License Extends beyond Environmental Responsibilities and I would like to bring attention to another benefit of operations.

- Buy local policy supporting many small to medium businesses in the NT
- Strong emphasis on local employment, More than 70% and looking to increase
- Relocation Assistance to bring People and their families to the NT

A point that deserves more than a bullet is the Training and upskilling of local employees that have struggled to find work in the current economic climate. This is a win win situation as in time these employees can progress from entry level positions to fill some of the skill shortages that the Industry has in the NT.

My personal Favourite of the NT Operations Core Values is "plan and do what we say we will". KLG has demonstrated the commitment to this in addition to the above mentioned by the recent upgrades of the U/R mill and Pine Creek and Cosmo Camps. This has been a significant investment and welcome work to local contractors who have done an excellent job and reinforces the fact that the NT business can get it done if given the opportunities. The time is here for External Stakeholders to give timely and thoughtful consideration to the proposals before them and allow the project to come to fruition.

Regards Trevor Edwards

08 8947 5485 P
08 8947 5486 F
admin@rhinosdiesel.com.au E
160 Winnellie Road, Winnellie NT 0820 A
PO Box 37151 Winnellie NT 0821 PO
www.rhinosdiesel.com.au W
ABN 86 111 032 467

16th January 2020

To whom it may concern:

Rhinos Diesel Services is a direct supporter to the operations of NTMO
I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable.
Rhinos Diesel Services employ 26 people most of which are directly involved with Cosmo and Union Reef operations
Subject to approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.
NTMO is a very valuable customer to many local businesses not just ours.
They have a very good reputation, for supporting local businesses and meeting the promises they make
If Darwin had more operations like this the economy would be much better

Kind Regards



Ryan Higgins
Managing Director
R Higgins Pty Ltd
T/A Rhinos Diesel Services

From: Kellie-Ann Fawcett <kellie@fawcettcontracting.com.au>
Sent: Saturday, 18 January 2020 1:33 PM
To: eia NTEPA <eia.NTEPA@nt.gov.au>
Subject: NTMO - extension of operations

To whom it may concern,

My business Fawcett Cattle Company is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 15 people (9 of these 15 employees are Indigenous Locals from within the region our business is located) and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

NTMO have always been supporters of our business and we strongly support NTMO in their endeavours. Not only because for our business but this will support many businesses in our region and many local businesses at that.

Yours sincerely,

Kellie-Ann Fawcett
Fawcett Cattle Company Pty Ltd
T/A Fawcett Contracting
196 Coach Road, Adelaide River NT 0846
ABN: 33 009 606 071
Phone: 08 8976 7040 | Mobile: 0427 857 994 | Fax: 08 8976 7090



From: Owen Pike <Owen.Pike@mmc1.com.au>
Sent: Friday, 17 January 2020 3:07 PM
To: ntepa epa <ntepa.epa@nt.gov.au>
Subject: Union Reefs North Underground Mine EIS

To whom it may concern:

Relating to the Union Reefs North Underground Mine EIS for review I have looked at the Draft environmental Impact statement at the following link:
https://ntepa.nt.gov.au/__data/assets/pdf_file/0009/760923/draft_eis_union_reefs_north_underground_mine_main_report.pdf**.**

I would like to inform MMC is a NT business owned by the Pike family who all reside in the NT, invest all profit in the NT and employs more than 150 local employees. MMC fully support NT Mining in the Mining operations at Union Reef. MMC is a current service provider to NT Mining and I have full confidence in them being responsible from environmental perspective. Furthermore MMC has been involved in the operations of the Union Reef plant with its many operators in its history and we have directly seen the benefit the operations has had for the regional area of Pine Creek but also the NT. We look forward to a quick approval of the EIS and we will see the benefit to the economy quickly as NT Mining execute as per the EIS.

Feel free to contact me for any further input.

Regards

Owen Pike
General Manager - Director | MMC Australia Pty Ltd

M: 0403 800 880
P: 08 8947 0777
E: Owen.Pike@mmc1.com.au



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Wilton Homes and Constructions Pty Ltd
PO BOX 36510, Winnellie NT 0821
ABN No: 84 153 960 957
ACN No: 153 960 957
Builders NT REG. NO. 152902CR

14th January 2020

To whom it may concern:

My business is a direct supporter to the operations of NTMO and I understand they have had an EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable.

My business directly employs 20 local people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

You would be aware of the current construction down- turn in the NT and without NTMO future carefully managed projects I would not be able to keep my current workers employed. NTMO stipulates in my contracts that I only use local workers and I support the smaller local suppliers through this.

I have witnessed through the previous 12 months on site an extremely well managed and regulated company in regards to all their policies and procedures, especially to flora, fauna, land and water management

Yours sincerely,

Shaun Wilton

Director

Mobile: 0428 583 526
Email: shaun@wiltonhomesnt.com.au
Website: www.wiltonhomesnt.com.au



TOTALWELD

Welding Equipment • Sales • Service • Hire

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P.O. Box 1409, Palmerston NT 0831
23 McCourt Road, Yarrawonga NT 0831
Phone: 08-8932 4669 Fax: 08-8932 4229
Email: sales@totalweld.com.au accounts@totalweld.com.au
ABN 27074658861

. To whom it may concern:

Totalweld Sales & Service who is a NT owned and operated local business is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations .

I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable.

My business employs 10 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Yours sincerely,

Alan Bennett

General Manager / Owner

Triple A Hoses Pty Ltd
5/48 Albatross Street, Winnellie NT 0820
Postal: PO Box 36940, Winnellie NT 0821
Mobile: 0419 182 201
Fax: (08) 8947 4725
Email: gordon@tripleahoses.com.au

ABN: 43 107 315 659
ACN: 107 315 659

16-1-2020

To whom it may concern:

My business is Triple A Hoses it is a direct supporter to the operations of NTMO and I understand they have had a EIS for review to extend their operations. I have looked at the web link for the EIS and would be pleased to support the proposed operations at Union Reef and surrounds going ahead as soon as practicable. My business employs 16 people and I am sure that with expeditious approval by the EPA, ongoing employment will be supported from what I believe to be the responsible environmental activities of this Mining Operation as reflected in the EIS.

Regards



Gordon Hounslow
Director
Triple A Hoses
0419182201
tripleahoses@gmail.com

Triple A HOSES
Any hose Anywhere Any time

Appendix 3 – Memo 1: Ghost Bat Activity Monitoring August 2019 – March 2020

KLG Ghost Bat Memorandum 1
March 2020

Union Reefs ghost bat activity monitoring August 2019 – March 2020

This memorandum and the appended report provide information from the ghost bat monitoring program at the Union Reefs project area between August 2018 and March 2020. The appended report (Barden et al. 2020) provides data collated since the preparation of the Union Reefs EIS technical report (Barden and Armstrong 2019) and provides a summary of results and an updated interpretation of the monitoring and key findings.

Key Findings

Union North and OK Adit

- Acoustic monitoring has confirmed that the Union North and OK adits are both used as diurnal roosts by ghost bats. The long-term acoustic monitoring indicates maximum calling activity at both sites across the wet season, with peaks of activity at Union North adit in the months October–November and at the OK adit in September–October and January.
- The Union North adit appears to be the main focus for ghost bat roosting. Lower activity is generally observed in the OK adit around the same time as peak activity occurs at Union North, suggesting that the bats sometimes move between the two structures.
- Ghost bat activity at the two adits was highly variable. The changing pattern of nightly activity levels across survey nights indicates that the colony may shift between the two roosts, or that the colony moves to other (unknown) roosts outside the Union Reefs project area.
- The highest levels of activity at the Union Reefs adits are around the time when ghost bats are potentially breeding and giving birth in northern Australia (August to November) (Hudson & Wilson 1986), suggesting that the colony spends some part of the breeding cycle in the Union Reefs project area.
- Based on the acoustic monitoring over two years (2018-2020) there are long periods when results indicate that ghost bats are absent from the Union Reefs project area, or there are very low levels of activity.
- Local movements are likely to be partly dependent on season. The OK adit is a shallow structure measuring c. 16 m in depth, with one crosscut tunnel around 8 m deep

entering approximately halfway down the main tunnel. The shallow depth of the OK adit is sufficient to maintain a suitable warm and humid roosting microclimate for the ghost bat during the wet season, but it is potentially unsuitably dry during the dry season. The OK adit is used as an occasional nocturnal refuge and feeding perch during the dry season.

- The Union North adit is much deeper (> 60 metres) and provides suitable roosting habitat across the dry season. However, fly-out counts and observations in March 2020 indicate that ghost bats do not roost at the Union North adit during periods of high rainfall. Monitoring and observational data suggests that the rear roosting chamber of the Union North adit may become temporarily unsuitable for ghost bats when water levels are high.
- An Internal survey of the adit using 3 dimensional laser scanning (Jensen 2019) revealed the adit floor has a declining grade of around 55 cm over 60 m. Water levels in late February 2020 potentially exceeding 1 m at the assumed ghost bat roost location. The roof level beyond 65 m is unknown but observations at the overhead stope at 60 m indicate that it may be lower than the front section of the adit.
- Comparison of the acoustics-based activity data and fly-out counts indicated a high level of correlation between numbers of ghost bats roosting at the OK adit and levels of social and other ghost bat calls detected on the acoustic recorders at the entrance. The portal-mounted microphone is approximately 14 m from the main daytime ghost bat roost location (due to the short length of the adit) allowing detection of daytime social calls generated by the roosting bats.
- As a result of the close proximity of the microphone to the roost, activity levels at the OK adit reflect the numbers roosting within the adit. The acoustics based monitoring shows that ghost bats are absent from the OK adit over long periods of time and only roost at this location occasionally. The monitoring also indicates that there are long periods of absence across the dry season (April to September).
- There is a lower degree of correlation between the numbers of ghost bats counted and the levels of activity detected on the detector at the Union North adit, because the actual roost location is remote from the microphone at the portal (greater than 60 m), and daytime social calls from the roosting cluster are not recorded. The apparent lower levels of activity at the Union North adit during some periods may be related to the absence of detectability of the bats at the roost location. The actual location of the Union North roost has not been accessed due to safety concerns related to an unstable

overhand stope at approximately 60 m depth. Ghost bats in the Union North adit are detectable as they exit or perch close to the portal before exiting.

Prospect Adit

- Acoustic monitoring at the Prospect adit suggests a low level of use, mainly as a nocturnal feeding site, and occasionally as a diurnal roost site by a small number or individual ghost bats. Low levels of ghost bat vocalisations have been detected at Prospect adit during the day on 20% of the monitored nights, predominantly across the pre-monsoon build-up and wet season (September to January).
- During a 5-day period in September 2019, higher levels of ghost bat activity (social calls) were detected during the day at Prospect adit, indicating that the site was used as a daytime roost by a small group of ghost bats.
- The data indicates that diurnal use of the Prospect adit by ghost bats is extremely uncommon across the dry season. Considering the short length of the adit and the location of the microphone, it is unlikely that ghost bats would be present during the day but remain undetected.
- As was observed at the Union North adit and OK adit, there are periods where ghost bats are apparently absent from the Prospect adit, particularly through the dry season from April to October. The acoustic data indicates that the Prospect adit is used on a less regular basis by ghost bats than the Union North adit and OK adit.

Lady Alice Adit

- In December 2019, the entrance to the Lady Alice adit was expanded using hand tools to allow human access, so that an internal structural assessment and placement of a humidity/temperature logger could be made. The opening was expanded to 0.5 m x 0.7 m.
- Bats were monitored with an Anabat Swift bat detector at the entrance of the Lady Alice adit between December 2019 and January 2020. During the initial monitoring period (to early January 2020) ghost bats were recorded on 83% of monitored dates (detection of social calls). In each 24-hour period, 0 to 3 echolocation calls (mean: 1.1) and 0 to 5 (mean: 1) social calls were recorded. All calls were recorded between 7 pm and 5 am and it is therefore not possible to determine whether ghost bats were using Lady Alice as a diurnal roost.
- During an internal inspection of the Lady Alice adit following the enlargement of the adit, a small pile of ghost bat scats was located on the floor approximately halfway

along the tunnel, indicating that ghost bats had accessed the adit. Up to 15 dusky leaf-nosed bats (*Hipposideros ater*) and orange diamond-faced bats (*Rhinonicteris aurantia*) were present within the adit during retrieval of the temperature and humidity data in late February 2020.

Other Bat Species

- The dusky leaf-nosed bat and orange diamond-faced bat were recorded at the Union North adit, OK adit, Lady Alice adit and Prospect adit, with the Union North adit having the most activity. These species were also recorded commonly at the OK adit, but with fewer nightly detections.
- Acoustic analysis has included scans for the northern leaf-nosed bat (*Hipposideros stenotis*), a species listed as Vulnerable under the Northern Territory *Territory Parks and Wildlife Conservation Act 2014*. This species has not been detected at any of the Union Reefs adits across the 2018–2020 monitoring period.

Paul Barden/Nicola Hanrahan/Kyle Armstrong
Ecological Management Services Pty Ltd
6 March 2020

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Barden, P, Armstrong, A. and Hanrahan, N. (2020). Union Reefs Ghost Bat Monitoring Program Interim Report, March 2020. Unpublished report by Ecological Management Services Pty Ltd, Specialised Zoological, and Nicola Hanrahan Consulting Services to Kirkland Lake Gold Ltd, 5 March 2020.

Union Reefs Ghost Bat Monitoring Program Interim Report March 2020

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SZ Specialised Zoological



Prepared for
Kirkland Lake Gold

Revision 3
5 March 2020



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Project

Union Reefs Ghost Bat Monitoring Program Interim Report

March 2020

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Cover Photo

Entrance of the Ok Adit, Prospect Pit, Union Reefs

Document History

Version	Date	Author/s	Reviewer
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Contents

1. Introduction **1**

2. Monitoring Methods **2**

2.1. Acoustic Monitoring 2

2.2. Video Monitoring 2

2.3. Data Loggers 3

3. Acoustic Monitoring Results **3**

3.1. Union North and OK Adit 3

3.2. Prospect Adit 5

3.3. Lady Alice Adit 5

3.4. Other Bat Species 6

4. Video Monitoring Results **10**

5. Summary of Findings **14**

5.1. Union North and OK Adit 14

5.2. Prospect Adit 15

5.3. Lady Alice Adit 16

5.4. Other Bat Species 16

6. References **17**

Table 4.1 Video Count Data: Union North and OK Adits, Union Reefs Project Area, August 2018 – March 2020

Figure 1 Union Reefs Project Area

Figure 2 Ghost Bat Social Call Acoustic Data and Thermal/Infrared Video Fly-out Counts, October 2018 – January 2020.

Figure 3 Prospect Adit Ghost Bat Social Call Acoustic Data October 2018 – January 2020

Figure 4 Ghost Bat Video Fly-out Counts, October 2018 – March 2020

1. Introduction

Northern Territory Mining Operations (NTMO), owned by Kirkland Lake Gold (KLG), is in the process of developing approvals for the Union Reefs North Underground Mine (the project) to target the Prospect Claim gold deposit mineralisation. The site is located 13 km north of Pine Creek and 170 km south-east of Darwin (Figure 1). Underground mining is proposed for two years, with the possibility of an extension of operations. Mine development will be completed along the Union Line and extend into the Lady Alice Line. The underground development will also be used as an exploration point to test mineralisation deeper in the Union trend, as well as new mineralisation on the Lady Alice trend. Both of these mineralised trends have been mined previously via the Union North, Prospect, Lady Alice, Crosscourse and Millars open pits.

The underground mine will be accessed via a portal and decline developed from within the existing Prospect North open pit. The Prospect north and south open pits will be completely dewatered to facilitate portal construction. The Prospect south open pit will be used to store waste rock, prior to this material being returned underground and used as backfill during mining operations. This is the same model for waste rock management used at the Cosmo Deeps mine by KLG.

This report details the results of the analysis of baseline data collected during a monitoring program targeting ghost bats within the Union Reefs project area between the August 2018 and March 2020, and provides an update of data since the preparation of the Union Reefs EIS ghost bat technical report (Armstrong and Barden 2019). The current program of ghost bat monitoring at Union Reefs commenced during initial surveys conducted in August 2018, and continued through the subsequent the exploration drilling program, as was outlined in the ghost bat monitoring plan for the Union Reefs Exploration Drilling Program 2018–2019 (Armstrong and Barden 2018b). The present report also includes data derived from occasional memoranda that summarised results over the monitoring period. The data generated from the acoustic monitoring and roost fly-out counts covers a period spanning two ghost bat breeding periods.

2. Monitoring Methods

2.1. Acoustic Monitoring

Monitoring the presence of bats using ultrasonic sound recorders ('bat detectors'; AnaBat Swift full spectrum bat detectors fitted with S-O Omnidirectional Ultrasonic Microphone, Titley Electronics) began at the Union North adit and OK adit on 22 October 2018, and at Prospect adit on 31 October 2018. Monitoring was undertaken at the Union North adit and OK adit over the period to January 2020 (445 nights) with occasional gaps in the data collection. The recording data gaps were mainly due to interference from wildlife, cable and battery failures or storage media reaching capacity. On two occasions detectors were rotated from the field to repair minor faults that did not interrupt the collection of data. Bat detectors were placed at the entrance of the adits with microphones directed inside the portal. 10 m microphone extension leads were added to allow microphones to be placed inside the entrance of each adit while reducing any disturbance to the roosts during maintenance of the detectors and retrieval of data. Acoustic data was recovered weekly by KLG environment staff and data analysis was conducted by Nicola Hanrahan.

Bat calls were grouped based on the similarity of their signature structure into preliminary clusters by Wildlife Acoustics Kaleidoscope Pro version 4.5 software. Examples within each cluster were then checked manually, and identified as ghost bat echolocation or social calls, or as the echolocation calls of other bat species. Acoustic data was also checked for the presence of the northern leaf-nosed bat (*Hipposideros stenotis*), a cave-roosting species that is listed as Vulnerable under Northern Territory legislation.

Results were exported for plotting using an [R] computing language script and presented graphically as numbers of acoustic detections per day. Separate analysis was undertaken where required to determine if calls were recorded at adits during the day, indicating that the location was being used as a diurnal roost.

2.2. Video Monitoring

Video monitoring was conducted at the OK adit and Union North adit to obtain estimates of the numbers of ghost bats using these structures as diurnal roosts. Video fly-out counts were conducted at intervals across the acoustic monitoring program (August 2018 to March 2020). Video recordings were collected at the entrance of the adits using a FLIR Tau thermal camera connected to a SportDV digital video recorder, or a Raspberry Pi micro-computer infrared video recording system developed by Specialised Zoological for the project. The earliest counts (August 2018) were also conducted using a Sony Handycam FDR-ax33 with low light recording capability. Camera systems were set a short distance (5 to 10 m depending on the local topography) from the portal at an angle allowing framing of the bats exiting each adit during the fly-out.

Camera systems were set to commence recording at or just after sunset (c. 15 minutes before the end of civil twilight) and to record continuously across the most likely emergence period (dusk to 9 pm). Recording was continued until 11 pm to account for late emergence. Video files were inspected in VLC version 3.0.x software, and the number of ghost bats re-entering the roost was subtracted from the number exiting to generate a daily count of colony size.

2.3. Data Loggers

Data loggers (Tinytag Plus 2) were placed in the Lady Alice and Union Reefs adits in December 2019 to record internal temperature and humidity levels. An additional Tinytag vibration logger was placed within the Union North Adit. Data loggers were placed within the Lady Alice adit 12 m from the portal, and at a pile of debris below an overhead stope in the Union North adit approximately 60 m from the portal. Data was downloaded in late February 2020 and will be used to inform the design of artificial ghost bat roosts planned for the Union Reefs project area. Results will be reported in the roost design project report. The adits were entered at night after the period when ghost bats generally emerge, and following observations at the portal of each adit to ensure that ghost bats were not disturbed. Ghost bats were not observed at either adit during the period of entry.

3. Acoustic Monitoring Results

3.1. Union North and OK Adit

- Acoustic monitoring has confirmed that the Union North and OK adits are both used as diurnal roosts by ghost bats (Figure 2). The long-term acoustic monitoring indicates maximum calling activity at both sites across the wet season, with peaks of activity at Union North in the months October–November and at the OK adit in September–October and January.

- The Union North adit appears to be the main focus for ghost bat roosting. Lower activity is generally observed in the OK adit around the same time of peaks at Union North, suggesting that the bats sometimes move between the two structures.

- Ghost bat activity at the two adits was highly variable. The changing pattern of nightly activity levels across survey nights indicates that the colony may shift between the two roosts, or that it moves to other (unknown) roosts outside the Union Reefs project area.

- The highest levels of activity at the Union Reefs adits are around the time when ghost bats are potentially breeding and giving birth in northern Australia (August to November) (Hudson & Wilson 1986), suggesting that the colony spends some part of the breeding cycle in the Union Reefs project area.

- Based on the acoustic monitoring there are long periods when ghost bats are absent from the Union Reefs site, or there are very low levels of activity.

- Local movements are likely to be partly dependent on season. The OK adit is a shallow structure measuring c. 16 m in depth, with one crosscut tunnel around 8 m deep entering approximately halfway down the main tunnel. The shallow depth of the OK adit is sufficient to maintain a suitable warm and humid roosting microclimate for the ghost bat during the wet season, but it is potentially unsuitably dry during the dry season. The OK adit is used as an occasional nocturnal refuge and feeding perch during the dry season.

- The Union North adit is much deeper (> 60 metres) and provides suitable roosting habitat across the dry season. However, fly-out counts and observations in March 2020 indicate that ghost bats do not roost at the Union North adit during periods of high rainfall. Monitoring and observational data suggests that the rear roosting chamber of the Union North adit may become temporarily unsuitable for ghost bats when water levels are high. Internal survey of the adit using 3 dimensional laser scanning (Jensen 2019) revealed the adit floor has a declining grade of around 55 cm over 60 m with water levels in late February 2020 potentially exceeding 1 m at the assumed ghost bat roost location. The roof level beyond 65 m is unknown but observations at the overhead stope at 60 m indicate that it may be lower than the front section of the adit.

- Comparison of the acoustics-based activity data and fly-out counts indicated a high level of correlation between numbers of ghost bats roosting at the OK adit and levels of social and other ghost bat calls detected on the acoustic recorders at the entrance. The portal-mounted microphone is approximately 14 m from the main daytime ghost bat roost location due to the short length of the adit, allowing detection of daytime social calls generated by the roosting bats.

- As a result of the close proximity of the microphone to the roost, activity levels at the OK adit reflect the numbers roosting within the adit. The acoustics-based monitoring shows that ghost bats are absent from the OK adit over long periods of time, and only roost at this location occasionally, and that there are long periods of absence across the dry season (April to September).

- There is a lower degree of correlation between the numbers of ghost bats counted and the levels of activity detected on the detector at Union North, because the actual roost location is remote from the microphone at the portal (greater than 60 m), and daytime social calls from the roosting cluster are not recorded. The apparent lower levels of activity at the Union North adit during some periods may be related to the absence of detectability of the bats at the roost location. The actual location

of the Union North roost has not been accessed due to safety concerns related to an unstable overhand stope at approximately 60 m depth. Ghost bats in the Union North adit are detectable as they exit or perch close to the portal before exiting.

3.2. Prospect Adit

- Acoustic monitoring at the Prospect adit suggests a low level of use, mainly as a nocturnal feeding site, and occasionally a diurnal roost site by a small number or individual ghost bats. Low levels of ghost bat vocalisations have been detected at Prospect adit during the day on 20% of the monitored nights, predominantly across the pre-monsoon build-up and wet season (September to January) (Figure 3).

- During a 5-day period in September 2019, higher levels of ghost bat activity (social calls) were detected during the day at Prospect adit, indicating that the site was used as a daytime roost by a small group of ghost bats.

- The data indicates that diurnal use of the Prospect adit by ghost bats is extremely uncommon across the dry season, and given the placement of the acoustic device and short length of the adit, it is unlikely that ghost bats would be present during the day but remain undetected.

- As was observed at the Union North adit and OK adit, there are periods where ghost bats are apparently absent from the Prospect adit, particularly through the dry season from April to October (Figure 3). The acoustic data indicates that the Prospect adit is used on a less regular basis by ghost bats than the Union North adit and OK adit.

3.3. Lady Alice Adit

- In December 2019, the entrance to the Lady Alice adit was expanded using hand tools to allow human access, so that an internal structural assessment and placement of a humidity/temperature logger could be made. The opening was expanded to 0.5 m x 0.7 m.

- Bats were monitored with an AnaBat Swift bat detector at the entrance of the Lady Alice adit between December 2019 and January 2020. During the initial monitoring period (to early January 2020) ghost bats were recorded on 83% of monitored dates (detection of social calls). In each 24-hour period, 0 to 3 echolocation calls (mean: 1.1) and 0 to 5 (mean: 1) social calls were recorded. All calls were recorded between 7 pm and 5 am and it is therefore not possible to determine whether ghost bats were using Lady Alice as a diurnal roost.

- During an internal inspection of the adit following the enlargement of the adit, a small pile of ghost bat scats was located on the floor approximately halfway along the tunnel, indicating that ghost bats had accessed the site. Up to 15 dusky leaf-nosed bats (*Hipposideros ater*) and orange diamond-faced bats (*Rhinonicteris aurantia*) were present within the adit during retrieval of the temperature and humidity data in late February 2020.

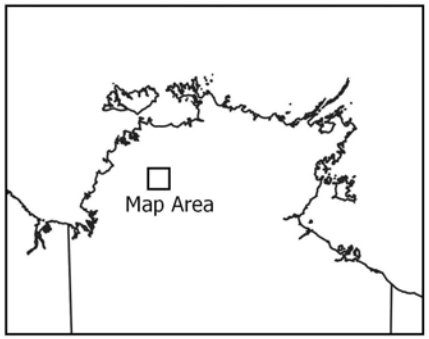
3.4. Other Bat Species

- The dusky leaf-nosed bat and orange diamond-faced bat were recorded at the Union North adit, OK adit, Lady Alice adit and Prospect adit, with the Union North adit having the most activity. These species were also recorded commonly at the OK adit, but with fewer nightly detections.

- Acoustic analysis has included scans for the northern leaf-nosed bat (*Hipposideros stenotis*), a species listed as Vulnerable under the Northern Territory *Territory Parks and Wildlife Conservation Act 2014*. This species has not been detected at any of the Union Reefs adits across the 2018–2020 monitoring period.

Figure 1. Union Reefs Project Area

Mapping data source: GEOScience Australia/ALA/NT Fauna Atlas 2019
Datum: Map Grid of Australia 94
Zone 52/GDA94 UTM
Original mapping layer data Copyright EMS Pty Ltd 2019
ems@ems.eco
Client: KLG
Project: UR Ghost Bat Monitoring
Date: 25 FEB 2020
Author: PB

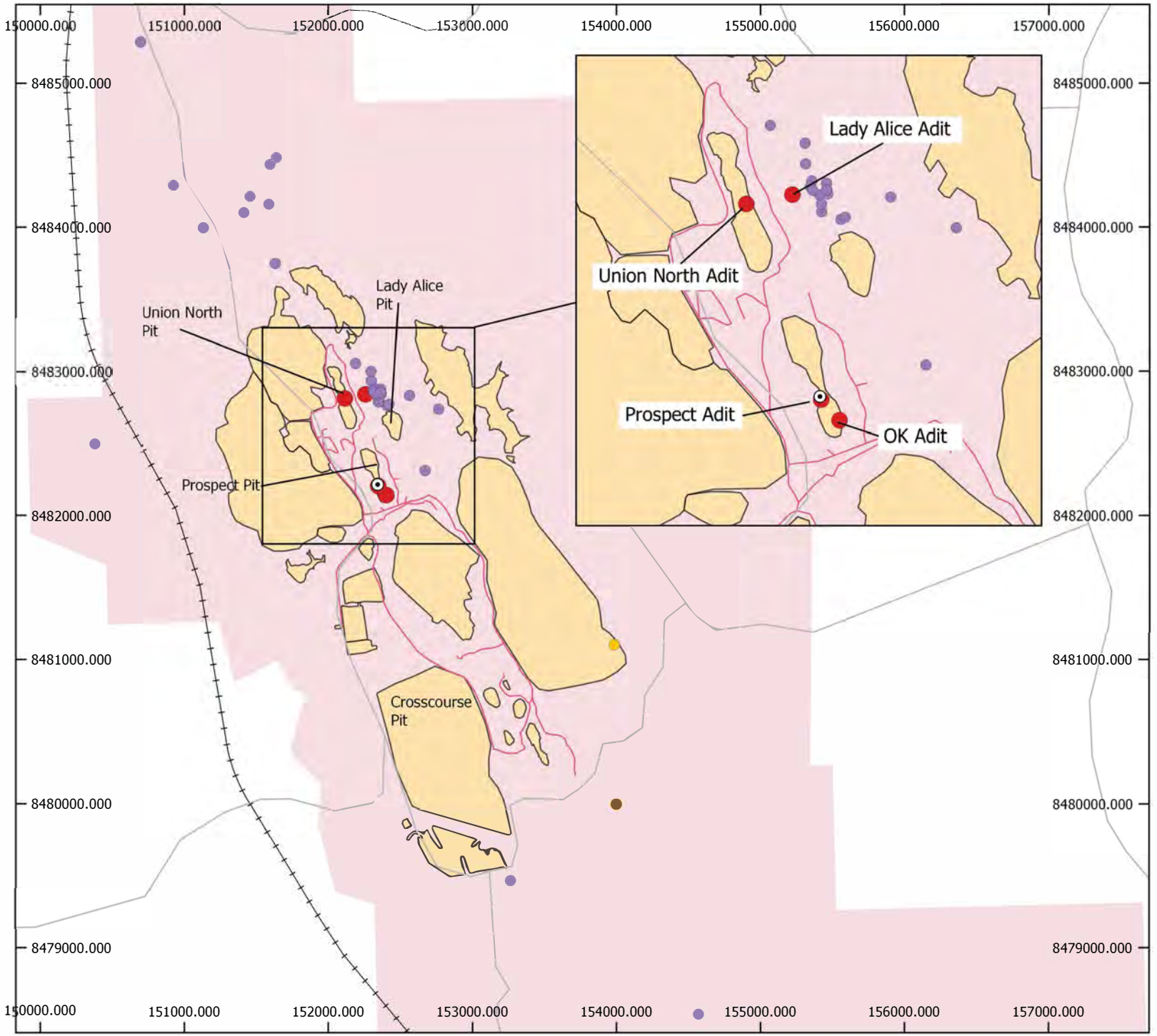


Legend

- Ghost Bat Records NT Fauna Atlas
- Adit (Historical)
- Proposed Portal
- Heritage Mining Sites (Checked)
- roads
- railways
- Mineral Titles Granted
- Union Reefs Operations

0 500 1000 1500 m

N



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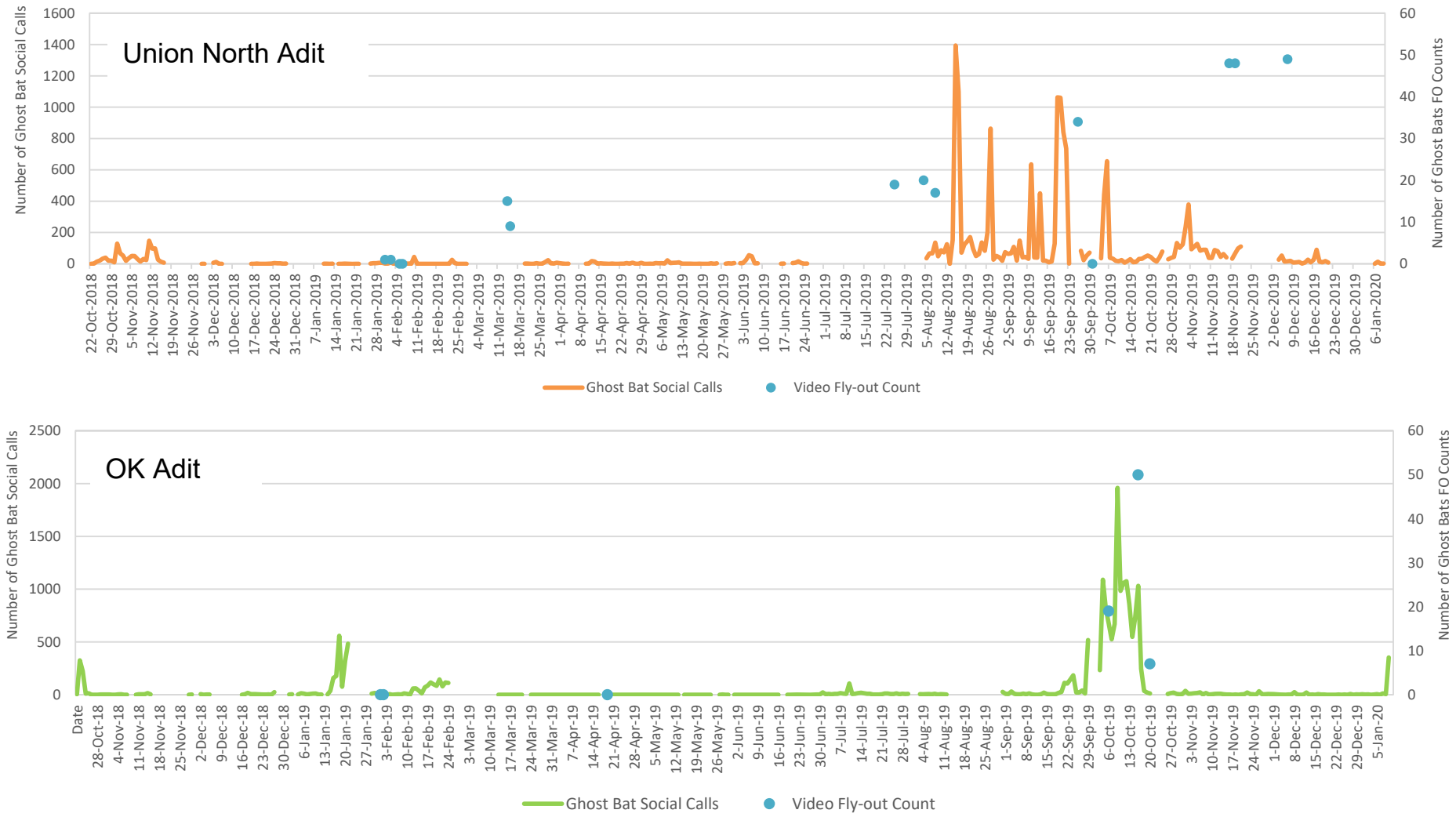


Figure 2. Ghost Bat Social Call Acoustic Data and Thermal/Infrared Video Fly-out Counts, October 2018 – January 2020

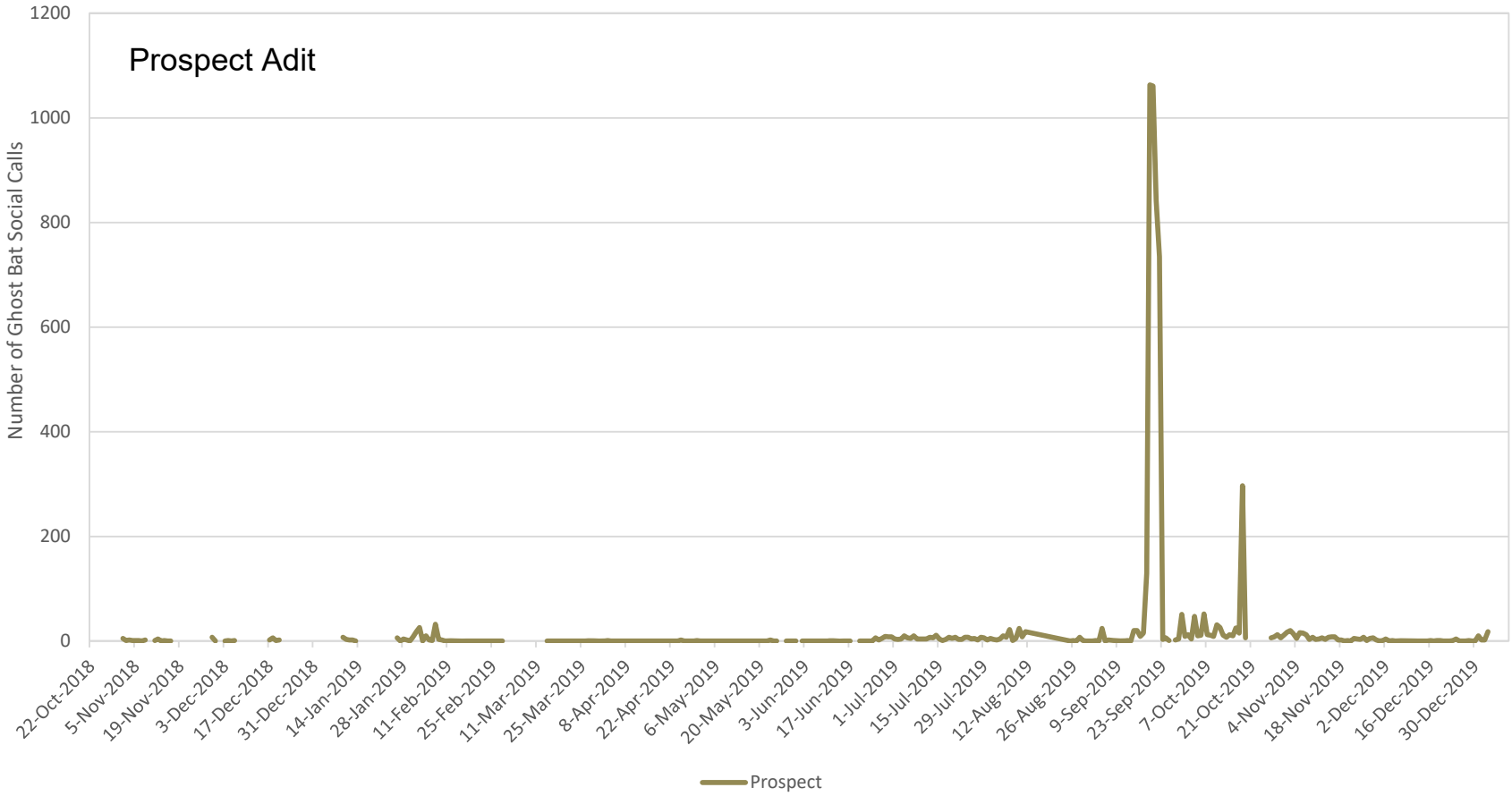


Figure 3. Prospect Adit Ghost Bat Social Call Acoustic Data, October 2018 – January 2020

4. Video Monitoring Results

- 53 video fly-out counts were conducted at the Union North adit and OK adit from August 2018 to March 2020. Video recordings (thermal or infrared) helped to give reliable counts of colony size. Colony size for the Union Reefs adits varied between c. 0–50 individuals across the sample period.

- 28 of the fly-out counts successfully recorded the entire fly-out period (dusk to 9 pm), allowing an estimate of ghost bat numbers occupying the adits (Table 4.1; Figure 4). The successful counts were conducted using three different camera types, including a Sony Handycam FDR-ax33 with a low light capability setting (n=3), a FLIR Tau 320 thermal video camera (n=17) and infrared cameras (n=10). Simultaneous counts using two different camera types (infrared and thermal cameras) were conducted at the same adit on three occasions to compare the two methods.

- 44 percent of fly-out counts failed to provide an accurate count of ghost bats (designated F in Table 4.1) due to a number of factors, including rainfall, humidity on the lens or mist obscuring bats leaving the portal, equipment failure due to wildlife interference or other unspecified equipment failure. Fly-out counts were considered to have failed if any part of the main flyout period from dusk to 9 pm was not recorded.

- Counts conducted prior to October 2019 using infra-red and thermal video cameras at both the OK adit and Union North adit indicated a colony size of approximately 20-30 individuals (maximum count 34 individuals, September 2019). Fly-out counts conducted in October, November and December 2019 recorded a peak of 48–50 ghost bats. These ghost bats roosted mainly in the Union North adit, but the entire group roosted at the OK adit on at least one occasion (mid-October 2019).

- The fly-out counts confirmed that ghost bats are absent from the Union North and OK adits at certain times.

Table 4.1 Video Count Data: Union North and OK Adits, Union Reefs Project Area, August 2018 – March 2020

Location	Union North	Union North	Union North	OK Adit	OK Adit
Camera Type	Sony HC	Thermal FLIR	Infrared	Thermal FLIR	Infrared
20-Aug-2018		4			
21-Aug-2018	7				
22-Aug-2018	10				
23-Aug-2018	7				
8-Dec-2018			F		
9-Dec-2018			F		
10-Dec-2018			F		
11-Dec-2018			F		
30-Jan-2019					F
31-Jan-2019			1		
1-Feb-2019			F		F
2-Feb-2019			1		0
3-Feb-2019					0
4-Feb-2019			F		F
5-Feb-2019			0		F
6-Feb-2019			0		
7-Feb-2019					F
1-Mar-2019					
16-Mar-2019			F		
17-Mar-2019			F		
18-Mar-2019			F		
19-Mar-2019			F		
26-Mar-2019					F
27-Mar-2019					F
30-Mar-2019			F		F
3-Apr-2019			F		F
14-Apr-2019		15	15		
15-Apr-2019		9	9		
16-Apr-2019			F		
20-Apr-2019				0	0
1-May-2019					
1-Jun-2019					
25-Jul-2019		19			
4-Aug-2019		20	19		
8-Aug-2019		17			
8-Sep-2019		17			
26-Sep-2019		34			
4-Oct-2019					F
7-Oct-2019				19	
17-Oct-2019				50	

Location	Union North	Union North	Union North	OK Adit	OK Adit
Camera Type	Sony HC	Thermal FLIR	Infrared	Thermal FLIR	Infrared
21-Oct-2019				7	
17-Nov-2019		48			
19-Nov-2019		48			
7-Dec-2019		49			
1-Mar-2020		0		20	
Total Counts at Site	3	12	20	5	13
Maximum Count	10	49	19	50	0
Total Flyout Counts					53

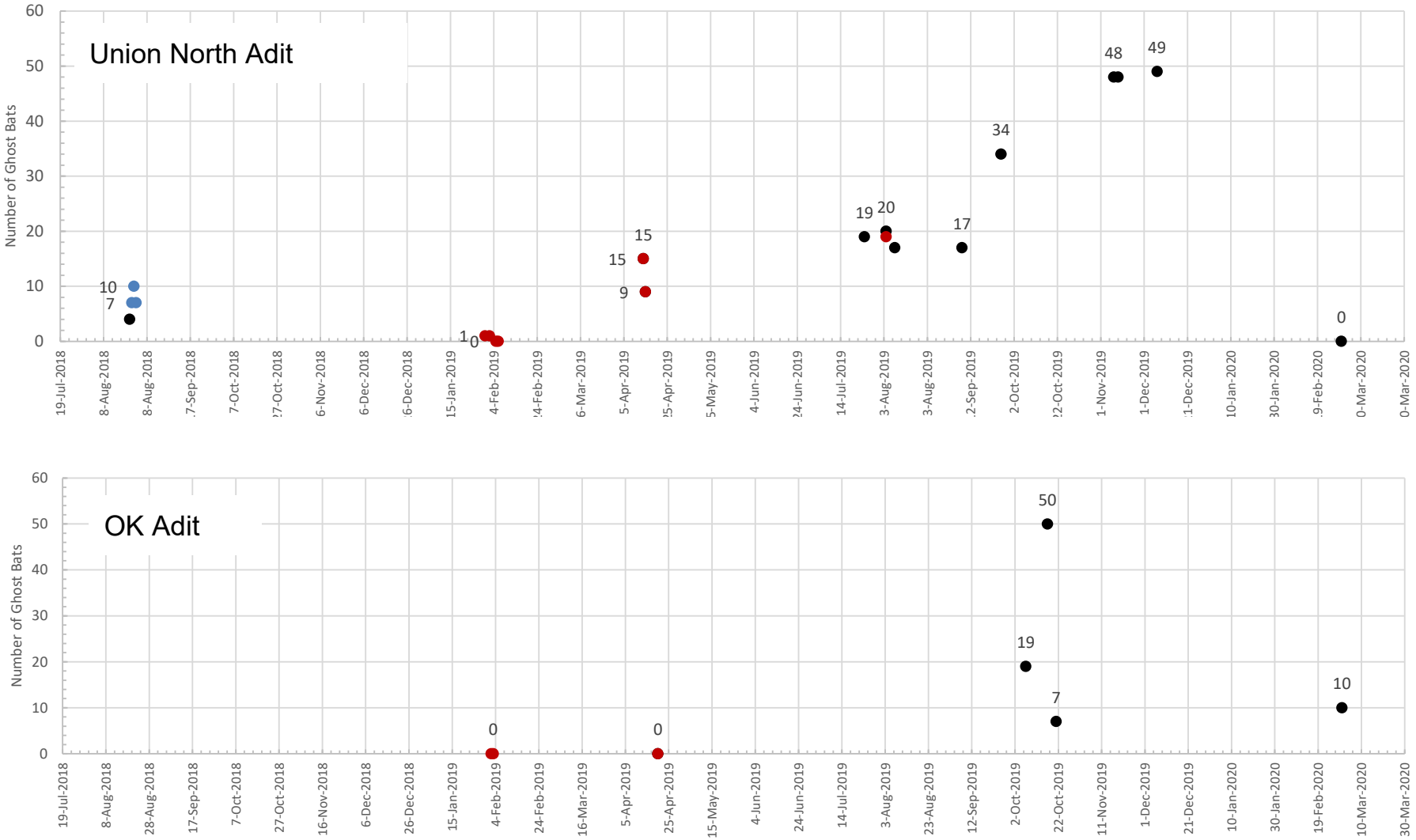


Figure 4. Ghost Bat Video Fly-out Counts, October 2018 – March 2020. Blue circle = Sony HC; Red circle = Infrared; Black circle = Thermal FLIR

5. Summary of Findings

5.1. Union North and OK Adit

- Acoustic monitoring has confirmed that the Union North and OK adits are both used as diurnal roosts by ghost bats. The long-term acoustic monitoring indicates maximum calling activity at both sites across the wet season, with peaks of activity at Union North adit in the months October–November and at the OK adit in September–October and January.

- The Union North adit appears to be the main focus for ghost bat roosting. Lower activity is generally observed in the OK adit around the same time as peak activity occurs at Union North, suggesting that the bats sometimes move between the two structures.

- Ghost bat activity at the two adits was highly variable. The changing pattern of nightly activity levels across survey nights indicates that the colony may shift between the two roosts, or that the colony moves to other (unknown) roosts outside the Union Reefs project area.

- The highest levels of activity at the Union Reefs adits are around the time when ghost bats are potentially breeding and giving birth in northern Australia (August to November) (Hudson & Wilson 1986), suggesting that the colony spends some part of the breeding cycle in the Union Reefs project area.

- Based on the acoustic monitoring over two years (2018-2020) there are long periods when results indicate that ghost bats are absent from the Union Reefs project area, or there are very low levels of activity.

- Local movements are likely to be partly dependent on season. The OK adit is a shallow structure measuring c. 16 m in depth, with one crosscut tunnel around 8 m deep entering approximately halfway down the main tunnel. The shallow depth of the OK adit is sufficient to maintain a suitable warm and humid roosting microclimate for the ghost bat during the wet season, but it is potentially unsuitably dry during the dry season. The OK adit is used as an occasional nocturnal refuge and feeding perch during the dry season.

- The Union North adit is much deeper (> 60 metres) and provides suitable roosting habitat across the dry season. However, fly-out counts and observations in March 2020 indicate that ghost bats do not roost at the Union North adit during periods of high rainfall. Monitoring and observational data

suggests that the rear roosting chamber of the Union North adit may become temporarily unsuitable for ghost bats when water levels are high.

- An Internal survey of the adit using 3 dimensional laser scanning (Jensen 2019) revealed the adit floor has a declining grade of around 55 cm over 60 m. Water levels in late February 2020 potentially exceeding 1 m at the assumed ghost bat roost location. The roof level beyond 65 m is unknown but observations at the overhead stope at 60 m indicate that it may be lower than the front section of the adit.

- Comparison of the acoustics-based activity data and fly-out counts indicated a high level of correlation between numbers of ghost bats roosting at the OK adit and levels of social and other ghost bat calls detected on the acoustic recorders at the entrance. The portal-mounted microphone is approximately 14 m from the main daytime ghost bat roost location (due to the short length of the adit) allowing detection of daytime social calls generated by the roosting bats.

- As a result of the close proximity of the microphone to the roost, activity levels at the OK adit reflect the numbers roosting within the adit. The acoustics based monitoring shows that ghost bats are absent from the OK adit over long periods of time and only roost at this location occasionally. The monitoring also indicates that there are long periods of absence across the dry season (April to September).

- There is a lower degree of correlation between the numbers of ghost bats counted and the levels of activity detected on the detector at the Union North adit, because the actual roost location is remote from the microphone at the portal (greater than 60 m), and daytime social calls from the roosting cluster are not recorded. The apparent lower levels of activity at the Union North adit during some periods may be related to the absence of detectability of the bats at the roost location. The actual location of the Union North roost has not been accessed due to safety concerns related to an unstable overhand stope at approximately 60 m depth. Ghost bats in the Union North adit are detectable as they exit or perch close to the portal before exiting.

5.2. Prospect Adit

- Acoustic monitoring at the Prospect adit suggests a low level of use, mainly as a nocturnal feeding site, and occasionally as a diurnal roost site by a small number or individual ghost bats. Low levels of ghost bat vocalisations have been detected at Prospect adit during the day on 20% of the monitored nights, predominantly across the pre-monsoon build-up and wet season (September to January).

- During a 5-day period in September 2019, higher levels of ghost bat activity (social calls) were detected during the day at Prospect adit, indicating that the site was used as a daytime roost by a small group of ghost bats.

- The data indicates that diurnal use of the Prospect adit by ghost bats is extremely uncommon across the dry season. Considering the short length of the adit and the location of the microphone, it is unlikely that ghost bats would be present during the day but remain undetected.

- As was observed at the Union North adit and OK adit, there are periods where ghost bats are apparently absent from the Prospect adit, particularly through the dry season from April to October. The acoustic data indicates that the Prospect adit is used on a less regular basis by ghost bats than the Union North adit and OK adit.

5.3. Lady Alice Adit

- In December 2019, the entrance to the Lady Alice adit was expanded using hand tools to allow human access, so that an internal structural assessment and placement of a humidity/temperature logger could be made. The opening was expanded to 0.5 m x 0.7 m.

- Bats were monitored with an AnaBat Swift bat detector at the entrance of the Lady Alice adit between December 2019 and January 2020. During the initial monitoring period (to early January 2020) ghost bats were recorded on 83% of monitored dates (detection of social calls). In each 24-hour period, 0 to 3 echolocation calls (mean: 1.1) and 0 to 5 (mean: 1) social calls were recorded. All calls were recorded between 7 pm and 5 am and it is therefore not possible to determine whether ghost bats were using Lady Alice as a diurnal roost.

- During an internal inspection of the Lady Alice adit following the enlargement of the adit, a small pile of ghost bat scats was located on the floor approximately halfway along the tunnel, indicating that ghost bats had accessed the adit. Up to 15 dusky leaf-nosed bats (Hipposideros ater) and orange diamond-faced bats (Rhinonicteris aurantia) were present within the adit during retrieval of the temperature and humidity data in late February 2020.

5.4. Other Bat Species

- The dusky leaf-nosed bat and orange diamond-faced bat were recorded at the Union North adit, OK adit, Lady Alice adit and Prospect adit, with the Union North adit having the most activity. These species were also recorded commonly at the OK adit, but with fewer nightly detections.

- Acoustic analysis has included scans for the northern leaf-nosed bat (*Hipposideros stenotis*), a species listed as Vulnerable under the Northern Territory *Territory Parks and Wildlife Conservation Act 2014*. This species has not been detected at any of the Union Reefs adits across the 2018–2020 monitoring period.

Paul Barden, Kyle Armstrong, Nicola Hanrahan
Ecological Management Services Pty Ltd/Specialised Zoological
5 March 2020

6. References

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Appendix 4 – Ghost Bat Action Plan

An Action Plan for the management of Ghost Bats in the Union Reefs project area



Prepared for Kirkland Lake Gold Ltd

Version 2020-03-11

Specialised Zoological

EMS | ECOLOGICAL MANAGEMENT SERVICES
ENVIRONMENTAL CONSULTANTS

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Version 2020-03-11

Prepared for Kirkland Lake Gold Ltd
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Contents

	Page
Background	4
Glossary	6
Vision	7
Overall goal	7
Specific objectives of the Action Plan	7
Specific questions addressed by the Action Plan	8
Strategy of this Action Plan	8
Summary of Actions	10
Phased timing of the Actions	11
Action 1—Exclude the Ghost Bat from the OK adit	12
Action 2—Characterise the internal dimensions of the Lady Alice adit, OK adit, and Union North adit.	15
Action 3—Create several artificial habitats.	17
Action 4—Re-open and rehabilitate the Lady Alice adit.	21
Action 5—Manage the Union North adit.	23
Action 6—Implement management and protection measures at the Pine Creek roost.	25
Action 7—Monitor the Ghost Bat at known local and regional roosts.	28
Action 8—Provide a portion of the new mine for Ghost Bat occupancy.	32
Action 9—Conduct field surveys for Ghost Bat diurnal roosts in natural caves.	34
Action 10—Investigate the connectedness of Ghost Bat colonies in the region.	37
Action 11—Provide support for further academic research on the Ghost Bat.	39
References	41

Background

This Action Plan was developed as part of the Environmental Impact Statement (EIS) for the Union Reefs North Underground Project (the Project) by NT Mining Operations Pty Ltd (NTMO), which is owned by Kirkland Lake Gold Ltd (KLG). They plan to further develop deposits of gold ore in the Union Reefs project area, north of Pine Creek in the Northern Territory, by constructing a new underground mine with an entrance portal in the existing Prospect pit.

The Ghost Bat *Macroderma gigas*, which is specially protected and listed as Vulnerable under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999*, has been detected in the Union Reefs project area, both in the past (NSR Environmental Consultants 1993), and on recent surveys (Armstrong and Barden 2018—contains a summary of the biology of the species; Hanrahan et al. 2019).

At present, Ghost Bats are known to use two main sites for diurnal roosting within the Union Reefs project area—'Union North adit' in the Union North pit; 'OK adit' in the Prospect pit. These confirmed diurnal roosts are within the remnants of the lower parts of underground adits that are found extending back from the walls of two open-cut mine pits. The adits are small, with tunnels being around c. 1.5 m high by 1.5 m wide, and are part of the goldfield that was worked mostly between c. 1880 and 1910 (White et al. 1965). The open-cut mine pits are the result of contemporary mining activity in the past three decades. The extent of the underground remnants was unknown, as historical maps were not available (White et al. 1965), but a recent survey has shown them to be relatively deep (Barden 2020a).

A drilling programme being conducted currently has taken into consideration the presence of Ghost Bats in the two adits, and activities have been modified to avoid drilling within close proximity (within 130 m) of roost site positions and entrances (see management plan of Armstrong and Barden 2019). Data from continuous monitoring of Ghost Bat presence and activity conducted since the targeted Ghost Bat survey of August 2018 (encompassing two breeding seasons) has shown that the species is often present in the Union Reefs area, but there are also periods when ghost bats are absent or when colonies comprise just a few individuals (summary in Barden and Armstrong 2019; Barden et al. 2020a,b). This suggests that there is a flux of individuals in and out of the Union Reefs area.

A single colony of the Ghost Bat occurs in the Union Reefs area, using both the Union North adit and OK adit, with the majority of individuals switching between the two sites at various times during the year, (Hanrahan et al. 2019; Barden and Armstrong 2019; Barden et al. 2020). The size of the colony has been estimated at 20–30 individuals on some occasions, reaching 50 individuals in November–December 2019 (Armstrong and Barden 2018; Barden and Armstrong 2019; Hanrahan et al. 2019, Barden et al. 2020a,b).

The presence of the Ghost Bat has been noted during most of the breeding cycle (Hanrahan et al. 2019; Barden and Armstrong 2019; Barden et al. 2020a,b), but few direct observations associated with breeding have been made (only when observations began in 1987; NSR Environmental Consultants 1993), mainly because the sensitivity of this species to disturbance precludes capture and direct observations.

Two other adits nearby (the 'Prospect adit' in the Prospect pit, with an entrance portal c. 90 m from that of the OK adit; and what is thought to be the Lady Alice adit / Adit H, with an entrance portal 155 m to the east of the Union North adit entrance portal) are now visited by Ghost Bats temporarily or at night only. In 1987, the Lady Alice adit / Adit H contained c. 200 Ghost Bats, including females in breeding condition (NSR Environmental Consultants 1993).

The key consideration for the management of Ghost Bats in the Union Reefs area in the context of the Union Reefs North Underground Project is their usage of the OK adit as a diurnal roost site, and the proximity of this to the planned entrance portal of the new underground mine. To minimise the chance of mortality of Ghost Bat individuals from mining-related activity within a few tens of metres, it was proposed to temporarily (for the duration of underground mining) close off the OK adit to Ghost Bat usage. This action is itself a disturbance to the colony, but will be undertaken alongside ten other 'Actions' as part of a broad-scale strategy for Ghost Bat management in the region (the Daly Basin and Pine Creek IBRA bioregions). Ghost Bats are also found within 15 km to the north (underground workings in the Spring Hill active mining area) and within 15 km to the south (abandoned Kohinoor adit at Pine Creek), as well as several other locations in the region (see summary in Barden and Armstrong 2019). These sites are presumably connected by dispersing individuals.

This Action Plan describes each of the 11 Actions that were recommended in the Union Reefs North Underground Project EIS (replacing a previous version of a regionally-focussed Action Plan for Ghost Bats written for a Notice of Intent; Armstrong et al. 2019). The Actions were developed specifically in response to the Terms of Reference that were addressed in the EIS, and are consistent with the relevant "Conservation and Management Actions", "Survey and monitoring priorities" and "Information and research priorities" that were tabulated in the Conservation Advice for the Ghost Bat (TSSC 2016). A full analysis of the situation of Ghost Bats in the Union Reefs area and the region generally, plus an extended justification for the 11 Actions, has been provided in Barden and Armstrong (2019), which was written as a technical appendix to the EIS.

A glossary of relevant words is provided on the next page. The meaning of certain words can be critical in a management plan, underpinning expectations for activities and outcomes, and providing clarity and a common understanding for the proponent and the regulator. These words are highlighted in blue where the specific objectives of the Action Plan are listed.

A Ghost Bat Management Plan has been developed based on this Action Plan (GHD 2020), as part of KLG's environmental management system, and will be implemented upon successful project approval. It should be noted that some Actions have already been initiated (Armstrong 2020; Armstrong and Barden 2020; Barden 2020a,b; Barden et al. 2020a,b).

Glossary

Adit—a horizontal tunnel extending underground from an entrance portal in a near-vertical or sloped rock face. The adit may link to other horizontal cross-cuts on either side, and to vertical shafts that extend above or below the horizontal tunnels.

Alternative diurnal roost; contingency roost—any underground structure, including underground mine workings, natural caves, or other equivalent structures, which can provide the conditions required for diurnal roosting by the Ghost Bat. These are predicted to occur outside the project area, and within the nightly flight range of a Ghost Bat, but remain to be found or confirmed. They may also constitute any artificial structures constructed specifically as replacement roost habitat as part of the Project. Suboptimal alternative roosts are those structures that may be used temporarily by Ghost Bats following a disturbance, but they do not provide suitable conditions for longer term roosting.

Bat population—an interconnected set of colonies of Ghost Bats, in this case inferred to occupy an unknown number of roosts within the Daly Basin and Pine Creek IBRA bioregions. Gene flow occurs amongst members of the same population, but may not occur with other population/s (gene flow might occurs with colonies further north (Worthington Wilmer et al. 1999) and in other parts of the Northern Territory).

Colony—a set of individual Ghost Bats that occur in an underground diurnal roost at any one time. Members of one colony may move to another colony, and most or all individuals of a particular colony might move from one roost site to another. Based on previous genetic studies (Worthington Wilmer et al. 1994, 1999; K.N. Armstrong unpublished study in prep.), females do not move away or far from their natal roost, and males also show high fidelity to roosts but are more likely to disperse greater distances.

Further afield—the wider region that is occupied by the Ghost Bat population.

Local persistence; local occurrence—presence within the Union Reefs project area.

Persist—present and detectable at one or more roost sites within the Union Reefs project area during the time of the defined activity (the closure of the OK adit and Prospect adit to bats) and for at least 6 months after the OK adit is re-opened.

Project area—the area within tenements held by Kirkland Lake Gold Ltd and referred to as the Union Reefs project area.

Region—the Daly Basin and Pine Creek IBRA bioregions.

Roost; diurnal roost—an area within an underground structure where Ghost Bats remain during daylight hours, and sometimes during the night.

Stronghold colonies—the large colonies at Spring Hill c. 15 km to the north of Union Reefs project area, and the large colony c. 15 km south in the Kohinoor mine adit adjacent to the town of Pine Creek. These colonies have been known for many years, and are also known to be subject to a range of threats.

Temporary closure—the period in which the OK adit is closed to bats while underground tunnels are excavated and used nearby (accessed from a portal within the Prospect pit), estimated at around two years.

Vision

Kirkland Lake Gold Ltd will be recognised as a leader nationally in efforts to manage, conserve and support research on the threatened Ghost Bat.

Overall goal

The overall goal of this Action Plan is to enact measures that will protect Ghost Bats from the potential effects of project-related mining activity; anticipate potential issues with continued occupancy in the Union Reefs project area and provide contingencies for them; and contribute to knowledge and conservation of the Ghost Bat at local, regional and national scales.

Specific objectives of the Action Plan

Specific objectives are presented so that the success of supported management Actions can be assessed. The relevant Actions are listed against the objectives for easier cross-reference. Implementing the various Actions as they are described in this document will allow the objectives to be met.

1. Protect Ghost Bats from disturbances associated with mining-related activity in the Prospect pit. **[Action 1]**

2. Provide confirmation that the Ghost Bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield. **[Actions 2, 7, 9]**

3. Confirm that Ghost Bats maintain connectedness amongst colonies in the population, thus demonstrating the capacity for Ghost Bats to move from the Union Reefs project area to other colonies, including stronghold colonies. **[Action 10]**

4. Encourage and protect the persistence of the Ghost Bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost Bats, and provide contingencies for roosting in the area if the Union North adit becomes unsuitable temporarily. **[Actions 3, 4, 5]**

5. Contribute to the long-term persistence of the Ghost Bat in the Union Reefs project area. **[Actions 3, 4, 8]**

6. Contribute to the long-term persistence of the Ghost Bat in the region by helping to protect stronghold colonies at Pine Creek and Spring Hill. **[Actions 6, 7]**

7. Seek further understanding of the Ghost Bat distribution, numbers and movements in the region to inform their conservation and management. **[Action 11]**

Specific questions addressed by the Action Plan

These questions helped to formulate the objectives and strategy of this Action Plan:

1. Will Ghost Bats continue to use the Union North adit, and thus persist in the project area, following the temporary closure of the OK adit?

2. When Ghost Bats are excluded from the OK adit, are there other alternative diurnal roosts (contingency roosts) nearby if for some reason they cannot use the Union North adit?

3. Is there evidence that individual Ghost Bats move between the Union Reefs project area and other roost sites further afield?

4. Can we improve protections around colonies further afield already identified as key stronghold colonies under threat in the population, so that any unintended effects of mining-related activity in the Union Reefs project area do not significantly compound threats within the bat population.

5. Will Ghost Bats be able to persist in the Union Reefs area in the long-term after the current proposal for mining has concluded?

Strategy of this Action Plan

It is common to build a monitoring component into a management plan for a threatened species. These require the definition of one or more event types that would 'trigger' a prepared 'contingency' response to halt or reduce the impact of activities that arise during an approved development. The triggers are based on a defined 'threshold' that is associated with a particular response level by the species, so that there is a clear and quantitative basis for deciding when to enact a contingency plan.

Ghost Bats might respond in various ways to different kinds of disturbance. The most obvious response is an exit into the open if a major disturbance occurs within the underground roost during the day (e.g., entry by people). Another might be a relocation to another roost during the night following an event that is not tolerated by the species. Bats may also show higher levels of activity inside a roost during the day following a stimulus. Unfortunately, there is almost no information on:

1. What levels of different disturbance types are significant (apart from people entering roosts during the day);

2. What cumulative levels of low-level disturbance are significant; and

3. What magnitude of response can be interpreted as significant.

Furthermore, there is little information on natural patterns that would allow us to separate responses to some types of disturbance from natural behaviours that are not influenced by mining-related activity.

Therefore, the derivation of trigger levels would essentially be an unjustified guess. Rather than cross-apply triggers and thresholds from other projects that have similar limitations or quite different contexts, we were guided by two questions:

1. Would we be able to recognise reliably during our monitoring program when a particular observation of bat behaviour or pattern or trend was indicative of a negative response to mining-related activity?

2. Would we be able to act quickly enough to prevent or limit the negative response of bats if we did observe such a response?

The realistic answer to both questions was 'no'. The Mitigation Hierarchy and the Conservation Advice for the species (TSSC 2016) have provided a structure within which to develop this Action Plan, and we also sought a multi-faceted strategy that was most appropriate to the situation under consideration:

- Over-compensate for the temporary deprivation of what baseline monitoring has demonstrated to be a relatively minor roost in a regional context, effectively removing the residual risk;
- Avoid forcing trigger thresholds in areas where there is insufficient knowledge to make an accurate interpretation;
- Avoid attempting to make determinations where the outcomes of a variable natural process are inseparable from responses to an anthropogenic disturbance;
- Provide a threefold level of redundancy for the temporary loss of access to one known roost, and the possible temporary unsuitability of another;
- Provide the contingencies and protections in advance so that, should something unfortunate or undesirable happen, alternative refuges are available immediately, and are already known by the bats;
- Provide protection for alternative known stronghold roosts that bats may move to in the event of a disturbance, given that these alternatives are subject to threatening processes;
- Generate information on a range of aspects that continue to inform the management of the species, maximise the chance of success of Actions, and also corroborate existing but limited information.

Summary of Actions

⌦ **Action 1**. Exclude the Ghost Bat from the OK adit and Prospect adit based on a carefully planned protocol.

⌦ **Action 2**. Characterise the internal dimensions and microclimates of the Lady Alice adit, OK adit and Union North adit, and the position of Ghost Bat roost areas within.

⌦ **Action 3**. Create several artificial habitats for the roosting of Ghost Bats in the Union Reefs project area, for both contingencies and redundancy.

⌦ **Action 4**. Re-open and rehabilitate the Lady Alice adit so that it is suitable for Ghost Bat occupancy.

⌦ **Action 5**. Manage the Union North adit during the period of mining.

⌦ **Action 6**. Implement management measures at the Koohinoor adit at Pine Creek to protect the Ghost Bat roost.

⌦ **Action 7**. Conduct a programme of continuous monitoring of Ghost Bat presence, activity levels and colony size at all known (Union North adit) and potential (Lady Alice adit, artificial roost habitats newly created) roosts within the project area, and other key sites in the region (Pine Creek; Spring Hill; any newly discovered caves of significance surrounding the project area).

⌦ **Action 8**. Provide a portion of the new mine for Ghost Bat occupancy once mining has been completed.

⌦ **Action 9**. Conduct field surveys for Ghost Bat diurnal roosts in natural caves in the hills surrounding the Union Reefs project area.

⌦ **Action 10**. Investigate the connectedness of Ghost Bat colonies in the region using an advanced genetic method based on genome-scale DNA sequencing.

⌦ **Action 11**. Provide support for further academic research on the ecology of the Ghost Bat.

Phased timing of the Actions

The Actions are expected to be conducted in several phases, with some Actions beginning in one phase and extending into others.

Phase 1. Before new underground mine construction.

Action 2—Characterise the internal dimensions of the Lady Alice adit, OK adit and Union North adit.
Action 3—Create two artificial habitats.
Action 4—Re-open and rehabilitate the Lady Alice adit.
Action 7—Monitor the Ghost Bat at known local and regional roosts.
Action 9—Conduct field surveys for Ghost Bat diurnal roosts in natural caves.
Action 10—Investigate the connectedness of Ghost Bat colonies in the region.
Action 11—Provide support for further academic research on the Ghost Bat.

Phase 2. Exclusion Phase, immediately prior to site works in the Prospect pit.

Action 1—Exclude the Ghost Bat from the OK adit and Prospect adit.
Action 7—Monitor the Ghost Bat at known local and regional roosts.

Phase 3. During mining.

Action 3—Create artificial habitats (based upon an assessment of whether more are required).
Action 5—Manage the Union North adit.
Action 6—Implement management and protection measures at the Pine Creek roost.
Action 7—Monitor the Ghost Bat at known local and regional roosts.
Action 9—Conduct field surveys for Ghost Bat diurnal roosts in natural caves.
Action 10—Investigate the connectedness of Ghost Bat colonies in the region.
Action 11—Provide support for further academic research on the Ghost Bat.

Phase 4. After mining has been completed.

Action 7—Monitor the Ghost Bat at known local and regional roosts.
Action 8—Provide a portion of the new mine for Ghost Bat occupancy.
Action 11—Provide support for further academic research on the Ghost Bat.

Action 1—Exclude the Ghost Bat from the OK adit and Prospect adit

Mitigation Hierarchy step: Both Avoidance and Mitigation/Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Habitat loss.
2. **Knowledge gap addressed**: No specific knowledge gap.
3. **Specific priorities addressed in the Conservation Advice by this Action**: Protect roost sites from disturbance.

Applicable objectives of the Action Plan

Objective 1. Protect Ghost Bats from disturbances associated with mining-related activity in the Prospect pit.

Benefits of the Action: By discouraging the presence of Ghost Bats in close proximity to noise, vibration and other disturbances associated with machinery and blasting in the Prospect pit, the risk of elevated mortality from the new mine will be removed. The Action will temporarily restrict access to one relatively shallow diurnal roost and possible site for breeding individuals, but it removes Ghost Bats from the proximity of mining-related activity at the entrance portal to the proposed new mine, and removes the risk of the negative impacts of noise and vibration from blasting underground on any individuals that might otherwise occupy the OK adit.

Details of the Action

The Ghost Bat will need to be excluded from the OK adit before it can be closed to their entry. This needs to be done in the least invasive way possible. It will occur when bats have shifted their attention to the Union North adit. When there is acoustic evidence from bat detectors that Ghost Bats are not using the OK adit as a diurnal roost site, the entrance of the OK adit will be sealed at night to prevent their access prior to dawn.

While Ghost Bats do not use the Prospect adit in the same way as the OK adit, the same protocol will be undertaken at the Prospect adit at the same time.

The Exclusion will proceed as follows:

1. The current programme of acoustic and video monitoring will continue at the OK adit and Prospect adit (Phase 1). The Exclusion Phase (Phase 2) will occur over a minimum of three nights, and will begin as soon as possible after project approval, but:
    a. when Ghost Bats are observed to be absent;
    b. after a survey of the Union North adit, OK adit and Lady Alice adit has been undertaken (*Action 2*);
    c. after the contingency roosts have been established and opened (two artificial roosts; Lady Alice adit; *Action 3, Action 4*); and

d. and after the cave occupancy surveys have been initiated and provided initial results (*Action 9*).

2. The entrance portal will be monitored with bat detectors and video recorders from dusk to dawn on each night during the Exclusion Phase.
3. On each of the three nights, a bright light will illuminate the entrance from three hours after sunset until dawn to discourage any species of bat from re-entering the structure throughout the night. Introducing the bright light beginning three hours after dusk will give all species of bats sufficient time to leave the structure without disturbance. The remaining time until dawn (with the entrance illuminated) will give bats sufficient time to find an alternative roost.
4. The acoustic and video recordings will be reviewed after each night to determine if bats were seen returning to the structure before dawn.
5. At the end of the third night, the OK adit will be designated as 'probably empty' if no bats were seen leaving at dusk on the third night, or re-entering during the night before dawn on the third night.
6. The application of bright light will be continued after three nights if bats are still using the structure, until they stop using the structure.
7. If bats are absent after the third night (or a subsequent night), a temporary soft cloth barricade will be placed over the portal after dawn.
8. At dusk on the fourth night, the blocked entrance will be monitored with bat detectors and with investigators present from sunset for three hours to ensure that no bats of any species are trapped within the structure. Bats remaining in the structure will be let out from behind the cloth barricade after sunset.
9. Once it has been established that no bats remain in the structure, the cloth barricade will be checked for its integrity and left in place. The adit will also be entered to confirm the absence of all bats.
10. The following day after fourth night, the cloth will be replaced by a permanent barricade. Small gaps will be left for reptiles.
11. The sealed entrance portals will be illuminated by strong light to immediately discourage bats seeking to return during the night. This light will remain until the Underground Mine is constructed.
12. The entrance of the OK adit and Prospect adit will be checked for dead bats for 14 days after the permanent barricade has been established.
13. Acoustic monitoring will continue for 14 nights after the portals have been permanently sealed (*see Table 1 in Action 7*). Thermal video recordings will continue for seven nights after the portals have been permanently sealed—unless bat carcasses are found at the entrance, in which case the thermal video monitoring will be extended another seven nights. Illumination levels will be increased if bat carcasses are observed.
14. A report will be produced to document the process, with a deadline of one month after the completion of the Exclusion.

Monitoring by video (thermal and/or infrared) and acoustic (with AnaBat Swift bat detectors) recorders will continue at the Union North adit for the period that the OK adit is closed (*see Action 7*), as well as during the Exclusion Phase (Phase 2).

Acoustic monitoring will also be extended to include other species of bat that occupy the adits, but especially the more physiologically fragile species (Dusky Leaf-nosed Bat *Hipposideros ater*; Orange Diamond-faced Bat *Rhinonicteris aurantia*). The method is appropriate for detecting the presence of the Northern Leaf-nosed Bat *Hipposideros stenotis*.

Monitoring will continue for six months after the OK adit is reopened following the cessation of mining in the new mine to determine if Ghost Bats were able to return. This will coincide with a monitoring effort to determine if the Ghost Bat moves into this new mine after mining has finished (*see Action 8*).

It is important that the patterns documented from acoustic and video recordings of Ghost Bat activity in the Union North adit can be correlated with mining-related activity on the site, and ideally with empirical data. One such measure will be the level of ground vibration in the Union North adit (and Lady Alice adit) during blasting, which will rely on the installation of a vibration datalogger. Vibration data will be recorded continuously, should entry to the structure/s to place equipment be possible and safe (*see Action 2*; also Barden 2020a).

Acknowledged risks and limitations

It is acknowledged that the Action itself is a disturbance (temporary loss of a confirmed diurnal roost site and possible breeding site, for at least some of the breeding cycle), but the Action is designed to avoid other disturbances (proximity of machinery and blasting), and then other Actions will mitigate the residual impacts or provide contingencies for roosting.

The noise and vibration modelling study (Velasco 2019) predicted that levels of vibration would be significantly greater than 10 mm/sec (29.6 mm/sec to 54.6 mm/sec; an indicative limit used by mining proponents in the Pilbara region of Western Australia) within the OK adit, but less than 2.5 mm/sec at other sites including the Union North adit and Lady Alice adit. The effect of ground-borne noise was also predicted to be around the level of human conversation within the OK adit (75 dBZ), and lower elsewhere, and at frequencies below the limit of hearing in the Ghost Bat. While there has been no systematic study of the responses of bats to different levels of vibration and ground-borne noise, the case presented by Velasco (2019) provides confidence that sites other than the OK adit will not experience significant levels of noise and vibration from blasting (see also Barden and Armstrong 2019). These two parameters will be logged in the long-term in the Union North adit and Lady Alice adit (*see Action 2*).

⌦ Action 2—Characterise the internal dimensions of the Lady Alice adit, OK adit and Union North adit

Mitigation Hierarchy step: Survey work to support Mitigation/Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites, Disturbance to breeding sites.

2. **Knowledge gap addressed**: The extent and condition of the two adits used by Ghost Bats in the Union Reefs project area, and the position underground where the bats congregate. Understanding how roost microclimates might change seasonally.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Monitor populations at key sites and where impacts from mining are occurring or likely.

Applicable objectives of the Action Plan

Objective 2. Provide confirmation that the Ghost Bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield.

Benefits of the Action: Having more knowledge of the internal structure and microclimate of the Lady Alice adit, OK adit and Union North adit allows a better understanding of how important the structures might be to the species. A survey of the internal structure of the adits will also provide information on low-level seasonal flooding that occurs in the Union North adit, which might require a management solution to keep this structure with optimal conditions for the Ghost Bat.

Details of the Action

The knowledge gaps are relevant to the likelihood of the long-term usage by Ghost Bats of the site, and the proximity of bats roosting underground to mining-related activities that may cause them disturbance. For example, the monitoring plan that set a buffer width for the minimum proximity of drilling to the OK adit and Union North adit had no information on where bats roosted (Armstrong and Barden 2019). The extent of the buffer was set based on predictions of the roost location in each case, in relation to the position of the adit portal and the minimal information available on tunnel length and direction.

A previous effort sought to determine the extent of the OK adit and Union North adit (Armstrong and Barden 2019). A pipe inspection robot, trailing cables to allow video to be viewed outside the structure, was introduced into both adits. Progress of the device was hindered within the Union Reefs adit by rocky debris and standing water, so the extent of the adit could not be confirmed.

Another solution is to have a person suitably experienced in underground work, and with appropriate training and equipment for confined space entry, enter the structures. This would result in the availability of more detailed information, but would be contingent on whether the

investigator entering the structures judged them to be stable enough to allow a safe inspection of some or all of the tunnel lengths.

If entry was indeed possible, within a relatively short period of time, this investigator will be able to confirm the length of the main adit, the presence of any further tunnels or shafts, and determine where Ghost Bats roost in the structure. An electronic laser distance measure and compass can be used to map the structures, and measure where the bat roosts occur. As an update, some of these activities are reported on in Barden (2020b).

In addition, and depending on the possibility of a safe entry, it could be very useful to monitor how the roost microclimate changes seasonally. The Ghost Bat is known to prefer warm, humid microclimates, especially where young are born and raised. Having an understanding of roost microclimates would be useful when interpreting changes in the level of usage of structures, and the number of individuals occupying the structure at particular times of the year. Dataloggers will be placed into the Union North adit and Lady Alice adit that continuously record values of temperature and relative humidity.

A noise and vibration datalogger might also be introduced into the Union North adit and Lady Alice adit to record the level of ground movement and ground-borne noise that occurs during blasting. Very little information is available for underground structures that are used by animals on the levels of vibration associated with blasts. A datalogger placed in the Union North adit and the Lady Alice adit)(plus the new artificial roosts; *see Actions 3 and 4*) could be used to confirm that levels of vibration were not sufficient to cause the exodus of Ghost Bats. A datalogger placed temporarily in the OK adit will be used to validate the modelling work of Velasco (2019), which will provide comparative context for future similar studies.

The extent of the Lady Alice adit will also be determined (as far as this is possible given constraints on access) so that its suitability as a roost for the Ghost Bat can be confirmed. This information will also be used to plan for enhancements that need to be made to make the structure more suitable (*see Action 4*).

A report will be produced to document the results, which will be forwarded within 6 months of the project approval date.

Acknowledged risks and limitations

There is no cost to the Ghost Bat if entry is made when they are absent. The risk of entry to a roost is that Ghost Bats will abandon the structure when disturbed. However, this will be avoided by entering at night after bats have left to forage.

Action 3—Create several artificial habitats

Mitigation Hierarchy step: Mitigation/Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Roost habitat loss.

2. **Knowledge gap addressed**: The provision of artificial roost habitat is now considered more frequently as an option to manage Ghost Bats and other species of conservation significance, especially in the Pilbara region of Western Australia (Cramer et al. 2016). Several artificial roosts have been approved and some have been constructed, but there is very little information in the public sphere currently about how successful these have been in attracting and maintaining colonies of bats. Thus, this strategy is still essentially experimental. Creating several structures in the Union Reefs project area therefore provides the opportunity to test several factors that might be relevant for their success. This includes validating thermal models of their microclimates created by Computational Fluid Dynamics for different designs. It also provides the opportunity to determine whether Ghost Bats can be attracted to an artificial roost site based on broadcasts of their social calls.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Establish new or artificial roost sites, and evaluate their success.

Applicable objectives of the Action Plan

Objective 4. Encourage and protect the persistence of the Ghost Bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost Bats.

Objective 5. Contribute to the long-term persistence of the Ghost Bat in the Union Reefs project area.

Benefits of the Action: Creating artificial habitats will provide several alternative possible roosts for when the OK adit is closed. Having more than one possible replacement for the OK adit within the Union Reefs area, as well as any that may exist further afield within the nightly flight range of the Ghost Bat, gives redundancy if Ghost Bats occupy more than one alternative. This strategy anticipates the possibility that a trigger will occur (e.g., factors that might cause Ghost Bat movement, and therefore periods of absence at the Union North adit; see details in Barden and Armstrong 2019), and enacts the contingency response before it is actually needed. If a trigger occurs, the contingency sites need to be available immediately. Thus, two artificial roosts will be constructed before the new mine is constructed, and before the OK adit is closed to bats.

Details of the Action

With the temporary closure of the OK adit, the local occurrence of the Ghost Bat will have fewer opportunities for an alternative nearby roost if an unforeseen event causes them to vacate the Union North adit. This is important because bats are exposed to much a greater

risk of mortality from raptors and ambient conditions if they are forced to leave their roost during the day, or are disturbed to a degree that induces them to seek an alternative (possibly sub-optimal) diurnal roost between sunset and sunrise the night following the disturbance. Habitat creation has been considered as a useful mitigative option (it does not meet the strictest definition of an environmental offset) in situations where the interests of mining coincide with the location of a bat roost site. But habitat creation can also be used to increase the availability of roosts, rather than just maintain the number of roosting options of the species.

The construction of artificial roosts provides a contingency in the event that the Union North adit becomes unsuitable for Ghost Bats for some reason ('contingency roosts'; *see Glossary*). Two structures will be built providing redundancy in case one is not chosen by Ghost Bats. Construction of both roosts will also occur prior to mine construction, so that there is a maximal amount of time for Ghost Bats to find and become familiar with them.

A contingency roost will be created by modifying the Lady Alice adit so that it is useful for Ghost Bat occupancy (*see Action 4*). There is currently no other disused underground mine within the Union Reefs project area that is known to, or likely to, support a colony of Ghost Bats. The construction of several artificial roosts will provide both contingency and redundancy for Ghost Bat roosting requirements within the Union Reefs project area.

Given that no guarantee can be given that Ghost Bats (and other species) will move into any newly-created artificial roost habitat, there are several ideas that will be incorporated to maximise the chance of success:

1. Build more than one artificial roost to provide redundancy in case one or more examples has shape or site-related characteristics that do not make it suitable for bat colonisation. There are several locations surrounding the current mining area that are relatively accessible by existing vehicle tracks, which will allow heavy equipment to transport and emplace the units that will make up the structure. More than one site will be chosen in these areas for placement of an artificial roost. Site selection will be an important part of the Action, and placement will also consider whether earthworks involving waste rock will lead to acidification, which could compromise the structure of the artificial roosts.

2. Build relatively small structures so that it is cost-effective to have the redundancy of multiple structures. Natural caves used by Ghost Bats in some parts of their range are relatively deep and complex. Artificial structures will be modelled to some degree on known roosts elsewhere to ensure that an optimal roost microclimate can be retained. Rather than a long tunnel, the artificial sites might be 'bent' or 'folded' to save space, materials and earthmoving costs, and the structure can be inclined slightly to reduce atmospheric flushing of areas at the back where bats might roost. There are numerous shape options for commercially-available prefabricated concrete units (e.g. see https://www.holcim.com.au/humes), and they are relatively cost effective. These will give several options for the shape of artificial roosts (see also Armstrong 2020).

3. Encourage bats to roost in areas where optimal microclimate conditions are predicted to occur. If artificial structures are assembled from prefabricated blocks, there will be little opportunity for bats to hang from smooth vertical surfaces. Thus, objects (or perhaps

spray-on concrete product) will be attached to the ceiling in various places to allow bats to hang.

4. Artificial roost structures will be designed to retain optimal roost microclimates. Ghost Bats need a warm, humid microclimate for roosting, and especially for birthing and raising young. The artificial structures will be shaped so that they retain high humidity and warm air, and not be subject to flushing from outside air movements that would remove these optimal interior microclimates. To confirm that these shapes can retain warm, humid conditions, thermal modelling will be undertaken by engineers with experience in Computational Fluid Dynamics (CFD), with advice provided by a bat biologist (see Armstrong 2020). The shape and extent of more than one example will be modelled with CFD, providing alternatives in case a particular design does not perform as expected.

5. Increase the awareness of Ghost Bats of the structures. If Ghost Bats do not often visit areas where the artificial roosts are placed while out foraging, then they might be attracted to them by broadcasting their social calls. 'Acoustic lures' have been used to increase the rate of capture success in several parts of the world, including Australia (Hill et al. 2015). Research submitted for publication (N. Hanrahan et al. manuscript in review) has also demonstrated that Ghost Bats respond to playback of their social calls. These calls are also relatively loud, and suitable for broadcasting. Thus, a small, inexpensive electronic device set to periodically broadcast examples of calls most likely to elicit a response by Ghost Bats will be placed and maintained at each artificial roost until the species is recorded entering them.

6. Prevent disturbance and entry of people to the structures. Ghost Bats are very sensitive to disturbance of their roosts, and the entry of people can cause abandonment. This is obviously undesirable when efforts are being made to attract bats to the structure. Thus, measures will be enforced to prevent casual visitation by non-essential personnel working on-site, and strict guidelines will be implemented for those conducting monitoring work at the structures. In addition, casual entry by any person will be discouraged by several measures including: 1. signs to provide information and safety cautions associated with the structure; 2. an entrance portal that is fully or partly open but situated at the top of a vertical face so that people cannot simply walk in; and 3. restricted access to vehicular tracks approaching the structures.

7. Monitor the conditions of the inside environment. Without feedback on whether microclimate and other aspects of the interior are suitable for Ghost Bats, it will be difficult to evaluate the success of the structures. The structure design will incorporate small vertical access points to allow the introduction of equipment into the roost areas. This equipment will include temperature and relative humidity dataloggers, a vibrational datalogger on a weight, and other devices relevant to making observations on bats. The data from these devices will be summarised in quarterly monitoring reports (*see Table 1 in Action 1*).

8. Monitor the presence of bats inside the structure. Given the habit of several species of bat to visit structures at night, but not use them as diurnal roosts, it will be important to confirm diurnal roosting with a method other than the placement of recording equipment

at the entrance to the structure. The equipment access point at an area where bats are likely to hang will allow video cameras to view whether bats are present, and bat detector microphones will allow continuous monitoring of presence. These video and acoustic recorders might also detect evidence of breeding if it occurs, given the close proximity to bats. The opportunity to observe Ghost Bats in the roost directly is relatively unique and could provide much information relevant to their management on a national scale.

A full proposal will be developed prior to undertaking this Action, which will contain the details of the designs, site selection, materials, the results of thermal modelling and further details about attracting and monitoring bats in the structures (see guidelines for roost microclimate modelling in Armstrong 2020). A report will be produced on the modelling and construction process, to be submitted within 3 months of the completion of construction of the structures. The success of the structures in attracting and retaining Ghost Bats will be reported on as part of the long-term monitoring effort that will take place (*see Action 7*).

Acknowledged risks and limitations

There is no cost to the Ghost Bat with this Action. However, it is possible that: 1. the structures will not be used by Ghost Bats at all; or 2. if they are used, that a future disturbance at new artificial habitats might cause mortality. Critical aspects of the design, which is based on knowledge of the species roost requirements, as well as thermal modelling, maximise the chance that they are used by Ghost Bats.

The EIS describes how a 'relocation', whereby bats are captured and physically placed into an alternative roost site, is fraught with a range of undesirable factors. It is important to note that this species cannot be 'forced' into using certain structures, so the best strategy is to influence site usage by making some sites undesirable (with strong lighting at night; and then closing them off), and maximising the desirability of others through good design and enhancements based on a knowledge of Ghost Bat roost requirements. The various Actions in the present plan will together provide a relatively low impact approach to influencing and monitoring Ghost Bat usage of sites in the Union Reefs project area.

Action 4—Re-open and rehabilitate the Lady Alice adit

Mitigation Hierarchy step: Mitigation/Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Roost habitat loss.

2. **Knowledge gap addressed**: It is not known whether Ghost Bats will readily move from a suitable roost to another site nearby if the latter is modified to be more suitable. The effectiveness of certain enhancements in attracting Ghost Bats, and the validity of thermal microclimate modelling are both unknown but very relevant to strategies that provide Ghost Bats with alternative habitat when plans for development coincide with a known roost.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Establish new roost sites and evaluate their success; Protect roost sites from disturbance; Modify roost sites to reduce risk of collapse.

Applicable objectives of the Action Plan

Objective 4. Encourage and protect the persistence of the Ghost Bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost Bats.

Objective 5. Contribute to the long-term persistence of the Ghost Bat in the Union Reefs project area.

Benefits of the Action: Opening and modifying the Lady Alice will provide a potential replacement for the OK adit after is closed. Having a possible replacement for the OK adit within the Union Reefs area might reduce the impact of the OK adit closure, especially if it is similar in structure, or even better for Ghost Bat roosting.

Details of the Action

This small adit is 155 m east of the Union North entrance portal (referred to as "the adit at waypoint 118" in Armstrong and Barden 2018). It is a straight horizontal tunnel approximately 12 metres long and 1.7 metres high (see scan in Barden 2020b). Prior to December 2019, the entrance portal was partially occluded by earth, with the aperture only accessible to species such as the Orange Diamond-faced Bat *Rhinonicteris aurantia*, which was detected inside with a camera, and on a bat detector recording (Armstrong and Barden 2018). The aperture was widened with hand tools in December 2019, and Ghost Bat scats were subsequently observed inside the adit (Barden 2020b). There is a shaft entrance further up the slope that connects to the horizontal adit via a small opening. Calls of the Ghost Bat have been detected on a microphone placed inside the portal in December 2019 and January 2020 (Barden 2020b).

Together with the construction of artificial roosts (*see Action 3*), making the Lady Alice adit available to Ghost Bats following the closure of the OK adit will provide roost habitat

replacement, contingency and redundancy in the Union Reefs project area, with possibly minimal effort.

It is proposed to remove some of the earth obstructing the entrance to allow Ghost Bat entry. Any augmentation of the Lady Alice adit is likely to maintain accessibility to other bat species.

The internal structure has been checked to confirm its extent (Barden 2020b).

The effect of the enhancements to the microclimate conditions will also be modelled using CFD, following the survey of the interior to obtain information about its dimensions, and the nature of the rock (for information on 'boundary conditions' needed to build the numerical models) (obtained during implementation of *Action 2*; Barden 2020a).

Equipment will be introduced to monitor the microclimate conditions of the interior, noise and vibration from blasting, and the presence of bats (in a similar way to *Action 3*). Some of these actions (bat acoustic, relative humidity and temperature monitoring) commenced in December 2019 (Barden 2020b).

The site will be included in the long-term monitoring effort to document whether the enhancements have been successful in providing an additional roost for the species (*see Action 7*). Details of the outcome of Action 4 will be included in reports for Actions 2, 3 and 7. Some of this information is presented in Barden (2020a,b).

Acknowledged risks and limitations

There is no cost to the Ghost Bat with this Action. However, it is possible that: 1. the structure will not be used by Ghost Bats at all; or 2. if it is used, that a future disturbance at the site might cause mortality. However, ghost bats have already been detected using the adit following a minor expansion of the entrance using hand tools. The effect of the enhancements on microclimate condition and stability will be modelled with CFD, and additional site measures incorporated if required. The site will be managed against the entry of people in the same way as the Union North adit and artificial structures.

Given that Ghost Bats are already aware of and occasionally enter the site, and vibration and noise modelling predicted a similar level of minimal disturbance as with the Union North adit, it is suggested that augmentation and protection of the Lady Alice adit could provide a good alternative to the OK adit.

Action 5—Manage the Union North adit during the period of mining

Mitigation Hierarchy step: Mitigation/Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites, Disturbance to breeding sites.

2. **Knowledge gap addressed**: No specific knowledge gap.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Protect land with significant colonies; Protect roosts from disturbance; Educate people not to disturb roost sites.

Applicable objectives of the Action Plan

Objective 4. Encourage and protect the persistence of the Ghost Bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost Bats.

Benefits of the Action: The Union North adit will remain undisturbed and a refuge for Ghost Bats. Without implementing certain protections for bats using the Union North adit, there is a possibility that mine personnel might enter the roost site, which would create a disturbance to the species, and possibly cause them to exit into daylight where they would be exposed to raptorial birds and unsuitable ambient conditions. Other potential risks to bat roosting in this structure are also addressed. The issue of flooding in the Union North adit is also addressed by this Action Plan.

Details of the Action

Once the OK adit has been closed, the colony of Ghost Bats in the Union Reefs area will become reliant on the Union North adit, as well as other sites, yet to be determined, nearby. Thus, it is imperative that no disturbance occurs at the Union North adit.

Given observation of a significant level of flooding in the Union North adit during a site inspection in February 2020, it was concluded that flooding was the likely cause of ghost bats moving from the Union North adit to the much shallower OK adit at certain times in the wet season. The level of water can reach waist depth at a point 60 m into the tunnel, and the slope of the adit suggests that the tunnel further along experiences much greater levels of inundation. The simplest way to reduce the reliance on the OK adit and increase the suitability of the Union North adit year-round is to install a pump nearby (shielded for noise) and run a hose down the length of the adit as far as it is safe for people to enter (as far as the debris pile at c. 60 m depth).

A range of restrictions and education measures will be implemented and enforced as part of this Action, which are elaborated upon further in the Ghost Bat Management Plan (GHD 2020).

1. Prohibition of vehicles and other machinery in the Union North pit, and above the extent of the underground structure (*see Action 2*). Areas of restricted access will be established, communicated at safety inductions, and enforced.

2. Restriction of the use of heavy machinery within 135 m of the adit portal (consistent with the buffer zone established for the drilling programme; Armstrong and Barden 2019).

3. Adequate signage and blocking vehicular access, to guide personnel on the location of boundaries around important sites for bats. Severe consequences will be enforced for non-compliance of entry restrictions.

4. Prohibition of mining and contractor personnel from approaching and entering the Union North adit, unless an approved activity under this Action Plan is being undertaken (e.g. placement/retrieval of acoustic and video monitoring equipment [*Action 7*]; entry to determine the extent of the structure and placement/retrieval of dataloggers [*Action 2*]).

5. Inclusion of information in safety and environment inductions about the presence and value of the Ghost Bats on-site, and the restrictions in place around the access of the Union North adit, and the other underground structures that might contain Ghost Bats at any time (OK adit, Lady Alice adit, artificial adits).

6. Specification that the prohibition by mining and contractor personnel of entry of adits and the disturbance of Ghost Bats extends to the Kohinoor adit at Pine Creek and underground structures at Spring Hill (should this tenement be acquired by KLG).

7. The top strand on barbed wire fences in the Union reefs area will be plain unbarbed wire. Where barbed wire is required to meet Australian Standards to restrict access of personnel for safety reasons, metal disks will be placed between the top two strands to make the fence more visible to bats in flight.

8. The potential for foraging habitat modification in the Union Reefs area from frequent fires will be managed through a separate document that specifies burning practices.

9. Dust suppression activities will be conducted where heavy machinery is operating to reduce the accumulation of dust on native vegetation that forms part of the foraging habitat of ghost bats.

10. Additional lights will not be installed near Ghost Bat roosts, and certainly not within 135 metres.

11. Noise and vibration will be monitored in the Union North adit and Lady Alice adit, and blast timing and sizes will be reassessed if vibration exceeds 10 mm/sec, ground-borne noise levels exceed 75 dB, AND Ghost Bat occupancy is found to decrease at times when colonies are normally present.

12. A pump will be installed near the Union North adit, and a long hose placed at least as far as the debris pile that occurs part-way (c. 60 m) along the tunnel length. The adit will be pumped when water can be observed from the entrance. This will be checked every

time the bat detector flash memory cards need to be downloaded, and in intervening periods after heavy rainfall.

13. Reporting requirements, for any breach of these conditions, and details of follow-up actions, are specified in the Ghost Bat Management Plan.

Acknowledged risks and limitations

There is no cost to the Ghost Bat with this Action. The likelihood of any disturbance from mining personnel is very low given the typical high standards of safety and behaviour on Australian minesites. Enforcement can be aided by security cameras, if deemed necessary.

⌦ Action 6—Implement management and protection measures at the Pine Creek roost

Mitigation Hierarchy step: Mitigation/Minimisation (candidate Offset).

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites, Disturbance to breeding sites.

2. **Knowledge gap addressed**: No specific knowledge gaps have been identified at the Kohinoor adit, beyond how colony size might change in the future, and how it is connected to other colonies (*see Action 10*). However, this Action could generate an exemplar for an imaginative and collaborative strategy to conserve Ghost Bats, transforming an undesirable situation where previously there had been very little consideration given to the value of a colony of a vulnerable and declining species.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Protect land with significant colonies; Protect roosts from disturbance; Educate people not to disturb roost sites.

Applicable objectives of the Action Plan

Objective 6. Contribute to the long-term persistence of the Ghost Bat in the region by helping to protect stronghold colonies at Pine Creek and Spring Hill.

Benefits of the Action: Greater focus on protection of the colony in the Kohinoor adit will help to increase the security of the whole regional population. Without some level of effort to protect and manage stronghold colonies in the region, the colony at Union Reefs may have fewer options for dispersal to undisturbed sites. Concurrent disturbances at multiple roost sites within the Pilbara region has been identified as an issue previously (Armstrong 2010).

Details of the Action

The largest known colony of Ghost Bats in Australia (and therefore globally) occurs within the Kohinoor adit on the outskirts of the town of Pine Creek. It is very likely that this site is within the nightly flight range of the Union Reefs project area, and the outcome of genetic studies could support this (*Action 10*).

There is widespread knowledge of this site as ‘a place to see Ghost Bats’. Information about the location of the mine is available readily in books and on the internet. This actively encourages people to enter the mine to see the bats, which is entirely undesirable for reasons of safety, liability and the conservation of threatened bats. Local townspeople are also known to enter the mine regularly. Objects such as beer bottles and the remnants of fireworks have been discovered inside the structure in the past. Videos of the roost interior have also been posted on the internet by ‘wildlife tourists’.

Monitoring of the size of the Ghost Bat colony at Pine Creek has been undertaken by Nicola Hanrahan as part of a PhD study since November 2015. The study has found that colony size fluctuates between 300–800 individuals depending on the time of year, with peak numbers

counted during the mating season and after the parturition (birthing) period. The study has confirmed that there is frequent human visitation to the colony.

There is potential to completely turn around the situation at the Kohinoor adit—by transforming a very undesirable situation into one that enhances simultaneously both the conservation of threatened species and provides for other positive outcomes for people in the town. A strategy needs to be introduced to ensure that this colony achieves better protection, and is therefore maintained as a potential refuge for any Ghost Bats that may arrive from the Union Reefs project area.

Such a strategy will be developed further in consultation with key people in Pine Creek, but essential first steps include:

1. Reducing access to the 'attraction'. Impediments to human visitation of the site will include the construction of a suitable fence further away from the entrance, signage warning of danger to entry of a collapsing structure, and natural screening to reduce the visibility of the adit portal from the road.

2. Liaising with the local Government to discuss ways that access to the colony can be reduced, that townspeople and visitors are effectively educated against visitation of the site, and also to discuss ways that proactive management at the site may actually contribute to the 'well-being' of the town. The inclusion of Traditional Owners in consultations will also be a valuable opportunity for collaboration. Specific management actions are not listed here, as they will be dependent on the outcomes of liaisons, and they will also be led by the Postdoctoral Researcher (see Action 11).

3. The Kohinoor adit will be included in the long-term monitoring effort (*see Action 7*), which will involve the deployment of video and acoustic recorders at the entrance.

As part of Step 2 above, the idea of installing permanent, remotely-operated video cameras within the roost area of the adit (when bats are out foraging at night) could be discussed. The proponent will commit to assisting with the implementation of this idea. Continuous video monitoring of individuals inside the roost would be of significant value for obtaining a better understanding of Ghost Bat numbers and behaviour in this roost. Importantly, it could also present an opportunity for public education, and a way to draw the attention of curious tourists away from the actual site if the video can be displayed elsewhere in the town (e.g. a tourist centre, a hotel and bar). If the curiosity of most people could be sated away from the roost, pressure at the site from undesirable visitation might reduce significantly, and a culture of local ownership and protection of the site be developed instead.

A precedent for such an installation can be seen in Naracoorte, South Australia, where permanent, remotely-operated videos can be used by the public in a visitor centre (https://www.naracoortecaves.sa.gov.au/Home). This is a major and promoted attraction not only for the town of Naracoorte, but for tourism in South Australia. There is enormous potential for a similar operation to be established in Pine Creek, to the benefit of numerous stakeholders—local Pine Creek residents and business people, Traditional Owners and Aboriginal corporations, tourists, biological researchers, the mining proponent, and of course the Ghost Bats.

As a reportable outcome of Step 2 above, a report will be produced, which will expand on the idea of a permanent video link to the roost, should discussions be favourable. A report summarising all collaborative conservation and management actions at Pine Creek will be submitted two years from the date of project approval.

Acknowledged risks and limitations

Ghost Bats are still present in the Kohinoor adit despite a long history of disturbance. They are also still present despite recent disturbances at several workings within the Spring Hill area. Rather than suggesting that Ghost Bats are tolerant of regular roost intrusions, we may instead infer that these two sites are of high importance to the species because there are no structures nearby that provide similar habitat quality—so the species has an obligate reliance on them. There is a continuing risk that a random event will produce a catastrophic disturbance at the Kohinoor adit, and this risk can be reduced significantly by implementing this Action. The planned management actions will be installed with as little disturbance to colonies as possible, with all required entries taking place at night.

⌦ Action 7—Monitor the Ghost Bat at known local and regional roosts

Mitigation Hierarchy step: Mitigation/Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites, Disturbance to breeding sites.

2. **Knowledge gap addressed**: Despite monitoring the presence, activity levels and colony size of the Ghost Bat at sites within the Union Reefs project area as part of monitoring associated with a drilling programme (Armstrong and Barden 2019), and longer term investigations at the Kohinoor adit by N. Hanrahan as part of a PhD study, understanding of Ghost Bat colony sizes and movements in the region is still relatively poor. In addition, there is a need to understand the responses of Ghost Bats to some of the planned Actions that will be implemented in response to plans for mining in the Union Reefs project area.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Monitor populations at key sites and where impacts from mining are occurring or likely; Develop cost-effective monitoring protocols (e.g. thermal tracking software) at a set of standardised sites that contain most of the known population.

Applicable objectives of the Action Plan

Objective 2. Provide confirmation that the Ghost Bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield.

Objective 6. Contribute to the long-term persistence of the Ghost Bat in the region by helping to protect stronghold colonies at Pine Creek and Spring Hill.

Benefits of the Action: Information about presence and levels of usage at monitoring sites provides the basis for triggers and contingencies. Extending the current monitoring program at Union Reefs to the longer term and additional sites within and outside of the Union Reefs project area will provide information relevant for continuous assessment of whether mining-related activity might be affecting the presence, activity levels and colony size of Ghost Bats in the Union Reefs project area, and other sites in the region.

Details of the Action

Various essential aspects of the monitoring effort are described below:

1. **Continuous and broad-scale monitoring**. Monitoring will take place at all relevant sites throughout the duration of the Union Reefs North Underground Project. This will include the OK adit (*Action 1*), Union North adit, newly created artificial roost sites (*Action 3*), Lady Alice adit (*Action 4*), the working containing Ghost Bats at Spring Hill, and the Kohinoor adit at Pine Creek plus any other natural caves in the hills surrounding the Union Reefs project area that might be discovered supporting a colony (*Action 9*).

2. **Regularity of monitoring**. A different amount of effort will be given to monitoring of different sites, based on their ease of access. A summary of how often recordings will be made and processed at the various study sites is provided in **Table 1**.

Table 1. Planned monitoring and reporting frequency during the period of mining, and for six months after completion of mining in the Prospect Pit and re-opening of the OK adit.

Location	Recording type	Recording frequency	Reporting frequency
OK adit Prospect adit	Acoustic	Continuing nightly until the Exclusion Nightly for two weeks after Exclusion	Mention in quarterly summary, annual report; no other monitoring after Exclusion has finished
	Thermal video	Nightly for one week before exclusion Nightly for one week after exclusion	Mention in quarterly summary, annual report; no other monitoring after Exclusion has finished
Union North adit	Acoustic	Nightly for duration of the program. Also dataloggers for noise, vibration, temperature, relative humidity	6-weekly internal memorandum, Quarterly summary, annual report
	Thermal video	Two consecutive nights every two weeks	Quarterly summary, annual report
Lady Alice adit artificial roosts	Acoustic	Nightly for duration of the program. Also dataloggers for noise, vibration, temperature, relative humidity	***6-weekly memorandum, Quarterly summary, annual report
	Thermal video	Two consecutive nights every two weeks	Quarterly summary, annual report
Kohinoor adit, Pine Creek	Acoustic	Nightly for duration of the program	Quarterly summary, annual report
	Thermal video	Two consecutive nights every two months, at minimum	Quarterly summary, annual report
Spring Hill mine	Acoustic	Nightly for duration of the program	Quarterly summary, annual report
	Thermal video	Two consecutive nights every two months, at minimum	Quarterly summary, annual report
Natural caves surrounding the Union Reefs project area (*as dependent on discovery; 1–2 of the largest/most active confirmed diurnal roosts)	Acoustic	Nightly for duration of the program	Quarterly summary, annual report
	Thermal video	Two consecutive nights every two months, at minimum	Quarterly summary, annual report
Underground Mine (post-mining only)	Acoustic	Nightly for six months	Report 6 months after commencement

	Thermal video	Two consecutive nights every month	Report 6 months after commencement

3. **Use of the best available non-invasive technology**. Ghost Bat presence, overall activity and colony size will be assessed through both acoustic and video recordings, both of which will not represent a disturbance to the colony. High quality acoustic recordings capable of providing detailed representations of Ghost Bat social calls will be made with Titley Scientific Anabat Swift bat detectors. Activity levels based on counts of social calls will be derived from these recordings using a semi-automated processing system (in the commercial software Kaleidoscope, via optimised settings developed by N. Hanrahan as part of a postgraduate research study). This approach has been undertaken to date in the monitoring effort conducted as part of the drilling programme (Barden and Armstrong 2019; Hanrahan et al. 2019). Activity levels provide information on both presence of the target species and the relative usage of a roost site, and a large acoustic dataset from a continuous recording effort is straightforward to analyse. Other species of bat present will also be represented in the recordings by their echolocation calls, and their presence/absence will also be reported.

4. **The best indicator of usage comes from counts of colony size**. Autonomous thermal video recorder units will be deployed at adit entrances to capture at least the first three hours after sunset when most or all of the Ghost Bat colony emerge for nightly foraging. Ghost Bats can be distinguished from other species of bat in thermal recordings by their large size. Recordings will be made at 30–60 frames per second and the recording units will be placed a few metres back from the adit portals to ensure that sufficient frames are available to capture the swiftly moving animals. Bat size can be calibrated against the size of the portal. The recordings will be processed by a semi-automated method (K.N. Armstrong unpublished) to clip out periods of non-activity, and the emergences will be identified and counted manually.

   Video recordings have been used to derive counts of colony size in the present monitoring programme. A FLIR Tau 320 thermal camera connected to a generic miniature Digital Video Recorder (DVR) has been used on numerous occasions. This equipment relies on investigators being present at dusk to switch the equipment on, and collect it when the recording is finished. A second system was developed during the programme, which relies on a Raspberry Pi 3B+ micro-computer connected to an infrared-capable video camera, and infrared spotlight light source. This system was designed to make an unattended recording for four hours during a standardised time period, as set by a scheduled start and stop time, and over 2 nights. This allowed investigators to set the unit at any time of the day and return to collect it after two nights. Both these systems have now been replaced. A new unit comprises a FLIR Boson 640 thermal camera core connected to a miniature DVR capable of programmable operation. This ‘third generation’ unit is autonomous, able to be deployed at any time of the day, avoids the use of infrared red spotlights, is significantly more reliable based on tests in February 2020, and has been chosen for use in this study.

5. **Sustained wider focus on context**. The monitoring program will need information on surrounding colonies to determine whether activities outside the Union Reefs project area might be having an effect on the number of Ghost Bats within the project area. Both of the two known major colonies within 15 km of the Union North adit are on other mining leases and might be subject to the effects of activities not related to the current

Proposal. The Pine Creek and Spring Hill colonies will also be monitored using acoustic and thermal video recorders, though on a less regular basis (**Table 1**).

6. **Triggers**. Two sets of separate, independent factors might cause Ghost Bat movement and therefore periods of absence at the Union North adit—natural factors, and mining-related activities. Being certain about which of the two has caused a period of absence is simply not possible, unless there is clear evidence of a major disturbance of the site, or a major change in the form of the underground tunnel structure (including major flooding). Baseline monitoring from long-term acoustic recordings has so far documented periods of several weeks where bats are absent (Barden et al. 2020b). Therefore, defining a trigger based on a certain period of absence will not be reliable for separating the effects of natural patterns and responses to disturbances. Rather than a monitoring programme that relies on triggers, thresholds and contingency actions as a basis for responding to unexpected effects from mining-related activity, the strategy taken by the proponent is to provide the contingencies and protections in advance so that refuges are available, and known, immediately should something happen (see rationale in section *Strategy of this Action Plan*).

7. **Contingencies**. The present Action Plan has already considered responses to the possibility that Ghost Bats cease using the Union North adit, if the implementation of *Action 5* is not sufficient for maintaining their usage of the site. Rather than reactive actions in response to a defined trigger, provision has been made for dispersing individuals through Actions that require a longer period of preparation, and that are specifically designed to provide a contingency roost and redundancy of these (*Actions 3 and 4*). Other Actions describe efforts to determine whether contingencies already exist in the form of alternative roosts already known to the species, thereby providing reassurance that dispersing individuals might be reaching known, optimal roost sites if they vacate the Union North adit (*Actions 6, 9 and 10*). Monitoring via *Action 7* may also provide reassurance that bats from the Union North adit have appeared at other sites. This might be more obvious at sites where smaller colonies are usual, such as cave sites. The scope of this monitoring program (*Action 7*) includes numerous alternative roosts in the Union Reefs project area and the wider region, so a reduction of activity and usage at the Union North adit will be interpreted in the context of any change that might occur at these alternative sites.

Acknowledged risks and limitations

There is no risk to the Ghost Bat with this Action, as the methods for monitoring are non-invasive.

⌦ Action 8—Provide a portion of the new mine for Ghost Bat occupancy

Mitigation Hierarchy step: Candidate Offset.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites, Disturbance to breeding sites.

2. **Knowledge gap addressed**: We know that Ghost Bats will colonise underground mines that have become derelict or otherwise disused, but the timeframe over which this happens is not well understood. This information, though a minor consideration in the current context, will contribute to any strategy that seeks to provide replacement habitat for the species.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Establish new or artificial roost sites, and evaluate their success.

Applicable objectives of the Action Plan

Objective 5. Contribute to the long-term persistence of the Ghost Bat in the Union Reefs project area.

Benefits of the Action: A new, additional major roost resource for Ghost Bats. The provision of a large, secure, stable underground structure for longer term use by Ghost Bats could be profound—resulting in a stable centre for the regional population that provides a better focus than the Kohinoor adit.

Details of the Action

The underground mine planned for construction as part of the Union Reefs North Underground Project will be relatively deep, and include multiple horizontal tunnels running from a main decline (descending tunnel) that will corkscrew to a depth of around 500 m. If some of this structure, essentially parts that will remain above the water table, are available for the Union Reefs Ghost Bat colony after mining has finished, it could ensure the long-term persistence of the colony in the local area, and possibly in the region.

This Action, the provision of a portion of the new mine to function as a Ghost Bat after the completion of mining, will only be enacted if it is safe to do so. The portal must be able to be made safe from an Occupational Health and Safety perspective, which would include keeping mine waste below the water level in the main decline, and the removal of the risk of oxidation of pit walls and backfilled areas.

Assuming this Action is feasible, the donation of the new mine for Ghost Bat use meets the criterion of 'like for like' under an Environmental Offset. While it would not be provided until after mining ceases, the structure is likely to be more suitable for Ghost Bat roosting than the OK adit. Thus, the contribution will exceed the value of the original structure. Together with the relatively non-invasive set of strategies outlined in this Action Plan, not only will the residual effects of the closure of the OK adit be more than accounted for, the Union Reefs area could

become a stronghold area for the species based on the quality of the habitat left following mining—artificial roosts, Lady Alice adit and the new mine all contributing to the survival of the Ghost Bat in the long term.

Several aspects of the mine structure will need to be considered when giving it over to use by Ghost Bats. The stability of the upper portion (any part above the water table) that will be used by bats will need to be checked. If there are no stoped sections in the tunnel ceiling that could hold warm, humid microclimate conditions, then such an 'aven' could be created with machinery.

The entrance to the mine will need to be barricaded against entry by people. In addition to warning signs, earthworks could be undertaken to ensure that the portal was fronted by water, or at height above a vertical section of pit, to discourage casual entry. Gating will also be installed, but a gap large enough for Ghost Bats to navigate will need to be maintained above the gate. If the portal was above head height on a vertical wall, additional bars could discourage climbing.

This site would be included in the monitoring of Ghost Bats in the six months following the cessation of mining to demonstrate whether the species was still present in the Union Reefs project area (*see Action 7*).

A report will be produced that contains an evaluation of the closure and gating of the mine entrance, as well as any resulting actions that are considered to be effective in maintaining Ghost Bat presence and that of other bat species at the site in the long term.

Acknowledged risks and limitations

There is unlikely to be any risk with giving over a mine to use by Ghost Bats if the design considerations above are met. The mine will be deep enough to maintain a suitable microclimate, and structurally stable in the long term. In addition, the entrance will be made secure against entry by people. The remoteness of the site from the nearest town will help to limit interest from tourists.

⌦ Action 9—Conduct field surveys for Ghost Bat diurnal roosts in natural caves

Mitigation Hierarchy step: Survey to support Mitigation /Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites; Disturbance to breeding sites.

2. **Knowledge gap addressed**: There is no information about whether the Ghost Bat uses caves in the hilly landscape that surrounds in the Union Reefs project area. If the Ghost Bat does use one or more caves, the size of the structure, the size of colonies, and the periods that they are occupied are all relevant to understanding the fluctuations in the size of the colony in the Union Reefs project area, and why this colony switches roosts on occasions.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Additional surveys are required in remote parts of the Northern Territory; Assess population size and significance of all known subpopulations.

Applicable objectives of the Action Plan

Objective 2. Provide confirmation that the Ghost Bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield.

Benefits of the Action: Will generate information relevant to the exclusion of bats at the OK adit, as well as knowledge about the longer-term presence of the species in and around the Union Reefs project area. Without information on whether roosts in natural caves exist in the hills surrounding the Union Reefs project area, it can only be assumed that individual Ghost Bats will have alternative roosts close to the OK adit when the exclusion is implemented.

Details of the Action

Knowledge of the presence of natural roost sites in caves in the hills surrounding the project area will provide further evidence that Ghost Bats have a nearby roost option (contingency roost) if an unforeseen event causes the exodus of Ghost Bats at the Union North adit during the period of mining. There are numerous mesa hills within a 15 km radius surrounding the Union Reefs project area that have not been searched for caves and Ghost Bat roost sites.

The various hill formations surrounding the Union Reefs project area can be examined in the first instance from freely-available satellite imagery and other coverages in a brief GIS study to prioritise areas for on-ground exploration. A targeted 'ground truthing' field survey will then be undertaken to check the bluff areas of mesa hills for Ghost Bat roosts. The survey will also consider the possibility of other areas where historical workings are present, and these will be examined and documented in a similar way to the survey of Barden and Armstrong (2018)

The presence of Ghost Bats will be established from scat material accumulations at the entrance of caves, and bat detector and video recordings made at cave entrances. Caves will not be entered initially, given the likelihood of having bats exit into daylight (daytime entry of Ghost Bat roosts has been identified as a threatening process). Equipment used to detect the presence of Ghost Bats, and provide information on colony size, includes custom-designed autonomous thermal camera and digital video recorder units, and Anabat Swift full spectrum detectors that record good detail of social calls and that maximise the detection range of the relatively soft echolocation pulses. Analysis of the video and acoustic recordings will be semi-automated using custom-designed processing systems and computer scripts that give higher efficiency and robustness than singular commercial products.

No caves will be entered until safety issues and the perspectives of Traditional Owners have been considered and permission granted from the landowners. Cave entry will only to be undertaken at night after bats have exited, and only if deemed necessary. Most of the pertinent information will likely be evident on video and acoustic recordings, including presence and colony size.

Ghost Bats are known to enter large steel culverts beneath roads and railways at night to rest and consume captured prey (e.g., Armstrong and Barden 2018). Culverts may also be used on occasions as diurnal roosts. Studies of Ghost Bat habitat usage can be extended to the examination of these feeding sites, which might assist with understanding foraging range and roost site connectedness. Extending the roost site exploration to include an examination of railway culverts further afield from the Union Reefs area could highlight the importance of culverts for Ghost Bat dispersal on a larger scale, and provide evidence of the connectedness of Ghost Bats within the central part of the Top End. Culverts would be examined in the late Dry season, noting presence of scats, prey remains, size, type and location of culverts.

Selected caves used by Ghost Bats will be monitored periodically and non-invasively during the time of closure of the OK adit, but with longer monitoring intervals than Union North, and depending on the ease of access to their location. An assessment of their inclusion into the monitoring programme can be made following their discovery.

This Action will begin in May 2020. Subsequent trips will be needed to fully search the mesa hills that surround the Union Reefs project area. Efficiency will be increased using helicopters and drones to assist in the location of caves prior to them being examined on follow-up foot surveys.
A separate report will be produced 3 months after the surveys have been completed to document the results. The results of any follow-up monitoring will be included in reports summarising the results of monitoring efforts (*see Action 7*).

Acknowledged risks and limitations

If cave entry is not undertaken, there is no cost to the Ghost Bat. There is a risk that Ghost Bats could fly into daylight if investigators enter caves. Thus, cave entry will not be conducted. All detections will be made remotely to remove the possibility of disturbance to Ghost Bats in their roost.

⌦ Action 10—Investigate the connectedness of Ghost Bat colonies in the region

Mitigation Hierarchy step: Scientific research to support Mitigation /Minimisation.

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Disturbance to roost sites; Disturbance to breeding sites.

2. **Knowledge gaps addressed**: Several colonies are known from the region, and the size of the colony occupying either the Union North adit or OK adit has been observed to vary in the past 12 months (Barden and Armstrong 2019; Hanrahan et al. 2019). It is not known whether bats in these two adits move regularly to caves (as yet unknown) in the hills surrounding the Union Reefs project area, and further afield to stronghold colonies at Pine Creek and Spring Hill.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Assess population size and significance of all known subpopulations [note: the genetic study helps to define what are populations; *see Glossary; note that the concept of a 'subpopulation' is not useful in the present context, at least until larger scale genetic studies are completed*].

Applicable objectives of the Action Plan

Objective 3. Confirm if Ghost Bats can maintain connectedness amongst colonies in the population, thus demonstrating the capacity for Ghost Bats to move from the Union Reefs project area to other colonies, including stronghold colonies.

Benefits of the Action: Confirmation that bats can move readily amongst the known colonies in the region, providing reassurance that the closure of the OK adit will simply prompt individuals to seek other roost sites within their nightly flight range. Without a genetic study, connections among colonies within the region, especially between the Union Reefs colony and those at Pine Creek and Spring Hill, can only be assumed.

Details of the Action

Previous efforts applying genetic markers to samples of Ghost Bats showed structuring of their northern range into disconnected geographical regions (Worthington Wilmer et al. 1994, 1999). Further work with modern techniques has since shown structuring within some regions (K.N. Armstrong unpublished data; N. Hanrahan unpublished data). An advanced genetic study method can be used to show that Ghost Bats move amongst roosts in the Daly Basin and Pine Creek IBRA bioregions (though at minimum among the Pine Creek, Spring Hill, and the Union Reefs areas), and thus are part of the same population.

In performing this study, the level of genetic similarity of individuals from different colonies will be used to determine whether gene flow occurs amongst these sites, which will infer the movement of individuals and the level of connectedness among major known colonies within the region. This type of study gives information at the level of both individuals and the population, and over time-scales that extend from a few generations to much longer. By

contrast, intensive studies focused on individuals, such as by radiotracking or genetics-based identification of individuals from scat material, will provide a much narrower understanding of movements.

The method, a genome-scale high-throughput DNA sequencing method called 'DArTseq' (Diversity Arrays, Canberra; https://www.diversityarrays.com/), will be used to confirm that colonies of bats are part of the same gene pool, thus confirming contemporary movement among regional colonies. The method provides information about not only population connectedness, but relatedness of individuals and indices relevant to conservation such as genetic diversity and inbreeding coefficients. The priority will be to establish if bats in the Union Reefs project area and surrounding hills are part of the same gene pool as the bats at Pine Creek and Spring Hill.

Usually such a genetic study requires the collection of samples from outside small focal areas of interest to help establish the extent of gene pools and population connectedness. This comparative framework is already available from prior studies across northern Australia conducted by Nicola Hanrahan and Kyle Armstrong, and the data will be made available.

The generation of markers is relatively cost effective per sample, but there is a requirement to use fresh tissue for this. Thus, Ghost Bats will need to be captured so that a non-lethal biopsy skin plug can be sampled from the wing membrane (a standard technique globally for bat studies; the hole closes within 4 weeks; Worthington Wilmer and Barratt 1996; Armstrong 2006; Faure et al. 2009; Weaver et al. 2009). Ideally, capture will be made away from the roost, but nearby, using an acoustic lure next to a harp trap and mist net arrangement. This strategy is based on observations made in the PhD research programme conducted by Nicola Hanrahan that Ghost Bats respond to broadcast playback of their social calls.

A separate report will be submitted six months from the completion of the field component that details the results of the field and analytical components of the study, and makes conclusions about the connectedness of the known colonies in the region. Consideration will also be given to releasing this information to the public domain via a peer-reviewed scientific publication, representing a collaboration between the postdoctoral researcher and the specialist consultants.

Acknowledged risks and limitations

A relatively low level of disturbance to Ghost Bats will be maintained near several known roost sites. This study involves the capture of bats, and relevant permits. If this is done at a roost entrance, there is a significant risk that Ghost Bats will vacate the structure, and move to suboptimal sites. The difference between this situation and the proposed exclusion at the OK adit is that the latter will be timed for periods when the Ghost Bat is not present. Capture will therefore be made away from the entrance, so that Ghost Bats do not associate the roost site with the disturbance.

⌦ Action 11—Provide support for further academic research on the Ghost Bat

Mitigation Hierarchy step: Scientific research to support overall management. Not part of the Mitigation Hierarchy (candidate Offset).

Considerations from the Conservation Advice

1. **Threat factor/s addressed**: Relevant to most threat factors listed in TSSC (2016).

2. **Knowledge gaps addressed**: A more comprehensive and contemporary understanding of distribution in the region; current size of various colonies and overall population; a deeper understanding of the movements of individuals; better knowledge of the timing of breeding and the bioacoustic characteristics of each stage; other information generated as determined by the researcher.

3. **Specific priorities addressed in the Conservation Advice by this Action**: Relevant to most specific actions and priorities listed in TSSC (2016).

Applicable objectives of the Action Plan

Objective 7. Seek further understanding of the Ghost Bat distribution, numbers and movements in the region to inform their conservation and management.

Benefits of the Action: A more informed basis for recommending strategies for the conservation and management of Ghost Bats, and better information on the distribution of the regional population. A better overall understanding of Ghost Bat ecology that can be applied to environmental impact assessment and conservation and management strategies.

Details of the Action

KLG will support a multi-year postdoctoral position at Charles Darwin University for a researcher to undertake studies on the biology of the Ghost Bat in the Northern Territory, and specifically in the region. Priority will be given to basic research that assists with the management and conservation of the species. The knowledge gaps listed above will be a core focus.

There are many possible themes for the study of Ghost Bats, given how little is known about many aspects of their biology. The Actions in the present document have been devised carefully to provide minimally-sufficient information to achieve the seven objectives of the Action Plan, while simultaneously minimising the invasiveness of the various investigations themselves. Additional efforts to provide further corroborating observations about regional movements are unlikely to change the strategy for managing the colony of Ghost Bats in the Union Reefs project area. By extending the scope of studies beyond the need to maintain the presence of Ghost Bats in the Union Reefs project area, efforts to conserve the species can be more broad-scale in nature, extending to other parts of the region, the Northern Territory, and nationally. However, it will still be relevant to prioritise knowledge gaps and the allocation of available resources so that disturbance from biological studies is minimised and only introduced by an investigator when there is a clear benefit to the species.

Acknowledged risks and limitations

This Action will cause potentially some level of disturbance to Ghost Bats at or near several known roost sites. Some of the techniques might require capture of individuals or entry of roost sites, potentially causing disturbance and disruption to normal patterns of behaviour. The use of various techniques will need to be rationalised against the value of the information gained. Ultimately, it will be the responsibility of the researcher to evaluate, prioritise, and seek approval for methods they consider to be relevant and worth the cost of disturbance to this species.

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Appendix 5 – Ghost Bat Management Plan



NT Mining Operations Pty Ltd
Union Reefs North Underground Mine

Ghost Bat Management Plan

KL | KIRKLAND LAKE GOLD

DECLARATION OF ACCURACY

I, Sally Horsnell, declare that all the information and documentation supporting this Ghost Bat Management Plan is true and correct. I am authorised to bind the Northern Territory Mining Operations Pty Ltd to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration. In making this declaration, I am aware that Sections 490 and 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (the EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents.

This document details the strategies proposed for managing the Ghost bat colony that, at times, utilise roosting habitat within the Union Reefs project area north of Pine Creek, Northern Territory.

Signed: _____

Full Name: Sally Horsnell

Position: Environmental Manager

Organisation: Northern Territory Mining Operations Pty Ltd (ABN: 65 36 525 990)

EPBC Number: XXXX

Date: _____

TABLE OF CONTENTS

1 Introduction 1

1.1 Project Description 1

1.2 Purpose and Objectives 1

2 Legal and Other Requirements 2

2.1 EPBC Conditions of Approval 2

2.2 Other Legal Requirements 2

2.3 Guidelines 2

2.4 Integrated Management System 3

2.4.1 The Ghost Bat Action Plan 3

2.5 Standard Operation Procedures 4

3 Roles and Responsibilities 5

4 Environmental Training 6

5 Emergency Contacts and Procedures 7

6 Species Information 8

7 Potential Risks and Impacts 10

8 Environmental Management Measures 14

8.1 Closure of OK and Prospect Adit 14

8.2 Disturbance from Unauthorised Visitation 16

8.3 Wet Season Flooding 18

8.4 Vibration and Ground Borne Noise Emissions 21

8.5 Dust Generating Mining Activities 23

8.6 Fencing 25

8.7 Artificial Lighting 26

8.8 Use of Vehicles and Machinery 27

8.9 Fire Management Activities 28

9 Ghost Bat Management Schedule 29

10 Audit and Review 31

TABLES

Table 2-1 Conditions of Approval 2
Table 2-2 Action Plan for the Management of Ghost Bats in the URPA – Summary of Actions 3
Table 5-1 Emergency Contacts 7
Table 6-1 Species Information for the Ghost Bat 8
Table 7-1 Project Activities, Risks and Potential Impacts on Ghost Bats 10
Table 8-1 Management of Risks from Closure of OK and Prospect Adit 14
Table 8-2 Management of Risks from Mining Activity 16
Table 8-3 Management of Risks from Wet Season Flooding 18
Table 8-4 Management of Risks from Vibration Emissions 21
Table 8-5 Management of Risks from Dust Generating Mining Activities 23
Table 8-6 Management of Risks from Fencing 25
Table 8-7 Management of Risks from Lighting 26
Table 8-8 Management of Risks from the Use of Vehicles and Machinery 27
Table 8-9 Management of Risks from Fire Management Activities 28
Table 9-1 Ghost Bat Management Schedule 29

FIGURES

Figure 6-1 Ghost Bat / *Macroderma gigas* 8
Figure 6-2 Habitat 9

APPENDICES

Appendix A – Ghost Bat Action Plan

1 INTRODUCTION

1.1 Project Description

Northern Territory Mining Operations Pty Ltd (NTMO) propose to develop the Union Reefs North Underground Mine (the project) at the Union Reefs Project Area (URPA), a highly modified brownfield mine site that has been subject historically to gold mining. The URPA is located approximately 20 km northwest of the township of Pine Creek and 175 km southeast of Darwin. Authorised activities at the URPA include ore processing and tailings storage.

The Union Reefs underground mine will be accessed via a portal and decline developed from within the existing Prospect pit. Prospect pit is divided into two sections, north and south, each of which has a pit lake. Both pits will be dewatered completely prior to portal construction. The Prospect pit (south) will be used to store waste rock that will then be returned underground and used as backfill during mining operations. Ore will be trucked directly to the existing Run of Mine pad, and then fed into the existing processing plant crusher using the existing infrastructure and equipment. Tailings will be deposited in the existing Crosscourse pit tailings storage facility.

The key features and infrastructure referred to in this Ghost Bat Management Plan (GBMP) are listed below. This includes four underground horizontal tunnels (adits) that are used as diurnal roosts by the Ghost bat *Macroderma gigas* (listed as Vulnerable under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999*). The characteristics of these adits and pits and their surrounding environments are described in detail in the Union Reefs North Underground Mine Draft Environmental Impact Statement (EIS) 2019.

- Prospect pit containing Prospect adit and OK adit
- Union North pit containing Union North adit
- Lady Alice adit, east of the Union North pit
- Artificial roosts to be constructed

1.2 Purpose and Objectives

The purpose of the GBMP is to provide the details of appropriate controls that will be implemented to protect Ghost bats at the URPA. This Environmental Management Plan (EMP) forms part of the NTMO Integrated Management System, to minimise the likelihood of potential impacts of the mining activities on Ghost bats. This GBMP has been developed from the Ghost Bat Action Plan (GBAP) that was included as part of the EIS, which provides the high-level strategy for protecting, managing and researching the Ghost bat within URPA, and at regionally important stronghold colonies present in other underground mines to the north (Spring Hill) and south (Pine Creek). This EMP will be treated as a dynamic document, to be revised and/or amended as required, to accurately reflect changing on-ground conditions and Ghost bat management measures.

Through implementing this EMP, NTMO aims to meet the following objectives:

1. Gather more information on the movements of Ghost bats that inhabit the URPA
2. Manage disturbance to Ghost bats and their habitat from mining and related activities
3. Avoid and control adverse impacts to Ghost bats
4. Promote awareness amongst mine staff of the need to protect threatened species

A key objective in this EMP is the management of a colony of Ghost bats that are known to use the Union North adit and OK adit on a regular (though not continuous) basis. This EMP describes the threats, mitigation measures and management strategies for Ghost bats known to occupy the URPA.

NTMO aim to be recognised as a leader nationally in efforts to manage, conserve and support research on the threatened Ghost bat.

2 LEGAL AND OTHER REQUIREMENTS

2.1 EPBC Conditions of Approval

Any activity that will have, or is likely to have a significant impact on a matter of national environmental significance requires Commonwealth Government approval under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). This includes nationally threatened animal and plant species and ecological communities. The EPBC Act approval condition requirements the project will address will be detailed in Table 2-1 below once issued.

TABLE 2-1 CONDITIONS OF APPROVAL

Ref.	Condition Number	Condition Requirement	Document Reference	Demonstration of How This Plan Addresses Condition Requirements
1	tbc			
2	tbc			
3	tbc			

2.2 Other Legal Requirements

Legal requirements applicable to this Ghost Bat Management Plan include:

- *Environmental Assessment Act 1982* – Administered by the Northern Territory Environmental Protection Agency (NT EPA). This Act is yet to be superseded by the *Environmental Protection Act 2019.*
- *Bushfires Management Act 2016* – Requires the prevention and control of bushfires including fire breaks, fire management plans and permits for lighting fires (Permit to Burn).
- *Mining Management Act 2001* – Mining Management Plans (MMPs) require technical studies, data and management plans based on the risk assessment of proposed activities.
- *Territory Parks and Wildlife Conservation Act 1976* – Lists plants and animals that are protected in the NT and requires management plans for impacts on protected species. Permits may be required to undertake studies for approvals or to remove or relocate problem animals during development or operations (Permit to Take or Interfere with Wildlife and/or Permit to Undertake Scientific Research).
- *Weeds Management Act 2001* – Duties of land owners to manage and prevent the spread of weeds into and out of the NT in accordance with a Weed Management Plan.

2.3 Guidelines

Guidelines applicable to this Ghost Bat Management Plan include:

- An Action Plan for the management of Ghost bats in the Union Reefs project area (Armstrong, Barden and Hanrahan, 2020)
- Environmental Management Plan Guidelines (Commonwealth of Australia, 2014)
- Conservation Advice, *Macroderma gigas* (Ghost bat), established under the EPBC Act (Threatened Species Scientific Committee, 2016)

2.4 Integrated Management System

NTMO manages significant environmental and social aspects of its operations through a series of EMPs, which are included in the NTMO Integrated Management System. The EMPs applicable to this GBMP are:

- Environmental Emergency Response Plan
- Dust Management Plan
- Fire Management Plan
- Flora and Fauna Management Plan

2.4.1 THE GHOST BAT ACTION PLAN

This Management Plan should also be read in conjunction with the Ghost Bat Action Plan (GBAP). The GBAP is a plan with a wider application than the URPA and encompasses actions to manage the wider regional population of Ghost bats and provide direction for scientific research for conservation of the species. The following table provides a summary of actions from the GBAP that are referred to in this document.

TABLE 2-2 ACTION PLAN FOR THE MANAGEMENT OF GHOST BATS IN THE URPA – SUMMARY OF ACTIONS

Action	Description	Objective
Action 1	Exclude the Ghost bat from the OK and Prospect adits based on a carefully planned protocol.	Protect Ghost bats from disturbances associated with mining-related activity in the Prospect pit.
Action 2	Characterise the internal dimensions of OK, Lady Alice and Union North adits.	Provide confirmation that the Ghost bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield.
Action 3	Create artificial habitats (contingency roosts) for the Ghost bats in the Union Reefs project area, for both contingencies and redundancy.	Encourage and protect the persistence of the Ghost bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost bats, and provide contingencies for roosting in the area if the Union North adit becomes unsuitable temporarily. Contribute to the long-term persistence of the Ghost bat in the Union Reefs project area. (Actions 3, 4, 8)
Action 4	Re-open and rehabilitate the Lady Alice adit so that it is suitable for Ghost bat occupancy.	Encourage and protect the persistence of the Ghost bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost bats, and provide contingencies for roosting in the area if the Union North adit becomes unsuitable temporarily. Contribute to the long-term persistence of the Ghost bat in the Union Reefs project area. (Actions 3, 4, 8)

Action	Description	Objective
Action 5	Manage the Union North adit during the period of mining to avoid direct impact from mining personnel (also discussed in Table 8-2).	Encourage and protect the persistence of the Ghost bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost bats, and provide contingencies for roosting in the area if the Union North adit becomes unsuitable temporarily.
Action 6	Implement management and protection measures to increase the security of the Pine Creek roost.	Contribute to the long-term persistence of the Ghost bat in the region by helping to protect stronghold colonies at Pine Creek and Spring Hill. (Actions 6, 7)
Action 7	Conduct a programme of continuous monitoring of Ghost bat presence, activity levels and colony size at all known (Union North adit) and potential (Lady Alice adit and newly created artificial roosts) within the project area.	Provide confirmation that the Ghost bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield. Contribute to the long-term persistence of the Ghost bat in the region by helping to protect stronghold colonies at Pine Creek and Spring Hill. (Actions 6, 7)
Action 8	Provide a portion of the new mine for Ghost bat occupancy once mining has been completed.	Contribute to the long-term persistence of the Ghost bat in the Union Reefs project area.
Action 9	Conduct field surveys for Ghost bat diurnal roosts in natural caves in the hills surrounding the Union Reefs project area.	Provide confirmation that the Ghost bat has continued suitable alternative diurnal roost habitat (contingency roosts) within the Union Reefs project area and further afield.
Action 10	Investigate the connectedness of Ghost bat colonies in the region using an advanced genetic method based on genome-scale DNA sequencing.	Confirm that Ghost bats maintain connectedness amongst colonies in the population, thus demonstrating the capacity for Ghost bats to move from the Union Reefs project area to other colonies, including stronghold colonies.
Action 11	Provide support for further academic research on the ecology of the Ghost bat.	Seek further understanding of the Ghost bat distribution, numbers and movements in the region to inform their conservation and management.

2.5 Standard Operation Procedures

NTMO Standard Operating Procedures (SOPs) applicable to the Ghost Bat Management Plan include:

- NTMO ES – SOP011 Fauna Monitoring
- NTMO ES – SOP031 Incident and Complaint Notification and Reporting
- NTMO ES – SOP032 Pest and Vector Management
- NTMO ES – SOP033 Fauna Injury and Death Management
- NTMO ES – SOP034 Feral Animal Management

3 ROLES AND RESPONSIBILITIES

The roles relevant for conducting management strategies in this GBMP are listed below. The timing and responsibilities of each relevant position are documented throughout Section 8 of this GBMP.

Internal Roles

- KLG Environmental Officer
- KLG Senior Environmental Officer
- KLG Environment Manager
- KLG Safety Officer
- KLG Operations Manager

External Roles

- Charles Darwin University Post-Doctoral Research Fellow
- Ghost Bat Specialist Consultants

4 Environmental Training

All NTMO personnel and external parties (including contractors and consultants) entering the URPA to conduct work activities will undergo a compulsory site induction before commencing works. This includes a Safety and Environment Induction, which includes (but is not limited to):

- Identifying the key points of environmental value on the URPA, including Ghost bats, their conservation status, ecology, sensitivities and key threats.
- Requirements of the GBMP, including environmental incident response procedures, site environmental controls, such as the restricted access areas of the URPA, and the consequences of not meeting their environmental responsibilities.
- Awareness training so that all personnel are made aware of their environmental responsibilities under the GBMP in relation to implementing mitigation measures, reporting environmental incidents and complaints, and implementing corrective actions.

Records of all training conducted will be maintained and include:

- The person receiving the training
- The date the training was received
- The name of the person conducting the training
- A summary of the training

5 EMERGENCY CONTACTS AND PROCEDURES

Incorporated into the Integrated Management System, NTMO has developed an Environmental Emergency Response Plan (Appendix 9.1 of the URPA MMP) to provide a framework for the safe response and management of environmental emergencies. Emergency responses to environmental issues are integrated within NTMO emergency response procedures. In the event of an environmental emergency, the following key personnel must be contacted.

TABLE 5-1 EMERGENCY CONTACTS

Emergency	Contact	Details
Medical emergency	**Emergency Services**	**Ph:** 000 or 112
Environmental emergency	**Sally Horsnell** Environment and Community Manager	**Ph:** 08 8982 4415 **Mob:** 0436 643 620 **Email:** SHorsnell@klgold.com.au
Ghost bat related query, sighting, injury or fatality	**Emer McGowan** Environmental Office (Ghost Bats)	**Ph:** **Mob:** **Email:** EMcgowan@klgold.com.au

6 SPECIES INFORMATION

The Ghost bat has a history of decline across its broad distribution, and now exists as a fragmented group of geographically isolated populations across northern Australia. The Daly River regional Ghost bat population is thought to comprise between 8.1 % and 12.5 % of the national Ghost bat population.

Part of this regional population is a colony of up to 50 individuals at different times of the year, that is confirmed to roost during the day in either the OK adit (in the Prospect pit) or the Union North adit (in the Union North pit) within the URPA. Diurnal roosting also occurs at times in the Prospect adit (in the Prospect pit). These diurnal roosts are within the remnants of the lower parts of historical workings that are found extending back from the walls of two open-cut mine pits. The adits are small, with tunnels being around c. 1.5 m high by 1.5 m wide, and are part of the goldfield that was worked mostly between c. 1880 and 1910. The open-cut mine pits are the result of contemporary mining activity in the past three decades. Monitoring indicates that Ghost bats switch between adits within the URPA, or move completely out of the area to roost elsewhere at different times. Table 6-1 summarises information about the Ghost bat.

TABLE 6-1 SPECIES INFORMATION FOR THE GHOST BAT

Common / Scientific Name	Ghost bat / *Macroderma gigas*
Conservation Status	• 'Vulnerable' under the Commonwealth EPBC Act 1999 • 'Near Threatened' under the Territory Parks and Wildlife Conservation Act
Description	The Ghost bat is the largest microchiropteran bat in Australia, with females being larger than males and weighing up to 170 g. They have a head and body length of 10 to 13 cm, a forearm length of 10 to 11 cm and a wingspan of up to 60 cm. It is Australia's only carnivorous bat. The fur is light to dark grey above and paler below. It has long ears which are joined together, large eyes, a simple nose leaf and no tail (TSSC, 2019).  **FIGURE 6-1 GHOST BAT / *MACRODERMA GIGAS***

Habitat	Ghost bats roost in deep limestone or sandstone caves, shallow sandstone caves with domed ceilings or in historical mine sites, i.e. disused mine adits (see images of this habitat below). The types of subterranean structures that provide diurnal roosts and support the larger colonies of Ghost bats and function as breeding sites are generally deep, with warm, humid microclimates.   **FIGURE 6-2 HABITAT**
Feeding	Diet consists of small mammals (including other bats), birds, reptiles, frogs, and usually a considerable proportion of large insects, and it varies regionally and depending on seasonal availability. Ghost bats forage either by ambushing passing prey in the air or on the ground. Most prey is taken to a feeding perch in trees, rock overhangs, or cave entrances to be consumed.
Life Cycle	Females breed at an age of two to three years and give birth to a single young, and occasionally twins. Birthing occurs over the period of a month commencing in August in the Top End. Young can be shifted to other warm caves as summer progresses. Juvenile bats commence flying at seven weeks, with all young capable of flight by the end of January.
Key Threats	Key threats are detailed in Section 7 of this GBMP. Of primary significance, Ghost bats are highly sensitive to disturbance at the entrance of and inside their roosts during the day. Noise, light and the presence of people and vehicles near daytime roost sites may result in Ghost bats leaving their roost. If Ghost bats are disturbed during the day and fly out of the roost, they risk predation by raptorial birds, and/or death from exposure to unfavourable outside ambient conditions.

7 POTENTIAL RISKS AND IMPACTS

The components of the project that pose potential risks and impacts to Ghost bats have been identified and are detailed in Table 7-1 below. The impact pathways have provided a basis for evaluation and justification of the proposed controls and management measures to modify the risk. The risk assessment methodology and risk rating system is as per Section 10 of the Draft EIS.

TABLE 7-1 PROJECT ACTIVITIES, RISKS AND POTENTIAL IMPACTS ON GHOST BATS

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Closure of OK adit and Prospect adit prior to mine construction	Development / construction	All Ghost bats disperse out of the URPA after closure of the OK adit, relocating to caves and other structures, or to alternative sites such as Pine Creek and Spring Hill.	• Reproductive success may be lowered when bats are forced to move elsewhere. • Habitat loss – temporary removal of one of two Ghost bat diurnal roost sites in the Union Reefs project area and possible breeding site. This also represents a loss of redundancy in the event that one remaining roost becomes unsuitable or is disturbed.	***Medium***
Closure of OK and Prospect adits prior to mine construction	Development / construction	Ghost bats are unable to find alternative roosts with suitable conditions.	• Loss of up to 30 individuals from the URPA (population potentially represents 2.6 % of the upper estimated regional Ghost bat population or approx. 1.5 % of the Top End population).	***Medium***

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Mining personnel in the vicinity of roosting sites	All mining phases	Disturbance to roosting habitat.	• Roost is not returned to after dusk exodus, and bats may need to travel further in one night to reach an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate. • Some or all bats exit into the daylight exposing them to predation by raptorial birds, and exposure to unfavourable outside ambient conditions causing mortality of some or all bats comprising the URPA colony. • Total colony loss would constitute 2.6 % of the Daly River regional population, or approx. 1.5 % of the Top End population Reduced reproductive success due to disturbance during breeding cycle.	***Medium***
Wet season flooding	All mining phases	Union North adit microclimate is changed due to being flooded and may become a sub-optimal roost.	• Potential habitat loss: Bats are forced to aggregate in fewer roost sites or find an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate. • Occurs at a critical part of the breeding cycle that causes an interruption to breeding activity and lowered reproductive output.	***Medium***
Vibration and ground borne noise emissions from mining activities	Operations / production	Disturbance to roosting habitat.	• Roost is not returned to after dusk exodus and bats may need to travel further in one night to reach an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate. • Some or all bats exit into the daylight exposing them to predation by raptorial birds, and exposure to unfavourable outside ambient conditions causing mortality of some or all bats within the URPA colony. • Total loss would constitute 2.6 % of the Daly River regional population, or approx. 1.5 % of the Top End population. • Reduced reproductive success due to disturbance during breeding cycle.	***Medium***

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Vibration and ground borne noise emissions from mining activities	Operations / production	Damage to roost sites from vibration (adit collapse / blockage) during the day.	• Mortality of some or all Ghost bats. Total colony loss would constitute 2.6 % of the Daly River regional population, or approx. 1.5 % of the Top End population.	***Medium***
	Operations / production	Damage to roost sites (adit collapse / blockage) during the night.	• Potential habitat loss: Roosting habitat is rendered unsuitable, roost is not re-occupied at dawn and bats may need to reach an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate.	***Low***
Dust generating mining activities, e.g. haul road, blasting, waste rock deposit, etc.	All mining phases (particularly operation phase)	Dust may reduce the suitability of roosting habitat, e.g. dust enters adits.	• Potential roost habitat modification. Bats are forced to find an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate. • Potentially coinciding with breeding cycle and reducing reproductive success.	***Low***
	All mining phases (particularly operation phase)	Dust reduces the suitability of foraging habitat, e.g. dust emissions and deposition in surrounding woodland.	• Reduced foraging success, forcing bats to travel longer distances to forage each night, which may or may not result in adequate feeding success. • Potentially coinciding with breeding cycle and reducing reproductive success. • Potential foraging habitat modification. May result in URPA colony relocating to alternate habitat outside of the URPA.	***Low***
Fencing	All mining phases	Ghost bats may become entangled in fencing in and around the URPA.	• Mortality of some or all Ghost bats. Total loss would constitute 2.6 % of the Pine Creek regional population, or approx. 1.5 % of the Top End population.	***Low***

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Lighting	All mining phases	Artificial light from the mine may reduce the suitability of foraging and roosting habitat.	• Potential habitat modification. Bats are forced to find an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate. • Reduced foraging success, forcing bats to travel longer distances to forage each night, which may or may not result in adequate feeding success. • Potentially coinciding with breeding cycle and reducing reproductive success.	***Low***
Use of vehicles and machinery within the URPA	All mining phases	Collision.	• Mortality of some or all Ghost bats. Total colony loss would constitute 2.7 % of the Pine Creek regional population, or approx. 1.5 % of the Top End population.	***Low***
Fire management activities	All mining phases	Burning activities reduce the suitability of foraging and/or roosting habitat.	• Potential habitat modification. Bats are forced to find an alternative site, which may or may not contain a suitable roosting and/or breeding microclimate. • Reduced foraging success, forcing bats to travel longer distances to forage each night, which may or may not result in adequate feeding success. • Potentially coinciding with breeding cycle and reducing reproductive success.	***Low***

8 Environmental Management Measures

The tables below represent each potential risk to Ghost bats or their habitat identified in Table 7-1 of this GBMP.

This Section describes the commitments of NTMO, pertaining to each of these risks, for the following:

- Objectives and targets
- Management strategies and associated actions from the action plan (GBAP; Armstrong et al. 2020)(Appendix A)
- Performance indicators, listing triggers where relevant
- Monitoring
- Reporting
- Corrective actions
- Timing of each aspect of the management strategy
- Roles and responsibilities

8.1 Closure of OK and Prospect Adit

TABLE 8-1 MANAGEMENT OF RISKS FROM CLOSURE OF OK AND PROSPECT ADIT

Closure of OK and Prospect Adits Prior to Mine Construction	Description	Responsibility	Timing
Objectives	Protect Ghost bats from disturbances associated with mining-related activity in the Prospect pit, and reduce the likelihood of mortality of individual Ghost bats due to closure of the adits in Prospect pit.		
Management Strategies / Actions	Exclude the Ghost bat from the OK adit and Prospect adit based on a carefully planned protocol. This protocol is detailed in the GBAP Action 1. Closure to take place: • When Ghost bats are observed to be absent. • After a survey of adits is complete. • After the contingency roosts have been established and opened (two artificial roosts; Lady Alice adit; Action 3, 4). • After the cave occupancy surveys have been initiated (Action 9).	NTMO Environmental Officers and Ghost Bat Specialist Consultants, Contractors and the CDU Research Team	Pre-construction

Closure of OK and Prospect Adits Prior to Mine Construction	Description	Responsibility	Timing
Monitoring	A monitoring program related to this objective will be conducted at several adits as per Action 7, as follows: • **OK adit and Prospect adit** – 24-hour acoustic monitoring and thermal video monitoring nightly one week before and after the exclusion protocol has been implemented. • **Union North adit and Lady Alice adit** – 24-hour acoustic monitoring and thermal video for two consecutive nights every two weeks for duration of the project. • **Kohinoor adit at Pine Creek, Spring Hill adits and natural caves surrounding URPA (dependent on discovery)** – 24-hour acoustic monitoring nightly and thermal video for two consecutive nights every two months for duration of the project.	**Deploying equipment:** KLG Environment Officer **Maintaining monitoring equipment and collating data:** Ghost Bat Specialist Consultants	Prior to closure; during and after closure
Reporting	A report will be produced to document the process and will detail the following: • Protocol for adit closure and observations made during the exclusion. • Monitoring results at each adit and artificial roost detailing activity levels and colony counts. • Summary of information from dataloggers (noise, vibration, temperature, relative humidity) at the Union North adit, Lady Alice adit, artificial roosts. The report can be assessed for the suitability of its release to the public domain once the information has been compiled.	**Data analysis and reporting:** Ghost Bat Specialist Consultants	Report submitted one month after the exclusion
Performance Indicators	No bat carcasses of any bat species are found outside the sealed portals to the OK adit or Prospect adit for 14 days after the permanent barricades have been established. Changes in the level of usage of the Union North adit, Lady Alice adit, artificial roosts, or any other regional site used by Ghost bats does not provide meaningful interpretation for the exclusion. Responses to exclusion (other than the presence of bat carcasses outside the adit entrances) cannot be separated from those occurring because of natural processes.		
Corrective Actions	If a carcass of any bat species is found at the sealed portal of the OK adit or Prospect adit, then the illumination designed to discourage the presence of bats will be re-evaluated and improved. Thermal video recordings and acoustic recordings will be made for seven nights after the Exclusion, unless bat carcasses are observed, in which case thermal video monitoring will be extended another seven nights.	As above	As above

8.2 Disturbance from Unauthorised Visitation

TABLE 8-2 MANAGEMENT OF RISKS FROM MINING ACTIVITY

Unauthorised Visitation in the Vicinity of Roosting Sites	Description	Responsibility	Timing
Objectives	Encourage and protect the persistence of the Ghost bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost bats by excluding visitation or disturbance of alternative roost sites (particularly Union North adit) from personnel, equipment and/or machinery.		
Management Strategies / Actions	Action 5 from the GBAP (Armstrong et al. 2019) details the management requirements of the Union North adit to exclude visitation and disturbance from mining personnel and equipment / machinery from Union North pit. Each adit within the URPA (Union North, Lady Alice and artificial roosts) will have designated exclusion zones: • Vehicles and other machinery prohibited in the Union North pit and above the extent of the underground structure. • Heavy machinery (not including light vehicles) prohibited within 135 m of the adit entrance (consistent with buffer zones established for the drilling program; Armstrong and Barden, 2019). • All mining and contractor personnel are prohibited from approaching or entering roost sites. Exceptions to this include approved activities and personnel under the GBAP, including (but not limited to) placement / retrieval of monitoring equipment (Action 7), and adit characterisation (Action 2). Exclusion zones will be made apparent with adequate signage. Mine personnel will be made aware of the threat of disturbance on Ghost bats through the inclusion of information in a compulsory 'Safety and Environment' induction on the presence and value of Ghost bats on-site, the restrictions in place including camera surveillance, and the consequences for non-compliance to these exclusion zone requirements.	**Adhering to exclusion zones:** All mining and contractors personnel **Maintaining integrity of exclusion zones:** KLG Environmental Officer **Safety and Environment Inductions:** KLG Safety Officer	Enacted during all mining phases

Unauthorised Visitation in the Vicinity of Roosting Sites	Description	Responsibility	Timing
Monitoring	Surveillance to allow enforcement of these restrictions will be implemented using wildlife camera traps placed at the Ghost bat roosts. The units will face out from the entrance, or another point where they are deemed to be effective for identifying people. They will be reviewed every two weeks, coinciding with the thermal camera deployments.	**Deploying, maintaining and data analysis:** KLG Environmental officer	Continuously throughout all mine phases CCTV footage reviewed every two weeks
Reporting	Any breach of these exclusion zones will be reported immediately to the KLG Environmental Officer who will lodge an incident report, to include in the quarterly and annual reporting requirements.	**Enforcing requirements and incident reporting:** KLG Environmental Officer	Quarterly and annual reports
Performance Indicators	No Ghost bats exiting their diurnal roosts into the open (daylight) as the result of a disturbance from personnel or equipment at the entrance of or within any of the adits within the URPA. An indicator of performance is no reported incidents.		
Corrective Actions	Incident reporting will be used in corrective actions that allow compliance with the management actions listed in this plan to be achieved. Non-conformance will be reported and addressed to prevent reoccurrence.	N/A	As required

8.3 Wet Season Flooding

TABLE 8-3 MANAGEMENT OF RISKS FROM WET SEASON FLOODING

Wet Season Flooding	Description	Responsibility	Timing
Objectives	To maintain the suitability of the Union North adit for Ghost bat roosting during and following rainfall events.		
Management Strategies / Actions	The source of the water that accumulates in the Union North adit is unknown; however, there is a straightforward solution to maintaining low water levels, and therefore the long-term (i.e. wet season) suitability of the Union North adit for Ghost bats. If an accumulation of water (defined as a complete inundation of the adit floor; not pooled or puddled) is visible from the portal, the water will be pumped out of Union North adit using the following non-invasive protocol: 1 Observations to date do not suggest that water is entering the adit from the entrance, rather the level increases from a source inside the adit. However, if a future observation suggests that some contribution to the water level originates from water running in via the entrance, a bund of dirt will be applied and maintained using hand tools. 2 A pump will be installed permanently a minimum distance of 40 metres from the entrance to Union North adit, with a noise-reducing shroud included. The chosen pump will be a model that emits relatively low noise, and consideration will be given to smaller models that may need to pump for longer but emit less noise. The pump will be located out of direct line of sight of the adit entrance, to reduce noise transmission further. The pump intake pipe will be installed permanently in the Union North adit, which will extend as far as the debris pile c. 60 metres from the entrance. The intake pipe will be installed at night when bats are absent, in the same way that occasional inspections of the adit have been undertaken previously. 3 The adit will be inspected from the portal on a weekly basis, and after heavy rainfall events, to determine internal water levels. Note that both the length of the tunnel and the pile of debris in the middle of the adit prevent torchlight reaching areas where the bats roost, so no disturbance from regular inspections of water level is likely. 4 If water is observed to have accumulated in the base of the adit from the portal, the pump will be turned on. Operation of the pump will be conducted at night only to reduce disturbance. The pump will be turned on no sooner than two hours after sunset, to give enough time for bats to vacate the structure.	KLG Environment Officer	When required during large rainfall events

Wet Season Flooding	Description	Responsibility	Timing
	5 Water from the adit will be pumped into the adjacent lower lever pit lake to the north of Union North adit. 6 Pumping will cease when water levels have reduced to the point that inundation is no longer visible. 7 Inspections of water level will be continued on a daily basis for three days after the last pumping event, and then return to the standard inspection regime once pumping has not been required for three days.		
Performance Indicators / Triggers	No trigger or performance indicator based on the activity of Ghost bats will be implemented, given that we cannot separate the effects of changing roost conditions from natural patterns of Ghost bat movement or roost usage; and also that the practical limitations of the acoustic monitoring do not allow for an immediate assessment of any possible response to flooding. If water inundation is observed in the Union North adit from the entrance (the trigger), it will be pumped after the next sunset. Water inundation is defined as complete inundation the adit floor visible from the entrance; not pooled or puddled. It should be noted that if any inundation is visible from the entrance, then the rear of the adit is likely to be flooded to a greater depth. It should also be noted that it is not possible to estimate the water depth at any point of the adit tunnel from a casual inspection from the entrance, but given that water depth is known to increase with distance from the entrance, any inundation visible from the entrance will indicate the need to pump to reduce water levels in the area where bats roost. The performance indicator will be a complete reduction in the water level observed in the adit from the entrance. Small pools or puddles remaining after pumping in depressions of the floor do not count as water inundation.	KLG Environment Officer to monitor large rainfall events and rainfall data Ghost Bat Specialist Consultants to analyse Ghost bat movement data for correlations with rainfall events	When required during large rainfall events; weekly throughout the wet season (November to April inclusive)
Monitoring	Water levels will be inspected weekly across the wet season, with increased frequency during and following large rainfall events.	KLG Environment Officer to monitor rainfall data	When required during large rainfall events
Reporting	Any inundation of the adit, and the details of subsequent pumping will be included in the regular bat activity monitoring reports that are prepared as part of Action 7 in the Ghost Bat Action Plan.	KLG Environment Officer to pass on information to	Reporting in regular bat activity

Wet Season Flooding	Description	Responsibility	Timing
		Ghost Bat Specialist Consultants; to include information in regular bat activity monitoring reports	monitoring reports as scheduled in Action 7 of the Ghost Bat Action Plan
Corrective Actions	Management strategies listed above can be considered corrective action.	KLG Environment Officer to coordinate pumping	As the need for pumping of the adit arises

8.4 Vibration and Ground Borne Noise Emissions

TABLE 8-4 MANAGEMENT OF RISKS FROM VIBRATION EMISSIONS

Vibration and Ground Borne Noise Emissions from Mining Activities	Description	Responsibility	Timing
Objectives	Encourage and protect the persistence of the Ghost bat in the Union Reefs project area during the period of mining, and the period that the OK adit is temporarily closed to Ghost bats: 1 Vibration emissions recorded at all URPA roost sites to remain below 10 mm/sec. 2 Ground-borne noise emissions recorded at all URPA roost sites to remain below 75 dBZ. 3 No daylight exodus of Ghost bats from URPA roost sites as a result of noise and vibration disturbance from drilling and blasting in the Underground Mine.		
Management Strategies / Actions	• Alternative roost site locations (Union North adit, Lady Alice adit, artificial roosts) are all predicted to experience vibration emissions at a level that is not expected to disturb Ghost bats. The value of 10 mm/sec for vibration and 75 dBZ for ground-borne noise level (based on modelling conducted by Velasco 2019) are defined here as thresholds, and their exceedance will trigger a response. • A continuous program of monitoring will be conducted within URPA roost sites, which will allow mining activities to be correlated with the activity of Ghost bats). • The entrance portals to all URPA roosts will be examined for blockages or instability when acoustic, video and datalogger equipment is being maintained.	**Adit inspections and equipment deployment:** KLG Environment Officer	For the duration of mine operation / production phase
Monitoring	Noise and vibration dataloggers will be installed in the Union North adit, Lady Alice adit and all artificial roosts. Dataloggers will be installed that do not require regular human entry of adits, only an initial entry to place probes on a long cable into position at night when bats have left. The recording and controlling device will be placed at the entrance. Dataloggers will be downloaded when acoustic and video equipment is maintained, which is every two weeks.	**Deploying equipment:** KLG Environment Officer **Maintaining monitoring equipment and collating data:** Ghost Bat Specialist Consultants	Data review every two weeks for the duration of mine operation / production phase

Vibration and Ground Borne Noise Emissions from Mining Activities	Description	Responsibility	Timing
Reporting	Data from noise and vibration dataloggers will be included in quarterly and annual reports that document Ghost bat activity in URPA. Any values of noise and vibration above the thresholds would be identified and correlated with Ghost bat activity. This information is valuable to document, and consideration will be made of whether to release this to the public domain, given its potential cross-application to other projects.	**Data analysis and reporting:** Ghost Bat Specialist Consultants	Quarterly and annual reports
Performance Indicators / Triggers	Documentation of whether the threshold level of 10 mm/sec for vibration and 75 dBZ for ground-borne noise emissions have been exceeded. If these levels are exceeded, this will be correlated with the activity levels of Ghost bats to determine if there was an obvious, remarkable and unusual change. If there was, as determined by the Ghost Bat Specialist Consultants, then a modification to the blasting regime would be enacted as a minimisation action, as described above. No threshold levels for Ghost bat activity change are specified, given the difficulty of defining them, and disentangling their natural patterns of movement from changes related to mining activity (see GBAP Strategy of this Action Plan; Armstrong et al. 2019).		
Corrective Actions	The project has the capacity to adjust blasting pattern / timing / sequence / duration if the noise and vibration thresholds are exceeded. If noise and vibration levels exceed the thresholds stated above, then the following actions will be implemented: • Blasting will only be permitted to occur between 0500 and 0600, and between 1700 and 1800 each day, which correspond to times of the day when Ghost bats might be active inside the roost prior to leaving after dusk, or just after returning before dawn, and thus less likely to be disturbed compared with when they are resting. • Consideration of different blast conditions to reduce the magnitude of noise and vibration emissions. • Noise and vibration monitoring in URPA roosts to check whether the altered blasting regime results in noise and vibration levels decrease below the threshold levels.	KLG Operations Manager	When required

8.5 Dust Generating Mining Activities

TABLE 8-5 MANAGEMENT OF RISKS FROM DUST GENERATING MINING ACTIVITIES

Dust Generating Mining Activities	Description	Responsibility	Timing
Objectives	Prevent and avoid modification to roosting or potential foraging habitat due to dust emissions and deposition.		
Management Strategies / Actions	There is no information about levels of dust that would cause a significant impact to Ghost bats. To approach the issue of potential impacts of dust on Ghost bats, and limit levels of dust, we will rely on the regular procedures for dust suppression that are enacted during normal operation of mine sites. A dust monitoring program is already in place as part of operational management for the URPA and is detailed in the Dust Management Plan. An outline of the dust management strategies are as follows: • Water from the Plant Spill Pond is used for dust suppression around the processing plant and ROM areas. • Vehicle exclusion zones (as detailed in Table 8-2) to mitigate dust around Ghost bat roosting sites. • A dust monitoring program is implemented within the URPA (detailed below). • The haul and main access roads are sprayed continuously to reduce dust from traffic.	**Dust suppression around processing plant and roads:** KLG Operations Manager	During all mine phases
Monitoring	Dust monitoring is conducted for a minimum of three months in the dry season, and sampling is in accordance with the Dust Deposition Sampling Procedure. The program consists of two dust deposition gauges to capture various dust criteria measures from the main dust generating areas of the URPA on sensitive receptors (given the prevailing wind direction during the dry season).	**Deployment and maintenance of dust monitoring equipment:** KLG Environment Officer	For three months during the dry season
Reporting	Annual dust reporting of total loads and metals to DPIR and National Pollutant Inventory (NPI) to the federal regulator. Estimates of fugitive emissions of Particulate Matter 10.0 µm (PM_{10}) and Particulate Matter 2.5 µm ($PM_{2.5}$) are reported for the URPA.	**Data analysis and reporting:** KLG Environmental Officer	Reporting annually following dry season data collection

Dust Generating Mining Activities	Description	Responsibility	Timing
Performance Indicators / Triggers	Consistent results showing dust deposition levels below the internal trigger threshold will confirm whether monitoring can be decommissioned after sufficient data has been collected (i.e. 3 years) and a risk assessment has been completed. The criteria have been derived from subjective observations and investigation of dust levels and nuisance effects. NTMO compare dust deposition results to the New South Wales (NSW) Department of Environment and Conservation's *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*. The dust deposition criteria allow a mine to add a certain amount of dust to the atmosphere. A mine may increase deposited (background) dust levels by up to 2 g/m$_2$/month (annual average). However, the total deposited dust level should not exceed 4 g/m$_2$/month (annual average). Based on this, an internal dust deposition guideline value of 2 g/m$_2$/month plus the control level is applied as a guide only to determine the risk and effectiveness of dust management strategies.		
Corrective Actions	If guideline values are not met, management strategies will be reassessed and alternative and additional dust suppression options will be considered.	KLG Operations Manager	When required

8.6 Fencing

TABLE 8-6 MANAGEMENT OF RISKS FROM FENCING

Fencing	Description	Responsibility	Timing
Objectives	Prevent and avoid Ghost bat fatalities from barbed wire fence entanglement within the URPA.		
Management Strategies / Actions	When new fences are constructed or old fencing is replaced, plain wire only, and no barbed wire, will be used. All fencing near roost sites must not have any barbed wire. Where barbed wire is found near roost sites, it will be replaced as soon as practicably possible with plain wire. Where barbed wire is required to meet Australian Standards to restrict access of personnel for safety reasons, metal disks will be placed between the top two strands to make the fence more visible to bats in flight.	**Fence inspections:** KLG Environment Officer Fencing to be replaced by KLG nominated team member or fencing contractor	Inspections to be conducted during mine development / construction phase
Monitoring	N/A	N/A	N/A
Reporting	Any Ghost bat death from a fence entanglement will be documented in the fauna register and the fauna fatality register, which is reported monthly and quarterly to National and International KLG and shareholder and annually to DPIR. The observation of any entanglements will also be included in the regular quarterly and annual monitoring reports of Ghost bat activity and numbers (Action 7 of the GBAP).	KLG Environment Officer	As required
Performance Indicators / Triggers	No recorded Ghost bat injuries or fatalities from barbed wire fence entanglement within the URPA.		
Corrective Actions	Where barbed wire fence is found near URPA roost sites, it will be replaced as soon as practicably possible with plain wire. The need for the fence will also be reconsidered.	**Fence inspections:** KLG Environment Officer	During mine construction / development phase

8.7 Artificial Lighting

TABLE 8-7 MANAGEMENT OF RISKS FROM LIGHTING

Artificial Lighting	Description	Responsibility	Timing
Objectives	No addition of lights to areas near Ghost bat roosts in order to avoid associated disturbance.		
Management Strategies / Actions	No artificial lighting will be added within the restriction areas (as detailed in Table 8-2) for the Union North adit, Lady Alice adit and artificial roosts.	KLG will incorporate this clause into any infrastructure development approvals	Throughout all mine phases
Monitoring	N/A		
Reporting	N/A		
Performance Indicators / Triggers	N/A		
Corrective Actions	N/A		

8.8 Use of Vehicles and Machinery

TABLE 8-8 MANAGEMENT OF RISKS FROM THE USE OF VEHICLES AND MACHINERY

Use of Vehicles and Machinery	Description	Responsibility	Timing
Objectives	No recorded Ghost bat injuries or fatalities from vehicle collision within the URPA.		
Management Strategies / Actions	As described in Table 8-2, Action 5 of the GBAP will be implemented to reduce disturbance surrounding known Ghost bat roost sites through the definition of exclusion zones. The implementation of this management strategy will eliminate the risk of Ghost bat vehicle collision around roosting sites. The risk of collision in the greater URPA area is mitigated by a maximum site speed limit of 40 km/hr. This will reduce the likelihood of fauna collisions. The requirement to obey posted speed limits is included in safety and environment inductions for all mine personnel and contractors.	All mine personnel and people entering the URPA	At all times, during all mining phases
Performance Indicators / Triggers	No recorded Ghost bat injuries or fatalities from vehicle collision within the URPA.		
Monitoring	N/A	N/A	N/A
Reporting	Report any collisions on fauna register and fauna fatality register and/or to KLG environmental officer. Any incidences of speeding are reported in the INX incident reporting system. The observation of any collisions will also be included in the regular quarterly and annual monitoring reports of Ghost bat activity and numbers (Action 7 of the GBAP).	Incident logged by all site personnel and KLG safety department are responsible for reporting data into system	As required during all mining phases
Corrective Actions	If Ghost bat collisions are reported in areas not currently enforced with speed limits, they will be introduced to reduce the likelihood of similar future events.	KLG Environment Manager	As required during all mining phases

8.9 Fire Management Activities

TABLE 8-9 MANAGEMENT OF RISKS FROM FIRE MANAGEMENT ACTIVITIES

Fire Management Activities	Description	Responsibility	Timing
Objectives	No reduction in the quality of roosting and foraging habitat due to inappropriate fire management.		
Management Strategies / Actions	An existing Fire Management Plan is already in place at the URPA and can be found in the NTMO IMS and URPA MMP. Key management strategies applicable to this GBMP include: • Large fuel loads around sensitive receptors will be reduced through hazard reduction burning from the mid wet season to the end of wet season to reduce the likelihood of Ghost bat disturbance due to high intensity wild fire. • When conducting hazard reduction burning in woodland areas, low intensity mosaic-style burns will be implemented to avoid vegetation simplification and retain suitable foraging habitat for Ghost bats. • With the exception of the Union North adit, there is potential for fire to burn the area immediately around the entrance portal. At the Lady Alice adit and the artificial roosts, burns will be kept at least 20 metres from the entrance to avoid any stimulus for Ghost bats to fly into daylight.	**Monitoring of fire risk surrounding sensitive receptors:** KLG Environmental Officer **Fire management:** Emergency Response team and contractors	Mid to end of the wet season
Performance Indicators / Triggers	N/A	N/A	N/A
Monitoring	N/A	N/A	N/A
Reporting	Monitor and record the occurrences of controlled and wildfires.	KLG Environmental Officer	Annual reporting
Corrective Actions	N/A	N/A	N/A

9 GHOST BAT MANAGEMENT SCHEDULE

Table 9-1 below shows an indicative schedule for all Ghost bat actions and associated management strategies detailed in this GBMP, including monitoring duration and frequency. These are shown in relation to relevant major mining activities.

TABLE 9-1 GHOST BAT MANAGEMENT SCHEDULE

Activity	Start	End	Duration (days)	Frequency	Comments
Development / Construction Phase					
Monitoring – OK adit and Prospect adit (acoustic)	01/10/2018	Until adit closure	-	Continuous	
Monitoring – OK adit and Prospect adit (thermal video)	01/10/2018	Until adit closure	-	2 consecutive nights every 2 weeks	
Action 1 – Closure of OK adit and Prospect adit	Within the low/no occupancy opportunity window	Prior to mine production phase	Minimum 3	Once	
Action 4 – Re-open Lady Alice adit	01/12/2019	01/12/2020	1	Once	This action was completed in December 2019
Action 6 – Implement management at Kohinoor adit	01/05/2020	-	-	Continuous	
Action 5 – Manage disturbance to Union North	01/10/2018	-	-	Continuous	
Action 9 – Survey for unknown cave roost sites in areas surrounding URPA	01/05/2020	01/12/2021	1 day / survey	Several field surveys	
Ghost bat management Action 2 – Characterise OK adit and Union North adit	01/12/2019	01/12/2019	1	Once	This action was completed in December 2019
Action 3 – Construct artificial roosts	01/04/2020	Prior to commence-ment of Action 1	5	Once	At least 2 structures built
All Mine Phases					
Union North adit (acoustic monitoring)	01/10/2018	Until post closure	-	Continuous	
Union North adit (thermal video monitoring)	01/10/2018	Until post closure	-	2 consecutive nights every 2 weeks	

Activity	Start	End	Duration (days)	Frequency	Comments
Lady Alice adit (acoustic monitoring)	01/10/2018	Until post closure	-	Continuous	
Lady Alice adit (thermal video monitoring)	01/10/2018	Until post closure	-	2 consecutive nights every 2 weeks	
Kohinoor adit (acoustic monitoring)	01/05/2020	Until post closure	-	Continuous	
Kohinoor adit (thermal video monitoring)	01/05/2020	Until post closure	-	2 consecutive nights every 2 weeks	
Spring Hill roosts (acoustic monitoring)	01/01/2020	Until post closure	-	Continuous	
Spring Hill roosts (thermal video monitoring)	01/01/2020	Until post closure	-	2 consecutive nights every 2 weeks	
Natural caves surrounding URPA (acoustic monitoring)	Immediately following discovery	Until post closure			
Natural caves surrounding URPA (thermal video monitoring)	Immediately following discovery	Until post closure			
Artificial roosts (acoustic monitoring)	Immediately following construction	Until post closure	-	Continuous	
Artificial roosts (thermal video monitoring)	Immediately following construction	Until post closure	-	2 consecutive nights every 2 weeks	
Action 10 – Study of colony connectedness using genetic markers	01/03/2020	01/12/2021	-	Continuous	
Action 11 – Provide support for university research project on general ecology	01/03/2020	01/03/2023	Duration of program	Continuous	
Closure and Post Closure Phase					
Action 8 – Convert underground mine for Ghost bat habitat	01/05/2023	01/05/2023	1	Once	
Action 8 – Underground mine (acoustic monitoring)	01/05/2023	01/11/2023	186	Continuous for 6 months	

10 Audit and Review

This GBMP will be reviewed and/or updated annually, and more frequently as required, to make sure that it is current and addresses any changes, including:

- Information or discoveries occurring after the preparation of this GBMP
- Environmental incidents
- Site conditions or requirements
- Statutory requirements or community expectations
- Operational activities, technology or equipment
- Guidelines, policies or procedures

Review and update of this GBMP shall also be triggered where any project activities have potential for an environmental impact that is not sufficiently controlled through existing management practices. The review will assess whether the plan is achieving its objectives and the requirements of any relevant approval conditions. The review will be based largely around a checklist, environmental monitoring records, corrective actions and the results of any audits.

Review and update of this GBMP will provide for continuous improvement. Compliance auditing will primarily be the responsibility of the KLG Environmental Manager with any identified changes or deficiencies being promptly addressed and new revisions of the GBMP issued as necessary.

Appendices

Appendix A – Ghost Bat Action Plan

(The Ghost Bat Action Plan will be appended to this Ghost Bat Management Plan, but for the purposes of reporting, see Appendix 4 in the EIS Supplementary report)


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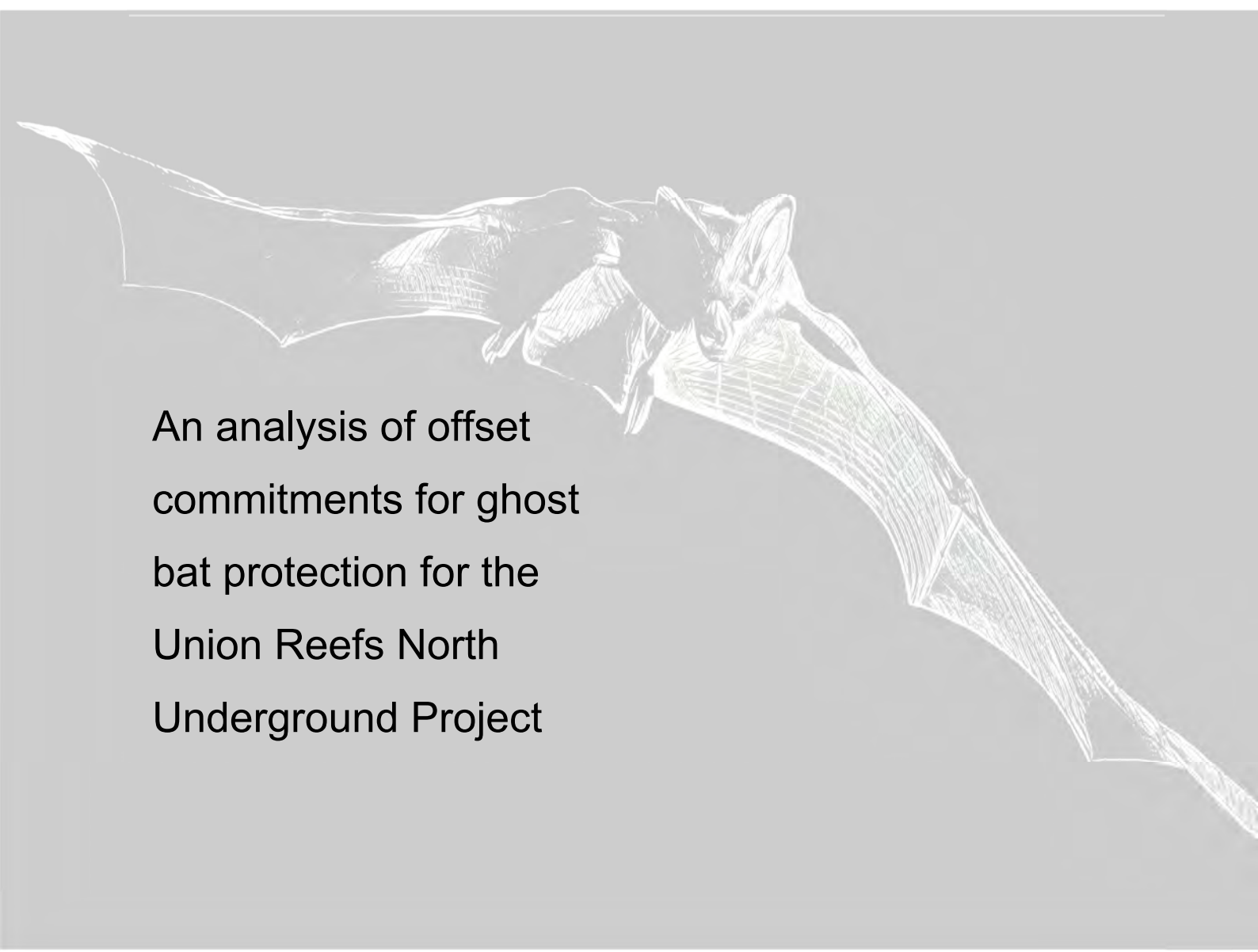
Appendix 6 – Memo 2: An Analysis of Commitments to Ghost Bat Protection under the EPBC Act 1999 Environmental Offsets Policy October 2012

KLG Ghost Bat Memorandum 2
March 2020

An analysis of commitments to ghost bat protection under the *EPBC Act 1999* Environmental Offsets Policy October 2012

This document is an attachment to the Supplementary, prepared in response to comments on the EIS technical document:

Barden, P. and Armstrong, K. (2019). Union Reefs North Underground Project. Environmental Impact Assessment. Ghost Bat Technical Report. November 2019. Unpublished document by Ecological Management Services Pty Ltd and Specialised Zoological to Kirkland Lake Gold Ltd. Final Revision 4, 22 November 2019.



An analysis of offset commitments for ghost bat protection for the Union Reefs North Underground Project

Specialised Zoological

EMS | ECOLOGICAL MANAGEMENT SERVICES ENVIRONMENTAL CONSULTANTS

Prepared for Kirkland Lake Gold Ltd

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Contents

	Page
1 Introduction	1
2 Environmental offsets under the EPBC Act	2
2.1 What are environmental offsets?	2
2.2 When do EPBC Act offsets apply?	2
2.3 Types of Offsets	3
2.4 How are EPBC Act offsets determined?	8
3 Offset delivery options for the ghost bat at Union Reefs	10
4 Future management and monitoring of offsets	11
5 References	12

1 Introduction

This analysis was developed as part of the Environmental Impact Statement (EIS) for the Union Reefs North Underground Project by NT Mining Operations Pty Ltd (NT Mining Operations), which is owned by Kirkland Lake Gold Ltd. NT Mining Operations plan to further develop deposits of gold ore in the Union Reefs project area, north of Pine Creek in the Northern Territory, by constructing a new underground mine with an entrance portal in the existing Prospect pit.

The ghost bat *Macroderma gigas*, which is specially protected and listed as Vulnerable under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999*, and Vulnerable under the *Territory Parks and Wildlife Conservation Act 1976* (Northern Territory), was detected at roost sites in the Union Reefs project area in the past (NSR Environmental Consultants 1993), and during recent survey and monitoring (Armstrong and Barden 2018; Barden and Armstrong 2019).

The ghost bat uses three historical mine adits for roosting during the day—'Union North adit' in the Union North pit; 'OK adit' and 'Prospect adit' in the Prospect pit. Plans to construct a new underground mine in the Prospect pit will involve the development of a mine portal very close to the OK adit and Prospect adit. To avoid the range of potential disturbances that close proximity to mining-related activity will bring, the primary avoidance action is to close the OK adit to ghost bat usage for the duration of mining.

Monitoring of ghost bat usage and activity at the OK adit has so far shown that it is used less, and is therefore less important, than the Union North adit (Barden et al. 2020). Both of these sites are confirmed as diurnal roosts, and they support a colony of up to 50 individuals, but colony size and occupancy varies considerably over the year. The Prospect adit is used as an occasional nocturnal refuge and feeding site, and only rarely as a diurnal roost.

The strategy to minimising any unforeseen effects has been to produce a series of Actions that anticipate potential effects and provide multiple redundant contingencies in advance, generate new information that will provide a deeper understanding of how much bats move around the region amongst roost sites, and provide protections for alternative roost sites that contain 'stronghold' colonies ('An Action Plan for the management of Ghost Bats in the Union Reefs project area'; Armstrong et al. 2020).

Some of the Actions in the Action Plan might qualify as environmental offsets under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Environmental Offsets Policy October 2012. The present document provides a discussion about offsets to:

- demonstrate an understanding of the EPBC Act Environmental Offsets Policy (SEWPaC 2012) in the context of the Union Reefs North Underground Project; and

- outline direct and indirect offsets which might compensate for the potential impacts that the project would have on the ghost bat *Macroderma gigas*.

2 Environmental offsets under the EPBC Act

2.1 What are environmental offsets?

The Commonwealth Department of the Environment provides a framework for considering environmental offsets in the context of proposed development projects under its 'Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy' (SEWPaC 2012).

The policy provides guidance, consistency, transparency and flexibility for delivering good environmental outcomes. SEWPaC (2012) defines environmental offsets as:

> "…measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures."

Offsets are therefore intended to compensate for residual significant impacts, and do not reduce the likely impacts of a proposed action. 'Residual impacts' are those that remain and cannot be avoided, even with avoidance and mitigation. Under the EPBC Act, offsets are only required if residual impacts are significant, as defined under the EPBC Act.

2.2 When do EPBC Act offsets apply?

Offsets are usually considered during the assessment phase of a project, but not until all reasonable avoidance and mitigation measures have been considered; or acceptable reasons are provided as to why avoidance or mitigation of impacts is not reasonably achievable.

In order to determine if an offset is appropriate, NT Mining Operations is required to fully understand the potential impacts of closing the OK adit to ghost bat usage. This can be determined through investigation of five questions:

1. What is the nature of the likely impacts on protected matters?
2. Can impacts on protected matters be avoided?
3. Can impacts on protected matters be mitigated?
4. Are the residual impacts likely to be significant?
5. Are offsets a suitable approach?

2.2.1 Potential impacts on the ghost bat

Potential impacts that the Union Reefs North Underground Project may have on the ghost bat are identified as:

1. Closing (temporarily, for the period of mining) the OK adit that is used by ghost bats as a confirmed diurnal roost.
2. Closing (temporarily, for the period of mining) the Prospect adit that is used by ghost bats as an occasional confirmed diurnal roost.
3. Introducing disturbances to the colony that occupies the Union North adit, which is a confirmed diurnal roost that has higher usage than either the OK adit or Prospect adit.
4. Potential impacts on foraging habitat in the surrounding areas that might increase the mortality of ghost bats, such as entanglement in barbed wire fences, reduction of

foraging habitat quality from frequent fires and dust accumulation, direct disturbance or mortality from moving machinery/vehicles, and inappropriately placed lighting.

Further risks are evaluated as part of the Risk Register in the Environmental Impact Statement. The remainder of these are considered to be low.

The predicted extent and severity of these impacts varies. The Action Plan (Armstrong et al. 2020) has been designed to overcompensate in terms of mitigation and minimisation, as well as provide for multiple redundant contingencies in advance of a potential effect, and follow-up knowledge generation to confirm the perspectives already established from baseline empirical studies. The existence of a significant residual impact after the implementation of this Action Plan is considered to be very unlikely. Offsets under the EPBC Act may therefore not be relevant, but three Actions are offered as potential offsets if they are required.

Offsets are not required for the approval of all projects. Offsets are only required for projects where all reasonable actions to avoid or mitigate environmental damage have been planned or implemented, and the remaining residual impact is likely to be significant, as defined under the EPBC Act. An analysis is provided to firstly quantify the residual impacts of the proposed mine, and then evaluate whether these Actions qualify as offsets under the policy.

2.3 Types of Offsets

Offsets for the Union Reefs North Underground Project would comprise an 'offsets package', which is a suite of actions that NT Mining Operations commits to undertake, in order to compensate for the significant residual impact of the project. Under the policy, offsets need to correlate directly with the impacts of a proposed action.

An offsets package implemented by NT Mining Operations will comprise 'direct offsets', but could also include 'other compensatory measures' (indirect). A minimum of 90% of the offset requirements for any given impact must be direct offsets, unless it can be shown that greater benefit can be achieved through other compensatory measures, or there is sufficiently high scientific uncertainty regarding the expected benefits of the direct offset proposed.

Offset actions (direct or indirect) made prior to the impact occurring are called 'advanced offsets'.

2.3.1 Direct offsets

NT Mining Operations has considered "actions that provide a measurable conservation gain for an impacted protected matter". Conservation gain is the benefit that a direct offset delivers to the protected matter, which maintains or increases its viability or reduces any threats of damage, destruction or extinction. Conservation gains may be achieved by:

— improving existing habitat for the protected matter
— creating new habitat for the protected matter
— reducing threats to the protected matter
— increasing the values of a heritage place, and/or
— averting the loss of a protected matter or its habitat that is under threat.

Some of these conservation gains can be achieved in the context of the Union Reefs project through mitigative actions, as described in the Action Plan (Armstrong et al. 2020). A summary

of the Actions that will be committed to as part of the project is summarised in **Table 1**. For example, "reducing threats to the protected matter" will be achieved by managing the Union North adit against intrusion and activity in close proximity by mining staff and equipment (part of Action 5). The conservation gain "increasing the values of a heritage place" will be achieved by making minor changes to the Lady Alice adit (an underground working of a pioneering goldfield in the late 1800s) so that it is suitable for use by roosting ghost bats (Action 4).

Potential offsets that help protect ghost bats and their habitat are most likely achievable through the first and second conservation gains. In summary, there are five potential direct offsets that qualify as first and second conservation gains.

The first conservation gain "improving existing habitat for the protected matter" will be achieved by:

- Re-open and rehabilitate the Lady Alice adit so that it is suitable for Ghost Bat roost occupancy (**Action 4**). This involves the removal of accumulated dirt at the entrance so that the portal is wide enough for ghost bat entry (already completed).

- Manage the Union North adit during the period of mining to avoid disturbances and enhance suitability for the Ghost Bat (**Action 5**). This will involve the installation of a hose so that water can be pumped from the adit when it accumulates during heavy rainfall in the wet season, causing ghost bats to seek a refuge elsewhere. Maintaining the suitability of this roost year-round will be a significant improvement, ensuring that ghost bats have a roost option in the project.

- Implement management measures at the Kohinoor adit at Pine Creek to protect the Ghost Bat roost (**Action 6**). This is the site of the largest colony in Australia, and colony size has varied over the years. The colony is extremely vulnerable to casual visitation. It has been subject to countless intrusions and disturbances, given its location on the edge of the town of Pine Creek, its accessibility from a sealed road that passes within 50 m of the entrance, and that it is well-known by local townspeople and the online community of wildlife tourists. By implementing a range of measures to reduce or prevent casual intrusion, the quality of this important habitat for ghost bats will be improved.

The second conservation gain, "creating new habitat for the protected matter", can be achieved by other Actions:

- Create several artificial habitats for the roosting of Ghost Bats in the Union Reefs project area, for both contingencies and redundancy (**Action 3**). To replace the OK adit and Prospect adit, the construction of two artificial roosts has begun (currently in the planning and modelling stages). These will be assembled from sections of u-shaped concrete culverts, and sited in parts of the project area that will not be subjected the activity from mining, or future mining interest.

- Provide a portion of the new mine for Ghost Bat occupancy once mining has been completed (**Action 8**). Once mining has been completed, a relatively large, stable underground structure will remain. While the lower parts of it will be backfilled and sealed (and flooded), retaining the upper portion will very likely represent extremely high-value potential roosting opportunity for ghost bats in the entire region.

