Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

GIANT MINE REMEDIATION PROJECT

Underground Design Plan

Version 1.2

July 2021

LAND ACKNOWLEDGEMENT

The Giant Mine Remediation Project acknowledges the Indigenous Peoples and the importance of the land in and around the Giant Mine site, which is located in Chief Drygeese Territory. From time immemorial, it has been and is the traditional land of the Yellowknives Dene First Nation. We acknowledge that the Giant Mine site is also within the homeland of the North Slave Metis Alliance and the Tłıchǫ Mǫwhì Gogha Dè Nįįtłèè boundary. The Giant Mine Remediation Project respects the histories, languages, and cultures of First Nations, Metis, Inuit, and all First Peoples of Canada, whose presence continues to enrich our vibrant community.

VERSION HISTORY

Version	Date Issued / Effective Date	Description of Version
1.0	February 26 2021	Submitted to the Mackenzie Valley Land and Water Board as per Water Licence MV2007L8-0031, Part E, Condition 3
1.1	June 11, 2021	Submitted to the Mackenzie Valley Land and Water Board as per Water Licence MV2007L8-0031, Part E, Condition 3. Changes to this Plan include updates to address Board's direction dated May 20, 2021. A summary of changes is appended to the cover letter submitted with this version.
1.2	July 2, 2021	Submitted to the Mackenzie Valley Land and Water Board as per Water Licence MV2007L8-0031, Part E, Condition 3. Changes to this Plan include the addition of a caveat to acknowledge that changes to the minewater action levels are not approved and that further engagement on these numbers is ongoing. Engagement will be scheduled in the fall/winter 2021. Following engagement, an update to the Plan will be submitted to the MVLWB for review and approval.

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List of Abbreviations, Units, and Symbols

Abbreviation	Definition
ALARP	as low as reasonably practicable
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CRP	Closure and Reclamation Plan
GMRP	Giant Mine Remediation Project
GNWT	Government of the Northwest Territories
HDPE	high-density polyethylene
MMP	Management and Monitoring Plan
MVLWB	Mackenzie Valley Land and Water Board
N/A	not applicable
NWT	Northwest Territories
QA/QC	quality assurance / quality control
PSPC	Public Services and Procurement Canada
Site	Giant Mine Site
TCA	Tailings Containment Area
WTP	water treatment plant

Unit/Symbol	Definition
%	percent
cm	centimetre
ha	hectare
kPa	kilopascal
m	metre
m^3	cubic metre
m^3/h	cubic metres per hour
m amsl	metres above mean sea level
mbgs	metres below ground surface
mg/kg	milligrams per kilogram
mm	millimetre
MPa	megapascal

1 INTRODUCTION

1.1 Purpose

The Giant Mine (Site) is located within the city of Yellowknife boundary, approximately 1.5 km from the community of Ndilǫ and 9 km from the community of Dettah. The Site is situated on Commissioner's Land administered by the Government of the Northwest Territories (GNWT); Reserves (R622T and 85 J/8-257-2) have been established to allow the implementation of the remediation of the Site. Ongoing care, maintenance, and remediation of the Site is known as the Giant Mine Remediation Project (GMRP). For a history of the Giant Mine and planned remediation activities, please refer to the Closure and Reclamation Plan (CRP).

The GNWT and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) are in the process of executing the GMRP under Water Licence MV2007L8-0031 and Land Use Permit MV2019X0007. This Underground Design Plan has been developed by the GMRP Team to provide the Mackenzie Valley Land and Water Board (MVLWB) with the information required to approve the GMRP to begin remediation of the underground mine workings. This document presents the design plan for underground stabilization and backfill activities, including soil processing for arsenic waste disposal into Chamber 15, closure of openings to surface, grouting historical and project surface boreholes, design of a long-term access portal, routing surface runoff to the mine pool through the underground, and monitoring requirements during remediation implementation in the adaptive management phase post-construction. Concordance with the conditions of the Water Licence is summarized in Appendix A.

1.2 Overview

The excavation of rock during mining operations resulted in the development of underground voids, referred to as stopes, chambers, and access development drifts (Plate 1-1). The voids are commonly grouped by their corresponding overlying open pit excavation except for the GKP area which is located at the northern extent of the Site. Some of the underground development excavations are connected to surface, and these are referred to as openings to surface. Some mined-out stopes are used as storage areas for arsenic trioxide; these are referred to as arsenic stopes. Purpose-built arsenic storage chambers were also used to store arsenic trioxide. Crown pillars (the mass of bedrock overlying an underground excavation) separate the stope and chamber voids from the ground surface. Several arsenic and non-arsenic stopes have already been backfilled, having been identified as posing an unacceptable risk if crown pillars were to fail.

As part of the remediation, selected remaining voids left by underground mining development will be backfilled to stabilize the underground workings (Plate 1-1). The stabilization focuses on mined-out voids (stopes) near the surface that, if failure occurs, could form hazardous sinkholes; selected deeper stopes that could pose a risk to arsenic containment if they were to fail; and arsenic trioxide storage chambers and stopes that could form hazardous sinkholes or release arsenic to the environment if they failed. These stopes and chambers will be backfilled using flowable cemented fills (consisting of tailings or other granular material mixed with cement) or cemented rock fill. In some cases, adjacent underground voids will also be backfilled to provide lateral support to existing uncemented mine fill, promoting long-term stability in the event of minewater level fluctuations. Backfill will also be added to the non-arsenic side of arsenic bulkheads in the underground openings connected to the arsenic stopes and chambers to provide long-term support to them. Plates 1-2 to 1-4 show schematics of the underground workings at the Site as they relate to surface, the current minewater level, connections to surface, and other underground voids, particularly arsenic stopes and chambers.

Backfill for underground Chamber 15 will be sourced from highly arsenic-impacted material excavated from around the former roaster area. Where appropriate, the volume of material to be disposed of in Chamber 15 will be reduced through “soil washing.” This process reduces the volume of arsenic-impacted material by removing the arsenic dust from the coarse-grained material, concentrating the arsenic within the fine portions of the soil into a filter cake. The arsenic concentrated filter cake is then processed into a flowable cemented fill that will be used to backfill Chamber 15 following the stabilization methods used for other mined voids. Non-liquefiable arsenic-impacted material may also be placed in Chamber 15 and will not be cemented. The coarse fraction remaining after soil washing will be suitable for placement into a Tailings Containment Area (TCA) or open pit as per the Waste Management and Monitoring Plan (MMP).

Existing openings from the surface to the underground will be closed. The openings will either be capped with a concrete slab or securely filled with backfill so that subsidence will not pose a future hazard. This backfilling will include historical boreholes that connect surface to underground. Where they can be identified and located, these boreholes will be backfilled with cementitious grout to prevent the flow of water to underground workings.

The High Test System is a network of underground ditches, channels, sumps, piping, and pumps designed to isolate infiltrating water which contains high concentrations of arsenic. The goal is to isolate this water from workers and the overall mine pool. The underground High Test System will be decommissioned prior to abandonment of the underground after stabilization work is completed. Some existing piping systems will be changed and protected so that remnant contaminated flows are routed away from the C Shaft submersible pumping system that will feed water to the water treatment plant (WTP), starting in 2026.

The current portals that lead to the underground are located in areas that will either be closed or will be inaccessible after remediation activities are completed. Therefore, a new access portal, lockable to prevent unauthorized entry, will be developed to allow re-entry into the underground should access be required.

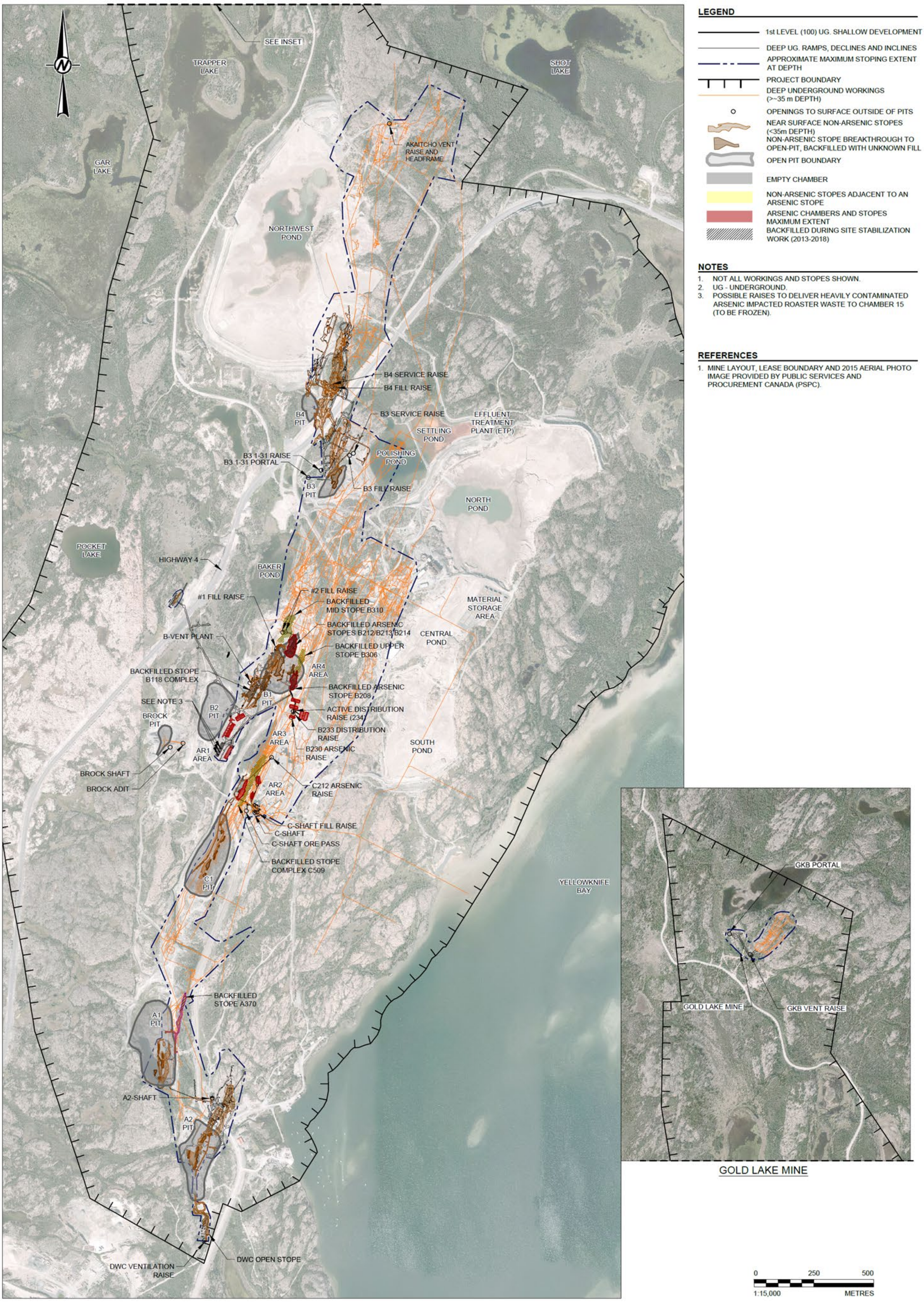

Plate 1-1: **Location of Underground Workings**

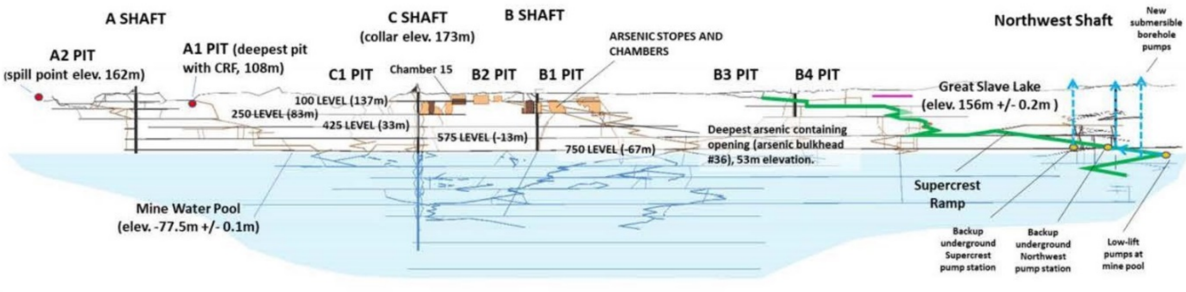

Plate 1-2: **Schematic Long Section of Giant Mine (looking west) Showing Current Location of Minewater Elevation and Flooded Workings Below**