The proponent has committed to enacting the Action Plan (Armstrong et al. 2020), upon receiving approval. Work on some of these Actions has already begun (Actions 2, 3, 4, 5, 7,11).

Table 1. Summary of Actions that will form the core commitments to ghost bat protection and management throughout the project.

Action description	Type
Action 1. Exclude the Ghost Bat from the OK adit and Prospect adit based on a carefully planned protocol.	Avoidance + Mitigation
Action 2. Characterise the internal dimensions and microclimates of the Lady Alice adit, OK adit and Union North adit, and the position of Ghost Bat roost areas within.	Support for Mitigation
Action 3. Create several artificial habitats for the roosting of Ghost Bats in the Union Reefs project area, for both contingencies and redundancy.	Mitigation Candidate offset
Action 4. Re-open and rehabilitate the Lady Alice adit so that it is suitable for Ghost Bat occupancy.	Mitigation Candidate offset
Action 5. Manage the Union North adit during the period of mining to avoid disturbances and enhance suitability for the Ghost Bat.	Avoidance + Mitigation Candidate offset
Action 6. Implement management measures at the Kohinoor adit at Pine Creek to protect the Ghost Bat roost.	Mitigation Candidate offset
Action 7. Conduct a programme of continuous monitoring of Ghost Bat presence, activity levels and colony size at all known (Union North adit) and potential (Lady Alice adit, artificial roost habitats newly created) roosts within the project area, and other key sites in the region (Pine Creek; Spring Hill; any newly discovered caves of significance surrounding the project area).	Support for Mitigation
Action 8. Provide a portion of the new mine for Ghost Bat occupancy once mining has been completed.	Candidate offset
Action 9. Conduct field surveys for Ghost Bat diurnal roosts in natural caves in the hills surrounding the Union Reefs project area.	Support for Mitigation
Action 10. Investigate the connectedness of Ghost Bat colonies in the region using an advanced genetic method based on genome-scale DNA sequencing.	Scientific research to support Mitigation
Action 11. Provide support for further academic research on the ecology of the Ghost Bat.	Scientific research Candidate offset

2.3.2 Other compensatory measures (Indirect offsets)

Other compensatory measures are: “those actions that do not directly offset the impacts on the protected matter, but are anticipated to lead to benefits for the impacted protected matter, for example funding for research or educational programs.”

The Environmental Offset Assessment Guide stipulates that research or education programs need to be "Priority Actions" (i.e., those identified in approved governmental documents such as Recovery Plans).

There is currently no Recovery Plan adopted or being prepared for the ghost bat (URL: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=174). In addition, the list of Recovery Plans in preparation does not include the ghost bat (URL: https://www.environment.gov.au/biodiversity/threatened/recovery-plans/required), but this list is dated 1 May 2013, and the ghost bat was listed as Vulnerable under the EPBC Act on 2 May 2016.

Instead of a Recovery Plan, a Conservation Advice has been developed (TSSC 2016; http://www.environment.gov.au/biodiversity/threatened/species/pubs/174-conservation-advice-05052016.pdf), however the SPRAT profile does state that a Recovery Plan is required because "stopping decline and supporting recovery of the species is complex" and "existing mechanisms are not adequate to address these needs". This is because of a "requirement for a high level of planning to abate the threats, a high level of support by key stakeholders, and a high level of prioritisation". High level planning has not yet been realised, despite being identified as important in scientific publications (Armstrong and Anstee 2000; Armstrong 2010, 2011), but there is potential for the proponent to assist with this as a "key stakeholder".

Action 11 will provide support for further academic research on the ecology of the ghost bat. This Action could qualify as an indirect offset. The Conservation Advice (TSSC 2016) lists four information and research priorities, as well as five survey and monitoring priorities. Each of these is likely to qualify as a "Priority Action" as defined under Indirect Offsets in the Environmental Offset Assessment Guide. There are certainly other aspects that need attention, such information on movements and connectedness within regions, and reproductive biology.

There is, therefore, much scope to develop a research program based on priorities listed in the Conservation Advice and other knowledge gaps. An agreement has already been implemented between the proponent and Charles Darwin University, whereby the proponent will provide financial support for a 3-year Postdoctoral Researcher. Particular emphasis has been given to the desire for the Postdoctoral Researcher to develop and implement a research program independently of the priorities the proponent might have. For practical reasons and to avoid duplication of disturbance to roosting bats, there will certainly be opportunities for some collaborative effort (e.g. Action 10 that will investigate the connectedness of colonies using genetic markers). However, the Postdoctoral Researcher will primarily:

1. Develop a research program based on research priorities identified in the Conservation Advice (TSSC 2016);

2. Draft a Recovery Plan that provides a more comprehensive pathway for stopping decline and supporting recovery of the species.

While much attention has been given to the ghost bat in the context of environmental impact assessment since its listing as Vulnerable under the EPBC Act in 2016, mostly by proponents in the Pilbara region of Western Australia, there are still many gaps in our knowledge of the basic biology of the species. This hinders effective management. A PhD on the 'acoustic ecology' of the ghost bat has also just been completed (by the person who will fill the Postdoctoral Researcher role at CDU). This examined the behaviour of the species in the

context of academic questions (evolution and behavioural ecology), but the application of the knowledge generated by this series of studies has practical application that is already being incorporated into surveys begun by the Northern Territory Government, and which is also incorporated into the Action Plan (e.g., Actions 7, 10).

Note that work since October 2018 by a consultant for the proponent (Dr Kyle Armstrong, Specialised Zoological) has already contributed to one theme in the Conservation Advice under survey and monitoring priorities (the development of a cost-effective monitoring protocol based on an autonomous thermal camera recorder and analysis system).

2.3.3 Advanced offsets

Offset actions (e.g. protection or improvement of habitat) made prior to the impact occurring are called advanced offsets (SEWPaC 2012). In the course of developing the Action Plan, the proponent has incorporated several Actions that could qualify as advanced offsets, which can be shown to deliver a conservation gain. Higher value is placed on offsets that achieve a conservation gain in a shorter time period, and this can reduce overall offset requirements.

In the Union Reefs project, the OK adit and Prospect adits, two underground structures that provide either rare or occasional diurnal roost habitat for the ghost bat, will be replaced by two artificial structures (whose design is being optimised by numerical modelling of microclimate conditions using Computational Fluid Dynamics to maximise the chance of usage by the species), plus another historical working that has already been enhanced to become more suitable for the species (with early indications of success). The provision of a minimum of three underground structures to replace diurnal roosts before they have been closed to bats as part of an avoidance action could mean that Actions 3 and 4 qualify as an advanced offset.

As part of Action 2, the features and microclimate of the Union North adit and Lady Alice adit have been characterised to inform the design process for the artificial roosts under Action 3. In addition, baseline monitoring of ghost bats that has been undertaken at the Union North adit, OK adit and Prospect adit since October 2018 for monitoring during a nearby drilling program, has been extended to the Lady Alice adit (in December 2019), and also ‘stronghold roosts’ that support a regionally significant congregation that occupies several underground workings at Spring Hill (in February 2020; both under Action 7). Thus, baseline bat activity monitoring data that will support the establishment of the offsets and any improvements that may need to be made during the life of the mining project, has commenced and compiled and analysed a relatively large dataset. This is important because the impact of the closure of the OK adit and Prospect adit will be immediate and require the offsets to be available at that time. Other Actions that will validate the interpretations from the bat activity monitoring (investigations into other nearby natural cave alternative roosts—Action 9; investigations into regional roost connectivity—Action 10) are also included, and will be commenced before the closure of adits, to help evaluate whether additional artificial roosts might be needed over the course of the project.

2.4 How are EPBC Act offsets determined?

In accordance with recommendations from SEWPaC (2012) suitable offsets that have been considered by NT Mining Operations will:

- deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action;
- be built around direct offsets but may include other compensatory measures;
- be in proportion to the level of statutory protection that applies to the protected matter;
- be of a size and scale proportionate to the residual impacts on the protected matter;
- effectively account for and manage the risks of the offset not succeeding;
- be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action);
- be efficient, effective, timely, transparent, scientifically robust and reasonable; and
- have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

Determining and securing environmental offsets is generally done on a case-by-case basis, and can become complicated. For this reason, the following information is limited to the main components of the EPBC Offset requirements and particulars; and does not enquire into the details that are likely to warrant consideration.

2.4.1 The offset assessment guide

Offsets will be calculated using the Commonwealth Department's Environmental Offsets Assessment Guide. The guide is a spreadsheet that is used to determine the suitability of offset proposals under the EPBC Act in a clear and consistent manner.

Specific information about impacts and offsets is required in order to calculate whether a proposed offset adequately compensates for the residual significant impacts of the proposed action. Specific quantitative and qualitative information includes:

- the size and nature of the impact of the proposed action;
- the size and nature of the proposed offset; and
- risks associated with delivery of the proposed offset.

To use the offsets assessment guide effectively, certain parameters for the protected matter and its habitat (in this case the ghost bat in the Union Reefs area and surrounds in the bioregion) must be quantified in detail. Parameters include (but are not limited to) the following:

Annual probability of Extinction (in the wild) – value based on criteria for the International Union for the Conservation of Nature (IUCN) Red List for threatened species. For example, for a Vulnerable species such as the ghost bat, the (global) population is likely to decline at a substantial rate of 10 percent in the next three generations due to a reduction in extent of occurrence, area of occupancy, habitat and number of locations. Therefore, given that

generation time is assumed to be 8 years (Woinarski et al. 2014), the annual probability of extinction in the wild is 0.42%.

Protected matter attribute – what attribute of the protected matter is being affected? For the ghost bat in the Union Reefs area, the primary and immediate loss will be denied access to an underground structure that varying numbers of bats use occasionally, though in likely response to a nearby deeper structure becoming flooded after heavy seasonal rains. As is typical with consideration of impacts on the roost habitat of obligate cave-dwelling bats, a precautionary approach considers the possibility of elevated mortality rate if bats cannot find an alternative roost habitat that provides a suitable microclimate. There are several other possible contributors to elevated mortality, but preventing access to a diurnal roost is considered to be the primary source of risk.

Quality score for area of habitat – how well the site supports the species. This comprises three components:

1. Site condition: in terms of threatened species' ecological requirements (of particular relevance to the ghost bat is the depth and complexity of underground diurnal roost sites);

2. Site context: relative importance in terms of its landscape position, considering the threatened species' connectivity needs (e.g., movement patterns, site proximity relative to other areas of suitable habitat, and the site's role relative to the population or extent of the species; of particular relevance to the ghost bat is the distance between diurnal roosts, both artificial tunnels and natural caves);

3. Species stocking rate: usage of the site, and/or density of a species at a site, including consideration of the site's role in regards to the overall species population viability or community extent (of particular relevance to the ghost bat is the size of diurnal roosts, both entrance and roost chamber size, which will determine how many individuals might use a structure).

The guide incorporates three measures of habitat quality: current habitat quality, future quality without offsets and future quality with offsets (i.e., the 'do-nothing' approach versus the active management/improvement approach). Given the baseline bat activity monitoring data that has been collected almost continuously since October 2018, the relative importance of the adits in the Union Reefs area is considered to differ, with the OK adit and Prospect adit being of lower importance (because of a lower quality roost microclimate; and shorter tunnel length and therefore area of full darkness) to the species than the Union North adit, except when the latter floods after seasonal heavy rain. Assessed against what have been termed 'stronghold colonies' in this assessment, the OK adit and Prospect adit will be considered of even lower importance, though their role in enabling within-region movements might add to their value.

The time over which loss is averted must be considered. This is the number of years over which changes in the level of risk to a proposed offset site can be considered and quantified (e.g., duration of a conservation covenant, or duration of active management and protection of habitat for the purpose of conservation gain). Longer time frames are valued more highly than shorter time frames. In the case of the ghost bat, all the newly-provided and enhanced habitat are expected to last several decades, even if taking a conservative position.

The time until ecological benefit must be considered. This is the number of years it takes for the proposed offset habitat to improve to the point of conservation gain. In the case of the ghost bat, it is unknown how long it will take ghost bats to discover and use artificial habitat, though there is already evidence that ghost bats have roosted or used the Lady Alice adit as a nocturnal feeding site since the entrance portal was enlarged in December 2019. The timeframes for improving the context for ghost bat roosting at sites outside the Union Reefs area will be dependent on how liaison progresses with townspeople at Pine Creek to enact protect measures, and plans for mining at Spring Hill.

Risk of loss must be considered. This is the chance (%) that the offset habitat will be completely lost (i.e. no longer hold any value for the protected matter) over the foreseeable future (either the life of the offset or 20 years, whichever is shorter). For the ghost bat in the Union Reefs, and Pine Creek areas, this will be different. At Union Reefs, the artificial habitats being constructed, and the Lady Alice adit, are all outside geological formations of economic interest, and are therefore unlikely to be lost. At Pine Creek, the effectiveness of the final on-ground conservation measures that are enacted will be dependent on the outcomes of negotiations—it should be noted that the proponent is keen for progress given that they have committed to ensuring that ghost bats at Union Reefs have alternatives in the case of catastrophe (such as collapse and closure of an adit due to natural deterioration) that removes a roost at Union Reefs.

Confidence in result describes the level of certainty (%) about the success of the proposed offset. The construction of artificial roosts for ghost bats is still essentially experimental. However, there is increasing consideration of this in mining projects in northern Australia (e.g., efforts by Atlas Iron, and BHP, as well as an early effort by Hamersley Iron). The chance of success will be maximised through several measures: numerical modelling of roost microclimates to assist in design choice; playback of social calls near artificial roost entrances to encourage what is a relatively curious and intelligent predatory bat species to investigate the roost entrance; design features to exclude casual entry by people. The protection of the Pine Creek roost in the Kohinoor adit will be dependent on how well relationships can be developed amongst the Postdoctoral Researcher, the people of Pine Creek, Traditional Owners with an interest in helping to manage the ghost bat, and the proponent.

3 Offset delivery options for the ghost bat at the Union Reefs project area

If offsets to compensate for impacts on the ghost bat are required, then an appropriate offsets package would be developed by NT Mining Operations in consultation with the Department of the Environment. An offsets proposal would be prepared using the EPBC Act Policy and Offsets assessment guide (SEWPaC, 2012), and include:

- a detailed and quantified determination of impacts on the ghost bat;
- an estimation of the potential quantum of offset required;
- identification of suitable offset site/s; and
- an assessment of whether the proposed offset site/s would meet the proposal's EPBC Act offsetting requirements.

There are candidate direct and indirect offsets that have been identified. Some of the candidate direct offsets might instead be defined as mitigations following a more detailed consideration. The candidate indirect offset of supporting a Postdoctoral Researcher is likely to qualify not just because it represents an investment in both applied and academic science

focussed on the ghost bat, but because it also will have a Recovery Plan as an outcome, which will further develop Priority Actions by building on the Conservation Advice for the species.

Direct offset measures, which are required for the bulk of the offsets package, are likely to be more difficult. SEWPaC (2012) states:

"For direct offsets, the securing of existing unprotected habitat as an offset only provides a conservation gain if that habitat was under some level of threat of being destroyed or degraded, and as a result of offsetting will instead be protected in an enduring way and actively managed to maintain or improve the viability of the protected matter."

In the case of the ghost bat, the artificial habitats may not qualify, but the threats to the colony in the Kohinoor adit are real—a catastrophic disturbance event could happen at any time because of its close proximity to the town of Pine Creek, the potential for natural deterioration and collapse of the adit structure over time, its accessibility for casual entry, and because it is relatively well known as a place that it is easy to view ghost bats.

Whilst the primary consideration in determining suitable offsets would be delivering a conservation gain for the ghost bat, the delivery of offsets that establish positive social or economic co-benefits would also be encouraged by the Commonwealth Minister. Examples of social or economic benefits relevant to Union Reefs project might be:

- Offsets that contribute to an area recognised as important to increasing landscape connectivity, above and beyond what is required by the impacted protected matter - e.g., the nationally significant colony in the Kohinoor adit at Pine Creek.

- Offsets that employ local Indigenous caretakers or rangers to assist with protection and public education measures of the nationally significant colony at Pine Creek, and potentially in the future at Union Reefs in the mine that is left for bats after the project has concluded.

Offsets can be delivered by a range of mechanisms, including market-based mechanisms (e.g., land brokering services, biodiversity banking schemes) and contracting third party providers (e.g., rural landholders, private conservation organisations, indigenous corporations).

4 Future management and monitoring of offsets

A critical component of offsets will be management and monitoring undertaken into the future. Performance of offsets is reviewed as part of the monitoring, compliance and audit program for all proposals considered under the EPBC Act. Monitoring is essential to provide frequent, regular and scientifically robust feedback on the performance of the offsets. In the Action Plan, a comprehensive equipment deployment and reporting schedule is outlined for the monitoring of bat activity via acoustic recorders (bat detectors) and colony size via thermal video recording (Action 7). This will encompass existing adits and artificial roosts built in the Union Reefs project area, and roosts at Pine Creek and Spring Hill. Any further monitoring and associated reporting requirements as part of an offsets package will be added to this. Reports may be made available publicly.

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Appendix 7 – Memo 3: Summary of Actions at Lady Alice Adit

KLG Ghost Bat Memorandum 3
March 2020

Summary of Actions at Lady Alice Adit, Union Reefs Project Area, December 2019 – February 2020

This memorandum outlines the actions undertaken at the Lady Alice adit in the Union Reefs project area between December 2019 and February 2020.

2018 Observations

- The Lady Alice adit is an historical gold mine located to the north-east of the Union North pit.
- The Lady Alice adit was located by KLG environment staff in 2018, when they observed a ghost bat in flight near the adit entrance. The location was described as an historical gold mine adit attached to a vertical shaft, with the adit entrance largely blocked by fallen material.
- The adit was visited in 2018 by specialist consultant biologists (Armstrong and Barden 2018). The entrance at the time was a small opening approximately 0.2 m high and 0.5 m long (Plate 1). Images taken using a GoPro camera extended into the opening on a pole revealed that internal structure of the adit was approximately 1.5 m high and 1 m wide extending to an unknown depth.
- It was estimated that the Lady Alice adit would intercept a shaft located on the slope above the adit entrance.
- The initial inspection indicated that the presence of fallen rocks and debris at the entrance and the very small aperture had rendered the location unsuitable as a roost site for ghost bats. Lady Alice was identified as a suitable candidate for rehabilitation as an alternative diurnal or contingency roost for bats due to the intact internal structure of the adit.
- Several areas where historical mine artefacts were protected using four-strand barbed wire fencing were present near the Lady Alice adit in 2018. These fences were subsequently removed by KLG/NTMO based on advice that they might present a risk to ghost bats.

December 2019

- In December 2019, the entrance to the Lady Alice adit was expanded using hand tools to allow access for a scan of the structure of the adit and placement of a humidity and temperature logger (Plate 2). The opening was expanded to 0.5 m x 0.7 m.
- The internal structure was scanned using a Leica BLK360 Imaging Laser Scanner to generate point cloud data.
- The adit was found to be approximately 12 m long and 1.7 m high, with the rear end blocked by material filling the adit from the shaft (Jensen 2019) (Figure 1, Figure 2).
- The rear of the adit was found to be almost filled with spoil and rocks from the shaft, with only a small opening allowing access to the surface.
- The Lady Alice adit is approximately double the length, but has a similar internal structure, to the Prospect adit. The Prospect adit is occasionally used as a nocturnal roost by individual or small numbers of ghost bats.
- The adit was investigated at night by specialist consultant biologists on 20 December 2019 (Nicola Hanrahan and Paul Barden) within two days of the entrance being enlarged. Several dusky leaf-nosed (*Hipposideros ater*) were observed entering the small opening allowing access to the shaft at the rear of the adit.
- A small pile of ghost bat scats was located on the floor at the mid-point of the adit, indicating that this species had previously accessed the location. The scats were fresh, potentially deposited within days or weeks of the inspection.
- A humidity/temperature logger (Tinytag) was placed at the distal end of the adit, close to the pile of material exiting from the shaft.
- An AnaBat Swift full spectrum bat detector fitted with an S-O Omnidirectional Ultrasonic Microphone (Titley Electronics) was installed at the entrance to monitor bat activity within the adit.

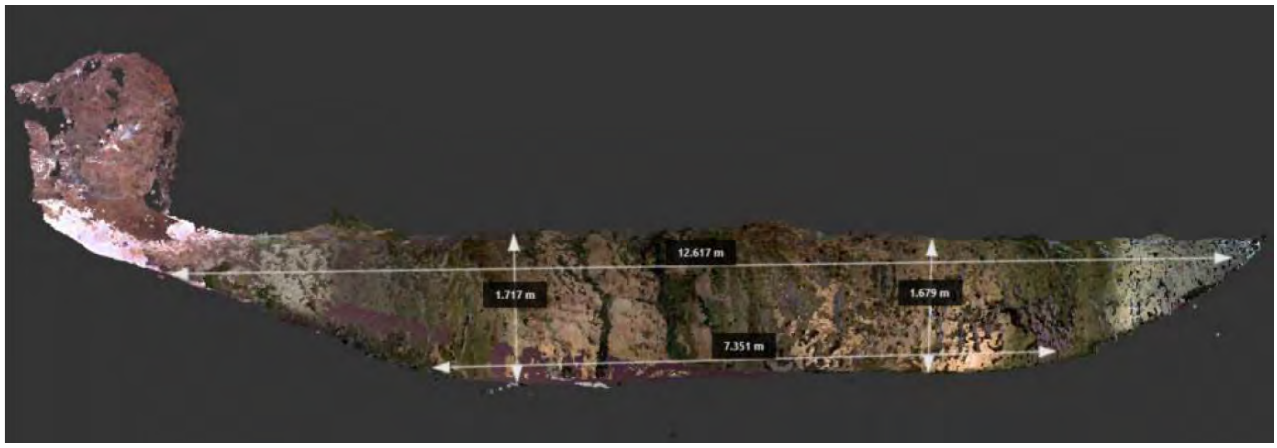


Figure 1. Internal Structure of the Lady Alice adit (side view) derived from the scan conducted by Jensen (2019).



Figure 2. Internal Structure of the Lady Alice adit (top down) derived from the scan conducted by Jensen (2019).



Plate 1. Entrance (left) and internal structure (right) of the Lady Alice adit, 2018.



Plate 2. Entrance of the Lady Alice adit following hand excavation, December 2019.

February 2020

- In February 2020, the adit was revisited to retrieve data from the humidity/temperature logger. Analysis of the data (along with data obtained from the Union North adit) is being used to inform the design of artificial roosts being constructed at Union Reefs.

- Bats were monitored acoustically at the entrance of the Lady Alice adit between December 2019 and January 2020. Ghost bats were recorded on 83% of monitored dates based on acoustic data (detection of social calls). In each 24-hour period, 0 to 3 echolocation calls (mean: 1.1) and 0 to 5 (mean: 1) social calls were recorded. All calls were recorded between 7 pm and 5 am, and it is therefore not possible to determine whether ghost bats were using the Lady Alice adit as a diurnal roost.

- Orange diamond-faced bat detections were low across the monitored period, with 2–9 detections (mean: 4.9) per night.

Summary

- The Lady Alice adit was located and inspected in 2018 by KLG environment staff and specialist consultant biologists. It was considered unsuitable as a permanent diurnal ghost bat roost because of the narrow dimensions of the opening.

- The site was revisited in December 2019 and the entrance was enlarged slightly using hand tools to allow access for an internal assessment and placement of a temperature and relative humidity datalogger.

- The internal inspection in the days following the enlargement of entrance revealed the presence of ghost bat scats in the central adit.

- Subsequent acoustic monitoring has identified the presence of ghost bats in the vicinity of the adit entrance (based on the detection of social calls) on 83% of the nights monitored.

- The adit has a similar internal structure to the Prospect adit, which is used occasionally as a nocturnal roost by individual or small numbers of ghost bats.

Paul Barden
Ecological Management Services Pty Ltd
6 March 2020

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Appendix 8 – Memo 4: Outcomes from Action 2: Internal Investigations of Adits in the Union Reefs Project Area

KLG Ghost Bat Memorandum 4
March 2020

Outcomes from Action 2: internal investigations of adits in the Union Reefs project area, December 2019 and February 2020

This memorandum outlines the actions undertaken at the Union Reefs project area adits in December 2019 and February 2020.

December 2019 Internal Scans and Logger Placement

- Three adits (Union North adit, OK adit and Lady Alice adit) known or potentially used as ghost bat roosts in the Union Reefs project area were investigated and scanned in 3D.
- The survey was designed to provide additional information on the internal dimensions and structure of the roost sites to inform the on-going design of artificial bat roosts planned for construction at Union Reefs in early 2020 (Action 3).
- The structural data was also required to enable further assessment of potential management issues associated with these bat roosts.
- During the internal inspection, relative humidity, temperature and vibration loggers were installed in two of the adits (Lady Alice adit and Union North adit). The data from these loggers will be used to inform the design of the artificial bat roosts.
- The internal investigation of the Union North adit was conducted at night following the exit of ghost bats based on observations and long-term acoustic monitoring. The sites were attended by specialist bat consultants (Nicola Hanrahan and Paul Barden).
- The Union North adit was assessed both visually and by using hand-held bat detectors to determine the presence of any remaining ghost bats. When no bats were present, the survey was commenced.
- The Lady Alice adit and OK adit were scanned during the day following confirmation based on observations, acoustic monitoring and fly-out counts that ghost bats were not occupying these sites at the time of the survey.
- The entrance to the Lady Alice adit was expanded using hand tools to allow human access (Plate 1; see Memorandum 3—Barden 2020).
- The internal structure of the adits was scanned by Land Surveys (Jensen 2019) using a Leica BLK360 Imaging Laser Scanner to generate point cloud data (Figure 1). The resulting data was provided as a point cloud 3-dimensional scan of the internal adit structure.

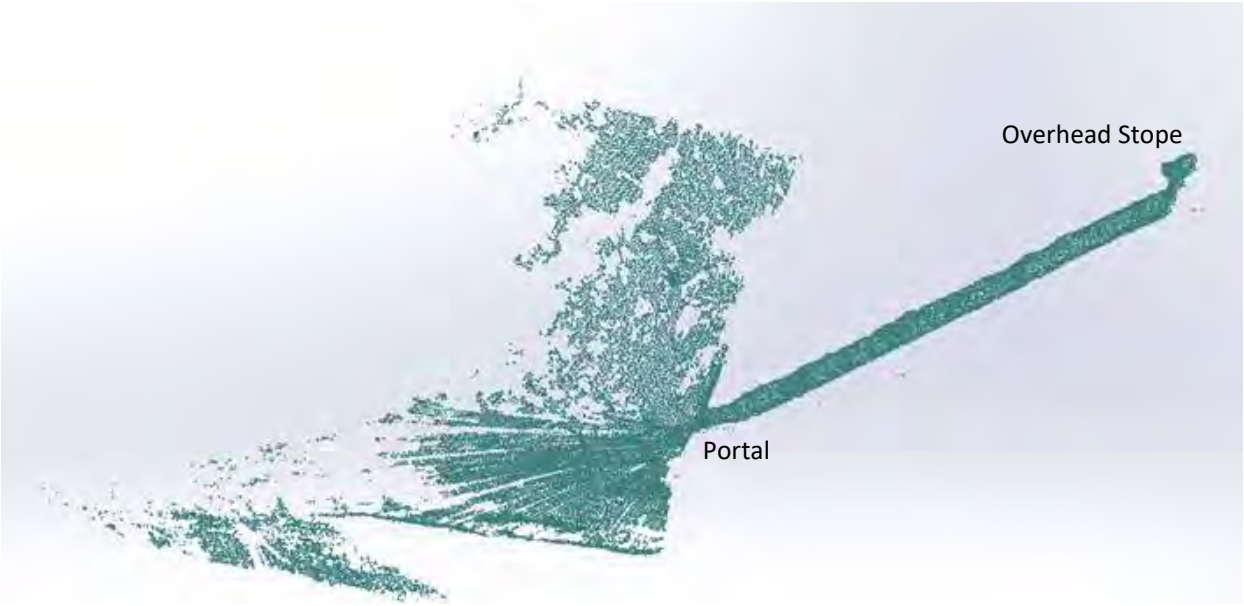


Figure 1. Example of an internal adit scan: Union North adit (side elevation) point cloud data derived from the scan by Jensen (2019).



Plate 1. Entrance of the Lady Alice adit following hand excavation, December 2019.

- Data loggers (Tinytag Plus 2) were placed in the Lady Alice and Union Reefs adits in December 2019 to record internal temperature and humidity.
- Data loggers were placed within the Lady Alice adit 12 m from the portal, and at a pile of debris below an overhead stope in the Union North adit approximately 60 m from the portal. The data loggers were downloaded on 27 February 2019.

February 2020: Retrieval of Data and Observations During Ex-tropical Cyclone Esther

- During the retrieval of the data loggers in February 2020, additional measurements were taken within the Union North and Lady Alice adits. This included a humidity reading, temperature reading and a surface measurement of temperature on the two walls and ceiling of the adits (three separate readings) at 5 m intervals in the Union North adit and 2 m intervals in the Lady Alice adit.
- The combined point cloud, humidity and temperature data will be used by engineers in the modelling to inform the design of artificial ghost bat roosts.
- The Internal survey of the adit using 3-dimensional laser scanning (Jensen 2019) revealed the Union North adit floor has a declining grade of around 55 cm over 60 m. During the February 2020 site visits, rain generated by ex-tropical cyclone Esther at the Union Reefs area caused elevated water levels in the Union North adit.
- Water levels potentially exceeded 1 m at the assumed ghost bat roost location at the rear of the overhead stope in the Union North adit. The roof height and grade of the adit floor beyond 65 m is unknown, but observations at the overhead stope at 60 m indicate that it may be lower than the front section of the adit.
- Fly-out counts conducted in early March following this rainfall event revealed that the ghost bats were not using the Union North adit. A small number of ghost bats (n=10) were roosting in the OK adit (Barden et al. 2020).
- These combined observations indicate that during large rainfall events, ghost bats move from Union North to alternative roosts due to high water levels in the rear chamber.
- This situation could be managed by pumping water from the Union North adit during peak rainfall events.

Paul Barden
Ecological Management Services Pty Ltd
10 March 2020

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Appendix 9 – Memo 5: Guide for the Thermal Modelling of Bat Roost Microclimates for Artificial Habitat Construction at Union Reefs

KLG Ghost Bat Memorandum 5
March 2020

Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs

An important part of the strategy to manage and protect ghost bats during the Union Reefs North Underground Mine construction and operation is to provide contingency roosts in advance of any potential disturbance that might cause the species to move out of the Union North adit.

Several artificial roosts have been installed in the Pilbara region in recent years for the ghost bat and Pilbara leaf-nosed bat when economic reserves of ore have coincided with caves that are important for the diurnal roosting of these species (see URLs below). In such cases, the roosts were designed as replacement habitat. There is no information in the public domain on whether these designs have managed to attract bats.

Given that the construction of artificial structures capable of accommodating ghost bats and other cave roosting bats is costly, but also that their installation before mine construction is a core part of our strategy to ensure that ghost bats remain in the Union Reefs project area, it is important to maximise the chance of their success. A useful approach to determining an optimal design is to use engineering tools and experience to model how an appropriate microclimate suitable for roosting bats might be retained in a structure of a defined size and shape.

The attached document “Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs” (Specialised Zoological 2020) is the first set of guidelines given to engineers at GHD Pty Ltd who have begun a modelling process using Computational Fluid Dynamics.

In addition to this Memorandum, a more comprehensive proposal will be developed, as per the description in Action 3 in the Union Reefs ghost bat Action Plan. A report documenting bat usage of the sites will also follow.

Dr. Kyle Armstrong
Specialised Zoological
6 March 2020

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Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs

Prepared for **GHD Pty Ltd**

Version **9 March 2020**

SZ project reference **SZ466**

Prepared by **Dr Kyle Armstrong**

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Specialised Zoological (2020). Guide for the thermal modelling of bat roost microclimates for artificial habitat construction at Union Reefs. Unpublished advice by Specialised Zoological for GHD Pty Ltd, 9 February 2020, project reference SZ466, version 2020-03-09.

Initial comments

These are my thoughts on how it might be most efficient and useful to approach the analysis. However, myself and colleagues are absolutely open and keen to discuss the details with you based on your own thoughts and ideas.

Note: there are several aspects that I have changed from a previous version of this document, given some observations made on a recent site visit. See the included photos to get a better idea of the materials that we plan to use.

See also a plot of the temperature and relative humidity data from the Union North adit, which was 60 metres into the straight tunnel (**Figure 5**).

We now have three preliminary sites selected, for two structures. We will supply this information separate to the present document.

Aim

To determine the minimal length of a standardised tunnel that will allow a terminating roost chamber to hold a microclimate of at least 26 degree Celsius and at least 80% Relative Humidity (vapour density 21 g m^{-3}).

Designs

We need to consider a few different designs. More than one design might end up being built, to maximise the chance of colonisation. We will build TWO roosts in the next few months, so we will build TWO separate designs first. There may be more constructions later. Given that modelling takes a large amount of computing resources, I am proposing four designs maximum, at least initially (**Figure 1**).

Each design differs from the next (successively, cumulatively) by one feature only.

- **Design 1**: Straight, flat tunnel, ending in a long chamber with a high ceiling.
- **Design 2**: The same straight tunnel with terminating roost chamber, but inclined at 5 degrees.
- **Design 3**: L-shaped tunnel, inclined at 5 degrees, roost chamber at end of 90-degree cross tunnel (standardised at length of a set of five culverts).
- **Design 4**: J-shaped tunnel, inclined at 5 degrees, roost chamber at end of two successive 90-degree cross tunnels (each cross tunnel standardised at length of a set of five culverts).
- **PLUS**: please model the Lady Alice adit. Make sure the small connection at the back to the shaft is visible from the point cloud model resulting from the scan.

If you have the compute resources, you could remove the 5 degree incline factor from Designs 3 and 4, so we can see just the effect of the bends. Or do this instead of including the 5 degree incline. Your opinion?

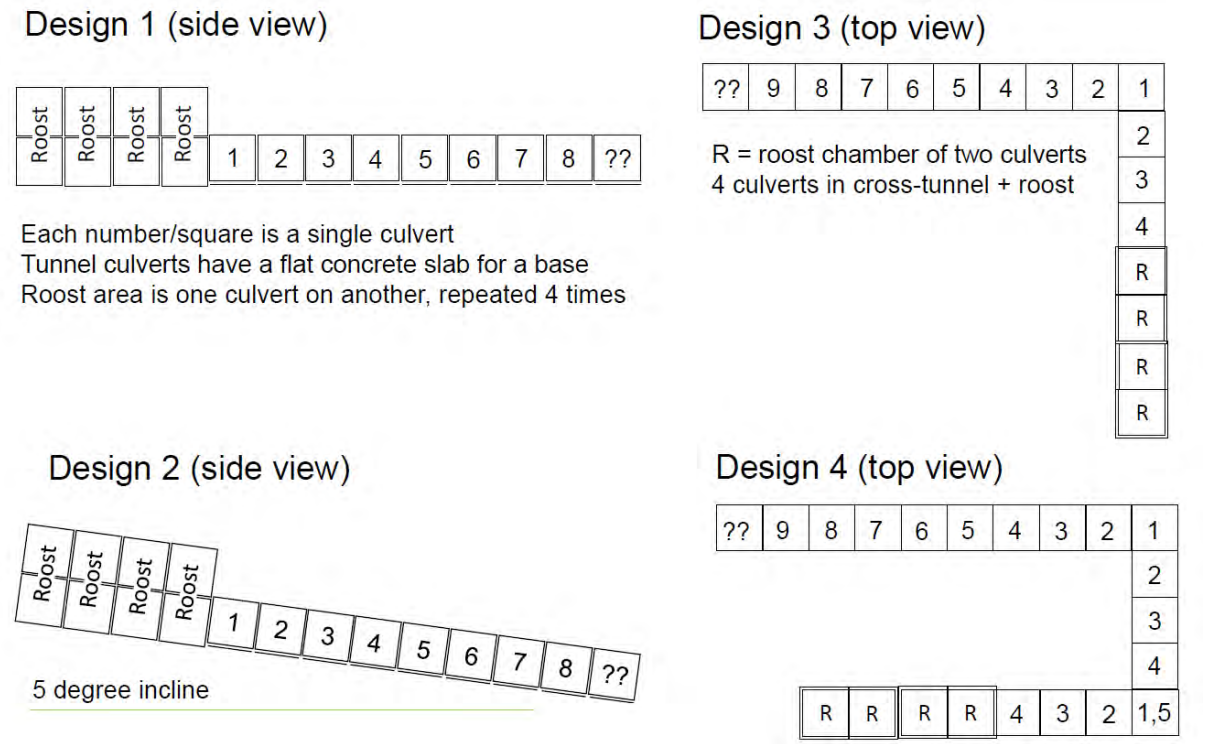


Figure 1. Summary of the four designs. A door for human access/maintenance can be placed at the side or at the back of the roost chamber itself, which will have no implications for your modelling.



Figure 2. Indicative miniature mock up using some materials already purchased.

Modelling units

We have a supplier that can provide U-shaped concrete culverts 1200 x 1200 x 2400 mm (**Figures 2** and **3**; blueprint in **Appendix 1**). The tunnel will be created by putting single culverts u-shape-down on top of a flat slab. The roost chamber is 4 pairs where each pair is one culvert on top of another that is upside down. See the indicative mock-up in **Figure 3.**

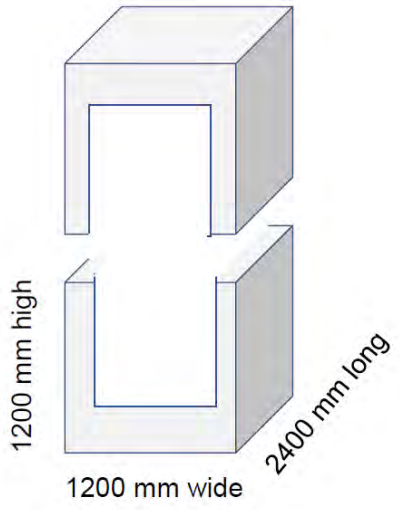


Figure 3. One ROOST CHAMBER unit (see also drawings and photos from site in Figures 1 and 2, and **Appendix 1**).

Variables

For each design, each model will vary by one variable only – tunnel length changes in increments of one culvert.

Each design changes by one feature only, successively and cumulatively. The main tunnel length still changes by a single variable for each model.

BUT, an alternative idea is that the design features are not cumulative – i.e., the designs with the bends can be flat instead of inclined at 5 degrees. We may also want to vary the length of cross tunnels. Let's discuss all this.

Model parameters

There may be several parameters needed for the model that are difficult to find out. We should standardise these to something sensible for all models. Boundary condition will be for concrete. We can assist with any weather conditions you may need, if you cannot source it.

Site placement and coverings

When constructing the models, I understand that you will need to place the designs in a context. If you simply add a layer of dirt on the top, this will approximate actual plans on the ground. The layer of dirt should be deep enough to promote thermal stability in the roost chamber. Your advice here on the depth needed for thermal stability will be required.

The aspect of the tunnel aperture ASPECT may or may not be relevant. If there were strong prevailing winds as perhaps near a coastal area, then prevailing wind direction and velocities would certainly be relevant. At Union Reefs, I do not think this would be important, but I would value your advice. If aspect of the aperture cannot be controlled because of some constraint at the site, maybe we could build dirt baffles nearby to reduce air movement. Again, I would value your thoughts.

Further notes

We are open to discussing aspects of the designs (e.g. how many units we should allocate per set, how many units in each 90-degree bend), as well as other designs. The engineers may have a better suggestion for some of the features in the models that promotes thermal stability.

We should also consider the minimum variables. It may actually be better to match the ideal microclimate to that of the Orange Leaf-nosed Bat (*Figure 8 in Churchill 1991—paper is attached*).

It is also interesting to consider the design below by Atlas Iron (see copies on the following pages). It is slightly modified from a design I submitted to them some years ago (before other consultants took over). It is also built for a different species than the Ghost Bat (instead the Pilbara Leaf-nosed Bat), which is smaller and better able to use small gaps. My thoughts on the various features are:

- The steel culvert idea was proposed by me many times to Pilbara miners as a way of have cheap, long tunnel length. I would be interested to hear opinions about whether round steel culvert in the approach tunnel only would be better or worse for maintaining a particular microclimate in a terminating roost chamber. The advice I have currently is that the concrete box culverts are cheaper and easier to install than long lengths of steel road culvert.

- Note the bend in the tunnel – this gives a relatively short tunnel length that keeps costs down. I have walked into quite a number of large straight tunnels in ironstone in the Pilbara, and even those well above 100 metres in length were relatively dry and cool at the end. I am very interested to see the comparative results of the straight and bend designs.

- The design below has a gate to keep people out, and rectangles cut into it to allow small-sized bats in and out. While the gate satisfies safety and liability considerations, it does limit the potential that bats will occupy the structure. The size of the rectangles is too small for humans, but also Ghost Bats. This gate is designed for Pilbara Leaf-nosed Bats, which are mouse-sized, and extremely acrobatic – quite the opposite of Ghost Bats that have a wingspan of at least half a metre and are not particularly agile. It will be very interesting to know if this gate works. In our case, our strategy will be to place open tunnels above head height, so people cannot simply walk in, and it will be made difficult for people to climb in from the side/top. Plus access by vehicles will be restricted so that people cannot climb in from the top of a vehicle. In short, our basic

design will leave the tunnel aperture completely open, but we may consider a baffle on the lower half (**Figure 4**). For KLG-approved access, we would need to build a side door that would not have a dual use for bat ingress/egress.

- We may also consider directing water to the roost chamber. Ideas involve low-level squirters/, a pool or soak on part of the roost chamber floor. This adds complication, but advice and thoughts are welcome. BUT, the preference is to make these passive devices, and not rely on intervention techniques to maintain humidity – hence our wish to use CFD to design something that functions passively to maintain the ideal microclimate.

- We downloaded dataloggers from the Union North adit at the end of February 2020. The logger was placed on a metal stake in the middle of the tunnel space at a point 60 metres from the entrance. After trimming the periods where the logger was elsewhere, you can see from **Figure 5** that the temperature and relative humidity is relatively stable, and similar to the microclimate described by Churchill (1991). This microclimate is assumed to be similar at a point further in where the bats actually roost. The Temperature and Relative Humidity might change with season. We have no data on this yet.

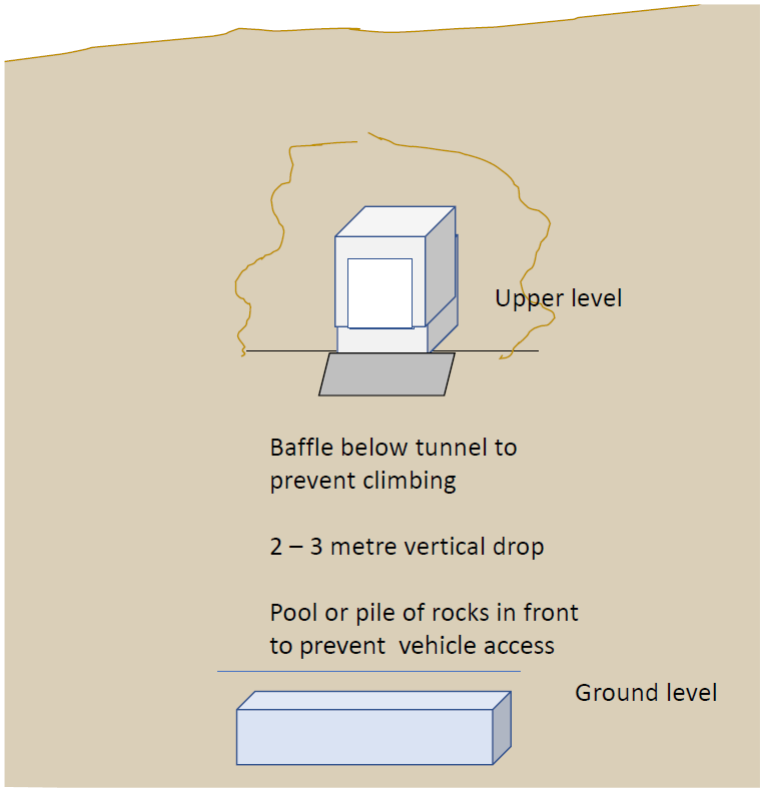


Figure 4. Design features at the tunnel aperture to keep it open for Ghost Bats, but reduce the access for people. The 'pool' could instead be a bunch of rocks that prevents 4WDs backing up to the opening, as well as not allowing climbing.

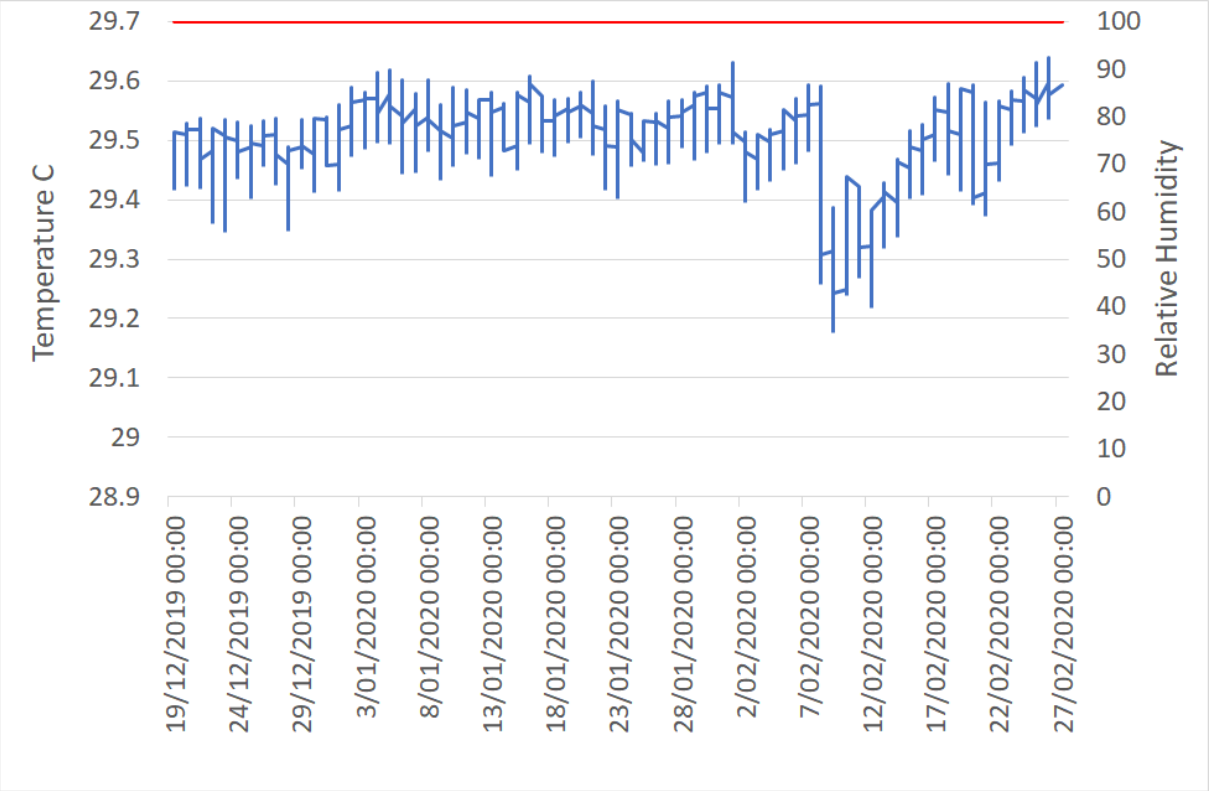
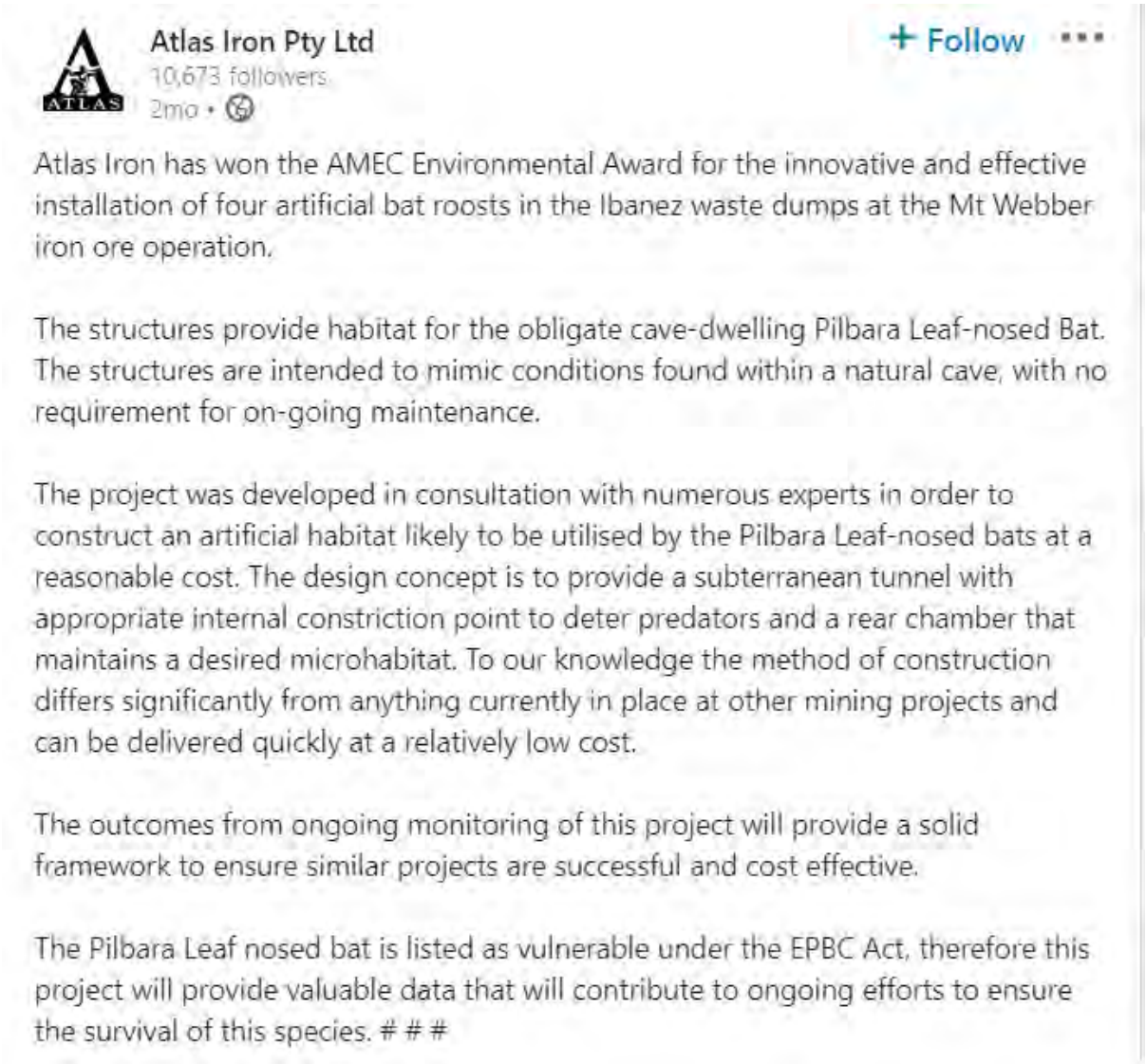


Figure 5. Stability of Temperature and Relative Humidity in the Union North adit (at the 60 metre point) between mid-December 2019 to end of February 2020.



Atlas Iron Pty Ltd
10,673 followers
2mo •

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Atlas Iron has won the AMEC Environmental Award for the innovative and effective installation of four artificial bat roosts in the Ibanez waste dumps at the Mt Webber iron ore operation.

The structures provide habitat for the obligate cave-dwelling Pilbara Leaf-nosed Bat. The structures are intended to mimic conditions found within a natural cave, with no requirement for on-going maintenance.

The project was developed in consultation with numerous experts in order to construct an artificial habitat likely to be utilised by the Pilbara Leaf-nosed bats at a reasonable cost. The design concept is to provide a subterranean tunnel with appropriate internal constriction point to deter predators and a rear chamber that maintains a desired microhabitat. To our knowledge the method of construction differs significantly from anything currently in place at other mining projects and can be delivered quickly at a relatively low cost.

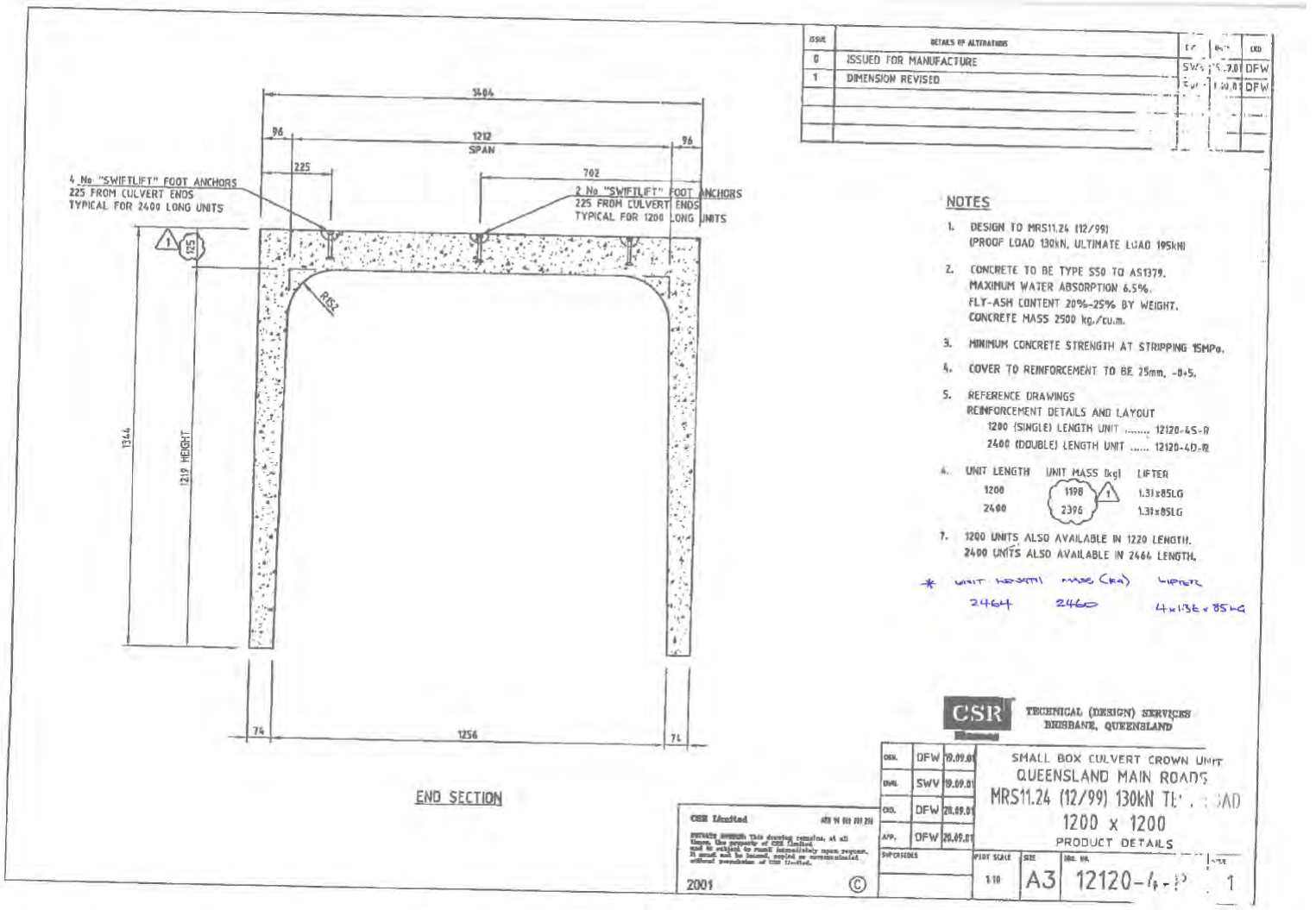
The outcomes from ongoing monitoring of this project will provide a solid framework to ensure similar projects are successful and cost effective.

The Pilbara Leaf nosed bat is listed as vulnerable under the EPBC Act, therefore this project will provide valuable data that will contribute to ongoing efforts to ensure the survival of this species. # # #




OVERSIZE

Appendix 1. Detail of the box culverts under consideration.



Appendix 10 – Memo 6: Progress Update: Artificial Ghost Bat Roost Design Project, Union Reefs

KLG Ghost Bat Memorandum 6
March 2020

Progress update: artificial ghost bat roost design project, Union Reefs.

This memorandum outlines progress on the design of artificial roosts for ghost bats at the Union Reefs project site. The artificial roost design project was commissioned by KLG in 2019. The artificial roost project is component of the Ghost Bat Action plan (Action 3 - Create several artificial habitats for the roosting of Ghost Bats in the Union Reefs project area, for both contingencies and redundancy) developed for the Union Reefs project (Armstrong and Barden 2020).

Design Principals

Preliminary work on the project included development of basic design principals, including:

- Development and construction using a cost-effective and uncomplicated design that will allow replication at Union Reefs and other sites.
- Use of readily available and prefabricated materials and components.
- Use of construction methods that are achievable using non-specialist mining equipment.
- Use of modelling (Computational Fluid Dynamics) to design optimal structures that meet humidity retention and other micro-climate requirements for roosting ghost bats while minimising expenditure on construction and materials.

Review of Existing Bat Roost Design Projects

- A review of previous artificial bat roost projects was undertaken, including two projects in the Pilbara (refer to online sources and references).

Existing Adit Internal Scans

- Three adits (Union North adit, OK adit and Lady Alice adit) known or potentially used as ghost bat roosts in the Union Reefs project area were investigated and scanned in 3D during December 2019.

- The internal structure of the adits was scanned by Land Surveys (Jensen 2019) using a Leica BLK360 Imaging Laser Scanner to generate point cloud data. The resulting data was provided as a point cloud 3-dimensional scan of the internal adit structure.

- The scan data was passed to engineers in March 2020 to contribute to the modelling and design of artificial roosts, to enable assessment of the internal climate characteristics of existing ghost bat roosts at the Union Reefs project area.

Humidity and Temperature Data from Existing Adits

- Data loggers (Tinytag Plus 2) were placed in the Lady Alice and Union Reefs adits in December 2019 to record internal temperature and humidity.

- Data loggers were placed within the Lady Alice adit 12 m from the portal, and at a pile of debris below an overhead stope in the Union North adit approximately 60 m from the portal. The data loggers were downloaded on 27 February 2019.

- During the retrieval of the loggers, additional measurements were taken within the Union North and Lady Alice adits. This included a humidity reading, temperature reading and a surface measurement of temperature on the two walls and ceiling of the adit (three separate readings) at 5 m intervals in the Union North adit and 2 m intervals in the Lady Alice adit.

- The humidity and temperature data will be used by engineers in the modelling to inform the design of artificial ghost bat roosts.

Field Assessment of Preliminary Locations of Ghost Bat Roosts at Union Reefs

- In late February 2020, environment and mining staff from KLG and consultant ecologists (Kyle Armstrong and Paul Barden) conducted site inspections to determine potential locations for artificial adits to be constructed.

- This site inspection followed a preliminary site survey conducted by KLG staff and Armstrong and Barden in September 2019.

- Preliminary sites were selected to be within suitable range of known ghost bat roost locations and nocturnal feeding sites, in an area of the landscape where topographic location would reduce disturbance and noise, at location safe from impacts from floods or other climatic events, at a location removed from any current or future mine activity or infrastructure and remote from potential ore deposits.

- Three preliminary sites were selected approximately 1600 m north-east of the OK adit and 1 km north-east of the Union North adit (Figure 1). A known ghost bat feeding roost is located on the railway line to the west of the potential artificial roost locations in a straight line to the Union North adit.

- The locations are removed from current or proposed mining activities and are protected from mining activities to the east by the local topography (low hills and rises). The locations are relatively easy to access for maintenance and monitoring, including during the wet season.

Paul Barden/Kyle Armstrong
Ecological Management Services Pty Ltd
6 March 2020

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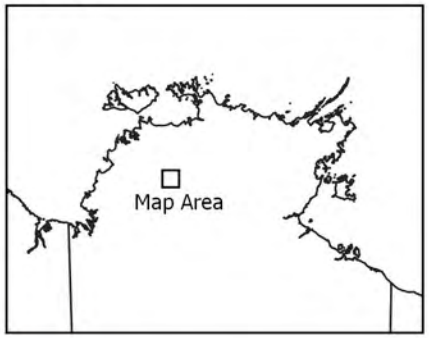
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Thomson, B. (2002). Australian handbook for the conservation of bats in mines and artificial cave-bat habitats. Australian Centre for Mining Environmental Research, Kenmore, Queensland.

Tuttle, M.D. and Taylor, D.A.R (1998). Bats and mines. Bat Conservation International Inc, Resource Publication No. 13.

Figure 1. Ghost Bat Roost Locations + Proposed Artifical Adit Sites

Mapping data source: GEOScience Australia/ALA/NT Fauna Atlas 2019
Datum: Map Grid of Australia 94
Zone 52/GDA94 UTM
Original mapping layer data
Copyright EMS Pty Ltd 2020
ems@ems.eco
Client: KLG
Project: EIS Response
Date: 3 March 2020
Author: PB





- Adits Open
- Adits Temp Closure
- Artificial Adit Locations
- Ghost Bat Feeding Roosts
- 130 m Buffer
- EMS/SZ GB Records 2018 - 2020
- Ghost Bat Records ALA

NT Atlas Ghost Bat Records

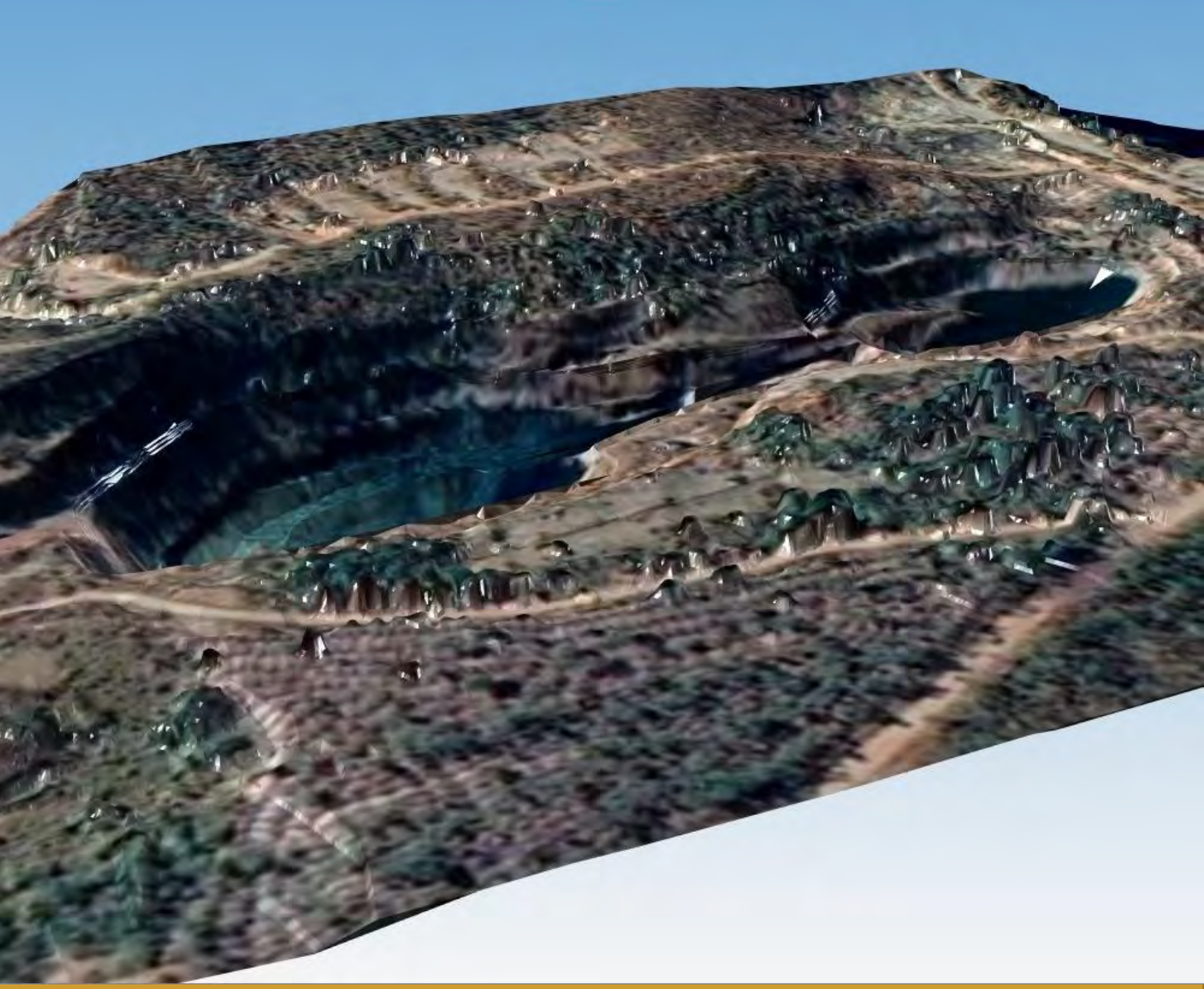
- Pre-2000

0 0.5 1 1.5 km

N

EMS | ECOLOGICAL MANAGEMENT SERVICES ENVIRONMENTAL CONSULTANTS

Appendix 11 – Water Management Plan



NT Mining Operations Pty Ltd
Union Reefs North Underground Mine

Water Management Plan

Draft for Review – March 2020

KL | KIRKLAND LAKE GOLD

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Internal	NT Mining Operations Pty Ltd (NTMO)
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Sam Yang Environmental Engineer	Samantha Cseh Environmental Officer	Nicole Conroy Technical Director	Sally Horsnell Environment and Community Manager
Author	**Author**	**Reviewer**	**Authorised**

TABLE OF CONTENTS

1 Introduction 1

1.1 Project Description 1

1.2 Purpose and Objectives 1

2 Legal and Other Requirements 2

2.1 Legal Requirements 2

2.2 Guidelines 3

2.3 Integrated Management System 3

2.4 Standard Operating Procedures 3

3 Roles and Responsibilities 4

4 Emergency Contacts and Procedures 4

5 Site Conditions 5

5.1 Physical Environment 5

5.1.1 Climate 5

5.1.2 Hydrology 6

5.1.3 Hydrogeology 6

5.1.4 Existing Surface Water Infrastructure 11

5.1.5 Surface Water Flow 14

6 Underground Mine Water Management 18

6.1 Operational Water Infrastructure 18

6.2 Operational Water Balance 20

6.2.1 Direct Rainfall, Catchment Runoff and Evaporation 22

6.2.2 Raw Water from Dam C 22

6.2.3 Groundwater Ingress 22

6.2.4 Retained in Tailings 22

6.2.5 Seepage In and Out of Crosscourse Pit 22

6.2.6 Discharge under WDL and Change in Storage 23

6.2.7 Sensitivity to Rainfall Conditions 24

6.3 Operational Phase and Flooding Assessment 25

7 Crosscourse Pit (Tailings Storage facility) water management 29

7.1 Crosscourse Pit Background 29

7.2 Proposed Ore Processing Operations 31

8 URPA Annual Water Accounting 42

9 Active Crosscourse Pit Dewatering Concept Plan 45

9.1 Installation of New Monitoring Stations at McKinlay River 47

9.2 River Dilution Factor and Discharge Algorithm 48

9.3 Emergency Spillway of Dam B 50
10 Potential Risks and Impacts 53
11 Water Management and Monitoring 56
12 Water Management Schedule 59
13 Appendices ..... A
Appendix A – Flooding Risk Analysis and Preparedness ..... A
Appendix B – Aquatic Ecology Management Plan ..... B
Appendix C – Water Abstraction Management Plan C
Appendix D – Water Quality Management Plan ..... D

TABLES

Table 4-1 Emergency contact details 4
Table 5-1 URPA and Regional Hydrogeological Properties of Geological Units 7
Table 5-2 Surface Water Management Infrastructure 11
Table 5-3 Mine Impacted Water Sources and Receiving Environments 14
Table 5-4 Union Reef Surface Water Flow under Different Rainfall Scenario 14
Table 6-1 Site Water Management 19
Table 6-2 Tailings Processing Pump Infrastructure 19
Table 6-3 Site Water Balance – Mine Operations 21
Table 6-4 Site Water Balance – Mine Operations – Wet Conditions 24
Table 6-5 Prospect Pit Portal Flooding Risk Assessment 26
Table 6-6 Prospect North Pit Storage Pond Maximum Level and Minimum Requirements 27
Table 7-1 Crosscourse Current Freeboard May 2019 30
Table 7-2 URPA LOM Processing Tonnes (2019-2023) 31
Table 7-3 72hrs Crosscourse pit flooding risk assessment 33
Table 7-4 Scenario 1-Crosscourse Life Cycle Analysis Average Rainfall April 2020-April 2024 without Discharge 34
Table 7-5 Scenario 1 (Average Rainfall without Discharge) Summary 34
Table 7-6 Scenario 2-Crosscourse Life Cycle Analysis Four Consecutive Years Wet Rainfall April 2020-April 2024 without Discharge 36
Table 7-7 Scenario 2 (Four Consecutive Years Wet Rainfall April 2020-April 2024 without Discharge) Summary 36
Table 7-8 Scenario 3- Crosscourse Life Cycle Analysis Average Rainfall April 2020-April 2024 with Discharge 38
Table 7-9 Scenario 3 (Average Rainfall with Discharge) Summary 38
Table 7-10 Scenario 4- Crosscourse Life Cycle Analysis Four Consecutive Years Wet Rainfall April 2020-April 2024 with Discharge 40
Table 7-11 Four Consecutive Years (Wet Rainfall April 2020-April 2024) with Discharge Summary 40
Table 9-1 Crosscourse Tailing Water Treatment Trial Results (Trail A and B) 49

Table 9-2 Crosscourse Dewatering Algorithm 50
Table 10-1 Project Activities, RISks and potential impacts on surrounding environment and sensitive receptors 53
Table 11-1 objectives, Management actions, Roles and Responsibilities 57
Table 12-1 Water Management Schedule 59
Table A-1 Monsoonal North Rare Temporary Pattern for Flooding Analysis ..... F

FIGURES

Figure 1-1 Prospect Pit Portal Location 2
Figure 5-1 URPA Monthly Rainfall 2013-2019 5
Figure 5-2 Mean Daily Evapotranspiration (BoM) 6
Figure 5-3 Regional Groundwater Aquifer Boundaries (NR Map) 9
Figure 5-4 Regional Groundwater Faults (NR MAP) 9
Figure 5-5 Surface Water Management Infrastructure Map 13
Figure 5-6 URPA Surface Hydrolines 15
Figure 5-7 URPA Stormwater Runoff Direction 16
Figure 5-8 URPA Water Management Schematic 17
Figure 6-1 Prospect Pit Initial Dewatering Schematic 18
Figure 6-2 Mine operational water Circuit 20
Figure 6-3 Crosscourse Pit Groundwater Flux 23
Figure 6-4 72 Hours Runoff Cumulative Volume vs Proposed Storage Pond Freeboard Capacity for Prospect Pit 25
Figure 6-5 Prospect Pit Mining Water Management Schematic 28
Figure 7-1 Crosscourse pit Current Tailing Deposition and Water Level (May 2019) 29
Figure 7-2 Crosscourse Pit Cross Section A-A' and progressing tailings Level 2011-2017 30
Figure 7-3 Crosscourse Tailing Volume 3D model 30
Figure 7-4 72 Hours Runoff Inrush Hydrograph of Crosscourse Pit 32
Figure 7-5 72 Hours Runoff Cumulative Volume VS Crosscourse Freeboard Capacity 32
Figure 7-6 Crosscourse Pit Volume Diagram Average Rainfall without Discharge 35
Figure 7-7 Crosscourse Level RL Average Rainfall without Discharge 35
Figure 7-8 Crosscourse Pit Volume Diagram Wet Rainfall without Discharge 37
Figure 7-9 Crosscourse Level RL high Rainfall without Discharge 37
Figure 7-10 Crosscourse Pit Volume Diagram Average Rainfall with Discharge 39
Figure 7-11 Crosscourse Level RL Average Rainfall with Discharge 39
Figure 7-12 Crosscourse Pit Volume Diagram Wet Rainfall with Discharge 41
Figure 7-13 Crosscourse Level RL Wet Rainfall with Discharge 41
Figure 8-1 UR Average rainfall water flow footprint 43

Figure 8-2 UR Wet rainfall water flow footprint 44
Figure 9-1 Active Discharge Management Site Layout 46
Figure 9-2 URSW08 EC vs TDS Relationship 48
Figure 9-3 Dam B Overflow Profile 51
Figure 9-4 Dam B Overflow Pathway DTM Modelling 52
Figure A-1 Tropical Cyclones in the Northern Region of Australia, 1964 to 2015 Source: (BoM) ..... B
Figure A-2 2016 IFD Table C
Figure A-3 Prospect Pit Area Annual Exceedance Probability (Rare to Extreme) ..... D
Figure A-4 SIMHYD Model schematic (eWater guideline) ..... E
Figure A-5 1 in 100 year ARR 2016 Pattern 1 ..... G
Figure A-6 1 in 500 year ARR2016 Pattern 1 ..... H
Figure A-7 1 in 1000 year 72 hrs ARR 2016 Pattern 1 I
Figure A-8 72 Hours Runoff Inrush Hydrograph of Prospect Pit Catchment ..... J

1 INTRODUCTION

1.1 Project Description

Northern Territory Mining Operations Pty Ltd (NTMO) propose to develop the Union Reefs North Underground Mine (the project) at the Union Reefs Project Area (URPA), a highly modified brownfield mine site that has historically been subject to gold mining. The URPA is located approximately 20 km northwest of the township of Pine Creek and 175 km southeast of Darwin. Authorised activities at the URPA include ore processing and tailings storage.

The strategy over the next five years is to feed ROM ore to the URPA processing plant at a rate of over 2 million tonnes per annum, from underground mines at the Cosmo Howley Project Area, URPA and Pine Creek Project Area to produce over 200,000 ounces of gold per year.

The underground mine will be accessed via a portal and decline developed from within the existing Prospect pit. Prospect pit is divided into two sections, north and south which each have a pit lake (Figure 1-1). Prospect north and south pit(s) will be completely dewatered prior to portal construction. Prospect pit (south) will be used to store waste rock that will then be returned underground and used as backfill during mining operations. Ore will be trucked directly to the existing Run of Mine pad, and then fed into the existing processing plant crusher using the existing infrastructure and equipment. Tailings will be deposited in the existing Crosscourse pit Tailings Storage Facility.

Much of the URPA has been subject to intense mining by previous operators, leaving the site with environmental legacy issues associated with minor acid and metalliferous drainage from some of the mined rock faces and stockpiled rock. The key environmental challenge at the Prospect Pit mine addressed by NTMO is the management of these elevated solutes in drainage from the site structures, including the temporary waste stockpile, surface water and groundwater management as well as the tailings dam life cycle.

NTMO has been working closely with the DPIR and EPA since taking on management of the site and has implemented measures to improve water quality within the URPA, which are detailed in this WMP.

1.2 Purpose and Objectives

NTMO has prepared this Water Management Plan (WMP) to address the requirements of the *Mining Management Act 2001* for the Union Reefs Project Area (URPA) for Prospect Pit portal development.

This WMP provides an overview of the environmental performance of Prospect Pit mine from project development through to the post closure phase as it relates to water management. This WMP also describes planned activities for the next two years mine life cycle of the authorisation period and should be treated as a living document, to be revised and/or amended as required to accurately reflect changing on-ground conditions and water management measures.

Through implementing the management systems in this WMP, NTMO aims to meet the following objectives:

- To reduce the generation of low quality mine impacted water
- Reduce the risk of uncontrolled discharges of low quality mine impacted water from the project
- Effectively avoid and control adverse impacts to the surrounding environment
- Reuse, recycle, treat and discharge (if necessary) mine impacted water to control the onsite water inventory
- Promote awareness of mine personnel of the importance of adhering to this WMP when operating the project



FIGURE 1-1 PROSPECT PIT PORTAL LOCATION

2 LEGAL AND OTHER REQUIREMENTS

2.1 Legal Requirements

Legal requirements applicable to this WMP include various pieces of NT legislation:

- The project must gain approval to proceed by the NT Environmental Protection Authority (NT EPA) under the *Environmental Assessment Act 1982*
- This WMP will form part of the URPA Underground Mine MMP 2020-2021 which must be approved by DPIR under the *Mining Management Act 2001*
- Any pollution events that can be directly attributed to the URPA water discharge (passive or managed) must be reported to the NT EPA under the *Waste Management and Pollution Control Act 1998*
- A Waste Discharge Licence (WDL) is required for URPA controlled discharge of waste water and is issued by the NT EPA under the *Water Act 1992*
- NTMO has a previously authorised water entitlement (water extraction from Dam C) under mining authorisation # 0539-03. Water is taken for mining activities pursuant to a mine management plan approved under the *Mining Management Act 2001* before 30 June 2019.
- NTMO will submit an application for a water extraction licence and will include details on the pumping station and its power supply to be assessed under the *Water Act 1992.*

2.2 Guidelines

- NT EPA Guideline for the Preparation of an Environmental Management Plan, 2015
- NT EPA Guidelines on Conceptual Site Models, 2013
- The Australian and New Zealand Environment Conservation Council (ANZECC), Guidelines for fresh and marine water quality Australian National Committee on Large Dams Incorporated.
- Mineral Council of Australia's 2014 Water Accounting Framework for the Minerals Industry.

2.3 Integrated Management System

NTMO manages significant environmental and social aspects of its operations through a series of EMPs, which are included in the NTMO Integrated Management System. The EMPs applicable to this WMP are:

- Environmental Emergency Response Plan
- Flora and Fauna Management Plan / Threatened Species Management Plan
- Hazardous Substances Management Plan
- Landform, Erosion and Sediment Control Plan
- Rehabilitation Plan
- Tailings Management Plan
- Waste Rock Management Plan

2.4 Standard Operating Procedures

NTMO Standard Operating Procedures (SOPs) applicable to the Threatened Species Management Plan include:

- NTMO ES – SOP028 Ground Disturbance
- NTMO ES – SOP030 Weed Control
- NTMO ES – SOP031 Incident and Complaint Notification and Reporting
- NTMO ES – SOP001 Surface Water Sampling
- NTMO ES – SOP002 Groundwater Sampling
- NTMO ES – SOP003 Water Sampling, Packaging and Delivery
- NTMO ES – SOP013 Sediment Sampling
- NTMO ES – SOP038 Macroinvertebrate Sampling
- NTMO ES – SOP007 YSI Quatro Meter
- NTMO ES – SOP021 Spill Response
- NTMO ES – SOP052 Discharge Management

3 Roles and Responsibilities

The roles relevant for conducting management strategies in this WMP are listed below. The timing and responsibilities of each relevant position are documented throughout Section 11 of this WMP.

Internal Roles

- KLG Environmental Officer (Hydrology)
- KLG Senior Environmental Officer
- KLG Environment Manager
- KLG Safety Officer
- KLG Operations Manager

External Roles

- Drilling Contractors
- Specialist Hydrogeologist
- Specialist Aquatic Ecologist

4 Emergency Contacts and Procedures

Incorporated into the IMS, NTMO has developed an Environmental Emergency Response Plan (i.e. Appendix 9.1 of the URPA MMP) to provide a framework for the safe response and management of environmental emergencies. Emergency response to environmental issues are integrated within NTMO emergency response procedures. In the event of an environmental emergency, key personnel should be contacted:

TABLE 4-1 EMERGENCY CONTACT DETAILS

Emergency	Contact	Details
Medical emergency	Emergency Services	**Ph:** 000 or 112
Environmental emergency	Environment and Community Manager	**Ph:** 08 8982 4415 **Mob:** 0436 643 620 **Email:**
Water related emergency or incident	Name Position	**Ph:** tbc **Mob:** tbc **Email:** tbc

5 SITE CONDITIONS

5.1 Physical Environment

5.1.1 Climate

The climate of the Darwin-Katherine region is broadly classified as tropical monsoonal. It is characterised by seasonal shifting of the prevailing winds and consequently marked changes of air mass properties. Two distinct seasons can be identified – the dry and wet season, with two subsidiary transitional periods between them.

The dry season occurs from May to September and is characterised by prevailing south-easterly winds. The transition period from dry to wet season occurs in October and November and has high humidity and variable winds. The wet season occurs from December to March with dominant northwest to westerly winds. The second transition period, from wet to dry season, occurs in April and has variable winds, with dominant easterlies.

Most rainfall in the Darwin-Katherine region occurs in the wet season. Rainfall generally decreases with distance from the coast. The average annual rainfall between Douglas Daly and Pine Creek is 1,274 mm, compared to 970 mm for Katherine. Rainfall intensities are high, which is typical for areas located in the tropical north of Australia.

Long term regional rainfall data is available from the Bureau of Meteorology (BoM) weather station in Pine Creek. This station is located approximately 12 km southeast of the URPA and has 117 years of rainfall observation data. The mean annual rainfall for Pine Creek is 1,141 mm. January and February are the wettest months, with mean rainfalls of 279 mm and 248 mm, respectively. The highest mean monthly rainfall recorded was 762.6 mm in January 1894.

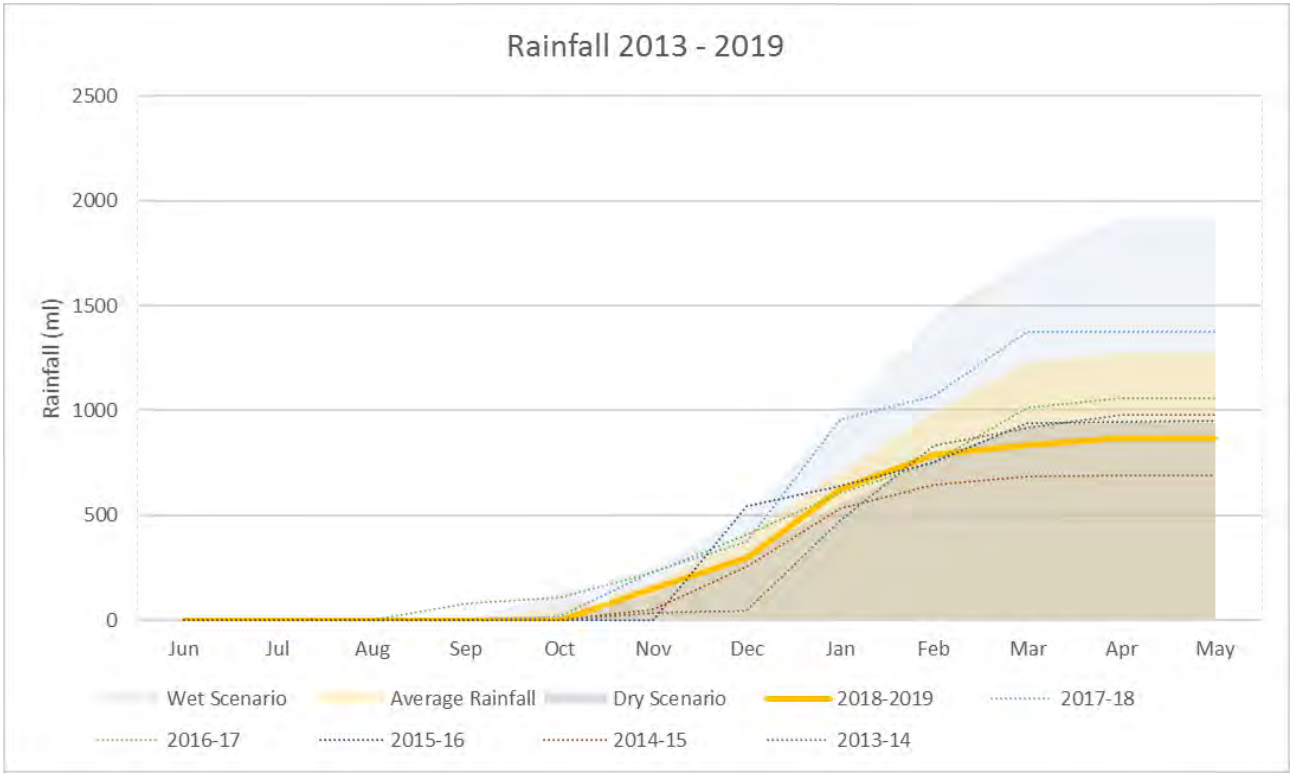


FIGURE 5-1 URPA MONTHLY RAINFALL 2013-2019

The NTMO Environment Department independently monitor rainfall at the URPA. Weekly measurements are taken from a rain gauge located at the site office. For the 12-month period, July 2018 to June 2019, a total of 871.6 mm rainfall was recorded on site.

Evapotranspiration of the Northern Territory region is at an average of 5.68 mm per day. Total evapotranspiration for the 12-month period was 2431 mm. Evaporation rate of large water bodies is approximately 60-70% of the evapotranspiration rate. Figure 5-2 provides an overview of evapotranspiration rates during the 2018-19 period.

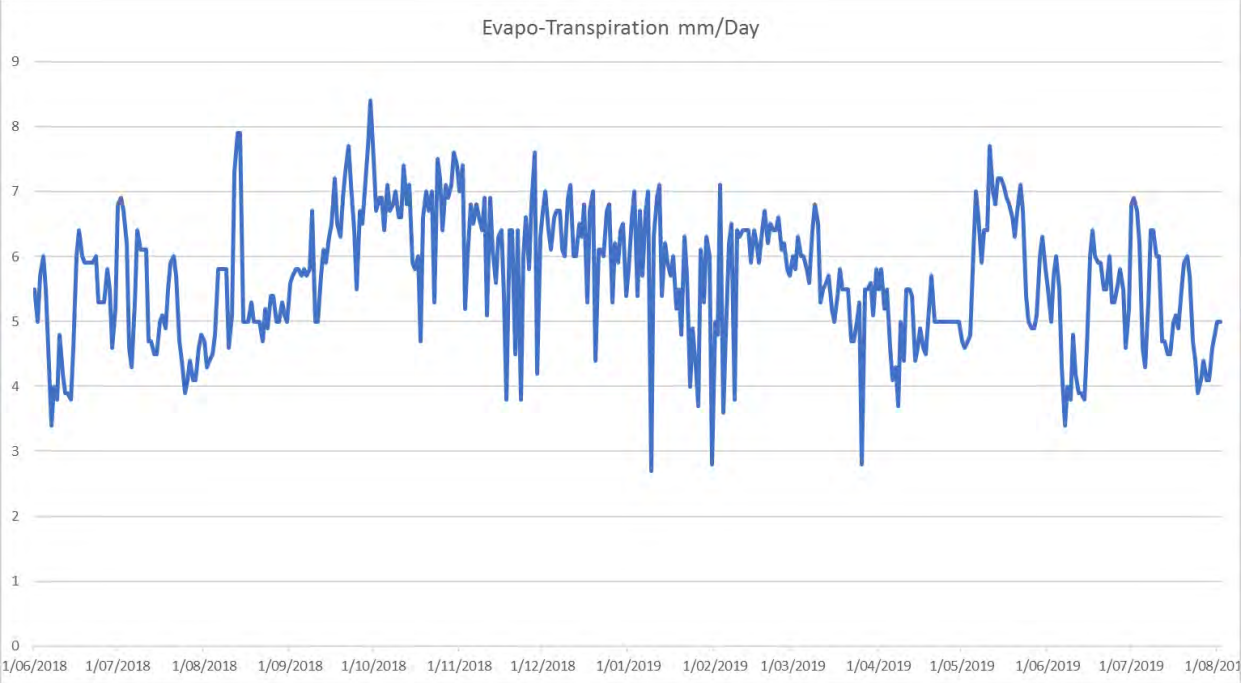


FIGURE 5-2 MEAN DAILY EVAPOTRANSPIRATION (BOM)

5.1.2 Hydrology

The URPA is located within the Mary River Catchment area. The main drainage sub-catchment system is the McKinlay River, which has its headwaters within the URPA. The McKinlay River flows northwards from the project area into the Mary River, which then meets the ocean approximately 200 km north of the project area. The Mary River flows all year-round but many of the associated tributaries draining its catchment area are ephemeral, flowing only during the wet season. Stream flows are highly variable and extremely responsive to rainfall, reaching peak levels between February and March.

The two main sub-catchments that drain the project area include Wellington Creek to the north and Esmeralda Creek to the south. These flow into the McKinlay River, which flows along the western edge of the URPA lease.

Background surface water quality within the McKinlay River sub-catchment area is monitored at URSW09, which is upstream of all mining areas.

5.1.3 Hydrogeology

The complex lithology and structure in the Pine Creek region results in a similarly complex hydrogeological environment, in which aquifer characteristics are expected to show significant variation according to lithology, tectonic history, weathering and recharge conditions. A summary of the hydrogeological properties of various geological units in the region is provided in the below table.

TABLE 5-1 URPA AND REGIONAL HYDROGEOLOGICAL PROPERTIES OF GEOLOGICAL UNITS

Age		Unit		Characteristics
Quaternary		Upper Sand & Soil layer, predominantly constitutes in the sequence of Silt, Sand, Clay, Humic soils, iron-stone, gravels & lithosols		Structure, mostly above regional water table, forms thin layers and highly localised, lower base permeable drainages conduit. Causes temporary water logging on water table on lower slope with seepage faces.
Cretaceous		Fe-sandstone & pudding stone		Confined aquifer (acts as an aquiclude) to local karstic aquifer of Daly basin, with very low permeability drainage conduit by direct rainfall and regionally lies occasional below the water table.
Daly River Group	Palaeozoic	Karstic Limestone	Oolloo dolostone	Local unconfined aquifer of Daly basin with moderate to high permeability, consists of large network of cavities and fresh groundwater with bore yield greater than 15 litres per second (L/s).
			Tindall formation	
			Junduckin formation	Aquitard in nature with lower yield than above limestone.
Edith River Group	Proterozoic	Cullen batholiths granite		Both confined units with very little permeability, yield below 0.05 L/s and defined by their intrusion nature.
		Zamu Dolerite		
South Alligator Group (SAG)		Fractured & weathered rock	Mt Bonnie formation	Indurate aquifer with mainly secondary permeability, widespread zone of fault and shear, highly localised as present throughout both project areas and possible yield range from 0.5 to 5 L/s. Slightly acidic to mildly alkaline and arsenic groundwater type.
			Gerrowie tuff	
			Koolpin formation	
Mount Partridges Group (MPG)		Fractured & weathered rock with minor ground-water resource	Burrell Creek formation	Member of Finniss River group and regionally conformed to on top South Alligator Group member.
			Wildman siltstone	Similar characteristic as above fractured and weathered rock aquifer with enhanced permeability along the fault and shear zone. Mainly older basement units apart from Burrell Creek formation. Lower yield (0.05 to 0.5 L/s).
			Mundogie sandstone	
			Masson formation	

Data taken from AGT (2006), CSIRO (2009), Dames & Moore (1988), McGowan (1987) and SKM (2006).

The Burrell Creek Formation forms the major aquifer in the URPA, while the Mt Bonnie Formation is intersected in the southern regions of the Tenement.

- The Burrell Creek Formation Aquifer
  The Burrell Creek Formation is widespread within the Pine Creek Geosyncline (Prowse 1983). It is largely formed of greywacke, siltstone and mudstones (AGT 2006; McKay & Miezitis 2007; Prowse 1983; SKM 2006) and regionally overlies the Masson Formation aquifer (AGT 2006). Unlike other fractured rock aquifers, the permeability of the Burrell Creek Formation aquifer has been enhanced within a localised fault and shear zone that has been intensely weathered. Typically, yield within this zone ranges between 0.5 and 2 L/s (AGT 2006).
- Mt Bonnie Formation Aquifer
  The lower layers of Mt Bonnie Formation aquifer consist of two major greywacke/mudstone units each generally 20 to 50 m thick, where each of these units is separated by 30-60 m of laminated siltstone, shale, chert and tuff (AGT 2006).

The fresh bedrock in the URPA has little or no primary permeability. Locally, the permeability is higher with the occurrence of secondary structures. The weathered zone is generally an aquifer, when saturated, particularly in areas of regional cross-cutting structures. As an aquifer, the weathered bedrock will be inhomogeneous and anisotropic, with the largest permeability's being in zones that run parallel to both geological strike, particularly in the presence of secondary structures.

Secondary permeability is associated with geological structures including quartz veins, fracture or shear zones in greywacke, gold mineralisation and quartz veins, faults, lineaments and weathered bedrock. The upper oxidised zone is more permeable than the fresh rock, in which the permeability decreases markedly with depth, away from physical and geochemical weathering processes.

The hydraulic conductivity of the identified aquifers is generally small, between 0.1 to 0.3 m/day, with the host bedrock having a permeability of 0.001 m/day. Storability values of the aquifer have been estimated between 0.0005 and 0.03 (dimensionless) indicating they are unconfined to weakly confined. Historical dewatering of the Crosscourse Pit during mining indicated relatively low dewatering rates; less than 10 L/sec during the dry season with increases associated with wet season recharge.

Groundwater flow at the Crosscourse Pit is inferred to be northward along the primary shear zone aquifer. However, local influences including waste dumps, tailings storage facilities, ridgelines, water storages and the tailings-filled Crosscourse Pit are also likely to influence groundwater levels. Based on recent dry season groundwater levels, groundwater is apparently recharged in elevated areas, flows down the topography and ultimately discharges to the local creek lines.

Tailings materials have been historically placed in an above ground tailings storage facility, and since August 2002 is placed into the Crosscourse Pit. Laboratory tailings testing indicates the Crosscourse Pit tailings have the properties of an aquitard. The tailings and bedrock zone both have low permeability and it is considered that the Crosscourse Pit TSF currently has limited influence on the surrounding groundwater regime. The water balance indicates that groundwater ingress occurs into the Crosscourse Pit potentially because hydraulic gradients are locally reversed due to the pit lake levels.

Natural groundwater at the URPA typically has a low salinity with Total Dissolved Solids (TDS) less than 200 mg/L. However, the salinity is higher in previous operational areas (TSF decant bores) where it is between 800-900 mg/L. Groundwater is of a Ca-Mg-Na-HCO_3-SO_4 type that is reflective of the geochemistry of the bedrock and presence of sulphide mineralisation. Historically, the groundwater pH has ranged between 6.6 and 7.9, which is within the normal range for groundwater (6.5 to 8.5).

Regional groundwater boundaries and faults are presented in Figure 5-3 and Figure 5-4 respectively.

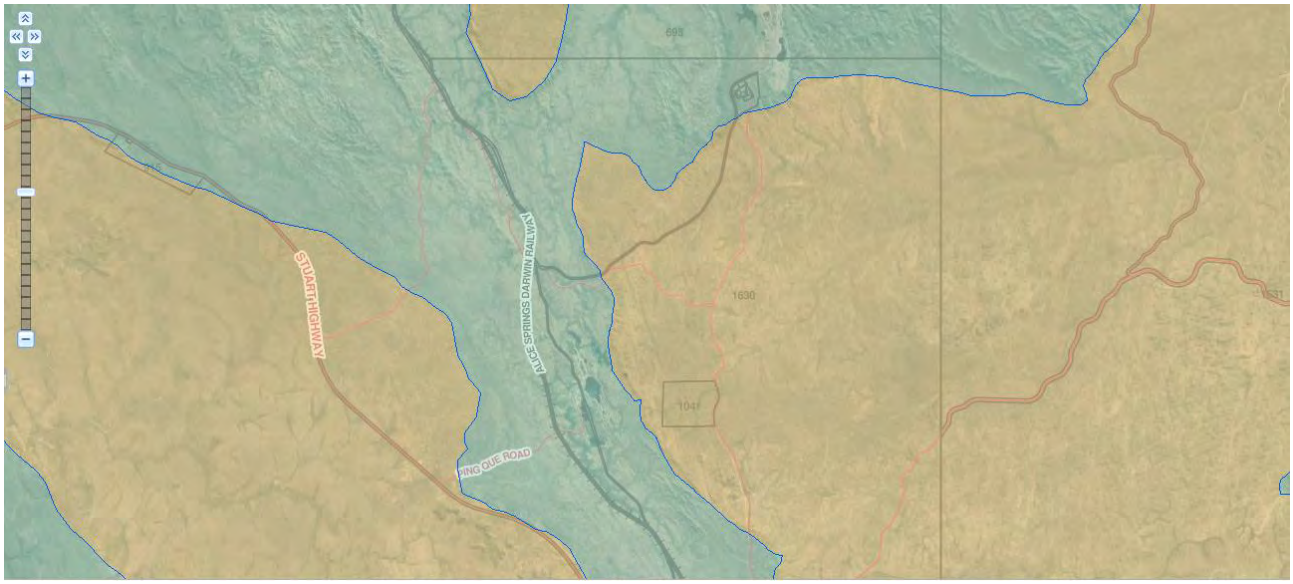


FIGURE 5-3 REGIONAL GROUNDWATER AQUIFER BOUNDARIES (NR MAP)

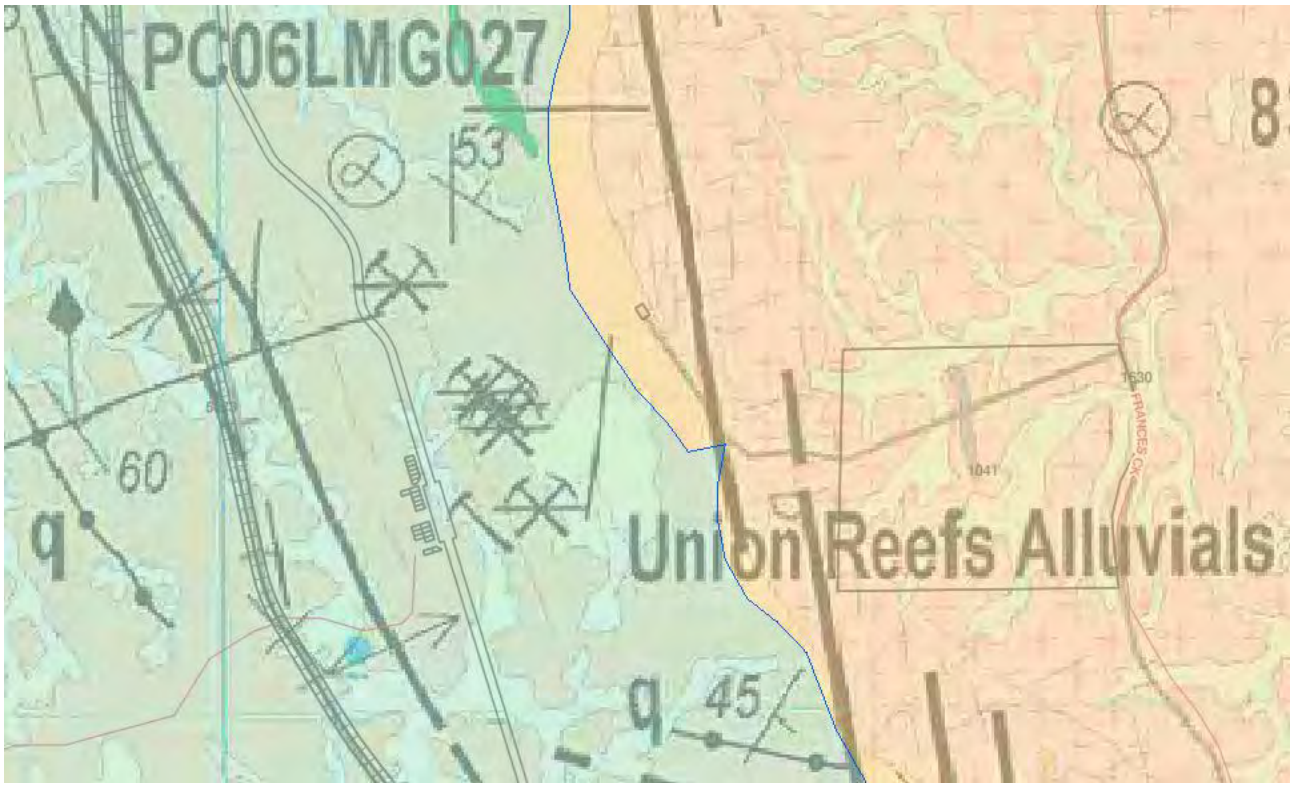


FIGURE 5-4 REGIONAL GROUNDWATER FAULTS (NR MAP)

The main aquifer system is an elongated north-south trending fractured and weathered rock system associated with the Union Reef shear zone. It is around 300-500 m wide and extends over many kilometres to the north and south. Groundwater flow in the Union Reef area is highly variable due to the structural controls on the groundwater system. Regional groundwater flow is generally from the south, while local flows are influenced by topography and recharge zone. Depth to water varies seasonally over the area with the detail yet to be documented. Groundwater has been noted to regionally rise to the surface during the wet season and fall 15 m during the dry season (Coffey 2012).

Groundwater levels near the Crosscourse Pit were originally 5-10 m below the ground surface, at about 1,180 mRL. The original average hydraulic gradient from the ridge is reported to have been about 0.025, possibly declining during the dry season. The regional direction of groundwater movement was towards the north (URS, 2002).

Constant rate aquifer testing of twelve test production bores indicated transmissivity in fractured bedrock of between <5 and 162 m^2/day, with storativity (dimensionless) ranging between 0.0005 and 0.03. Test bores were pumped for durations of between six and seventy-two hours with abstraction rates ranging between 0.5 and 4.5 L/sec (Dames and Moore, 1998).

The pit lakes including Crosscourse, Lady Alice, Prospect and Union North Pit are currently around 1173 to 1175 mRL. At the present, these pits are likely to be groundwater sinks and surrounding groundwater levels are slightly higher. The predicted low case groundwater inflow is 7 L/s, and the extreme high case is 18 L/S (AQ2, 2019) which will be used for Prospect Pit mine flooding calculation in this WMP.

5.1.4 Existing Surface Water Infrastructure

Existing surface water management infrastructure within the URPA is described below in Table 5-2 and Figure 5-5 of this WMP.

TABLE 5-2 SURFACE WATER MANAGEMENT INFRASTRUCTURE

Facility	Description
Dam A	Dam A (previously referred to as Union Reefs Lower Water Dam, URLWD) is an historical open pit situated within the northern part of the URPA. The dam receives rainfall and catchment runoff from the ridges to its eastern and western sides and overtops annually via a spillway to Wellington Creek, with the water quality monitored at monitoring point URSW01. In previous years, Dam A received overtopping water from Dam C via a connected drainage line.
Dam B	Dam B is located to the west of the fuel bay and wash-down areas. It acts as a sediment trap and settling pond for runoff from these areas. Any overflow from Dam B flows into Union Reefs Sediment Trap 3 (URST3). Water quality in this area is monitored at the monitoring point URST3.
Dam C	Dam C (previously referred to as Union Reefs Upper Water Dam, URUWD) is situated in the northeast of the URPA. It receives surface rainfall and catchment runoff from the hilly ridges to the east of the dam, as well as receiving runoff and seepage from the East WRD to the south. Discharge volumes from Dam C to Dam A are reflective of seasonal rainfall volumes. Dam C is used as a raw water source for the URPA and supplements the Processing Mill and Prospect Pit mine. A poly-pipeline runs from the northwest dam wall to a pumping station near the southwest corner of Dam A which then pumps the water to the mill.
Crosscourse Pit	Crosscourse Pit is the large pit in the centre of the URPA site. Since 2002, it has been used to store tailings. The water in Crosscourse Pit is extracted and recycled for use by the mill. A second pipeline and pump were installed in September 2010 to increase the volume capacity to be returned to the mill. This system is designed to increase the reuse of water from Crosscourse Pit, minimising the requirements for processing additives and consequently reducing the potential for environmental impacts, extending the life of Crosscourse Pit as a tailings storage facility and reducing operating costs for NTMO.
Decant Pond	The Decant Pond (previously referred to as the Tails Run-Off Pond (TROP) is located within the south of the URPA, south of the rehabilitated TSF. The decant pond receives runoff from the surface of the Old TSF via a designed spillway at the south-eastern corner, as well as low levels of subterranean flow-in from the decant tower system, which is located in the southern wall of the Old TSF. Passive discharge occurs during the wet season via a spillway running from the northwest corner of the decant pond to the McKinlay River, upstream of the McKinlay River Weir Wetlands. This discharge was monitored and regulated under the previous Waste Discharge Licence (WDL).
Sediment and Wetland Filters	The URPA site rehabilitation included the construction of several sediment traps (Sediment Trap 3, Sediment Trap 4A and Sediment Trap 5B) to reduce total suspended materials, and wetland filters to assist with attenuation of metals in the water. The sediment trap constructed to the south of the West WRD also acts as a settling pond that captures fuel bay and haulage wash-down area runoff.

Facility	Description
	The majority of surface water runoff and seepage from the West WRD is directed to Sediment Trap 4A prior to discharge into a tributary of the McKinlay River. A small portion of surface water runoff sheds to the north entering Wellington Creek; this is monitored at URSW01.
McKinlay River Weir Wetlands (URSW03)	Previous operators dammed the McKinlay River to create an additional area to capture freshwater during the wet season. Freshwater is no longer sourced here as the operation seeks to recycle the majority of its process water, and the pipeline and pumping infrastructure have been removed, but the area remains a haven for wildlife. Water discharging from the Decant Pond spillway enters the McKinlay River upstream of this wetland.
Plant Spill Pond	The Plant Spill Pond (URPSP) for the mill is a small rectangular pond which captures runoff from the plant area (including water used in the mill peripheral area and crusher areas) and is a contingency sump for any chemical or processing spills in the mill area. The URPSP can also be used as a backup return water supply for the mill and water can be pumped to Crosscourse Pit. In the event of URPSP overflow, the water will be captured in the neighbouring Union Dam to the south. The recently refined contours of this area suggest that the mill area will be underwater before the Union dam spills to the south. This has not been observed in the past.
Smaller Open Cut Pits and Facilities	The remaining smaller pits and dams (Lady Alice, Ping Que South Pit, Union South Pit, Big Tree Pit, Temple Pit, Millars Pit, Union North Pit, Union North South Pit, Union North southern extension and Union Dam) within the URPA do not form part of the current operational URPA, as they are not within NTMO's current disturbance footprint and have maintained consistent water levels without pumping since 2009. For these reasons they are not included in the current surface water monitoring schedule. Spot sampling has taken place on a number of these pits historically, however has been deemed unsafe due to the unstable pit walls.

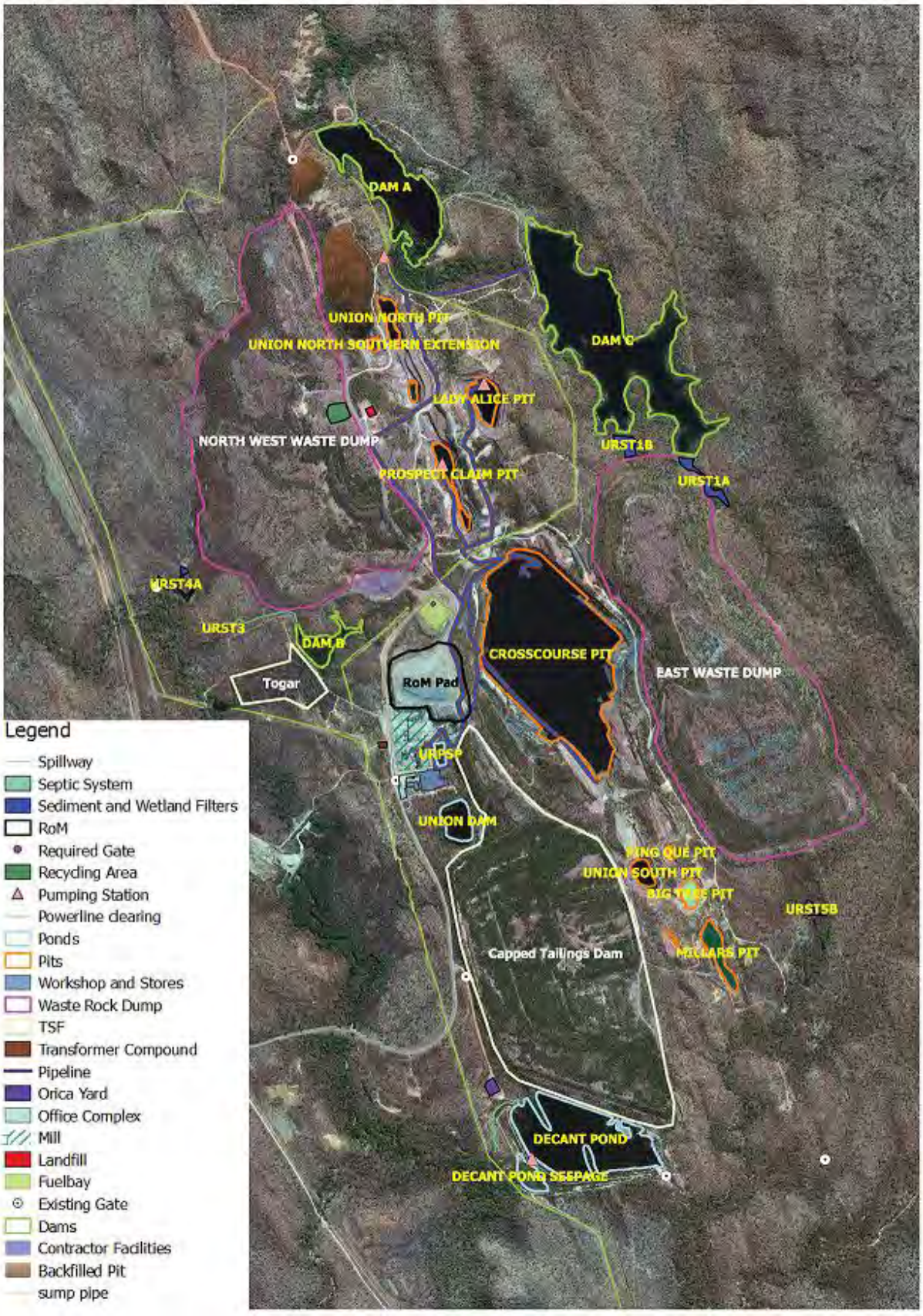


FIGURE 5-5 SURFACE WATER MANAGEMENT INFRASTRUCTURE MAP

5.1.5 Surface Water Flow

Mine impacted water from the URPA originates mainly from previously rehabilitated mining areas.

Table 5-3 describes sources of mine impacted water, the receiving environments and subsequent KLG water quality monitoring locations. Table 5-4 quantifies surface water flow across the URPA, and into the receiving environment under average and high rainfall scenarios.

TABLE 5-3 MINE IMPACTED WATER SOURCES AND RECEIVING ENVIRONMENTS

Source	Receiving Environment 1	Receiving Environment 2	Final Receiving Environment	Monitoring Location
East WRD (North)	Dam C	Dam A	Wellington Creek	Dam C
				Dam A
				URSW01
West WRD (South)	Dam B	Sediment Trap 3	McKinlay River	Dam B
				URST3
				URSW04
Fuel Bay and Wash-Down Areas	Dam B	Sediment Trap 3	McKinlay River	Dam B
				URST3
				URSW04
West WRD (West)	Sediment Trap A	-	McKinlay River	URST4A
				URSW04
Old TSF	Decant Pond	-	McKinlay River	URDP
				URSW03
East WRD (South)	Sediment Trap 5B	-	Esmeralda Creek	URST5B
				URSW03

TABLE 5-4 UNION REEF SURFACE WATER FLOW UNDER DIFFERENT RAINFALL SCENARIO

	1,380 mm Average Rainfall Surface runoff Volume (ML)	1,846 mm High Rainfall Surface runoff Volume (ML)
Dam B overflow to Sediment Trap 3	309	646
Sediment Trap 3 overflow to McKinlay River	278	631
Sediment Trap 4A overflow to McKinlay River	191	318
Dam C overflow to Dam A	0	300

	1,380 mm Average Rainfall Surface runoff Volume (ML)	1,846 mm High Rainfall Surface runoff Volume (ML)
Dam A overflow to Wellington Creek	368	1050
Decant Pond to McKinlay River	475	723
Sediment Trap 5B overflow to Esmeralda Creek	251	419

The hydrolines, drainage and flow paths of mine impacted waters at the URPA are shown in Figure 5-6 URPA Surface Hydrolines and Figure 5-7 URPA Stormwater Runoff Direction respectively. Figure 5-8 is a representation of the water management schematic, demonstrating current infrastructure and flow paths of each Dam and Pit.

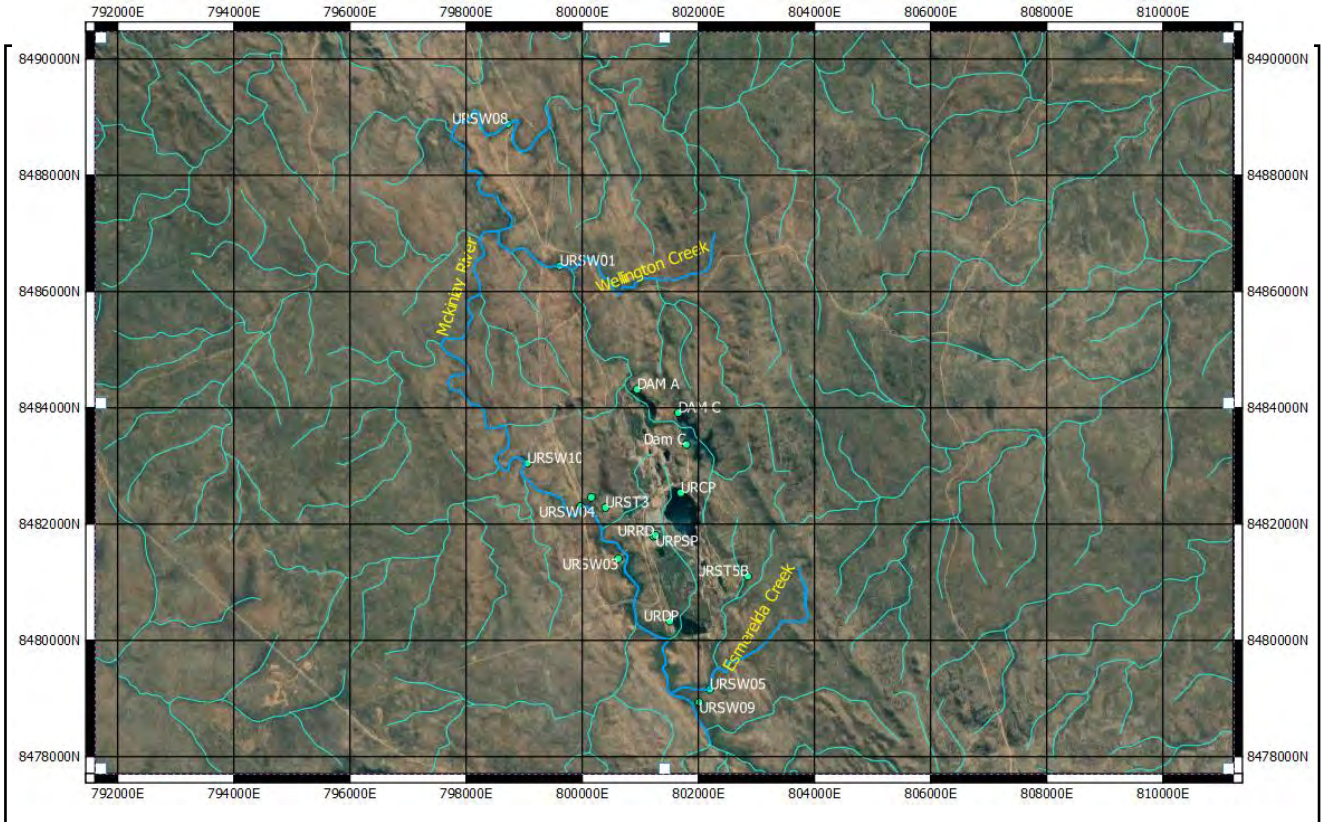


FIGURE 5-6 URPA SURFACE HYDROLINES

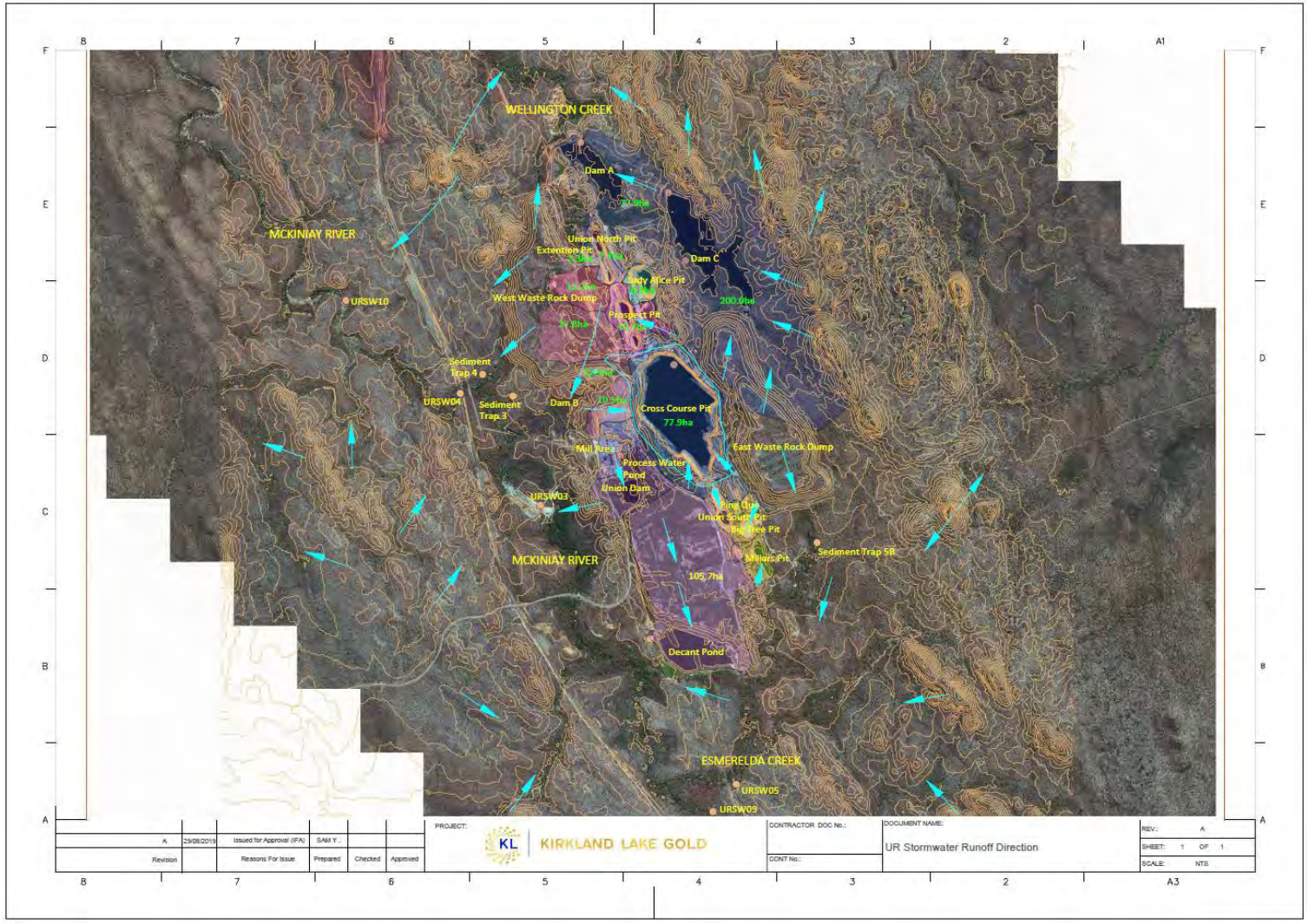


FIGURE 5-7 URPA STORMWATER RUNOFF DIRECTION

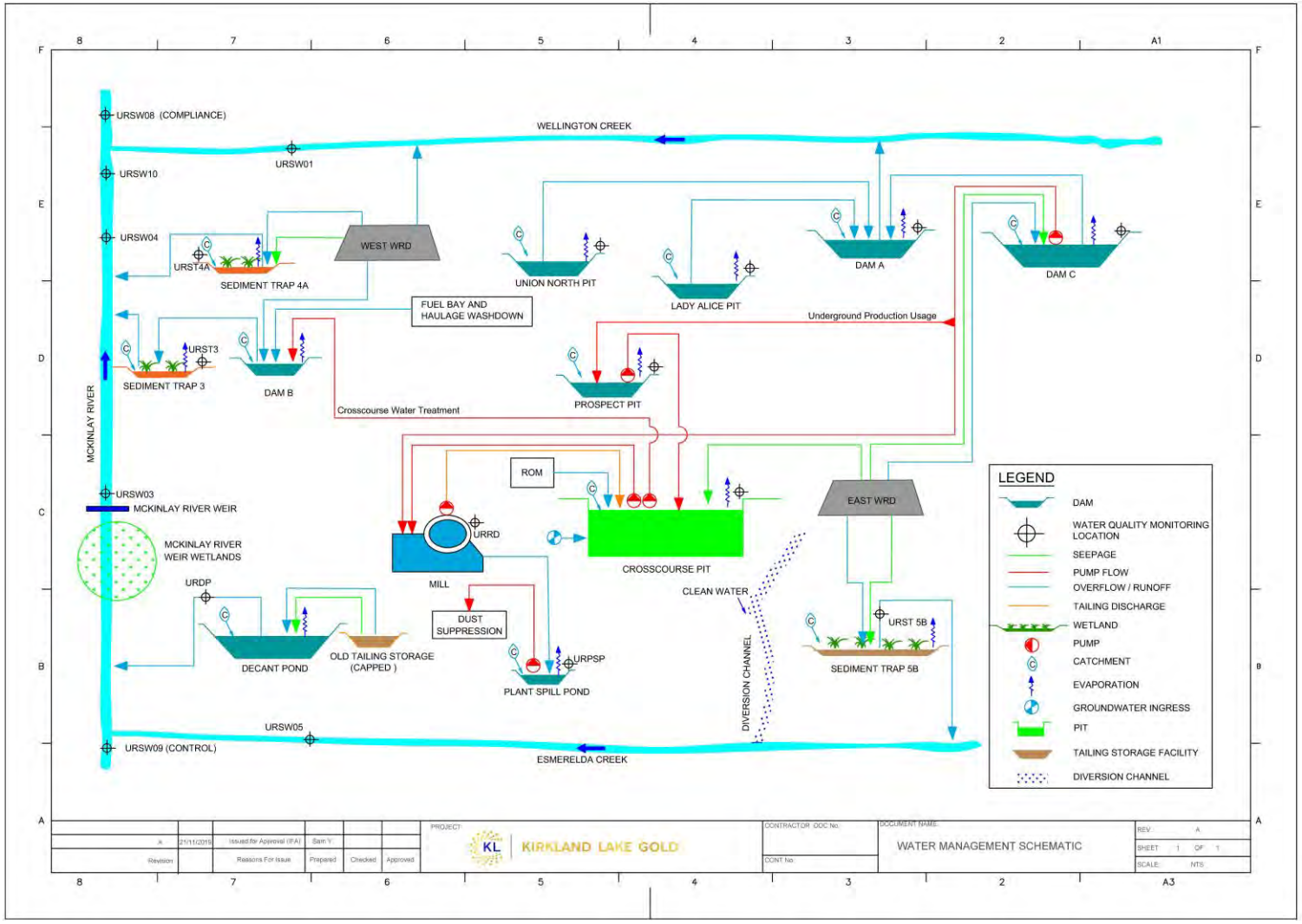


FIGURE 5-8 URPA WATER MANAGEMENT SCHEMATIC

6 UNDERGROUND MINE WATER MANAGEMENT

6.1 Operational Water Infrastructure

A number of the process and mine water dams constructed by previous operators at the URPA will be utilised to support the project.

The processing plant water circulation process includes reclaim from the Crosscourse TSF, supplemented by raw water from Dam C, i.e. some processing activities (i.e. elution) require a higher quality water and this is sourced from Dam C.

Prospect pit (North and South) will be completely dewatered prior to portal construction, with only a small dewatering sump remaining during the operation of the project. Approximately 100 ML of water will be pumped into Crosscourse pit via a 350 mm diameter pipeline using a 90 kW submersible floating pump.

See Figure 6-1 below for the initial dewatering schematic.

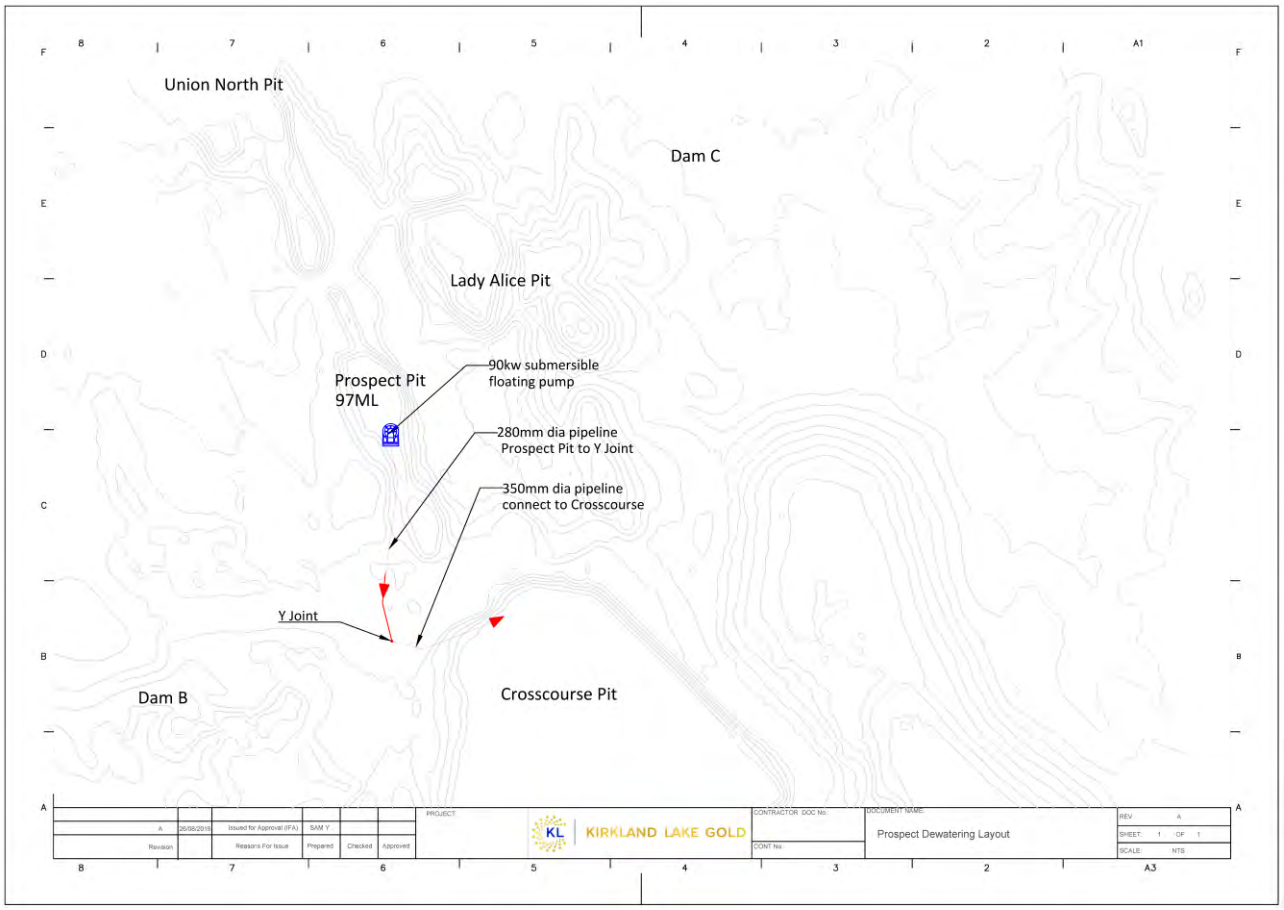


FIGURE 6-1 PROSPECT PIT INITIAL DEWATERING SCHEMATIC

All waste rock from underground mining will be temporarily stockpiled in Prospect South pit. A small water storage pond (sump) will be constructed to collect runoff from Prospect South pit, to be pumped into the main water storage pond in Prospect North pit.

The underground mine is expected to use around 1.5 to 2 L/s for underground drilling and dust suppression, equivalent to 47 to 63 ML/year. This water will be sourced from Dam C and pumped underground via two 30,000 L

water tanks installed adjacent to the Prospect pit. Underground wastewater and groundwater ingress (7 to 18 L/s, see Section 7 will also be pumped into Prospect North pit.

Prospect North pit water storage will be dewatered regularly into Crosscourse pit. Prospect North pit water level will be maintained in a dewatered state to avoid flooding risk of the portal. A flood risk assessment has been completed and is summarised in Appendix A – Flooding Risk Analysis and Preparedness.

Tailings from the processing plant will be deposited in Crosscourse pit. The potential impacts of the project on water volumes in Crosscourse pit are discussed in Section 7.

The water management circuit for the project is summarised in Table 6-1 and Figure 6-2 below. Table 6-2 lists tailings processing pump infrastructure to be utilised in Prospect pit.

TABLE 6-1 SITE WATER MANAGEMENT

Facility	Type	Inflows	Discharges
Crosscourse pit	Pit, tailings storage, recycled water.	Rainfall, groundwater ingress, tailings deposition.	Recycled for use in processing plant, discharge, and groundwater seepage when water level greater than 172-173 mAHD. (Proposed WDL to discharge treated water to McKinlay River in 2020/2021 wet season).
Prospect pit	Access and dewatering sump for underground mine production.	Rainfall, runoff catchment, pumped water from underground operations and groundwater ingress.	Discharge to Crosscourse pit.
Underground mine	Underground mine.	Pumped Dam C water for mine operations and groundwater ingress.	Discharge to Crosscourse pit.
Dam C	Raw water supply dam.	Rainfall, runoff catchment.	Supplementary process water supply, underground mine water supply. Discharges into Dam A via a constructed drainage line (in above average wet seasons).

TABLE 6-2 TAILINGS PROCESSING PUMP INFRASTRUCTURE

Pump Location	Pump Type	Purpose	No. of pumps	Horse Power (kw)	Capacity (L/s)	Pipe Diameter (mm)	Pipe Length (m)	Comments
Dam C	Electric Centrifugal	Raw Water Supply	1 duty, 1 spare	45	245	300	3300	Supplementary Plant Water Supply
Prospect Pit	Submersible	Dewatering	1 duty, 1 spare	90	150-220	300	1280	Pit Dewatering
Crosscourse Pit TSF	Submersible	Decant Return	2	90	290	225 > 200	1400	Process Water Recycling

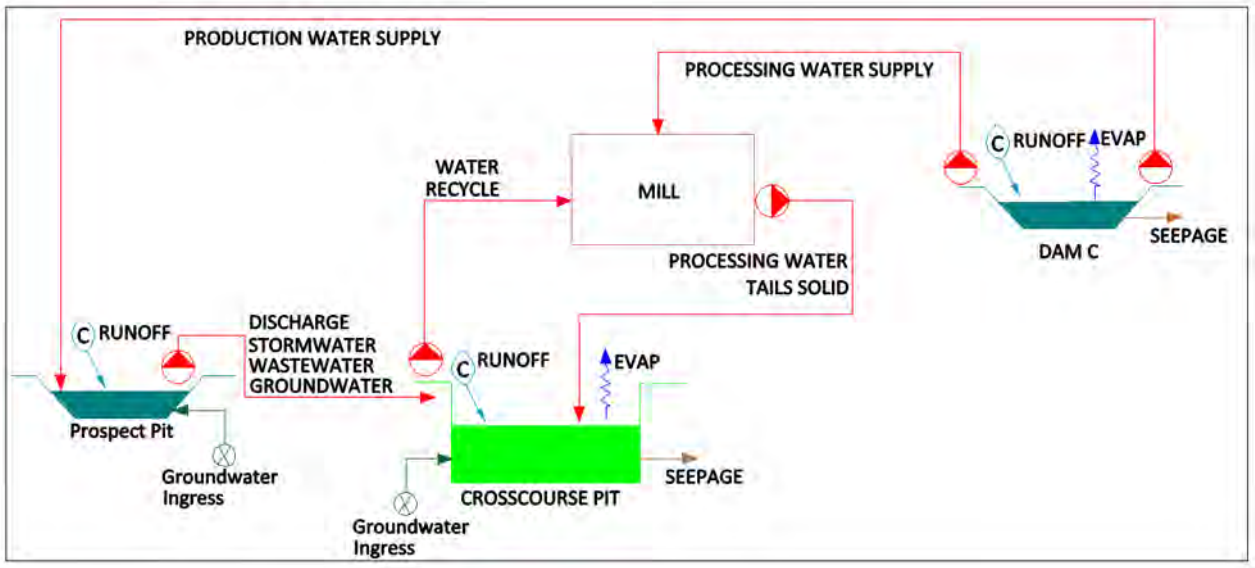


FIGURE 6-2 MINE OPERATIONAL WATER CIRCUIT

6.2 Operational Water Balance

The following site water balance for the operational phase of the project (i.e. year ending April 2021 – April 2023) has been developed as part of the site water management planning. The site water balance considers all inflows and outflows of the water management features identified in Section 6.1 of this WMP. The operational water balance is based on real data including the proposed water production rate from dewatering, process water requirements, and average annual rainfall from the historical record described in Section 6.3 and under the Flooding Risk Analysis and Preparedness provided in Appendix A – Flooding Risk Analysis and Preparedness of this WMP. The average annual water balance is summarised in Table 6-3, with discrete components described below.

The URPA processing tonnes for 2020 to 2024, including processing tonnes from the CHPA have been included in this site water balance. The URPA Underground Mine will contribute processing tonnes in 2021 to 2023.

TABLE 6-3 SITE WATER BALANCE – MINE OPERATIONS

	Year ending April 2020	Year ending April 2021	Year ending April 2022	Year ending April 2023	Year ending April 2024
Inputs					
Rainfall (mm/year)	1,380	1,380	1,380	1,380	1,380
Mining rate (Mt/year)	0	0.092	0.092	0.092	0
Production rate (Mt/year)	0.1	0.785	0.74	0.705	0.6
Inflows (ML/year)					
Catchment runoff – Prospect pit	113	113	113	113	113
Direct rainfall and catchment runoff – Crosscourse pit	941	941	941	941	941
Raw water from Dam C for processing plant	32	251	236	225	192
Raw water from Dam C for underground operations	0	63	63	63	0
Groundwater ingress to underground workings	0	79	221	221	0
Seepage to Crosscourse pit	36	62	62	62	62
Total Inflows	1,122	1,509	1,636	1,625	1,308
Outflows (ML/year)					
Evaporation from Crosscourse pit	599	599	599	599	599
Retained in tailings	32	251	236	225	192
Seepage from Crosscourse pit	8	0	0	0	0
Discharge under WDL	0	2,037	1,342	1,287	931
Total Outflows	639	2,887	2,177	2,111	1,722
Change in Storage (ML/year)					
Change in water inventory	483	-1,378	-541	-486	-414
Crosscourse Pit Storage Balance					
Change in tailings volume (ML)	69	541	541	486	414
Change in water volume (ML)	483	-1,378	-541	-486	-414
Change in Crosscourse pit freeboard volume (ML)	-552	837	0	0	0

6.2.1 Direct Rainfall, Catchment Runoff and Evaporation

The direct rainfall, catchment runoff and evaporation have been estimated based on the catchment area of Prospect pit North and South (15.7 ha), catchment area and surface area of Crosscourse pit (173 ha and 27 ha respectively) and the annual rainfall and evaporation depths described in Section 5.1.1. The net balance of direct rainfall, catchment runoff and evaporation is estimated to be 455 ML on average, indicating that the site is hydrologically in water excess.

6.2.2 Raw Water from Dam C

Operational requirements of underground operations and some components of the processing plant require a water with a relatively high quality that is not available from the existing water storage in Crosscourse pit. This water will be sourced from Dam C, which has a relatively large catchment and is expected to readily supply the required water demand up to 299 ML/year. Water for processing operations will be recycled from Crosscourse pit wherever possible.

6.2.3 Groundwater Ingress

The underground workings are expected to intercept groundwater at a rate of 18 L/s (i.e. the extreme high case predicted by AQ2, 2018 appended to Appendix H of the draft EIS), that will be required to be dewatered to Prospect pit and from there pumped to Crosscourse pit for the safe operation of the mine. Groundwater ingress is included in the site water balance in Table 6-3.

6.2.4 Retained in Tailings

Some water in tailings slurry sub aqueously deposited in Crosscourse pit will remain entrained in the tailings, with the remainder released through consolidation and available for recycling to the processing plant. The water retained in tailings is effectively lost from the water balance, so it is accounted for as an outflow, rather than change in storage. However, it still accounted for in available water storage capacity in Crosscourse pit as the change in the volume of tailings, along with the volume of the tailings solids themselves.

6.2.5 Seepage In and Out of Crosscourse Pit

The net groundwater flux into or out of Crosscourse pit depends on the water level elevation in the pit. The relationship was estimated using a groundwater model (refer Appendix H of the draft EIS) and is summarised in Figure 6-3.

Since the completion of mining in Crosscourse pit, it has so far been a groundwater sink, with inflows estimated to be 85 ML/year in early 2019, however if the water level in Crosscourse pit rises, the pit has the potential to become a groundwater source. Figure 6-3 shows that Crosscourse pit is anticipated to shift from being a net groundwater sink to a net groundwater source is at a water level between 173-176 m AHD. Further information Crosscourse Pit water management and water levels in various scenarios is detailed in 7 of this WMP.

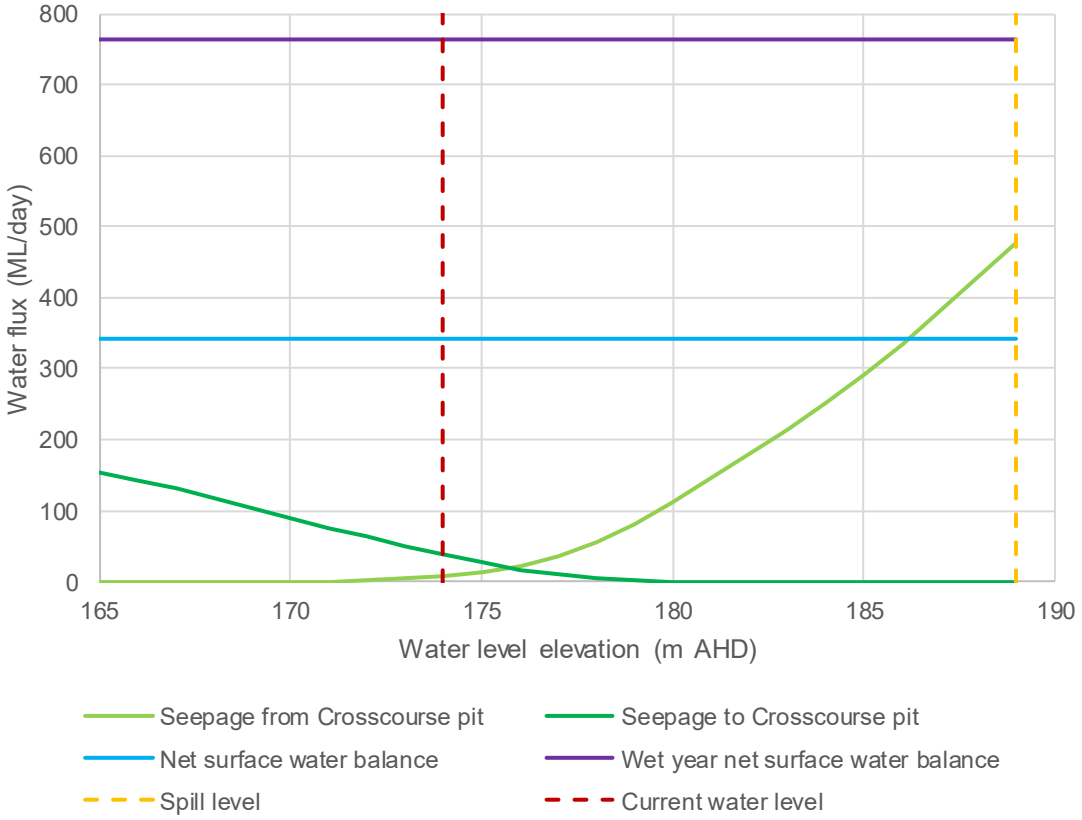


FIGURE 6-3 CROSSCOURSE PIT GROUNDWATER FLUX

Figure 6-3 also shows the net surface water balance (direct rainfall and catchment runoff less evaporation) of Crosscourse pit. This balance is a fundamental property of the climate, hydrogeology and geometry of Crosscourse pit and independent of existing and proposed operations. As is typical for open cut pits in tropical Northern Territory, Figure 6-3 shows that the net surface balance is expected to reach equilibrium with groundwater seepage out at about 186 m AHD, just below the surface water spill level of 189 mAHD. In an above average rainfall year, the net surface water balance is well in excess of the maximum groundwater seepage outflow rate. Overall, this indicates that in the long term, Crosscourse pit is expected to fill and remain near to the spill level. The post closure water balance of Crosscourse pit is considered further in Section 7 of this WMP.

6.2.6 Discharge under WDL and Change in Storage

As discussed above, the groundwater and water balance modelling indicates that the long term equilibrium water level in Crosscourse pit is close to the spill level; however, the timing of the increase in water levels is hastened by aspects of the project including:

- Dewatering of Prospect pit and subsequent dewatering of the underground workings.
- Displacement of water by deposition of tailings in Crosscourse pit.

Without additional water management actions, the effect of this water excess would be increasing water surface elevations in Crosscourse pit, resulting in:

- Reduction in the available water storage capacity in Crosscourse pit to contain extreme floods.
- Groundwater seepage from Crosscourse pit that is expected to report to downstream water management features and watercourses, including the McKinley River.

The potential impacts will be mitigated by a range of measures, including extraction (recycle to the processing plant) and treatment and discharge of water from Crosscourse pit under a Waste Discharge Licence (WDL).

The estimated average annual volumes expected to be discharged to maintain the water level in Crosscourse pit at about current levels are included in Table 6-3. The approval of the WDL is not anticipated until late 2020, and therefore no discharges are expected in the first year of the project, with an accordingly higher discharge volume in the second year to realise target water levels to minimise potential seepage rates and impacts.

Over the life of the project, a total of about 6 GL of water would need to be managed during the operation of the project in order to maintain water levels at current levels, and therefore, minimise seepage from Crosscourse pit.

A framework for the development of a waste discharge licence has been presented in Section 9 of this WMP.

6.2.7 Sensitivity to Rainfall Conditions

The operational water balance shown in Table 6-3 is based on average rainfall conditions. An additional scenario was considered, sampling the wettest consecutive five years in the historical rainfall record (refer to Appendix A – Flooding Risk Analysis and Preparedness of this WMP). Higher rainfall is expected to result in proportional higher direct rainfall and catchment runoff, while other flows remain similar.

Changes to the key results sensitive to rainfall conditions in Table 6-3 are summarised in Table 6-4. Table 6-4 shows that the total volume of water required to be managed to minimize seepage from Crosscourse pit may vary up to about 7 GL (approximately 17% higher when compared to average conditions) over the life of the project.

TABLE 6-4 SITE WATER BALANCE – MINE OPERATIONS – WET CONDITIONS

	2019	2020	2021	2022	2023
Inputs					
Rainfall (mm/year)	1,552	1,629	1,601	1,788	1,846
Inflows (ML/year)					
Catchment runoff – Prospect pit	127	133	131	146	151
Direct rainfall and catchment runoff – Crosscourse pit	1,058	1,111	1,092	1,219	1,259
Results (ML/year)					
Discharge under WDL	0	2,358	1,511	1,598	1,287

6.3 Operational Phase and Flooding Assessment

All waste from underground production will be temporarily stockpiled in Prospect South Pit. A small water storage pond will be constructed to collect runoff from Prospect South Pit and pumped to the main storage pond in Prospect North Pit. Dam C water will be pumped into the head tanks to be used for underground production water usage.

Underground waste water and groundwater ingress will be pumped into Prospect North Pit to be dewatered regularly to Crosscourse Pit. Prospect North Pit water storage pond water level will be maintained to eliminate flooding risk of the portal. A flood risk assessment has been completed and summarised below. The complete flood assessment is contained in Appendix A – Flooding Risk Analysis and Preparedness.

Figure 6-4 is the cumulative rainfall for each simulated event (1 in 100 year, 1 in 500 year, and 1 in 1000 year) over a 72 hour period. The maximum water storage volume of Prospect Pit is 121 ML during portal development. As shown, Prospect Pit has enough freeboard to hold a 1 in 1000 year rainfall event with a 150 L/s pump installed to remove water.

With no pumps installed, Prospect pit can withstand a 1 in 100 year rainfall event over a 72 hour period.

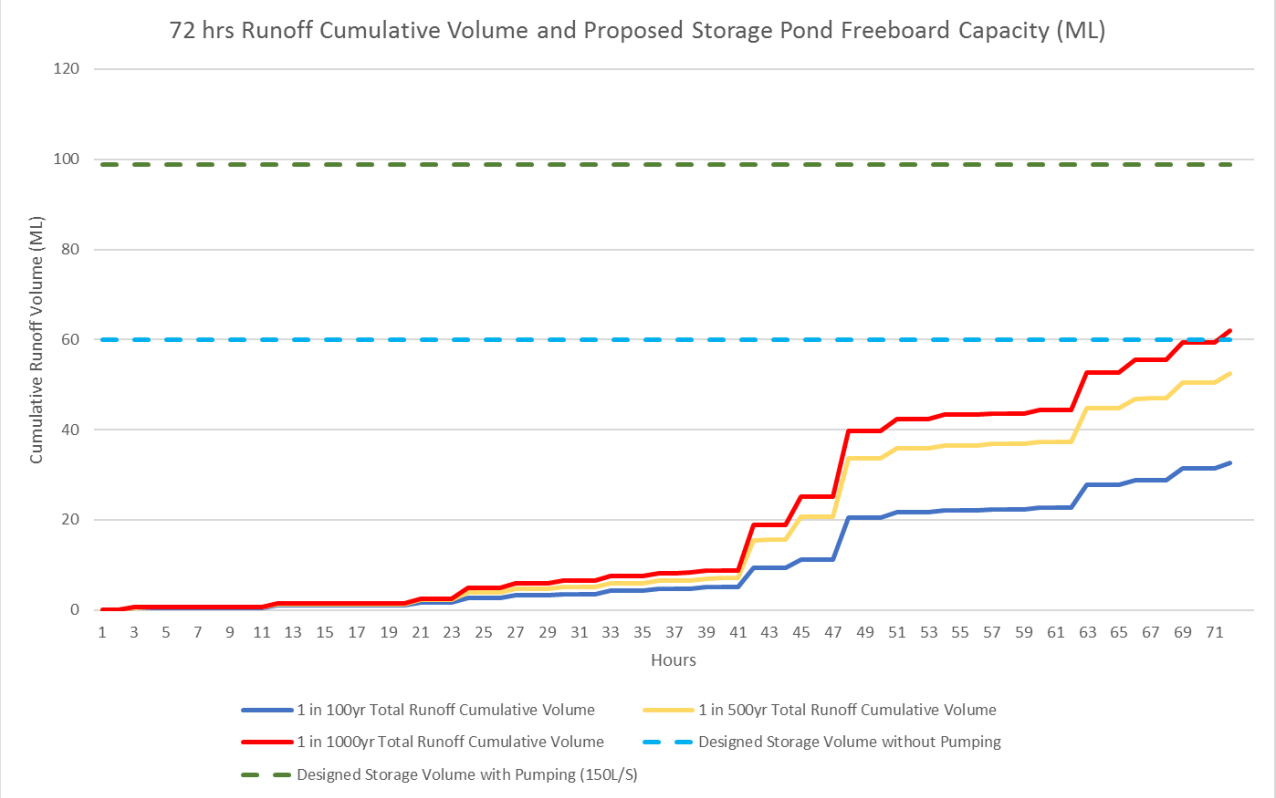


FIGURE 6-4 72 HOURS RUNOFF CUMULATIVE VOLUME VS PROPOSED STORAGE POND FREEBOARD CAPACITY FOR PROSPECT PIT

Table 6-5 provides the calculations for the Prospect Pit flooding risk assessment. Peak flow rate refers to the maximum runoff rate anticipated for each rainfall scenario, while groundwater ingress accounts for the groundwater inflow; in this scenario the extreme high flow prediction was utilised (AQ2, 2019).

As shown above, Prospect Pit can retain water from a 1 in 100 year rainfall event over a 72 hour period and retain enough freeboard not to overtop. Prospect has enough storage capacity to withstand a 1 in 500 year or 1 in 1000 year rainfall event with a 150 l/s pump installed, however there is an overflow risk if pumps are not installed.

Table 6-6 describes the planned maintained level of Prospect Pit during dewatering, and associated freeboard to overflow. A minimum of 60 ML freeboard is required with a 150 l/s dewatering pump installed.

TABLE 6-5 PROSPECT PIT PORTAL FLOODING RISK ASSESSMENT

Annual Exceedance Probability	Total Rainfall (mm)	Total Catchment (ha)	Total Surface inflow (ML)	Peak Flow Rate (L/S)	72hrs Total Groundwater Ingress (18L/S) plus underground Production Waste Water (12L/S) (ML)	Total Inflow (ML)	Proposed Storage Freeboard Capacity without Pumping (ML)	Proposed Storage Freeboard Capacity with 150L/S Pumping Out (ML)
1 in 100 72hours	425	15.74	32.5	2566	7.78	40.28	60 (Safe)	99 (Safe)
1 in 500 72hours	555	15.74	52.47	3558	7.78	60.25	60 (Overflow Risk)	99 (Safe)
1 in 1000 72hours	617	15.74	61.98	4004	7.78	69.76	60 (Overflow Risk)	99 (Safe)

TABLE 6-6 PROSPECT NORTH PIT STORAGE POND MAXIMUM LEVEL AND MINIMUM REQUIREMENTS

Proposed Portal RL	Prospect North Pit RL	Prospect Pit North Pit Volume (ML)	Operational Phase Water Level Management	Designed Freeboard Capacity (ML)	Comments
1179.5	1173.5	121	6m below portal RL	60ML	60ML freeboard with 150L/S dewatering capacity is the minimum requirement
1177.5	1168.5	121	9m below portal RL	60ML	60ML freeboard with 150L/S dewatering capacity is the minimum requirement



FIGURE 6-5 PROSPECT PIT MINING WATER MANAGEMENT SCHEMATIC

7 CROSSCOURSE PIT (TAILINGS STORAGE FACILITY) WATER MANAGEMENT

7.1 Crosscourse Pit Background

Crosscourse Pit is the largest open pit at the URPA. From 1993 to 2002 more than 80 Mt of material was mined to a depth of around 234 m. In 2002 formal approval was given to utilise Crosscourse Pit as a tailings repository for the URPA Processing Plant, until 2003 when it was put under care and maintenance. In 2006 milling recommenced until 2017 when the mill ceased operations. NTMO recommenced the Processing Mill in line with Cosmo underground mining in late 2019.

The original tailings deposition method used from 2002 to 2005 is unclear, however since 2005 the tailings deposition method has been via a single discharge point on the western perimeter into the Crosscourse Pit TSF. Tailings discharge rates are up to 300 tonnes / hour during normal processing conditions.

The water circulation process for the processing plant is reclaimed from the TSF. Some processing activities (i.e. elution) require a higher quality water and this is sourced from Dam C. Pipelines are routinely inspected during tailings discharge to proactively manage pipeline repairs and prevent potential pipeline failures.

Previous laboratory tailings testing indicates the oxide materials have a permeability of 1.2 x 10-2 m/day, and a primary/oxide mix has a permeability of 6.7 x 10-3 m/day. These values indicate the tailings have the properties of an aquitard. The tailings and bedrock zone both have low permeability and it is considered that the Crosscourse Pit TSF currently has limited influence on the surrounding groundwater regime. The water balance indicates that groundwater ingress occurs into the Crosscourse Pit, possibly because hydraulic gradients are locally reversed due to the pit lake levels.

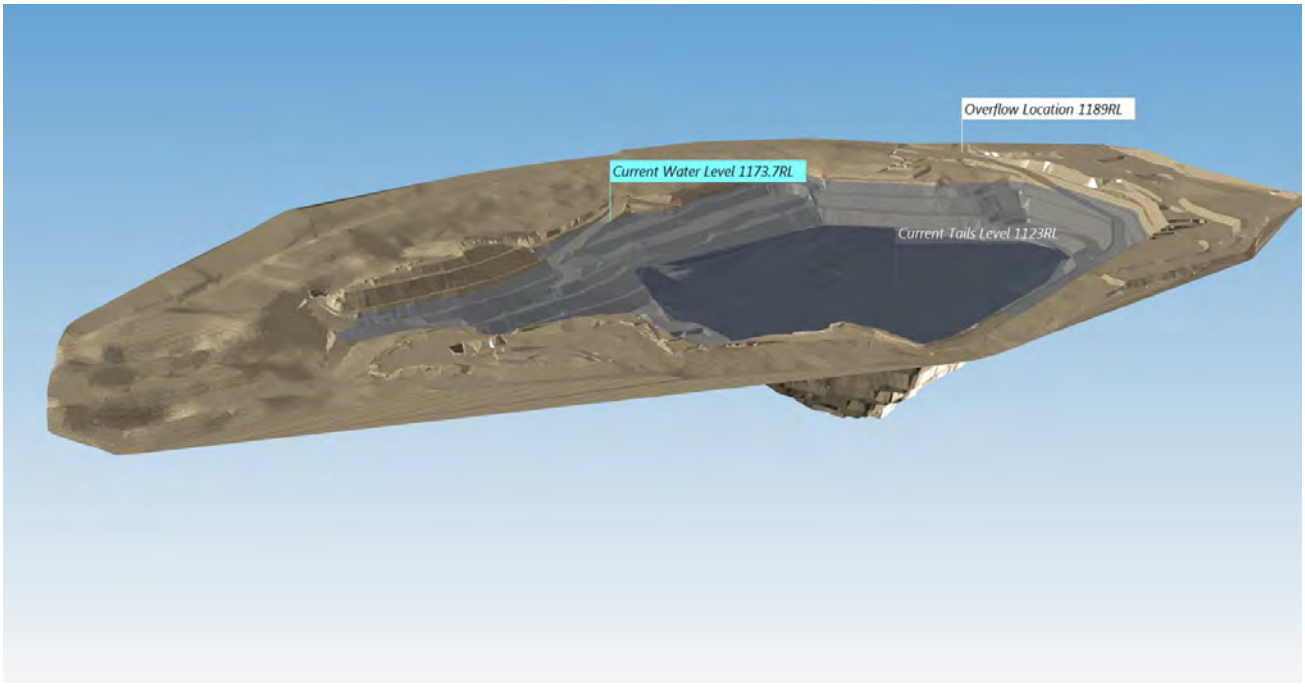


FIGURE 7-1 CROSSCOURSE PIT CURRENT TAILING DEPOSITION AND WATER LEVEL (MAY 2019)

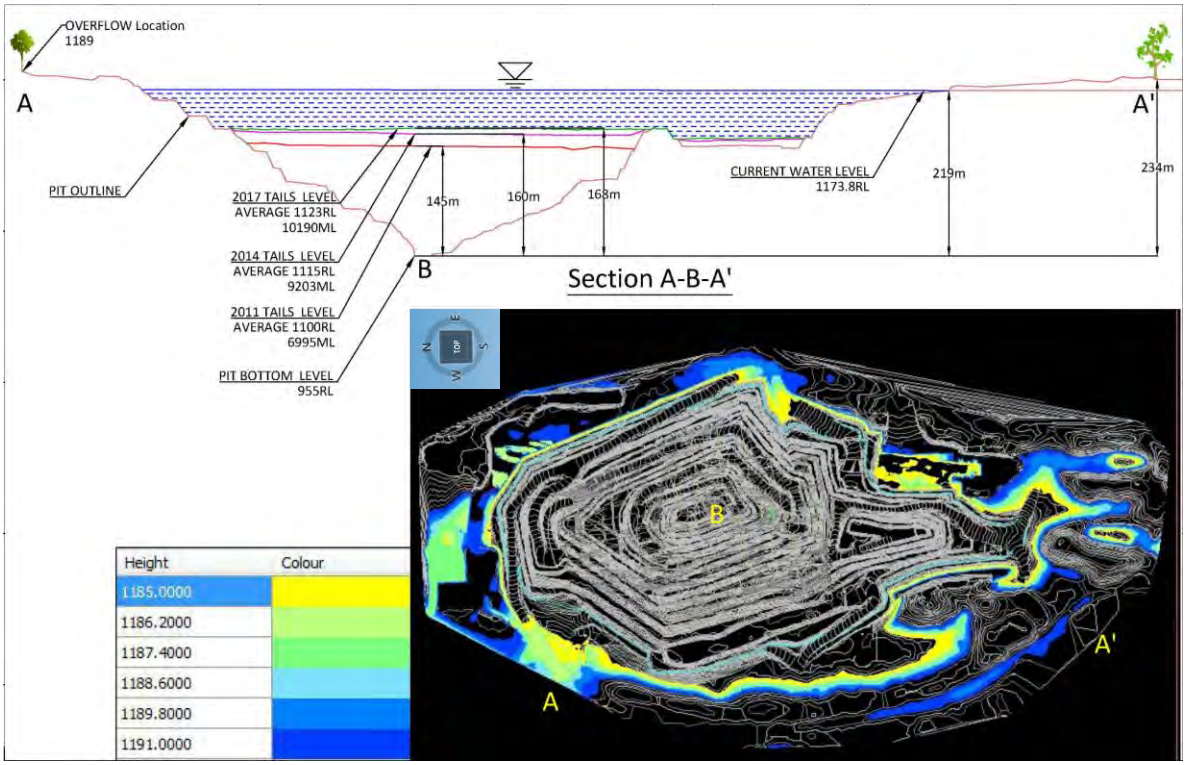


FIGURE 7-2 CROSSCOURSE PIT CROSS SECTION A-A' AND PROGRESSING TAILINGS LEVEL 2011-2017

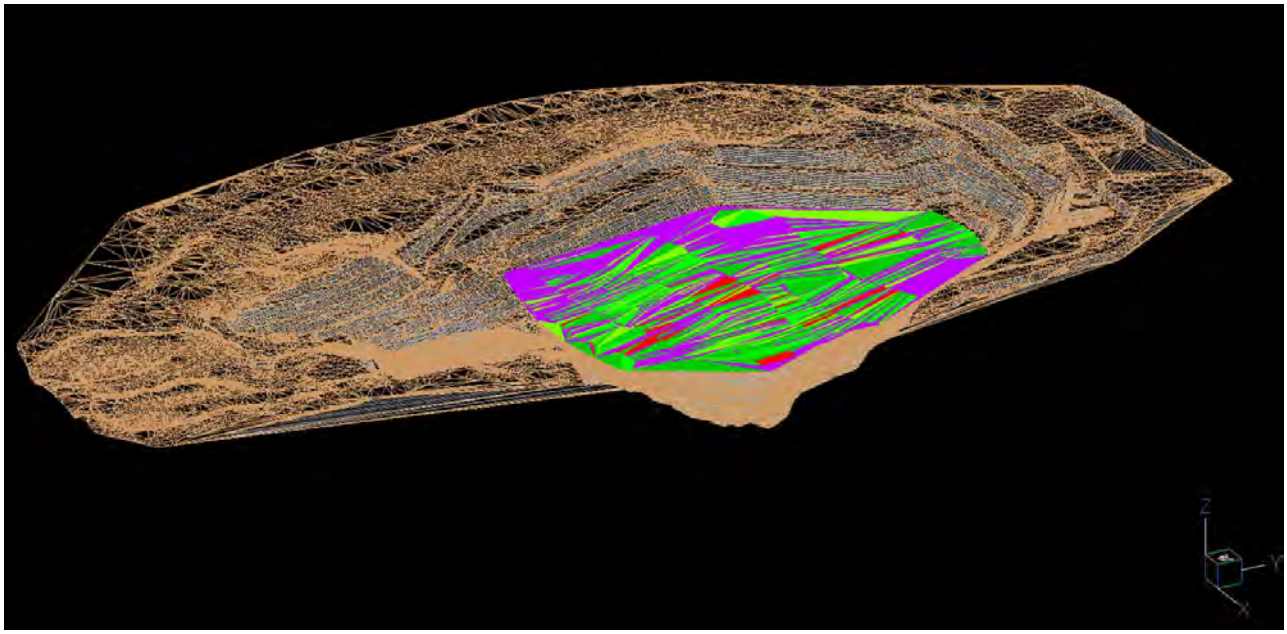


FIGURE 7-3 CROSSCOURSE TAILING VOLUME 3D MODEL

TABLE 7-1 CROSSCOURSE CURRENT FREEBOARD MAY 2019

Total Capacity (ML)	Tails Deposition (ML)	Current Water Volume Above Tails (ML)	Freeboard Capacity (ML)	Freeboard in meters
29282	10190	12605	6487	15m to overflow

7.2 Proposed Ore Processing Operations

The URPA Processing Plant is the only gold processing facility for NTMO. The historical performance of the plant indicates that it is a reliable, efficient and low-cost ore processing facility. Milling operations recommenced in October 2019.

The URPA Processing Plant has a maximum capacity of 2.5 million tonnes per annum (Mtpa) and has a high level of flexibility. The plant can be operated efficiently at a lower throughput rate with the use of only one of the ball mill circuits. The current planned URPA LOM processing tonnes, grade, recovery and ounces for 2019-2023 are provided in Table 7-2 below.

TABLE 7-2 URPA LOM PROCESSING TONNES (2019-2023)

Month	Processing Tonnes Cosmo / Lantern (T)	Processing Tonnes Prospect (T)	Total Processing Tonnage (T)
End December 2019	100,000		100,000
End December 2020	750,000	35,000	785,000
End December 2021	600,000	140,000	740,000
End December 2022	600,000	105,000	705,000
End December 2023	600,000		600,000

Peak hourly inrush distribution based on a 1 in 100 year, 1 in 500 year and 1 in 1000 year rainfall event at Crosscourse Pit is shown in Figure 7-4. The peak volume is predicted to occur between hours 13 and 23.

Figure 7-5 is the cumulative rainfall for each simulated event (1 in 100 year, 1 in 500 year, and 1 in 1000 year) over a 72-hour period. As shown, Crosscourse Pit has enough freeboard to withstand multiple 1 in 1000 year rainfall events without overflowing, which is also summarised below in Table 7-3.

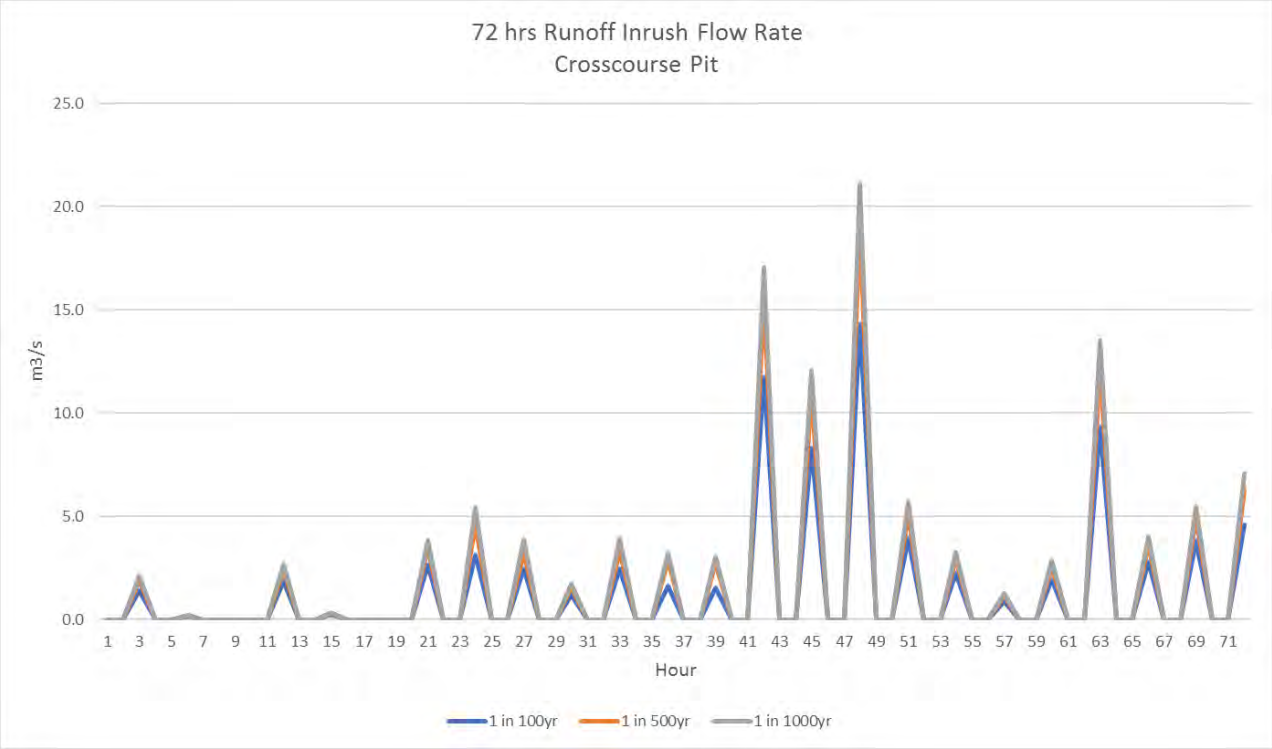


FIGURE 7-4 72 HOURS RUNOFF INRUSH HYDROGRAPH OF CROSSCOURSE PIT

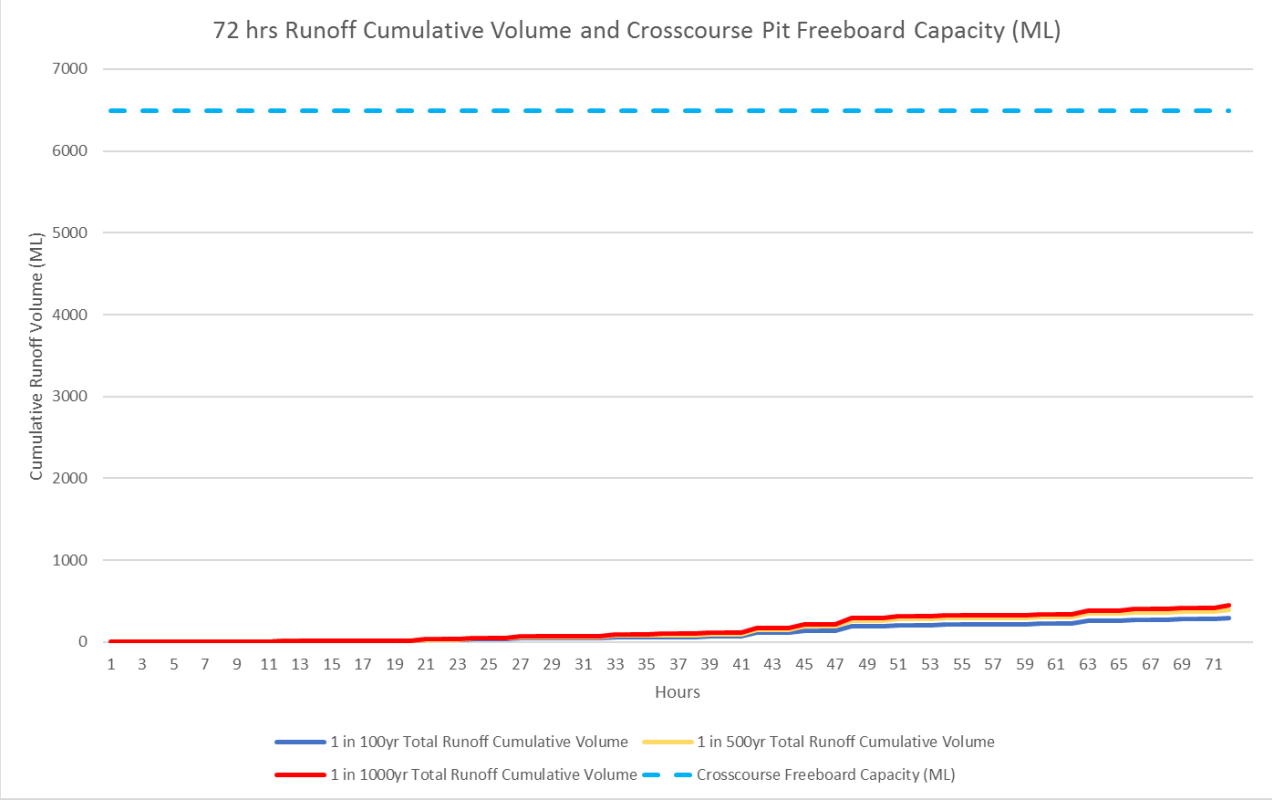


FIGURE 7-5 72 HOURS RUNOFF CUMULATIVE VOLUME VS CROSSCOURSE FREEBOARD CAPACITY

TABLE 7-3 72HRS CROSSCOURSE PIT FLOODING RISK ASSESSMENT

Annual Exceedance Probability	Total Rainfall(mm)	Total Catchment (ha)	Total Surface inflow (ML)	Peak Flow Rate (L/S)	Receive from Prospect Pit (ML)	Total Inrush (ML)
1 in 100 (72hours)	425	77.86	297.7	14315	40.28	337.98
1 in 500 (72hours)	555	77.86	398.66	18915	60.25	458.91
1 in 1000 (72hours)	617	77.86	446.1	21073	69.76	515.86

The tables below outline the remaining freeboard in Crosscourse pit during and after mining, under different rainfall scenarios. Each table has water inputs from rainfall, seepage, dewatering Prospect pit and the underground mine, and tailings inputs from processing material from CHPA and URPA. Tables include:

- Table 7-4 Scenario 1-Crosscourse Life Cycle Analysis Average Rainfall April 2020-April 2024 without Discharge
- Table 7-6 Scenario 2-Crosscourse Life Cycle Analysis Four Consecutive Years Wet Rainfall April 2020-April 2024 without Discharge
- Table 7-8 Scenario 3- Crosscourse Life Cycle Analysis Average Rainfall April 2020-April 2024 with Discharge
- Table 7-10 Scenario 4- Crosscourse Life Cycle Analysis Four Consecutive Years Wet Rainfall April 2020-April 2024 with Discharge

Table 7 4 and Table 7 5 show an extrapolated water balance scenario for a five-year period, with average rainfall and no discharge commencing from Crosscourse Pit. In this scenario, 3.9 m freeboard would still be available in the pit by April 2024; from 14.3 m in April 2020. This result is further displayed Figure 7-6 and Figure 7-7, with Figure 7-6 also demonstrating the predicted volume of tailings and water present in the pit. The red section of the figure represents the volume of tailings, while the blue represents water volume.

A high rainfall scenario under a no-discharge regime is shown in Table 7-6. This would result in a 3.4 m freeboard in Crosscourse Pit by April 2024. The equivalent freeboard is due to the progressively increasing seepage expected during higher intensity rainfall events. Figure 7-8 demonstrates the predicted volume of tailings and water present in the pit.

Conversely, Table 7-8 demonstrate an average rainfall scenario under an active discharge regime at Crosscourse Pit. In this scenario, the pit water level will gradually decrease below current levels over the following 5 years to leave a freeboard of 23.9 m. Figure 7-10 demonstrates the predicted volume of tailings and water present in the pit, and Figure 7-11 presents a visual demonstration of the water balance scenario over 5 years.

A high rainfall scenario with active discharge will also lead to Crosscourse Pit water level dropping below the current level after 5 years. A freeboard of 18.8 m will be achieved by April 2024 under this scenario. This is also demonstrated in Figure 7-12 and Figure 7-13, which represent the anticipated volumes of tailings and water, and the predicted water balance scenario over 5 years, consecutively.

TABLE 7-4 SCENARIO 1-CROSSCOURSE LIFE CYCLE ANALYSIS AVERAGE RAINFALL APRIL 2020-APRIL 2024 WITHOUT DISCHARGE

	Hydrology				Processing Mass Balance										Crosscourse Life Cycle			
Year	Average Rainfall (1380mm/year) Runoff (ML)	Surface Evaporation (ML)	Seepage (ML)	Groundwater Ingress (ML)	Processing Tonnage (T)	In-situ solids SG	Deposited Tails SG	Pulp Density	Processing Water Usage (ML)	Processing Water Recycled 100% After Tails Solid Saturation (ML)	Additional Process Water Required from Dam C (ML)	Total Tails solid Deposit (ML)	Prospect Pit Surface Discharge into Crosscourse (ML)	Prospect Pit Groundwater Discharge into Crosscourse (ML)	Total Balance (ML)	Crosscourse Remaining Capacity (ML)	Predicted RL	Crosscourse Remaining Freeboard in meters
April 2020	941	599	0	0	100,000	2.70	1.45	60%	67	35	32	69	113		524	6,125	1174.7	14.3
April 2021	941	599	14	0	785,000	2.70	1.45	60%	523	273	251	541	113	142	1,124	5,000	1177.7	11.3
April 2022	941	599	14	0	740,000	2.70	1.45	60%	493	257	236	510	113	284	1,235	3,765	1180.8	8.2
April 2023	941	599	80	0	705,000	2.70	1.45	60%	470	245	225	486	113	284	1,145	2,619	1183.5	5.5
April 2024	941	599	178	0	600,000	2.70	1.45	60%	400	208	192	414	113		691	1,928	1185.1	3.9

TABLE 7-5 SCENARIO 1 (AVERAGE RAINFALL WITHOUT DISCHARGE) SUMMARY

Year	Discharge (ML)	Tailings volume Balance (ML)	Total Capacity (ML)	Deposited tailings (ML)	Water above tailings (ML)	Freeboard(ML)	Volume Occupied (ML)	RL	Water Balance(ML)
Apr-20	0	69	29280	10095	13060	6125	23155	1174.7	455
Apr-21	0	541	29280	10636	13643	5001	24279	1177.7	583
Apr-22	0	510	29280	11146	14368	3766	25514	1180.8	725
Apr-23	0	486	29280	11632	15027	2621	26659	1183.5	659
Apr-24	0	414	29280	12046	15305	1929	27351	1185.1	277

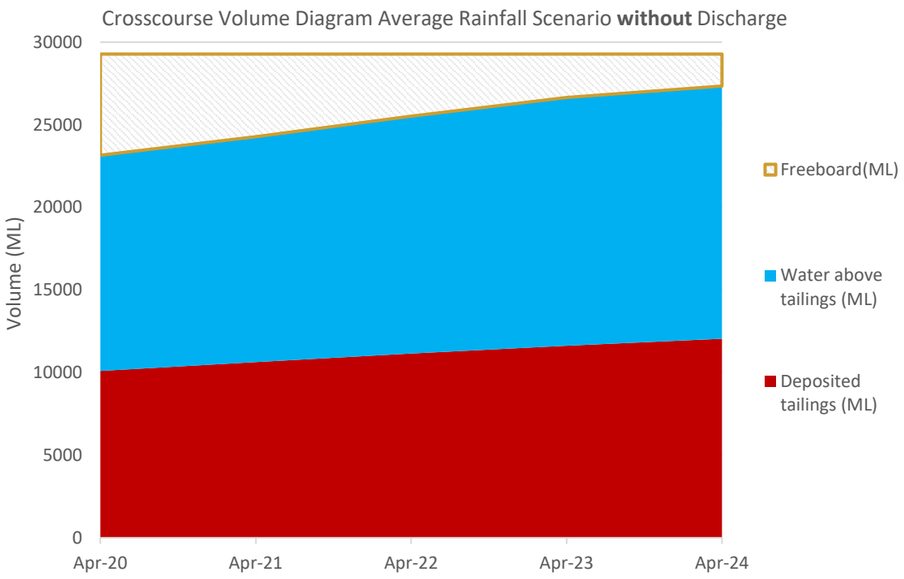


FIGURE 7-6 CROSSCOURSE PIT VOLUME DIAGRAM AVERAGE RAINFALL WITHOUT DISCHARGE

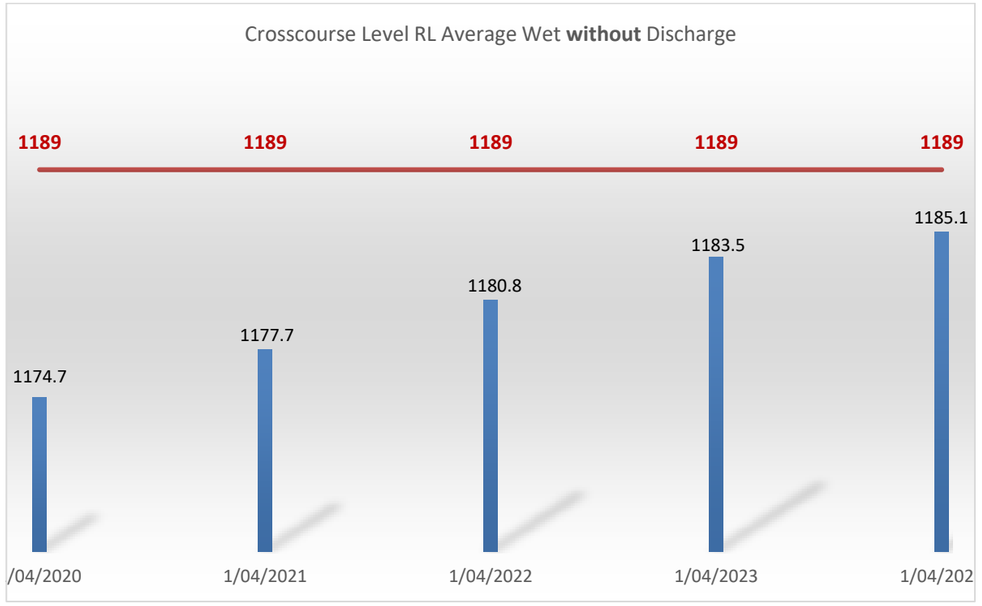


FIGURE 7-7 CROSSCOURSE LEVEL RL AVERAGE RAINFALL WITHOUT DISCHARGE

TABLE 7-6 SCENARIO 2-CROSSCOURSE LIFE CYCLE ANALYSIS FOUR CONSECUTIVE YEARS WET RAINFALL APRIL 2020-APRIL 2024 WITHOUT DISCHARGE

	Hydrology				Processing Mass Balance										Crosscourse Life Cycle			
Year	Rainfall /year Runoff (ML) 2019/1552mm 2020/1629mm 2021/1601mm 2022/1788mm 2023/1846mm	Surface Evaporation (ML)	Seepage (ML)	Ground water Ingress (ML)	Processing Tonnage (T)	In-situ solids SG	Deposited Tails SG	Pulp Density	Processing Water Usage (ML)	Processing Water Recycled 100% After Tails Solid Saturation (ML)	Additional Process Water Required from Dam C (ML)	Total Tails solid Deposit (ML)	Prospect Pit Surface Discharge into Crosscourse (ML)	Prospect Pit Groundwater Discharge into Crosscourse (ML)	Total Balance (ML)	Crosscourse Remaining Capacity (ML)	Predicted RL	Crosscourse Remaining Freeboard in meters
April 2020	1010	599	14	0	100,000	2.70	1.45	60%	67	35	32	69	127		593	6,056	1174.9	14.1
April 2021	1060	599	80	0	785,000	2.70	1.45	60%	523	273	251	541	133	142	1,197	4,859	1178.1	10.9
April 2022	1042	599	178	0	740,000	2.70	1.45	60%	493	257	236	510	131	284	1,190	3,669	1181.1	7.9
April 2023	1164	599	290	0	705,000	2.70	1.45	60%	470	245	225	486	146	284	1,191	2,478	1184	5
April 2024	1202	599	380	0	600,000	2.70	1.45	60%	400	208	192	414	151		788	1,690	1185.6	3.4

TABLE 7-7 SCENARIO 2 (FOUR CONSECUTIVE YEARS WET RAINFALL APRIL 2020-APRIL 2024 WITHOUT DISCHARGE) SUMMARY

Year	Discharge (ML)	Tailings volume Increment (ML)	Total Capacity (ML)	Deposited tailings (ML)	Water above tailings (ML)	Freeboard(ML)	Volume Occupied (ML)	RL	Water Balance(ML)
Apr-20	0	69	29280	10095	13129	6056	23224	1174.9	524
Apr-21	0	541	29280	10636	13785	4859	24421	1178.1	656
Apr-22	0	510	29280	11146	14464	3670	25610	1181.1	680
Apr-23	0	486	29280	11632	15169	2479	26801	1184.0	705
Apr-24	0	414	29280	12046	15543	1691	27589	1185.6	374

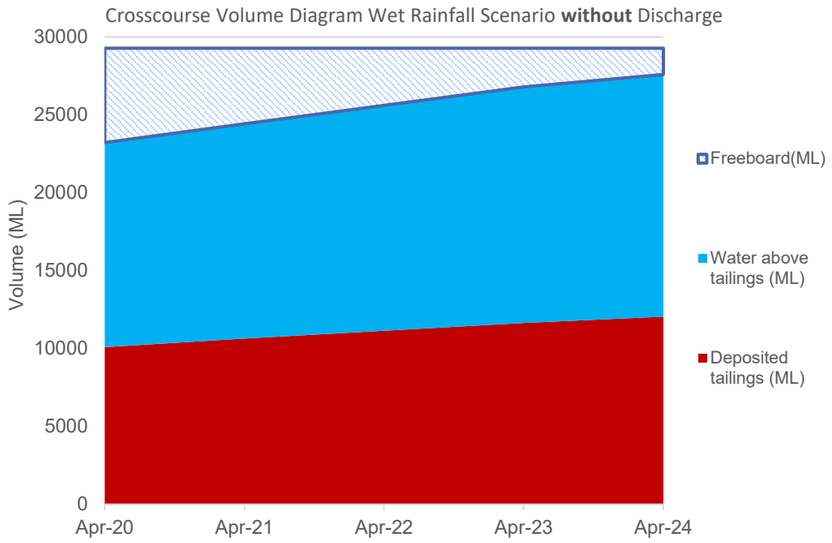


FIGURE 7-8 CROSSCOURSE PIT VOLUME DIAGRAM WET RAINFALL WITHOUT DISCHARGE

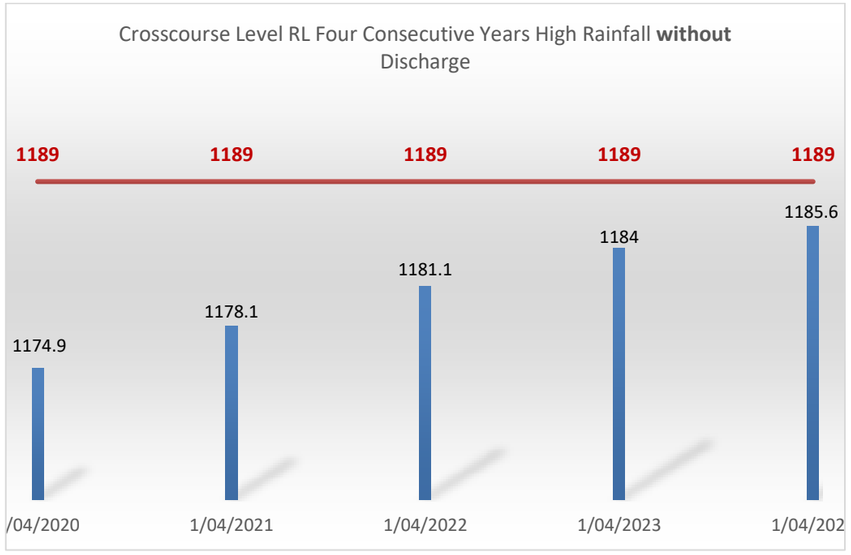


FIGURE 7-9 CROSSCOURSE LEVEL RL HIGH RAINFALL WITHOUT DISCHARGE

TABLE 7-8 SCENARIO 3- CROSSCOURSE LIFE CYCLE ANALYSIS AVERAGE RAINFALL APRIL 2020-APRIL 2024 WITH DISCHARGE

	Hydrology				Processing Mass Balance										Crosscourse Life Cycle				
Year	Average Rainfall (1380mm/year) Runoff (ML)	Surface Evaporation (ML)	Seepage (ML)	Groundwater Ingress (ML)	Processing Tonnage (T)	In-situ solids SG	Deposited Tails SG	Pulp Density	Processing Water Usage (ML)	Processing Water Recycled 100% After Tails Solid Saturation (ML)	Additional Process Water Required from Dam C (ML)	Total Tails solid Deposit (ML)	Prospect Pit Surface Discharge into Crosscourse (ML)	Prospect Pit Groundwater Discharge into Crosscourse (ML)	Discharge (ML)	Total Balance (ML)	Crosscourse Remaining Capacity (ML)	Predicted RL	Crosscourse Remaining Freeboard in meters
April 2020	941	599	0	0	100,000	2.70	1.45	60%	67	35	32	69	113		0	524	6,125	1174.7	14.3
April 2021	941	599	0	85	750,000	2.70	1.45	60%	523	273	251	541	113	142	2,421	-1198	7,323	1172.4	16.6
April 2022	941	599	0	85	600,000	2.70	1.45	60%	493	257	236	510	113	284	1,574	-240	7,563	1170.1	18.9
April 2023	941	599	0	85	600,000	2.70	1.45	60%	470	245	225	486	113	284	1,661	-351	7,914	1167.6	21.4
April 2024	941	599	0	85	600,000	2.70	1.45	60%	400	208	192	414	113		1,661	-707	8,620	1165.1	23.9

TABLE 7-9 SCENARIO 3 (AVERAGE RAINFALL WITH DISCHARGE) SUMMARY

Year	Discharge (ML)	Tailings volume Increment (ML)	Total Capacity (ML)	Deposited tailings (ML)	Water above tailings (ML)	Freeboard(ML)	Volume Occupied (ML)	RL	Water Balance (ML)
Apr-20	0	69	29280	10095	13060	6125	23155	1174.7	455
Apr-21	2,421	541	29280	10636	11321	7323	21957	1172.4	-1739
Apr-22	1,574	510	29280	11146	10571	7563	21717	1170.1	-750
Apr-23	1,661	486	29280	11632	9734	7914	21366	1167.6	-837
Apr-24	1,661	414	29280	12046	8614	8620	20660	1165.1	-1121

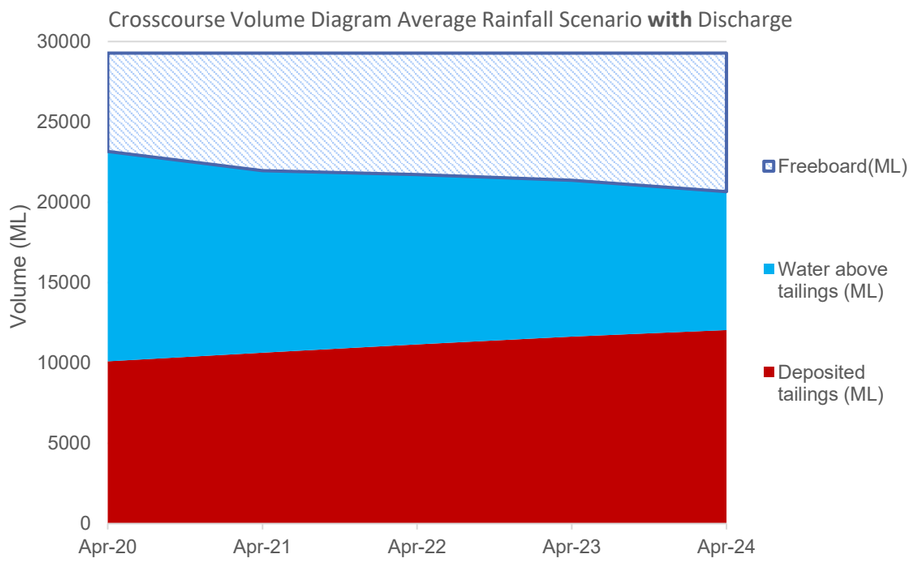


FIGURE 7-10 CROSSCOURSE PIT VOLUME DIAGRAM AVERAGE RAINFALL WITH DISCHARGE

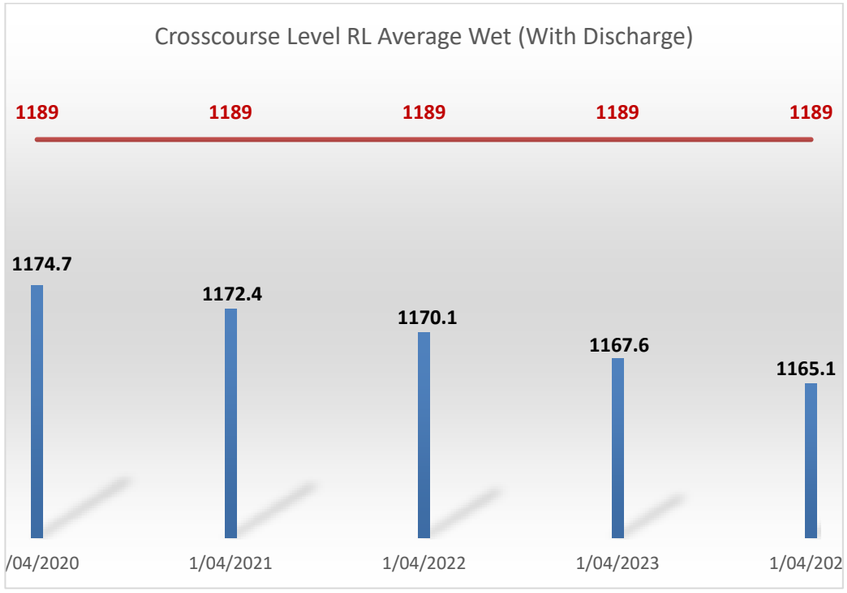


FIGURE 7-11 CROSSCOURSE LEVEL RL AVERAGE RAINFALL WITH DISCHARGE

TABLE 7-10 SCENARIO 4- CROSSCOURSE LIFE CYCLE ANALYSIS FOUR CONSECUTIVE YEARS WET RAINFALL APRIL 2020-APRIL 2024 WITH DISCHARGE

	Hydrology				Processing Mass Balance										Crosscourse Life Cycle				
Year	Rainfall /year Runoff (ML) 2019/1552mm 2020/1629mm 2021/1601mm 2022/1788mm 2023/1846mm	Surface Evaporation (ML)	Seepage (ML)	Groundwater Ingress (ML)	Processing Tonnage (T)	In-situ solids SG	Deposited Tails SG	Pulp Density	Processing Water Usage (ML)	Processing Water Recycled 100% After Tails Solid Saturation (ML)	Additional Process Water Required from Dam C (ML)	Total Tails solid Deposit (ML)	Prospect Pit Surface Discharge into Crosscourse (ML)	Prospect Pit Groundwater Discharge into Crosscourse (ML)	Discharge (ML)	Total Balance (ML)	Crosscourse Remaining Capacity (ML)	Predicted RL	Crosscourse Remaining Freeboard in meters
April 2020	1010	599	0	0	100,000	2.70	1.45	60%	67	35	32	69	127		0	607	6,042	1174.9	14.1
April 2021	1060	599	0	85	750,000	2.70	1.45	60%	523	273	251	541	133	142	2,421	-1059	7,101	1172.0	17
April 2022	1042	599	0	85	600,000	2.70	1.45	60%	493	257	236	510	131	284	1,574	-121	7,223	1171.6	17.4
April 2023	1164	599	0	85	600,000	2.70	1.45	60%	470	245	225	486	146	284	1,661	-95	7,318	1171.3	17.7
April 2024	1202	599	0	85	600,000	2.70	1.45	60%	400	208	192	414	151		1,661	-408	7,726	1170.2	18.8

TABLE 7-11 FOUR CONSECUTIVE YEARS (WET RAINFALL APRIL 2020-APRIL 2024) WITH DISCHARGE SUMMARY

Year	Discharge (ML)	Tailings volume Increment (ML)	Total Capacity (ML)	Deposited tailings (ML)	Water above tailings (ML)	Freeboard(ML)	Volume Occupied (ML)	RL	Water Balance With Discharge (ML)
Apr-20	0	69	29280	10095	13143	6042	23238	1174.9	538
Apr-21	2,421	541	29280	10636	11543	7101	22179	1172.0	-1600
Apr-22	1,574	510	29280	11146	10911	7223	22057	1171.6	-631
Apr-23	1,661	486	29280	11632	10330	7318	21962	1171.3	-581
Apr-24	1,661	414	29280	12046	9508	7726	21554	1170.2	-822

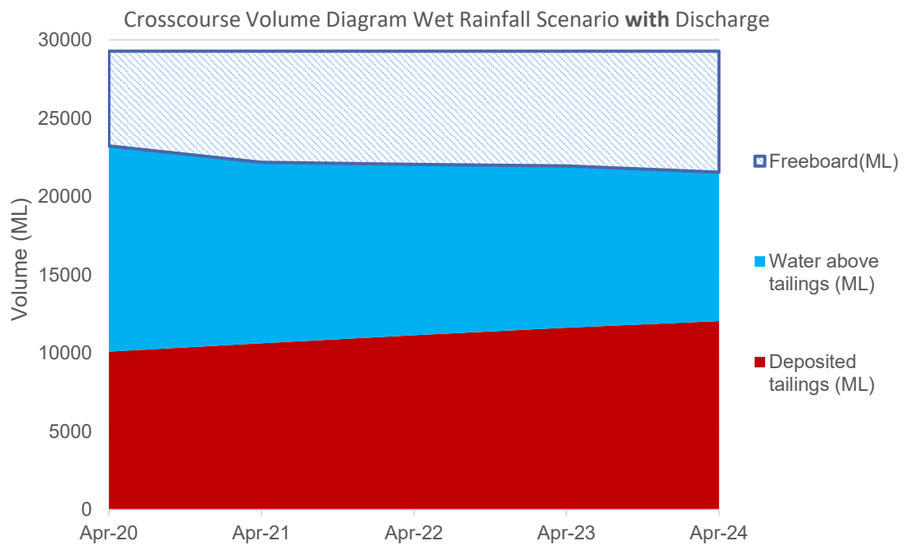


FIGURE 7-12 CROSSCOURSE PIT VOLUME DIAGRAM WET RAINFALL WITH DISCHARGE

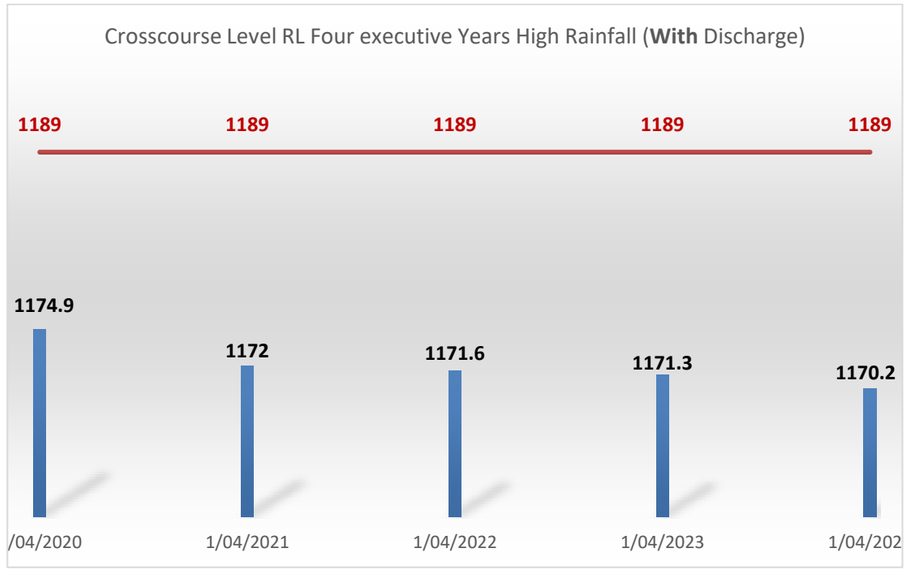


FIGURE 7-13 CROSSCOURSE LEVEL RL WET RAINFALL WITH DISCHARGE

8 URPA Annual Water Accounting

Figure 35 and Figure 36 below present an average and above average rainfall, water flow footprint for the URPA during the project. These figures include seepage volumes, pit and dam storage capacity, overflow levels, runoff and evaporation.