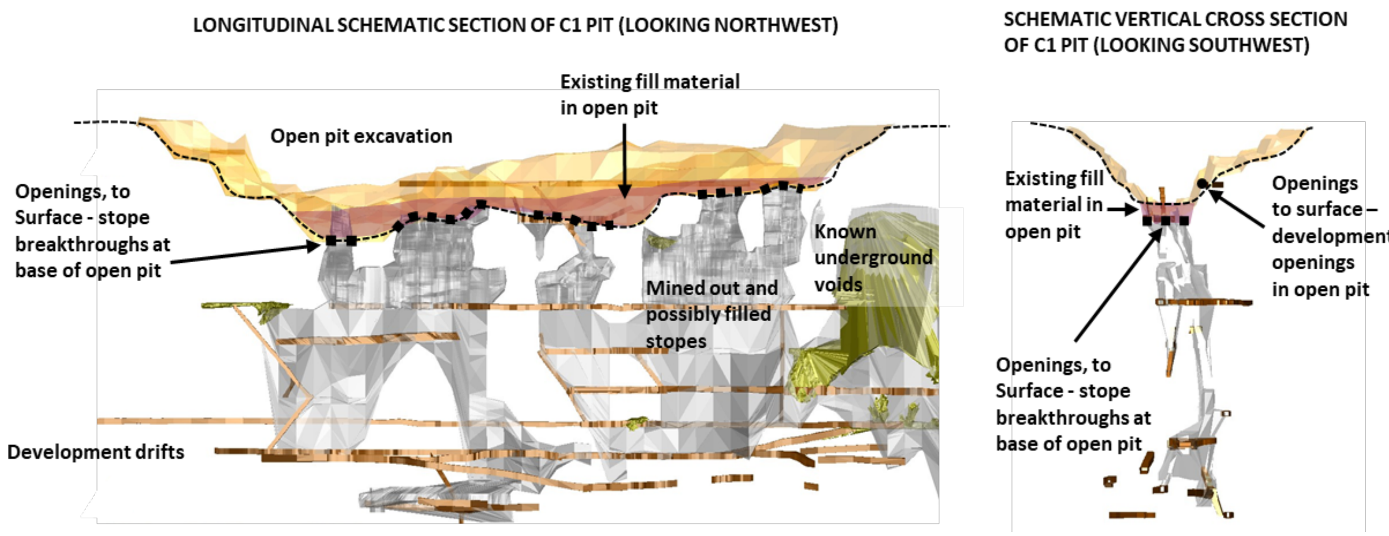

Plate 1-3: **Schematic Cross-Sections of Underground Voids and their Interactions with Open Pits**

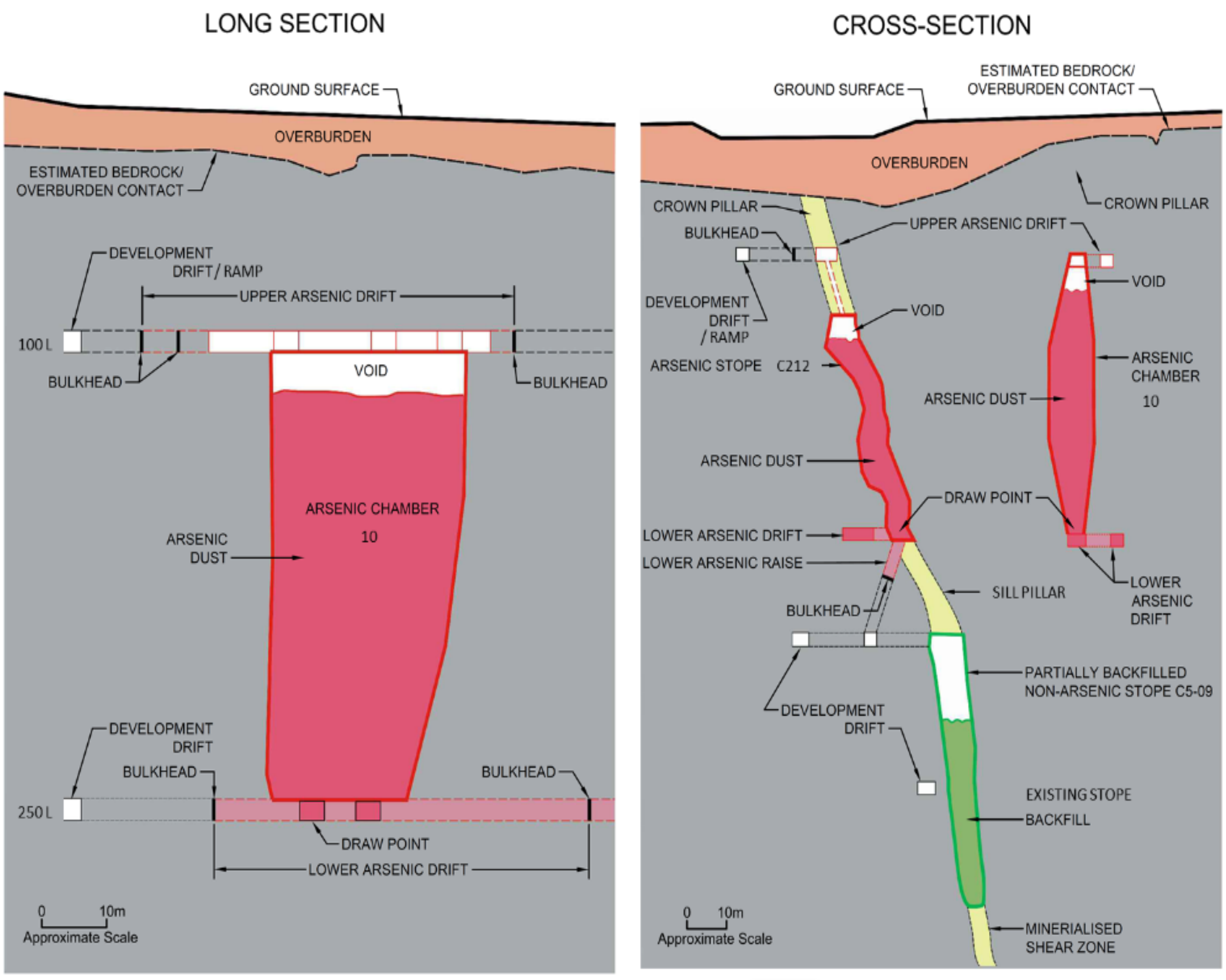

Plate 1-4: Schematic Vertical Sections of Arsenic Stope C212 and Arsenic Chamber 10 Area to Describe Common Underground Terminology (existing conditions)

1.3 Linkages to Other Project Components

The work described in the Underground Design Plan is linked to other project components (Table 1-1).

Table 1-1: Underground Key Linkages to other Project Components

Project Component	Inter-dependency	Sequence Implications
Arsenic trioxide frozen shell	Provides improved stability to arsenic stopes and chambers	Arsenic bulkhead support backfill needs to be placed in front of arsenic bulkheads prior to drilling of thermosyphon holes. Underground stabilization and placement of fill material in B1 Pit must occur prior to construction of AR 4 freeze pad. The AR1 freeze pad must be excavated before Chamber 15 can be backfilled. The AR1 thermosyphon holes can be drilled and thermosyphons installed before filling of Chamber 15, however, they must not be charged until Chamber 15 is backfilled.
Open pit	Provides stabilization below pits to support placement of pit fill Closure of pits includes drainage of runoff water to the mine pool in a manner that limits build up of water in pit fills and on a pathway that minimizes impacts to underground stability	Underground stabilization under pits must occur prior to the majority of pit filling work. Infrastructure associated with directing pit basin runoff to designated underground areas is to be installed prior to backfilling underground workings and loss of access to the underground.
Contaminated soils and sediment	Arsenic-contaminated soil from around the roaster area will be processed and used to backfill Chamber 15	Roaster area soils must be excavated and processed prior to backfilling Chamber 15. Heavily arsenic-impacted roaster area soils must be excavated prior to excavating underlying arsenic impacted soils.
Baker Creek and Surface Water	Provides stabilization under some reaches of Baker Creek	N/A
Tailings Containment Areas	Underground stabilization will use tailings to produce flowable cemented backfill Excess material from soil washing may be relocated to the Tailings Containment Areas.	Underground stabilization work that requires cemented paste backfill which uses tailings must occur prior to completion of work on North, Central, and South tailings ponds. Excess material from soil washing must be relocated prior to final grading.
Borrow material	Underground stabilization requires borrow for cemented rock fill	Borrow material is required prior to backfilling stopes in the A2 and B4 open pit areas with cemented rock fill.
Water treatment plant and outfall systems	Water from High Test System could affect influent	Re-routing the water to the mine pool away from C Shaft prior to commissioning of water treatment plant.
Buildings and site infrastructure	Roaster area soil excavation will be conducted adjacent active site buildings including C-Dry	Access to site buildings may need to be replaced after highly contaminated soil is excavated from the Roaster Complex / C-Dry area.
Non-hazardous waste landfill	N/A	N/A

N/A = not applicable.

2 PROJECT ENVIRONMENT

The environmental conditions at the Site, including location and topography, drainage, groundwater, geology, geochemistry, and permafrost, are described in Section 2 of the CRP. Two brief updates related to the drainage and geology are provided below.

Investigations into underground void geometry and condition were conducted in winter 2018/2019 and are summarized in the Underground Design Basis (Appendix B1). Investigations consisted of inspections of travel ways and stopes using a combination of visual inspections, laser scanners (LiDAR), cavity monitoring surveys, and unmanned aerial vehicle surveys. These tools provided high resolution spatial data to assist in planning underground backfill placement approaches. Unmanned aerial vehicle and cavity monitoring system scans allowed collection of spatial data beyond line of site into open voids.

An additional relevant observation is that ice was identified at the A1 portal. Characterization of the area was completed. Work is underway as part of care and maintenance of the Site to eliminate this ice to allow access to the portal.

The Water Licence requires a summary of erosional site assessments. This is not relevant to this design plan as the main components are underground and the underground void stability assessments outlined below and in Appendix B1 are more relevant.

For other background information specific to this Project Component please refer to CRP Chapter 5.1 and Appendices B1 and B2 of this document.

3 DESIGN CONSIDERATIONS AS REQUIRED BY WATER LICENCE

3.1 Environmental Assessment Measures

The following environmental assessment measures inform the underground stabilization design:

- **Measure 5**—In order to mitigate significant adverse impacts that are otherwise likely, the Developer will commission an independent quantitative risk assessment to be completed before the Project receives regulatory approvals. This will include:
  - explicit acceptability thresholds, determined in consultation with potentially affected communities
  - an examination of risks from a holistic perspective, integrating the combined environmental, social, health and financial consequences
  - possible events of a worst-case / low frequency high consequence nature
  - additional considerations specified in Appendix O of the Report of EA [*Report of Environmental Assessment and Reasons for Decision*; MVEIRB 2013]

  From this, the Developer will identify any appropriate Project improvements and identify management responses to avoid or reduce the severity of predicted unacceptable risks.

The Quantitative Risk Assessment is discussed in Section 3.4.

3.2 Engagement Outcomes Since the Closure and Reclamation Plan

Engagement in relation to the underground mine workings is summarized in the CRP and the GMRP Engagement Log. Since the CRP was filed in 2019, engagement in relation to the underground mine workings consisted of the following:

- Discussions during the Water Licence proceedings during technical sessions and hearings
- Closure criteria in development engagement with the Giant Mine Working Group in October 2020
- Quantitative Risk Assessment workshops and meetings (April 2018 to April 2019)
- Brief discussions during the new Aquatic Advisory Committee meetings (September 2020)

The key outcomes of engagement that informed design comprised the following:

- **No trial minewater elevation raise**—The trial minewater elevation raise is removed from the CRP (Appendix 5.1B). During Technical Session 1 of the Water Licence proceedings, 9 to 12 July 2019, rights holders and stakeholders expressed concern about the risks of a possible reclamation research plan to investigate a raise of the existing minewater level. The Yellowknives Dene First Nation outlined that this was not an acceptable risk. In a 14 August 2019 letter to the MVLWB, CIRNAC on behalf of the GMRP requested removal of the trial minewater elevation raise from the CRP.

- **Changes to closure criteria**—During the Water Licence proceedings in the Closure Criteria Workshop in September 2019, discussions about the underground closure occurred and edits were made to the original criteria. These edits were provided to the MVLWB in October 2019 as part of Information Request 1 and were conditionally approved in the CRP with the issuance of the Water Licence. During the Closure Criteria Workshop, further concerns were raised by reviewers about closure criteria that were not yet finalized. The GMRP Team committed to engaging further on closure criteria in development prior to submission of the Underground Design Plan. On 9 October 2020, the GMRP Team provided information to the Giant Mine Working Group about the underground closure criteria in development from the CRP. On 23 October 2020, the GMRP Team engaged with the Giant Mine Working Group on the closure criteria in development for the underground, as well as the non-hazardous waste landfill. The GMRP Team proposed deleting two criteria in development (Appendix A, Table A-2) as redundant to other criteria, and reviewers did not disagree. Reviewers provided comments requesting additional clarity about thickness of underground stopes, and a commitment was made to provide thickness in the Underground Design Plan. Revisions to the closure criteria in development were made by the GMRP Team and are included in this design plan for approval (see Table 4-1 below and Table A-2 in Appendix A).
- **Quantitative risk assessment**—Extensive discussions about the stability of the underground post-closure occurred during the Quantitative Risk Assessment workshops. Key feedback included concerns over sinkhole formation on surface and the minewater level rising and causing flooding (see Section 3.4 for more detail).

Additionally, during the first Aquatic Advisory Committee meetings (17 September 2020) about Baker Creek, the Yellowknives Dene First Nation reinforced the importance of underground stability and flood protection. They commented that stabilization of the underground and protection of the underground arsenic chambers was paramount.

3.3 Traditional Knowledge

The consideration of Traditional and Community Knowledge has been integrated into project planning, wherever relevant and available. The CRP outlined how this knowledge influenced project decisions. The Engagement Plan, specifically Appendix C, summarizes the Traditional and Community Knowledge provided to date. The GMRP Team is committed to continuing to incorporate Traditional and Community Knowledge into the implementation of remediation and future versions of this plan, where information is available and appropriate. Since the CRP was filed, the GMRP did not receive Traditional and Community Knowledge specific to the underground design beyond the concepts already included into the Project. Instead, local and Traditional Knowledge holders reinforced the critical need for protection of the environment through stabilization of the underground.

3.4 Quantitative Risk Assessment Findings

A Quantitative Risk Assessment was conducted to meet Measure 5 of the *Report of Environmental Assessment and Reasons for Decision* (MVEIRB 2013). The Quantitative Risk Assessment was initiated in 2018 and included seven community engagement sessions. The assessment is focused on residual risks that might remain on the Site after the remediation is complete (residual risk). The Quantitative Risk Assessment identified several risk scenarios related to the underground that were of concern to people, either through Indigenous Way of Life or to general health, environment, socio-economic, or financial considerations. The Quantitative Risk Assessment viewed the network of underground openings generically as a single unit with a conglomerated risk of collapse.