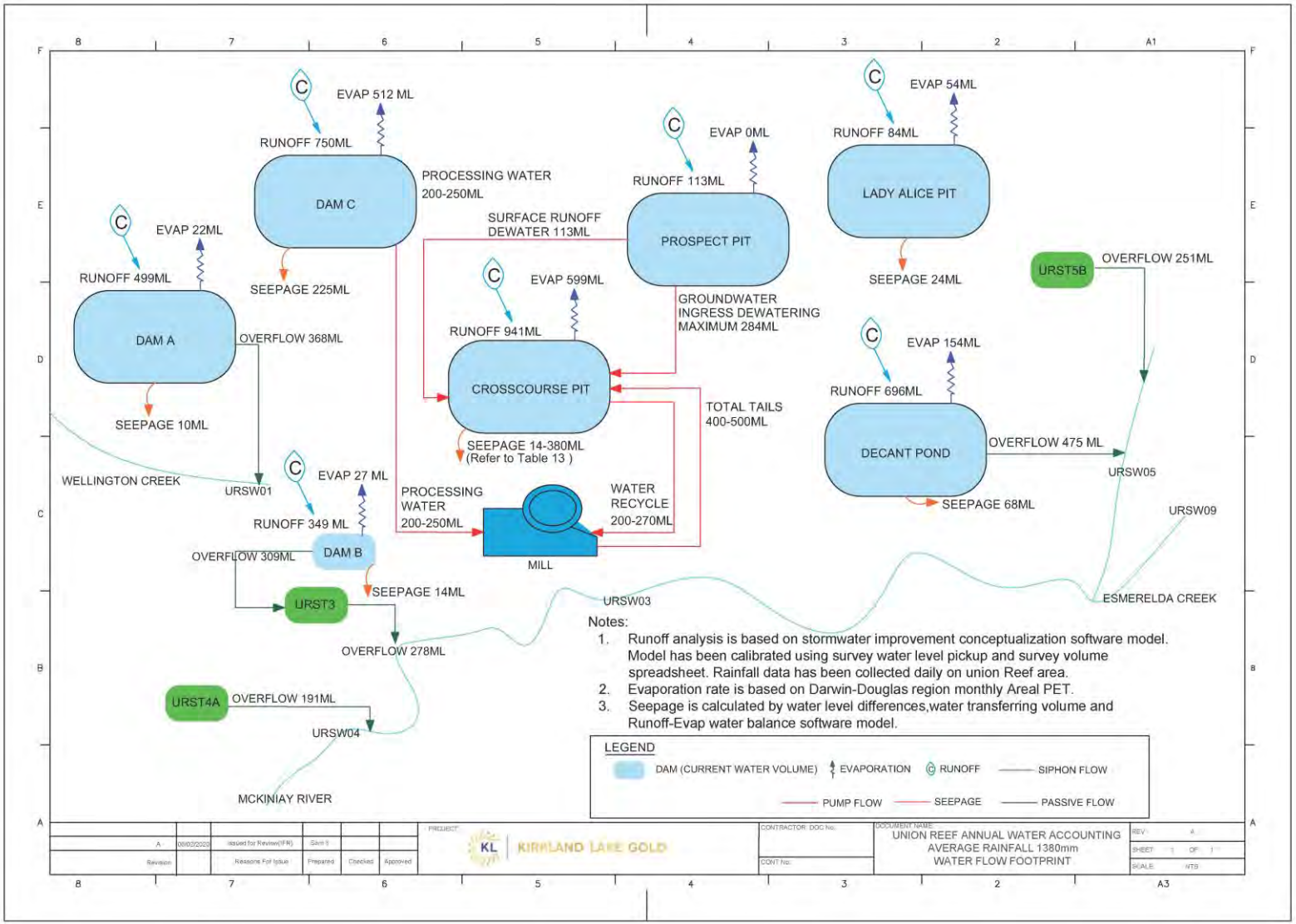


FIGURE 8-1 UR AVERAGE RAINFALL WATER FLOW FOOTPRINT

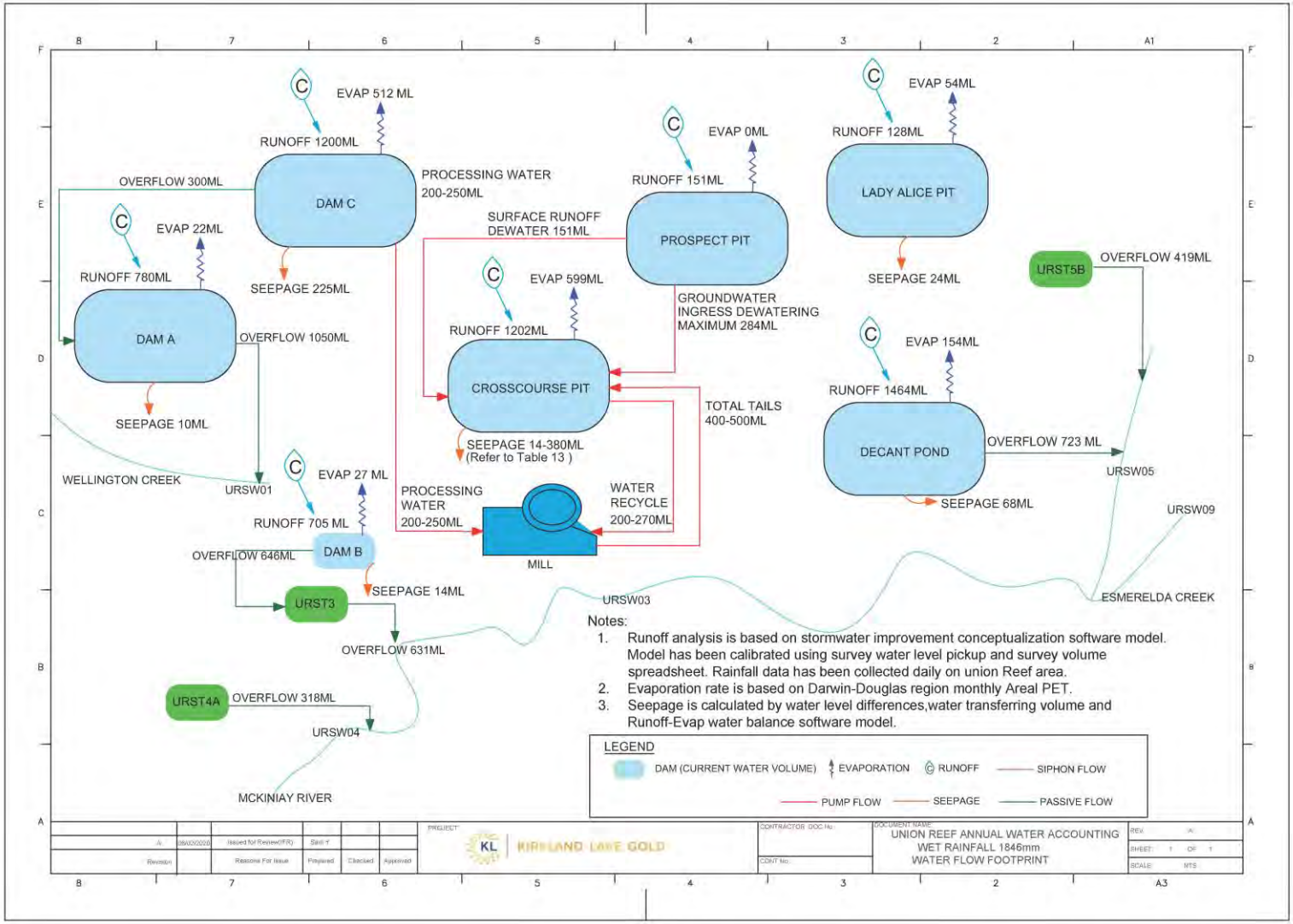


FIGURE 8-2 UR WET RAINFALL WATER FLOW FOOTPRINT

9 Active Crosscourse Pit Dewatering Concept Plan

Treated Crosscourse Pit water is proposed to be discharged to the McKinlay River under an active discharge WDL. The tailings water will be treated into Dam B with a controlled release algorithm to McKinlay River.

The proposed treatment method is a two-stage in-pipe dose, using a Caustic 50 treatment first to raise the pH to 9.0. This targets the heavy metals which precipitate out as insoluble hydroxides. Caustic dosing is then followed further down the pipe with a Ferric Chloride dose to remove the Arsenic and reduce the pH to the desired 8.0. The dose quantities are kept to the minimum required to meet the target water quality, with an anticipated dose rate of approximately 0.05 g/l of C50 and 0.08 g/l of $FeCl_3$. Strict control is maintained throughout the dosing process to ensure the supernatant is not contaminated with the dose chemicals. Tests of the treated water to date have shown this method adequately ameliorates the water quality to meet target levels.

The proposed dosing system automatically controls the dosing process and continually monitors and logs all key variables including raw water flow, pH, EC and the quantities and flows of reagents used. This data is archived and available to download to USB as a CSV file. All key process factors are monitored and if outside desired parameters the process is stopped and an alarm raised. The system is regularly monitored by site personnel.

The treated water is discharged into a specially designed settling pond which allows all precipitate to drop out prior to the supernatant flowing into a holding dam. This water is then stored and available for controlled release to the environment when dilution conditions are met.



FIGURE 9-1 ACTIVE DISCHARGE MANAGEMENT SITE LAYOUT

9.1 Installation of New Monitoring Stations at McKinlay River

Three new telemetered monitoring stations have been installed at the following water quality monitoring points:

- URSW11
- URSW04
- URSW08

The monitoring stations are proposed to have a lifespan in excess of 10 years, and to maximize data quality and consistency.

All sites are required to log the following parameters:

- Water level
- Water temperature
- pH
- Electrical Conductivity
- Dissolved Oxygen
- Turbidity
- Rainfall (URSW04 Only)

Water level measurement for the sites is proposed via automatic bubbler, as is currently recorded at the existing KL Gold monitoring stations at Cosmo Deeps. Recording water level measurements on a separate sensor from water quality permits year-round collection of level data, and facilitates identification of stream conditions during shoulder seasons for water quality sonde deployment, amongst other benefits.

Automatic bubbler systems are the preferred technology due to their reliability, accuracy and physical separation of contact with the water body.

A full gauge market post range is also to be installed at each site to permit visual correlation of water level with logged data via onsite visits.

A tipping bucket rain gauge is installed at the URSW04 site to provide rainfall data on volume, intensities and temporal distribution. Water quality measurement at the sites is provided via an InSitu Aquatroll 500 multiparameter water quality sonde. These sondes:

- Can be interfaced just as easily with the main station datalogger and telemetry;
- Have a physical size that will permit deployment into the sensor mounting infrastructure of all sites;
- Can measure Temperature, EC, pH, DO and Turbidity all within the one sonde;
- Have a wiping mechanism to keep the sensors clear of fouling during long term deployments (thereby improving data quality);
- Are already in use by KL Gold (600 series sondes) for other discrete monitoring activities allowing some standardization of technology for the Environmental Team; and
- Have user exchangeable sensors, so the sensors on the current 600 sondes could effectively act as emergency backups.

9.2 River Dilution Factor and Discharge Algorithm

A real time flow rating for URSW04 and URSW08 will be collected between January 2020 and April 2020. Flow cannot be measured automatically and must be obtained through a height to flow relationship.

A number of gauging will be conducted at each site at different heights throughout the wet season to formulate the rating table. Once developed, flow volumes in the creek can be determined from water level measurements. A theoretical table will be generated from onsite surveying during the pre-wet, which will provide an approximation of flow volumes until empirical measurements can occur.

Empirical flow measurements will be recorded at the two locations is proposed via a combination of temporary insitu acoustic droppler velocimeters, coupled with physical gauging at opportunistic times. Collection of flow data is rainfall dependent, and rapid mobilization to site will be required in order to capture flow events.

It is anticipated that several site visits will be necessary over the duration of the wet season to adequately formulate the rating tables for the two locations. Once the rating tables have been generated, a dilution factor will be applied according to the relationship between Electrical Conductivity and Total Dissolved Solids.

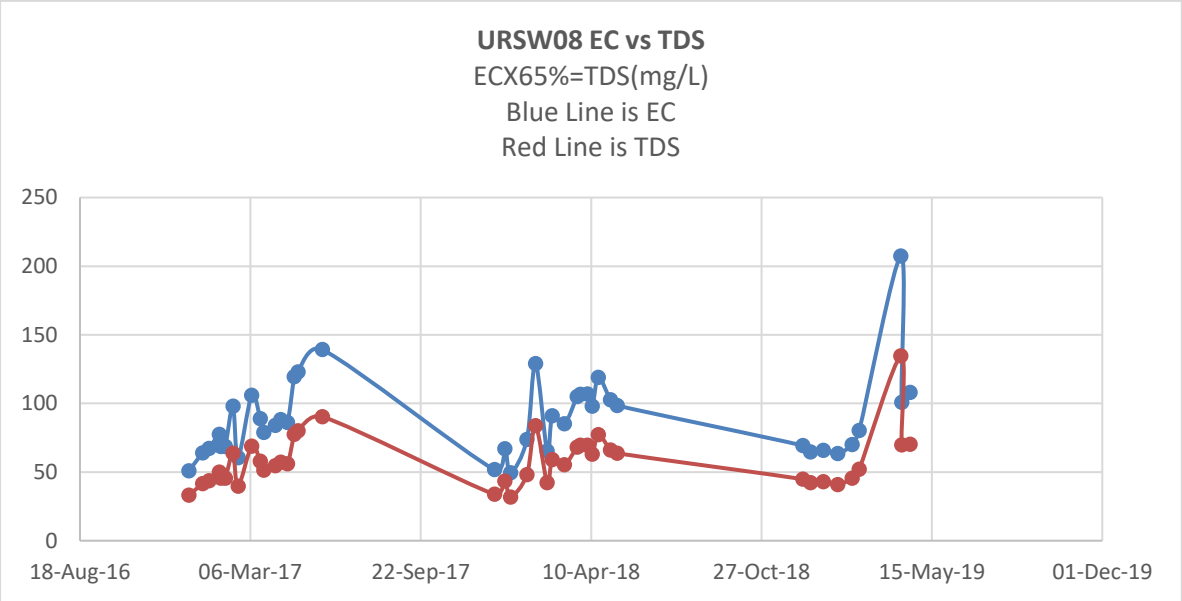


FIGURE 9-2 URSW08 EC VS TDS RELATIONSHIP

The above plot shows a consistent relationship between EC and TDS at URSW08. This indicates that an EC dilution algorithm is valid for the discharge measurement as discussed above.

Two Crosscourse Pit treatment trials have been conducted. Sample B CCFT 190917B is showing promising results using both caustic and ferrous chloride. Crosscourse tailing water treatment trial results (Trial A and B) are provided in Table 9-1 below.

TABLE 9-1 CROSSCOURSE TAILING WATER TREATMENT TRIAL RESULTS (TRAIL A AND B)

Date	FLS EC (uS/cm)	FLS pH	Aluminium-Dissolved (µg/L)	Arsenic-Dissolved (µg/L)	Cadmium-Dissolved (µg/L)	Chromium-Dissolved (µg/L)	Cobalt-Dissolved (µg/L)	Copper-Dissolved (µg/L)	Free Cyanide (mg/L)	Iron-Dissolved (µg/L)	Lead-Dissolved (µg/L)	Manganese-Dissolved (µg/L)	Nickel-Dissolved (µg/L)	Sulphate (mg/L)	WAD Cyanide (mg/L)	Zinc-Dissolved (µg/L)
Median Mill Processing 2015-2017 (URCP)	2756	7.86	100	860	0.2	<1	310	15	0.014	21	<1	21	7	1,100	0.024	15
2017-2019 Median No Processing URCP	2,527	7.64	20	910	0.5	<1	160	2	0.004	<10	<1	39	5	1,200	0.007	52
URCP ST1 (Caustic)	2,692	8.2	80	600	<0.1	<1	110	1		<10	<1	12	2	1,200		4
URCP Trail Sample A CCFT 190917A	2,829	6.62	20	8	0.2	<1	120	3		61	<1	190	7	1,300		53
URCP Trail Sample B CCFT 190917B	2,730	6.96	<10	14	0.2	<1	110	<1		24	<1	140	5	1,300		5
URSW04	250.4	6.61	<10	3	<0.1	<1	<1	<1	<0.004	55	<1	97	<1	70	<0.004	5
URSW08	100.8	7.27	<10	2	<0.1	<1	<1	<1	<0.004	180	<1	14	<1	16	<0.004	<1
SSTV URSW08	250	8			0.2					340	3.4	1,900	11			31
Aquatic 95% protection)	250-	8-	-	-	0.2-	-	-	-	0.007-	-	3.4-	1,900-	11-	-	-	8-

A desktop study of URSW08 catchment runoff has been conducted and a concept discharge table is listed below (Table 9-2). This describes the conditions and resulting dilution ratios required to meet Crosscourse Pit water discharge targets and remain within the proposed URSW08 compliance EC trigger values. The results will be calibrated according to the real time rating table which will be available around September 2020.

TABLE 9-2 CROSSCOURSE DEWATERING ALGORITHM

	EC	Discharge Dilution Ratio Discharge VS Creek Flow	Average Rainfall Estimated Discharge Volume (ML)	Dewatering Requirement for Crosscourse Maintain Maximum Life Span (2030)
Treated Crosscourse EC	2730	-	-	
URSW08 Dilution Background EC	100	-	-	
Proposed Compliance EC at URSW08	250	1:10	1200	3021
Proposed Compliance EC URSW08	700	1:3	4000	3021
Proposed Compliance EC URSW08	1000	1:1.8	6667	3021

9.3 Emergency Spillway of Dam B

The existing spillway is used to prevent the critical operational issues and ensure unrestricted flow does not damage the Dam wall structure, the spillway profile is shown in Figure 9-3 and the overflow pathway is shown in the model in Figure 9-4.

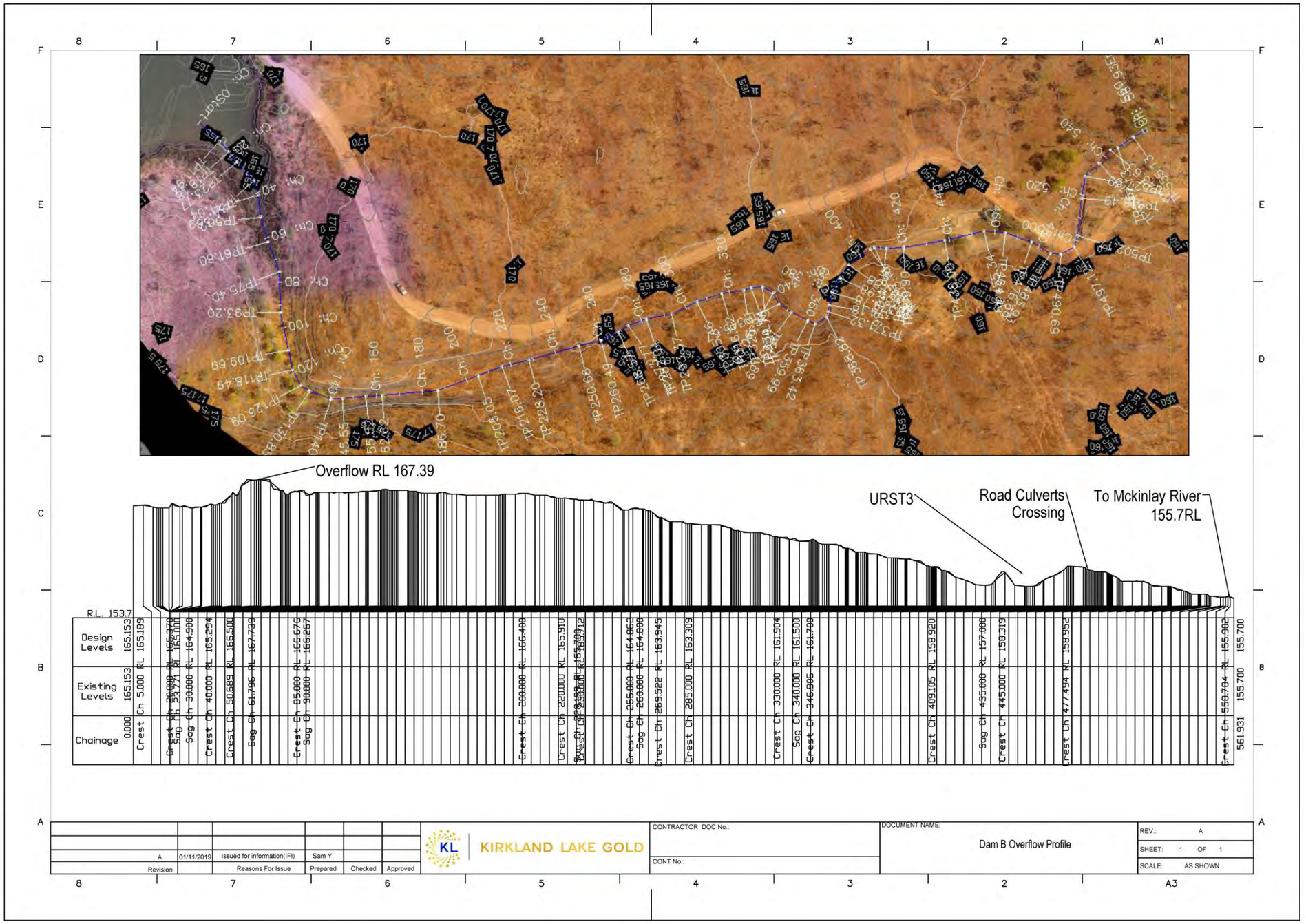


FIGURE 9-3 DAM B OVERFLOW PROFILE

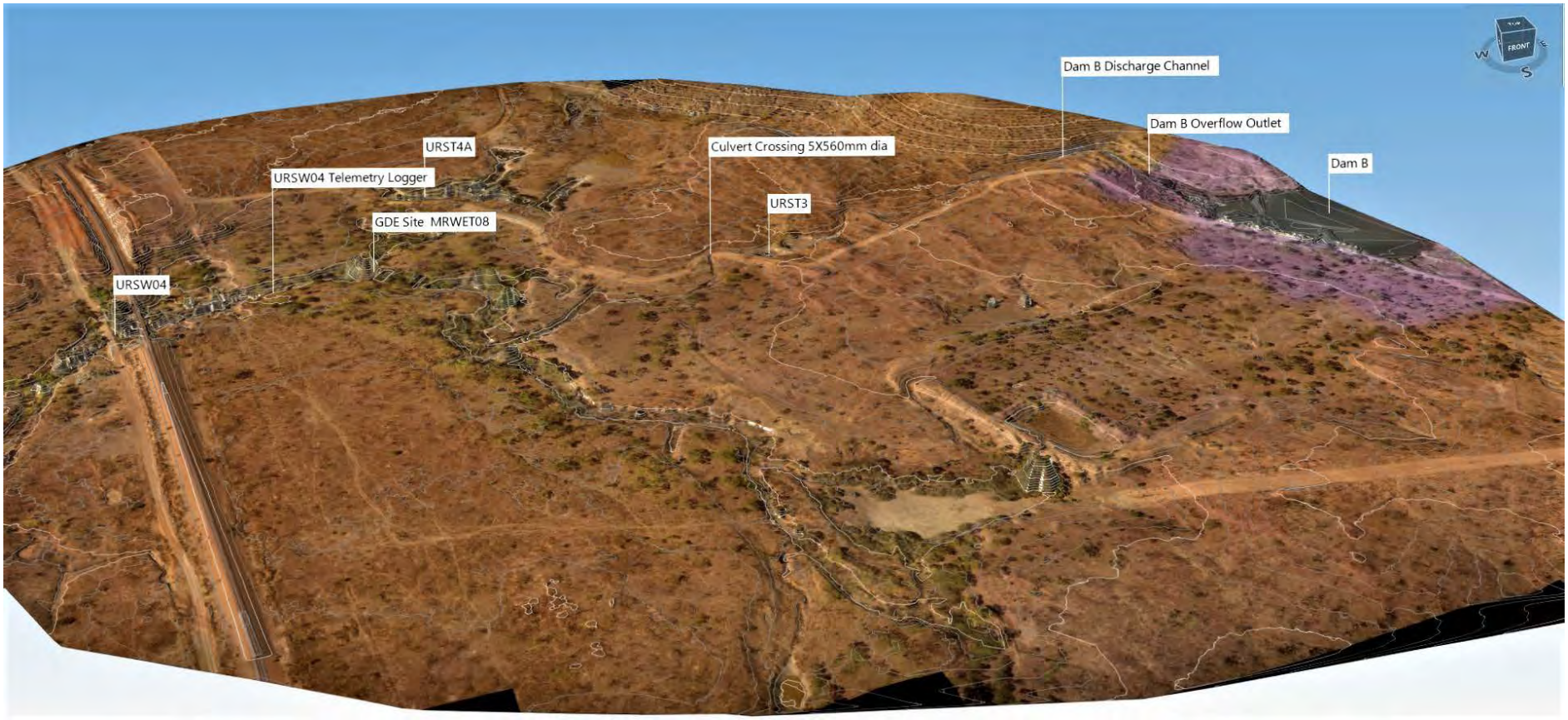


FIGURE 9-4 DAM B OVERFLOW PATHWAY DTM MODELLING

10 Potential Risks and Impacts

Risk assessment provides a framework for identifying components of the project with the potential for greater environmental risk, and highlights areas of focus for water management, in order to minimise the likelihood and consequence of these identified potential impacts. This risk assessment is based on the Union Reefs North Underground Mine Draft Environmental Impact Statement (2019).

TABLE 10-1 PROJECT ACTIVITIES, RISKS AND POTENTIAL IMPACTS ON SURROUNDING ENVIRONMENT AND SENSITIVE RECEPTORS

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Mine Dewatering	Development/ construction	Drawdown may result in reduction in groundwater available for other users.	• Drawdown propagates southwards and impacts groundwater availability for the Pine Creek township (PWC bores). • Drawdown propagates and impacts groundwater availability for adjacent stations (closest stock and domestic bores) and other miners (Territory Iron rail siding bore).	Low
Mine Dewatering	Development/ construction	Drawdown may result in reduction in groundwater available for other users.	• Drawdown in the aquifer delivers less water available for discharging to the McKinlay River (and baseflows in the Mary River catchment area) and impacts refuge water quality and longevity (and therefore available habitat, space and substrate). • Drawdown impacts groundwater availability for terrestrial fauna and flora (GDEs).	Medium
Mine Dewatering	All mining phases	Failure of pumps to redirect accumulating water in Prospect pit resulting in infiltration to groundwater.	• If the water is of poor quality this may have potential to impact receptors down-gradient.	Low

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Waste Rock Storage	All mining phases	Contaminated seepage/runoff from oxidation of sulphidic rocks in the walls of Prospect pit exposed to the atmosphere following dewatering and/or, change in groundwater quality as a result of dissolution of oxidation products after groundwater rebound following closure.	• Acidic leachate may open up new oxygen pathways in pit walls and add to the load of contaminants in pit water pumped to Crosscourse pit. This can potentially adversely affect water quality in Crosscourse pit during operation and, with potential impact on surrounding groundwater and surface water bodies connected to Crosscourse. • Decline in pit water quality post closure could adversely impact down gradient aquatic ecosystems.	Low
Waste Rock Storage	All mining phases	Contaminated seepage during surface storage of underground mine waste rock (241,000 t temporarily stockpiled).	• Acidic pH, salinity and/or metals/metalloids affecting groundwater and/or surface water flowing into the mine or into surface water within Prospect pit. • May also affect capacity to discharge water from Crosscourse pit if seepage from waste material contributes significantly to a decline in water quality as a result of capture and pumping to Crosscourse.	Low
Waste Rock storage	All mining phases	Contaminated seepage from permanent surface storage (i.e. in-pit storage in Prospect pit) of underground mine waste rock (50,000 t) and waste rock sourced from the Prospect North pit used in the portal development.	• Acidic pH, salinity and/or metals/metalloids causing ongoing damage to ecosystems, groundwater and/or surface water during operations and post closure.	Low

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Crosscourse Pit water management	All mining phases	Crosscourse pit is left unmanaged (no management of water level) and allowed to fill to high pit lake conditions.	• Crosscourse Pit becomes a source - outward seepage leaving Crosscourse Pit and contaminating groundwater and downstream aquatic ecosystems in the McKinlay River. i.e. Acidic pH, salinity and/or metals causing ongoing damage to ecosystems, shallow groundwater and surface water	Medium
Crosscourse Pit water management	All mining phases	Contaminated seepage from Crosscourse pit migrating to the underground development during operations.	• This could result in the accumulation of water with elevated levels of dissolves species such as Zn and As. In the Crosscourse pit.	Low
Crosscourse Pit water management	All mining phases	Contaminated seepage from underground development and backfilled waste rock and/or pit walls at closure infiltrating groundwater.	• Acidic pH, salinity and/or metals causing ongoing damage to ecosystems, groundwater and/or surface water at closure.	Medium
Use of ROM pad	All mining phases	AMD from ROM pad leading to contaminated seepage run-off.	• Damage to associated surface water and aquatic ecosystems in the McKinlay River.	Low
Waste material management	Operation / Construction	Poor management of waste materials during operations leads to closure plans being unachievable or costly.	• Delays to effective rehabilitation including seepage resulting in contaminated ecosystems and groundwater effects. • Delays associated with cost overruns could be a period of years. • Impacts to receiving environment associated with these delays.	Low

Project Activity	Mining Phase	Potential Impact	Potential Consequence	Residual Risk Rating
Mine Closure	Closure	Closure designs not developed in detail to enable appropriate closure execution, including ineffective implementation of design, poor rehabilitation execution or design failure, resulting in significantly higher closure cost above closure provisioning.	• Insufficient closure cost provision resulting in inability to execute closure plan. • Delays or inability to achieve effective rehabilitation by project proponent. • Delays in achieving rehabilitation criterion and could be a period of years, with un-remediated project site potentially acting as source of ongoing environmental hazard.	Low
Unexpected Early Mine Closure	Operation / Construction	Unexpected early closure of the project, due to delays or falling commodity prices or another unexpected issue.	• Delays to effective rehabilitation by project proponent, including through erosion or seepage resulting in contaminated ecosystems and groundwater and / or surface water effects. • Potentially exacerbated by closure designs not yet developed in detail at time of early closure.	Low
Mine Closure	Closure	Unable to reach agreement with stakeholders on closure objectives.	• Mine closure objectives unable to be implemented, delays to effective rehabilitation.	Low

11 Water Management and Monitoring

Information provided in the table below represent each potential impact to the environment and sensitive receptors identified in Table 10-1 of this WMP. This section will describe the NTMO commitments, pertaining to each of these risks, for the following:

- Objectives and targets
- Management strategies
- Performance indicators, listing triggers where relevant.
- Roles and responsibilities

Further detail on management strategies, monitoring, reporting and corrective actions are provided as appendices to this WMP. These appendices are as follows:

- Appendix B – Aquatic Ecology Management Plan – Union Reefs North Underground Mine Aquatic Ecosystem Monitoring Program Framework (Aquatic Ecology Services, 2020)
- Appendix C – Water Abstraction Management Plan – Water Abstraction Management Plan (GHD, 2020)
- Appendix D – Water Quality Management Plan – Water Quality Management Plan (GHD, 2020)

The timing of each aspect of this WMP is provided in full detail in the water management schedule, in Section 12 of this WMP.

TABLE 11-1 OBJECTIVES, MANAGEMENT ACTIONS, ROLES AND RESPONSIBILITIES

Activity	Objectives	Management Action/strategy	Roles & Responsibilities
Mine dewatering	Manage level of drawdown to avoid and control impacts of reduced groundwater availability for other users	• A monitoring program will be conducted (Section 4 Appendix C – Water Abstraction Management Plan), which will include: o Cumulative volumes removed and daily groundwater inflows o Standing surface and ground water levels (trigger and response set) o Hourly rainfall o Flow rates of all water pumped on site (trigger and response set) o Mitigation strategies for the event trigger levels are met are also described in Appendix C – Water Abstraction Management Plan	tbc
	Ongoing mine dewatering must not allow water to accumulate in Prospect Pit	• Ensure that spare pumps and generator are available for emergency backup of pumping. • Pump capacity for 1000 year ARI back up pumps will be available on site	tbc
Waste Rock Storage	Avoid and control impacts on groundwater and/or surface water from contaminated seepage during storage of waste rock.	• Static testing ahead of mining to develop waste rock segregation criteria and management options. • A groundwater monitoring program will be conducted (Section 4 Appendix D) • Mitigation strategies for the event trigger levels are met are also provided in Appendix D. • Use geochemical data as an input into model to help predict likely water quality during and post operations.	tbc

Activity	Objectives	Management Action/strategy	Roles & Responsibilities
		• Implement AMD management plan including segregation of high As/PAF wastes during surface storage, and ensure this material is used during backfill for closure and only NAF low As material left at surface. • Waste storage to minimise oxidation and reduce acid leachate. • Seepage will be captured and pumped constantly into in Crosscourse pit- captured seeps pumped into Prospect North pit (short term) and then pumped to Crosscourse pit. • Introduction of WDL	
Crosscourse Pit water management	For Crosscourse pit level not to exceed high pit lake conditions, and to avoid and control impacts on groundwater and/or surface water from contaminated seepage	• Maintain the water level in the Crosscourse pit such that it remains a sink, i.e. manage the volume of water coming into and out of the pit via water recycle to process plant and via treatment and discharge under licence in the wet season to reduce the water level. This will maintain the balance and minimise the risk of seepage. • Groundwater quality monitoring as described in Appendix C – Water Abstraction Management Plan.	tbc
Use of ROM pad	Avoid and control the potential impacts associated with AMD from the ROM pad	• ROM pad has been re-contoured and drains to Crosscourse pit rather than to Dam B. • Bund ROM pad, capture run-off and pump to Crosscourse pit	tbc
Waste Material Management	To effectively plan for and manage waste material in a way that assists closure environment and timing objectives.	• Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. • Regular monitoring of seepage of mine affected water to the groundwater and associated pit lake levels as per Appendix C – Water Abstraction Management Plan. • Performance monitoring of progressive rehabilitation and correction of designs/execution if required. • Working in conjunction with centre for mine rehabilitation at UQ to understand latest technology and rehabilitation methods	tbc

12 WATER MANAGEMENT SCHEDULE

Table 12-1 below shows an indicative schedule for all water management strategies detailed in this WMP, including monitoring duration and frequency. These are shown in relation to relevant major mining activities.

TABLE 12-1 WATER MANAGEMENT SCHEDULE

Activity	Start	End	Duration (days)	Frequency	Comments
Development/ Construction Phase					
Installation of flow gauge on upper McKinlay River	1/03/2020	5/03/2020	ongoing	Once	Gauging work already commenced.
Installation of additional groundwater monitoring bores	03/03/2020	10/04/2020	48	Once	
Surface water quality data collection	1/04/2020	1/12/2020	1	Monthly	
Sediment quality data collection	1/04/2020	1/06/2020	1	Once	
Active fish survey	1/04/2020	30/04/2020	3	Once	
Groundwater quality data collection	1/04/2020	1/09/2020	2	Quarterly	Assumes installation of bores in March/April
Post-wet season macroinvertebrate monitoring	1/04/2020	1/06/2020	5	Once	
Groundwater level data collection	14/04/2020	1/09/2020	1	Daily	Assumes installation of bores in March, data collected monthly, recorded daily.
Post-wet season fauna monitoring	15/04/2020	15/07/2020	90	Once	
Establishment of regionally relevant GDE reference location	1/05/2020	3/05/2020	3	Once	Assumes end of wet season by April.
Riparian vegetation survey	1/06/2020	1/07/2020	5	Once	
Passive fish survey	1/08/2020	1/09/2020	2	Once	
Baseline aquatic ecology reporting	1/09/2020	31/12/2020	10	Once	
Baseline water and sediment quality reporting	1/09/2020	31/12/2020	5	Once	

Activity	Start	End	Duration (days)	Frequency	Comments
Dry season macroinvertebrate monitoring	1/10/2019	15/08/2020	60	Annually	
Development of site specific values for groundwater drawdown	TBC				
All Mining Phases					
Wet season surface water quality sampling	1/12/2020	1/04/2027	1	Fortnightly /monthly	Only during wet season months (normally December-April)
Post-wet season sediment sampling	1/03/2021	1/06/2027	1	Annually	Includes total period of groundwater availability loss.
Dry season surface water quality sampling	1/04/2021	1/12/2027	1	Monthly	
Surface water quality reporting	30/09/2020	31/12/2027		Various	Commencement of mining, 3, 6, 12 & 24 months into mining, 1 and 5 years post mining.
Pit water quality and volume monitoring	30/09/2020	31/12/2027			Refer to Water Quality management Plan (Appendix D – Water Quality Management Plan) and Water Abstraction Management Plan (Appendix C – Water Abstraction Management Plan)
Treatment studies	TBC				
Rebounded mine water quality at outflow or in prospect pit at closure					Refer to Water Quality Management Plan (Appendix D – Water Quality Management Plan)
Post-wet season macroinvertebrate monitoring	1/04/2021	1/06/2027	5	Annual	

Activity	Start	End	Duration (days)	Frequency	Comments
Active fish survey	1/04/2021	1/06/2027	2	Annual	
Post-wet season fauna monitoring	1/05/2021	1/09/2027	90	Annual	
Riparian vegetation monitoring	1/06/2023	1/06/2027	3	Triennial	
Dry season macroinvertebrate monitoring	1/07/2021	1/09/2027	30	Annual	
Passive fish survey	1/08/2021	1/09/2027	2	Annual	
Biological and sediment reporting	1/09/2021	31/12/2027	10	Annual	
Groundwater quality monitoring					Refer to Water Quality Management Plan (Appendix D – Water Quality Management Plan)
Groundwater Quality Reporting					Refer to Water Quality Management Plan (Appendix D – Water Quality Management Plan)
Groundwater level monitoring					Refer to Water Abstraction Management Plan (Appendix C – Water Abstraction Management Plan)
Groundwater level reporting					Refer to Water Abstraction management Plan (Appendix C – Water Abstraction Management Plan)

13 APPENDICES

APPENDIX A – FLOODING RISK ANALYSIS AND PREPAREDNESS

There are on average 7.7 days per season when a cyclone exists in the northern region of Australia. The north western Gulf of Carpentaria near Gove has the highest concentration of cyclone days. The Gulf of Carpentaria averages two cyclones a year, while the Arafura and Timor Seas average one a year (BoM, 2016). Cyclones in the Gulf of Carpentaria move very erratically, whereas those in the Arafura and Timor Seas tend to follow more regular tracks to the southwest. Over half the cyclones generated in the Northern region, move either southwest or southeast into adjoining regions. Tropical cyclones can contribute up to 40% of seasonal rainfall in Australia, and are a heavy contributor to flood events (Dare et al, 2011). The likelihood of a cyclone passing over the Union Reefs site is low due to its southerly location, but associated winds and rainfall may affect the site. Cyclones occur most frequently in the wet season months, particularly from January to March. The outlook for tropical cyclones affecting NTMO operations is regularly reviewed throughout wet season in accordance with safety management practices.

Figure A-1 displays cyclone frequency and severity in the Northern Region of Australia. Cyclones are categorised by number in chronological order of severity (BOM 2019).

CATEGORY 1 *(tropical cyclone)*

A Category 1 cyclone's strongest winds are GALES with typical gusts over open flat land of 90 - 125 km/h. These winds correspond to Beaufort 8 and 9 (Gales and strong gales).

CATEGORY 2 *(tropical cyclone)*

A Category 2 cyclone's strongest winds are DESTRUCTIVE winds with typical gusts over open flat land of 125 - 164 km/h. These winds correspond to Beaufort 10 and 11 (Storm and violent storm).

CATEGORY 3 *(severe tropical cyclone)*

A Category 3 cyclone's strongest winds are VERY DESTRUCTIVE winds with typical gusts over open flat land of 165 - 224 km/h. These winds correspond to the highest category on the Beaufort scale, Beaufort 12 (Hurricane).

CATEGORY 4 *(severe tropical cyclone)*

A Category 4 cyclone's strongest winds are VERY DESTRUCTIVE winds with typical gusts over open flat land of 225 - 279 km/h. These winds correspond to the highest category on the Beaufort scale, Beaufort 12 (Hurricane).

CATEGORY 5 *(severe tropical cyclone)*

Extremely dangerous with widespread destruction.

A Category 5 cyclone's strongest winds are VERY DESTRUCTIVE winds with typical gusts over open flat land of more than 280 km/h. These winds correspond to the highest category on the Beaufort scale, Beaufort 12 (Hurricane).

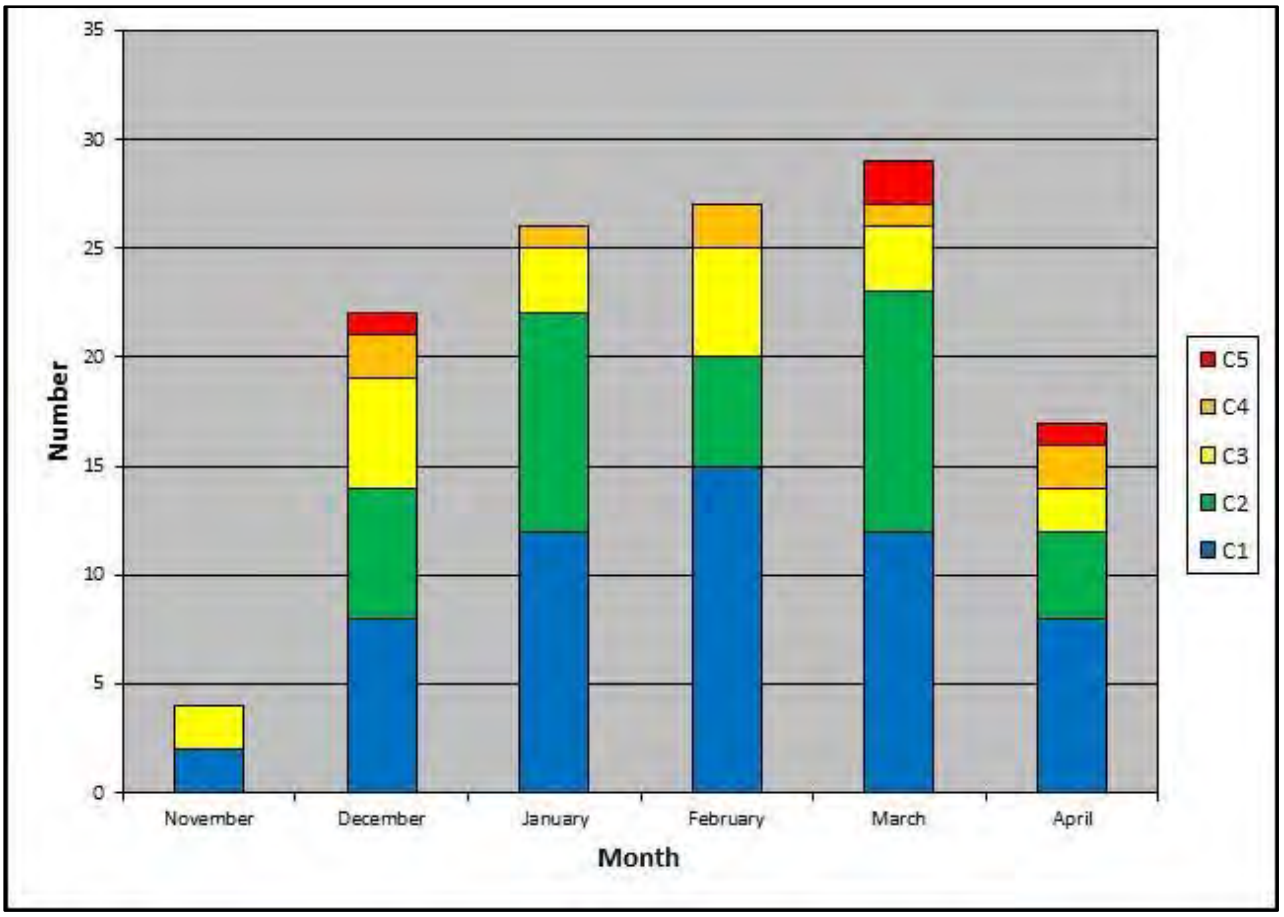


FIGURE A-1 TROPICAL CYCLONES IN THE NORTHERN REGION OF AUSTRALIA, 1964 TO 2015 SOURCE: (BOM)

An Intensity-Frequency-Duration (IFD) design rainfall was obtained from BoM and presented in Figure A-2. This data was utilised to create modelling of the potential amount of rainfall received in different rainfall scenarios. This in turn enabled extrapolation of the most accurate rainfall scenario for the Union Reefs area.

	Annual Exceedance Probability (1 in x)				
Duration	**1 in 100**	**1 in 200**	**1 in 500**	**1 in 1000**	**1 in 2000**
1 min	5.59	6.49	7.70	8.72	9.83
2 min	9.30	10.7	12.6	14.2	15.9
3 min	13.4	15.5	18.3	20.6	23.1
4 min	17.4	20.2	23.8	26.9	30.3
5 min	21.2	24.6	29.1	33.0	37.1
10 min	36.7	42.7	50.8	57.5	64.9
15 min	47.9	55.7	66.2	75.0	84.7
20 min	56.4	65.6	77.9	88.2	99.5
25 min	63.2	73.4	87.1	98.6	111
30 min	68.8	79.9	94.8	107	121
45 min	81.5	94.5	112	127	143
1 hour	90.7	105	124	141	158
1.5 hour	104	121	143	162	182
2 hour	115	133	158	178	200
3 hour	131	152	181	204	230
4.5 hour	151	176	209	236	267
6 hour	168	195	232	263	297
9 hour	196	228	272	308	349
12 hour	219	256	305	346	391
18 hour	258	301	358	406	458
24 hour	290	337	399	452	510
30 hour	317	365	434	491	553
36 hour	339	389	461	521	586
48 hour	375	427	503	565	631
72 hour	425	478	555	617	682
96 hour	455	509	585	645	708
120 hour	474	528	603	662	723
144 hour	486	539	614	672	731
168 hour	493	544	620	677	735

FIGURE A-2 2016 IFD TABLE

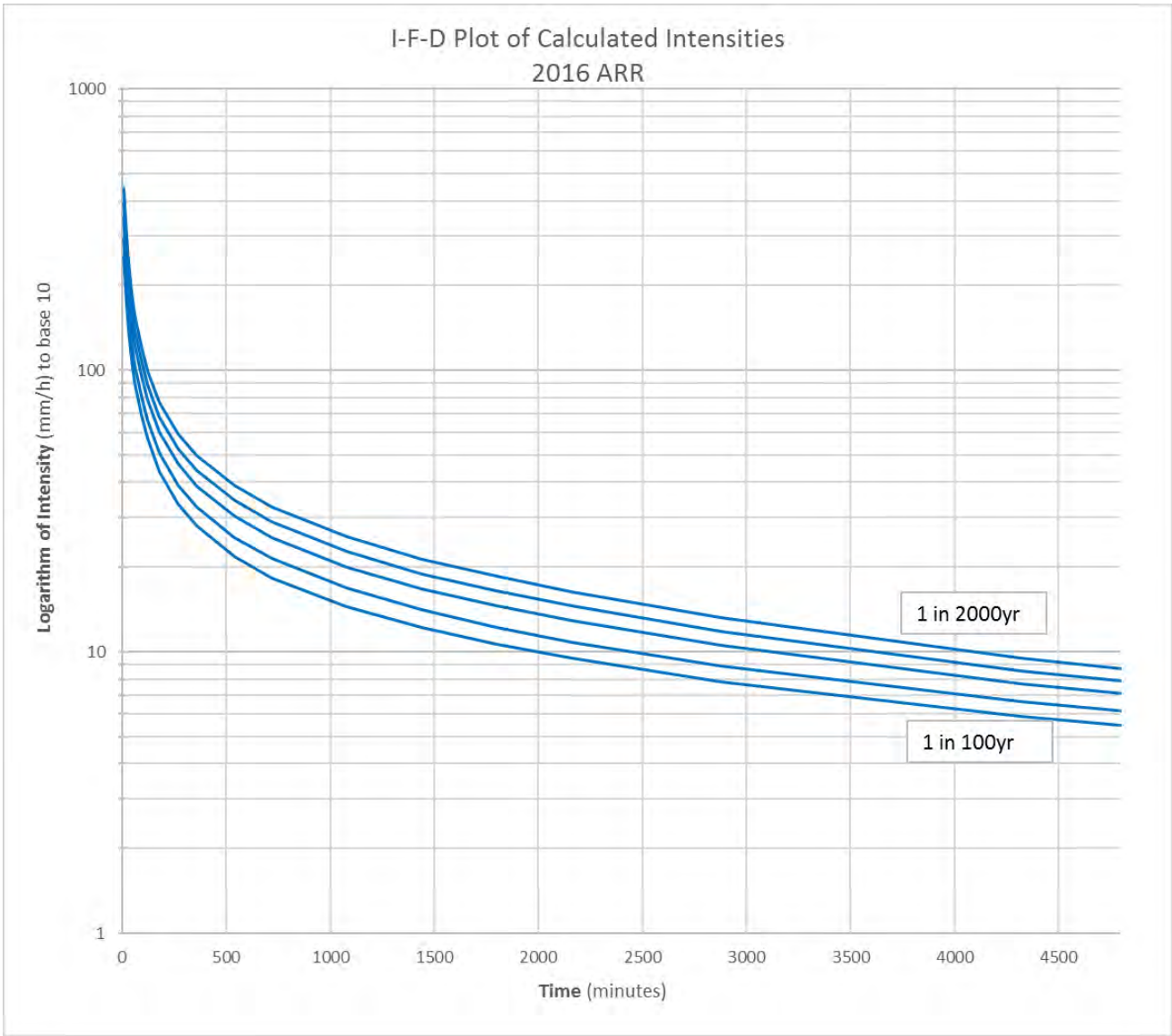


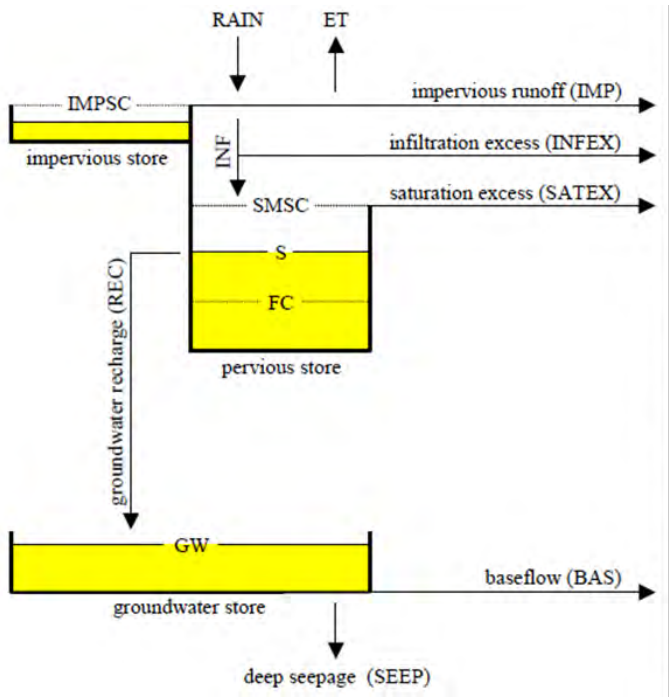
FIGURE A-3 PROSPECT PIT AREA ANNUAL EXCEEDANCE PROBABILITY (RARE TO EXTREME)

Figure 13 models the potential amount of rainfall received in different rainfall scenarios. A 1 in 100 year rainfall event is rare, while above 1 in 1000 year is extreme. NTMO based rainfall modelling on 72 hour 1 in 100, 1 in 500, and 1 in 1000 year scenarios. This figure demonstrates the negative relationship between rainfall intensity and length of rainfall event.

The algorithm adopted in this study is based on a SIMHYD rainfall-runoff model. The SIMHYD model allows for separate runoff generation processes on impervious and pervious portions of a catchment. All rainfall on the impervious area becomes runoff once a small storage capacity or initial loss is exceeded. The initial loss storage is emptied each day. Pervious part of the catchment is subject infiltration, and defined as an exponential function of the soil moisture storage.

- Infiltration rate is at a maximum when the soil moisture storage is empty and gradually decreases to a minimum when the storage is full.
- If the rainfall exceeds the infiltration rate, it becomes infiltration excess runoff.
- If the soil moisture store has reached its maximum, it becomes soil saturation excess runoff.

Evapotranspiration is subtracted from the soil moisture store. Soil Moisture recharges groundwater whenever the soil moisture store exceeds field capacity.



Model inputs

RAIN = daily rainfall (mm)
PET = areal potential evapotranspiration (mm)

Model parameters

IMPSC = impervious store capacity (mm)
SMSC = soil moisture store capacity (mm)
COEFF = maximum infiltration loss (mm)
SQ = infiltration loss exponent
FC = field capacity of soil moisture store (mm)
RFAC = soil moisture to groundwater recharge factor
BFAC = groundwater to baseflow factor
SFAC = groundwater to deep seepage factor

Model relationships

IMP = greater of {(RAIN - ***IMPSC***), 0}
INF = lesser of {***COEFF*** × exp (-***SQ*** × S / ***SMSC***), RAIN}
INFEX = RAIN - INF
SATEX = greater of {(S - SMSC), 0}
REC = greater of {(***RFAC*** × (S - ***FC***)), 0}
ET = lesser of {(10 × S / ***SMSC***), PET}
BAS = ***BFAC*** × GW
SEEP = ***SFAC*** × GW

FIGURE A-4 SIMHYD MODEL SCHEMATIC (EWATER GUIDELINE)

TABLE A-1 MONSOONAL NORTH RARE TEMPORARY PATTERN FOR FLOODING ANALYSIS

Time (Hrs)	1 in 100 year Rainfall Depth (mm) for Temporary Pattern	1 in 500 year Rainfall Depth (mm) for Temporary Pattern	1 in 1000 year Rainfall Depth (mm) for Temporary Pattern
3	9.99	13.04	14.48
6	1.02	1.33	1.48
9	0.00	0.00	0.00
12	11.77	15.37	17.06
15	1.57	2.05	2.28
18	0.00	0.00	0.00
21	16.83	21.98	24.39
24	20.95	27.36	30.37
27	15.56	20.31	22.55
30	7.52	9.82	10.90
33	15.68	20.48	22.73
36	10.37	13.54	15.03
39	9.82	12.82	14.23
42	54.49	71.15	78.97
45	38.59	50.39	55.93
48	69.53	90.80	100.78
51	18.23	23.81	26.43
54	10.50	13.71	15.22
57	4.12	5.38	5.98
60	9.18	11.99	13.31
63	43.22	56.44	62.65
66	12.96	16.93	18.79
69	17.60	22.98	25.50
72	25.50	33.30	36.96

Table A-1 describes the rainfall distribution anticipated for 1 in 100 year, 1 in 500 year and 1 in 1000 year rainfall events over a 72 hour period. Rainfall begins at a low intensity, peaks at the 48 hour mark and gradually eases off at the end of the event.

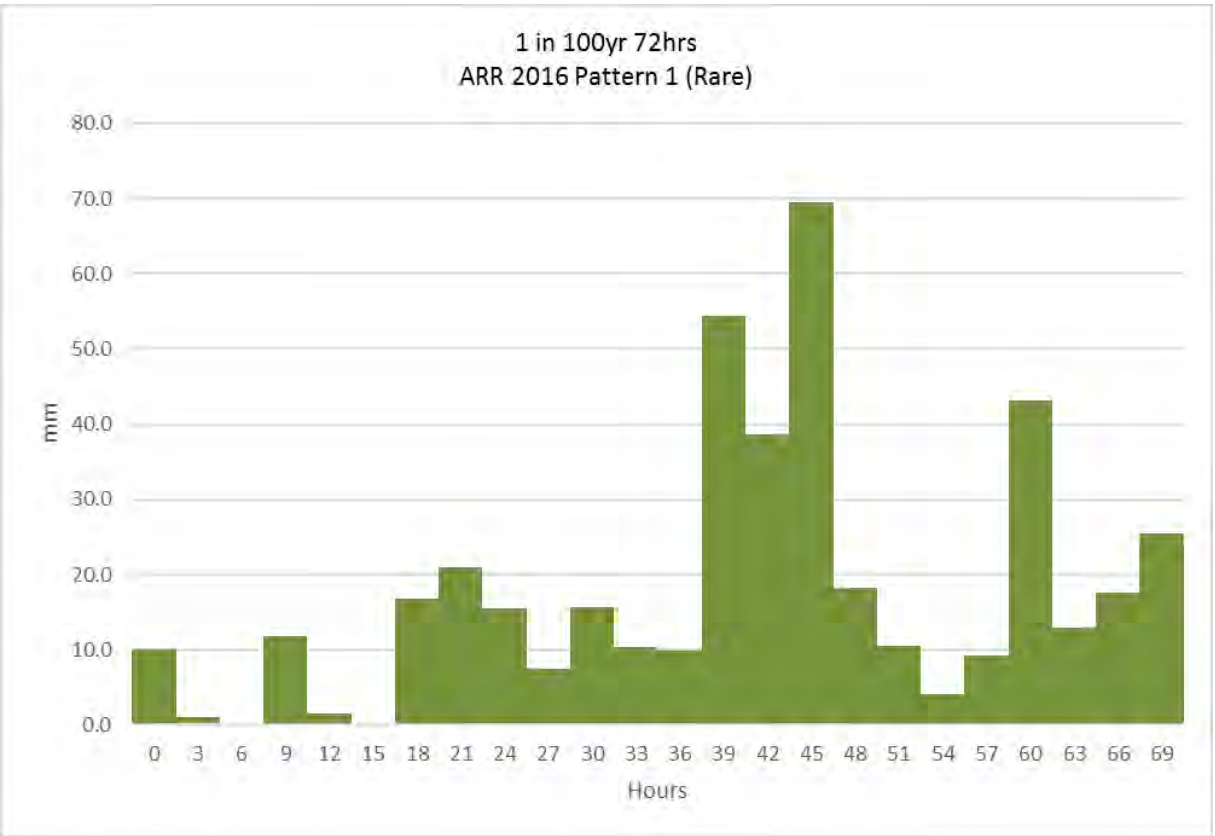


FIGURE A-5 1 IN 100 YEAR ARR 2016 PATTERN 1

Figure A-5 presents a rainfall modelling scenario similar to rainfall behaviour anticipated at Union Reefs. This is a 1 in 100 year rainfall event, beginning with low intensity rain for the first few hours and increasing to a peak intensity of 70 mm around the 45 hour mark.

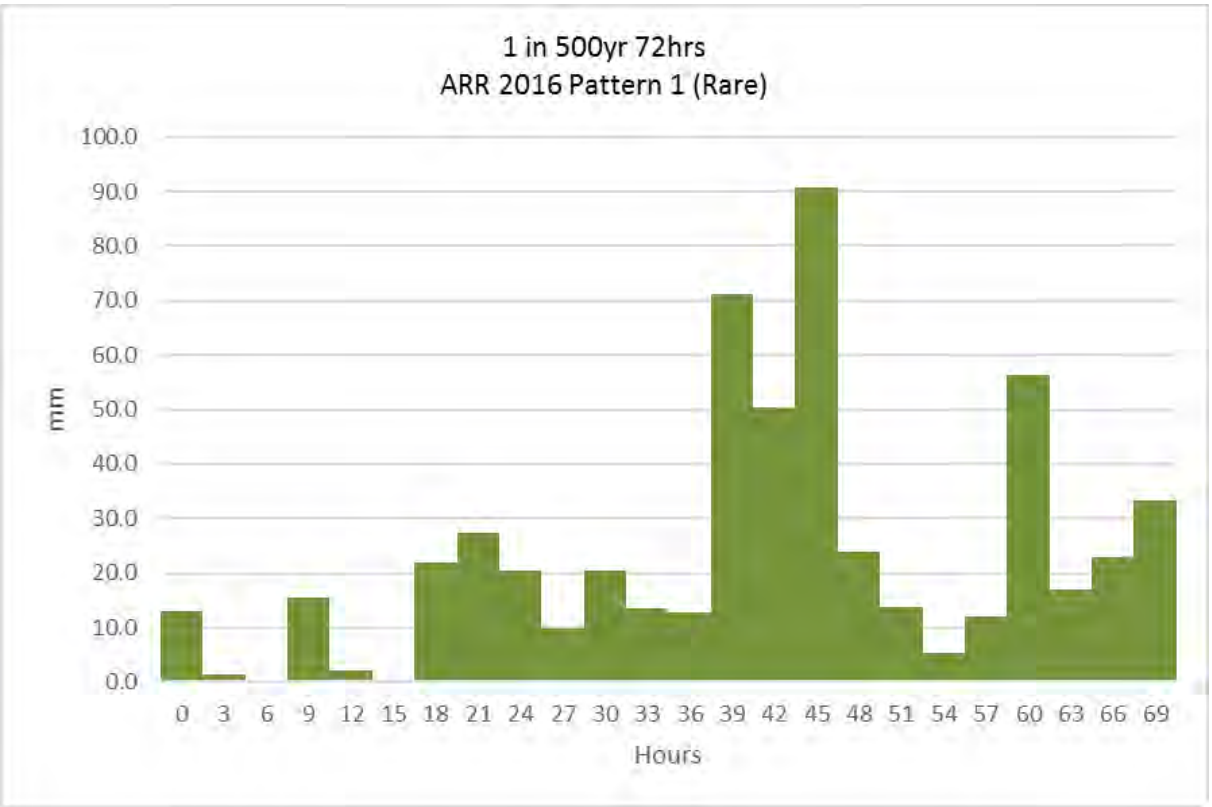


FIGURE A-6 1 IN 500 YEAR ARR2016 PATTERN 1

Figure A-6 presents a 1 in 500 year rainfall event over 75 hours. This follows the same rainfall pattern of Figure A-5 with an increased rainfall intensity peaking at 90 mm.

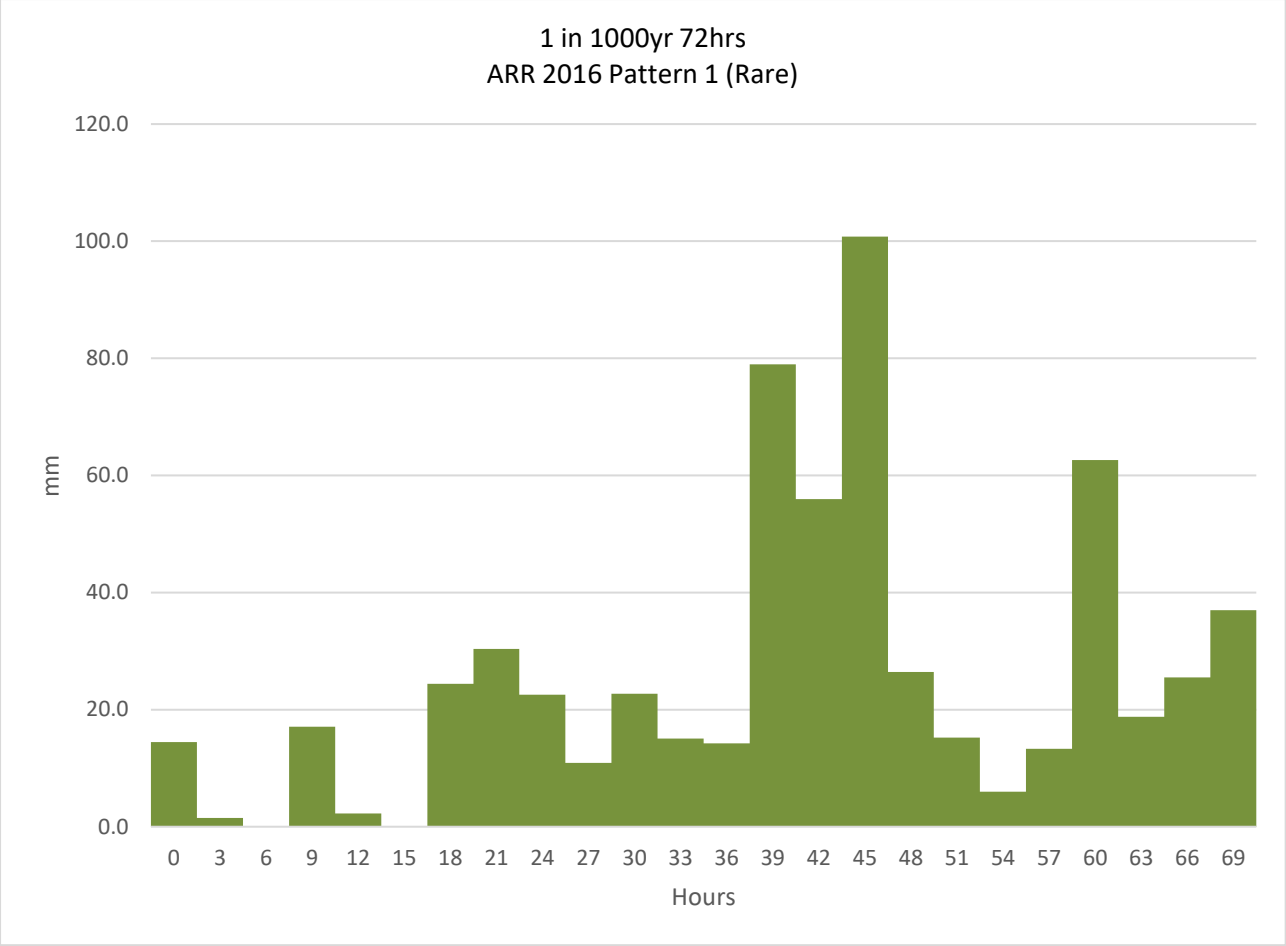


FIGURE A-7 1 IN 1000 YEAR 72 HRS ARR 2016 PATTERN 1

Figure A-7 demonstrates the rainfall patterns anticipated during a 1 in 1000 year rainfall event, similar in distribution to the previous two figures and peaking at approximately 100 mm of rain.

Pattern 1 was chosen as the representative mean pattern to run in the hydraulic model. Temporal pattern 1 is relatively slow rising with high peak storm which is similar to Union Reef site rainfall behaviour. Due to the long run time hydraulic model (approximately 72 hours) only the selected mean temporal pattern was run in the hydraulic model.

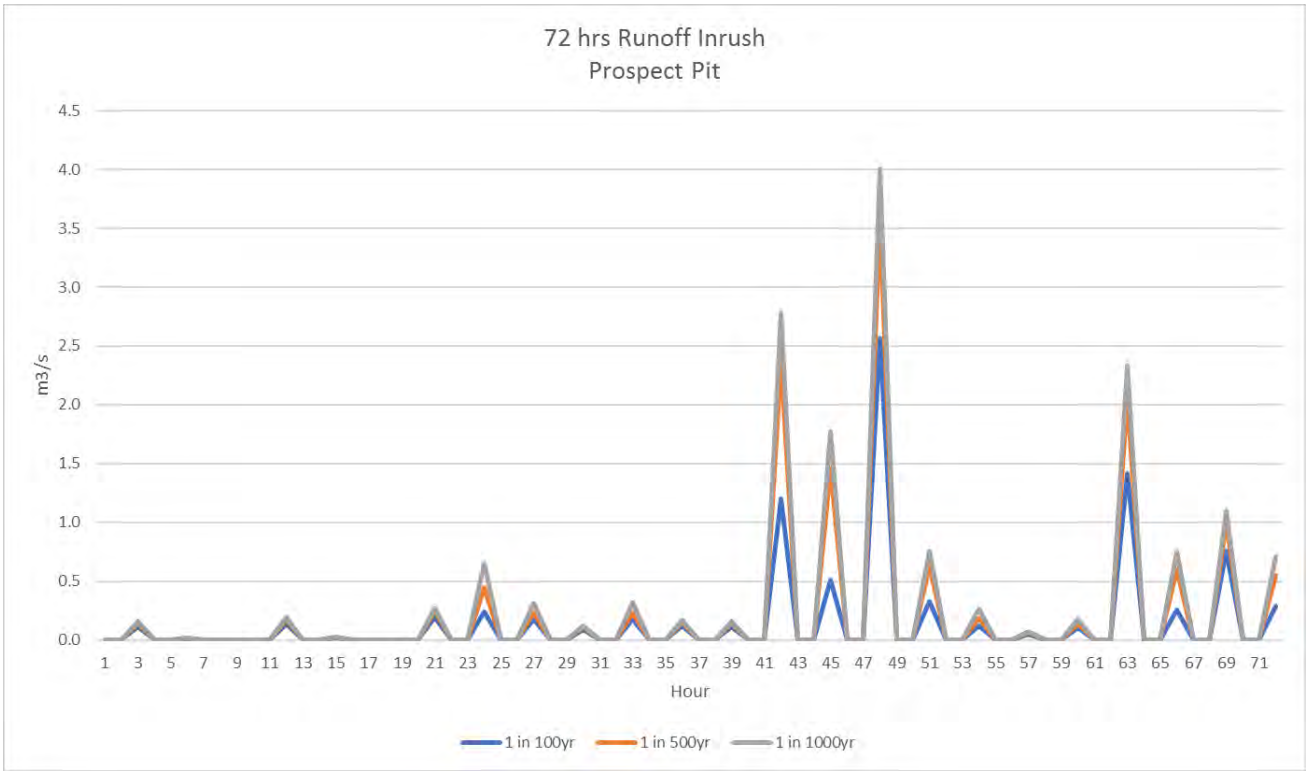


FIGURE A-8 72 HOURS RUNOFF INRUSH HYDROGRAPH OF PROSPECT PIT CATCHMENT

Figure A-8 is a representation of Prospect Pit catchment inrush under the three previous rainfall scenario figures. The distribution closely matches the pattern 1 model shown above.

APPENDIX B – AQUATIC ECOLOGY MANAGEMENT PLAN

Union Reefs North Underground Mine

Aquatic Ecosystem Monitoring Program Framework

Aquatic Ecology Services



Contents

1. Introduction *1*
1.1 Background 1
1.2 Aims and objectives 1
2. Survey sites and timing *1*
3. Survey Methods *4*
3.1 Water level monitoring 4
3.2 Habitat assessment 4
3.3 Water quality and sediment 5
3.4 Macroinvertebrates 5
3.4.1 Dry season sampling 5
3.4.2 Post-wet season sampling 5
3.4.3 Sample processing 6
3.5 Fish monitoring 6
3.6 Riparian vegetation 7
3.7 Aquatic fauna 7
4. Statistical analysis and reporting *8*
References *10*

Tables

Table 1 – GDE Pool sites to be monitored during the life of The Project. 2
Table 2 – McKinlay River sites to be monitored annually in the post-wet season 2

Figures

Figure 1 – Aquatic Ecology Monitoring Program survey locations. 3

1. Introduction

1.1 Background

The Union Reefs Northern Underground Mine (The Project) is currently in the supplementary phase of environmental approvals. As requested by the Northern Territory Environment Protection Authority (NT EPA), the details of an aquatic ecosystem monitoring program (AEMP) are detailed below. The following document is a framework, which is an overview of monitoring activities, and will be expanded to a formal document to be appended to the Water Management Plan.

1.2 Aims and objectives

The AEMP will be conducted with the following overall objectives:

- Characterise groundwater dependent ecosystems (GDEs) located on the Upper McKinlay River
- Monitor aquatic ecosystem health of GDE pools and the McKinlay River in the vicinity of the Union Reefs Project Area for the life of The Project
- Understand temporal variation in aquatic ecosystem health, community composition and riparian vegetation health as a result of environmental factors, such as climate

2. Survey sites and timing

The monitoring program will employ a BACI (before, after, control, impact) study design. The location of proposed survey sites is presented in Figure 1. GDE monitoring will be undertaken at five sites (Table 1). Four sites are identified GDE pools in the Upper McKinlay River, and an additional site will be identified outside of the catchment as a regionally relevant control GDE site. The majority of aquatic ecology monitoring associated with GDEs will take place annual in the mid-dry season (June-September), when conditions are considered the most stable and flow has ceased. Dry season macroinvertebrate monitoring commenced in the late dry season of 2019, and will continue in 2020 (including fish monitoring) to collect data prior to the commencement of the project at control and potentially impacted sites.

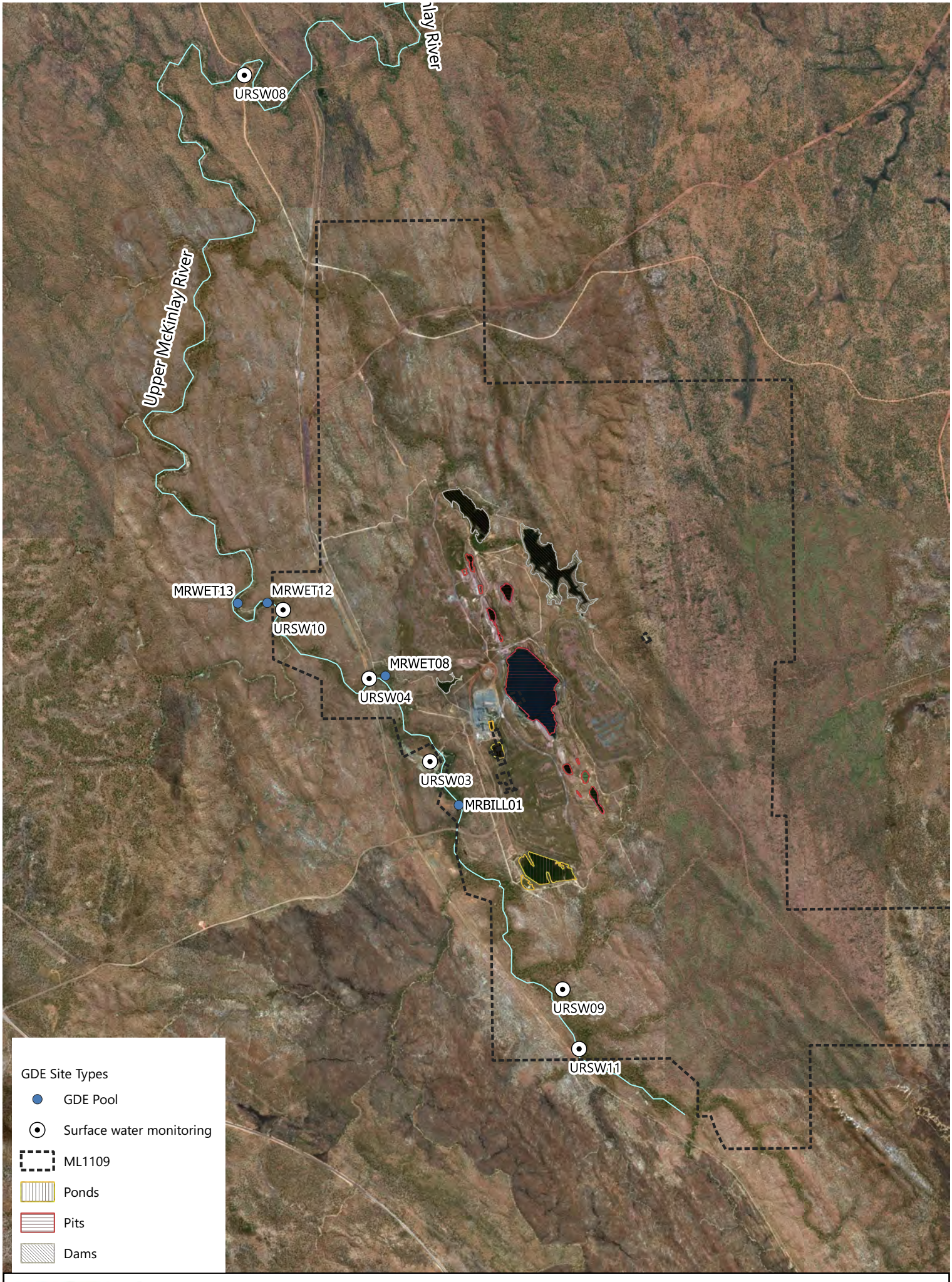
Current AUSRIVAS sampling is conducted in the post-wet season and will continue for the life of The Project. Six river sites to be sampled, including an additional site downstream of GDE pools will be incorporated in the program (Table 2). River sites are likely to be required in the event that a WDL is granted for active discharge, but the listed sites below may not represent the full set of sites required under a WDL.

Table 1 – GDE Pool sites to be monitored during the life of The Project.

Site Code	Site Type	Site description	Latitude	Longitude
MRBILL01	Control	Billabong on Upper McKinlay River in a zone of very low modelled groundwater availability loss	13.72527	131.7824
TBC	Control (regional)	GDE pool outside of the Upper McKinlay River catchment	TBC	TBC
MRWET08	Potentially impacted	GDE pool close to area of groundwater drawdown. Also known as URSW04.	13.71275	131.7751
MRWET12	Potentially impacted	GDE pool downstream of groundwater availability loss	13.70567	131.7633
MRWET13	Potentially impacted	GDE pool downstream of groundwater availability loss	13.70571	131.7604

Table 2 – McKinlay River sites to be monitored annually in the post-wet season

Site Code	Site Type	Site description	Latitude	Longitude
URSW11	Upstream	River site upstream of URPA operations	13.78783	131.7944
URSW09	Upstream	River site upstream of URPA operations	13.74323	131.7926
URSW10	Downstream	River site downstream of URPA operations, upstream of MRWET12 and MRWET13	13.70626	131.7647
URSW10A	Downstream	River site downstream of URPA operations, downstream of MRWET12 and MRWET13	TBC	TBC
URSW08	Downstream	River site furthest downstream of URPA operations	13.65333	131.7612



Aquatic Ecology Services

Union Reef Aquatic Ecosystem Monitoring Program Framework
Figure 1 - Aquatic Ecology Survey Sites
Data Source: Google Earth Pro (extracted 1/9/2019)

0 1 2 km

3. Survey Methods

3.1 Water level monitoring

Monitoring of standing groundwater levels and GDE pool volumes will be conducted as part of the Water Abstraction Management Plan. The results of this monitoring will be available for use in interpreting the results of biological monitoring.

3.2 Habitat assessment

Descriptions of habitat conditions are to be recorded at each site following the criteria listed in the Northern Territory AUSRIVAS Darwin Daly Region Model field sheets (Lamche, 2007). Habitat assessments will be undertaken in consideration of the whole reach sampled (100 m longitudinal section of The River) and include:

- Site description
- Water quality
- Characteristics of macroinvertebrate habitat
- Instream physical characteristics (flow velocity and depth, instream habitat characteristics, bank height, riparian width)
- Riparian vegetation characteristics (types, %cover, exotic species, erosion, land use)
- Water quality observations (clarity, odour, oils, foam/scum, plumes etc.)
- Sketches of the site, including a cross - section of the reach

Data recorded is used in conjunction with the biological community information as the basis of the overall health assessment. Photos are to be taken of upstream and downstream portions of the reach sampled, as well as bank habitat and other key habitat features. This will further characterise the habitat conditions at each site, serving as a pictorial record of site conditions that can be tracked over time using photos taken from the same photo points.

In addition to AUSRIVAS fieldsheets, bioassessment forms (DNRM 2001) will be completed as an assessment of overall habitat quality that can be quantified and compared over time.

3.3 Water quality and sediment

In situ measurements of water quality will be recorded at each survey site using a calibrated multi-parameter water quality meter. *In situ* water quality readings will be taken during all monitoring activities at all sites. Parameters to be recorded are:

- Water temperature (°C)
- pH
- Electrical conductivity (µS/cm)
- Dissolved oxygen (mg/L and % saturation)
- Turbidity

Sediment and water quality grab samples will be collected at each site as close as practicable to where macroinvertebrate monitoring takes place. Sediment samples will be collected annually, whilst water sampling will be conducted as per the frequency set out in the Water Management Plan.

3.4 Macroinvertebrates

3.4.1 Dry season sampling

Macroinvertebrate monitoring in the GDE pools has been identified as a significant safety risk for samplers. Although the AUSRIVAS method provides a standardised sampling technique which is repeatable and comparable to historical data upstream, it is not considered to be appropriate for the existing conditions. The presence of estuarine crocodiles in several pools was confirmed during EIS surveys, and it is considered likely that they would be present in all permanent pools during the dry season.

As an alternative to AUSRIVAS sampling, replicated artificial substrates will be deployed in each pool in the mid-dry season. Substrates will be deployed for one moth to allow for colonisation by macroinvertebrates. Using standardised, replicated artificial substrates in all pools would enable baseline macroinvertebrate data to be collected from aquatic habitats difficult to sample using other methods. The technique also reduces the variability in taking samples, thus helping to standardise a sampling program. Although this method differs from AUSRIVAS sampling techniques, it has been used successfully to characterise macroinvertebrate communities spatially and temporally in waterbodies across Australia, including tropical intermittent waterways.

Each substrate will be processed on site to remove all fauna, samples will then be labelled, preserved and processed at a laboratory.

3.4.2 Post-wet season sampling

The continuation of annual biological monitoring, that is: early dry season macroinvertebrate monitoring using NT AUSRIVAS protocols will be undertaken. This work will assist with understanding how aquatic ecosystems recover after wet season rainfall. An additional site downstream of pools MRWET12 and MRWET13 will assist with monitoring macroinvertebrate community health close to GDEs. Previously,

monitoring has employed family level identifications, but the finer resolution of genus level identifications will be employed for these samples going forward. Family level macroinvertebrate data has historically been sufficient to demonstrate differences in the macroinvertebrate community between upstream and downstream sites at the URPA. This has largely been attributed to differences in habitat availability. The finer resolution taxonomy will aim to understand if there are environmental factors or water management strategies that are impacting on ecological health. Replicated sampling will take place at each site to improve statistical power.

3.4.3 Sample processing

Regardless of the season in which macroinvertebrates are collected, sample processing will follow protocols set out in the Darwin-Daly Region AUSRIVAS Manual (Lamche 2007).

Each sample will be washed through 10mm and 500µm sieves. All animals in the 10mm fraction will be identified, and the 500µm fraction sub-sorted to a minimum of 200 animals using a Marchant subsampler. Macroinvertebrates will be identified to genus level, where keys are available. All other taxa (such as worms and microcrustaceans) will be identified to the lowest possible taxonomic unit (e.g. order, family, subfamily).

The identification of macroinvertebrates to finer taxonomic resolution than family level is a component of the Darwin-Daly AUSRIVAS protocol, for which a genus-level model exists. It is not suggested that AUSRIVAS modelling would be undertaken for this project, as they are not appropriate for intermittent streams and some methods of collection. It is suggested, however, that the finer level of taxonomic resolution (genus) be employed. This will allow for data analysis to be more sensitive to changes in the macroinvertebrate community over time, whilst allowing for processing and identification to be undertaken in a timely and cost-effective manner.

3.5 Fish monitoring

Fish monitoring has not been undertaken in the Upper McKinlay River since the original EIS for the Union Reefs Mine (AES 2019). Additional characterisation of aquatic fauna communities in GDE pools was suggested by AES (2019), which included the use of underwater cameras (baited remote underwater video survey or BRUVS) in the dry season to understand fish communities of permanent pools, as well as post-wet season electrofishing surveys to gather data on the fish community of the Upper McKinlay River more generally. The use of BRUVS to gather baseline data on fish communities will allow for an assessment of changes to the aquatic ecology of the GDE pools over time, and backpack electrofishing surveys in shallower waters upstream and downstream outside of the pools will allow for characterisation of the fish community that establishes during flowing conditions.

The risk of crocodile attack associated with entering these pools was highlighted as a concern for any active monitoring techniques that could be employed in those locations.

Annual BRUVS will be undertaken during the dry season when the McKinlay River has ceased surface flows. When water is pooled, water clarity is improved and the fish community is no longer transient, which provides conditions that are appropriate for BRUVS to take place. Should any groundwater level or quality

triggers be met, historical data will assist with an assessment of impact relating to fish communities and their composition. The historical data will also assist in understanding the role of antecedent climate conditions (i.e. poor/average/above average wet season rainfall).

Backpack electrofishing will be conducted in shallow, clear waters in the post-wet season whilst water remains in the majority of the McKinlay River, preferably when flow is still present. Electrofishing will focus on areas upstream and downstream of GDE pools where it is considered safe to do so. All fish will be identified, measured and returned to the water.

3.6 Riparian vegetation

It is noted that surface water ecosystems are likely to indicate stress related to groundwater drawdown impacts before riparian vegetation. A baseline survey of riparian vegetation prior to the start of mining will assist in measuring the impact (if any) to this community as a result of drawdown. The use of methods for bio-condition assessment (Eyre et al. 2015) would allow for repeat monitoring to take place every three years for the life of The Project, or when a groundwater level trigger is met.

3.7 Aquatic fauna

Mertens Water Monitors are likely to be sparsely distributed in the Upper McKinlay River. A short survey (10 days) was undertaken during EIS surveys, which may not have been sufficient to capture uncommon fauna. The NT Government guide for the use of remote cameras states that the increased length of deployment substantially increases the probability of detecting fauna that is rare within the landscape (Gillespie et al. 2015). Deployment of cameras as a follow-up survey for an extended period (preferably three months) will take place during the post-wet season period of 2020 when Monitors are likely to be active or migrating to permanent water. Habitat assessment at each camera deployment location will be completed to understand the likelihood of occurrence of water monitors. Habitat assessments will assist in interpretation of data gathered from remote cameras.

The surveys will have an indirect benefit of allowing for other pressures, such as hard-hoofed animals to be considered as an impact on permanent pools of the McKinlay River. The results of this monitoring will determine if further surveys are required. Should Mertens Water Monitors be detected, future survey timing, locations and length of deployment will be reviewed and adjustments made to the program where necessary.

4. Statistical analysis and reporting

During the baseline data collection phase, data analysis and reporting will focus on the characterisation of the aquatic ecology community at GDE Pools (including control sites) and the Upper McKinlay River more generally. Analysis is also likely to be directed to understanding the similarities or differences between sites, and differences between years of data based on rainfall and antecedent flow conditions. Bio-condition assessments undertaken to assess the riparian vegetation community along the McKinlay River will be interpreted for the area, and comparisons made every three years as data is collected.

When mining commences, comparisons of data collected will be made to baseline findings. If changes are detected, an investigation into data trends at control sites, as well as groundwater level trends will be undertaken. This investigation will aim to understand how other factors associated with climate and flow are influencing GDE pools, as well as to test the effectiveness of triggers for standing groundwater levels.

Macroinvertebrate and sediment monitoring undertaken at river sites will employ similar data analysis methods to those of previous events. Univariate measures (biotic indices) will be used to assess the health of the macroinvertebrate community at each site. For each analysis, replicate samples will be used to allow for robust statistical analyses to take place. Multivariate analysis of community composition will be performed to understand similarities or differences between sites and between years. Additional multivariate techniques, such as ANOSIM, SIMPER and BIOENV may be employed to further explore key drivers in macroinvertebrate community composition. A similar approach will be used for fish data collected actively and passively. Comparisons will be made between fishing methods in an effort to understand the value of residual fish communities of GDE pools in the dispersal of fish during the wet season. Data analysis of fish communities will also assess the merit of each sampling method to achieve its purpose.

An annual report detailing the outcome of biological monitoring will be produced. This is likely to be a summary document outlining the findings of all technical aspects of monitoring.

Technical documents will be made available on request. The assessment report will focus on:

- Qualitative assessment of community composition and sensitivity metrics
- Comparison of diversity metrics and community composition between GDE pools and between river sites
- Comparison of community composition and sensitivity metrics to historic data collected prior to commencement of mining
- Comparison of macroinvertebrate metrics to water quality and sediment quality collected at the time of sampling and historical trends
- Comparison of community composition and metric trends at regionally relevant control GDE sites

Technical reports are likely to be delineated into the following categories:

- McKinlay River AEMP – post-wet season surveys at river sites
  - Macroinvertebrate sampling
  - Sediment sampling
  - *In situ* and grab simples for surface water quality
  - Active fish surveys in rivers surrounding GDE pools
- McKinlay River AEMP – dry season surveys at GDE pools
  - *In situ* and grab simples for surface water quality
  - Macroinvertebrate monitoring of GDE pools
  - Passive fish surveys
  - Sediment monitoring
  - Riparian vegetation assessment
  - Aquatic fauna camera trapping
  - GDE pool water level monitoring

References

Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2015). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane.

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Lamche, G. (2007). The Darwin-Daly Regional AUSRIVAS Models –Northern Territory: User Manual. Aquatic Health Unit –Department of Natural Resources, Environment and the Arts. Report 06/2007D.

Marshall, J.C., Steward, A.L. & Harch, B.D. (2006). Taxonomic Resolution and Quantification of Freshwater Macroinvertebrate Samples from an Australian Dryland River: The Benefits and Costs of Using Species Abundance Data. *Hydrobiologia*. Vol. 572, pp. 171–194.



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APPENDIX C – WATER ABSTRACTION MANAGEMENT PLAN



NT Mining Operations Pty Ltd
Union Reefs North Underground Mine

Water Abstraction Management Plan

KL | KIRKLAND LAKE GOLD

TABLE OF CONTENTS

1. Introduction 1

2. Background Information 1

3. Groundwater Monitoring Infrastructure 1

3.1 Existing Groundwater Monitoring Infrastructure 1

3.2 Proposed Groundwater Monitoring Infrastructure 3

3.2.1 Monitoring bore installation and development 5

3.2.2 Monitoring bore installation reporting 5

4. Groundwater Monitoring 5

4.1 Pumping 5

4.2 Standing Water Levels 5

4.3 Rainfall 5

5. Reporting 6

5.1 Anticipated Pumping Rates 6

5.2 Anticipated Standing Water Levels 6

6. Mitigation and Management 7

7. Groundwater Modelling 8

8. References 8

TABLES

Table 1 Existing Groundwater Monitoring Infrastructure Locations 1

Table 2 Existing Pit Lake and Mine Feature Surface Water Level Monitoring 2

Table 3 Proposed Groundwater Monitoring Infrastructure Locations 3

FIGURES

Figure 1 Proposed Monitoring Locations 4

1. INTRODUCTION

The Water Abstraction Management Plan is intended to document the commitments in relation to the monitoring of groundwater in relation to the mining and associated groundwater abstraction for the Union Reefs North Underground Mine at the Union Reefs Project Area (URPA). This document is intended to be included in a broader Water Management Plan (WMP) and Mine Management Plan. This plan relates to groundwater quantity (flows and levels) with groundwater quality being considered elsewhere.

2. BACKGROUND INFORMATION

The Union Reefs North Underground Mine is summarised in the EIS (KLG, 2019).
The groundwater study of the EIS (GHD, 2019A) and additional monitoring documented in GHD (2019B) form the key background information of this plan.

3. GROUNDWATER MONITORING INFRASTRUCTURE

3.1 Existing Groundwater Monitoring Infrastructure

Existing groundwater monitoring infrastructure locations are presented on Figure 1 and provided in Table 1. In addition the surface water levels in pit lakes and mine features provide additional standing water level data (Table 2 and Figure 1). Existing groundwater monitoring bores, pit lakes and mine features water levels will be monitored at least monthly.

TABLE 1 EXISTING GROUNDWATER MONITORING INFRASTRUCTURE LOCATIONS

Location	Easting (GDA 1994 MGA Zone 52)	Northing (GDA 1994 MGA Zone 52)	Minimum Monitoring Frequency
URDB1	801950	8480027	Monthly
URDB2	801954	8480007	Monthly
URDB3	801801	8480006	Monthly
URDB4	801804	8479985	Monthly
URDB5	801700	8479992	Monthly
URDB6	801703	8479968	Monthly
URDB7	801275	8483594	Monthly
URDB9	801485	8483779	Monthly
URMB25	801485	8482576	Monthly
URMB26	802131	8482107	Monthly
RN036105	799463	8485209	Monthly

TABLE 2 EXISTING PIT LAKE AND MINE FEATURE SURFACE WATER LEVEL MONITORING

Pit Lake or Mine Feature	Minimum Monitoring Frequency
Crosscourse Pit	Monthly
Big Tree Pit	Monthly
Temple Pit	Monthly
Ping Que Pit	Monthly
Millars Pit	Monthly
Union South Pit	Monthly
Prospect Pit (north)	Monthly
Prospect Pit (south)	Monthly
Lady Alice Pit	Monthly
Union North Pit	Monthly
Union North Pit Extension	Monthly
Union North South Pit	Monthly
Union Reef Dam	Monthly
Decant Seepage	Monthly
Dam A	Monthly
Dam B	Monthly
Dam C	Monthly
McKinlay Weir	Monthly

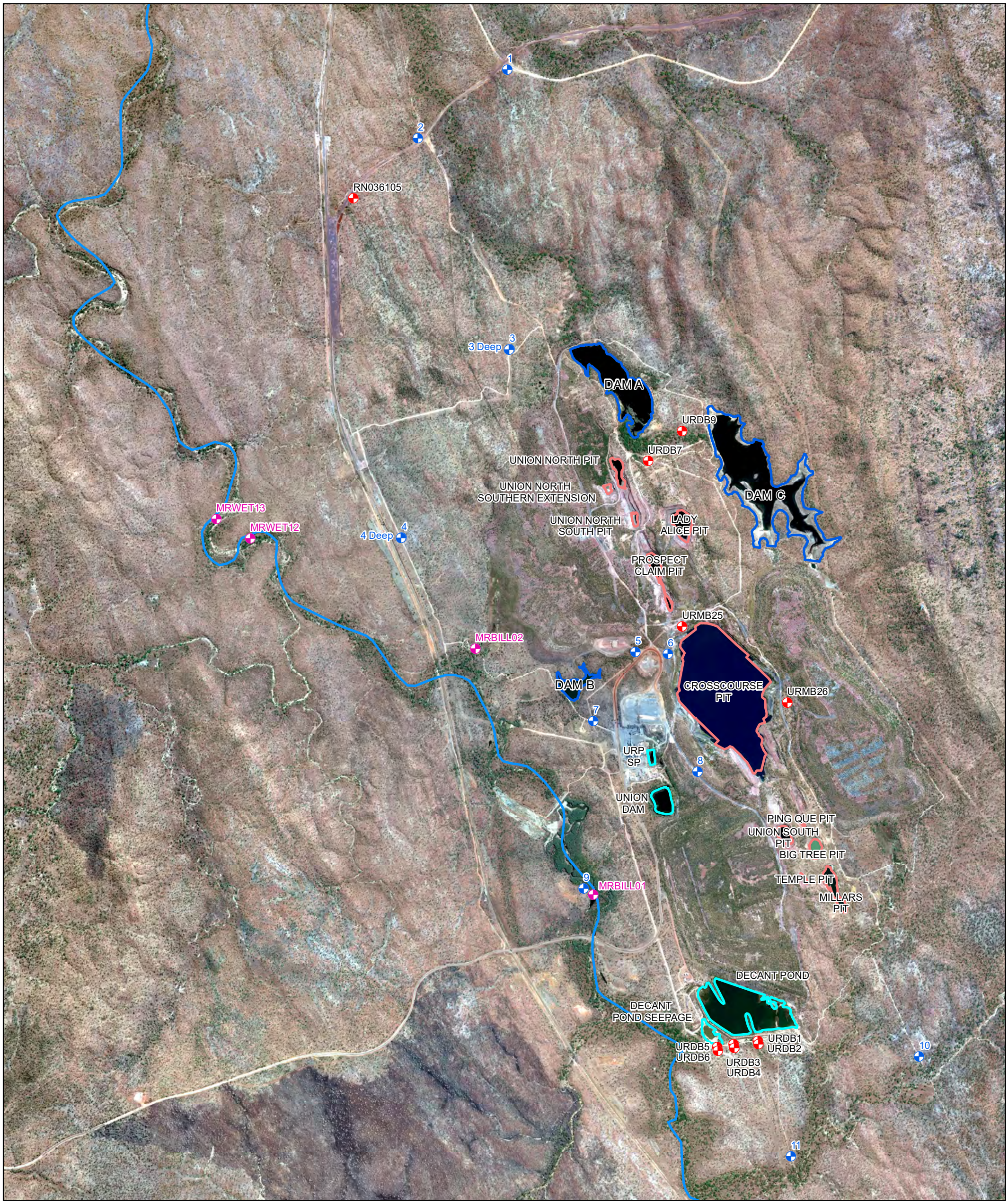
3.2 Proposed Groundwater Monitoring Infrastructure

KLG are committed to installing and monitoring 13 new groundwater bores to augment the mine's broader monitoring network. Completion of the proposed additional groundwater monitoring infrastructure requires the design, hydrogeological supervision and installation of 13 monitoring groundwater bores.

It is anticipated that 11 of the 13 bores will be drilled to approximately 30m depth, with two additional bores drilled to approximately 50m depth to monitor deeper aquifer units and provide advanced warning of depressurisation due to mining activities. The proposed locations of the additional monitoring bores are presented on Figure 1 and provided in Table 3. Locations 3 and 4 are the nominal locations for the dual (deep, 50m and shallow 30m) installations.

TABLE 3 PROPOSED GROUNDWATER MONITORING INFRASTRUCTURE LOCATIONS

Location	Easting (GDA 1994 MGA Zone 52)	Northing (GDA 1994 MGA Zone 52)	Logger monitoring frequency	Minimum manual monitoring frequency	Minimum logger download frequency during operation
MRWET12	798830	8483118	Hourly	Monthly	Monthly
MRWET13	798622	8483238	Hourly	Monthly	Monthly
MRBILL01	800935	8480923	Hourly	Monthly	Monthly
MRBILL02	800214	8482438	Hourly	Monthly	Monthly
11	802152	8479317	Hourly	Monthly	Monthly
10	802940	8479931	Hourly	Monthly	Monthly
4	799759	8483122	Hourly	Monthly	Monthly
4 deep	799755	8483120	Hourly	Monthly	Monthly
1	800409	8486001	Hourly	Monthly	Monthly
5	801198	8482419	Hourly	Monthly	Monthly
6	801396	8482409	Hourly	Monthly	Monthly
8	801579	8481683	Hourly	Monthly	Monthly
3	800425	8484281	Hourly	Monthly	Monthly
3 deep	800420	8484280	Hourly	Monthly	Monthly
2	799860	8485579	Hourly	Monthly	Monthly
7	800939	8481993	Hourly	Monthly	Monthly
9	800879	8480964	Hourly	Monthly	Monthly



LEGEND

- Proposed Groundwater Monitoring Point
- Proposed Surface Water Monitoring Point
- Existing Monitoring Locations
- Ponds
- Dams
- Pits

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0 0.125 0.25 0.5 0.75 1

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

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Kirkland Lake Gold
Union Reef EIS

Job Number	12512776
Revision	A
Date	14 Feb 2020

Proposed Monitoring Locations

Figure 1

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3.2.1 MONITORING BORE INSTALLATION AND DEVELOPMENT

It is proposed to complete the installation over the following campaigns:

- Drilling and installation
- Development and hydraulic testing
- Survey and instrumentation

Wells are to be installed utilising air hammer drilling, which will allow the site hydrogeologist to accurately log chip returns and identify with greater certainty water bearing zones. Following installation wells will be developed via airlifting to remove any residual drilling fluids. When drilling fluids have been removed, and the bore has recovered, hydraulic testing of the aquifers will be performed. This will include:

- Airlift and recovery testing; and/or
- Slug testing

Monitoring bores will be installed in line with the Minimum Construction Requirements for Water Bores in Australia 2012.

3.2.2 MONITORING BORE INSTALLATION REPORTING

Following installation and development of the wells a final report will be produce including:

- Final well installation logs
- Standing water levels for each well and updated groundwater contours
- Installed equipment specifications and calibration certificates
- Equipment operations manual
- Results and interpretation of the hydraulic testing
- Recommended ongoing monitoring and bore maintenance schedule

4. GROUNDWATER MONITORING

4.1 Pumping

Pumping will be monitored by the daily collection of calibrated cumulative volumes removed from the underground pumping system. Where water is added for use underground this will also be tracked.

Together the pumped volume out minus the supply volume in will calculate the daily groundwater inflow.

Mining will not commence until the pumping network includes adequate flow meters.

4.2 Standing Water Levels

Standing water levels will be monitored at all existing locations for surface water level and groundwater level at a monthly intervals as a minimum monitoring frequency (Table 1 and Table 2). Where pits or mine features are dry they will be recorded as dry. In addition groundwater levels in new bores and water levels at MRBILL01, MRBILL02, MRWET12 and MRWET13 will be monitored (Table 3). Loggers will be fitted to all of the new bores and these 4 surface water features so readings can be recorded at hourly readings. Hourly readings are intended to provide insight into recharge mechanisms and material properties to further inform groundwater modelling.

Monitoring frequencies will be maintained during operation and reviewed for the rebound and closure period.

4.3 Rainfall

Hourly rainfall at the URPA will be recorded using an automated weather station.

5. REPORTING

Given the short duration of the underground mine, we propose analysis of standing water levels and reporting on them at:

- commencement of mining;
- 3 months into mining;
- 6 months into mining;
- 1 year into mining;
- 2 years into mining;
- 1 year post mining; and
- 5 years post mining.

This reporting will also include the rainfall, water levels of all pits and the flow rates of all water pumped on site. Where results exceed anticipated rates (pumping triggers), groundwater drawdown or visible evidence of impact is observed (standing water level triggers), responses will be enacted including if required mitigation and management measures (Section 6).

5.1 Anticipated Pumping Rates

Previous groundwater studies proceeded on the understanding that pumping from (dry season inflows to the Crosscourse Pit peaked at 8 L/s based on URS (2002). Based on this, the AQ2 (2018) upper estimate of 18 L/s forms the upper estimate for pumping predictions.

5.1.1.1 Pumping Rate Trigger

Due to sporadic operational variation of underground mine pumping rates we propose a dry season 30 day rolling average of 18L/s as the first groundwater flow trigger. For the purpose of this plan and this trigger we define "dry season" as any month not greater than 30mm rainfall. Thus, if the 30 day rolling average is greater than 18L/s for measured groundwater inflow to the underground and the previous or current month's rainfall did not exceed 30mm the first groundwater flow trigger is exceeded.

The "dry season" measure is applied as it is recognised that high rainfalls could result in shallow inflows exceeding the triggers depending on how the underground workings interact with shallow groundwaters.

We propose the second trigger at 27L/s and the third at 36L/s using the above approach. Lower pumping rates than anticipated to not warrant a trigger.

5.1.1.2 Pumping Rate Trigger Response

The first pumping trigger (18L/s) enacts a groundwater investigation, which includes consideration of the standing water levels and reporting of the implication of the exceedance relative to the stage of the mining's progress.

The second pumping trigger (27L/s) enacts a groundwater investigation which includes, as a minimum, consideration of the standing water levels, re-modelling and reporting of the implications.

The third pumping trigger (36L/s) enacts cessation of advancement of mining (additional development) until a groundwater investigation is completed which includes, as a minimum, consideration of the standing water levels, re-modelling and reporting of the implications.

5.2 Anticipated Standing Water Levels

The standing water level triggers need significant consideration of the seasonality of recharge. Existing groundwater monitoring bores are all located adjacent to surface water features so their seasonal variation is small (less than 2m) as they are likely to be masked by the adjacent water bodies. The range in the proposed bores could therefore be significantly larger and dry season recessions greater than 2m should be anticipated. Following the first wet season recovery, standing

water level triggers may be able to refined from the below, primarily subjective measures, to more quantifiable measures. Prior to this, a comparison of the relative change, between bores that are distal compared to bores that are proximal to the underground mine, will be required to infer drawdown impact.

5.2.1.1 Standing Water Level Trigger

The first standing water level trigger is a groundwater level recession which does not recover to a reasonable level following the wet season recharge.

The second groundwater level trigger is a groundwater level lower than the adjacent section of the McKinlay River.

The third standing water level trigger is a groundwater level that demonstrates an impact on a known or potential groundwater dependent ecosystem (GDE), the Pine Creek borefield and the closest neighbouring groundwater bore (RN036105).

Known or potential groundwater dependent ecosystems (GDEs) include the McKinlay River as a whole, the McKinlay River at MRBILL01, MRBILL02, MRWET12 and MRWET13.

If the standing water level at a known potential groundwater dependent ecosystem (GDE), the Pine Creek borefield and the closest neighbouring groundwater bore (RN036105) is depleted, but a coincident and causal groundwater level depletion is not recognised in the groundwater monitoring network, then this is not a standing water level trigger exceedance.

5.2.1.2 Standing Water Level Trigger Response

The first standing water level trigger enacts a groundwater investigation which includes consideration of the pumping rates, re-modelling and reporting of the implication of the exceedance relative to the stage of the mining's progress.

The second standing water level trigger enacts a groundwater investigation which includes, as a minimum, consideration of the standing water levels, re-modelling and reporting of the implications.

The third trigger standing water level trigger enacts a fast-tracked mitigation and management process (Section 6) and a groundwater investigation which includes, as a minimum consideration of the pumping rates, re-modelling and reporting of the implications.

6. MITIGATION AND MANAGEMENT

The above monitoring program and triggers are considered adequate to track:

- the extent of the depressurisation zone and its effect during dewatering of the Prospect pits and underground mine
- the extent of groundwater drawdown, on surface and groundwater flows as well as on other water bodies within and adjacent to the Proposal, from dewatering the Prospect pits and underground mine; and
- any impact on beneficial uses of groundwater (notably the McKinlay River as a whole, the McKinlay River at MRBIL01, MRBILL02, MRWET12 and MRWET13, the Pine Creek borefield and the closest neighbouring groundwater bore (RN036105).

In the unlikely event mitigation is considered required, the large water stores on site could be considered as temporary mitigation for example as:

- rapid deliberate flooding of the underground mine;
- one off, out of seasons flush discharge to the McKinlay River (pending water quality results);
- target irrigation along the McKinlay River (i.e. at MRBILL01, MRBILL02, MRWET12 and MRWET13);
- as a substitute for groundwater extraction at neighbouring bores.

It is recognised that all of these would require significant multidisciplinary consideration and regulatory approval.

7. Groundwater Modelling

The current groundwater modelling was considered adequate at the EIS stage to demonstrate scale of the impact of dewatering of the Prospect pit and underground mine at URPA on the groundwater flow regime. Ongoing modelling will be undertaken to increase confidence in predictions for the underground but also so these models can be used as a management tool for the whole of the URPA. The proposed mining (pumping) and monitoring presents an opportunity to improve the groundwater model.

Groundwater assessments and modelling works will continue to:

- seek additional historical records (including pumping data and standing water levels) from site;
- further incorporate Pine Creek data especially if more data becomes available from external stakeholders;
- further delineation of zones of higher permeability if appropriate.

The first major model update will consider incorporating and calibrating to a transient dataset. Both groundwater levels (model targets) and pumping data (model inputs) will be required to produce this. A target calibration scaled root mean squared residual of less than 10% will be sought.

Receipt of the following reports also warrant a model review, recognising that a model review may not trigger a model update or re-modelling.

- Drilling Report
- Commencement of mining;
- 3 months into mining;
- 6 months into mining;
- 1 year into mining;
- 2 years into mining;
- 1 year post mining; and
- 5 years post mining.

In addition, re-modelling may be triggered by, exceedences of:

- the above second or third pumping rate triggers; or
- the above first, second or third standing water level triggers.

8. References

AQ2 (2018) Predicted Groundwater Inflows to Prospect Underground Mine, letter report to Kirkland Lake Gold, Australia

GHD (2019A) Groundwater Study, Report for NT Mining Operations Pty Ltd - Kirkland Lake Gold North Underground Mine EIS

GHD (2019B) Additional Groundwater Modelling, Report for NT Mining Operations Pty Ltd - Kirkland Lake Gold North Underground Mine EIS

KLG (2019) Kirkland Lake Gold North Underground Mine Environmental Impact Statement (EIS)

URS (2002) Qualitative Risk Analysis of In-Pit Tailings Disposal Crosscourse Pit, Pine Creek. Unpublished report for AngloGold Australia Ltd, dated 2 April 2002. Report reference 44265-017-562 / 507-F4805.0


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APPENDIX D – WATER QUALITY MANAGEMENT PLAN



NT Mining Operations Pty Ltd

Union Reefs North Underground Mine

Water Quality Management Plan

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TABLE OF CONTENTS

1 Introduction 1

2 Background Information 1

3 Groundwater Monitoring Infrastructure 4

3.1 Existing Groundwater Monitoring 4

3.2 Additional Groundwater Monitoring 5

3.3 Existing Surface Water Monitoring 6

3.4 Additional Surface Water Monitoring 7

4 Reporting 9

4.1 Anticipated Water Quality 9

4.1.1 Water Quality Triggers 9

4.1.2 Water Quality Trigger Response 9

5 Mitigation and Management 10

6 References 10

TABLES

Table 3-1 Existing Groundwater Monitoring Infrastructure Locations 4

Table 3-2 Existing Groundwater Monitoring Types 4

Table 3-3 Existing Groundwater Monitoring Frequencies 4

Table 3-4 Proposed Additional Groundwater Monitoring Type and Frequency 5

Table 3-5 Proposed Additional Groundwater Monitoring Types 5

Table 3-6 Proposed Additional Groundwater Monitoring Frequencies 6

Table 3-7 Existing Pit Lake and Mine Feature Surface Water Quality Monitoring Type and Frequency 6

Table 3-8 Existing Surface Water Quality Monitoring Types 7

Table 3-9 Existing Surface Water Quality Monitoring Frequencies 7

Table 3-10 Additional Pit Lake and Mine Feature Surface Water Quality Monitoring Type and Frequency 8

Table 3-11 Additional Surface Water Quality Monitoring Types 8

Table 3-12 Additional Surface Water Quality Monitoring Frequencies 8

FIGURES

Figure 2-1 Proposed Monitoring Locations 2

Figure 2-2 Existing Monitoring Locations 3

1 INTRODUCTION

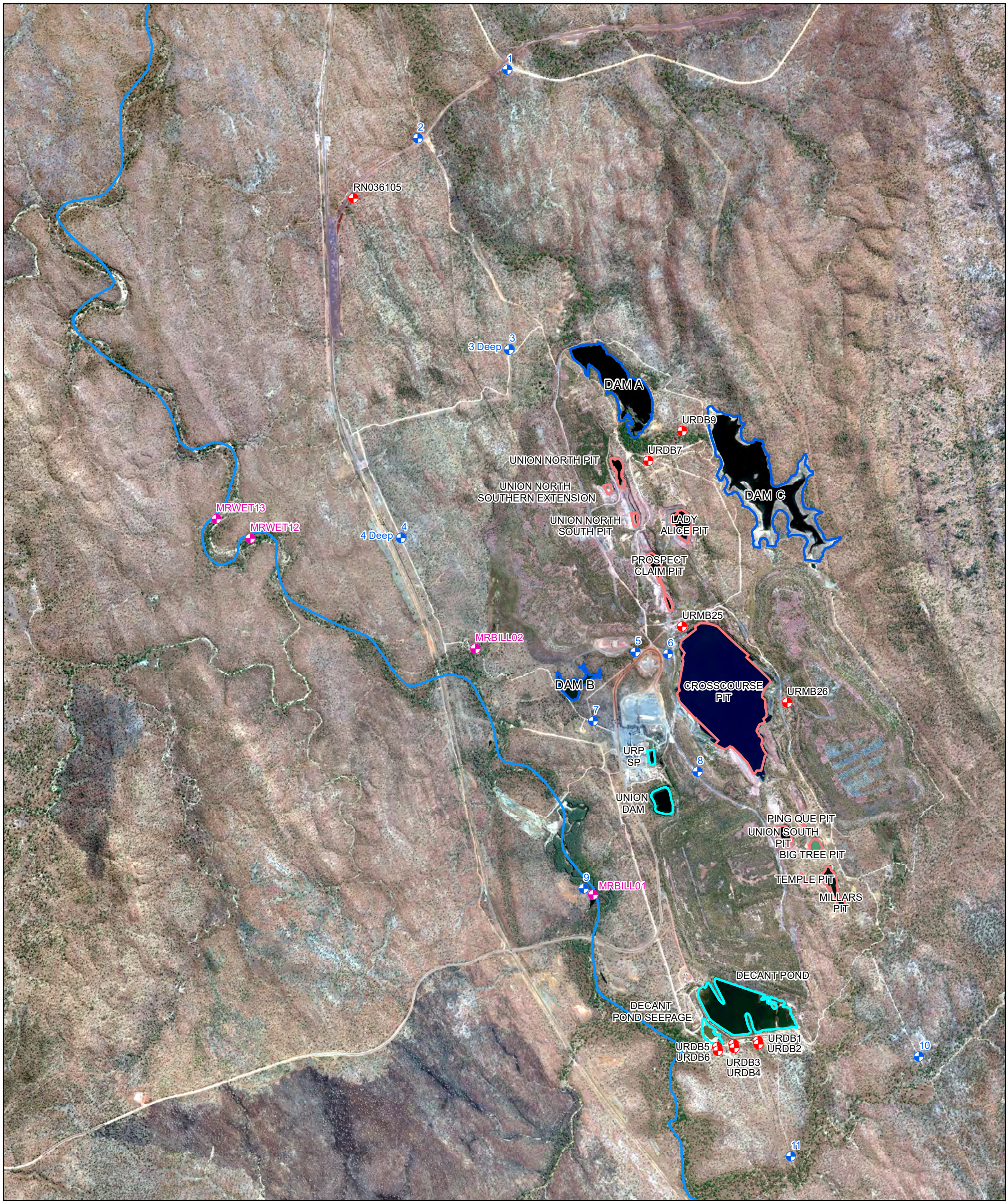
The Water Quality Management Plan (WQMP) is intended to document the commitments in relation to the monitoring of surface water and groundwater in relation to the mining and associated groundwater abstraction for the Union Reefs North Underground Mine at the Union Reefs Project Area (URPA). This document is intended to be included in a broader Water Management Plan (WMP) and Mine Management Plan. This plan relates to groundwater quality with groundwater quantity being considered elsewhere. The plan documents both existing proposed additional monitoring specifically for the Union Reefs North Underground Mine (Figure 2-1) and existing URPA monitoring (Figure 2-2) which is already included in the URPA Mine Management Plan (MMP).

2 BACKGROUND INFORMATION

The Union Reefs North Underground Mine and water management is summarised in the EIS (KLG, 2019) and the WMP. In addition, the groundwater study of the EIS (GHD, 2019A) and additional monitoring documented in GHD (2019B) form background information for consideration in relation to this plan.

The applicable sampling procedures for the outlined monitoring programs are as follows:

- NTMO ES – SOP 01 Surface Water Sampling;
- NTMO ES – SOP 02 Groundwater Sampling;
- NTMO ES – SOP 03 Water Sampling Packaging and Delivery;
- NTMO ES – SOP 13 Sediment Sampling; and
- NTMO ES – SOP 38 Macroinvertebrate Sampling.



LEGEND

- Proposed Groundwater Monitoring Point
- Proposed Surface Water Monitoring Point
- Existing Monitoring Locations
- Ponds
- Dams
- Pits

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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

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Kirkland Lake Gold
Union Reef EIS

Job Number	12512776
Revision	A
Date	14 Feb 2020

Proposed Monitoring Locations

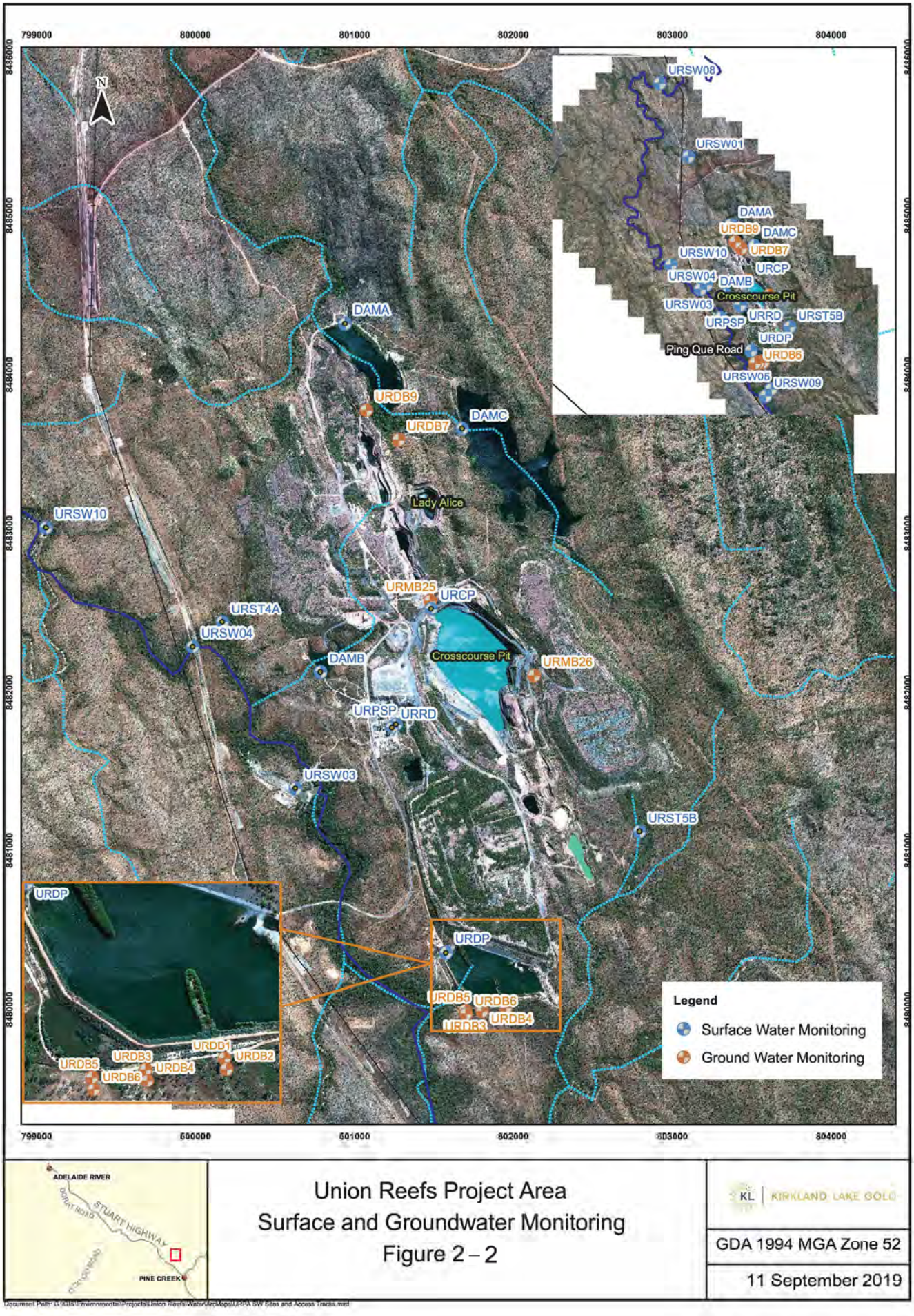
Figure 2-1

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URRD
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URPSP
URDP
Ping Que Road
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DAMA
URDB9
DAMC
URDB7
Lady Alice
URSW10
URMB25
URCP
URST4A
URSW04
DAMB
Crosscourse Pit
URMB26
URPSP
URRD
URSW03
URST5B
URDP
URDB5
URDB6
URDB3
URDB4
URDB1
URDB2
URDP
URDB5
URDB6
URDB3
URDB4
Legend
Surface Water Monitoring
Ground Water Monitoring
ADELAIDE RIVER
DARWIN ROAD
STUART HIGHWAY
PINE CREEK
Union Reefs Project Area
Surface and Groundwater Monitoring
Figure 2 – 2
KL | KIRKLAND LAKE GOLD
GDA 1994 MGA Zone 52
11 September 2019

3 GROUNDWATER MONITORING INFRASTRUCTURE

3.1 Existing Groundwater Monitoring

Existing groundwater monitoring locations are presented on Figure 2-2 and provided Figure 2-1 along with their frequency and monitoring types which are defined in Table 3-2 and Table 3-3.

TABLE 3-1 EXISTING GROUNDWATER MONITORING INFRASTRUCTURE LOCATIONS

Location	Easting (GDA 1994 MGA Zone 52)	Northing (GDA 1994 MGA Zone 52)	0	1	2	3	4	5
URDB1	801950	8480027	M	Q	Q	Q	Q	
URDB2	801954	8480007	M	Q	Q	Q	Q	
URDB3	801801	8480006	M	Q	Q	Q	Q	
URDB4	801804	8479985	M	Q	Q	Q	Q	
URDB5	801700	8479992	M	Q	Q	Q	Q	
URDB6	801703	8479968	M	Q	Q	Q	Q	
URDB7	801275	8483594	M	Q	Q	Q	Q	
URDB9	801485	8483779	M	Q	Q	Q	Q	
URMB25	801485	8482576	M	Q	Q	Q	Q	
URMB26	802131	8482107	M	Q	Q	Q	Q	Q
RN036105	799463	8485209	M					

TABLE 3-2 EXISTING GROUNDWATER MONITORING TYPES

Type	Analytes
Type 0	Manual Standing Water Level (SWL)
Type 1	Field parameters (pH, EC)
Type 2	Filtered metals (Al, As, Cd, Co, Cu, Cr, Fe, Mn, Mo, Ni, Pb and Zn)
Type 3	Major cations (Ca, K, Na and Mg) anions (Cl, SO4)
Type 4	Titratable acidity, alkalinity, hardness (CaCO3), Total Suspended Solids (TSS), turbidity
Type 5	WAD CN, total CN, free CN

Note: Lead (Pb) has been added on EGI's (2019) recommendation and chromium (Cr) EPAs (2020) EGI's request.

TABLE 3-3 EXISTING GROUNDWATER MONITORING FREQUENCIES

Code	Frequency
M	Monthly
Q	Quarterly

3.2 Additional Groundwater Monitoring

Additional groundwater monitoring locations are presented on Figure 2-1 and provided in Table 3-4 along with their frequency and monitoring types which are defined in Table 3-5 and Table 3-6.

TABLE 3-4 PROPOSED ADDITIONAL GROUNDWATER MONITORING TYPE AND FREQUENCY

Location	Easting (GDA 1994 MGA Zone 52)	Northing (GDA 1994 MGA Zone 52)	0	1	2	3	4	5
MRWET12	798830	8483118	M	Q	B	B	B	
MRWET13	798622	8483238	M	Q	B	B	B	
MRBILL01	800935	8480923	M	Q	B	B	B	
MRBILL02	800214	8482438	M	Q	Q	Q	Q	Q
11	802152	8479317	M					
10	802940	8479931	M	Q	B	B	B	
4	799759	8483122	M	Q	Q	Q	Q	Q
4 deep	799755	8483120	M	Q	Q	Q	Q	Q
1	800409	8486001	M	Q	B	B	B	
5	801198	8482419	M	Q	Q	Q	Q	Q
6	801396	8482409	M	Q	Q	Q	Q	Q
8	801579	8481683	M	Q	B	B	B	
3	800425	8484281	M	Q	Q	Q	Q	Q
3 deep	800420	8484280	M	Q	Q	Q	Q	Q
2	799860	8485579	M					
7	800939	8481993	M	Q	Q	Q	Q	Q
9	800879	8480964	M	Q	B	B	B	

TABLE 3-5 PROPOSED ADDITIONAL GROUNDWATER MONITORING TYPES

Type	Analytes
Type 0	Manual Standing Water Level (SWL)
Type 1	Field parameters (pH, EC)
Type 2	Filtered Metals (Al, As, Cd, Co, Cu, Cr, Fe, Mn, Mo, Ni, Pb and Zn)
Type 3	Major Cations (Ca, K, Na and Mg) Anions (Cl, SO4)
Type 4	Titratable Acidity, Alkalinity, Hardness (CaCO3), Total Suspended Solids (TSS), Turbidity
Type 5	WAD CN, Total CN, Free CN

Note: Lead (Pb) has been added on EGI's (2019) recommendation and chromium (Cr) EPAs (2020) EGI's request.

TABLE 3-6 PROPOSED ADDITIONAL GROUNDWATER MONITORING FREQUENCIES

Code	Frequency
M	Monthly
Q	Quarterly
B	Biannual (March and September)

3.3 Existing Surface Water Monitoring

Existing surface water quality locations are presented on Figure 2-2 and provided in Table 3-7 along with their frequency and monitoring types which are defined in Table 3-8 and Table 3-9.

TABLE 3-7 EXISTING PIT LAKE AND MINE FEATURE SURFACE WATER QUALITY MONITORING TYPE AND FREQUENCY

Existing Site Code	Pit Lake or Mine Feature	0	1	2	3	4	5	6	7	8
URSW01	Wellington creek downstream of raw water dams	F	F	M	M	M		M		
URSW03	McKinlay weir downstream of decant pond and east WRD	F	F	M	M	M		M		
URSW04	McKinley river downstream of west WRD		F	M	M	M	M			
URSW05	Esmeralda creek downstream of east WRD		F	M	M	M	M			
URSW08	McKinley river downstream edge of mixing zone	F	F	M	M	M	M	M		
URSW09	McKinley river upstream of MLN1109 – Control	F	F	M	M	M		M		
URSW10	McKinley river downstream of west WRD and decant pond (lease boundary)	F	F	M	M	M	M	M		
URST4A	Wetland outflow from west WRD	Q	Q	Q	Q	Q				
URST5B	Wetland outflow from east WRD	Q	Q	Q	Q	Q				
Dam A	Raw water dam, lower dam	M	M	M	M	M				
Dam B	Water dam, downstream of ROM, fuel bay, workshop, and south of west WRD	F	F	F	F	F	F			Q
Dam C	Raw water dam, upper dam	M	M	Q	Q	Q				
URPSP	Secondary containment pond	M	M	Q	Q	Q	Q			
URDP	Decant pond spillway	M	M	Q	Q	Q				
URRD	Tailings slurry		M	M	M	M	M			
URCP	Crosscourse pit	M	M	M	M	M	M			

Note: The frequency of Dam B has been monitoring increased on the premise that Dam B will be utilised as a discharge facility.

TABLE 3-8 EXISTING SURFACE WATER QUALITY MONITORING TYPES

Type	Analytes
Type 0	Water height level reading
Type 1	Field parameters (DO, pH, EC, temp, flow)
Type 2	Total and filtered metals (Al, As, Cd, Co, Cu, Cr, Fe, Mn, Mo, Ni, Pb and Zn)
Type 3	Major cations (Ca, K, Na and Mg) anions (Cl, SO4)
Type 4	Titratable acidity, alkalinity, hardness (CaCO3), Total Suspended Solids (TSS), turbidity
Type 5	WAD CN, total CN, free CN
Type 6	Total Phosphorus (P), total Nitrogen (N), ammonia, nitrogen oxides and filterable reactive phosphorus
Type 7	Australian Drinking Water Guidelines (Total coliforms, E. coli and total viable bacteria)
Type 8	Total Petroleum Hydrocarbons (TPH)

Note: Lead (Pb) has been added on EGI's (2019) recommendation and chromium (Cr) EPAs (2020) EGI's request.

TABLE 3-9 EXISTING SURFACE WATER QUALITY MONITORING FREQUENCIES

Code	Frequency
F	Fortnightly (During wet season or discharge, otherwise monthly)
M	Monthly
Q	Quarterly
B	Biannual (March and September)

3.4 Additional Surface Water Monitoring

Additional surface water monitoring locations are presented on Figure 2-1 and provided in Table 3-10 along with their frequency and monitoring types which are defined in Table 3-11 and Table 3-12.

TABLE 3-10 ADDITIONAL PIT LAKE AND MINE FEATURE SURFACE WATER QUALITY MONITORING TYPE AND FREQUENCY

Existing Site Code	Pit Lake or Mine Feature	0	1	2	3	4	5	6	7	8
	Big Tree pit	M								
	Temple pit	M								
	Ping Que pit	M								
	Millars pit	M	Q	Q	Q	Q	Q			
	Union South pit	M	Q	Q	Q	Q	Q			
	Prospect pit (north)	M								
	Prospect pit (south)	M								
	Lady Alice pit	M	Q	Q	Q	Q	Q			
	Union North pit	M	Q	Q	Q	Q	Q			
	Union North pit extension	M								
	Union North South pit	M								
	Union Reef dam	M	Q	Q	Q	Q	Q			
	Decant seepage	M								
	McKinlay weir	M								

TABLE 3-11 ADDITIONAL SURFACE WATER QUALITY MONITORING TYPES

Type	Analytes
Type 0	Water height level reading
Type 1	Field parameters (DO, pH, EC, Temp, Flow)
Type 2	Total and filtered metals (Al, As, Cd, Co, Cu, Cr, Fe, Mn, Mo, Ni, Pb and Zn)
Type 3	Major cations (Ca, K, Na and Mg) Anions (Cl, SO4)
Type 4	Titratable acidity, alkalinity, hardness (CaCO3), Total Suspended Solids (TSS), turbidity
Type 5	WAD CN, total CN, free CN
Type 6	Total Phosphorus (P), total Nitrogen (N), ammonia, nitrogen oxides and filterable reactive phosphorus
Type 7	Australian Drinking Water Guidelines (total coliforms, E. coli and total viable bacteria)
Type 8	Total Petroleum Hydrocarbons (TPH)

Note: Lead (Pb) has been added on EGI's (2019) recommendation and chromium (Cr) EPAs (2020) EGI's request.

TABLE 3-12 ADDITIONAL SURFACE WATER QUALITY MONITORING FREQUENCIES

Code	Frequency
M	Monthly
Q	Quarterly

4 REPORTING

Given the short duration of the underground mine, we propose reporting on water quality at:

- Commencement of mining
- 3 months into mining
- 6 months into mining
- 1 year into mining
- 2 years into mining
- 1 year post mining
- 5 years post mining

This reporting will also include consider the water levels reporting described in the Water Abstraction Management Plan (WAMP). Where results exceed anticipated water quality (triggers), responses will be enacted including if required mitigation and management measures (Section 5).

4.1 Anticipated Water Quality

The commencement of mining water quality report will provide insight to the anticipated water quality for each location and draw on information from EGI (2019 and 2020). URPA Water Quality Guideline Values (GVs) defined in the MMP will form the interim measures for water quality.

4.1.1 WATER QUALITY TRIGGERS

The commencement of mining water quality report will identify preliminary water quality triggers for each location. The triggers defined in the MMP will form the interim triggers for water quality.

EGi (2019) recommend that water quality be:

- Compared to ANZG (2018) guidelines for the slightly disturbed ecosystems.
- Compared to long terms site specific guidelines that need to be developed.

EGI (2019) recommended that if monitoring detects any adversely impacted groundwater or exceedance of guidelines, the sampling will need to be repeated and if previous results are confirmed, the reasons of any changes investigated.

4.1.2 WATER QUALITY TRIGGER RESPONSE

The commencement of mining water quality report will identify preliminary water quality trigger responses for each location. The trigger responses defined in the MMP will form the interim trigger responses for water quality.

5 Mitigation and Management

In addition to the trigger responses in the MMP, a key mitigation and management measure is likely to be the introduction of the Waste Discharge Licence (WDL). The details of this will be further explored in the WDL application.

In addition, EGI (2019) provides the following mitigation and management measures including, but not limited to:

- "Contaminated water generated in the underground development and potentially contaminated water from the in -pit waste rock dump (Prospect pit) will be managed by disposal in the Crosscourse pit during development and operation."
- "Seepage from Crosscourse Pit should be monitored downgradient of the pit, especially if the water level in the pit is allowed to reach 1 m below the spill level during operations. To facilitate this, a series of bores along the groundwater flowpath towards the River need to be established for ongoing monitoring of seepage quality."
- "The disposal of waste into the underground void will be managed so that PAF material is maintained saturated long term. This will begin at closure as the groundwater level starts recovering, but there will be potential for oxidation of some sulphide in void walls and backfill until these materials are completely inundated."
- "The backfilled underground void will remain saturated and any potential acid rock drainage will be limited. Management will therefore focus on maintaining saturation in the backfilled void. Groundwater monitoring downgradient of the void will help detect any potential contamination and provide early warning for any unexpected changes."
- "If the water level in the Crosscourse Pit is allowed to reach 188 m AHD this will (sic may) result in seepage to all dams and 13 L/s outflow via groundwater mainly reporting in the McKinlay River. To manage this, a system of interceptions may be needed to prevent the poor-quality water entering the shallow alluvium or river water. It is recommended to keep the water level in this pit at steady state of 173 mAHD to avoid this seepage."

6 References

ANZG (2018) Guidelines https://www.waterquality.gov.au/anz-guidelines.

EPA (2020) Draft EIS Comments.

EGI (2019) Union Reefs North Underground Project – Geochemical water quality modelling Northern Territory Mining Operations (NTMO) – Kirkland Lake Gold.

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GHD (2019A) Groundwater Study, Report for NT Mining Operations Pty Ltd – Kirkland Lake Gold North Underground Mine EIS.

GHD (2019B) Additional Groundwater Modelling, Report for NT Mining Operations Pty Ltd – Kirkland Lake Gold North Underground Mine EIS.

KLG (2019) Kirkland Lake Gold North Underground Mine Environmental Impact Statement (EIS).

URS (2002) Qualitative Risk Analysis of In-Pit Tailings Disposal Crosscourse Pit, Pine Creek. Unpublished report for AngloGold Australia Ltd, dated 2 April 2002. Report reference 44265-017-562 / 507-F4805.0.


KL
KIRKLAND LAKE GOLD

Appendix 12 – Geochemical Characterisation of Union Reefs North Drillcore Samples

Reference 3203/1327

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Union Reefs North Underground Project

Geochemical characterisation of waste rock and ore

December 2019

Environmental Geochemistry International

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FROM:	EGi
DATE:	17/12/2019
REFERENCE:	3203/1327
SUBJECT:	Union Reefs North Underground Project - Geochemical characterisation of waste rock and ore

AUTHOR(S):	Warwick Stewart, Russell Schumann		
DATE:	16/12/2019		
DOCUMENT NUMBER:	3203/1327	**VERSION:**	2.1
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Table of Contents

1. Introduction 1
2. Previous geochemical characterisation 3
3. Current geochemical characterisation 7
   - 3.1 Geology and core inspection 7
   - 3.2 Multi-element analysis results 16
   - 3.3 Geochemical test results 27
     - 3.3.1 ARD classification 27
     - 3.3.2 Waste segregation criteria 31
     - 3.3.3 Water and peroxide extractable elements 34
     - 3.3.4 Correlation of water and peroxide extractable elements with geochemical properties 37

APPENDIX A - ABA & NAG Test Results 47

APPENDIX B – Sequential NAG Test Results 53

APPENDIX C – ABCC Test Results 55

APPENDIX D1 – Water Extraction Test Results 58

APPENDIX D2 – Peroxide Extraction Test Results 61

List of Plates

Plate 1 Benign waste rock with scattered thin quartz-carbonate veins with associated pyrite. Hole URNNDD0100, 123.59 to 127.53m. 9

Plate 2 Benign waste rock with scattered thin quartz-carbonate veins with associated pyrite. Hole URNNDD0100, 184.30 to 188.07m. 9

Plate 3 Examples of thin quartz-carbonate veins with associated pyrite scattered within benign waste rock. Top: Hole URNNDD0100, 186.85m. Bottom: Hole URNNDD0105, 69.10m. 10

Plate 4 Ore zone with quartz-carbonate veins and moderate associated pyrite. Hole URNNDD0105, 241.25 to 245.40m. 10

Plate 5 Sharp contact of ore zone with waste rock. Hole URNNDD0105, 290.00 to 294.20m. 11

Plate 6 Significant pyrite in the waste rock zone close to the ore zone. Hole URNNDD0105, 233.00 to 237.20m. 11

Plate 7 Waste rock close to ore contact with significant pyrite. Hole URNNDD0105, 229.20m. 11

Plate 8 Zone of quartz-carbonate veins with low to moderate associated pyrite within waste rock. Hole URNNDD0100, 238.80 to 242.50m. 12

Plate 9 Ore zone with pyrite, sphalerite and galena. Hole URNNDD0105, 239.20m. 12

Plate 10 Ore zone with pyrite and arsenopyrite. Hole URNNDD0105, 239.20m. 13

Plate 11 Quartz carbonate veining with possible ankerite and Mn containing carbonate. Hole URNNDD0100, 65.60m. 13

Plate 12 Quartz carbonate veining with possible ankerite and Mn containing carbonate. Hole URNNDD0100, 104.15m. 13

Plate 13 Quartz carbonate veining in oxide zone with no sulphide but iron oxide after pyrite. Hole URNNDD0061, 18.50m. 14

Plate 14 Quartz carbonate veining in oxide zone with no sulphide but iron oxide after pyrite. Hole URNNDD0061, 51.00m and 51.85m. 14

Plate 15 Weakly oxidised interval within the oxide zone showing minor thin pyrite veining. Hole URNNDD0061, 40.60m. 15

Plate 16 Typical transition zone showing pyritic zones. Hole URNNDD0061, 57.71 to 61.61m. 15

Plate 17 Iron oxide after pyrite in transition zone. Hole URNNDD0055, 54.60m. 15

List of Figures

Figure 1: NAGpH versus total S for the Union Reefs 2011 compiled dataset. 4

Figure 2: Box plot showing the distribution of ICP S split by rock type. Box plots show 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles and means. 5

Figure 3: Box plot showing the distribution of ICP As split by rock type. Box plots show 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles and means. 6

Figure 4: Plan showing drillhole traces of holes (URNDD0055, URNDD0061, URNDD0100 and URNDD0105) selected for inspection and geochemical testing relative to ore zones and underground development. 8

Figure 5: Downhole concentrations of S (left) and As (right) for hole URNDD0100 17

Figure 6: Downhole concentrations of Pb (left) and Zn (right) for hole URNDD0100 18

Figure 7: Downhole concentrations of Co (left) and Cu (right) for hole URNDD0100 19

Figure 8: Downhole concentrations of Mn (left) and Ni (right) for hole URNDD0100 20

Figure 9: Downhole concentrations of S (left) and As (right) for hole URNDD0105 21

Figure 10: Downhole concentrations of Pb (left) and Zn (right) for hole URNDD0105 22

Figure 11: Downhole concentrations of S (left) and As (right) for hole URNDD0061 23

Figure 12: Downhole concentrations of Pb (left) and Zn (right) for hole URNDD0061 24

Figure 13: Downhole concentrations of Co (left) and Cu (right) for hole URNDD0061 25

Figure 14: Downhole concentrations of Mn (left) and Ni (right) for hole URNDD0061 26

Figure 15: Initial ARD classification plot for development waste and ore samples from holes URNDD0055, URNDD0061, URNDD0100 and URNDD0105. Samples classified as UC and subjected to further testing are indicated by the red arrows and circle. 28

Figure 16: ARD classification plot for development waste and ore samples from holes URNDD0055, URNDD0061, URNDD0100 and URNDD0105 including results from sulphur speciation analysis, sequential NAG testing and ABCC testing. 30

Figure 17: ARD classification plot for development waste samples from holes URNDD0055, URNDD0061, URNDD0100 and URNDD0105 highlighting ARD classifications based on detailed geochemical testing. 33

Figure 18: Box plots for pH measured in water and peroxide extracts for 60 samples tested for water and peroxide leachability. The red squares show the pH measured in Crosscourse pit in July 2019. 35

Figure 19: Box plots for metals and sulphate concentrations measured in water (top) and peroxide (bottom) extracts for 60 samples tested for water and peroxide leachability. The red squares show the concentrations measured in Crosscourse pit in July 2019. 36

Figure 20: Concentrations of metals in water extracts as a function of extract pH 39

Figure 21: Concentrations of metals in water extracts as a function of bulk concentration. Samples are split by ARD classification 40

Figure 22: Concentrations of metals in water extracts as a function of bulk concentration. Samples are split by oxidation. Ore samples are included separately. 41

Figure 23: Concentrations of sulphate in water extracts as a function of extract pH (top left), bulk concentration split by ARD classification (top right) and bulk concentration split by oxidation (bottom left). Ore samples are included separately. 42

Figure 24: Concentrations of metals in peroxide extracts as a function of extract pH (NAGpH) 43

Figure 25: Concentrations of metals in peroxide extracts as a function of bulk concentration. Samples are split by ARD classification 44

Figure 26: Concentrations of metals in peroxide extracts as a function of bulk concentration. Samples are split by oxidation. Ore samples are included separately. 45

Figure 27: Concentrations of sulphate in peroxide extracts as a function of NAGpH (top left), bulk concentration split by ARD classification (top right) and bulk concentration split by oxidation (bottom left). Ore samples are included separately. 46

List of Tables

Table 1: Preliminary classification of rock types from holes URNDD0100, URNDD0105 and URNDD0114 based on ICP analysis results 5

Table 2: Percentage by volume of development waste (n = 227) and ore (n = 22) classified as NAF, PAF and UC based on initial geochemical test results 27

Table 3: results for sulphur speciation for samples classified as UC based on initial geochemical test results 29

Table 4: Percentage by volume of development waste (n = 227) and ore (n = 22) classified as NAF, PAF-LC, PAF and UC based on detailed geochemical test results 30

Table 5: Percentage by volume of oxide (n = 38), transitional (n = 8) and fresh (n = 181) wastes classified as NAF, PAF-LC, PAF and UC based on detailed geochemical test results 31

Table 6: Percentage by volume of development waste classified as NAF or PAF based on Total S and NAGpH. Classifications based on detailed geochemical test results are included for comparison. 32

Executive Summary

Environmental Geochemistry International Pty Ltd (EGi) have been commissioned by Kirkland Lake Gold Northern Territory Mining Operations (NTMO) to carry out geochemical assessment of the Union Reefs (UR) North Underground Mine.

The Union Reefs North Underground Mine will be accessed via a portal and decline developed from within the existing Prospect Pit. The underground mine plan includes the development of the orebody to around 220 m below ground surface.

Approximately 291,000 tonnes of waste rock will be stored within Prospect South pit of which approximately 50,000 tonnes will remain in situ as surface infrastructure (access to waste dump for reclamation of waste backfill) and 241,000 tonnes will be temporarily stockpiled and progressively returned underground as backfill. A small water storage pond (sump) will be constructed to collect runoff from Prospect South pit, to be pumped into the main water storage pond in Prospect North pit, which in turn will be dewatered during mining by pumping to Crosscourse pit, so that runoff from the waste rock will ultimately be sent to Crosscourse pit.

Mining activities will expose waste rock and ore (temporarily in most cases) to the atmosphere which potentially could result in the generation of acid rock drainage (ARD) or neutral mine drainage (NMD) that might impact water quality in permanent water bodies at the Union Reefs Project Area (URPA) and in nearby waterways

The potential for ARD or NMD was identified as a key issue to be addressed in the EIS prepared for the proposed UR project. In particular, the NT EPA identified that potential impacts and risks to inland water environmental quality might arise from surface storage of potentially acid forming (PAF) waste rock, use of water with high arsenic concentrations, and post closure water quality in Prospect and Crosscourse mine pit lakes.

This report describes results from a geochemical characterisation program designed to address the EIS terms of reference, and in particular, issues raised under the Inland water environmental quality key environmental factor relating to impacts from ARD and saline drainage.

This report supersedes an earlier version (Union Reefs North Underground Project – Geochemical characterisation of waste rock and ore, Ref. 3202/1327, 19/11/2019) which was included as Appendix F in the Draft Environmental Impact Statement “NT Mining Operations Pty Ltd Union Reefs North Underground Mine”. It contains what was included in the previous version in its entirety, but also has added sections (Sections 3.3.3 and 3.3.4) that present the results on water and hydrogen peroxide extraction experiments, which were not available at the time of submission of the Draft EIS. The added results do not change any of the findings presented in the previous report included in the Draft EIS, but rather validate the waste segregation criteria and geochemical classifications assigned to the various waste rock types and ore.

Samples from drill core which represent fresh underground rock development materials and the oxidation profile of the development waste were selected and these samples were prepared and multi-element ICP analyses conducted. As samples representing process residues were not available, ore samples, principally from lode 400, were selected to represent tailings materials from processing of the Prospect ore and were included in the test program.

Using the ICP results for screening, a sub-set of samples from the sources mentioned above was selected for detailed geochemical assessment. The sub-set included samples representing waste rock, low grade ore and ore, and samples were chosen to represent the variation in geochemical properties, including sulphur, key metal/metalloids associated with sulphide mineralisation (including those elements of concern listed by the DENR in recent feedback), carbonate content and oxidation status.

The geochemical characterisation program involved a combination of standard and specialised testing. All samples were analysed for pH and EC, acid neutralising capacity (ANC), net acid producing potential (NAPP) and single addition net acid generation (NAG). Following completion of these tests, further specialised testing was carried out as required on selected samples to resolve any uncertainties in sample classifications and to provide more information on particular geochemical characteristics. Specialised tests included sulphur speciation (total S, sulphate S, sulphide S), carbon speciation (total C, organic C, inorganic C), sequential NAG tests, acid buffering characteristic curves (ABCC), and multi-element testing of water extracts and NAG liquors.

The results of these additional tests were used to better define total acid generating capacities, relative reactivities of sulphides and neutralising components, and ARD and NMD chemistries. They also provide input data for the geochemical water quality prediction modelling that is part of other studies being conducted and which will be reported separately.

Prior to geochemical testing, the core from drill holes selected for testing was inspected so that test results could be supported by geological observations. Key findings of the drill core inspection were as follows:

- The vast majority of development waste rock is likely to be NAF and will not require special handling.
- The oxide zone appears to be devoid of significant pyrite, and it is likely that all materials above the logged contact with transition can be assumed to be NAF without the need for routine ARD testing.
- Sulphidic zones are distinct and discrete, and PAF materials should be readily identifiable through geological logging.
- Sulphidic and PAF rock appears to be mainly associated with the ore zones, which means exposed stopes and drives close to the ore will be the main potential sources of ARD from underground development.
- The slow reacting nature of carbonate mineralisation (possibly ferroan) may be a consideration in the lag times for PAF rock to acidify if exposed to atmospheric conditions.
- The key sulphide minerals present at the Prospect deposit are pyrite, sphalerite, galena and arsenopyrite, and hence in addition to acid potential, geochemical assessment will need to consider the potential for Zn, Pb and As mobilisation.
- There may also be potential for mobilisation of Mn as a consequence of acid generated by pyrite oxidation reacting with Mn-carbonate.

Preliminary geochemical testing (S, ANC, NAPP and NAG) was subsequently undertaken on 170 fresh rock samples representing decline development waste and 22 ore samples. Testing of another 57 samples which mainly represent oxidised waste (35 samples) from the decline development, was also conducted. Based on the preliminary tests, 90% of development waste samples were classified as non-acid forming (NAF) and 6% as potentially acid forming (PAF). Classification of the remaining samples was uncertain based on preliminary test results and so further detailed geochemical testing was conducted on these samples.

Following detailed testing, ARD classification was made for samples previously classified as uncertain. To further assist with mine waste planning the PAF classification was also split to differentiate PAF waste with a low capacity for acid generation (PAF-LC) from PAF waste with significant acid potential. PAF-LC was defined as having a $NAG_{pH4.5}$ less than 5 kg H_2SO_4/t, and PAF as having a $NAG_{pH4.5}$ above 5 kg H_2SO_4/t.

Based on the test samples, it is expected the majority of waste will be NAF or only marginally PAF. Only approximately 5% of the development waste will produce significant acid and metalliferous leachate. The results for ore samples suggest around 20% will be clearly PAF, with the remaining ore NAF or marginally PAF.

A number of criteria for segregation of NAF and PAF wastes were assessed. They included the use of a sulphur cut-off, a NAGpH cut-off, and/or geological controls. Geological controls based on drill core geological logs were included because visual inspection of the core suggested sulphide mineralisation was mainly associated with quartz veining. The results of this analysis indicated that rocks containing quartz carbonate veining were all NAF, while rocks containing veins of the other types were variously classified as NAF, PAF-LC or PAF, indicating no clear geological control for ARD classification, other than quartz carbonate veins as NAF. It was concluded from the geochemical test results that the following criteria could be used to reliably segregate development waste as either NAF or PAF:

- NAF
  - S ≤0.3%, or
  - Oxide, or
  - Quartz carbonate veins, or
  - S >0.3% *AND* NAGpH ≥4.5
- PAF
  - S >0.3% *AND* NAGpH <4.5

Multielement assay data from fresh rock indicate strong correlations between sulphur content and As, Pb and Zn concentrations, indicating the presence of arsenopyrite, galena and sphalerite as identified during visual inspection of the core. It is evident there are sections of elevated sulphur within both the development waste zone as well as in the intersection with the lode 400 ore body. The sulphidic waste zones appear to be mainly associated with the same quartz carbonate veining that occurs in the ore zones, but without gold mineralisation. Multielement assay data indicate that sulphur concentrations will be low within the oxide zone, consistent with replacement of pyrite with iron oxides as observed during visual inspection of the core. As such, it is expected that oxide waste produced during development of the decline will be NAF and therefore will not be a source of low pH drainage.

The geochemical program also included batch water and hydrogen peroxide extraction tests to assess the potential for mobilisation of metals and metalloids from mined materials. Batch water extracts provide an indication of elemental solubilities within recently mined rock, while peroxide extractions provide information of metal mobility for sulphidic materials that undergo oxidation. These two tests represent the two extremes of the leaching process. As waste rock at Union Reefs North will only be stored on the surface for a short period of time, and residual ore remaining in stopes will only be exposed for a relatively short time prior to inundation, it is expected any sulphidic material will only undergo partial oxidation during surface storage, hence the potential for metals leaching will lie somewhere between the findings of the tests representing the two extremes.

A sub-set of 60 samples were selected for leach testing from the original set of 249 samples included in the geochemical assessment program. The selected samples covered the range of oxidation, rock types, bulk elemental composition and ARD classes, to provide as representative a sample set as possible.

The results from water and peroxide extraction tests suggest that seepage from surface-stored waste rock will likely have neutral pH and relatively low salinity. As seepage from development waste will be captured and pumped to the Prospect North pit, and from there into the Crosscourse pit, the chemistry of extracts considered representative of seepage was compared with recent Crosscourse pit water quality. The pHs of both water and peroxide extracts were, on average, similar to that of Crosscourse pit water, indicating that disposal of seepage from the waste rock stored in Prospect South pit during mining into Crosscourse would be unlikely to cause any shift in the pH of pit water. Results also indicate that the salinity of any seepage from the waste rock will be lower than that of Crosscourse pit water (current EC around 2500 μS/cm) and so disposal of seepage to Crosscourse will not adversely impact salinity levels in the pit water.

There were measurable, but low concentrations of Al, As, Mn and sulphate in the water extracts of most samples, but the concentrations of most other metals were at, or below, the limits of analytical detection. In the peroxide extracts, metal concentrations were generally about an order of magnitude higher than in the water extracts, with the exception of Mn and Zn which were about 100 times higher in the peroxide extracts. Sulphate concentrations in the peroxide extracts were about 50-fold more than those in the water extracts.

Comparison of metal concentrations in the water and peroxide extracts with those in Crosscourse pit water, suggests that metal concentrations in seepage from the waste rock stockpile will be similar to that in pit water. Given the very low volumes of seepage water that will be pumped to Crosscourse pit relative to the volume of pit water, there should be little, if any, potential for seepage to adversely impact Crosscourse pit water quality.

Results suggest that walls of mined stopes could contain some PAF material, which, prior to backfill and groundwater rebound, will be exposed to oxidative conditions. The peroxide extraction tests indicate that leachate from PAF rock might contain elevated concentrations of leachable metals such as Al, Cr, Cu, Fe, Mn, Ni, Pb and Zn. These metals may be mobilised by inflow of groundwater through any PAF rocks in the underground workings, potentially affecting the quality of the groundwater. Post closure any groundwater entering the Prospect North pit from the groundwater in the mine will not be returned to Crosscourse pit with

subsequent dilution of elevated concentrations of metals. The impact of potentially poorer quality groundwater from the closed mine on surrounding groundwater and pit lake water will be examined using geochemical water quality prediction modelling and reported separately.

The results from the water and peroxide extraction tests also show that the elemental composition of development waste itself is not a reliable predictor of seepage water quality. Instead, the results indicated that the NAF/PAF criteria as defined above are better predictors of likely seepage quality, with the poorest quality seepage associated with PAF waste rock and pH conditions the key control. This included arsenic, and, as a result, the preliminary arsenic in solid classification criteria cut-off of 100 mg/kg was removed.

Given the low volume of PAF waste that will be mined and temporarily stored at the surface, selective handling and isolation (e.g. encapsulation with NAF waste), should readily achieve mitigation of higher metal concentrations in seepage from PAF waste. Also, the use of oxide materials for construction of the permanent portal bench should not result in contaminated run-off from the portal post closure of the underground operation, as these materials appear to be essentially inert.

1. Introduction

Environmental Geochemistry International Pty Ltd (EGi) have been commissioned by Kirkland Lake Gold Northern Territory Mining Operations (NTMO) to carry out geochemical assessment of the Union Reefs (UR) North Underground Mine.

The Union Reefs North Underground Mine will be accessed via a portal and decline developed from within the existing Prospect Pit. The underground mine plan includes the development of the orebody to around 220 m below ground surface (980 mRL).

Approximately 291,000 tonnes of waste rock will be stored within Prospect South pit of which approximately 50,000 tonnes will remain in situ as surface infrastructure (access to waste dump for reclamation of waste backfill) and 241,000 tonnes will be temporarily stockpiled and progressively returned underground as backfill. A small water storage pond (sump) will be constructed to collect runoff from Prospect South pit, to be pumped into the main water storage pond in Prospect North pit.

Ore will be trucked directly from the portal to the Run of Mine (ROM) pad, and then fed into the processing plant crusher using the existing infrastructure and equipment in place.

The URPA processing plant is only 2 km from the proposed underground mine. This plant will treat blended ore from the Cosmo Underground Mine and Union Reefs North underground mine. The URPA Processing Plant recovers gold by gravity concentration and carbon in leach (CIL) technology. Tailings generated from the URPA Processing Plant are deposited into the Crosscourse Pit. The use of Crosscourse pit for tailings deposition is consistent with previous authorisations.

Each of the above activities will expose either waste rock or ore (temporarily in most cases) to the atmosphere where there is the potential for oxidation of any sulphidic material present within the waste and ore, with subsequent generation of acid and metalliferous drainage (AMD, also known as acid rock drainage or ARD) or neutral mine drainage (NMD). Waste material includes rock removed during decline development and pit wall rock exposed following pit dewatering. Ore material includes ore mined for processing and process wastes (tailings) and residual ore remaining in stopes following removal of the ore. Generation of ARD or NMD has the potential to impact water quality in permanent water bodies at URPA and in nearby waterways

The potential impact for ARD or NMD has been identified as a key issue to be addressed in the EIS being prepared for the Proposal. In particular, the NT EPA has identified that potential impacts and risks to inland water environmental quality from the Proposal arise from surface storage of potentially acid forming (PAF) waste rock, use of water with high arsenic concentrations, and post closure water quality in Prospect and Crosscourse mine pit lakes.

The EIS terms of reference include:

For each potential impact identified below, provide evidence to quantify the expected impact as well as associated risks:

potential impacts on groundwater from ARD and saline drainage from surface waste rock storage and the ability of the waste rock classification system to identify waste rock that may produce ARD, saline drainage and all contaminants of concern

- potential impact on water quality during and post mining from the permanent surface storage of waste rock used as the bench in the Prospect Pit

any passive discharge or seepage of non-benign contaminants (including from ARD and saline drainage), including:

- surface waste rock storage
- exposure of historic mining material through dewatering Prospect Pit and/or lowering water levels in other pit lakes and dams

Discuss changes to water quality from the Proposal, including:

the release of water from the Proposal sites through unintended loss of control/containment or intended discharge

provide consideration in the water balance for:

- alternative locations for the transfer of better quality water from pit lakes such as Prospect North
- immediate and long-term water quality and discharge requirements across all water bodies affected by the Proposal

predictions associated with water quality and contaminants of concern between connected mine pit lakes and existing dams with consideration of:

- any recharge of the Prospect Pit and underground mine due to connection with Dam A via Lady Alice and Union North pit lakes
- lowering of adjacent pit lake and dam levels due to connectivity with the Prospect Pit and underground mine, and any potential for non-benign waste rock present in the walls and floor to be exposed thus oxidise and produce acid, saline and/or metalliferous drainage

This should be supported by conceptual site models describing sources of potential contaminants, mechanisms for their release, transport pathways, receptors, and fate of any potentially contaminated waters from the Proposal, with reference to the NT EPA Guidelines on Conceptual Site Models (NT EPA 2013a). A conceptual site model should be provided for each phase of the Proposal, including:

development, including any dewatering of existing pits/storages

during mining/processing, including any dewatering

post-mining at Prospect Pit, while pit lake is filling

at closure

beyond the expected time of stabilisation

This report describes results from a geochemical characterisation program designed to address issues raised by the NT EPA[1] which are detailed above in response to NTMO's Notice of Intent submitted for the UR North Underground. In particular, the program is designed to address issues raised under the Inland water environmental quality key environmental factor relating to impacts from ARD and saline drainage. The report provides a summary of previous geochemical test work conducted by EGi at the UR Project Area (URPA), a detailed outline of the test program conducted, and the results obtained.

[1] ntepa Statement of Reasons NTMO – Union Reefs North Underground Mine 7 August 2019.

2. Previous geochemical characterisation

EGi was involved with the Union Reefs Mine (Crosscourse and Union Reef North) from 1993 to mid-2011 and most of the work carried out was documented in the following reports:

- *EGi (July 1993): Union Reefs Project – Environmental geochemistry of waste rock, marginal ore and process residues, Document No. 3203/160.*

  The study involved environmental geochemical testing of 35 waste rock and tailings samples from the Crosscourse and Union North Pits.

- *EGi (January 1995): Union Reefs Gold Mine – Development of an operational monitoring programme for environmental management of waste rock, Document No. 3203/1/265.*

  The study involved environmental geochemical testing of 68 waste rock and ore samples from the Union Reefs deposit, and development of a waste management protocol. The test work focussed on the identification of key geochemical parameters and associated cut-offs allowing discrimination between non-acid forming (NAF) and potentially acid forming (PAF) materials, as well as identification of materials with potential for arsenic leaching.

- *EGi (June 1998): Waste rock geochemistry review – Site visit report, Document No. 3203/374.*

  This report reviews the laboratory protocol used to segregate waste rock based on its inherent ARD potential.

- *EGi (July 2011): Site visit report – ARD rock type classification, Document No. 5203.*

  This report summarises the geochemical test work results for 71 waste rock samples previously tested for Union Reefs, as part of a broad tenement ARD review.

In addition, leach column test work was conducted on marginal ore and process residue to assess the potential for ARD and metal/metalloid leaching, and in particular arsenic, from the Union Reefs Project (1993).

Static test work results from previous investigations suggested that oxide/weathered waste rock was NAF, had negligible sulphur (S) content, and low acid neutralising capacity (ANC). Transitional and fresh materials had variable potential to generate ARD. It was noted that waste rock close to ore intervals was more likely to be acid producing compared to fresh waste rock away from ore horizons. Similar conclusions were reached for ore and low-grade ore, whereby oxide ore was unlikely to be acid generating, while primary ore had the potential to oxidise and generate ARD. Kinetic test work confirmed the potential for arsenic (and zinc) leaching from marginal ore and tailings. None of the columns produced low pH leachates.

These static and kinetic studies concluded that the key environmental hazard for the deposits at Union Reefs was arsenic (and metal) leaching, rather than ARD, due to the elevated arsenic in waste rock and ore, relatively low S in the samples tested, and moderate acid neutralising capacity in fresh waste rock. However, these conclusions were preliminary due to the limited number of samples tested.

The ARD test results for 71 waste rock samples compiled as part of the 2011 EGi report showed that NAGpH provided a reliable discriminator of NAF and PAF ARD types for Union Reefs, and site criteria based on NAGpH were developed in which samples with NAGpH ≥ 4.5 were classified NAF, and those with NAGpH < 4.5 were classed as PAF. The results also indicated that S could also be used to classify samples, and although not as discriminating as NAG, it would be suitable as a first pass classification in the absence of more detailed geochemical test data.

Figure 1 is a plot of NAGpH versus total S for the 2011 dataset, which shows that a S cut-off of ≤ 0.3%S excludes all samples with a NAGpH < 4.5, and hence can be used to reliably classify samples as NAF. Note that these S criteria are more conservative, in that a proportion of samples with S > 0.3% also have a NAGpH ≥ 4.5 and are likely to be NAF. These S criteria were applied to the ICP S from holes URNDD0100, URNDD0105 and URNDD0114 as a preliminary guide to the proportion of NAF and PAF until more detailed ARD testing was carried out.

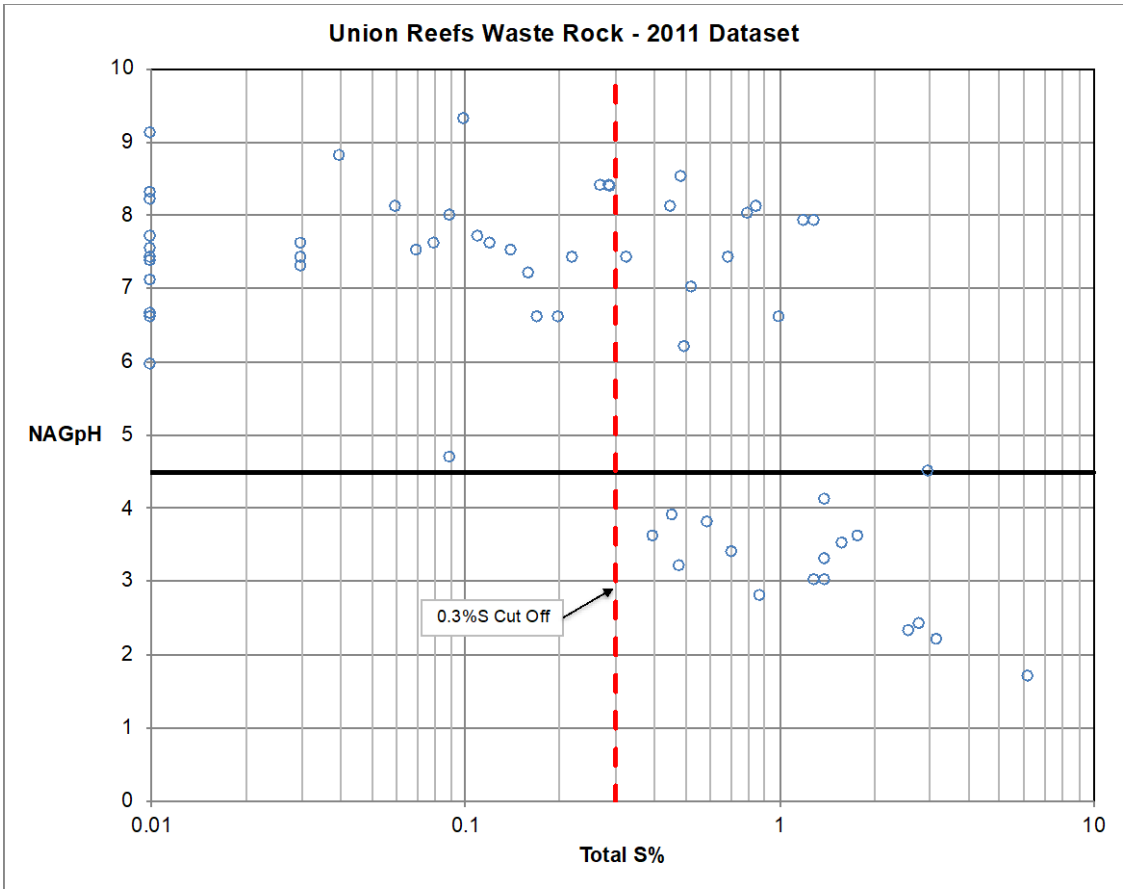


Figure 1: NAGpH versus total S for the Union Reefs 2011 compiled dataset.

The previous assessments also provided arsenic criteria, in which only NAF materials with <100mg/kg arsenic were deemed suitable for placement in the outer 10m of the waste rock dump. Again, these arsenic criteria were applied to the ICP results as a preliminary guide to arsenic mobilisation potential.

In 2018, EGi were provided with multi-element ICP analysis results for drill cores (holes URNDD0100, URNDD0105 and URNDD0114) that were specifically drilled to capture the geological variation of rock types to be excavated from the Union Reefs North Underground Mine.

Preliminary S and arsenic criteria based on the earlier studies were applied to the ICP test results to classify the samples as follows:

NAF-Low As =	S ≤ 0.3% and As < 100 mg/kg
NAF-Elevated As =	S ≤ 0.3% and As ≥ 100 mg/kg
PAF=	S > 0.3%

Results showed that the majority of S values are 0.3% and less, with the elevated S in distinct zones both associated with the ore and away from the ore.

A full set of arsenic results were available for hole URNDD0100, with selected intervals of arsenic results available URNDD0105 and URNDD0114. The elevated arsenic zones generally corresponded to elevated S zones. Consequently, management of elevated S materials would also account for most material with elevated arsenic.

Table 1 gives the proportions of geochemical rock types for development waste and ore materials, based on sample interval length, and the assay results for samples where both S and arsenic contents were available.

Table 1: Preliminary classification of rock types from holes URNDD0100, URNDD0105 and URNDD0114 based on ICP analysis results

Material Type	NAF-Low As	NAF-Elevated As	PAF
Development Waste	79%	11%	10%
Ore	12%	24%	64%

These preliminary results suggested that the majority of development waste to be extracted from the Union Reefs North Underground Mine will be benign, with potentially problematic materials only accounting for approximately 20% of waste using the conservative criteria applied.

Figure 2 shows a box plot of the distribution of ICP S by rock type. The plot shows that the higher S samples were generally vein, fault and shear rock types. Ninety five percent of samples from other rock types contained less than 0.5%S. This is consistent with the earlier geochemical work and observations by site personnel during core logging that sulphidic zones were primarily associated with quartz veining.

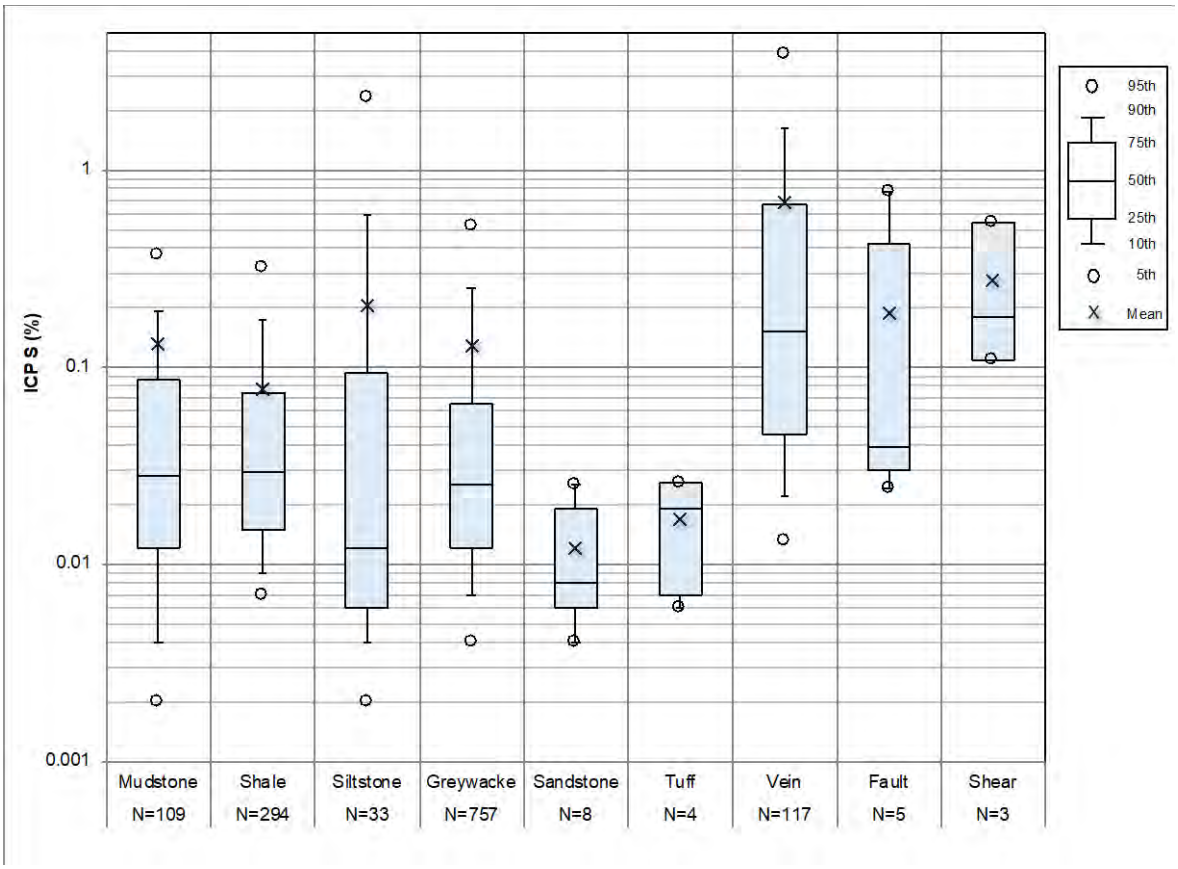


Figure 2: Box plot showing the distribution of ICP S split by rock type. Box plots show 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles and means.

Figure 3 is a box plot of the distribution of arsenic by rock type. As with sulphur, high arsenic contents mainly occurred in vein samples, supporting the observation that high arsenic zones correspond with elevated S.

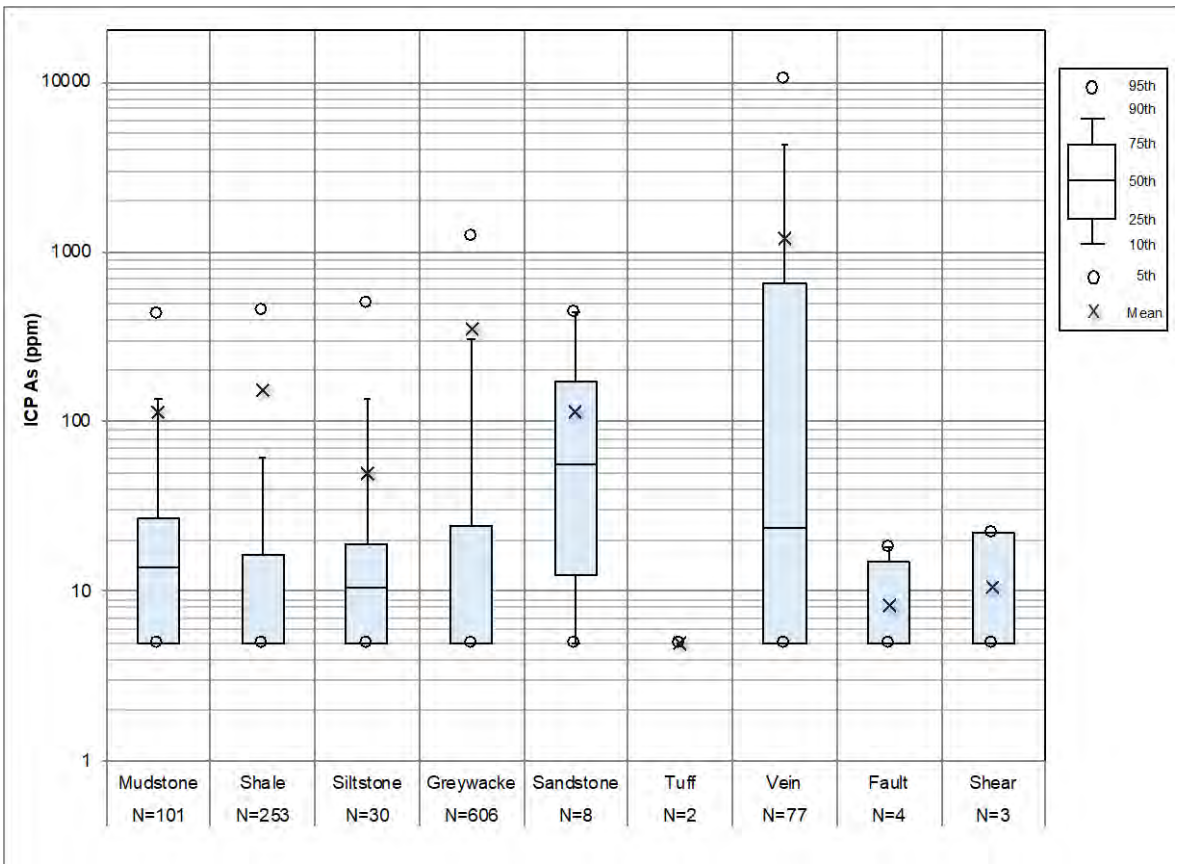


Figure 3: Box plot showing the distribution of ICP As split by rock type. Box plots show 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles and means.

The preliminary results suggest that the majority of materials to be extracted from the Union Reefs North Underground Mine development will be NAF with low As. If it is conservatively assumed that materials with S greater than 0.3%S and/or arsenic greater than 100 mg/kg are potentially problematic, then preliminary investigations suggest these materials would account for approximately 20% of waste.

Comparison of S and arsenic distribution with geological descriptions indicates that potentially problematic materials could be identified and segregated based on geological observation, with vein materials being the dominant contributor. The low proportion of potentially problematic materials means there will be considerable flexibility in selective waste handling.

However, because of the limited numbers of samples and under-representation of some rock and materials types, particularly oxides, it was concluded there were still uncertainties in the ARD and metal/metalloid leaching potential of the development materials, and further broader geochemical investigations were recommended.

3. Current geochemical characterisation

To address uncertainties in the ARD and metal/metalloid leaching potential of the development materials and ore, further broader geochemical investigations were undertaken during the current program. They included:

- Selection of key drill holes and samples across the Union Reefs North Underground Mine development for geochemical testing to define key geochemical rock types and determine their geochemical properties, including capacities, reaction rates and lag times.
- More detailed assessment of the potential for leaching of metals/metalloids from oxide, transition and fresh materials, with particular emphasis on arsenic but including other metals of potential concern (e.g. Co, Cu, Ni, Pb, Sb, Zn).
- Refinement of the current conservative segregation criteria based on the findings of these investigations to facilitate selective handling of waste based on geochemical characteristics, including acid potential, salinity and potential for metal/metalloid leaching. These criteria may be a combination of geology and key indicator assay values.

Full ICP multi-element scans of samples from holes URNDD0100, URNDD0105, URNRC0114, URNDD0186, URNDD0188 and URNDD0189 had become available at the time of undertaking the current work, which represent the fresh underground rock development materials. In addition, samples representing the oxidation profile of the development waste were selected from older holes (drilled 2012) URNDD0055 and URNDD0061, and these samples were prepared and multi-element ICP analyses conducted. Because of the lack of available metallurgical samples, ore samples, principally from lode 400, were selected to represent tailings materials from processing of the Prospect ore and were included in the test program.

Using the ICP results for screening, a sub-set of samples from the sources mentioned above was selected for detailed geochemical assessment. The sub-set included samples representing waste rock, low grade ore and ore, and samples were chosen to represent the variation in geochemical properties, including sulphur, key metal/metalloids associated with sulphide mineralisation (including those elements of concern listed by the DENR in recent feedback), carbonate content and oxidation status.

The geochemical characterisation program involved a combination of standard and specialised testing. All samples were analysed for pH and EC on water extracts, acid neutralising capacity (ANC), net acid producing potential (NAPP) and single addition net acid generation (NAG). Following completion of the preliminary geochemical tests, further specialised testing was carried out as required to resolve any uncertainties in sample classifications and to provide more information on particular geochemical characteristics. Specialised tests included sulphur speciation (total S, sulphate S, sulphide S), carbon speciation (total C, organic C, inorganic C), sequential NAG tests, acid buffering characteristic curves (ABCC), and multi-element testing of water extracts and NAG liquors. The results of these additional tests conducted on selected samples were used to better define total acid generating capacities, relative reactivities of sulphides and neutralising components, and ARD and NMD chemistries. They will also provide input data for the geochemical water quality prediction modelling that is part of other studies being conducted for the draft EIS and reported separately.

3.1 Geology and core inspection

The Prospect deposit at Union Reefs occurs within the Burrell Creek Formation, with the host rock primarily comprising greywacke interbedded with shale. The gold mineralisation occurs within a variety of quartz-carbonate-sulphide vein settings, including stockworks, sheeted veins and lode style quartz reefs. Sulphides associated with the gold mineralisation include pyrite, arsenopyrite, galena, sphalerite, marcasite and pyrrhotite. Gangue minerals comprise, quartz, chlorite, carbonate and albite. There is broad chlorite alteration, with local more intense chlorite and sericite alteration associated with quartz carbonate veins.

Drill core from four holes was examined on site in conjunction with site geologists. Holes URNDD0055 and URNDD0061 were laid out to view representative development materials through the oxidation profile, and

URNDD0100 and URNDD0105 to represent the variability of fresh materials either side of the ore zones. Locations are shown in Figure 4.

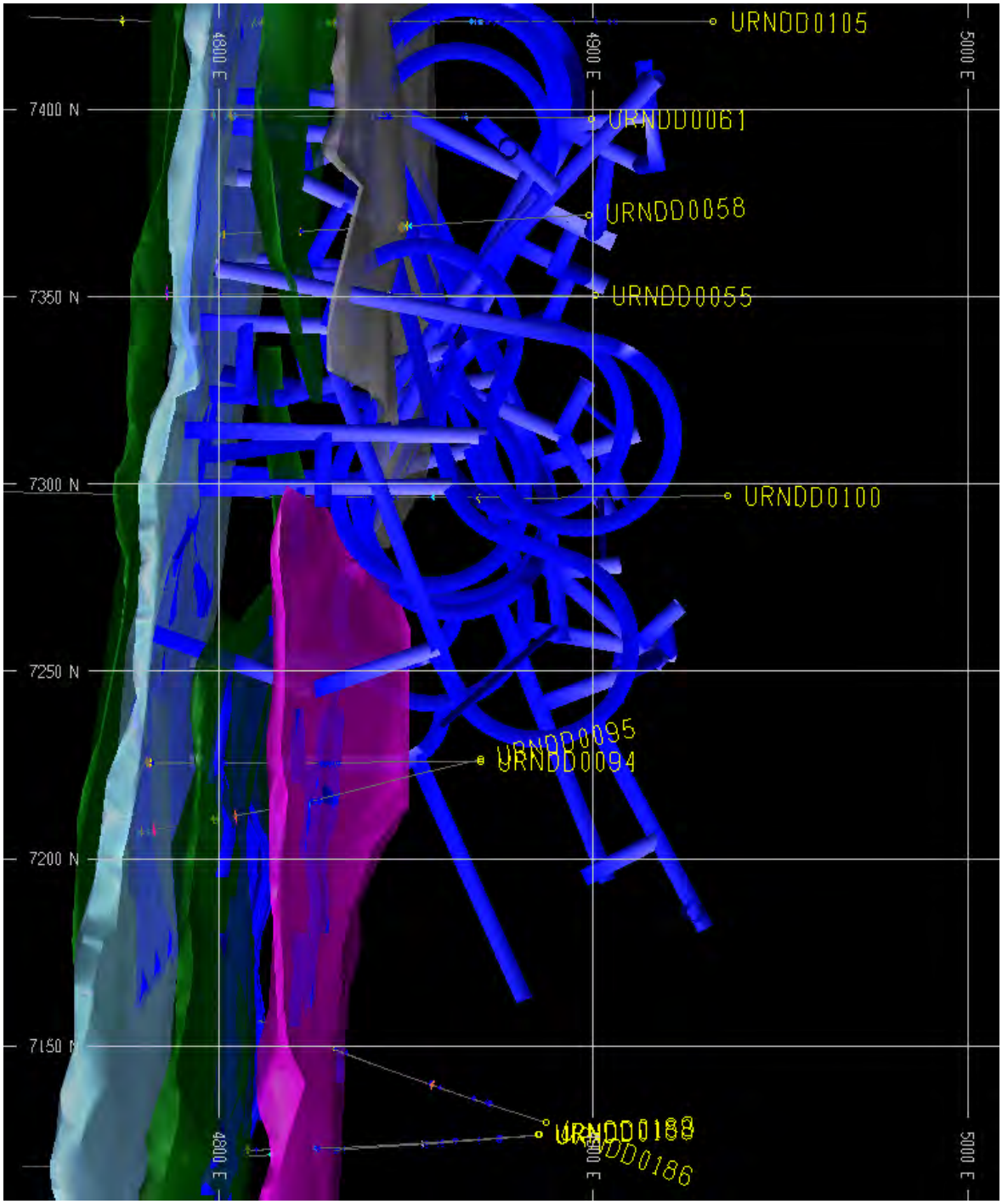


Figure 4: Plan showing drill hole traces of holes (URNDD0055, URNDD0061, URNDD0100 and URNDD0105) selected for inspection and geochemical testing relative to ore zones and underground development.

Fresh core through the development waste rock envelope was primarily benign, with scattered minor thin pyrite veins associated with quartz carbonate veins (Plate 1 to Plate 3). Moderate to strongly sulphidic zones were associated with the quartz-carbonate veining that also hosts the gold mineralisation. These zones were

visually distinct (Plate 4), generally with sharp boundaries (Plate 5), and usually in ore zones (Plate 4) or in close proximity to ore zones (Plate 6 and Plate 7), but absent in the vast majority of the materials representative of development waste rock. Where present in the development waste rock zone, the sulphidic zones were isolated and visually identifiable due to the strong quartz vein association (Plate 8). Pyrite was the dominant sulphide observed (Plate 7), but sphalerite and galena (Plate 9) and arsenopyrite (Plate 10) were common. It is understood that chalcopyrite is relatively rare, and none was observed during the core inspection.



Plate 1 Benign waste rock with scattered thin quartz-carbonate veins with associated pyrite. Hole URNNDD0100, 123.59 to 127.53m.

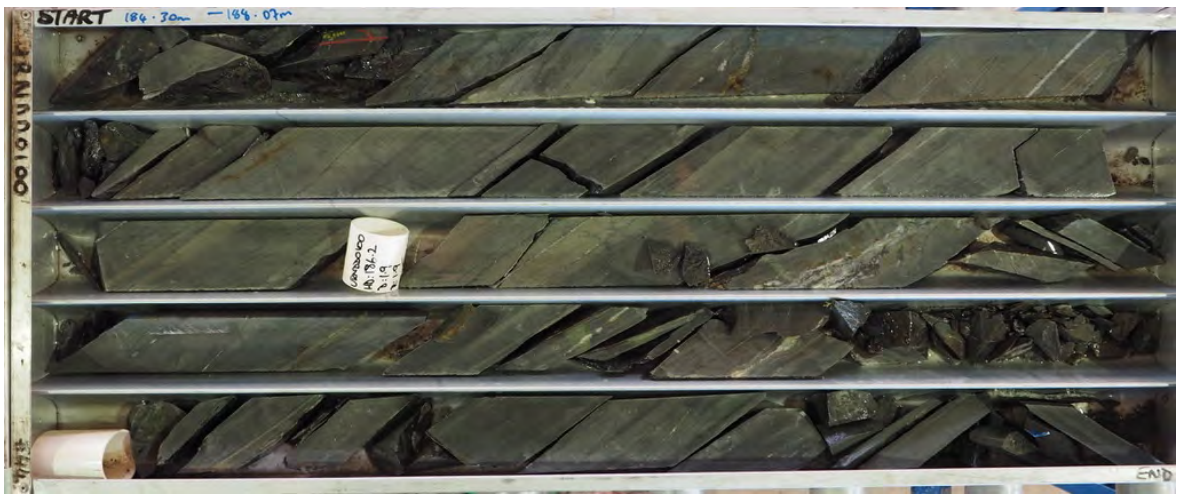


Plate 2 Benign waste rock with scattered thin quartz-carbonate veins with associated pyrite. Hole URNNDD0100, 184.30 to 188.07m.

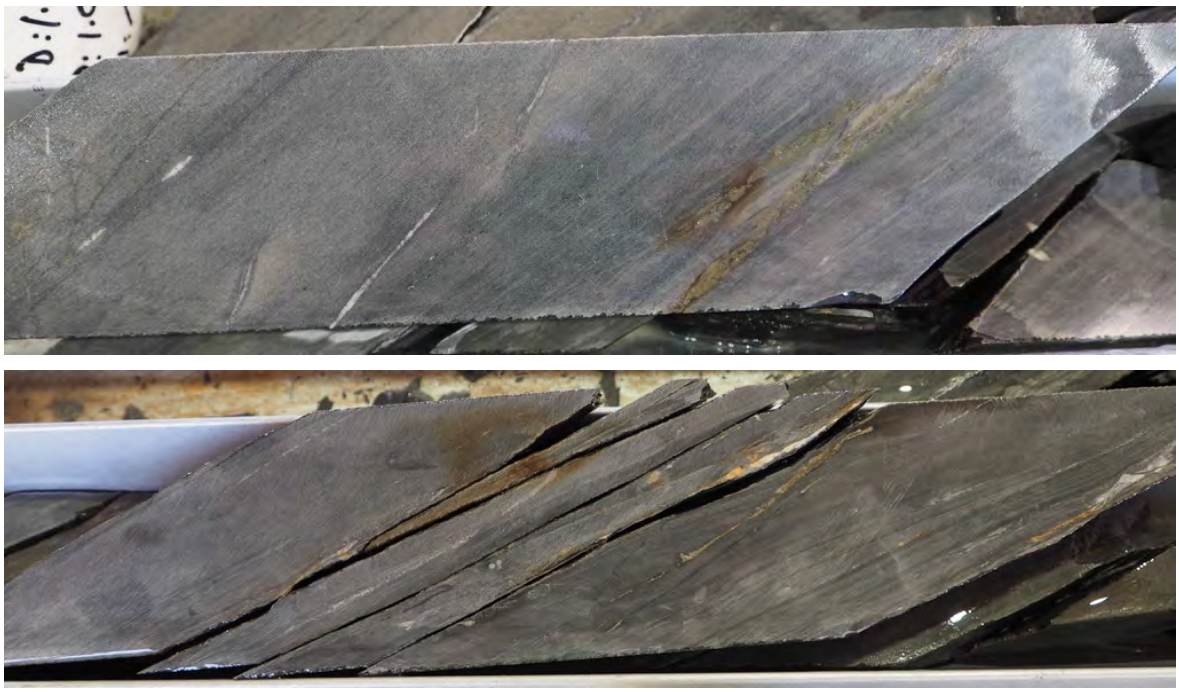


Plate 3 Examples of thin quartz-carbonate veins with associated pyrite scattered within benign waste rock. Top: Hole URNNDD0100, 186.85m. Bottom: Hole URNNDD0105, 69.10m.

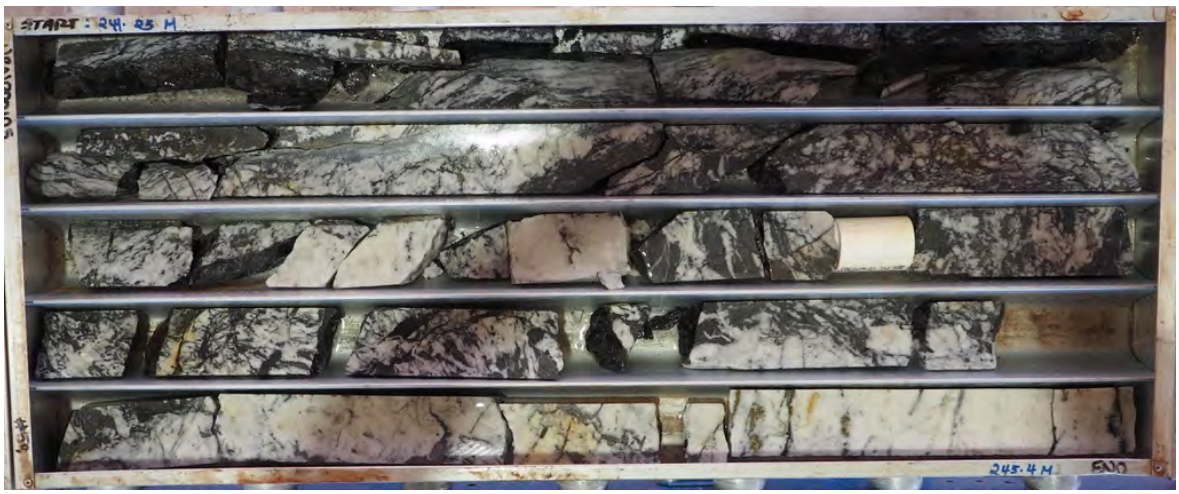


Plate 4 Ore zone with quartz-carbonate veins and moderate associated pyrite. Hole URNNDD0105, 241.25 to 245.40m.



Plate 5 Sharp contact of ore zone with waste rock. Hole URNNDD0105, 290.00 to 294.20m.

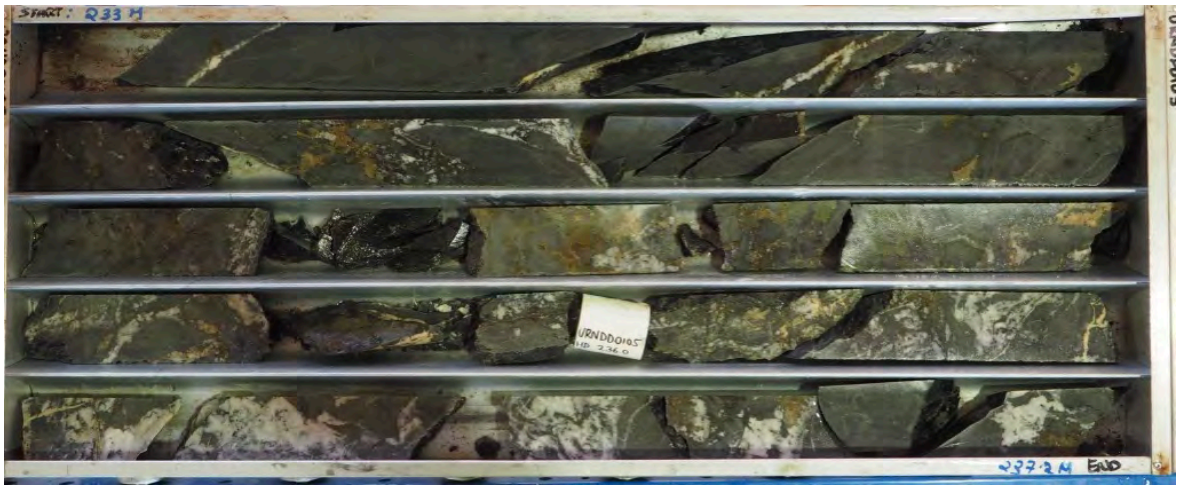


Plate 6 Significant pyrite in the waste rock zone close to the ore zone. Hole URNNDD0105, 233.00 to 237.20m.



Plate 7 Waste rock close to ore contact with significant pyrite. Hole URNNDD0105, 229.20m.



Plate 8 Zone of quartz-carbonate veins with low to moderate associated pyrite within waste rock. Hole URNNDD0100, 238.80 to 242.50m.

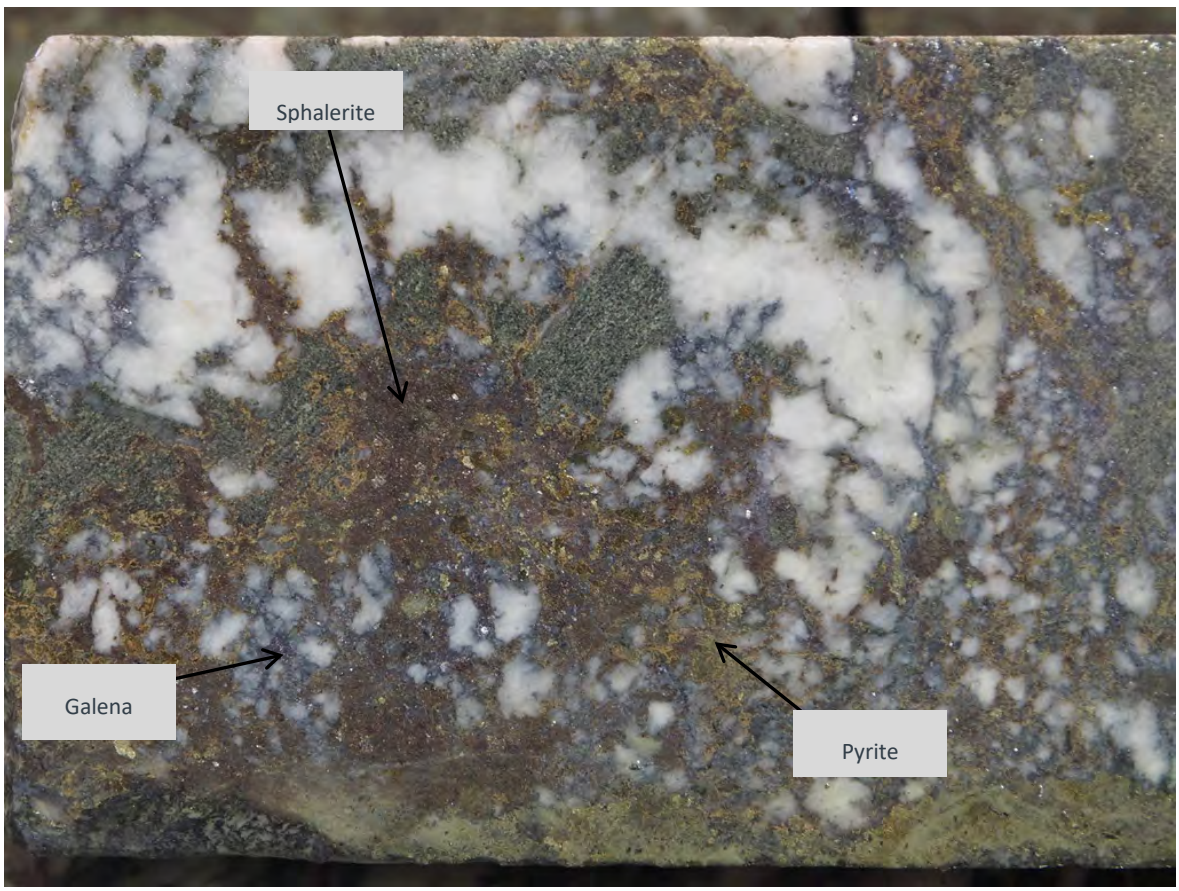


Plate 9 Ore zone with pyrite, sphalerite and galena. Hole URNNDD0105, 239.20m.

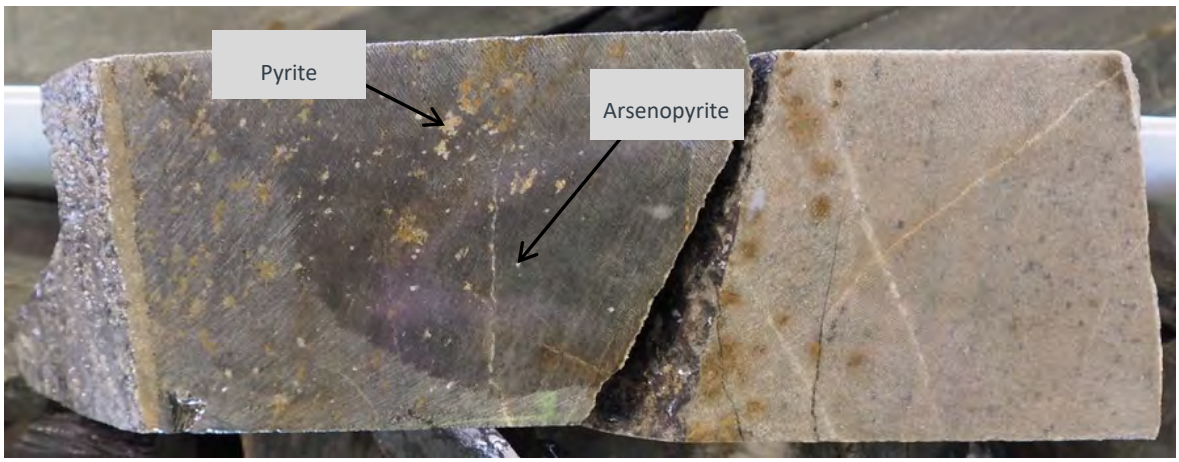


Plate 10 Ore zone with pyrite and arsenopyrite. Hole URNNDD0105, 239.20m.

During inspection of the core, 10% HCl was used to provide an indication of the presence of reactive carbonate. The application of 10% HCl to rock containing significant amounts of reactive acid neutralising carbonates (such as calcite and dolomite) results in vigorous fizzing. Most of the core showed a lack of fizzing, suggesting only limited neutralising potential overall. Strong fizzing was observed with some quartz-carbonate veins but in most cases there was only weak fizzing that is typically indicative of ferroan carbonates such as ankerite and ferroan dolomite. Some of the carbonate mineralisation observed in the core had a yellow/brown tinge that is typical of ankerite, and some had a pink tinge that is typical of Mn containing carbonate (Plate 11 and Plate 12).



Plate 11 Quartz carbonate veining with possible ankerite and Mn containing carbonate. Hole URNNDD0100, 65.60m.



Plate 12 Quartz carbonate veining with possible ankerite and Mn containing carbonate. Hole URNNDD0100, 104.15m.

The oxidation profile from holes URNDD0055 and URNDD0061 showed consistency, with the oxide zone extending to a depth of approximately 50m. Iron oxide occurred within the oxide zone, mainly associated with quartz-carbonate veining (Plate 13 and Plate 14), but there was no evidence of significant residual pyrite, apart from one minor occurrence where pyrite in the form of thin veins was observed in an interval showing only weak oxidation and weathering (Plate 15). The transition zone ranged from 7 to 10m, and was marked by the first occurrence of significant pyrite (Plate 16), with a portion of the pyrite completely oxidised to iron oxide

(Plate 17). Although the oxidation profile from holes URNDD0100 and URNDD0105 were outside of the development envelope, the profiles showed similar trends to URNDD0055 and URNDD0061, indicating a general continuity.



Plate 13 Quartz carbonate veining in oxide zone with no sulphide but iron oxide after pyrite. Hole URNNDD0061, 18.50m.



Plate 14 Quartz carbonate veining in oxide zone with no sulphide but iron oxide after pyrite. Hole URNNDD0061, 51.00m and 51.85m.

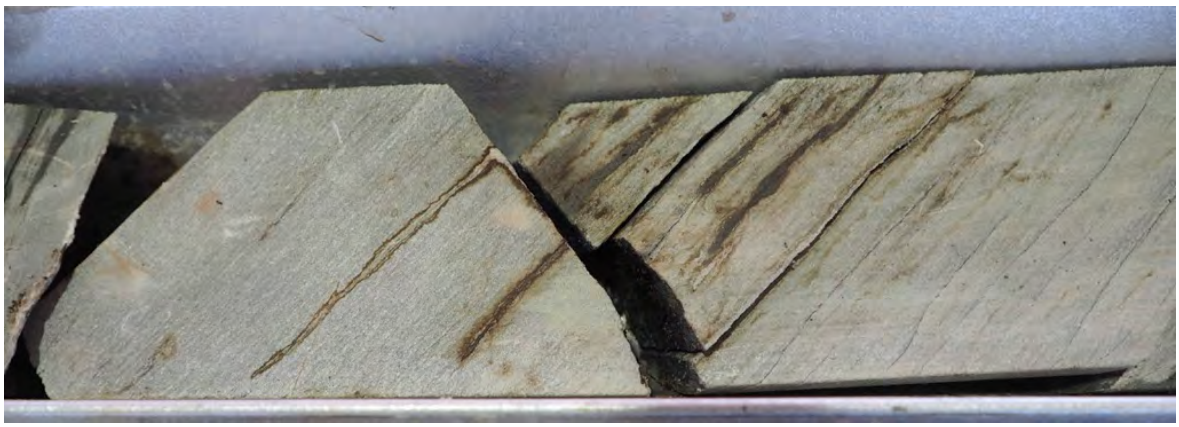


Plate 15 Weakly oxidised interval within the oxide zone showing minor thin pyrite veining. Hole URNNDD0061, 40.60m.

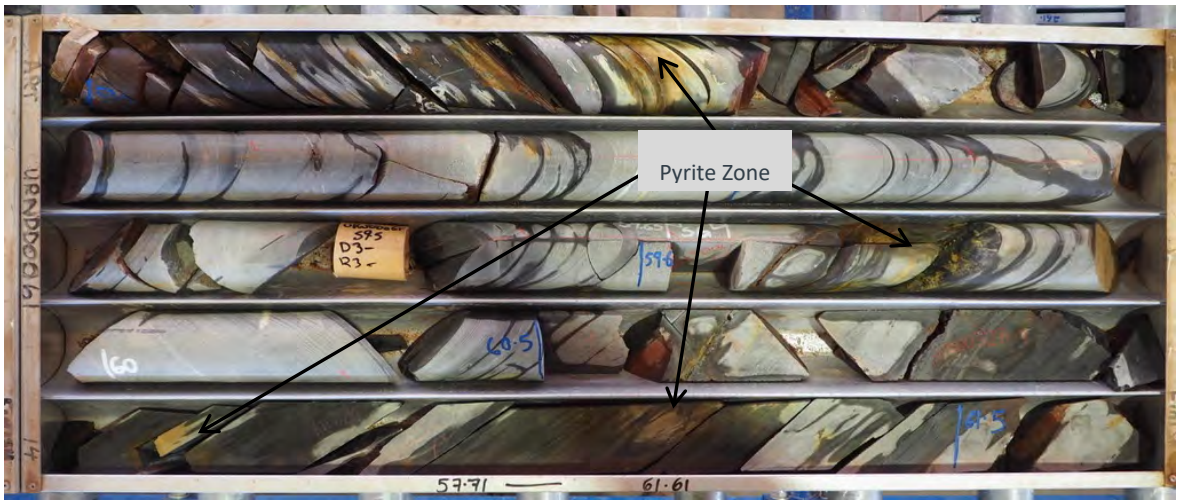


Plate 16 Typical transition zone showing pyritic zones. Hole URNNDD0061, 57.71 to 61.61m.



Plate 17 Iron oxide after pyrite in transition zone. Hole URNNDD0055, 54.60m.

Key findings of the drill core inspection were as follows:

- The vast majority of development waste rock is likely to be NAF and will not require special handling.
- The oxide zone appears to be devoid of significant pyrite, and it is likely that all materials above the logged contact with transition can be assumed to be NAF without the need for routine ARD testing.
- Sulphidic zones are distinct and discrete, and PAF materials should be readily identifiable through geological logging.
- Sulphidic and PAF rock appears to be mainly associated with the ore zones, which means exposed stopes and drives close to the ore will be the main potential sources of ARD from underground development.
- The slow reacting nature of carbonate mineralisation (possibly ferroan) may be a consideration in the lag times for PAF rock to acidify if exposed to atmospheric conditions.
- The key sulphide minerals present at the Prospect deposit are pyrite, sphalerite, galena and arsenopyrite, and hence in addition to acid potential, geochemical assessment will need to consider the potential for Zn, Pb and As mobilisation.
- There may also be potential for mobilisation of Mn as a consequence of acid generated by pyrite oxidation reacting with Mn-carbonate.

3.2 Multi-element analysis results

The concentrations of S and various metals/metalloids as a function of depth in hole URDDN0100 are shown in Figure 5 to Figure 8. The data indicate strong correlations between S content and As, Pb and Zn concentrations (Figures 5 & 6), suggesting these metals likely occur as sulphides such as arsenopyrite, galena and sphalerite. It is evident there are sections core of elevated S within both the development waste zone as well as in the intersection with the lode 400 ore body. The sulphidic waste zones appear to be mainly associated with the same quartz carbonate veining that occurs in the ore zones, but without gold mineralisation. The concentrations of other elements (Co, Cu, Mn and Ni) exhibit less variability and they do not appear to correlate with S content (Figures 5 and 6).

The results for elemental analysis of the core from hole URDDN0105 demonstrate similar correlation between S content and the concentrations of As, Pb and Zn, and highlight similar regions of elevated S content within zones of development waste and ore (Figure 9 and Figure 10).

Figure 11 to Figure 14 show concentrations of S and various metals/metalloids as a function of depth in hole URDDN0061, and similar results were obtained for hole URDDN0055 (not shown). These holes were drilled through the oxide zone within the proposed development waste region and into the transition/fresh zones (Section 3.1). Again, there appears to be a correlation between S content and As and Pb in samples within the fresh rock region of these holes (Figure 11 and Figure 12), but the correlation between S and Zn is less obvious. These results support the presence of arsenopyrite, galena and sphalerite in fresh rock as identified during visual inspection of the core.

Overall, the results indicate that sulphur concentrations will be low within the oxide zone, consistent with replacement of pyrite with iron oxides as observed during visual inspection of the core. As such, it is expected that oxide waste produced during development of the decline will be NAF and therefore will not be a source of low pH drainage. However, the contents of most metals/metalloids in oxide rock are comparatively similar to the contents in fresh rock, and for Zn appear to be, on average, slightly higher within the oxide zone (Figure 12) suggesting zinc is retained in secondary minerals during oxidative alteration. The potential for metal leaching from oxide materials was investigated during further geochemical testing.

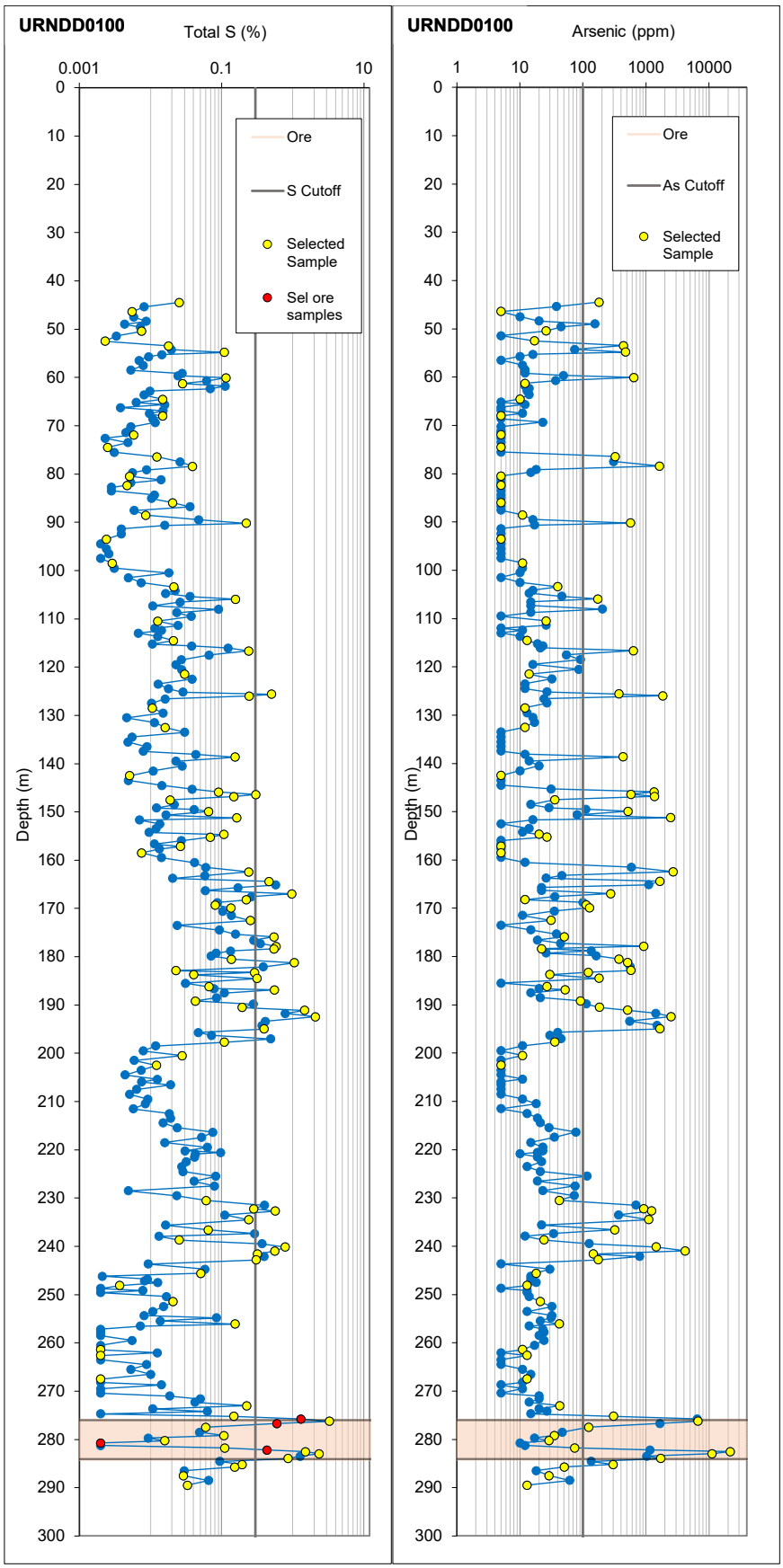


Figure 5: Downhole concentrations of S (left) and As (right) for hole URNDD0100

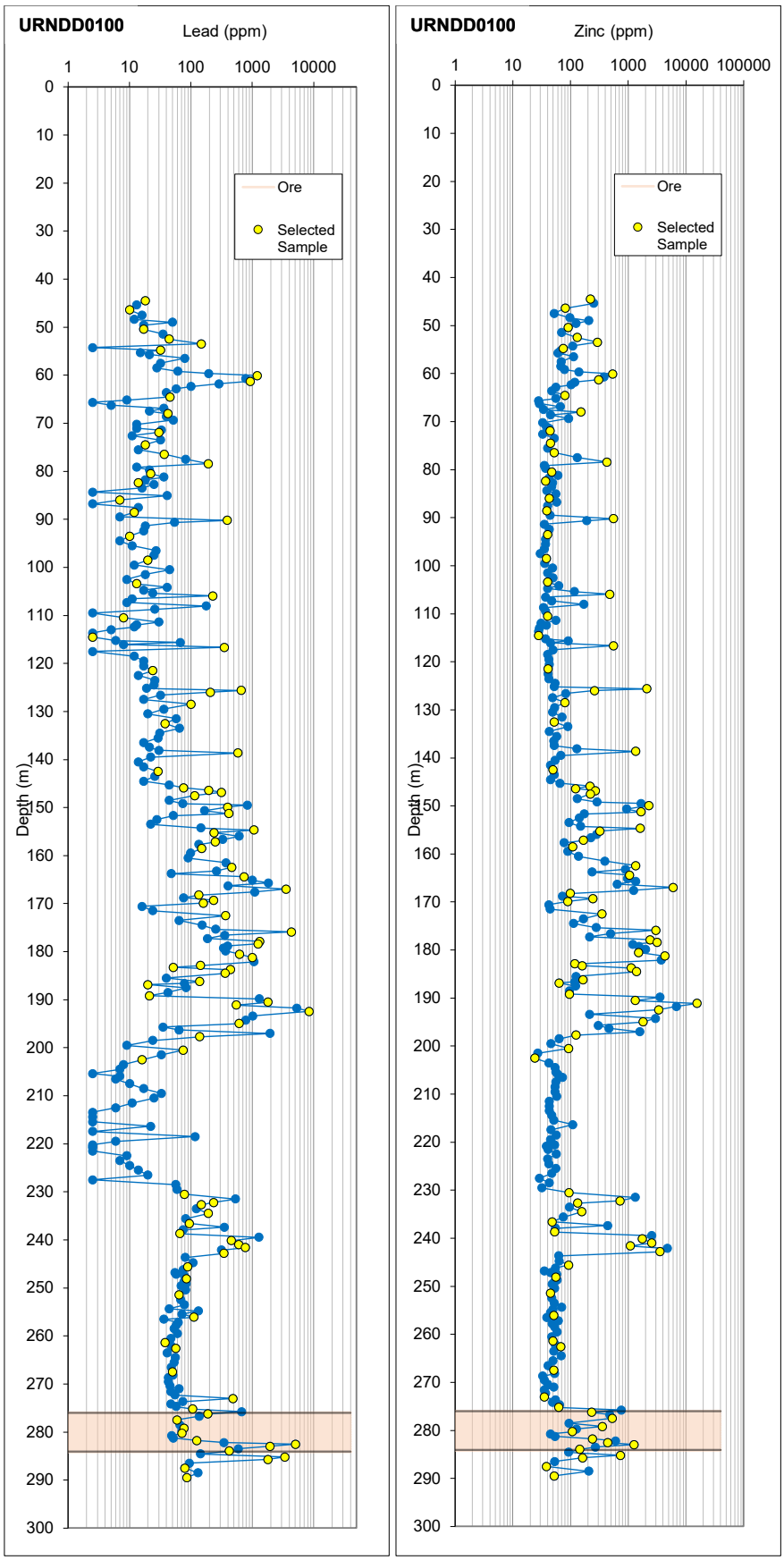


Figure 6: Downhole concentrations of Pb (left) and Zn (right) for hole URNDD0100

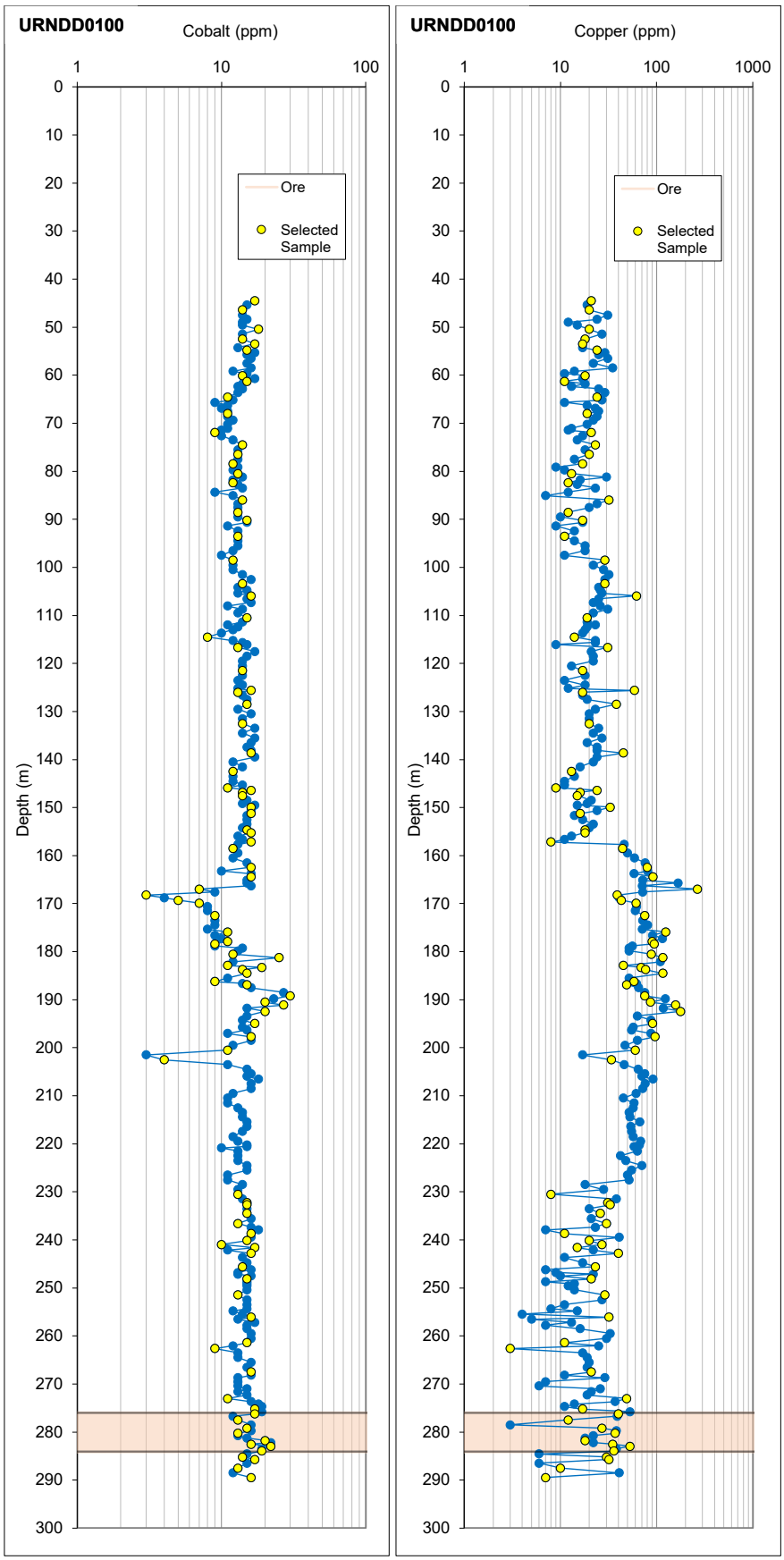


Figure 7: Downhole concentrations of Co (left) and Cu (right) for hole URNDD0100

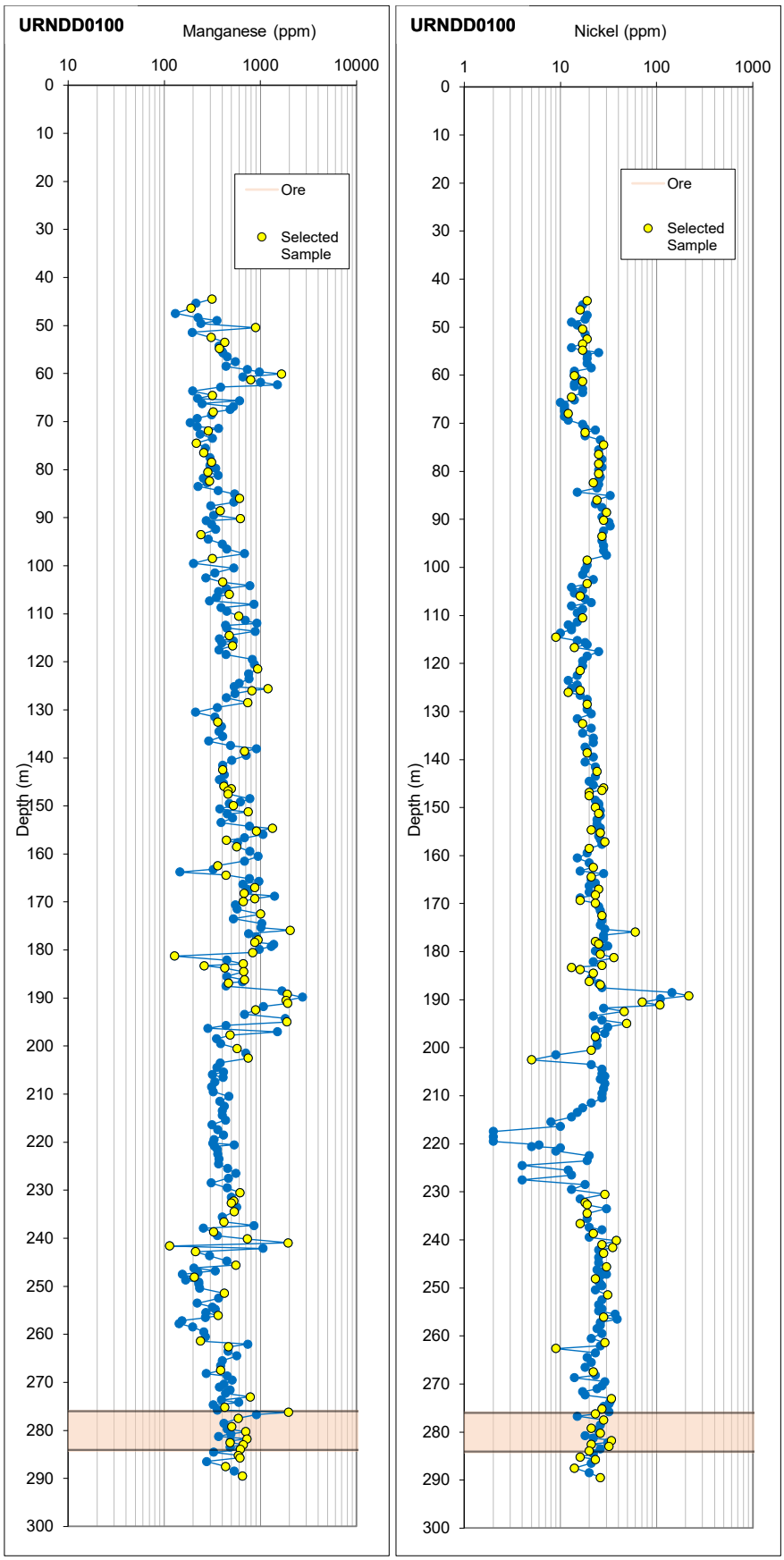


Figure 8: Downhole concentrations of Mn (left) and Ni (right) for hole URNDD0100

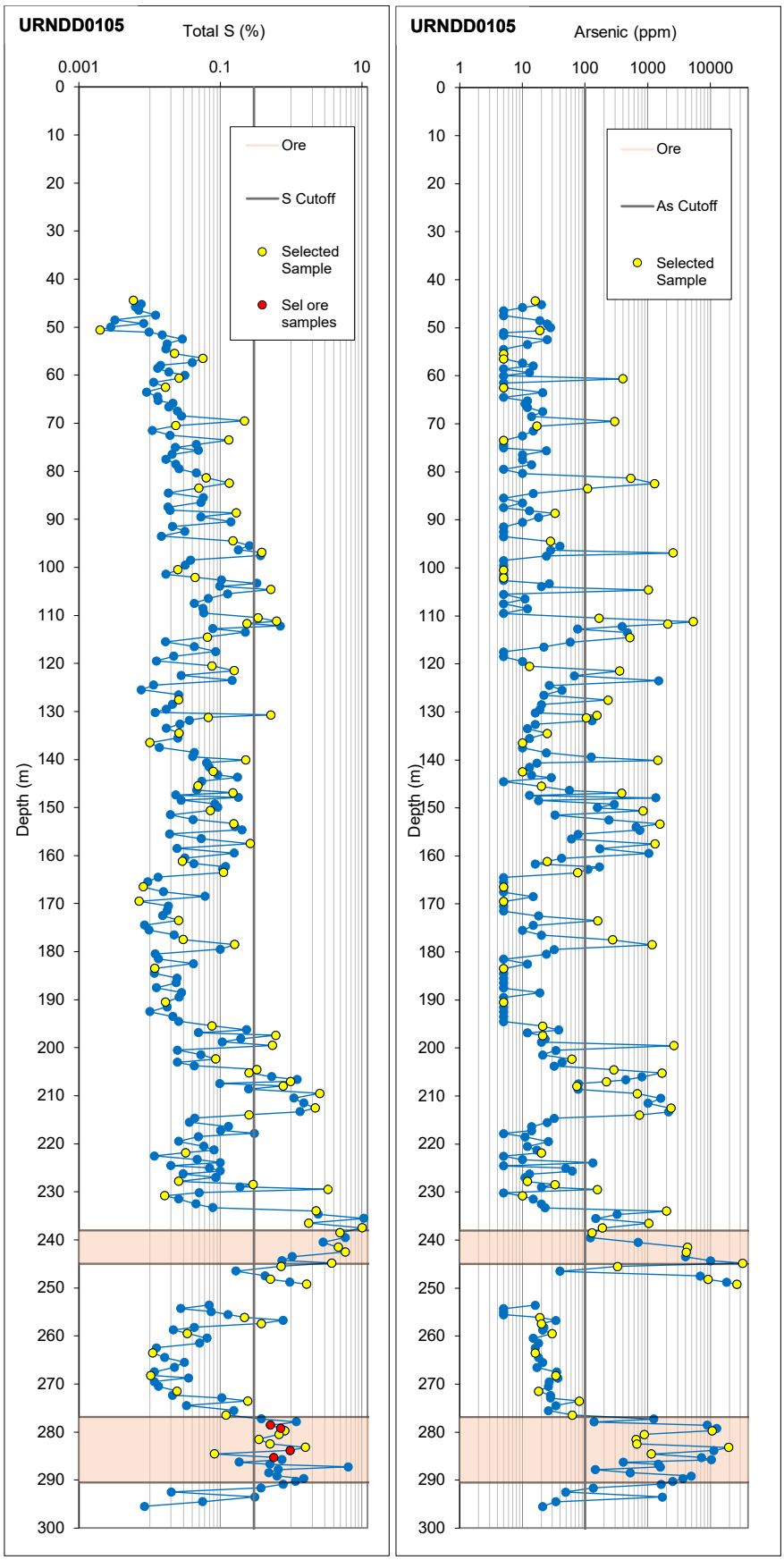


Figure 9: Downhole concentrations of S (left) and As (right) for hole URNDD0105

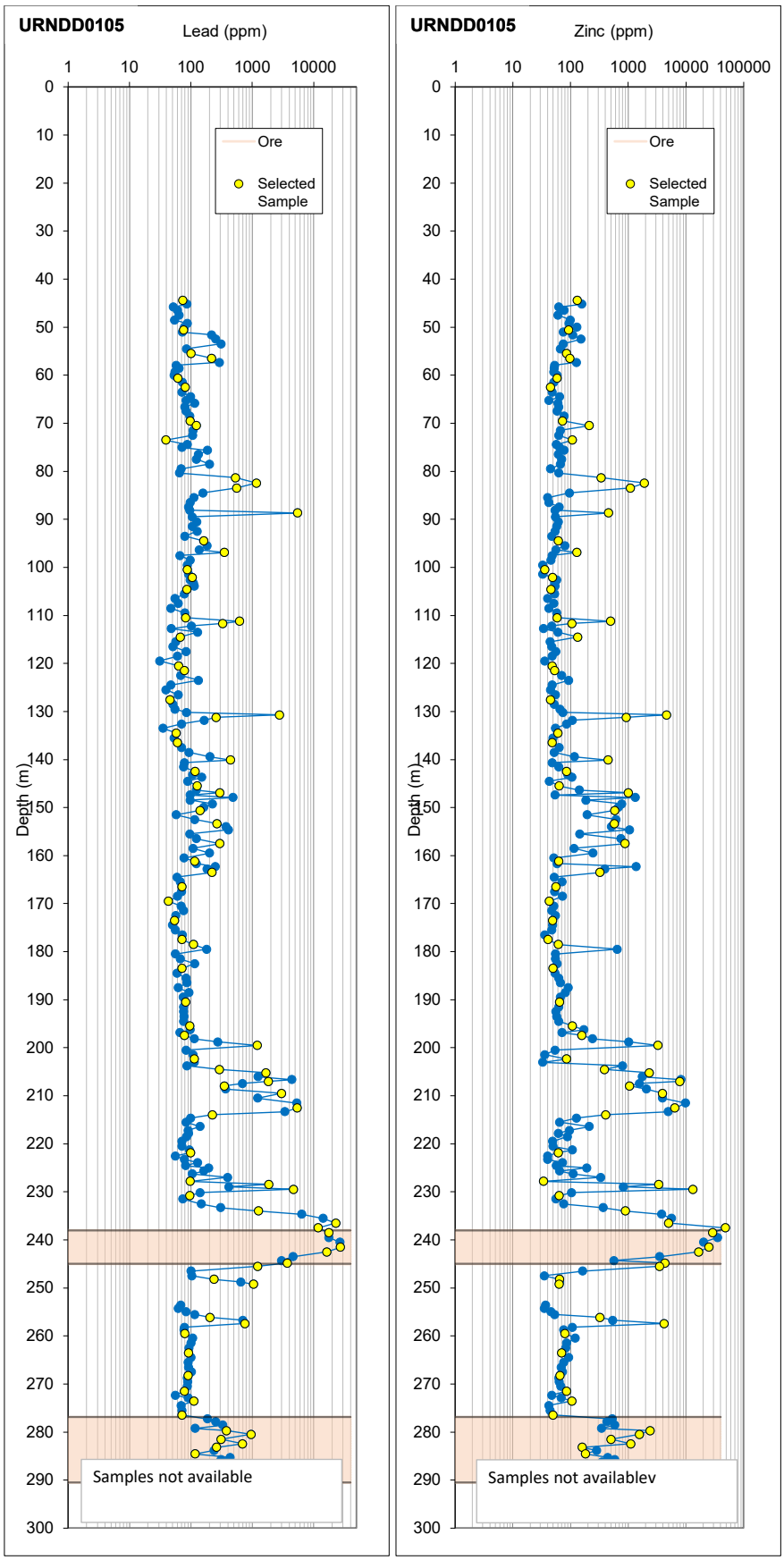


Figure 10: Downhole concentrations of Pb (left) and Zn (right) for hole URNDD0105

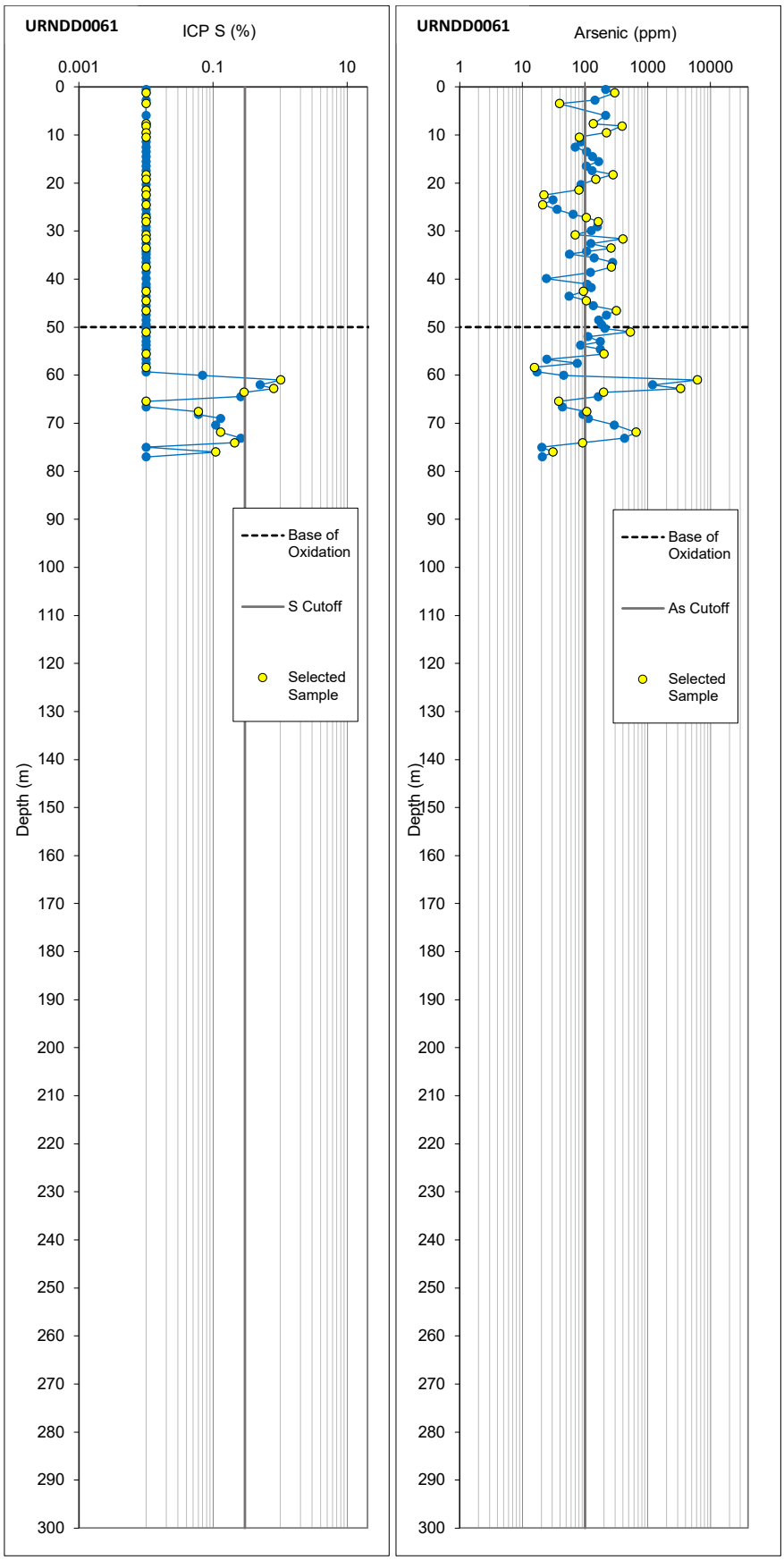


Figure 11: Downhole concentrations of S (left) and As (right) for hole URNDD0061

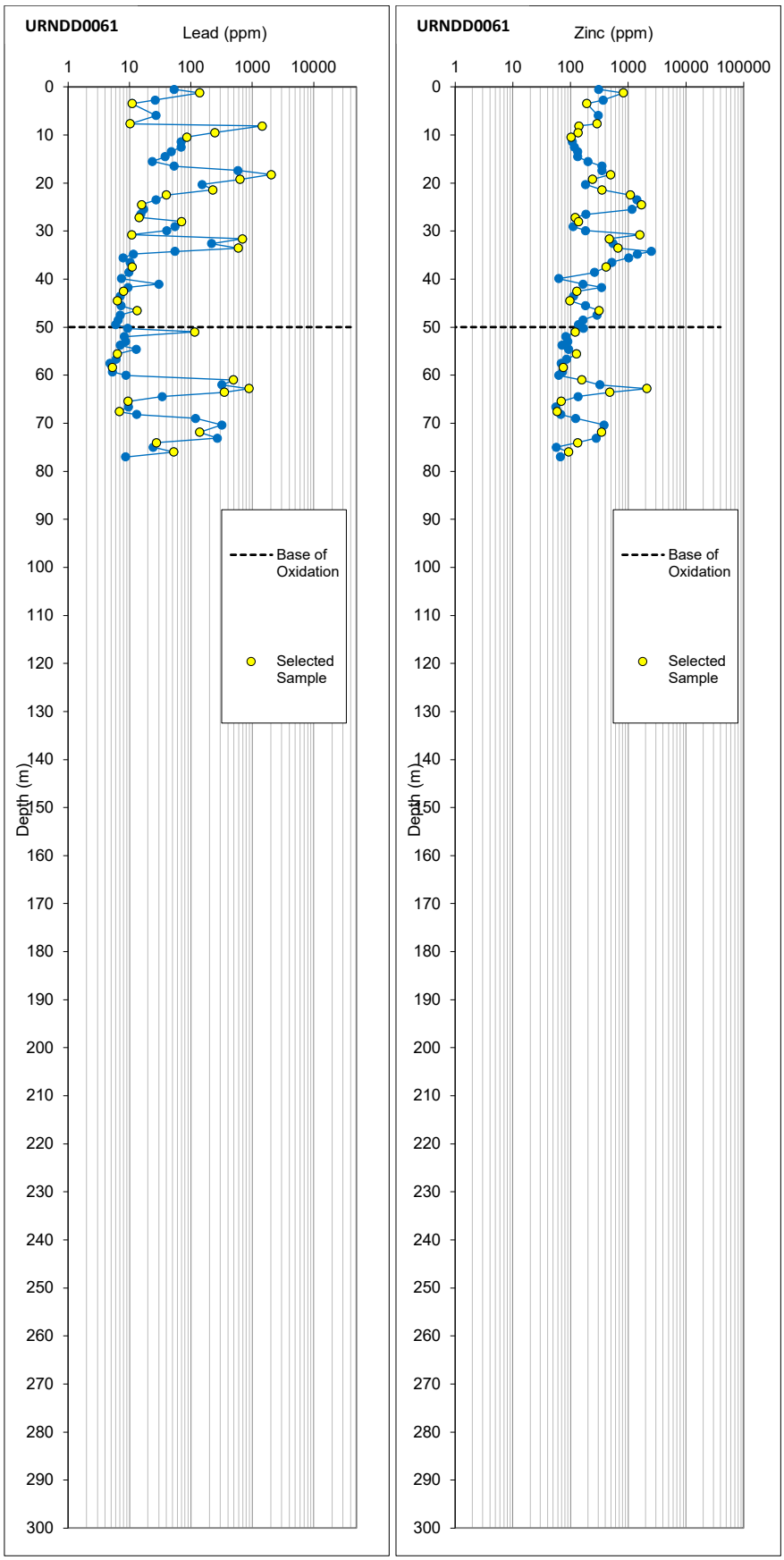


Figure 12: Downhole concentrations of Pb (left) and Zn (right) for hole URNDD0061

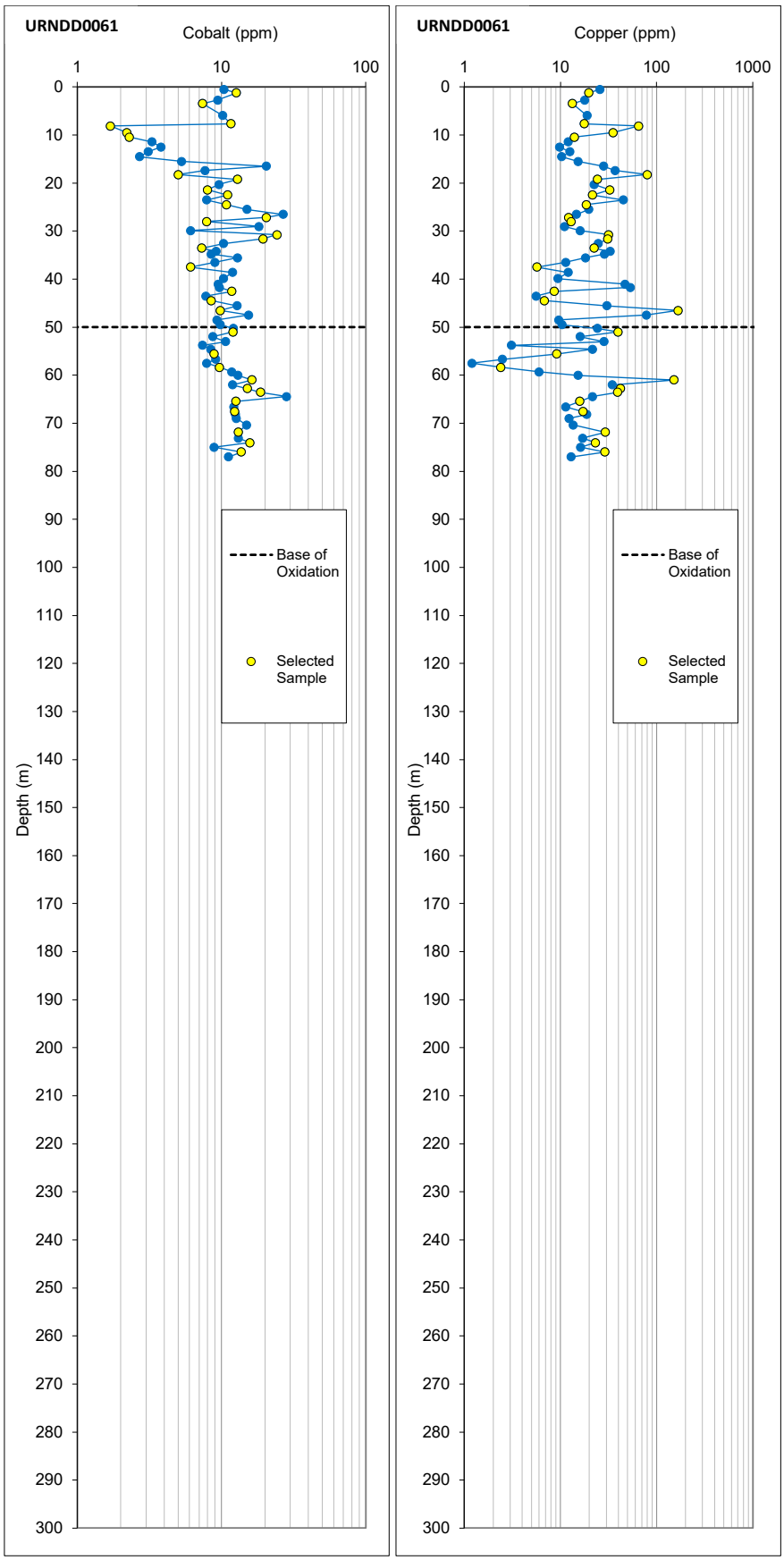


Figure 13: Downhole concentrations of Co (left) and Cu (right) for hole URNDD0061

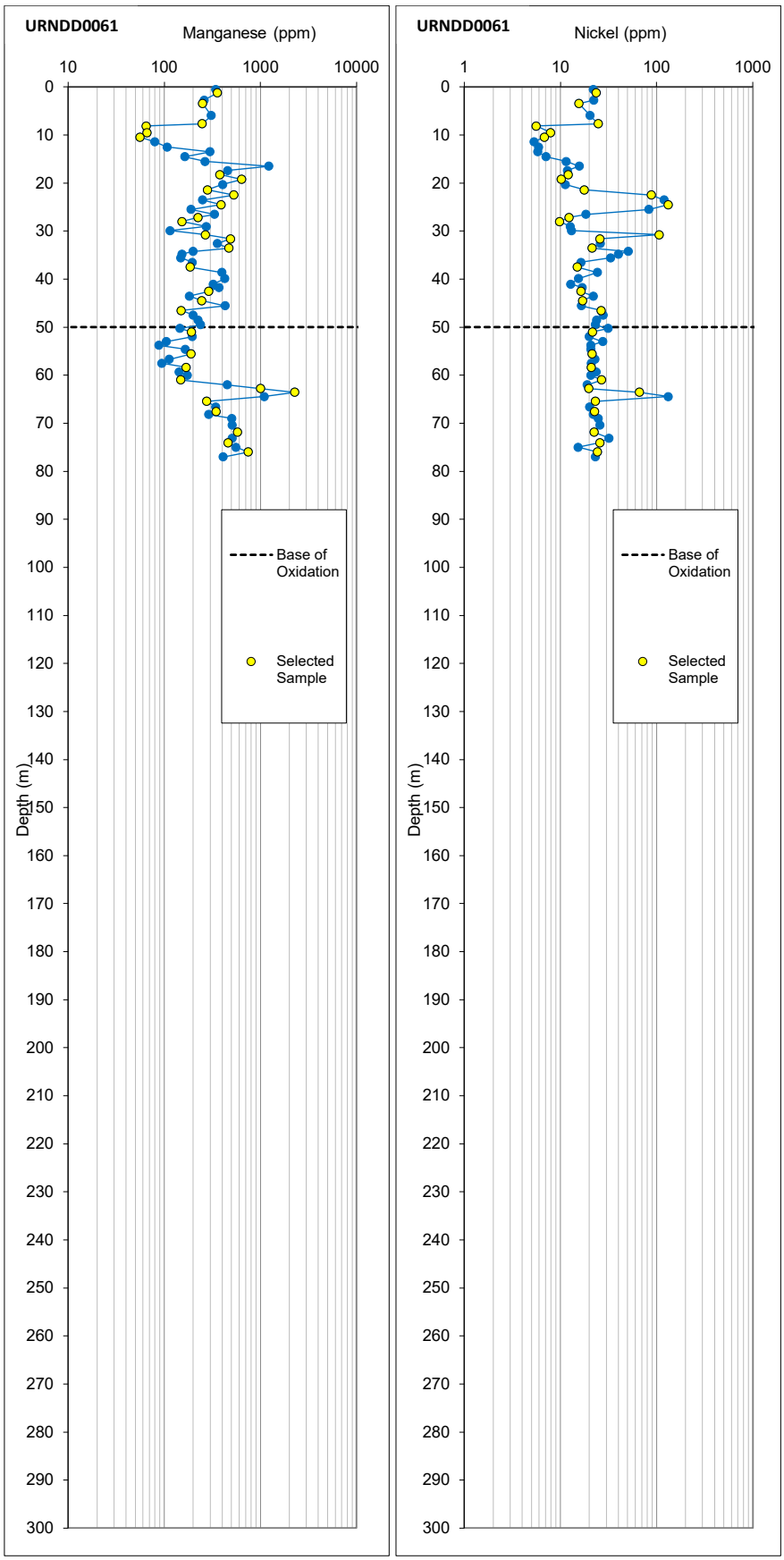


Figure 14: Downhole concentrations of Mn (left) and Ni (right) for hole URNDD0061

3.3 Geochemical test results

3.3.1 ARD classification

Preliminary geochemical testing (S, ANC, NAPP and NAG) was undertaken on core samples from holes URDDN0100 and URDDN0105. They included 170 fresh rock samples representing decline development waste and 22 ore samples. Testing of another 57 samples from drill holes URNDD0055 and URNDD0061, which mainly represent oxidised waste (35 samples) that will be produced during decline development, was also conducted.

Figure 15 shows an ARD classification plot for all of the 249 samples tested. The ARD classification plot combines results from ABA (ICP S and ANC) and NAG (NAGpH) testing. Where there is agreement between ABA (NAPP = %S x 30.6 - ANC) and NAGpH results, ARD classification can be made as either NAF (-ve NAPP and NAGpH ≥4.5) or PAF (+ve NAPP and NAGpH <4.5). However, where there is disagreement between the test results and uncertain classification is made and further testing is required to remove the uncertainty if possible.

Based on the ARD classification plot, the percentage volume of materials classified as NAF, PAF and UC in both development waste and ore were determined. Percentage volumes were calculated from the length of drill core represented by each ARD classification. The results of these calculations are provided in Table 2. Results indicate around 90% of development waste that will be removed during construction of the mine decline and access tunnels will be NAF, with only 6% classified as PAF and the remaining as uncertain. For the ore, results suggest around three quarters of this will be NAF and the remaining 25% PAF. This result is in agreement with visual observations, which indicated gold mineralisation is often associated with sulphidic quartz veining, with the higher sulphide content in the ore zones increasing the likelihood of PAF classification.

Table 2: Percentage by volume of development waste (n = 227) and ore (n = 22) classified as NAF, PAF and UC based on initial geochemical test results

Classification	ARD Classification Plot[1]	
	Development Waste	Ore
NAF	90%	74%
PAF	6%	26%
UC	4%	0%

1. NAGpH≥4.5 & NAPP<0 = NAF, NAGpH<4.5 & NAPP≥0 = PAF, NAGpH≥4.5 & NAPP≥0 or NAGpH<4.5 & NAPP<0 = UC

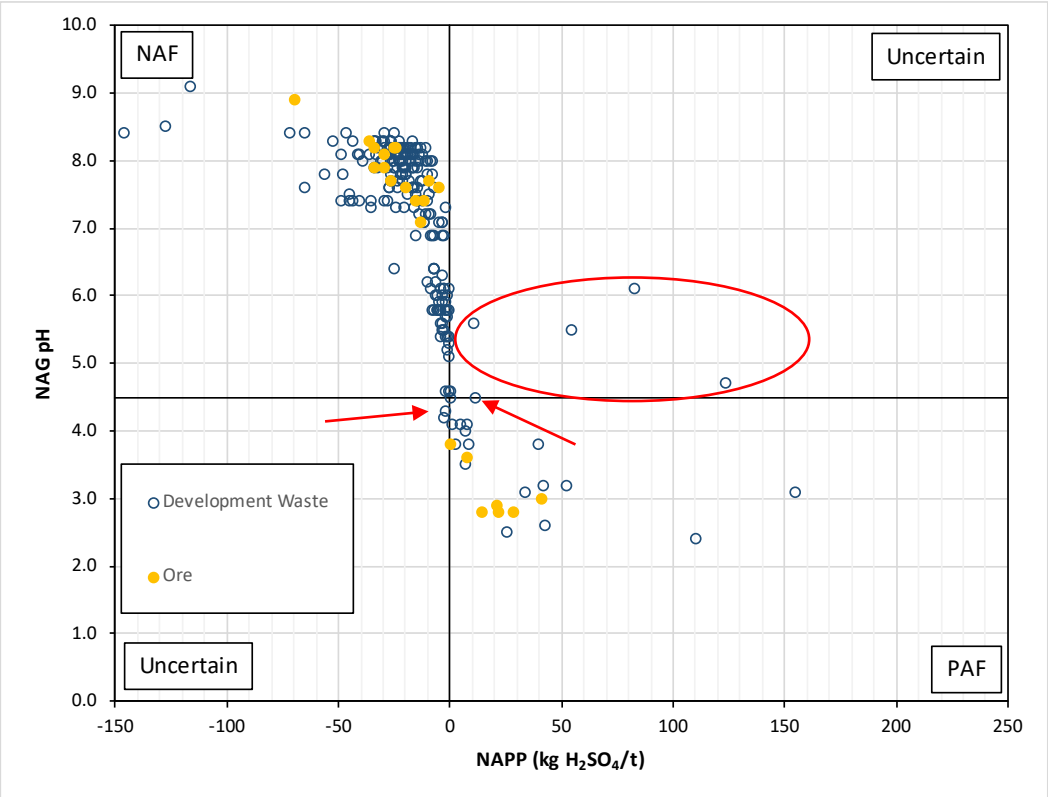


Figure 15: Initial ARD classification plot for development waste and ore samples from holes URNDD0055, URNDD0061, URNDD0100 and URNDD0105. Samples classified as UC and subjected to further testing are indicated by the red arrows and circle.

Following completion of the preliminary geochemical tests, further specialised testing was carried out to resolve classification of the few uncertain samples (Figure 15). Specialised tests included sulphur speciation, carbon speciation, sequential NAG, and acid buffering characteristic curve (ABCC).

Sulphur Speciation

The sulphur speciation results are provided in Table 3. Sulphur analyses included total S by high temperature combustion (LECO S). Sulphate analysis was also undertaken using extraction with 1M HCl followed by ICP analysis. Sulphide S was then determined by difference between total S and sulphate S. In general, the majority of total S in the samples was sulphide S. However, there were some discrepancies between total S initially measured by ICP and the subsequent analysis by LECO, with the ICP S usually slightly higher than that measured by LECO S. For the majority of the samples, the use of sulphide S rather than ICP S did not make any difference in the ARD classification after adjustment of the calculated NAPP value. However, two samples (C719193 and C725243) that had slightly negative NAPP value based on the original ICP S values, had slightly positive NAPP values when sulphide S was used, which is consistent with the mildly acidic NAGpH values obtained for the two samples.

Sequential NAG

For five of the samples (C719161, C725401, C725413, C725417, C725422) with higher S content NAGpH were 4.5 or above. This was despite ANC measurements indicating these samples would likely be PAF. This suggests that not all sulphide was oxidised during a single stage of NAG testing and so sequential NAG testing was conducted. The results of these tests (Appendix B) confirmed this for three of the five samples, with a pH less than 4.5 obtained in one or more subsequent stages of NAG testing. For the remaining two samples (C725413 and C719161) sequential NAG testing did not result in a NAGpH below 4.5 for any stage of the test.

ABCC Testing

The ABCC test (Appendix C) conducted on sample C725413 demonstrated the presence of substantial ANC in the form of dolomite/ferroan dolomite which is probably only slowly dissolved through successive stages of NAG testing. Using the ANC measured for this sample by ABCC testing corroborates the positive NAPP value calculated using a standard ANC value and suggests that eventually ANC from slowly dissolving carbonate will be consumed and the sample will produce acid, but with a considerable lag time. For the remaining sample (C719161), all additional testing failed to resolve the discrepancy between a positive NAPP value and failure to produce low pH during multiple stages of NAG testing. It was therefore conservatively assumed to be PAF.

Based on the results of detailed testing the samples with uncertain ARD classification were reclassified. The ARD classification plot shown in Figure 16 shows the final ARD classifications of all of the development waste and ores samples tested. The full results are provided in Appendix A. From these results the percentage volume of each ARD type following reclassification of uncertain samples were calculated as before (Table 4). As all uncertain samples were reclassified as PAF there was no change to the original percentage volume of NAF materials.

To further assist with mine waste planning the PAF classification was also split to differentiate PAF waste with a low capacity for acid generation (PAF-LC) from PAF waste with significant acid potential. PAF-LC was defined as having a $NAG_{pH4.5}$ less than 5 kg H_2SO_4/t, and PAF as having a $NAG_{pH4.5}$ above 5 kg H_2SO_4/t. Results show that only around 5% of the development waste is likely to produce significant acid and metalliferous leachate with the majority of the waste NAF or only marginally PAF. For the ore samples, results suggest around 20% of this material will be clearly PAF, with the remaining ore NAF or marginally PAF.

Table 3: results for sulphur speciation for samples classified as UC based on initial geochemical test results

Hole Name	Sample No	ICP S (%)	LECO S (%)	Sulphate S (%)	Sulphide S (%)
URNDD0100	C719161	0.97	0.91	0.082	0.83
URNDD0100	C719193	0.55	0.64	0.007	0.63
URNDD0105	C725243	0.24	0.35	0.005	0.35
URNDD0105	C725401	3.31	3.4	0.15	3.3
URNDD0105	C725413	4.88	3.9	0.88	3.0
URNDD0105	C725417	4.64	3.8	0.29	3.5
URNDD0105	C725422	0.72	0.55	0.18	0.37

Table 4: Percentage by volume of development waste (n = 227) and ore (n = 22) classified as NAF, PAF-LC, PAF and UC based on detailed geochemical test results

Classification	ARD Classification Plot[1]	
	Development Waste	Ore
NAF	91%	74%
PAF-LC	4%	8%
PAF	5%	19%
UC	0.3%	0%

1. NAGpH≥4.5 & NAPP<0 = NAF, NAGpH<4.5 & $NAG_{(pH4.5)}$<5 & NAPP≥0 = PAF-LC, NAGpH<4.5 & $NAG_{(pH4.5)}$ ≥5 & NAPP≥0 = PAF, NAGpH≥4.5 & NAPP≥0 or NAGpH<4.5 & NAPP<0 = UC

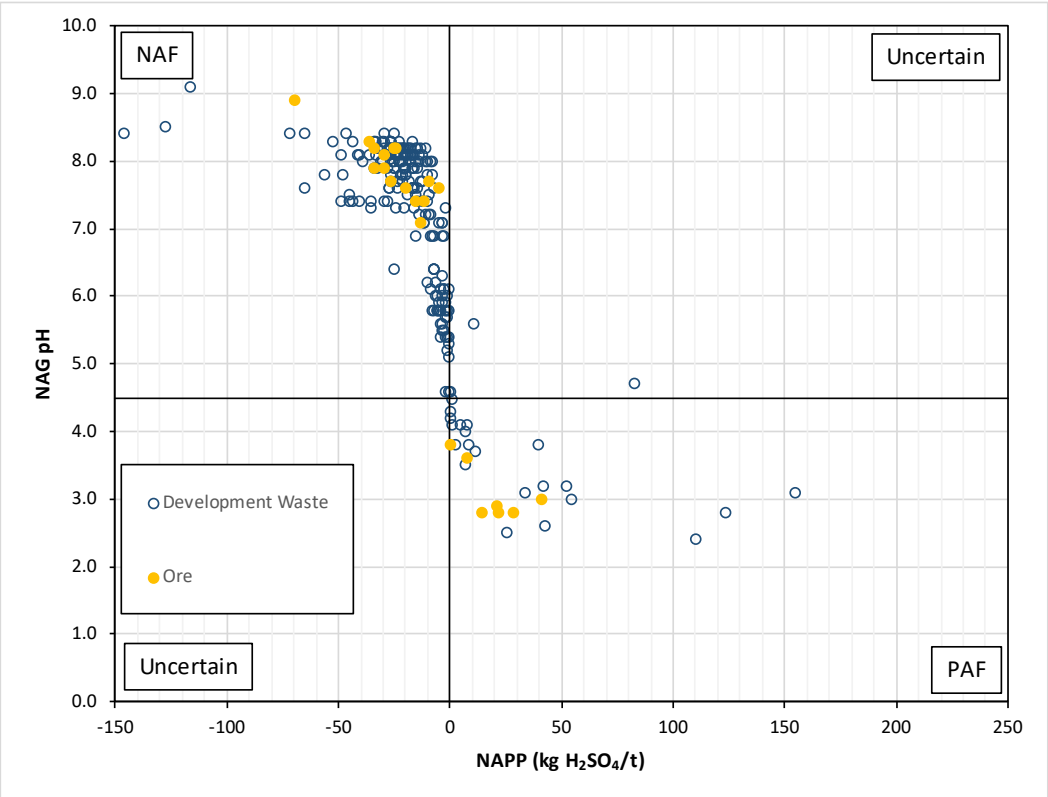


Figure 16: ARD classification plot for development waste and ore samples from holes URNDD0055, URNDD0061, URNDD0100 and URNDD0105 including results from sulphur speciation analysis, sequential NAG testing and ABCC testing.

Table 5 shows the distribution of ARD material types segregated by oxidation state (i.e. oxide, transition and fresh). All oxide samples tested were NAF, while transitional rock gave the highest volume percentage of PAF material (20%). Fresh rock which represented the highest volume of samples tested, gave results similar to the classifications for development waste as a whole.

Although transitional material is partial oxidised, some still contains significant sulphidic mineralisation resulting in more samples classified as PAF. However, this partially oxidised zone represents only a very small proportion of the development waste, and consequently the higher percentage of PAF material in transitional rock does not greatly affect the total amount of PAF material that will be mined during mine development.

Table 5: Percentage by volume of oxide (n = 38), transitional (n = 8) and fresh (n = 181) wastes classified as NAF, PAF-LC, PAF and UC based on detailed geochemical test results

Classification	ARD Classification Plot[1]		
	Oxide	Transitional	Fresh
NAF	100%	79%	89.5%
PAF-LC	0%	8%	4%
PAF	0%	13%	6%
UC	0%	0%	0.5%

1. NAGpH≥4.5 & NAPP<0 = NAF, NAGpH<4.5 & $NAG_{(pH4.5)}$<5 & NAPP≥0 = PAF-LC, NAGpH<4.5 & $NAG_{(pH4.5)}$ ≥5 & NAPP≥0 = PAF, NAGpH≥4.5 & NAPP≥0 or NAGpH<4.5 & NAPP<0 = UC

3.3.2 Waste segregation criteria

A number of criteria for ARD classification of development waste have been assessed. They included the use of S with a cut-off of 0.3%S and NAGpH with a cut-off of 4.5. Geological controls based on drill core geological logs were also investigated, because visual inspection of the core suggested sulphide mineralisation was mainly associated with quartz veining.

Two geological controls were examined. They were the presence of veining and visual sulphide identification and content. There were no clear distinctions between NAF and PAF samples evident from examining the sulphide type or content based on visual inspection. This is not surprising, since quantitative analysis of sulphur shows a cut-off of 0.3% S for NAF materials, equating to around only 0.6% pyrite, which is not readily quantified visually with any accuracy.

The second approach to investigate geological control involved correlating the type and amount of veining with ARD classification. Using this approach not all vein types were equally represented, and, within the sample set examined, there were enough samples only for the vein types quartz carbonate, quartz chlorite pyrite and quartz pyrite veins to make any meaningful correlations. The results of this analysis indicated that rocks containing quartz carbonate veining were all NAF, while rocks containing veins of the other types were variously classified as NAF, PAF-LC or PAF, indicating no clear geological control for ARD classification, other than quartz carbonate veins as NAF.

The NAF/PAF distributions of samples based on the Total S and NAGpH classification criteria are provided in Table 6. Using a S cut-off of 0.3%S results in 82% of development waste being classified as NAF and the remaining 18% PAF. However, a cut-off of 0.3 %S for NAF rock is conservative, as some samples containing more than 0.3%S did not acidify under NAG test conditions and were classified as NAF based on detailed geochemical testing (Figure 17). Therefore, operational use of a 0.3%S cut-off for waste classification would invariably mean selective handling of more "PAF" material, as some would actually be NAF.

Conversely, classification based on NAGpH appears to slightly overestimate the amount of NAF material present in development waste (Table 6) due to incomplete reaction during a single stage NAG tests for a small number of samples.(Figure 17). For such samples a sequential NAG test was required to correctly identify them as PAF. However, the volume of material incorrectly classified as NAF based on NAGpH appears to be low and indicates that NAGpH can be used to refine classification of samples with S >0.3%.

Results from geochemical testing of development waste suggest that the following criteria can be used to reliably segregate waste as either NAF or PAF:

- NAF
  - S ≤0.3%, or
  - Oxide, or
  - Quartz carbonate veins, or
  - S >0.3% *AND* NAGpH ≥4.5
- PAF
  - S >0.3% *AND* NAGpH <4.5 = PAF

Table 6: Percentage by volume of development waste classified as NAF or PAF based on Total S and NAGpH. Classifications based on detailed geochemical test results are included for comparison.

Classification	S Cut-off 0.3%[1]	NAGpH[2]	ARD Classification Plot[3]
NAF	82	93	91
PAF-LC	-	-	4
PAF[5]	18	7	5
UC	-	-	0.3

1. S≤0.3 = NAF, S>0.3 = PAF
2. NAGpH≥4.5 = NAF, NAGpH<4.5 = PAF
3. NAGpH≥4.5 & NAPP<0 = NAF, NAGpH<4.5 & $NAG_{(pH4.5)}$<5 & NAPP≥0 = PAF-LC, NAGpH<4.5 & $NAG_{(pH4.5)}$ ≥5 & NAPP≥0 = PAF, NAGpH≥4.5 & NAPP≥0 or NAGpH<4.5 & NAPP<0 = UC

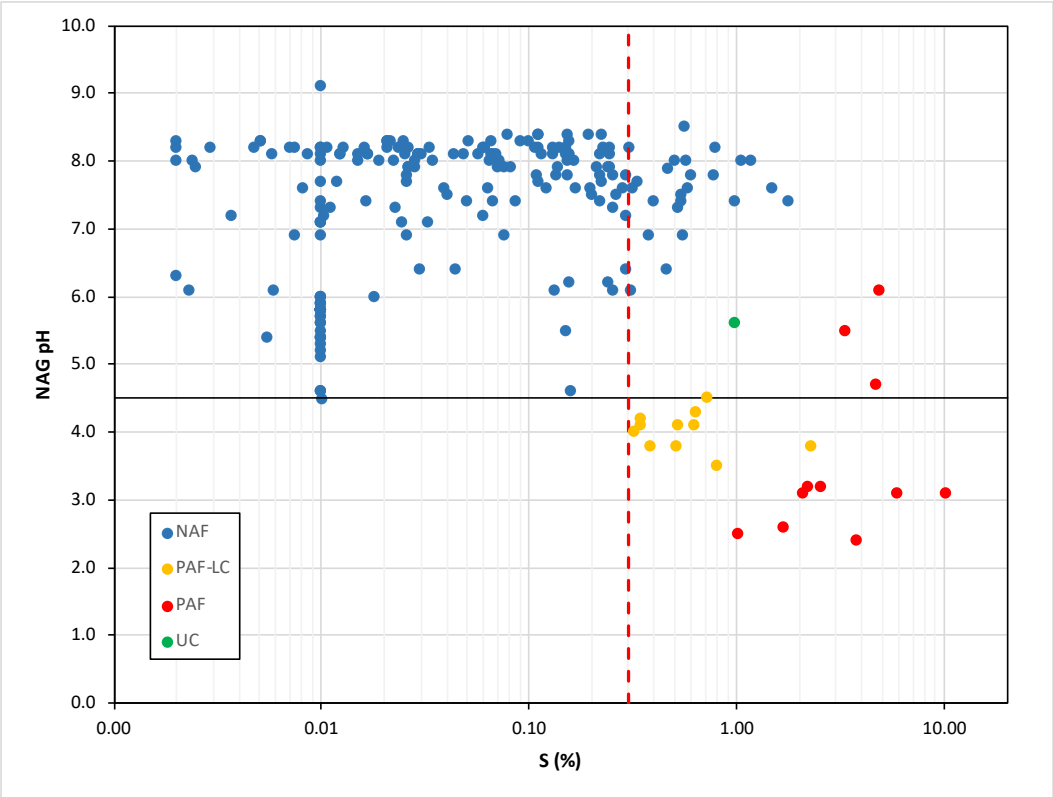


Figure 17: ARD classification plot for development waste samples from holes URNDD0055, URNDD0061, URNDD0100 and URNDD0105 highlighting ARD classifications based on detailed geochemical testing.

3.3.3 Water and peroxide extractable elements

Batch water extraction tests provide an insight into elemental solubilities within recently mined rock. The samples were extracted with deionised water at a solid to liquid ratio of 1:20 for 24 hours, which is generally sufficient for chemical equilibrium to be established. Extract pHs were recorded after the equilibration period, then the liquors were filtered and analysed for a suite of elements, the results of which are given in Appendix D1.

A series of accelerated oxidation tests based on the NAG test procedure were also carried out to provide indicative data on metals and metalloids that are likely to occur in acidic runoff from waste rock that is subject to oxidation processes following surface storage. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphides that are present. Normally only the pH and acidity of the NAG solution are measured following the oxidation stage, but elemental analysis of the NAG liquor can also be carried out to provide data on the release of elements that may be of interest. The NAG test is conducted using a solid to liquid ratio of 1:100, so the results from multielement analysis of the NAG liquors were multiplied by a factor of five to provide comparable results to those of the water extract (solid to liquid ratio of 1:20). Past experience has also suggested NAG test concentrations typically need to be multiplied by between 3 to 10 times to provide a reasonable guide to what might be expected from column leach tests, so multiplication by a factor of five will also give indicative metal/metalloids concentrations from column tests. The results for multielement analysis of NAG liquors are provided in Appendix D2.

These two tests represent the two extremes of the leaching process for PAF materials. On the one hand, the results of water extraction provide an indication of chemical mobility for a material that is freshly mined and exposed to atmospheric conditions, and on the other hand, the results of the peroxide extractions provide information of metal mobility for sulphidic materials that undergo oxidation and acidification. These two tests represent the two extremes of the leaching process. As waste rock at Union Reefs North will only be stored on the surface for a short period of time, and residual ore remaining in stopes will only be exposed for a relatively short time prior to inundation, it is expected any sulphidic material will only undergo partial oxidation, hence the potential for metals leaching will lie somewhere between the findings of the tests representing the two extremes.

A sub-set of 60 samples were selected for leach testing from the original set of 249 samples included in the geochemical assessment program. The selected samples covered the range of oxidation, rock types, bulk elemental composition and ARD classes, to provide as representative a sample set as possible.

Figure 18 shows box plots for pH measurements made in the water and peroxide extracts for the sub-set of 60 samples examined. The median pH of water extracts was around 9, with the majority of water extracts having a pH above 7. The lowest pH recorded was 6.6.

Water extract salinities were generally low, with a median EC of only 116 µS/cm, and a maximum of 980 µS/cm. Potassium and calcium were the principal cations and sulphate the principal anion.

The pHs of peroxide extracts were typically lower than the pH of corresponding water extract, but the peroxide extracts of the majority of samples were still circum-neutral (median pH 7.3), apart from the PAF samples which (by definition) produced pHs less than 4.5 (minimum pH 2.5). The ECs of peroxide extracts were not measured, but similar to the water extracts, the chemistries were dominated by Ca, K, Mg and sulphate, albeit with an increase in Ca, Mg and sulphate concentrations of around 30-fold.

The results of the extraction tests indicate that seepage from surface-stored waste rock will, in the main, have neutral pH and relatively low salinity. Seepage from development waste temporarily stored in Prospect South pit during mining will be captured and pumped to the Prospect North pit, and from there into the Crosscourse pit. Figure 18 shows the pH measured in Crosscourse pit in July 2019 (shown as red squares) for comparison with the extract pH results. The similarity of typical extract values with the pH of Crosscourse pit water suggests that any seepage discharge into Crosscourse would be unlikely to cause any shift in the pH of pit water. Results also indicate that the salinity of any seepage from the waste rock will be lower than that of Crosscourse pit water (current EC around 2500 µS/cm) and so disposal of seepage to Crosscourse should not adversely impact salinity levels in the pit water.

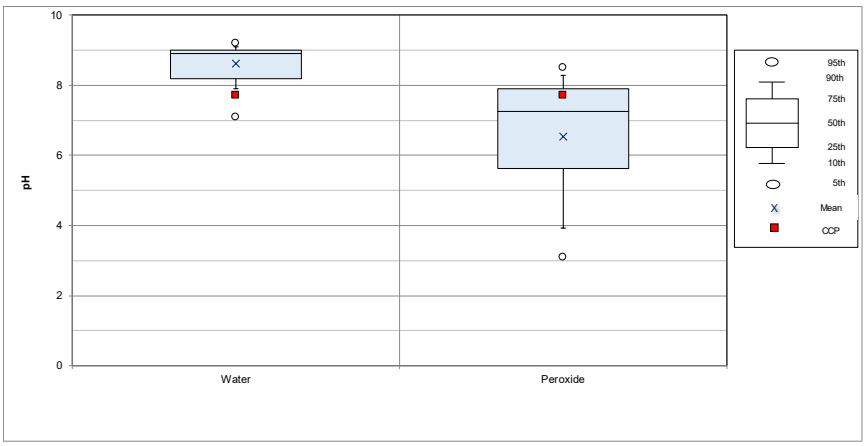


Figure 18: Box plots for pH measured in water and peroxide extracts for 60 samples tested for water and peroxide leachability. The red squares show the pH measured in Crosscourse pit in July 2019.

A similar analysis was also undertaken for various metals and sulphate in the water and peroxide extracts. These results are shown in the box plots provided in Figure 19. There were measurable, but low concentrations of Al, As, Mn and sulphate in the water extracts of most samples, but the concentrations of most other metals were at, or below, the limits of analytical detection. In the peroxide extracts, metal concentrations were generally about an order of magnitude higher than in the water extracts, with the exception of Mn and Zn which were about 100 times higher in the peroxide extracts. Sulphate concentrations in the peroxide extracts were about 50-fold those in the water extract.

Comparison of extract metal and sulphate concentrations with those in Crosscourse pit water (Figure 19) shows that concentrations in water extracts were generally lower than those in the pit water, with the exception of Al and Pb. With peroxide extracts, there were a number of metals that were present at higher concentrations than occur in Crosscourse pit water, including Al, Cr, Cu, Fe, Mn, Ni, Pb and Zn. However, the peroxide extract produced by a PAF sample represents the end result of complete or near complete oxidation of the sulphides present, hence the chemistry of the extract can be considered to be at upper end of the range for seepage from PAF waste under field conditions. It is likely that seepage concentrations will lie somewhere in between those of the peroxide and water extracts. If that is the case, metal concentrations in seepage will be no greater than concentrations that currently occur in Crosscourse pit water, and therefore it is unlikely seepage discharge to Crosscourse pit will adversely impact the quality of the pit lake.

Whilst the results of batch extraction tests provide an insight into seepage water quality, they are not kinetic based, and the results should be considered as qualitative rather than quantitative. Factors that affect the chemistries of batch test extracts include the solid to liquid ratio used (1:20 for water and 1:100 for peroxide) and the contact time between sample and extractant (typically 24 hours). Under field conditions within a waste rock emplacement, the solid to pore water ratio at any given time will be significantly lower than the ratios used in the batch tests, but leaching will be an ongoing progression through time. Also, under field conditions only a fraction of the rock surface will be in contacted with water as it flows through waste rock pile, while in the leach tests, the rock is finely ground increasing surface area and all of the sample is contacted by extractant.

Notwithstanding these limitation, given the similarity in extract concentrations and Crosscourse pit water quality, and the low volumes of seepage water that will be pumped to Crosscourse pit relative to the existing volume of pit water, there should be little, if any, potential for seepage to adversely impact Crosscourse pit water quality.

While testing (Section 3.3.1) indicates the volume of PAF material in the development waste will be only a small percentage of the total amount of the waste, a larger percentage (≈20%) of the ore is likely to be PAF material. This suggests that walls of mined stopes could contain some PAF material, which, prior to backfill and groundwater rebound, will be exposed to oxidative conditions. The peroxide extraction tests indicate that PAF rock might contain elevated concentrations of leachable metals such as Al, Cr, Cu, Fe, Mn, Ni, Pb and Zn. These metals may be mobilised by inflow of groundwater through any PAF rocks in the underground workings,

potentially affecting the quality of the groundwater. Post closure any groundwater entering the Prospect North pit from the groundwater in the mine will not be returned to Crosscourse pit with subsequent dilution of elevated concentrations of metals. The impact of potentially poorer quality groundwater from the closed mine on surrounding groundwater and pit lake water will be examined using geochemical water quality prediction modelling and reported separately.

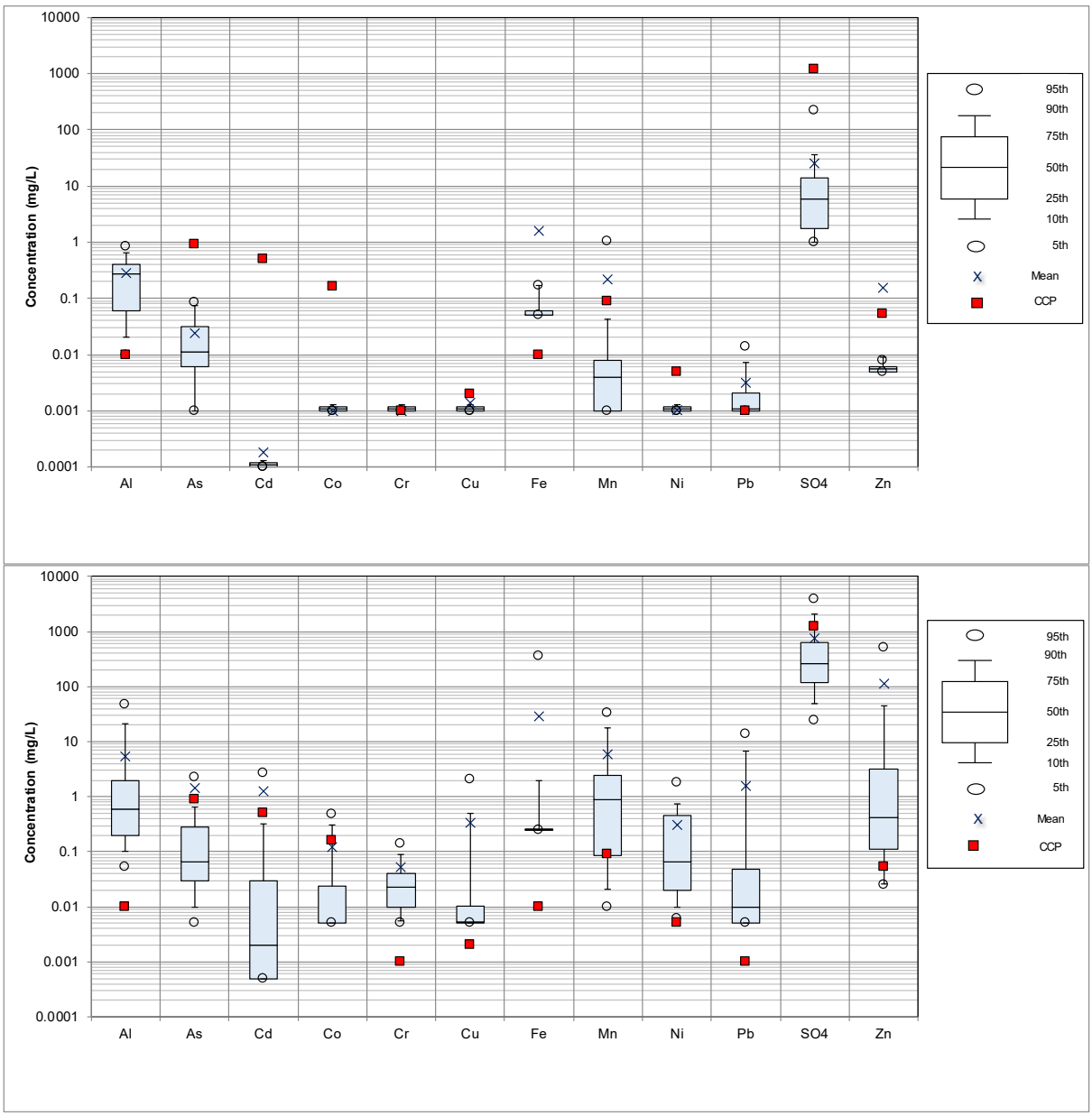


Figure 19: Box plots for metals and sulphate concentrations measured in water (top) and peroxide (bottom) extracts for 60 samples tested for water and peroxide leachability. The red squares show the concentrations measured in Crosscourse pit in July 2019.

3.3.4 Correlation of water and peroxide extractable elements with geochemical properties

The previous discussion dealt with the chemistry of water and peroxide extracts averaged across the whole set of 60 samples. However, further detailed analysis of the results was undertaken to determine if extract concentrations of the various metals and sulphate could be correlated with other sample properties such as the elemental composition of the solids, ARD classification or oxidation type. If, for example, higher concentrations of specific metals could be correlated with ARD classification, then this could potentially provide further refinement of the classification criteria described in Section 3.3.2.

Comparisons of selected water extract parameters with geochemical characteristics are shown in Figures 20 to 23. Similar comparisons for peroxide extracts are shown in Figures 24 to 27. The main findings were as follows:

Water Extracts

- Overall, there was no correlation between the bulk concentrations of various metals/metalloids and the amounts extracted by water.
- However, there was a correlation between concentrations of sulphate in water extracts and the total sulphur contents of the test samples, with increasing total S leading to increased sulphate measured in the water extract (Figure 23). As might be expected, sulphate concentrations in water extracts were highest for PAF samples, which typically had the highest measured total sulphur contents.
- Arsenic and lead concentrations in water extracts were independent of pH (Figure 20) and did not correlate with the ARD classification of the rock (Figure 21).
- In contrast, manganese and zinc concentrations were significantly lower in extracts with pHs above 7.2, and these two elements were essentially only extracted by water from PAF samples.
- Concentrations of As appear to be independent of the original oxidation state (oxide, transition or fresh) of the sample, but for other metals oxidation appears to play some role, with highest water extract concentrations in fresh samples and very low concentrations for all oxide samples (Figure 22). Sulphate concentrations show a similar dependency on oxidation, with highest concentrations in water extracts for fresh samples (highest total S) and negligible concentration for oxide samples (lowest total S) (Figure 23).

Peroxide Extracts

- There was a general relationship between NAGpH and the concentrations of metals (Figure 24) and sulphate (Figure 27) in the peroxide extracts, with higher concentrations occurring when the NAGpH was <4.5. The exception to this is As, with no correlation apparent. It should be noted that there was only one sample in the set in which the NAGpH was below 3 and this sample gave a significantly higher concentration of As in the peroxide extract. This may suggest some pH control on As mobility via coprecipitation and/or sorption by high surface area amorphous or poorly crystalline iron oxyhydroxides such as 2-line ferrihydrite or schwertmannite.
- Concentrations of metals and sulphate typically follow the order PAF > PAF-LC > NAF (Figure 25), which is consistent with the PAF samples producing the lowest NAGpHs.
- No trends were evident between metal concentrations in the peroxide extract and the metals contents of the solids (Figure 25). However, similar to results for water extracts, sulphate concentrations in peroxide extracts did increase with increasing total sulphur content (Figure 27).
- In general, there was limited correlation between the original oxidation state in the sample and the concentrations of metals/metalloids and sulphate in the peroxide extracts, to the extent that concentrations were generally lower for oxide samples compared to transition and fresh rock samples (Figure 26).

In summary, the results from the water and peroxide extraction tests suggest that elemental compositions of sample solids cannot be used as a predictor of seepage water quality from waste rock or ore. Instead, the results indicated that the NAF/PAF criteria as defined in section 3.3.2 are better predictors of likely seepage

quality, with the poorest quality seepage associated with PAF waste rock and pH conditions the key control. This included arsenic, and as a result, the preliminary arsenic in solid classification criteria cut-off of 100 mg/kg was removed.

Given the low volume of PAF waste that will be mined and temporarily stored at the surface, selective handling and isolation (e.g. encapsulation with NAF waste), should readily achieve mitigation of higher metal concentrations in seepage from PAF waste. Also, the use of oxide materials for construction of the permanent portal bench should not result in contaminated run-off from the portal post closure of the underground operation, as these materials appear to be essentially inert.

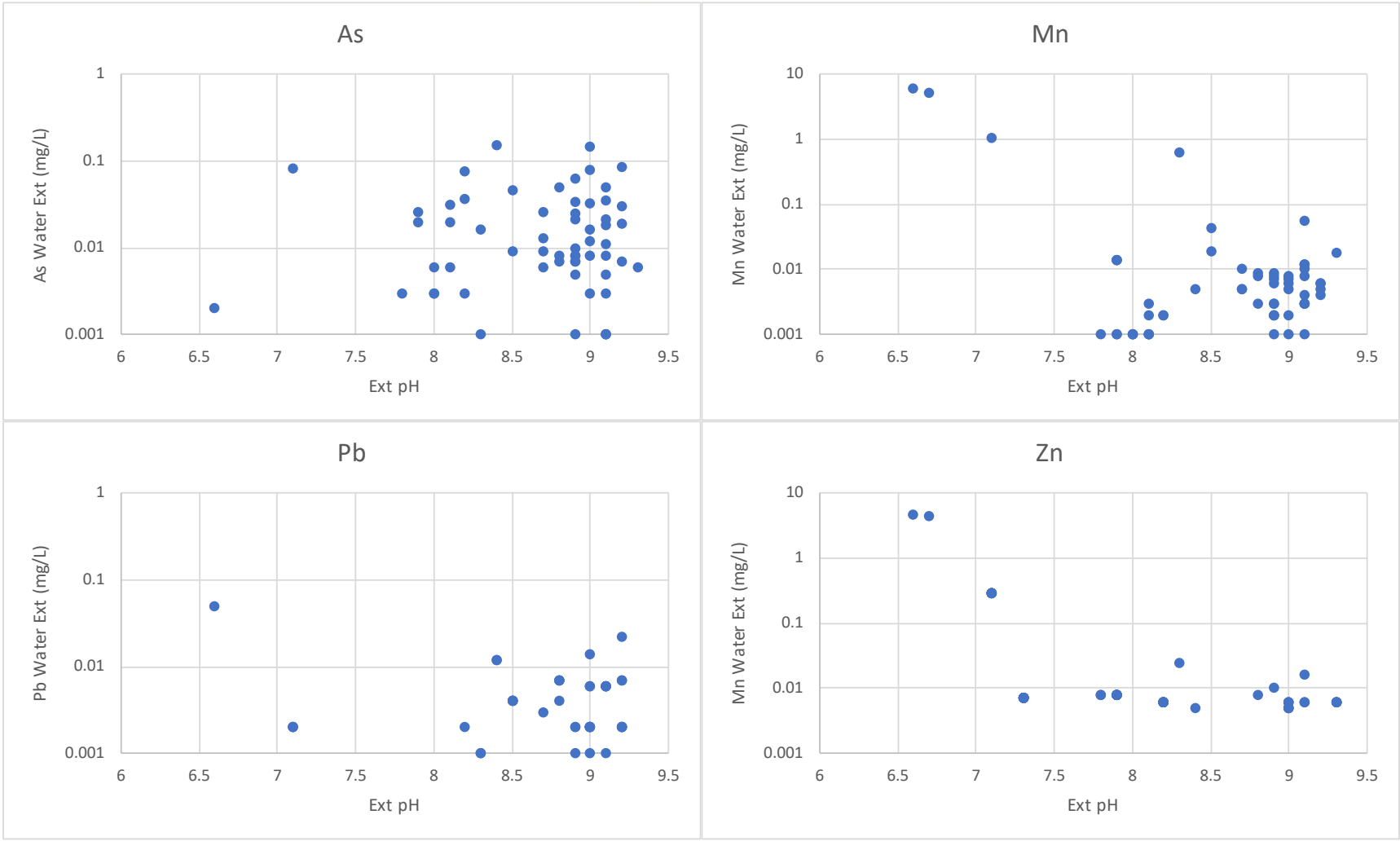


Figure 20: Concentrations of metals in water extracts as a function of extract pH

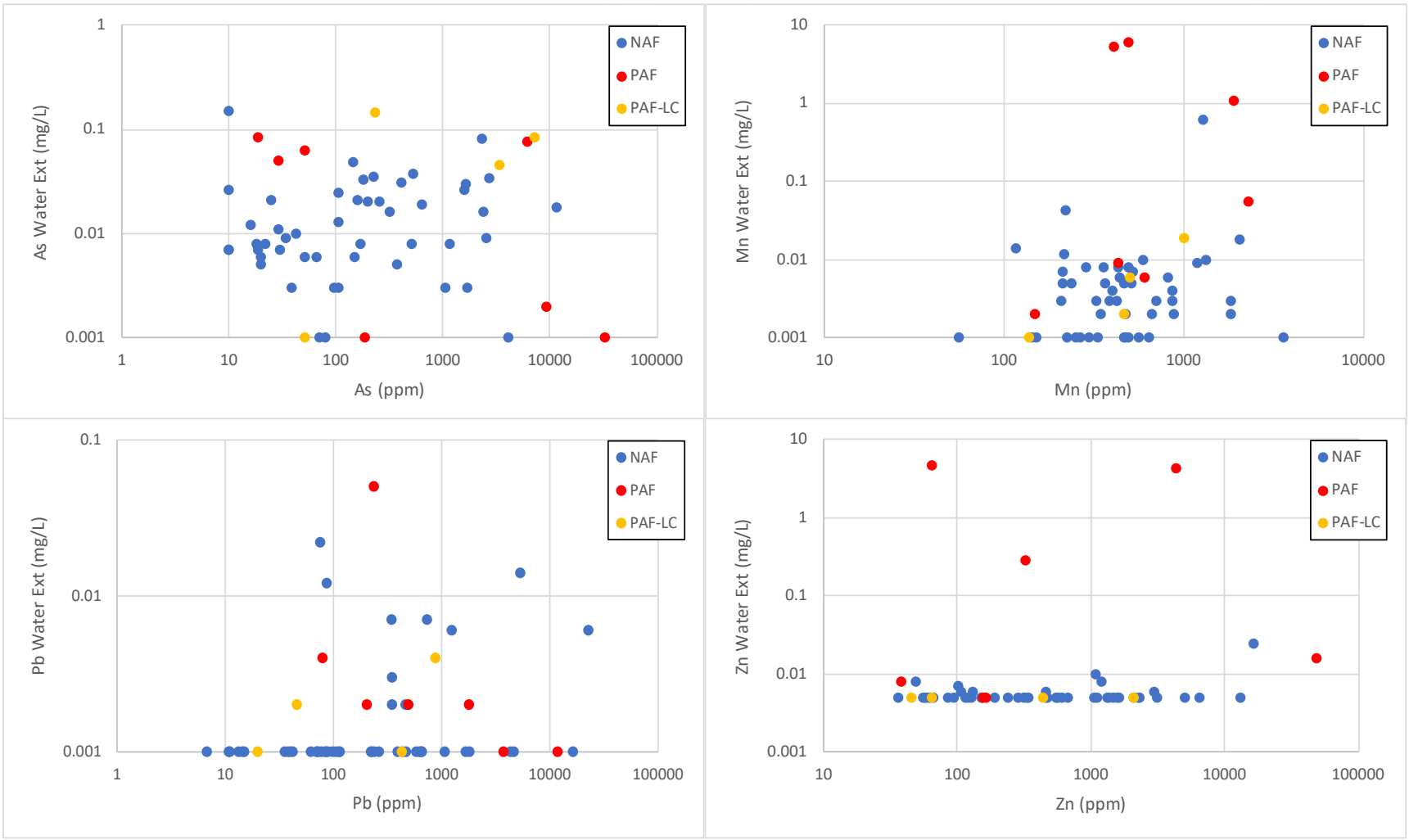


Figure 21: Concentrations of metals in water extracts as a function of bulk concentration. Samples are split by ARD classification

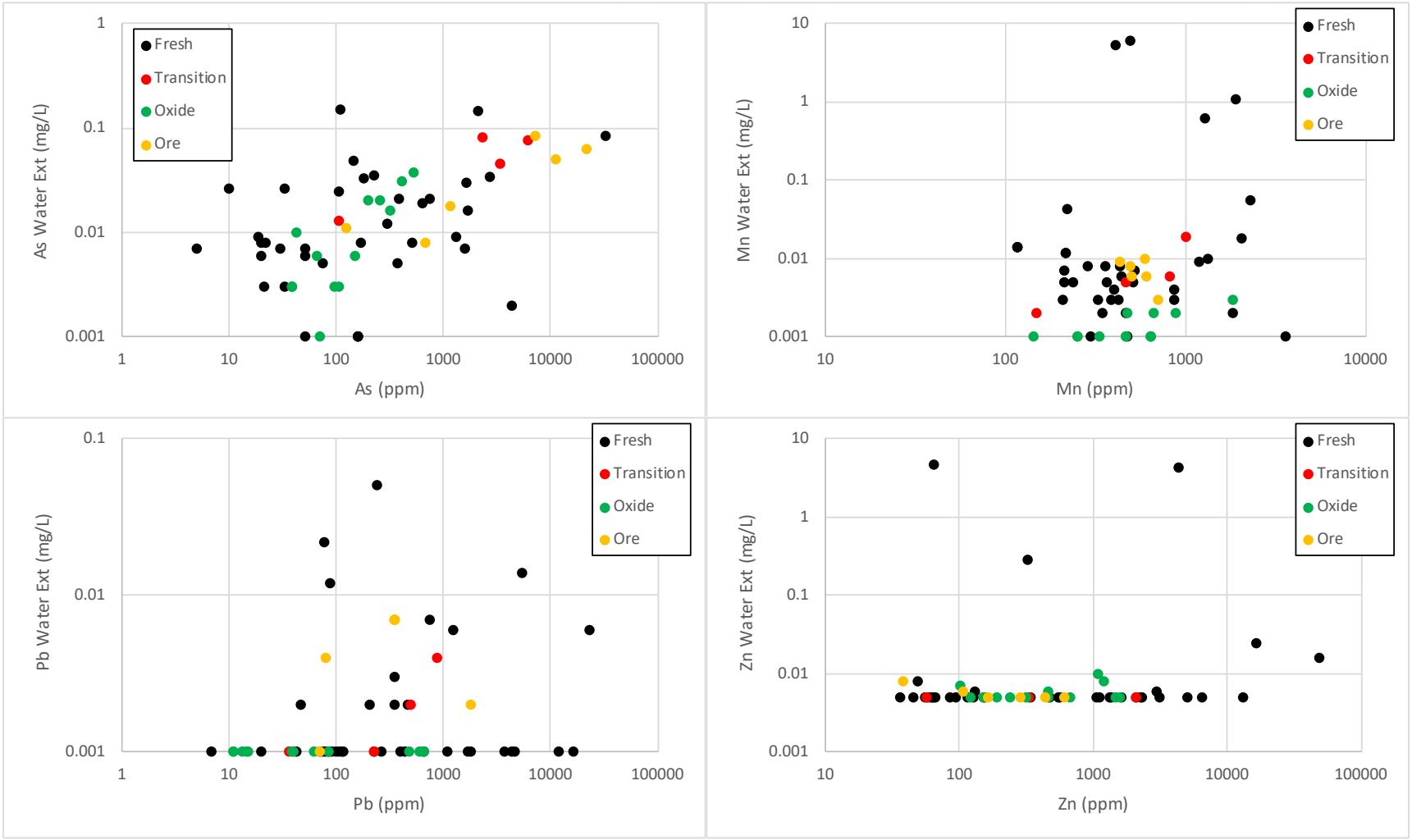


Figure 22: Concentrations of metals in water extracts as a function of bulk concentration. Samples are split by original oxidation state. Ore samples are included separately.

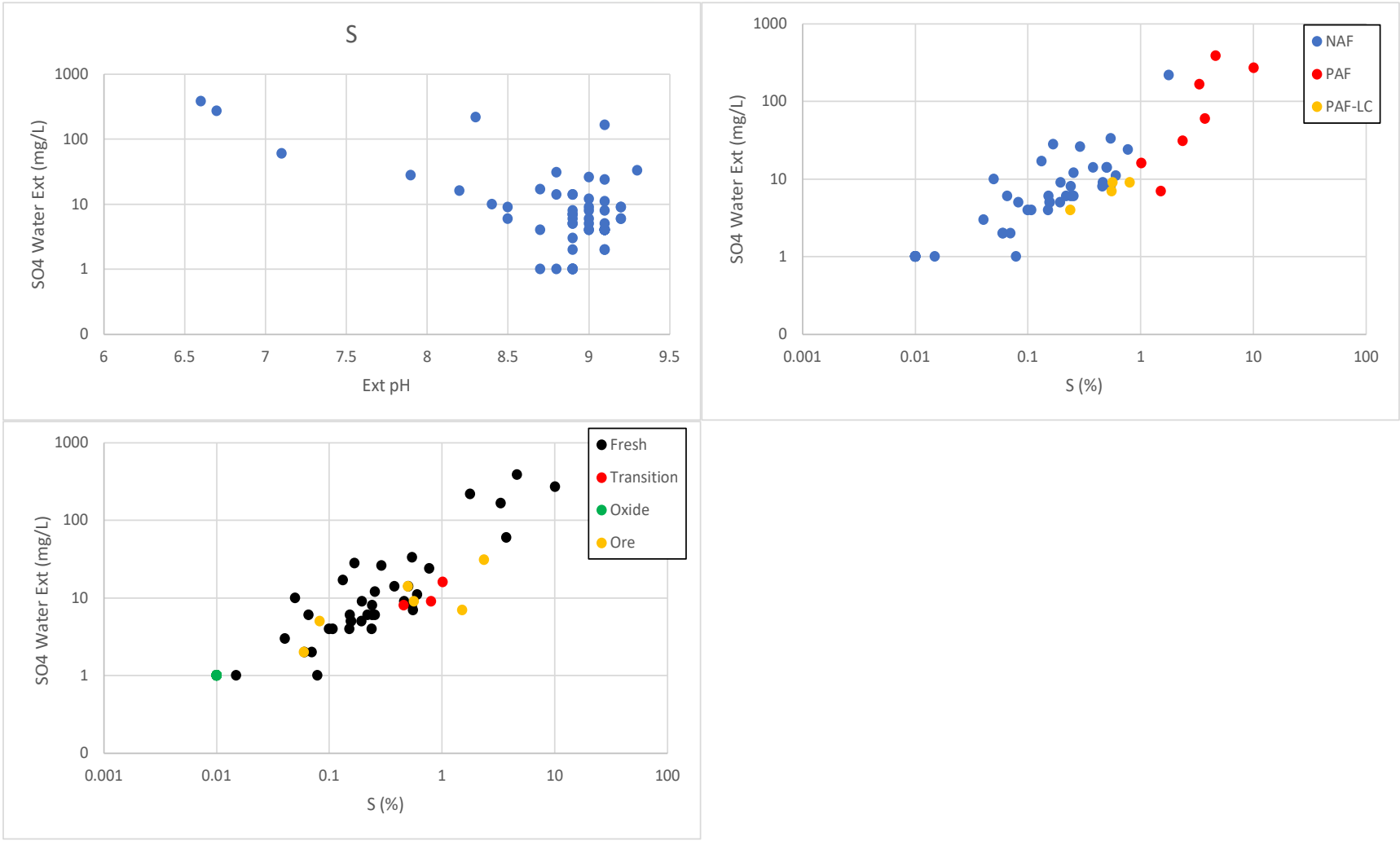


Figure 23: Concentrations of sulphate in water extracts as a function of extract pH (top left), bulk concentration split by ARD classification (top right) and bulk concentration split by original oxidation state (bottom left). Ore samples are included separately.

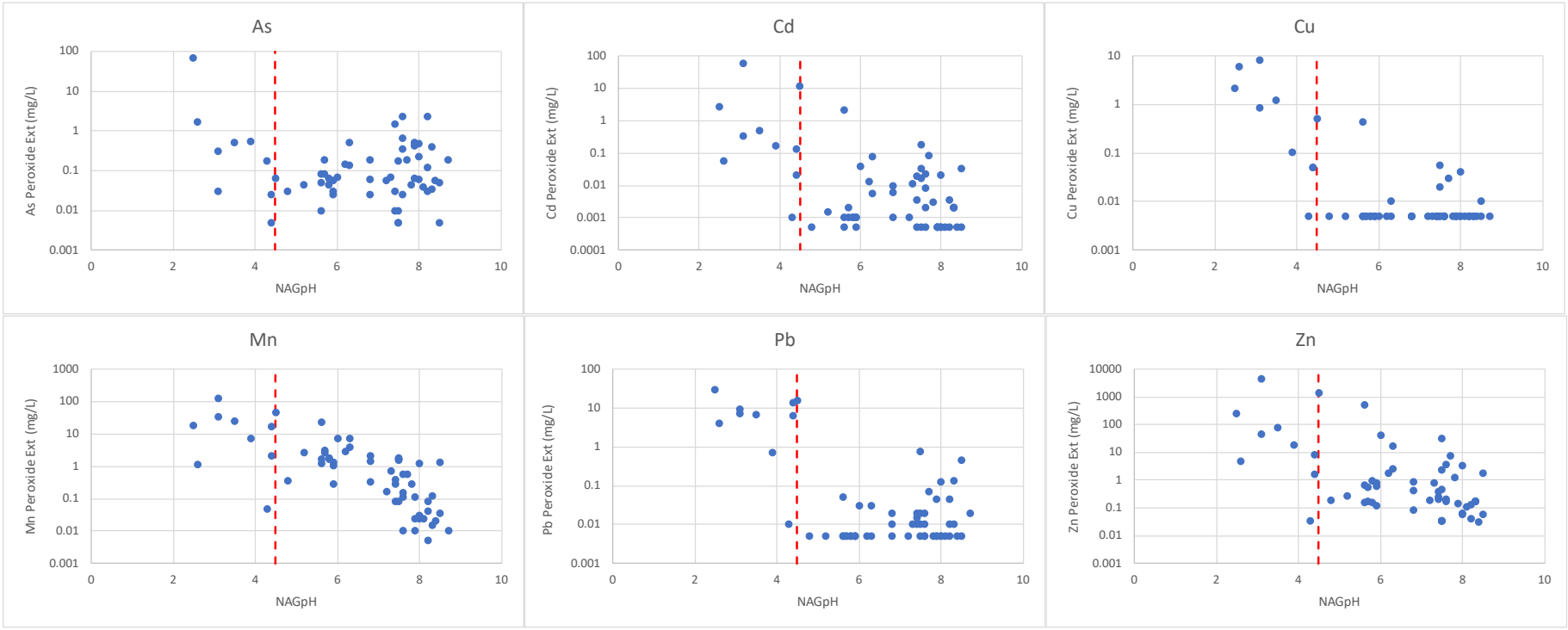


Figure 24: Concentrations of metals in peroxide extracts as a function of extract pH (NAGpH)

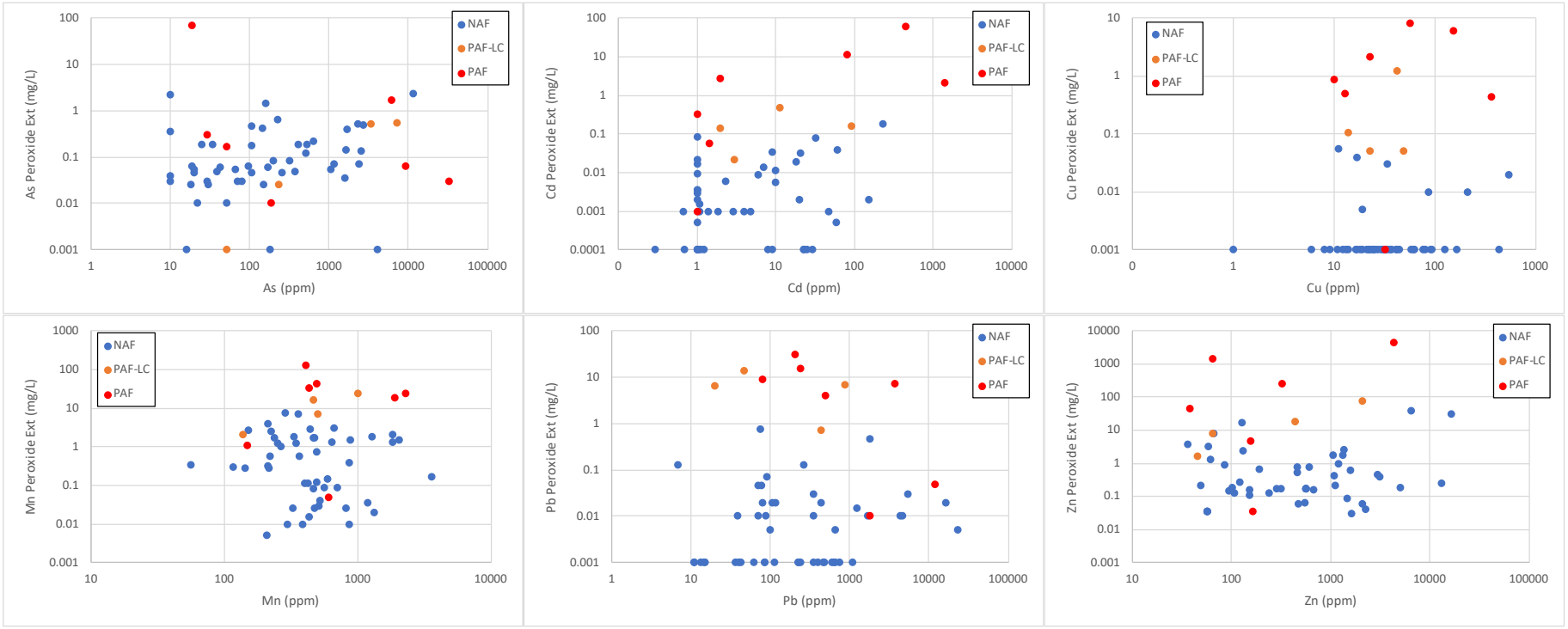


Figure 25: Concentrations of metals in peroxide extracts as a function of bulk concentration. Samples are split by ARD classification

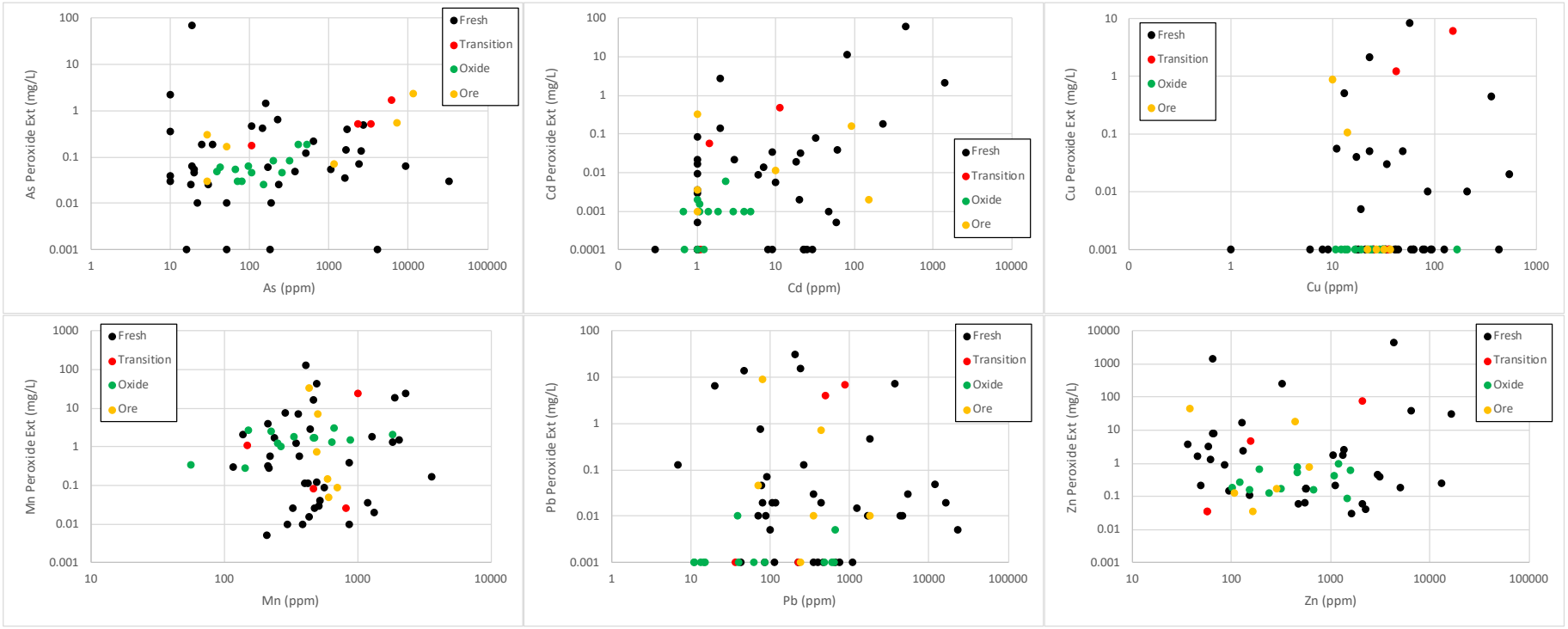


Figure 26: Concentrations of metals in peroxide extracts as a function of bulk concentration. Samples are split by original oxidation state. Ore samples are included separately.

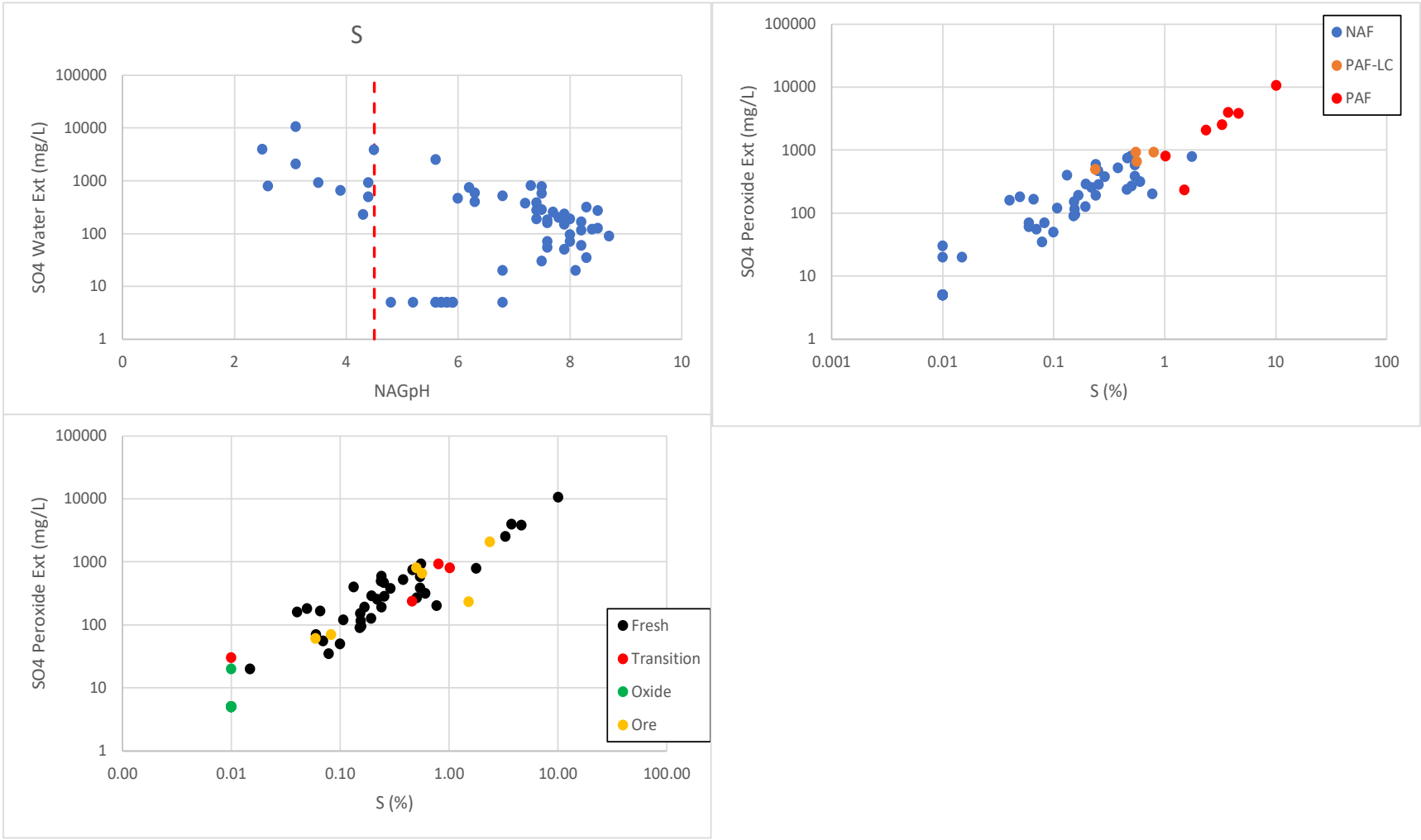


Figure 27: Concentrations of sulphate in peroxide extracts as a function of NAGpH (top left), bulk concentration split by ARD classification (top right) and bulk concentration split by original oxidation state (bottom left). Ore samples are included separately.

APPENDIX A - ABA & NAG Test Results

Table A1: ABA and NAG test results

Hole Name	Sample No	Rock Type	Material Type	Oxidation	Lode	Depth (m) From	Depth (m) To	Interval (m)	NAGpH	$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC/MPA	pH1:2	EC1:2 uS/cm	ARD Classification	
URNDD0100	C718992	Sandstone	Development Waste	Oxide		45.80	47.00	1.20	5.4	0	9	0.01	0	4	-4	25	7.7	75	NAF	
URNDD0100	C718997	Siltstone	Development Waste	Oxide		50.00	50.88	0.88	6.9	0	0	0.01	0	4	-3	15	7.8	91	NAF	
URNDD0100	C718999	Siltstone	Development Waste	Transitional		52.00	53.00	1.00	6.1	0	4	0.00	0	2	-2	35	7.9	146	NAF	
URNDD0100	C719000	Sandstone	Development Waste	Transitional		53.00	54.00	1.00	6.0	0	4	0.02	1	4	-3	7	8.6	155	NAF	
URNDD0100	C719002	Siltstone	Development Waste	Fresh		54.50	55.10	0.60	7.7	0	0	0.11	3	16	-12	5	8.7	179	NAF	
URNDD0100	C719011	Greywacke	Development Waste	Fresh		59.90	60.30	0.40	8.1	0	0	0.12	4	52	-49	15	8.7	189	NAF	
URNDD0100	C719013	Greywacke	Development Waste	Fresh		61.15	61.45	0.30	8.0	0	0	0.03	1	27	-26	31	9.1	145	NAF	
URNDD0100	C719018	Greywacke	Development Waste	Fresh		64.10	65.00	0.90	8.1	0	0	0.01	0	24	-23	52	8.7	144	NAF	
URNDD0100	C719025	Siltstone	Development Waste	Fresh		67.85	68.20	0.35	8.0	0	0	0.01	0	31	-31	68	8.6	246	NAF	
URNDD0100	C719031	Siltstone	Development Waste	Fresh		71.62	72.20	0.58	8.1	0	0	0.01	0	36	-36	202	8.5	252	NAF	
URNDD0100	C719035	Greywacke	Development Waste	Fresh		74.00	75.00	1.00	7.9	0	0	0.00	0	16	-16	215	8.4	264	NAF	
URNDD0100	C719037	Greywacke	Development Waste	Fresh		76.00	76.95	0.95	8.1	0	0	0.01	0	17	-17	45	9.2	271	NAF	
URNDD0100	C719039	Greywacke	Development Waste	Fresh		78.00	78.85	0.85	7.6	0	0	0.04	1	28	-27	24	9.1	194	NAF	
URNDD0100	C719042	Greywacke	Development Waste	Fresh		80.00	81.00	1.00	8.3	0	0	0.01	0	27	-26	170	9.0	188	NAF	
URNDD0100	C719045	Greywacke	Development Waste	Fresh		82.20	82.50	0.30	8.2	0	0	0.00	0	18	-18	125	8.9	196	NAF	
URNDD0100	C719051	Mudstone	Development Waste	Fresh		85.40	86.50	1.10	8.2	0	0	0.02	1	27	-26	42	8.7	276	NAF	
URNDD0100	C719054	Greywacke	Development Waste	Fresh		88.10	89.00	0.90	8.1	0	0	0.01	0	24	-24	92	8.6	257	NAF	
URNDD0100	C719056	Mudstone	Development Waste	Fresh		89.95	90.45	0.50	7.8	0	0	0.22	7	26	-20	4	8.5	321	NAF	
URNDD0100	C719060	Greywacke	Development Waste	Fresh		93.00	94.00	1.00	8.0	0	0	0.00	0	11	-11	146	8.4	259	NAF	
URNDD0100	C719066	Greywacke	Development Waste	Fresh		98.00	99.00	1.00	8.2	0	0	0.00	0	22	-22	245	8.7	240	NAF	
URNDD0100	C719071	Greywacke	Development Waste	Fresh		103.00	103.80	0.80	8.3	0	0	0.02	1	23	-23	36	8.6	252	NAF	
URNDD0100	C719075	Greywacke	Development Waste	Fresh		105.80	106.10	0.30	8.1	0	0	0.16	5	32	-27	7	8.8	366	NAF	
URNDD0100	C719082	Greywacke	Development Waste	Fresh		110.00	111.00	1.00	8.2	0	0	0.01	0	27	-27	70	8.9	311	NAF	
URNDD0100	C719088	Greywacke	Development Waste	Fresh		114.00	115.00	1.00	8.3	0	0	0.02	1	34	-34	54	9.1	276	NAF	
URNDD0100	C719092	Greywacke	Development Waste	Fresh		116.30	117.00	0.70	7.9	0	0	0.24	7	27	-19	4	9.0	219	NAF	
URNDD0100	C719098	Greywacke	Development Waste	Fresh		121.00	122.00	1.00	8.1	0	0	0.03	1	41	-40	45	8.9	288	NAF	
URNDD0100	C719103	Greywacke	Development Waste	Fresh		125.40	125.80	0.40	8.0	0	0	0.50	15	46	-30	3	8.6	279	NAF	
URNDD0100	C719104	Greywacke	Development Waste	Fresh		125.80	126.20	0.40	8.1	0	0	0.24	7	35	-27	5	8.8	316	NAF	
URNDD0100	C719107	Greywacke	Development Waste	Fresh		128.00	129.00	1.00	8.2	0	0	0.01	0	25	-24	76	8.9	325	NAF	
URNDD0100	C719112	Greywacke	Development Waste	Fresh		132.00	133.00	1.00	8.2	0	0	0.02	0	24	-24	49	8.6	346	NAF	
URNDD0100	C719119	Mudstone	Development Waste	Fresh		138.30	139.00	0.70	8.1	0	0	0.15	5	25	-20	5	8.7	1352	NAF	
URNDD0100	C719123	Greywacke	Development Waste	Fresh		142.00	143.00	1.00	8.3	0	0	0.01	0	27	-26	170	8.8	341	NAF	
URNDD0100	C719128	Vein	Development Waste	Fresh		145.60	146.15	0.55	8.3	0	0	0.09	3	32	-29	12	8.9	361	NAF	
URNDD0100	C719129	Greywacke	Development Waste	Fresh		146.15	146.65	0.50	8.2	0	0	0.30	9	24	-15	3	9.1	399	NAF	
URNDD0100	C719130	Greywacke	Development Waste	Fresh		146.65	147.00	0.35	8.1	0	0	0.15	5	23	-19	5	9.0	355	NAF	
URNDD0100	C719131	Greywacke	Development Waste	Fresh		147.00	148.00	1.00	8.0	0	0	0.02	1	25	-25	44	7.9	295	NAF	
URNDD0100	C719135	Greywacke	Development Waste	Fresh		149.65	150.16	0.51	8.1	0	0	0.07	2	26	-24	13	8.4	246	NAF	
URNDD0100	C719137	Greywacke	Development Waste	Fresh		151.10	151.40	0.30	8.0	0	0	0.16	5	27	-22	5	8.5	279	NAF	
URNDD0100	C719143	Vein	Development Waste	Fresh		154.50	154.85	0.35	8.2	0	0	0.11	3	35	-32	11	8.3	288	NAF	
URNDD0100	C719144	Mudstone	Development Waste	Fresh		154.85	155.65	0.80	8.1	0	0	0.07	2	21	-19	10	8.4	321	NAF	
URNDD0100	C719147	Greywacke	Development Waste	Fresh		157.00	157.35	0.35	7.9	0	0	0.03	1	15	-15	19	8.5	339	NAF	
URNDD0100	C719149	Greywacke	Development Waste	Fresh		158.00	159.00	1.00	8.2	0	0	0.01	0	20	-20	89	8.6	346	NAF	
URNDD0100	C719153	Greywacke	Development Waste	Fresh		162.00	162.85	0.85	6.2	0	1	0.24	7	17	-10	2	8.7	254	NAF	
URNDD0100	C719157	Greywacke	Development Waste	Fresh		164.00	164.80	0.80	6.4	0	1	0.46	14	39	-25	3	8.8	263	NAF	
URNDD0100	C719161	Greywacke	Development Waste	Fresh		166.65	167.30	0.65	5.6	0	9	0.97	30	19	11	1	8.9	255	UC	
URNDD0100	C719163	Greywacke	Development Waste	Fresh		167.90	168.55	0.65	7.7	0	0	0.22	7	30	-24	4	9.1	249	NAF	
URNDD0100	C719165	Mudstone	Development Waste	Fresh		169.00	169.55	0.55	7.9	0	0	0.08	2	36	-34	15	9.0	271	NAF	
URNDD0100	C719166	Mudstone	Development Waste	Fresh		169.55	170.20	0.65	7.8	0	0	0.14	4	26	-22	6	8.8	288	NAF	
URNDD0100	C719170	Mudstone	Development Waste	Fresh		172.00	173.00	1.00	7.8	0	0	0.25	8	18	-10	2	8.9	316	NAF	
URNDD0100	C719174	Mudstone	Development Waste	Fresh		175.65	176.18	0.53	7.5	0	0	0.54	17	62	-45	4	9.1	319	NAF	
URNDD0100	C719177	Greywacke	Development Waste	Fresh		177.50	178.20	0.70	7.6	0	0	0.58	18	34	-16	2	9.0	339	NAF	
URNDD0100	C719178	Shear	Development Waste	Fresh		178.20	178.55	0.35	7.4	0	0	0.54	17	26	-10	2	9.0	412	NAF	
URNDD0100	C719182	Mudstone	Development Waste	Fresh		180.15	180.90	0.75	7.9	0	0	0.14	4	36	-32	9	8.9	376	NAF	
URNDD0100	C719183	Mudstone	Development Waste	Fresh		180.90	181.60	0.70	8.0	0	0	1.05	32	41	-8	1	9.1	516	NAF	
URNDD0100	C719186	Vein	Development Waste	Fresh		182.65	183.10	0.45	7.3	0	0	0.02	1	24	-24	35	8.9	296	NAF	

Table A1: ABA and NAG test results

Hole Name	Sample No	Rock Type	Material Type	Oxidation	Lode	Depth (m) From	Depth (m) To	Interval (m)	NAGpH	$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC/MPA	pH1:2	EC1:2 uS/cm	ARD Classification	
URNDD0100	C719187	Greywacke	Development Waste	Fresh		183.10	183.45	0.35	6.4	0	2	0.29	9	16	-7	2	8.8	363	NAF	
URNDD0100	C719188	Greywacke	Development Waste	Fresh		183.45	184.00	0.55	7.5	0	0	0.04	1	20	-19	16	8.7	355	NAF	
URNDD0100	C719189	Greywacke	Development Waste	Fresh		184.00	185.00	1.00	7.6	0	0	0.32	10	33	-23	3	8.8	392	NAF	
URNDD0100	C719191	Greywacke	Development Waste	Fresh		186.00	186.48	0.48	8.1	0	0	0.07	2	35	-33	17	8.4	329	NAF	
URNDD0100	C719193	Greywacke	Development Waste	Fresh	Lode 100	186.75	187.00	0.25	4.3	1	5	0.63	19	19	0.6	1	8.6	334	PAF-LC	
URNDD0100	C719196	Mudstone	Development Waste	Fresh		189.00	189.35	0.35	8.1	0	0	0.04	1	158	-157	120	8.7	352	NAF	
URNDD0100	C719198	Greywacke	Development Waste	Fresh		190.27	190.75	0.48	8.4	0	0	0.19	6	78	-72	13	8.8	476	NAF	
URNDD0100	C719200	Greywacke	Development Waste	Fresh		190.75	191.50	0.75	7.6	0	0	1.48	45	110	-65	2	8.6	398	NAF	
URNDD0100	C719202	Greywacke	Development Waste	Fresh		192.00	192.85	0.85	3.1	16	35	2.09	64	30	34	0	8.9	415	PAF	
URNDD0100	C719205	Vein	Development Waste	Fresh		194.55	195.40	0.85	7.4	0	0	0.40	12	55	-43	5	9.1	346	NAF	
URNDD0100	C719209	Greywacke	Development Waste	Fresh		197.45	198.00	0.55	7.8	0	0	0.11	3	11	-8	3	9.0	216	NAF	
URNDD0100	C719212	Greywacke	Development Waste	Fresh		200.00	201.00	1.00	7.9	0	0	0.03	1	26	-25	30	8.9	329	NAF	
URNDD0100	C719215	Tuff	Development Waste	Fresh		202.00	203.00	1.00	8.1	0	0	0.01	0	42	-41	111	8.7	246	NAF	
URNDD0100	C719247	Greywacke	Development Waste	Fresh		230.00	231.00	1.00	8.2	0	0	0.06	2	27	-25	14	7.9	311	NAF	
URNDD0100	C719249	Greywacke	Development Waste	Fresh		232.00	232.40	0.40	7.6	0	0	0.28	9	25	-17	3	8.2	325	NAF	
URNDD0100	C719250	Greywacke	Development Waste	Fresh		232.40	233.00	0.60	8.0	0	0	0.56	17	25	-8	1	8.4	249	NAF	
URNDD0100	C719252	Greywacke	Development Waste	Fresh		234.00	235.00	1.00	8.2	0	0	0.24	7	28	-21	4	8.3	255	NAF	
URNDD0100	C719255	Greywacke	Development Waste	Fresh		236.18	237.00	0.82	8.0	0	0	0.06	2	17	-15	9	7.8	263	NAF	
URNDD0100	C719258	Mudstone	Development Waste	Fresh		238.14	239.20	1.06	8.1	0	0	0.03	1	13	-12	17	7.7	279	NAF	
URNDD0100	C719260	Vein	Development Waste	Fresh		239.70	240.56	0.86	8.2	0	0	0.79	24	35	-11	1	8.3	327	NAF	
URNDD0100	C719261	Vein	Development Waste	Fresh		240.56	241.35	0.79	8.5	0	0	0.56	17	145	-128	8	8.9	255	NAF	
URNDD0100	C719262	Mudstone	Development Waste	Fresh		241.35	241.87	0.52	4.0	3	8	0.32	10	3	7	0	9.1	166	PAF-LC	
URNDD0100	C719264	Vein	Development Waste	Fresh		242.33	243.25	0.92	6.1	0	2	0.31	9	10	0	1	7.9	316	NAF	
URNDD0100	C719267	Greywacke	Development Waste	Fresh		245.40	245.80	0.40	8.3	0	0	0.05	2	45	-43	29	8.0	329	NAF	
URNDD0100	C719273	Greywacke	Development Waste	Fresh		247.75	248.50	0.75	7.2	0	0	0.00	0	9	-9	79	8.1	421	NAF	
URNDD0100	C719278	Greywacke	Development Waste	Fresh		250.92	252.00	1.08	8.3	0	0	0.02	1	30	-30	48	8.4	411	NAF	
URNDD0100	C719285	Greywacke	Development Waste	Fresh		255.95	256.25	0.30	8.0	0	0	0.15	5	26	-21	6	8.3	246	NAF	
URNDD0100	C719292	Mudstone	Development Waste	Fresh		261.00	261.85	0.85	8.0	0	0	0.00	0	10	-10	166	8.5	255	NAF	
URNDD0100	C719294	Greywacke	Development Waste	Fresh		262.21	263.00	0.79	8.3	0	0	0.00	0	17	-17	273	7.9	263	NAF	
URNDD0100	C719300	Greywacke	Development Waste	Fresh		267.00	268.00	1.00	8.2	0	0	0.00	0	15	-15	241	7.8	276	NAF	
URNDD0100	C719308	Vein	Development Waste	Fresh		272.61	273.40	0.79	8.4	0	0	0.22	7	53	-47	8	8.4	281	NAF	
URNDD0100	C719312	Mudstone	Development Waste	Fresh		274.90	275.55	0.65	8.2	0	0	0.15	5	18	-13	4	8.5	294	NAF	
URNDD0100	C719313	Vein	Ore		Lode 400	275.55	276.00	0.45	2.8	12	22	1.30	40	25	14	1	8.2	329	PAF	
URNDD0100	C719314	Mudstone	Ore		Lode 400	276.00	276.45	0.45	7.1	0	0	3.30	101	114	-13	1	8.7	289	NAF	
URNDD0100	C719315	Greywacke	Ore		Lode 400	276.45	277.00	0.55	8.2	0	0	0.60	18	52	-33	3	8.1	294	NAF	
URNDD0100	C719316	Greywacke	Ore		Lode 400	277.00	278.00	1.00	8.1	0	0	0.06	2	31	-29	17	8.6	293	NAF	
URNDD0100	C719318	Siltstone	Ore		Lode 400	279.00	279.40	0.40	8.2	0	0	0.11	3	27	-24	8	8.3	371	NAF	
URNDD0100	C719321	Greywacke	Ore		Lode 400	280.00	280.50	0.50	8.3	0	0	0.02	0	36	-36	75	8.4	364	NAF	
URNDD0100	C719322	Greywacke	Ore		Lode 400	280.50	281.00	0.50	7.7	0	0	0.00	0	26	-26	428	8.4	285	NAF	
URNDD0100	C719324	Greywacke	Ore		Lode 400	281.55	282.00	0.45	8.2	0	0	0.11	3	28	-25	8	8.5	329	NAF	
URNDD0100	C719325	Greywacke	Ore		Lode 400	282.00	282.36	0.36	7.6	0	0	0.44	13	18	-5	1	8.6	363	NAF	
URNDD0100	C719326	Greywacke	Ore		Lode 400	282.36	282.70	0.34	2.8	13	18	1.51	46	17	29	0	8.3	245	PAF	
URNDD0100	C719327	Greywacke	Ore		Lode 400	282.70	283.20	0.50	3.0	15	24	2.36	72	31	41	0	8.6	411	PAF	
URNDD0100	C719329	Greywacke	Ore		Lode 400	283.80	284.10	0.30	7.4	0	0	0.86	26	37	-11	1	7.9	276	NAF	
URNDD0100	C719331	Greywacke	Development Waste	Fresh		285.00	285.40	0.40	7.6	0	0	0.20	6	33	-27	6	8.3	345	NAF	
URNDD0100	C719332	Greywacke	Development Waste	Fresh		285.40	286.00	0.60	7.8	0	0	0.15	5	24	-20	5	9.0	212	NAF	
URNDD0100	C719335	Greywacke	Development Waste	Fresh		287.00	288.00	1.00	8.1	0	0	0.03	1	19	-18	21	8.3	329	NAF	
URNDD0100	C719337	Greywacke	Development Waste	Fresh		289.00	290.00	1.00	8.2	0	0	0.03	1	27	-26	27	8.4	346	NAF	
URNDD0105	C725156	Greywacke	Development Waste	Oxide		44.05	44.85	0.80	6.1	0	5	0.01	0	4	-4	23	8.1	276	NAF	
URNDD0105	C725165	Greywacke	Development Waste	Transitional		50.40	50.85	0.45	6.3	0	2	0.00	0	4	-4	60	8.0	291	NAF	
URNDD0105	C725171	Shale	Development Waste	Fresh		55.00	56.00	1.00	8.0	0	0	0.02	1	18	-17	26	7.8	265	NAF	
URNDD0105	C725172	Greywacke	Development Waste	Fresh		56.00	57.00	1.00	8.1	0	0	0.06	2	18	-16	10	7.9	271	NAF	
URNDD0105	C725179	Shale	Development Waste	Fresh		60.30	61.00	0.70	8.2	0	0	0.03	1	26	-25	33	7.9	216	NAF	
URNDD0105	C725181	Greywacke	Development Waste	Fresh		62.00	63.00	1.00	8.1	0	0	0.02	1	18	-17	35	7.8	196	NAF	
URNDD0105	C725190	Shale	Development Waste	Fresh		69.00	70.00	1.00	8.1	0	0	0.22	7	20	-14	3	7.6	221	NAF	

Table A1: ABA and NAG test results

Hole Name	Sample No	Rock Type	Material Type	Oxidation	Lode	Depth (m) From	Depth (m) To	Interval (m)	NAGpH	$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC/MPA	pH1:2	EC1:2 uS/cm	ARD Classification	
URNDD0105	C725191	Shale	Development Waste	Fresh		70.00	71.00	1.00	8.2	0	0	0.02	1	19	-18	27	7.5	239	NAF	
URNDD0105	C725195	Greywacke	Development Waste	Fresh		73.00	74.00	1.00	8.2	0	0	0.13	4	25	-21	6	8.3	199	NAF	
URNDD0105	C725205	Vein	Development Waste	Fresh		80.70	81.95	1.25	7.6	0	0	0.06	2	19	-17	10	8.2	169	NAF	
URNDD0105	C725206	Greywacke	Development Waste	Fresh		81.95	83.00	1.05	6.1	0	2	0.13	4	12	-8	3	8.0	176	NAF	
URNDD0105	C725207	Greywacke	Development Waste	Fresh		83.00	84.00	1.00	7.4	0	0	0.05	2	14	-12	9	7.9	203	NAF	
URNDD0105	C725213	Greywacke	Development Waste	Fresh		88.30	89.00	0.70	7.6	0	0	0.17	5	12	-7	2	7.7	166	NAF	
URNDD0105	C725220	Greywacke	Development Waste	Fresh		94.00	95.00	1.00	5.5	0	2	0.15	5	8	-3	2	7.6	255	NAF	
URNDD0105	C725223	Vein	Development Waste	Fresh		96.70	97.10	0.40	3.8	4	10	0.38	12	9	2	1	9.2	211	PAF-LC	
URNDD0105	C725228	Greywacke	Development Waste	Fresh		100.00	101.00	1.00	8.3	0	0	0.03	1	27	-27	36	7.9	279	NAF	
URNDD0105	C725230	Shale	Development Waste	Fresh		101.87	102.30	0.43	6.4	0	3	0.04	1	8	-7	6	8.0	311	NAF	
URNDD0105	C725235	Greywacke	Development Waste	Fresh		104.20	105.00	0.80	4.1	3	9	0.52	16	8	8	0	9.1	196	PAF-LC	
URNDD0105	C725241	Greywacke	Development Waste	Fresh		110.00	111.00	1.00	4.1	2	6	0.34	10	9	1	1	8.9	151	PAF-LC	
URNDD0105	C725242	Greywacke	Development Waste	Fresh		111.00	111.47	0.47	4.1	1	8	0.62	19	14	5	1	9.0	126	PAF-LC	
URNDD0105	C725243	Vein	Development Waste	Fresh		111.47	111.87	0.40	4.2	1	5	0.35	11	10	0.5	1	9.1	135	PAF-LC	
URNDD0105	C725248	Greywacke	Development Waste	Fresh		114.00	115.00	1.00	8.3	0	0	0.07	2	35	-33	18	8.3	203	NAF	
URNDD0105	C725255	Greywacke	Development Waste	Fresh		120.00	121.00	1.00	6.9	0	0	0.08	2	11	-8	5	8.2	211	NAF	
URNDD0105	C725256	Shale	Development Waste	Fresh		121.00	122.00	1.00	6.2	0	3	0.16	5	11	-6	2	8.1	275	NAF	
URNDD0105	C725262	Greywacke	Development Waste	Fresh		127.06	128.00	0.94	6.9	0	0	0.03	1	8	-8	11	8.4	245	NAF	
URNDD0105	C725267	Greywacke	Development Waste	Fresh		130.43	131.00	0.57	7.3	0	0	0.52	16	51	-35	3	8.6	241	NAF	
URNDD0105	C725268	Shale	Development Waste	Fresh		131.00	131.50	0.50	7.4	0	0	0.07	2	30	-28	15	7.9	239	NAF	
URNDD0105	C725272	Tuff	Development Waste	Fresh		134.00	135.00	1.00	7.9	0	0	0.03	1	28	-28	35	8.1	252	NAF	
URNDD0105	C725275	Greywacke	Development Waste	Fresh		136.00	137.00	1.00	8.2	0	0	0.01	0	23	-23	76	8.3	263	NAF	
URNDD0105	C725279	Greywacke	Development Waste	Fresh		139.85	140.35	0.50	8.2	0	0	0.23	7	32	-25	5	8.2	279	NAF	
URNDD0105	C725282	Greywacke	Development Waste	Fresh		142.00	143.00	1.00	8.4	0	0	0.08	2	149	-146	62	8.3	291	NAF	
URNDD0105	C725287	Greywacke	Development Waste	Fresh		145.00	146.00	1.00	8.1	0	0	0.05	1	25	-24	17	8.2	289	NAF	
URNDD0105	C725289	Vein	Development Waste	Fresh		146.75	147.10	0.35	8.4	0	0	0.15	5	69	-65	15	8.6	354	NAF	
URNDD0105	C725296	Greywacke	Development Waste	Fresh		150.20	151.00	0.80	8.0	0	0	0.07	2	41	-39	18	8.5	321	NAF	
URNDD0105	C725299	Greywacke	Development Waste	Fresh		153.00	153.74	0.74	8.3	0	0	0.16	5	38	-34	8	8.7	346	NAF	
URNDD0105	C725305	Greywacke	Development Waste	Fresh		157.00	158.00	1.00	7.5	0	0	0.26	8	23	-15	3	9.0	363	NAF	
URNDD0105	C725309	Shale	Development Waste	Fresh		161.00	161.30	0.30	8.1	0	0	0.03	1	23	-22	25	9.1	279	NAF	
URNDD0105	C725313	Greywacke	Development Waste	Fresh		163.00	164.00	1.00	8.2	0	0	0.11	3	33	-29	10	8.9	297	NAF	
URNDD0105	C725317	Greywacke	Development Waste	Fresh		166.00	167.05	1.05	7.6	0	0	0.01	0	17	-17	70	8.4	345	NAF	
URNDD0105	C725320	Greywacke	Development Waste	Fresh		169.00	170.00	1.00	8.2	0	0	0.01	0	25	-24	113	8.1	321	NAF	
URNDD0105	C725325	Greywacke	Development Waste	Fresh		173.00	174.00	1.00	7.7	0	0	0.03	1	14	-13	17	7.9	333	NAF	
URNDD0105	C725329	Greywacke	Development Waste	Fresh		177.00	178.00	1.00	6.4	0	2	0.03	1	8	-7	8	7.8	369	NAF	
URNDD0105	C725330	Shale	Development Waste	Fresh		178.00	179.00	1.00	4.6	0	2	0.16	5	7	-2	1	7.7	412	NAF	
URNDD0105	C725336	Greywacke	Development Waste	Fresh		183.00	184.00	1.00	7.7	0	0	0.01	0	21	-21	59	8.3	379	NAF	
URNDD0105	C725343	Shale	Development Waste	Fresh		190.00	191.00	1.00	8.1	0	0	0.02	1	28	-27	54	8.5	322	NAF	
URNDD0105	C725349	Shale	Development Waste	Fresh		195.00	195.90	0.90	7.9	0	0	0.08	2	18	-16	8	8.9	246	NAF	
URNDD0105	C725352	Vein	Development Waste	Fresh		197.15	197.70	0.55	7.8	0	0	0.60	18	66	-48	4	9.3	259	NAF	
URNDD0105	C725356	Greywacke	Development Waste	Fresh		199.00	200.00	1.00	6.9	0	0	0.55	17	24	-7	1	9.0	252	NAF	
URNDD0105	C725359	Mudstone	Development Waste	Fresh		201.85	202.80	0.95	7.4	0	0	0.09	3	32	-30	12	9.2	263	NAF	
URNDD0105	C725362	Greywacke	Development Waste	Fresh		204.23	204.80	0.57	7.7	0	0	0.33	10	36	-26	4	8.4	278	NAF	
URNDD0105	C725363	Greywacke	Development Waste	Fresh		204.80	205.65	0.85	6.1	0	2	0.25	8	11	-3	1	8.6	327	NAF	
URNDD0105	C725367	Greywacke	Development Waste	Fresh		206.85	207.15	0.30	7.4	0	0	0.98	30	79	-49	3	8.7	411	NAF	
URNDD0105	C725369	Fault	Development Waste	Fresh		207.70	208.23	0.53	7.8	0	0	0.77	24	44	-21	2	8.8	429	NAF	
URNDD0105	C725371	Greywacke	Development Waste	Fresh		209.00	210.00	1.00	3.2	13	39	2.54	78	35	42	0	9.2	966	PAF	
URNDD0105	C725375	Greywacke	Development Waste	Fresh		212.05	213.00	0.95	3.2	14	43	2.19	67	15	52	0	8.4	1240	PAF	
URNDD0105	C725377	Vein	Development Waste	Fresh		213.65	214.30	0.65	7.3	0	0	0.25	8	28	-20	4	8.2	721	NAF	
URNDD0105	C725388	Greywacke	Development Waste	Fresh		221.60	222.10	0.50	7.1	0	0	0.03	1	12	-12	13	7.7	188	NAF	
URNDD0105	C725398	Greywacke	Development Waste	Fresh		227.40	228.18	0.78	7.8	0	0	0.03	1	27	-26	34	8.9	196	NAF	
URNDD0105	C725399	Vein	Development Waste	Fresh		228.18	228.70	0.52	7.2	0	0	0.29	9	20	-11	2	8.5	215	NAF	
URNDD0105	C725401	Mudstone	Development Waste	Fresh		229.18	229.75	0.57	3.0	16	53	3.31	101	47	55	0	8.4	329	PAF	
URNDD0105	C725403	Mudstone	Development Waste	Fresh		230.60	231.00	0.40	7.4	0	0	0.02	0	15	-14	30	7.9	378	NAF	
URNDD0105	C725408	Siltstone	Development Waste	Fresh		233.60	234.35	0.75	3.8	0	0	2.25	69	29	40	0	8.3	621	PAF-LC	

Table A1: ABA and NAG test results

Hole Name	Sample No	Rock Type	Material Type	Oxidation	Lode	Depth (m) From	Depth (m) To	Interval (m)	NAGpH	$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC/MPA	pH1:2	EC1:2 uS/cm	ARD Classification	
URNDD0105	C725411	Vein	Development Waste	Fresh		236.00	237.00	1.00	7.4	0	0	1.77	54	99	-45	2	7.6	3310	NAF	
URNDD0105	C725412	Greywacke	Development Waste	Fresh		237.00	238.00	1.00	3.1	11	152	10.11	309	57	252	0	6.5	4110	PAF	
URNDD0105	C725413	Greywacke	Development Waste	Fresh		238.00	239.00	1.00	4.7	0	15	4.88	149	66	83	0	7.7	2770	PAF	
URNDD0105	C725417	Vein	Development Waste	Fresh	Lode 310	241.00	242.00	1.00	2.8	16	59	4.64	142	18	124	0	6.5	4330	PAF	
URNDD0105	C725418	Vein	Development Waste	Fresh	Lode 310	242.00	243.00	1.00	3.1	9	66	5.88	180	25	155	0	6.7	3030	PAF	
URNDD0105	C725421	Vein	Development Waste	Fresh	Lode 310	244.60	245.00	0.40	2.4	42	86	3.74	114	4	110	0	7.3	1290	PAF	
URNDD0105	C725422	Vein	Development Waste	Fresh		245.00	246.00	1.00	3.7	1	8	0.72	22	10	12	0	7.9	1160	PAF-LC	
URNDD0105	C725426	Vein	Development Waste	Fresh		247.93	248.50	0.57	3.8	2	12	0.51	16	7	8	0	8.5	648	PAF-LC	
URNDD0105	C725428	Vein	Development Waste	Fresh		249.00	249.50	0.50	2.6	29	44	1.66	51	8	43	0	8.7	887	PAF	
URNDD0105	C725439	Vein	Development Waste	Fresh		255.76	256.50	0.74	7.4	0	0	0.22	7	47	-40	7	8.6	569	NAF	
URNDD0105	C725441	Vein	Development Waste	Fresh		257.00	257.85	0.85	6.9	0	0	0.38	12	27	-15	2	8.9	526	NAF	
URNDD0105	C725445	Greywacke	Development Waste	Fresh		259.00	260.00	1.00	8.0	0	0	0.03	1	24	-23	23	8.8	726	NAF	
URNDD0105	C725449	Mudstone	Development Waste	Fresh		263.00	264.00	1.00	7.3	0	0	0.01	0	16	-16	47	7.8	233	NAF	
URNDD0105	C725455	Mudstone	Development Waste	Fresh		268.00	268.45	0.45	7.2	0	0	0.01	0	14	-14	45	8.0	216	NAF	
URNDD0105	C725459	Mudstone	Development Waste	Fresh		271.00	272.00	1.00	7.1	0	0	0.02	1	12	-11	16	8.1	197	NAF	
URNDD0105	C725462	Greywacke	Development Waste	Fresh		273.10	274.00	0.90	7.9	0	0	0.25	8	28	-20	4	8.7	581	NAF	
URNDD0105	C725466	Greywacke	Development Waste	Fresh		276.00	276.90	0.90	7.6	0	0	0.12	4	18	-14	5	8.6	477	NAF	
URNDD0105	C725469	Greywacke	Ore		Lode 400	278.10	279.00	0.90	8.9	0	0	0.51	16	85	-69	5	8.8	375	NAF	
URNDD0105	C725470	Greywacke	Ore		Lode 400	279.00	279.45	0.45	3.8	2	6	0.72	22	21	1	1	9.0	469	PAF-LC	
URNDD0105	C725471	Vein	Ore		Lode 400	279.45	280.00	0.55	7.9	0	0	0.82	25	54	-29	2	8.5	431	NAF	
URNDD0105	C725472	Greywacke	Ore		Lode 400	280.00	281.00	1.00	7.6	0	0	0.67	21	40	-20	2	8.4	656	NAF	
URNDD0105	C725473	Greywacke	Ore		Lode 400	281.00	282.00	1.00	7.9	0	0	0.35	11	45	-34	4	7.9	521	NAF	
URNDD0105	C725475	Greywacke	Ore		Lode 400	282.00	282.90	0.90	7.4	0	0	0.50	15	31	-15	2	7.9	319	NAF	
URNDD0105	C725476	Vein	Ore		Lode 400	282.90	283.50	0.60	2.8	16	32	1.60	49	26	22	1	7.7	255	PAF	
URNDD0105	C725477	Vein	Ore		Lode 400	283.50	284.11	0.61	2.9	15	24	0.97	30	8	21	0	8.9	409	PAF	
URNDD0105	C725478	Vein	Ore		Lode 400	284.11	285.00	0.89	7.7	0	0	0.08	3	12	-9	5	8.3	293	NAF	
URNDD0105	C725479	Vein	Ore		Lode 400	285.00	285.55	0.55	3.6	4	9	0.56	17	10	8	1	9.1	321	PAF-LC	
URNDD0055	UD018241		Development Waste	Oxide		17.70	19.00	1.30	7.1	0	0	0.01	0	3	-3	10.9	7.9	81	NAF	
URNDD0055	UD018244		Development Waste	Oxide		21.50	22.40	0.90	7.3	0	0	0.01	0	2	-2	6.6	7.1	58	NAF	
URNDD0055	UD018249		Development Waste	Oxide		26.50	27.30	0.80	5.7	0	4	0.01	0	1	-1	4.1	6.7	37	NAF	
URNDD0055	UD018250		Development Waste	Oxide		27.30	28.20	0.90	5.8	0	2	0.01	0	2	-2	6.1	6.7	53	NAF	
URNDD0055	UD018253		Development Waste	Oxide		30.00	31.00	1.00	5.9	0	2	0.01	0	2	-2	7.6	6.8	32	NAF	
URNDD0055	UD018257		Development Waste	Oxide		33.10	34.10	1.00	5.8	0	2	0.01	0	2	-1	5.1	6.7	38	NAF	
URNDD0055	UD018259		Development Waste	Oxide		35.00	36.00	1.00	5.6	0	8	0.01	0	3	-3	10.9	7.0	43	NAF	
URNDD0055	UD018265		Development Waste	Oxide		41.00	42.00	1.00	5.8	0	5	0.01	0	6	-5	18.8	6.9	94	NAF	
URNDD0055	UD018267		Development Waste	Oxide		43.00	44.20	1.20	5.8	0	6	0.01	0	8	-7	24.6	7.3	55	NAF	
URNDD0055	UD018271		Development Waste	Oxide		46.00	47.00	1.00	5.8	0	6	0.01	0	8	-7	25.3	7.3	54	NAF	
URNDD0055	UD018275		Development Waste	Oxide		50.00	51.90	1.90	7.1	0	0	0.01	0	4	-4	12.6	7.0	68	NAF	
URNDD0055	UD018277		Development Waste	Oxide		53.00	53.50	0.50	5.8	0	7	0.01	0	6	-5	18.3	7.3	49	NAF	
URNDD0055	UD018279		Development Waste	Oxide		54.50	55.50	1.00	7.1	0	0	0.01	0	5	-5	17.0	6.3	231	NAF	
URNDD0055	UD018286		Development Waste	Transitional		60.00	61.50	1.50	7.4	0	0	0.01	0	36	-35	117.0	8.7	105	NAF	
URNDD0055	UD018287		Development Waste	Transitional		61.50	62.50	1.00	7.9	0	0	0.46	14	35	-21	2.5	8.6	147	NAF	
URNDD0055	UD018291		Development Waste	Fresh		65.50	66.60	1.10	8.1	0	0	0.01	0	21	-21	68.5	8.6	108	NAF	
URNDD0055	UD018292		Development Waste	Fresh		66.60	67.80	1.20	8.0	0	0	0.01	0	14	-14	46.2	8.4	176	NAF	
URNDD0055	UD018295		Development Waste	Fresh		69.00	70.00	1.00	8.2	0	0	0.01	0	27	-27	89.4	8.8	106	NAF	
URNDD0055	UD018297		Development Waste	Fresh		70.90	71.90	1.00	7.2	0	0	0.06	2	10	-8	5.6	8.8	142	NAF	
URNDD0055	UD018298		Development Waste	Fresh		71.90	72.40	0.50	7.9	0	0	0.07	2	27	-24	12.4	8.9	106	NAF	
URNDD0055	UD018299		Development Waste	Fresh		72.40	73.60	1.20	8.2	0	0	0.14	4	22	-18	5.1	8.4	256	NAF	
URNDD0055	UD018301		Development Waste	Fresh		74.60	75.90	1.30	8.4	0	0	0.11	3	28	-25	8.3	8.8	126	NAF	
URNDD0055	UD018302		Development Waste	Fresh		75.90	77.00	1.10	8.0	0	0	1.16	35	58	-22	1.6	8.6	211	NAF	
URNDD0055	UD018303		Development Waste	Fresh		77.00	78.20	1.20	7.5	0	0	0.20	6	16	-9	2.5	8.9	119	NAF	
URNDD0055	UD018304		Development Waste	Fresh		78.20	79.40	1.20	9.1	0	0	0.01	0	116	-116	380.3	8.8	145	NAF	
URNDD0055	UD018305		Development Waste	Fresh		79.40	80.70	1.30	8.3	0	0	0.10	3	55	-52	18.0	8.9	155	NAF	
URNDD0061	UD018310		Development Waste	Oxide		1.00	1.50	0.50	6.0	0	4	0.01	0	6	-6	19.7	8.3	109	NAF	
URNDD0061	UD018312		Development Waste	Oxide		3.00	3.90	0.90	5.4	0	7	0.01	0	2	-2	7.1	7.7	142	NAF	

Table A1: ABA and NAG test results

Hole Name	Sample No	Rock Type	Material Type	Oxidation	Lode	Depth (m) From	Depth (m) To	Interval (m)	NAGpH	$NAG_{(pH4.5)}$ (kg H_2SO_4/t)	$NAG_{(pH7.0)}$ (kg H_2SO_4/t)	S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC/MPA	pH1:2	EC1:2 uS/cm	ARD Classification	
URNDD0061	UD018314		Development Waste	Oxide		7.30	8.00	0.70	5.8	0	7	0.01	0	5	-5	16.9	7.8	90	NAF	
URNDD0061	UD018315		Development Waste	Oxide		8.00	8.30	0.30	4.5	0	10	0.01	0	0	0	-0.2	6.0	25	NAF	
URNDD0061	UD018316		Development Waste	Oxide		9.00	10.00	1.00	4.6	0	11	0.01	0	1	0	2.2	5.7	29	NAF	
URNDD0061	UD018317		Development Waste	Oxide		10.00	10.90	0.90	4.6	0	10	0.01	0	0	0	0.0	5.6	22	NAF	
URNDD0061	UD018326		Development Waste	Oxide		17.80	18.70	0.90	5.3	0	2	0.01	0	0	0	0.9	6.6	55	NAF	
URNDD0061	UD018327		Development Waste	Oxide		18.70	19.80	1.10	6.0	0	1	0.01	0	1	-1	4.4	6.5	47	NAF	
URNDD0061	UD018329		Development Waste	Oxide		20.80	22.00	1.20	5.4	0	5	0.01	0	1	-1	2.8	6.8	36	NAF	
URNDD0061	UD018330		Development Waste	Oxide		22.00	23.00	1.00	6.9	0	0	0.01	0	3	-3	9.6	6.7	49	NAF	
URNDD0061	UD018333		Development Waste	Oxide		24.00	25.00	1.00	5.7	0	4	0.01	0	2	-2	7.2	6.6	62	NAF	
URNDD0061	UD018336		Development Waste	Oxide		27.00	27.30	0.30	5.2	0	8	0.01	0	1	-1	3.3	6.7	48	NAF	
URNDD0061	UD018337		Development Waste	Oxide		27.30	28.70	1.40	5.1	0	7	0.01	0	1	0	2.3	6.5	79	NAF	
URNDD0061	UD018340		Development Waste	Oxide		30.40	31.10	0.70	5.9	0	4	0.01	0	3	-3	11.2	7.1	47	NAF	
URNDD0061	UD018341		Development Waste	Oxide		31.10	32.10	1.00	5.8	0	2	0.01	0	1	-1	2.7	7.2	40	NAF	
URNDD0061	UD018343		Development Waste	Oxide		33.10	34.00	0.90	5.8	0	3	0.01	0	2	-2	6.4	7.3	47	NAF	
URNDD0061	UD018349		Development Waste	Oxide		37.00	38.00	1.00	5.4	0	8	0.01	0	2	-1	5.3	7.1	64	NAF	
URNDD0061	UD018354		Development Waste	Oxide		42.00	43.10	1.10	5.9	0	3	0.01	0	5	-5	16.9	7.4	66	NAF	
URNDD0061	UD018356		Development Waste	Oxide		44.00	45.00	1.00	5.8	0	5	0.01	0	4	-4	13.7	7.3	79	NAF	
URNDD0061	UD018358		Development Waste	Oxide		46.10	47.00	0.90	5.6	0	7	0.01	0	4	-4	13.9	7.4	57	NAF	
URNDD0061	UD018364		Development Waste	Oxide		50.50	51.50	1.00	5.5	0	7	0.01	0	3	-3	9.3	7.4	52	NAF	
URNDD0061	UD018369		Development Waste	Oxide		55.10	56.10	1.00	5.8	0	6	0.01	0	5	-4	15.7	7.7	73	NAF	
URNDD0061	UD018372		Development Waste	Transitional		57.70	59.00	1.30	6.0	0	4	0.01	0	7	-6	21.3	7.9	72	NAF	
URNDD0061	UD018375		Development Waste	Transitional		60.50	61.50	1.00	2.5	14	19	1.02	31	6	26	0.2	7.1	217	PAF	
URNDD0061	UD018378		Development Waste	Transitional		62.50	63.10	0.60	3.5	2	6	0.80	24	17	7	0.7	7.6	196	PAF-LC	
URNDD0061	UD018379		Development Waste	Fresh		63.10	64.00	0.90	7.8	0	0	0.29	9	65	-56	7.3	7.3	427	NAF	
URNDD0061	UD018381		Development Waste	Fresh		64.90	66.00	1.10	7.7	0	0	0.01	0	18	-18	59.4	8.8	125	NAF	
URNDD0061	UD018383		Development Waste	Fresh		67.20	68.00	0.80	8.2	0	0	0.06	2	24	-22	13.2	8.8	108	NAF	
URNDD0061	UD018387		Development Waste	Fresh		71.10	72.60	1.50	8.1	0	0	0.13	4	28	-24	7.1	8.8	120	NAF	
URNDD0061	UD018390		Development Waste	Fresh		73.60	74.50	0.90	7.9	0	0	0.21	6	23	-17	3.6	7.9	674	NAF	
URNDD0061	UD018392		Development Waste	Fresh		75.50	76.50	1.00	8.4	0	0	0.11	3	33	-30	9.8	8.7	103	NAF	

APPENDIX B – Sequential NAG Test Results

Table B1: Sequential NAG Results

EGi Code	Sample No.	Sulphide S (%)	ANC	NAPP*	STAGE 1			STAGE 2			STAGE 3			STAGE 4			STAGE 5			Total			ARD Classification (NAPP*)	ARD Classification (SNAG)
			(kg H_2SO_4/t)		NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	Lowest NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$		
						(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)				
17053	C719161	0.83	19	6	5.4	0	4	6.8	0	0	6.4	0	0	7.3	0	0				5.4	0	4	UC	UC
17167	C725401	3.25	47	52	5.8	0	12	3.0	15	32	3.9	1	6	4.3	0.3	3				3.0	16	53	UC	PAF
17172	C725413	3.02	66	26	6.1	0	11	4.7	0	3	5.2	0	1	5.7	0	0.3				4.7	0	15	UC	UC
17173	C725417	3.51	18	89	4.5	0	30	2.8	12	20	3.3	3	6	3.7	1	3	4.0	1	2	2.8	16	59	UC	PAF
17176	C725422	0.37	10	1	4.5	0	3	3.7	1	3	4.2	0.1	1	4.4	0.1	1				3.7	1	8	UC	PAF-LC

APPENDIX C – ABCC Test Results

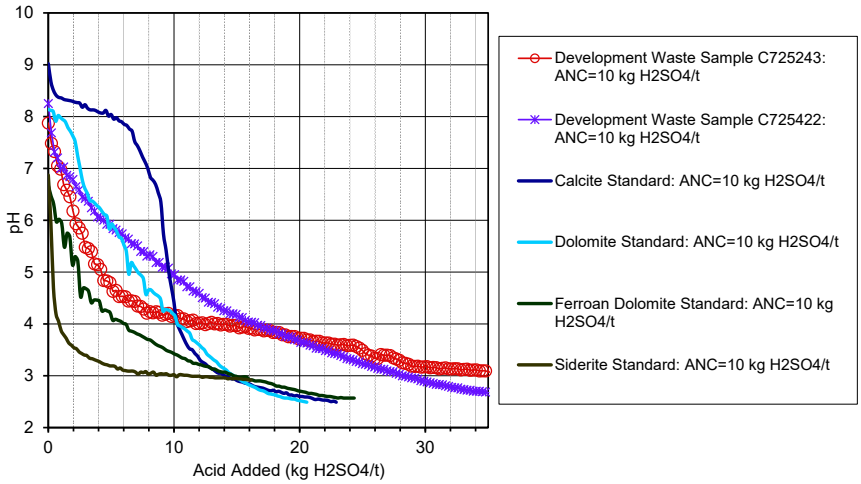


Figure C1: ABCC profile for samples with an ANC of 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

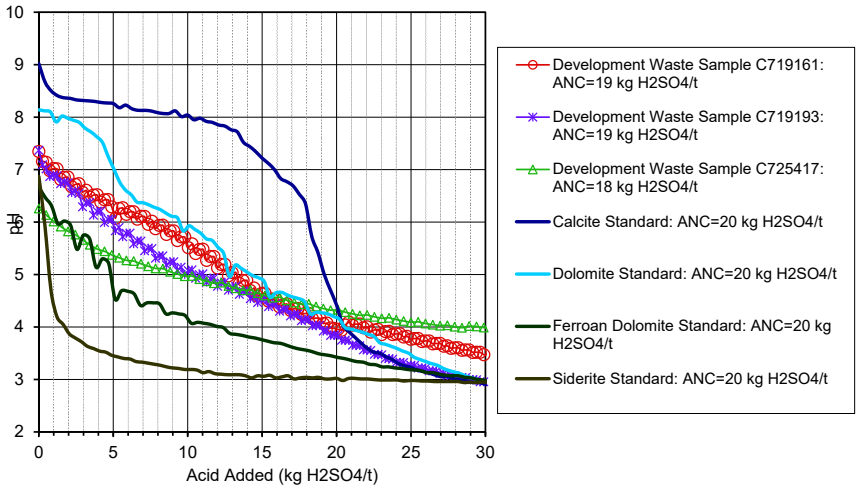


Figure C2: ABCC profile for samples with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

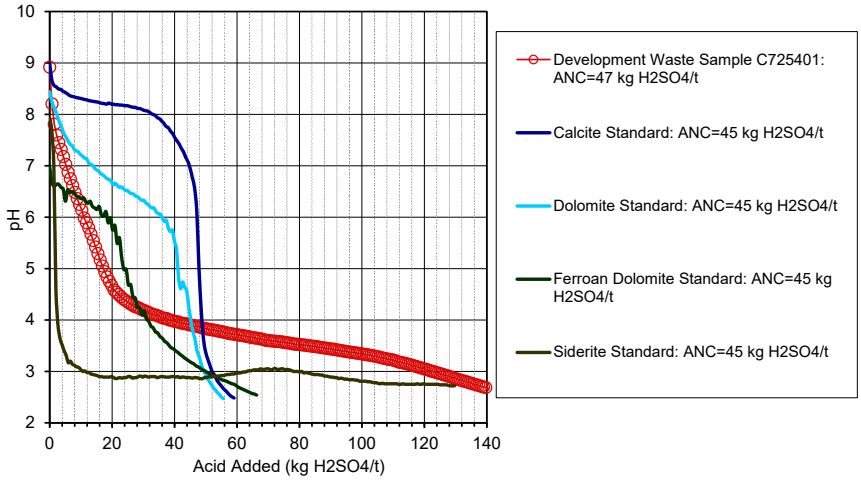


Figure C3: ABCC profile for sample C725401 with an ANC value close to 45 kg H_2SO_4/t. Carbonate standard curves are included for reference.

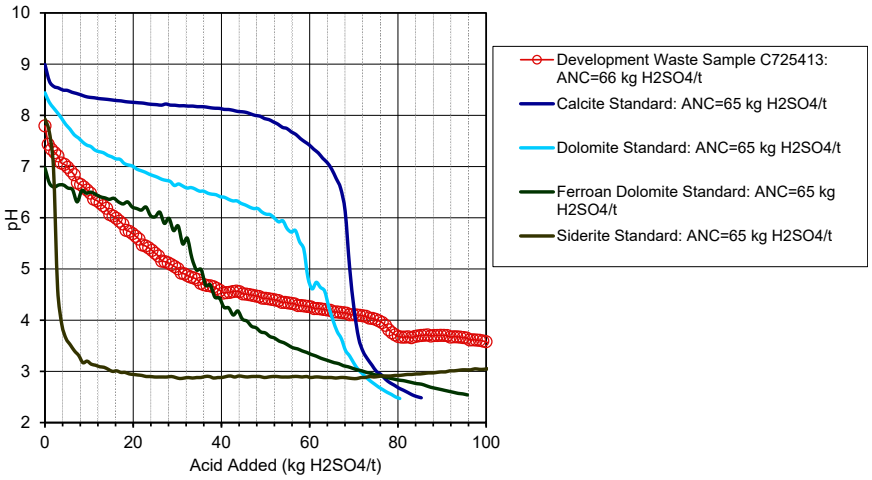


Figure C4: ABCC profile for sample C725413 with an ANC value close to 65 kg H_2SO_4/t. Carbonate standard curves are included for reference.