The Quantitative Risk Assessment first screened risk scenarios such as crown pillar collapse using a qualitative screening method. Any scenario that was rated as “Moderate-High Hazard or higher” was then assessed using a quantitative approach. Risks were rated as unacceptable, as low as reasonably practicable (ALARP), or negligible. Full details may be found in the report of results (Wood 2020), which was provided to the MVLWB in May 2020.

Key finding related to the underground—The Quantitative Risk Assessment identified underground hazards associated with crown pillar collapse due to an instability underground and then a subsequent release of contaminated water to the environment. It was assessed that this would have risk to both human health (fatality) and socio-economics (financial impacts). Crown pillar failure due to non-backfilled stopes was the primary driver of risk identified by the Quantitative Risk Assessment, accounting for 94% of the assessed risk of future failure. The remaining 6% of the crown pillar collapse risk was determined to be due to movement of fill or to inadequate fill. The reason stopes were thought to remain “un-backfilled” was because of potential errors and omissions in mine plans whereby previously unidentified stopes exist that would not have been stabilized (backfilled). Simply put, it was thought there could be risks that a crown pillar could collapse in the event that the GMRP did not know about a stope and did not backfill it or a crown pillar could collapse because a stope should have been filled.

Both fatality and socio-economic risks related to crown pillar collapse were determined to be within the ALARP range. However, the Quantitative Risk Assessment recommended that the GMRP demonstrate that the risks have been mitigated to the extent practicable as outlined below.

Addressing Risks Identified by QRA—To address the risks identified in the Quantitative Risk Assessment, the GMRP Team conducted a mine records/field investigation and re-evaluated the risks (qualitatively and semi-quantitatively) in an engineering assessment of each stope, rather than the underground ‘as a whole’ as was done through the Quantitative Risk Assessment. The results of these are reported in Appendix B1 and summarized below.

Identifying if there are unknown backfilled stopes—The GMRP addressed the risk of potential errors or omissions in mine plans by completing a comprehensive assessment of the available historical mine survey records along with underground investigations of travel ways and connecting stopes and chambers. During the investigations, some stopes or underground travel ways that could pose a hazard were identified but could not be reached either by foot or with unmanned aerial vehicles due to safe access considerations. In these cases, exploratory drilling was completed along with borehole camera surveys and cavity monitoring surveys. These investigations showed that the potential for large, previously unidentified underground voids was minimal (see Appendix B1 for the results of these investigations and assessments).

Confirm which stopes to fill (Stope-specific risk assessments (qualitative)—The Quantitative Risk Assessment identified the risk of future crown pillar collapse as within the ALARP range based on mitigation activities of the CRP being completed. The CRP required stabilization of near surface non-arsenic stopes (defined as less than 35 m below ground surface), arsenic stopes and chambers crown pillars, and non-arsenic stopes under and adjacent to arsenic-containing voids and open pits, primarily through placing backfill. Increased amounts of backfill generally resulted in lower residual risks. The CRP outlined backfilling of near surface stopes to mitigate potential surface impacts based on a risk ranking to be completed during detailed design. To create this risk ranking, engineers completed a “stope-specific qualitative risk assessment” of each near surface stope and chamber, both arsenic and non-arsenic, as well as selected deeper non-arsenic stopes which underly critical site features such as freeze infrastructure, arsenic stopes and chambers, or Baker Creek.

The ‘stope specific quantitative risk assessment’ determined consequence and likelihood categories for each stope with risk categories of Low, Moderate, Moderate High, High and Very High (see Table 3-1 for risk to human health and Table 3-2 for financial risk). Previously backfilled stopes (e.g., those filled during the Site Stabilization Program) were generally not re-assessed, provided that the level of backfilling was consistent with the current backfilling approaches (Section 4.5.3). Note that previous backfilling programs done in the Site Stabilization Program targeted high risk stopes and chambers, and therefore no stope or chamber was identified as “high or very high risk” in the stope specific assessment. This includes arsenic stopes B208 and the B212/13/14 arsenic stope complex. Details on the assessment are found in Appendix B1.

The result of the ‘stope-specific qualitative risk assessment’ was that stopes which presented a Moderate or higher risk for either human health or financial risk were recommended for backfilling; this is noted as any stopes above the purple line in Tables 3-1 and 3-2. No stopes were recommended for backfilling on the basis of risk to human health (Table 3-1) and twenty-six stopes were recommended for backfilling on the basis of financial risk (Table 3-2). This will further reduce the risk at surface and mitigate risks to the extent practicable as outlined by the Quantitative Risk Assessment.

Table 3-1: Human Health Risk Assessment Results for Underground Stopes

Likelihood	Consequence Severity				
	Minor Ailment, No Treatment	**Treatable Illness or Injury**	**Permanent Illness or Injury Limits Some Activities**	**Permanent Illness or Injury Stops Daily Activities**	**People Die**
Very Likely	Moderate High	Moderate High	High	Very High	Very High
Likely	Moderate	Moderate High	High	High	Very High
Possible	Low	Moderate	Moderate High	Moderate High	High
Unlikely	Low	Low	Moderate	Moderate	Moderate High
Very Unlikely	Low: 2-71W, 2-68N, 3-69NE, 3-70S, 3-70, DWC-05, 2-02E, 2-01#3, 2-02W, 2-01NHW, 2-01NFW, 2-01 Storage, 2-06, 2-62, 3-60, 2-20S, 2-22N, 2-22S, 3-24N, 3-06N, 3-02, 1-18EA, 2-07, 1-29, 1-33, 1-27, 2-33, 1-34, 1-26S, 1-43 Upper, CH11, CH12, CH14, C212, CH09, CH10, B230, B233, B234, B235, B236	Low: 2-69W, 2-06, 1-31, DWC-06, 3-61, 1-31W, 2-35,	Low: 2-68S, 2-67W, 2-69, 2-15, 1-37, 1-37W, 1-38 Upper	Low: 2-69N, 3-01, 3-24S, 2-05, 1-38 Lower, 2-28, 1-35, 1-43 #1	Low: 3-69SW, 3-02, 3-58, 2-19, 2-20N, CH15, 2-18, 2-30, UBC, 1-26 #5, 1-26S Upper

Note: Stopes assessed above the purple line represent a moderate or higher risk (Table 18, Appendix B1) and were identified for further review. Also note there are no stopes that fall in the category of "high to very high"; C509 was a higher risk stope and it has been already filled during Site Stabilization.

Table 3-2: Financial Risk Assessment Results for Underground Stopes

Likelihood	Consequence Severity				
	Low < $100 K	**Minor $100 K - $1 M**	**Moderate $1 M - $10 M**	**Major $10 M - $30 M**	**High > $30 M**
Very Likely	Moderate High	Moderate High	High	Very High	Very High
Likely	Moderate	Moderate High	High	High	Very High
Possible	Low	**2-67W, 2-69, 2-69W, 3-02, 3-58, 2-06, 3-60, 3-61, 2-19, 2-20N, 2-20S, 2-22N, 2-22S*, 3-24N, 3-24S, 1-18EA, 2-06, 1-37, 1-37W, 1-38 Lower**	**2-15, 1-31, 1-33**	Moderate High	High
Unlikely	Low	2-69N, 2-02W, 2-01NHW, 2-05	**3-01, 1-26S Upper, 1-43 Upper**	**CH15**	Moderate High
Very Unlikely	3-02, CH11, CH12, CH14, C212, CH09, B230, B233, B234, B235, B236	2-71W, 2-02E, 2-01#3, 2-01NFW, 2-01 Storage, 3-21E, 2-28, 3-25, 3-06N, 1-29, 1-27, 2-37, 1-34, 1-35	2-68S, 2-68N, 3-69SW, 3-69NE, 3-70S, DWC-06, DWC-05, 3-12S, UBC, 2-07, 1-31W, 2-35, 2-33, 1-38 Upper, 1-26 #5, 1-26S, 1-43#1	2-18	Low

Note: Stopes assessed above the purple line represent a moderate or higher risk (Table 18, Appendix B1) and were identified for further review. Also note there are no stopes that fall in the category of "high to very high"; C509 was a higher risk stope and it has been already filled during Site Stabilization.

*Confirmed filled by borehole camera survey – does not require further backfilling.

Stope-specific assessments (semi-quantitative)—In addition to the 'stope-specific qualitative risk assessments', stope-specific semi-quantitative risk assessments were also conducted. These semi-quantitative risk assessments used the same categories of unacceptable, ALARP, and negligible used in the Quantitative Risk Assessment (Wood 2020). This semi-quantitative assessment utilized human exposure levels identified in the Quantitative Risk Assessment and likelihoods of crown pillar collapse as the primary drivers to calculate an annual probability of a given stope creating a sinkhole causing a fatality. Similar work was done for infrastructure to determine the likelihood of significant financial consequences from a crown pillar collapse. See Appendix B1 for further detail on this assessment.

The result of the stope-specific semi-quantitative risk assessment was that any stope which ranked within the ALARP range for human health or financial hazard was recommended for backfilling (Appendix B1, Table 18). No stopes were found to rate in the ALARP or unacceptable range for financial risk based on this assessment but, fifteen stopes (2-06, 1-31, 2-69, 2-15, 1-37, 1-37W, 3-01, 3-24S, 2-05, 1-38 Lower, 3-02, 3-58, 2-19, 2-20N and Chamber 15) plotted within the ALARP range for human health risk and were selected for backfilling. Note that, except for the 2-05 stope in the B1 Pit area, these stopes were previously selected for backfilling on the basis of a Moderate or higher qualitative financial risk.

Additional mitigation—Arsenic stopes and chambers, and stopes underlying critical surface infrastructure such as Baker Creek, tailings dams, pit covers, and public roadways, were also determined to require backfilling. This was not based on the various risk assessments but based on conservative engineering judgement and to support site-wide criterion SW3-1 in reducing perpetual care requirements with low probability of failure of engineering controls. Therefore, all ten arsenic stopes and chambers which currently contain arsenic trioxide and are not currently frozen or previously backfilled were selected for backfilling. These stopes and chambers are: Chamber 11, Chamber 12, Chamber 14, C212, Chamber 9, B230, B233, B234, B235 and B236. Chamber 15 as well as DWC-05, 2-07, DWC-06, 1-38 Upper, 2-28, 1-35, 1-43#1, 2-18, UBC, 1-26#5, 1-26S, 3-12S, 3-06N, 2-05 were selected for backfilling on the basis of overlying infrastructure for fifteen additional stopes. Stope specific reasoning is provided in Table 18 of Attachment B1.

Summary—In summary, the stope-by-stope assessments building on the Quantitative Risk Assessment resulted in a series of "decisions" that inform design and are used to select stopes for backfilling:

- Stopes which rank Moderate or higher risk on the 'stope-specific qualitative risk assessment' will be filled (Table 3-1 and Table 3-2).
- Stopes which have a risk ranking of ALARP or higher on the 'stope-specific semi-quantitative risk assessment' will be filled.
- All arsenic stopes and chambers will be filled (except Chamber 10 which is already frozen through the Freeze Optimization Study and chambers B208, B212/13/14 which were previously backfilled)
- Stopes which were identified based on engineering judgement considering project risk tolerance to protect overlying features such as pit covers, arsenic stopes and chambers or freeze infrastructure and dams or to provide support to existing underground fill will be filled.

On the basis of all these combined three assessments, 52 stopes and chambers were selected for backfilling. The full results are provided in Table 18 of the Underground Design Basis (Appendix B1) and a summary of stopes selected for backfilling is provided in Table 4-2 in Section 4.4.2 and Figures 1, 2 and 3. Figure 1 shows surface projections of stopes included in the risk assessment and they are colour coded based on the backfilling decision. Non-arsenic stopes are differentiated from arsenic stopes and chambers. Figure 2 presents the surface projections of the stopes and chambers as well as outlines of all known underground development, similar to Plate 1-1. Finally, Figure 3 presents surface projections of only the stopes and chambers identified for backfilling. With the Quantitative Risk Assessment and the stope-by-stope risk assessments, the Underground Design plans resulted in conservative backfilling decisions that reduce risk.

Public Services and Procurement Canada / Services publics et Approvisionnement Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

GOLDER

LEGEND

- ARSENIC CHAMBER OR STOPE - FILLED
- ARSENIC CHAMBER OR STOPE - NOT FILLED
- ARSENIC CHAMBER OR STOPE - TO BE FILLED
- NON-ARSENIC CHAMBER OR STOPE - FILLED
- NON-ARSENIC CHAMBER OR STOPE - NOT FILLED
- NON-ARSENIC CHAMBER OR STOPE - TO BE FILLED
- UNDERGROUND OPENINGS TO SURFACE (TO BE CAPPED)
- UNDERGROUND OPENINGS TO SURFACE (TO BE BACKFILLED)

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED. COORDINATE SYSTEM IS THE GMRP COORDINATE SYSTEM.
2. THE UNDERGROUND MINE GEOMETRY INFORMATION SHOWN CONTAINS ERRORS AND OMISSIONS WHICH NEED TO BE CONSIDERED WHEN USING IT FOR DESIGN PURPOSES.
3. ACCESS ROUTE GROUND SUPPORT TO BE CONFIRMED BY PROPONENT.

REFERENCES

1. 2018 AERIAL PHOTO IMAGE PROVIDED BY AECOM, FLOWN: SEPTEMBER 24, 2018.
2. COMPOSITE LEVEL PLANS AND MINE LAYOUT PROVIDED BY "PSPC".

SCALE 0 40 80 120 METRES

DO NOT SCALE DRAWINGS

Revision/Revision	Description/Description	Date/Date
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0	ISSUED AS FINAL	2021-02-03

Client/client
PUBLIC SERVICES AND PROCUREMENT CANADA

Project title/Titre du projet
GIANT MINE REMEDIATION PROJECT YELLOWKNIFE, N.W.T.

UNDERGROUND STABILIZATION

Approved by/Approuve par

Designed by/Concept par
RYAN PRESTON

Drawn by/Dessine par
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DAVE COLBOURNE

PWGSC, Architectural and Engineering Resources Manager/Ressources Architectural et de Directeur d'Ingénierie, TPSGC

Client/client
PSPC

Drawing title/Titre du dessin
GENERAL SITE PLAN OF ALL STOPES AND CHAMBERS TO BE BACKFILLED

Project No./No. du projet	Sheet/Feuille	Revision no./La Révision no.
13-1426-0010 47000	1 (1 OF 3)	0

01-47-0875

Public Services and Procurement Canada / Services publics et Approvisionnement Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

GOLDER

LEGEND

- ARSENIC CHAMBER OR STOPE - FILLED
- ARSENIC CHAMBER OR STOPE - FROZEN
- ARSENIC CHAMBER OR STOPE - TO BE FILLED
- NON-ARSENIC CHAMBER OR STOPE - FILLED
- NON-ARSENIC CHAMBER OR STOPE - NOT TO BE FILLED
- NON-ARSENIC CHAMBER OR STOPE - TO BE FILLED
- UNDERGROUND OPENINGS TO SURFACE (TO BE CAPPED)
- UNDERGROUND OPENINGS TO SURFACE (TO BE BACKFILLED)
- UNDERGROUND (UG) RAMPS, DECLINES AND INCLINES
- INTERMEDIATE DEVELOPMENT BETWEEN LEVELS
- 100 L (1st LEVEL): C-SHAFT UG DEVELOPMENT; 200 L (1st LEVEL): A-SHAFT UG DEVELOPMENT
- 250 L (2nd LEVEL): C-SHAFT UG DEVELOPMENT; 325 L (2nd LEVEL): A-SHAFT UG DEVELOPMENT
- 425 L (3rd LEVEL): C-SHAFT UG DEVELOPMENT; 450 L (3rd LEVEL): A-SHAFT UG DEVELOPMENT
- 575 L (4th LEVEL): C-SHAFT UG DEVELOPMENT; 590 L (4th LEVEL): A-SHAFT UG DEVELOPMENT
- 750 L (5th LEVEL): C-SHAFT UG DEVELOPMENT; 750 L (5th LEVEL): A-SHAFT UG DEVELOPMENT
- UG DEVELOPMENT BELOW 750 L (5TH LEVEL)

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED. COORDINATE SYSTEM IS THE GMRP COORDINATE SYSTEM.
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3. ACCESS ROUTE GROUND SUPPORT TO BE CONFIRMED BY PROPONENT.

REFERENCES

1. 2018 AERIAL PHOTO IMAGE PROVIDED BY AECOM, FLOWN: SEPTEMBER 24, 2018.
2. COMPOSITE LEVEL PLANS AND MINE LAYOUT PROVIDED BY "PSPC".

SCALE 0 40 80 120 METRES

DO NOT SCALE DRAWINGS

Revision/Revision	Description/Description	Date/Date
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0	ISSUED AS FINAL	2021-02-03

Client/client
PUBLIC SERVICES AND PROCUREMENT CANADA

Project title/Titre du projet
GIANT MINE REMEDIATION PROJECT YELLOWKNIFE, N.W.T.

UNDERGROUND STABILIZATION

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DAVE COLBOURNE

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Client/client
PSPC

Drawing title/Titre du dessin
GENERAL SITE PLAN OF ALL UNDERGROUND GEOMETRY

Project No./No. du projet	Sheet/Feuille	Revision no./La Révision no.
13-1426-0010 47000	2 (2 OF 3)	0

01-47-1006

Public Services and Procurement Canada / Services publics et Approvisionnement Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

GOLDER

LEGEND

- ARSENIC CHAMBER OR STOPE - TO BE FILLED
- NON-ARSENIC CHAMBER OR STOPE - TO BE FILLED
- UNDERGROUND OPENINGS TO SURFACE (TO BE CAPPED)
- UNDERGROUND OPENINGS TO SURFACE (TO BE BACKFILLED)

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED. COORDINATE SYSTEM IS THE GMRP COORDINATE SYSTEM.
2. THE UNDERGROUND MINE GEOMETRY INFORMATION SHOWN CONTAINS ERRORS AND OMISSIONS WHICH NEED TO BE CONSIDERED WHEN USING IT FOR DESIGN PURPOSES.
3. ACCESS ROUTE GROUND SUPPORT TO BE CONFIRMED BY PROPONENT.

REFERENCES

1. 2018 AERIAL PHOTO IMAGE PROVIDED BY AECOM, FLOWN: SEPTEMBER 24, 2018.
2. COMPOSITE LEVEL PLANS AND MINE LAYOUT PROVIDED BY "PSPC".

0 40 80 120
SCALE METRES

DO NOT SCALE DRAWINGS

Revision/Revision	Description/Description	Date/Date
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0	ISSUED AS FINAL	2021-02-03

Client/client
PUBLIC SERVICES AND PROCUREMENT CANADA

Project title/Titre du projet
GIANT MINE REMEDIATION PROJECT YELLOWKNIFE, N.W.T.

UNDERGROUND STABILIZATION

Approved by/Approuve par

Designed by/Concept par
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Client/client
PSPC

Drawing title/Titre du dessin
GENERAL SITE PLAN OF STOPE BACKFILLING

Project No./No. du projet	Sheet/Feuille	Revision no./La Révision no.
13-1426-0010 47000	3 (3 OF 3)	0

01-47-1007

4 DESIGN

4.1 Closure Objectives, Activities, and Criteria

The final closure objectives, activities, and criteria for the Underground Design Plan are listed in Table 4-1. As noted in Section 3, this table is updated from the version in Section 5.1 of the approved CRP. No changes to the closure objectives were made. Criteria that are final and approved in the CRP are unchanged and the "criteria in development" were consolidated and finalized. These changes were discussed during engagement with the Giant Mine Working Group in Fall 2020. Appendix A, Table A-2 is a concordance table of the CRP criteria against the final criteria in this design plan.

The criteria in development from the CRP were finalized through engineering design. This includes the following specific changes:

UG2-2 – minewater drawdown rate: this criterion in development was removed based on the decision to maintain the mine water level at the range defined in UG2-1 and changes to the finalized UG4-4 criteria.

UG3-3 – stabilizing backfill stays in place: this criterion in development was removed as UG3-4 now addresses the intent of maintaining rock mass stability for arsenic containment.

UG3-4 – potentially unstable crown pillar voids are backfilled – this criterion in development was revised to limit failure depth of crown and rib pillars adjacent to arsenic stopes and chambers to 1.5 m to protect arsenic bulkheads, freeze pads and thermosyphons.

UG4-4 – stabilizing backfill stays in place – this criterion in development was revised to require maintenance of a minimum 5 m thick crown pillar which meets the original intent of stabilizing backfill staying in place (to provide support to the crown pillar) while making the goal quantitative.

UG4-5 – Voids under potentially unstable crown pillars will be filled to limit surface subsidence to a maximum of 1m. This criterion in development was removed as it is now accounted for by UG4-6.

UG4-6 – Voids under pits will be filled to limit surface subsidence to a maximum of 1 m – this criterion in development was revised to include the DWC stope as it is the only known stope with a crown pillar thickness less than 5 m and therefore not addressed by UG4-4. As a result of the elimination of UG4-5 the criterion previously known as UG4-6 has also been renumbered to UG4-5.

Three key closure activities in this design plan have closure objectives and criteria directly associated with them. A brief description of the key activities is outlined below:

- **Backfilling underground voids including non-arsenic stopes, arsenic stopes and chambers, Chamber 15, and arsenic bulkheads with flowable cement backfill**—The flowable cemented backfill will consist of a fine-grained aggregate, either Giant Mine tailings or the arsenic-impacted residual material from soil washing, cement binder, and water. This cemented backfill will be delivered to the underground voids via boreholes and to the boreholes via either cement truck or purpose-built pipelines from a batch plant or a mobile batch plant at each borehole. Batch plants will consist of hopper and a mechanical mixing apparatus to blend the aggregate, binder, and water prior to delivery to the void.

- **Backfilling or otherwise closing underground openings to surface**—Twenty-four openings to surface, including stope breakthroughs, portals, and raises, have been identified for closure. They will be capped with concrete or backfilled to prevent access and provide long-term stability. In addition to large openings to surface, historical boreholes which connect to the underground will be backfilled with cementitious grout to prevent flow of surface water to the underground. Historical and remediation project boreholes will be closed.
- **Excavating a new, long-term underground access portal**—A long-term access portal is needed for future users to access the arsenic stopes and chambers, if necessary. The portal will be advanced using conventional drill and blast methods with the blasted rock used as borrow in other areas of the Site or for making cemented rock fill, provided it is geochemically acceptable (i.e., low arsenic and acid generation potential). The portal will be located on the western edge above B2 Pit and ramp down to connect with the existing UBC ramp to provide underground access.

Table 4-1: Underground Mine Workings Closure Objectives, Activities, and Criteria

Closure Objectives	Closure Activity	Final Number	Closure Criteria	Monitoring/Maintenance and Inspection	
				Approach	Reporting to MVLWB
UG1. Access to underground workings from surface openings is restricted for the safety of humans and wildlife	■ Seal existing vertical openings to surface with either a cast-in--place engineered concrete cap, or a pre-cast cap placed over the opening. ■ Seal existing horizontal openings to surface using waste rock, concrete, polyurethane foam, or combinations thereof. ■ Close existing openings to surface present within the open pits in a manner that supports pit closure criteria (see Section 5.3). ■ New long-term underground mine access (see UG-3) portal is secured with a locked gate until underground access is confirmed to not be required, then it will be sealed.	**UG1-1**	■ All existing openings to surface that are connected to the underground are secured in a manner that meets the NWT Mine Health and Safety Act.	■ Security for the existing openings to the underground will be designed to meet the NWT Mine Health Safety Act. A satisfactory final inspection by Mines Inspector will be used to confirm the regulation was met once constructed.	■ Results from the final inspection report from the Mines Inspector included in Annual Water Licence Report
		UG1-2	■ Design engineering drawings are signed and stamped by a Qualified Professional and the specifications outlined therein are met, such that access to the underground is restricted.	■ Designs provided to the MVLWB prior to commencement of construction, including stamped design drawings. Supervising engineer provides construction oversight, QA/QC approval as outlined in a construction plan. ■ Final as-built reporting prepared and stamped, documenting that approved design has been constructed in accordance with design intent.	■ Design Plan ■ Construction Plan ■ As-built report provided in the Reclamation Completion Report ■ Final Closure and Reclamation Completion Report
		UG1-3	■ There is no unauthorized access to the underground via the new portal. ■ (Refer to Surface Infrastructure 32 regarding post-closure access)	■ Periodic security inspections confirm wildlife and humans are not accessing the portal (refer to Objective SI3-2).	■ Performance Assessment Report (submitted periodically – nominally on a 5-year interval)
UG2. Minewater elevation will be managed to maintain mine physical stability and chemical stability	■ Construct the new deep well station in the C Shaft area to pump water from the mine pool to the new WTP (refer to Objective WTP2) ■ Maintain the minewater elevation such that it forms a groundwater sink for chemical stability of the underground and surrounding area (see Water Management and Monitoring Plan for details on pumping and elevation)	**UG2-1**	■ Maintain minewater level at or below approximately the 750L which is equivalent to - 77 m amsl[(b)] above mean sea level (amsl) ± seasonal fluctuation (refer to Water Management and Monitoring Plan)	■ Minewater elevation will monitored with pressure sensors in the underground. This will be reported through the Annual Water Licence Report.	■ Annual Water Licence Report ■ Performance Assessment Report (submitted periodically – nominally on a 5-year interval)
UG3. Structures, controls, and adaptive management approaches used for the remediation of the arsenic trioxide meet appropriate design levels required for long-term care	■ Plug underground openings connected to arsenic stopes and chambers and backfill all voids on top of arsenic stopes and chambers to provide thermal continuity to the frozen shell. ■ Backfill voids on top of arsenic stopes and chambers and near-surface non-arsenic stopes and boundary pillars as necessary ■ Establish new long-term underground mine access location within the Core Industrial Area.	**UG3-1**	■ Meets the NWT *Mine Health and Safety Act* for plugging underground openings and backfilling voids and the establishment of the new long-term underground mine access	■ Satisfactory final inspections are performed by a Qualified Professional and by the Mines Inspector. Because the underground will be remediated in stages and accordingly, some areas of the mine may no longer be accessible, it is assumed multiple inspections by the Mines Inspector will be required.	■ Results from the final inspection report from the Mines Inspector included in Annual Water Licence Report
		UG3-2	■ Design engineering drawings are signed and stamped by a Qualified Professional and the specifications outlined therein are met, so that the voids and backfill provide stabilization	■ Designs provided to the MVLWB prior to commencement of construction, including stamped design drawings. Supervising engineer provides construction oversight, QA/QC approval as outlined in a construction plan. ■ Final As-built reporting prepared and stamped, documenting that approved design has been constructed in accordance with design intent.	■ Design Plan ■ Construction Plan ■ As-built report provided in the Reclamation Completion Report ■ Final Closure and Reclamation Completion Report
		UG3-3[(a)]	■ No more than 1.5 m of the rock in the crown pillar of an arsenic stope or chamber, or in the top of an adjacent non-arsenic stope separated by a boundary pillar, can fall into void spaces, such that subsidence does not damage critical infrastructure(c)	■ Monitoring of crown pillar movement using extensometers into the crown pillar of arsenic stopes and chambers and into the boundary pillar between arsenic and non-arsenic stopes. ■ Ongoing monitoring for first 5 years of digital instruments and bi-annual for manual monitoring. Reduced to periodically every 5 years until the arsenic chambers and stopes are frozen after which excessive settlement of the stope fill should not occur and monitoring will cease.	■ Design plan ■ Annual Water Licence Report ■ Performance Assessment Report (submitted periodically – nominally on a 5-year interval)