APPENDIX D1 – Water Extraction Test Results

HOLEID	PROJECTCODE	SAMPLEID	Sample Type	Oxidation	ARD Classification		pH	EC	Alkalinity	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	F	Fe	Hg	K
								dS/m	mg CaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
URNDD0055	UR	UD018241	Development Waste	Oxide	NAF		8.9	0.035	15	<0.001	0.12	0.01	<0.05	0.028	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.6	0.08	<0.0001	<1
URNDD0055	UR	UD018249	Development Waste	Oxide	NAF		7.8	0.025	13	<0.001	0.05	0.003	<0.05	0.03	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.5	<0.05	<0.0001	2
URNDD0055	UR	UD018250	Development Waste	Oxide	NAF		8.1	0.019	14	<0.001	0.05	0.02	<0.05	0.079	<0.001	<1	<0.0001	2	<0.001	<0.001	<0.001	0.5	<0.05	<0.0001	3
URNDD0055	UR	UD018257	Development Waste	Oxide	NAF		8.2	0.046	13	<0.001	0.04	0.037	<0.05	0.116	<0.001	<1	<0.0001	2	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	4
URNDD0055	UR	UD018275	Development Waste	Oxide	NAF		8.1	0.052	13	<0.001	0.06	0.031	<0.05	0.079	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	2
URNDD0055	UR	UD018277	Development Waste	Oxide	NAF		8.0	0.061	13	<0.001	0.12	0.006	<0.05	0.164	<0.001	<1	<0.0001	1	<0.001	<0.001	<0.001	0.3	0.06	<0.0001	<1
URNDD0055	UR	UD018286	Development Waste	Transitional	NAF		8.7	0.048	40	<0.001	0.9	0.013	<0.05	0.238	<0.001	3	<0.0001	<1	<0.001	<0.001	<0.001	0.3	0.17	<0.0001	12
URNDD0055	UR	UD018287	Development Waste	Transitional	NAF		9.0	0.035	46	<0.001	0.62	0.08	<0.05	0.065	<0.001	5	<0.0001	2	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	16
URNDD0055	UR	UD018298	Development Waste	Fresh	NAF		9.1	0.029	37	<0.001	0.64	0.035	<0.05	0.161	<0.001	3	<0.0001	2	<0.001	<0.001	<0.001	0.2	0.06	<0.0001	11
URNDD0055	UR	UD018305	Development Waste	Fresh	NAF		9.1	0.061	36	<0.001	0.55	0.049	<0.05	0.062	<0.001	4	<0.0001	<1	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	13
URNDD0061	UR	UD018312	Development Waste	Oxide	NAF		8.0	0.059	13	<0.001	0.02	0.003	<0.05	0.161	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	4
URNDD0061	UR	UD018317	Development Waste	Oxide	NAF		7.3	0.061	15	<0.001	<0.01	<0.001	<0.05	0.094	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	3
URNDD0061	UR	UD018327	Development Waste	Oxide	NAF		8.1	0.055	11	<0.001	0.02	0.006	<0.05	0.1	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	3
URNDD0061	UR	UD018336	Development Waste	Oxide	NAF		8.2	0.046	12	<0.001	0.02	0.003	<0.05	0.103	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	3
URNDD0061	UR	UD018340	Development Waste	Oxide	NAF		8.3	0.036	13	<0.001	0.04	0.001	<0.05	0.12	<0.001	<1	<0.0001	<1	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	3
URNDD0061	UR	UD018343	Development Waste	Oxide	NAF		7.9	0.029	14	<0.001	0.1	0.02	<0.05	0.054	<0.001	<1	<0.0001	1	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	4
URNDD0061	UR	UD018358	Development Waste	Oxide	NAF		8.3	0.036	13	<0.001	0.05	0.016	<0.05	0.12	<0.001	<1	<0.0001	1	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	1
URNDD0061	UR	UD018375	Development Waste	Transitional	PAF		8.2	0.076	14	<0.001	0.14	0.076	<0.05	0.248	<0.001	<1	<0.0001	2	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	12
URNDD0061	UR	UD018378	Development Waste	Transitional	PAF-LC		8.5	0.089	28	<0.001	0.47	0.046	<0.05	0.175	<0.001	2	<0.0001	2	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	14
URNDD0061	UR	UD018383	Development Waste	Fresh	NAF		8.9	0.087	39	<0.001	0.75	0.025	<0.05	0.203	<0.001	2	<0.0001	<1	<0.001	<0.001	<0.001	0.2	0.09	<0.0001	13
URNDD0100	UR	C719025	Development Waste	Fresh	NAF		8.8	0.146	31	<0.001	0.27	0.007	<0.05	0.201	<0.001	5	<0.0001	5	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	9
URNDD0100	UR	C719075	Development Waste	Fresh	NAF		8.9	0.175	38	<0.001	0.29	0.008	<0.05	0.27	<0.001	6	<0.0001	5	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	12
URNDD0100	UR	C719092	Development Waste	Fresh	NAF		9.2	0.166	37	<0.001	0.32	0.019	<0.05	0.256	<0.001	5	<0.0001	5	<0.001	<0.001	<0.001	0.3	0.06	<0.0001	11
URNDD0100	UR	C719103	Development Waste	Fresh	NAF		8.9	0.143	37	<0.001	0.12	0.005	<0.05	0.295	<0.001	8	<0.0001	6	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	9
URNDD0100	UR	C719135	Development Waste	Fresh	NAF		9.0	0.159	40	<0.001	0.3	0.008	<0.05	0.042	<0.001	4	<0.0001	4	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	15
URNDD0100	UR	C719143	Development Waste	Fresh	NAF		8.7	0.191	34	<0.001	0.22	0.006	<0.05	0.27	<0.001	4	<0.0001	7	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	12
URNDD0100	UR	C719153	Development Waste	Fresh	NAF		8.9	0.155	35	<0.001	0.52	0.034	<0.05	0.035	<0.001	2	<0.0001	4	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	18
URNDD0100	UR	C719157	Development Waste	Fresh	NAF		9.2	0.116	31	<0.001	0.41	0.03	<0.05	0.244	<0.001	3	<0.0001	4	<0.001	<0.001	<0.001	0.2	0.08	<0.0001	13
URNDD0100	UR	C719174	Development Waste	Fresh	NAF		9.3	0.112	33	<0.001	0.23	0.006	<0.05	0.05	<0.001	8	<0.0001	5	<0.001	<0.001	<0.001	0.3	<0.05	<0.0001	24
URNDD0100	UR	C719178	Development Waste	Fresh	NAF		9.1	0.103	35	<0.001	0.33	0.008	<0.05	0.269	<0.001	3	<0.0001	5	<0.001	<0.001	<0.001	0.3	0.07	<0.0001	13
URNDD0100	UR	C719188	Development Waste	Fresh	NAF		8.9	0.075	34	<0.001	0.21	0.007	<0.05	0.035	<0.001	2	<0.0001	3	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	11
URNDD0100	UR	C719193	Development Waste	Fresh	PAF-LC		8.9	0.089	31	<0.001	0.4	0.001	<0.05	0.221	<0.001	2	<0.0001	4	<0.001	<0.001	<0.001	0.2	0.09	<0.0001	10
URNDD0100	UR	C719198	Development Waste	Fresh	NAF		9	0.092	38	<0.001	0.21	0.033	<0.05	0.045	<0.001	5	<0.0001	5	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	12
URNDD0100	UR	C719316	Ore		NAF		9.1	0.124	35	<0.001	0.31	0.011	<0.05	0.284	<0.001	4	<0.0001	4	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	9
URNDD0100	UR	C719326	Ore		PAF		8.9	0.129	24	<0.001	0.11	0.063	<0.05	0.036	<0.001	3	<0.0001	6	<0.001	<0.001	<0.001	0.1	<0.05	<0.0001	9
URNDD0100	UR	C719327	Ore		PAF		8.8	0.169	30	<0.001	0.23	0.05	<0.05	0.3	<0.001	8	<0.0001	6	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	20
URNDD0100	UR	C719331	Development Waste	Fresh	NAF		9	0.216	33	<0.001	0.22	0.012	<0.05	0.026	<0.001	4	<0.0001	4	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	13
URNDD0100	UR	C719332	Development Waste	Fresh	NAF		9.2	0.099	39	<0.001	0.85	0.007	<0.05	0.23	<0.001	4	<0.0001	4	<0.001	<0.001	<0.001	0.3	0.24	<0.0001	14
URNDD0105	UR	C725206	Development Waste	Fresh	NAF		8.7	0.114	25	<0.001	0.28	0.009	<0.05	0.032	<0.001	2	<0.0001	4	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	18
URNDD0105	UR	C725207	Development Waste	Fresh	NAF		8.4	0.124	33	<0.001	0.56	0.151	<0.05	0.293	<0.001	3	<0.0001	5	<0.001	<0.001	<0.001	0.2	0.22	<0.0001	12
URNDD0105	UR	C725213	Development Waste	Fresh	NAF		7.9	0.132	13	<0.001	0.08	0.026	<0.05	0.052	<0.001	3	<0.0001	4	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	19
URNDD0105	UR	C725243	Development Waste	Fresh	PAF-LC		9	0.111	23	<0.001	0.36	0.143	<0.05	0.09	<0.001	<1	<0.0001	5	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	12
URNDD0105	UR	C725282	Development Waste	Fresh	NAF		8.7	0.139	39	<0.001	0.24	0.026	0.12	0.062	<0.001	4	<0.0001	4	<0.001	0.008	<0.001	0.4	<0.05	<0.0001	9
URNDD0105	UR	C725289	Development Waste	Fresh	NAF		9.1	0.218	39	<0.001	0.69	0.021	0.15	0.036	<0.001	2	<0.0001	4	<0.001	<0.001	<0.001	0.6	<0.05	<0.0001	27
URNDD0105	UR	C725299	Development Waste	Fresh	NAF		8.9	0.179	47	<0.001	0.32	0.007	0.15	0.317	<0.001	5	<0.0001	6	<0.001	<0.001	<0.001	0.5	<0.05	<0.0001	17
URNDD0105	UR	C725352	Development Waste	Fresh	NAF		9.1	0.151	41	<0.001	0.4	0.003	<0.05	0.312	<0.001	7	<0.0001	6	<0.001	<0.001	<0.001	0.5	<0.05	<0.0001	21
URNDD0105	UR	C725363	Development Waste	Fresh	NAF		9	0.164	26	<0.001	0.43	0.016	<0.05	0.023	<0.001	2	<0.0001	4	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	17
URNDD0105	UR	C725369	Development Waste	Fresh	NAF		9.1	0.175	36	<0.001	0.59	0.005	<0.05	0.024	<0.001	6	<0.0001	4	<0.001	<0.001	<0.001	0.5	<0.05	<0.0001	29
URNDD0105	UR	C725377	Development Waste	Fresh	NAF		8.9	0.147	38	<0.001	1.12	0.021	<0.05	0.165	<0.001	2	<0.0001	5	<0.001	<0.001	<0.001	0.7	0.17	<0.0001	31
URNDD0105	UR	C725399	Development Waste	Fresh	NAF		9	0.162	32	<0.001	0.3	0.003	<0.05	0.376	<0.001	6	<0.0001	8	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	21
URNDD0105	UR	C725401	Development Waste	Fresh	PAF		9.1	0.416	24	0.002	0.05	0.001	<0.05	0.075	<0.001	37	<0.0001	14	<0.001	<0.001	<0.001	0.5	<0.05	<0.0001	63
URNDD0105	UR	C725411	Development Waste	Fresh	NAF		8.3	0.981	32	0.001	0.06	<0.001	<0.05	0.04	<0.001	61	0.0002	13	<0.001	<0.001	<0.001	0.4	<0.05	<0.0001	52
URNDD0105	UR	C725412	Development Waste	Fresh	PAF		6.7	0.876	16	<0.001	<0.01	<0.001	<0.05	0.077	<0.001	50	0.0022	10	<0.001	<0.001	0.016	0.1	27.7	0.0002	37
URNDD0105	UR	C725417	Development Waste	Fresh	PAF		6.6	0.921	16	<0.001	<0.01	0.002	<0.05	0.128	<0.001	45	0.0024	7	0.001	<0.001	0.009	0.1	61.8	0.0004	28
URNDD0105	UR	C725421	Development Waste	Fresh	PAF		7.1	0.416	16	<0.001	<0.01	0.083	<0.05	0.35	<0.001	12	0.0005	12	<0.001	0.001	<0.001	0.2	1.23	<0.0001	2
URNDD0105	UR	C725439	Development Waste	Fresh	NAF		8.5	0.211	34	<0.001	0.31	0.009	<0.05	0.024	<0.001	3	<0.0001	6	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	14
URNDD0105	UR	C725441	Development Waste	Fresh	NAF		8.9	0.215	31	<0.001	0.27	0.008	<0.05	0.021	<0.001	4	<0.0001	5	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	16
URNDD0105	UR	C725475	Ore		NAF		8.8	0.123	28	<0.001	0.57	0.008	<0.05	0.248	<0.001	3	<0.0001	5	<0.001	<0.001	<0.001	0.4	0.08	<0.0001	20
URNDD0105	UR	C725478	Ore		NAF		9.1	0.091	26	<0.001	0.16	0.018	<0.05	0.026	<0.001	4	<0.0001	8	<0.001	<0.001	<0.001	0.1	<0.05	<0.0001	6
URNDD0105	UR	C725479	Ore		PAF-LC		9.2	0.103	23	<0.001	0.32	0.084	<0.05	0.021	<0.001	2	<0.0001	2	<0.001	<0.001	<0.001	0.2	<0.05	<0.0001	15

HOLEID	PROJECTCODE	SAMPLEID	Sample Type	Oxidation	ARD Classification		Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	Sn	SO4	Sr	Th	Tl	U	Zn
							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
URNDD0055	UR	UD018241	Development Waste	Oxide	NAF		<1	0.002	<0.001	5	<0.001	<1	<0.001	<0.001	<0.01	2.98	<0.001	1	<0.001	<0.001	<0.001	<0.001	0.01
URNDD0055	UR	UD018249	Development Waste	Oxide	NAF		<1	0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.99	<0.001	<1	<0.001	<0.001	<0.001	<0.001	0.008
URNDD0055	UR	UD018250	Development Waste	Oxide	NAF		<1	0.002	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.87	<0.001	<1	0.001	<0.001	<0.001	<0.001	<0.005
URNDD0055	UR	UD018257	Development Waste	Oxide	NAF		<1	0.002	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.74	<0.001	<1	0.002	<0.001	<0.001	<0.001	0.006
URNDD0055	UR	UD018275	Development Waste	Oxide	NAF		<1	0.003	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.78	<0.001	<1	0.002	<0.001	<0.001	<0.001	<0.005
URNDD0055	UR	UD018277	Development Waste	Oxide	NAF		<1	0.001	<0.001	3	<0.001	<1	<0.001	<0.001	<0.01	2.09	<0.001	<1	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0055	UR	UD018286	Development Waste	Transitional	NAF		1	0.005	<0.001	3	<0.001	<1	<0.001	<0.001	<0.01	2.3	<0.001	1	0.009	<0.001	<0.001	<0.001	<0.005
URNDD0055	UR	UD018287	Development Waste	Transitional	NAF		1	0.006	<0.001	1	<0.001	<1	<0.001	0.003	<0.01	1.92	<0.001	8	0.01	<0.001	<0.001	<0.001	<0.005
URNDD0055	UR	UD018298	Development Waste	Fresh	NAF		<1	0.003	<0.001	3	<0.001	<1	<0.001	0.002	<0.01	2.23	<0.001	2	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0055	UR	UD018305	Development Waste	Fresh	NAF		2	0.003	0.001	2	<0.001	<1	<0.001	0.003	<0.01	1.8	<0.001	4	0.007	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018312	Development Waste	Oxide	NAF		<1	0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.67	<0.001	<1	0.002	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018317	Development Waste	Oxide	NAF		<1	<0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.12	<0.001	<1	0.001	<0.001	<0.001	<0.001	0.007
URNDD0061	UR	UD018327	Development Waste	Oxide	NAF		<1	0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.44	<0.001	<1	0.001	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018336	Development Waste	Oxide	NAF		<1	<0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.6	<0.001	<1	0.001	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018340	Development Waste	Oxide	NAF		<1	<0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.39	<0.001	<1	0.001	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018343	Development Waste	Oxide	NAF		<1	0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.4	<0.001	<1	0.001	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018358	Development Waste	Oxide	NAF		<1	<0.001	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	2.03	<0.001	<1	0.002	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018375	Development Waste	Transitional	PAF		<1	0.002	<0.001	2	<0.001	<1	0.002	0.005	<0.01	1.66	<0.001	16	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018378	Development Waste	Transitional	PAF-LC		1	0.019	0.006	2	<0.001	<1	0.004	0.002	<0.01	2.14	<0.001	9	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0061	UR	UD018383	Development Waste	Fresh	NAF		1	0.002	<0.001	2	<0.001	<1	<0.001	0.001	<0.01	2.15	<0.001	2	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719025	Development Waste	Fresh	NAF		<1	0.003	<0.001	4	<0.001	<1	<0.001	<0.001	<0.01	2.3	<0.001	1	0.009	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719075	Development Waste	Fresh	NAF		<1	0.001	0.002	4	<0.001	<1	<0.001	<0.001	<0.01	1.8	<0.001	5	0.015	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719092	Development Waste	Fresh	NAF		1	0.005	<0.001	4	<0.001	<1	0.002	0.002	<0.01	2.1	<0.001	6	0.011	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719103	Development Waste	Fresh	NAF		2	0.009	<0.001	4	<0.001	<1	<0.001	0.001	<0.01	1.0	<0.001	14	0.016	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719135	Development Waste	Fresh	NAF		1	0.007	0.001	2	<0.001	<1	<0.001	0.002	<0.01	1.4	<0.001	6	0.011	<0.001	<0.001	<0.001	0.005
URNDD0100	UR	C719143	Development Waste	Fresh	NAF		1	0.01	0.001	2	<0.001	<1	<0.001	<0.001	<0.01	1.34	<0.001	4	0.008	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719153	Development Waste	Fresh	NAF		<1	0.008	0.001	1	<0.001	<1	0.002	<0.001	<0.01	1.58	<0.001	8	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719157	Development Waste	Fresh	NAF		<1	0.006	0.002	2	<0.001	<1	0.007	0.002	<0.01	1.92	<0.001	9	0.009	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719174	Development Waste	Fresh	NAF		2	0.018	<0.001	<1	<0.001	<1	<0.001	<0.001	<0.01	0.84	<0.001	33	0.017	<0.001	<0.001	<0.001	0.006
URNDD0100	UR	C719178	Development Waste	Fresh	NAF		1	0.004	<0.001	2	<0.001	<1	0.006	<0.001	<0.01	1.45	<0.001	8	0.007	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719188	Development Waste	Fresh	NAF		<1	0.003	0.002	1	<0.001	<1	<0.001	<0.001	<0.01	1.25	<0.001	3	0.003	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719193	Development Waste	Fresh	PAF-LC		1	0.002	0.008	3	<0.001	<1	<0.001	<0.001	<0.01	1.73	<0.001	7	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719198	Development Waste	Fresh	NAF		1	0.002	0.003	<1	<0.001	<1	<0.001	0.001	<0.01	1.08	<0.001	5	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719316	Ore		NAF		1	0.003	0.001	3	<0.001	<1	<0.001	<0.001	<0.01	1.93	<0.001	2	0.008	<0.001	<0.001	<0.001	0.006
URNDD0100	UR	C719326	Ore		PAF		1	0.006	0.003	2	<0.001	<1	0.002	0.002	<0.01	1.12	<0.001	7	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0100	UR	C719327	Ore		PAF		2	0.009	0.007	3	0.001	<1	0.004	0.003	<0.01	1.25	<0.001	31	0.013	<0.001	<0.001	<0.001	0.008
URNDD0100	UR	C719331	Development Waste	Fresh	NAF		1	0.005	0.002	1	<0.001	<1	0.001	0.002	<0.01	1.28	<0.001	9	0.006	<0.001	<0.001	<0.001	0.006
URNDD0100	UR	C719332	Development Waste	Fresh	NAF		<1	0.004	0.005	2	<0.001	<1	0.022	0.004	<0.01	1.94	<0.001	6	0.008	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725206	Development Waste	Fresh	NAF		1	0.005	0.001	<1	<0.001	<1	0.003	<0.001	<0.01	1.14	<0.001	17	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725207	Development Waste	Fresh	NAF		1	0.005	0.002	3	<0.001	<1	0.012	0.002	<0.01	1.76	<0.001	10	0.005	<0.001	<0.001	<0.001	0.005
URNDD0105	UR	C725213	Development Waste	Fresh	NAF		2	0.014	<0.001	1	<0.001	<1	<0.001	<0.001	<0.01	0.83	<0.001	28	0.004	<0.001	<0.001	<0.001	0.008
URNDD0105	UR	C725243	Development Waste	Fresh	PAF-LC		<1	<0.001	<0.001	3	<0.001	<1	0.002	<0.001	<0.01	1.18	<0.001	4	0.002	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725282	Development Waste	Fresh	NAF		2	<0.001	0.002	<1	<0.001	<1	<0.001	<0.001	<0.01	0.8	<0.001	<1	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725289	Development Waste	Fresh	NAF		1	0.001	0.002	<1	<0.001	<1	<0.001	<0.001	<0.01	1.72	<0.001	4	0.002	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725299	Development Waste	Fresh	NAF		1	0.003	0.003	2	<0.001	<1	<0.001	<0.001	<0.01	1.09	<0.001	5	0.007	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725352	Development Waste	Fresh	NAF		2	0.008	0.002	2	<0.001	<1	<0.001	0.001	<0.01	1.11	<0.001	11	0.011	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725363	Development Waste	Fresh	NAF		<1	0.008	<0.001	<1	<0.001	<1	0.014	<0.001	<0.01	1.2	<0.001	12	0.003	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725369	Development Waste	Fresh	NAF		1	0.012	0.008	<1	<0.001	<1	0.001	<0.001	<0.01	1.13	<0.001	24	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725377	Development Waste	Fresh	NAF		<1	<0.001	<0.001	2	<0.001	<1	0.001	<0.001	<0.01	2.24	<0.001	6	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725399	Development Waste	Fresh	NAF		1	0.001	0.012	3	<0.001	<1	0.006	<0.001	<0.01	1.4	<0.001	26	0.01	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725401	Development Waste	Fresh	PAF		4	0.056	0.006	<1	<0.001	<1	<0.001	0.002	<0.01	0.95	<0.001	165	0.027	<0.001	<0.001	<0.001	0.016
URNDD0105	UR	C725411	Development Waste	Fresh	NAF		11	0.616	<0.001	1	<0.001	<1	0.001	0.003	<0.01	0.45	<0.001	217	0.052	<0.001	<0.001	<0.001	0.024
URNDD0105	UR	C725412	Development Waste	Fresh	PAF		12	5.24	<0.001	2	0.002	<1	<0.001	<0.001	<0.01	1.44	<0.001	271	0.056	<0.001	<0.001	<0.001	4.29
URNDD0105	UR	C725417	Development Waste	Fresh	PAF		19	6.04	<0.001	2	0.001	<1	0.05	<0.001	<0.01	2.4	<0.001	384	0.043	<0.001	<0.001	<0.001	4.61
URNDD0105	UR	C725421	Development Waste	Fresh	PAF		8	1.06	<0.001	5	0.001	<1	0.002	0.003	<0.01	0.97	<0.001	60	0.027	<0.001	<0.001	<0.001	0.284
URNDD0105	UR	C725439	Development Waste	Fresh	NAF		2	0.043	0.001	1	<0.001	<1	<0.001	<0.001	<0.01	0.88	<0.001	6	0.004	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725441	Development Waste	Fresh	NAF		1	0.007	<0.001	<1	<0.001	<1	<0.001	0.003	<0.01	0.96	<0.001	14	0.005	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725475	Ore		NAF		1	0.008	0.005	2	<0.001	<1	0.007	0.004	<0.01	1.78	<0.001	14	0.006	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725478	Ore		NAF		2	0.01	<0.001	2	<0.001	<1	<0.001	<0.001	<0.01	0.72	<0.001	5	0.002	<0.001	<0.001	<0.001	<0.005
URNDD0105	UR	C725479	Ore		PAF-LC		1	0.006	<0.001	1	<0.001	<1	<0.001	0.002	<0.01	1.16	<0.001	9	0.002	<0.001	<0.001	<0.001	<0.005

APPENDIX D2 – Peroxide Extraction Test Results

HOLEID	PROJECTCODE	SAMPLEID	Sample Type	Oxidation	ARD Classification		pH	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	F	Fe	Hg	K	Mg
								mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
URNDD0055	UR	UD018241	Development Waste	Oxide	NAF		6.8	<0.005	0.25	0.06	2.3	1.745	<0.005	<5	0.006	25	0.01	0.015	0.005	5	0.25	<0.0005	10	5
URNDD0055	UR	UD018249	Development Waste	Oxide	NAF		5.8	<0.005	0.15	0.065	2.3	2.025	<0.005	<5	0.001	<5	0.005	0.02	0.005	4	0.25	0.004	15	5
URNDD0055	UR	UD018250	Development Waste	Oxide	NAF		5.6	<0.005	0.1	0.085	2.05	0.435	<0.005	<5	0.0005	15	0.005	0.02	0.005	4	0.25	<0.0005	20	<5
URNDD0055	UR	UD018257	Development Waste	Oxide	NAF		5.7	<0.005	0.05	0.19	2.15	2.005	<0.005	<5	0.001	15	0.005	0.01	0.005	4.5	0.25	<0.0005	15	<5
URNDD0055	UR	UD018275	Development Waste	Oxide	NAF		6.8	<0.005	0.25	0.19	2.15	0.37	<0.005	<5	0.001	10	0.005	0.005	0.005	5	0.25	<0.0005	15	<5
URNDD0055	UR	UD018277	Development Waste	Oxide	NAF		5.9	<0.005	0.3	0.055	2.3	2.63	<0.005	10	0.0005	<5	0.005	0.02	0.005	3.5	0.25	<0.0005	15	10
URNDD0055	UR	UD018286	Development Waste	Transitional	NAF		7.5	<0.005	1.75	0.175	2.1	0.42	<0.005	60	0.0005	10	0.005	0.035	0.005	5	0.25	<0.0005	35	5
URNDD0055	UR	UD018287	Development Waste	Transitional	NAF		7.9	<0.005	1.35	0.52	1.75	0.165	<0.005	130	0.0005	15	0.005	0.02	0.005	4.5	0.25	<0.0005	40	30
URNDD0055	UR	UD018298	Development Waste	Fresh	NAF		7.6	<0.005	1.1	0.65	1.8	0.105	<0.005	90	0.0005	15	0.005	0.035	0.005	5	0.25	<0.0005	35	10
URNDD0055	UR	UD018305	Development Waste	Fresh	NAF		7.9	<0.005	1.05	0.415	1.9	0.1	<0.005	90	0.0005	15	0.005	0.1	0.005	4.5	0.25	<0.0005	35	<5
URNDD0061	UR	UD018312	Development Waste	Oxide	NAF		5.6	<0.005	0.2	0.05	2.2	2.05	<0.005	5	0.001	<5	0.005	0.035	0.005	3.5	0.25	<0.0005	20	<5
URNDD0061	UR	UD018317	Development Waste	Oxide	NAF		4.8	<0.005	0.65	0.03	2	0.32	<0.005	<5	0.0005	15	0.005	0.02	0.005	2	0.25	<0.0005	15	<5
URNDD0061	UR	UD018327	Development Waste	Oxide	NAF		5.9	<0.005	0.15	0.025	2.05	0.27	<0.005	<5	0.001	10	0.005	0.01	0.005	4	0.25	<0.0005	15	<5
URNDD0061	UR	UD018336	Development Waste	Oxide	NAF		5.2	<0.005	0.2	0.045	1.85	0.435	<0.005	<5	0.0015	15	0.005	0.01	0.005	2.5	0.25	<0.0005	15	<5
URNDD0061	UR	UD018340	Development Waste	Oxide	NAF		5.9	<0.005	0.1	0.03	1.95	2.2	<0.005	<5	0.001	<5	0.005	0.015	0.005	3.5	0.25	<0.0005	15	10
URNDD0061	UR	UD018343	Development Waste	Oxide	NAF		5.8	<0.005	0.05	0.045	2.05	0.475	<0.005	<5	0.001	30	0.005	0.01	0.005	3.5	0.25	<0.0005	20	5
URNDD0061	UR	UD018358	Development Waste	Oxide	NAF		5.7	<0.005	0.1	0.085	1.95	0.545	<0.005	<5	0.002	<5	0.005	0.02	0.005	2.5	0.25	<0.0005	15	5
URNDD0061	UR	UD018375	Development Waste	Transitional	PAF		2.6	0.01	49.05	1.67	2.45	0.83	0.01	15	0.057	20	0.47	0.025	6	4.5	35	<0.0005	50	20
URNDD0061	UR	UD018378	Development Waste	Transitional	PAF-LC		3.5	<0.005	22.1	0.52	2.4	0.78	0.005	130	0.4755	15	0.485	0.01	1.21	5.5	2	<0.0005	55	65
URNDD0061	UR	UD018383	Development Waste	Fresh	NAF		8	<0.005	0.25	0.475	2.1	0.295	<0.005	85	0.021	15	0.02	0.04	0.04	5	0.25	<0.0005	40	5
URNDD0100	UR	C719025	Development Waste	Fresh	NAF		8.1	<0.005	1.8	0.04	1.55	2.465	<0.005	95	0.0005	40	0.005	0.04	0.005	4	0.25	<0.0005	30	20
URNDD0100	UR	C719075	Development Waste	Fresh	NAF		8.0	<0.005	1.6	0.06	1.5	0.235	<0.005	90	0.0005	45	0.005	0.045	0.005	3.5	0.25	<0.0005	35	15
URNDD0100	UR	C719092	Development Waste	Fresh	NAF		8.0	<0.005	1.95	0.22	1.45	0.145	<0.005	130	0.0005	20	0.005	0.02	0.005	3.5	0.25	<0.0005	40	30
URNDD0100	UR	C719103	Development Waste	Fresh	NAF		8.5	<0.005	1.55	0.05	1.65	0.1	<0.005	130	0.0005	25	0.005	0.005	0.005	3.5	0.25	<0.0005	30	30
URNDD0100	UR	C719135	Development Waste	Fresh	NAF		8.2	<0.005	1.3	0.12	1.55	0.105	<0.005	110	0.0005	20	0.005	0.02	0.005	4	0.25	<0.0005	45	25
URNDD0100	UR	C719143	Development Waste	Fresh	NAF		8.4	<0.005	1.9	0.055	1.65	0.085	<0.005	100	0.0005	25	0.005	0.01	0.005	3.5	0.25	<0.0005	45	10
URNDD0100	UR	C719153	Development Waste	Fresh	NAF		6.3	<0.005	0.5	0.495	1.7	0.17	<0.005	130	0.0055	20	0.08	0.035	0.005	2.5	0.25	0.001	85	60
URNDD0100	UR	C719157	Development Waste	Fresh	NAF		6.2	<0.005	0.25	0.145	1.7	0.145	<0.005	195	0.0135	20	0.025	0.02	0.005	3.5	0.25	<0.0005	50	80
URNDD0100	UR	C719174	Development Waste	Fresh	NAF		7.5	<0.005	0.15	0.01	1.6	0.81	<0.005	160	0.0325	30	0.005	0.01	0.005	4	0.25	<0.0005	80	60
URNDD0100	UR	C719178	Development Waste	Fresh	NAF		7.4	<0.005	0.25	0.01	1.8	0.215	<0.005	125	0.019	30	0.005	0.02	0.005	5	0.25	<0.0005	50	50
URNDD0100	UR	C719188	Development Waste	Fresh	NAF		7.6	<0.005	0.4	0.025	1.75	0.12	<0.005	85	0.0085	20	0.005	0.035	0.005	4	0.25	<0.0005	40	15
URNDD0100	UR	C719193	Development Waste	Fresh	PAF-LC		4.4	<0.005	5.5	0.005	1.65	0.85	<0.005	185	0.136	10	0.18	0.025	0.05	3	0.25	0.0005	55	100
URNDD0100	UR	C719198	Development Waste	Fresh	NAF		8.5	<0.005	0.3	0.005	1.7	0.175	<0.005	95	0.033	20	0.01	0.035	0.01	3	0.25	<0.0005	35	10
URNDD0100	UR	C719316	Ore		NAF		8.2	<0.005	0.6	0.03	1.55	0.07	<0.005	80	0.0035	20	0.005	0.04	0.005	3.5	0.25	<0.0005	30	15
URNDD0100	UR	C719326	Ore		PAF		4.3	<0.005	1	0.17	1.5	0.055	<0.005	95	0.001	25	0.005	0.01	0.005	3.5	0.25	<0.0005	30	30
URNDD0100	UR	C719327	Ore		PAF		3.1	<0.005	72	0.305	1.95	0.245	0.01	365	0.332	30	0.28	0.06	0.87	4	2.65	0.001	105	150
URNDD0100	UR	C719331	Development Waste	Fresh	NAF		7.5	<0.005	0.75	0.005	1.85	0.3	<0.005	95	0.0165	20	0.015	0.005	0.055	2.5	0.25	<0.0005	35	25
URNDD0100	UR	C719332	Development Waste	Fresh	NAF		7.9	<0.005	0.2	0.065	1.6	0.155	<0.005	90	0.0005	20	0.005	0.005	0.005	4	0.25	<0.0005	45	10
URNDD0105	UR	C725206	Development Waste	Fresh	NAF		6.3	<0.005	0.15	0.135	2.05	0.11	<0.005	60	0.0765	<5	0.115	0.04	0.01	3.5	0.25	0.001	80	40
URNDD0105	UR	C725207	Development Waste	Fresh	NAF		7.6	<0.005	0.15	0.355	1.9	0.07	<0.005	60	0.022	20	0.02	0.04	0.005	5	0.25	<0.0005	45	35
URNDD0105	UR	C725213	Development Waste	Fresh	NAF		7.4	<0.005	0.1	0.03	1.95	2.33	<0.005	30	0.0035	30	0.005	0.01	0.005	5	0.25	<0.0005	50	25
URNDD0105	UR	C725243	Development Waste	Fresh	PAF-LC		4.4	<0.005	11.1	0.025	2.25	1.525	<0.005	25	0.021	<5	0.095	0.05	0.05	4	0.25	0.0165	105	65
URNDD0105	UR	C725282	Development Waste	Fresh	NAF		8.3	<0.005	0.3	0.035	1.7	0.18	<0.005	55	0.002	25	0.005	0.6	0.005	4.5	0.25	<0.0005	25	25
URNDD0105	UR	C725289	Development Waste	Fresh	NAF		8.7	<0.005	2.4	0.19	1.9	0.075	<0.005	75	0.0005	30	0.005	0.1	0.005	5	0.25	<0.0005	60	15
URNDD0105	UR	C725299	Development Waste	Fresh	NAF		8.2	<0.005	2.9	2.25	1.8	0.065	<0.005	60	0.0005	25	0.005	0.055	0.005	6	0.25	<0.0005	120	5
URNDD0105	UR	C725352	Development Waste	Fresh	NAF		8.3	<0.005	2.55	0.405	1.7	0.07	<0.005	145	0.0005	25	0.005	0.025	0.005	5	0.25	<0.0005	95	20
URNDD0105	UR	C725363	Development Waste	Fresh	NAF		6	<0.005	0.55	0.07	1.95	0.12	<0.005	90	0.0375	20	0.14	0.045	0.005	3	0.25	<0.0005	75	40
URNDD0105	UR	C725369	Development Waste	Fresh	NAF		7.8	<0.005	2.75	0.045	1.8	2.24	<0.005	100	0.003	30	0.005	0.015	0.005	5	0.3	<0.0005	105	10
URNDD0105	UR	C725377	Development Waste	Fresh	NAF		7.4	<0.005	2.35	1.44	1.95	0.2	<0.005	70	0.0005	25	0.005	0.06	0.005	7	0.95	<0.0005	155	20
URNDD0105	UR	C725399	Development Waste	Fresh	NAF		7.2	<0.005	0.9	0.055	1.85	0.09	<0.005	110	0.001	25	0.005	0.03	0.005	5	0.4	<0.0005	75	40
URNDD0105	UR	C725401	Development Waste	Fresh	PAF		5.6	<0.005	0.1	0.01	1.9	0.49	<0.005	385	2.135	30	0.345	0.01	0.445	2.5	0.25	<0.0005	240	155
URNDD0105	UR	C725411	Development Waste	Fresh	NAF		7.5	<0.005	0.05	0.005	2	0.095	<0.005	210	0.1835	35	0.02	0.005	0.02	6	0.25	<0.0005	110	55
URNDD0105	UR	C725412	Development Waste	Fresh	PAF		3.1	0.01	46.35	0.03	2.15	0.14	0.01	730	59	35	0.79	0.025	8.25	0.5	443.5	<0.0005	75	290
URNDD0105	UR	C725417	Development Waste	Fresh	PAF		4.5	<0.005	4.3	0.065	2.15	0.125	<0.005	180	11.25	30	0.26	0.005	0.5	2	373	<0.0005	60	140
URNDD0105	UR	C725421	Development Waste	Fresh	PAF		2.5	<0.005	39.4	69	2	0.115	<0.005	55	2.72	30	3.445	0.785	2.11	3.5	885	<0.0005	10	45
URNDD0105	UR	C725439	Development Waste	Fresh	NAF		7.7	<0.005	0.6	0.185	1.85	2.015	<0.005	85	0.0835	35	0.135	0.015	0.03	4	2	<0.0005	45	35
URNDD0105	UR	C725441	Development Waste	Fresh	NAF		6.8	<0.005	0.3	0.025	1.9	0.23	<0.005	145	0.0095	25	0.005	0.08	0.005	5	0.25	<0.0005	55	60
URNDD0105	UR	C725475	Ore		NAF		7.3	<0.005	0.3	0.07	1.75	0.22	<0.005	215	0.011	20	0.005	0.025	0.005	5	0.25	<0.0005	75	90
URNDD0105	UR	C725478	Ore		NAF		7.6	<0.005	1.7	2.3	1.7	0.075	<0.005	65	0.002	20	0.005	0.14	0.005	4.5	0.25	<0.0005	15	30
URNDD0105	UR	C725479	Ore		PAF-LC		3.9	<0.005	36	0.545	1.75	1.415	0.005	60	0.164	5	0.305	0.09	0.105	4	0.25	0.0015	120	45

HOLEID	PROJECTCODE	SAMPLEID	Sample Type	Oxidation	ARD Classification		Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	Sn	SO4	Sr	Th	Tl	U	Zn
							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
URNDD0055	UR	UD018241	Development Waste	Oxide	NAF		1.455	<0.005	45	0.01	<5	0.01	<0.005	<0.05	34	<0.005	20	0.02	<0.005	<0.005	<0.005	0.43
URNDD0055	UR	UD018249	Development Waste	Oxide	NAF		1.825	<0.005	35	<0.005	<5	0.005	<0.005	<0.05	37.3	<0.005	<5	0.03	<0.005	<0.005	<0.005	0.955
URNDD0055	UR	UD018250	Development Waste	Oxide	NAF		1.675	<0.005	20	<0.005	<5	0.005	<0.005	<0.05	35.8	<0.005	<5	0.02	<0.005	<0.005	<0.005	0.16
URNDD0055	UR	UD018257	Development Waste	Oxide	NAF		3.09	<0.005	30	<0.005	<5	0.005	<0.005	<0.05	29.6	<0.005	<5	0.045	<0.005	<0.005	<0.005	0.535
URNDD0055	UR	UD018275	Development Waste	Oxide	NAF		2.095	<0.005	20	<0.005	<5	0.005	<0.005	<0.05	27.35	<0.005	<5	0.035	<0.005	<0.005	<0.005	0.085
URNDD0055	UR	UD018277	Development Waste	Oxide	NAF		0.28	<0.005	35	<0.005	<5	0.005	<0.005	<0.05	43.45	<0.005	<5	0.055	<0.005	<0.005	<0.005	0.79
URNDD0055	UR	UD018286	Development Waste	Transitional	NAF		0.08	0.025	25	<0.005	<5	0.005	0.015	<0.05	25.5	<0.005	30	0.19	<0.005	<0.005	<0.005	0.035
URNDD0055	UR	UD018287	Development Waste	Transitional	NAF		0.025	<0.005	20	<0.005	<5	0.005	0.055	<0.05	20.4	<0.005	235	0.42	<0.005	<0.005	<0.005	0.025
URNDD0055	UR	UD018298	Development Waste	Fresh	NAF		0.01	<0.005	25	<0.005	<5	0.005	0.035	<0.05	27.75	<0.005	55	0.135	<0.005	<0.005	<0.005	0.025
URNDD0055	UR	UD018305	Development Waste	Fresh	NAF		0.01	0.005	20	<0.005	<5	0.005	0.055	<0.05	24.3	<0.005	50	0.155	<0.005	<0.005	<0.005	0.025
URNDD0061	UR	UD018312	Development Waste	Oxide	NAF		1.26	<0.005	30	<0.005	<5	0.005	<0.005	<0.05	33.75	<0.005	<5	0.035	<0.005	<0.005	<0.005	0.645
URNDD0061	UR	UD018317	Development Waste	Oxide	NAF		0.35	<0.005	20	<0.005	<5	0.005	<0.005	<0.05	27.25	<0.005	<5	0.01	<0.005	<0.005	<0.005	0.19
URNDD0061	UR	UD018327	Development Waste	Oxide	NAF		1.29	0.005	20	<0.005	<5	0.005	<0.005	<0.05	25	<0.005	<5	0.015	<0.005	<0.005	<0.005	0.125
URNDD0061	UR	UD018336	Development Waste	Oxide	NAF		2.58	<0.005	20	<0.005	<5	0.005	<0.005	<0.05	32.5	<0.005	<5	0.03	<0.005	<0.005	<0.005	0.275
URNDD0061	UR	UD018340	Development Waste	Oxide	NAF		1.025	<0.005	25	<0.005	<5	0.005	<0.005	<0.05	32.05	<0.005	<5	0.03	<0.005	<0.005	<0.005	0.625
URNDD0061	UR	UD018343	Development Waste	Oxide	NAF		1.71	<0.005	20	<0.005	<5	0.005	<0.005	<0.05	30.05	<0.005	<5	0.015	<0.005	<0.005	<0.005	0.16
URNDD0061	UR	UD018358	Development Waste	Oxide	NAF		2.71	<0.005	20	<0.005	<5	0.005	<0.005	<0.05	35.1	<0.005	<5	0.025	<0.005	<0.005	<0.005	0.175
URNDD0061	UR	UD018375	Development Waste	Transitional	PAF		1.115	<0.005	35	0.45	<5	3.91	0.015	<0.05	62	<0.005	795	0.07	<0.005	<0.005	0.005	4.8
URNDD0061	UR	UD018378	Development Waste	Transitional	PAF-LC		24.7	0.125	25	0.525	<5	6.8	0.005	<0.05	54	<0.005	920	0.11	<0.005	<0.005	<0.005	74.5
URNDD0061	UR	UD018383	Development Waste	Fresh	NAF		1.245	0.015	25	0.02	<5	0.125	0.025	<0.05	25.8	<0.005	70	0.095	<0.005	<0.005	<0.005	3.3
URNDD0100	UR	C719025	Development Waste	Fresh	NAF		0.025	<0.005	30	<0.005	<5	0.005	0.01	<0.05	18.7	<0.005	20	0.365	<0.005	<0.005	<0.005	0.11
URNDD0100	UR	C719075	Development Waste	Fresh	NAF		0.025	<0.005	15	<0.005	<5	0.005	0.05	<0.05	18.15	<0.005	95	0.34	<0.005	<0.005	<0.005	0.06
URNDD0100	UR	C719092	Development Waste	Fresh	NAF		0.03	<0.005	20	<0.005	<5	0.005	0.07	<0.05	20.25	<0.005	190	0.365	<0.005	<0.005	<0.005	0.065
URNDD0100	UR	C719103	Development Waste	Fresh	NAF		0.035	<0.005	20	<0.005	<5	0.005	0.06	<0.05	18.25	<0.005	270	0.27	<0.005	<0.005	<0.005	0.06
URNDD0100	UR	C719135	Development Waste	Fresh	NAF		0.04	<0.005	15	<0.005	<5	0.005	0.03	<0.05	22.35	<0.005	165	0.38	<0.005	<0.005	<0.005	0.04
URNDD0100	UR	C719143	Development Waste	Fresh	NAF		0.02	<0.005	15	<0.005	<5	0.005	0.04	<0.05	20.5	<0.005	120	0.16	<0.005	<0.005	<0.005	0.03
URNDD0100	UR	C719153	Development Waste	Fresh	NAF		7.15	<0.005	15	0.035	<5	0.005	0.035	<0.05	63.5	<0.005	585	0.14	<0.005	<0.005	<0.005	2.64
URNDD0100	UR	C719157	Development Waste	Fresh	NAF		2.89	<0.005	15	0.01	<5	0.005	0.02	<0.05	32.45	<0.005	750	0.13	<0.005	<0.005	<0.005	1.78
URNDD0100	UR	C719174	Development Waste	Fresh	NAF		1.485	<0.005	20	0.005	<5	0.01	<0.005	<0.05	22.4	<0.005	575	0.425	<0.005	<0.005	<0.005	0.455
URNDD0100	UR	C719178	Development Waste	Fresh	NAF		0.38	<0.005	20	<0.005	<5	0.015	0.02	<0.05	21.25	<0.005	380	0.12	<0.005	<0.005	<0.005	0.39
URNDD0100	UR	C719188	Development Waste	Fresh	NAF		0.11	<0.005	15	<0.005	<5	0.02	0.025	<0.05	26.25	<0.005	160	0.065	<0.005	<0.005	<0.005	0.215
URNDD0100	UR	C719193	Development Waste	Fresh	PAF-LC		16.8	0.07	20	0.37	<5	6.35	<0.005	<0.05	56.5	<0.005	925	0.12	<0.005	<0.005	<0.005	8.2
URNDD0100	UR	C719198	Development Waste	Fresh	NAF		1.35	0.01	15	0.03	<5	0.465	0.035	<0.05	19.05	<0.005	125	0.07	<0.005	<0.005	<0.005	1.755
URNDD0100	UR	C719316	Ore		NAF		0.085	<0.005	15	<0.005	<5	0.045	0.03	<0.05	20.15	<0.005	60	0.13	<0.005	<0.005	<0.005	0.13
URNDD0100	UR	C719326	Ore		PAF		0.05	<0.005	15	<0.005	<5	0.01	0.02	<0.05	15.7	<0.005	230	0.21	<0.005	<0.005	<0.005	0.035
URNDD0100	UR	C719327	Ore		PAF		33.35	<0.005	30	0.78	<5	9.1	0.005	<0.05	108.5	<0.005	2060	0.63	<0.005	<0.005	0.01	45.75
URNDD0100	UR	C719331	Development Waste	Fresh	NAF		1.67	<0.005	15	0.04	<5	0.74	<0.005	<0.05	18	<0.005	285	0.15	<0.005	<0.005	<0.005	2.4
URNDD0100	UR	C719332	Development Waste	Fresh	NAF		0.11	0.005	15	<0.005	<5	0.045	0.075	<0.05	17.45	<0.005	150	0.105	<0.005	<0.005	<0.005	0.145
URNDD0105	UR	C725206	Development Waste	Fresh	NAF		3.91	<0.005	25	0.065	<5	0.03	0.025	<0.05	71	<0.005	400	0.07	<0.005	<0.005	<0.005	17.2
URNDD0105	UR	C725207	Development Waste	Fresh	NAF		0.57	<0.005	25	0.01	<5	0.01	0.03	<0.05	30.6	<0.005	180	0.035	<0.005	<0.005	<0.005	3.675
URNDD0105	UR	C725213	Development Waste	Fresh	NAF		0.29	<0.005	30	<0.005	<5	0.02	0.01	<0.05	29.85	<0.005	190	0.045	<0.005	<0.005	<0.005	0.21
URNDD0105	UR	C725243	Development Waste	Fresh	PAF-LC		2.13	<0.005	35	0.335	<5	13.8	0.005	<0.05	95	<0.005	495	0.065	<0.005	<0.005	<0.005	1.685
URNDD0105	UR	C725282	Development Waste	Fresh	NAF		0.12	0.01	20	0.01	<5	0.13	0.01	<0.05	18.3	<0.005	35	0.095	<0.005	<0.005	<0.005	0.165
URNDD0105	UR	C725289	Development Waste	Fresh	NAF		0.01	0.005	20	<0.005	<5	0.02	0.035	<0.05	20.65	<0.005	90	0.12	<0.005	<0.005	<0.005	0.025
URNDD0105	UR	C725299	Development Waste	Fresh	NAF		0.005	0.01	20	<0.005	<5	0.01	0.04	<0.05	24.2	<0.005	115	0.07	<0.005	<0.005	<0.005	0.025
URNDD0105	UR	C725352	Development Waste	Fresh	NAF		0.015	0.01	20	<0.005	<5	0.01	0.1	<0.05	18.3	<0.005	315	0.3	<0.005	<0.005	<0.005	0.025
URNDD0105	UR	C725363	Development Waste	Fresh	NAF		7.4	<0.005	20	0.1	<5	0.03	0.015	<0.05	55.5	<0.005	465	0.185	<0.005	<0.005	<0.005	39.95
URNDD0105	UR	C725369	Development Waste	Fresh	NAF		0.285	0.01	25	<0.005	<5	0.005	0.03	<0.05	18.3	<0.005	200	0.075	<0.005	<0.005	<0.005	1.26
URNDD0105	UR	C725377	Development Waste	Fresh	NAF		0.085	<0.005	25	<0.005	<5	0.01	0.065	<0.05	25.65	<0.005	280	0.04	<0.005	<0.005	<0.005	0.24
URNDD0105	UR	C725399	Development Waste	Fresh	NAF		0.165	0.015	20	<0.005	<5	0.005	0.03	<0.05	26.2	<0.005	375	0.07	<0.005	<0.005	<0.005	0.19
URNDD0105	UR	C725401	Development Waste	Fresh	PAF		23.5	<0.005	25	0.455	<5	0.05	0.005	<0.05	88.5	<0.005	2525	0.16	<0.005	<0.005	<0.005	515
URNDD0105	UR	C725411	Development Waste	Fresh	NAF		1.785	<0.005	25	0.03	<5	0.02	0.005	<0.05	12.95	<0.005	780	0.1	<0.005	<0.005	<0.005	30.95
URNDD0105	UR	C725412	Development Waste	Fresh	PAF		127	<0.005	35	2.045	<5	7.2	0.005	<0.05	115.5	<0.005	10600	0.06	<0.005	<0.005	0.01	4415
URNDD0105	UR	C725417	Development Waste	Fresh	PAF		44.1	<0.005	25	0.5	<5	15.35	<0.005	<0.05	123	<0.005	3830	0.04	<0.005	<0.005	<0.005	1425
URNDD0105	UR	C725421	Development Waste	Fresh	PAF		18	<0.005	25	0.72	<5	30.3	0.075	<0.05	79.5	<0.005	3970	0.05	<0.005	<0.005	<0.005	254
URNDD0105	UR	C725439	Development Waste	Fresh	NAF		0.57	<0.005	30	0.03	<5	0.07	0.02	<0.05	19.65	<0.005	255	0.055	<0.005	<0.005	<0.005	7.75
URNDD0105	UR	C725441	Development Waste	Fresh	NAF		0.32	<0.005	25	<0.005	<5	0.02	0.03	<0.05	23.2	<0.005	515	0.065	<0.005	<0.005	<0.005	0.905
URNDD0105	UR	C725475	Ore		NAF		0.73	0.02	20	<0.005	<5	0.01	0.07	<0.05	30.25	<0.005	800	0.215	<0.005	<0.005	<0.005	0.76
URNDD0105	UR	C725478	Ore		NAF		0.15	<0.005	20	<0.005	<5	0.005	0.025	<0.05	22.15	<0.005	70	0.045	<0.005	<0.005	<0.005	0.17
URNDD0105	UR	C725479	Ore		PAF-LC		7.25	<0.005	20	0.39	<5	0.7	0.025	<0.05	106	<0.005	650	0.08	<0.005	<0.005	<0.005	18.25



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KL
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Appendix 13 – Mine Closure Plan



NT Mining Operations Pty Ltd
Union Reefs North Underground Mine

Mine Closure Plan

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TABLE OF CONTENTS

1 Introduction 3

2 Post-Mining Land Use 3

3 Closure Objectives 3

4 Completion Criteria 4

5 Collection and Analysis of Closure Data 4

6 Engagement 4

7 Mine Closure Plan Review 5

8 Materials Characterisation, Including Mineral Waste 5

9 Sustainability 5

9.1 Alternatives in Consideration 5

9.2 Climate Change Considerations 5

10 Closure Domain Summaries 6

10.1 Union Reefs North Underground Mine Closure Domain 9

10.2 Haul Road Closure Domain 15

10.3 Prospect South Pit Closure Domain 18

10.4 Prospect North Pit Closure Domain 21

10.5 Dam A and Dam C Closure Domain 24

10.6 Dam B Closure Domain 27

10.7 Crosscourse Pit Closure Domain 30

10.8 Processing Operations Closure Domain 33

11 Summary of Disturbance Areas and Required Rehabilitation Soil/Growth Medium 37

12 Decommissioning and Rehabilitation 38

13 Risks and Opportunities 39

13.1 Risks 39

13.2 Opportunities 40

14 Post Closure Monitoring 41

15 Residual Liabilities 41

16 Closure Costs 41

TABLES

Table 10-1 Closure Domain Classification and Nominal Duration 6
Table 10-2 Union Reefs North Underground Mine 9
Table 10-3 Haul Road 15
Table 10-4 Prospect South Pit 18
Table 10-5 Prospect North Pit 21
Table 10-6 Dam A and Dam C 24
Table 10-7 Dam B 27
Table 10-8 Crosscourse Pit and Tailings Storage Facility 30
Table 10-9 Processing Operations 33
Table 11-1 DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM 37
Table 12-1 Unplanned Mine Closure Scenarios and Mitigation Measures 38
Table 13-1 Mine Closure Risks 39

FIGURES

Figure 10-1 URPA Closure Layout 7
Figure 10-2 Prospect Pit Proposed Closure Layout 8

APPENDICES

Appendix A – Closure Data and Reports Log

1 Introduction

The Union Reefs North Underground Mine project is proposed within the larger URPA. This chapter is intended to provide input specific to the mine closure for the project under review only. Details for the broader mine closure of the URPA are contained in the URPA Mine Closure Plan. The URPA is a highly modified, brownfields mining area that consists of numerous mine features or Closure Domains unrelated to this draft EIS. Approximately 495 ha at URPA has been disturbed historically (prior to 2004), of which 355 ha has been rehabilitated/revegetated. This chapter addresses mine features (Closure Domains) that are specifically and primarily associated with the underground mine (this draft EIS). Closure Domains are therefore discussed using the following classifications:

- **Primary:** Mine features primarily associated with the underground mine (closure aspects addressed in this EIS).
- **Secondary:** Active and ongoing URPA mine features that interact with the project, but both pre-date and to operate beyond the period of the project (discussed in this EIS but closure aspects addressed in the broader URPA Mine Closure Plan).
- **Tertiary:** URPA mine features that do not interact with the project (not discussed in this EIS but closure aspects addressed in the broader URPA Mine Closure Plan).

The draft EIS commits to updating an integrated URPA Mine Closure Plan, including the following aspects related specifically to the Union Reefs Underground Mine (i.e. this project).

2 Post-Mining Land Use

The proposed final post-mining land use of much of the URPA is natural habitat compatible with pastoral use. It is recognised, however, that immediately after mining the Union Reefs North Underground Mine will remain isolated on all sides by the broader URPA. Thus such a land use in not likely in the short term, rather, the Union Reefs North Underground Mine immediate post mining land use will be its incorporation into the broader URPA.

3 Closure Objectives

The long term closure objective of the much of the URPA is achieving a post-mining land use of natural habitat compatible with pastoral use.

Additionally, KLG is a signatory to the Responsible Gold Mining Principles set out by the World Gold Council, including the following mine closure objective:

- We will plan for the social and environmental aspects of mine closure in consultation with authorities, our workforce, affected communities and other relevant stakeholders. We will make financial and technical provision to ensure planned closure and post-closure commitments are realised, including the rehabilitation of land, beneficial future land use, preservation of water sources and prevention of acid rock drainage and metal leaching.

The key closure objective specifically associated with the Union Reefs North Underground Mine is long term public safety. The objective is to inhibit public access to underground workings. Public access will be prevented by the construction of an abandonment bund around the Prospect pit and sealing of the portal and ventilation shafts, prior to allowing groundwater in the pit to naturally rebound post cessation of dewatering. It is planned to have this completed within 12 months of mining being completed at the project.

Mine closure planning will also include specific approaches to protect and/or creating Ghost bat roosts and maintain habitat stability on advice from Ghost bat consultant experts. NTMO will continue to work on understanding how this site could be used for Ghost bat preservation after closure while meeting other closure requirements as detailed within this closure plan.

The objective for groundwater is the recovery of groundwater levels to their pre mining levels. Groundwater will naturally recharge in the backfilled underground workings so that Potentially Acid Forming (PAF) material is maintained in an anoxic subaqueous environment, long term. Groundwater monitoring down gradient of the underground mine void will help detect any potentially contaminated seepage and provide early warning for unexpected changes. Groundwater will be managed in accordance with the URPA Water Management Plan (WMP) and specifically the Union Reefs North Underground Mine Water Abstraction Management Plan (WAMP) and Water Quality Management Plan (WQMP).

All pumps, water tanks and other facilities will be removed or transferred to other sites depending on requirements of NTMO at the time of mine closure.

In addition, general closure objectives are:

- To be (physically) safe to humans and animals, (geotechnically) stable, (geochemically) non-polluting/ non-contaminating, and capable of sustaining an agreed post-mining land use.
- Decommissioned and rehabilitated in an ecologically sustainable manner.

All other surface infrastructure associated with the underground mine will be decommissioned and removed with the affected areas rehabilitated. All pumps, water tanks and other facilities will be removed. NTMO commits that all pumps, water tanks and other facilities will be removed from the project area within 3 months of mining being completed. This will need to be completed prior to final abandonment bunding being placed around the open pit. All equipment will be reassigned to other operations, sold or scrapped on removal from the Union Reefs North underground project depending on site requirements at the time.

4 Completion Criteria

The completion criteria are outlined per closure domain in Section 10.

5 Collection and Analysis of Closure Data

A log of closure data will be created and continually updated by KLG (Appendix A). These data will be kept in a secure digital data store. Closure data to be collected and analysed annually will include, but be not limited to:

- Historical reports;
- Raw historical data;
- The Environmental Impact Statement (EIS) and any associated data;
- Closure designs; as well as
- All data and reporting collected as part of the:

    1. Mine Management Plan (MMP)
    2. Water Management Plan (WMP)
    3. Water Abstraction Management Plan (WAMP)
    4. Water Quality Management (WQMP)
    5. Weed Management Plan (WeedMP)
    6. Stakeholder Engagement Strategy (SES)

6 Engagement

As part of the stakeholder engagement strategy (SES), closure engagement is logged starting with the Draft EIS Closure Comments.

7 Mine Closure Plan Review

The above data and reporting will be synthesised into ongoing updates of the Mine Closure Plan (MCP). These data and reporting will to assist operations to review and update the MCP. The following information will be summarised and put into context within the MCP:

- Changes to the operation since the last MCP that will affect closure (for example increased disturbance footprints, results of research trials or studies aimed at closing knowledge gaps).
- An up-to-date record of legal obligations for closure and any revisions/additions to such legal obligations arising from the MCP reporting year.
- Any changes to commitments made in relation to site rehabilitation and closure (including a record of approval(s) associated with these changes).
- Updates to the engagement of stakeholders regarding mine closure as per the Stakeholder Engagement Strategy (SES).
- Updates on the further refinement and development of completion criteria (development of completion criteria provides direction and focus for research and trials).

Once summarised in the MCP, the above information will also be used to update research and/or closure implementation tasks that were created in the previous iteration of the MCP.

8 Materials Characterisation, Including Mineral Waste

Material classification, including mineral waste has been undertaken historically at Union Reefs and as part of the EIS for the Union Reefs North Underground Mine. Ongoing material characterisation and validation of the EIS works will be undertaken throughout and beyond mining.

A review of the success of existing mine rehabilitation at Union Reefs will identify and guide successful outcomes for both the Union Reefs North Underground Mine areas and the broader URPA. Mining activities at Union Reefs were completed in 2004 with previous mining operations on care and maintenance since that time (excluding the Processing Plant and Tailings Storage Facility).

9 Sustainability

This section documents alternatives in consideration and climate change considerations. KLG's full Sustainability Report can be found at **https://www.klgold.com/sustainability/default.aspx**

9.1 Alternatives in Consideration

The Union Reefs processing plant was commissioned in 1994 and operates using an industry standard CIL process. The plant is currently in operation and has safely operated since commissioning was completed.

A new technology that has been developed by CSIRO and is now marketed by Clean Mining has only been shown to work on smaller scaled projects and while a newer way to processes gold ores it is not well understood if this technology would work on the scale of the Union Reefs plant. More work would be required to understand if it would operate at the current mill scale and what retrofitting would be required (including capital costs) to use this new technology in the Northern Territory. While the technology is still in the early stages of commercialization (only one small plant built to date) it would be a financial risk for NTMO to move to this type of processing at this time. However, the fact that it has "*the potential to eliminate tailings dams*" (Clean Mining, 2019), it would be a technology that Kirkland Lake should investigate for future use as both the environmental and financial benefits warrant a further investigation.

9.2 Climate Change Considerations

The overall footprint of this project is relatively small which highlights the small greenhouse gas emissions reported in the draft EIS. The EIS is for the development of an underground portal within the Union Reefs Project Area. The Union

Reefs processing facility is currently authorized for use and sources ore from other mines (Cosmo). Therefore the greenhouse gas emissions from that ore would be related to the Cosmo and Union Reefs processing plant authorisations.

In terms of Climate Change – NTMO and Kirkland Lake Gold are constantly looking at ways to reduce environmental impact. Kirkland Lake Gold's Macassa Mine in Canada was one of the first major mines to us battery operated mining equipment underground and worked closely with Artisan (now part of Sandvik) in developing this equipment. NTMO is working closely with EPIROC to investigate use of their battery operated equipment and will consider these for long term use at Union Reefs as not only is the technology better for the environment it is also cheaper to run as fuel costs are lower and the requirements for air and ventilation underground are reduced compared to mines using diesel equipment.

Another issue that NTMO is investigating is the use of alternate electricity supplies for the processing plant and mines. NTMO has entered into a Memorandum of Understanding (MoU) with Charles Darwin University (CDU) to specifically investigate alternative energy supplies. The current situation is using Power from the NT Government owned power grid that runs close to all mines and plants, however the use of solar or wind has not been discounted at this stage, more work is required to understand if this can support the demands of our operations for either peak or base load. CDU will assist with understanding these requirements and what technology could be used to fulfil our requirements both at the Union Reefs Underground mine and the whole of operations.

10 Closure Domain Summaries

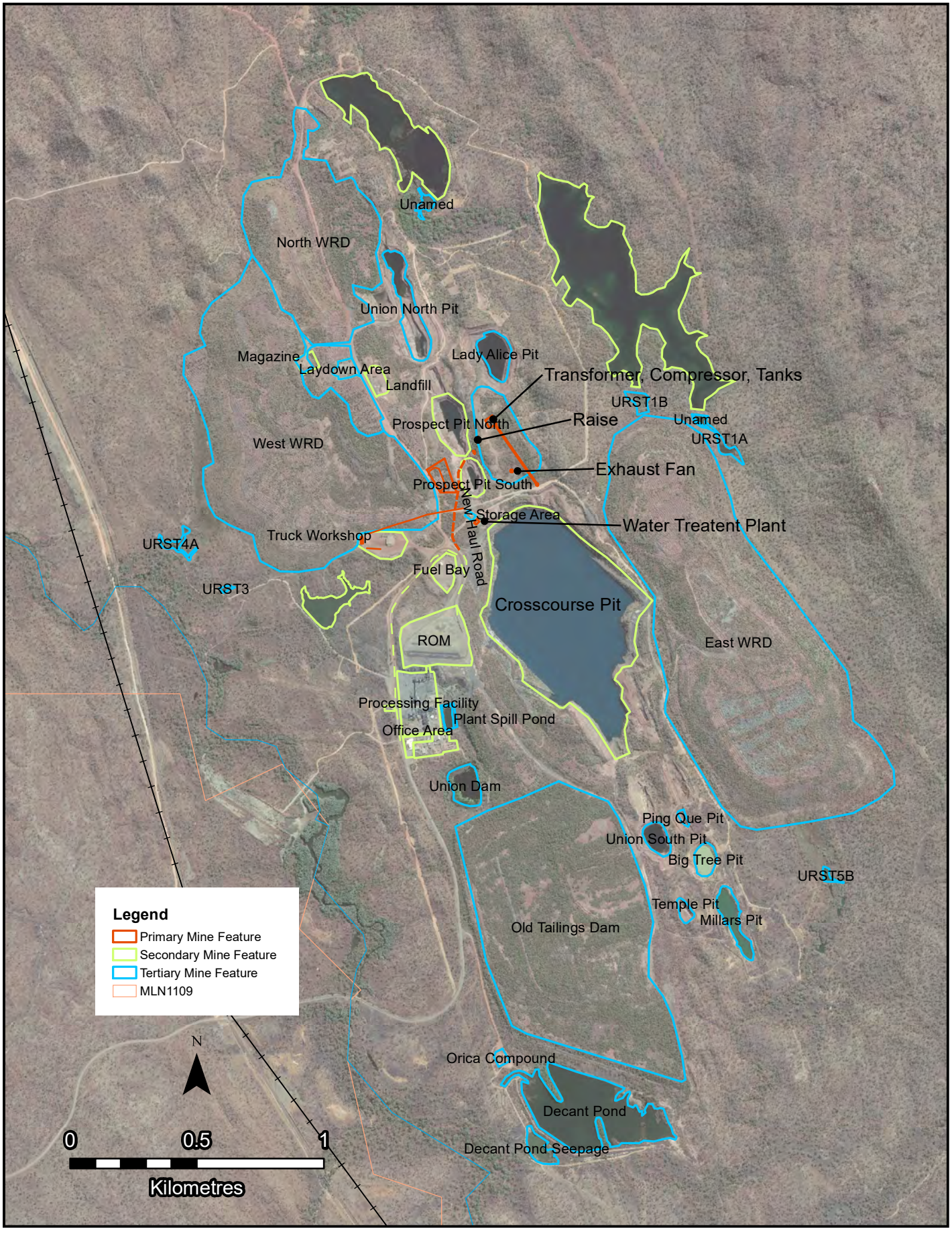
Closure domains are summarised in Table 10-1, and the closure execution plans detailed in Table 10-2 to Table 10-9 and presented in Figure 10-1 and Figure 10-2.

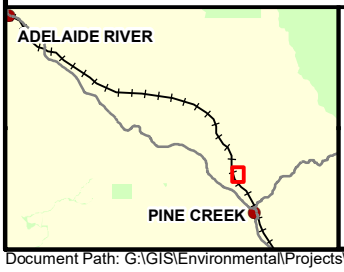
TABLE 10-1 CLOSURE DOMAIN CLASSIFICATION AND NOMINAL DURATION

Closure Domain	Closure Classification	Nominal Closure Start Year	Nominal Closure End Year	Nominal Closure Duration (Years)	Reference
Union Reefs North Underground Mine	Primary	2022	2023	1	Table 10-2
Haul road	Secondary	2022#	2023#	1	Table 10-3
Prospect South pit	Secondary	2022#	2023#	1	Table 10-4
Prospect North pit	Secondary	2022#	2023#	1	Table 10-5
Crosscourse pit	Secondary	N/A	N/A	N/A	Table 10-8
Dam A and Dam C	Secondary	N/A	N/A	N/A	Table 10-6
Dam B	Secondary	N/A	N/A	N/A	Table 10-7
Processing operations	Secondary	N/A	N/A	N/A	Table 10-9

Closure years only relate to aspects associated with the underground mine / the project.

Closure tasks by Closure Domain (where applicable to the Union Reefs Underground Mine) are outlined in the sections below.





Union Reefs Project Area (URPA) Closure Layout

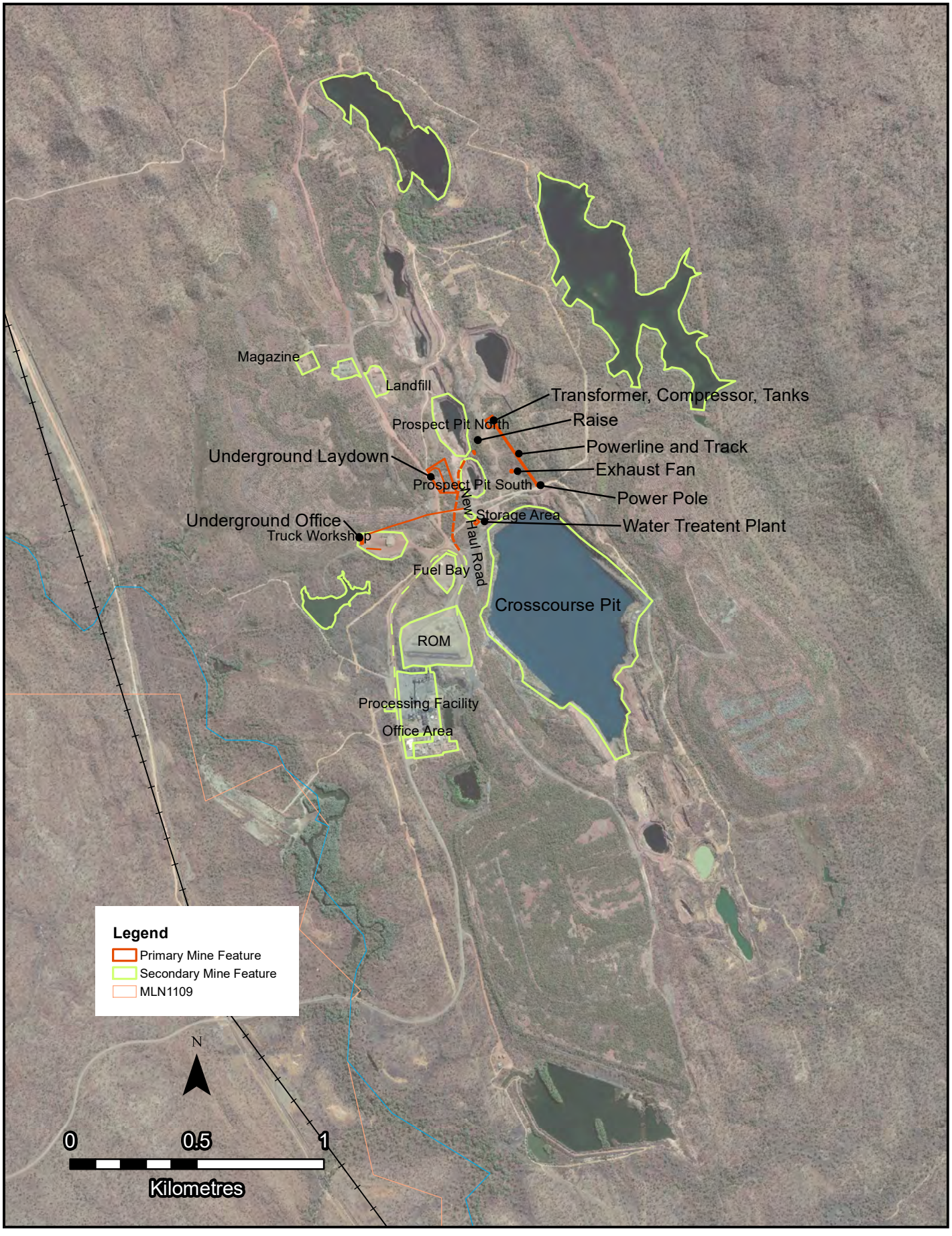
Figure 10-1

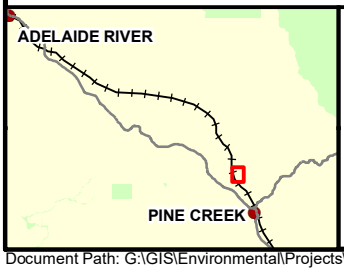
KIRKLAND LAKE GOLD

GDA 1994 MGA Zone 52

30 February 2020

Document Path: G:\GIS\Environmental\Projects\Contractors\URPA EIS 2019\URPA Prospect Infrastructure.mxd





Prospect Pit Proposed Closure Layout

Figure 10-2

KIRKLAND LAKE GOLD

GDA 1994 MGA Zone 52

30 February 2020

Document Path: G:\GIS\Environmental\Projects\Contractors\URPA EIS 2019\URPA Prospect Infrastructure.mxd

10.1 Union Reefs North Underground Mine Closure Domain

TABLE 10-2 UNION REEFS NORTH UNDERGROUND MINE

Union Reefs North Underground Mine – Closure Task Register	
Description of Domain or Feature	
The Underground Mine area is within a brownfields area of the URPA. The mining area consists of exploration drilling disturbance and the portal is located within the Prospect pit. At the End Of Mine (EOM) the elements that will require closure consideration are: • The portal • The portal ramp • Temporary waste rock piles • Temporary water management sumps • The network of underground workings including the decline, horizontal drives, vertical development, stopes • Tanks/power/compressor/raise area • Vertical development headworks • Surface exploration drillholes and pads	
Location	URPA
Tenements	Mineral Lease Number 1109 (MLN1109)
Authorisations	Not yet authorised.
Status	Not yet developed.(located on previously mined site)
Current disturbance	• Exploration drilling. • URPA brownfields mining area. • URPA Processing facility and supporting infrastructure. • Previous Historical Mining. • Previous Pastoral Lease and Cattle Grazing.
Life of asset disturbance	2 years (LOM)
Estimated closure start date	2022
Estimated closure end date	2023
Closure works duration	1 year
Land-Use Information	
Post-mining land use	• Natural habitat compatible with pastoral use.
Rehabilitated landform objective	• Reinstate natural (unmanaged) ecosystem(s) similar to the pre-underground-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. • Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential

Union Reefs North Underground Mine – Closure Task Register		
	for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.	
Post-mining landform design	• Flat area rehabilitation with gently sloping drainage. • Prospect Open pit to remain in place post-mining of underground development	
Closure completion criteria and performance indicators	• Certification that no contamination remains in place that would prevent the closure objectives being met. • Certification that adequate controls are in place to inhibit public access. • Certification that adequate vegetation has been reinstated to meet the closure objectives.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Rehabilitate, deep rip and seed exploration/disturbed areas not required for access to vertical development headworks.	2020 during construction
Decommission	• Cease mining. • Remove all mining mobile plant from underground. • Remove all chemicals and fuel from underground (if any). • Remove temporary surface waste rock piles to underground as required. • De-sludge temporary water management sumps. • Cease pumping underground inflows. • Remove air supply and management infrastructure from surface. • Remove water supply and management infrastructure from surface. • Remove tanks/power/compressor/raise area infrastructure. • Allow the network of underground workings including the decline, horizontal drives, vertical development and stopes to flood. • Monitor groundwater level rebounds. • Construct final portal geometry that precludes public access but allows groundwater outflow/inflow. Look to brick up face using standard mining approach. • Alter portal ramp geometry to final landform if required • Remove vertical development headworks including exhaust fans. • Construct concrete slab or similar to preclude public access from vertical development • Bund the Prospect pits to prevent accidental access to the pit and vertical development areas. • Rehabilitate, deep rip and seed access to vertical development.	2022 to 2023 1 year

Union Reefs North Underground Mine – Closure Task Register		
	• Monitor rebounded mine water quality at outflow or in Prospect pit.	
Demolish / reallocate / remove from site	• Vertical development headworks and exhaust fans. • Air supply and management infrastructure. • Water supply and management infrastructure. • Tanks/power/compressor/raise area infrastructure.	2022 to 2023 1 year
Site landform and drainage reconstruction	• Reshape/re-contour area to generally radially drainage and to remove any erosion prone features. • Retain locally occurring tree species where possible. • Remove any exotic plant species as required. • Establish bunding around mine to ensure public access is restricted. • Deep rip all haul roads not required by the post-closure land user.	2022 to 2023 1 year
Rehabilitation and re-vegetation	• Spread available topsoil at >100 mm where required and rip on contour. • Seed with local pioneer species and mulch with any available vegetation detritus. • Create fauna habitats (e.g. using rocks and available vegetation detritus).	2022 to 2023 1 year
Security and signage	• The underground mine will have no access for public access post-closure. • No security fencing or signage is required. • Stock fencing put in place around the pit bund to keep cattle off the bund surface, particularly during the early growth years immediately post-closure. Fencing will be maintained by post-closure landowner/pastoralist if required to be maintained in the long term.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Undertake further materials characterisation test work on available rehabilitation cover materials to confirm understanding of results Document and review learnings from existing URPA rehabilitation.	Ongoing
Portals	• Research requirements for final portal geometry that would allow Ghost bat access but preclude public access.	Ongoing
Completion criteria	• Using monitoring results, research, investigation and trials, develop criteria that are specific to the Closure Domains.	Ongoing

Union Reefs North Underground Mine – Closure Task Register		
Performance indicators	• Develop specific, quantitative performance indicators for the measurement of success that are based on research and monitoring outcomes.	Ongoing
Landform and rehabilitation design	• Continue with progressive rehabilitation and/or rehabilitation trials and subsequent flora and/ or fauna performance monitoring to inform closure design.	Ongoing
Seeding	• Conduct ongoing trials and investigations that will inform the success of seeding.	Ongoing
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Disturbed areas	• As discussed above.	As discussed above.
Pit bunds	• As discussed above. NTMO commits that the construction of the final safety bund around the Prospect Pit will be completed within 12 months of final mining of the underground mine. This will be completely closed when no further work is required in the pit or the underground – for example when ghost bat monitoring programs are completed. However, the bund will be constructed within 12 months of completion of mining with only the main access left open until access to the open pit is no longer required.	As discussed above.
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Area requiring landforming and contouring based on surface area of disturbed areas.	See Table 11-1 DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM
	• Other areas requiring minor earthworks/landscaping (i.e. exterior haul roads).	See Table 11-1 DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM
Topsoil	• Spread to areas as required at >100 mm. Topsoil stockpiled adjacent to pits.	See Table 11-1 DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM
	• Spread topsoil to other areas.	See Table 11-1 DISTURBANCE AREAS AND REQUIRED

Union Reefs North Underground Mine – Closure Task Register		
		REHABILITATION SOIL/GROWTH MEDIUM
Seeding	• Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 11-1 DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Anywhere where the early closure has resulted in a partially completed landforms, further earthworks will be required to meet the final design specifications. • This includes any non-competent material left exposed at the time of closure which will need to be covered in competent rock to the minimum thickness required by the design specifications.	At early closure
	• Remove and/or process any remaining ore stockpiles.	At early closure
Temporary closure	• Put in place additional bunding and/or fencing to prevent public access to unsafe areas.	On announcement of temporary closure.
	• Develop underground and pit water management in the care and maintenance plans.	On announcement of temporary closure.
	• Establish weed management plan.	During the period of temporary closure.
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Determine the optimum landform profile for maximum stability and vegetation establishment success. • Accessing suitable topsoil	Ongoing

Union Reefs North Underground Mine – Closure Task Register		
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-closure monitoring	• Implement agreed post-closure monitoring program.	2022 to 2028
Post-closure maintenance	• Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	• Implement post-closure maintenance activities as required.	As required to relinquishment

10.2 Haul Road Closure Domain

TABLE 10-3 HAUL ROAD

Haul Road – Closure Task Register	
Description of Domain or Feature	
The existing haul road leading to the ROM Pad will connect to the upgraded haul road connection to the Prospect pit North portal. At the End Of Mine (EOM) the elements that will require closure consideration are: • The haul road no-longer remaining in use as part of the URPA activities. • The haul road remaining in use as part of the URPA activities.	
Location	URPA
Tenements	Mineral Lease Number 1109 (MLN1109)
Authorisations	Existing haul road is part of the URPA activities, Authorisation #0539-03 New haul road not yet authorised.
Status	New haul road not yet developed.
Current disturbance	• Existing tracks and old Prospect Pit haul road and access ramp.
Life of asset disturbance	2 years (LOM)
Estimated closure start date	2022
Estimated closure end date	2023
Closure works duration	1 year
Land-Use Information	
Post-mining land use	• Natural habitat compatible with pastoral use.
Rehabilitated landform objective	• Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. • Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-mining landform design	• Flat area rehabilitation with gently sloping drainage.
Closure completion criteria and	• Certification that no contamination remains in place that would prevent the closure objectives being met. • Certification that adequate topsoil is in place.

Haul Road – Closure Task Register		
performance indicators	• Certification that adequate vegetation has been reinstated to meet the closure objectives.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Stockpile soil.	2020 during construction.
Decommission	• Rehabilitate haul road no-longer remaining in use as part of the URPA activities. • Maintain the haul road remaining in use as part of the URPA activities.	2022 to 2023 1 year
Demolish	• Not applicable	Not applicable
Clean-up and dispose	• Not applicable	Not applicable
Site landform and drainage reconstruction	• Reshape/re-contour area to generally radially drainage and to remove any erosion prone features. • Retain locally occurring tree species where possible. • Remove any exotic plant species as required. • Deep rip all haul roads not required by the post-closure land user.	2022 to 2023 1 year
Rehabilitation and re-vegetation	• Spread available topsoil at >100 mm where required and rip on contour. • Seed with local pioneer species and mulch with any available vegetation detritus. • Create fauna habitats (e.g. using rocks and available vegetation detritus).	2022 to 2023 1 year
Security and signage	• The haul road area will be safe for public access post-closure. • No security fencing or signage is required. • Stock fencing put in place around the pit bund to keep cattle off the bund surface, particularly during the early growth years immediately post-closure. Fencing will be maintained by post-closure landowner/pastoralist if required to be maintained in the long term.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Undertake further detailed materials characterisation for available rehabilitation cover materials. Document and use learnings from existing URPA rehabilitation.	Ongoing

Haul Road – Closure Task Register		
Completion criteria	• Using monitoring results, research, investigation and trials, develop criteria that are specific to the closure domains.	Ongoing
Performance indicators	• Develop specific, quantitative performance indicators for the measurement of success.	Ongoing
Landform and rehabilitation design	• Continue with progressive rehabilitation and/or rehabilitation trials and subsequent vegetation performance monitoring to inform closure design.	Ongoing
Seeding	• Conduct ongoing trials and investigations that will inform the success of seeding.	Ongoing
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable.	• Not applicable.	Not applicable.
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Area requiring landforming and contouring based on surface area of haul road.	See Table 11-1
	• Other areas requiring minor earthworks/landscaping (i.e. soil stockpile areas).	See Table 11-1
Topsoil	• Spread to areas as required at >100 mm. Topsoil stockpiled adjacent to haul road.	See Table 11-1
	• Spread topsoil to other disturbed areas.	See Table 11-1
Seeding	• Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 11-1
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Anywhere where the early closure has resulted in a partially completed haul road, further earthworks will be required to meet the final design specifications.	At early closure
	• Remove and spread soil stockpiles.	At early closure
Temporary closure	• Put in place additional bunding and/or fencing to prevent public access to unsafe areas.	On announcement of temporary closure.
	• Develop care and maintenance plans.	On announcement of temporary closure.

Haul Road – Closure Task Register		
	• Establish weed management plan.	During the period of temporary closure.
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Determine the optimum landform profile and cover design for maximum stability and vegetation establishment success.	Ongoing
• Performance Monitoring and Maintenance Schedule		
Aspect	• Performance Monitoring and Maintenance Task	**Schedule**
Post-closure monitoring	• Implement agreed post-closure monitoring program.	Relinquishment
Post-closure maintenance	• Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	• Implement post-closure maintenance activities as required.	As required to relinquishment

10.3 Prospect South Pit Closure Domain

TABLE 10-4 PROSPECT SOUTH PIT

Prospect South Pit – Closure Task Register	
Description of Domain or Feature	
The Prospect South pit is a partially flooded open pit within the URPA. The Prospect South pit will be the location of a temporary waste rock dump which will be built up to approximately the decant/connection to the Prospect North pit and portal level. The Prospect South pit will be dewatered prior to waste rock placement. All waste produced from the decline will be returned underground on completion of the project meaning conditions within Prospect South pit are highly likely to approximate pre-underground mining conditions as a partially flooded open pit. This domain will be managed within the broader URPA Mine Closure Plan. At the End Of Mine (EOM) the elements that will mine require closure consideration are: • The open pit	
Location	URPA
Tenements	Mineral Lease Number 1109 (MLN1109)
Authorisations	The Prospect South pit is part of the URPA activities. Using the Prospect South as a temporary waste rock facility is not yet authorised.
Status	The Prospect South pit has been mined.
Current disturbance	• Prospect South Pit.
Life of asset disturbance	2 years (LOM)

Prospect South Pit – Closure Task Register		
Estimated closure start date	2022	
Estimated closure end date	2023	
Closure works duration	1 year	
Land-Use Information		
Post-mining land use	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Rehabilitated landform objective	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Post-mining landform design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure completion criteria and performance indicators	• Certification that no contamination remains in place that would prevent the closure objectives being met (e.g. pit water quality). • Certification that adequate topsoil is in place. • Certification that adequate vegetation has been reinstated to meet the closure objectives.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Not applicable.	Not applicable.
Decommission	• Remove any remaining temporary surface waste rock piles underground. • De-sludge temporary water management sumps. • Remove water supply and management infrastructure from surface. • Allow the open pit to flood. • Monitor groundwater level rebounds. • Bund the Prospect pits to prevent accidental access to the pit area. • Monitor rebounded mine water quality.	2022 to 2023 1 year
Demolish	• Not applicable	Not applicable
Clean-up and dispose	• Not applicable	Not applicable
Site landform and drainage reconstruction	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Rehabilitation and re-vegetation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

Prospect South Pit – Closure Task Register		
Security and signage	• No security fencing or signage is required. • Stock fencing put in place around the pit bund to keep cattle off the bund surface and from accessing pit water, particularly during the early growth years immediately post-closure. Fencing will be maintained by post-closure landowner/pastoralist if required to be maintained in the long term.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Completion criteria	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	• Not applicable. Managed within the URPA Mine Closure Plan.	Not applicable
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Topsoil	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**

Prospect South Pit – Closure Task Register		
Early closure	• Anywhere where the early closure temporary waste rock storage, further earthworks will be required to return the waste rock underground.	At early closure
Temporary closure	• Return temporary waste rock underground. • Put in place additional bunding and/or fencing to prevent public access to unsafe areas.	On announcement of temporary closure.
Temporary closure	• Develop care and maintenance plans. • Establish weed management plan.	During the period of temporary closure.
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not Applicable
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-closure monitoring	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Relinquishment
Post-closure maintenance	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Annually
	• Not applicable. Managed within the broader URPA Mine Closure Plan.	As required to relinquishment

10.4 Prospect North Pit Closure Domain

TABLE 10-5 PROSPECT NORTH PIT

Prospect North Pit – Closure Task Register	
Description of Domain or Feature	
The Prospect North pit is a partially flooded open pit within the URPA. Existing non-mineralised, oxide stockpile within the Prospect pit will provide approximately 7,000 to 12,000 t of material to construct/upgrade the portal bench in Prospect North pit prior to mine development. The remainder of the Prospect North pit will be utilised as a temporary water management sump. The Prospect North pit will be dewatered prior to portal bench placement. Conditions within Prospect North pit are highly likely to approximate pre-underground mining conditions as a partially flooded open pit and this domain will be managed within the broader URPA Mine Closure Plan. At the End Of Mine (EOM) the elements that will mine require closure consideration are: • The open pit • The portal ramp • The portal	
Location	URPA

Prospect North Pit – Closure Task Register		
Tenements	Mineral Lease Number 1109 (MLN1109)	
Authorisations	The Prospect North pit is part of the URPA activities. Using the Prospect North pit for the portal and portal ramp is not yet authorised.	
Status	The Prospect North pit has been mined.	
Current disturbance	• Prospect North pit	
Life of asset disturbance	2 years (LOM)	
Estimated closure start date	2022	
Estimated closure end date	2023	
Closure works duration	1 year	
Land-Use Information		
Post-mining land use	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Rehabilitated landform objective	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Post-mining landform design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure completion criteria and performance indicators	• Certification that no contamination remains in place that would prevent the closure objectives being met (e.g. pit water quality). • Certification that adequate topsoil is in place. • Certification that adequate vegetation has been reinstated to meet the closure objectives.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Not applicable.	Not applicable.
Decommission	• Remove any remaining temporary surface waste rock piles underground. • Alter portal ramp geometry to final landform if required. • De-sludge temporary water management sumps. • Remove water supply and management infrastructure from surface. • Allow the open pit to flood. • Monitor groundwater level rebounds. • Bund the Prospect pits to prevent accidental access to the pit area. • Monitor rebounded mine water quality.	2022 to 2023 1 year

Prospect North Pit – Closure Task Register		
Demolish	• Not applicable	Not applicable
Clean-up and dispose	• Not applicable	Not applicable
Site landform and drainage reconstruction	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Rehabilitation and re-vegetation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Security and signage	• No security fencing or signage is required. • Stock fencing put in place around the pit bund to keep cattle off the bund surface and from accessing pit water, particularly during the early growth years immediately post-closure. Fencing will be maintained by post-closure landowner/pastoralist if required to be maintained in the long term.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Completion criteria	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

Prospect North Pit – Closure Task Register		
Topsoil	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Anywhere where the early closure temporary waste rock storage, further earthworks will be required to return the waste rock underground.	At early closure
Temporary closure	• Return temporary waste rock underground. • Put in place additional bunding and/or fencing to prevent public access to unsafe areas.	On announcement of temporary closure.
Temporary closure	• Develop care and maintenance plans. • Establish weed management plan.	During the period of temporary closure.
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Not applicable. Managed within the URPA Mine Closure Plan.	Not applicable
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-closure monitoring	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Post-closure maintenance	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

10.5 Dam A and Dam C Closure Domain

TABLE 10-6 DAM A AND DAM C

Dam A and Dam C – Closure Task Register
Description of Domain or Feature
Dam A and Dam C are up-gradient water supply features for the URPA. Both dams have the potential to be water supply sources for the project. Dam A and Dam C will remain active beyond the project and will be managed within the broader URPA Mine Closure Plan. At the end of mine (EOM) the elements that will mine require closure consideration are:

Dam A and Dam C – Closure Task Register		
• Dam A • Dam C		
Location	URPA	
Tenements	Mineral Lease Number 1109 (MLN1109)	
Authorisations	Dam A and Dam C have been water supply sources at the URPA since the 1990s. Authorised under Authorisation # 0539-03.	
Status	Dam A and Dam C are the current water supply sources at the URPA.	
Current disturbance	• Dam A and Dam C are the current water supply sources at the URPA.	
Life of asset disturbance	Beyond 2 years (LOM)	
Estimated closure start date	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Estimated closure end date	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure works duration	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Land-Use Information		
Post-mining land use	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Rehabilitated landform objective	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Post-mining landform design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure completion criteria and performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Decommission	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Demolish	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

Dam A and Dam C – Closure Task Register		
Clean-up and dispose	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Site landform and drainage reconstruction	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Rehabilitation and re-vegetation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Security and signage	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Completion criteria	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Topsoil	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		

Dam A and Dam C – Closure Task Register		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Temporary closure	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-closure monitoring	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Post-closure maintenance	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

10.6 Dam B Closure Domain

TABLE 10-7 DAM B

Dam B – Closure Task Register	
Description of Domain or Feature	
Dam B is a down-gradient water features for the URPA. Dam B has the potential to be a water quality management features for the project. Dam B will remain active beyond the project and will be managed within the broader URPA Mine Closure Plan. At the End Of Mine (EOM) the elements that will mine require closure consideration are: • Dam B	
Location	URPA
Tenements	Mineral Lease Number 1109 (MLN1109)
Authorisations	The use of Dam B as a water quality management feature is not yet authorised.
Status	Dam B has been used as a water storage at the URPA since the 1990s.
Current disturbance	• Dam B has been used as a water storage at the URPA since the 1990s.
Life of asset disturbance	Beyond 2 years (LOM)
Estimated closure start date	Not applicable.

Dam B – Closure Task Register		
Estimated closure end date	Not applicable.	
Closure works duration	Not applicable.	
Land-Use Information		
Post-mining land use	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Rehabilitated landform objective	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Post-mining landform design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure completion criteria and performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Not applicable.	Not applicable.
Decommission	• Water quality testing to ensure Dam B has not been adversely impacted by the project.	2022 1 Year
Demolish	• Not applicable	Not applicable
Clean-up and dispose	• Not applicable	Not applicable
Site landform and drainage reconstruction	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Rehabilitation and re-vegetation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Security and signage	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Undertake further detailed materials characterisation for available rehabilitation cover materials. Document and use learnings from existing URPA rehabilitation.	Ongoing
Completion criteria	• Using monitoring results, research, investigation and trials, develop criteria that are specific to the closure domains.	Ongoing

Dam B – Closure Task Register		
Performance indicators	• Develop specific, quantitative performance indicators for the measurement of success that are based on research and monitoring outcomes.	Ongoing
Landform and rehabilitation design	• Continue with progressive rehabilitation and/or rehabilitation trials and subsequent vegetation performance monitoring to inform closure design.	Ongoing
Seeding	• Not applicable.	Not applicable.
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	• Not applicable	Not applicable
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Topsoil	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the URPA Mine Closure Plan.	Not applicable
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Not applicable. Managed within the broader URPA Mine Closure Plan.	At early closure
Temporary closure	• Not applicable. Managed within the broader URPA Mine Closure Plan.	On announcement of temporary closure.
	• Not applicable. Managed within the broader URPA Mine Closure Plan.	During the period of temporary closure.
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Determine the optimum landform profile and cover design for maximum stability and vegetation establishment success.	Ongoing
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**

Dam B – Closure Task Register		
Post-closure monitoring	• Implement agreed post-closure monitoring program.	Relinquishment
Post-closure maintenance	• Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	• Implement post-closure maintenance activities as required.	As required to relinquishment

10.7 Crosscourse Pit Closure Domain

TABLE 10-8 CROSSCOURSE PIT AND TAILINGS STORAGE FACILITY

Crosscourse Pit – Closure Task Register
Description of Domain or Feature
The Crosscourse pit is a partially flooded open pit within the URPA which has been utilised for tailings disposal since 2002. The Crosscourse pit is planned to be utilised for tailings disposal by both the project and other projects within the URPA. The Crosscourse pit will remain active beyond the project and will be managed within the URPA Mine Closure Plan. At the End Of Mine (EOM) the elements that will mine require closure consideration are: • The open pit and tailing storage facility. The Water Management Plan (WMP) presents the predicted water levels for the Crosscourse Pit under a number of scenarios. The likelihood of Crosscourse Pit to fill and remain near to the spill level is a major risk to the long term use of Crosscourse Pit as a tailings storage facility. It is likely that the management of the likely that the positive water balance of the Crosscourse Pit requires a waste discharge licence (WDL). A life of mine (LOM) tailings study will be produced and this will include as a minimum: • The proposed maximum tailings and water levels over time; • Closure and Capping Designs; and a • Seepage Assessments. The LOM tailings study will provide input to the URPA Mine Closure Plan. The Union Reefs North Underground Mine only contributes a small percentage (<2%) of the current tailings. As noted in the EIS, the Union Reefs tailings facility that is located within the Crosscourse Open pit will continued to be used by the Union Reefs Project to store tailings generated from the Cosmo and potentially other deposits. On completion of the Union Reefs underground Mining project it is envisaged that the processing plant will continue operating processing ore from various other locations (Pine Creek, Cosmo and other current exploration targets like Bon's Rush). Only considering the Union Reefs North Underground Mine, the current plan for the Crosscourse Pit tailings storage facility is to prepare for closure after mining. The strategy to achieve this is active discharge via a WDL. Alternatively continued discharging and dewatering Crosscourse entirely could result in an active tailings storage facility in the Crosscourse Pit lasting until 2036 with tailing reaching capacity in the pit. Given the Crosscourse pit and tailings storage facility water balance is positive, a long term water cover is considered a major risk. Capping is the most likely mitigation and management approach to address this risk at closure. KLG is considering the options of both "Hardpan" and conventional backfill capping methodologies. KLG is currently working with University Queensland on developing the "Hardpan" capping technology for this application.

Crosscourse Pit – Closure Task Register		
Location	URPA	
Tenements	Mineral Lease Number 1109 (MLN1109)	
Authorisations	The use of Crosscourse pit as a tailings storage facility is an authorised activity at the URPA. Authorisation # 0539-03	
Status	The Crosscourse pit is the current tailings storage facility at URPA.	
Current disturbance	• The Crosscourse pit is the current tailings storage facility at URPA.	
Life of asset disturbance	Beyond 2 years (LOM)	
Estimated closure start date	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Estimated closure end date	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure works duration	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Land-Use Information		
Post-mining land use	• Not applicable. Managed within the URPA Mine Closure Plan.	
Rehabilitated landform objective	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Post-mining landform design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure completion criteria and performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Not applicable.	Not applicable.
Decommission	• Not applicable.	Not applicable.
Demolish	• Not applicable	Not applicable
Clean-up and dispose	• Not applicable	Not applicable
Site landform and drainage reconstruction	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Rehabilitation and re-vegetation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

Crosscourse Pit – Closure Task Register		
Security and signage	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation materials characterisation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Completion criteria	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Topsoil	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Temporary closure	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Information Gaps		

Crosscourse Pit – Closure Task Register		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-closure monitoring	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Post-closure maintenance	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

10.8 Processing Operations Closure Domain

TABLE 10-9 PROCESSING OPERATIONS

Processing Operations – Closure Task Register	
Description of Domain or Feature	
The project will utilise processing operations that already exist at the URPA. After the project these authorised processing operations will remain active and be managed within the broader URPA Mine Closure Plan. The existing processing plant (mill) will be used for processing. The existing ROM will be used as the ROM for the project. The existing fuel bay, wash-down area and minor repairs workshop will be used for refueling, and repairs. The existing magazine will be used as a magazine for the project. The existing administration area, energy infrastructure, laydown and landfill areas will be utilised for the project. At the End Of Mine (EOM) the elements that will mine require closure consideration are: • The existing URPA processing plant (mill area) • The existing ROM area • The existing URPA administration area • The existing URPA laydown and landfill areas • The existing energy infrastructure • The existing fuel bay, wash-down area and minor repairs workshop In this chapter, these are collectively referred to as the processing operations.	
Location	URPA
Tenements	Mineral Lease Number 1109 (MLN1109)
Authorisations	The use of the processing operations at URPA is already authorised. Authorisation # 0539-03
Status	Processing operations at the URPA have been active intermittently since the 1990s.
Current disturbance	• Processing operations at the URPA have been at the current disturbance scale since the 1990s.
Life of asset disturbance	Beyond 2 years (LOM)

Processing Operations – Closure Task Register		
Estimated closure start date	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Estimated closure end date	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure works duration	Not applicable. Managed within the broader URPA Mine Closure Plan.	
Land-Use Information		
Post-mining land use	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Rehabilitated landform objective	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Post-mining landform design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure completion criteria and performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	
Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Timing and Duration**
Development	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Decommission	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Demolish	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Clean-up and dispose	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Site landform and drainage reconstruction	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Rehabilitation and re-vegetation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Security and signage	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**

Processing Operations – Closure Task Register		
Rehabilitation materials characterisation	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Completion criteria	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Performance indicators	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Landform and rehabilitation design	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable.
Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	• Not applicable	Not applicable
Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Topsoil	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Seeding	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early closure	• Notify workers, contractors and the appropriate local and government authorities. • Assign a person to authorise site access and project management of care and maintenance activities. • Process all material at the ROM or on stockpiles. • Construct fences/barriers as required to restrict access to processing areas. • Remove all petroleum, chemicals and explosive products, run down stocks or return to suppliers. • Drain all tanks and pipelines. • Shutdown mechanical, hydraulic, and electrical systems and make sure they are effectively isolated. • Remove mobile equipment, and as required salvage and sell machinery/infrastructure.	At early closure

Processing Operations – Closure Task Register		
	• Seal, secure and lock buildings or remove/demolish demountable buildings.	
Temporary closure	• Notify workers, contractors and the appropriate local and government authorities. • Assign a person to authorise site access and project management of care and maintenance activities. • Process all material at the ROM or on stockpiles. • Construct fences/barriers as required to restrict access to processing areas. • Establish a program for road maintenance to ensure access is maintained. • Continue regular inspections. • Ensure any required water management infrastructure remains operational. • Establish a schedule and continue required environmental monitoring and management activities. • Assign an appropriately qualified person to review and report all monitoring data collected. • Review and update the broader URPA Mine Closure Plan.	On announcement of temporary closure.
Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Not applicable.	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-closure monitoring	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable
Post-closure maintenance	• Not applicable. Managed within the broader URPA Mine Closure Plan.	Not applicable

11 SUMMARY OF DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM

A summary of the above disturbance areas and closure volumes (required soil/growth medium) are presented in Table 11-1. Soil/growth medium may include oxide material where it has or can be made to have the growth appropriate properties (i.e. through the addition of fertilisers etc.).

TABLE 11-1 DISTURBANCE AREAS AND REQUIRED REHABILITATION SOIL/GROWTH MEDIUM

Primary Areas	Length (m)	Length (km)	Width (m)	Actual Designated Area (Ha)	Actual Designated Area (m^2)	Soil Resource m^3 (Lower Limit 100 mm)	Soil Resource m^3 (Upper Limit 1,000 mm)	Minimum Required Rehabilitation Soil m^3 (at 100 mm)
Exploration and vertical development areas#	675	0.7	360	10.1	101,213	10,121	101,213	10,121
Haul roads to be closed	400	0.4	15	0.6	6,000	600	6000	600

Not all of exploration and vertical development area between the haul road, Prospect pits, Lady Alice pit and Crosscourse pit are disturbed. To be calculated based on actual disturbed areas.

Breakdown of Secondary Areas	Length (m)	Length (km)	Width (m)	Actual Designated Area (Ha)	Actual Designated Area (m^2)	Soil Resource m3 (Lower Limit 100 mm)	Soil Resource m3 (Upper Limit 1,000 mm)	Minimum Required Rehabilitation Soil m3 (at 100 mm)
Not Applicable.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total of Primary Soils Required	**TBC**	**TBC**	**TBC**	**TBC**	**TBC**	**TBC**	**TBC**	**TBC**

TBC - To be calculated based on actual disturbed areas.

12 DECOMMISSIONING AND REHABILITATION

On completion of mining for the NTMO in the Pine Creek region the processing plant will be assessed for the asset value of the infrastructure and supporting site features. As the site is classed as a company asset this may be sold or divested to other potential project developers in the Pine Creek region. As the only currently operating processing facility in the region it would be seen as an asset to other potential mining companies. With this in mind it is possible the project could be divested with no long-term requirement by NTMO for processing ore from its sites.

NTMO will redevelop the broader URPA Mine Closure Plan (MCP) 2015 in accordance with the Western Australian Guidelines for Preparing Mine Closure Plans (Western Australia Department of Mines and Petroleum, 2015).

The structure and information in the URPA MCP 2015 will need to be reconfigured and reassessed to meet new guideline requirements, and the revised URPA MCP is likely to be substantially different to previously submitted versions. NTMO will work with the DPIR to agree on a realistic submission date for the redeveloped URPA MCP.

This draft EIS is focused on the recommencement of active mining operations at the URPA, and it is considered that the risk of any unplanned closure of operations is low. However, the scenarios under which unplanned closure may occur and the corresponding NTMO mitigation measures are outlined in Table 12-1.

TABLE 12-1 UNPLANNED MINE CLOSURE SCENARIOS AND MITIGATION MEASURES

Unplanned Closure Scenario	Mitigation Measures
Significant Gold Price Drop Operations suspended and placed into care and maintenance until economic mining and processing could resume.	• Development of a robust Business Case. • Operational approval by President/CEO and Board. • Annual budgets with actual and forecast expenditure. • Extensive management and operation expertise.
Major Infrastructure Failure or Incident Operations suspended until the infrastructure failure or incident is addressed, and mining and processing can resume.	• Routine maintenance and inspections of infrastructure. • Risk assessments and management plans. • Emergency Response Team and Plans. • Established company insurance policies.
Instructed to Close by a Government Agency Operations suspended until any non-conformance with regulatory requirements is addressed and mining and processing can resume.	• Approved Mining and Risk Management Plans. • Routine reporting of monitoring and performance. • Regular consultation to provide updates on activities, clarify expectations and management of risks.
Owner Financial Bankruptcy Operations suspended and placed into care and maintenance until assets sold by administrators.	• Strong financial position with quarterly public reporting. • NI 43-101 compliant Probable gold Mineral Reserves. • Mid-tier gold producer with a solid base of quality assets.

The URPA has identified NI 43-101 compliant Probable gold Mineral Reserves and has an established processing plant, which are highly valued assets for mining operations. Based on this and in the event of any unplanned closure, the site would be placed into care and maintenance and mining and/or mineral processing operations would resume in the foreseeable future.

If no foreseeable plan for future operations is possible, then the broader, updated URPA Mine Closure Plan would be implemented. This would dramatically increase the cost of re-opening operations in the future, but would reduce the on-going closure liabilities.

13 Risks and Opportunities

13.1 Risks

Potential risks to successful closure, decommissioning and rehabilitation are outlined below. Key mine closure risks are identified in Table 13-1, with the proposed mitigation measures considered as Proponent commitments to further inform the broader URPA Mine Closure Plan.

TABLE 13-1 MINE CLOSURE RISKS

Hazard / Event – End of Life	Consequence	Mitigation Measures
Poor management of waste materials during mining operations leads to closure plans being unachievable or costly.	Delays to effective rehabilitation including seepage resulting in non-sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years. Impacts to receiving environment associated with delays.	• All waste rock will be temporarily stored in the Prospect South pit and not be stored long-term on surface • Conceptual closure plan developed for the project prior to start-up. • Increase level of detail in closure designs during operations (detailed design level throughout mining operations). • Prepare decommissioning and rehabilitation plan. • Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. • Regular monitoring of identified key environmental aspects of operation that are potentially most problematic during operation and at closure i.e. temporary surface waste rock storage, seepage of mine affected water to the groundwater and associated pit lake levels. • Underground mining allows for progressive backfill and review. • Employ closure project manager. • Undertake inspections and monitoring. • Performance monitoring of progressive rehabilitation and correction of designs/execution if required.
Closure designs not developed in detail to enable appropriate closure execution, including ineffective	Insufficient closure cost provision resulting in inability to execute closure plan. Delays or inability to achieve	• Reporting of spills. • Contaminated sites register. • Contaminated sites report. • Contaminated sites rehabilitation designs.

Hazard / Event – End of Life	Consequence	Mitigation Measures
implementation of design, poor rehabilitation execution or design failure, resulting in significantly higher closure cost above closure provisioning.	effective rehabilitation by project proponent. Delays in achieving rehabilitation criterion and could be a period of years, with un-remediated project site potentially acting as source of ongoing environmental hazard.	• Closure plan operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria. • Undertake further sampling/monitoring to accurately define level and extent of any contamination during operations.
Unexpected early closure of the project, due to delays or falling commodity prices.	Delays to effective rehabilitation by project proponent, including through erosion or seepage resulting in non-sustainable ecosystems and groundwater effects. Potentially exacerbated by closure designs not yet developed in detail at time of early closure.	• Strategic long term investment in Northern territory tenements. • Concept closure plan prior to mine start up. • Commit to developing/refining closure designs through operations. • In-pit waste storage progressively returned underground during mining operations, therefore limited impact should the project enter early closure. • Bonds held by NT Government requires 110% of estimated closure cost reviewed and provided annually.
Unable to reach agreement with stakeholders on closure objectives.	Mine closure objectives unable to be implemented, delays to effective rehabilitation.	• Stakeholder relationship is ongoing at URPA. • NTMO is a signatory to World Gold Council Responsible Gold Mining Principles including principles associate with stakeholder engagement. • NTMO has other interests in the region and is committed to working closely with stakeholders for long term benefit of the company and the community.

13.2 Opportunities

NTMO will investigate the potential sale of the Union Reefs processing facility at the end of its requirements for the Pine Creek regional projects. As the infrastructure is seen as a company asset there may be opportunities for the project to be sold to other potential operators in the region.

14 Post Closure Monitoring

Post closure monitoring activities include, but may not be limited to:

- Monitor groundwater level rebounds, if not already fully rebounded.
- Monitor groundwater quality (geochemical stability).
- Monitor surface water quality and levels (geochemical stability).
- Monitor rehabilitated surfaces (geotechnical stability).
- Monitor rehabilitation success (flora/fauna and ecological assessments).

15 Residual Liabilities

No residual liability should remain relating specifically to the Union Reefs North Underground Mine. Residual liabilities relating to the URPA final post mining land use include:

- The post closure monitoring activities.
- Any remaining highwalls associated to secondary mine features.
- Any pits left as water bodies associated to secondary mine features.

It is not yet clear these have been agreed to by key stakeholders, and this process will proceed as part of the ongoing URPA Mine Closure Plan development and SES.

16 Closure Costs

Closure costs will be estimated and tracked on an ongoing basis. This is required as part of Kirkland Lake Gold's financial reporting under its Asset Retirement Obligations (ARO) which is part of the company's annual reporting.

APPENDICES

Appendix A – Closure Data and Reports Log

Historical Period Data

AMD Characterisation (EGI)

Pine Creek Water Levels and Pumping Data (PWC, 2019)

URPA Water Levels and Pumping Data (KLG, 2019)

EIS Period Data

Geochemical Characterisation (EGI, 2019 & EGI, 2020)

Water Quality (EGI, 2019 & EGI, 2020)

Groundwater Study (GHD, 2019A GHD, 2019B and GHD, 2020)

Ghost Bat Technical Report (EMS, 2019)

Groundwater Dependent Ecosystem Characterisation (Aquatic Ecology, 2019)

Operational Period Data

WMP, 2020

WQMP, 2020

WAMP, 2020

Closure Period Data


KL
KIRKLAND LAKE GOLD

Appendix 14 – Additional Groundwater Modelling



NT Mining Operations Pty Ltd

Kirkland Lake Gold
Union Reefs North Underground Mine EIS
Additional Groundwater Modelling

November 2019

Table of contents

1. Introduction 2
2. Additional modelling approach 2
3. Historical calibration results and discussion 5
4. Steady state model results and discussion 7
5. Transient model results and discussion 8
6. Conclusions 11
7. References 12

Table index

Table 1 Summary of stages 3
Table 2 Model register 4
Table 3 Model input parameters and modelled inflow to pit 5
Table 4 Comparative Pine Creek catchments modelled discharges 6
Table 5 Comparative McKinlay River catchments modelled discharges 6
Table 6 Comparative steady state open pit outflow assessments 7
Table 7 Comparative assessments of a key model output (flow to McKinlay River) 9

Figure index

Figure 1 Modelled change in flow to the McKinlay River (L/s) 10
Figure 2 Modelled change in flow to the McKinlay River (%) 10

Cover Photograph: MRWET12 in September 2019 prior to being observed dry in November 2019.

1. Introduction

This report is intended to document additional groundwater flow modelling undertaken to improve confidence, and report on the numerical uncertainty associated to the flow modelling provided in the Groundwater Study report (GHD, 2019a). This report is subject to, and must be read in conjunction with, the limitations set out in GHD (2019a) and the assumptions and qualifications contained throughout that report.

2. Additional modelling approach

The additional modelling approach is based on the premise that the GHD (2018a) work documents a conservative set of model parameters of the scenarios presented in AQ2 (2018). Herein, the term conservative refers to a set of model parameters which are likely to predict a drawdown at (or above) the magnitude which is considered likely, based on the available information. This includes the requested modelling documented in the appendices of GHD (2018a) referred to as GHD (2019b), GHD (2019c) and GHD (2019d). Thus the additional modelling approach presented herein is intended to repeat each of the previous steps (see below), but with different input parameter values.

The steps for each stage are:

- alter the hydraulic conductivity input values;
- calibrate recharge (using PEST) with the new hydraulic conductivity input values;
- apply the calibrated recharge and new hydraulic conductivity input values to the predictive assessments approach documented in GHD (2019a);
- apply the calibrated recharge and new hydraulic conductivity input values to the steady state Crosscourse Pit behaviour assessments approach documented in GHD (2019c); and
- apply the calibrated recharge and new hydraulic conductivity input values to a simplified historical transient Crosscourse Pit approach (300 series models not previously documented).

The stages are summarised in Table 1 and as:

- Stage 1 K = 0.3 and 0.005 (m/day), 0.5% recharge;
- Stage 2 K = 0.3 and 0.005 (m/day), 0.7% recharge (calibrated based on additional information from PWC, 2019);
- Stage 3 K = 0.1 and 0.009 (m/day), calibrated recharge;
- Stage 4 K = 0.2 and 0.007 (m/day), calibrated recharge;
- Stage 5 Geological input, calibrated hydraulic conductivity and calibrated recharge;
- Stage 6 reconsideration of the effect of specific yield.

Table 1 Summary of stages

Stage	Specific Yield	Kx shallow (m/day)	Kx deep (m/day)	Recharge (m/day)
1	0.01 & 0.005	0.3	0.005	1.56E-05
2	0.01 & 0.005	0.3	0.005	2.18E-05
3	0.01 & 0.005	0.1	0.009	1.81E-05
4	0.01 & 0.005	0.2	0.007	2.02E-05
5	0.01 & 0.005	0.1, 0.3*	0.003, 0.0015*	1.87E-05
6	0.001	0.1, 0.3*	0.003, 0.0015*	1.87E-05

*these models include the introduction of a higher conductivity for material along strike and in areas of higher yields.

The model register is provided as Table 2.

Table 2 Model register

Description	Model No.	Stage	Recharge
K = 0.3 and 0.005 0.5% Recharge	KGL_UR_106	1	1.56E-05
PEST on 106	KGL_UR_107	1	1.56E-05
Mining	KGL_UR_050	1	1.56E-05
No Mining	KGL_UR_051	1	1.56E-05
Mining (Extended)	KGL_UR_052	1	1.56E-05
No Mining (Extended)	KGL_UR_053	1	1.56E-05
Mining (Extended) and Crosscourse up to 188 mAHD	KGL_UR_054	1	1.56E-05
Transient (steady state) for all pit levels	KGL_UR_200	1	1.56E-05
Transient historical for all pit levels	KGL_UR_300	1	1.56E-05
PWC, 2019 wells (Steady state)	KGL_UR_108	2	1.56E-05
PEST on 108, allowed slightly higher recharge 0.7%	KGL_UR_109	2	2.18E-05
No Mining 52 with PWC, 2019 wells at actual pumping rates & 0.7% Recharge	KGL_UR_110	2	2.18E-05
Mining 52 with PWC, 2019 wells at actual pumping rates & 0.7% Recharge	KGL_UR_111	2	2.18E-05
Transient Steady State at 0.7% Recharge	KGL_UR_201	2	2.18E-05
Transient historical for all pit levels 0.7% Recharge	KGL_UR_301	2	2.18E-05
Changes to K 0.1 & 0.009 at steady state	KGL_UR_112	3	2.18E-05
PEST on 112 for recharge	KGL_UR_113	3	1.81E-05
No Mining PWC, 2019 wells at actual pumping rates & 113 Recharge	KGL_UR_114	3	1.81E-05
Mining PWC, 2019 wells at actual pumping rates & 113 Recharge	KGL_UR_115	3	1.81E-05
Transient Steady State at 113 Recharge	KGL_UR_202	3	1.81E-05
Transient historical for all pit levels at K 0.1 & 0.009	KGL_UR_302	3	1.81E-05
Changes to K 0.2 & 0.007 at steady state	KGL_UR_116	4	2.18E-05
PEST on 116 for recharge	KGL_UR_117	4	2.02E-05
No Mining PWC, 2019 wells at actual pumping rates & 117 Recharge	KGL_UR_118	4	2.02E-05
Mining PWC, 2019 wells at actual pumping rates & 117 Recharge	KGL_UR_119	4	2.02E-05
Transient Steady State at 117 Recharge	KGL_UR_203	4	2.02E-05
Transient historical for all pit levels K 0.2 & 0.007	KGL_UR_303	4	2.02E-05
Changes to K 0.3 & 0.005 and decrease K off strike at steady state	KGL_UR_120	5	
PEST on 120 for recharge	KGL_UR_121_4_	5	1.87E-05
No Mining PWC, 2019 wells at actual pumping rates & 121_4_ Recharge	KGL_UR_122	5	1.87E-05
Mining PWC, 2019 wells at actual pumping rates & 121_4_ Recharge	KGL_UR_123	5	1.87E-05
Transient Steady State at 121_4_ Recharge and Ks	KGL_UR_204	5	1.87E-05
Transient historical for all pit levels K with geological input	KGL_UR_309 SSSH	5	1.87E-05
Changes to K 0.3 & 0.005 and decrease to K off strike at steady state (Sy at 0.01 & 0.005)	KGL_UR_309_1 SSSH	6	1.87E-05
No Mining PWC, 2019 wells at actual pumping rates & 121_4_ Recharge (Sy at 0.001)	KGL_UR_122_1	6	1.87E-05
Mining PWC, 2019 wells at actual pumping rates & 121_4_ Recharge (Sy at 0.001)	KGL_UR_123_1	6	1.87E-05

3. Historical calibration results and discussion

To provide an extra level of validation to both the AQ2 (2018) analytical modelling, and the current numerical modelling, a longer term historical calibration which included the mining of the Crosscourse Pit to -47mAHD was also completed. The aim of these works was also to look at the relative flow budgets to compare the previous open pit mining to the proposed underground mining. These models are denoted by the UR_KGL_300 series nomenclature.

The approach was to apply the calibrated recharge and hydraulic conductivity input values to a simplified historical transient Crosscourse Pit approach. The calibrated recharge values come from the PEST calibration on models UR_KGL_109, UR_KGL_113, UR_KGL_117 and UR_KGL_121_4_ (Table 2).

The key considerations for context are:

- Observed dry season groundwater inflows were in the order of 8 L/s (URS, 2002) ;
- Modelled decrease in the Pine Creek catchments (GHD, 2019a) was 0.00%; and
- Modelled decrease in the McKinlay Creek catchment (GHD, 2019a) was 3%.

The key model outputs for this stage are the:

- Maximum modelled groundwater inflow to pit (Table 3);
- Maximum modelled change for discharges in the Pine Creek catchment (Table 4).
- Maximum modelled change to discharges and groundwater available in the McKinlay River (Table 5);

Models now considered the most valid are shaded grey.

Table 3 Model input parameters and modelled inflow to pit

Model (UR_KGL_)	Sy	Kx shallow (m/day)	Kx deep (m/day)	Recharge (m/day)	Maximum modelled groundwater inflow to pit (m^3/day)	Maximum modelled groundwater inflow to pit (L/s)
300	0.001	0.3	0.005	1.56E-05	1351	16
301	0.001	0.3	0.005	2.18E-05	1351	16
302	0.001	0.1	0.009	1.81E-05	1662	19
303	0.001	0.2	0.007	2.02E-05	1479	17
309SSSH	0.001	0.1, 0.3	0.003, 0.0015	1.87E-05	805	9
309_1SSSH	0.01 & 0.0005	0.1, 0.3	0.003, 0.0015	1.87E-05	985	11

Table 4 Comparative Pine Creek catchments modelled discharges

Model (UR_KGL_)	Max Pine Creek Catchment Flows (m^3/day)	Max Pine Creek Catchment Flows (m^3/day)	Min Pine Creek Catchment Flows (m^3/day)	Min Pine Creek Catchment Flows (m^3/day)	Max % change at EOM
300	2793	32	2793	32	-0.002%
301	4024	47	4024	47	-0.001%
302	3309	38	3309	38	-0.005%
303	3717	43	3717	43	-0.004%
309SSSH	3441	40	3441	40	-0.002%
309_1SSSH	3441	40	3441	40	-0.002%

Table 5 Comparative McKinlay River catchments modelled discharges

Model (UR_KGL_)	Kx shallow (m/day)	Kx deep (m/day)	Recharge (m/day)	Base McKinlay River catchment Flows (m^3/day)	Base McKinlay River catchment Flows (L/s)	EOM McKinlay River catchment Flows (m^3/day)	EOM McKinlay River catchment Flows (L/s)	Max % change at EOM
300	0.3	0.005	1.56E-05	2972	34	2824	33	5%
301	0.3	0.005	2.18E-05	3681	43	3528	41	4%
302	0.1	0.009	1.81E-05	2607	30	2339	27	10%
303	0.2	0.007	2.02E-05	3176	37	2971	34	6%
309SSSH	0.1, 0.3	0.003, 0.0015	1.87E-05	2611	30	2568	30	2%
309_1SSSH	0.1, 0.3	0.003, 0.0015	1.87E-05	2611	30	2579	30	1%

The above indicates that the model that has the closest fit to historical information (thus considered the most likely to be more valid) was where the geological input was included and a low specific yield was applied (UR_KGL_309SSSH). It should be noted that all models yielded reasonable results given the detail of the historical information was limited.

The models also provide insight into to the 5% max change modelled McKinlay River discharges for the Crosscourse Pit mining vs the 3% for the proposed underground mining.

All models had a 0% modelled change for discharges in the Pine Creek catchment.

4. Steady state model results and discussion

The steady state models analogous to that documented in GHD (2019c). Only model UR_KGL_204, resulted in a groundwater decant level higher than 172 mAHD. Using 172 mAHD as a likely groundwater decant level is thus considered conservative.

Table 6 Comparative steady state open pit outflow assessments

Model Name (UR_KGL_)	Kx shallow (m/day)	Kx deep (m/day)	Recharge (m/day)	Decant Level (mAHD)	Max CHD Outflow (m^3/day)	Max CHD Outflow (L/s)
200	0.3	0.005	1.56E-05	172	1310	15
201	0.3	0.005	2.18E-05	172	1304	15
202	0.1	0.009	1.81E-05	172	502	6
203	0.2	0.007	2.02E-05	172	904	10
204	0.1, 0.3	0.003, 0.0015	1.87E-05	174	797	9

5. Transient model results and discussion

Comparative transient model results are presented in Table 7, Figure 1 and Figure 2. These demonstrate that all model results are comparative with those presented in GHD (2019a) which are included here (KGL_UR_50 and KGL_UR_51).

The following models were considered slightly less conservative with change in flow to the McKinlay River flows approaching 4% up from 3.3% (but based on the above assessments less likely to be more valid):

- KGL_UR _110 and KGL_UR _111;
- KGL_UR _114 and KGL_UR _115; and
- KGL_UR _118 and KGL_UR _119.

The model results which are more likely to be more valid, KGL_UR _122 and KGL_UR _123 as well as KGL_UR _122_1 and KGL_UR _123_1 have lower change in flow to the McKinlay River flows, peaking at 2.5% and 1.5%.

Table 7 Comparative assessments of a key model output (flow to McKinlay River)

Model	Description	Sy	Kx shallow (m/day)	Kx deep (m/day)	Recharge (m/day)	Max Flow to McKinlay River (m^3/day)	Max Flow to McKinlay River (L/s)	Max Difference in Flow McKinlay River (m^3/day)	Max Difference in Flow McKinlay River (L/s)	Max Difference in Flow McKinlay River (Percentage)
51	No mining	0.005 & 0.01 & 1	0.3	0.005	1.56E-05	3319	38			
50	Mining	0.005 & 0.01 & 1	0.3	0.005	1.56E-05	3296	38	96	1.1	3%
110	No mining	0.005 & 0.01 & 1	0.3	0.005	2.18E-05	4335	50			
111	Mining	0.005 & 0.01 & 1	0.3	0.005	2.18E-05	4333	50	104	1.2	3%
114	No mining	0.005 & 0.01 & 1	0.1	0.009	1.81E-05	3034	35			
115	Mining	0.005 & 0.01 & 1	0.1	0.009	1.81E-05	3030	35	104	1.2	4%
118	No mining	0.005 & 0.01 & 1	0.2	0.007	2.02E-05	3715	43			
119	Mining	0.005 & 0.01 & 1	0.2	0.007	2.02E-05	3713	43	112	1.3	4%
122	No mining	0.005 & 0.01 & 1	0.1, 0.3	0.003, 0.0015	1.87E-05	2998	35			
123	Mining	0.005 & 0.01 & 1	0.1, 0.3	0.003, 0.0015	1.87E-05	2988	35	34	0.4	2%
122_1	No mining	0.001	0.1, 0.3	0.003, 0.0015	1.87E-05	4051	47			
123_1	Mining	0.001	0.1, 0.3	0.003, 0.0015	1.87E-05	4046	47	49	0.6	2%

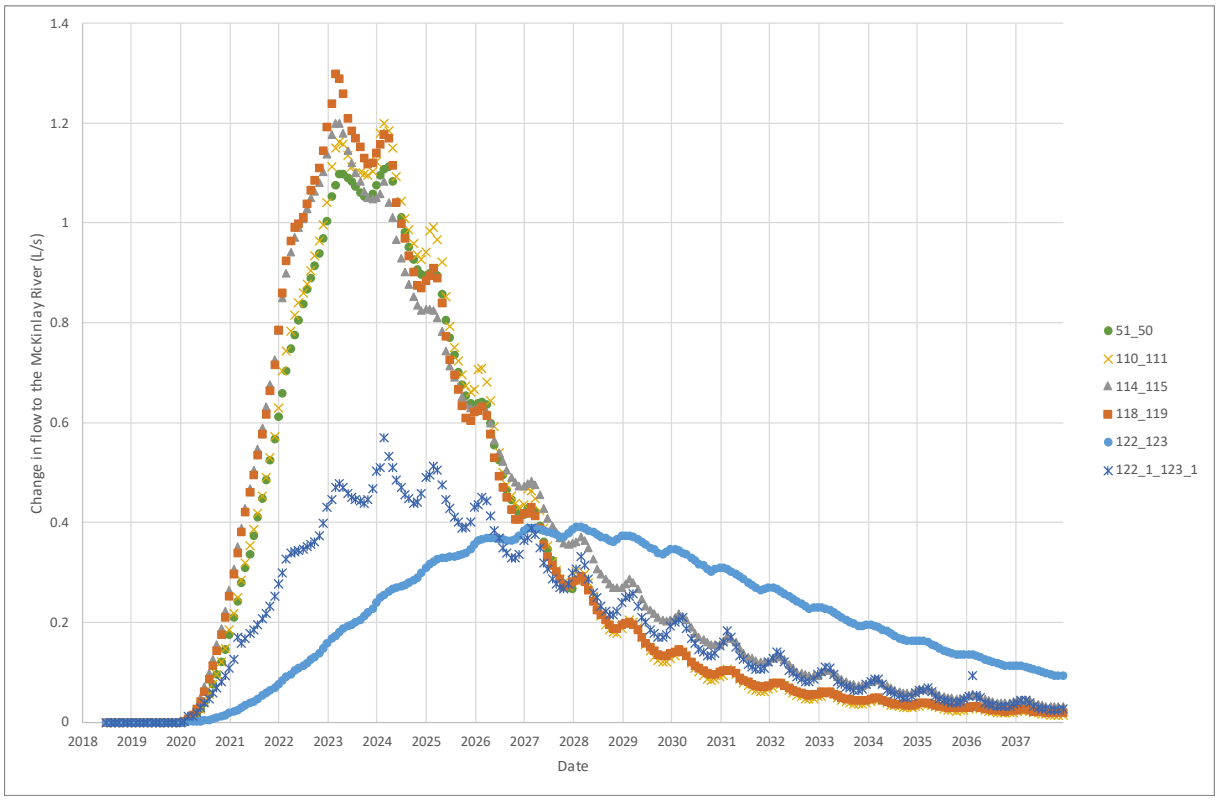


Figure 1 Modelled change in flow to the McKinlay River (L/s)

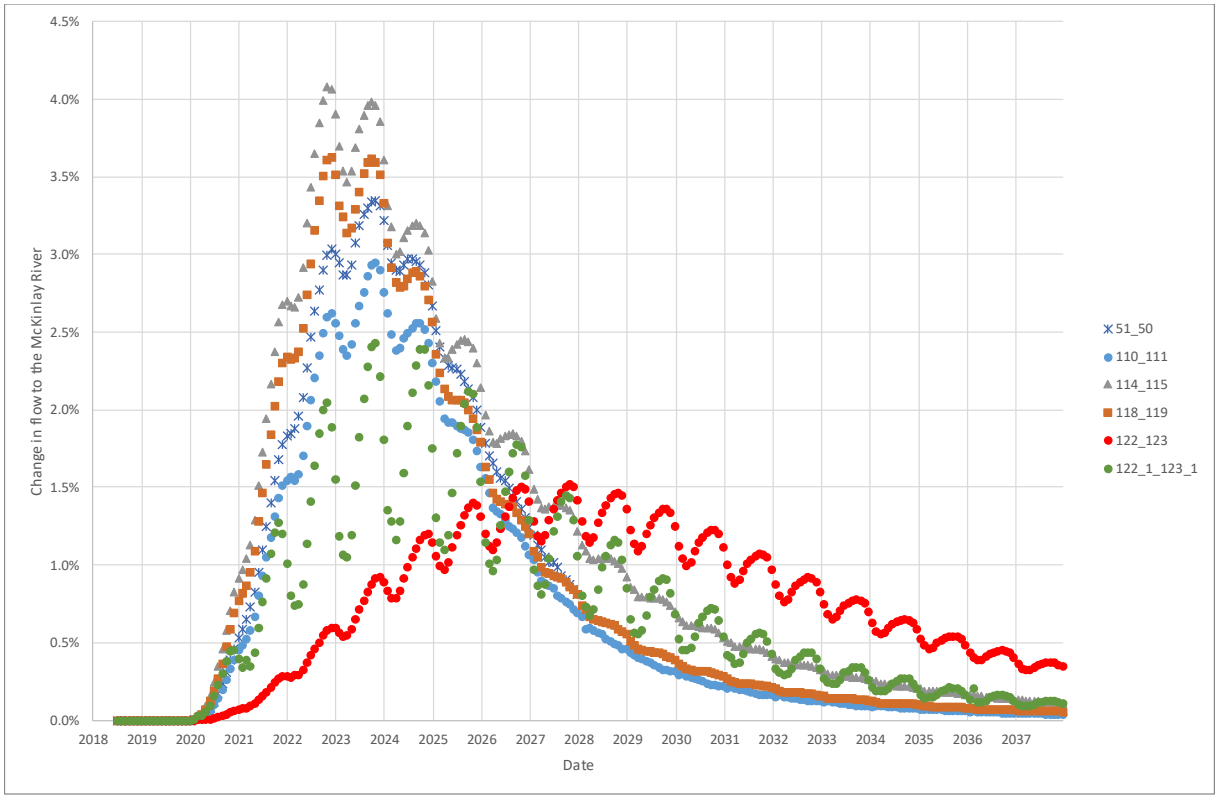


Figure 2 Modelled change in flow to the McKinlay River (%)

6. Conclusions

The models presented here report outcomes based on a series of additional changes to model parameters. The modelling presented in this report does not change the material outcomes of the modelling previously performed in GHD (2019a). Model outputs from this report increase the confidence of the previous models. Following on from this report we consider the results presented in GHD (2019a) to be conservative in nature and reasonable for inclusion in the Environmental Impact Statement.

7. References

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GHD, 2019a, NT Mining Operations Pty Ltd Kirkland Lake Gold Union Reefs North Underground Mine EIS Groundwater Study, October 2019.

GHD (2019b) Union Reefs North Underground Mine EIS Pit Water Level Predictions, Letter Report

GHD (2019c) Union Reefs North Underground Mine EIS Steady State Crosscourse Pit Behaviour Assessments, Letter Report

GHD (2019d) Union Reefs North Underground Mine EIS Crosscourse Pit High Pit Lake Scenario, Letter Report

Appendices N/A

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Appendix 15 – Crosscourse Pit Water Quality Prediction Modelling

Reference 3203/1328

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Northern Territory Mining Operations
Union Reefs North Underground Project
Crosscourse Pit Water Quality Prediction Modelling

February 2020

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Table of Contents

1. Introduction 6
1.1 Scope and limitations 6
2. Modelling approach 7
2.1 Scenarios 10
2.2 Modelled System 10
3. Inputs 11
3.1 Tailings 11
3.2 Water Qualities 12
3.3 Contact water 13
4. Results 14
4.1 Crosscourse Pit Lake 14
4.1.1 Pit lake elevation with no discharge 14
4.1.2 Pit lake elevation with discharge option 16
4.2 Crosscourse water quality: selected species 19
4.2.1 Sulphate 19
4.2.2 Copper 22
4.2.3 Nickel 26
4.2.4 Zinc 30
4.2.5 Arsenic 34
4.2.6 Cobalt 38
4.3 Summary water quality results 41
5. Prospect Pit 42
5.1 Pit Lake elevation 42
5.2 Water Quality 44
6. Discussion 44
7. Conclusions 46
8. Further work 47
9. References 48
APPENDIX A 49

Wet climate with discharge 50
Median climate, with discharge..... 63
Dry climate with discharge 76
Wet climate, no discharge 89
Median climate no discharge..... 102
Dry climate no discharge 115
APPENDIX B..... 128

List of Figures

FIGURE 1: GOLDSIM GRAPHICAL INTERFACE SHOWING MODEL ELEMENTS IN 'CONTAINERS' LAID OUT OVER A SITE AERIAL IMAGE. 7
FIGURE 2: PRELIMINARY USER DASHBOARD WHICH ALLOWS MODEL CONTROLS, INPUT ADJUSTMENTS AND DISPLAY OF RESULTS FOR USE ON SITE WITHOUT A GOLDSIM SUBSCRIPTION USING THE 'PLAYER FILE' OPTION. 9
FIGURE 3: PROBABILITY PLOT OF THE CROSSCOURSE PIT LAKE ELEVATION (NO DISCHARGE, DRY CLIMATE). 15
FIGURE 4: PROBABILITY PLOT OF THE CROSSCOURSE PIT LAKE ELEVATION (NO DISCHARGE, MEDIAN CLIMATE). 15
FIGURE 5: PROBABILITY PLOT OF THE CROSSCOURSE PIT LAKE ELEVATION (NO DISCHARGE, WET CLIMATE). 16
FIGURE 6: PROBABILITY PLOT OF THE CROSSCOURSE PIT LAKE ELEVATION (WITH DISCHARGE, DRY CLIMATE). 17
FIGURE 7: PROBABILITY PLOT OF THE CROSSCOURSE PIT LAKE ELEVATION (WITH DISCHARGE, MEDIAN CLIMATE). 17
FIGURE 8:PROBABILITY PLOT OF THE CROSSCOURSE PIT LAKE ELEVATION (WITH DISCHARGE, WET CLIMATE). 18
FIGURE 9: EXAMPLE OF WET CLIMATE SCENARIO WITH NO DISCHARGE, SHOWING OVERFLOW EVENTS IN THE FIRST HALF OF 2018. ...18
FIGURE 10: CUMULATIVE INFLOWS TO CROSSCOURSE PIT FOR MEDIAN CLIMATE WITH CROSSCOURSE PIT VOLUME. 19
FIGURE 11: WET CLIMATE WITH DISCHARGE ON, SO4. 20
FIGURE 12: MEDIAN WITH DISCHARGE ON, SO4. 20
FIGURE 13: DRY CLIMATE WITH DISCHARGE ON, SO4. 21
FIGURE 14: WET CLIMATE, NO DISCHARGE, SO4. 21
FIGURE 15: MEDIAN CLIMATE, NO DISCHARGE, SO4. 22
FIGURE 16: DRY CLIMATE NO DISCHARGE, SO4. 22
FIGURE 17: WET CLIMATE DISCHARGE ON, CU. 23
FIGURE 18: MEDIAN CLIMATE DISCHARGE ON, CU. 24
FIGURE 19: DRY CLIMATE, DISCHARGE ON, CU. 24
FIGURE 20: WET CLIMATE, NO DISCHARGE, CU. 25
FIGURE 21: MEDIAN CLIMATE, NO DISCHARGE, CU. 25
FIGURE 22: DRY CLIMATE, NO DISCHARGE, CU. 26
FIGURE 23: WET CLIMATE, DISCHARGE ON, NI. 27
FIGURE 24: MEDIAN CLIMATE, DISCHARGE ON, NI. 27
FIGURE 25: DRY CLIMATE, DISCHARGE ON, NI. 28
FIGURE 26: WET CLIMATE, NO DISCHARGE, NI. 28
FIGURE 27: MEDIAN CLIMATE, NO DISCHARGE, NI. 29
FIGURE 28: DRY CLIMATE, NO DISCHARGE, NI. 29
FIGURE 29: WET CLIMATE, WITH DISCHARGE, ZN. 30
FIGURE 30: MEDIAN CLIMATE, WITH DISCHARGE, ZN. 31
FIGURE 31: DRY CLIMATE, WITH DISCHARGE, ZN. 31
FIGURE 32: WET CLIMATE NO DISCHARGE, ZN. 32
FIGURE 33: MEDIAN CLIMATE NO DISCHARGE, ZN. 32
FIGURE 34: DRY CLIMATE NO DISCHARGE, ZN. 33
FIGURE 35: CUMULATIVE ZINC LOAD BY CONTRIBUTOR (GW=GROUNDWATER, SURFRO=SURFACE RUNOFF, UG=UNDERGROUND PUMPING). 34
FIGURE 36: WET CLIMATE, DISCHARGE ON, AS. 35
FIGURE 37: MEDIAN CLIMATE, WITH DISCHARGE, AS. 35
FIGURE 38: DRY CLIMATE, WITH DISCHARGE, AS. 36
FIGURE 39: WET CLIMATE, NO DISCHARGE, AS. 36
FIGURE 40: MEDIAN CLIMATE, NO DISCHARGE, AS. 37
FIGURE 41: DRY CLIMATE NO DISCHARGE, AS. 37
FIGURE 42: WET CLIMATE, WITH DISCHARGE, CO. 38
FIGURE 43: MEDIAN CLIMATE, WITH DISCHARGE, CO. 39
FIGURE 44: DRY CLIMATE, WITH DISCHARGE, CO. 39
FIGURE 45: WET CLIMATE, NO DISCHARGE, CO. 40
FIGURE 46: MEDIAN CLIMATE, NO DISCHARGE, CO. 40
FIGURE 47: DRY CLIMATE, NO DISCHARGE, CO. 41
FIGURE 48: PROSPECT PIT FIL PROFILE WET CLIMATE. 42

FIGURE 49: PROSPECT PIT FIL PROFILE MEDIAN CLIMATE 43
FIGURE 50: PROSPECT PIT FIL PROFILE DRY CLIMATE 43

List of Tables

TABLE 1: INDICATIVE PROJECT SCHEDULE ADAPTED FROM DRAFT EIS. 8
TABLE 2: SCENARIOS MODELLED 10
TABLE 3: TAILINGS DEPOSITION SCHEDULE ADAPTED FROM EIS 2019. 11
TABLE 4: TAILINGS SLURRY WATER QUALITY INPUTS DERIVED FROM MONITORING DATA (ROUNDED). 12
TABLE 5: GROUNDWATER AND SURFACE WATER INPUTS (ROUNDED). 12
TABLE 6: CONTACT WATER QUALITY INPUTS FOR MATERIAL CATEGORIES. 13
TABLE 7: DISCHARGE SCHEDULE FROM EIS 2019 13
TABLE 8: SUMMARY STATISTICS FOR CROSSCOURSE PIT WATER QUALITY, DRY CLIMATE, NO DISCHARGE 129
TABLE 9: SUMMARY STATISTICS FOR CROSSCOURSE PIT WATER QUALITY, MEDIAN CLIMATE, NO DISCHARGE 130
TABLE 10: SUMMARY STATISTICS FOR CROSSCOURSE PIT WATER QUALITY, WET CLIMATE, NO DISCHARGE. 131
TABLE 11: SUMMARY STATISTICS FOR CROSSCOURSE PIT WATER QUALITY, WET CLIMATE, WITH DISCHARGE 132
TABLE 12: SUMMARY STATISTICS FOR CROSSCOURSE PIT WATER QUALITY, MEDIAN CLIMATE, WITH DISCHARGE. 133
TABLE 13: SUMMARY STATISTICS FOR CROSSCOURSE PIT WATER QUALITY, DRY CLIMATE, WITH DISCHARGE. 134
TABLE 14:PROSPECT PIT POST 2023, DRY CLIMATE. 135
TABLE 15: PROSPECT PIT POST 2023 MEDIAN CLIMATE 136
TABLE 16: PROSPECT PIT POST 2023 WET CLIMATE 137

1. Introduction

The following report presents the findings of the water quality modelling produced for the supplementary EIS developed for the Northern Territory Mining Operations (NTMO) Union Reefs North Underground Mine. The modelling component is part of a commitment by NTMO to gain improved understanding regarding the potential water quality issues that may arise as a result of the proposed underground development and associated water management plans.

The modelling approach is described in the EIS (Appendix I) and the primary inputs to the model are presented in the design basis memorandum (DBM) also in Appendix I. This report focusses on the outputs of the modelling. Summary details are included here but the reader is referred to the EIS for additional detail.

The purpose of this water quality prediction model is to look at the possible effects of the underground mining, referred to as North Underground Mine, in terms of effects on the water quality of Crosscourse Pit lake and how this may lead to impacts on down gradient receptors, particularly the McKinlay River.

The modelling was performed using available measured and inferred data to enable NTMO to address the broad aims of understanding the potential water quality issues the project may produce. This type of modelling task is usually an iterative process as described in the previous document (Barnett *et al.*, 2012; KLG-NTMO, 2019) and as such this model is considered preliminary with further development recommended to refine the inputs, reduce areas of uncertainty, and improve the predictive power of the model with calibration and sensitivity analysis.

The model has been built in such a way to allow additional functionality to be utilised in subsequent iterations, including adding river flows and available dilution to schedule discharges, and a user dashboard to allow site personnel to model scenarios and adjust selected inputs.

1.1 Scope and limitations

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2. Modelling approach

The modelling was performed using the GoldSim modelling platform (Kossik and Miller, 2009) which is a flexible, Monte Carlo simulation package frequently used in mining and environmental applications. GoldSim allows for the incorporation of fixed values for deterministic modelling as well as employing stochastic elements sampled at random from predetermined statistical distributions to account for unpredictable events which may influence modelled outcomes. The details of the modelling approach are described in the EIS submission (EIS, 2019) Appendix I in the design basis memorandum, and this report is to be read with reference to that document.

GoldSim is a dynamic, probabilistic simulation software developed by GoldSim Technology Group. It is a graphical, object-orientated coding platform. This means that it is a flexible platform in which the user can program the software to represent any system (such as a mine site) within a graphical user interface. This makes it user-friendly to lay out equations, code logic and system influences, whilst reducing the risk of hidden error that may be experienced in spreadsheets. Figure 1 shows a screenshot of a high level view of the model showing the organisation of model components in 'containers' which overlay an aerial image of the site for context.

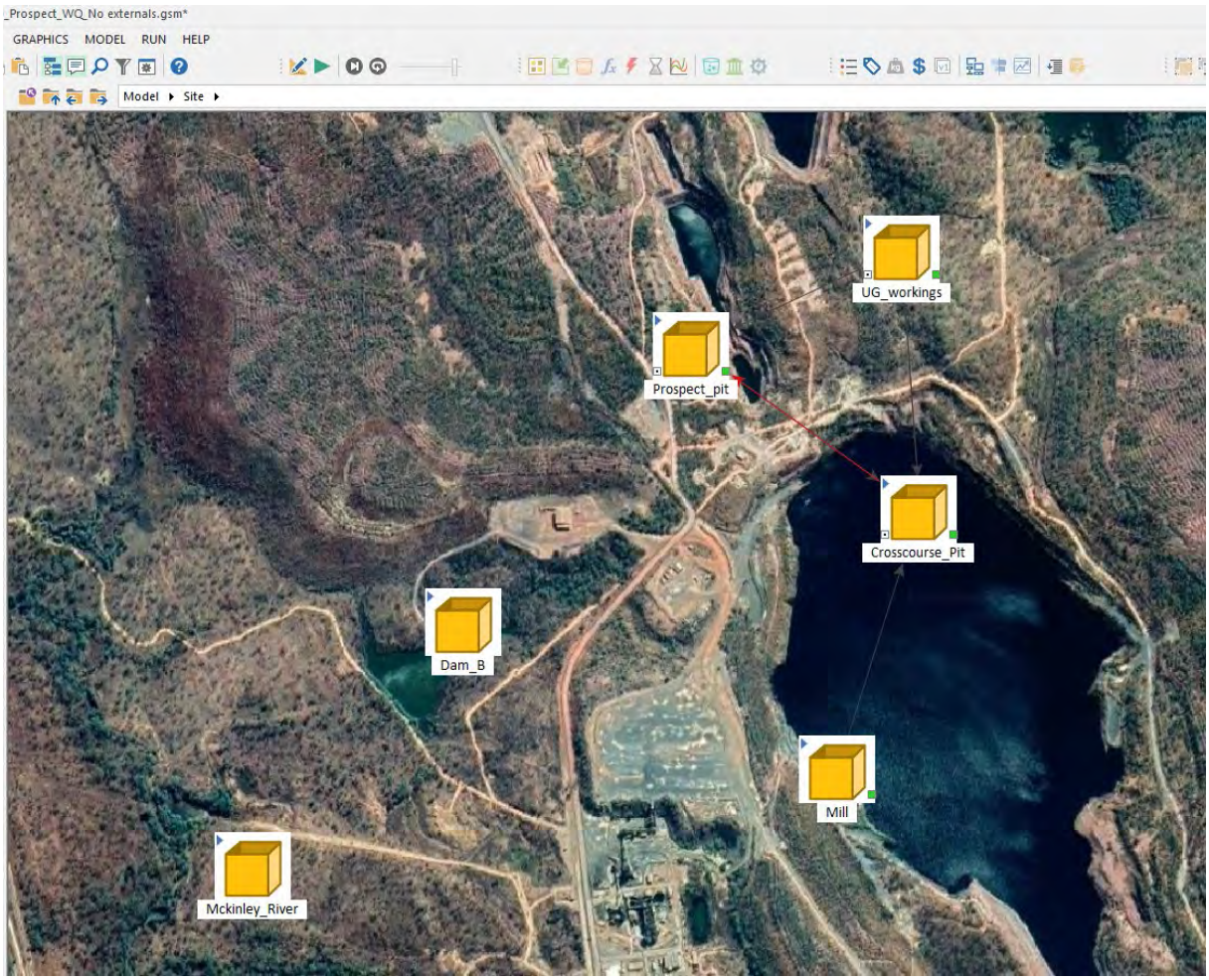


Figure 1: GoldSim graphical interface showing model elements in 'containers' laid out over a site aerial image.

GoldSim has been selected for the numerical model development because:

- It is particularly well suited for stochastic or probabilistic simulations using an inbuilt 'Monte Carlo' simulation framework.
- It is able to run dynamic simulations of complex, systems using a tailored development approach.
- is able to simulate both water balance and water quality in parallel, which is readily scalable.
- It is very well suited to environmental and engineering risk analysis, with successful applications in the areas of water resource management, mining and water quality assessments.
- It is able to run a series of different "what-if" scenarios and sensitivity analyses in which input parameters can be varied to understand the impact to the system. This makes it a very useful decision support tool.
- It has a dashboard function in which the model can be packaged with a front-end including input and results dashboard. This allows users who are not model developers to run different scenarios in the model to better understand the system and support the decision-making process.

The modelling construction process usually consists of the development of multiple iterations of the model, refining the inputs, reviewing the sensitivity of the outputs to the various inputs, and verifying/calibrating against empirical values measured on site.

For a geochemical model, the chemical inputs may also be refined, and if appropriate, additional geochemical modelling conducted to investigate mineralogical and thermodynamic controls on water quality. This model has been developed for the project EIS and is at an early phase of development, i.e. not calibrated, no kinetic geochemical inputs etc. The outputs should therefore be considered preliminary and indicative at this stage.

The model is designed to simulate the project schedule from mine development, mine operations, through to closure and post-closure. The modelled period nominally starts on 01/01/2020 and runs to the end of 2028. Table 1 shows the mine phases covered by the modelled period.

Table 1: Indicative project schedule adapted from Draft EIS.

Time (indicative)	**2 to 3 months**	**2020 to 2022**	**2022 to 2023**	**2023 to 2028**
Phase	Mine development	Mine operations	Mine closure	Post closure
Activities	Construction activities (dewatering Prospect pit)	Mining and processing activities	Closure and rehabilitation active	Monitoring activities

Detailed modelling of the minor pits and dams was not included in this stage of the modelling due to the findings of the groundwater modelling and preliminary modelling showing relatively minor changes to water levels due to project activity. There is also uncertainty regarding the characterisation and physical data for these facilities. This is coupled with the added complexity and introduced error in attempting to model numerous interconnected facilities using steady-state groundwater modelling results. The high uncertainty of the input data means that there is no perceived benefit until more data becomes available.

The mine component exerting the most influence on site water quality is Crosscourse pit. Crosscourse has been used as a tailings storage facility (TSF) and has relatively poor water quality compared to the other surface water stores on site, with more detail on this provided in EIS (2019) Appendix I. Because of the size and depth of the Crosscourse pit shell, Crosscourse is also the primary control on the migration of groundwater.

The water quality model aims to simulate the potential impact of the North Underground Mine on Crosscourse water quality under three climate conditions (wet, median and dry) and thus establish the possible effects on down gradient receptors.

Specialist groundwater modelling has established that at fill levels close to the spillway height of approximately 189m, Crosscourse Pit is a significant groundwater source and the groundwater connectivity means that there

will be rapid and continuous discharge to the McKinlay river under these conditions. Previous modelling indicates that these fill levels are likely to arise without a discharge option or other means to reduce the pit lake elevation in Crosscourse. Crosscourse becomes a net groundwater source well below the spillway height with the boundary between net source to net sink approximately where the current pit lake height is ~173mAHD (GHD, 2019). Under pit lake elevations close to the spillway height (188 mRL), groundwater modelling shows that Crosscourse will be upgradient for most of the surface water stores on site (EIS (2019), Appendix H), with rapid groundwater loss to downgradient receptors, particularly the McKinlay River. The resulting water quality emerging at the McKinlay River is not expected to be significantly different from the pit lake water quality due to the limited residence time and relatively high velocity replacing the pore water.

For these reasons, the modelling is focused on simulating the evolving water quality and pit lake elevation of Crosscourse Pit over the course of the North Underground Mine mining operations including : pre-mining, draining of Prospect Pit, storage of waste rock at the surface and replacement underground, tailings deposition, and the dewatering of the underground works to Crosscourse. The pumping rates, waste rock scheduling, tailings deposition scheduling, mill demand etc are all incorporated dynamically into the model.

The lowest point of the Crosscourse pit void is deeper than the underground works and so the migration of groundwater to and from the underground operation is controlled by the water level in Crosscourse Pit. In addition, while mining is operating, the underground is dewatered to Crosscourse, with possible oxidation products in solution. Post mining, the groundwater rebounds, excluding oxygen from the exposed surfaces as it is submerged, but also potentially dissolving oxidation products into groundwater as it rebounds.

As identified in the water quality review, EIS (2019) Appendix I, the water quality of the minor pits and dams (e.g. Lady Alice, Dam B, Dam C etc.) is significantly less saline and lower in dissolved metals than Crosscourse Pit. The latest groundwater modelling also indicates that drawdown effects on these water bodies as a result of dewatering of the underground works will be minimal. The good existing water quality and minor drawdown effects suggest that no significant water quality changes will result from dewatering.

As part of the model development and to efficiently operate the model and review outputs, a preliminary dashboard was created. The dashboard allows the user to interact with the model, adjust input parameters and display results. This functionality can be supplied to site staff as a 'player file' which requires no familiarity with GoldSim and does not need a GoldSim subscription. Figure 2 shows a screenshot of the preliminary user dashboard showing button navigation, input boxes and graphical displays of outputs.

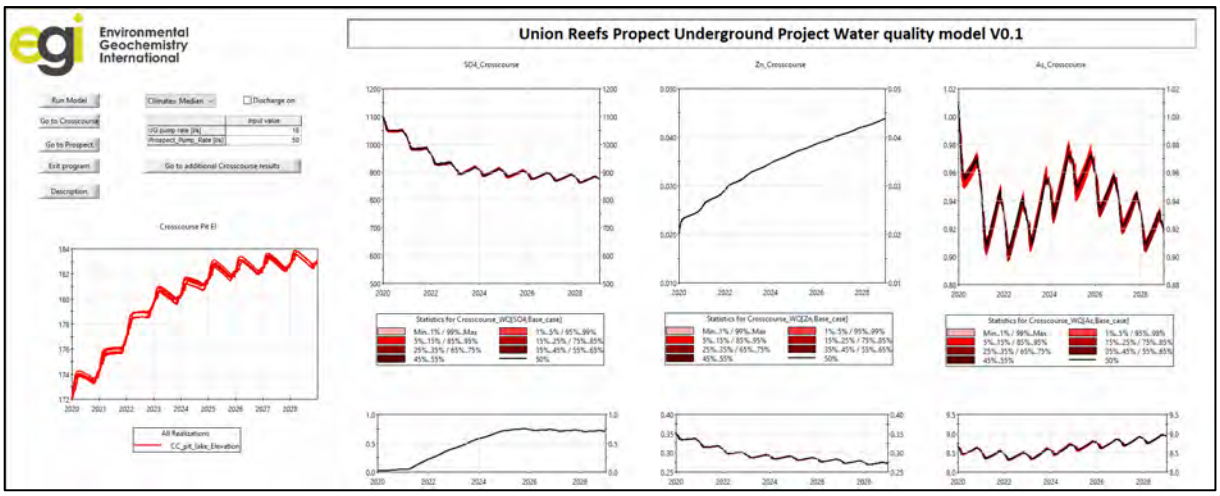


Figure 2: Preliminary user dashboard which allows model controls, input adjustments and display of results for use on site without a GoldSim subscription using the 'player file' option.

The Crosscourse pit will be receiving tailings according to the schedule presented in the water management plan. EGi has added a water quality input derived from the tailings slurry data provided by KLG. Tailings can be variable in geochemical content and in process additives, so as with the other inputs, the data has been

processed to generate a base case or expected case and an upper bound case based on the 95th percentile parameter values in the monitoring data.

For the purpose of delivering a model where there is uncertainty regarding modelling the system, professional judgement has been exercised in producing estimates, assumptions, and simplifications.

2.1 Scenarios

From the climate record at Pine Creek station (EIA 2019, Appendix I) since 1970 the wettest 5 years, driest 5 years and median 5 years based on annual rainfall were selected and used to generate three scenarios referred to as wet, dry and median. For each scenario the model picks a random start year and runs through the climate record, and when it reaches the end, starts again with a randomly selected year (referred to in GoldSim as 'time shifting') .Records since 1970 were selected due to some uncertainty with older records particularly evaporation records (Queensland Government Open Data Portal, 2019). The model run start date is nominally 01/01/2020 and runs to 31/12/2028. This allows for the variation in weather effects on outputs to be analysed using probabilistic plots by running multiple realisations with the random start date.

The model also simulates 'no discharge' and 'with discharge' conditions based on the discharge schedules presented in the EIS. These scenarios are presented in Table 2.

Table 2: Scenarios modelled

Scenario number	Climate	Discharge
1	Dry	No discharge
2	Median	No discharge
3	Wet	No discharge
4	Dry	With discharge
5	Median	With discharge
6	Wet	With discharge

2.2 Modelled System

The modelling was an inter disciplinary collaboration incorporating inputs from multiple sources including the site mine water management plan detailed in the EIS (2019). However, the mine water management plan is based on annual data and due to the relatively rapid changes in water quality that can potentially occur, (e.g. during a dry spell or following a high intensity rainfall event) a daily rainfall record was incorporated into the water quality prediction model, and the model set to simulate daily timesteps. This allows for higher resolution data to be captured which might otherwise be missed on a coarser resolution e.g. years.

This results in some minor deviations from the water balance presented in the EIS, but are generally within a few percent of the values in the water balance.

The water management plan describes how water accumulating in Prospect Pit will be more or less immediately pumped to Crosscourse Pit via a sump pit. For this reason, there is not expected to be a significant contribution to groundwater from Prospect Pit during operations.

Some of the inputs in use in the model will require refinement due to the availability of data, for example, waste rock tonnage scheduling and details of the underground works construction. The water ingress to the underground works are also an area of uncertainty, as was the case in the steady state groundwater modelling, a fixed pump rate of 18 L/s was incorporated in the water quality modelling.

During the pumping of the underground, the pumped water is assumed to be a mixture of unimpacted groundwater quality, the same as the baseline groundwater, and water ingress not captured by the pumping that has picked up solute load from the exposed rock in the tunnels and stopes. On rebound of groundwater to the pre-mining level over the next ~6 years, submerged works are not expected to generate significant oxidation products.

The underground workings have some uncertainty regarding the likely water quality evolved from the dewatering/pumping. It is expected to be a combination of background water quality and a proportion will be water that has taken on a solute load from interactions with the rock

In terms of potential impacts to water quality, Crosscourse dominates the site in both size and in potential for affecting downgradient receptors.

As discussed in EIS (2019), Appendix I, losses from Crosscourse during the underground operation are collected and recirculated to Crosscourse, this is also the case for any increased drawdown in the minor pits as the captured groundwater is redirected to Crosscourse via Prospect pit. Additional functionality can be added to the model to simulate events such as pump failures and bund failures to evaluate the possible effects.

3. Inputs

The input data was generally processed to produce two parallel results for each scenario, an expected case or base-case, and an upper bound. The benefit of this approach is to provide context to the expected case scenario. An example of this process would be the generation of tailings slurry water quality inputs. These are produced from the monitoring record of many measurements, showing a significant amount of variability.

In order to capture this variability in the model, the base-case or expected case use the median value for each parameter in the monitoring record, this presents the 'middle' value and is less skewed by outliers than the arithmetic average. The upper bound is generated by taking the 95th percentile of each parameter in the record. This approach presents the expected values (base case) but also gives an impression of the spread of values that could theoretically be encountered.

This is considered a more meaningful way of presenting the results than just producing expected values, particularly in the early stages of modelling where the uncertainties are significant. The upper bound results may combine and compound extreme values in the input data so are not presented as predictions but more as an indication of the possible spread of the values used to produce the inputs to the expected case (base case).

3.1 Tailings

The tailings deposition schedule is shown in Table 3 and the tailings slurry water quality inputs are presented in Table 4

Table 3: Tailings deposition schedule adapted from EIS 2019.

Time	Value [ML/yr]
1/01/2020	0
1/04/2020	69
1/04/2021	541
1/04/2022	541
1/04/2023	486
1/04/2024	414
1/04/2025	0
1/04/2026	0

Table 4: Tailings slurry water quality inputs derived from monitoring data (rounded).

Species	Base case (mg/l)	Upper bound (mg/l)
Alkalinity	180	290
Ag	0	0
Al	0.91	4.1
As	2.1	10
Ca	270	450
Cd	3.0E-4	0.0027
Cl	51	290
Co	0.33	1.5
Cr	0	0
Cu	5.9	77
Fe	2.6	35
Hg	0	0
K	76	96
Mg	1.7	9.8
Mn	0.016	0.13
Mo	0.3	0.99
Na	440	610
Ni	0.34	5
Pb	4.6E-4	4.6E-4
SO4	1000	1800
Sb	0	0
Se	0.026	0.1
Si	0	0
Sn	0	0
Sr	0	0
Zn	0.045	1.6
H	3.7E-11	1.1E-9
pH	10	9

3.2 Water Qualities

Runoff water quality reporting to Crosscourse was estimated from surface water monitoring on site and at the McKinlay River and consist of a mixture of natural catchment and mine influenced values. Groundwater inputs were also estimated from the monitoring data. The input values are presented in Table 5.

Table 5: Groundwater and surface water inputs (rounded).

Species	Groundwater base case mg/l	Groundwater upper bound mg/l	Runoff water quality base case mg/l	Runoff water quality upper bound mg/l
Alkalinity	300	340	37	71
Ag	0	0	0	0
Al	0.022	0.027	0.054	0.36
As	0.54	0.62	0.0026	0.0062
Ca	58	65	20	49
Cd	1.4E-4	4.1E-4	2.6E-4	0.0012
Cl	130	150	5.1	15
Co	0.16	0.2	0.0012	0.015
Cr	0.0023	0.0029	3.3E-4	4.8E-4
Cu	0.0012	0.0014	0.0017	0.0048
Fe	0.81	1.4	0.13	0.4
Hg	0	0	0	0
K	17	18	1.9	3.3

Mg	66	74	19	63
Mn	0.65	0.86	0.044	0.29
Mo	0.073	0.15	0.019	0.057
Na	180	190	12	30
Ni	0.0025	0.003	0.0032	0.0092
Pb	0.0034	0.0099	6.7E-4	0.0011
SO4	240	280	216	537
Sb	0	0	0	0
Se	0.0019	0.002	0.001	0.0012
Si	0	0	0	0
Sn	0	0	0	0
Sr	0	0	0	0
Zn	0.04	0.07	0.38	0.42
H	2.9E-7	5.6E-7	1.6E-7	9.9E-7
pH	6.7	6.4	6.8	6.2

3.3 Contact water

Contact water qualities associated with different waste and rock qualities were derived from aggressive peroxide oxidation tests (NAG tests) and water extracts. The raw inputs are provided in Table 6.

Table 6: Contact water quality inputs for material categories.

Species	Base Case mg/l						Upper bound mg/l				
	Dev. Waste PAF	Dev. Waste NAF	Ore PAF	Ore NAF	Oxide PAF	Oxide NAF	Dev Waste PAF	Dev Waste NAF	Ore PAF	Ore NAF	Oxide PAF
Alk	16	34	24	28	21	14	30	41	29	34	27
Ag	0.001	0.001	0.001	0.001	0.0013	0.001	0.0018	0.001	0.001	0.001	0.0015
Al	0.56	0.21	3.7	0.22	3.7	0.05	4.7	0.68	7	0.43	5
As	0.0035	0.0095	0.062	0.013	0.14	0.015	5.6	0.16	0.093	0.22	0.2
Ca	37	12	11	10	8	1	91	22	38	22	13
Cd	0.27	4.0E-4	0.016	4.0E-4	0.027	1.5E-4	4.9	0.0081	0.032	0.0011	0.046
Cl	8	5	5.5	4.5	2.8	2	10	7.6	6	5.9	3
Co	0.035	0.001	0.029	0.001	0.048	0.001	0.29	0.013	0.031	0.001	0.049
Cr	0.003	0.0035	0.0065	0.0045	0.0023	0.0025	0.064	0.0097	0.0092	0.014	0.0029
Cu	0.051	0.001	0.011	0.001	0.36	0.001	0.1	0.0047	0.08	0.001	0.1
Fe	38	0.05	0.05	0.05	1.9	0.05	110	0.17	0.27	0.064	3.4
Hg	1.0E-4	1.0E-4	1.5E-4	1.0E-4	1.0E-4	1.0E-4	2.3E-4	1.5E-4	2.0E-4	1.0E-4	1.0E-4
K	20	12	18	7.5	12	3	50	27	22	17	12
Mg	18	3	5	3.5	4.8	1	35	7.3	15	9.4	6.8
Mn	2.9	0.031	0.73	0.019	1.3	0.13	14	0.6	3.1	0.072	2.4
Mo	0.001	0.001	0.002	0.001	0.0083	0.001	0.0095	0.0044	0.0038	0.0042	0.015
Na	3.5	3	3	3	4	3.3	5.6	5	4.4	3.5	4.5
Ni	0.051	0.001	0.04	0.001	0.049	0.001	0.18	0.0091	0.075	0.001	0.053
Pb	0.72	0.0015	0.071	0.0015	0.54	0.001	2.8	0.07	0.83	0.0074	0.67
SO4	770	30	70	9.5	92	1	1900	84	210	79	99
Sb	0.001	0.0035	0.003	0.0035	0.0028	0.001	0.0075	0.0088	0.0039	0.0085	0.0039
Se	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Si	9.6	2.8	11	3.1	6.8	3.9	13	7.9	11	3.9	7.2
Sn	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sr	0.02	0.014	0.024	0.016	0.011	0.0043	0.042	0.046	0.065	0.025	0.013
Zn	52	0.027	1.8	0.02	4	0.021	380	2.5	4.3	0.073	7.1
H	2.0E-5	1.3E-8	6.3E-5	1.3E-8	7.1E-4	6.3E-7	0.0013	4.3E-7	3.6E-4	2.5E-8	0.0012
pH	5.8	8.3	6.4	8.4	5.6	7.1	4.6	7.2	6	8.1	5.4

Table 7: Discharge schedule from EIS 2019

Time	Value [ML/yr]
1/01/2020	0
1/04/2020	0
1/04/2021	2037
1/04/2022	1342
1/04/2023	1287
1/04/2024	931
1/04/2028	931
1/04/2030	931

4. Results

The outputs from the modelling are presented as timeseries of the modelled time frame which is nominally 01/01/2020 to 31/12/2028 representing the project timeline shown in Table 1. All modelled water quality outputs are presented in Appendix A, and selected species and other model outputs are discussed in the following sections. Summary statistics are presented in Appendix B.

4.1 Crosscourse Pit Lake

4.1.1 Pit lake elevation with no discharge

The probability plots are generated by running multiple realisations of the model. Because of the random factor in the selection of the climate record to run, each realisation represents a different climate input. This provides a convenient means to capture the variation in results due to climate variation. The model is currently run for 30 realisations. The Crosscourse pit lake elevation for the modelled period is presented in Figure 3, Figure 4, and Figure 5 under each climate scenario with no discharge. These show that the pit lake reaches a quasi-steady state at between 179m RL (dry climate) and 188m RL (wet climate). There is some variability indicated by the amount of spread in the probability plots due to variability in the climate data, but the overall picture is consistent.

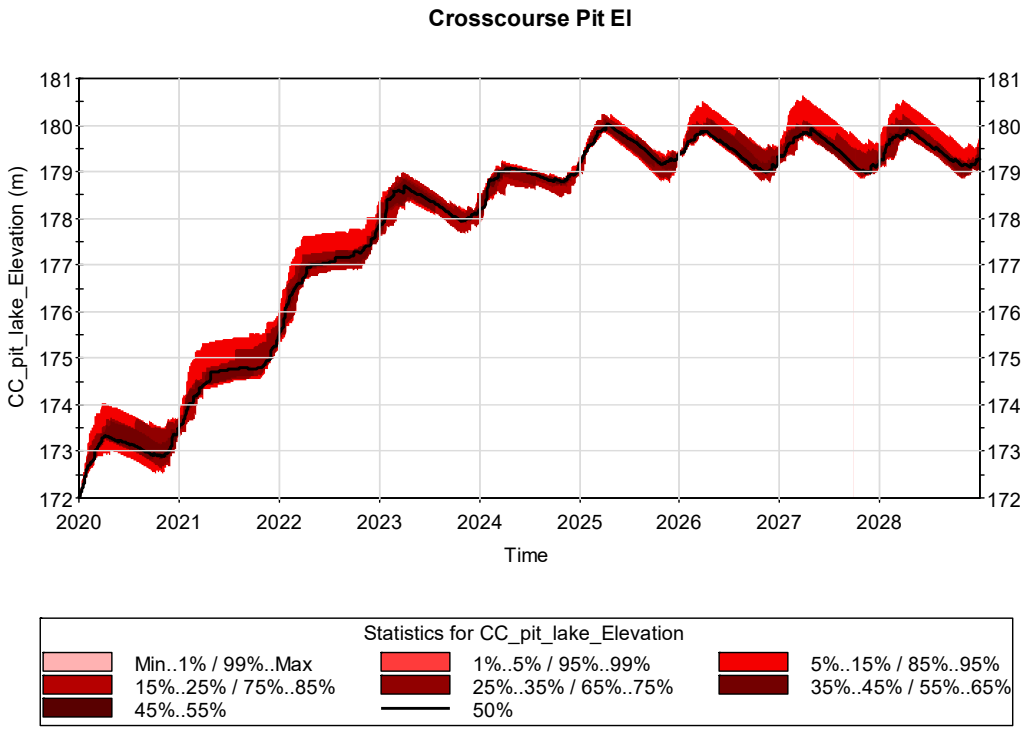


Figure 3: Probability plot of the Crosscourse pit lake elevation (no discharge, dry climate).

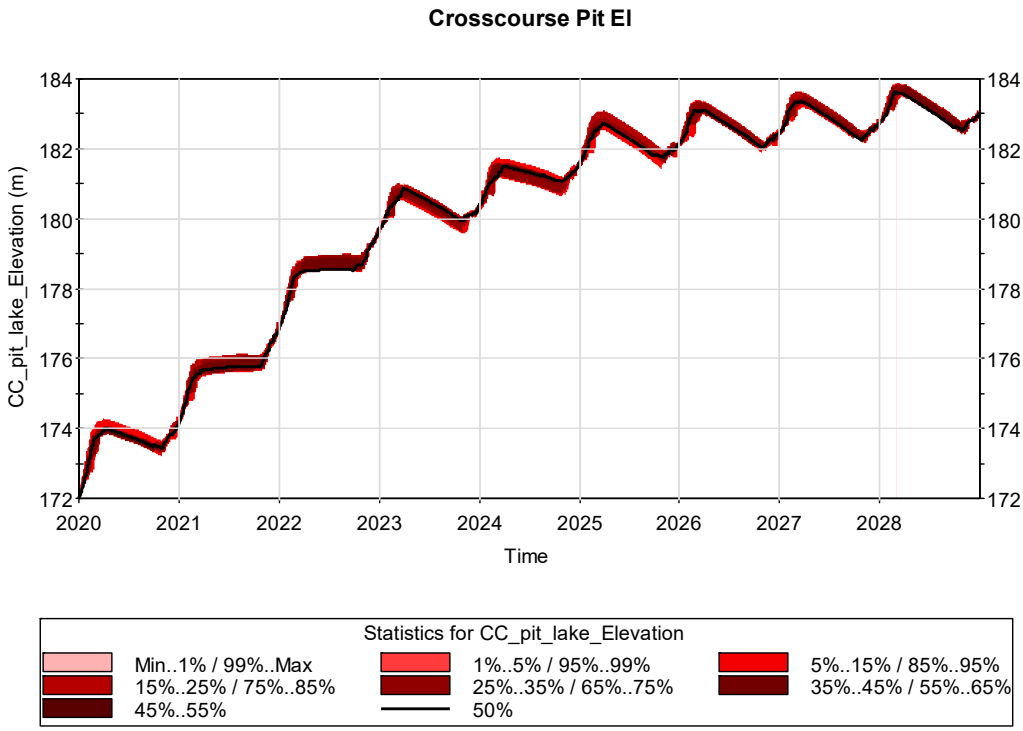


Figure 4: Probability plot of the Crosscourse pit lake elevation (no discharge, median climate).

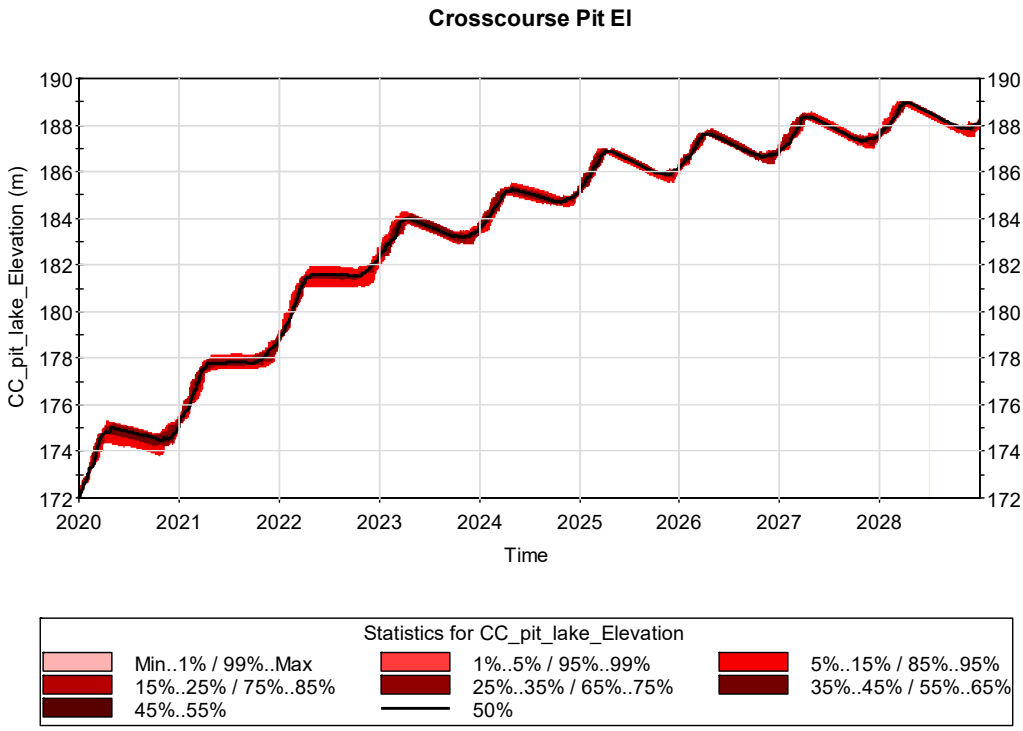


Figure 5: Probability plot of the Crosscourse pit lake elevation (no discharge, wet climate).

4.1.2 Pit lake elevation with discharge option

Figure 6, Figure 7 and Figure 8 show the modelled pit lake water levels with the discharge scenario active.

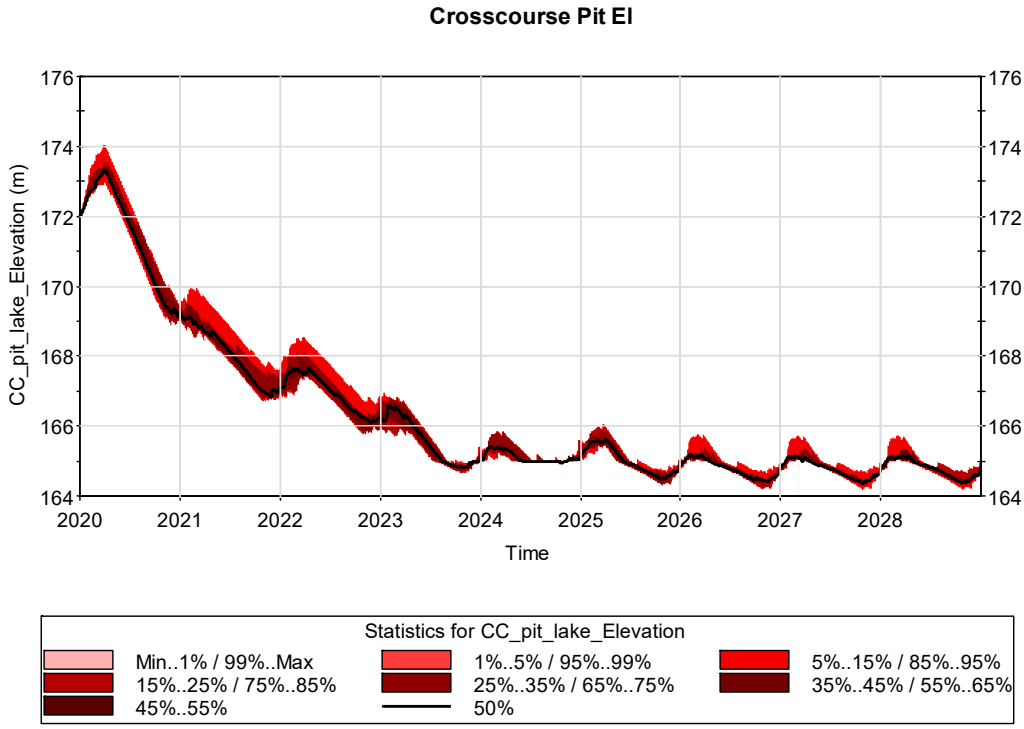


Figure 6: Probability plot of the Crosscourse pit lake elevation (with discharge, dry climate).

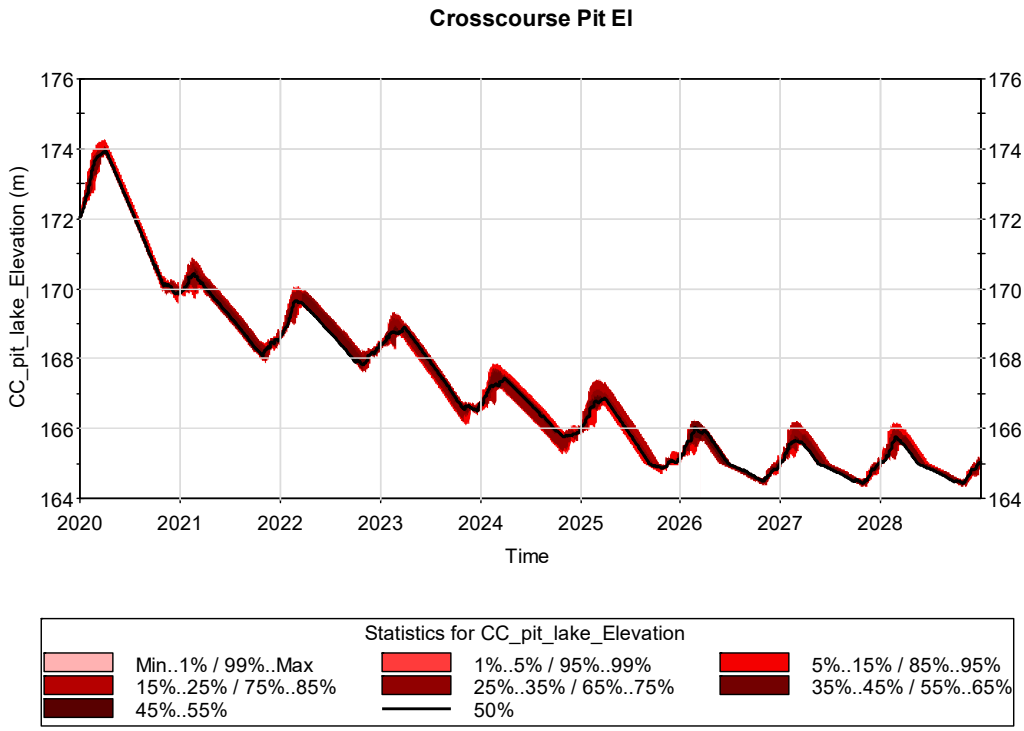


Figure 7: Probability plot of the Crosscourse pit lake elevation (with discharge, median climate).

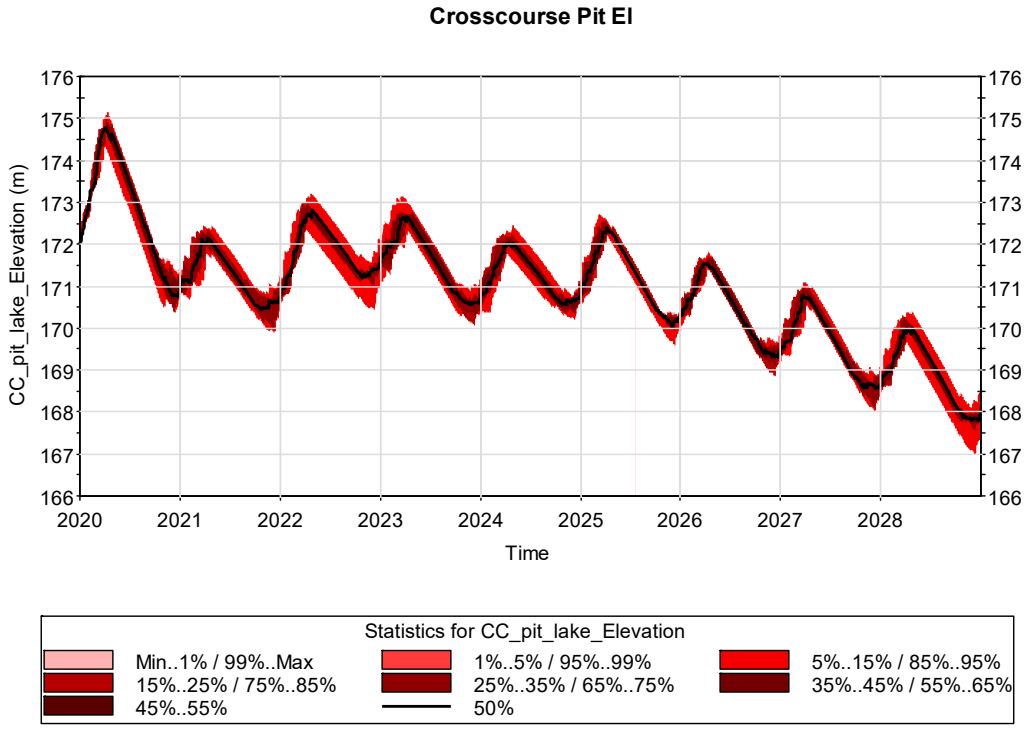


Figure 8:Probability plot of the Crosscourse pit lake elevation (with discharge, wet climate).

Under the wet climate conditions with no discharge the model predicts spillway overflow from Crosscourse in 18 out of 30 of the realisations. An example model realisation is presented in Figure 9. No overflow events are predicted in the dry or median scenarios, or any scenario with discharge active.

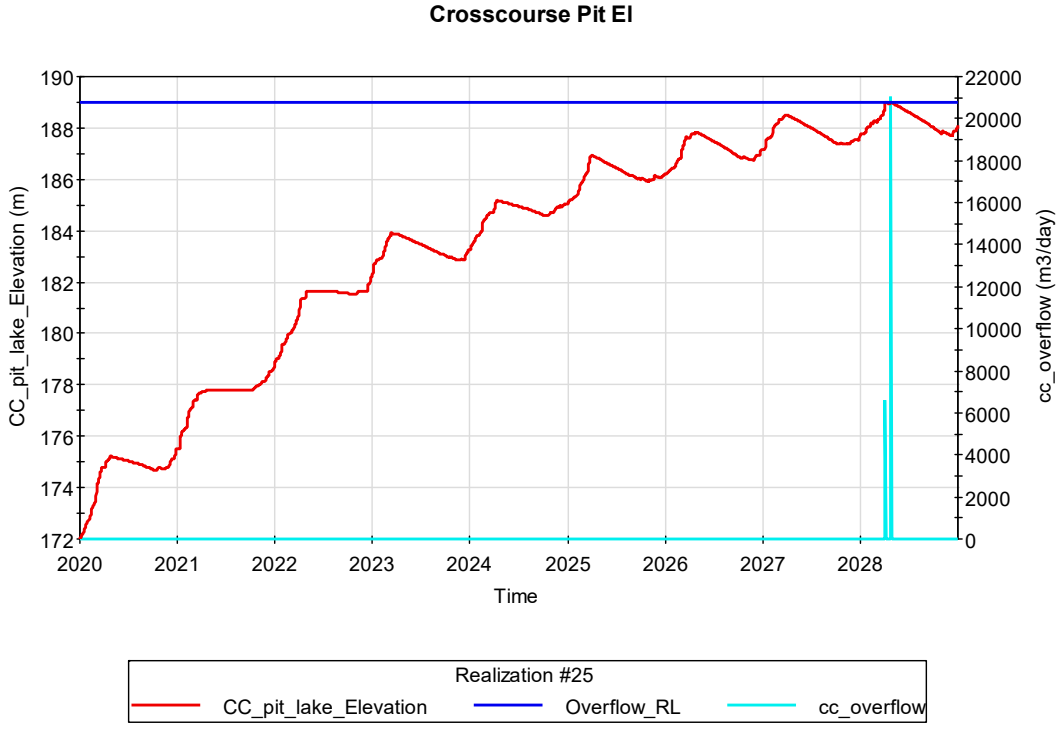


Figure 9: Example of wet climate scenario with no discharge, showing overflow events in the first half of 2018.

The Crosscourse pit void is approximately 19000 ML in volume at the spillway height. This is a large body of water and means that it requires a significant load to impact the water quality. This is illustrated in Figure 10, which shows the cumulative inputs to Crosscourse with the modelled volume of Crosscourse pit void.

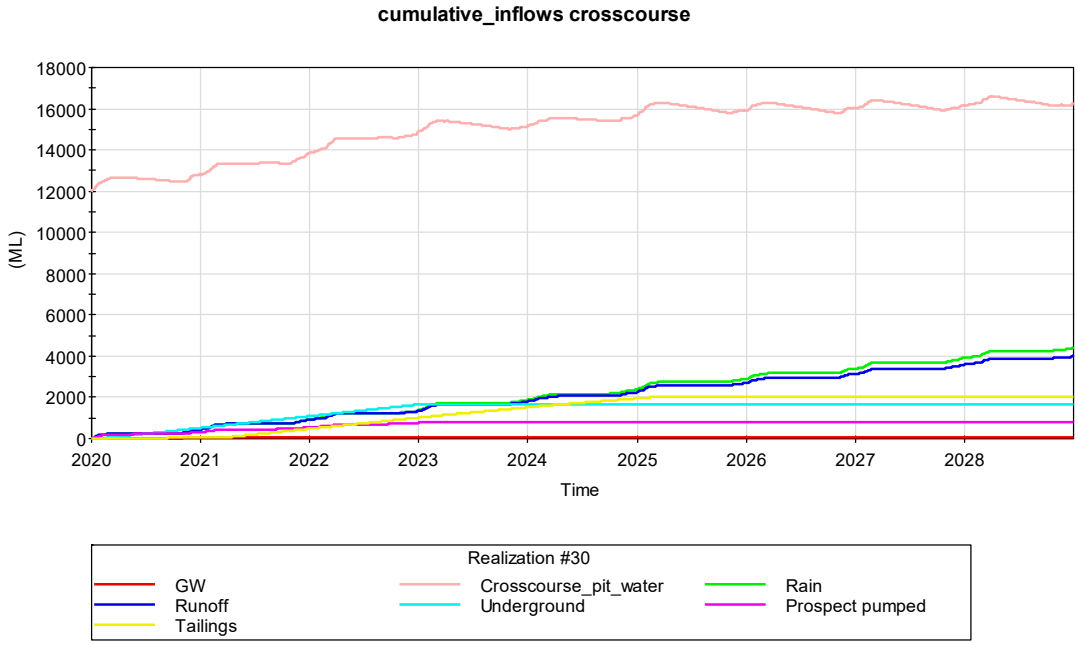


Figure 10: Cumulative inflows to Crosscourse pit for median climate with Crosscourse Pit volume.

4.2 Crosscourse water quality: selected species

4.2.1 Sulphate

The sulphate concentrations for the 'with discharge' scenario (Figure 10, Figure 11 and Figure 12) show a similar trend, with progressive decrease in concentration over the course of the model run. This is due to solute load being lost as discharge with the inputs serving to dilute the sulphate in the pit. The tailings provide a significant sulphate load to the pit but the concentration is relatively low in the tailings, with the addition of other inputs from rainfall and groundwater, also low in sulphate, the net effect is progressive dilution. The dry climate scenario shows a greater reduction in concentration as compared to the wet and median rainfall scenarios, which may be counter intuitive initially. This is a result of the discharge removing more relative load from the pit lake as the volume of the lake is smaller in the dry scenario, but the same discharge rates are applied in each scenario.

Without the active discharge, as shown in Figure 13 and Figure 14, there is a perceptible decrease in concentration over the modelled period, but less pronounced than in the 'with discharge' scenario. In the dry climate scenario, Figure 15, the concentration stabilises in the second half of the modelled period for the base case and is at levels comparable to the historical recorded sulphate levels of between 500 and 2000 mg/L sulfate.

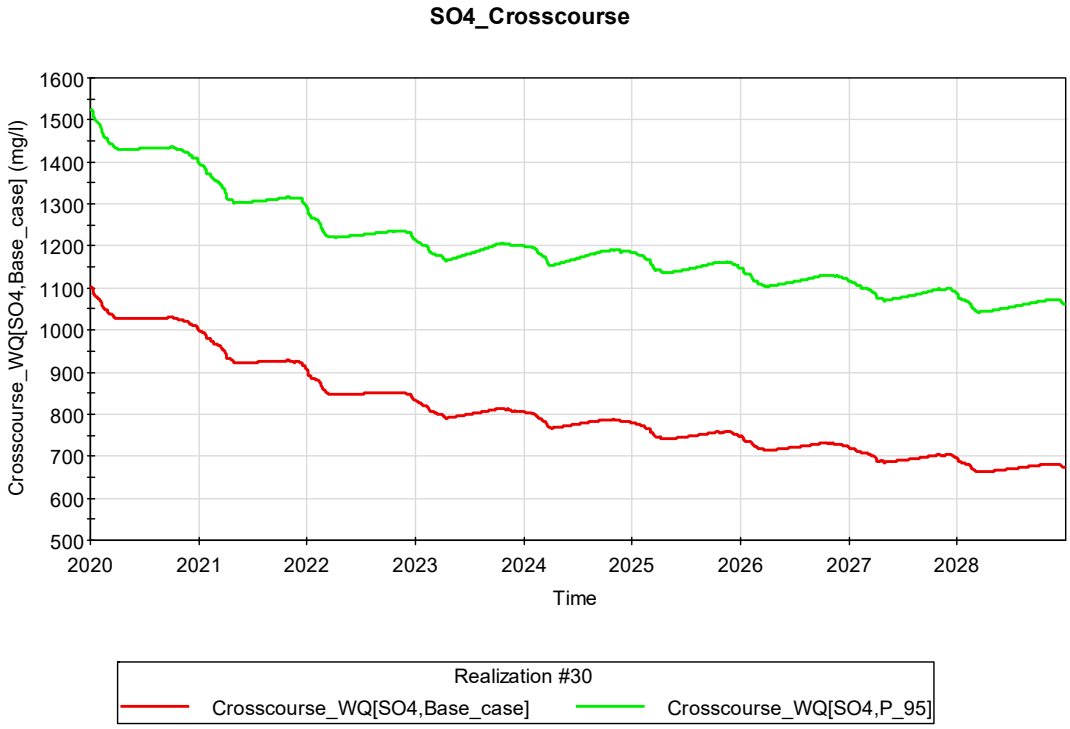


Figure 11: Wet climate with discharge on, SO4.

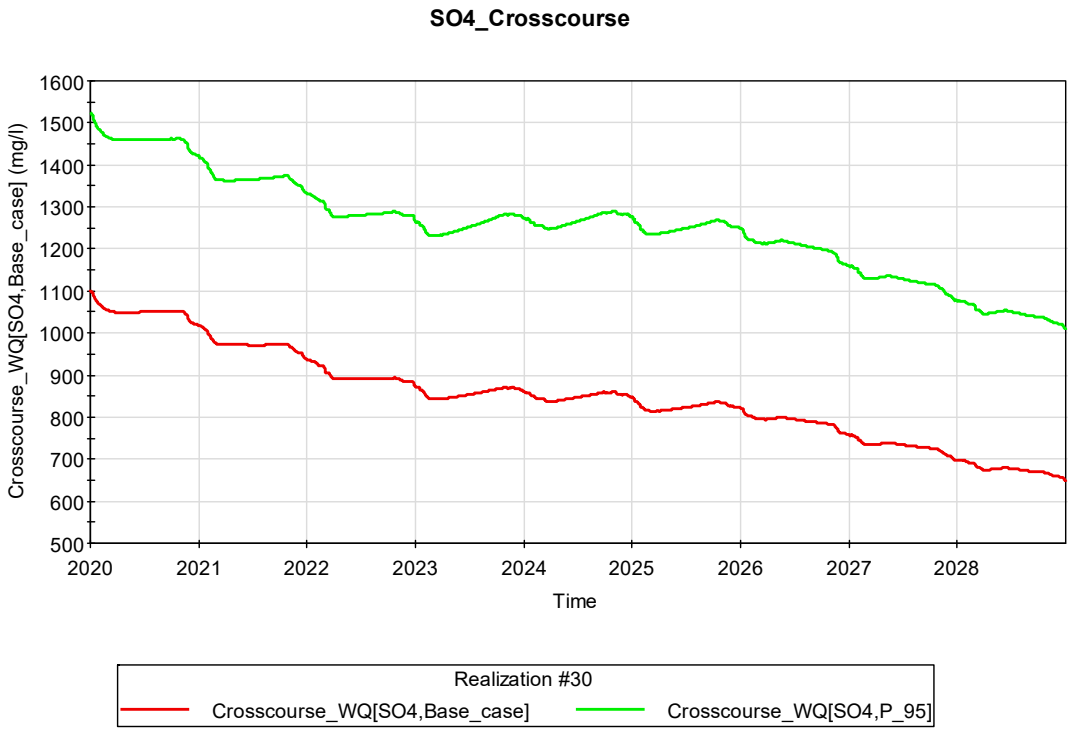


Figure 12: Median with discharge on, SO4.

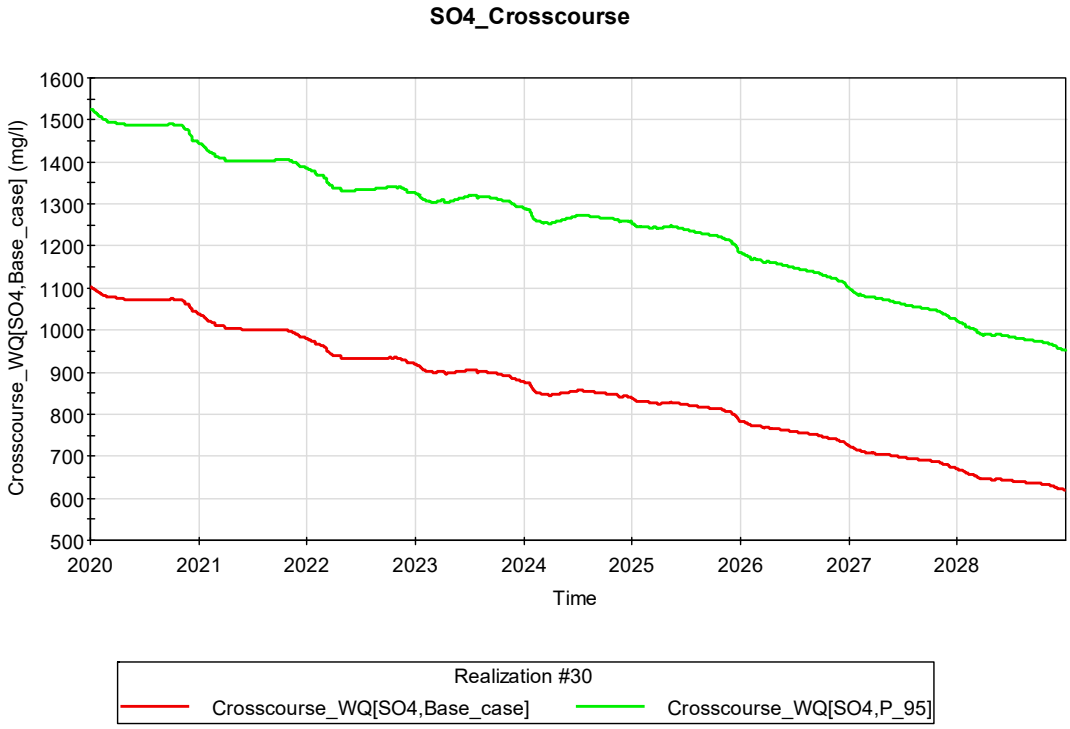


Figure 13: Dry climate with discharge on, SO4.

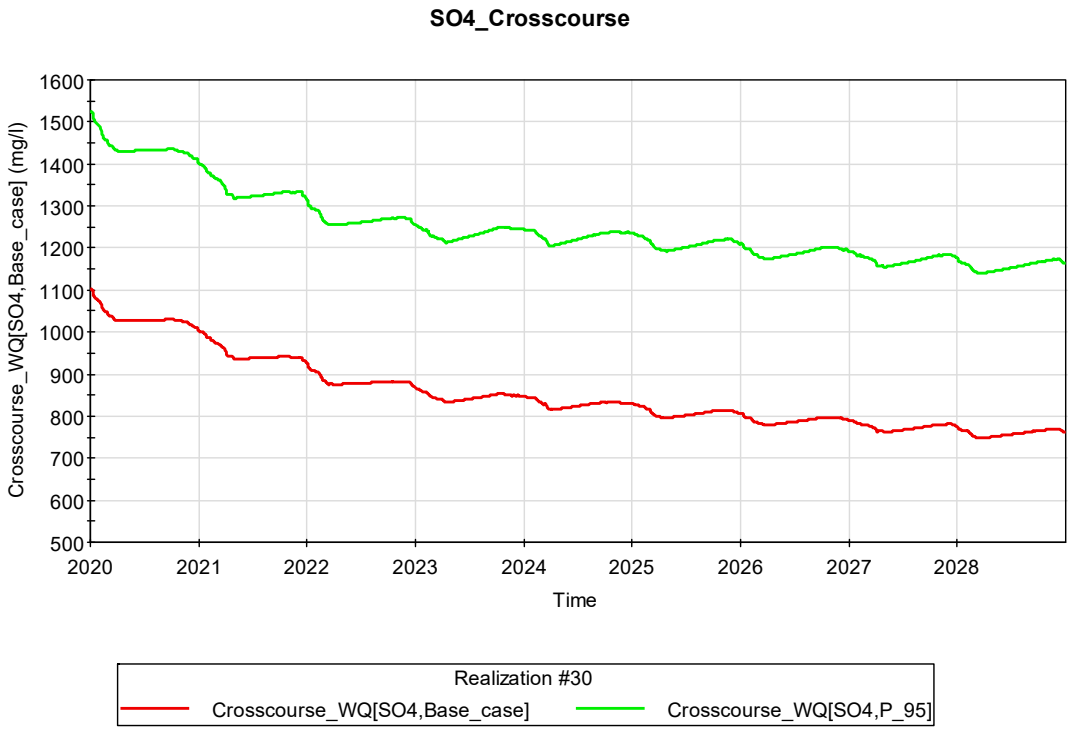


Figure 14: Wet climate, no discharge, SO4.