Table 4-1: Underground Mine Workings Closure Objectives, Activities, and Criteria

Closure Objectives	Closure Activity	Final Number	Closure Criteria	Monitoring/Maintenance and Inspection	
				Approach	Reporting to MVLWB
UG4. Underground is stabilized (geotechnically and physically) to reduce risks for public, workers, and wildlife safety	■ Stabilize voids under surface crown pillars and under pits with paste tailings or other suitable materials as required based on stability assessments. ■ Backfill drifts connected to arsenic stopes and chambers to protect bulkheads in the event of unexpected mine flood or thawing of arsenic in chambers.	**UG4-1**	■ Design engineering drawings for underground backfill are signed and stamped by a Qualified Professional and the specifications outlined therein are met	■ Designs provided to the MVLWB prior to commencement of construction, including stamped design drawings. Supervising engineer provides construction oversight, QA/QC approval as outlined in a construction plan. ■ Final as-built reporting prepared and stamped, documenting that approved design has been constructed in accordance with design intent.	■ Design Plan ■ Construction Plan ■ As-built report provided in the Reclamation Completion Report ■ Final Closure and Reclamation Completion Report
		UG4-2	■ Drifts connected to arsenic stopes will be filled to the extent of the frozen shell (see F1-2 related to definition of shell)	■ Design specification outlines full extent of drifts connected to arsenic stopes within the frozen shell. A satisfactory final inspection by a Qualified Professional confirms this was met.	■ Design Plan ■ As-built report provided in the Reclamation Completion Report ■ Final inspection copy included in Annual Water Licence Report and Reclamation Completion Report
		UG4-3	■ Paste backfill meets minimum 100 kPa specification to prevent liquefaction during seismic event	■ Design specification outlines minimum 100 kPa and a satisfactory final inspection by a Qualified Professional confirms this was met as well as satisfactory inspection by Mines Inspector	■ Design Plan ■ As-built report provided in the Reclamation Completion Report ■ Final inspection copy included in Annual Water Licence Report and Reclamation Completion Report
		UG4-4[(a)]	■ A minimum crown pillar rock thickness of 5 m (thickness of intact bedrock below overburden and above void) will be maintained where initial crown pillar thickness permits (Refer to criterion UG4-5 for the criterion applicable when the existing crown pillar thickness is less than 5 m.)	■ Stabilize voids under surface crown pillars and under pits with paste tailings or other suitable materials as required based on stability assessments. ■ Backfill drifts connected to arsenic stopes and chambers to protect bulkheads in the event of unexpected mine flood or thawing of arsenic in chambers.	■ Design Plan ■ Annual Water Licence Report ■ Performance Assessment Report (submitted periodically – nominally on a 5-year interval)
		UG4-5[(a)]	■ Voids under pits and Stope DWC will be filled so that no more than 1 m subsidence would occur at ground surface.	■ Stabilize voids under surface crown pillars and under pits with paste tailings or other suitable materials as required based on stability assessments. ■ Backfill drifts connected to arsenic stopes and chambers to protect bulkheads in the event of unexpected mine flood or thawing of arsenic in chambers. ■ Stabilize with cemented paste backfill the bottom of backfilled stopes under critical areas such as arsenic stopes and chambers or pits. This stabilization is to prevent negative impacts of minewater fluctuation on the stope backfill placed at the top of the stope.	■ Design Plan ■ Annual Water Licence Report ■ Performance Assessment Report (submitted periodically – nominally on a 5-year interval)

(a) A criterion in development from the CRP that is now final for approval through the Underground Design Plan.

(b) Number has been rounded to the nearest metre.

(c) Critical Infrastructure is defined as the freeze pads, thermosyphons, and arsenic bulkheads.

NWT = Northwest Territories; MVLWB = Mackenzie Valley Land and Water Board; WTP = water treatment plant; L = level; QA/QC = quality assurance and quality control; kPa = kilopascal.

4.2 Changes from the Closure and Reclamation Plan

No deviations from the CRP were necessary in the final design.

4.3 Design Basis

The following section outlines items that form the basis of the engineering design.

4.3.1 Site-Wide Closure Criteria

The Underground Design Plan will support site-wide objective SW3 "Remaining operational engineered structures/controls meet appropriate design levels required for long-term care" and specifically site-wide criterion SW3-2 "Minimize perpetual care requirements…"

This is largely achieved by using materials that are resistant to weathering, implementing designs that support existing rock mass:

- **Lower in maintenance**—This is achieved by preferentially using construction materials that are resistant to weathering for backfilling and closure of openings to surface. Closure of surface openings to underground will also reduce the load on the minewater pool, which reduces load on the WTP.
- **Lower long-term costs**—This is achieved by "over-designing" backfill heights to minimize risk of failure and maintain crown pillar thickness, as well as using a conservative selection process for selecting stopes to backfill (Section 3.4).
- **Remaining operational controls**—Backfill does not require operation, and therefore operational controls consist of monitoring as detailed in Section 5.
- **Low probability of failure of engineering controls**—The primary engineering control for the underground is the placement of backfill. The backfill itself has been designed to be long lasting without maintenance requirements and, additional backfill has been designed to provide support to existing backfill to keep it in place and support crown pillars and/or pit fill (i.e., Stope 2-28 in the C1 Pit area [Section 4.4.2]).
- **Demonstrated design redundancy**—Stope hazard assessments were conducted based on the ratio of crown pillar thickness to open void height to project the potential depth of sinkhole on surface in the event of crown pillar failure. Based on the closure criterion UG3-3, up to 1.5 m of crown pillar loss is allowed for in arsenic stopes, and UG4-4 states that non-arsenic stopes need only maintain a 5 m crown pillar. However, potential failure depth has been reduced further than required by the criteria through designing stope backfill heights to be as tight to the crown as practicable. Therefore, it is expected that backfilled stopes will maintain crown pillar thicknesses of greater than 5 m through backfilling. Stope backfill heights are summarized in the drawings in Appendix C.

4.3.2 Soil Excavation

Soil excavation has been designed based on the following:

- Soil with an arsenic concentration of greater than 4,500 mg/kg within the former roaster area will be excavated and placed within freeze zones.
- Post-excavation grading must maintain existing surface water drainage, trafficability, and building access.

4.3.3 Underground Stabilization

The design basis and technical requirements for the underground design to meet closure objectives UG3-3, 4-4, and 4-5 are as follows:

- Backfilling with weathering resistant materials will provide long-term support through confinement of the adjacent rock mass that is resistant to degradation over time and is designed to be maintenance free.
- Backfilling will be designed and placed to provide support as necessary to existing mine fill and prevent mobilization during minewater level changes.
- Backfill elevations have been designed to prevent impact to adjacent voids, freeze infrastructure, Baker Creek, and surface.
- Stopes which rated Moderate or higher in the stope-specific qualitative risk assessment will be backfilled.
- Stopes which rated ALARP or higher in the stope-specific semi-quantitative risk assessment will be backfilled.
- All arsenic stopes and chambers will be filled. (except Chamber 10 which is already frozen through the Freeze Optimization Study)

Stopes which were identified on the basis of engineering judgement considering project risk tolerance to protect overlying features such as pit covers, arsenic stopes and chambers or freeze infrastructure and dams or to provide support to existing underground fill will be filled (Section 3.4).

4.3.3.1 Stabilizing Arsenic Bulkheads

The design for stabilizing arsenic bulkheads meets closure criterion UG4-2 and supports UG3-3:

- Raises and sub-vertical development located below arsenic bulkheads must be filled as tight to the back as possible and over a sufficient lateral distance to prevent the fill from shearing under its own weight (a minimum of 5 m in front of the bulkhead), generally down into the nearest drift and to the full height of the drift.
- Raises and sub-vertical development located above arsenic bulkheads must be filled as tight as possible over 5 m with foam backfill to provide lateral support to the rock mass without applying significant increased load to the bulkheads.

4.3.4 Closure of Openings to Surface

The design for closure of openings to surface meets closure criterion UG1-1 to secure existing openings to surface that are connected to the underground. The design basis and technical requirements are summarized below.

Openings to surface will be secured through a combination of backfilling and surface caps. Their design will conform to the following constraints:

- Minimum design life is at least 100 years.
- Caps do not have to be covered unless covers are determined to improve the design life of the closure method or required for final grading purposes.
- Design meets the requirement of the NWT *Mine Health and Safety Act* that openings to surface from an underground mine must be capped or securely filled with material so that subsidence of the material will not pose a future hazard.

To achieve UG1-1, the closure of openings to surface will be based on the following:

- Backfilling with natural materials will provide long-term, maintenance-free support through confinement of the adjacent rock mass that is resistant to degradation over time.
- Backfill will be designed to resist weathering.
- Surface caps and closures will be designed to prevent access by people and wildlife.
- Surface caps will be constructed out of material with a long life.

4.3.5 Borehole Plugging

The design of borehole closure is intended to support closure criterion UG2-1, and accessible boreholes which are known or shown to intersect the underground will be plugged on the following basis:

- Boreholes will be plugged with a sufficient length of cementitious backfill to prevent communication from surface to underground.
- Remaining surface casing will not cause an impact to future surface works.

4.3.6 Long-Term Access Portal

The design of the long-term access portal meets closure criterion UG1-3 for no unauthorized access and F2-2 for potential future access to frozen areas for the purposes of arsenic remediation.

- The portal location must be above the probable maximum flood elevation of 167 m amsl.
- The tie-in location must provide access to key underground areas including arsenic stopes and adjacent non-arsenic stopes such as Stope Complex C509.
- The portal must be of sufficient dimensions to allow vehicular access.
- Balance construction considerations with budget and safety.
- Located in a convenient area to avoid interference with other activities.

4.3.7 High Test System

The design is based upon:

- Once personnel are no longer present in the underground to carry out maintenance of the High Test System, damage to the infrastructure present on the 750L during mine water level fluctuations could result in the highly arsenic-impacted water reporting to the C Shaft area.
- Need to anchor sections of the High Test System on the 750L track drive in the event of minewater fluctuation prior to the freeze that could damage infrastructure.
- Re-route sections such that the three main branches of the High Test System report to the northern end of the mine in two locations rather that the current one location. This will route water away from the C Shaft area in the middle of the mine such that there is not an immediate high arsenic load reporting to the WTP.

4.4 Design Overview

4.4.1 Excavation of Heavily Arsenic-Impacted Material

Excavation of contaminated soils is an intermediate step in the process of placing backfill material underground. The top layer of soil covering the approximately 10 ha area will be excavated and remediated using a method known as “soil washing” as shown in the drawings in Appendix D. Following remediation, the majority of the excavated soil will have an arsenic concentration of less than 4,500 mg/kg and will be disposed of within a TCA or open pit. The remaining material will consist of concentrated arsenic trioxide bound to fine-grained soil particles and will be used for backfilling of Chamber 15 and then frozen.

4.4.2 Stabilization of Underground Voids with Cemented Backfill

Near-surface non-arsenic stopes or other voids that have the potential to impact surface or arsenic stopes and chambers in the event of instability have been identified for backfilling based on the risk assessment process discussed in Section 3.4 and Appendix B1. In addition, arsenic stopes and chambers that have not been previously backfilled with arsenic trioxide dust will be backfilled to reduce the risk of small-scale rock mass failure causing damage to their surrounding thermosyphons. Existing bulkheads that contain the arsenic trioxide dust will be supported on the clean side with backfill to provide long-term stability. These areas will be filled with flowable cement backfill or cemented rockfill to set elevations (drawings in Appendix C) as determined by the risk assessments such that any subsequent failure of the surrounding rock mass will not result in an impact to surface or adjacent freeze infrastructure. Where required, adjacent stopes and underground development will also be backfilled to provide support to existing mine backfill which otherwise may vacate the void because of long-term minewater level fluctuations. The distribution of backfill will be controlled through placement of fill fences, barricades, and remote barricades constructed from thick flowable backfill or polyurethane fill.

Table 4-2 summarizes the stopes planned for backfilling based on Appendix B1, their associated closure criteria, which informs the monitoring plan detailed in Section 5, and the surface features above each stope/chamber. Figures 1 to 3 present surface projections of the stopes identified in Table 4-2 along with associated underground development and openings to surface outside of open pit footprints.

Table 4-2: Stopes Planned for Backfilling

Stope Name/Complex	Area	Backfill Type	Overlying Feature(s)	Closure Criteria
2-69	A1 Pit	Paste backfill	A1 Pit Cover	UG4-5
2-69W		Paste backfill	A1 Pit Cover	UG4-5
2-67W		Paste backfill	A1 Pit Cover	UG4-5
DWC-05	A2 Pit	Paste backfill	Adjacent to Main Road	UG4-5
DWC-06		Paste backfill	Adjacent to Main Road	UG4-5
3-01		Paste backfill	Baker Creek Re-alignment	UG4-4
3-02		Paste backfill	A2 Pit Cover	UG4-5
3-58		Paste backfill	A2 Pit Cover	UG4-5
3-61		Paste backfill	A2 Pit Cover	UG4-5
2-06		Paste backfill	A2 Pit Cover	UG4-5
3-60		Paste backfill	A2 Pit Cover	UG4-5

Table 4-2: Stopes Planned for Backfilling

Stope Name/Complex	Area	Backfill Type	Overlying Feature(s)	Closure Criteria
B3-06	B1 Pit	Paste backfill	Arsenic Stope and Freeze	UG4-4
3-02		Paste backfill	Arsenic Stope and Freeze	UG4-4
2-05		Paste backfill	B1 Pit Cover/Freeze	UG4-5
2-06		Paste backfill	B1 Pit Cover/Freeze	UG4-5
2-07		Paste backfill	B1 Pit Cover/Freeze	UG4-5
2-15		Paste backfill	B1 Pit Cover/Freeze	UG4-5
1-18EA		Paste backfill	B1 Pit Cover	UG4-5
UBC	B2 Pit	Paste backfill	Adjacent to Ingraham Trail	UG4-4
1-31	B3 Pit	Paste backfill	B3 Pit Cover	UG4-5
1-33		Paste backfill	Adjacent to Dam 1 and B3 Vent Raise	UG4-4
1-26 (1-26#5, 1-26S, 1-26S Upper)	B4 Pit	Cemented rock fill	Dam 21	UG4-4
1-35		Cemented rock fill	Ingraham Trail	UG4-4
1-37 (1-37/1-37W)		Cemented rock fill	Adjacent to Ingraham Trail	UG4-4
1-38 (Upper/Lower)		Cemented rock fill	Mine Access Road	UG4-4
1-43 (Upper/#1)		Cemented rock fill	Northwest Pond	UG4-4
2-18	C1 Pit	Paste backfill	Baker Creek (Reach 4)	UG4-4
2-19		Paste backfill	C1 Pit Cover	UG4-5
2-20 (N/S)		Paste backfill	C1 Pit Cover	UG4-5
2-22		Paste backfill	C1 Pit Cover	UG4-5
2-28		Paste backfill	C1 Pit Cover	UG4-5
3-24 (N/S)		Paste backfill	C1 Pit Cover	UG4-5
3-11		Paste backfill	C1 Pit Cover	UG4-5
3-12		Paste backfill	C1 Pit Cover	UG4-5
CH11	AR1	Paste backfill	Freeze Infrastructure	UG3-3
CH12		Paste backfill	Freeze Infrastructure	UG3-3
CH14		Paste backfill	Freeze Infrastructure	UG3-3
CH15		Lightly cemented contaminated backfill	Freeze Infrastructure	UG3-3
CH9	AR2	Paste backfill	Freeze Infrastructure	UG3-3
C212		Paste backfill	Freeze Infrastructure	UG3-3
B230	AR3	Paste backfill	Freeze Infrastructure	UG3-3
B233		Paste backfill	Freeze Infrastructure	UG3-3
B234		Paste backfill	Freeze Infrastructure	UG3-3
B235		Paste backfill	Freeze Infrastructure	UG3-3
B236		Paste backfill	Freeze Infrastructure	UG3-3

4.4.3 Closure of Openings to Surface

Openings to surface will be secured through surface caps and backfilling. For openings that will be capped, concrete caps will be used. The caps are designed as monolithic concrete slabs (i.e., formed from a single piece) that cover the extent of the existing opening and any potentially unstable ground. For openings that will be backfilled, backfilling will be done with a combination of cemented and uncemented fill. Cemented backfill will be used to close openings with a connection to the underground workings, where uncemented backfill alone would not be enough to secure the opening to surface if existing material obstructing access to lower levels were to fail. Uncemented backfill will be used to prevent inadvertent access to lateral openings to surface (e.g., adits and portals). Drawings presenting the cap designs for the openings listed in Table 4-3 are included in Appendix E and the locations of the openings relative to surface topography and underground workings are shown in Figures 1-3.

Table 4-3: Openings to Surface and Closure Methods

Name	Type	Closure Method
A2 Shaft	Shaft	Concrete cap
C Shaft	Shaft	Concrete cap
230 Arsenic Raise	Raise	Concrete cap
233 Distribution Raise	Raise	Concrete cap
234 Distribution Raise	Raise	Concrete cap
B Vent Shaft	Shaft	Concrete cap
DWC Vent Raise	Raise	Concrete cap
#1 Fill Raise	Raise	Concrete cap
B3 1-131 Raise	Raise	Concrete cap
B3 Fill Raise	Raise	Concrete cap
B3 Service Raise	Raise	Concrete cap
B4 Main Service Raise	Raise	Concrete cap
B4 Main Fill Raise	Raise	Concrete cap
Northwest Vent Raise	Raise	Concrete cap
C Ore Pass	Raise	Cemented backfill
212 Arsenic Raise	Raise	Cemented backfill
#2 Fill Raise	Raise	Cemented backfill
#3 Fill Raise	Raise	Cemented backfill
GKP Vent Raise	Raise	Cemented backfill
C Fill Raise	Raise	Cemented backfill
Brock Adit	Portal	Uncemented backfill
B3 1-31 Portal	Portal	Uncemented backfill
GKP Portal	Portal	Uncemented backfill

Note: Stope DWC is not included here as closure is to be undertaken as part of the stope and chamber backfilling discussed in Section 4.4.2.

4.4.4 Borehole Plugging

Over the life of the Giant Mine and the GMRP, approximately 2,200 boreholes have been drilled from surface, many of which intersect the underground workings. Identified boreholes (shown in Appendix E) will be backfilled with cementitious grout and their surface casing will be cut off below ground surface.

Project boreholes, many of which are required for project implementation and monitoring, will be closed in the same manner upon completion of their associated scope of work, i.e., backfilling holes will be closed upon completion of backfilling but monitoring holes will remain open until monitoring is completed (Section 5.2).

4.4.5 Long-Term Access Portal

The portal will be located on the western edge of B2 Pit and will descend entirely through bedrock to the existing UBC ramp over a length of approximately 250 m from a starting elevation above the probable maximum flood elevation. A lockable door will be installed at surface to prevent unauthorized access which may be replaced with backfill in the future when underground access is no longer required. Design drawings for the long-term access portal are provided in Appendix F.

4.4.6 High Test System

Planned changes to the High Test System consist of anchoring the pipes on the 750L so they will not float and be damaged if mine water level fluctuates and cutting existing sections and re-directing the flow down existing raises and sub-vertical connections to deeper levels of the mine by adding pipe extensions. Once the freeze has been established, flows from the High Test System are expected to stop.

4.5 Engineering Work

The following sections describe the designs in greater detail and their proposed implementation to meet their associated closure criteria.

4.5.1 Main Work Tasks

The following sections describe the main tasks associated with the underground stabilization work.

The general elements of the stabilization plan are as follows:

- Excavate heavily arsenic-impacted soil in the roaster area and stockpile as necessary as per the Waste MMP.
- Commission the soil washing plant and develop cemented backfill mixes using the residual soil filter cake material.
- Commission the flowable cemented backfill plant system, refine the backfill mix design, and test the delivery system.
- Backfill Chamber 15 with lightly cemented contaminated backfill.
- Drill additional backfill delivery and monitoring boreholes from surface to intersect underground voids.
- Excavate tailings process tailings to remove debris.
- Source rock for cemented rock fill.
- Rehabilitate the underground ground support system to allow safe underground access to execute the work.
- Install underground pipelines (slicklines) and backfill containment barricades as required.
- Commission a cemented rock fill batching process and delivery system.
- Implement remote monitoring systems for use during backfill placement.

- Produce paste backfill and place underground to targeted stope and chamber voids through surface boreholes and underground slicklines (if necessary).
- Excavate a long-term access portal and drift.
- Construct a closure door on the long-term portal and secure or close other openings to surface.
- Backfill with cement grout historical boreholes that connect to the underground and are not required for monitoring.

The above-listed activities can be divided into preparatory and stabilization activities, and these activities may be staged to accommodate the sequencing of work in the field. During these activities, all process water will be directed underground or captured and treated prior to discharge as per the Water MMP.

4.5.2 Excavation and Remediation (Soil Washing) of Arsenic-Impacted Soils

Soil chemistry sampling has been conducted to define the extents of soils with arsenic concentrations greater than 4500 mg/kg. The arsenic-impacted soil area centred around the roaster is approximately 470 m long by 220 m wide with an average thickness of highly arsenic impacted material (>4500 mg/kg) of 0.5 m but ranging from 0.1 to 2.2 m thick for a total estimated volume of 52 000 m^3. The heavily arsenic-impacted soil will be excavated from the C-Dry and mill/roaster area and processed on site in an area removed from water bodies and where erosion and sediment can be managed and process water contained while limiting the need to transport arsenic-impacted soil near water bodies. Transportation of arsenic-impacted material will be conducted with covered dump trucks or equivalent to prevent dust migration in accordance with the Dust MMP.

Soil washing will consist of mechanical and hydraulic separation of the excavated soils. The viability of the proposed remediation process was validated through bench-scale tests conducted by four pre-qualified contractors (Appendix B2). The soil washing plant will consist of:

- mechanical screening systems
- washing system consisting of water jets and conveyors
- a water treatment system to allow precipitation and concentration of the arsenic impacted fine soils and re-cycling of wash water (contact water)

The wash water will be recycled multiple times, potentially with the assistance of chemical reagents to hasten flocculation of fine soils, but will eventually require supplementing with additional water to be taken from the Polishing Pond, trucked from off site or sourced from Yellowknife Bay. Residual wash water will be directed underground into the minewater pool at the end of the program as per the Water MMP and treated. A maximum of 100 m^3 of contact water is anticipated to be discharged to the mine pool per season.

Chemical reagents will not be used to assist in separation of the arsenic trioxide from soil but may be used to assist in recycling process. Potential reagent types may include commonly used acids (typically organic acids, e.g., citric acid); consumer-grade detergents (e.g., trisodium phosphate); or inorganic salts (calcium chloride). The specific reagent is proprietary to each contractor, therefore the specific safety data sheets will be submitted for use by the GMRP and the MVLWB at the time that the contractor is selected.

Heavily arsenic-impacted soil excavation, soil washing, and production and placement of lightly cemented contaminated backfill will be run concurrently to limit the need for stockpiles. Stockpiles will be covered and bermed if required to be left inactive for more than eight hours and limited in dimensions to a single day's supply (approximately 500 m^3); stockpile management will follow the Waste MMP and the Erosion and Sediment MMP.

Soil washing will produce two output materials: arsenic concentrated waste residuals and washed granular material. Washed granular material will account for 70% to 80% of the excavated soil, will have arsenic concentrations of less than 4,500 mg/kg and will be disposed of within a TCA or open pit. Waste residuals will account for the remaining 20% to 30% of the excavated soil, will have arsenic concentrations of greater than 4,500 mg/kg and will be used for backfilling of Chamber 15. The arsenic concentrated waste residuals will be processed into a flowable cemented material (lightly cemented contaminated backfill) and used as the primary backfill for stabilizing Chamber 15.

4.5.3 Underground Void Closure

4.5.3.1 Backfill Type and Components

Backfill types for each void were selected following a benchmarking study which produced the flow chart shown in Plate 4-1. Considerations for backfill types included void accessibility, technical requirements of the fill, material availability, void geometry, and environmental implications. Flowable cemented backfill and cemented rock fill were identified as being the preferred backfill materials for the identified voids at the Site.

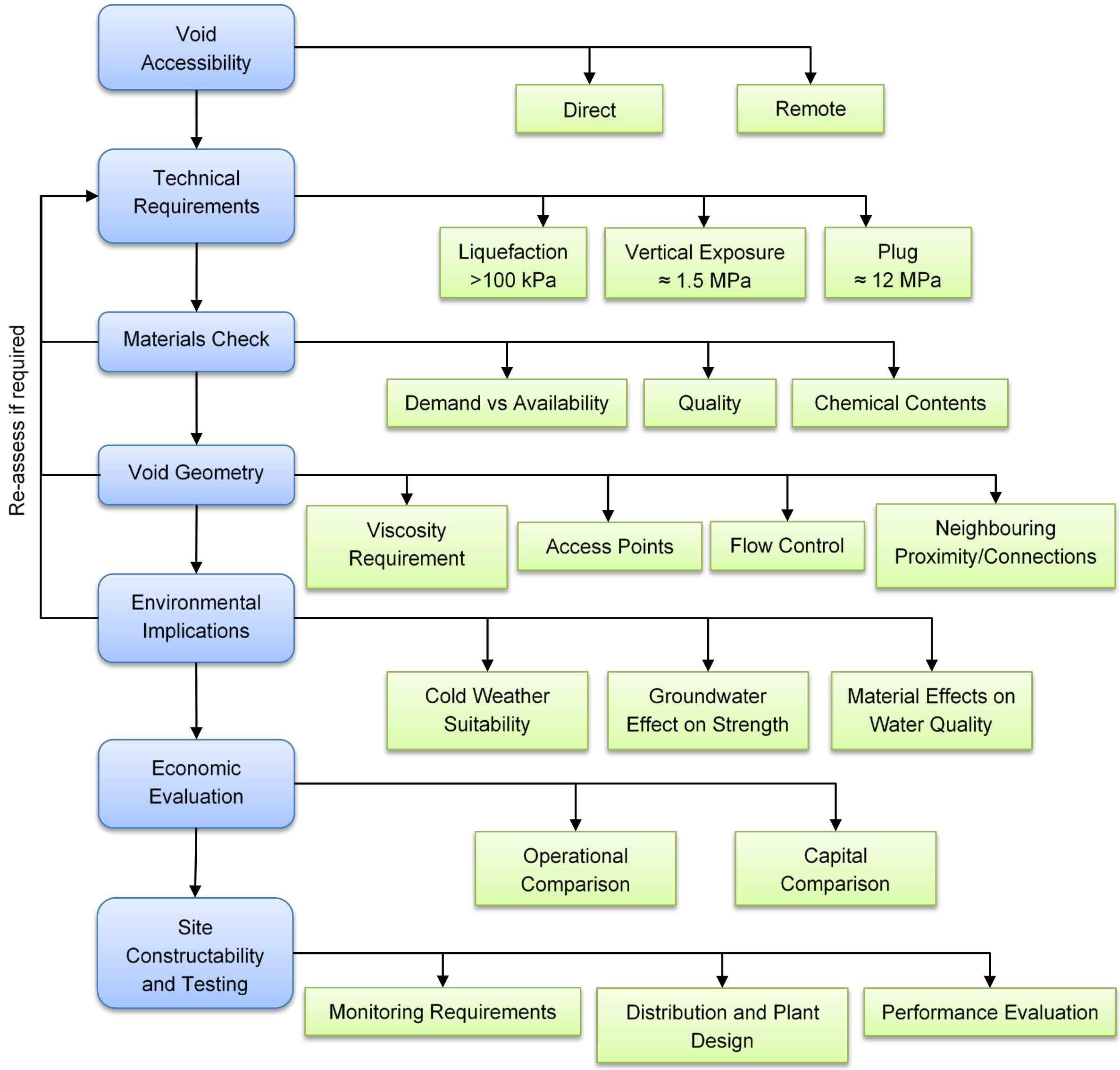


Plate 4-1: Backfill Selection Flowchart

4.5.3.1.1 Cemented Rock Fill

Cemented rock fill consists of aggregate or a coarse media (rock fill) bound together with a cement binder. The aggregate is processed through jaw crushers and screens to sort the material to a specific gradation and then mechanically mixed with a flowable cement mortar and mechanically placed in a stope, often via loaders. The fill can be constrained with berms or mechanical fill fences made of mesh and strapping until the cement sets and the fill becomes self-supporting. Depending on the requirements of the backfill, the residual void between the fill and the excavation back can be backfilled with a flowable cement material, often foaming cement. The gradation of the aggregate and the specifics of the cement binder are designed by the contractor to meet the strength requirements based on available material. Unconfined compressive strengths for the project are specified as a minimum of 2 MPa.