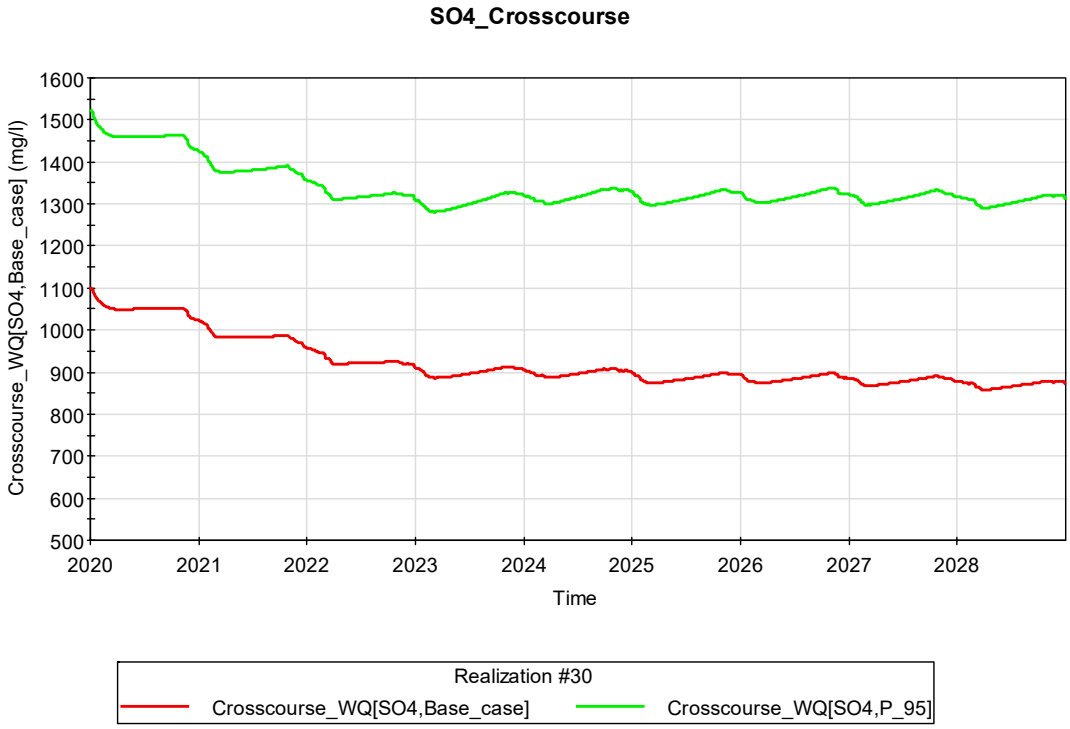


Figure 15: Median climate, no discharge, SO4.

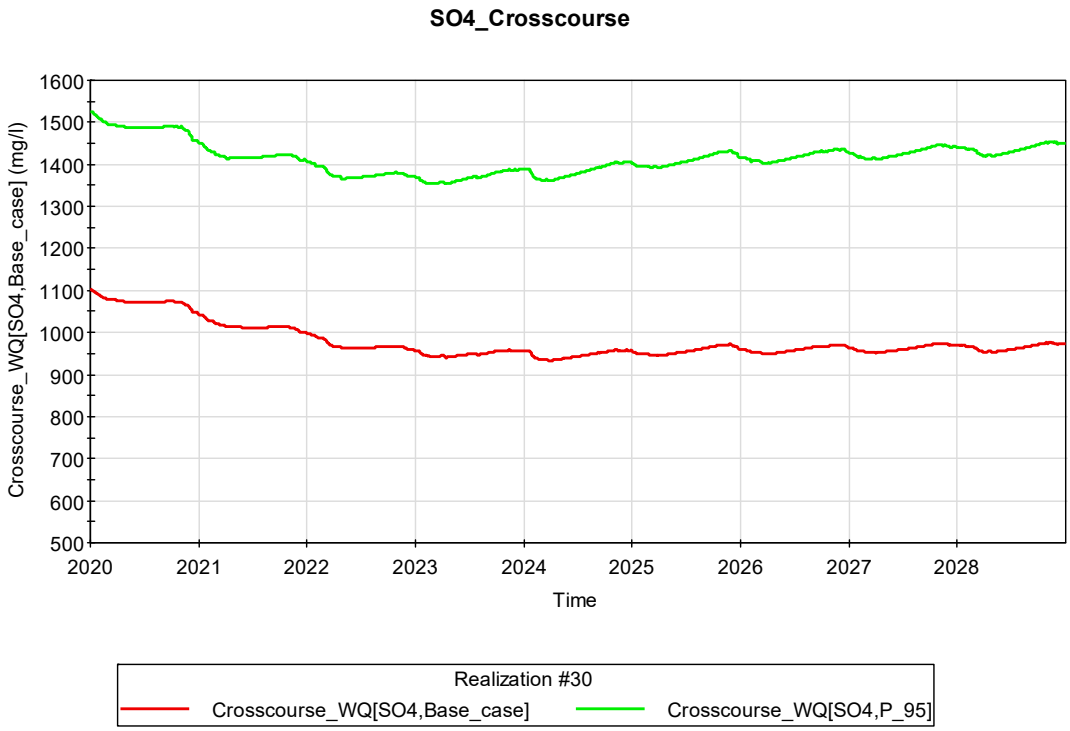


Figure 16: Dry climate no discharge, SO4.

4.2.2 Copper

For the discharge active scenario, the copper in Crosscourse pit appears to be most closely associated with the tailings (Figure 16, Figure 17 and Figure 18). The copper concentrations are relatively low (0.15- 0.2 mg/L) until

around April 2021 (modelled time), at which point there is a progressive increase in concentration. This coincides with the tailings deposition schedule beginning. There is a progressive rise in concentration until around April 2025 where the tailings deposition stops (0.85 mg/L base case, 10.5 mg/L upper bound), and then the concentration begins to drop to 0.7 mg/L base case, 9 mg/L upper bound by the end of the model run. The expected case (base case) shows values comparable to the historical records for periods of tailings deposition, but the upper bound concentrations are much higher. This is due to some very high copper concentrations in the tailings slurry (p95 value of 77 mg/L).

Copper in solution is pH sensitive and the typical pH in Crosscourse pit is around pH 8, Some preliminary geochemical modelling using PHREEQC has shown that copper at the concentrations predicted in the approximate water quality of Crosscourse pit is super saturated and expected to precipitate out of solution, which would lower the dissolved concentration. This is a limitation of the mass-balance approach, where the addition of chemical load likely exceeds the physical solubility of the element. In this instance the upper bound is not considered a realistic scenario. Future work can be directed at more geochemically dynamic modelling with solubility constraints incorporated, this would be appropriate when more representative kinetic test data becomes available.

The base case predications are also high at around 1mg/L, but concentrations of over 1 mg/l have been observed in the historical monitoring record, so although more confidence in the results will be possible with further investigation, the base case results are at least considered possible. When the tailings deposition stops the removal of chemical load via discharge is shown as a progressive decrease in the copper concentration. The site-specific trigger (SST) value for copper is 0.0044 mg/l, which is much lower than most of the historical concentrations recorded at Crosscourse, however, more recently concentrations have been decreasing to close to or below the trigger level.

The 'with discharge' results show a higher maximum concentration compared to the 'no discharge' options (Figure 19, Figure 20 and Figure 21) due to the reduced volume of Crosscourse pit resulting in a greater effect of the same volume of tailings (0.8 to 0.9 mg/L base case, 8.5 to 10.5 mg/L upper bound) . However, the 'no discharge' results plateau after tailings deposition stops, staying close to the maximum values by the end of the model run.

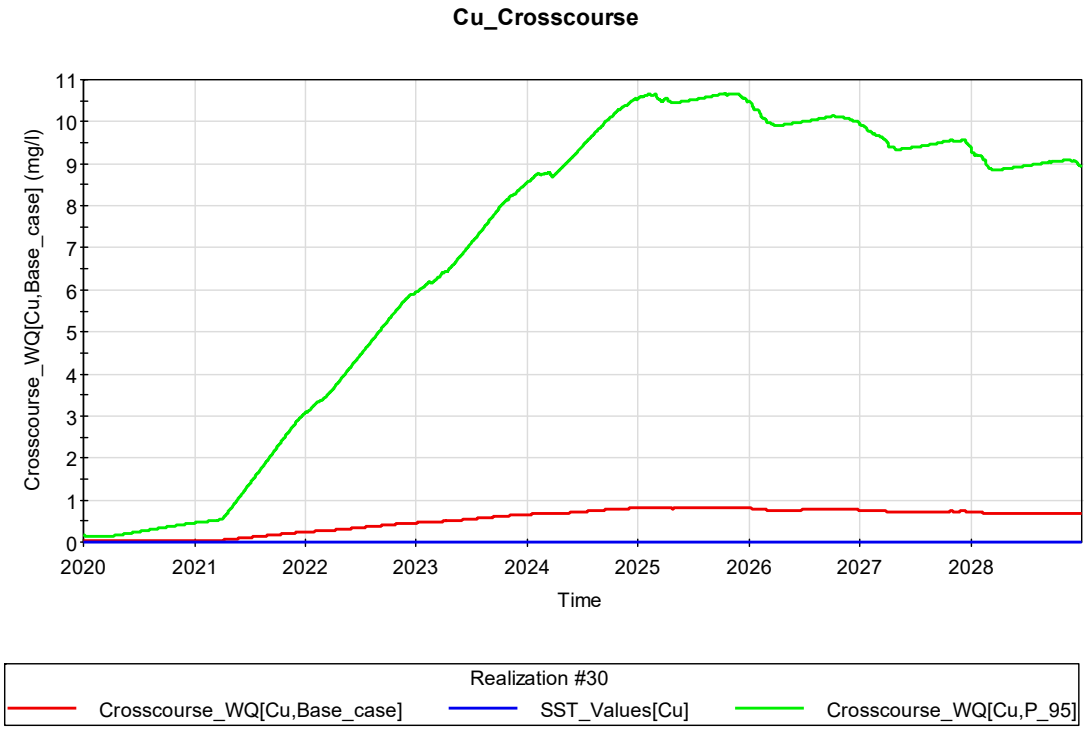


Figure 17: Wet climate discharge on, Cu.

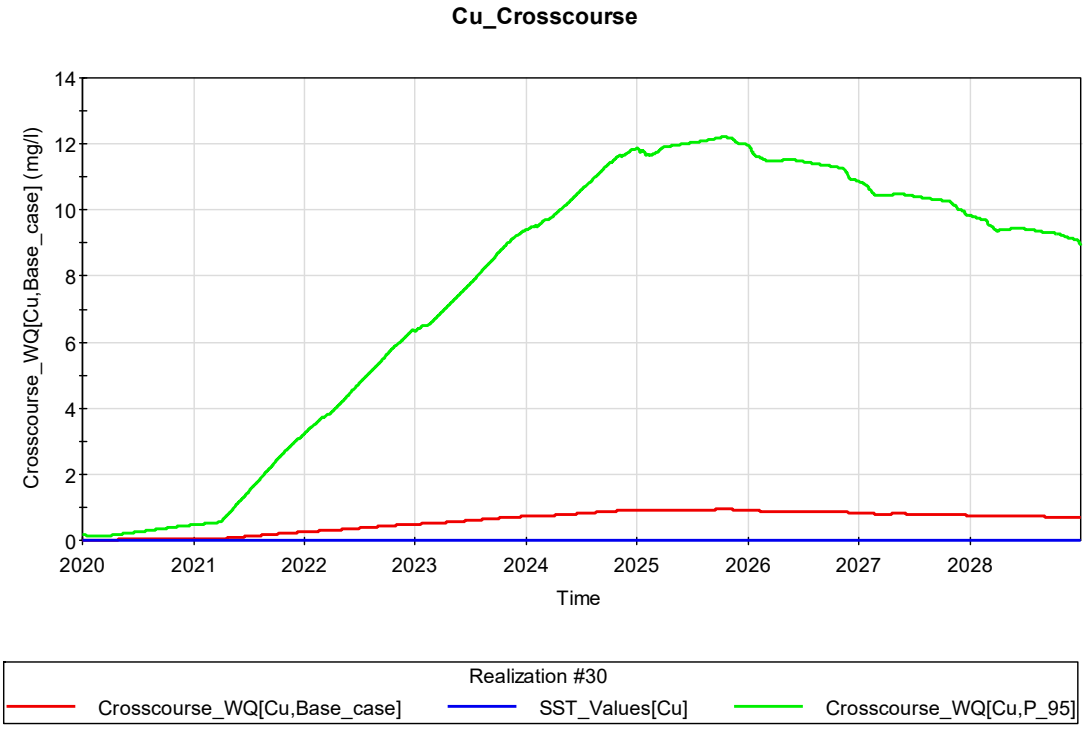


Figure 18: Median climate discharge on, Cu.

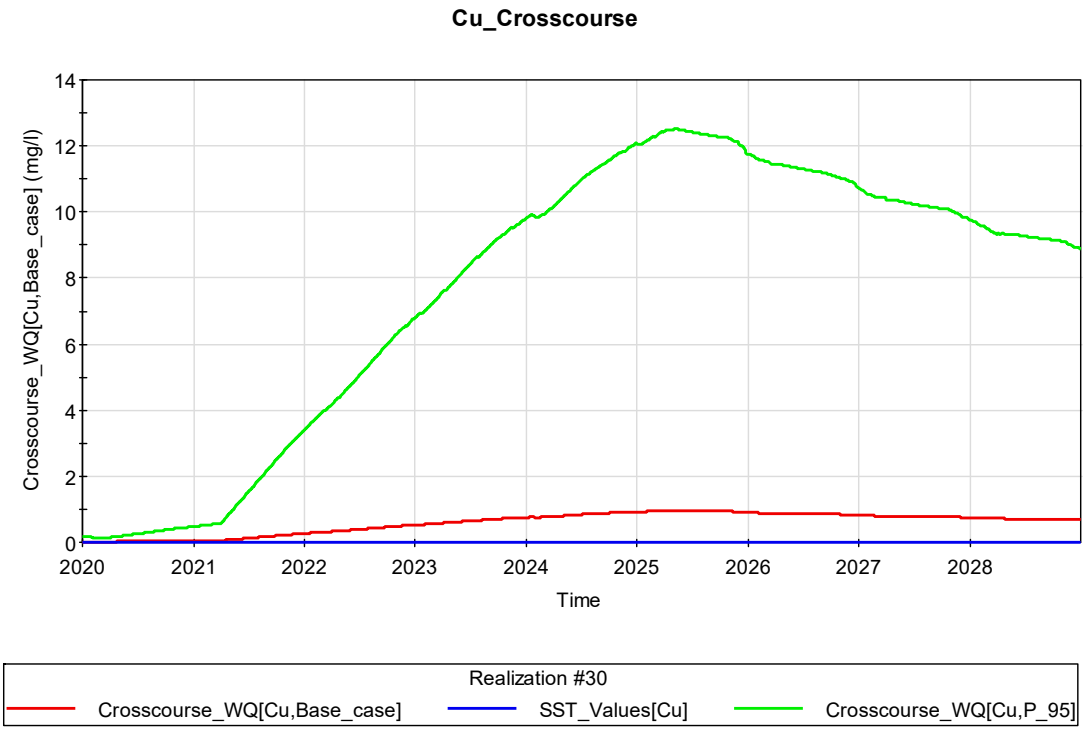


Figure 19: Dry climate, discharge on, Cu.

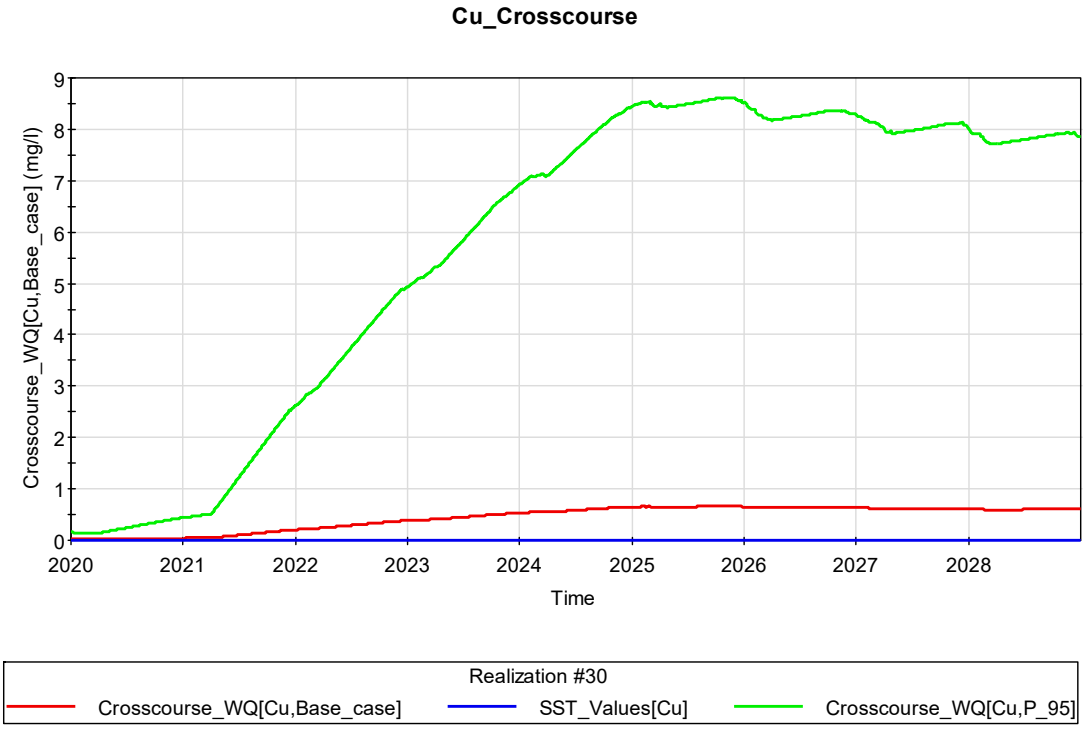


Figure 20: Wet climate, no discharge, Cu.

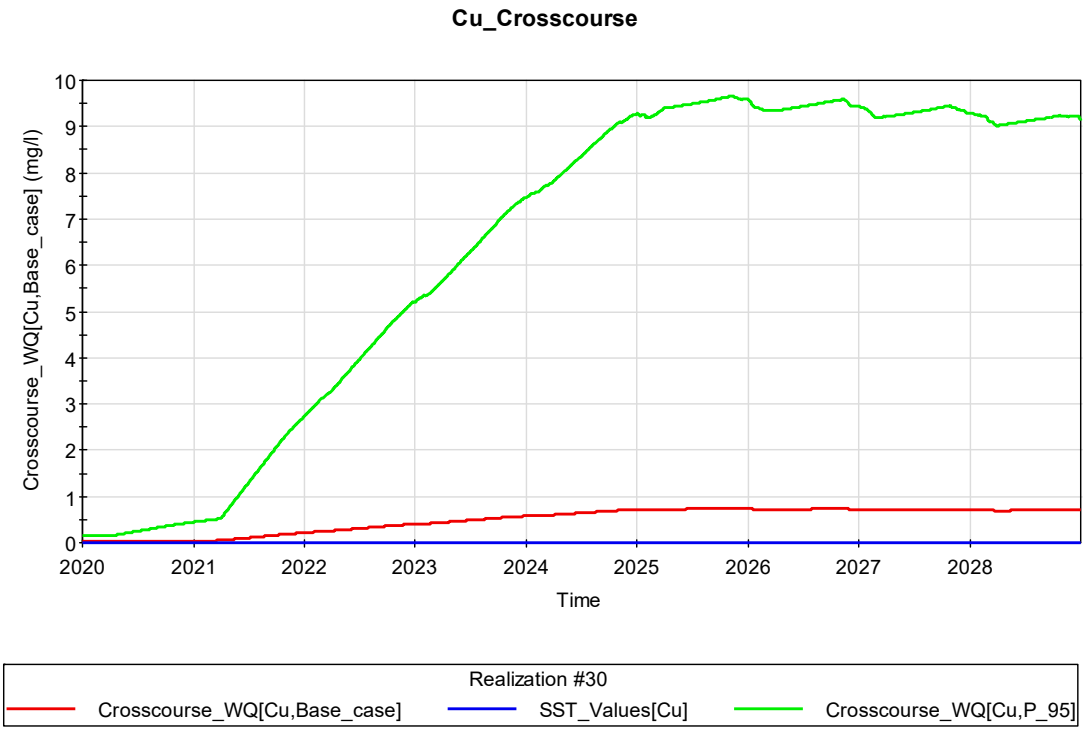


Figure 21: Median climate, no discharge, Cu.

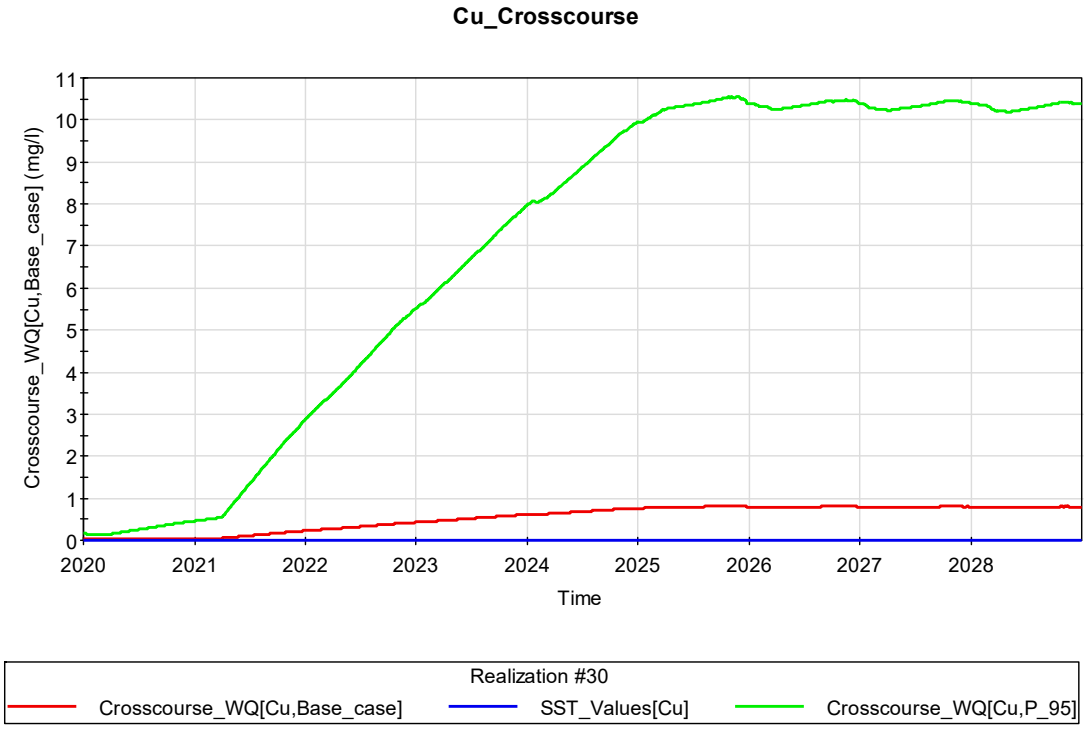


Figure 22: Dry climate, no discharge, Cu.

4.2.3 Nickel

Nickel shows a very similar behaviour to copper (Figure 29, Figure 30, Figure 31, Figure 32, Figure 33 and Figure 34). The notable difference is that the predicted concentrations are significantly higher than those observed historically.

The historical record has the majority of the readings below the SST value of 0.011 mg/L, in spite of the tailings slurry concentrations being up to approximately two orders of magnitude higher. This indicates a geochemical solubility control effect that the mass-balance does not allow for, this is particularly the case for the upper bound predictions. Further geochemical modelling conducted outside of GoldSim would increase the understanding of the thermodynamic controls on water quality. Future site-modelling approaches could then incorporate some fundamental geochemical controls on water quality. The 'with discharge' simulations show a progressive decline in concentration after the tailings deposition phase. The 'no discharge' results do not show an appreciable decrease in concentration with time (Figure 32, Figure 33 and Figure 34).

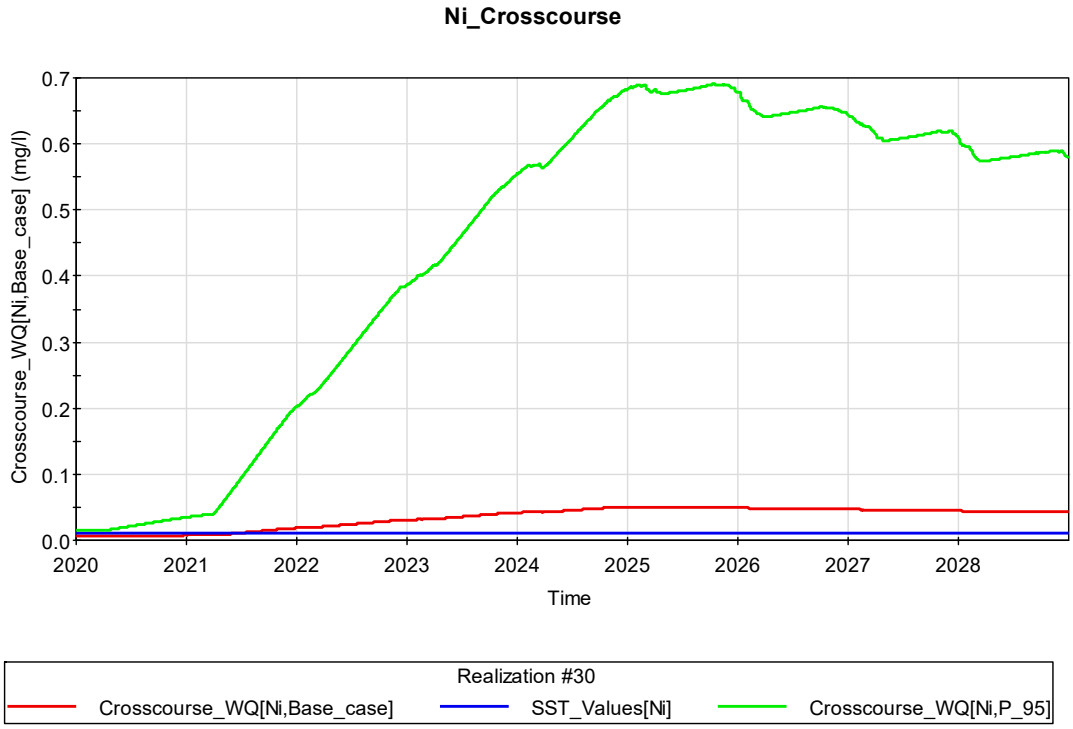


Figure 23: Wet climate, discharge on, Ni.

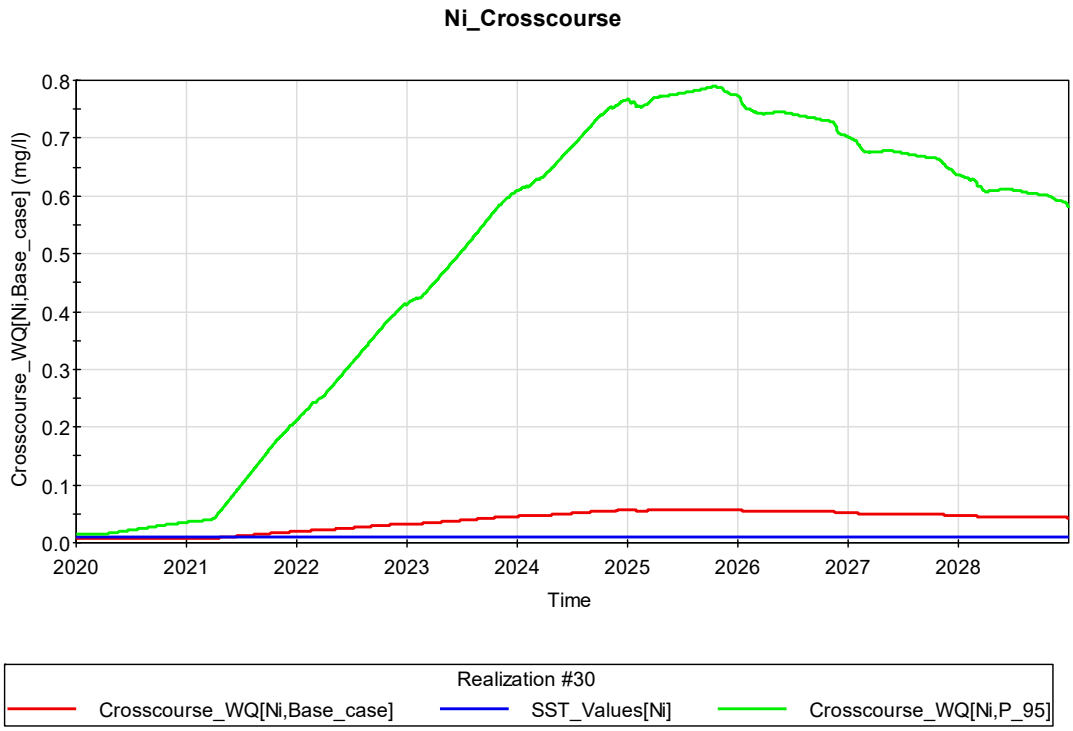


Figure 24: Median climate, discharge on, Ni.

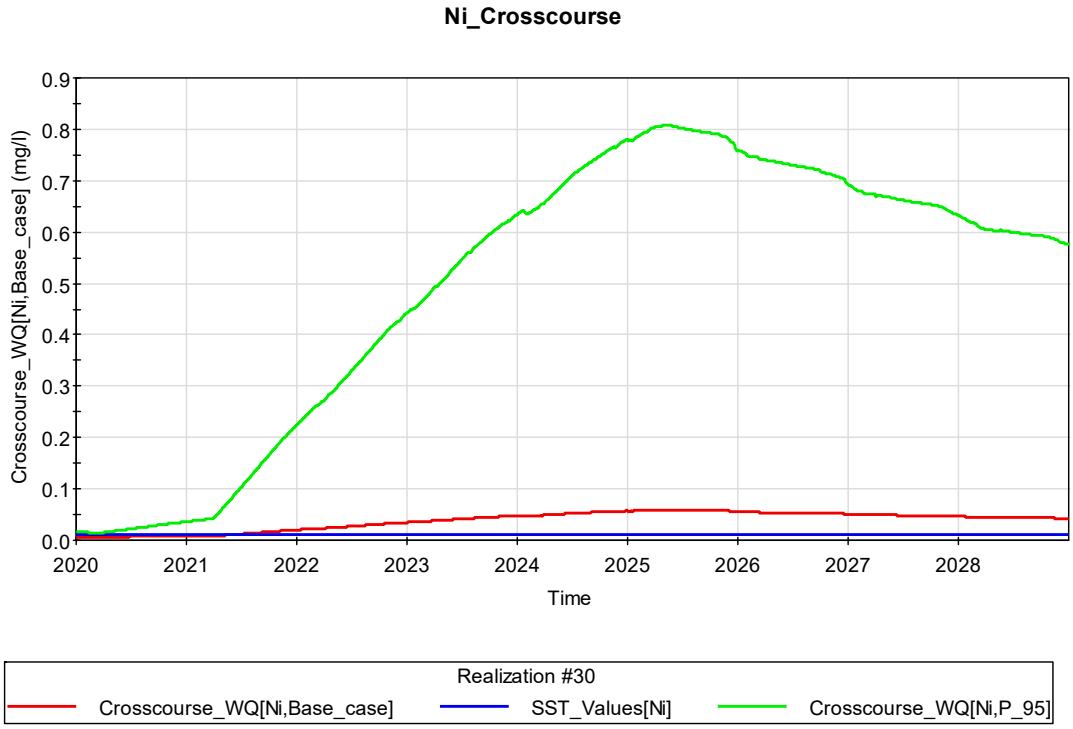


Figure 25: Dry climate, discharge on, Ni.

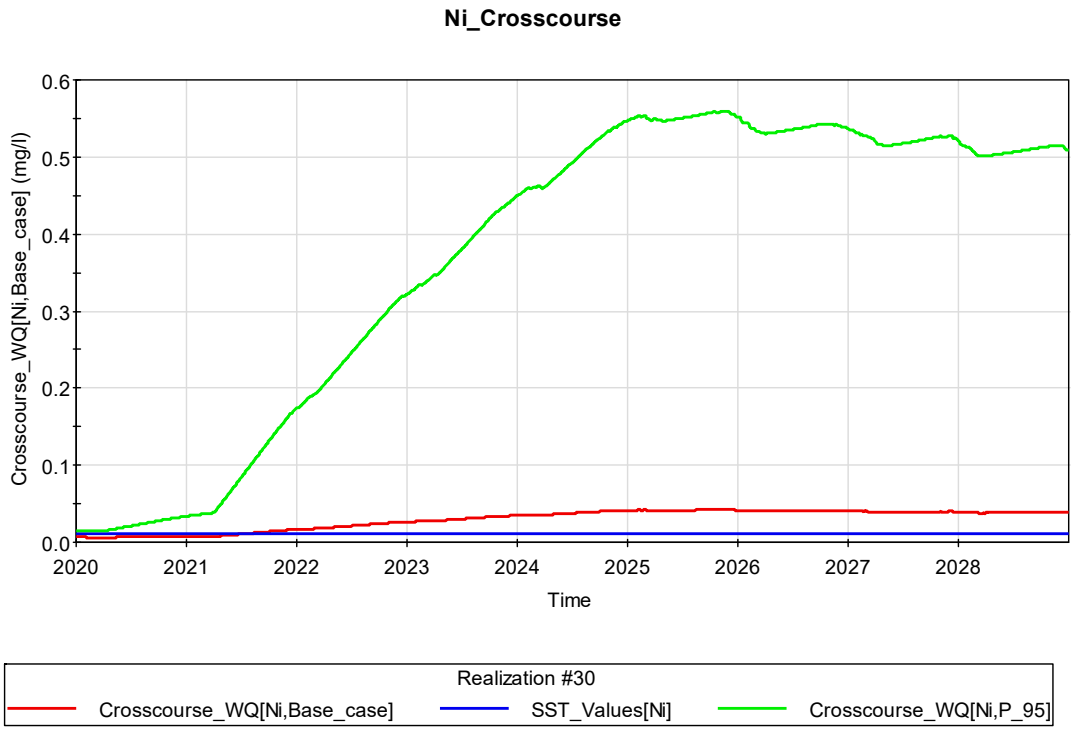


Figure 26: Wet climate, no discharge, Ni.

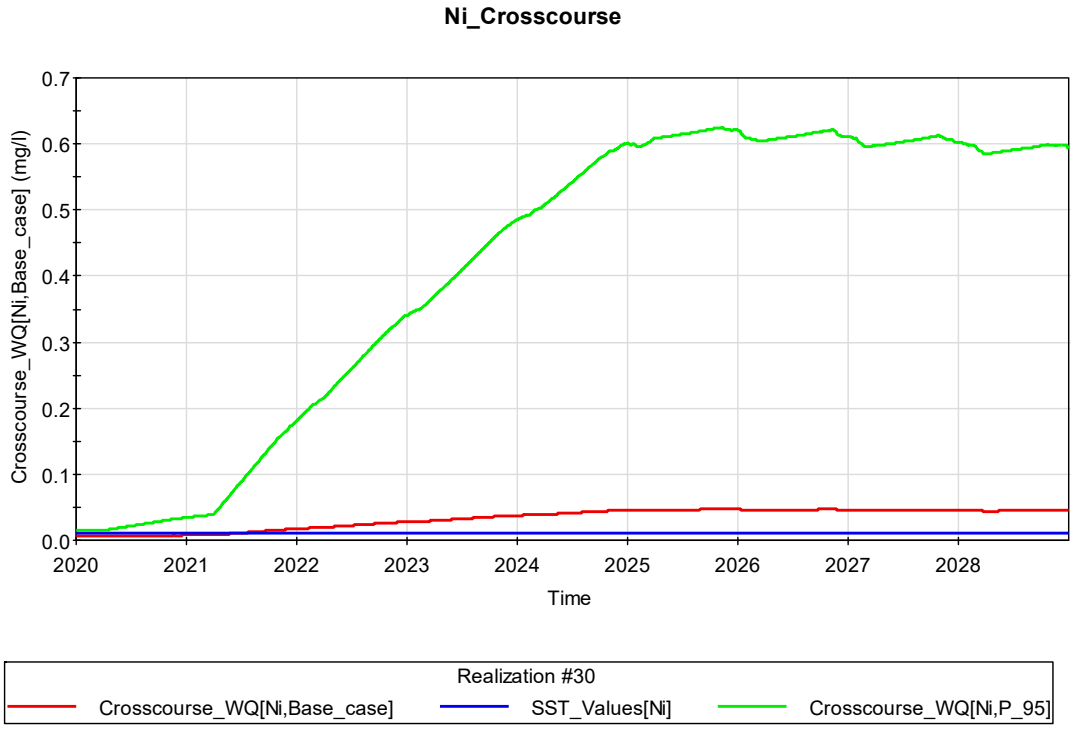


Figure 27: Median climate, no discharge, Ni.

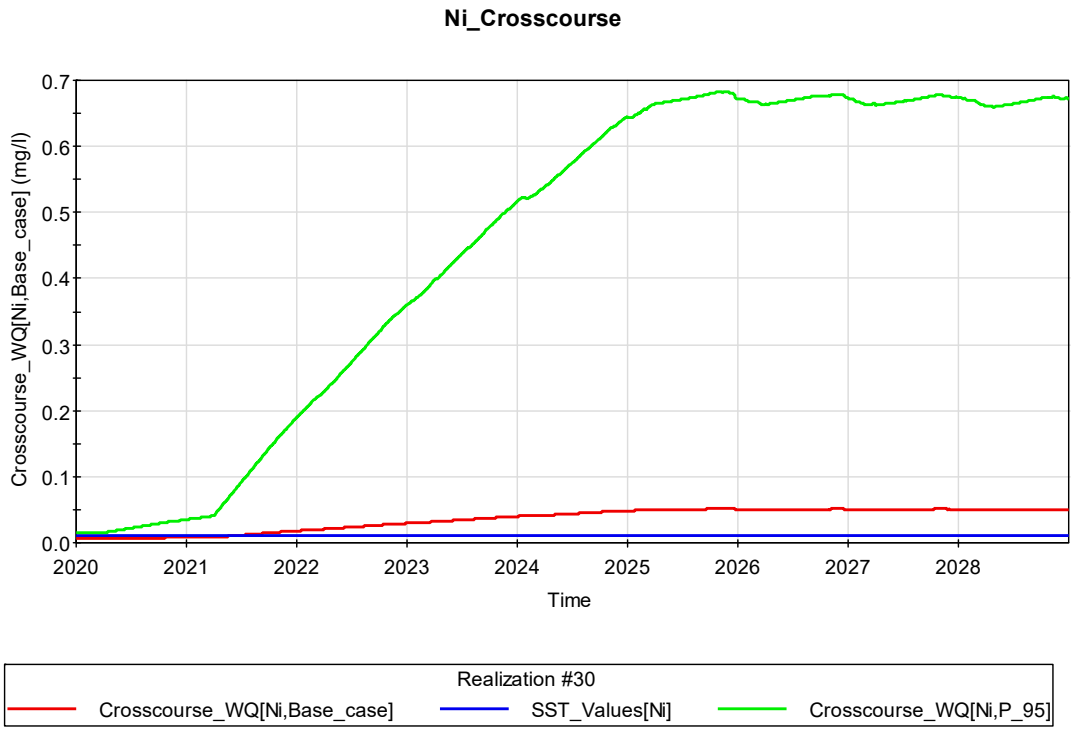


Figure 28: Dry climate, no discharge, Ni.

4.2.4 Zinc

Zinc concentrations in Crosscourse pit show a progressive increase starting before the tailings deposition begins for the 'with discharge' option. The base case progressively increases to the end of the simulation (max 0.14 mg/L) whereas the upper bound plateaus or mildly decreases towards the second half of the model run stabilising at 0.4 -0.5-mg/L. The SST value of 0.031mg/L is exceeded within the first year, but comparable values are seen in the historical monitoring record. The base case values are comparable to the historical record.

The 'without discharge' option shows a similar profile but without the decreases in concentration seen in the 'with discharge' scenario. The maximum concentration is 0.13 mg/L (base case) and 0.51 mg/L (upper bound).

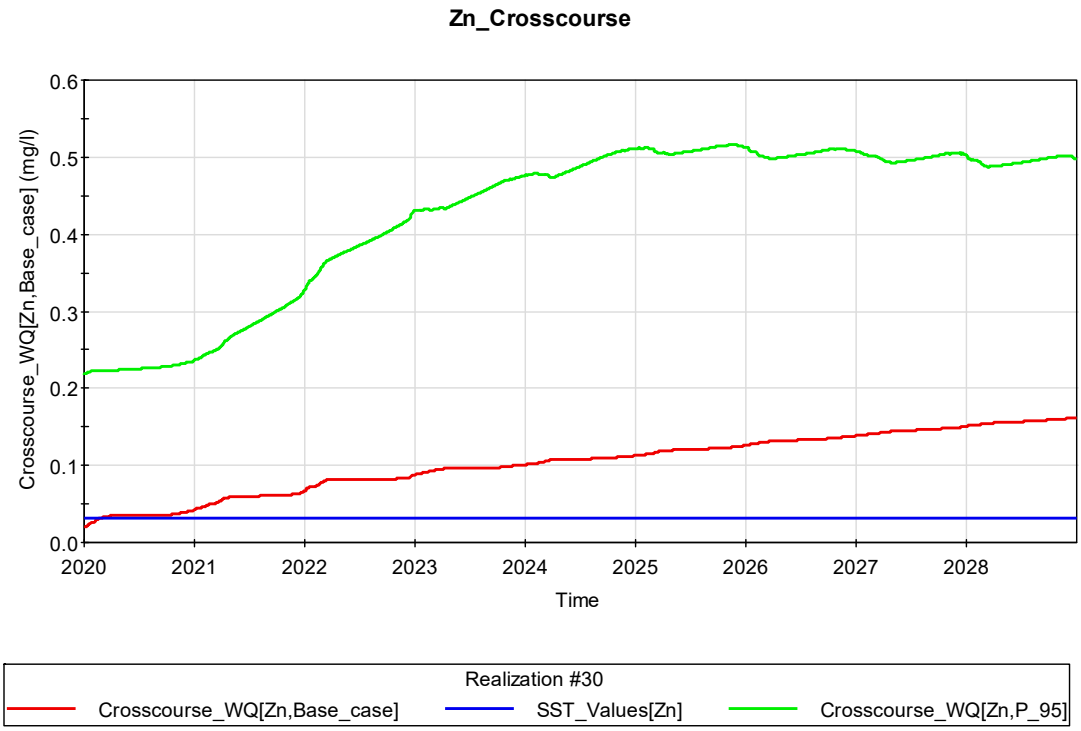


Figure 29: Wet climate, with discharge, Zn.

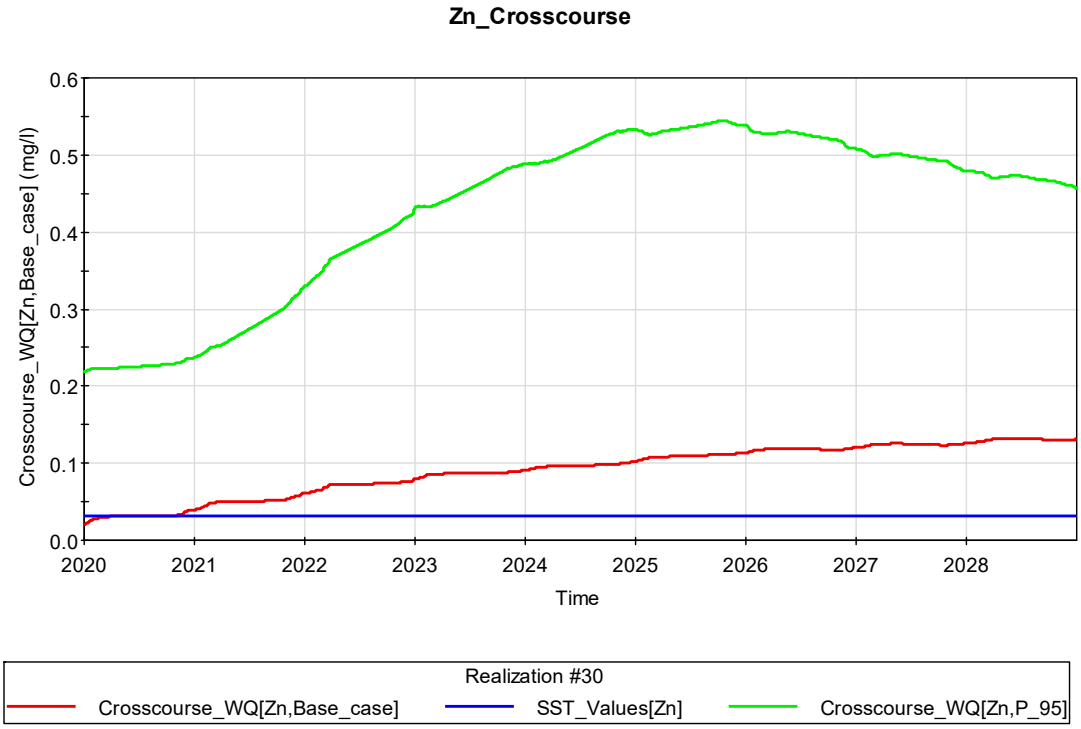


Figure 30: Median climate, with discharge, Zn.

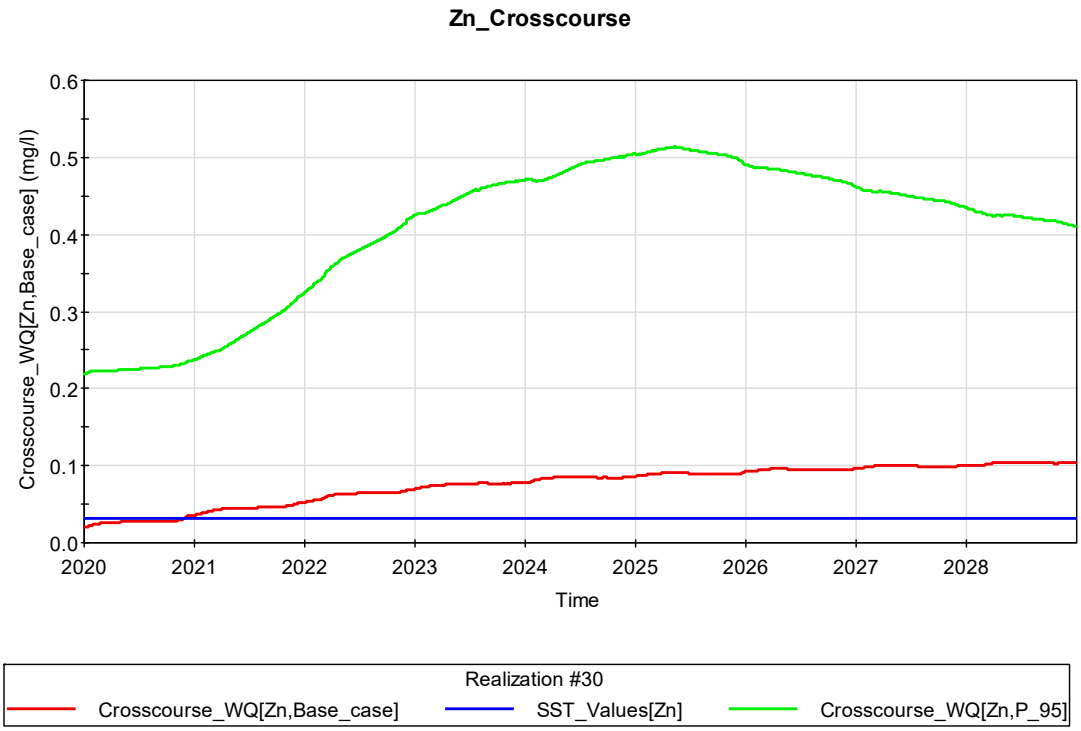


Figure 31: Dry climate, with discharge, Zn.

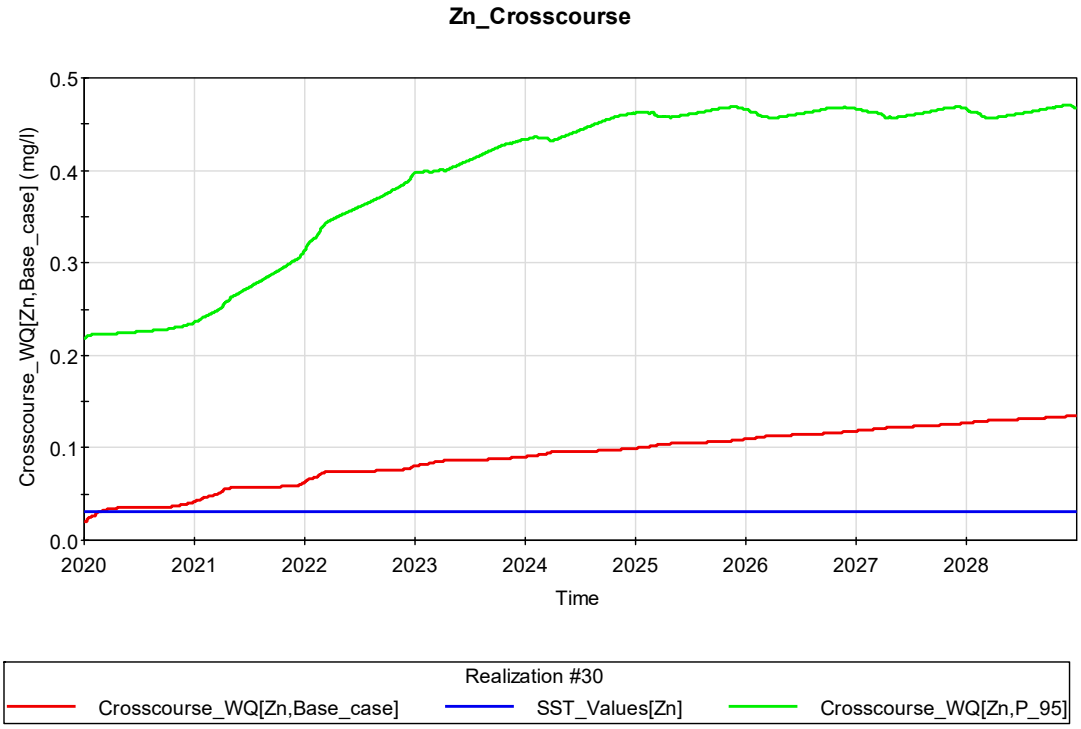


Figure 32: Wet climate no discharge, Zn

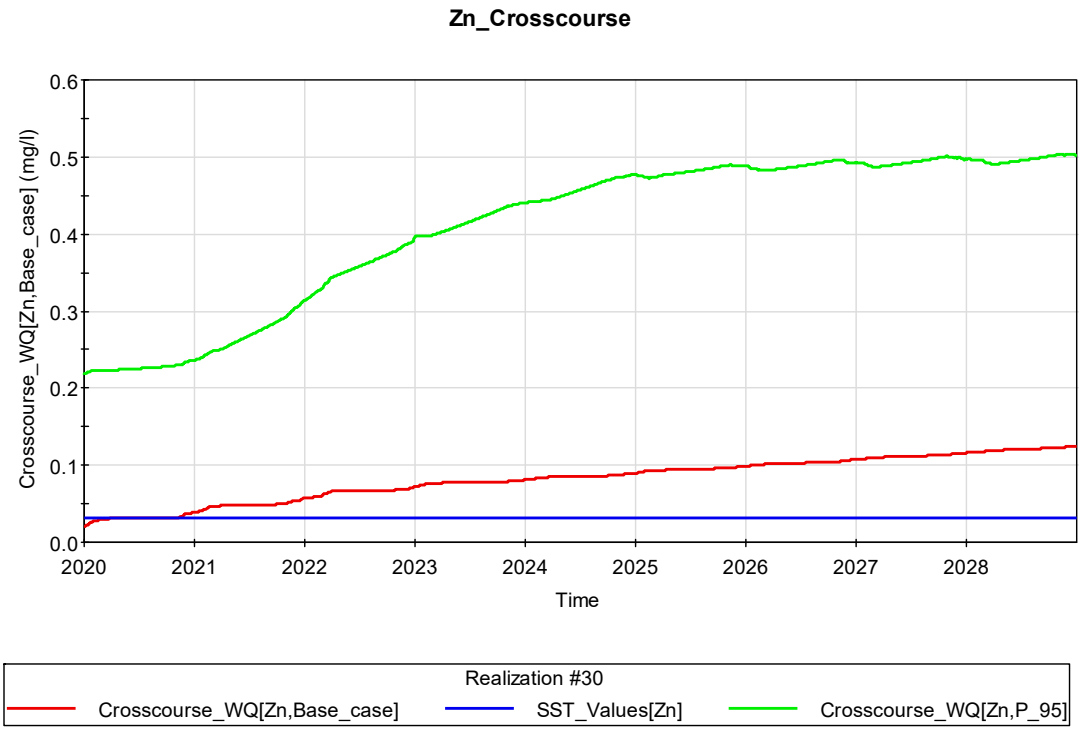


Figure 33: Median climate no discharge, Zn.

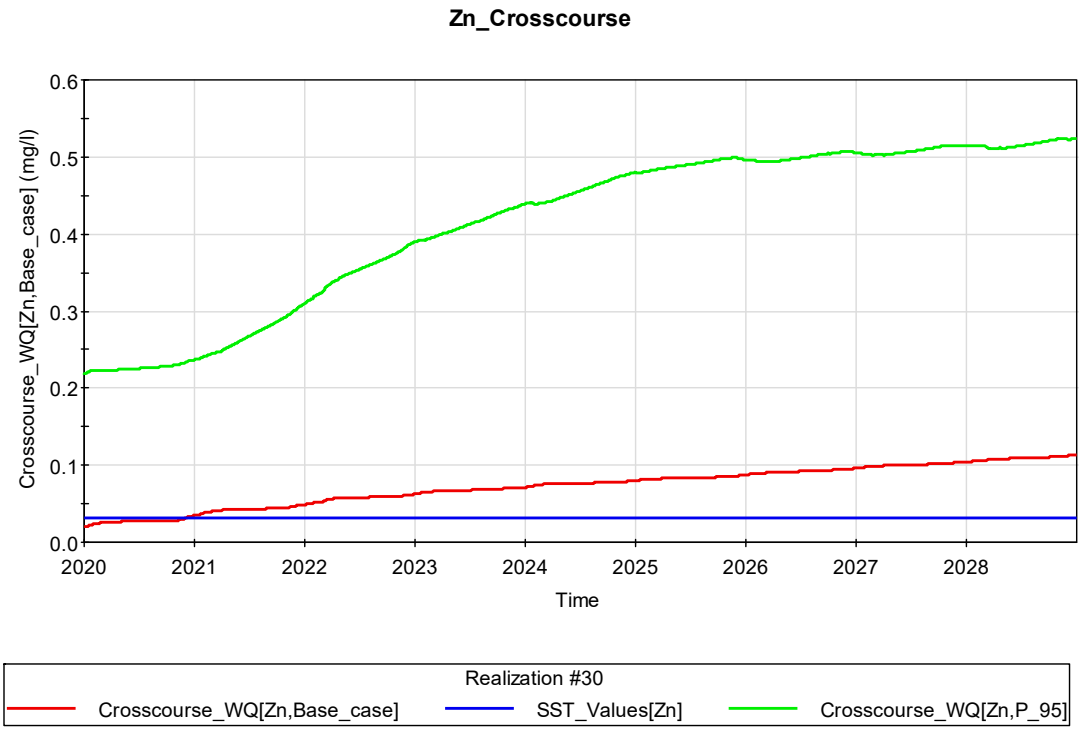


Figure 34: Dry climate no discharge, Zn.

Figure 28 shows the cumulative zinc load associated with different sources over the modelled timeframe. Whereas the copper load was dominated by the tailings slurry additions, the zinc load is much less associated with tailings and instead the load comes from surface runoff and pumping from Prospect pit.

It should be noted that this is load (kg), so although the surface runoff has a major loading it is mostly due to the large volume that surface runoff represents, not because the runoff is highly concentrated. This explains why there is no significant difference between the with and without discharge scenario as it is the runoff water quality that is dominating the concentration of zinc. Actual runoff water quality is not measured and is an area where more data is required.

The historical monitoring record also shows an increasing trend over time, with zinc concentrations recorded in Crosscourse Pit higher than in the tailings slurry. The SST for zinc is 0.0031 mg/l and the concentration is predicted to quickly exceed this, however, recent monitoring has measured values in exceedance of this at around 0.1 mg/L.

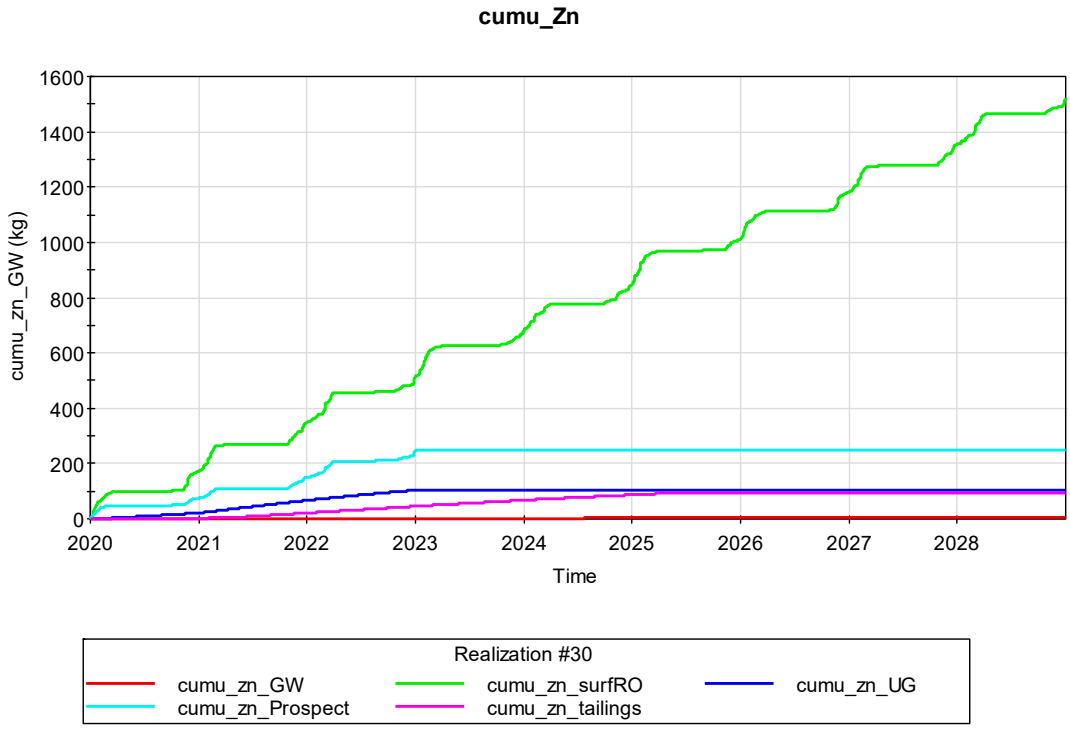


Figure 35: Cumulative zinc load by contributor (GW=groundwater, surfRO=surface runoff, UG=underground pumping).

4.2.5 Arsenic

Arsenic predictions are relatively stable across all scenarios, (Figure 35, Figure 36, Figure 37, Figure 38, Figure 39, and Figure 40). The 'with discharge' option shows a minor declining trend in concentration but remains well above the SST level of 0.0024 mg/l with values typically around 1 mg/L (base case) for all scenarios.

The 'no discharge' scenario shows a very slight decreasing trend in concentration. The arsenic results correlate quite well with the historical monitoring results, particularly the most recent monitoring with results also around 1 mg/L, however, earlier historical records show values many times this with concentrations > 6 mg/L. These are comparable with the upper bound values, but it was indicated in the surface water quality review that there is poor understanding of what is controlling the concentration of arsenic in Crosscourse Pit historically as it does not show a good correlation with the tailings slurry deposition, there is arsenic present in the groundwater contribution and in pumped water from the underground operations.

Geochemically arsenic is unlikely to be modelled accurately with a mass balance approach due its association with other species. Arsenic is often associated with iron compounds, oxides and oxyhydroxides and has a less straightforward relationship with pH, being soluble in both acid and alkali conditions. In all modelled scenarios there is no obvious impact on arsenic concentrations from either the tailings deposition or the underground operations.

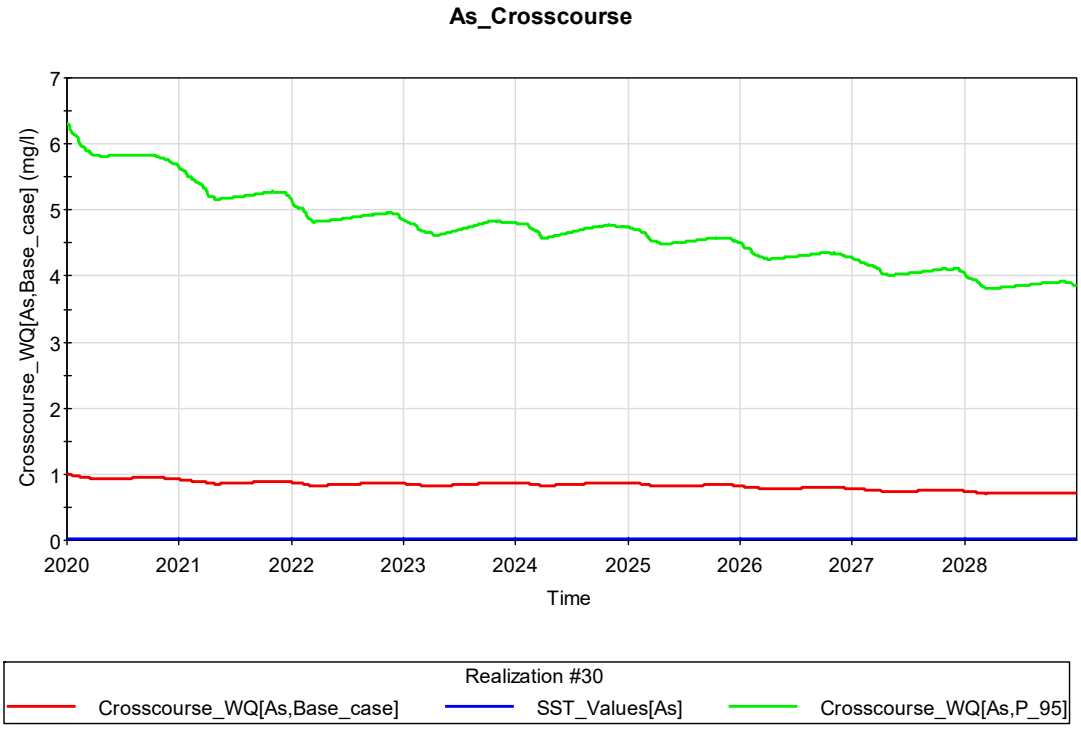


Figure 36: Wet climate, discharge on, As.

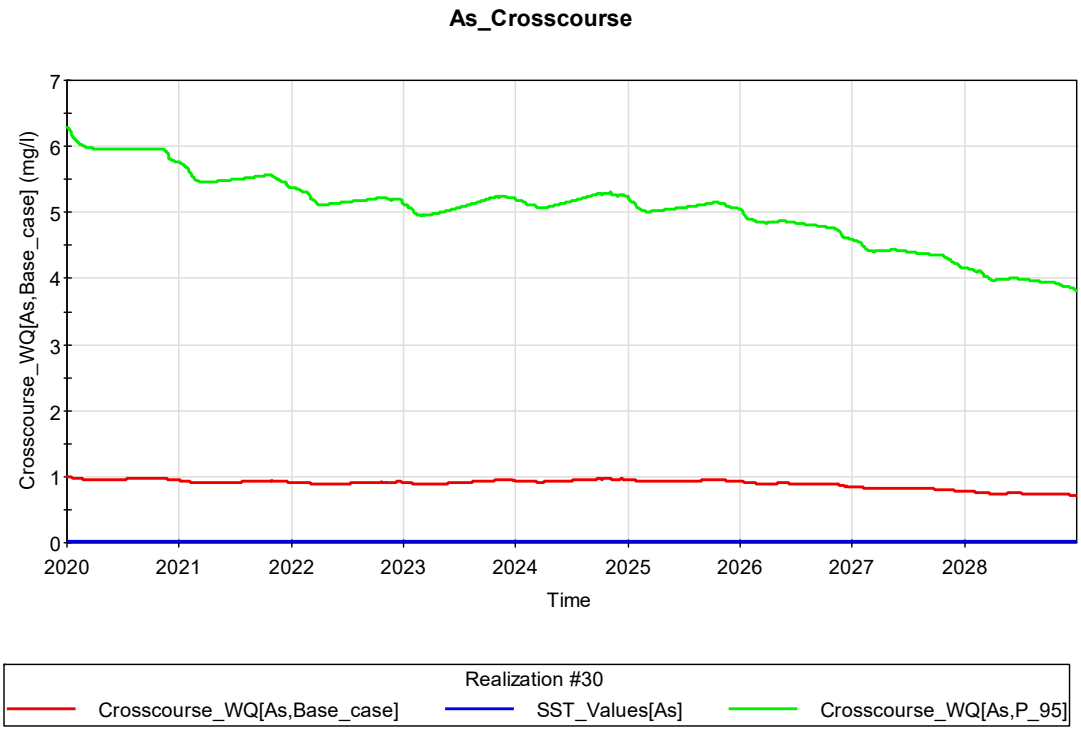


Figure 37: Median climate, with discharge, As.

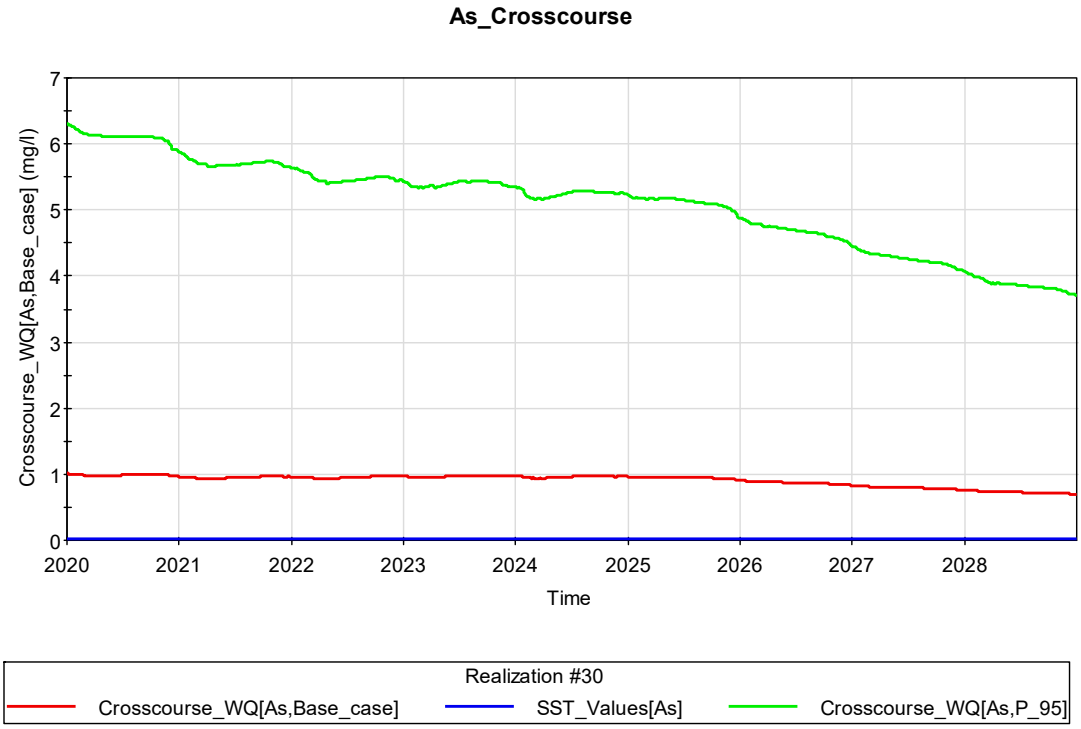


Figure 38: Dry climate, with discharge, As.

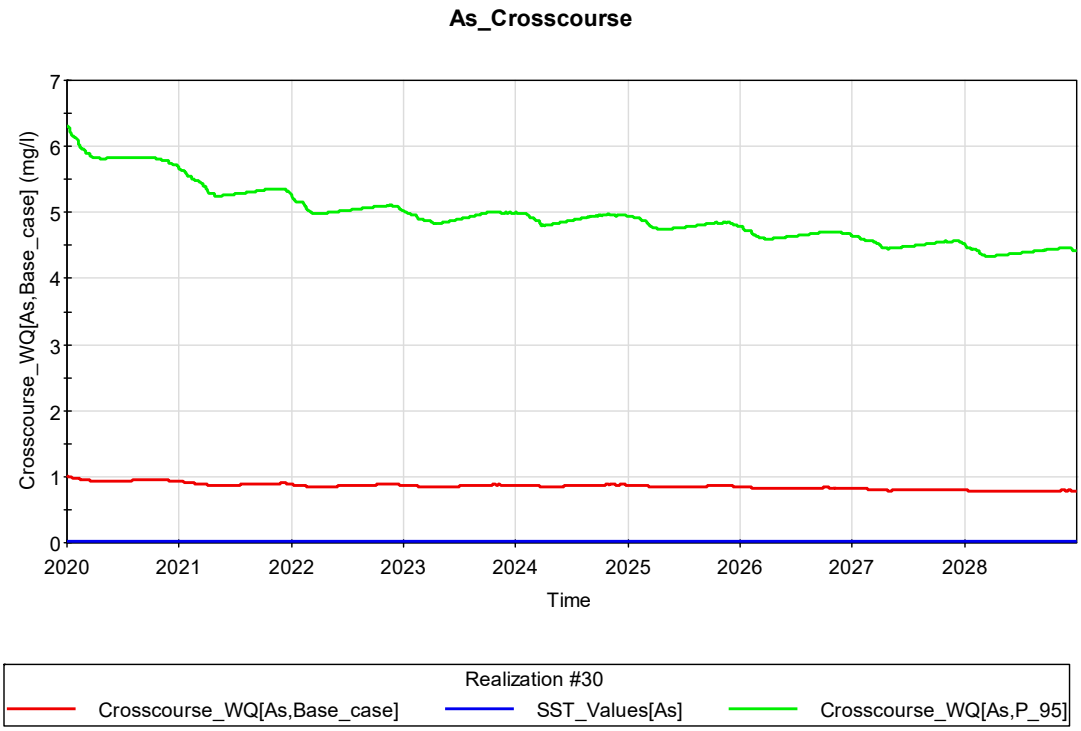


Figure 39: Wet climate, no discharge, As.

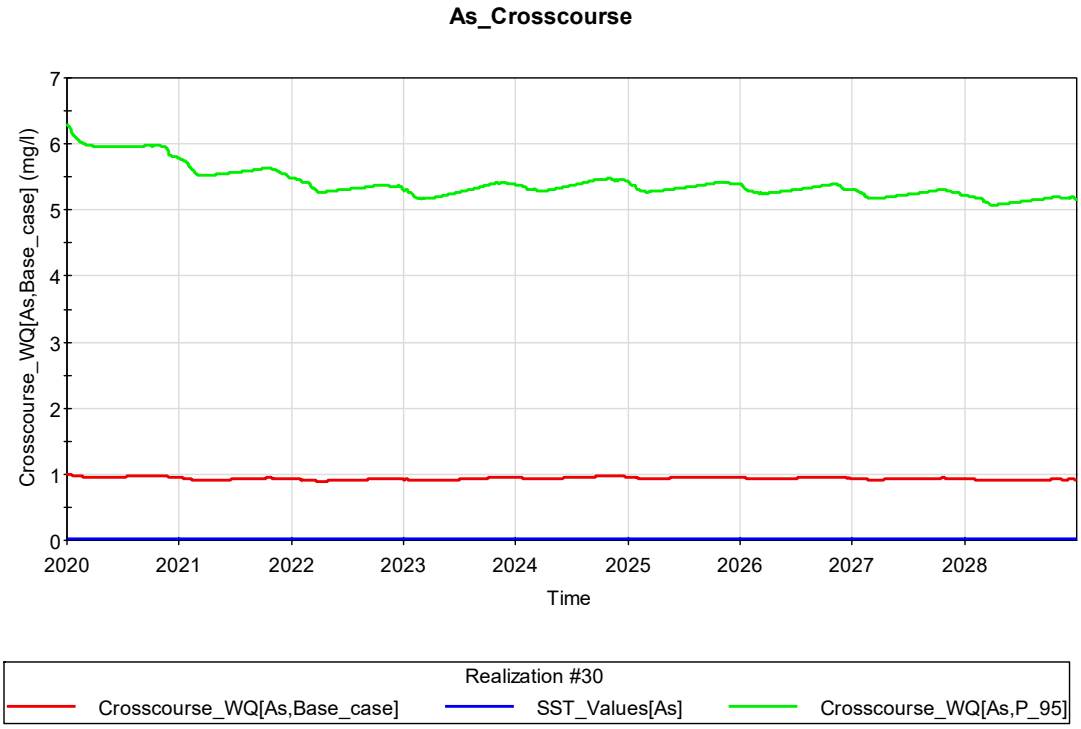


Figure 40: Median climate, no discharge, As.

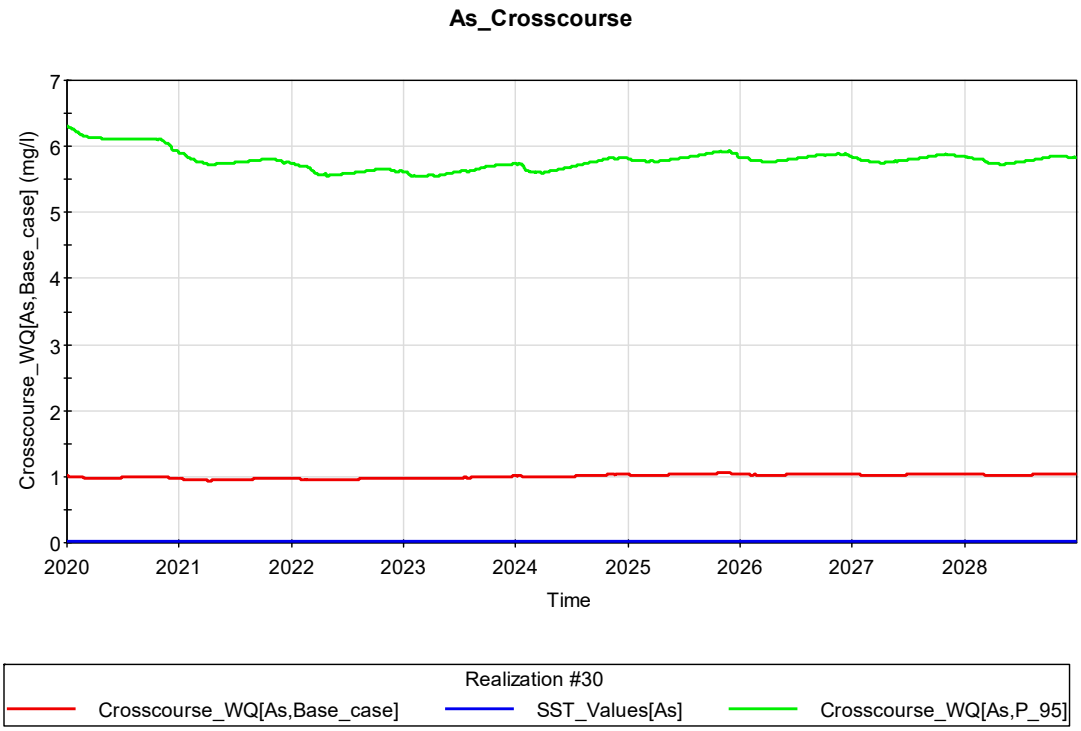


Figure 41: Dry climate no discharge, As.

4.2.6 Cobalt

The predicted concentrations of cobalt are well above the SST level of 0.0014 mg/l but do not show a significant impact from the underground operations. The base case predictions are in line with the historical record of between approximately 0.2 and 0.5 mg/L, starting at 0.35 mg/L and progressively decreasing to around 0.2 mg/L Figure 42 to Figure 47.

There is an influence on the upper bound values due to the tailings deposition. The upper bound simulation starts at 0.48 mg/L and decreases to approximately 0.4 mg/L with a peak at around the beginning of 2025 of between 0.45 and 0.55 mg/L.

In the 'no discharge' scenario, there is less of a decreasing trend in the second half of the simulation in the wet and median climate scenarios and no significant decrease in the dry scenario where the concentration starts at 0.35 mg/L and ends at 0.3 mg/L.

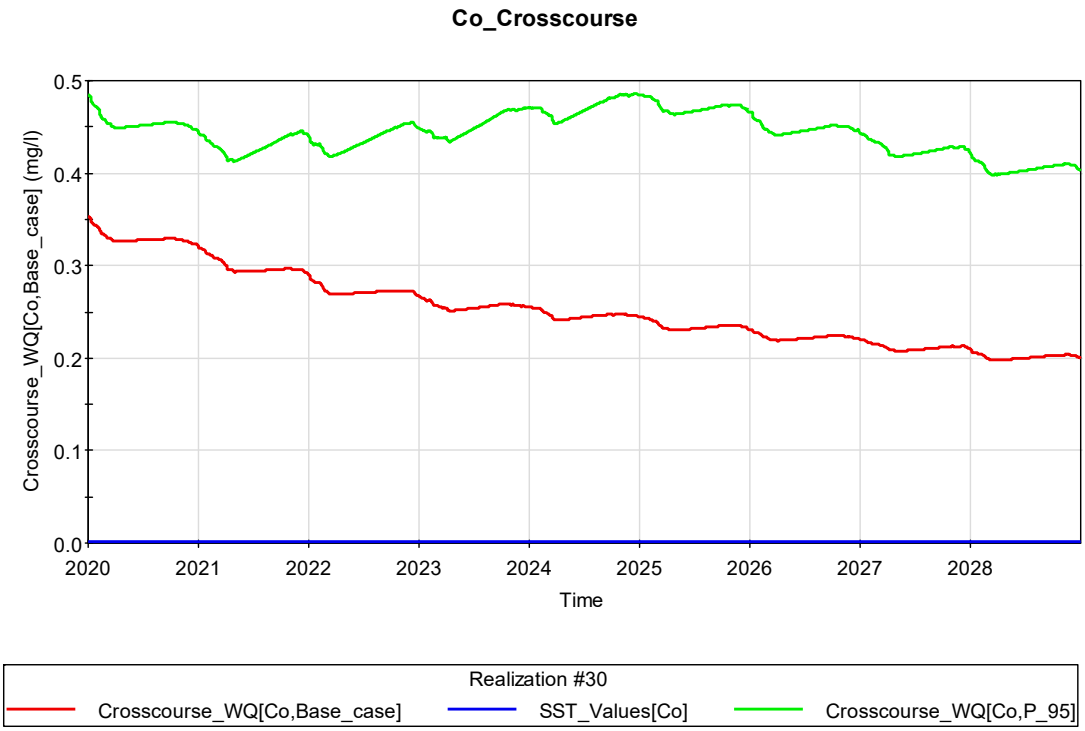


Figure 42: Wet climate, with discharge, Co.

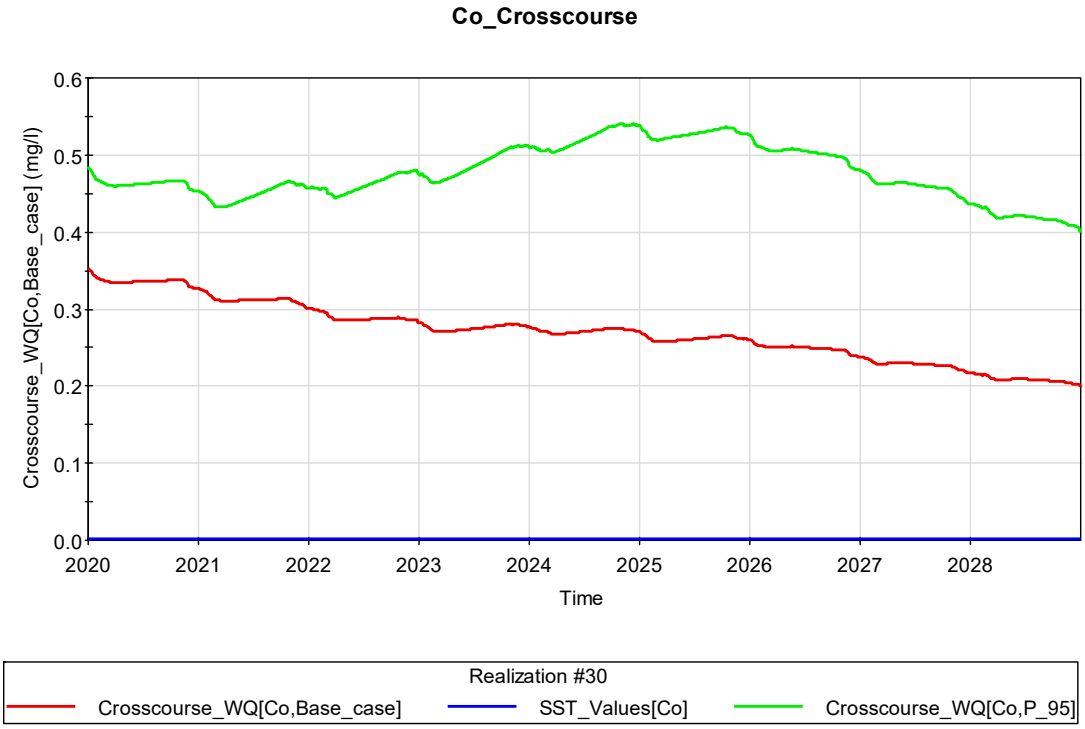


Figure 43: Median climate, with discharge, Co.

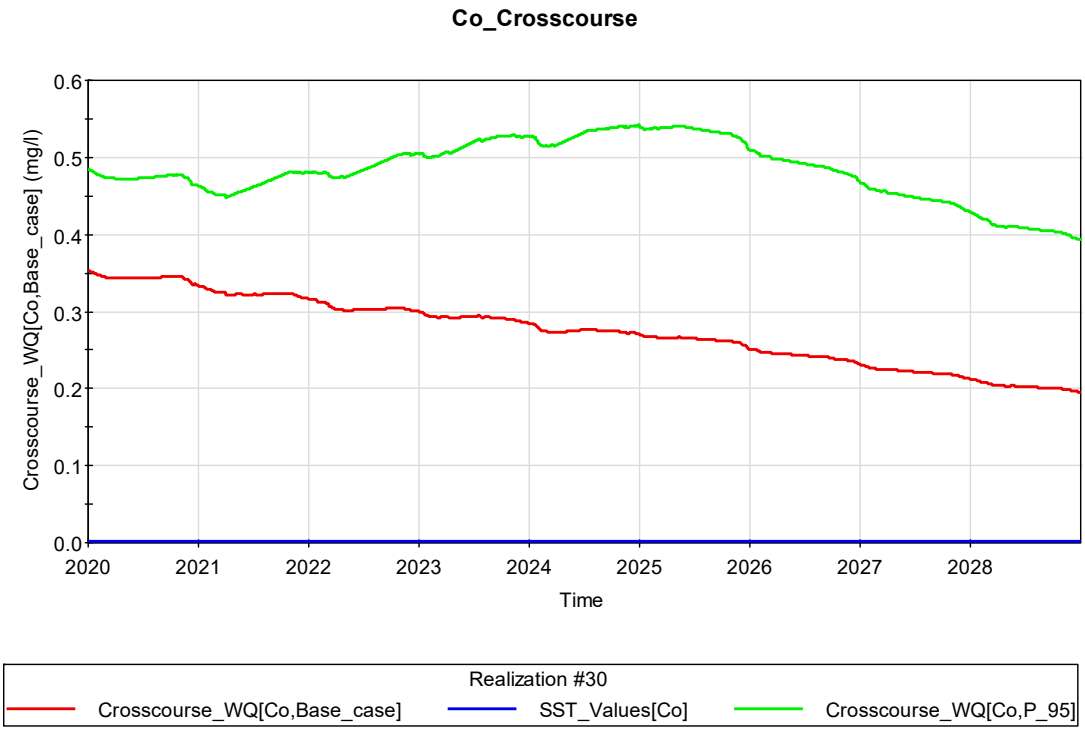


Figure 44: Dry climate, with discharge, Co.

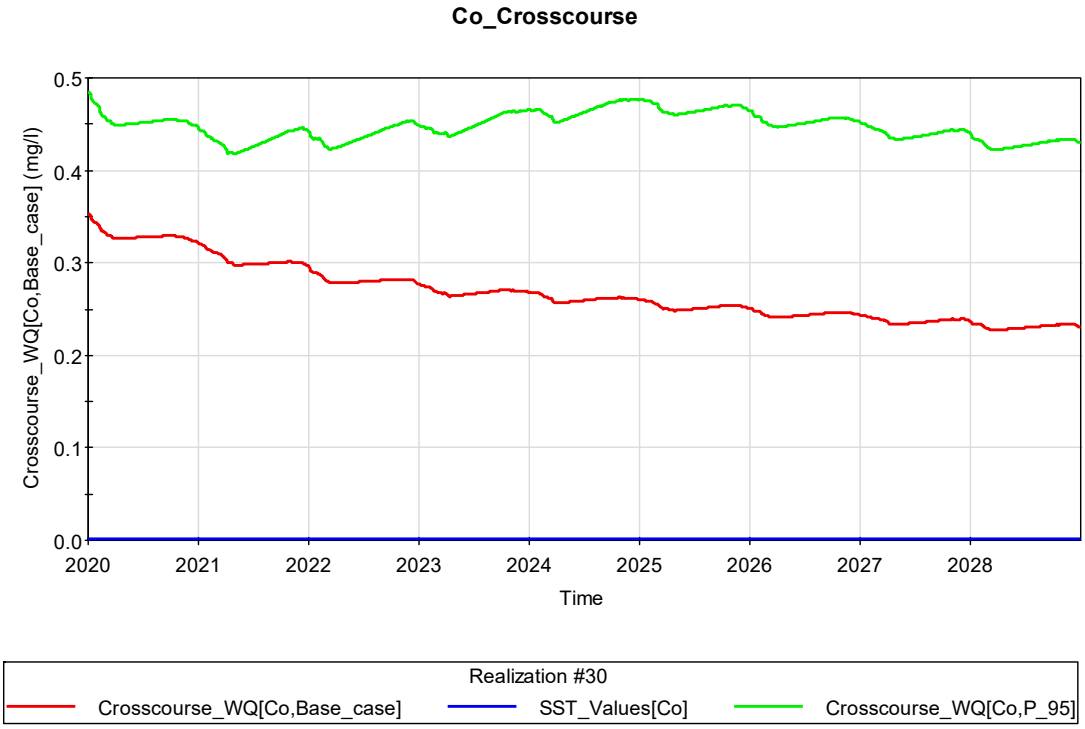


Figure 45: Wet climate, no discharge, Co.

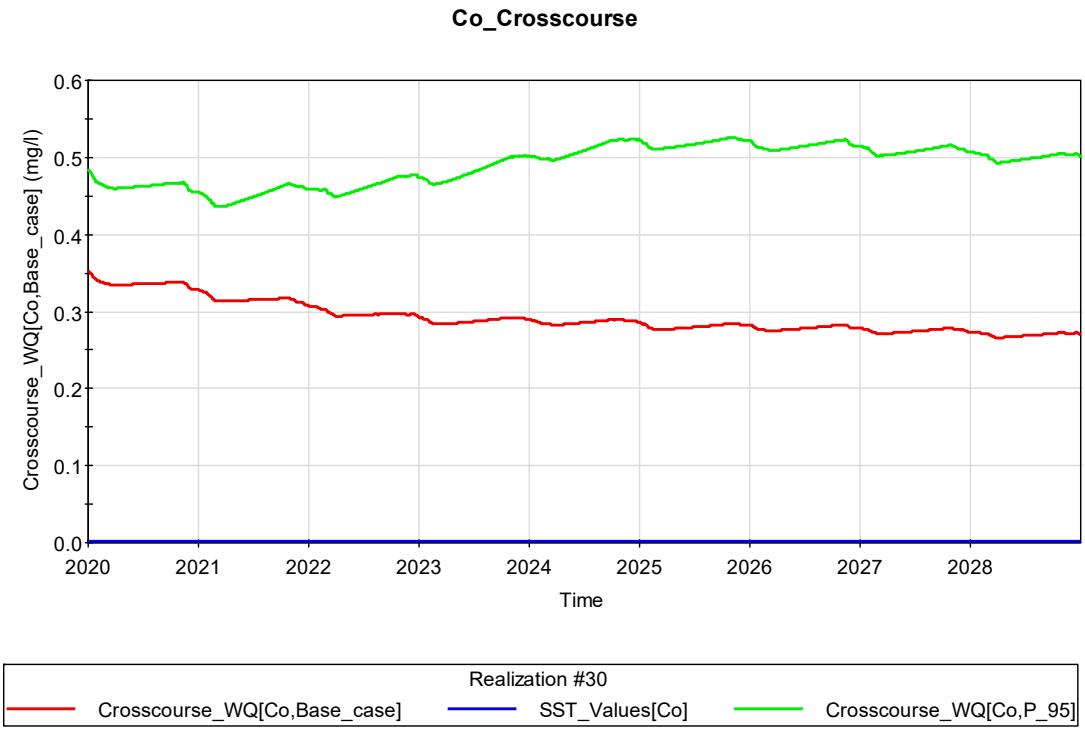


Figure 46: Median climate, no discharge, Co.

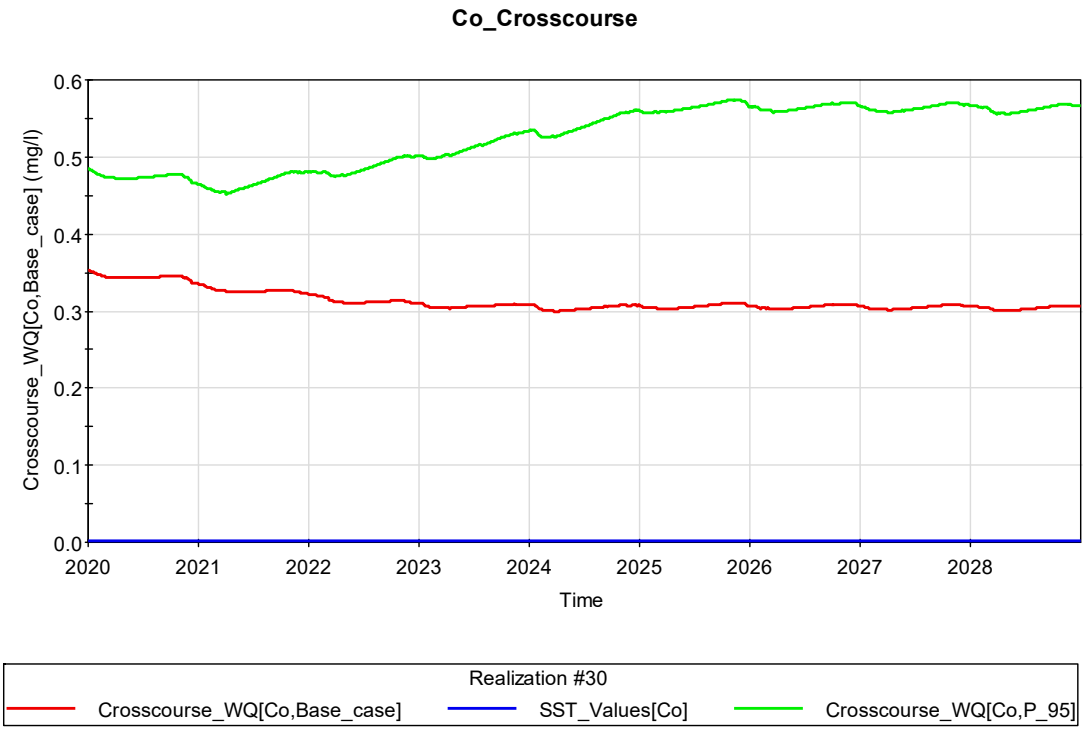


Figure 47: Dry climate, no discharge, Co.

4.3 Summary water quality results

Initial water quality modelling has been performed to indicate possible effects of the North Underground Mine operation on water quality in Crosscourse Pit. The model was constructed using preliminary geochemical inputs and uses available physical and project specific data. The model has not been calibrated against empirical values on site and there is known uncertainty associated with some of the inputs. The model is conservative in that it is a mass balance approach without introduced solubility caps or thermodynamic controls. The main findings of the modelling review are:

- Modelled results suggest that for some elements the main influence on water quality is the tailings deposition (e.g. Cu, Ni). Other species are more influenced by the pumping from underground and runoff water quality (Zn, As).
- There is potential for spillway release under wet climate conditions in the 'no discharge' scenario.
- The 'with discharge' results for species associated with the tailings (Cu, Ni, Co) show an increased concentration due to the reduced pit lake volume resulting from discharge, whilst still receiving tailings, this begins to decrease when tailings deposition ends.
- Nickel is modelled to be significantly higher than the historical levels and is above the SST values. This is believed to be an effect of the mass balance approach being overly conservative and in a real-world situation the nickel would be present at lower concentrations due to solubility constraints., but this should be investigated further.

The results for selected elements are summarised in the points below.

- Sulphate levels are comparable or lower than the historical record (peaking at around 1100 mg/L and decreasing to between 600 and 990 mg/L) with the lower values observed in the 'with discharge' scenario.
- Copper shows elevated concentrations and is primarily associated with tailings deposition (max value 0.75mg/L base case, 9.7 mg/L upper bound). The upper bound results are not considered realistic due to likely solubility controls. Copper concentrations are comparable to the historical levels observed during tailings deposition.

- Nickel shows the same behaviour as copper but has much higher concentrations in both the base-case (max 0.047 mg/L) predictions and the upper bound (max 0.63 mg/L) as compared to current and historical levels. The increase in concentration is associated with tailings deposition. This may indicate a potential impact to water quality from the operations but is considered more likely a result of the conservative mass-balance approach. Geochemical modelling will provide further insights, as will improved geochemical testing.
- Zinc concentration do not show significant impact related to the North Underground Mine operations but there is a steady increase in the expected case (base case) concentrations post operations suggesting runoff contributions.
- Arsenic concentrations are stable at around 1 mg/L (base case) and ~6 mg/L (upper bound). Although above SST level of 0.024 mg/L, there is no significant impact from the project operations and predictions are in line with the historical monitoring record.
- Cobalt concentrations in Crosscourse do not show a significant impact from the underground operations, although are highly elevated compared to the SST value of 0.0014 mg/L base case (max 0.35 mg/L) and upper bound (max 0.53 mg/L). However, these values are comparable to the historical record.

Summary statistics for the modelling results are presented in Appendix B.

5. Prospect Pit

5.1 Pit Lake elevation

The prospect pit fill profile is presented below for the three climate scenarios, Figure 48, Figure 49 and Figure 50. The behaviour is essentially the same for each scenario with the pit lake elevation stabilising at around 180mRL. During the dewatering phase the water level in prospect is expected to be minimal with the spikes in elevation shown in the diagrams appearing as artefacts of the daily timestep modelling.

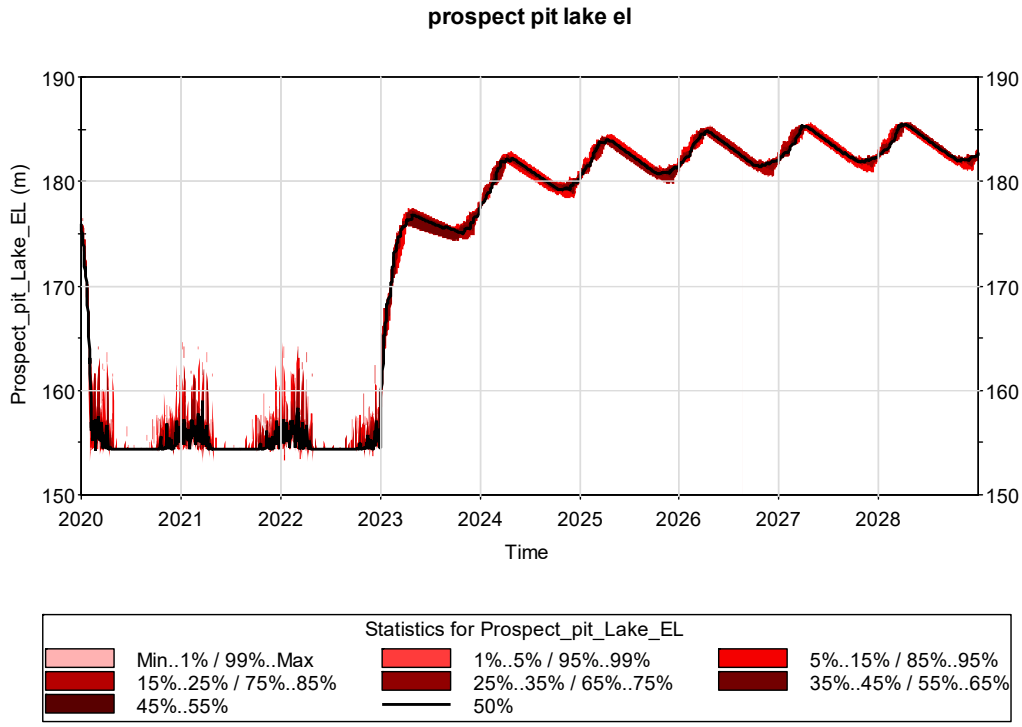


Figure 48: Prospect Pit fil profile wet climate.

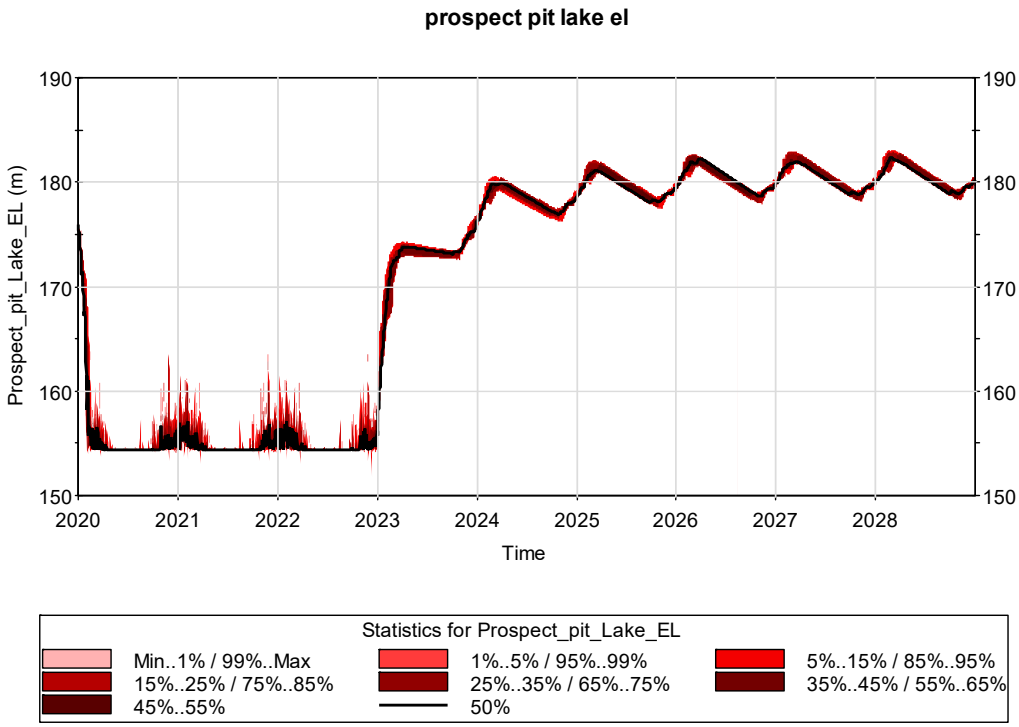


Figure 49: Prospect Pit fil profile median climate

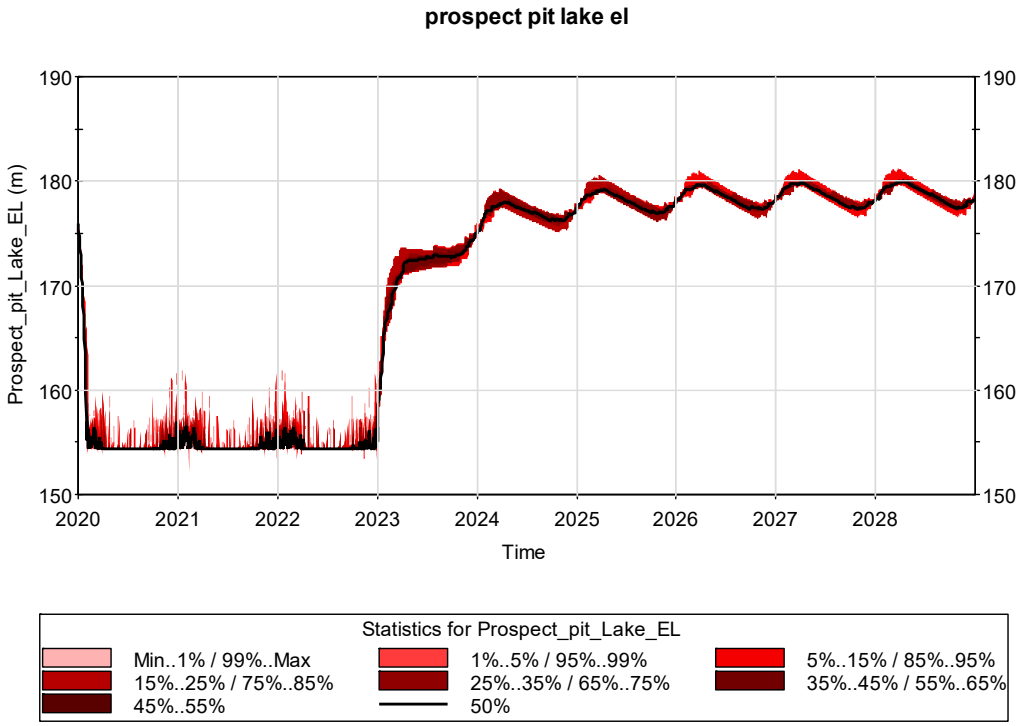


Figure 50: Prospect Pit fil profile dry climate

5.2 Water Quality

Another artefact of the modelling process for the period before 2023 in Prospect pit, where the volumes are very small, is dramatic peaks in concentration. These are the result of small water volume tending towards zero with evaporation, which means the calculation of concentration (mass divided by volume) tends to infinity (divide by zero errors). This makes the presentation of these outputs misleading and instead the summary data tables of post 2023 data are presented in Appendix B

The modelled water quality evolved essentially returns to approximately pre-operational levels in all three climate scenarios.

6. Discussion

The use of a mass balance model is considered appropriate for this stage of modelling due to the uncertainties regarding some of the geochemical inputs resulting from the testing method, and the fact that it is a conservative approach. The primary inputs to the water quality modelling come from the water extract and net acid generation (NAG) test liquor these inputs are presented in 'Geochemical characterisation of waste rock and ore' (EGi, 2019) . The use of accelerated oxidation test (NAG) results and analysis of the evolved liquor give some indication of the potential species likely to be released from materials as a result of oxidation but do not provide any rate information and has other inherent uncertainties. A single addition NAG test may not completely oxidise all the reduced species present, in addition the presence of certain species can catalyse the oxidation of the peroxide such that incomplete oxidation takes place and therefore the uncertainty associated with these tests is relatively high.

More reliable inputs are derived from kinetic tests, typically in the form of leach columns. These provide information on release rates of soluble species and estimates on lag-times for acid producing materials. Given the known significant uncertainty associated with using these geochemical inputs, adding complexity by including geochemical controls on the concentrations of species is not appropriate at this stage, and does not increase the reliability of the modelled results. A conservative approach is prudent at this stage of model development.

This is also the case for adding mechanisms that attempt to simulate other complex reactions associated with dynamically modelling the relationship between alkalinity, acidity and pH. The use of a mass-balance approach is generally conservative since concentrations can increase without constraint, whereas in nature there may be solubility limits and co-precipitation reactions limiting concentrations. One aspect that may be significant in this case is the association of As and Fe in co-precipitation reactions. If pH and redox conditions dictate that dissolved iron present in acidic waters pumped from the underground workings will precipitate on encountering the higher pH and more oxidising conditions predicted in Crosscourse Pit, then iron will typically precipitate as iron(oxy)hydroxides. When this occurs with dissolved arsenic present, then the arsenic tends to co-precipitate out of solution in association with the iron. This can significantly lower the concentration of dissolved arsenic but is highly dependent on the physicochemical conditions. Crosscourse Pit has shown relatively high arsenic concentrations in the monitoring record and this modelling predicts similar values.

Areas of known uncertainty in this model include:

- The reactive surfaces of the underground operations, this includes the characterisation of the material making up the walls, tunnels and stopes, as well as water ingress rates, and ingress water quality. This may be addressed by more detailed surveying of the likely rock material using block models or other detailed interpretation of drill core. Underground mines are notoriously difficult to predict water ingress in advance due to preferential pathways fracture zones and other factors hard to identify from the surface. This all feeds into uncertainty regarding the solute load associated with the underground operations.
- Some of the PAF development waste samples gave high zinc, copper and arsenic concentrations in the NAG extracts and water extracts. This may be a result of the aggressive peroxide oxidation and may not reflect the likely leachate water quality in the environment. It is also evolved in a low pH liquor which again may not reflect site conditions, and certainly does not represent current Crosscourse pit lake conditions. Arsenic is less pH dependent and commonly exists in multiple valence states, so the

relationship is less clear here. Again, kinetic leach columns will assist with improving understanding of likely water qualities developed on site.

- Differences between the site water-balance and the synthetic water balance constructed for this model may exist and refinement to both is likely in the future. This model operates on daily timesteps whereas the site water balance uses annual averages. The use of daily time steps captures shorter-time scale variability (e.g. seasonal, or even by rainfall or drought event). This approach required certain generalisations to be made such as converting annual rates to daily rates, which might not be operationally feasible, and there is likely to be more variation than this simple conversion generates, which could have short term impacts on predicted water quality.
- The discharge volumes are large, up to 2037 ML/year, and the feasibility of discharging this volume of water, presumably mostly during the wet season is not considered as part of this modelling exercise, although with more detail surrounding the dilution available at the McKinlay this functionality could be incorporated.
- Pit wall runoff water quality is difficult to estimate as this depends on the reactive surface of the pit wall as well as the geochemical composition, surface distribution of rock, fracture depth etc. In the case of Crosscourse, the upper portion of the walls is in well oxidised material and is not considered a major source of acidity or salinity/metalliferous drainage, this is supported by the pH in Crosscourse remaining >pH 7 .
- The water quality pumped from North Underground Mine operations is not known and presents challenges in predicting. The modelled approach generates a fractionated water quality based on the estimated rock type distribution, baseline water quality and a water quality composed of impacted and unimpacted water. These estimates should be reviewed as improved data becomes available.
- Physical properties and construction details of the waste rock storage, relating to runoff and infiltration etc. may affect the predicted water quality coming from the waste rock storage in Prospect pit. Kinetic leach columns will also give a more reliable estimate of evolved water quality coming from the storage area. PAF materials have the potential to contribute significant acidity and metalliferous leachate.
- Even though the mass balance approach is geochemically conservative, inaccuracies in other inputs may still result in underestimating the geochemical load particularly from large contributors such as groundwater and runoff water quality. Both show significant variability in the monitoring record and may influence predictions.
- The monitoring record shows that apart from Cu and Co, other parameters have remained relatively constant between 2010 and 2017. However, the modelled results without discharge show a decrease in the concentration of other parameters. e.g. sulphate, which suggests there is a discrepancy relating to the chemical loading in the simulation. Since a major input to the solute load in Crosscourse is associated with the runoff water quality, which is not sampled directly, this should be investigated. For modelling purposes, the runoff water quality is derived from the McKinlay river monitoring record which may not be an accurate analogue for the evolved water quality of runoff on site. Due to the relatively large fluxes associated with Crosscourse pit, relatively small changes in water quality inputs can have significant effects on evolved water quality.
- Some of the parameter concentrations are dominated by the tailings geochemistry. This suggests that a good understanding of and accurate prediction of the likely chemistry of the tailings inputs will be important for assessing the potential impacts on water quality. Other species, such as zinc are not associated with the tailings particularly and although potentially elevated, the source of solute load is a combination of surface runoff and pumping from prospect pit and the underground workings. Surface runoff should therefore be better characterised as a significant influence on the water quality.

Further model refinements would include sensitivity testing (where the magnitude of the effect of varying parameters has on selected outputs) to identify which inputs are exerting the most influence on selected outputs, and thereby highlighting which parameters require the most reliable input values.

It should be noted that the upper bound values do not represent an expected outcome, the data is based on the 95th percentile of variable results (e.g. monitoring records) so by definition are considered the more extreme results but are a guide to provide context to the base case (expected case) when the modelling requires an input sampled from a 'population' of data points. Future modelling can utilise more sophisticated methods to quantify this uncertainty and the effects on the outputs. One limitation of the upper bound

prediction occurs when combining upper bound inputs leads to very high values due to a 95th percentile combined with another 95th percentile value. Some of this is mitigated when geochemical controls are introduced in more sophisticated modelling since mineralogical effects may temper the predictions compared to a mass balance approach.

Crosscourse pit lake elevation is the controlling factor for potential water quality impacts. This control is determined by whether the pit lake is a groundwater source or a groundwater sink. With the 'discharge on' scenario, the pit remains a sink and the pit lake water quality generally improves due to relatively good water quality additions coming from rainfall and runoff diluting the pit lake.

The peroxide extract produced by a PAF sample represents the end result of complete or near complete oxidation of the sulphides present, hence the chemistry of the extract can be considered to be at upper end of the range for seepage from PAF waste under field conditions. It is likely that seepage concentrations will lie somewhere in between those of the peroxide and water extracts. As discussed in the geochemistry report, it is expected that metal concentrations in seepage will be no greater than concentrations that currently occur in Crosscourse pit water, but the peroxide extracts of the PAF samples are so elevated that they skew the predicted water quality. These values are included, as the water extracts also show highly elevated Zn. Copper on the other hand is orders of magnitude more concentrated in the peroxide leach. Simple geochemical modelling using PHREEQC was carried out on the peroxide leach and a pH adjustment using NaOH was performed to assess the likely effect of raising the pH to the Crosscourse Pit conditions on the copper and zinc in the water extracts. As expected, the equilibrated water quality shows a greatly reduced copper concentration. Kinetic leach column data and thermodynamic controls will address this issue.

Whilst the results of batch extraction tests provide an insight into seepage water quality, they are not kinetic based, and the results should be considered as qualitative rather than quantitative. Factors that affect the chemistries of batch test extracts include the solid to liquid ratio used (1:20 for water and 1:100 for peroxide) and the contact time between sample and extractant (typically 24 hours). Under field conditions within a waste rock emplacement, the solid to pore water ratio at any given time will be significantly lower than the ratios used in the batch tests, but leaching will be an ongoing progression through time. Also, under field conditions only a fraction of the rock surface will be in contacted with water as it flows through waste rock pile, while in the leach tests, the rock is finely ground increasing surface area and all of the sample is contacted by extractant. To address this scaling factors are applied as a correction. The scaling factors account for (amongst other things): particle size effects, water-rock contact and oxygen availability (e.g. saturated versus un-saturated) and are consistent with reported values elsewhere (e.g. Kempton, 2012; Linklater *et al.*, 2018).

7. Conclusions

This study supports the opinion presented in the associated assessments that the Prospect Project is not likely to have a major effect on the water quality in Crosscourse pit as compared to the current and historical water quality record. This statement is made with the knowledge that there are areas of uncertainty in the inputs used to make these water quality predictions and revisions to these inputs as well as any other design changes may change the predicted water qualities.

This means that the potential impacts to the local receptors are less associated with changes resulting from the water and waste management of the Prospect project but are instead to do with the water level in Crosscourse Pit, and whether Crosscourse Pit is a source of saline/metalliferous drainage. This would appear to be the case regardless of the status of the North Underground Mine.

The proposed discharge option as presented, appears feasible in terms of reducing the volume of water stored in Crosscourse to levels that maintain the pit as the local groundwater sink, mitigating the impact of saline and metalliferous water on downgradient receptors. The discharge option also helps reduce the overall salinity and lowers the concentration of dissolved species, both by losing solute in the discharge and increasing dilution from groundwater and other low salinity inputs.

The system is a complex combination of hydrological effects such as dilution, evaporation, natural loading (e.g. groundwater and runoff) and operational effects (e.g. pumping, tailings deposition etc.).

The findings presented here should be considered preliminary as the predictive reliability of a model improves with refinements to the inputs and, most importantly, calibrations of the modelled results against site-

conditions. The value of this kind model increases with commitment to further development. It has been designed with development in mind and to be used on site for 'what if' analysis and as an on-going decision-making aid for assessing water and waste management options. Estimates and assumptions have been incorporated based on professional experience where there are data gaps.

Aside from the water quality aspect, the model may provide additional functionality for site water management due to the ability run scenarios such as climate scenarios, pumping regimes, failure modelling, etc. and has been built to include a preliminary user dashboard to allow users without specific knowledge of GoldSim to adjust certain parameters and observe the resulting outputs. This can be developed further to provide a powerful decision-making tool.

The model shows that without the discharge option, as described in the water management plan, Crosscourse Pit will tend to continue to fill reaching a quasi-equilibrium close to the overflow elevation, and due to the net positive water balance, is expected to overflow periodically. This is not a result of the Prospect development but may happen sooner due to the pumping of prospect to Crosscourse. Overflow events were predicted within the modelled time frame presented here.

Underground works have been associated with environmental impacts post mining and difficulties in predicting their behaviour is well documented (e.g. Younger and Robins, 2002). The rebound of the groundwater to pre-dewatering levels is expected to take up to six years. During this time oxidation products are expected to be released; however the recent geochemical test work has indicated that the development waste is 90% NAF and the ore material is 75% NAF. The presence of substantial acid neutralising capacity (ANC) in the form of ferroan dolomite/dolomite may also provide a long lag-time before ANC is consumed and material begins to produce acid, reducing risk. But as already stated, the underground evolved water quality is an area of uncertainty.

In general, the water quality modelling supports the findings of the groundwater modelling and underlines that the critical factor controlling the potential impacts from poor water quality evolving in Crosscourse Pit is the pit lake elevation in Crosscourse. Modelling shows that without a discharge option, Crosscourse Pit becomes a major source of potentially harmful dissolved species, and as described in the groundwater modelling, this water quality will quite rapidly migrate towards the McKinlay river where it will appear as base flow and will negatively affect water quality. The magnitude of this impact is dependent on the flow in the river with a large flow rate in the river offering significant dilution, and low flow conditions likely to be more severely affected and exceed guidelines. As was also shown in the groundwater modelling, with Crosscourse at high elevations (180 m RL) the Crosscourse water quality may impact other surface water bodies (e.g. Lady Alice, Dam B). By keeping the water levels low enough in Crosscourse by discharge or other means, than even with the predicted relatively poor water quality in Crosscourse Pit, the pit remains a local groundwater sink and greatly reduces the potential for wider impact. This includes effects from poor water quality potentially evolved in the underground works during and after mining.

Due to the net positive water balance, there is not expected to be a progressive increase in dissolved solute as a result of ongoing evapoconcentration. Longer term, the water quality is expected to improve through a combination of dilution from low salinity low metal(oid) surface runoff, groundwater and rainfall.

Impacts on water quality to Dam B are not really project specific, as Crosscourse pit water quality will migrate to Dam B anyway as the pit lake elevation rises, if allowed to (i.e. no discharge).

With calibrated water qualities, the next stage of modelling would likely incorporate geochemical modelling using PHREEQC (Parkhurst and Appelo, 2013) or similar thermodynamic modelling package to investigate the mineralogical controls on the system. This addresses the limitation of the mass balance approach where the pH, redox, acidity and alkalinity are not modelled. This approach is not considered meaningful on NAG extract water qualities.

8. Further work

The model is preliminary, and the results are currently provided as indicative. Improvements to the model inputs to reduce uncertainty and further work items include:

- Update the geochemical inputs with data from kinetic leach column tests. This will allow geochemical modelling of solubility constraints as well as more realistic modelling of pH acidity and alkalinity.

- Improve characterisation of the underground mine exposed rock material, tunnels, shafts and stopes. This may come from a block model or other sub-surface investigations.
- Update inputs with design decision values e.g. daily pumping schedules, changes to underground mine design, waste rock deposition schedules, waste rock dump physical properties.
- Revise/improve confidence in values for underground mine water ingress rates and refine understanding of impacted versus unimpacted pumped water.
- Add dynamic geochemical controls when the confidence in the geochemical inputs justifies it.
- The model should be calibrated against field parameters and more reliable surface runoff water quality and groundwater quality values should be obtained.
- With flow ratings curves and improved surface water information, controlled discharge scheduling could be simulated to meet dilution requirements for discharge.

9. References

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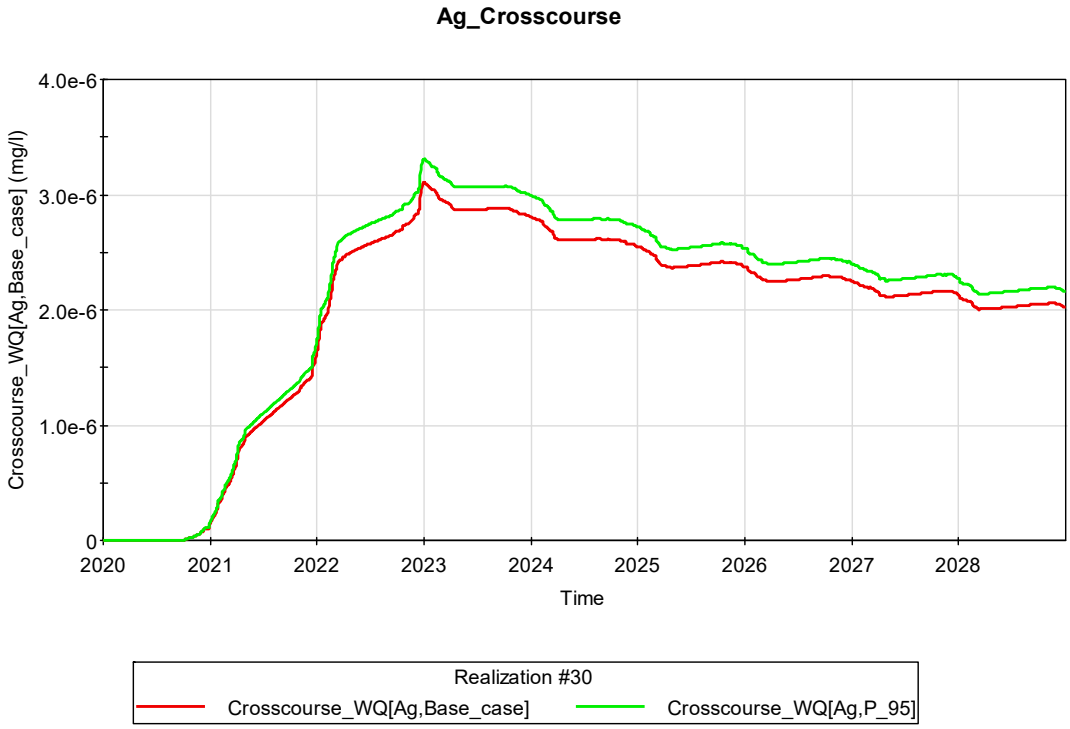
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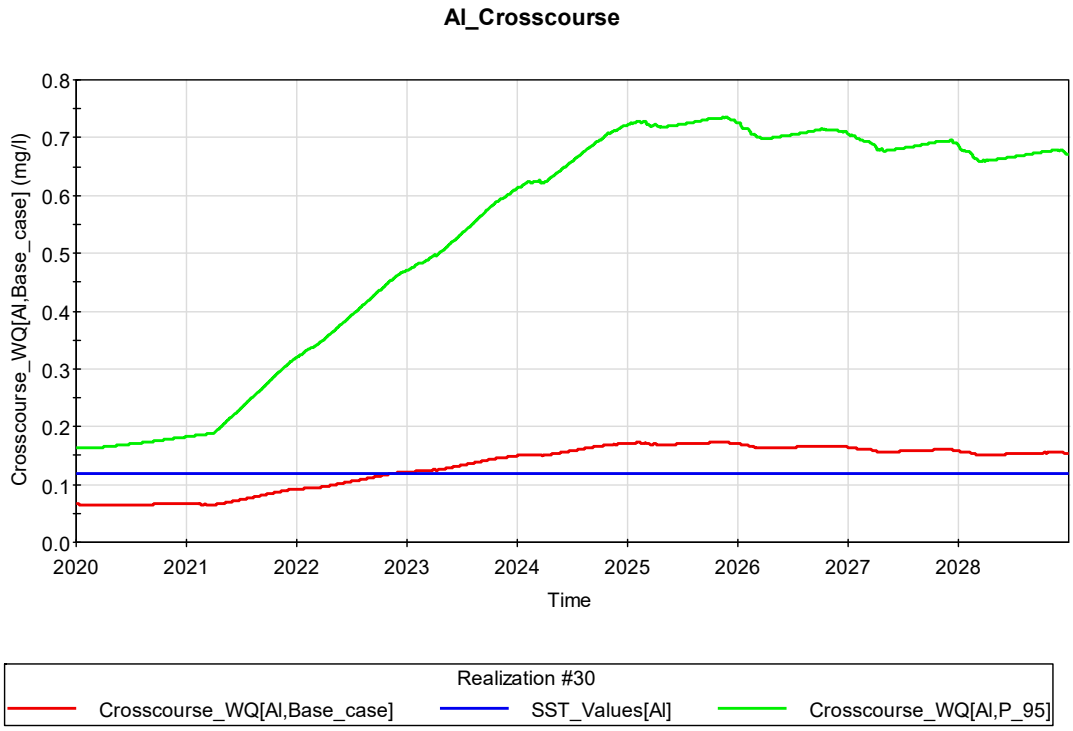
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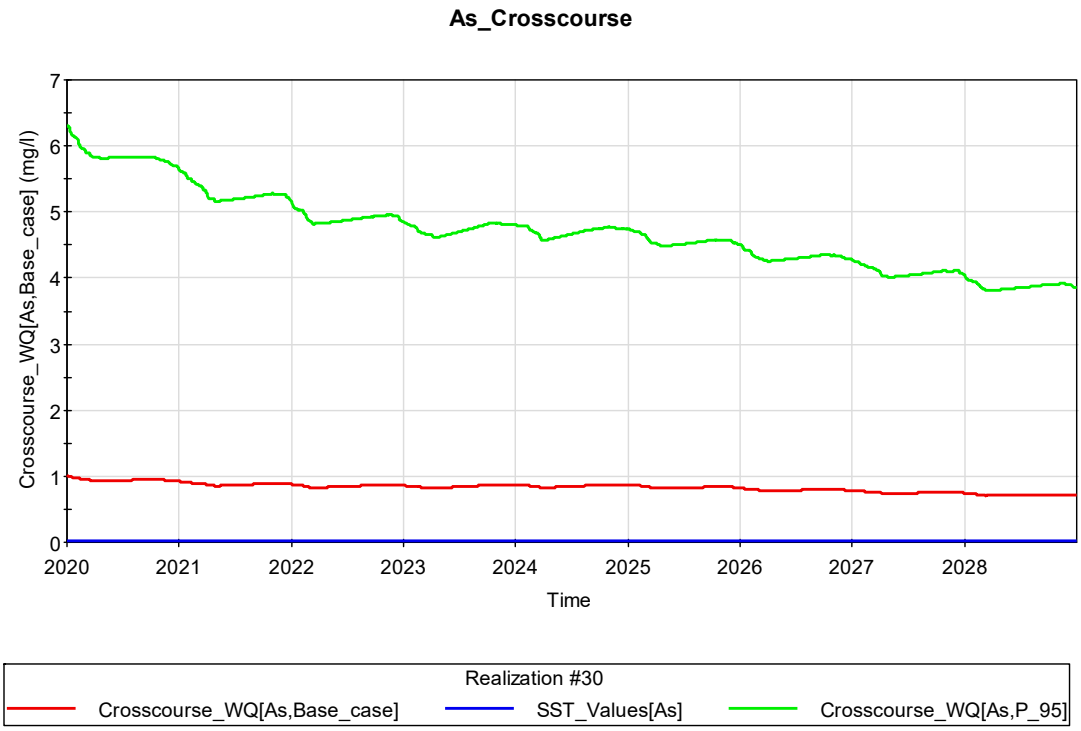
APPENDIX A

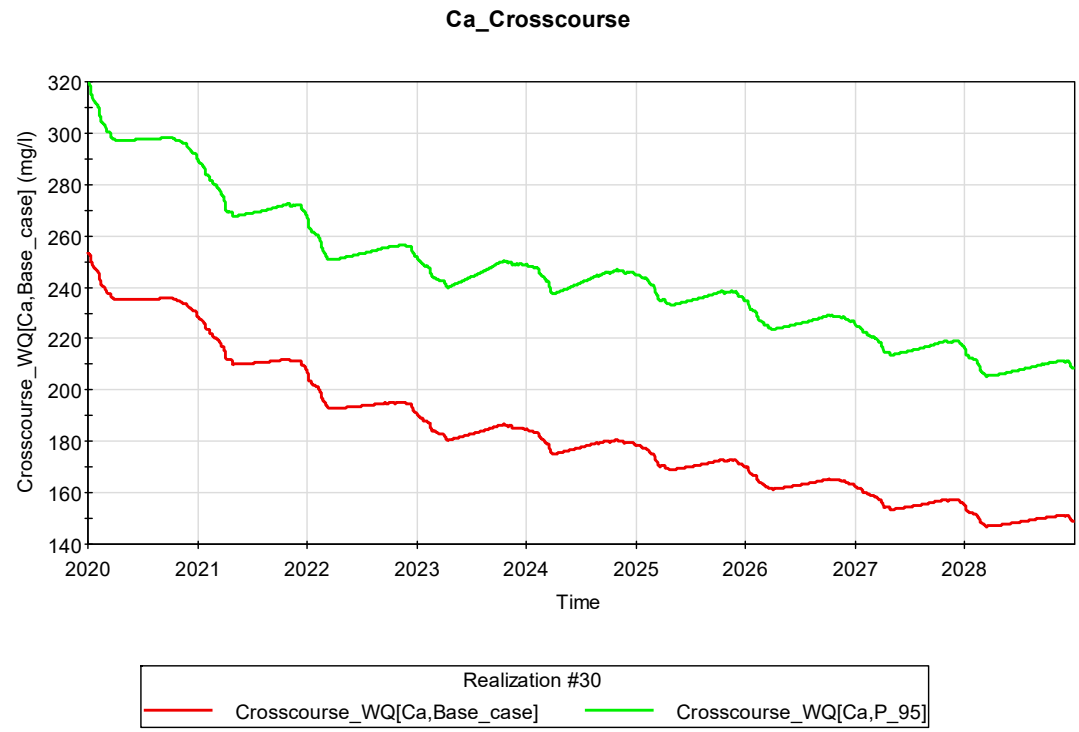
Crosscourse Pit Water Qualities All Output plots

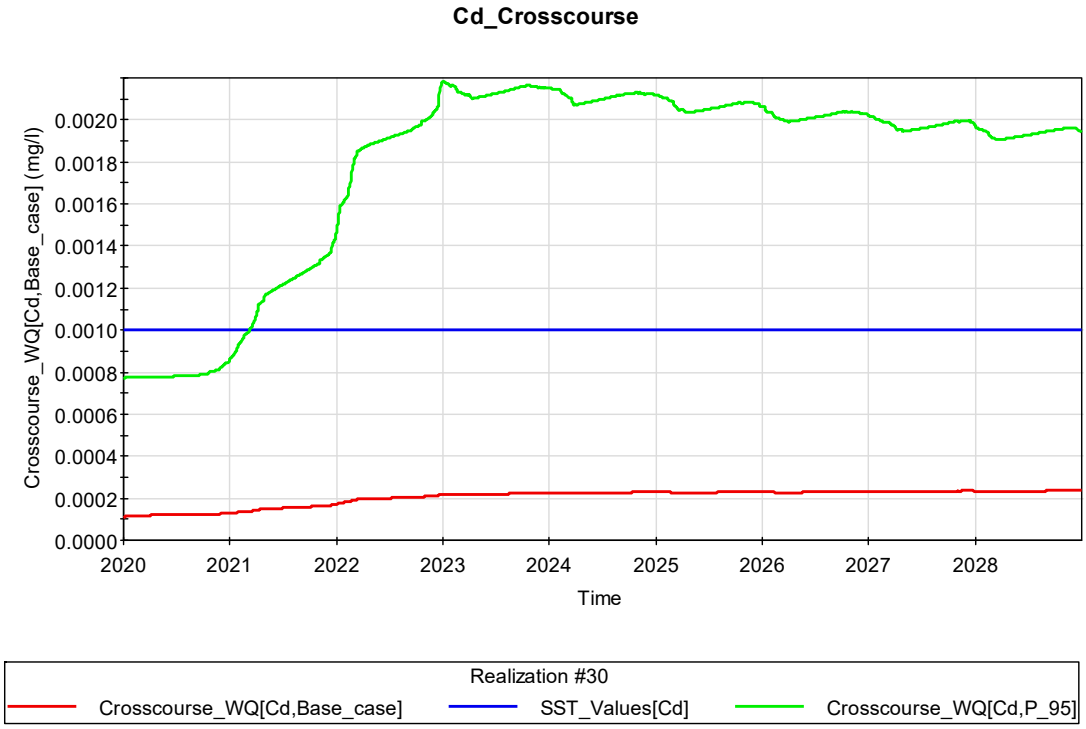
Wet climate with discharge

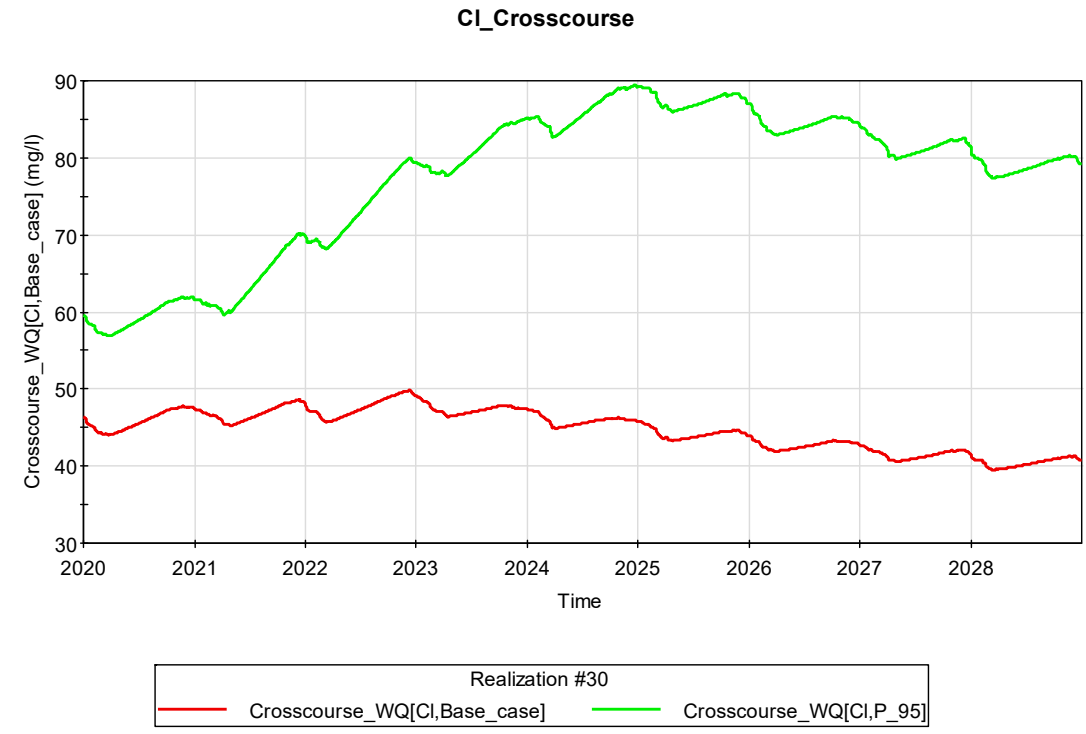


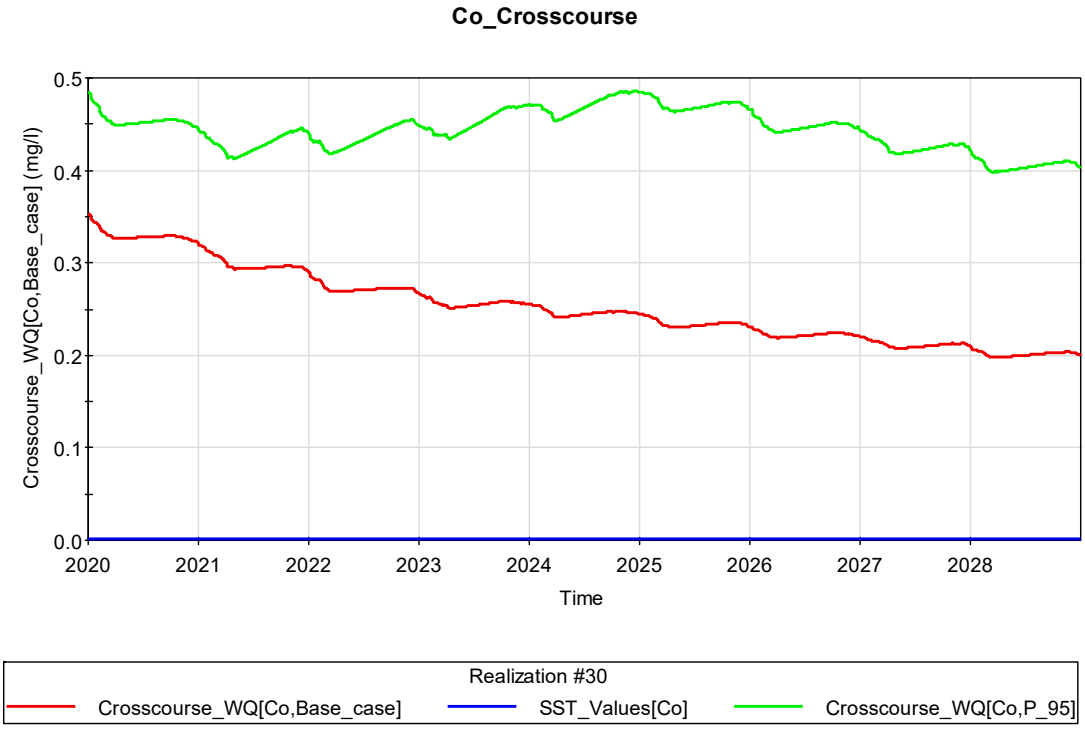


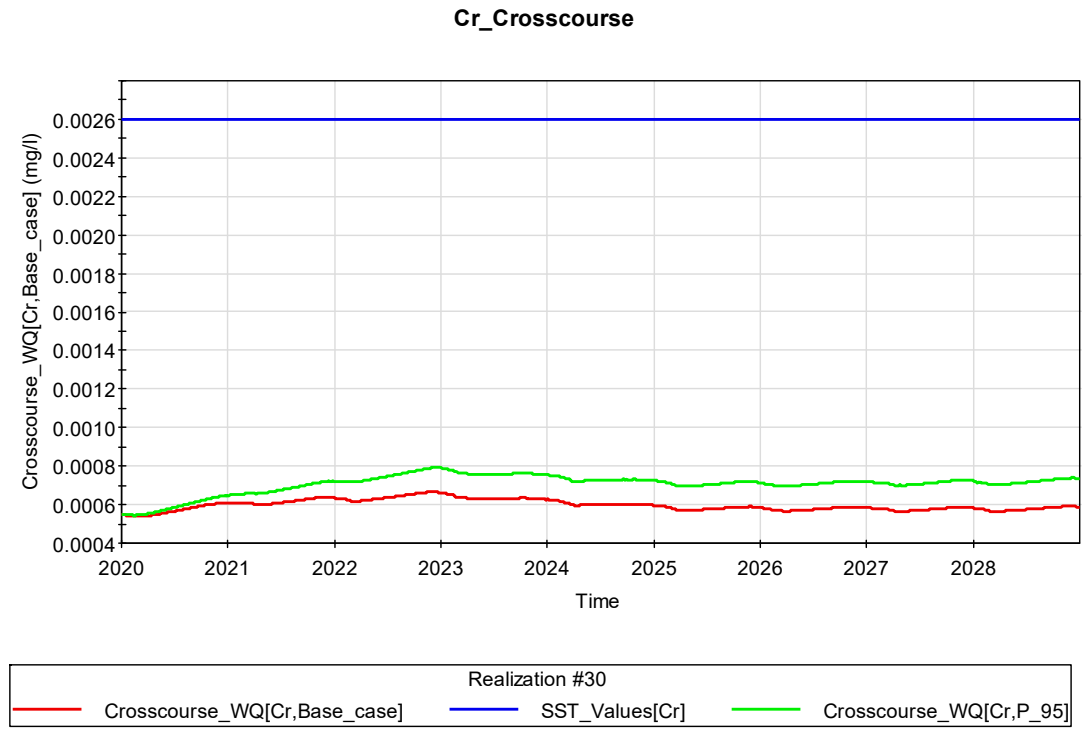

As_Crosscourse
Crosscourse_WQ[As,Base_case] (mg/l)
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1
2
3
4
5
6
7
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[As,Base_case]
SST_Values[As]
Crosscourse_WQ[As,P_95]

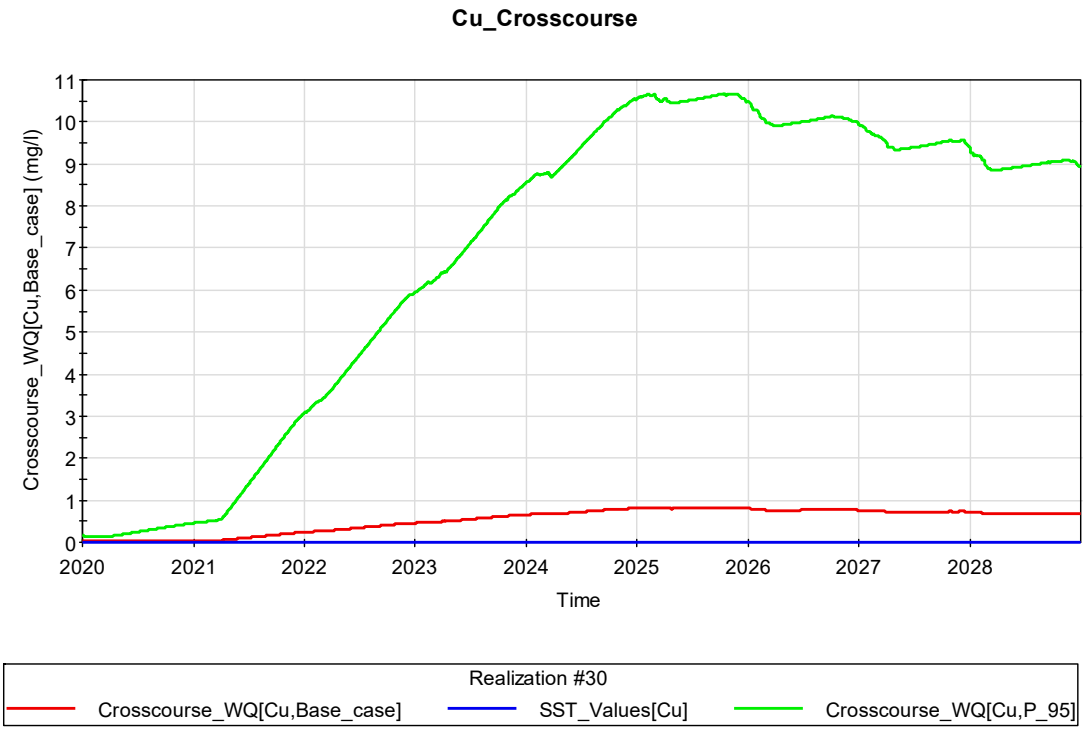

Ca_Crosscourse
Crosscourse_WQ[Ca,Base_case] (mg/l)
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160
180
200
220
240
260
280
300
320
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ca,Base_case]
Crosscourse_WQ[Ca,P_95]

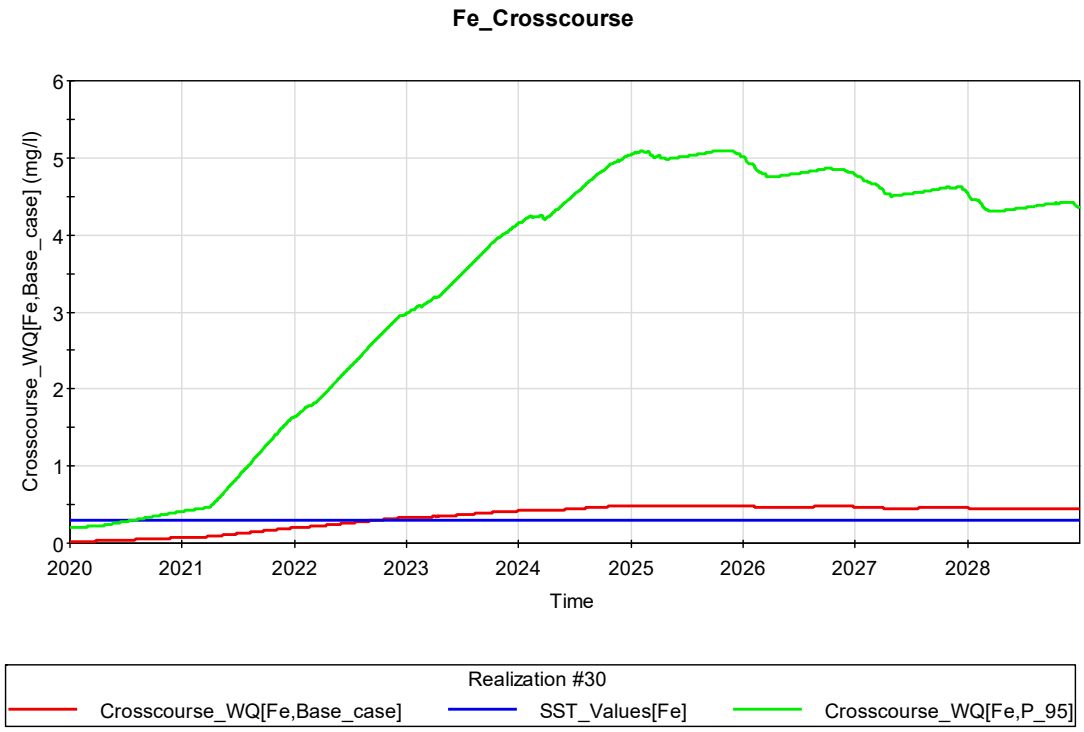

Cd_Crosscourse
Crosscourse_WQ[Cd,Base_case] (mg/l)
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0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cd,Base_case]
SST_Values[Cd]
Crosscourse_WQ[Cd,P_95]

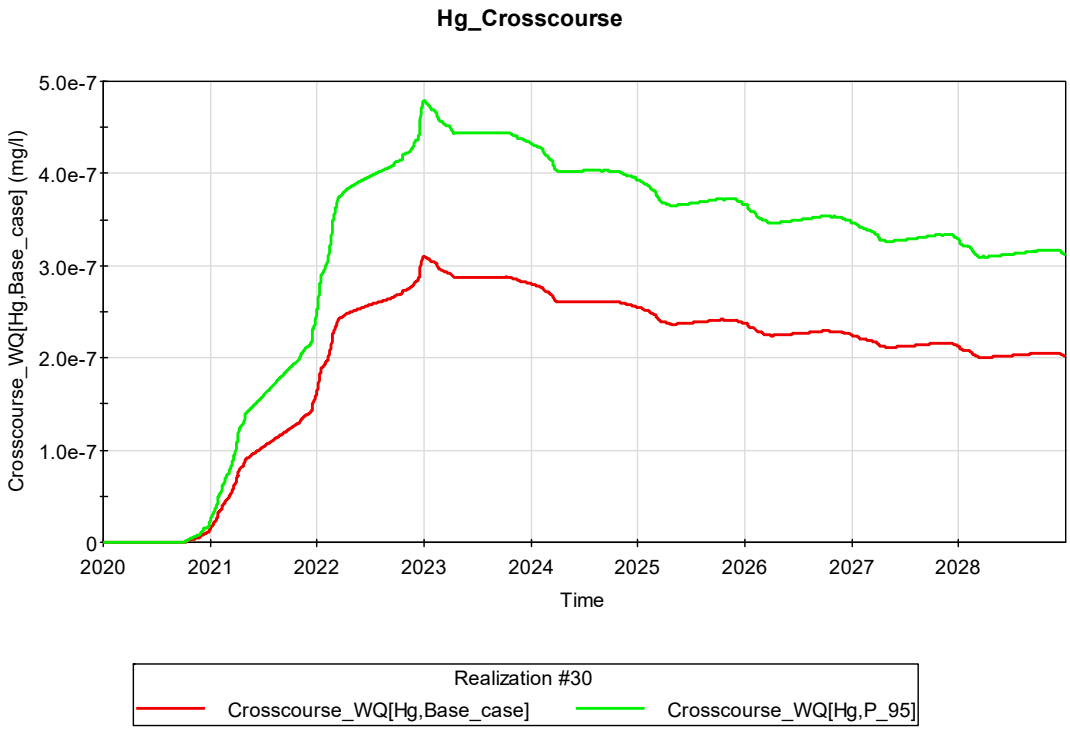

Cl_Crosscourse
Crosscourse_WQ[Cl,Base_case] (mg/l)
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80
70
60
50
40
30
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cl,Base_case]
Crosscourse_WQ[Cl,P_95]

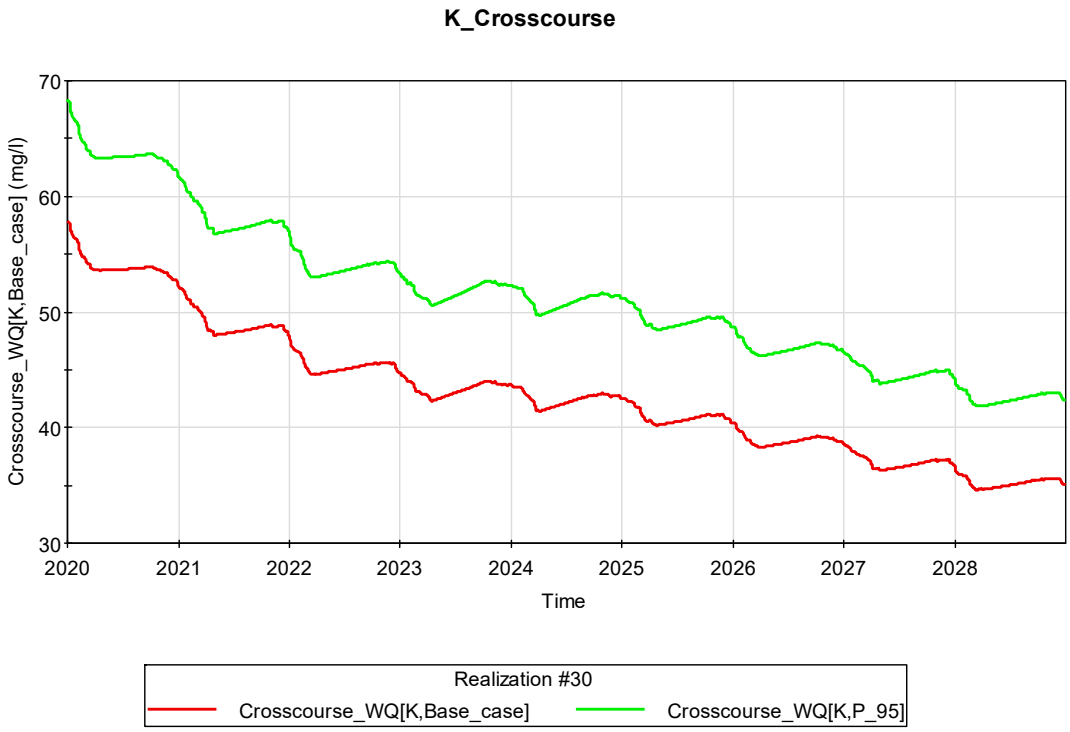

Co_Crosscourse
Crosscourse_WQ[Co,Base_case] (mg/l)
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0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
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SST_Values[Co]
Crosscourse_WQ[Co,P_95]

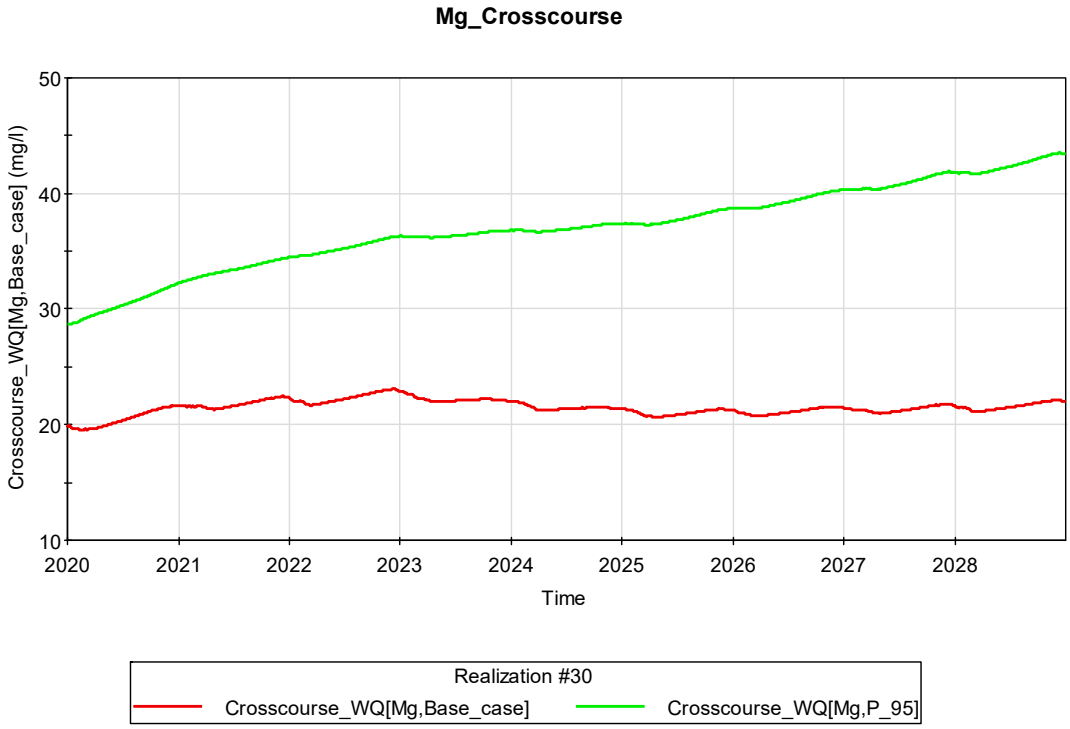

Cr_Crosscourse
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0.0020
0.0018
0.0016
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0.0012
0.0010
0.0008
0.0006
0.0004
2020
2021
2022
2023
2024
2025
2026
2027
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Time
Realization #30
Crosscourse_WQ[Cr,Base_case]
SST_Values[Cr]
Crosscourse_WQ[Cr,P_95]

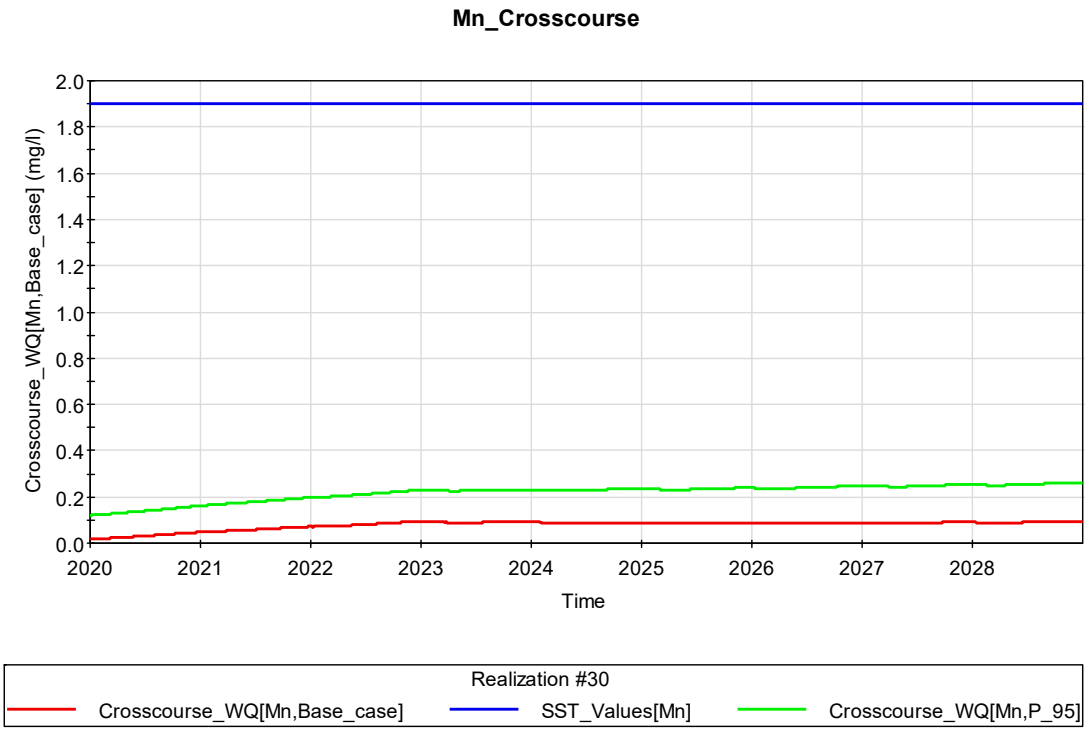

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Crosscourse_WQ[Cu,Base_case] (mg/l)
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10
9
8
7
6
5
4
3
2
1
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2021
2022
2023
2024
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Crosscourse_WQ[Cu,P_95]

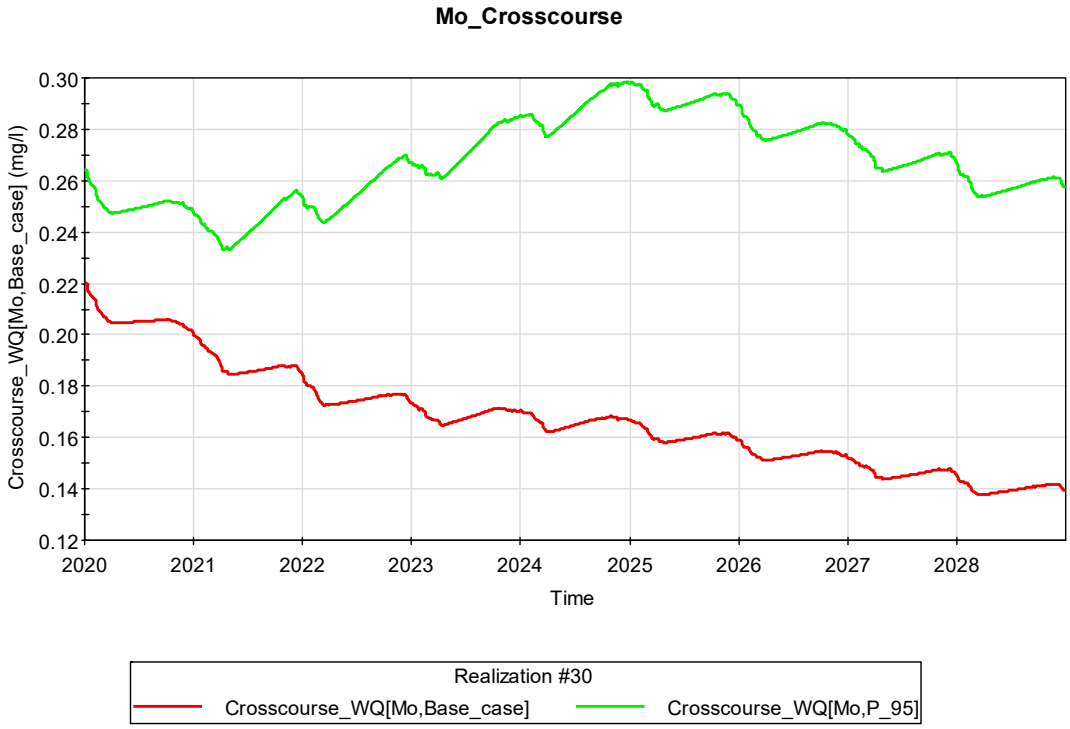

Fe_Crosscourse
Crosscourse_WQ[Fe,Base_case] (mg/l)
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5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
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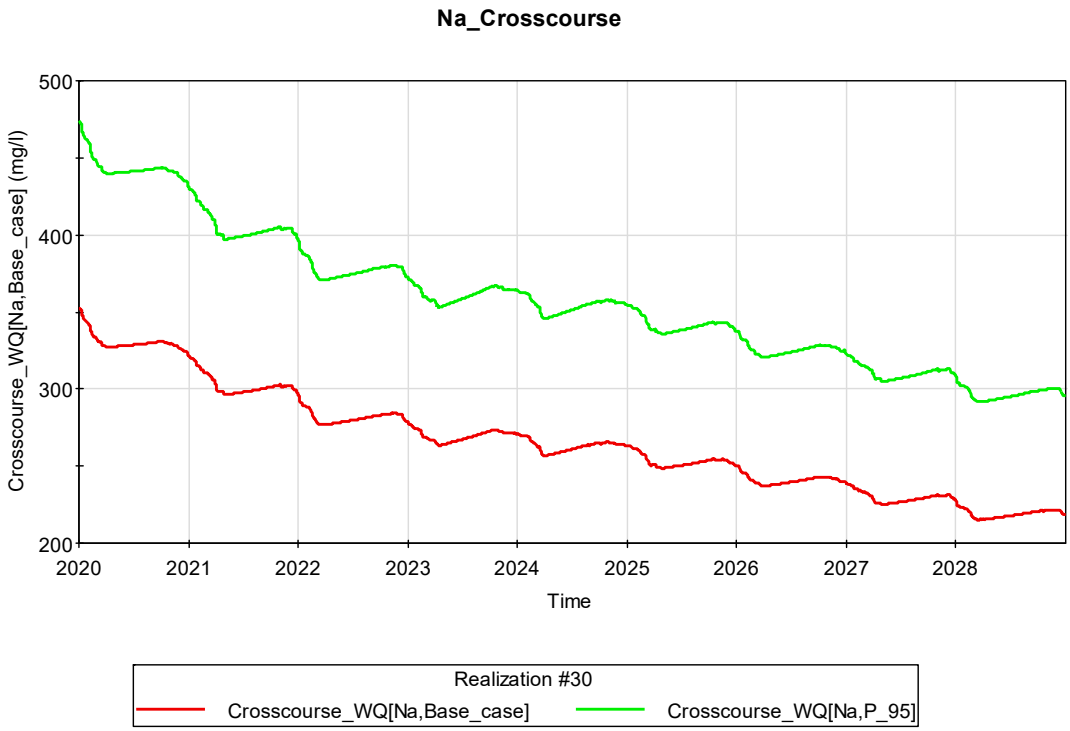

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4.0e-7
3.0e-7
2.0e-7
1.0e-7
0
Crosscourse_WQ[Hg,Base_case] (mg/l)
2020
2021
2022
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Crosscourse_WQ[Hg,P_95]

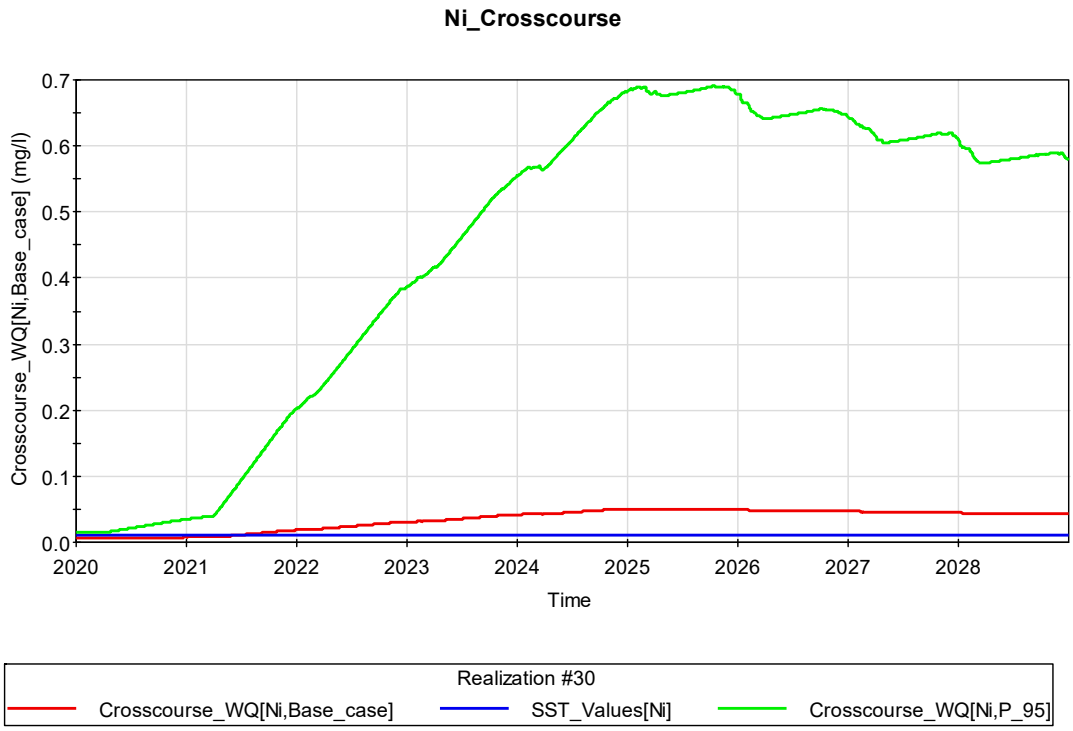

K_Crosscourse
70
60
50
40
30
Crosscourse_WQ[K,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[K,Base_case]
Crosscourse_WQ[K,P_95]

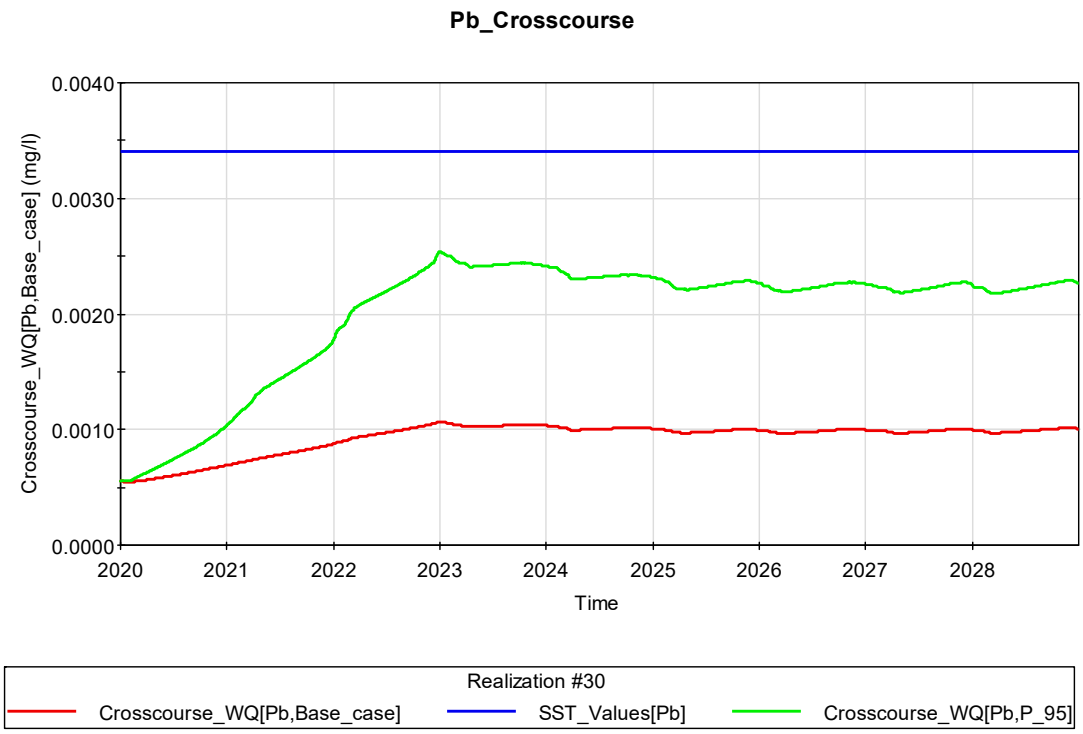

Mg_Crosscourse
Crosscourse_WQ[Mg,Base_case] (mg/l)
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40
30
20
10
2020
2021
2022
2023
2024
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2026
2027
2028
Time
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Crosscourse_WQ[Mg,Base_case]
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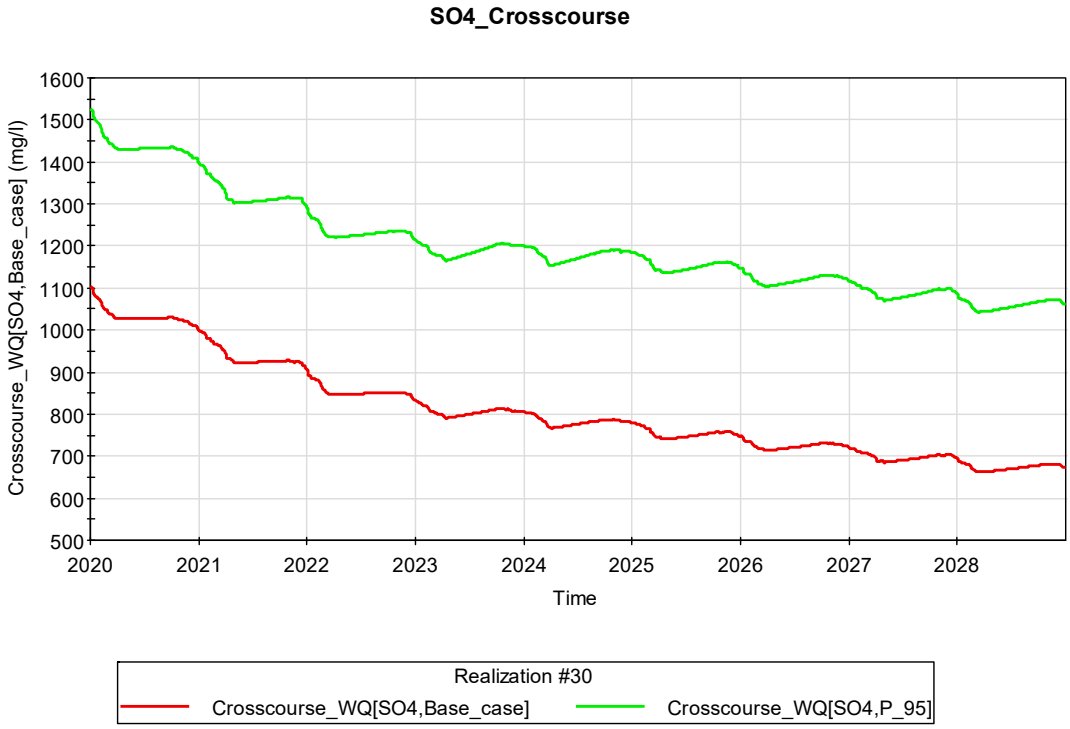

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1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mn,Base_case]
SST_Values[Mn]
Crosscourse_WQ[Mn,P_95]

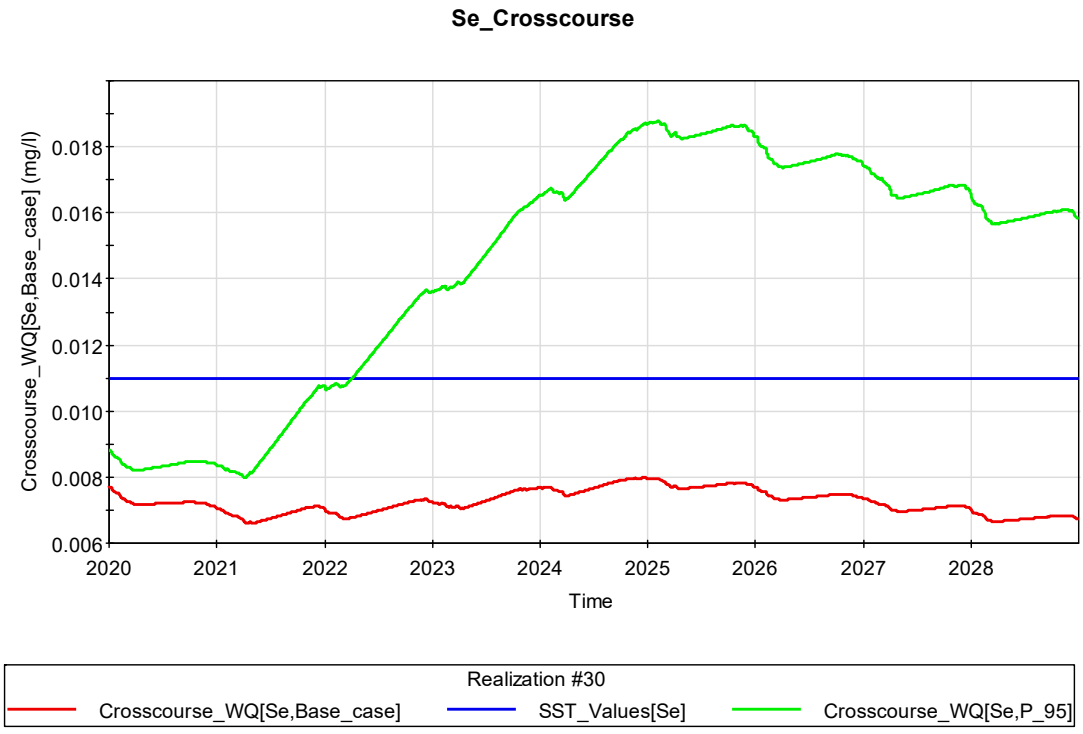

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0.22
0.20
0.18
0.16
0.14
0.12
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mo,Base_case]
Crosscourse_WQ[Mo,P_95]

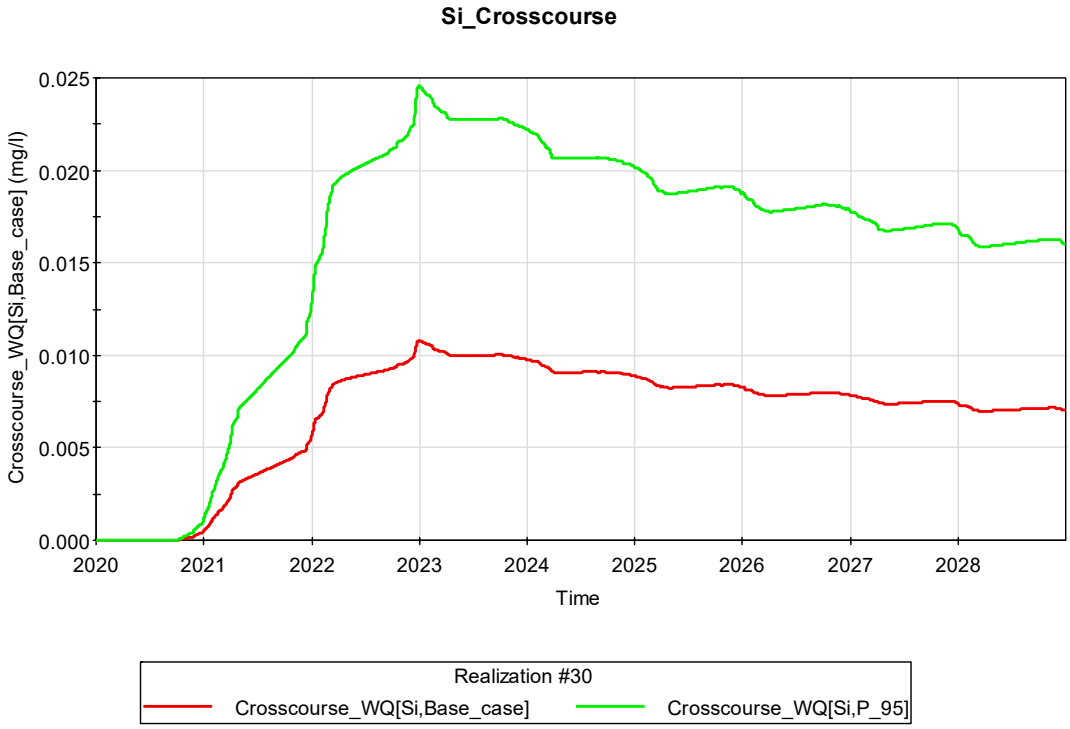

Na_Crosscourse
Crosscourse_WQ[Na,Base_case] (mg/l)
500
400
300
200
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Na,Base_case]
Crosscourse_WQ[Na,P_95]

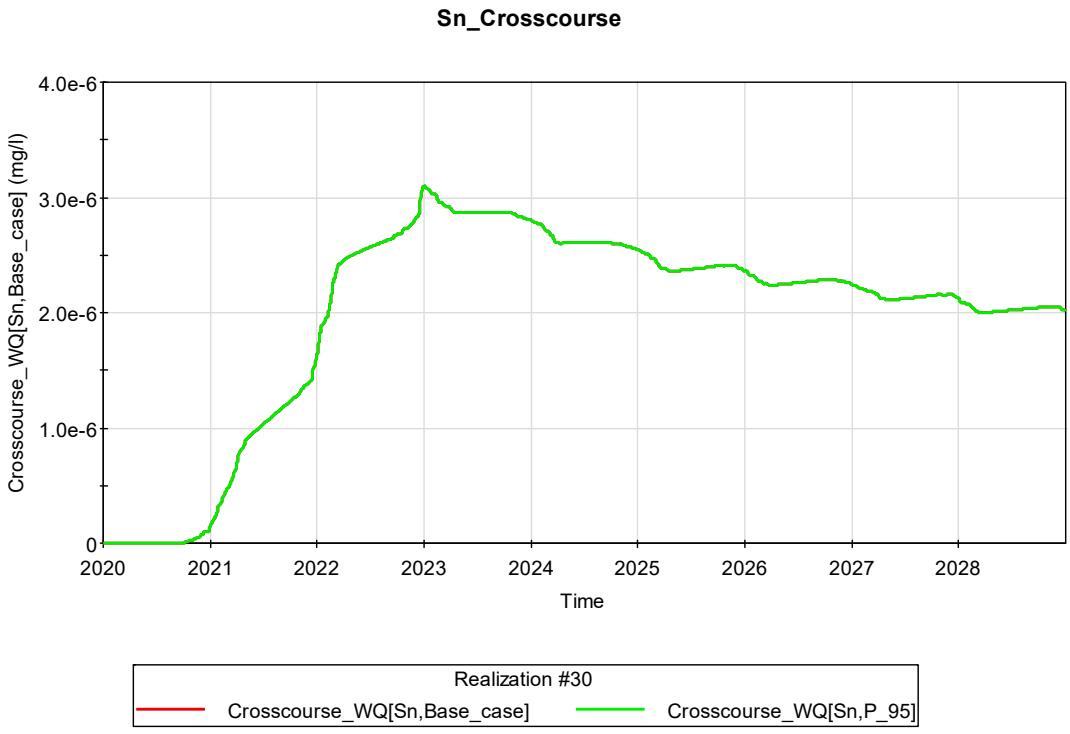

Ni_Crosscourse
Crosscourse_WQ[Ni,Base_case] (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ni,Base_case]
SST_Values[Ni]
Crosscourse_WQ[Ni,P_95]

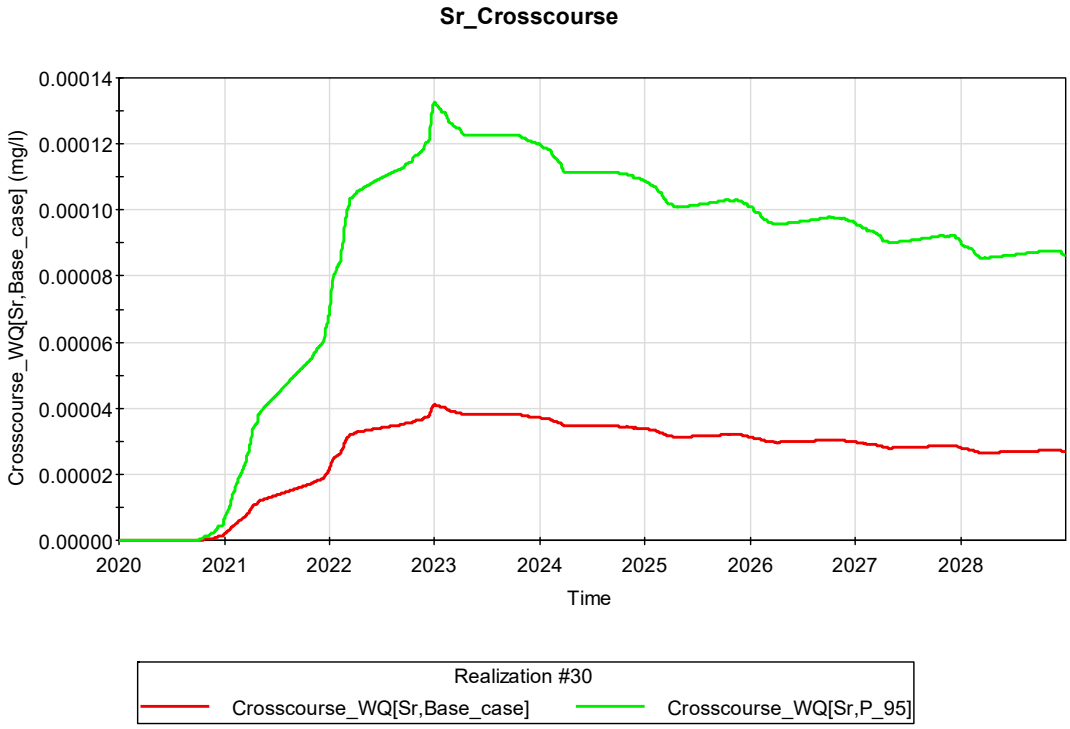

Pb_Crosscourse
Crosscourse_WQ[Pb,Base_case] (mg/l)
0.0040
0.0030
0.0020
0.0010
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Pb,Base_case]
SST_Values[Pb]
Crosscourse_WQ[Pb,P_95]

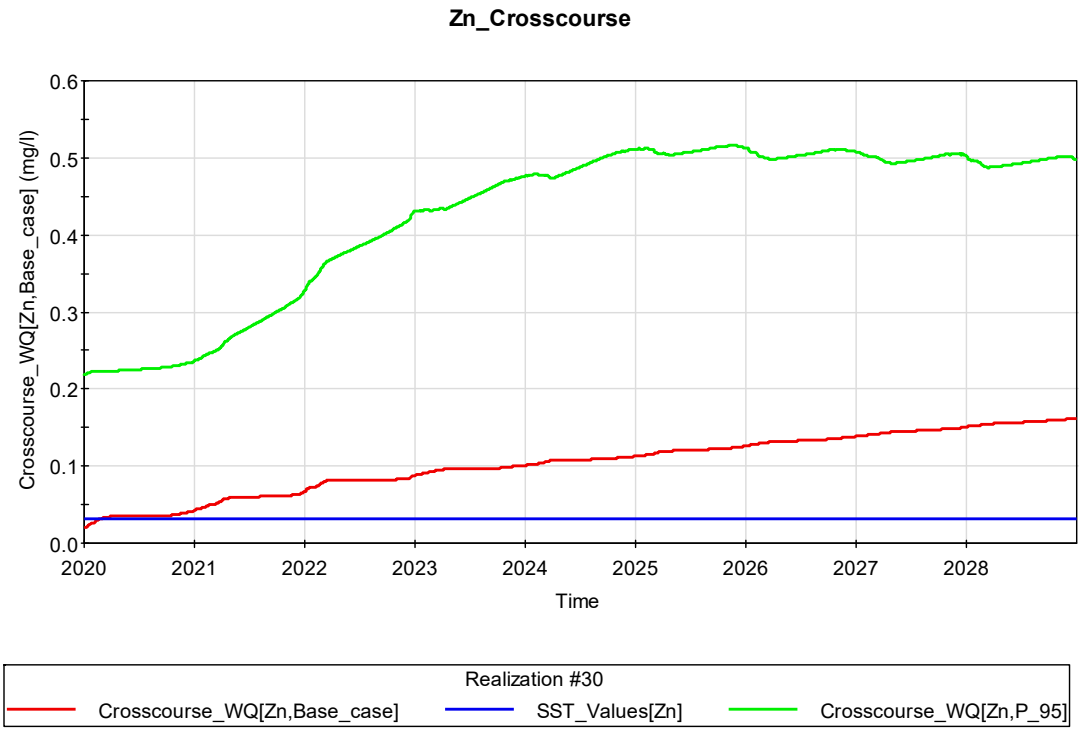

SO4_Crosscourse
Crosscourse_WQ[SO4,Base_case] (mg/l)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[SO4,Base_case]
Crosscourse_WQ[SO4,P_95]

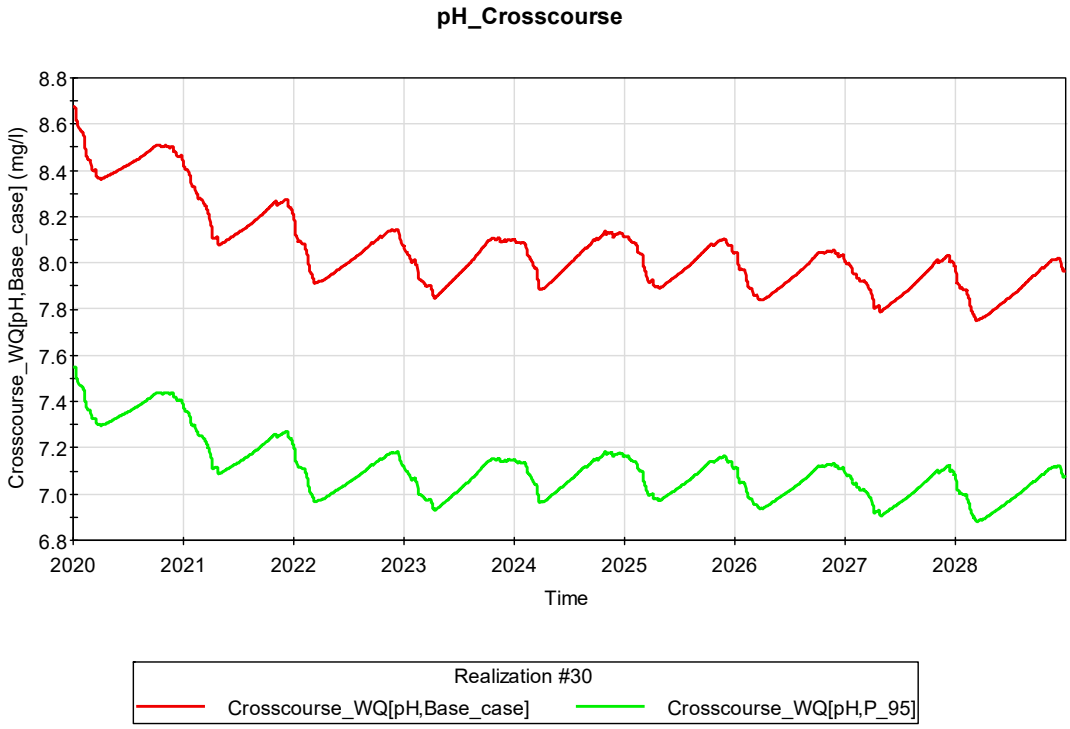

Se_Crosscourse
Crosscourse_WQ[Se,Base_case] (mg/l)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Se,Base_case]
SST_Values[Se]
Crosscourse_WQ[Se,P_95]


Si_Crosscourse
0.025
0.020
0.015
0.010
0.005
0.000
Crosscourse_WQ[Si,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Si,Base_case]
Crosscourse_WQ[Si,P_95]

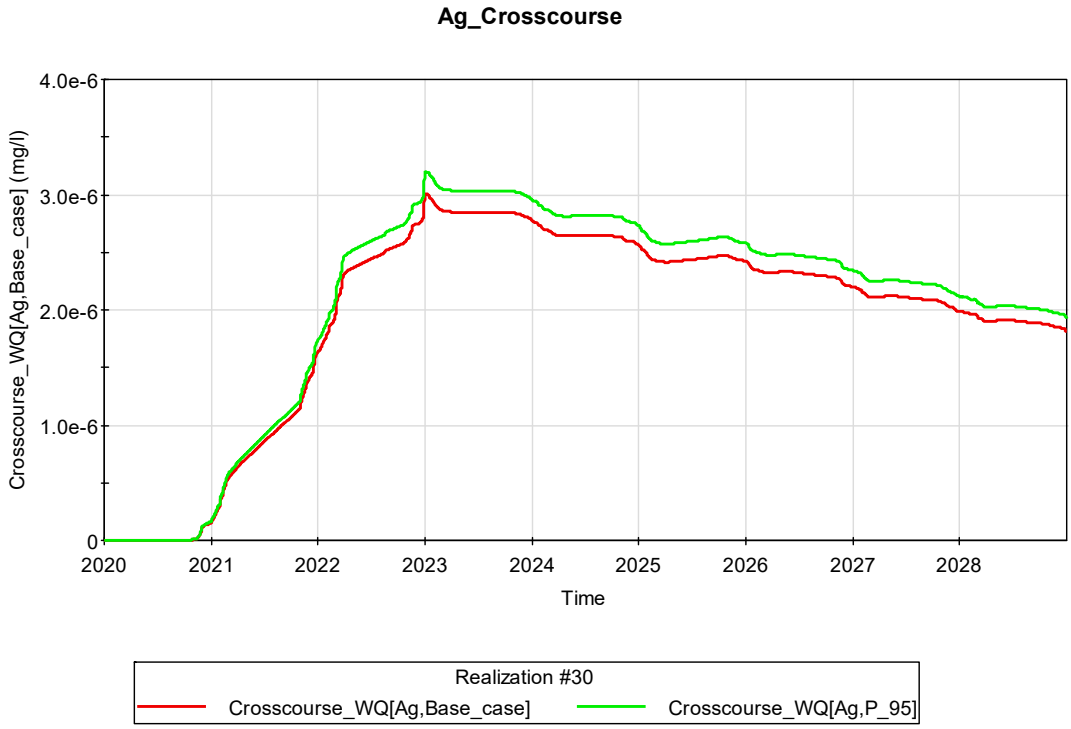

Sn_Crosscourse
4.0e-6
3.0e-6
2.0e-6
1.0e-6
0
Crosscourse_WQ[Sn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sn,Base_case]
Crosscourse_WQ[Sn,P_95]

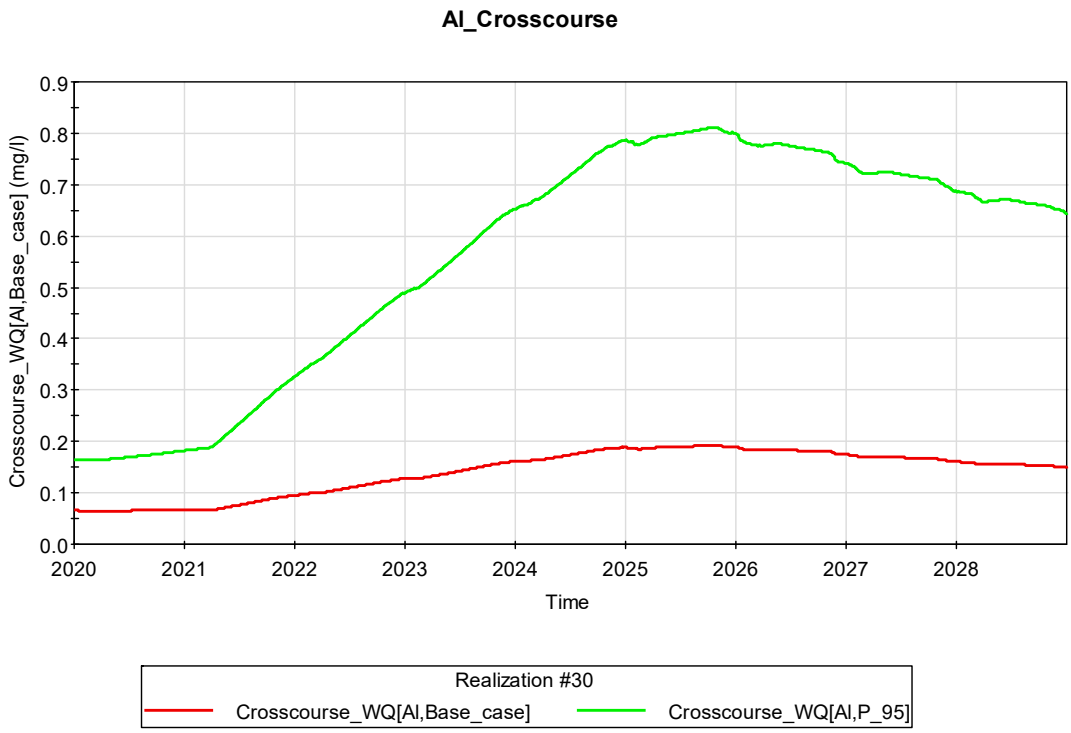

Sr_Crosscourse
0.00014
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Crosscourse_WQ[Sr,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sr,Base_case]
Crosscourse_WQ[Sr,P_95]