4.5.3.1.2 Flowable Cemented Backfill

Tailings, which is finely crushed rock and is the main by-product of milling ore, is proposed as the primary backfilling material. It is abundant on surface in the existing tailings ponds and is also present in large quantities in the underground as it was used during historical mining to stabilize voids. Tailings will primarily be excavated from the South, Central, and North tailings pond basins. The Northwest Pond tailings are also available for use.

As discussed in Section 4.5.2, heavily arsenic-impacted residual soils from soil washing will also be used as a backfilling material in Chamber 15. This chamber is a currently empty, purpose-excavated underground chamber that was originally intended for storage of arsenic trioxide dust.

The chosen backfill material is lightly cemented flowable backfill. The backfill will generally be made from a mixture of tailings or soil washing residuals, water, binder, and possibly some inert rock aggregate. The binder may be Type GU (general use) cement (normal Portland cement) or supplemental cementitious materials such as granulated blast furnace slag cement or fly ash. Backfill consisting of Giant Mine tailings, water, and binder is referred to as paste in this and other documents. Additives such as plasticizers and retardants (as approved by the MVLWB) may be used to enhance or alter the performance of flowable backfills.

Backfill mix designs will vary to deal with variability in the grain size and water content of the excavated tailings or arsenic residual soils, as well as the required slump for a particular application. High slump backfill will be used for the majority of the bulk fill as it will flow far from borehole insertion points. The appearance of this material while it is flowing is similar to basaltic lava flowing. The mobility of the backfill limits the amount of drilling required. Low slump backfill is required for those areas where greater placement control is required.

When additional water is required to be added to the excavated and processed tailings, treated minewater, water present in the tailings basins, or water sourced from off site or freshwater taken from Yellowknife Bay will be used as per the Water MMP. Treated minewater usage will vary daily but is expected to be approximately 300 m^3 per day.

4.5.3.2 Supporting Work

Required supporting work in preparation for and throughout the backfilling program is diverse and consists of the types of activities described below. Activity-specific mitigation, monitoring, and management of materials generated throughout implementation of this design plan (i.e., during construction) will be provided in more detail in the construction plan and will reflect approved site-wide management and monitoring plans, as referenced below.

4.5.3.2.1 Quarrying and Processing of Rock for Cemented Rock Fill

Rock backfill is planned for the B4 Pit area, and source material will be identified in the Borrow Design Plan and the Borrow Materials and Explosives MMP.

4.5.3.2.2 Excavating and Arrangement of Tailings

The backfilling work is primarily centred around the B1, B2, B3, B4 C1, A1 and A2, open pit areas. Tailings, which will comprise the main component of paste backfill, will primarily be excavated from the South, Central, and North ponds with the potential to also use the Northwest pond. Access roads to the tailings ponds may need to be repaired and a temporary road access may need to be constructed. Clean borrow material for these activities will be sourced from on-site approved quarries or off-site local commercial quarries.

Tailings will be excavated, processed, and stored on the Site in preparation for backfill production. Storage areas will likely include use of the Norseman Quonset constructed in 2013 on the northwestern edge of the South Pond. Excavated tailings on the tailings ponds outside of the building will be sprayed with water and/or an approved erosion control polymer to control dust per the Dust MMP.

Waste material may be encountered during the excavation of tailings in the South, Central, and North ponds. Hazardous waste material is not expected to be encountered. Waste material, such as wood, piping, impoundment foundation material (trees, peat), or any other debris will be relocated to the Central Pond for future management -per the Waste MMP.

4.5.3.2.3 Underground Workings Maintenance and Rehabilitation

To allow safe access for placement of backfill monitoring equipment, maintenance and rehabilitation of various underground areas including underground access portals will have to be done under the direction of the Workers' Safety and Compensation Commission (WSCC) Mines Inspector as follows:

- rehabilitation of ground control systems in existing underground mine access using scaling and installation of new ground support as required
- rehabilitation of existing wooden ladder ways to meet Workers' Safety and Compensation Commission regulatory requirements
- excavation (blasting) and installation of ground support in short sections of new drifts as required; note that all new mine development rock will remain underground unless it has been geochemically tested and shown to conform to the requirements for borrow outlined in the Borrow Materials and Explosives MMP
- installation of fresh air delivery and any new or upgraded electrical, water, and compressed air services to underground work areas as required
- maintenance of openings to surface that provide ventilation until such time as they are no longer needed
- installation and maintenance of a communication system between surface and the underground working areas

4.5.3.2.4 Backfill Placement Preparation

Paste, lightly cemented contaminated backfill, and cemented rock fill will be placed underground through pipelines from surface (cemented rock fill may be rehandled by equipment such as scoops once underground to achieve the desired profile). The installation of these lines consists of drilling boreholes from surface either directly into the void or to a nearby location where an underground pipeline (slickline) can be used to transport the flowable fill to the desired location. Drilling will also be conducted to gain access to stopes and voids for the purposes of monitoring backfill placement from surface.

Locations of current and proposed boreholes to be utilized during the backfilling work are shown in the drawings in Appendix C, which also includes cross-sections of proposed boreholes identifying their underground targets. Borehole diameters will have diameters of 96.1 or 200 mm depending on their intended use and will be used for monitoring and flowable backfill placement. Following completion of work, boreholes that will not be used for monitoring will be plugged by backfilling with cementitious grout as discussed in Section 4.5.4.3.

4.5.3.2.5 Installation of Monitoring System

Prior to placement of backfill underground, a monitoring program will be put in place to verify that the delivery of backfill to the non-arsenic stope voids is not causing any undue effects on barricades or any other infrastructure. Visual monitoring will also be in place during backfilling to verify that the backfill is reporting to the correct location. The types and frequencies of monitoring during backfill placement will be described in the Quality Control section of the Construction Plan.

4.5.3.3 Stabilization Activities

4.5.3.3.1 Backfill Placement

Geotechnical parameters for intact rock mass strength, rock mass quality, and geological structure were collected in various investigations. These, along with boreholes and local underground and surface mapping, were used to characterize the rock mass for the stability assessments. The stability assessments determined which stopes required backfilling based on each stope’s expected stability performance over the 100-year project life, as well as its potential surface impact. The purpose of backfilling is to provide stability to rock crown pillars to reduce the risk of surface impacts to an acceptable level over the project life.

The maximum permissible estimated surficial settlement depends on the closure criteria which govern a given stope as detailed in Sections 4.1 and 4.4.2, and stopes which were identified for backfilling have been designed such that crown pillar failure will produce the least surface impact possible. Backfill will be injected into the surface delivery boreholes either via gravity feed or through use of an in-line pump.

Upon cessation of backfilling under normal operating conditions or if blockages in the distribution lines occur, backfill delivery lines containing cemented backfill will need to be flushed using a compressed air system to push a wetted sponge through the pipeline or, if further cleaning is required, using treated minewater from the Polishing Pond and/or untreated tailings pond water. Uncemented backfill may also be used for flushing. Flushing of backfill delivery pipelines is required because the backfill cannot be allowed to harden (curing of cement) in the pipelines. The backfill delivery lines will be kept as short as possible, and only a minimal amount of treated minewater is anticipated to be required for each line flush. However, depending on the backfill delivery schedule, multiple daily flushes may be required—this is typically why the compressed air flush is the preferred approach.

If water flushing is required, most flush water required will be directed underground into the backfill distribution boreholes but some may need to be captured on the surface and deposited back into the tailings ponds. No flush water will be allowed to drain to areas outside of the tailings ponds. Flush water that enters the underground will enter the minewater pool and be directed to water treatment.

No personnel will be allowed adjacent to or below the stope complex during backfilling operations. Access will be allowed again after the backfill has begun curing or set.

Polyurethane foam will be used in selected areas, primarily to constrain the flow path of paste backfill. It consists of a two-part chemical and potential additional reagents to control the set-up time. The fill is placed remotely through small diameter piping run along boreholes, and when it reaches a void it begins to swell to several times its original volume. The fill is relatively viscous which allows it to mound in the area of interest and create a barrier.

Cemented rock fill will be placed either directly underground using a combination of trucks and loaders or first through boreholes and then via equipment. It is batched by mixing flowable cement mortar with appropriately sized rock fill at a surface batch plant prior to being trucked underground. Cemented rock fill is planned for the B4 pit area where stope geometry and access are favourable. After end dumping fill from the truck, a loader will place the rock fill in lifts until it is tight to the stope back.

Arsenic bulkheads were installed decades ago, in some cases with minimal documentation. In addition, they were not designed with the 100-year project lifespan in mind. Therefore, to facilitate long-term arsenic containment, accessible and inaccessible arsenic bulkheads will be supported by backfilling the development drives connected to them in front of the clean side of the bulkhead as tight to the back as possible to the extent of the frozen shell, or approximately 5 m, where possible. Where less than 5 m of void exists in front of the bulkhead, the full drift or stope will be backfilled.

4.5.3.3.2 Monitoring of Backfill Position and Profile

The position (level) and profile (shape) of the backfill placed in the non-arsenic stope void must be completed to the applicable specification. Boreholes drilled for monitoring of the level and profile of the backfill will be used for insertion of borehole cameras and cavity laser scanning survey equipment. Periodic measurement of the level and shape of the backfill will be carried out to manage the work, and a final survey will be carried out just as the backfill reaches the monitoring borehole breakthrough position.

4.5.4 Closure of Openings to Surface, Including Boreholes

The closure methods for the openings to surface are outlined in Table 4-2. Designs for closure methods are described in Sections 4.5.4.1 and 4.5.4.2. Closure of boreholes is discussed in Section 4.5.5.3, and the currently identified boreholes for backfilling are shown in Drawing 01-42-0001, included in Appendix F.

4.5.4.1 Concrete Caps

Caps placed at surface will be designed to resist a distributed or concentrated load that meets requirements of the NWT Mine Health and Safety Regulations. Caps will be secured to solid rock. In locations where caps will be located below current ground level, soil will be placed on the cap up to the existing ground level. A ventilation pipe will be installed through the cap, which can be used for future remote inspections and will be screened to prevent nesting.

The caps are designed as concrete slabs. The slabs are designed so that loads are carried in two directions with structural support provided on all sides (two-way slab) or so that loads are carried in one direction with structural support provided on two side (one-way slab). The choice of slab design is dependent on the dimensions of each cap. The majority of caps will be two-way slabs except for the caps on the A2 Shaft, 234 Distribution Raise, B Vent Shaft, #1 Fill Raise and the Northwest Vent Raise, which will be one-way slabs.

4.5.4.2 Backfill

Backfill used to close openings to surface will be either cemented or uncemented (Section 4.4.3).

The cemented backfill plugs are designed to be self-supporting with a minimum factor or safety of 3. The design of the cemented backfill includes the self-loading of the cemented backfill plug, a saturated column of uncemented backfill above the plug, and an additional 18 kPa uniformly distributed load on the plug. The 18 kPa additional load surpasses the minimum 12 kPa required under the NWT Mine Health and Safety Regulations.

Uncemented backfill will be placed tight to the back of the opening to a distance inside the working on 2.5 times the height of the opening. It will be mounded in front of the entrance to a minimum of 0.5 times the height of the opening above the top of the working.

4.5.4.3 Boreholes

Boreholes will be backfilled from surface to 30 m below ground surface or their breakthrough into the underground, whichever is shallower. A downhole plug will be used to constrain grout backfill which will have a water to cement ratio of minimum 0.35:1. Surface casings will be cut off to a minimum of 300 mm below ground surface.