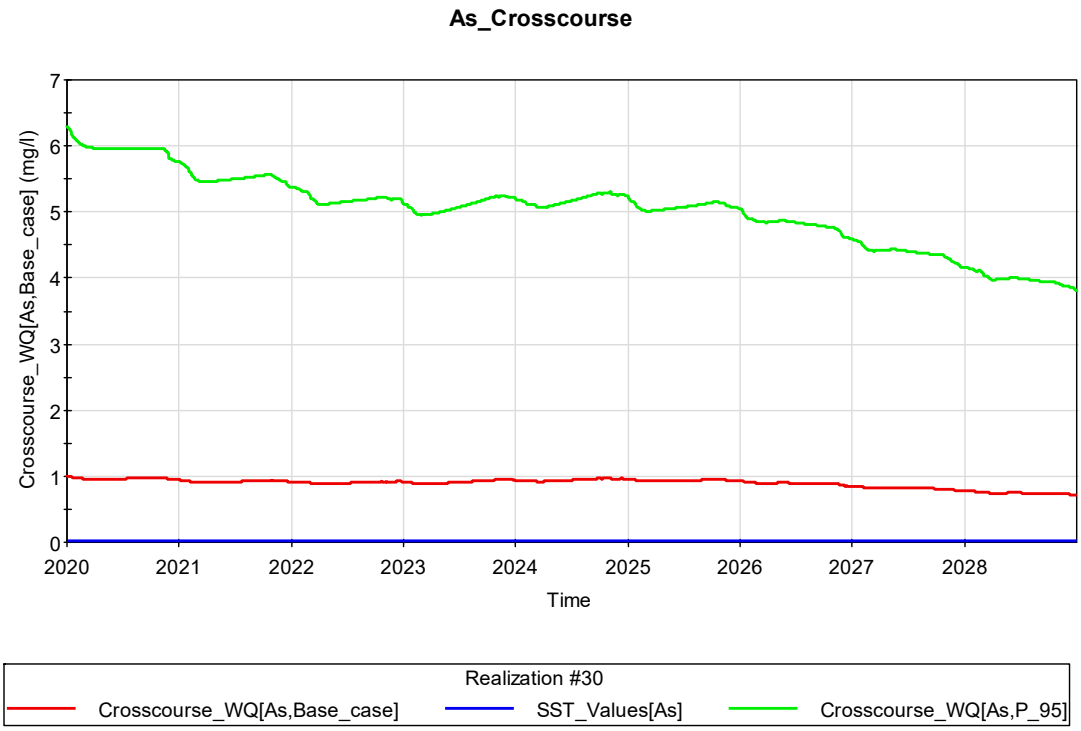

Zn_Crosscourse
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Zn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Zn,Base_case]
SST_Values[Zn]
Crosscourse_WQ[Zn,P_95]

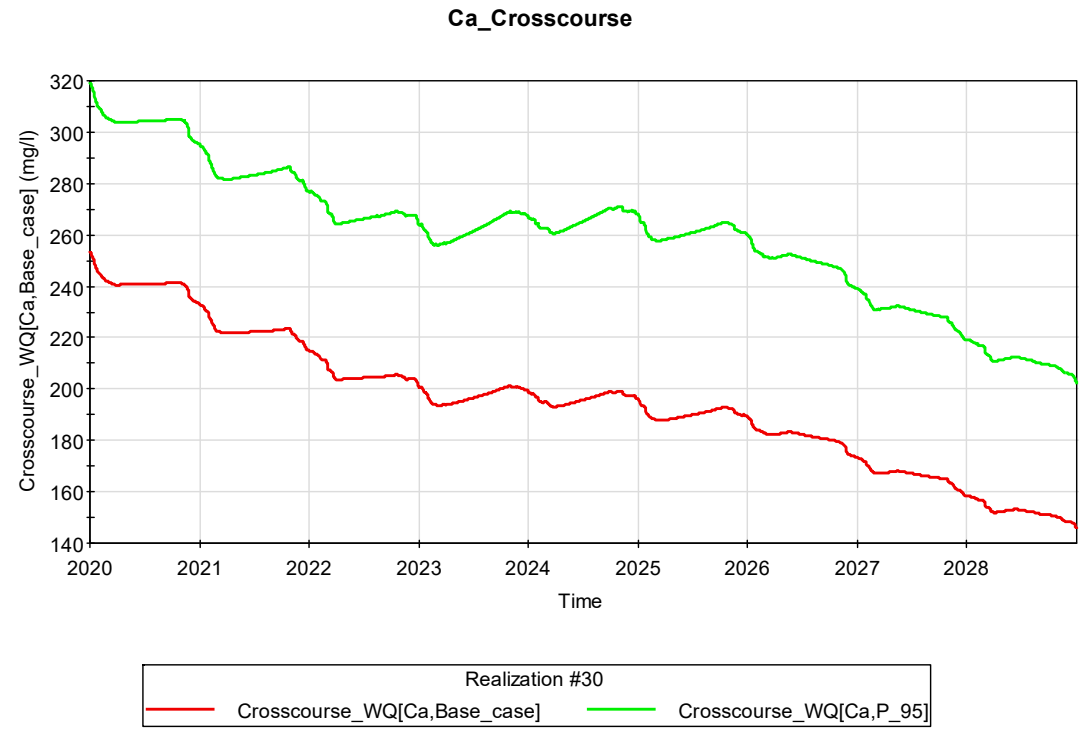

pH_Crosscourse
Crosscourse_WQ[pH,Base_case] (mg/l)
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[pH,Base_case]
Crosscourse_WQ[pH,P_95]

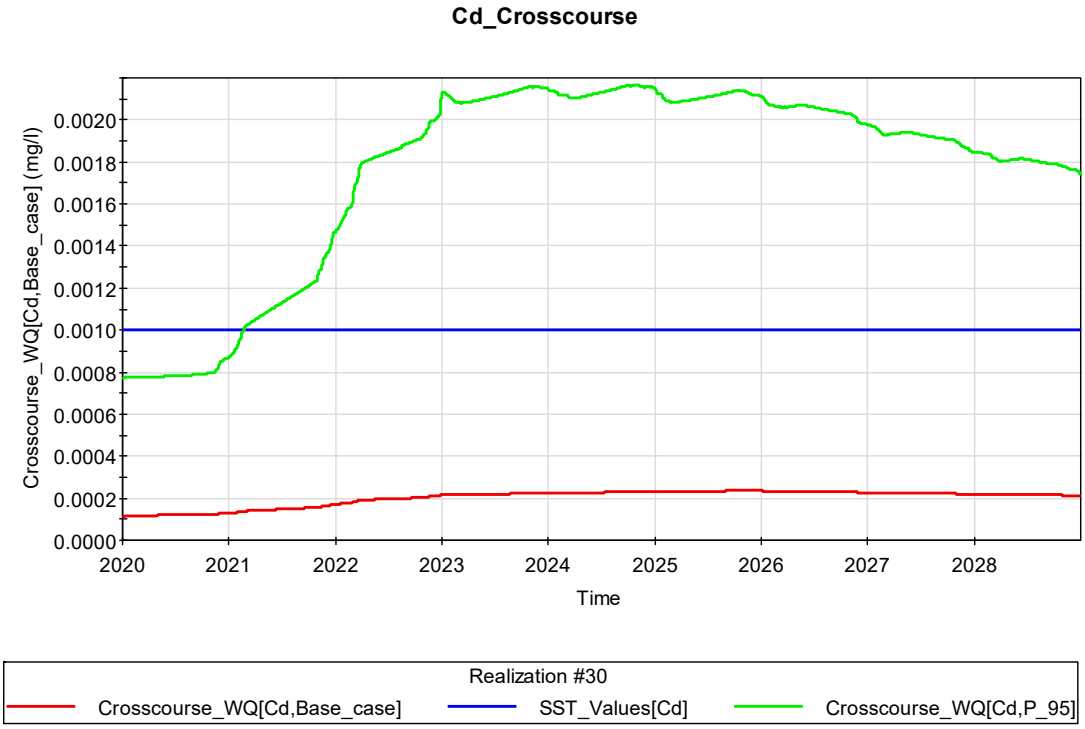
Median climate, with discharge

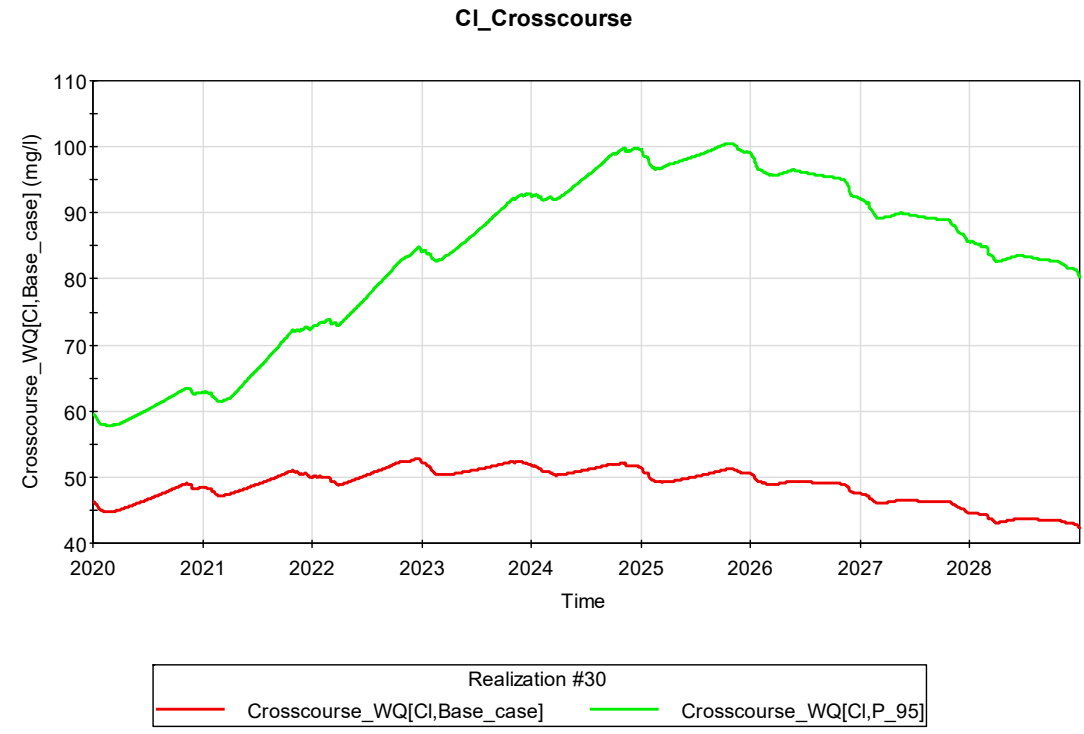


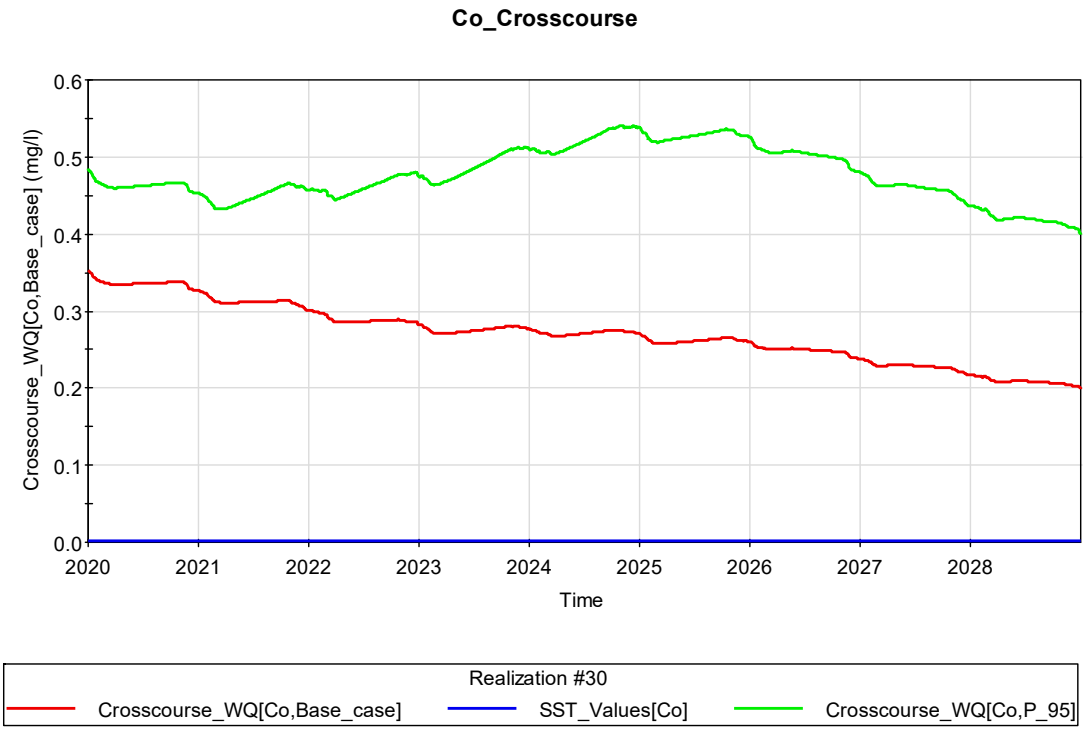


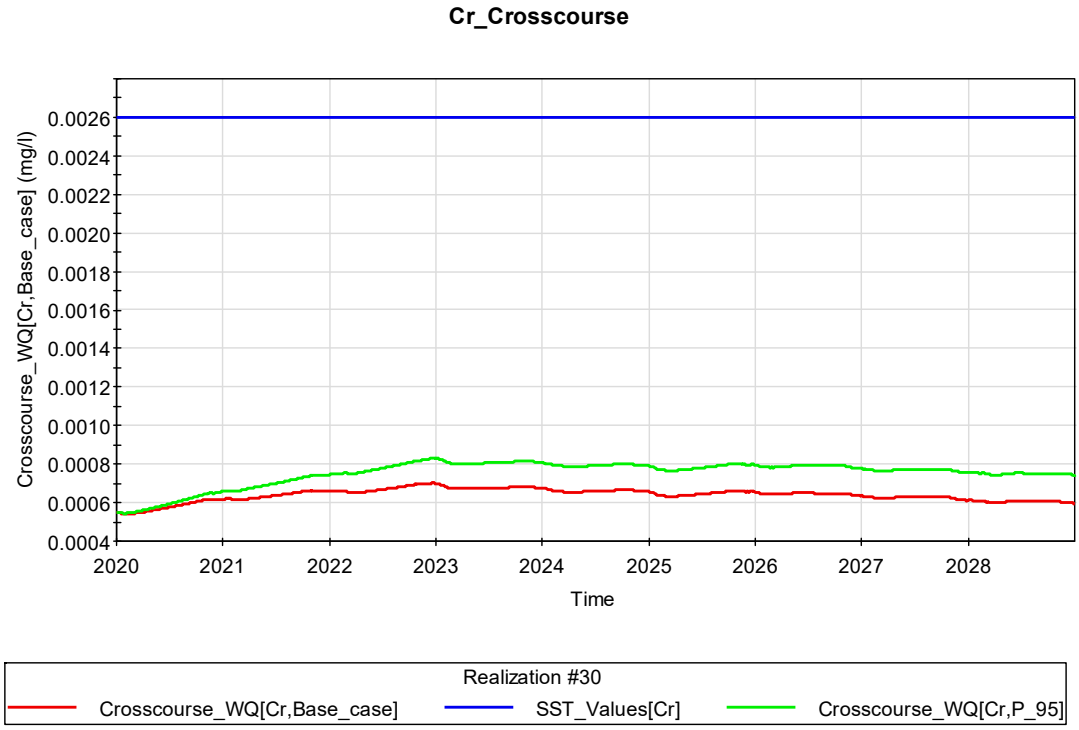

As_Crosscourse
Crosscourse_WQ[As,Base_case] (mg/l)
0
1
2
3
4
5
6
7
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[As,Base_case]
SST_Values[As]
Crosscourse_WQ[As,P_95]

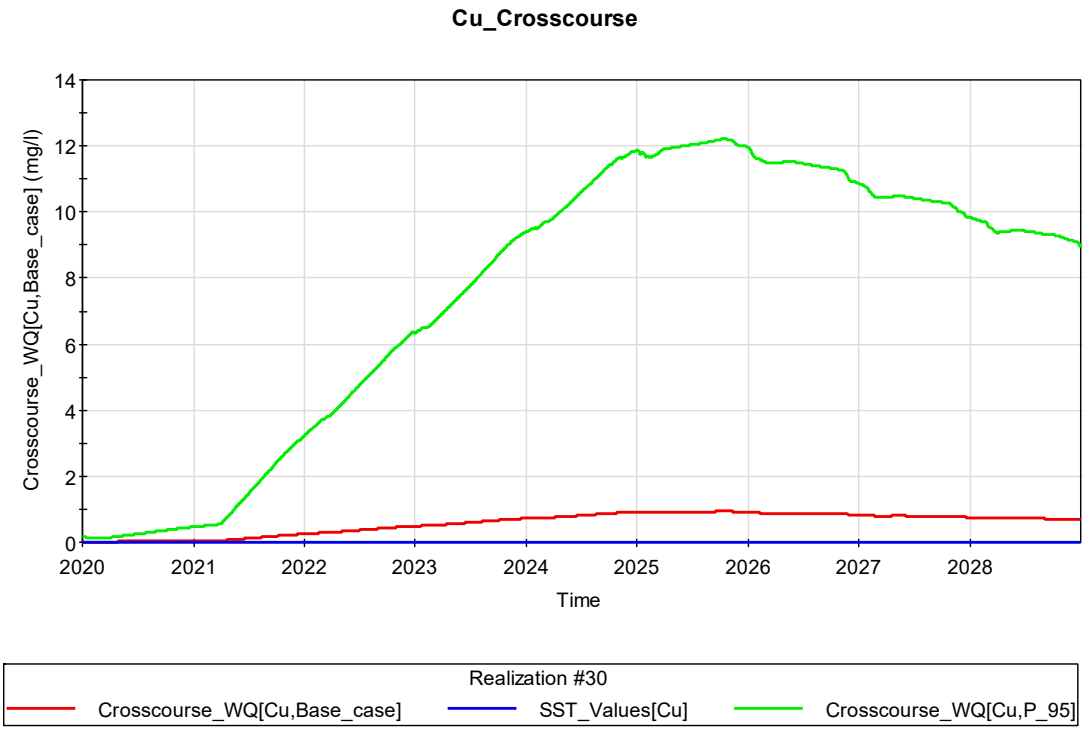

Ca_Crosscourse
Crosscourse_WQ[Ca,Base_case] (mg/l)
140
160
180
200
220
240
260
280
300
320
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ca,Base_case]
Crosscourse_WQ[Ca,P_95]

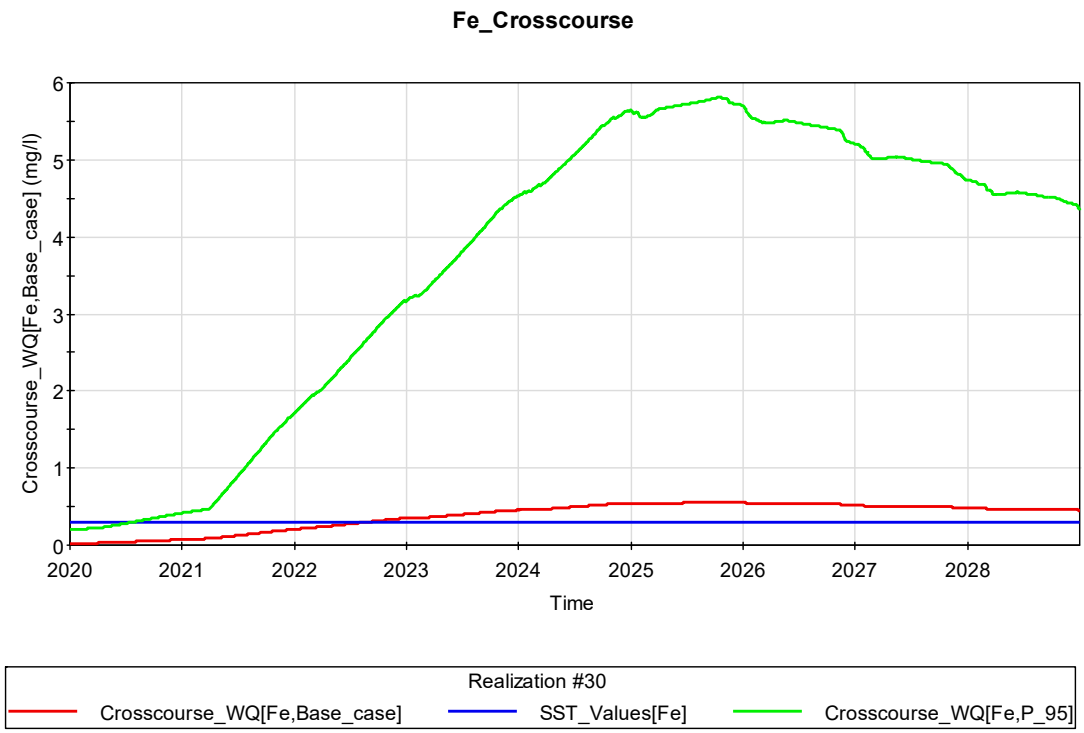

Cd_Crosscourse
Crosscourse_WQ[Cd,Base_case] (mg/l)
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cd,Base_case]
SST_Values[Cd]
Crosscourse_WQ[Cd,P_95]

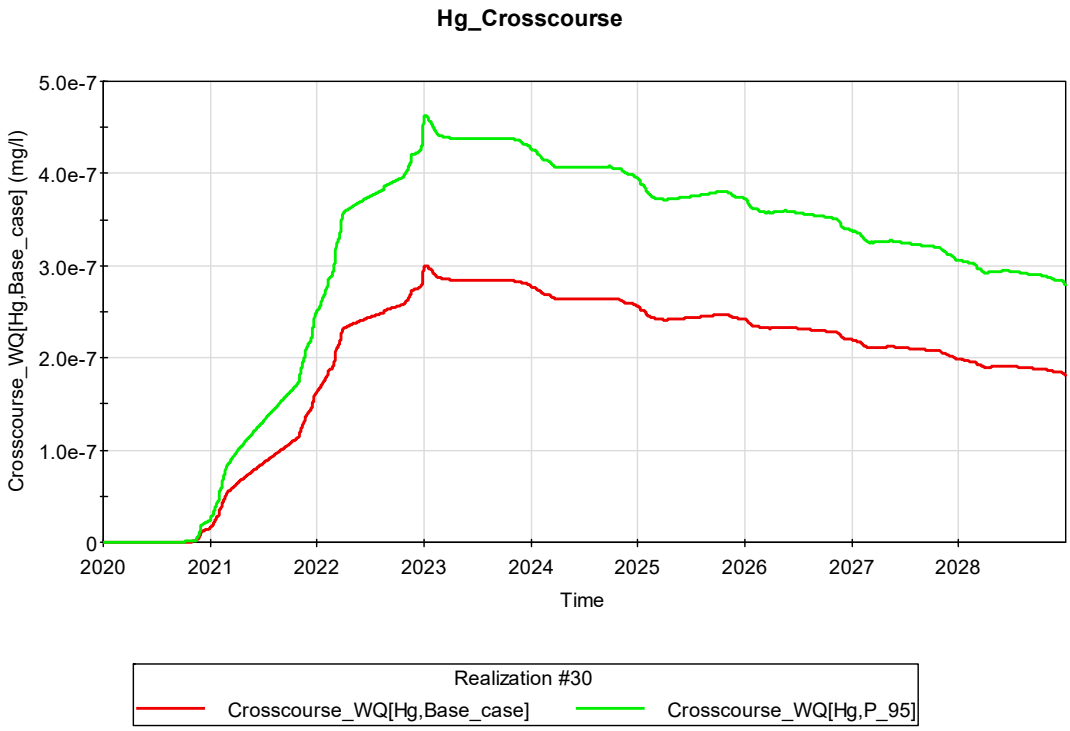

Cl_Crosscourse
Crosscourse_WQ[Cl,Base_case] (mg/l)
110
100
90
80
70
60
50
40
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cl,Base_case]
Crosscourse_WQ[Cl,P_95]

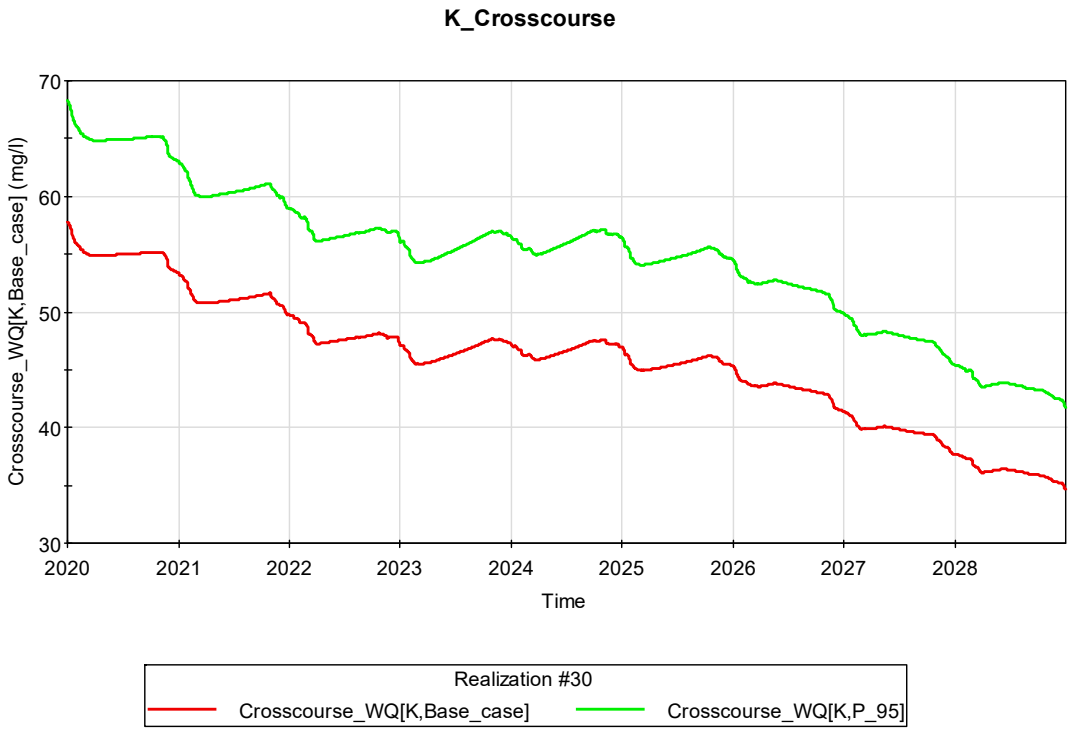

Co_Crosscourse
Crosscourse_WQ[Co,Base_case] (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Co,Base_case]
SST_Values[Co]
Crosscourse_WQ[Co,P_95]

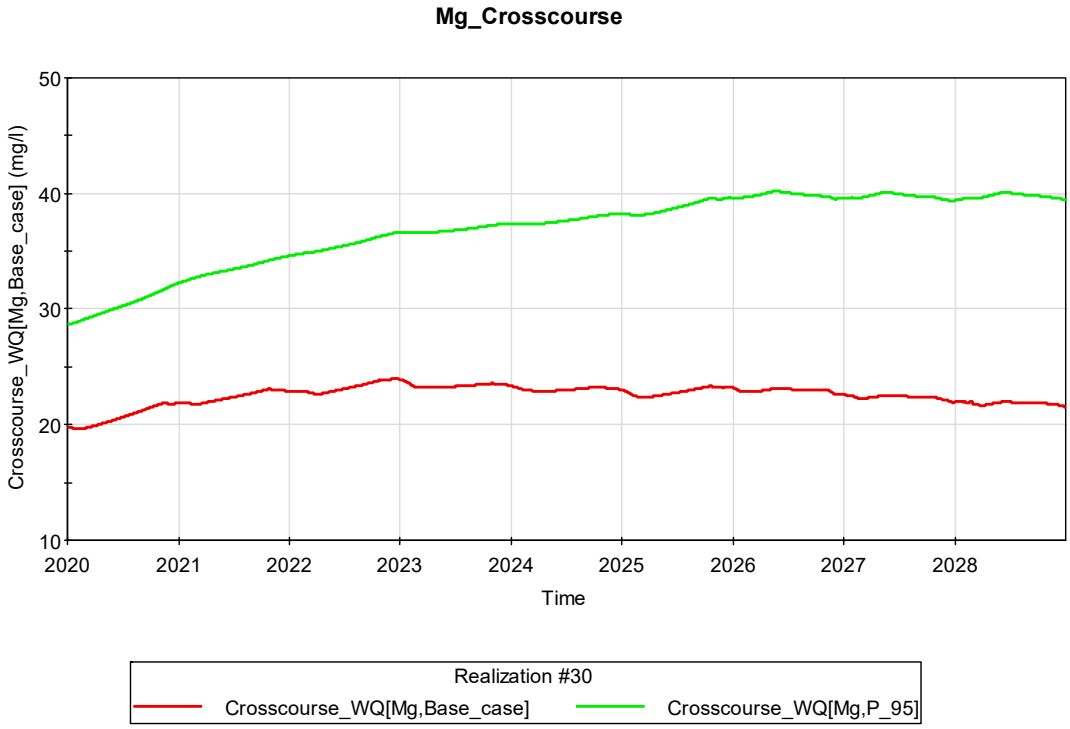

Cr_Crosscourse
Crosscourse_WQ[Cr,Base_case] (mg/l)
0.0026
0.0024
0.0022
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cr,Base_case]
SST_Values[Cr]
Crosscourse_WQ[Cr,P_95]

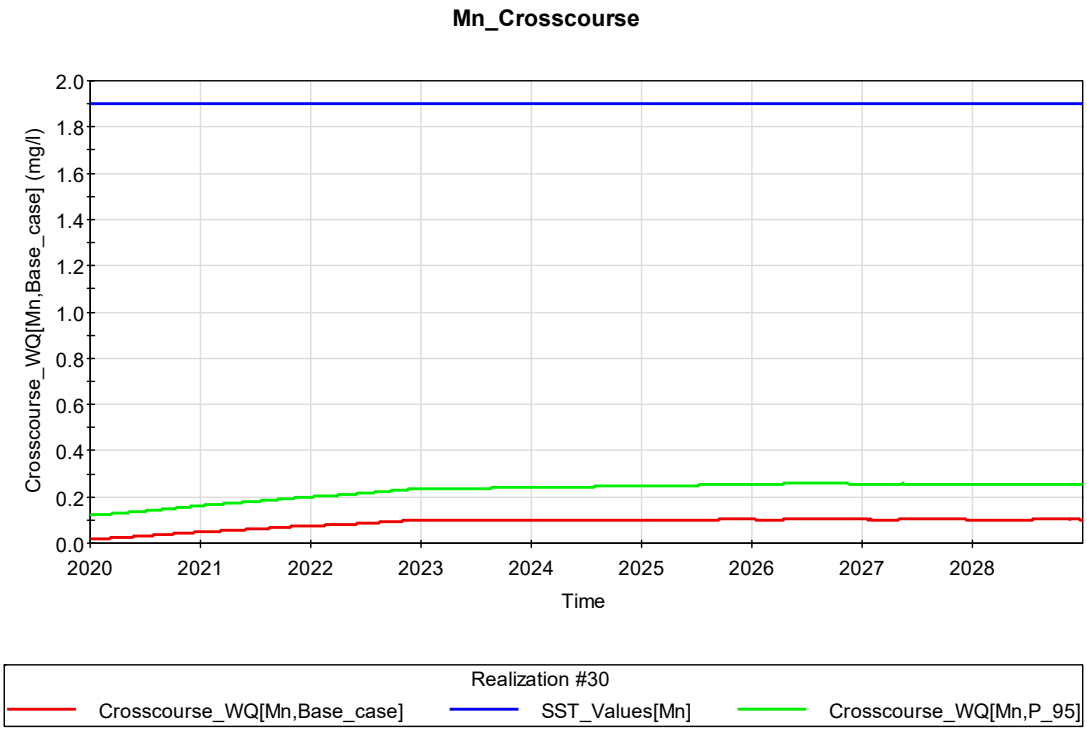

Cu_Crosscourse
Crosscourse_WQ[Cu,Base_case] (mg/l)
14
12
10
8
6
4
2
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cu,Base_case]
SST_Values[Cu]
Crosscourse_WQ[Cu,P_95]

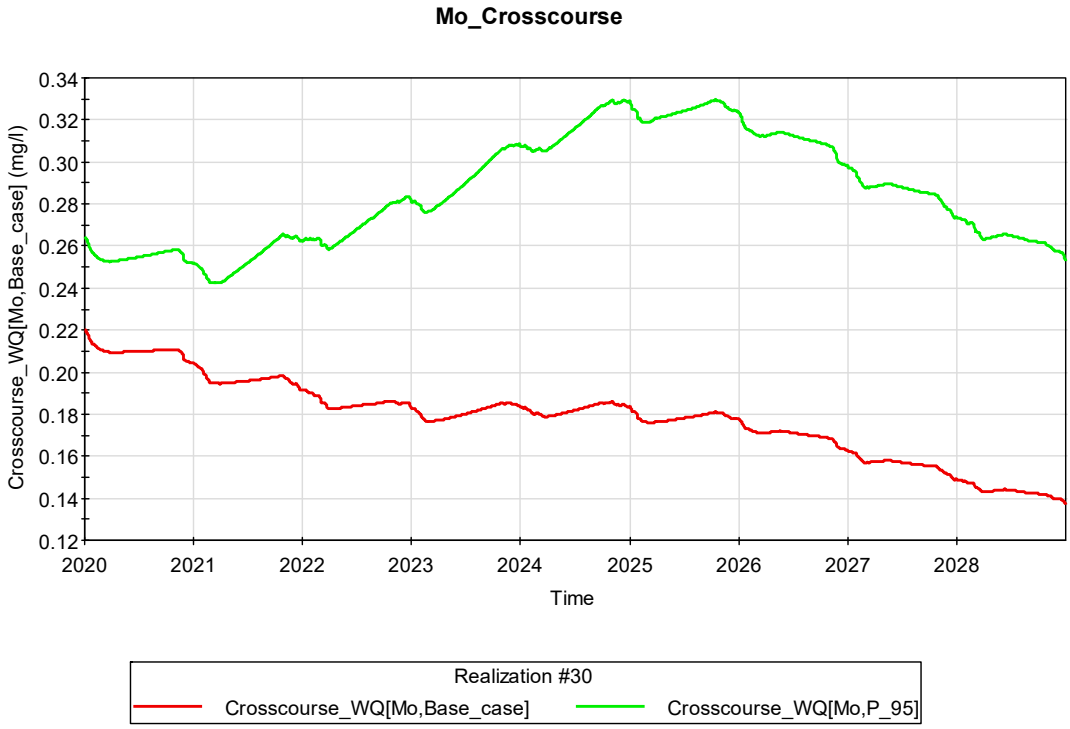

Fe_Crosscourse
Crosscourse_WQ[Fe,Base_case] (mg/l)
6
5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Fe,Base_case]
SST_Values[Fe]
Crosscourse_WQ[Fe,P_95]

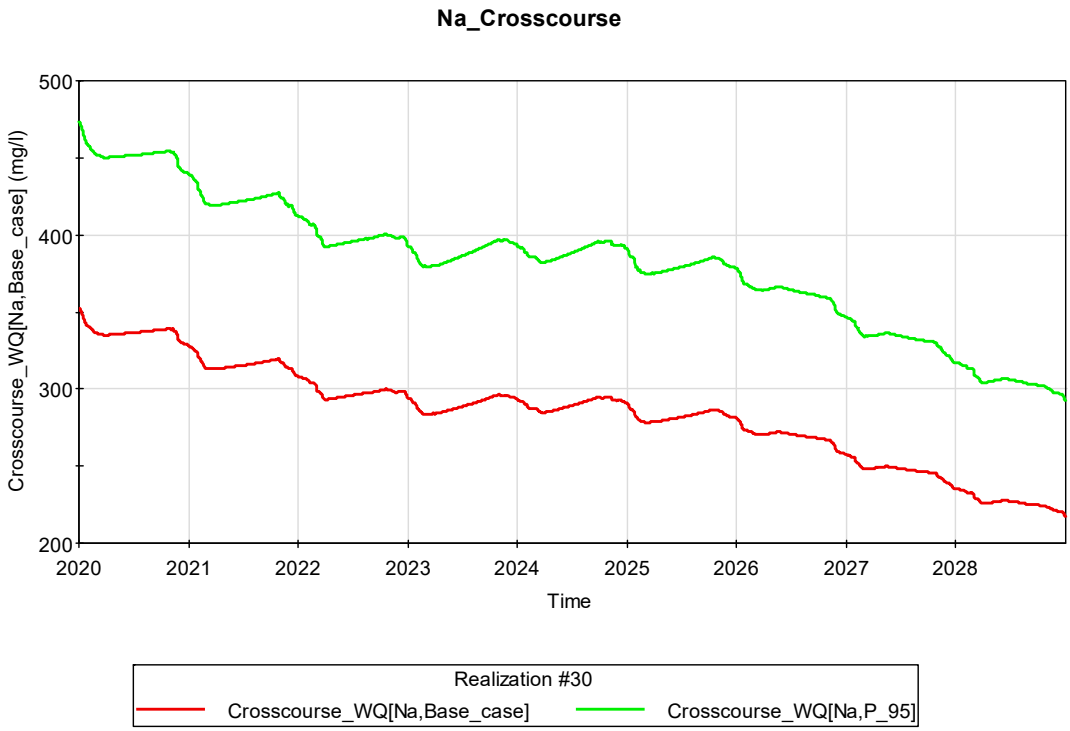

Hg_Crosscourse
5.0e-7
4.0e-7
3.0e-7
2.0e-7
1.0e-7
0
Crosscourse_WQ[Hg,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Hg,Base_case]
Crosscourse_WQ[Hg,P_95]

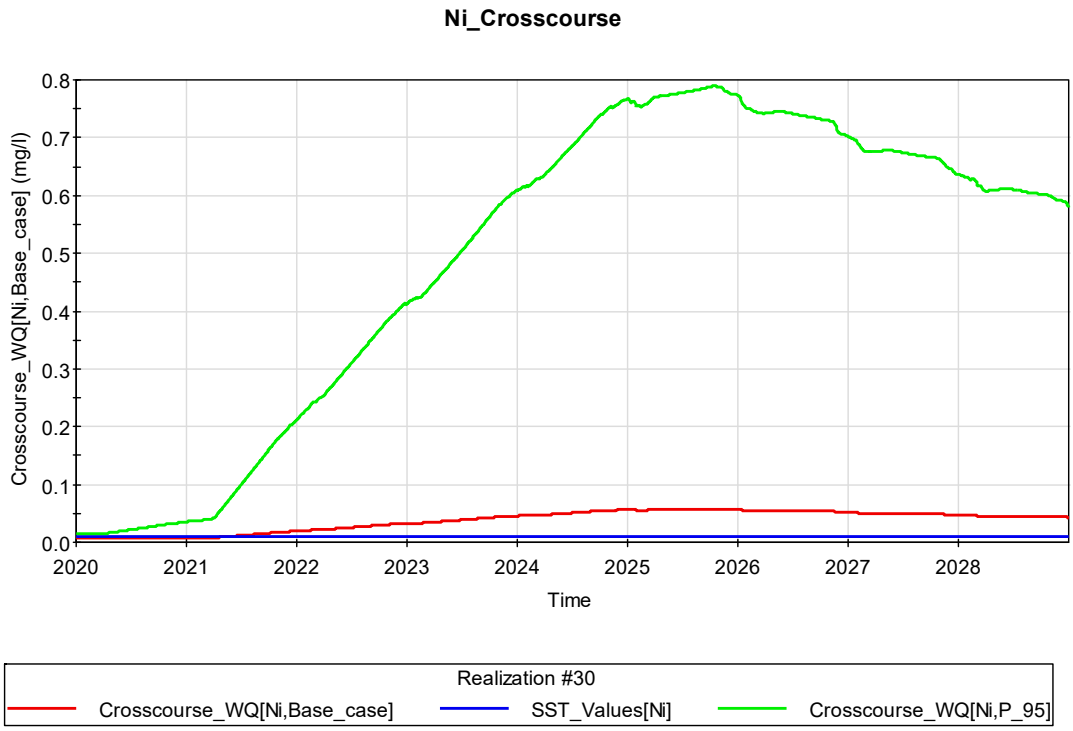

K_Crosscourse
70
60
50
40
30
Crosscourse_WQ[K,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[K,Base_case]
Crosscourse_WQ[K,P_95]

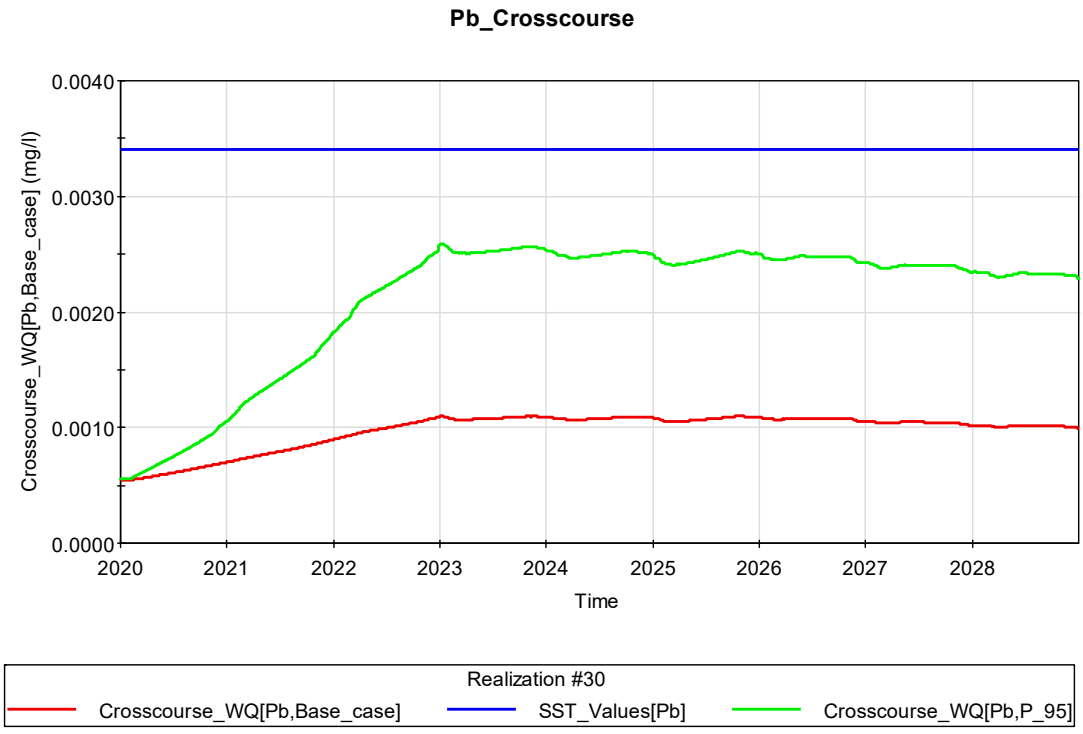

Mg_Crosscourse
Crosscourse_WQ[Mg,Base_case] (mg/l)
50
40
30
20
10
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mg,Base_case]
Crosscourse_WQ[Mg,P_95]

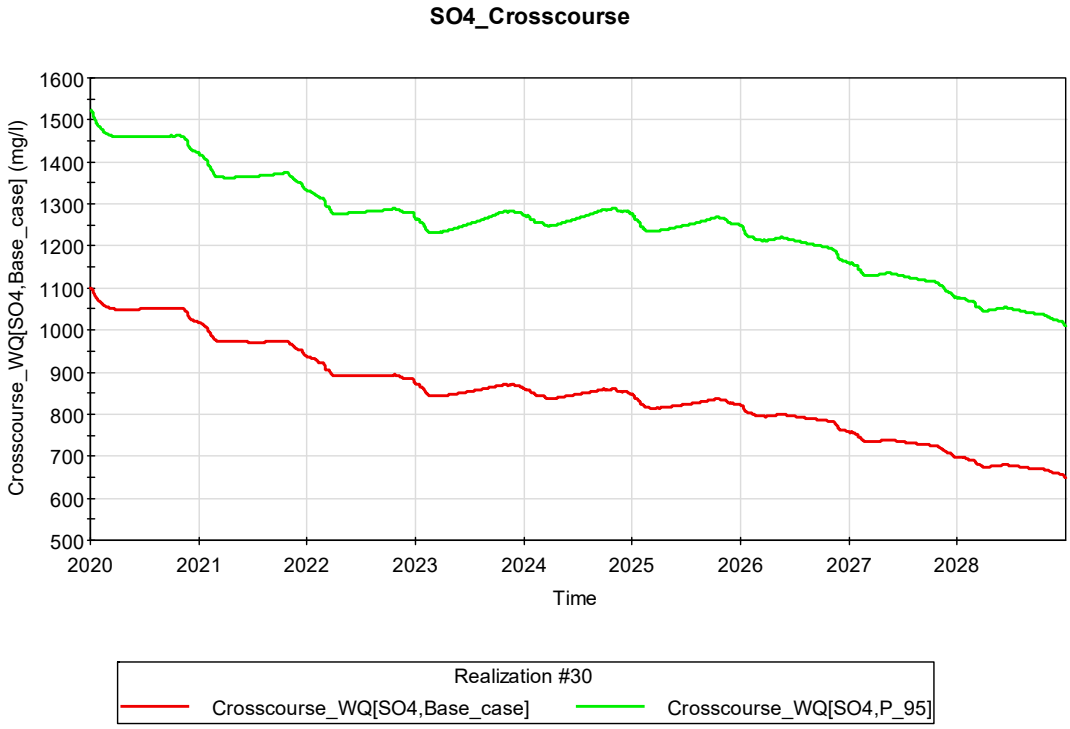

Mn_Crosscourse
Crosscourse_WQ[Mn,Base_case] (mg/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mn,Base_case]
SST_Values[Mn]
Crosscourse_WQ[Mn,P_95]

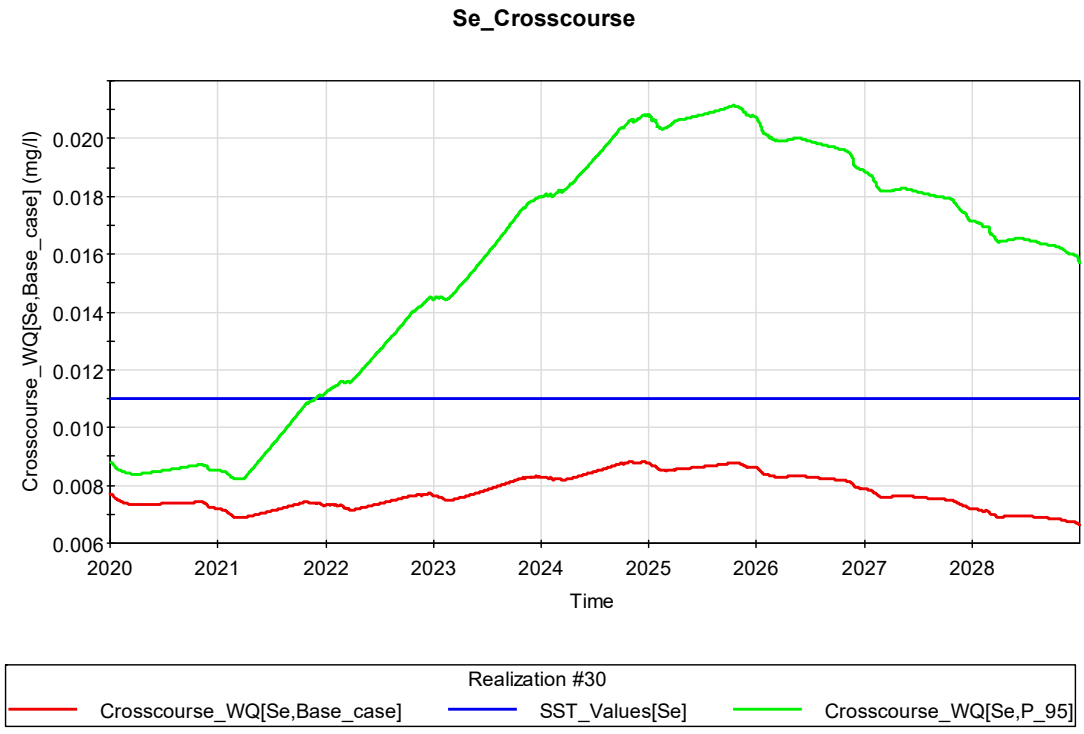

Mo_Crosscourse
Crosscourse_WQ[Mo,Base_case] (mg/l)
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mo,Base_case]
Crosscourse_WQ[Mo,P_95]

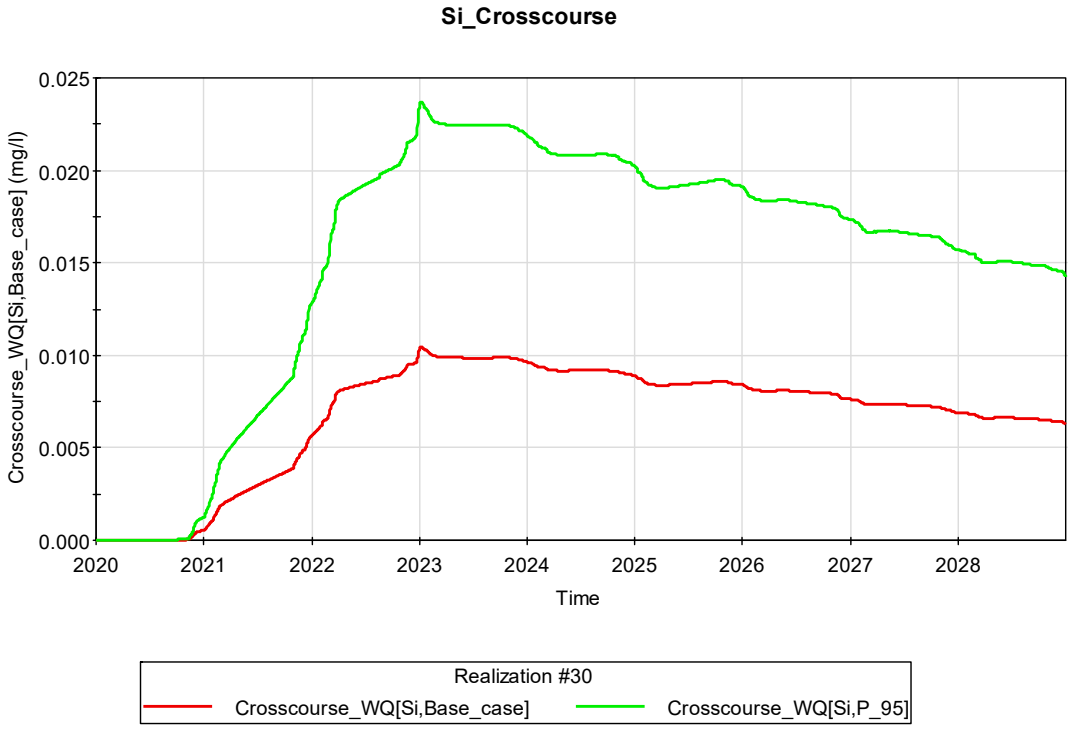

Na_Crosscourse
Crosscourse_WQ[Na,Base_case] (mg/l)
500
400
300
200
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Na,Base_case]
Crosscourse_WQ[Na,P_95]

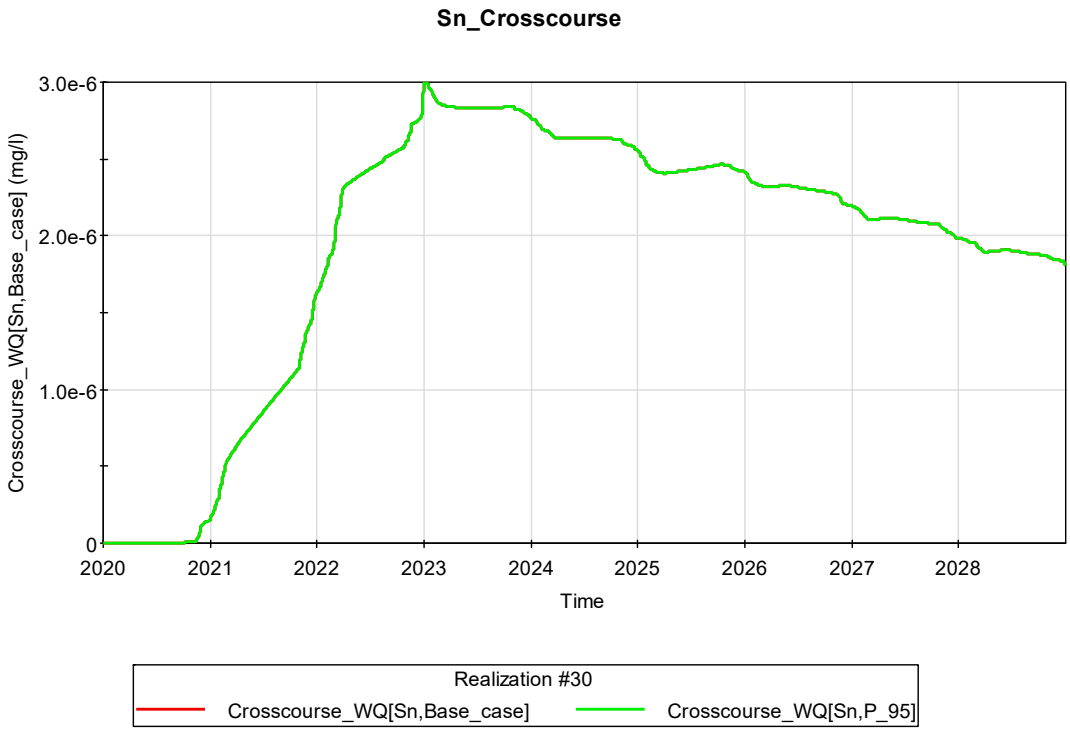

Ni_Crosscourse
Crosscourse_WQ[Ni,Base_case] (mg/l)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ni,Base_case]
SST_Values[Ni]
Crosscourse_WQ[Ni,P_95]

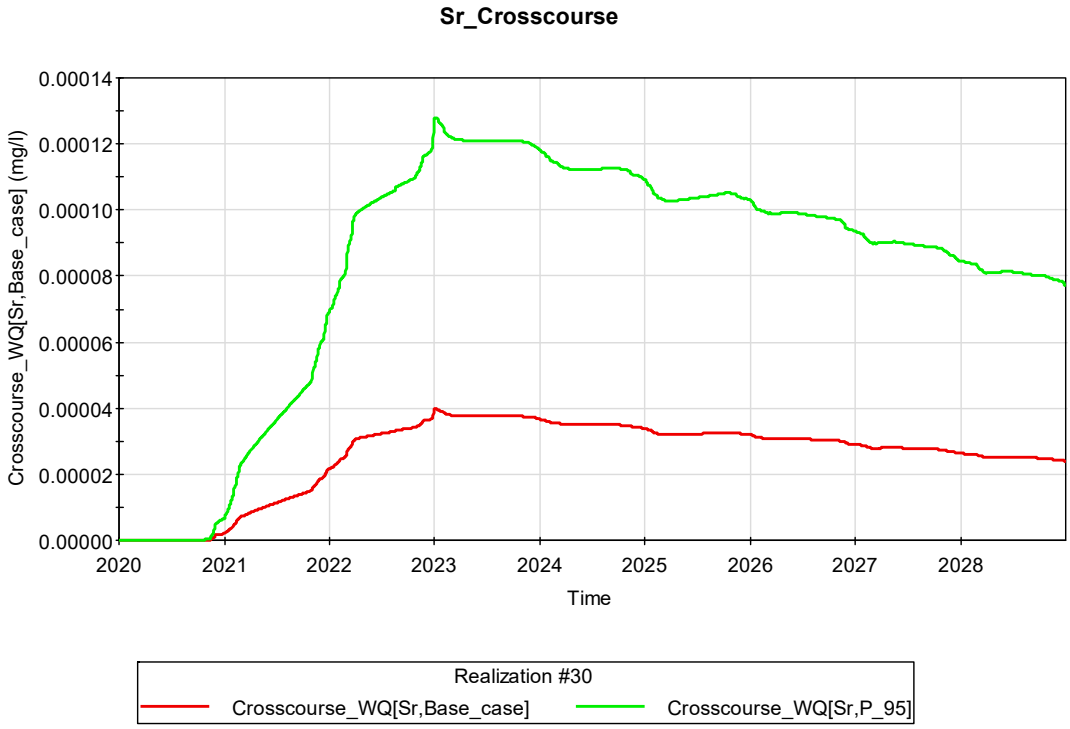

Pb_Crosscourse
Crosscourse_WQ[Pb,Base_case] (mg/l)
0.0040
0.0030
0.0020
0.0010
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Pb,Base_case]
SST_Values[Pb]
Crosscourse_WQ[Pb,P_95]

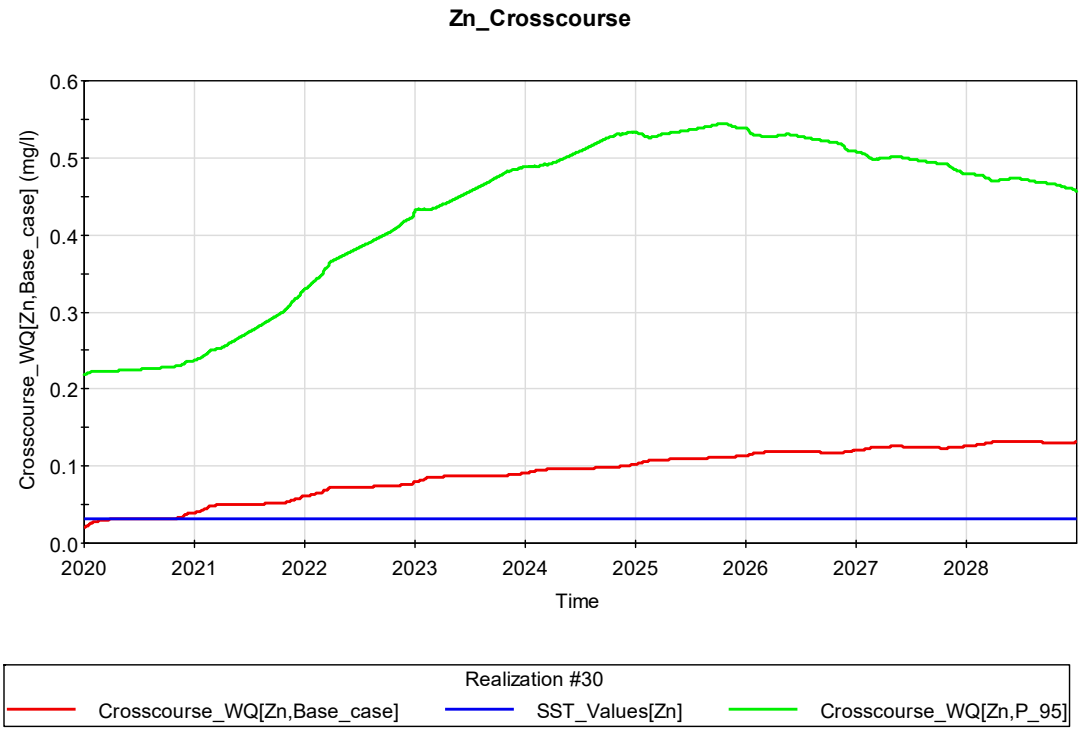

SO4_Crosscourse
Crosscourse_WQ[SO4,Base_case] (mg/l)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[SO4,Base_case]
Crosscourse_WQ[SO4,P_95]

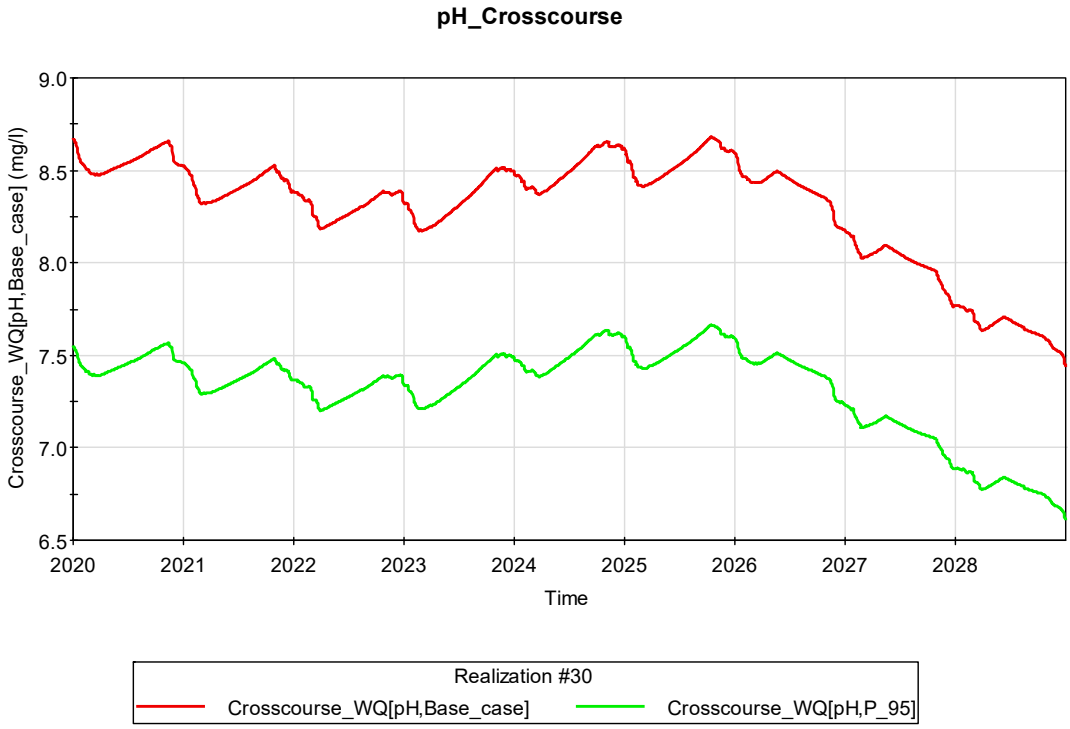

Se_Crosscourse
Crosscourse_WQ[Se,Base_case] (mg/l)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Se,Base_case]
SST_Values[Se]
Crosscourse_WQ[Se,P_95]


Si_Crosscourse
0.025
0.020
0.015
0.010
0.005
0.000
Crosscourse_WQ[Si,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Si,Base_case]
Crosscourse_WQ[Si,P_95]

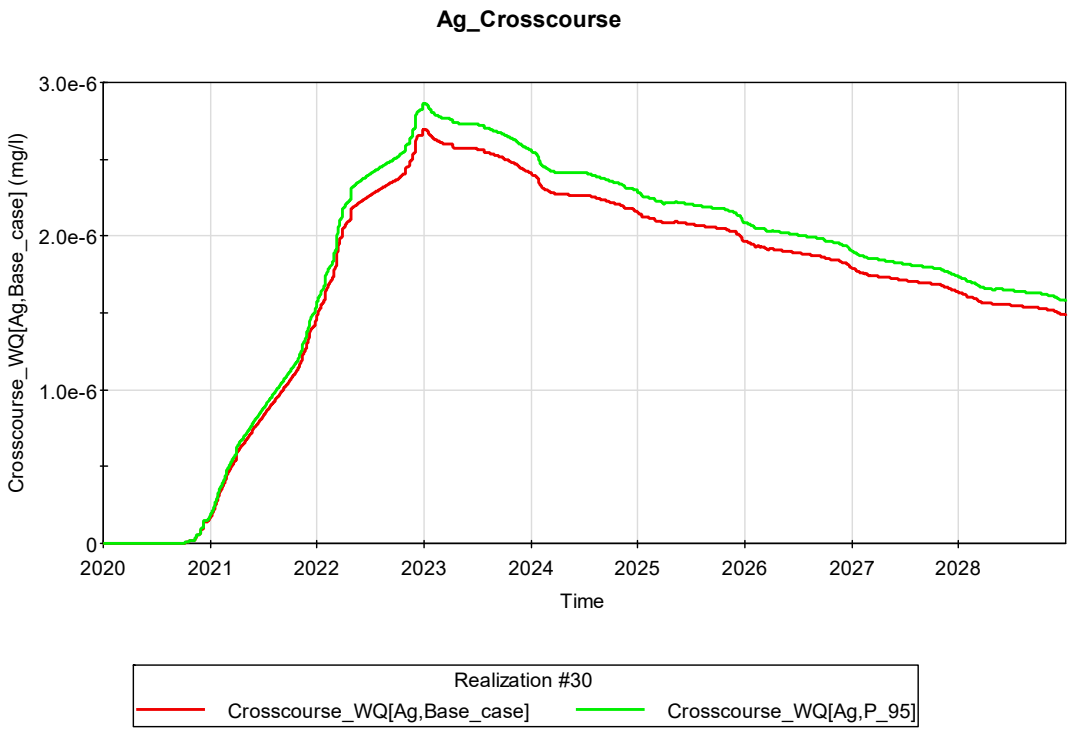

Sn_Crosscourse
3.0e-6
2.0e-6
1.0e-6
0
Crosscourse_WQ[Sn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sn,Base_case]
Crosscourse_WQ[Sn,P_95]

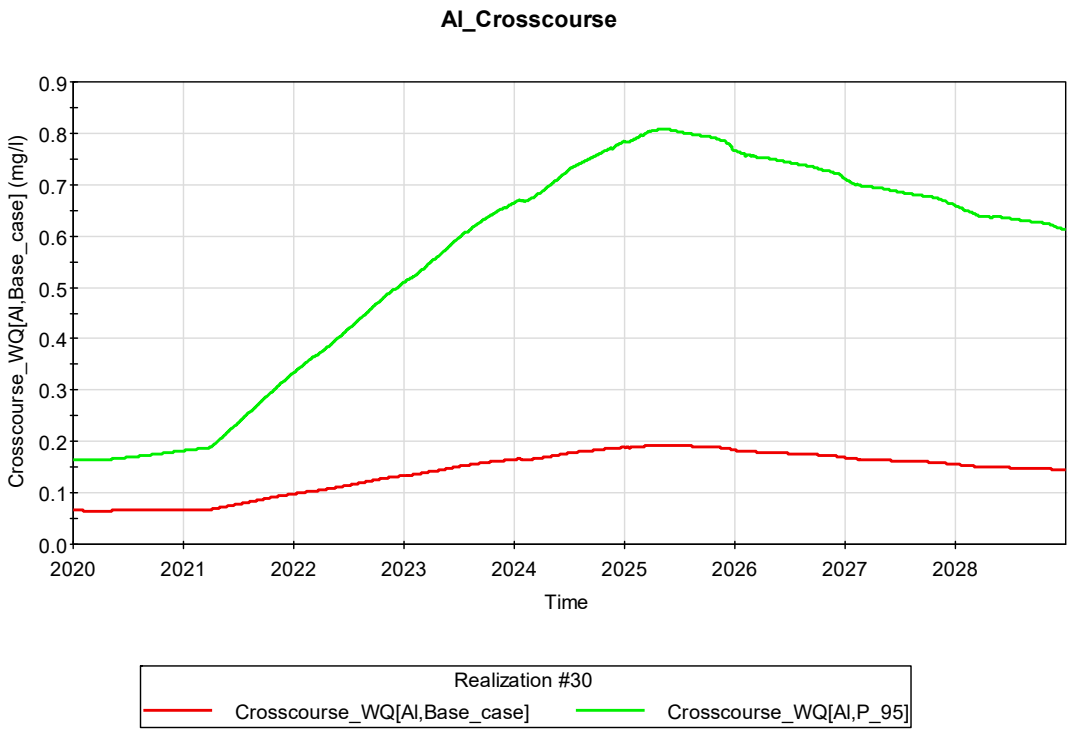

Sr_Crosscourse
0.00014
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Crosscourse_WQ[Sr,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sr,Base_case]
Crosscourse_WQ[Sr,P_95]

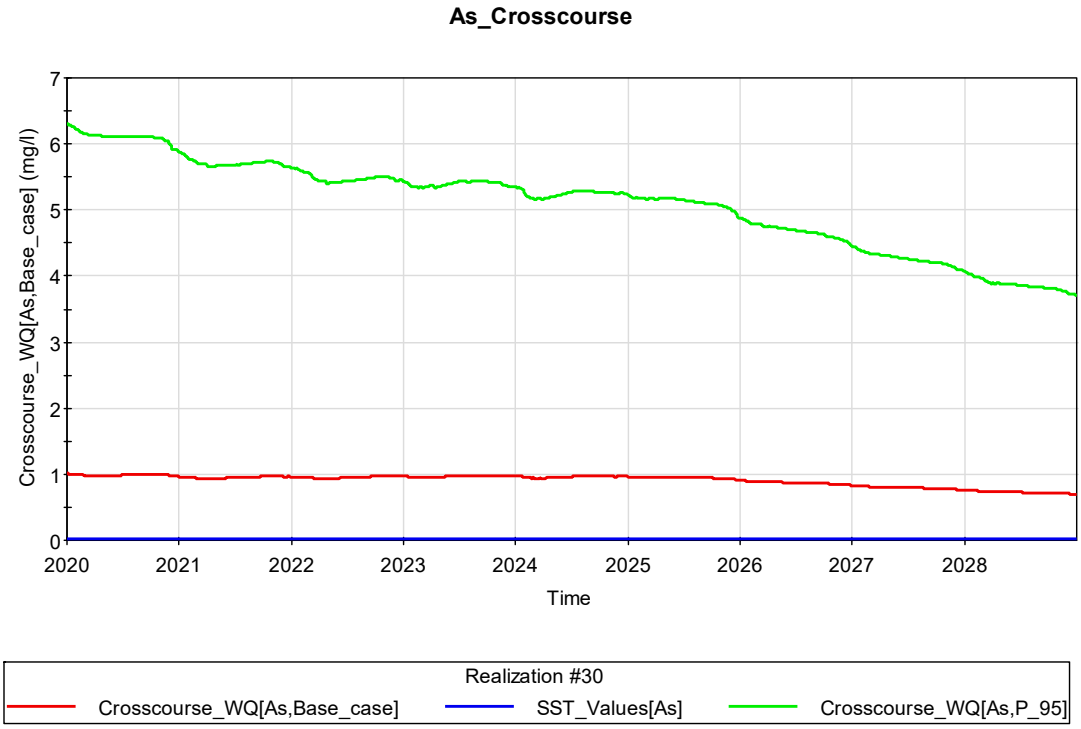

Zn_Crosscourse
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Zn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Zn,Base_case]
SST_Values[Zn]
Crosscourse_WQ[Zn,P_95]

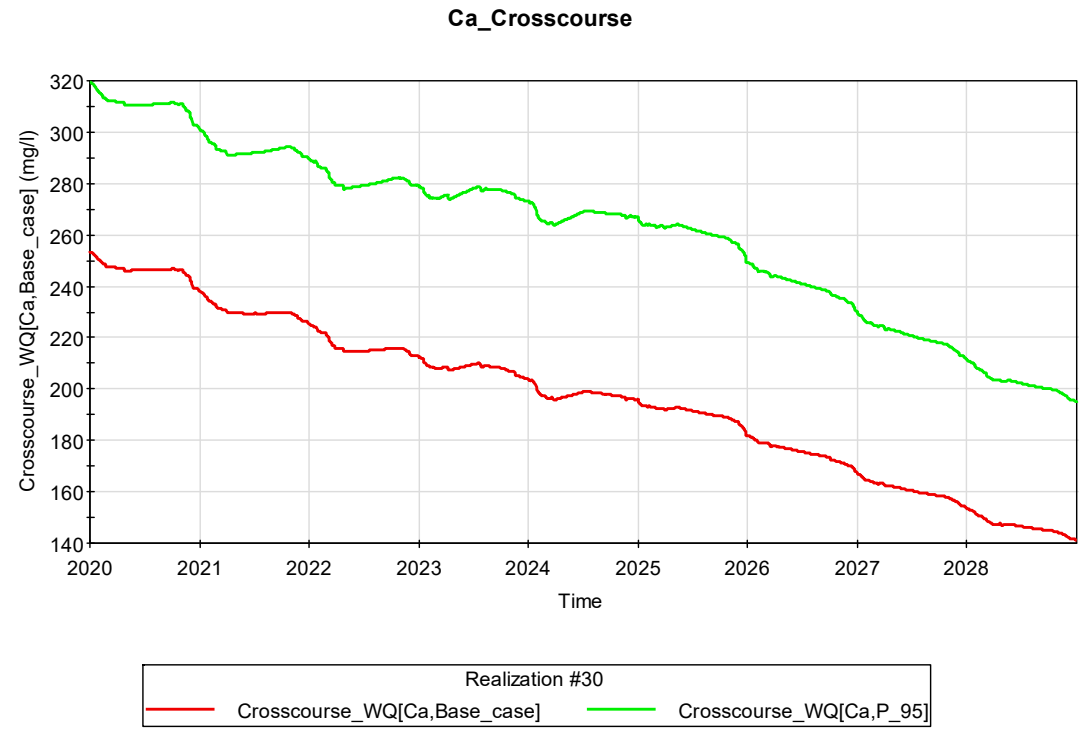

pH_Crosscourse
9.0
8.5
8.0
7.5
7.0
6.5
Crosscourse_WQ[pH,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[pH,Base_case]
Crosscourse_WQ[pH,P_95]

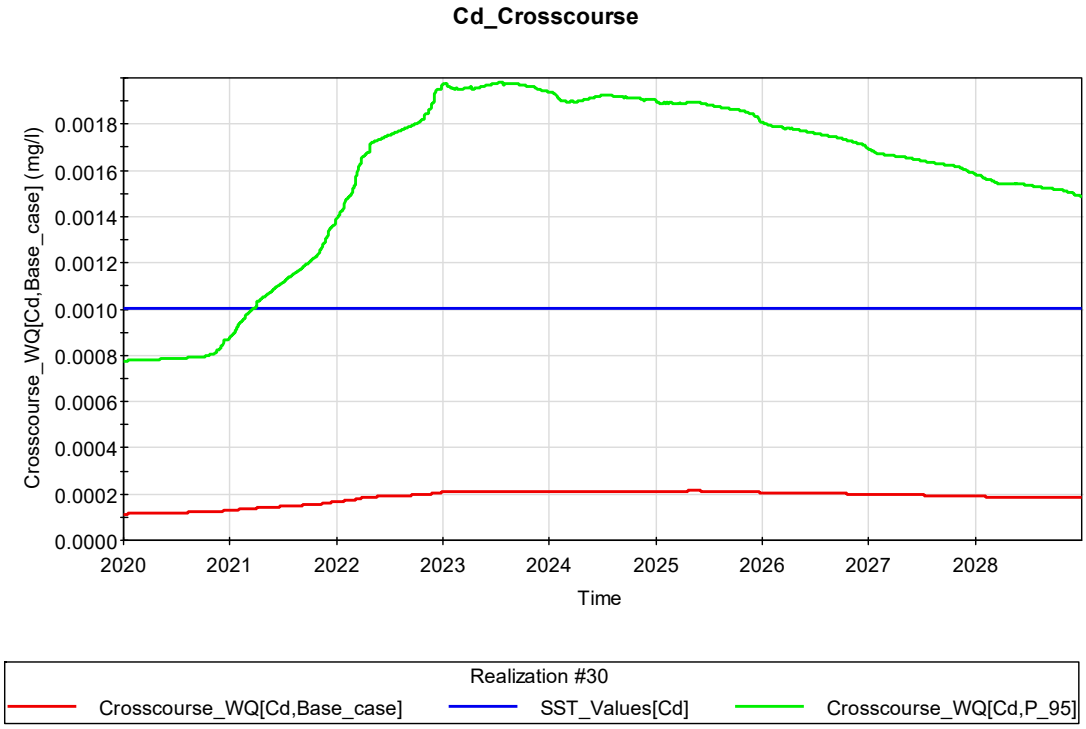
Dry climate with discharge

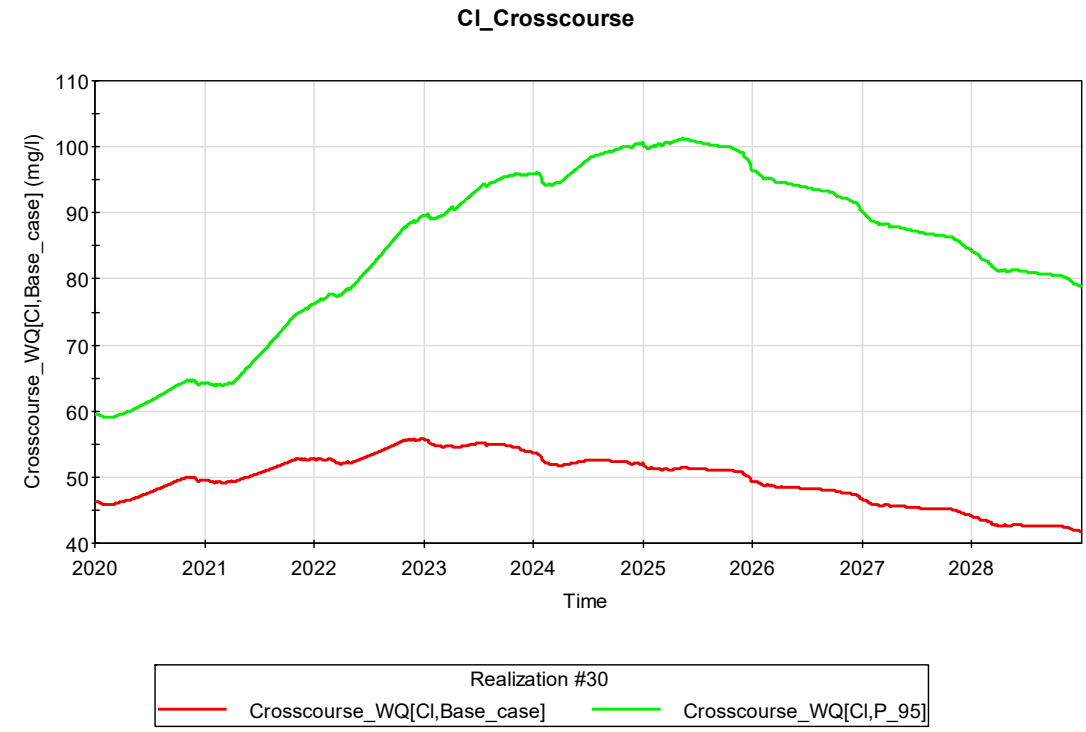


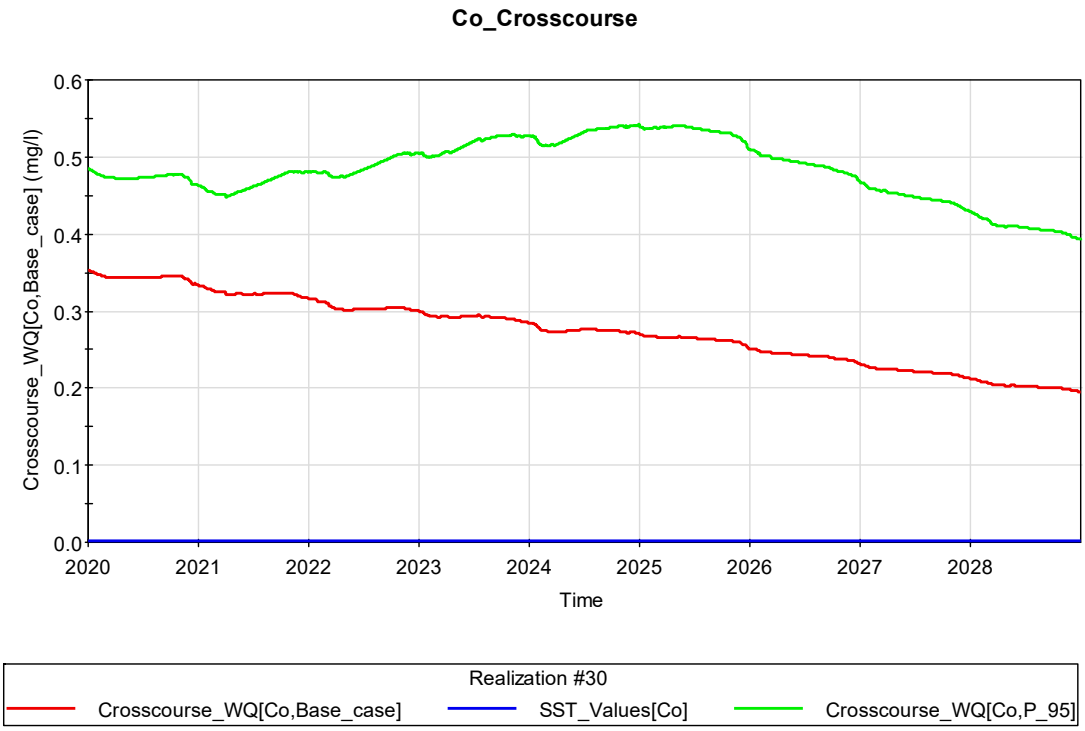


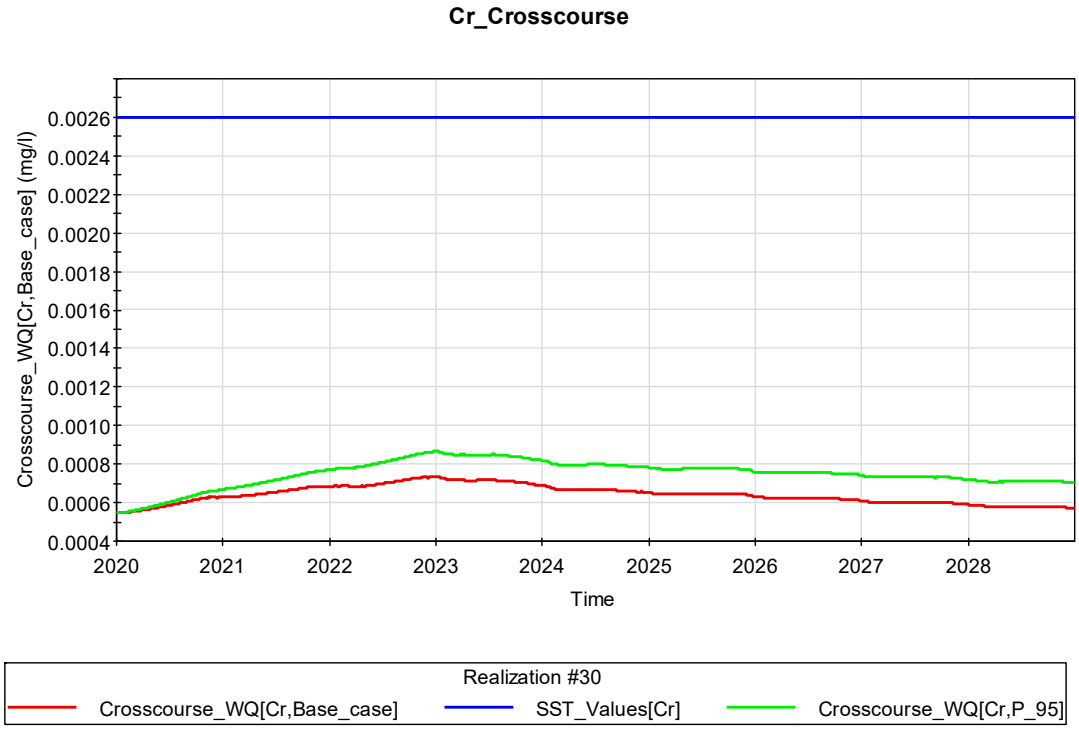

As_Crosscourse
Crosscourse_WQ[As,Base_case] (mg/l)
0
1
2
3
4
5
6
7
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[As,Base_case]
SST_Values[As]
Crosscourse_WQ[As,P_95]

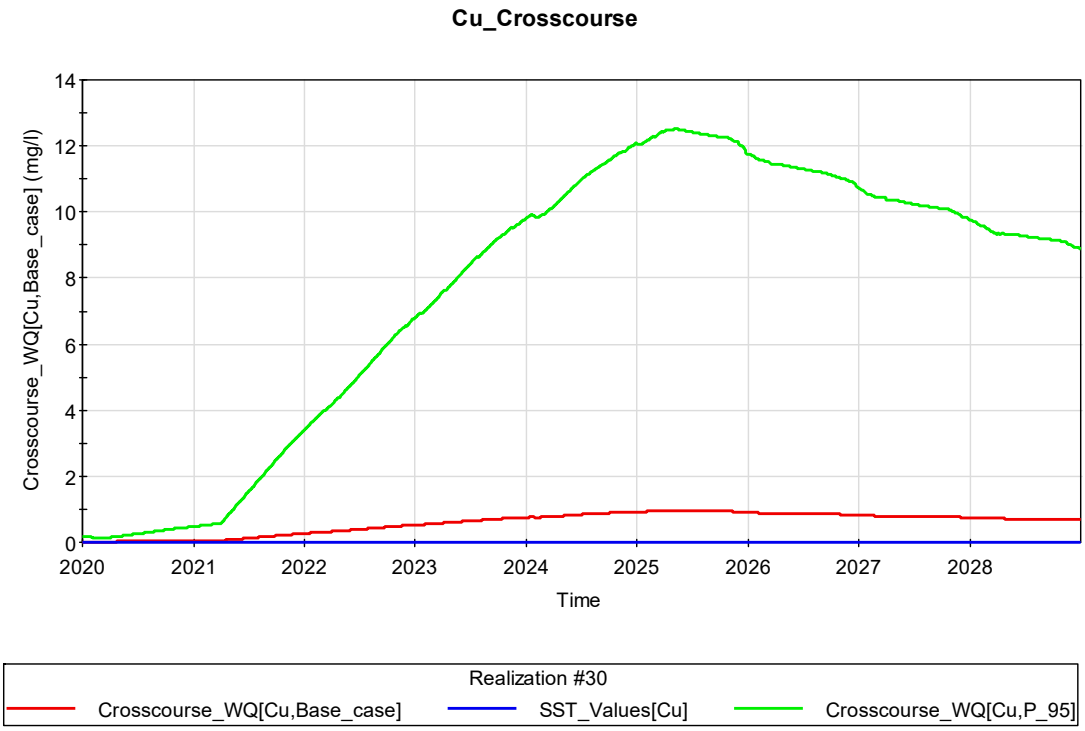

Ca_Crosscourse
Crosscourse_WQ[Ca,Base_case] (mg/l)
140
160
180
200
220
240
260
280
300
320
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ca,Base_case]
Crosscourse_WQ[Ca,P_95]

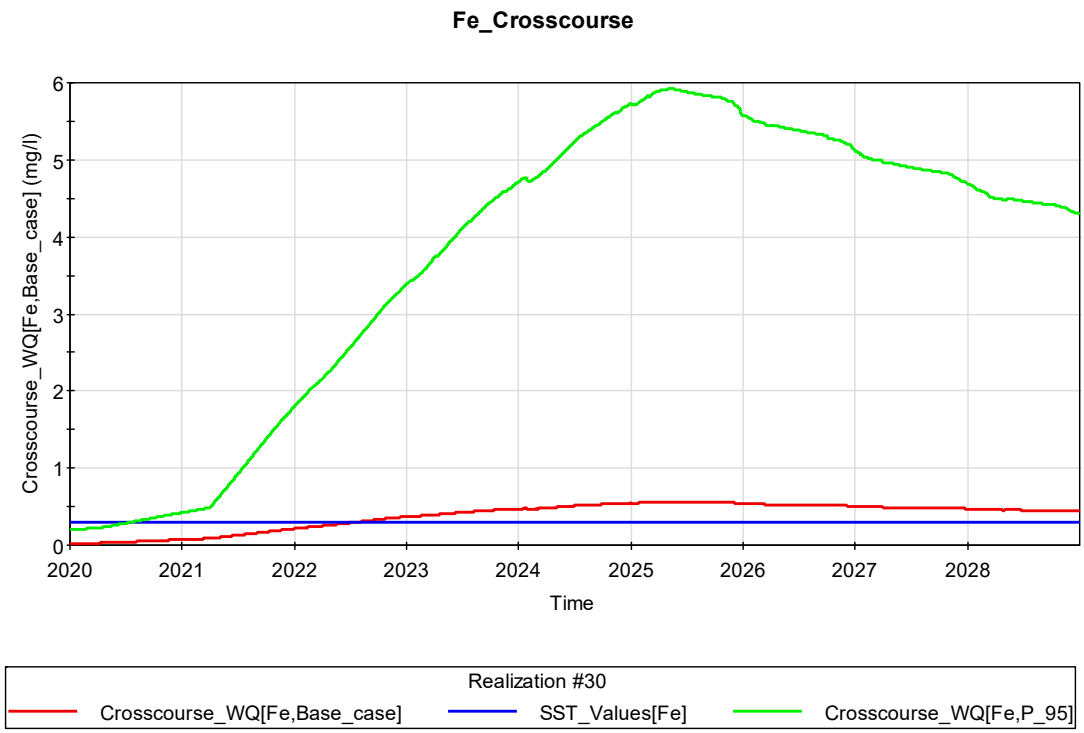

Cd_Crosscourse
Crosscourse_WQ[Cd,Base_case] (mg/l)
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cd,Base_case]
SST_Values[Cd]
Crosscourse_WQ[Cd,P_95]

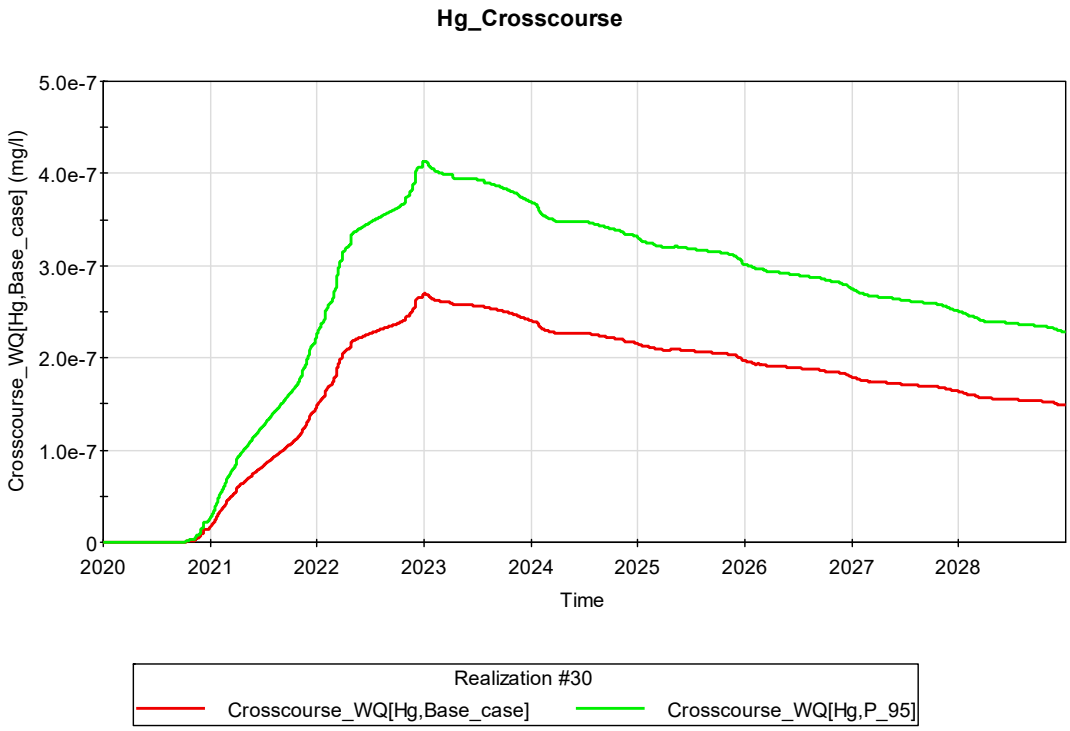

Cl_Crosscourse
Crosscourse_WQ[Cl,Base_case] (mg/l)
110
100
90
80
70
60
50
40
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cl,Base_case]
Crosscourse_WQ[Cl,P_95]

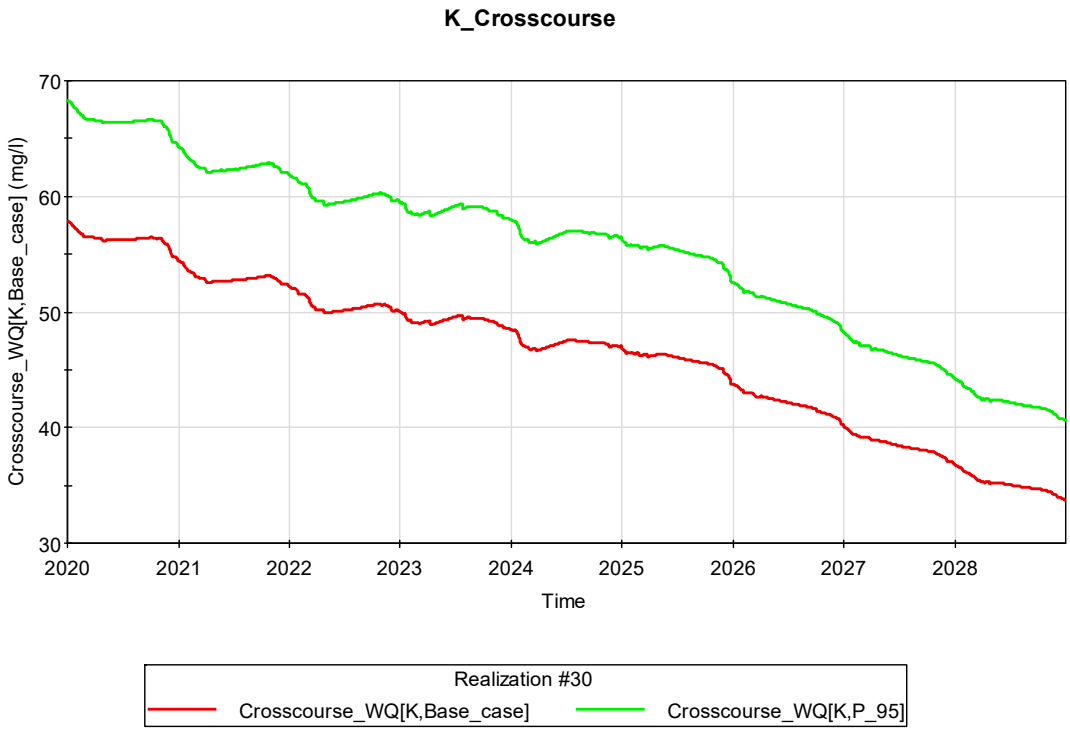

Co_Crosscourse
Crosscourse_WQ[Co,Base_case] (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Co,Base_case]
SST_Values[Co]
Crosscourse_WQ[Co,P_95]

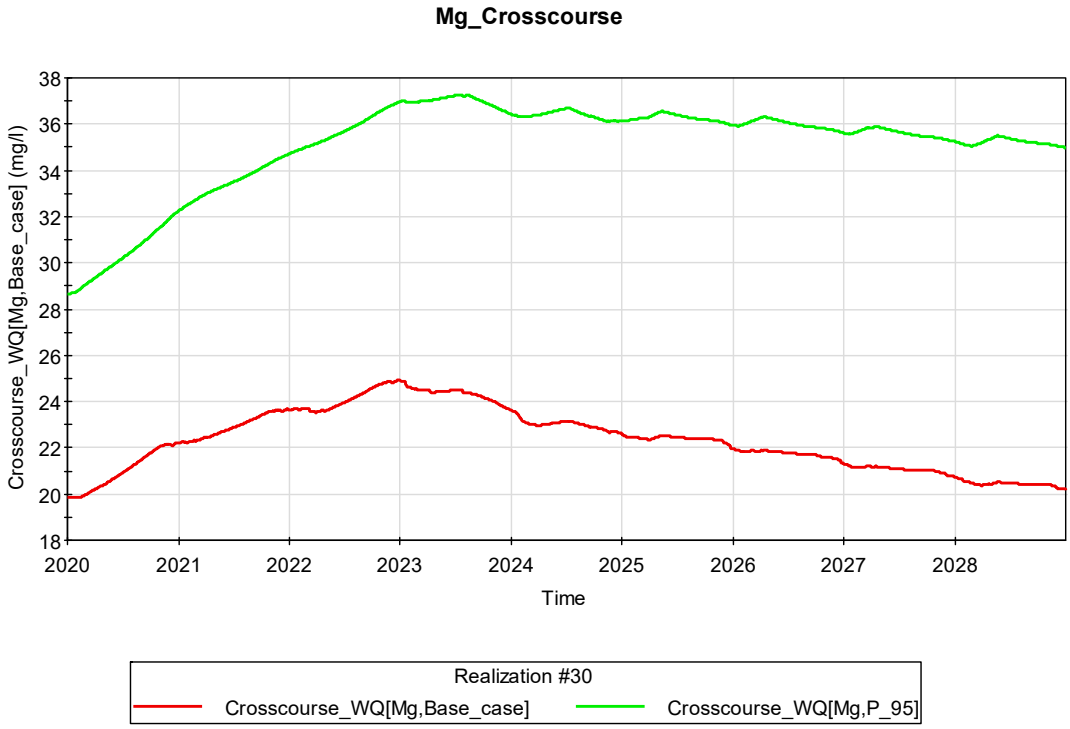

Cr_Crosscourse
Crosscourse_WQ[Cr,Base_case] (mg/l)
0.0026
0.0024
0.0022
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cr,Base_case]
SST_Values[Cr]
Crosscourse_WQ[Cr,P_95]

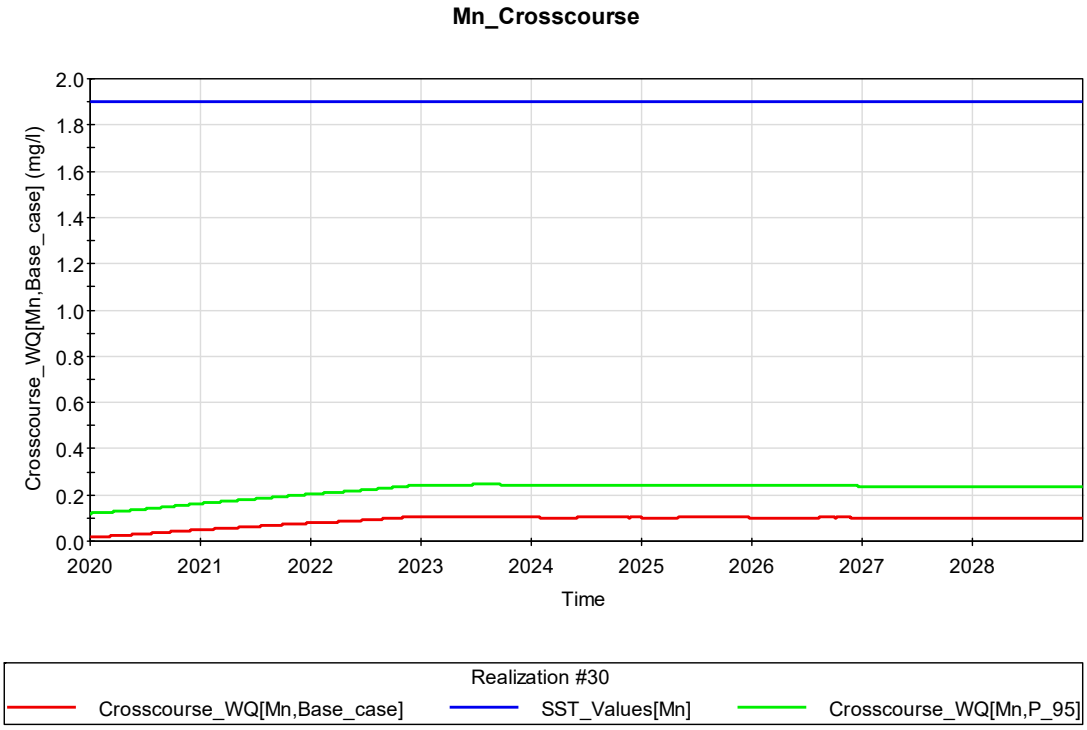

Cu_Crosscourse
Crosscourse_WQ[Cu,Base_case] (mg/l)
14
12
10
8
6
4
2
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cu,Base_case]
SST_Values[Cu]
Crosscourse_WQ[Cu,P_95]

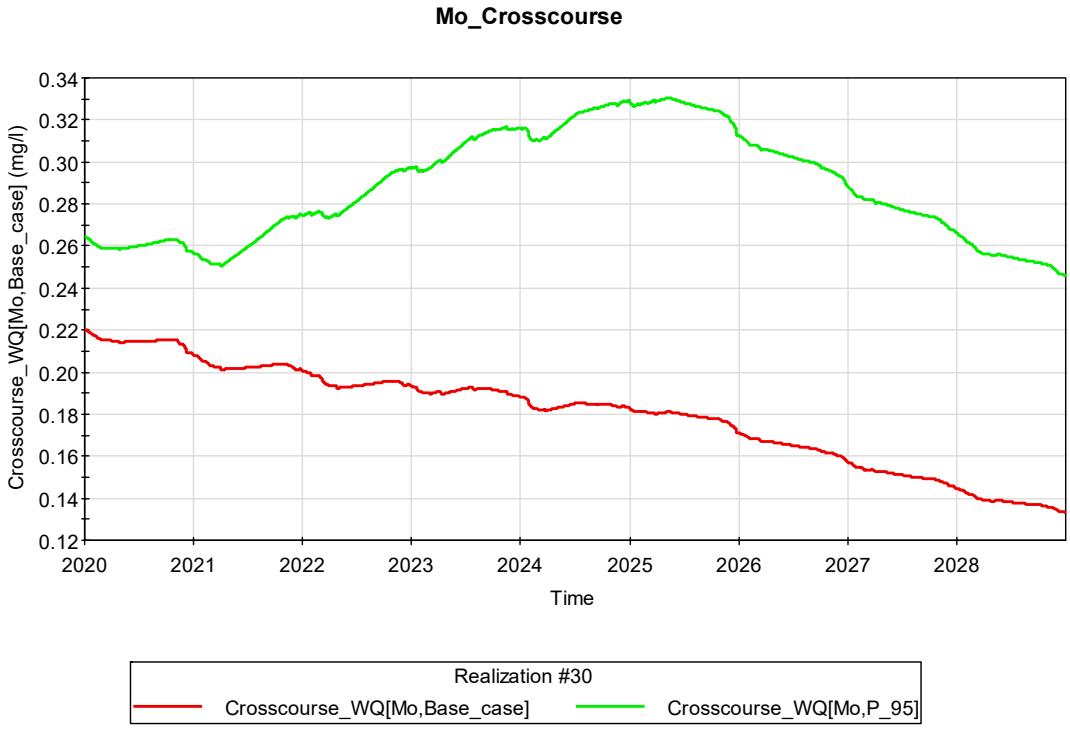

Fe_Crosscourse
Crosscourse_WQ[Fe,Base_case] (mg/l)
6
5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Fe,Base_case]
SST_Values[Fe]
Crosscourse_WQ[Fe,P_95]

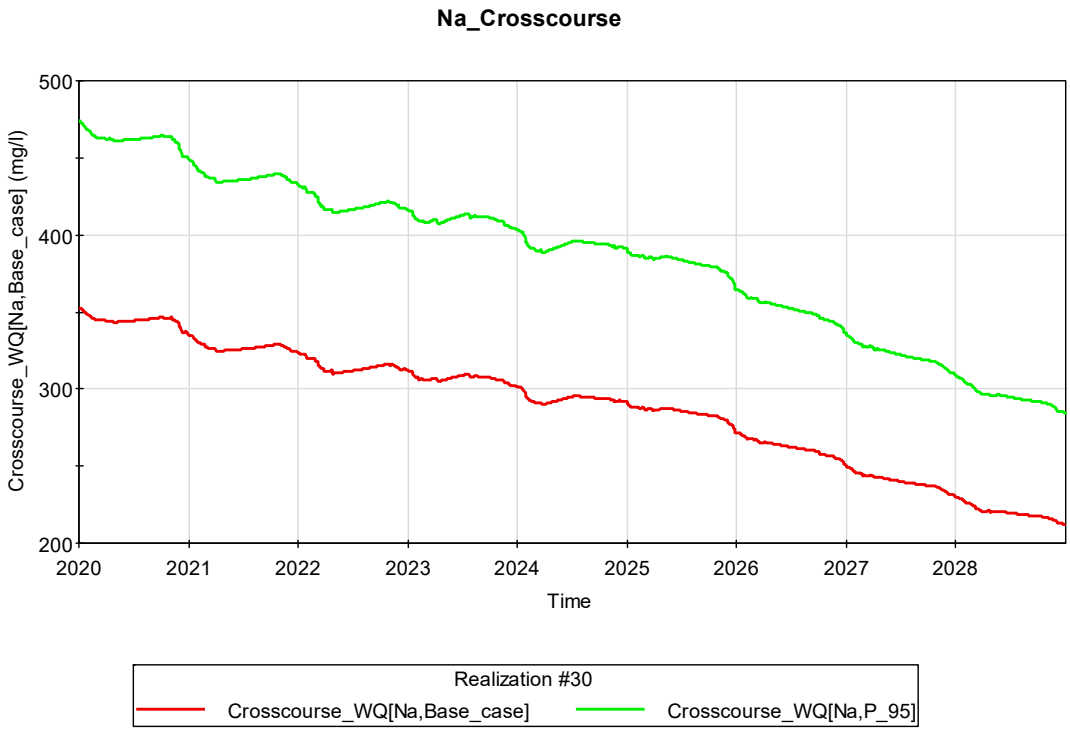

Hg_Crosscourse
5.0e-7
4.0e-7
3.0e-7
2.0e-7
1.0e-7
0
Crosscourse_WQ[Hg,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Hg,Base_case]
Crosscourse_WQ[Hg,P_95]

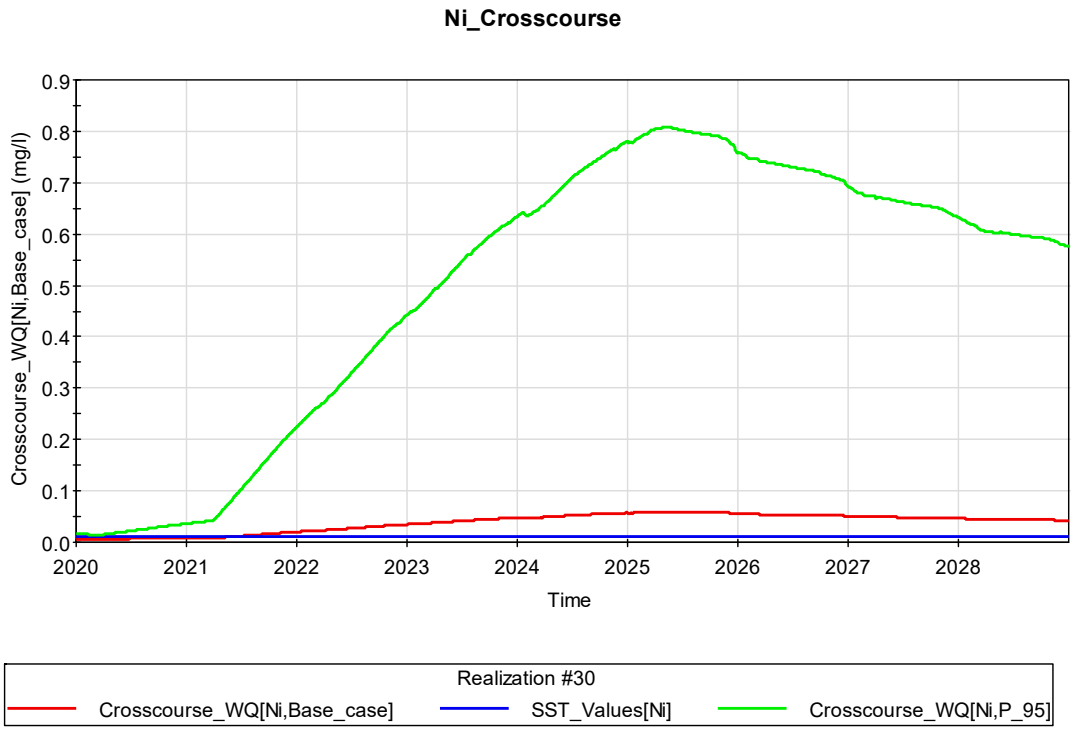

K_Crosscourse
70
60
50
40
30
Crosscourse_WQ[K,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[K,Base_case]
Crosscourse_WQ[K,P_95]

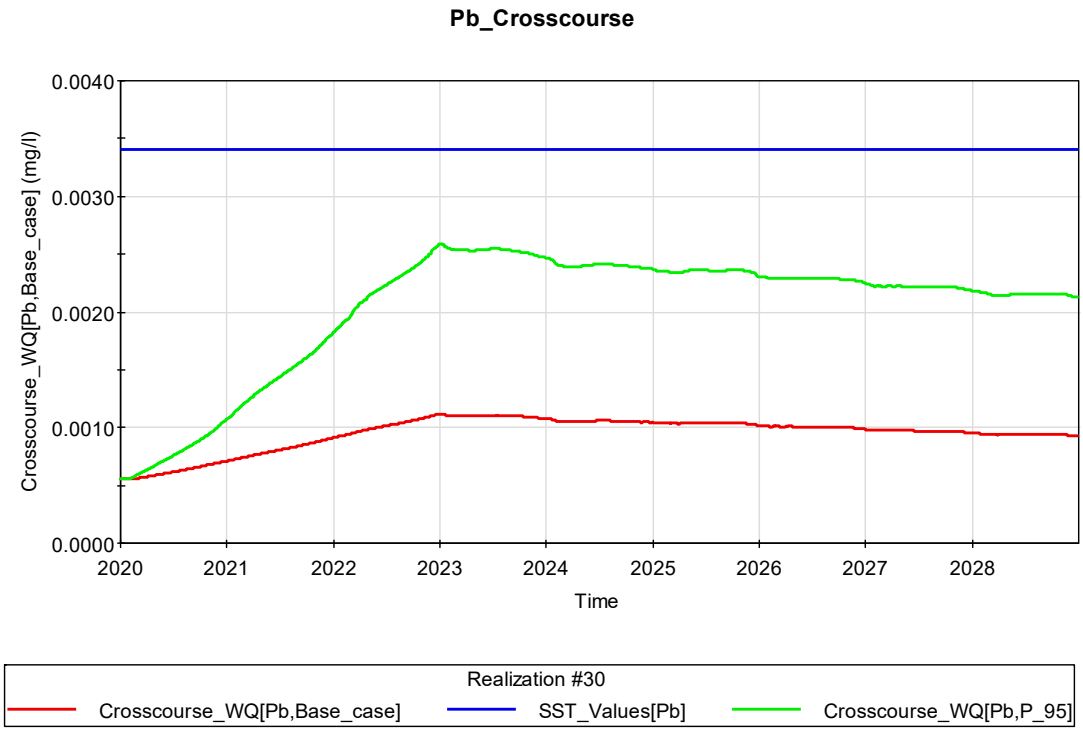

Mg_Crosscourse
Crosscourse_WQ[Mg,Base_case] (mg/l)
38
36
34
32
30
28
26
24
22
20
18
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mg,Base_case]
Crosscourse_WQ[Mg,P_95]

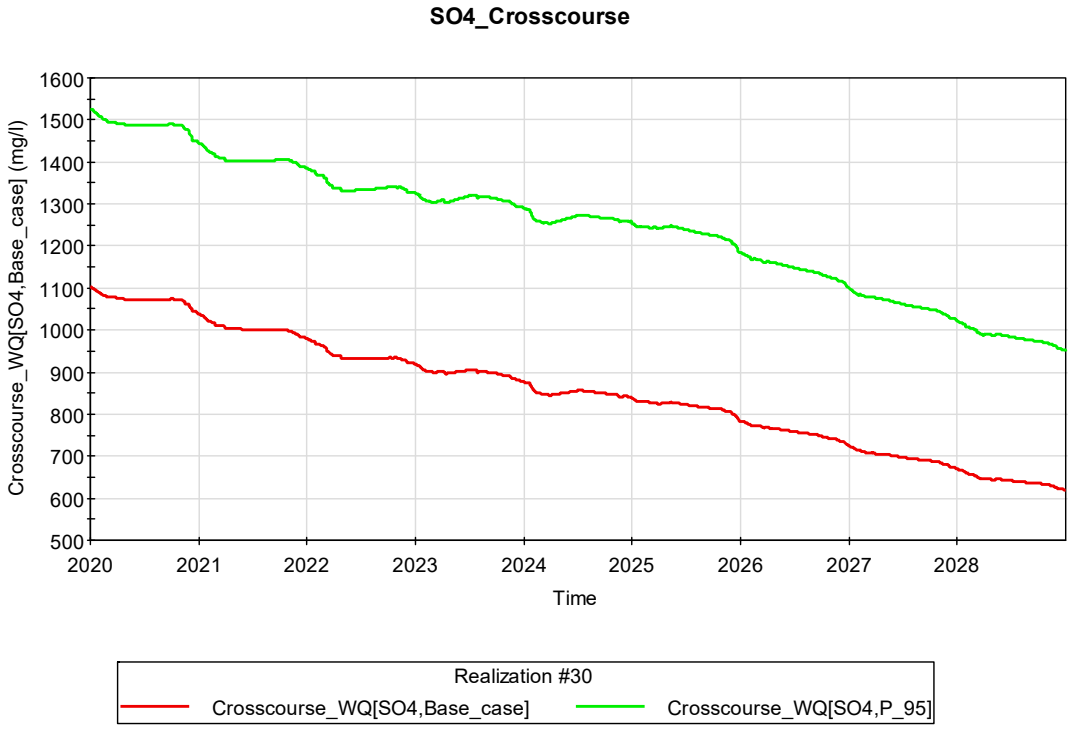

Mn_Crosscourse
Crosscourse_WQ[Mn,Base_case] (mg/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mn,Base_case]
SST_Values[Mn]
Crosscourse_WQ[Mn,P_95]

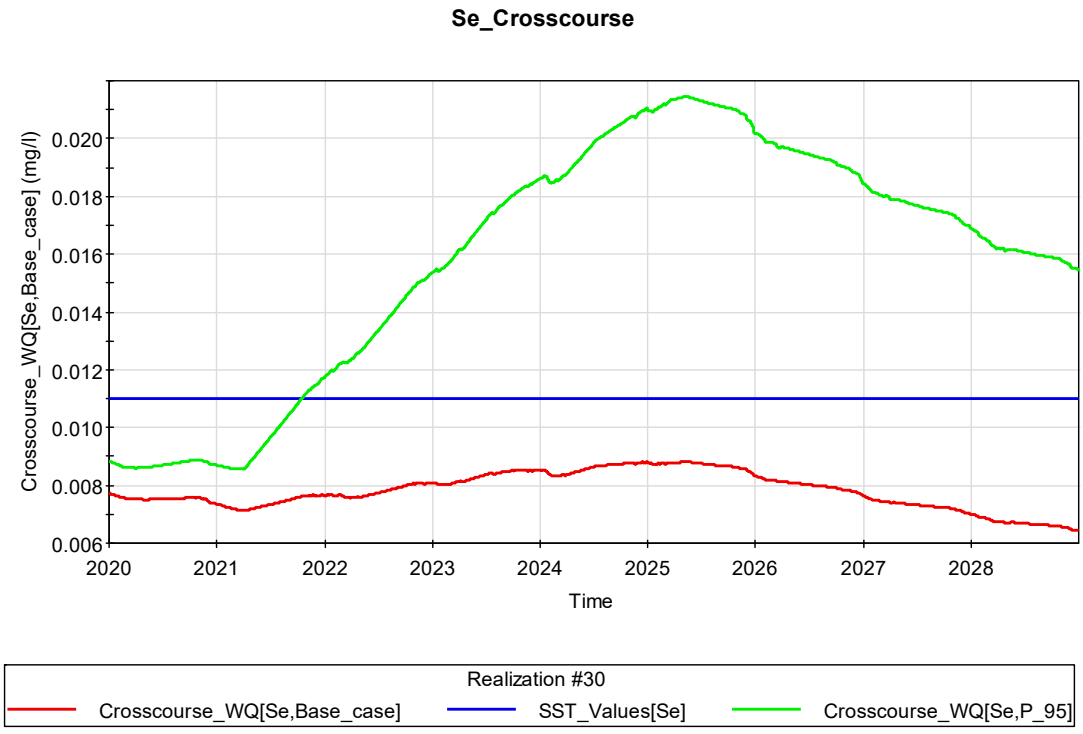

Mo_Crosscourse
Crosscourse_WQ[Mo,Base_case] (mg/l)
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mo,Base_case]
Crosscourse_WQ[Mo,P_95]

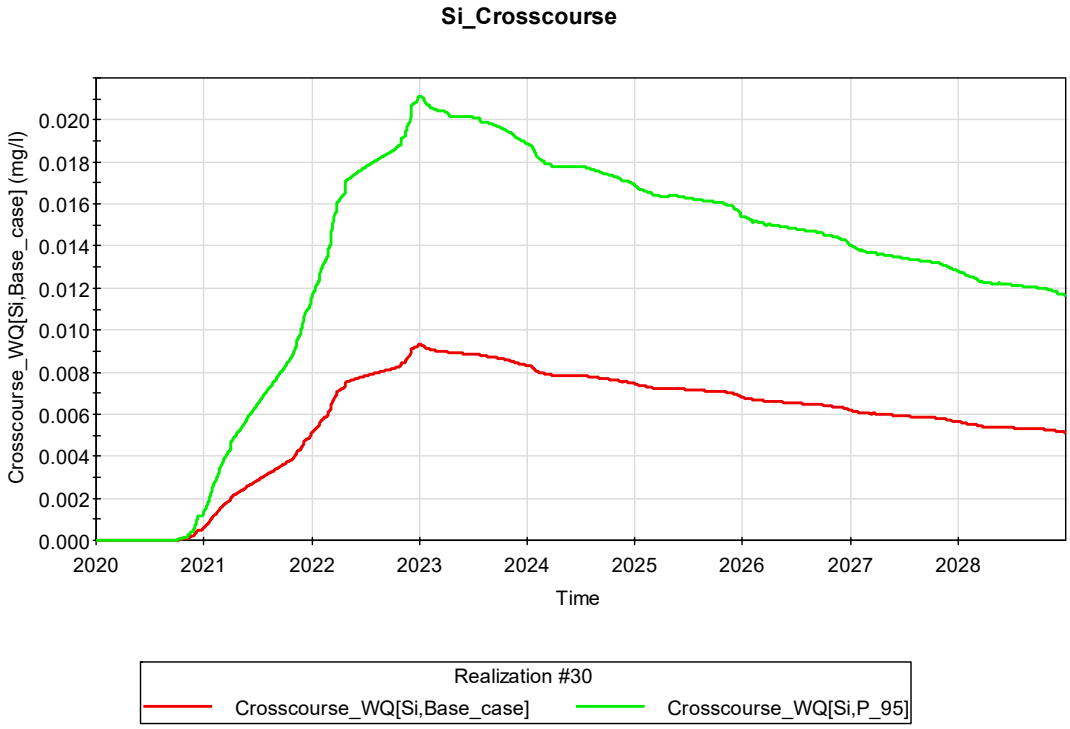

Na_Crosscourse
Crosscourse_WQ[Na,Base_case] (mg/l)
500
400
300
200
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Na,Base_case]
Crosscourse_WQ[Na,P_95]

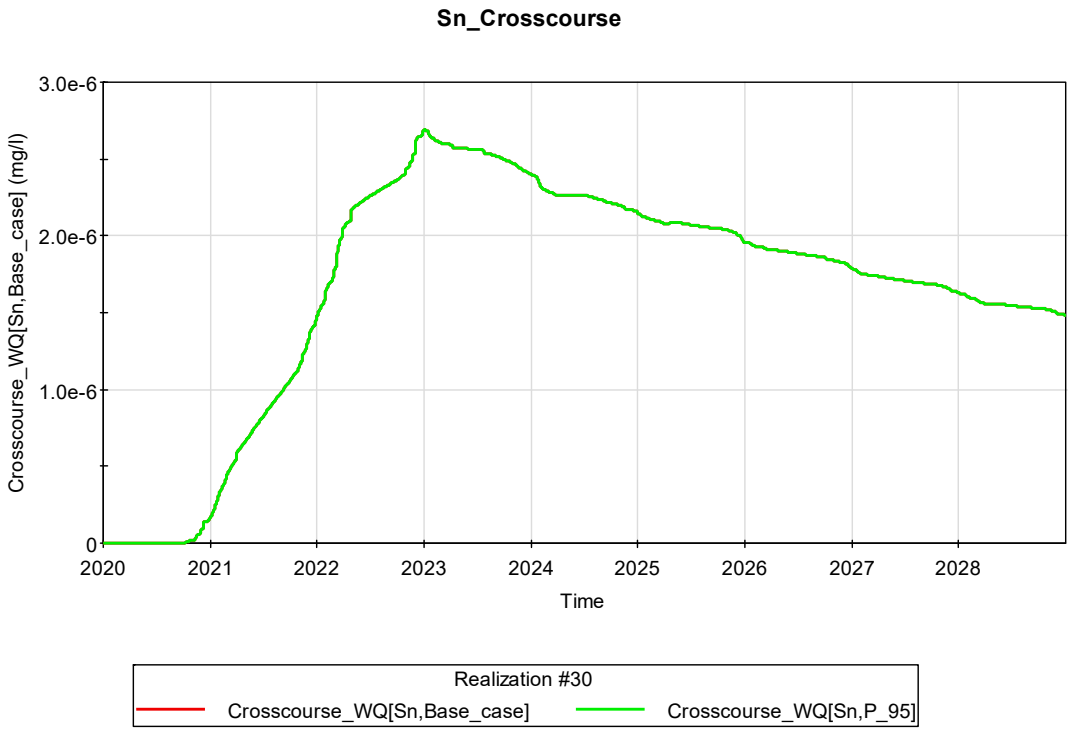

Ni_Crosscourse
Crosscourse_WQ[Ni,Base_case] (mg/l)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ni,Base_case]
SST_Values[Ni]
Crosscourse_WQ[Ni,P_95]

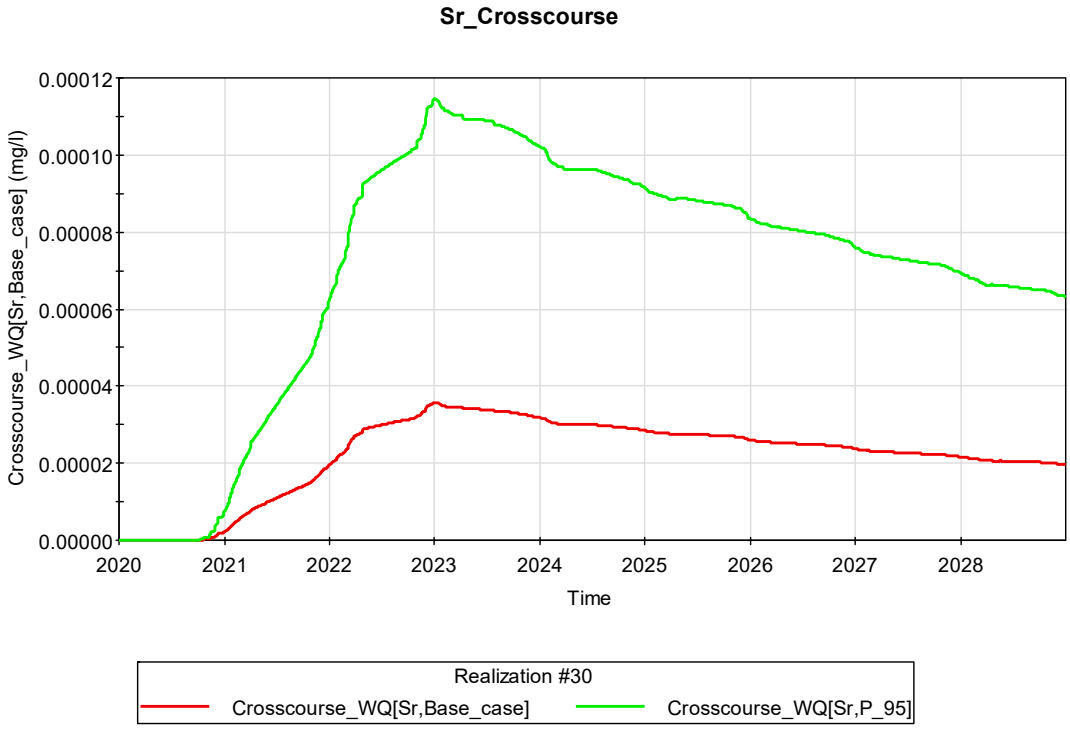

Pb_Crosscourse
Crosscourse_WQ[Pb,Base_case] (mg/l)
0.0040
0.0030
0.0020
0.0010
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Pb,Base_case]
SST_Values[Pb]
Crosscourse_WQ[Pb,P_95]

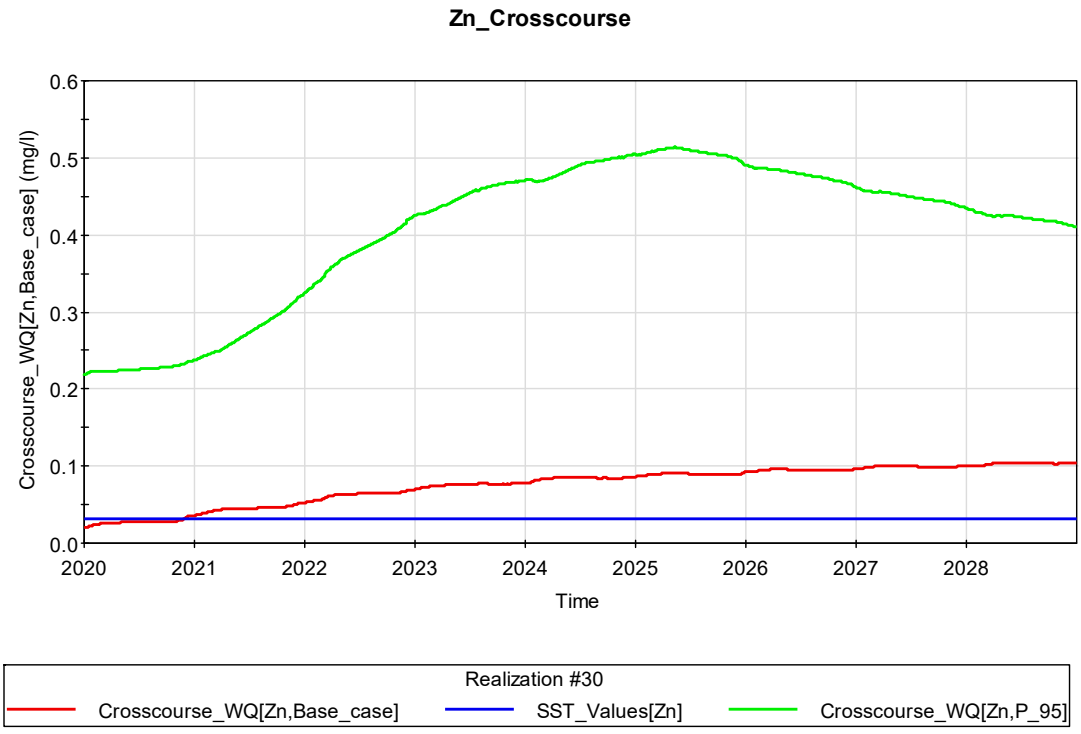

SO4_Crosscourse
Crosscourse_WQ[SO4,Base_case] (mg/l)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[SO4,Base_case]
Crosscourse_WQ[SO4,P_95]

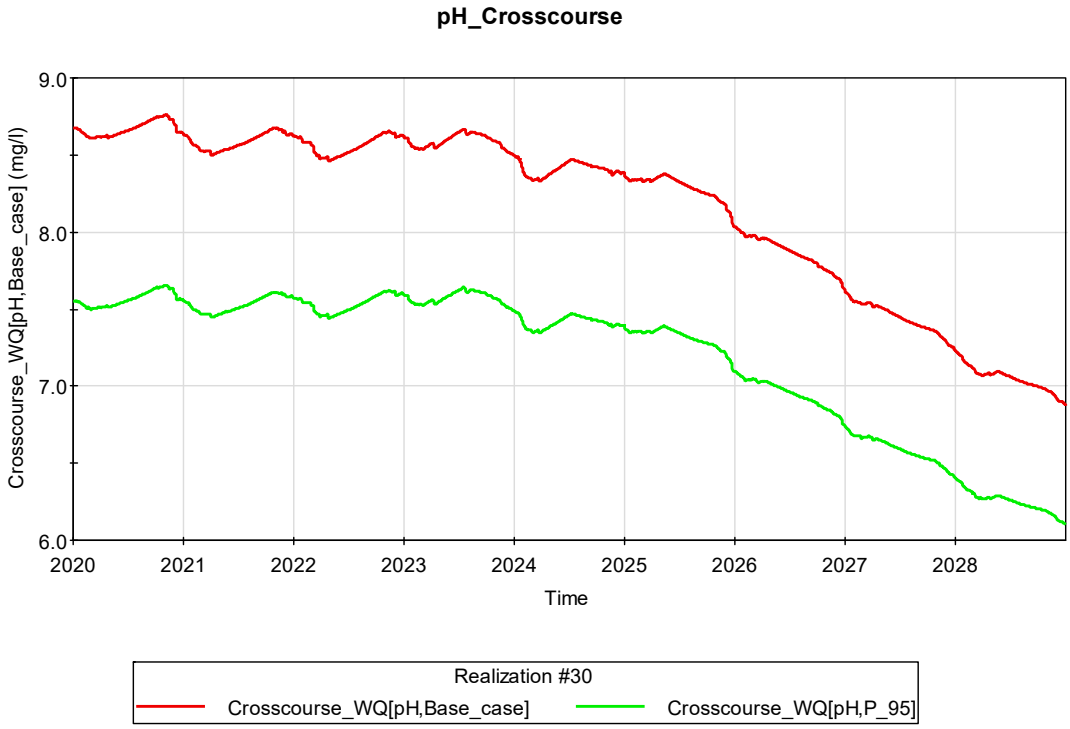

Se_Crosscourse
Crosscourse_WQ[Se,Base_case] (mg/l)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Se,Base_case]
SST_Values[Se]
Crosscourse_WQ[Se,P_95]


Si_Crosscourse
Crosscourse_WQ[Si,Base_case] (mg/l)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Si,Base_case]
Crosscourse_WQ[Si,P_95]

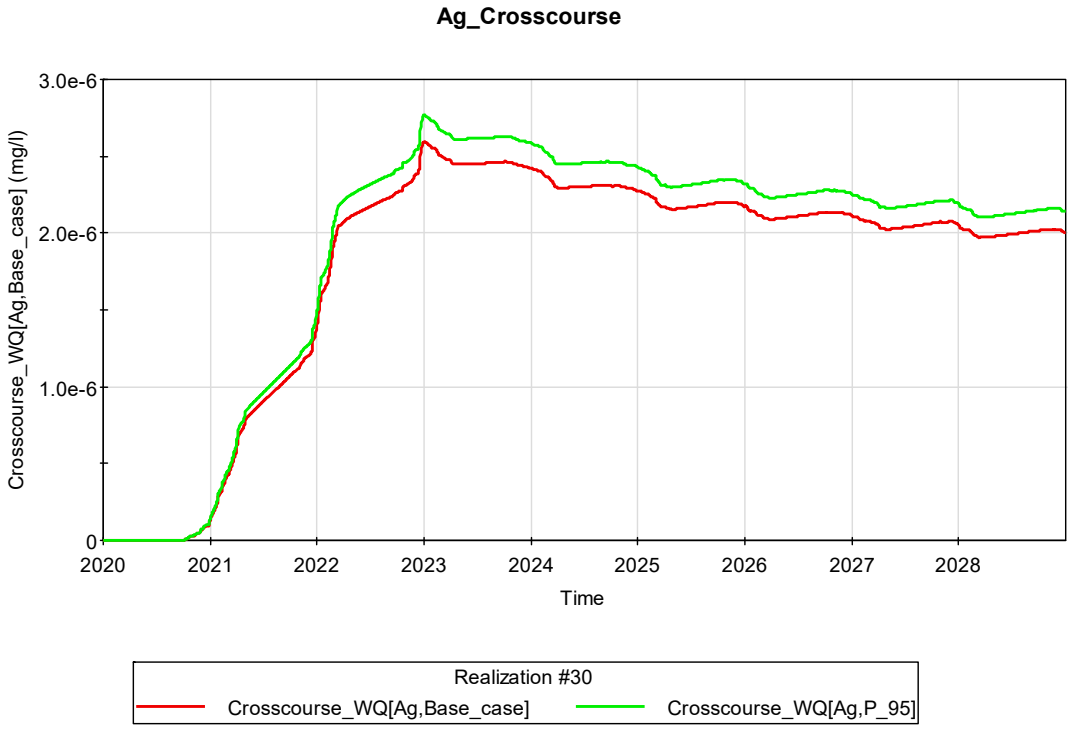

Sn_Crosscourse
Crosscourse_WQ[Sn,Base_case] (mg/l)
3.0e-6
2.0e-6
1.0e-6
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sn,Base_case]
Crosscourse_WQ[Sn,P_95]

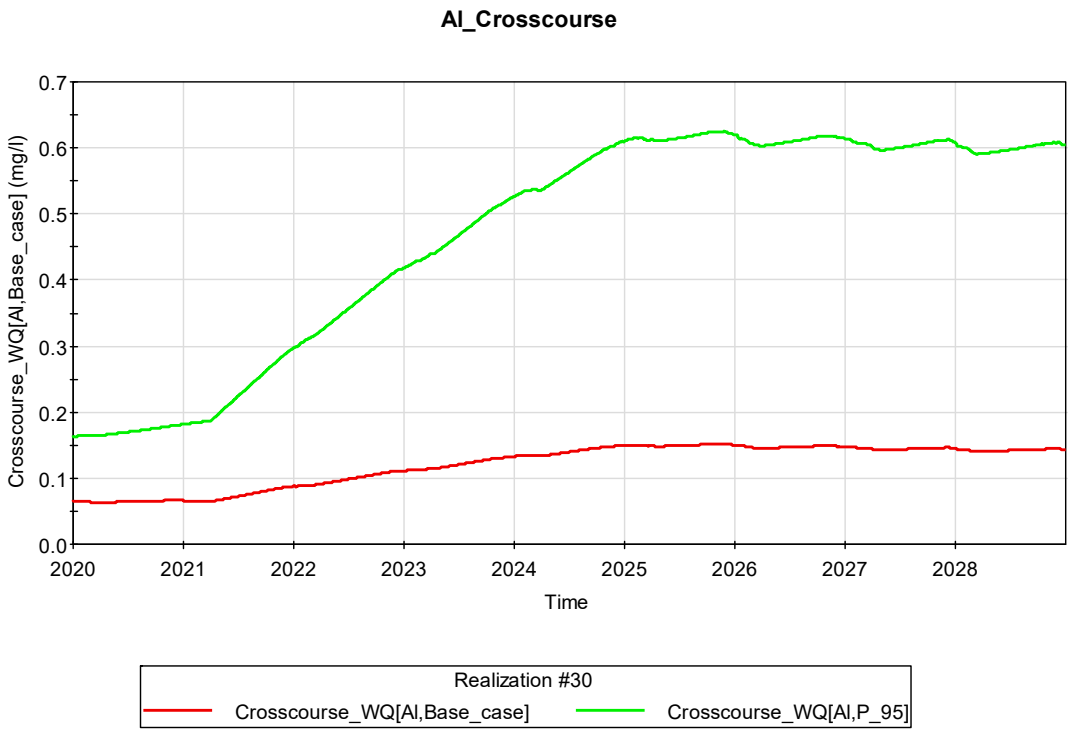

Sr_Crosscourse
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Crosscourse_WQ[Sr,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sr,Base_case]
Crosscourse_WQ[Sr,P_95]

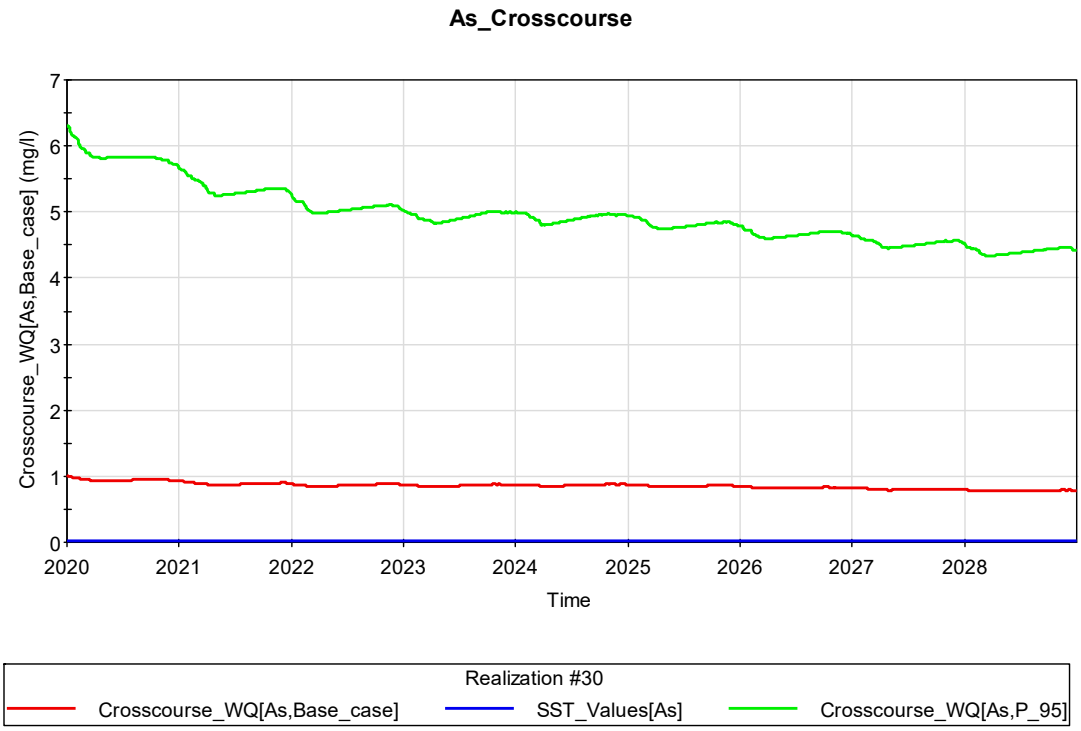

Zn_Crosscourse
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Zn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Zn,Base_case]
SST_Values[Zn]
Crosscourse_WQ[Zn,P_95]

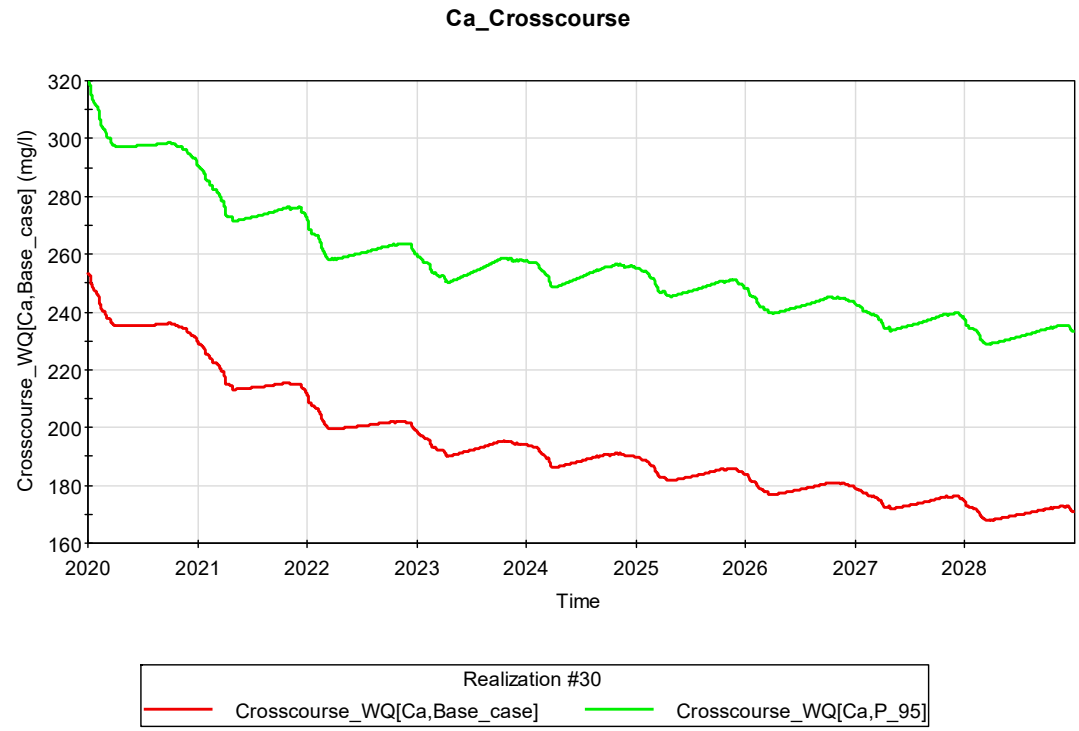

pH_Crosscourse
9.0
8.0
7.0
6.0
Crosscourse_WQ[pH,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[pH,Base_case]
Crosscourse_WQ[pH,P_95]

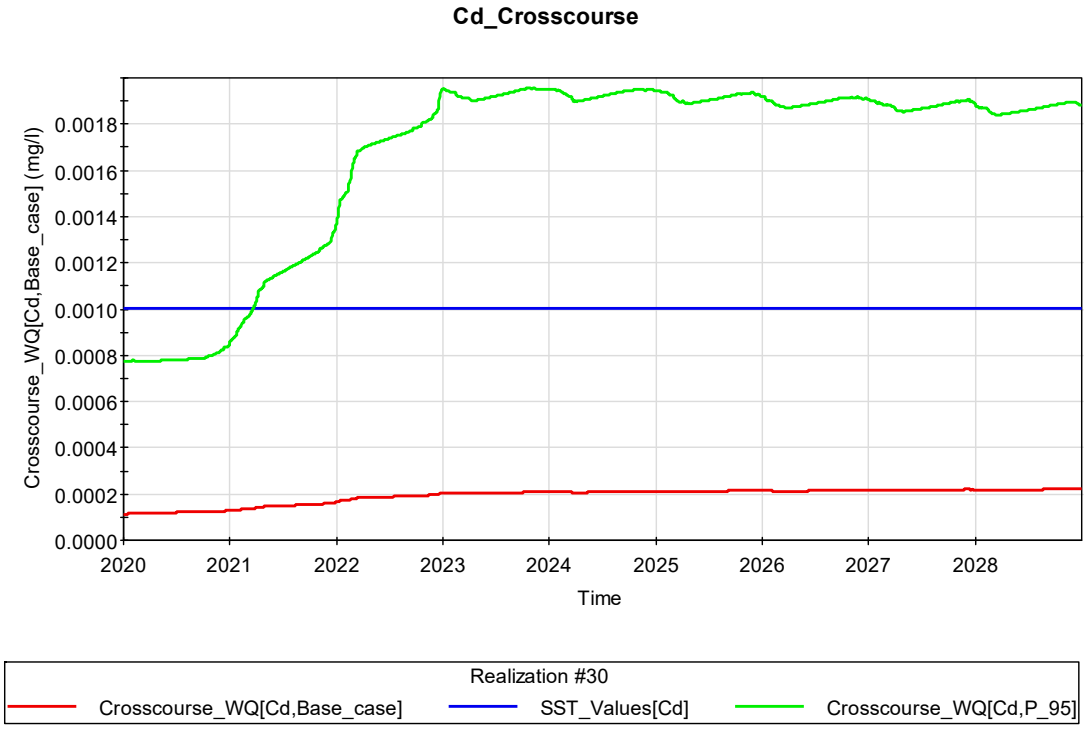
Wet climate, no discharge

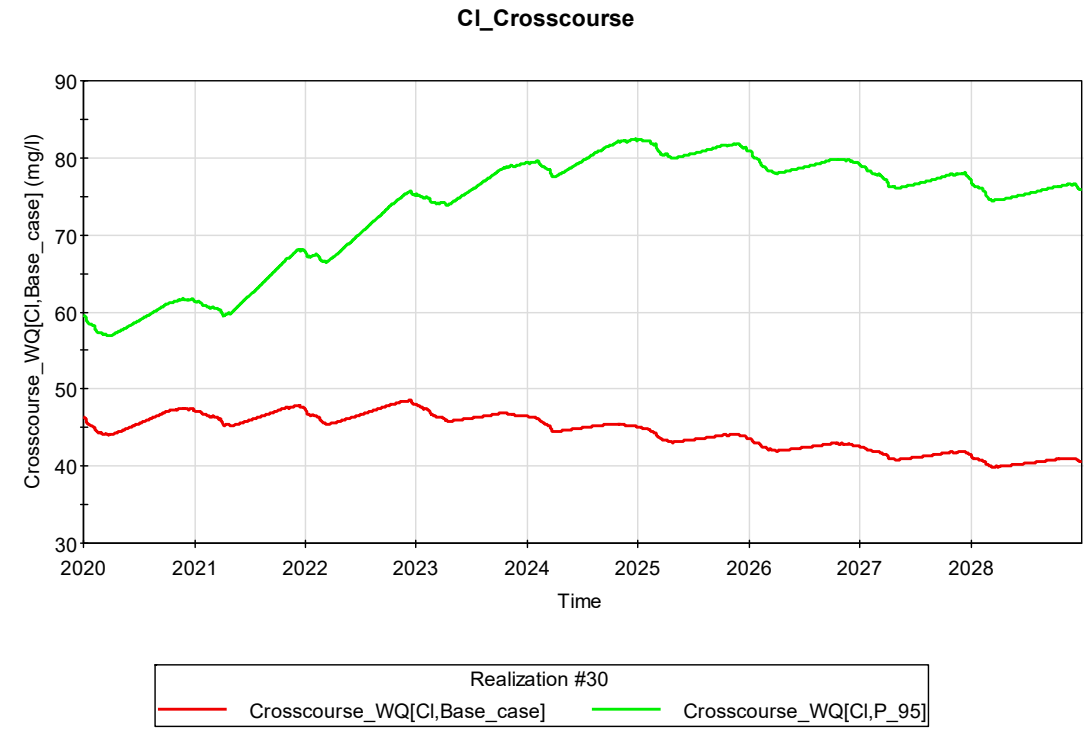


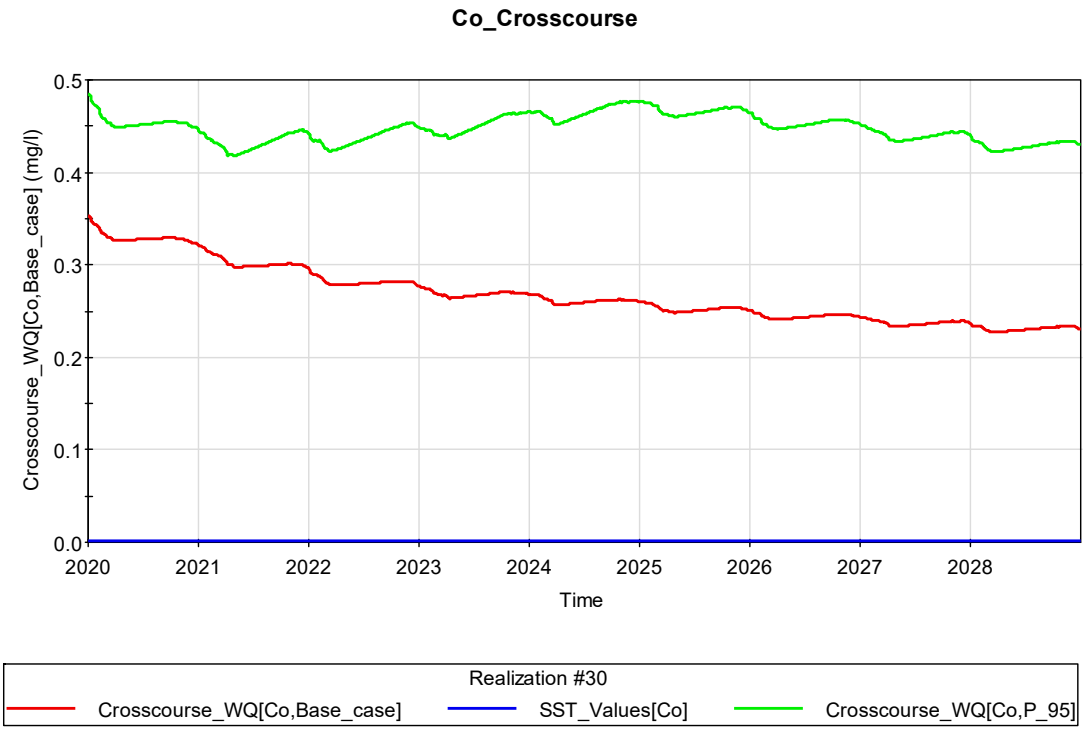


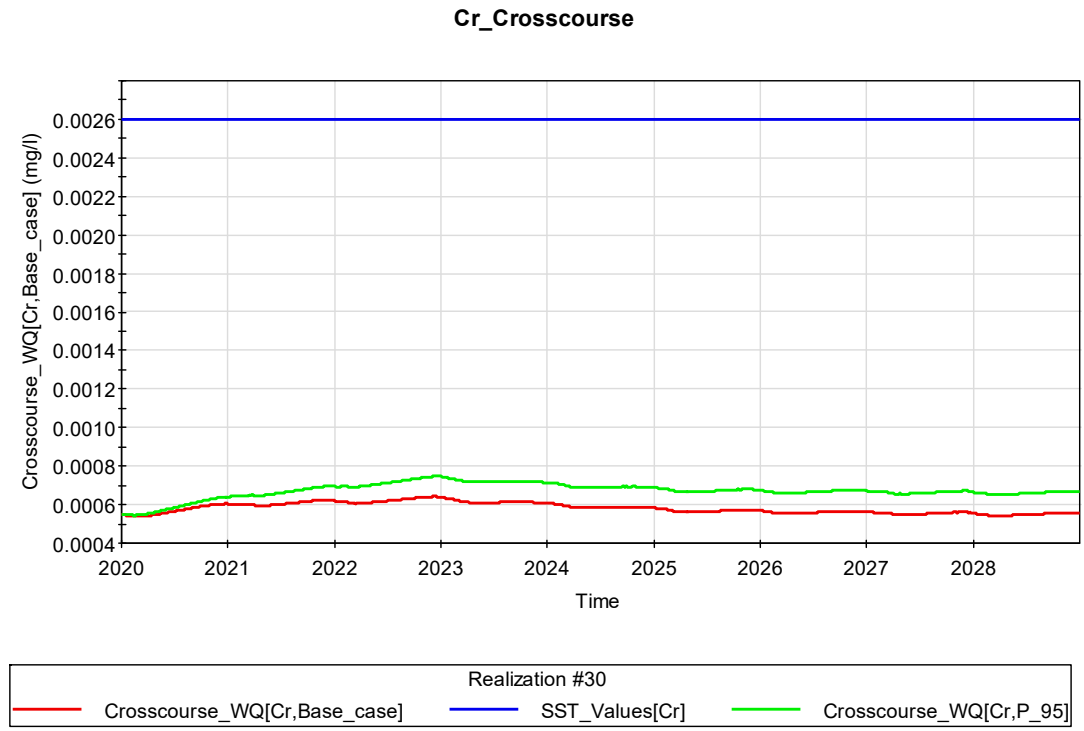

As_Crosscourse
Crosscourse_WQ[As,Base_case] (mg/l)
0
1
2
3
4
5
6
7
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[As,Base_case]
SST_Values[As]
Crosscourse_WQ[As,P_95]

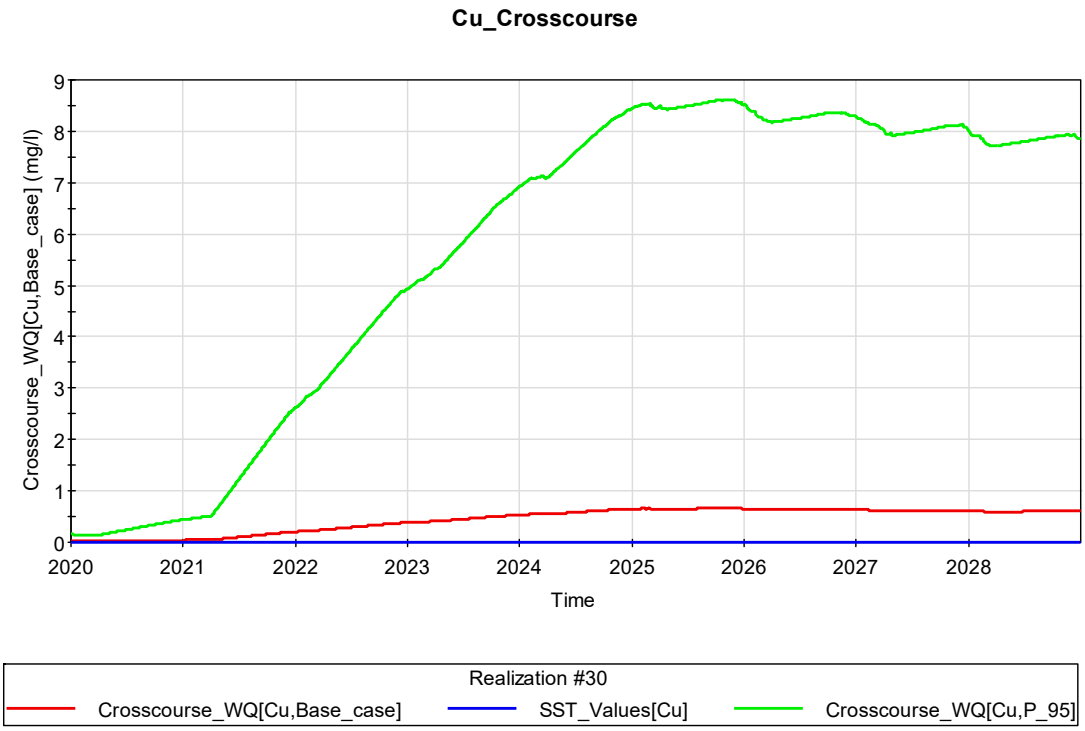

Ca_Crosscourse
Crosscourse_WQ[Ca,Base_case] (mg/l)
160
180
200
220
240
260
280
300
320
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ca,Base_case]
Crosscourse_WQ[Ca,P_95]

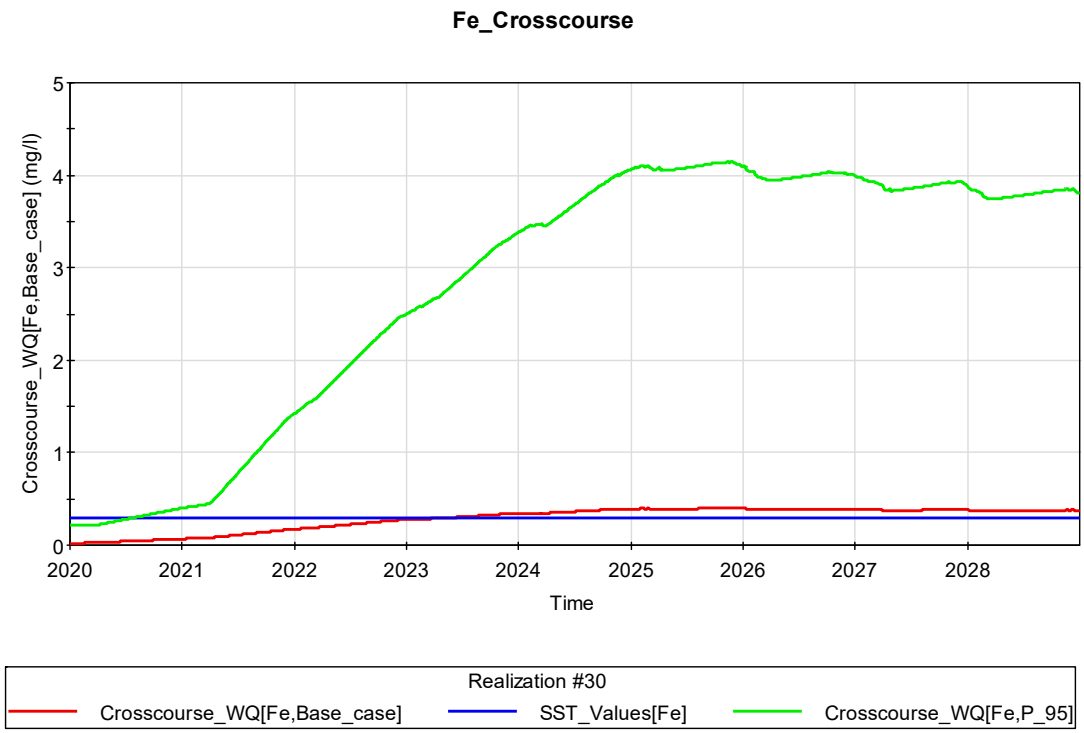

Cd_Crosscourse
Crosscourse_WQ[Cd,Base_case] (mg/l)
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cd,Base_case]
SST_Values[Cd]
Crosscourse_WQ[Cd,P_95]

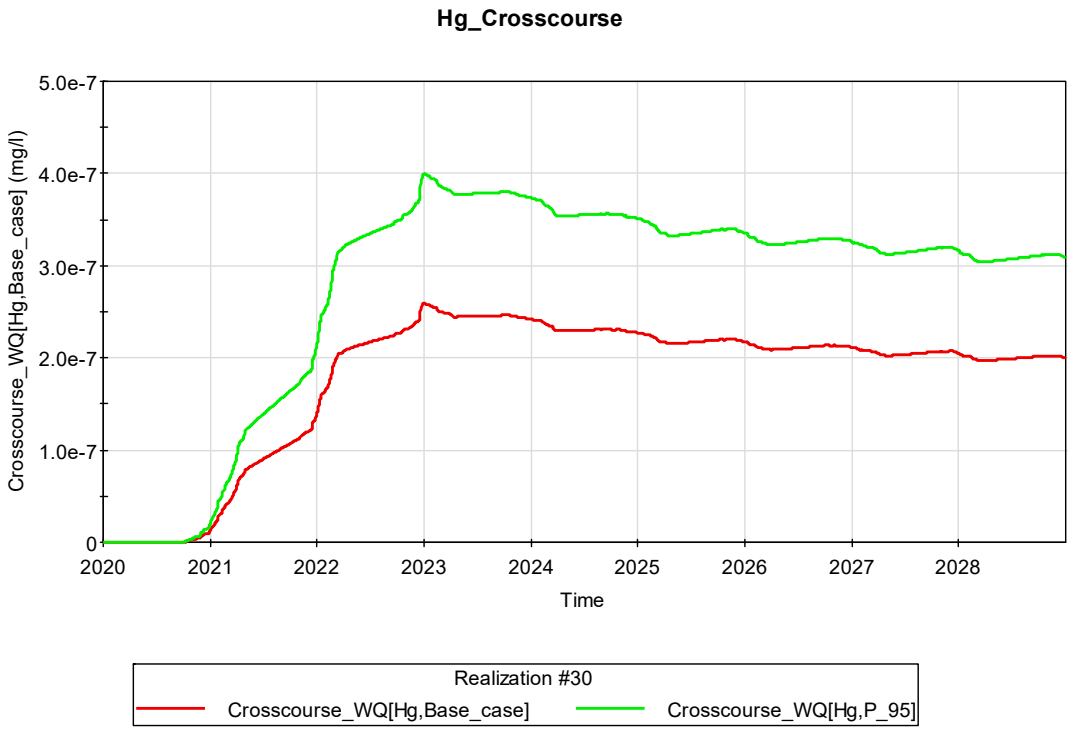

Cl_Crosscourse
Crosscourse_WQ[Cl,Base_case] (mg/l)
90
80
70
60
50
40
30
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cl,Base_case]
Crosscourse_WQ[Cl,P_95]

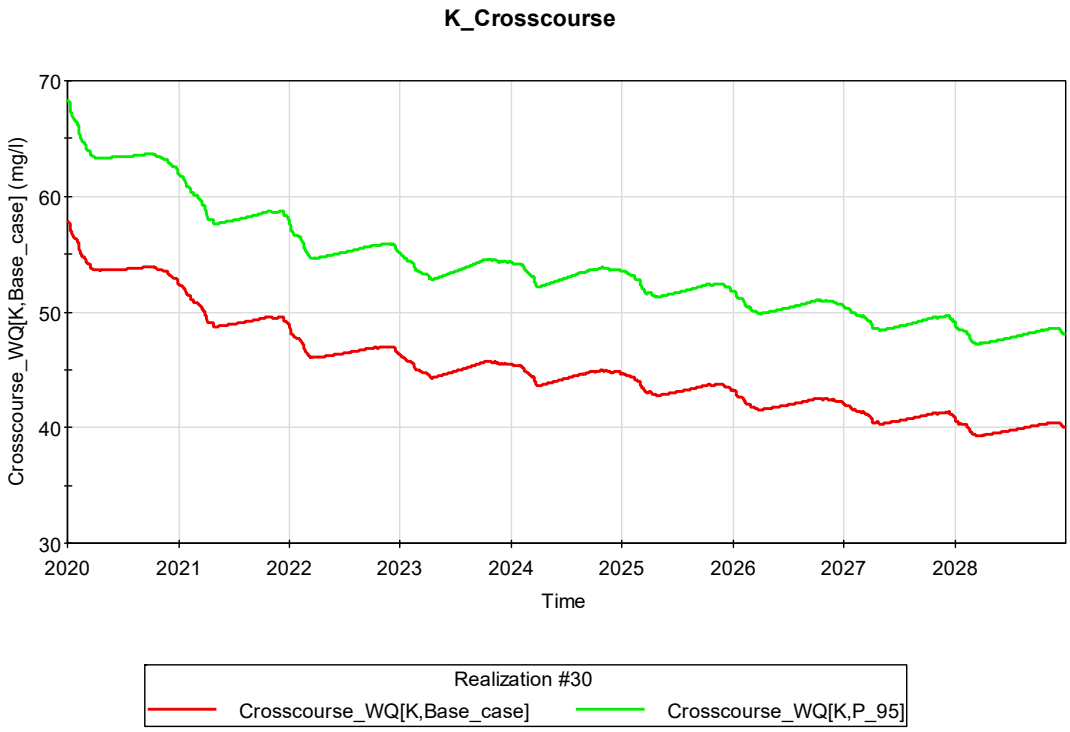

Co_Crosscourse
Crosscourse_WQ[Co,Base_case] (mg/l)
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Co,Base_case]
SST_Values[Co]
Crosscourse_WQ[Co,P_95]

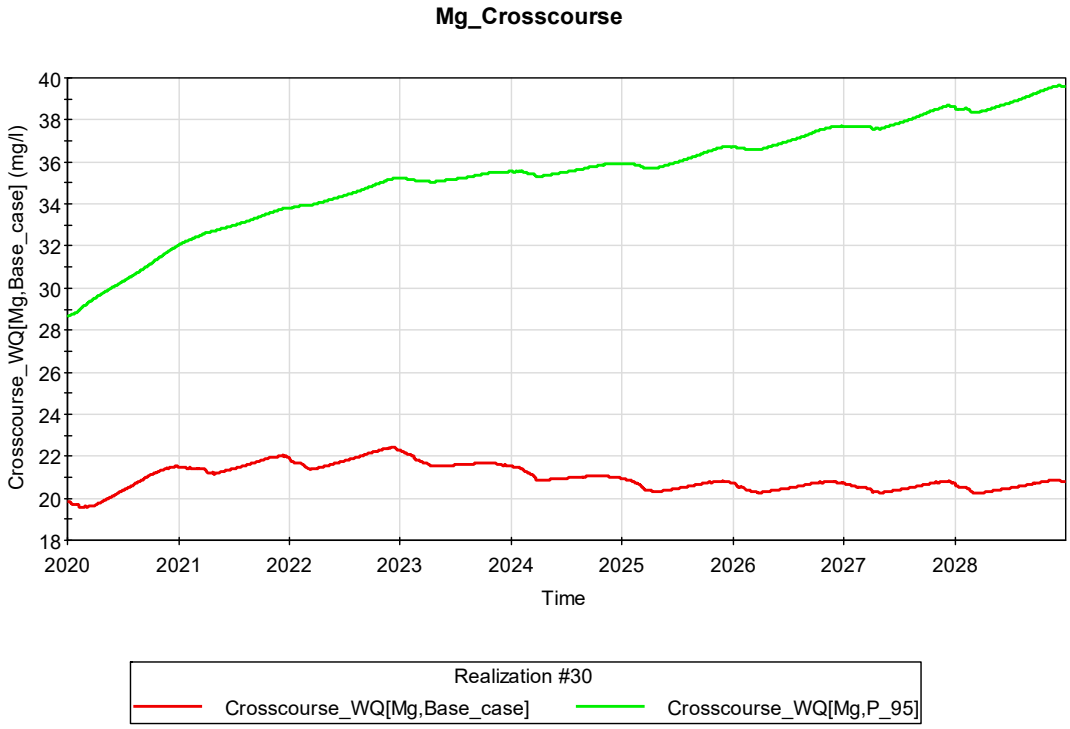

Cr_Crosscourse
Crosscourse_WQ[Cr,Base_case] (mg/l)
0.0026
0.0024
0.0022
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cr,Base_case]
SST_Values[Cr]
Crosscourse_WQ[Cr,P_95]

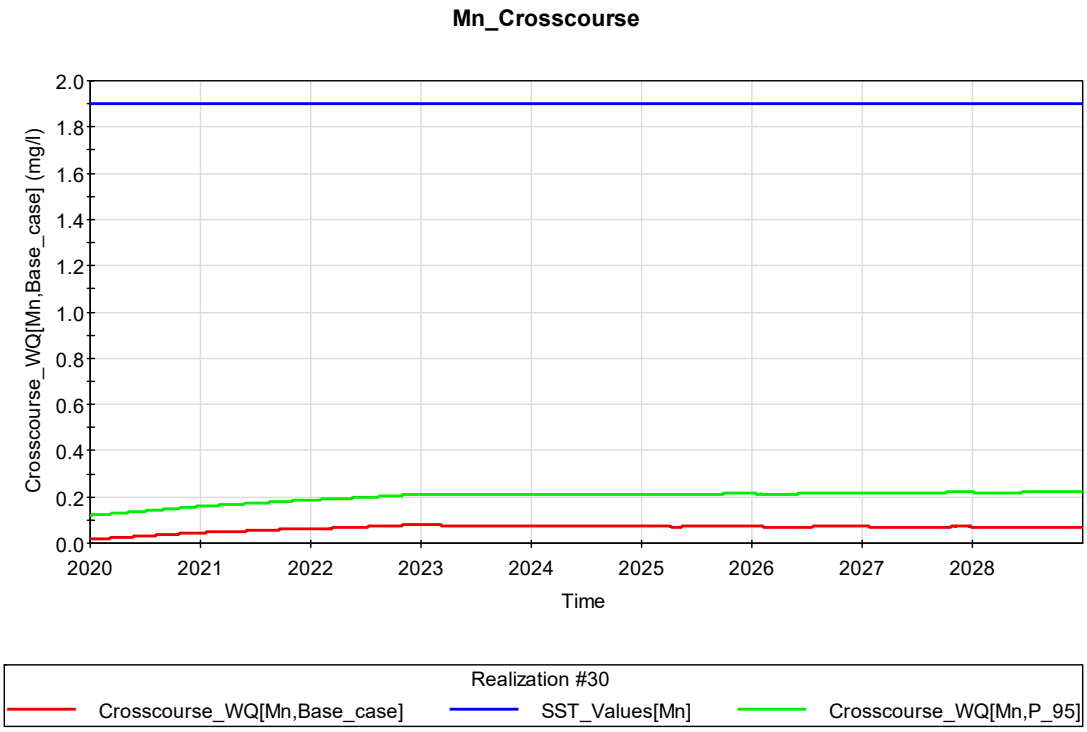

Cu_Crosscourse
Crosscourse_WQ[Cu,Base_case] (mg/l)
0
1
2
3
4
5
6
7
8
9
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cu,Base_case]
SST_Values[Cu]
Crosscourse_WQ[Cu,P_95]

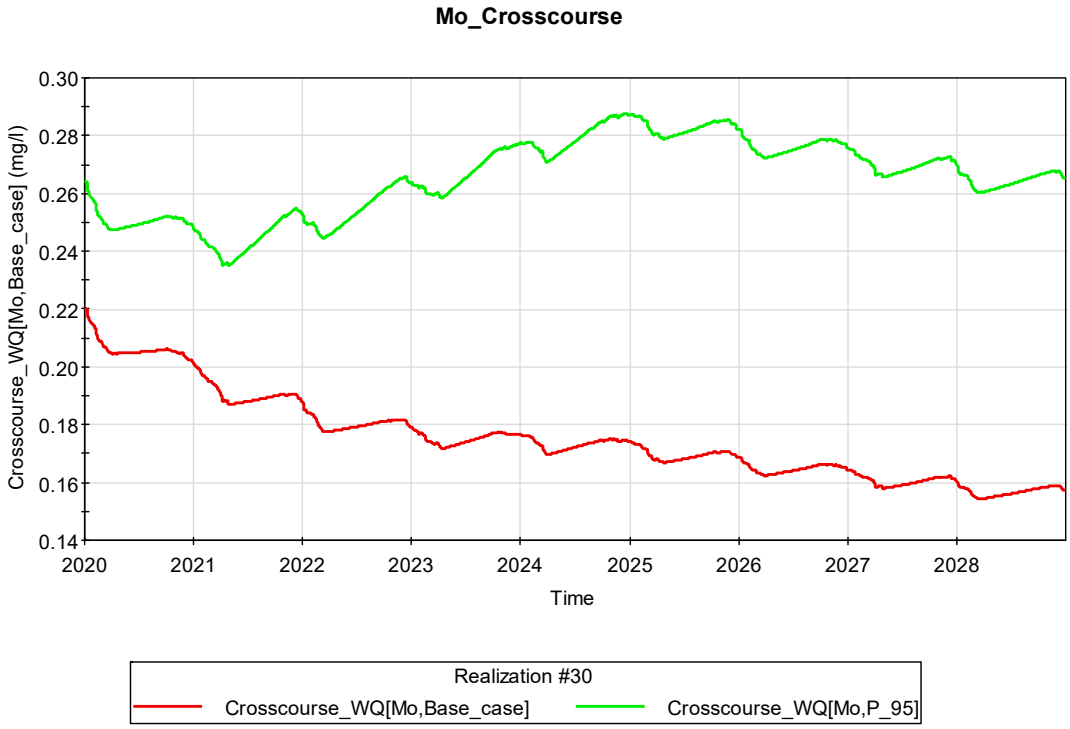

Fe_Crosscourse
Crosscourse_WQ[Fe,Base_case] (mg/l)
0
1
2
3
4
5
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Fe,Base_case]
SST_Values[Fe]
Crosscourse_WQ[Fe,P_95]

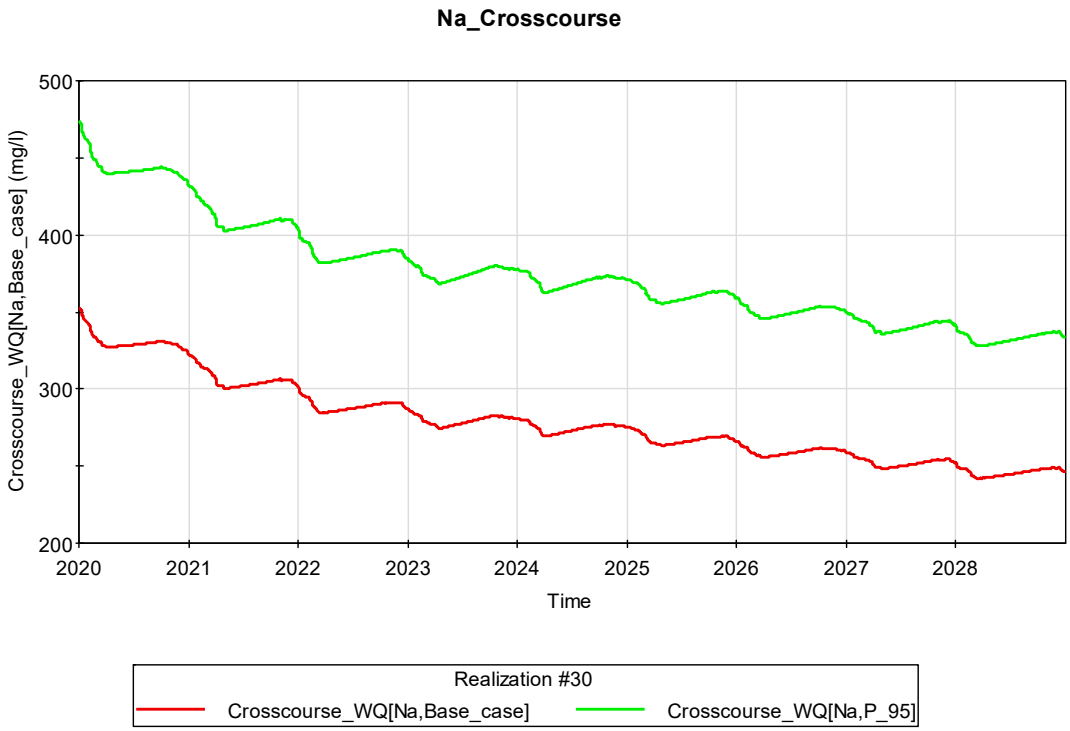

Hg_Crosscourse
5.0e-7
4.0e-7
3.0e-7
2.0e-7
1.0e-7
0
Crosscourse_WQ[Hg,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Hg,Base_case]
Crosscourse_WQ[Hg,P_95]

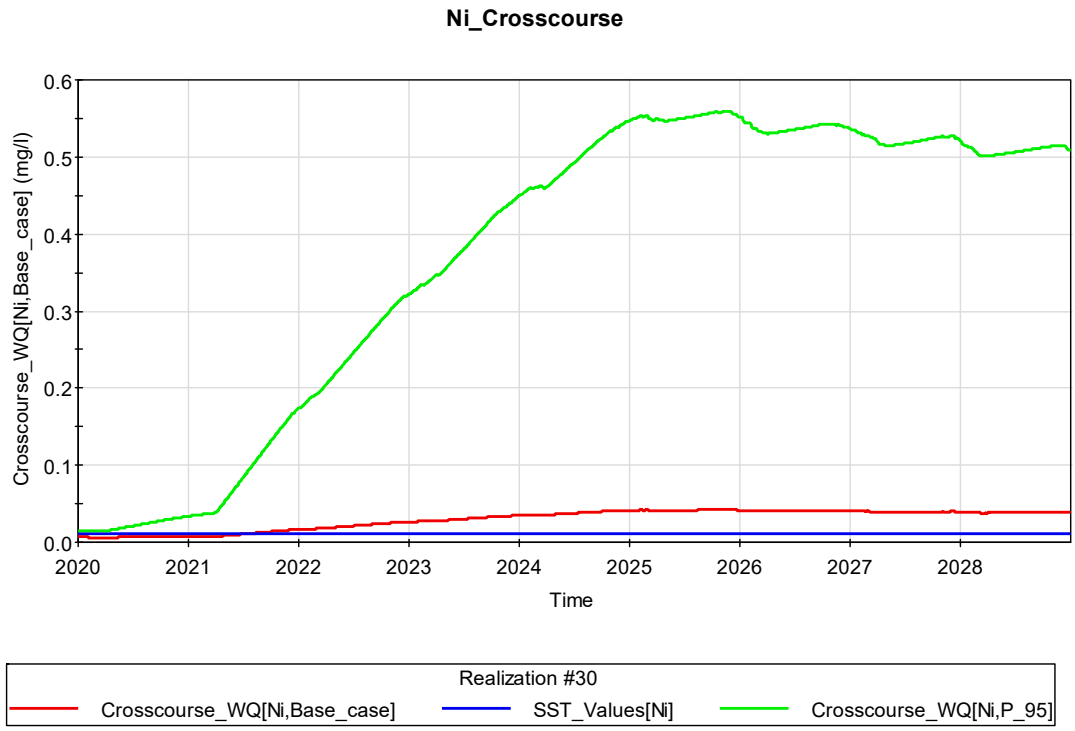

K_Crosscourse
70
60
50
40
30
Crosscourse_WQ[K,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[K,Base_case]
Crosscourse_WQ[K,P_95]

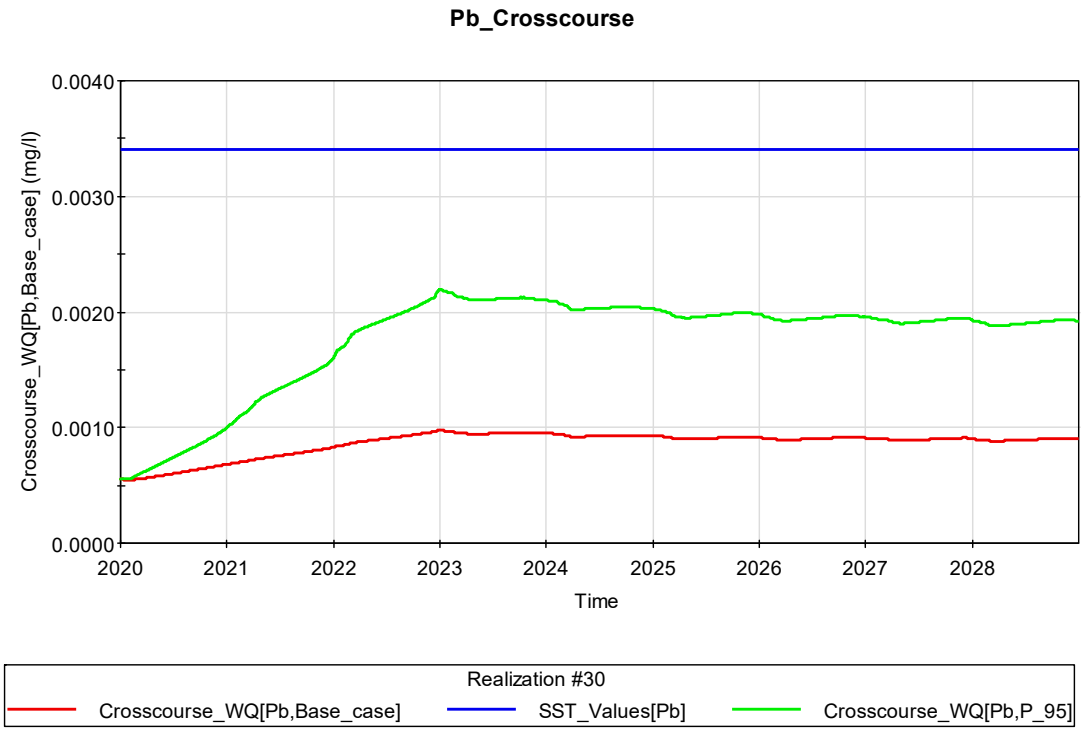

Mg_Crosscourse
Crosscourse_WQ[Mg,Base_case] (mg/l)
40
38
36
34
32
30
28
26
24
22
20
18
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mg,Base_case]
Crosscourse_WQ[Mg,P_95]

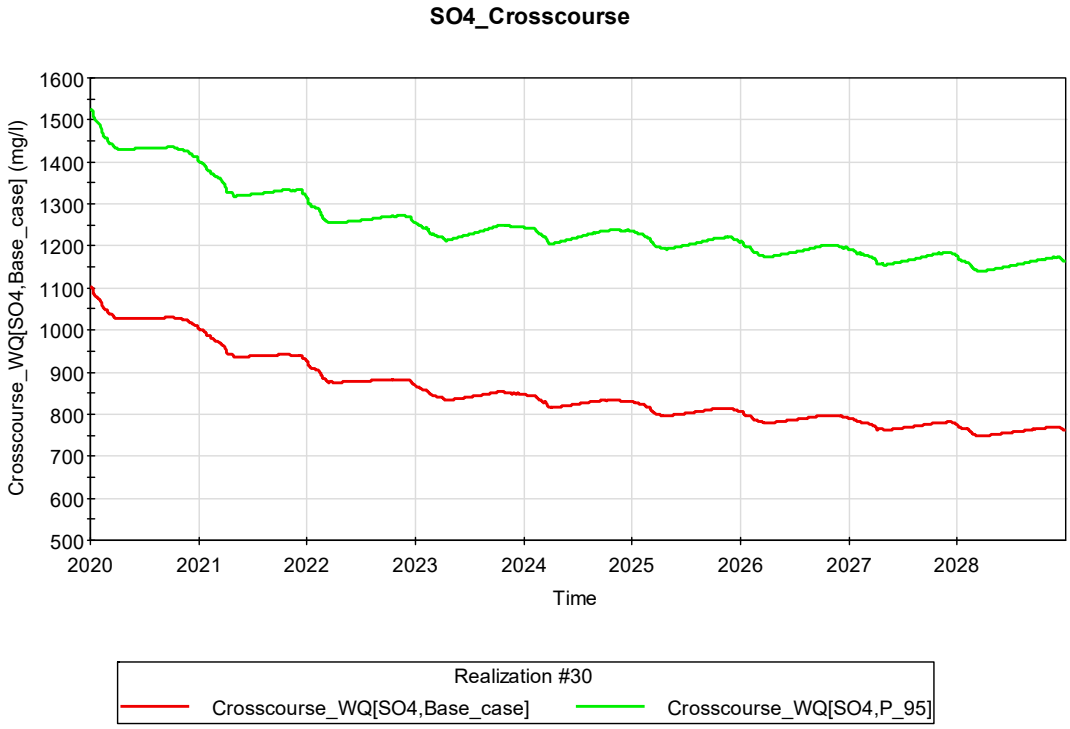

Mn_Crosscourse
Crosscourse_WQ[Mn,Base_case] (mg/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mn,Base_case]
SST_Values[Mn]
Crosscourse_WQ[Mn,P_95]

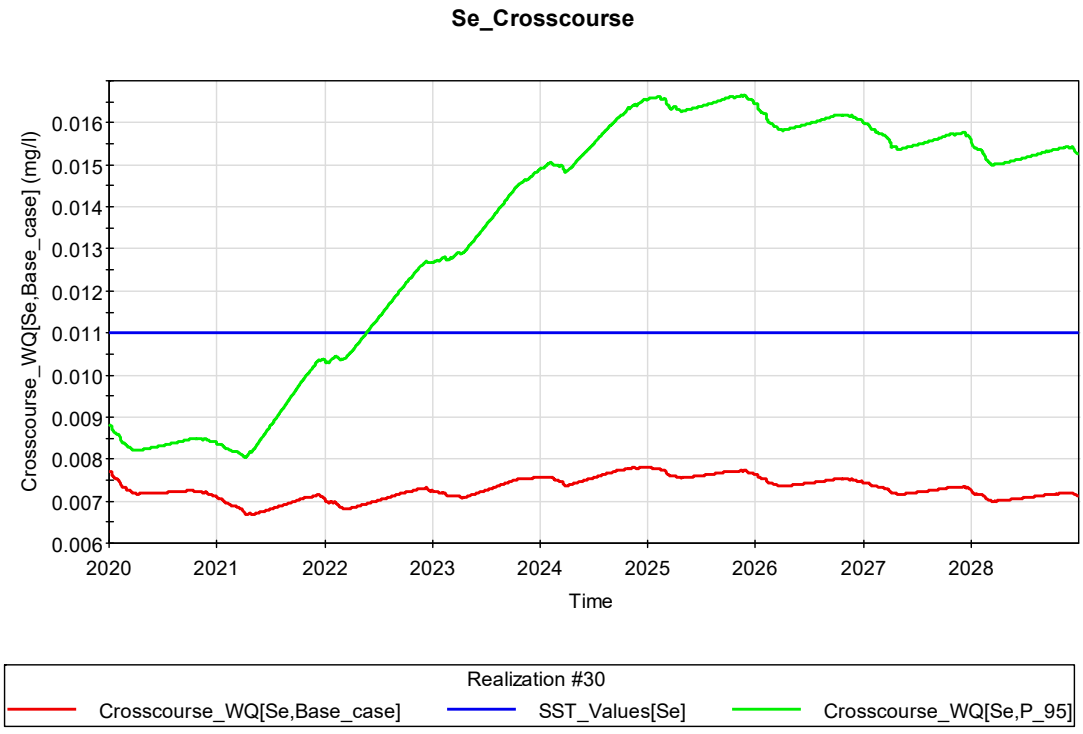

Mo_Crosscourse
Crosscourse_WQ[Mo,Base_case] (mg/l)
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mo,Base_case]
Crosscourse_WQ[Mo,P_95]

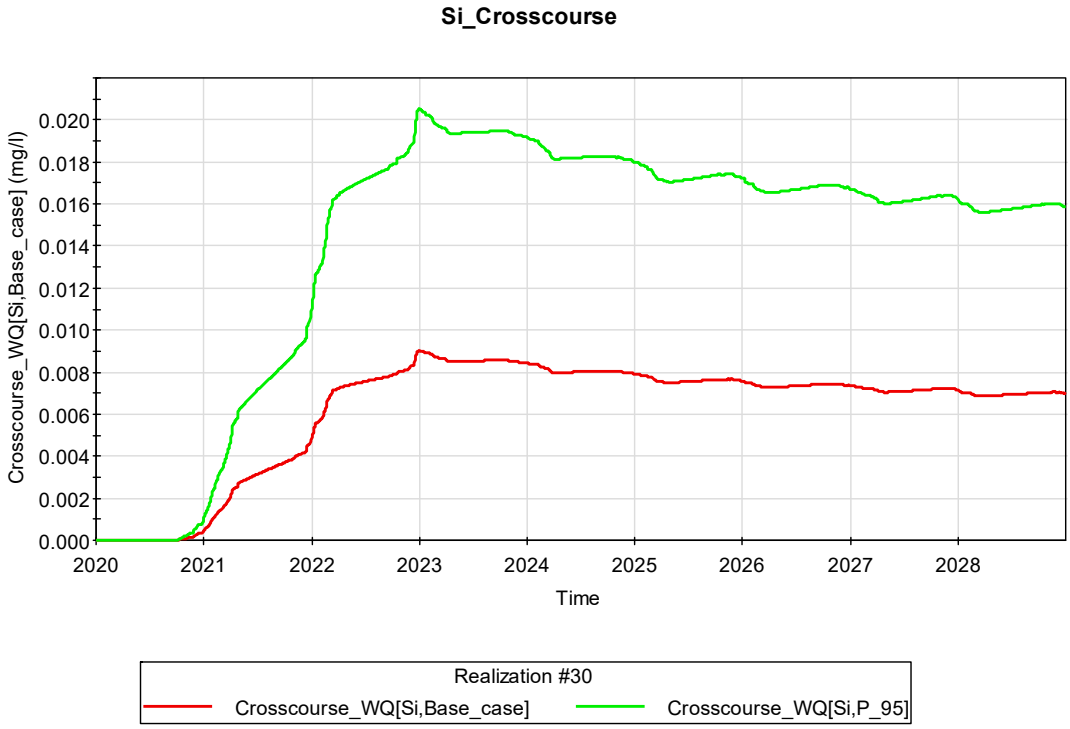

Na_Crosscourse
Crosscourse_WQ[Na,Base_case] (mg/l)
500
400
300
200
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Na,Base_case]
Crosscourse_WQ[Na,P_95]

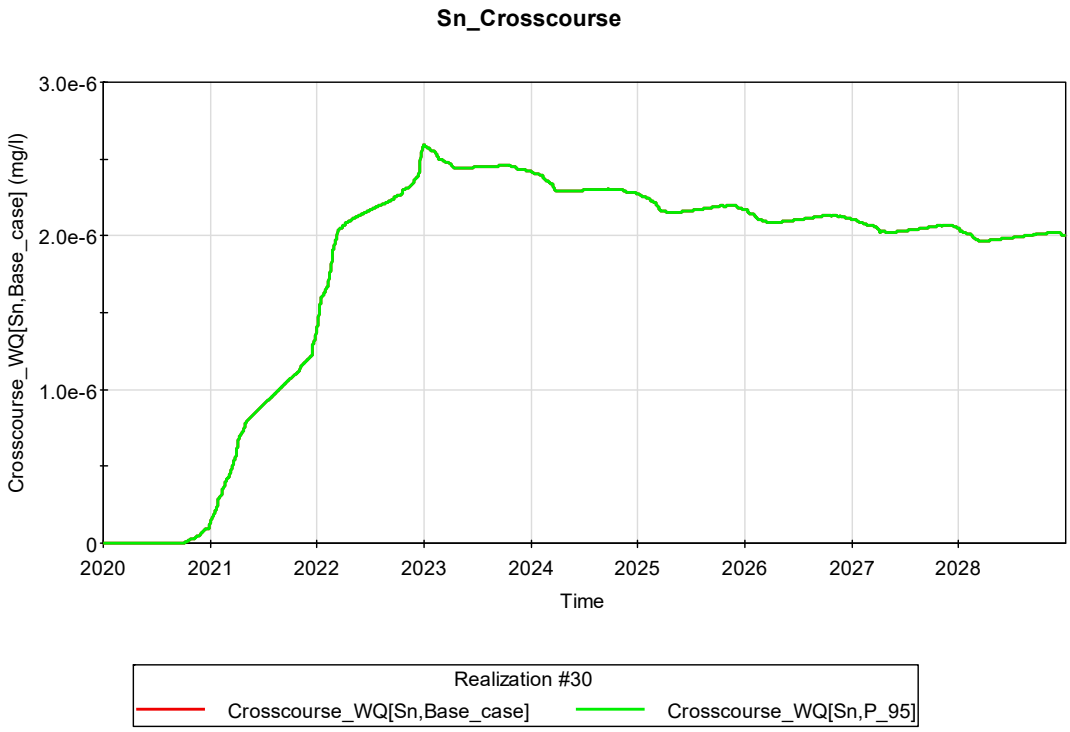

Ni_Crosscourse
Crosscourse_WQ[Ni,Base_case] (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ni,Base_case]
SST_Values[Ni]
Crosscourse_WQ[Ni,P_95]

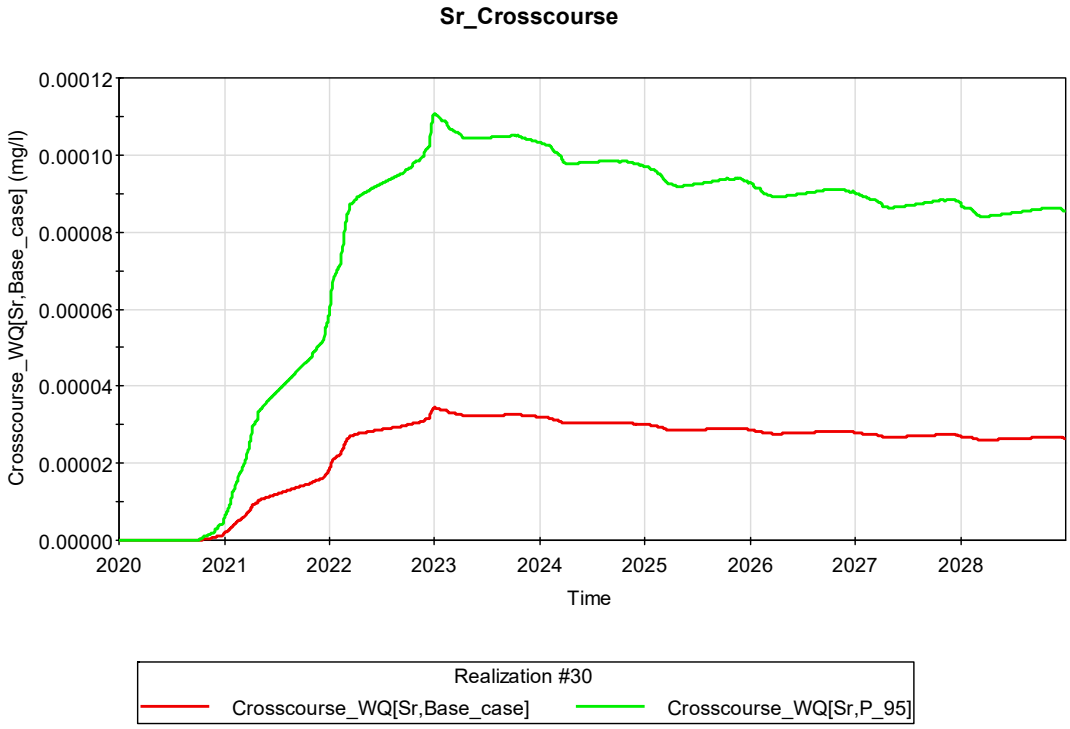

Pb_Crosscourse
Crosscourse_WQ[Pb,Base_case] (mg/l)
0.0040
0.0030
0.0020
0.0010
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Pb,Base_case]
SST_Values[Pb]
Crosscourse_WQ[Pb,P_95]

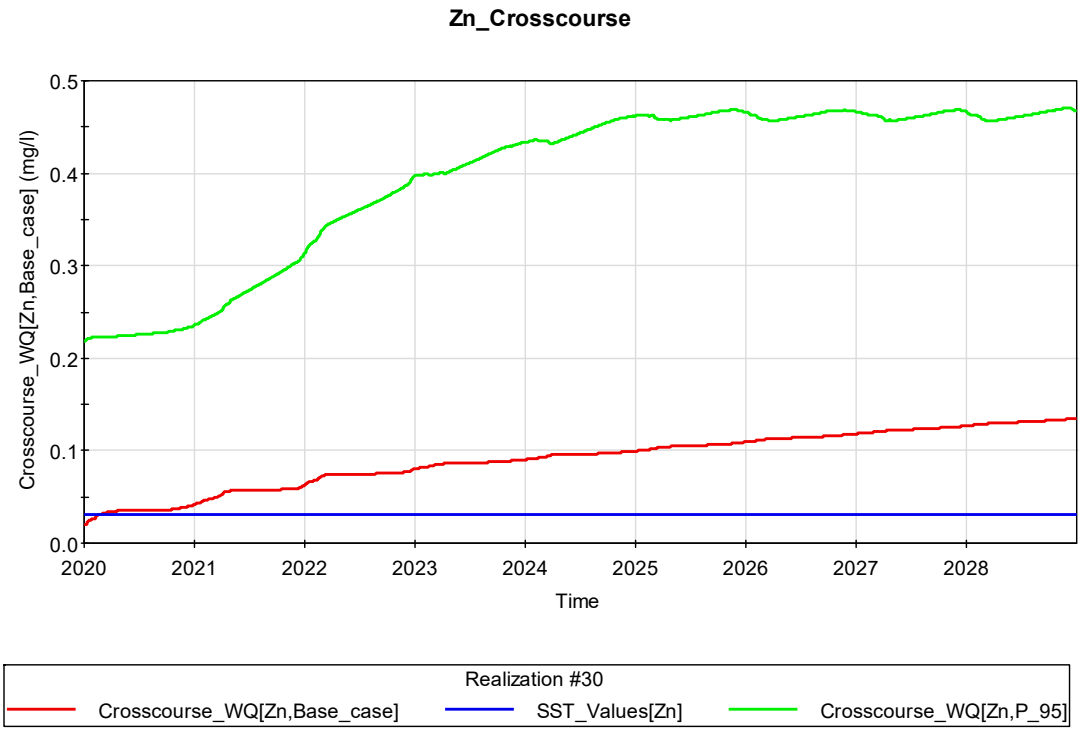

SO4_Crosscourse
Crosscourse_WQ[SO4,Base_case] (mg/l)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[SO4,Base_case]
Crosscourse_WQ[SO4,P_95]

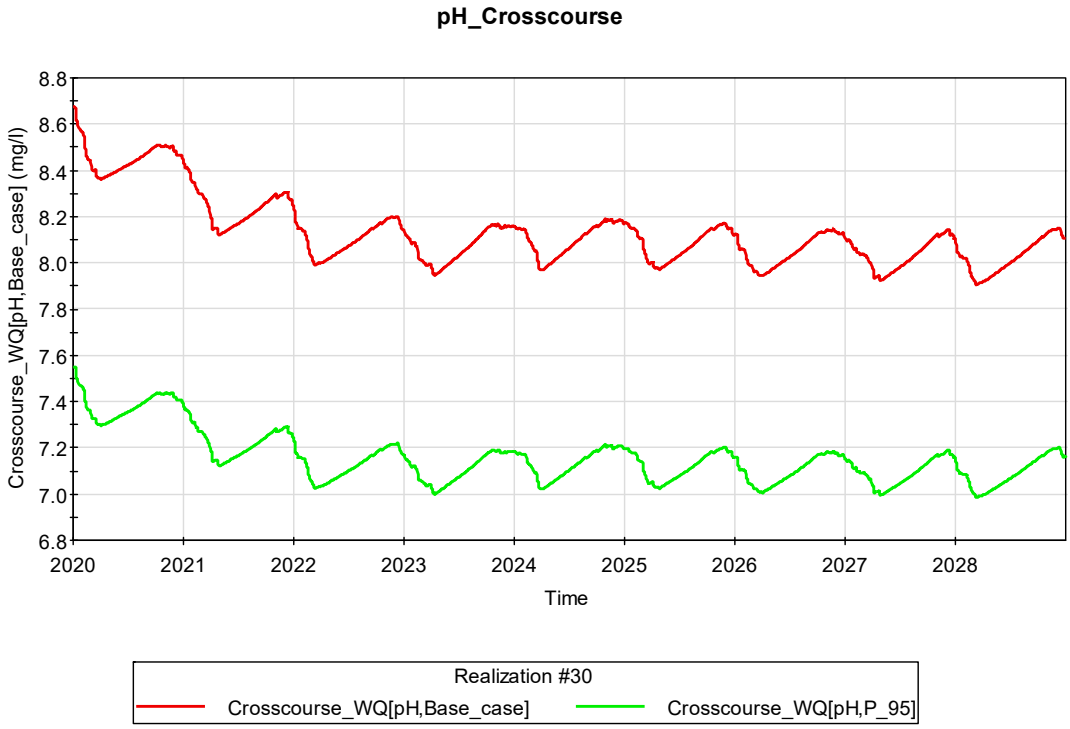

Se_Crosscourse
Crosscourse_WQ[Se,Base_case] (mg/l)
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Se,Base_case]
SST_Values[Se]
Crosscourse_WQ[Se,P_95]


Si_Crosscourse
Crosscourse_WQ[Si,Base_case] (mg/l)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Si,Base_case]
Crosscourse_WQ[Si,P_95]

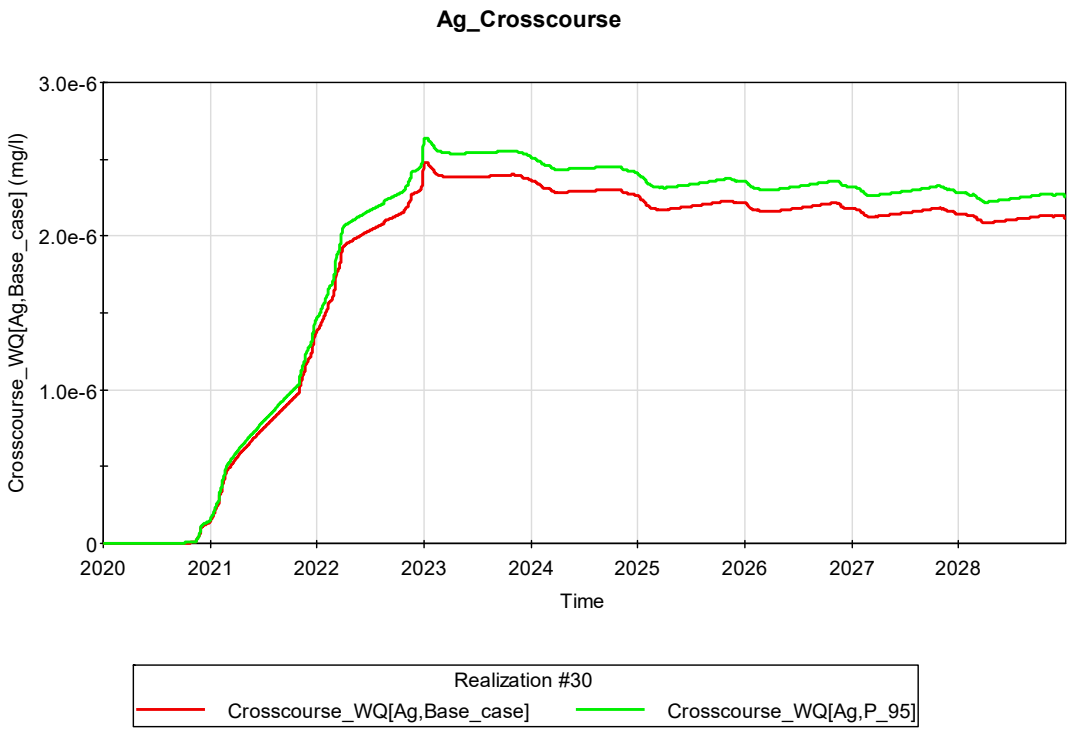

Sn_Crosscourse
Crosscourse_WQ[Sn,Base_case] (mg/l)
3.0e-6
2.0e-6
1.0e-6
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sn,Base_case]
Crosscourse_WQ[Sn,P_95]

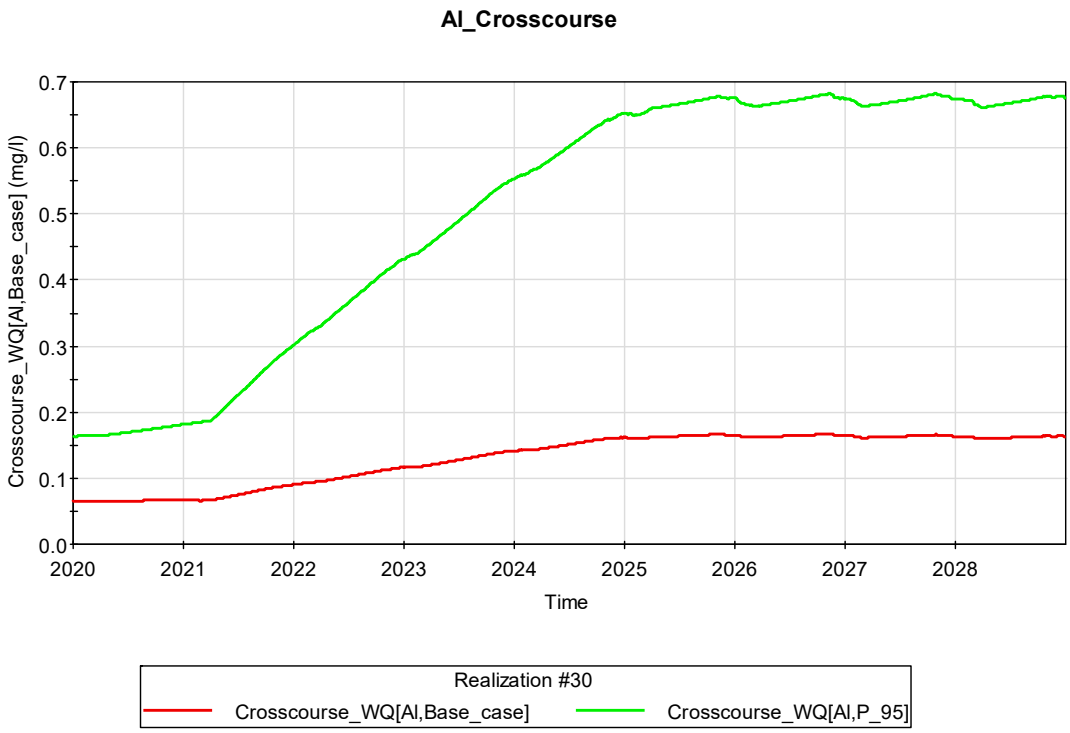

Sr_Crosscourse
0.00012
0.00010
0.00008
0.00006
0.00004
0.00002
0.00000
Crosscourse_WQ[Sr,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sr,Base_case]
Crosscourse_WQ[Sr,P_95]

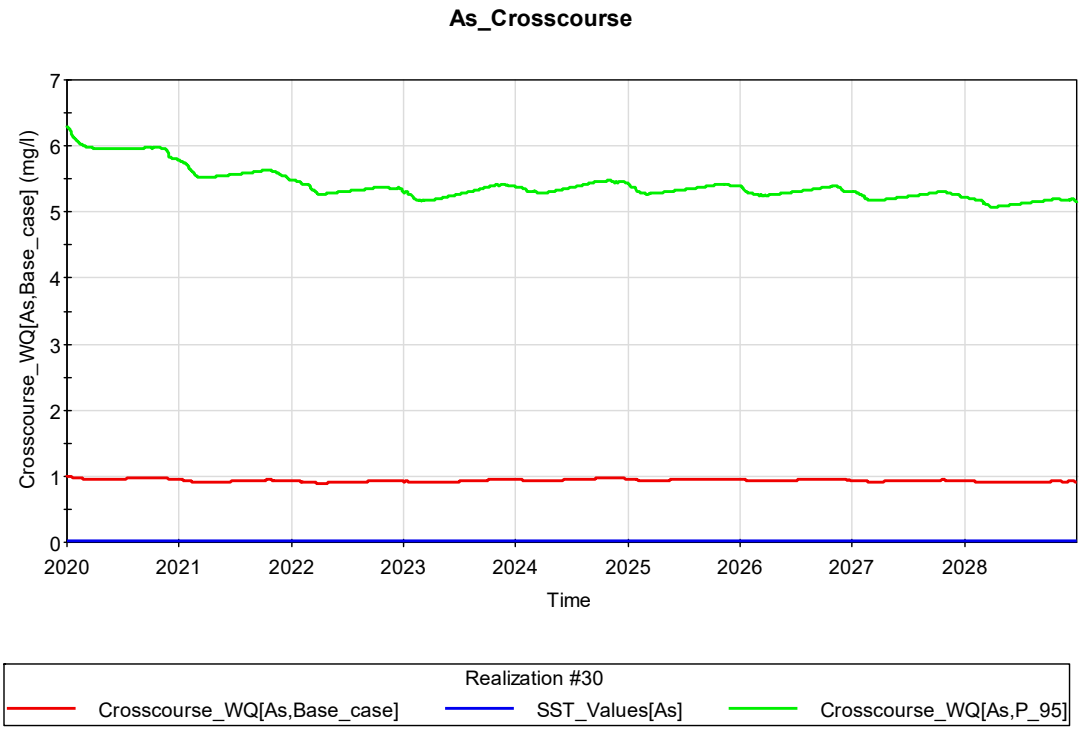

Zn_Crosscourse
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Zn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Zn,Base_case]
SST_Values[Zn]
Crosscourse_WQ[Zn,P_95]

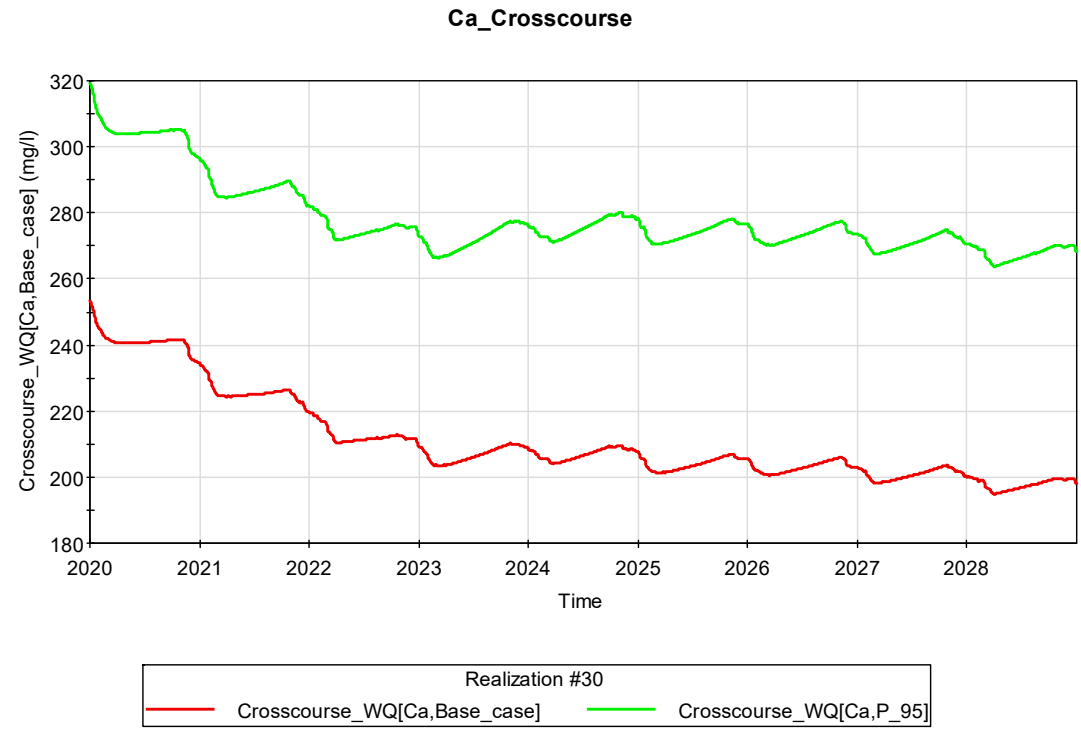

pH_Crosscourse
Crosscourse_WQ[pH,Base_case] (mg/l)
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[pH,Base_case]
Crosscourse_WQ[pH,P_95]

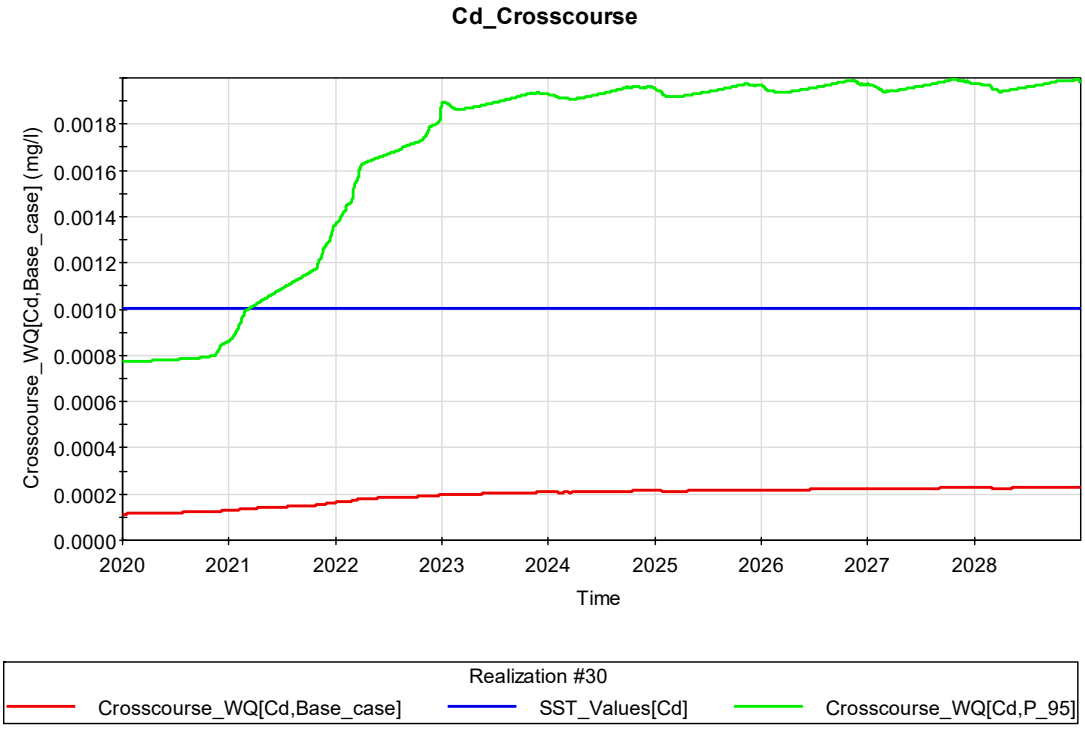
Median climate no discharge

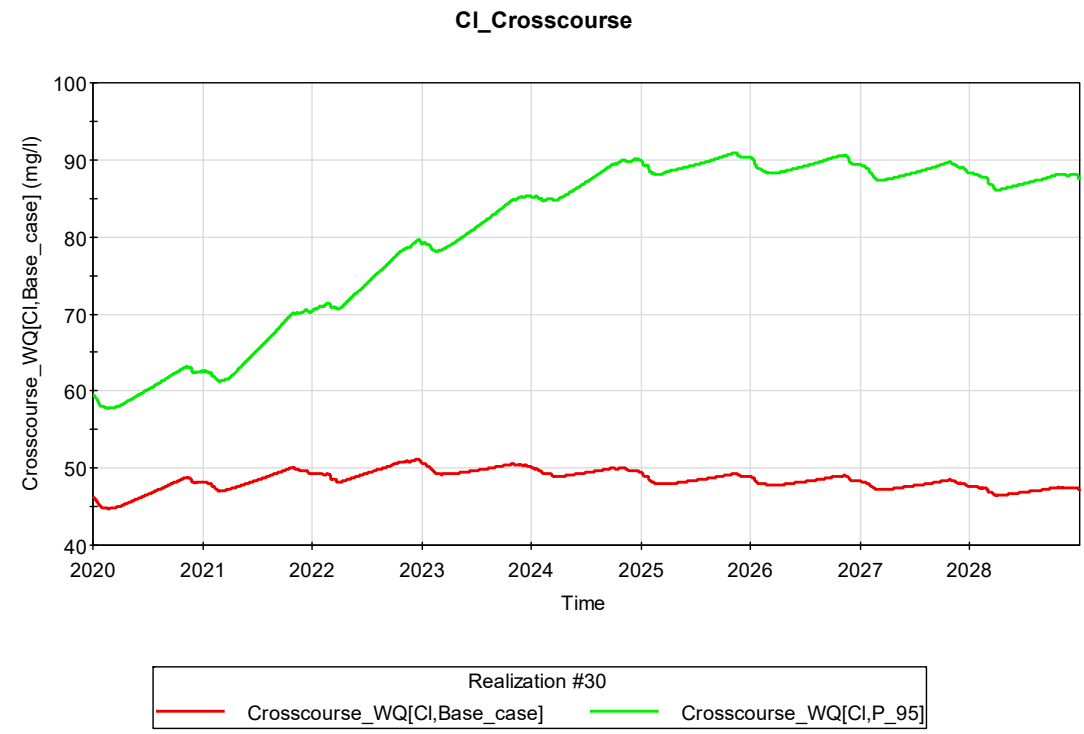


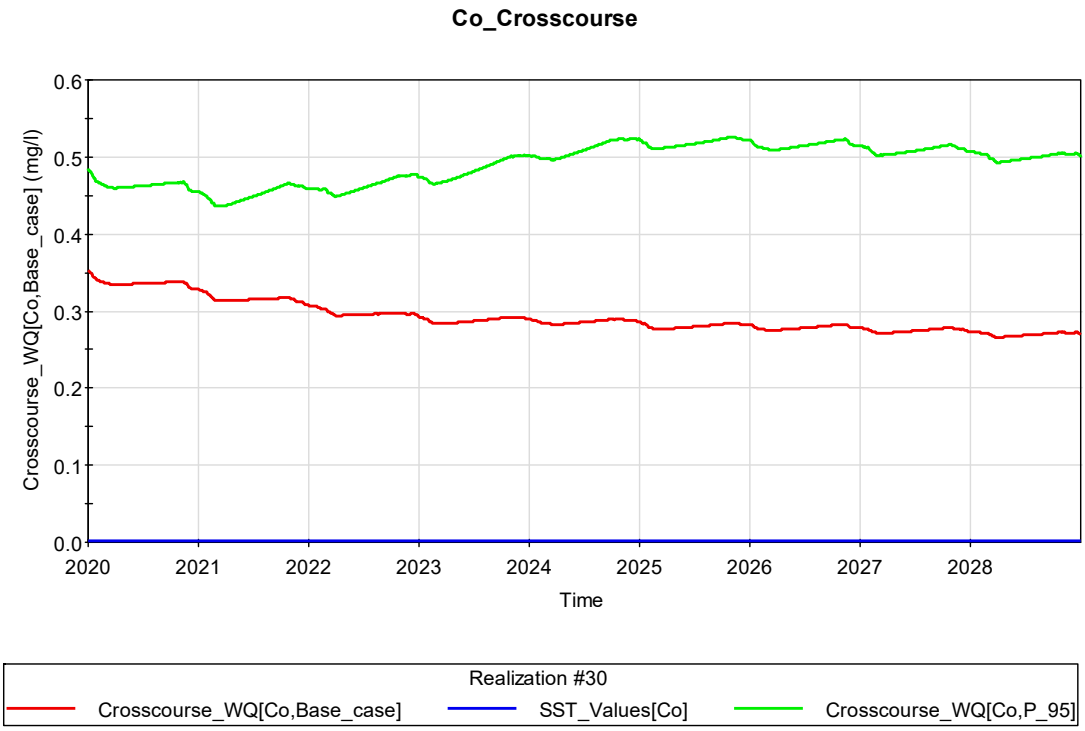


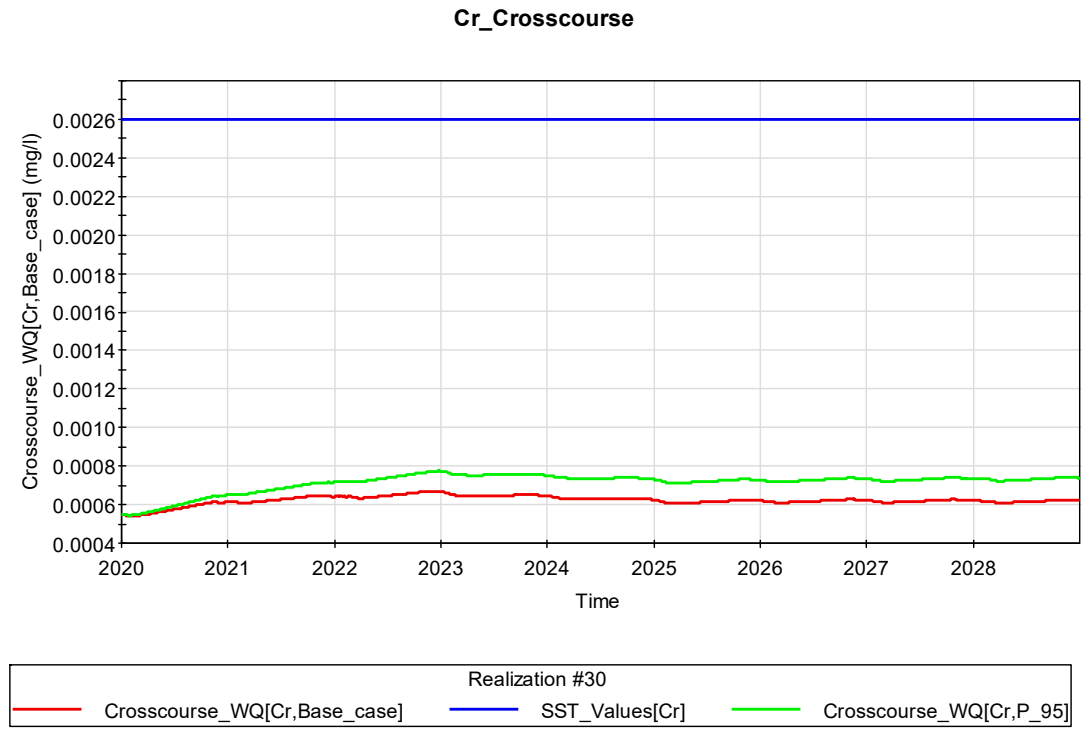

As_Crosscourse
Crosscourse_WQ[As,Base_case] (mg/l)
0
1
2
3
4
5
6
7
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[As,Base_case]
SST_Values[As]
Crosscourse_WQ[As,P_95]

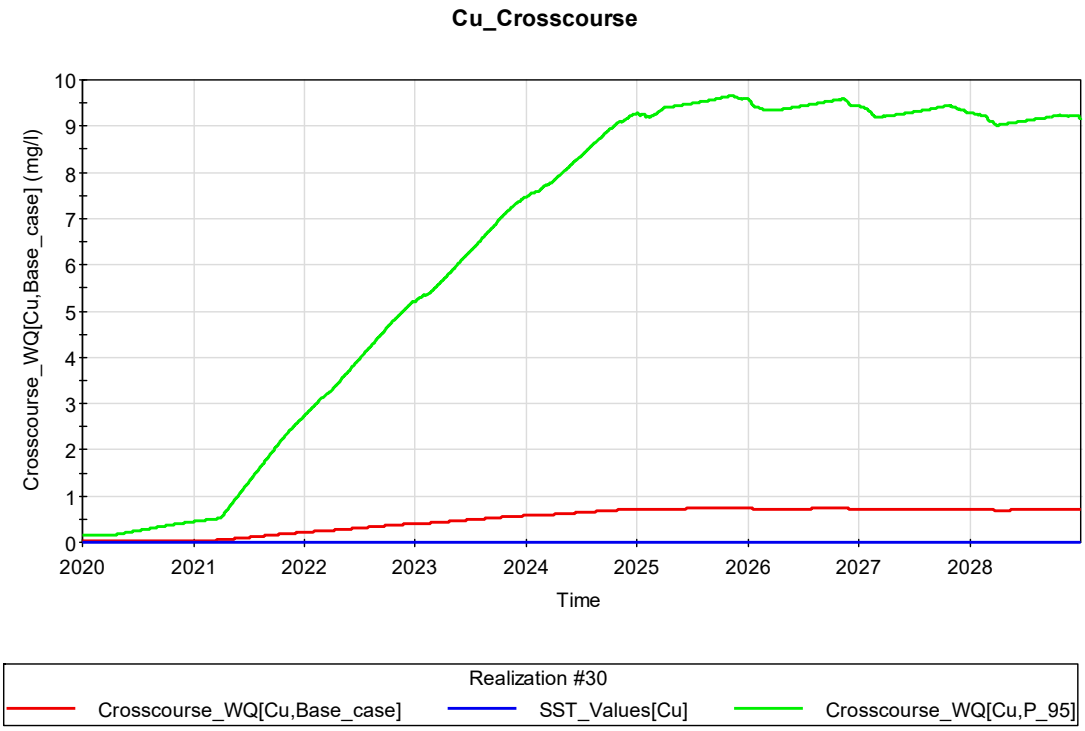

Ca_Crosscourse
Crosscourse_WQ[Ca,Base_case] (mg/l)
180
200
220
240
260
280
300
320
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ca,Base_case]
Crosscourse_WQ[Ca,P_95]

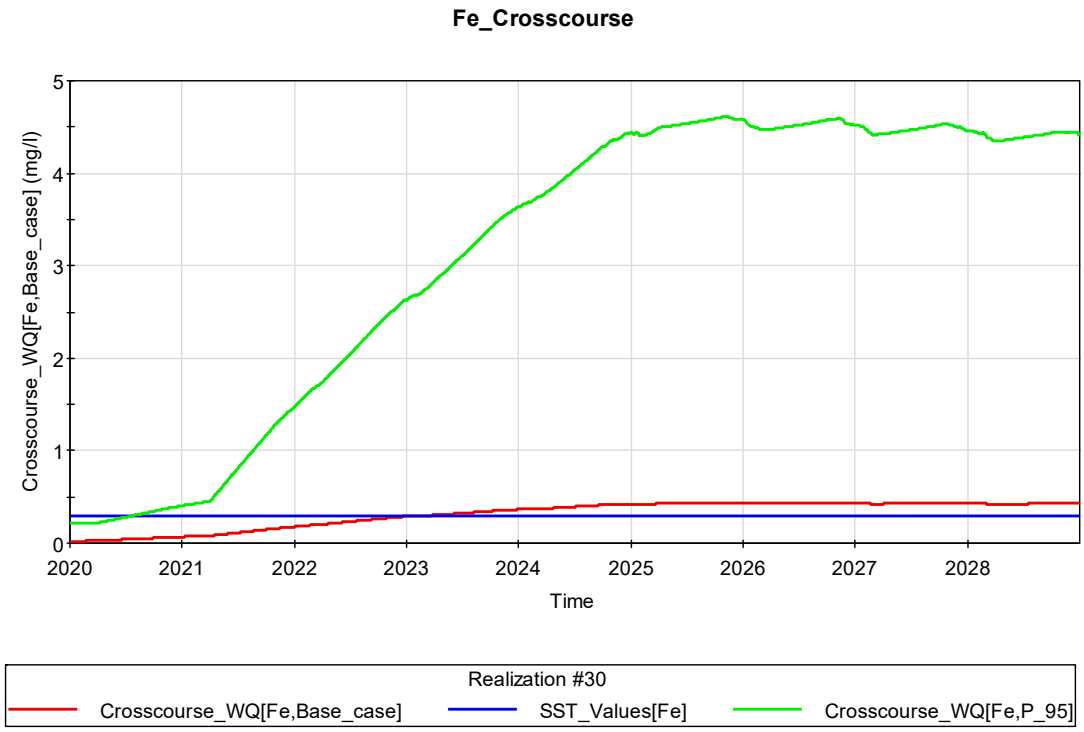

Cd_Crosscourse
Crosscourse_WQ[Cd,Base_case] (mg/l)
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cd,Base_case]
SST_Values[Cd]
Crosscourse_WQ[Cd,P_95]

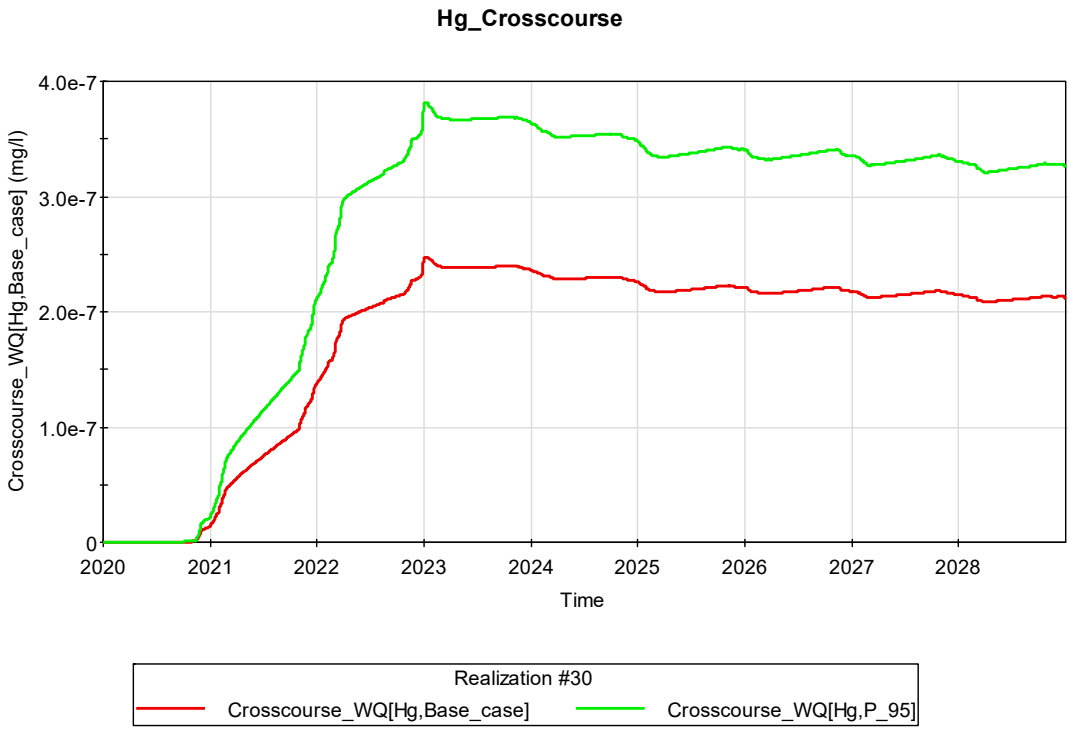

Cl_Crosscourse
Crosscourse_WQ[Cl,Base_case] (mg/l)
100
90
80
70
60
50
40
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cl,Base_case]
Crosscourse_WQ[Cl,P_95]

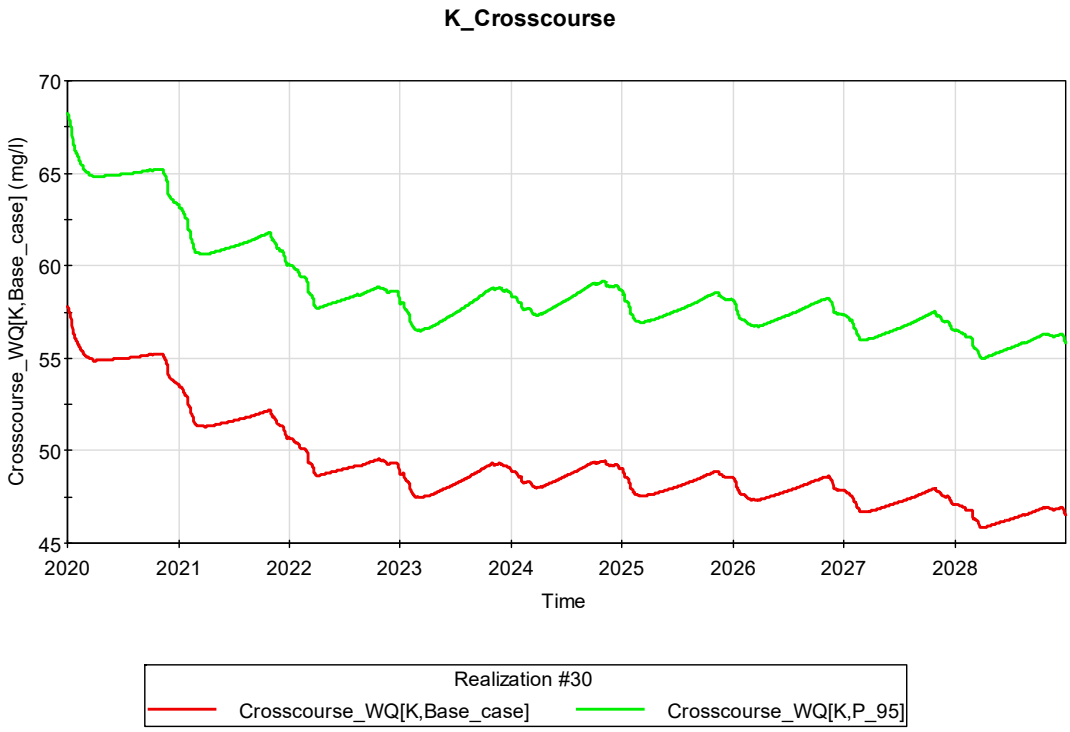

Co_Crosscourse
Crosscourse_WQ[Co,Base_case] (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Co,Base_case]
SST_Values[Co]
Crosscourse_WQ[Co,P_95]

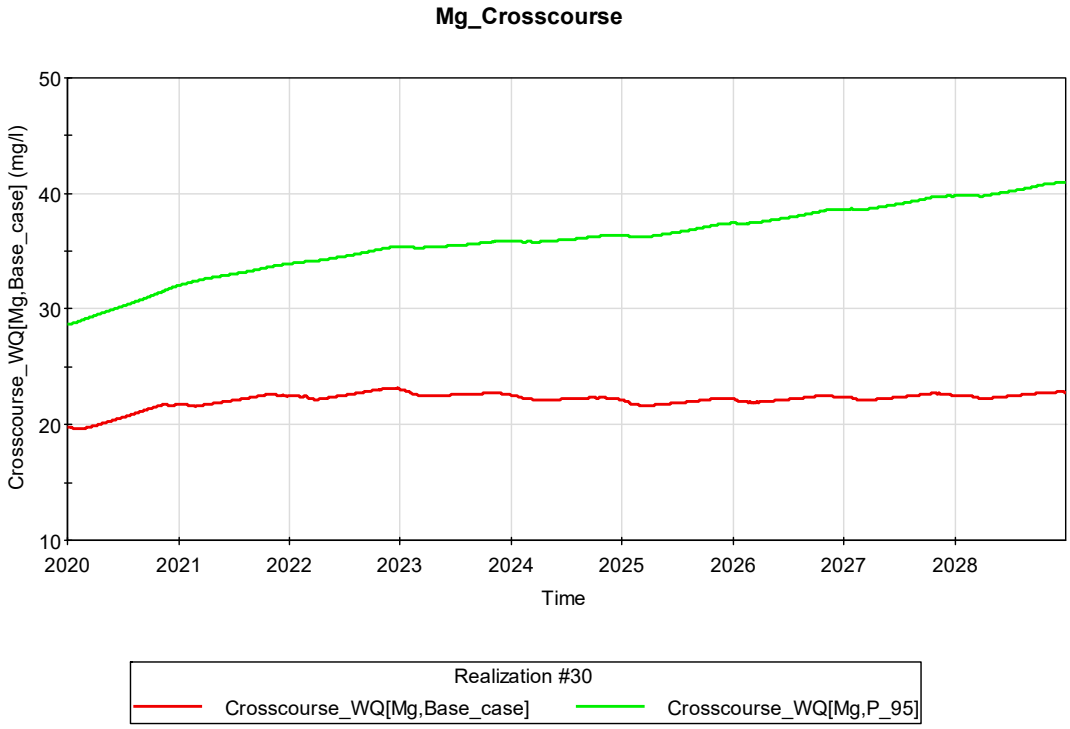

Cr_Crosscourse
Crosscourse_WQ[Cr,Base_case] (mg/l)
0.0026
0.0024
0.0022
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cr,Base_case]
SST_Values[Cr]
Crosscourse_WQ[Cr,P_95]

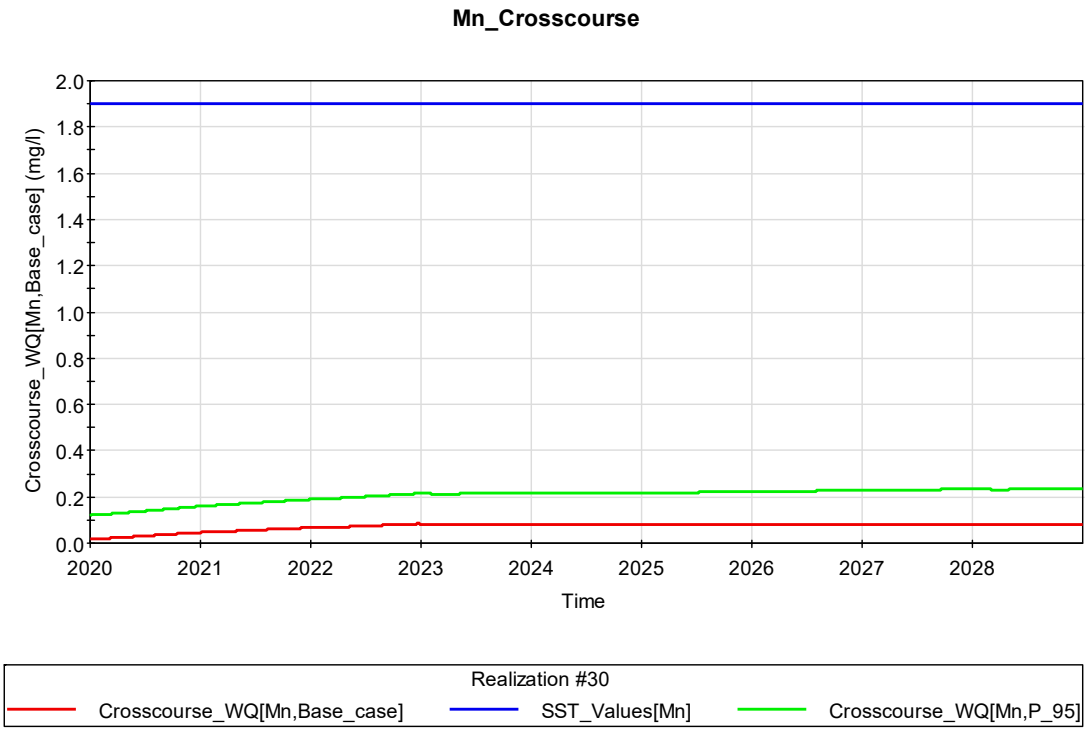

Cu_Crosscourse
Crosscourse_WQ[Cu,Base_case] (mg/l)
10
9
8
7
6
5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cu,Base_case]
SST_Values[Cu]
Crosscourse_WQ[Cu,P_95]

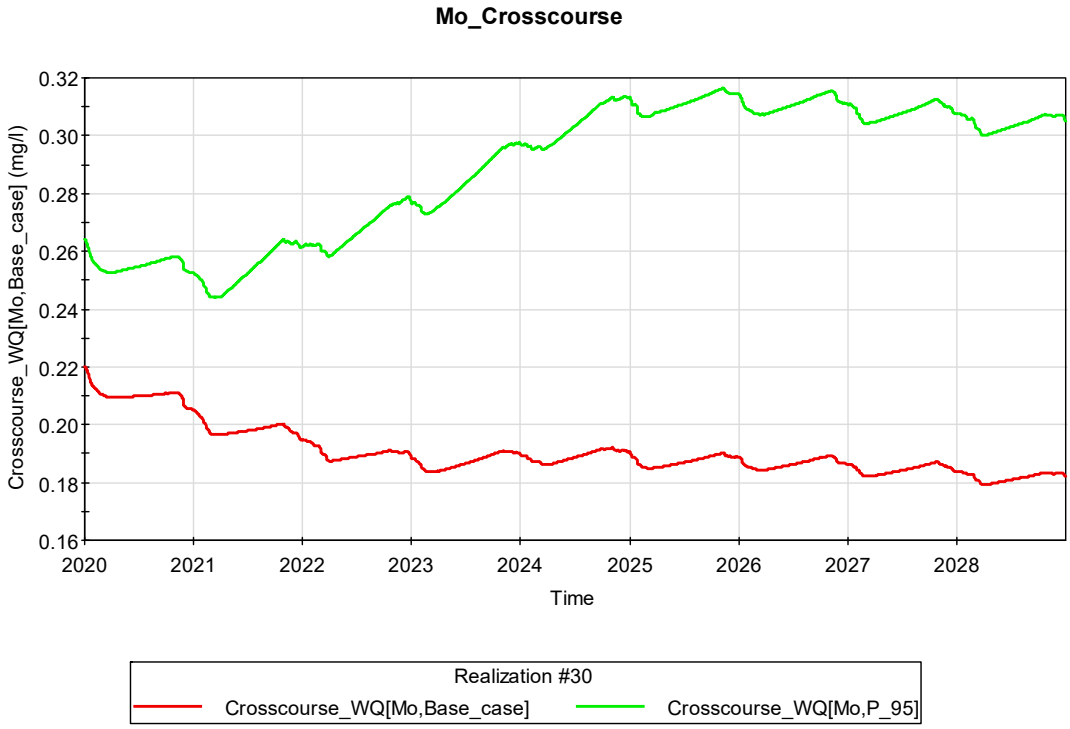

Fe_Crosscourse
Crosscourse_WQ[Fe,Base_case] (mg/l)
5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Fe,Base_case]
SST_Values[Fe]
Crosscourse_WQ[Fe,P_95]

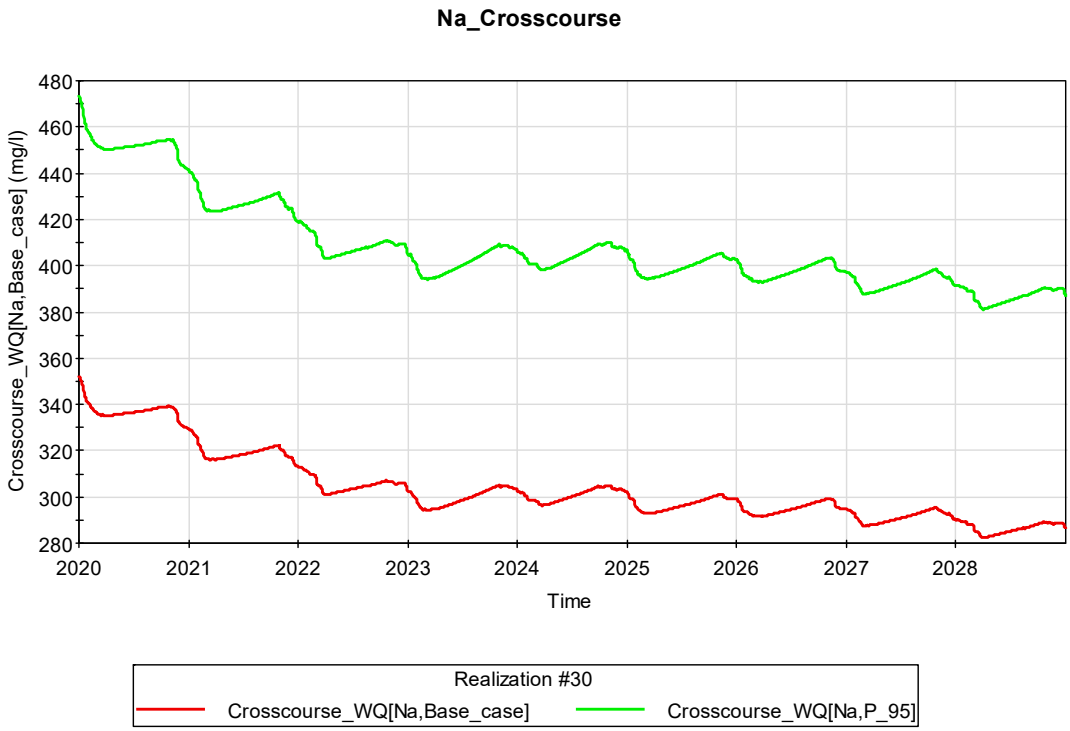

Hg_Crosscourse
4.0e-7
3.0e-7
2.0e-7
1.0e-7
0
Crosscourse_WQ[Hg,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Hg,Base_case]
Crosscourse_WQ[Hg,P_95]

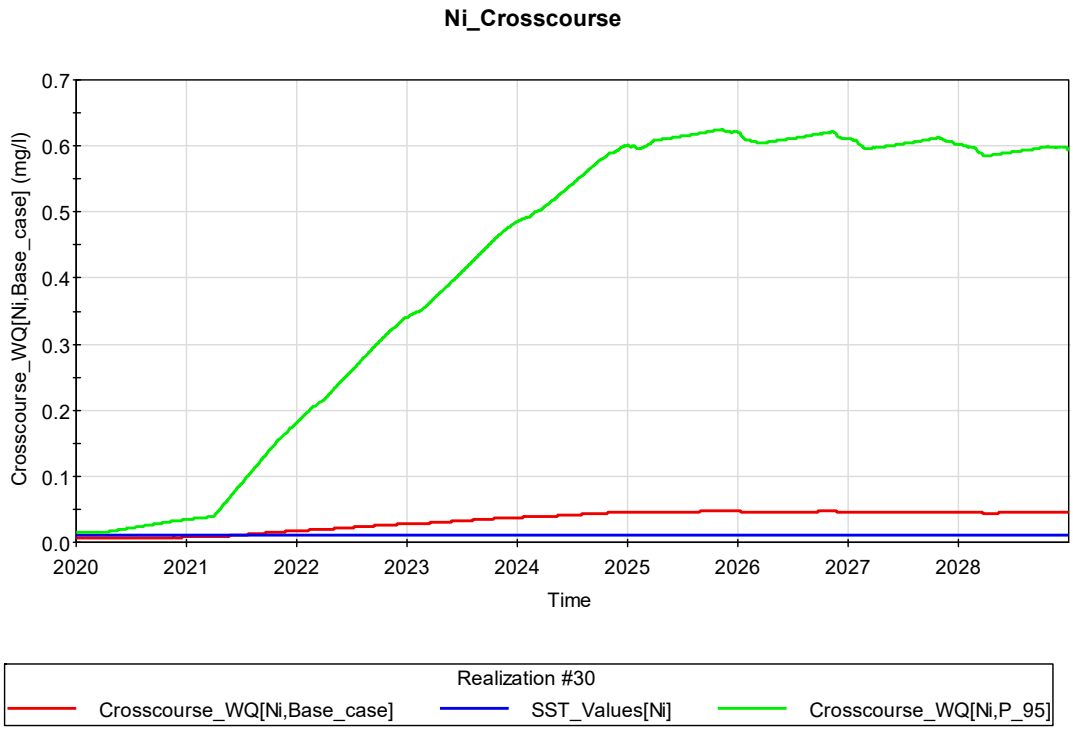

K_Crosscourse
70
65
60
55
50
45
Crosscourse_WQ[K,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[K,Base_case]
Crosscourse_WQ[K,P_95]

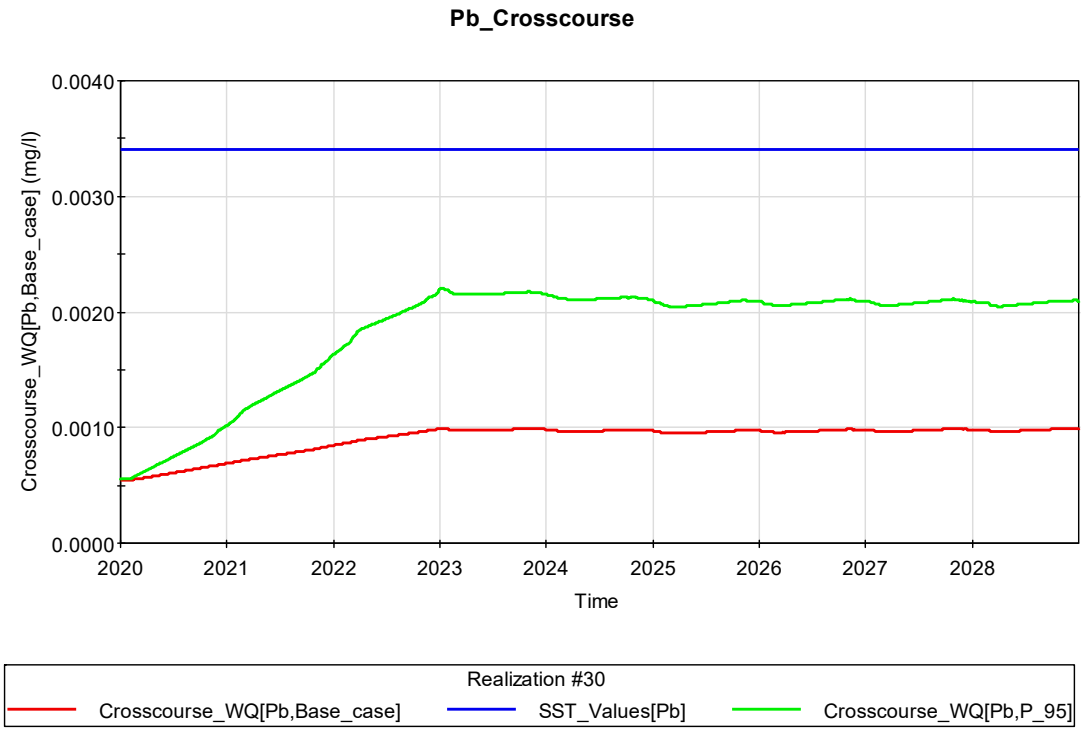

Mg_Crosscourse
Crosscourse_WQ[Mg,Base_case] (mg/l)
50
40
30
20
10
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mg,Base_case]
Crosscourse_WQ[Mg,P_95]

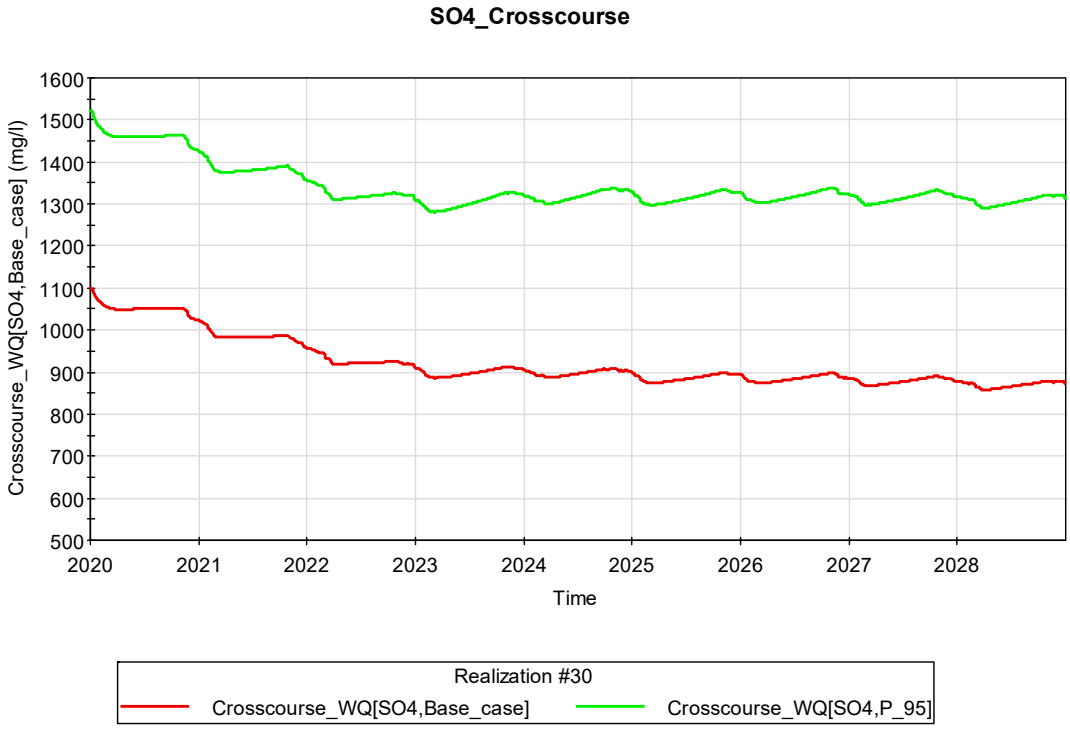

Mn_Crosscourse
Crosscourse_WQ[Mn,Base_case] (mg/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mn,Base_case]
SST_Values[Mn]
Crosscourse_WQ[Mn,P_95]

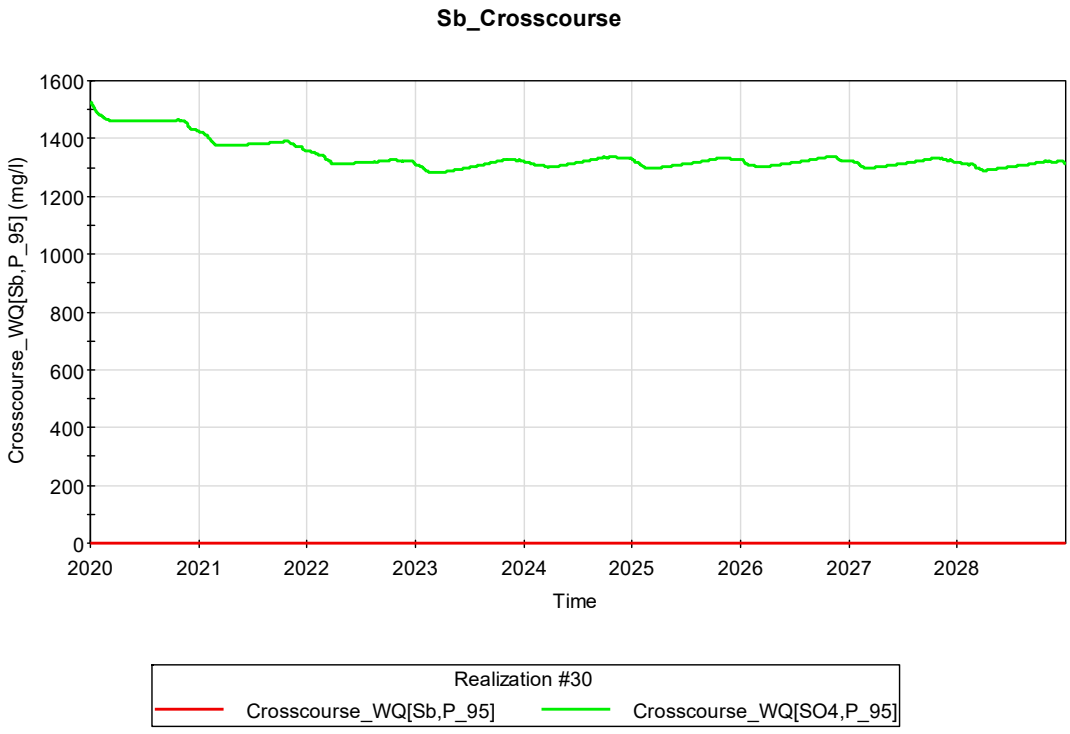

Mo_Crosscourse
Crosscourse_WQ[Mo,Base_case] (mg/l)
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mo,Base_case]
Crosscourse_WQ[Mo,P_95]

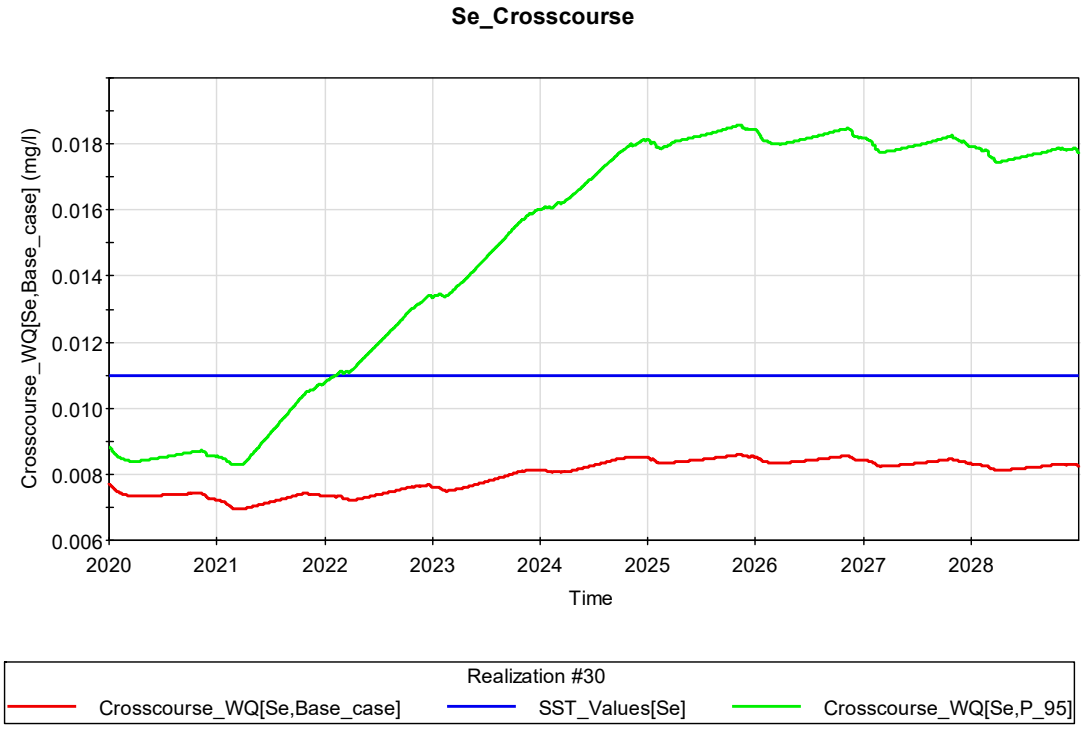

Na_Crosscourse
Crosscourse_WQ[Na,Base_case] (mg/l)
480
460
440
420
400
380
360
340
320
300
280
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Na,Base_case]
Crosscourse_WQ[Na,P_95]

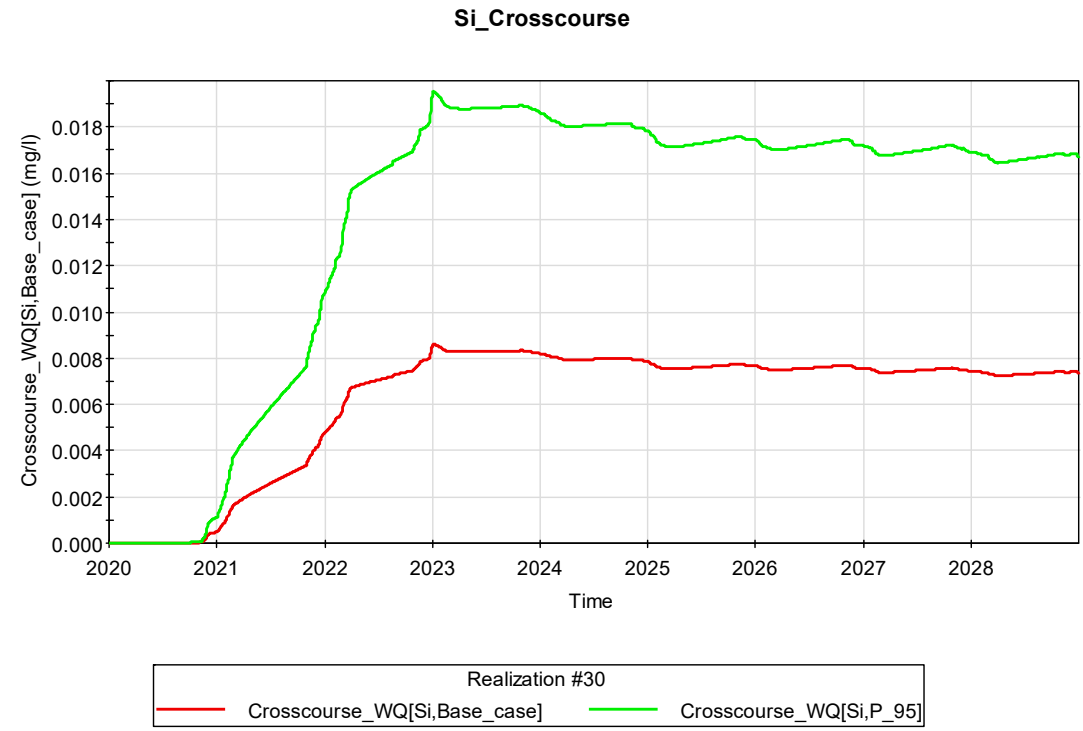

Ni_Crosscourse
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Ni,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ni,Base_case]
SST_Values[Ni]
Crosscourse_WQ[Ni,P_95]

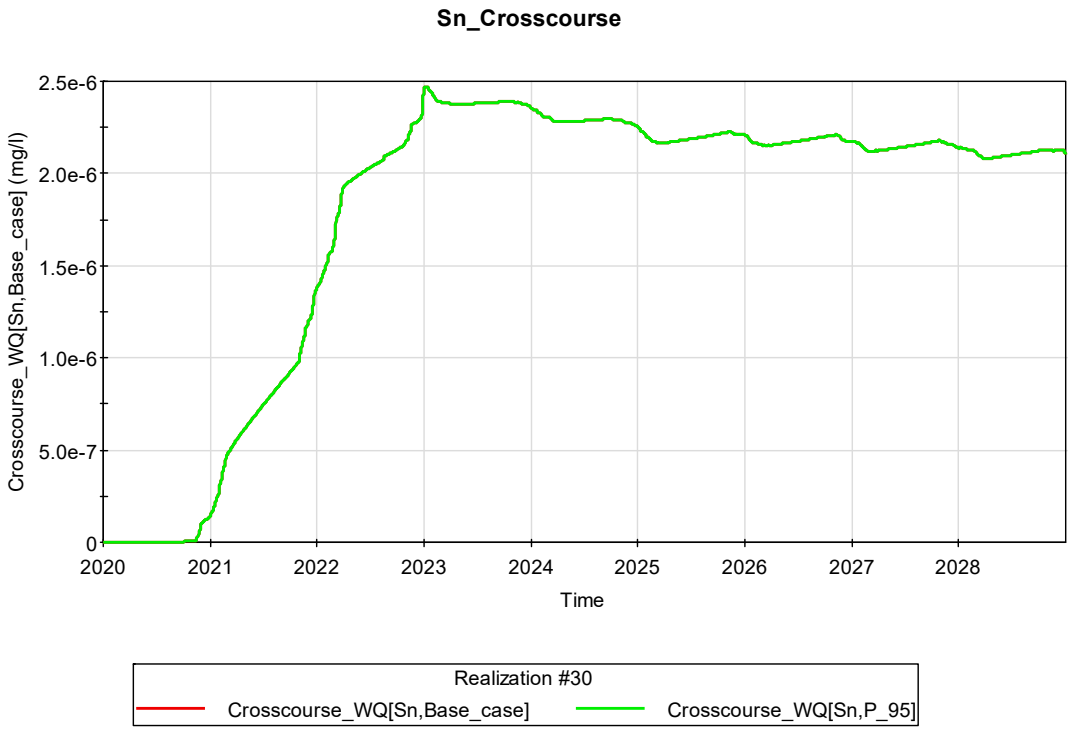

Pb_Crosscourse
0.0040
0.0030
0.0020
0.0010
0.0000
Crosscourse_WQ[Pb,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Pb,Base_case]
SST_Values[Pb]
Crosscourse_WQ[Pb,P_95]

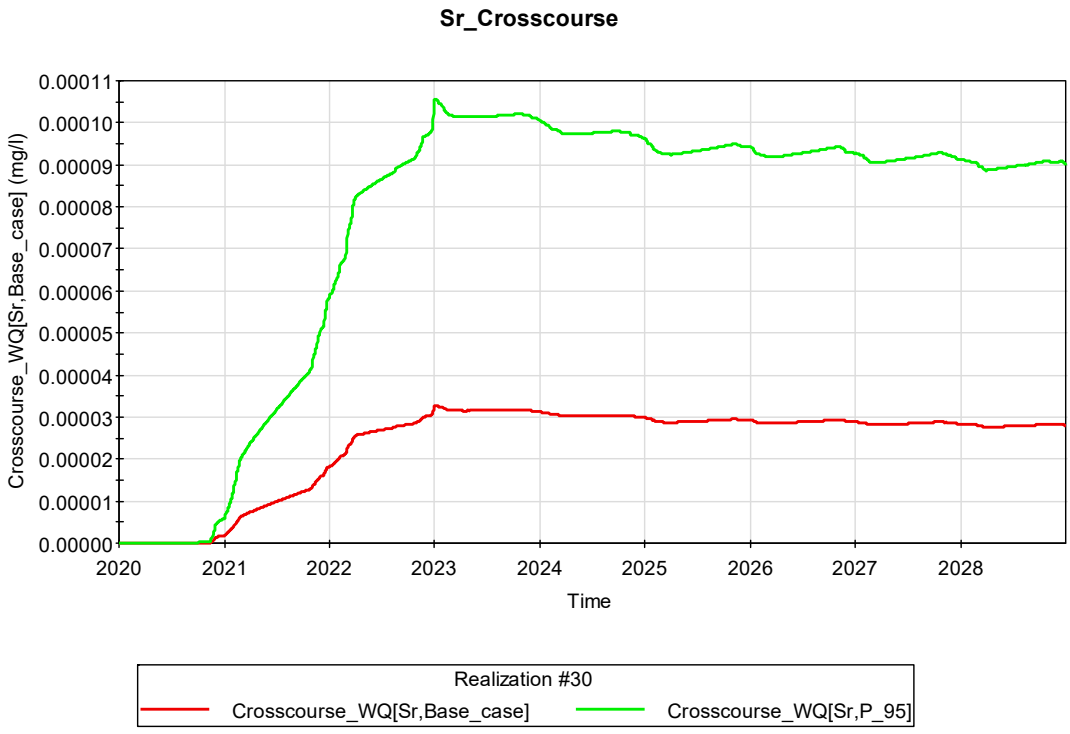

SO4_Crosscourse
Crosscourse_WQ[SO4,Base_case] (mg/l)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[SO4,Base_case]
Crosscourse_WQ[SO4,P_95]

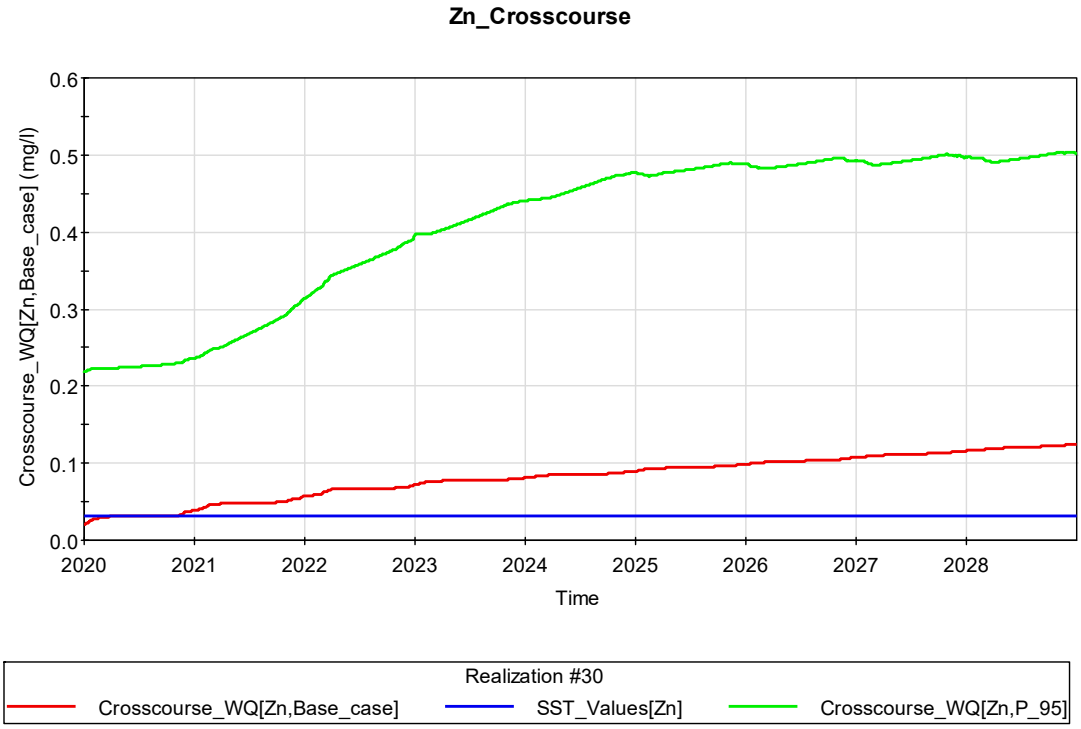

Sb_Crosscourse
Crosscourse_WQ[Sb,P_95] (mg/l)
1600
1400
1200
1000
800
600
400
200
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sb,P_95]
Crosscourse_WQ[SO4,P_95]

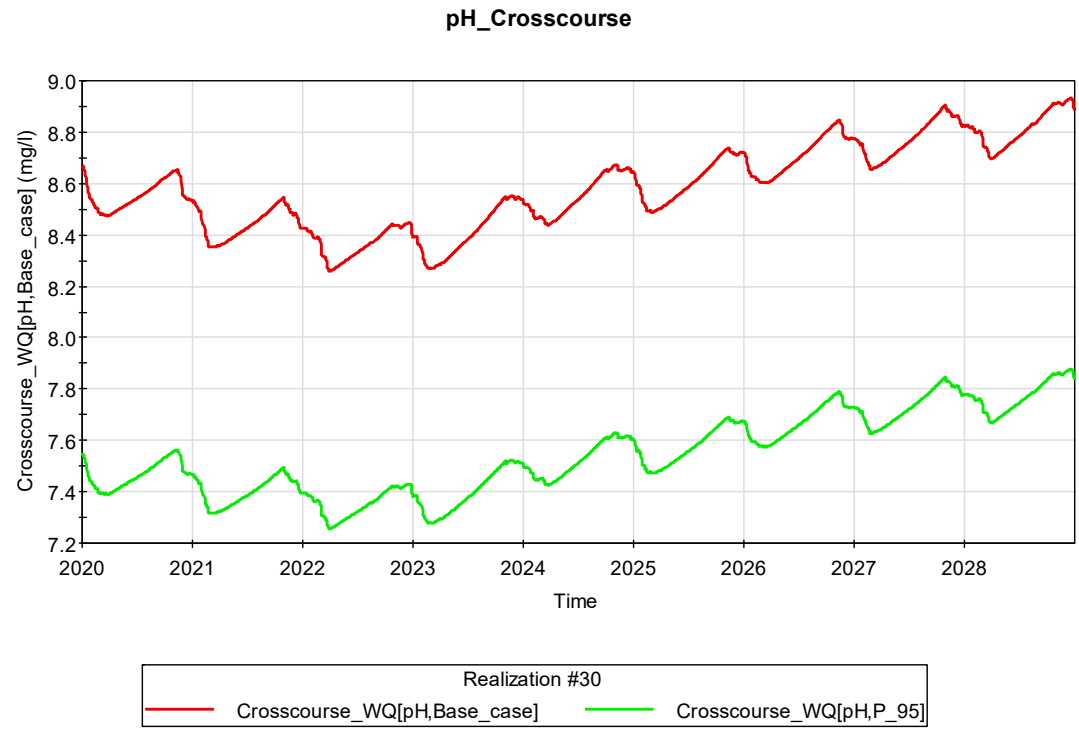

Se_Crosscourse
Crosscourse_WQ[Se,Base_case] (mg/l)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Se,Base_case]
SST_Values[Se]
Crosscourse_WQ[Se,P_95]


Si_Crosscourse
Crosscourse_WQ[Si,Base_case] (mg/l)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Si,Base_case]
Crosscourse_WQ[Si,P_95]

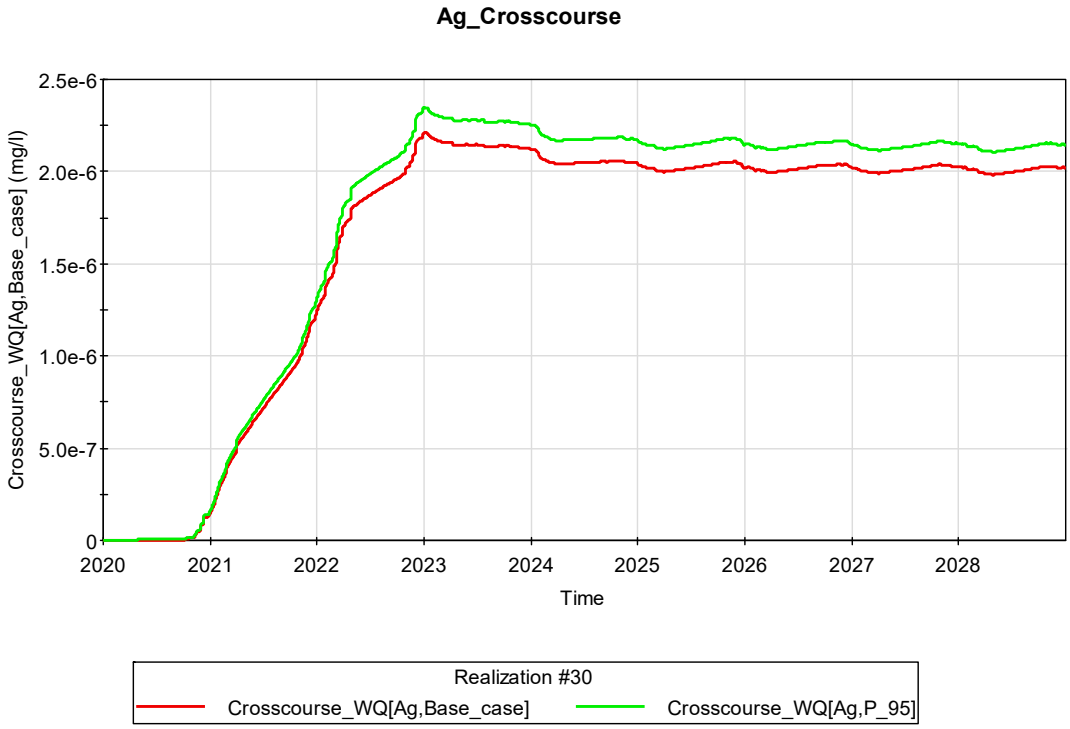

Sn_Crosscourse
2.5e-6
2.0e-6
1.5e-6
1.0e-6
5.0e-7
0
Crosscourse_WQ[Sn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sn,Base_case]
Crosscourse_WQ[Sn,P_95]

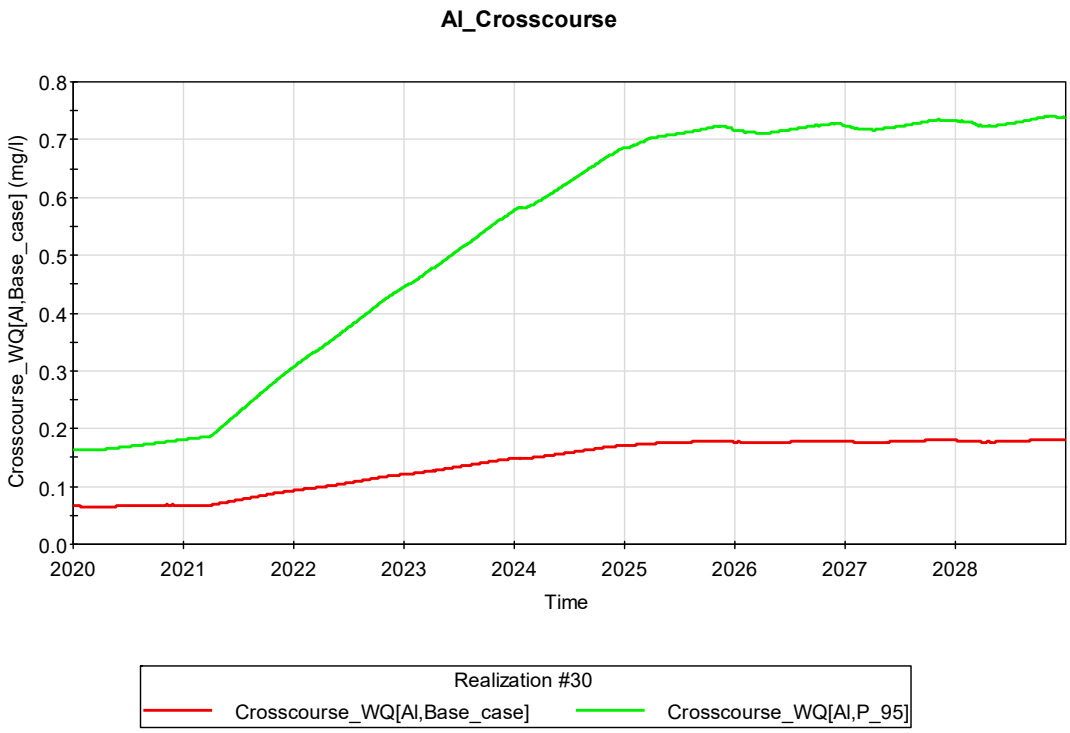

Sr_Crosscourse
0.00011
0.00010
0.00009
0.00008
0.00007
0.00006
0.00005
0.00004
0.00003
0.00002
0.00001
0.00000
Crosscourse_WQ[Sr,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sr,Base_case]
Crosscourse_WQ[Sr,P_95]

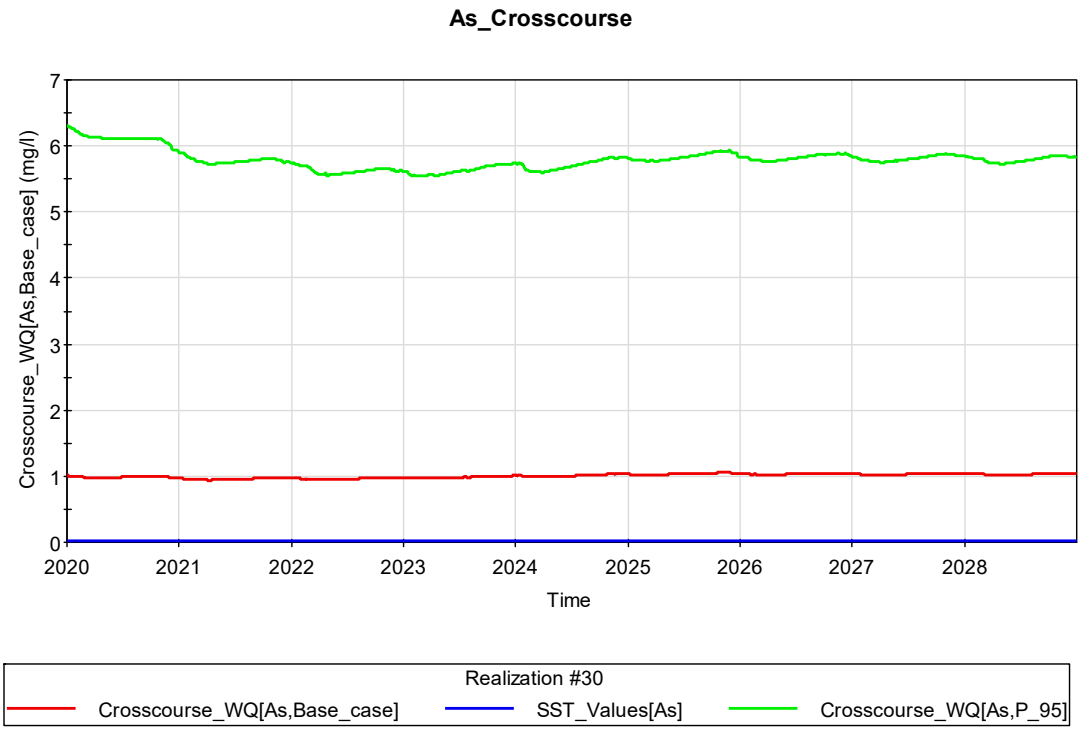

Zn_Crosscourse
Crosscourse_WQ[Zn,Base_case] (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Zn,Base_case]
SST_Values[Zn]
Crosscourse_WQ[Zn,P_95]

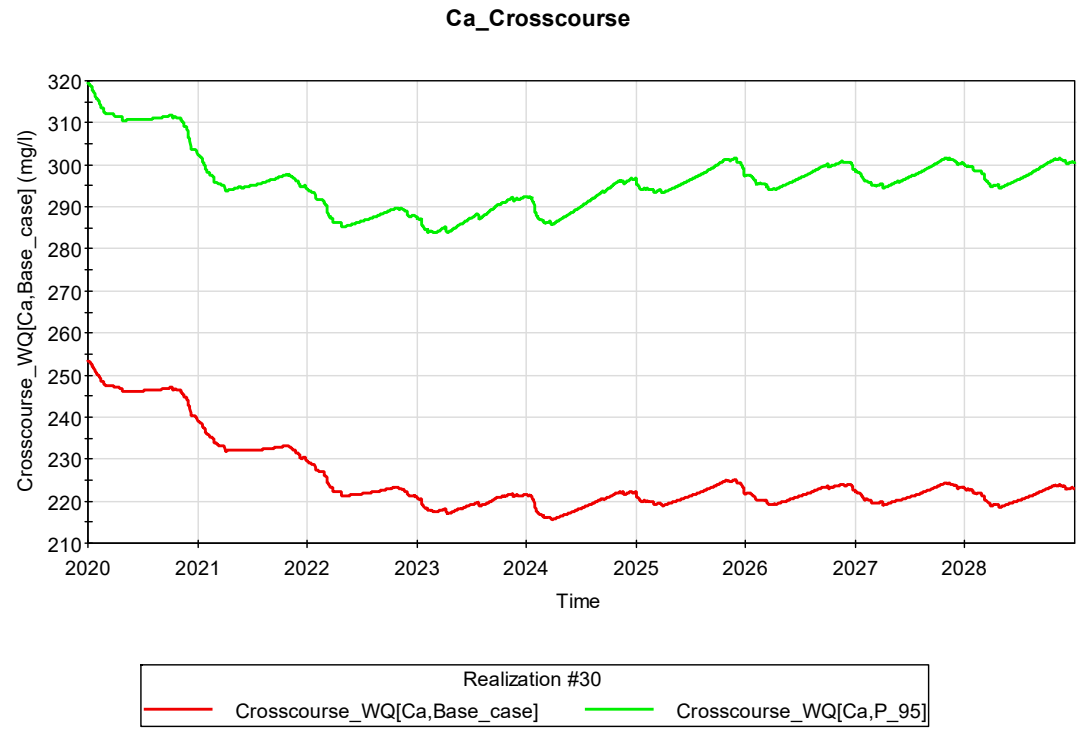

pH_Crosscourse
Crosscourse_WQ[pH,Base_case] (mg/l)
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[pH,Base_case]
Crosscourse_WQ[pH,P_95]

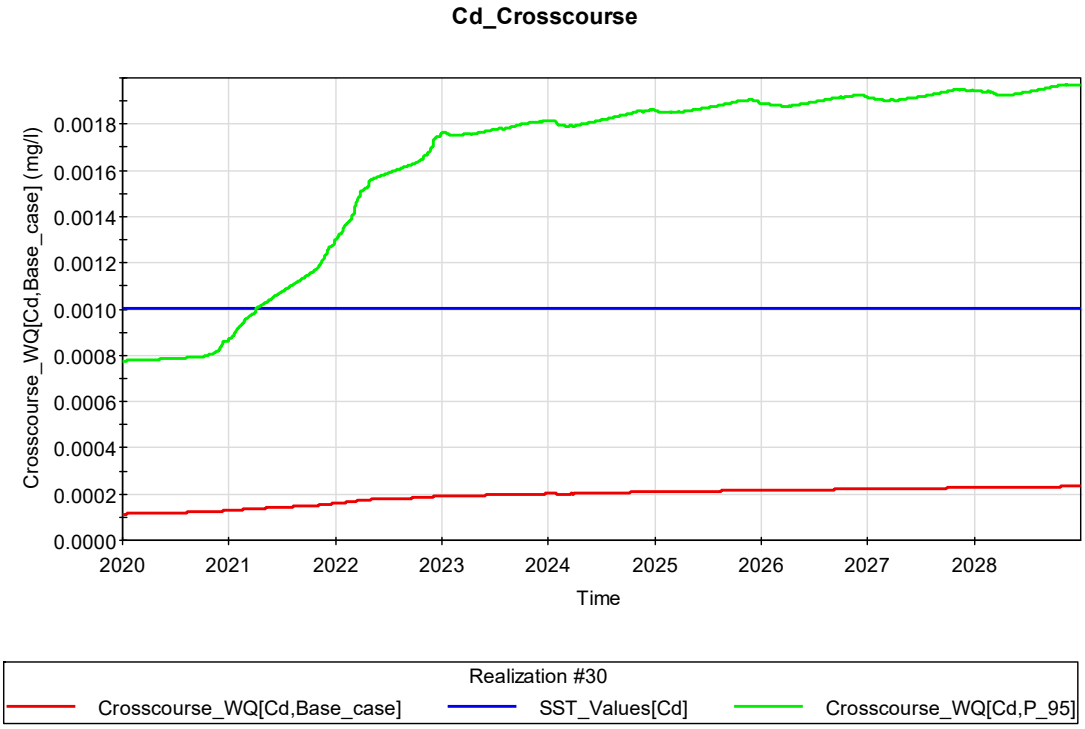
Dry climate no discharge

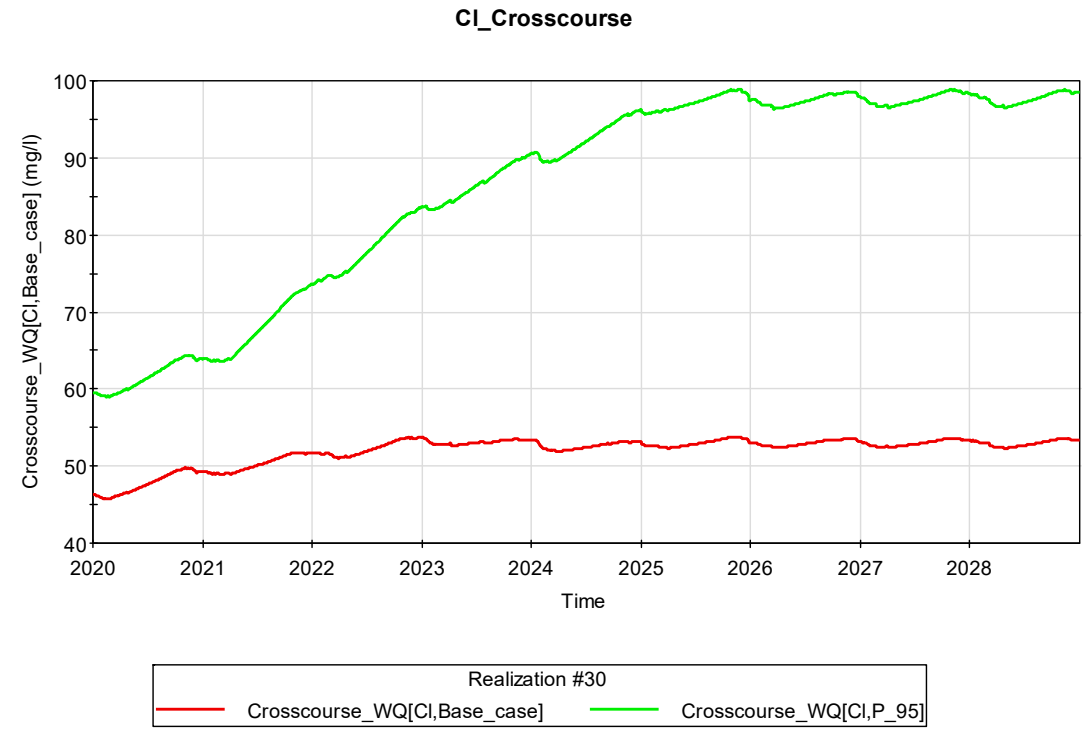


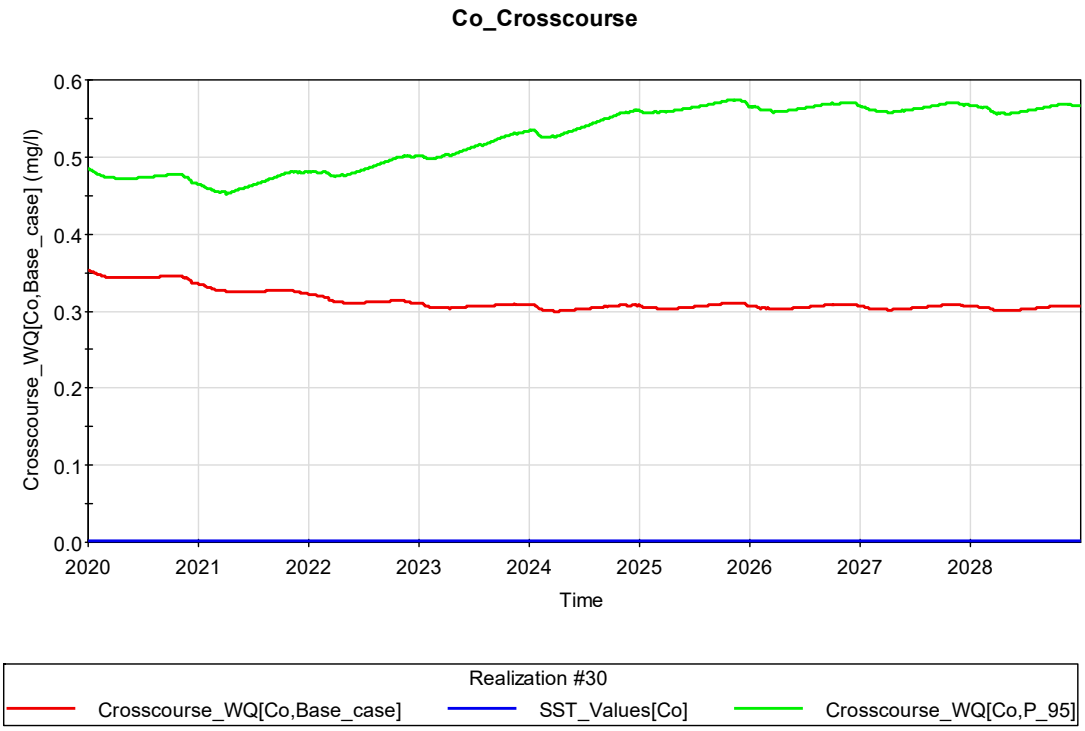


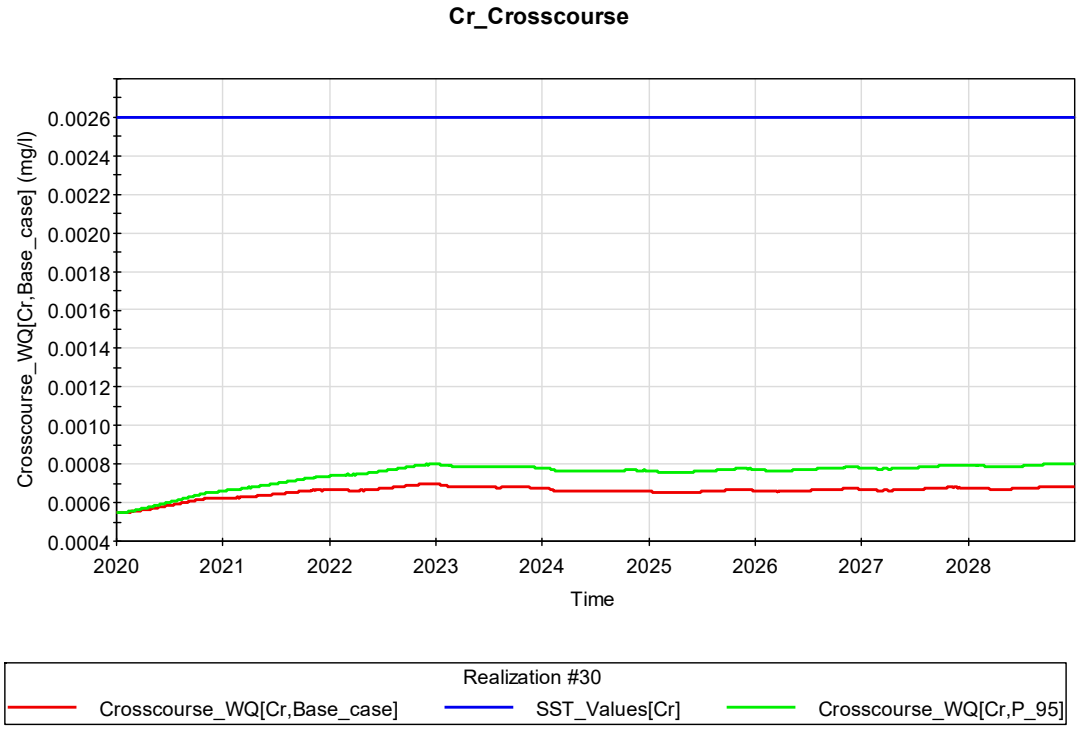

As_Crosscourse
Crosscourse_WQ[As,Base_case] (mg/l)
0
1
2
3
4
5
6
7
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[As,Base_case]
SST_Values[As]
Crosscourse_WQ[As,P_95]

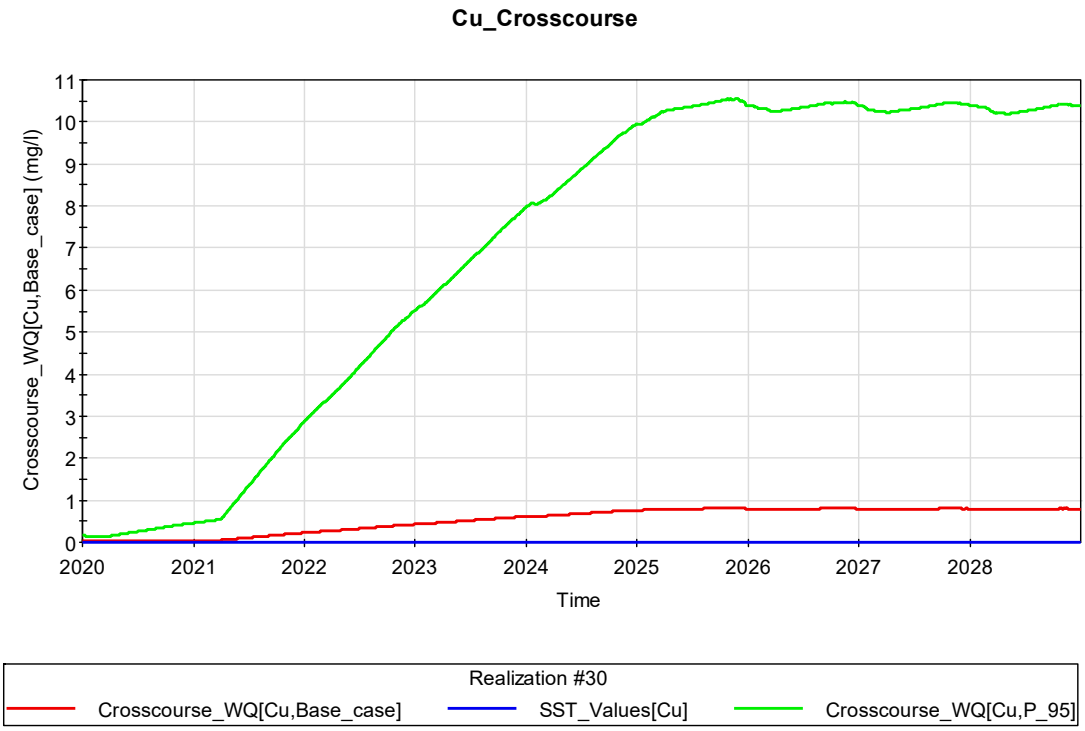

Ca_Crosscourse
Crosscourse_WQ[Ca,Base_case] (mg/l)
210
220
230
240
250
260
270
280
290
300
310
320
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ca,Base_case]
Crosscourse_WQ[Ca,P_95]

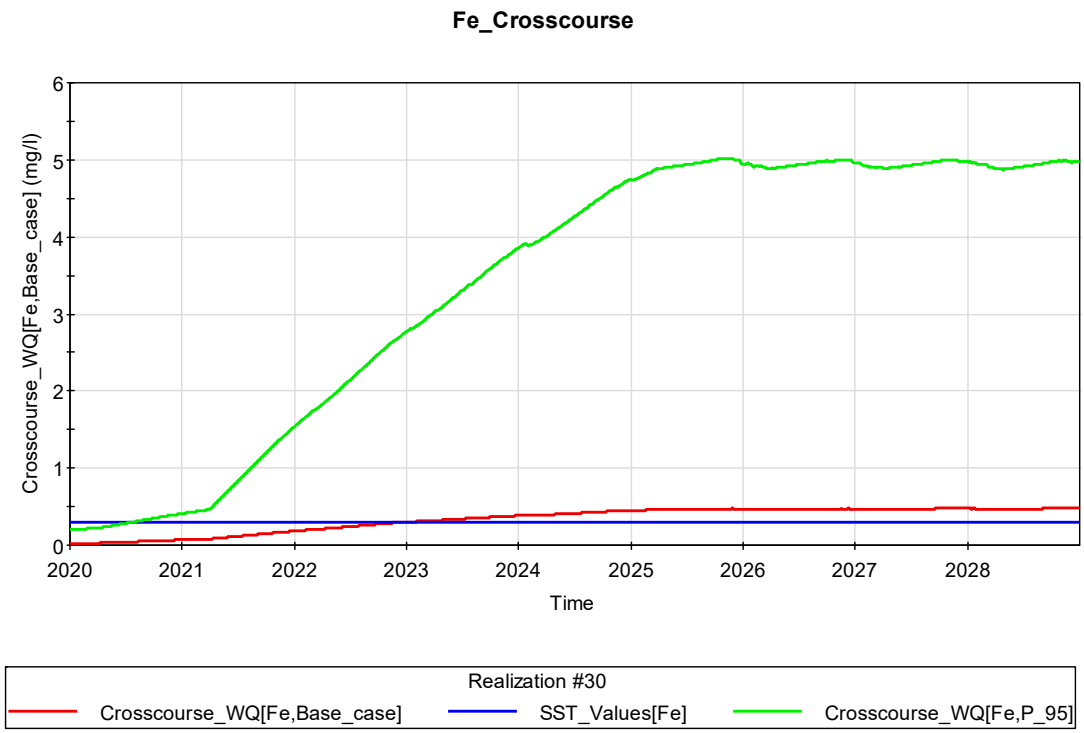

Cd_Crosscourse
Crosscourse_WQ[Cd,Base_case] (mg/l)
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cd,Base_case]
SST_Values[Cd]
Crosscourse_WQ[Cd,P_95]

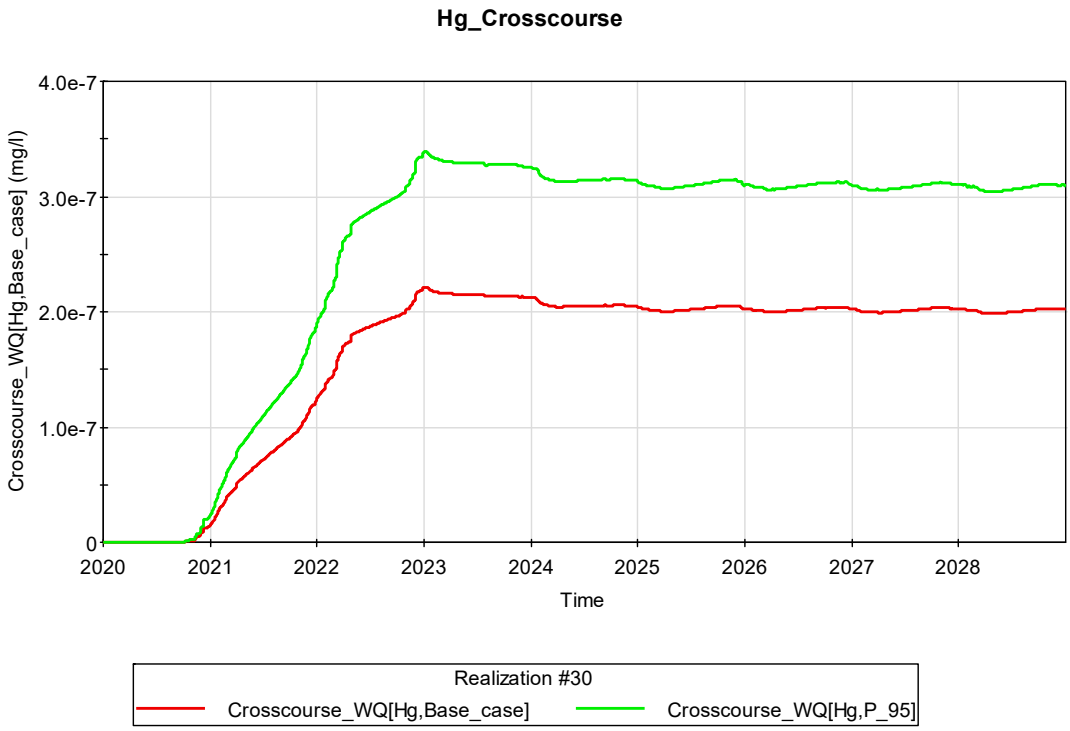

Cl_Crosscourse
Crosscourse_WQ[Cl,Base_case] (mg/l)
100
90
80
70
60
50
40
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cl,Base_case]
Crosscourse_WQ[Cl,P_95]

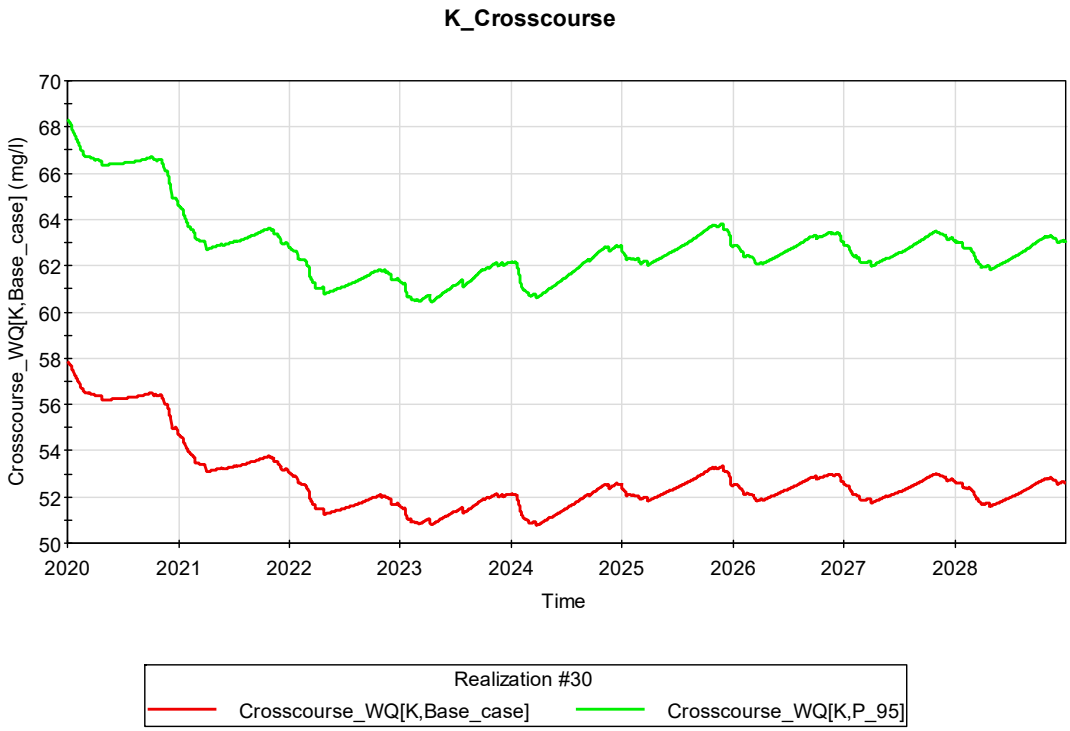

Co_Crosscourse
Crosscourse_WQ[Co,Base_case] (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Co,Base_case]
SST_Values[Co]
Crosscourse_WQ[Co,P_95]

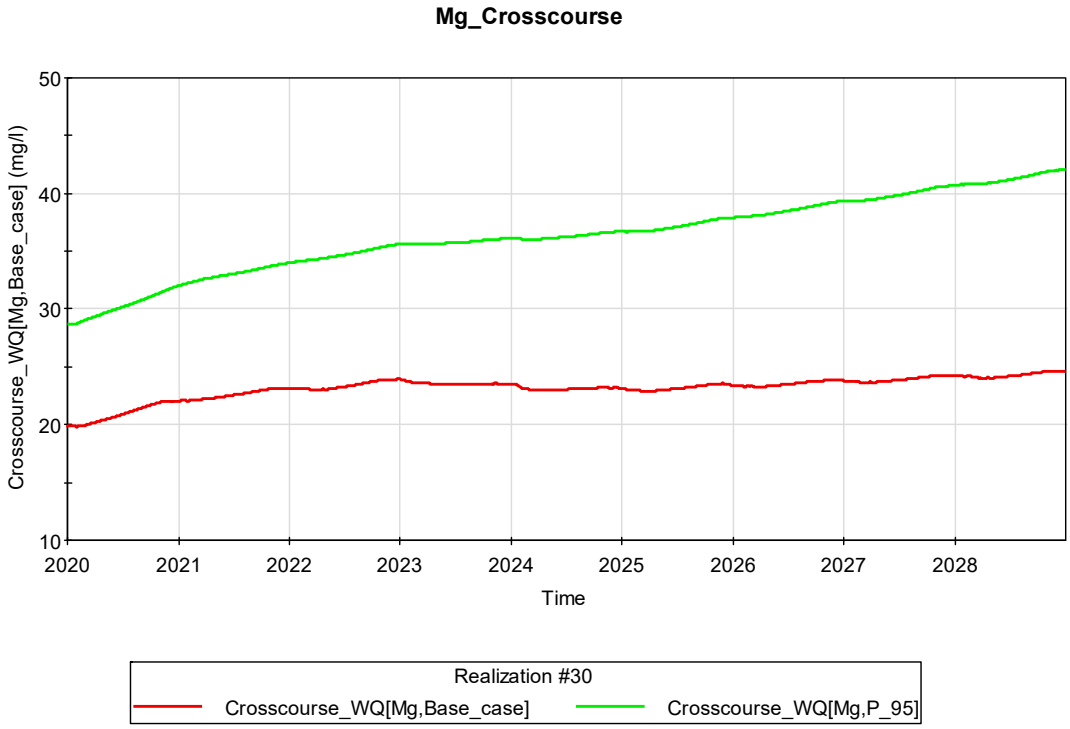

Cr_Crosscourse
Crosscourse_WQ[Cr,Base_case] (mg/l)
0.0026
0.0024
0.0022
0.0020
0.0018
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cr,Base_case]
SST_Values[Cr]
Crosscourse_WQ[Cr,P_95]

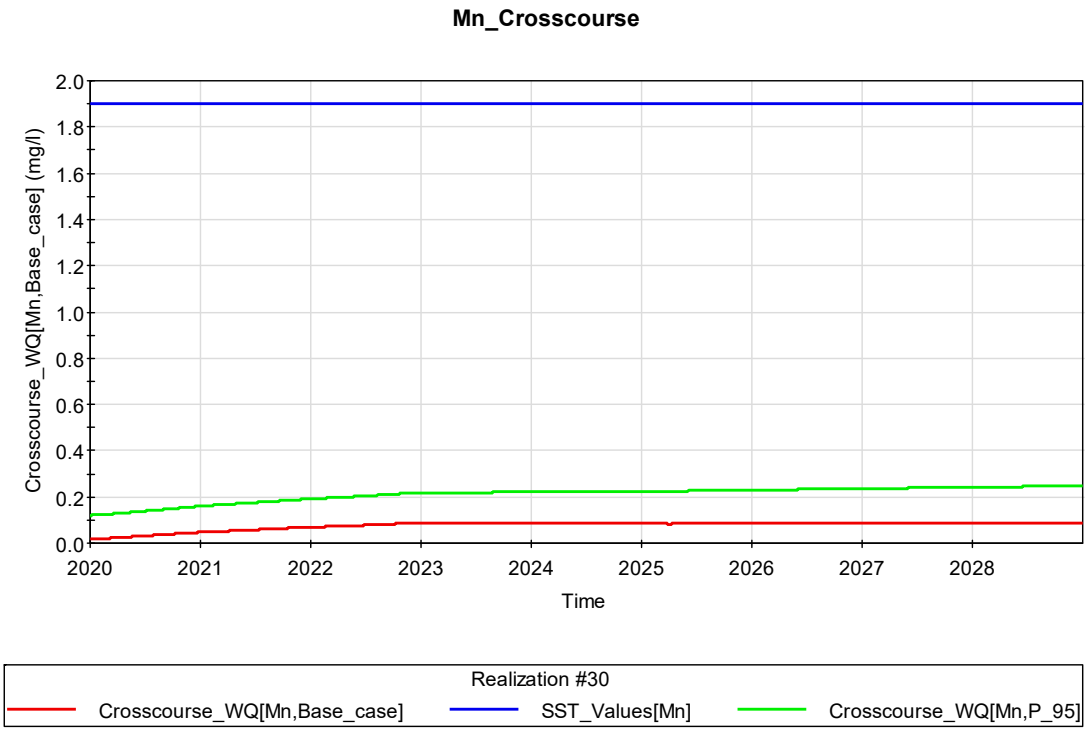

Cu_Crosscourse
Crosscourse_WQ[Cu,Base_case] (mg/l)
11
10
9
8
7
6
5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Cu,Base_case]
SST_Values[Cu]
Crosscourse_WQ[Cu,P_95]

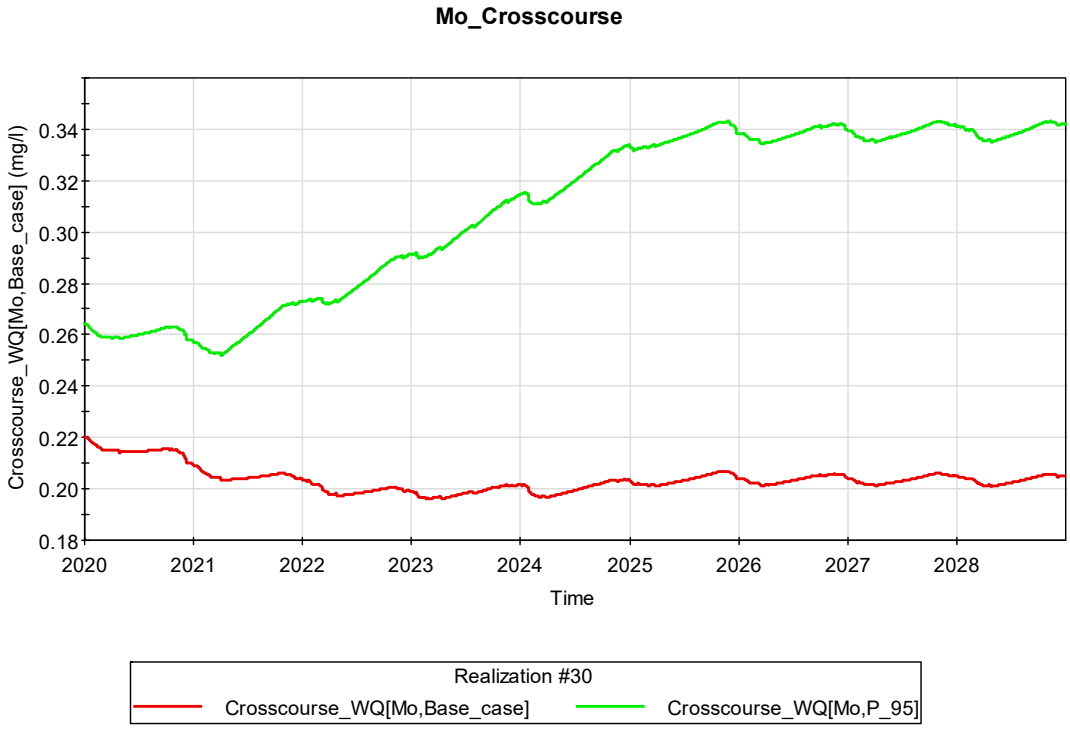

Fe_Crosscourse
Crosscourse_WQ[Fe,Base_case] (mg/l)
6
5
4
3
2
1
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Fe,Base_case]
SST_Values[Fe]
Crosscourse_WQ[Fe,P_95]

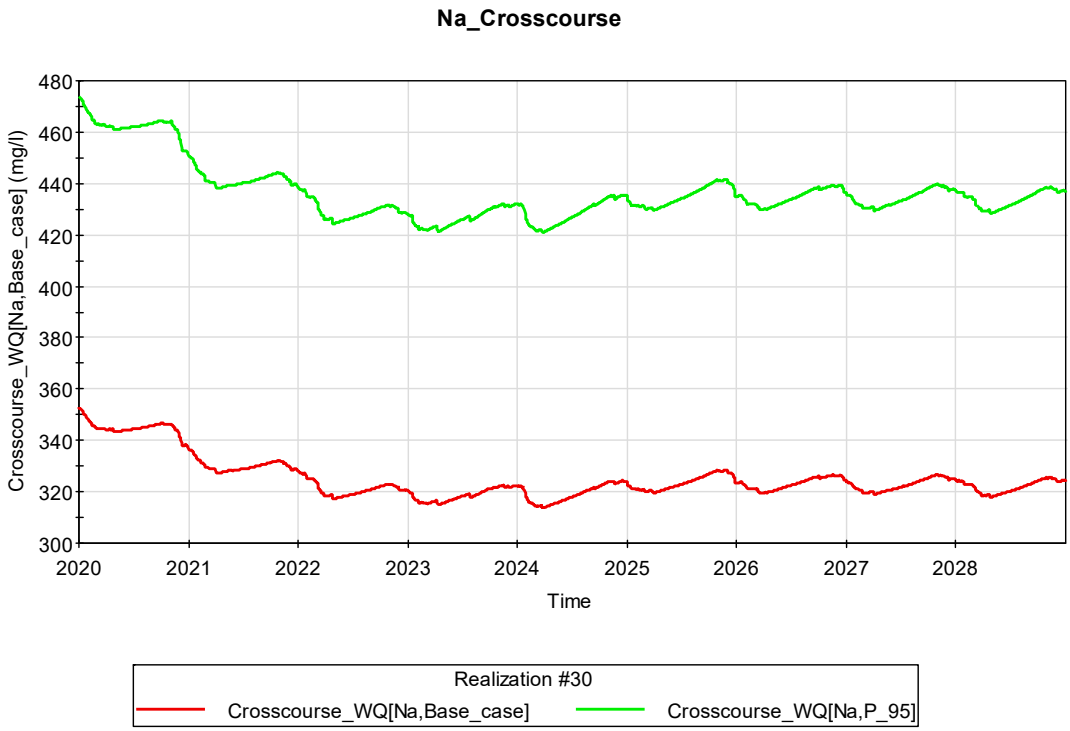

Hg_Crosscourse
4.0e-7
3.0e-7
2.0e-7
1.0e-7
0
Crosscourse_WQ[Hg,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Hg,Base_case]
Crosscourse_WQ[Hg,P_95]

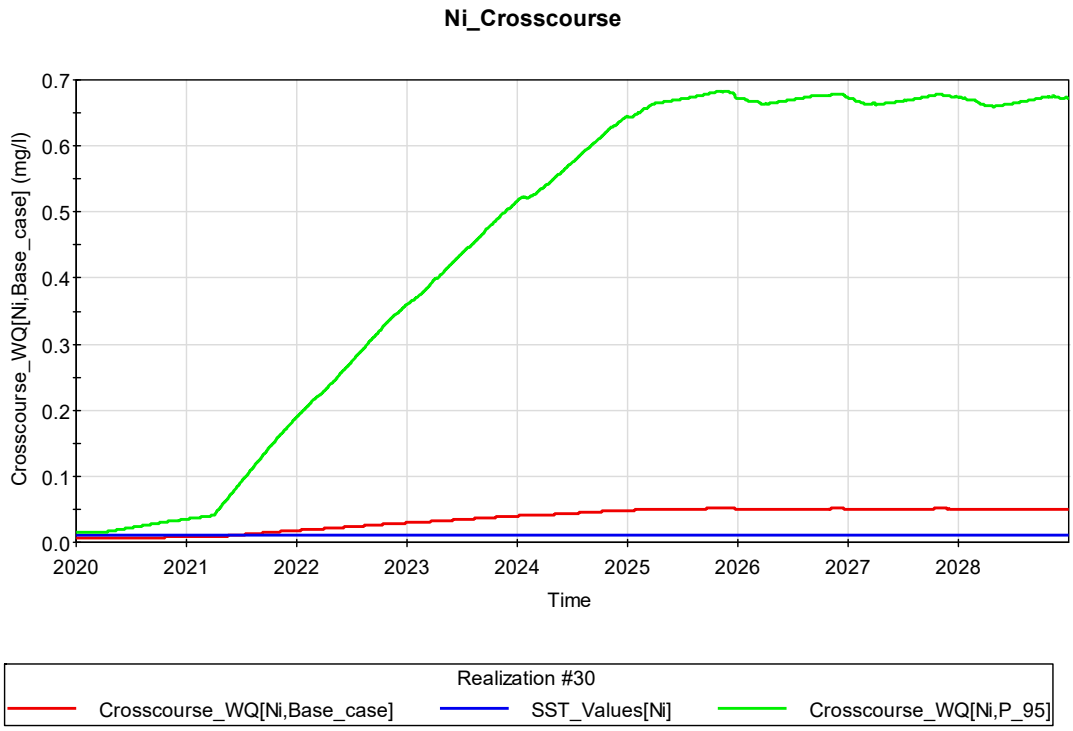

K_Crosscourse
70
68
66
64
62
60
58
56
54
52
50
Crosscourse_WQ[K,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[K,Base_case]
Crosscourse_WQ[K,P_95]

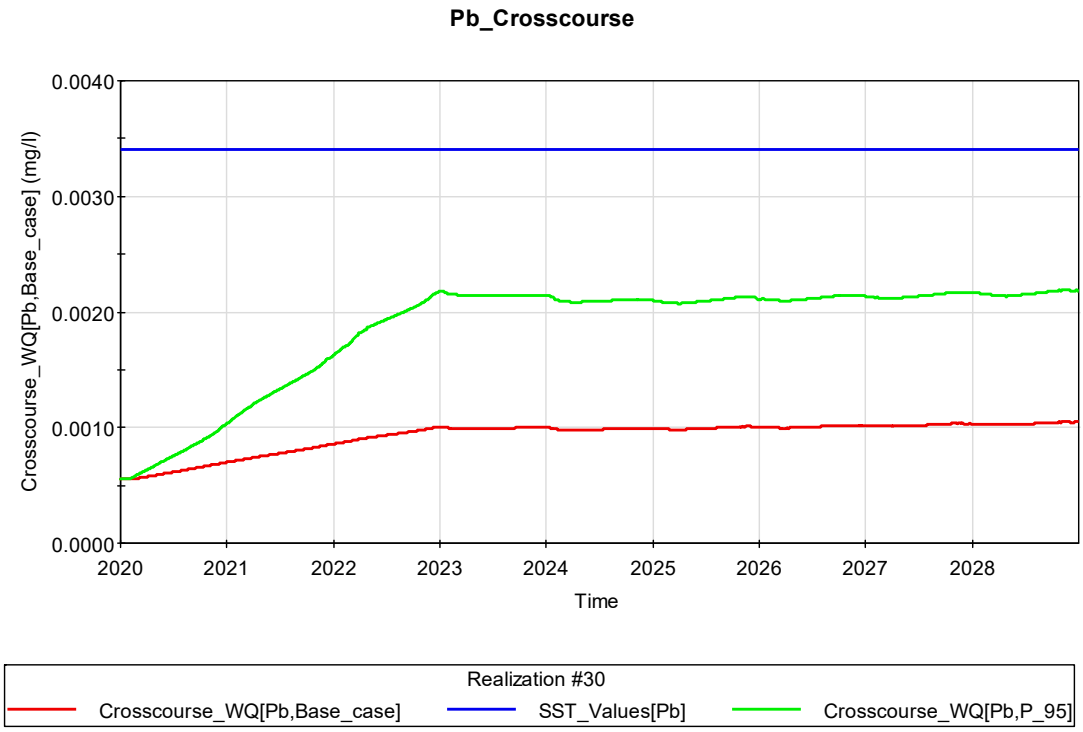

Mg_Crosscourse
Crosscourse_WQ[Mg,Base_case] (mg/l)
50
40
30
20
10
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mg,Base_case]
Crosscourse_WQ[Mg,P_95]

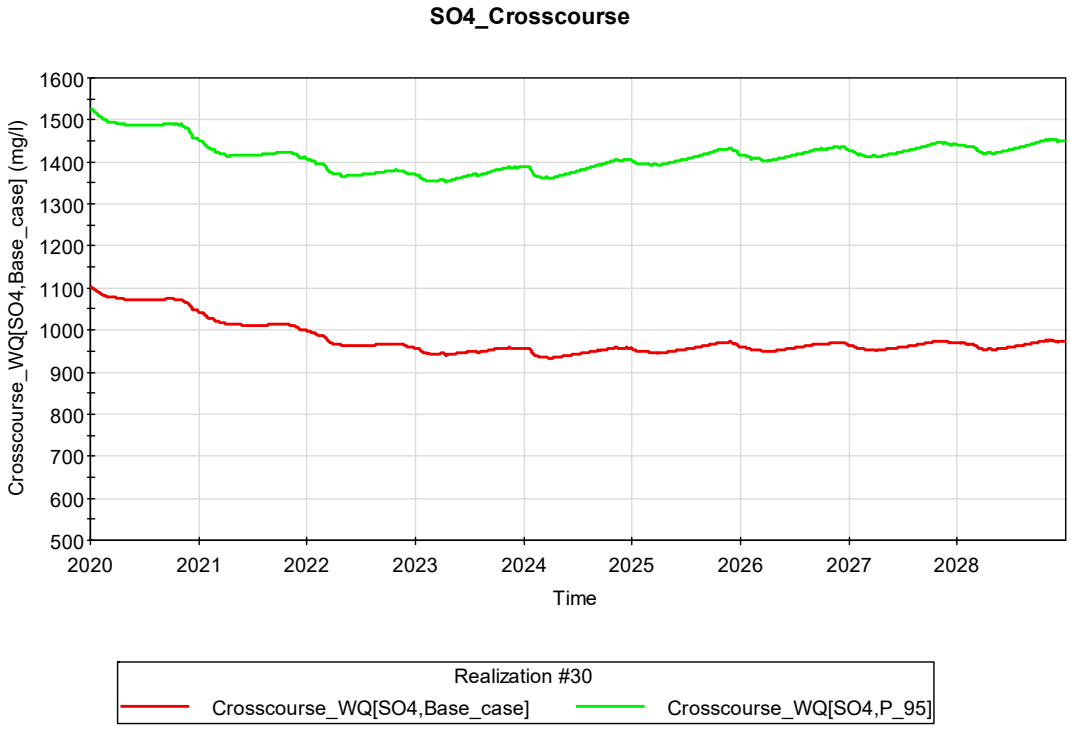

Mn_Crosscourse
Crosscourse_WQ[Mn,Base_case] (mg/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mn,Base_case]
SST_Values[Mn]
Crosscourse_WQ[Mn,P_95]

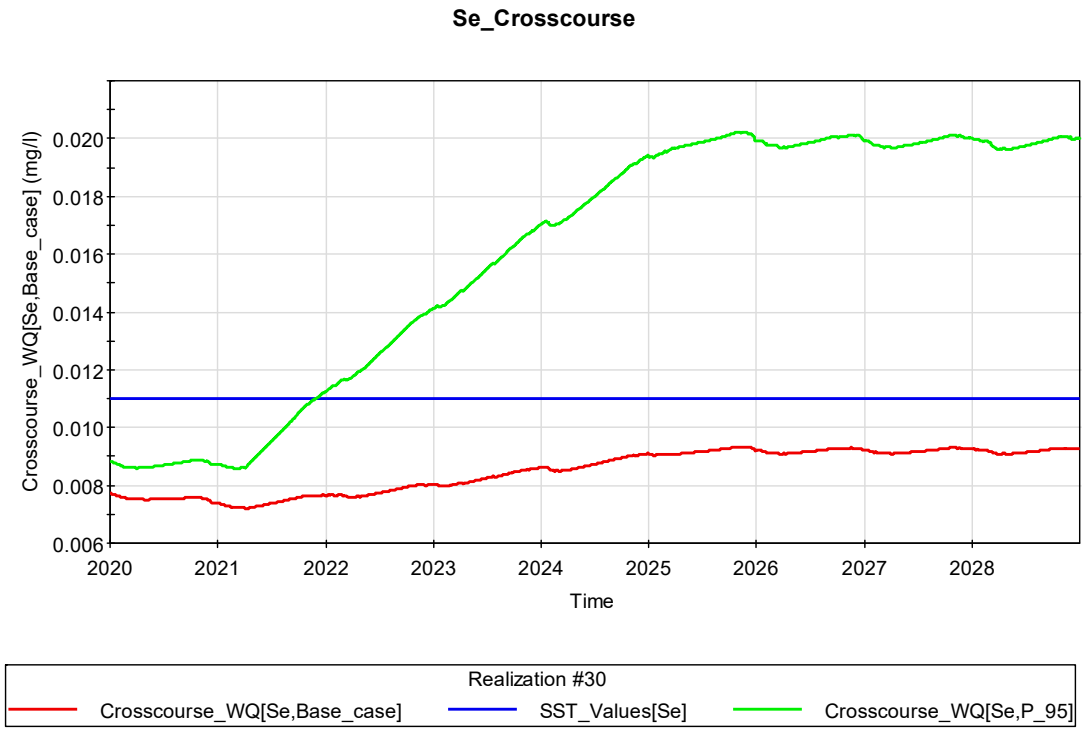

Mo_Crosscourse
Crosscourse_WQ[Mo,Base_case] (mg/l)
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Mo,Base_case]
Crosscourse_WQ[Mo,P_95]

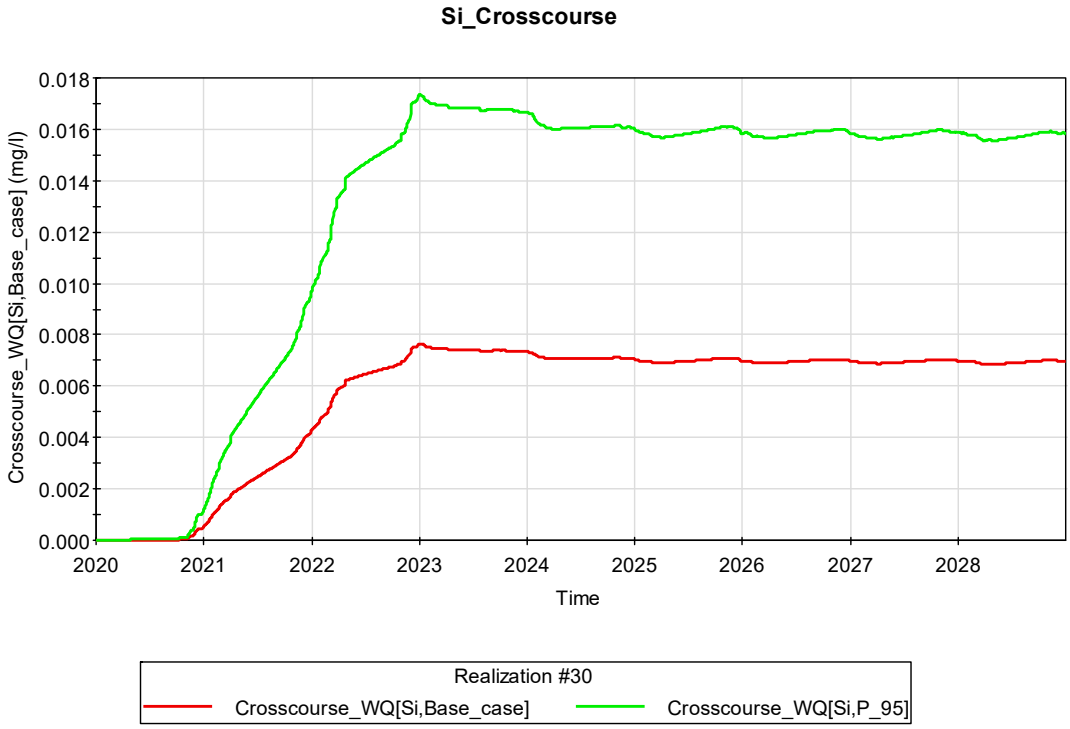

Na_Crosscourse
Crosscourse_WQ[Na,Base_case] (mg/l)
480
460
440
420
400
380
360
340
320
300
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Na,Base_case]
Crosscourse_WQ[Na,P_95]

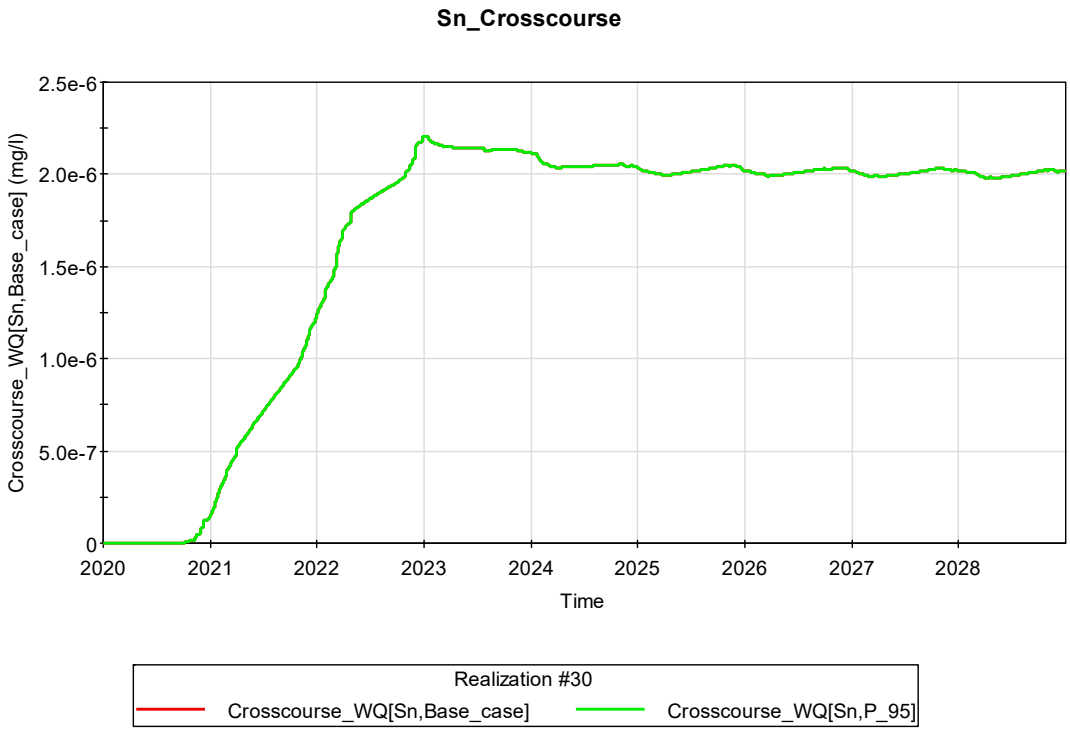

Ni_Crosscourse
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Ni,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Ni,Base_case]
SST_Values[Ni]
Crosscourse_WQ[Ni,P_95]

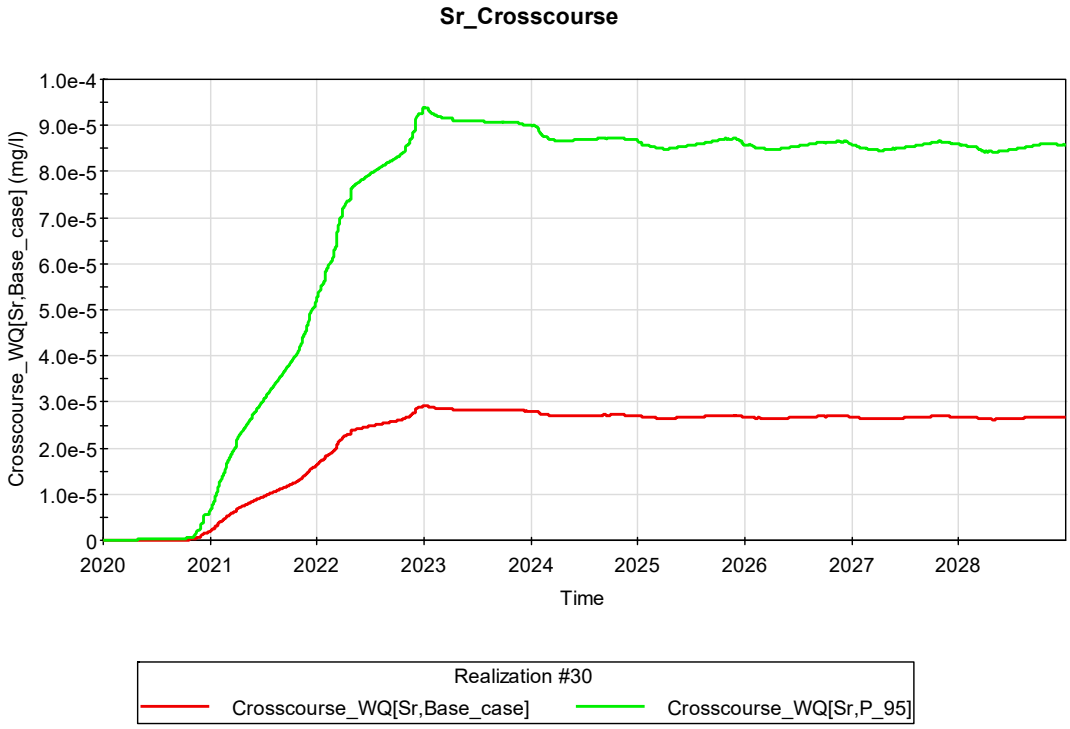

Pb_Crosscourse
0.0040
0.0030
0.0020
0.0010
0.0000
Crosscourse_WQ[Pb,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Pb,Base_case]
SST_Values[Pb]
Crosscourse_WQ[Pb,P_95]

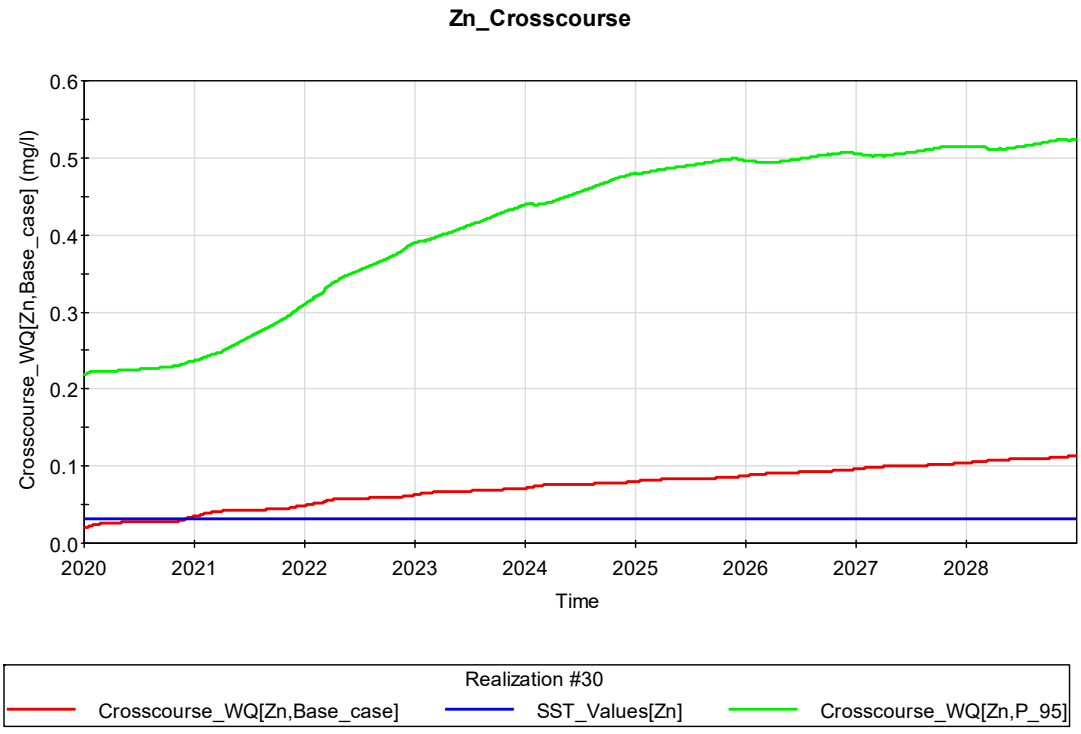

SO4_Crosscourse
Crosscourse_WQ[SO4,Base_case] (mg/l)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[SO4,Base_case]
Crosscourse_WQ[SO4,P_95]

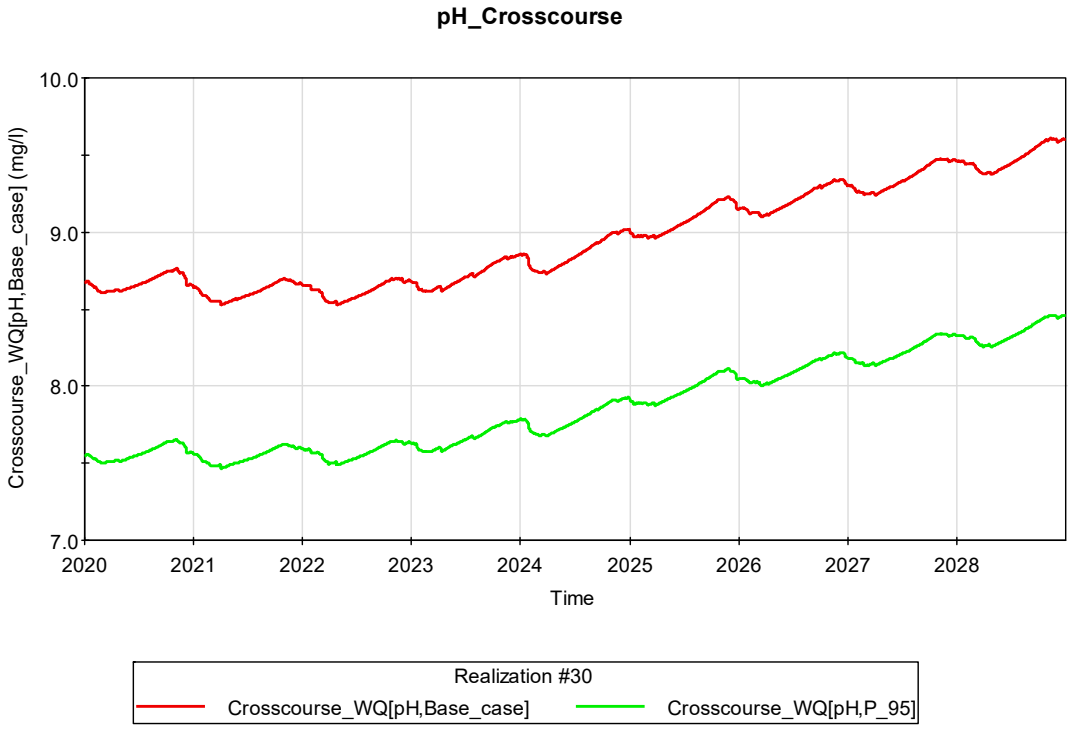

Se_Crosscourse
Crosscourse_WQ[Se,Base_case] (mg/l)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Se,Base_case]
SST_Values[Se]
Crosscourse_WQ[Se,P_95]


Si_Crosscourse
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Crosscourse_WQ[Si,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Si,Base_case]
Crosscourse_WQ[Si,P_95]


Sn_Crosscourse
2.5e-6
2.0e-6
1.5e-6
1.0e-6
5.0e-7
0
Crosscourse_WQ[Sn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sn,Base_case]
Crosscourse_WQ[Sn,P_95]


Sr_Crosscourse
1.0e-4
9.0e-5
8.0e-5
7.0e-5
6.0e-5
5.0e-5
4.0e-5
3.0e-5
2.0e-5
1.0e-5
0
Crosscourse_WQ[Sr,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Sr,Base_case]
Crosscourse_WQ[Sr,P_95]


Zn_Crosscourse
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Crosscourse_WQ[Zn,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[Zn,Base_case]
SST_Values[Zn]
Crosscourse_WQ[Zn,P_95]


pH_Crosscourse
10.0
9.0
8.0
7.0
Crosscourse_WQ[pH,Base_case] (mg/l)
2020
2021
2022
2023
2024
2025
2026
2027
2028
Time
Realization #30
Crosscourse_WQ[pH,Base_case]
Crosscourse_WQ[pH,P_95]

APPENDIX B

Pit Water Qualities Summary Statistics

Crosscourse Pit

Table 8: Summary statistics for Crosscourse Pit water quality, dry climate, no discharge

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	1.6E-6	2.0E-6	7.2E-7	0	2.2E-6
Ag, P_95	1.7E-6	2.1E-6	7.7E-7	0	2.4E-6
Al, Base_case	0.14	0.16	0.043	0.065	0.18
Al, P_95	0.53	0.63	0.21	0.16	0.74
Alkalinity, Base_case	110	110	10	83	120
Alkalinity, P_95	160	160	15	120	170
As, Base_case	1	1	0.031	0.94	1.1
As, P_95	5.8	5.8	0.15	5.5	6.3
Ca, Base_case	230	220	8.7	220	250
Ca, P_95	300	300	7.1	280	320
Cd, Base_case	1.9E-4	2.0E-4	3.6E-5	1.1E-4	2.3E-4
Cd, P_95	0.0016	0.0018	4.0E-4	7.7E-4	0.002
Cl, Base_case	52	53	1.9	46	54
Cl, P_95	86	92	13	59	99
Co, Base_case	0.31	0.31	0.013	0.3	0.35
Co, P_95	0.53	0.54	0.04	0.45	0.57
Cr, Base_case	6.6E-4	6.7E-4	3.0E-5	5.5E-4	7.0E-4
Cr, P_95	7.5E-4	7.7E-4	6.0E-5	5.5E-4	8.0E-4
Cu, Base_case	0.54	0.68	0.29	0.02	0.81
Cu, P_95	7	8.9	3.9	0.15	11
Fe, Base_case	0.34	0.41	0.16	0.019	0.48
Fe, P_95	3.4	4.3	1.8	0.21	5
H, Base_case	7.0E-8	7.7E-8	2.1E-8	1.5E-8	9.2E-8
H, P_95	4.7E-7	5.2E-7	1.3E-7	1.7E-7	6.1E-7
Hg, Base_case	1.6E-7	2.0E-7	7.2E-8	0	2.2E-7
Hg, P_95	2.5E-7	3.1E-7	1.1E-7	0	3.4E-7
K, Base_case	53	52	1.5	51	58
K, P_95	63	63	1.6	60	68
Mg, Base_case	23	23	0.98	20	25
Mg, P_95	36	36	3.3	29	42
Mn, Base_case	0.076	0.085	0.018	0.018	0.088
Mn, P_95	0.21	0.22	0.033	0.12	0.25
Mo, Base_case	0.2	0.2	0.0048	0.2	0.22
Mo, P_95	0.31	0.32	0.032	0.25	0.34
Na, Base_case	330	320	8.1	310	350
Na, P_95	440	430	11	420	470
Ni, Base_case	0.036	0.044	0.017	0.0065	0.051
Ni, P_95	0.45	0.58	0.25	0.015	0.68
Pb, Base_case	9.3E-4	9.9E-4	1.4E-4	5.5E-4	0.0011
Pb, P_95	0.0019	0.0021	4.7E-4	5.5E-4	0.0022
SO4, Base_case	980	960	40	930	1100
SO4, P_95	1400	1400	37	1400	1500
Sb, Base_case	5.1E-6	6.2E-6	2.2E-6	0	6.8E-6
Sb, P_95	1.4E-5	1.7E-5	6.1E-6	0	1.9E-5
Se, Base_case	0.0085	0.0087	7.3E-4	0.0072	0.0093
Se, P_95	0.016	0.018	0.0044	0.0086	0.02
Si, Base_case	0.0057	0.007	0.0025	0	0.0077
Si, P_95	0.013	0.016	0.0057	0	0.017
Sn, Base_case	1.6E-6	2.0E-6	7.2E-7	0	2.2E-6
Sn, P_95	1.6E-6	2.0E-6	7.2E-7	0	2.2E-6
Sr, Base_case	2.2E-5	2.7E-5	9.5E-6	0	2.9E-5
Sr, P_95	7.0E-5	8.5E-5	3.1E-5	0	9.4E-5
Zn, Base_case	0.073	0.077	0.026	0.02	0.11
Zn, P_95	0.41	0.46	0.1	0.22	0.52
pH, Base_case	9	8.9	0.32	8.5	9.6
pH, P_95	7.9	7.8	0.3	7.5	8.5

Table 9: Summary statistics for Crosscourse Pit water quality, median climate, no discharge

Species	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	1.8E-6	2.2E-6	7.7E-7	1.3E-13	2.5E-6
Ag, P_95	1.9E-6	2.3E-6	8.2E-7	1.4E-13	2.7E-6
Al, Base_case	0.13	0.15	0.038	0.064	0.17
Al, P_95	0.51	0.6	0.19	0.16	0.68
Alkalinity, Base_case	100	110	7.8	81	110
Alkalinity, P_95	150	150	11	120	160
As, Base_case	0.94	0.93	0.018	0.9	1
As, P_95	5.4	5.4	0.22	5.1	6.3
Ca, Base_case	210	210	13	200	250
Ca, P_95	280	280	10	270	320
Cd, Base_case	1.9E-4	2.1E-4	3.6E-5	1.1E-4	2.3E-4
Cd, P_95	0.0017	0.0019	4.3E-4	7.7E-4	0.002
Cl, Base_case	48	49	1.4	44	52
Cl, P_95	80	87	11	57	91
Co, Base_case	0.29	0.29	0.02	0.27	0.35
Co, P_95	0.49	0.5	0.026	0.44	0.53
Cr, Base_case	6.2E-4	6.2E-4	2.5E-5	5.4E-4	6.7E-4
Cr, P_95	7.1E-4	7.3E-4	5.0E-5	5.4E-4	7.7E-4
Cu, Base_case	0.5	0.64	0.27	0.019	0.75
Cu, P_95	6.4	8.3	3.5	0.14	9.7
Fe, Base_case	0.32	0.39	0.14	0.019	0.44
Fe, P_95	3.1	4	1.6	0.21	4.6
H, Base_case	7.2E-8	8.1E-8	2.1E-8	1.5E-8	9.4E-8
H, P_95	5.1E-7	5.8E-7	1.5E-7	1.7E-7	6.5E-7
Hg, Base_case	1.8E-7	2.2E-7	7.7E-8	1.3E-14	2.5E-7
Hg, P_95	2.8E-7	3.3E-7	1.2E-7	2.0E-14	3.8E-7
K, Base_case	49	49	2.4	46	58
K, P_95	59	58	2.6	55	68
Mg, Base_case	22	22	0.7	20	23
Mg, P_95	36	36	2.9	29	41
Mn, Base_case	0.071	0.079	0.016	0.018	0.084
Mn, P_95	0.21	0.22	0.03	0.12	0.24
Mo, Base_case	0.19	0.19	0.008	0.18	0.22
Mo, P_95	0.29	0.3	0.024	0.25	0.32
Na, Base_case	300	300	14	280	350
Na, P_95	410	400	18	380	470
Ni, Base_case	0.033	0.041	0.015	0.0064	0.047
Ni, P_95	0.42	0.54	0.22	0.015	0.63
Pb, Base_case	9.0E-4	9.7E-4	1.3E-4	5.5E-4	0.001
Pb, P_95	0.0018	0.0021	4.7E-4	5.5E-4	0.0022
SO4, Base_case	920	900	56	860	1100
SO4, P_95	1300	1300	47	1300	1500
Sb, Base_case	5.5E-6	6.6E-6	2.3E-6	3.8E-13	7.6E-6
Sb, P_95	1.5E-5	1.8E-5	6.5E-6	1.1E-12	2.1E-5
Se, Base_case	0.008	0.0082	5.0E-4	0.007	0.0086
Se, P_95	0.015	0.017	0.0038	0.0083	0.019
Si, Base_case	0.0063	0.0075	0.0027	4.5E-10	0.0086
Si, P_95	0.014	0.017	0.0061	1.0E-9	0.02
Sn, Base_case	1.8E-6	2.2E-6	7.6E-7	1.3E-13	2.5E-6
Sn, P_95	1.8E-6	2.2E-6	7.6E-7	1.3E-13	2.5E-6
Sr, Base_case	2.4E-5	2.9E-5	1.0E-5	1.7E-12	3.3E-5
Sr, P_95	7.7E-5	9.2E-5	3.3E-5	5.4E-12	1.1E-4
Zn, Base_case	0.082	0.086	0.028	0.02	0.13
Zn, P_95	0.41	0.46	0.098	0.22	0.51
pH, Base_case	8.6	8.6	0.17	8.3	9
pH, P_95	7.5	7.5	0.16	7.3	7.9

Table 10: Summary statistics for Crosscourse Pit water quality, wet climate, no discharge.

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	1.8E-6	2.1E-6	7.5E-7	6.0E-12	2.6E-6
Ag, P_95	1.9E-6	2.3E-6	8.0E-7	6.5E-12	2.8E-6
Al, Base_case	0.12	0.14	0.032	0.063	0.15
Al, P_95	0.47	0.56	0.17	0.16	0.63
Alkalinity, Base_case	95	96	4.9	81	100
Alkalinity, P_95	140	140	6.9	120	150
As, Base_case	0.86	0.86	0.047	0.77	1
As, P_95	4.9	4.9	0.43	4.3	6.3
Ca, Base_case	190	190	20	170	250
Ca, P_95	260	250	20	230	320
Cd, Base_case	1.9E-4	2.1E-4	3.3E-5	1.1E-4	2.2E-4
Cd, P_95	0.0017	0.0019	4.0E-4	7.7E-4	0.002
Cl, Base_case	44	45	2.3	40	49
Cl, P_95	74	76	7.5	57	83
Co, Base_case	0.27	0.26	0.031	0.23	0.35
Co, P_95	0.45	0.45	0.015	0.42	0.48
Cr, Base_case	5.8E-4	5.8E-4	2.8E-5	5.4E-4	6.4E-4
Cr, P_95	6.7E-4	6.7E-4	4.0E-5	5.4E-4	7.5E-4
Cu, Base_case	0.44	0.59	0.23	0.019	0.66
Cu, P_95	5.7	7.6	3	0.14	8.6
Fe, Base_case	0.29	0.36	0.13	0.019	0.4
Fe, P_95	2.8	3.7	1.4	0.21	4.1
H, Base_case	7.4E-8	8.3E-8	2.1E-8	1.5E-8	9.4E-8
H, P_95	5.3E-7	6.0E-7	1.5E-7	1.7E-7	6.6E-7
Hg, Base_case	1.8E-7	2.1E-7	7.5E-8	6.0E-13	2.6E-7
Hg, P_95	2.8E-7	3.3E-7	1.2E-7	9.5E-13	4.0E-7
K, Base_case	45	45	4.3	39	58
K, P_95	54	53	4.7	47	68
Mg, Base_case	21	21	0.62	20	22
Mg, P_95	35	36	2.5	29	40
Mn, Base_case	0.066	0.071	0.014	0.018	0.08
Mn, P_95	0.2	0.21	0.026	0.12	0.23
Mo, Base_case	0.18	0.17	0.015	0.15	0.22
Mo, P_95	0.27	0.27	0.013	0.24	0.29
Na, Base_case	280	280	26	240	350
Na, P_95	370	370	34	330	470
Ni, Base_case	0.03	0.038	0.013	0.0063	0.042
Ni, P_95	0.37	0.49	0.19	0.015	0.56
Pb, Base_case	8.6E-4	9.0E-4	1.1E-4	5.5E-4	9.8E-4
Pb, P_95	0.0018	0.0019	4.3E-4	5.5E-4	0.0022
SO4, Base_case	850	830	86	750	1100
SO4, P_95	1200	1200	86	1100	1500
Sb, Base_case	5.6E-6	6.4E-6	2.3E-6	1.8E-11	8.0E-6
Sb, P_95	1.5E-5	1.8E-5	6.3E-6	5.1E-11	2.2E-5
Se, Base_case	0.0073	0.0073	2.6E-4	0.0067	0.0078
Se, P_95	0.013	0.015	0.003	0.008	0.017
Si, Base_case	0.0064	0.0073	0.0026	2.2E-8	0.0091
Si, P_95	0.014	0.017	0.0059	4.9E-8	0.021
Sn, Base_case	1.8E-6	2.1E-6	7.5E-7	6.0E-12	2.6E-6
Sn, P_95	1.8E-6	2.1E-6	7.5E-7	6.0E-12	2.6E-6
Sr, Base_case	2.4E-5	2.8E-5	9.9E-6	8.0E-11	3.4E-5
Sr, P_95	7.8E-5	9.0E-5	3.2E-5	2.6E-10	1.1E-4
Zn, Base_case	0.091	0.096	0.03	0.02	0.14
Zn, P_95	0.4	0.44	0.086	0.22	0.47
pH, Base_case	8.1	8.1	0.15	7.9	8.7
pH, P_95	7.2	7.1	0.11	7	7.6

Table 11: Summary statistics for Crosscourse Pit water quality, wet climate, with discharge

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	2.0E-6	2.3E-6	8.5E-7	6.0E-12	3.1E-6
Ag, P_95	2.2E-6	2.4E-6	9.0E-7	6.5E-12	3.3E-6
Al, Base_case	0.13	0.15	0.038	0.063	0.17
Al, P_95	0.53	0.66	0.2	0.16	0.74
Alkalinity, Base_case	99	100	6.6	81	110
Alkalinity, P_95	140	150	9.3	120	150
As, Base_case	0.83	0.84	0.066	0.7	1
As, P_95	4.7	4.7	0.58	3.8	6.3
Ca, Base_case	180	180	27	150	250
Ca, P_95	250	240	27	210	320
Cd, Base_case	2.0E-4	2.3E-4	3.9E-5	1.1E-4	2.4E-4
Cd, P_95	0.0018	0.002	4.5E-4	7.7E-4	0.0022
Cl, Base_case	45	45	2.6	40	50
Cl, P_95	77	80	9.6	57	90
Co, Base_case	0.25	0.25	0.04	0.2	0.35
Co, P_95	0.44	0.45	0.022	0.4	0.49
Cr, Base_case	6.0E-4	5.9E-4	2.8E-5	5.4E-4	6.7E-4
Cr, P_95	7.1E-4	7.2E-4	5.1E-5	5.4E-4	7.9E-4
Cu, Base_case	0.53	0.68	0.28	0.019	0.82
Cu, P_95	6.9	8.9	3.7	0.14	11
Fe, Base_case	0.35	0.44	0.16	0.019	0.49
Fe, P_95	3.4	4.3	1.7	0.21	5.1
H, Base_case	8.5E-8	9.5E-8	2.7E-8	1.5E-8	1.1E-7
H, P_95	5.9E-7	6.7E-7	1.7E-7	1.7E-7	7.3E-7
Hg, Base_case	2.0E-7	2.3E-7	8.5E-8	6.0E-13	3.1E-7
Hg, P_95	3.1E-7	3.5E-7	1.3E-7	9.5E-13	4.8E-7
K, Base_case	43	43	5.6	35	58
K, P_95	51	51	6.3	42	68
Mg, Base_case	21	22	0.66	20	23
Mg, P_95	37	37	3.6	29	44
Mn, Base_case	0.078	0.088	0.019	0.018	0.094
Mn, P_95	0.22	0.23	0.036	0.12	0.26
Mo, Base_case	0.17	0.17	0.02	0.14	0.22
Mo, P_95	0.27	0.27	0.017	0.23	0.3
Na, Base_case	270	260	34	220	350
Na, P_95	360	350	44	290	470
Ni, Base_case	0.035	0.043	0.016	0.0063	0.051
Ni, P_95	0.45	0.58	0.24	0.015	0.69
Pb, Base_case	9.3E-4	9.9E-4	1.4E-4	5.5E-4	0.0011
Pb, P_95	0.002	0.0022	5.3E-4	5.5E-4	0.0025
SO4, Base_case	810	780	110	660	1100
SO4, P_95	1200	1200	110	1000	1500
Sb, Base_case	6.2E-6	6.9E-6	2.6E-6	1.8E-11	9.5E-6
Sb, P_95	1.7E-5	1.9E-5	7.1E-6	5.1E-11	2.6E-5
Se, Base_case	0.0073	0.0072	3.6E-4	0.0066	0.008
Se, P_95	0.015	0.016	0.0036	0.008	0.019
Si, Base_case	0.0071	0.0079	0.0029	2.2E-8	0.011
Si, P_95	0.016	0.018	0.0067	4.9E-8	0.025
Sn, Base_case	2.0E-6	2.3E-6	8.5E-7	6.0E-12	3.1E-6
Sn, P_95	2.0E-6	2.3E-6	8.5E-7	6.0E-12	3.1E-6
Sr, Base_case	2.7E-5	3.0E-5	1.1E-5	8.0E-11	4.1E-5
Sr, P_95	8.6E-5	9.7E-5	3.6E-5	2.6E-10	1.3E-4
Zn, Base_case	0.1	0.11	0.039	0.02	0.16
Zn, P_95	0.43	0.49	0.1	0.22	0.52
pH, Base_case	8.1	8	0.18	7.8	8.7
pH, P_95	7.1	7.1	0.13	6.9	7.6

Table 12: Summary statistics for Crosscourse Pit water quality, median climate, with discharge.

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	1.9E-6	2.3E-6	8.8E-7	0	3.0E-6
Ag, P_95	2.1E-6	2.4E-6	9.4E-7	0	3.2E-6
Al, Base_case	0.14	0.16	0.044	0.064	0.19
Al, P_95	0.56	0.66	0.22	0.16	0.81
Alkalinity, Base_case	110	110	10	82	120
Alkalinity, P_95	150	150	14	120	170
As, Base_case	0.89	0.91	0.067	0.71	1
As, P_95	5	5.1	0.56	3.8	6.3
Ca, Base_case	190	200	26	150	250
Ca, P_95	260	260	26	200	320
Cd, Base_case	2.0E-4	2.2E-4	3.8E-5	1.1E-4	2.4E-4
Cd, P_95	0.0018	0.0019	4.6E-4	7.7E-4	0.0022
Cl, Base_case	49	49	2.7	42	53
Cl, P_95	84	86	13	58	100
Co, Base_case	0.27	0.27	0.038	0.2	0.35
Co, P_95	0.48	0.47	0.035	0.4	0.54
Cr, Base_case	6.4E-4	6.5E-4	3.3E-5	5.4E-4	7.0E-4
Cr, P_95	7.5E-4	7.7E-4	6.6E-5	5.4E-4	8.3E-4
Cu, Base_case	0.58	0.72	0.32	0.019	0.94
Cu, P_95	7.6	9.4	4.2	0.15	12
Fe, Base_case	0.38	0.47	0.18	0.019	0.56
Fe, P_95	3.7	4.6	1.9	0.21	5.8
H, Base_case	8.4E-8	9.5E-8	2.6E-8	1.5E-8	1.1E-7
H, P_95	5.5E-7	6.4E-7	1.6E-7	1.7E-7	6.6E-7
Hg, Base_case	1.9E-7	2.3E-7	8.8E-8	0	3.0E-7
Hg, P_95	3.0E-7	3.5E-7	1.4E-7	0	4.6E-7
K, Base_case	46	46	5.4	35	58
K, P_95	55	55	6.1	42	68
Mg, Base_case	23	23	0.87	20	24
Mg, P_95	37	38	3.1	29	40
Mn, Base_case	0.087	0.099	0.024	0.018	0.1
Mn, P_95	0.23	0.24	0.039	0.12	0.26
Mo, Base_case	0.18	0.18	0.019	0.14	0.22
Mo, P_95	0.29	0.28	0.026	0.24	0.33
Na, Base_case	280	290	32	220	350
Na, P_95	380	390	42	290	470
Ni, Base_case	0.038	0.045	0.018	0.0064	0.058
Ni, P_95	0.49	0.61	0.27	0.015	0.79
Pb, Base_case	9.7E-4	0.0011	1.6E-4	5.5E-4	0.0011
Pb, P_95	0.0021	0.0024	5.9E-4	5.5E-4	0.0026
SO4, Base_case	850	850	110	650	1100
SO4, P_95	1300	1300	120	1000	1500
Sb, Base_case	6.0E-6	7.0E-6	2.7E-6	0	9.2E-6
Sb, P_95	1.6E-5	1.9E-5	7.5E-6	0	2.5E-5
Se, Base_case	0.0077	0.0076	6.0E-4	0.0066	0.0088
Se, P_95	0.016	0.017	0.0043	0.0082	0.021
Si, Base_case	0.0068	0.008	0.0031	0	0.01
Si, P_95	0.015	0.018	0.007	0	0.024
Sn, Base_case	1.9E-6	2.3E-6	8.8E-7	0	3.0E-6
Sn, P_95	1.9E-6	2.3E-6	8.8E-7	0	3.0E-6
Sr, Base_case	2.6E-5	3.0E-5	1.2E-5	0	4.0E-5
Sr, P_95	8.3E-5	9.8E-5	3.8E-5	0	1.3E-4
Zn, Base_case	0.091	0.097	0.032	0.02	0.13
Zn, P_95	0.43	0.47	0.11	0.22	0.55
pH, Base_case	8.3	8.4	0.29	7.4	8.7

Table 13: Summary statistics for Crosscourse Pit water quality, dry climate, with discharge.

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	150	150	13	120	170
Ag, P_95	1.7E-6	1.9E-6	7.7E-7	0	2.7E-6
Al, Base_case	1.8E-6	2.0E-6	8.1E-7	0	2.9E-6
Al, P_95	0.14	0.15	0.042	0.065	0.19
Alkalinity, Base_case	4.5E+4	4.5E+4	950	4.4E+4	4.7E+4
Alkalinity, P_95	110	110	10	83	120
As, Base_case	0.56	0.64	0.22	0.16	0.81
As, P_95	0.91	0.95	0.086	0.7	1
Ca, Base_case	5.1	5.3	0.67	3.7	6.3
Ca, P_95	200	200	31	140	250
Cd, Base_case	260	270	33	200	320
Cd, P_95	1.9E-4	2.0E-4	3.1E-5	1.1E-4	2.1E-4
Cl, Base_case	0.0016	0.0017	3.8E-4	7.7E-4	0.002
Cl, P_95	50	50	3.8	42	56
Co, Base_case	85	88	13	59	100
Co, P_95	0.27	0.28	0.044	0.2	0.35
Cr, Base_case	0.48	0.48	0.039	0.39	0.54
Cr, P_95	6.4E-4	6.4E-4	4.7E-5	5.5E-4	7.4E-4
Cu, Base_case	7.5E-4	7.6E-4	6.9E-5	5.5E-4	8.7E-4
Cu, P_95	0.59	0.72	0.32	0.02	0.96
Fe, Base_case	7.7	9.3	4.2	0.15	13
Fe, P_95	0.38	0.46	0.18	0.019	0.56
H, Base_case	0.41	0.44	0.093	0.22	0.51
H, P_95	7.7E-8	8.9E-8	2.3E-8	1.5E-8	9.1E-8
Hg, Base_case	3.7	4.5	1.9	0.21	5.9
Hg, P_95	1.7E-7	1.9E-7	7.7E-8	0	2.7E-7
K, Base_case	2.6E-7	2.9E-7	1.2E-7	0	4.1E-7
K, P_95	46	47	6.5	34	58
Mg, Base_case	55	57	7.4	41	68
Mg, P_95	22	22	1.4	20	25
Mn, Base_case	35	36	2	29	37
Mn, P_95	0.089	0.1	0.024	0.018	0.11
Mo, Base_case	0.22	0.24	0.034	0.12	0.25
Mo, P_95	0.18	0.18	0.023	0.13	0.22
Na, Base_case	0.29	0.28	0.026	0.25	0.33
Na, P_95	290	290	39	210	350
Ni, Base_case	390	390	52	280	470
Ni, P_95	0.038	0.045	0.018	0.0065	0.059
Pb, Base_case	0.5	0.6	0.27	0.015	0.81
Pb, P_95	9.5E-4	0.001	1.4E-4	5.5E-4	0.0011
SO4, Base_case	0.002	0.0022	5.5E-4	5.5E-4	0.0026
SO4, P_95	850	850	130	620	1100
Sb, Base_case	1200	1300	150	950	1500
Sb, P_95	5.1E-6	5.8E-6	2.4E-6	0	8.3E-6
Se, Base_case	1.4E-5	1.6E-5	6.5E-6	0	2.3E-5
Se, P_95	0.0078	0.0077	6.4E-4	0.0064	0.0088
Si, Base_case	0.016	0.017	0.0042	0.0085	0.022
Si, P_95	0.0058	0.0065	0.0026	0	0.0093
Sn, Base_case	0.013	0.015	0.006	0	0.021
Sn, P_95	1.7E-6	1.9E-6	7.6E-7	0	2.7E-6
Sr, Base_case	1.7E-6	1.9E-6	7.6E-7	0	2.7E-6
Sr, P_95	2.2E-5	2.5E-5	1.0E-5	0	3.6E-5
Zn, Base_case	7.1E-5	7.9E-5	3.3E-5	0	1.2E-4
Zn, P_95	0.076	0.085	0.025	0.02	0.11
pH, Base_case	4.8E-7	5.3E-7	1.3E-7	1.7E-7	5.9E-7
pH, P_95	8.2	8.4	0.55	6.9	8.8

Prospect Pit

Table 14:Prospect pit post 2023, dry climate.

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	2.8E-5	2.1E-5	1.5E-5	1.2E-5	7.8E-5
Ag, P_95	3.0E-5	2.3E-5	1.6E-5	1.3E-5	8.4E-5
Al, Base_case	0.018	0.018	0.0033	0.011	0.03
Al, P_95	0.1	0.1	0.016	0.057	0.15
Alkalinity, Base_case	8.1	8.4	1.6	3.4	11
Alkalinity, P_95	15	16	3.3	6	20
As, Base_case	8.1E-4	8.0E-4	1.4E-4	4.9E-4	0.0013
As, P_95	0.02	0.016	0.01	0.0097	0.055
Ca, Base_case	4.3	4.5	0.91	1.8	5.6
Ca, P_95	11	11	2.3	4.2	14
Cd, Base_case	8.2E-4	6.6E-4	4.1E-4	3.9E-4	0.0022
Cd, P_95	0.014	0.011	0.0074	0.0064	0.039
Cl, Base_case	1.1	1.2	0.22	0.5	1.5
Cl, P_95	3.1	3.2	0.68	1.2	4.1
Co, Base_case	3.7E-4	3.6E-4	6.2E-5	2.2E-4	5.9E-4
Co, P_95	0.0041	0.0042	6.5E-4	0.0022	0.0058
Cr, Base_case	1.6E-4	1.4E-4	4.3E-5	1.1E-4	3.2E-4
Cr, P_95	5.0E-4	4.3E-4	2.0E-4	2.8E-4	0.0012
Cu, Base_case	6.0E-4	5.8E-4	1.2E-4	3.9E-4	0.001
Cu, P_95	0.0014	0.0014	2.2E-4	7.6E-4	0.002
Fe, Base_case	0.13	0.11	0.054	0.075	0.32
Fe, P_95	0.38	0.33	0.15	0.22	0.92
H, Base_case	2.8E-7	2.4E-7	1.3E-7	1.5E-7	7.4E-7
H, P_95	4.2E-6	3.4E-6	2.2E-6	2.0E-6	1.2E-5
Hg, Base_case	2.8E-6	2.1E-6	1.5E-6	1.2E-6	7.8E-6
Hg, P_95	4.3E-6	3.4E-6	2.3E-6	1.9E-6	1.2E-5
K, Base_case	0.7	0.68	0.15	0.47	1.3
K, P_95	1.4	1.3	0.34	1	2.7
Mg, Base_case	3.8	4	0.91	1.4	5.1
Mg, P_95	13	14	3.1	4.7	18
Mn, Base_case	0.018	0.017	0.0042	0.013	0.034
Mn, P_95	0.11	0.11	0.024	0.075	0.2
Mo, Base_case	0.0038	0.004	9.4E-4	0.0013	0.0051
Mo, P_95	0.011	0.012	0.0028	0.0041	0.016
Na, Base_case	2.5	2.6	0.58	0.92	3.3
Na, P_95	6.1	6.3	1.5	2.2	8.2
Ni, Base_case	8.2E-4	8.3E-4	1.3E-4	4.1E-4	0.0011
Ni, P_95	0.0026	0.0026	4.0E-4	0.0014	0.0036
Pb, Base_case	0.0023	0.0019	0.0011	0.0011	0.0062
Pb, P_95	0.0095	0.0075	0.005	0.0043	0.026
SO4, Base_case	46	48	10	18	61
SO4, P_95	110	120	25	45	150
Sb, Base_case	8.3E-5	6.4E-5	4.5E-5	3.7E-5	2.4E-4
Sb, P_95	2.3E-4	1.8E-4	1.3E-4	1.0E-4	6.6E-4
Se, Base_case	4.8E-4	4.3E-4	1.3E-4	3.3E-4	9.5E-4
Se, P_95	5.2E-4	4.8E-4	1.2E-4	3.7E-4	9.9E-4
Si, Base_case	0.098	0.076	0.053	0.044	0.28
Si, P_95	0.22	0.17	0.12	0.099	0.63
Sn, Base_case	2.8E-5	2.1E-5	1.5E-5	1.2E-5	7.8E-5
Sn, P_95	2.8E-5	2.1E-5	1.5E-5	1.2E-5	7.8E-5
Sr, Base_case	3.6E-4	2.8E-4	2.0E-4	1.6E-4	0.001
Sr, P_95	0.0012	9.3E-4	6.4E-4	5.3E-4	0.0034
Zn, Base_case	0.22	0.19	0.069	0.14	0.47
Zn, P_95	1.2	0.97	0.59	0.58	3.2
pH, Base_case	1.6	1.6	0.3	0.7	2
pH, P_95	1.4	1.5	0.27	0.63	1.8

Table 15: Prospect Pit post 2023 median climate.

Attribute	Mean	Median	Standard Deviation	Minimum	Maximum
Ag, Base_case	3.4E-05	2.69E-05	1.83E-05	1.41E-05	9.68E-05
Ag, P_95	3.68E-05	2.91E-05	1.98E-05	1.53E-05	0.000105
Al, Base_case	0.022492	0.0221	0.003723	0.0123	0.0375
Al, P_95	0.126643	0.128	0.018468	0.0609	0.185
Alkalinity, Base_case	10.11287	10.6	2.043066	3.63	12.7
Alkalinity, P_95	18.95975	20.1	4.137729	6.43	24.3
As, Base_case	0.001009	0.001	0.000155	0.000525	0.0016
As, P_95	0.024897	0.0204	0.012312	0.0114	0.0679
Ca, Base_case	5.390718	5.68	1.142315	1.87	6.86
Ca, P_95	13.05641	13.8	2.834674	4.45	16.7
Cd, Base_case	0.001008	0.000826	0.000496	0.000463	0.00274
Cd, P_95	0.017307	0.0138	0.009091	0.0074	0.0487
Cl, Base_case	1.427327	1.49	0.275945	0.528	1.77
Cl, P_95	3.863254	4.1	0.853773	1.3	4.97
Co, Base_case	0.000458	0.000455	7.06E-05	0.000239	0.000727
Co, P_95	0.00513	0.0052	0.000754	0.00237	0.0072
Cr, Base_case	0.000196	0.00018	5.01E-05	0.000129	0.000395
Cr, P_95	0.000617	0.000529	0.000248	0.000338	0.00152
Cu, Base_case	0.000744	0.000721	0.000133	0.000423	0.00129
Cu, P_95	0.001696	0.00171	0.000247	0.000818	0.00248
Fe, Base_case	0.163533	0.14	0.065097	0.0904	0.401
Fe, P_95	0.467612	0.401	0.183213	0.261	1.14
H, Base_case	3.5E-07	2.95E-07	1.6E-07	1.73E-07	9.17E-07
H, P_95	5.23E-06	4.25E-06	2.64E-06	2.34E-06	1.44E-05
Hg, Base_case	3.39E-06	2.68E-06	1.82E-06	1.41E-06	9.65E-06
Hg, P_95	5.34E-06	4.23E-06	2.87E-06	2.22E-06	1.52E-05
K, Base_case	0.870612	0.83	0.168665	0.512	1.56
K, P_95	1.762383	1.64	0.397041	1.1	3.38
Mg, Base_case	4.769838	5.12	1.147481	1.5	6.27
Mg, P_95	16.12032	17.3	3.978195	4.96	21.3
Mn, Base_case	0.022435	0.021	0.004837	0.0138	0.0422
Mn, P_95	0.137946	0.131	0.027191	0.0818	0.25
Mo, Base_case	0.004693	0.00506	0.001193	0.00141	0.00626
Mo, P_95	0.014263	0.0154	0.003594	0.00431	0.019
Na, Base_case	3.087566	3.31	0.737386	0.977	4.05
Na, P_95	7.563416	8.12	1.855055	2.34	10
Ni, Base_case	0.001012	0.00104	0.000158	0.000435	0.00132
Ni, P_95	0.003165	0.0032	0.000463	0.00148	0.0045
Pb, Base_case	0.002834	0.002315	0.001407	0.00129	0.00774
Pb, P_95	0.011714	0.009385	0.00611	0.00505	0.0328
SO4, Base_case	57.2166	60.8	12.81563	19	73.9
SO4, P_95	142.346	151	31.82786	47.4	184
Sb, Base_case	0.000102	8.1E-05	5.5E-05	4.25E-05	0.000291
Sb, P_95	0.000287	0.000227	0.000154	0.000119	0.000817
Se, Base_case	0.000588	0.000542	0.000149	0.000386	0.00118
Se, P_95	0.000638	0.000594	0.000145	0.000401	0.00123
Si, Base_case	0.121155	0.0959	0.065158	0.0503	0.345
Si, P_95	0.276434	0.219	0.148675	0.115	0.788
Sn, Base_case	3.39E-05	2.68E-05	1.82E-05	1.41E-05	9.65E-05
Sn, P_95	3.39E-05	2.68E-05	1.82E-05	1.41E-05	9.65E-05
Sr, Base_case	0.000449	0.000355	0.000241	0.000186	0.00128
Sr, P_95	0.001468	0.00116	0.000789	0.00061	0.00418
Zn, Base_case	0.270974	0.244	0.081794	0.177	0.587
Zn, P_95	1.478294	1.215	0.721159	0.686	4
pH, Base_case	1.972084	2.06	0.366272	0.749	2.42
pH, P_95	1.782837	1.86	0.335063	0.672	2.2

Table 16: Prospect pit post 2023 wet climate

Result:	Mean	Median	Standard Deviation	Minimum	Maximum
Alkalinity, Base_case	13	14	2.2	6.9	16
Alkalinity, P_95	25	26	4.8	12	30
Ag, Base_case	3.7E-5	2.7E-5	2.8E-5	6.1E-6	1.1E-4
Ag, P_95	4.0E-5	2.9E-5	3.0E-5	6.6E-6	1.2E-4
Al, Base_case	0.027	0.026	0.004	0.024	0.044
Al, P_95	0.16	0.16	0.014	0.12	0.22
As, Base_case	0.0012	0.0012	1.4E-4	0.001	0.0019
As, P_95	0.027	0.02	0.019	0.0067	0.08
Ca, Base_case	7	7.4	1.3	3.6	8.5
Ca, P_95	17	18	3.3	8.5	21
Cd, Base_case	0.0011	8.3E-4	7.6E-4	2.8E-4	0.0032
Cd, P_95	0.019	0.014	0.014	0.0036	0.057
Cl, Base_case	1.8	1.9	0.29	1	2.2
Cl, P_95	5	5.4	0.99	2.5	6.2
Co, Base_case	5.6E-4	5.4E-4	6.5E-5	4.6E-4	8.5E-4
Co, P_95	0.0064	0.0065	5.3E-4	0.0045	0.0084
Cr, Base_case	2.3E-4	2.1E-4	7.1E-5	1.6E-4	4.6E-4
Cr, P_95	6.9E-4	5.6E-4	3.8E-4	2.9E-4	0.0018
Cu, Base_case	9.0E-4	8.4E-4	1.6E-4	7.5E-4	0.0015
Cu, P_95	0.0021	0.0021	1.8E-4	0.0016	0.0029
Fe, Base_case	0.18	0.15	0.098	0.078	0.47
Fe, P_95	0.53	0.43	0.28	0.23	1.3
Hg, Base_case	3.7E-6	2.6E-6	2.8E-6	6.1E-7	1.1E-5
Hg, P_95	5.8E-6	4.2E-6	4.4E-6	9.6E-7	1.8E-5
K, Base_case	1	0.98	0.21	0.84	1.8
K, P_95	2.1	1.9	0.54	1.5	4
Mg, Base_case	6.3	6.7	1.4	2.9	7.9
Mg, P_95	21	23	4.9	9.4	27
Mn, Base_case	0.027	0.025	0.0064	0.02	0.05
Mn, P_95	0.17	0.16	0.034	0.13	0.29
Mo, Base_case	0.0062	0.0067	0.0015	0.0027	0.008
Mo, P_95	0.019	0.02	0.0045	0.0082	0.024
Na, Base_case	4	4.3	0.89	1.9	5.1
Na, P_95	9.9	11	2.3	4.5	13
Ni, Base_case	0.0013	0.0013	1.2E-4	8.3E-4	0.0015
Ni, P_95	0.004	0.004	3.3E-4	0.0028	0.0053
Pb, Base_case	0.0031	0.0023	0.0022	7.6E-4	0.0091
Pb, P_95	0.013	0.0093	0.0094	0.0025	0.039
SO4, Base_case	75	80	15	36	93
SO4, P_95	190	200	37	90	230
Sb, Base_case	1.1E-4	8.0E-5	8.4E-5	1.8E-5	3.4E-4
Sb, P_95	3.1E-4	2.2E-4	2.4E-4	5.1E-5	9.6E-4
Se, Base_case	6.9E-4	6.2E-4	2.1E-4	4.7E-4	0.0014
Se, P_95	7.6E-4	6.9E-4	2.0E-4	5.5E-4	0.0014
Si, Base_case	0.13	0.095	0.1	0.022	0.41
Si, P_95	0.3	0.22	0.23	0.05	0.92
Sn, Base_case	3.7E-5	2.6E-5	2.8E-5	6.1E-6	1.1E-4
Sn, P_95	3.7E-5	2.6E-5	2.8E-5	6.1E-6	1.1E-4
Sr, Base_case	4.8E-4	3.5E-4	3.7E-4	8.1E-5	0.0015
Sr, P_95	0.0016	0.0011	0.0012	2.6E-4	0.0049
Zn, Base_case	0.31	0.27	0.12	0.19	0.69
Zn, P_95	1.6	1.2	1.1	0.42	4.7
H, Base_case	3.9E-7	3.0E-7	2.4E-7	1.2E-7	1.1E-6
H, P_95	5.7E-6	4.2E-6	4.0E-6	1.3E-6	1.7E-5
pH, Base_case	2.5	2.6	0.37	1.4	3
pH, P_95	2.3	2.4	0.34	1.3	2.7

The values in these tables have been rounded for presentation



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