4.5.5 Long-Term Access Portal

Geotechnical parameters for intact rock mass strength, rock mass quality, and geological structure were collected in various investigation campaigns. These, along with local terrain mapping and existing underground travel way condition mapping, were used to assess potential portal locations and paths. The long-term access portal will be located northwest of B2 Pit, at a rock outcrop approximately 15 m high. The portal will connect to the existing UBC ramp via a new decline tunnel approximately 250 m long and with a consistent slope gradient of 15%. A tunnel profile of 4 m width by 3 m height with a 1 m arched crown has been assumed for the portal and ramp design. The portal will start at an elevation of 169 m, which is above the maximum probable flood elevation.

Ground support along the portal and ramp will follow a systematic bolting pattern with welded wire mesh, likely installed using pneumatic drilling equipment. As the ramp is advanced, ground control systems will be installed.

4.5.6 High Test System

Work will be carried out locally on the High Test System to anchor it and protect it from damage during mine water level fluctuations and preferentially route the water away from the C Shaft area and reduce the arsenic load on the WTP during commissioning. Specific changes to the line consist of:

a) Cut the 750 Level high test line in two places north of C Shaft (near the 7-12 scoop shop) and connect it to a new HDPE line that would send water from both the C Shaft and B Ramp high test pipes down a raise where it will enter the mine pool.

b) Cut and plug the 750 Level high test line in the northern portion of the mine (at the Supercrest pump station) so that water in the northern high test pipes will flow south into the high test sump and to the mine pool north of the old Northwest underground pump station.

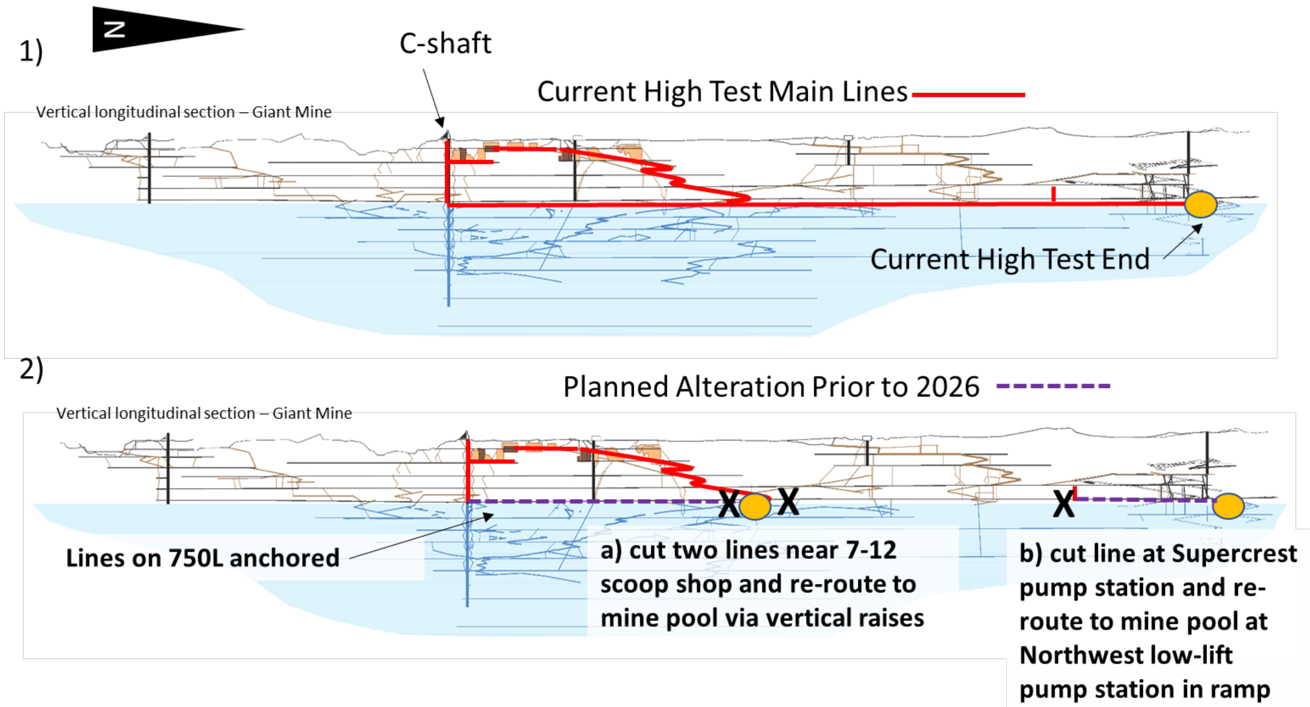


Plate 4-2: Vertical Longitudinal Section of Giant Mine Looking West Showing: 1) Current Main High Test System Path and 2) of Planned Alteration

4.6 Timing and Sequencing Considerations

The sequence of construction is expected to be as follows:

1) drilling backfill delivery boreholes and other preparatory works such as stockpiling tailings
2) excavating and soil washing material in the roaster area
3) backfilling of stopes (arsenic and non-arsenic), arsenic chambers, and arsenic bulkhead support
4) long-term portal construction

Backfilling of stopes is required before their associated pits can be backfilled or thermosyphons for freeze activities can be drilled. Although backfill activities have been successfully completed during the winter, it is preferable to complete them and associated support tasks such as material excavation during the summer-fall construction season. Soil washing and material excavation require unfrozen conditions and positive temperatures. The backfilling activities covered by this document will occur over three to four construction seasons early in the active remediation phase. In general, the operating season for stabilization activities is April to November each year, but this timeframe may be extended or shortened depending on weather and how it is affecting backfill production and delivery. Preparatory activities such as drilling and underground rehabilitation can occur year-round, while other activities such as tailings excavation are limited by weather.

Disassembly of the High Test System can occur after completion of the new WTP and after freeze is partially established around arsenic stopes and chambers as flows from the High Test System are expected to stop.

Openings to surface closure will occur throughout remediation. This is likely to be a precursor to different activities such as excavating heavily arsenic-impacted soil in the roaster area and backfilling pits, depending on the location of the opening. Borehole backfilling will occur over a similar timeline and be split between other scopes based on the location of given boreholes. Openings to surface that currently provide ventilation will not be capped until they are no longer needed.

Excavation of the long-term access portal is expected to be completed over a single construction season, with final hardware fitting being completed at any time of year.

5 POST-CONSTRUCTION OPERATIONS, MONITORING, AND MAINTENANCE

5.1 Operations

There are no post-construction operations associated with underground stabilization. The portal will have been closed prior to completion of surface construction activities. Similarly, the caps on openings to surface do not require operation, although periodic maintenance could be required and is discussed in Section 5.3.

5.2 Monitoring and Inspections

Geotechnical monitoring, specifically ground stability monitoring has been conducted at the Site repeatedly as part of care and maintenance activities. This monitoring has been used to support prioritization of interim stabilization activities to date, validate stability calculations, and inform the long-term monitoring program presented herein. The goal of both the long-term and short-term monitoring and maintenance programs is to demonstrate that closure activities are meeting their associated objectives (Table 5-1) and to inform any remedial or corrective actions required in the future.

The adaptive management phase for underground stability of each void and opening begins once backfilling is completed and consists of geotechnical and structural monitoring and potential associated contingency actions. The scope, duration, and frequency of post-closure monitoring efforts is based on experience with past monitoring programs executed during the care and maintenance phase and engineering assessments related to the design of the currently proposed remedial actions as well as anticipated failure modes.

Geotechnical and structural monitoring will be conducted according to the frequency and methods outlined in Tables 5-1 and 5-2 until the closure criteria have been shown to have been achieved per the monitoring milestones in Table 5-1. Long-term geotechnical stability of the underground can be affected by movement of backfill from near-surface stopes into deeper mine workings, fluctuations in the minewater pool, and degradation of rock quality leading to loss of crown pillar stability. Both existing backfill placed during mining operations and new backfill placed during remediation activities need to be monitored. Upon completion of construction, five years of annual or more frequent data for each monitoring location post-backfilling is required to establish a trend of favourable performance. Monitoring frequency will be reduced after this initial baseline data set, provided other indicators remain favourable (e.g., water level). The backfill and closure works have been designed to effectively eliminate the need for future maintenance. If instability is detected, using methods outlined in Table 5-2 which cover the entirety of site including voids that have not been targeted for backfill, that is determined to require further attention, maintenance will be completed to remediate the specific issue. Expected modes of maintenance include placement of additional backfill or grading over subsidence areas, depending on the results of the root cause investigation.

The concrete caps on closed openings to surface will be inspected by the Mines Inspector and the closure criterion can be met. No long -term monitoring of the closed caps is required. However, as part of best-practice, inspection by a qualified person to confirm their continued integrity is proposed (Section 5.3).

The design of the monitoring plan must account for the available access to the underground. Monitoring has been designed so that access to the underground for completion of monitoring activities is not required. Instrumentation currently installed (piezometers, extensometers) and recommended for use during the closure phase of work is assumed to remain operational/accessible from surface.

Table 5-1: Monitoring Programs and Associated Performance Closure Objectives and Criteria

Monitoring Program	Closure Objective	Closure Criteria	Monitoring	Monitoring Demonstrates Closure Criteria are Met	Reporting
Openings to surface	**UG1.** Access to underground workings from surface openings is restricted for the safety of humans and wildlife	**UG1-1** All existing openings to surface that are connected to the underground are secured in a manner that meets the NWT *Mine Health and Safety Act*.	Satisfactory final inspection by the Mine Inspector.	Mines inspector anticipated to review closures at the end of each construction season. Assumed to be approximately two construction seasons.	Annual Water Licence Report
		UG1-3 There is no unauthorized access to the underground via the new portal.	Visual inspections by site security.	Visual inspections of portal opening by site security for first five years or until portal is backfilled and access is not possible, whichever occurs first.	Performance Assessment Report
Minewater	**UG2.** Minewater elevation will be managed to maintain mine physical stability and chemical stability	**UG2-1** Maintain minewater level at or below approximately the 750L which is equivalent to -77 m[(a)] above mean sea level (amsl) ± seasonal fluctuation (refer to Water Management and Monitoring Plan).	Water elevation as measured by three underground piezometers in the B1, B4, and C1 areas of the Site.	Twice annual review of data from any one of three piezometers over 15 years after construction does not show a 24-hour average elevation greater than -27 m amsl[1].	Annual Water Licence Report Performance Assessment Report
Crown pillar stability	**UG3.** Structures, controls, and adaptive management approaches used for the remediation of the arsenic trioxide meet appropriate design levels required for long-term care	**UG3-3** No more than 1.5 m of the rock in the crown pillar of an arsenic stope or chamber, or in the top of an adjacent non-arsenic stope separated by a boundary pillar, can fall into void spaces, such that subsidence does not damage critical infrastructure.	Crown pillar condition as measured by 16 extensometers in crown pillars of all arsenic stopes and chambers except Chamber 10 (already frozen).	Extensometers record less than 1.5 m of crown pillar displacement averaged over the 15-years post construction or until the arsenic chambers and stopes are frozen after which excessive settlement of the stope fill should not occur and monitoring will cease. Note extensometers are to have a 24-hour rolling average applied when interpreting data to eliminate potential erroneous data points.	Backfill Completion Report Annual Water Licence Monitoring Reports during adaptive management phase Performance Assessment Report
	UG4. Underground is stabilized (geotechnically and physically) to reduce risks for public, workers, and wildlife safety	**UG4-4** A minimum crown pillar rock thickness of 5 m (thickness of intact bedrock below overburden and above void) will be maintained where initial crown pillar thickness permits.	Crown pillar condition as measured by 22 extensometers and 27 monitoring boreholes in crown pillars.	Extensometers or borehole cameras confirm that 5 m thick crown pillar thickness is maintained for each stope/stope complex. Note extensometers are to have a 24-hour rolling average applied when interpreting data to eliminate potential erroneous data points.	
		UG4-5 Voids under pits and Stope DWC will be filled so that no more than 1 m subsidence would occur at ground surface.	Surface subsidence through remote sensing (LiDAR/InSAR). Note this is the same monitoring as will be conducted to meet Criterion P2-4 which is related to the settlement of open pit fill. This criterion is also expected to limit settlement to less than 1 m.	Less than 1 m of differential settlement as measured over 3 m baseline within surface zone of influence projected to surface from stope (35 degrees through bedrock and 45 degrees through overburden/fill).	

Note: Design closure criteria are excluded as they are met with filing of reports/information/inspections as per Table 4-1.
(a) Number has been rounded to the nearest metre.
mbgs = metres below ground surface.

[1] The GMRP acknowledges that the minewater action levels are not approved through this version of the Underground Design Plan and engagement will be scheduled in fall/winter 2021. Following engagement, an update to the Plan will submitted to the MVLWB for review and approval.

5.2.1 Locations

Areas which will be monitored are shown in Plate 5-1 and example layouts of monitoring instruments for the B1 area are shown in Plates 5-2 and 5-3. Design instrument layouts of all monitoring locations across the Site are presented in Appendix H.

Mine water elevation will be monitored by three vibrating wire piezometers attached to data loggers and installed into deep boreholes below -78 m amsl connected 750 level or deeper mine workings in the C1, B1, and B4 pit areas. The remaining underground workings tend not to extend below the 750 level negating the need for deep piezometers.

Crown pillars were selected for monitoring based on their potential surface impact and mine water areas were selected based on their connection to deeper workings and proximity to sand filled stopes. Crown pillar stability will be monitored by sixteen extensometers attached to data loggers installed in the crown pillar of every arsenic stope and chamber (AR1, AR2, AR2, and AR4 areas). An additional twenty-two extensometers will be installed in non-arsenic crown pillars spread across the shallow underground mining areas associated with the A1, A2, C1, B1, B2, B3, and B4 pits. These extensometers will be supplemented with forty-three monitoring holes drilled into shallow stope crowns in the same areas.

As discussed in Section 1.2, the GKP mining area, (Plate 5-1) is significantly deeper than 35 m below ground surface and so has a reduced risk of failure. Therefore, a formalized monitoring program for this area is not anticipated at this time.

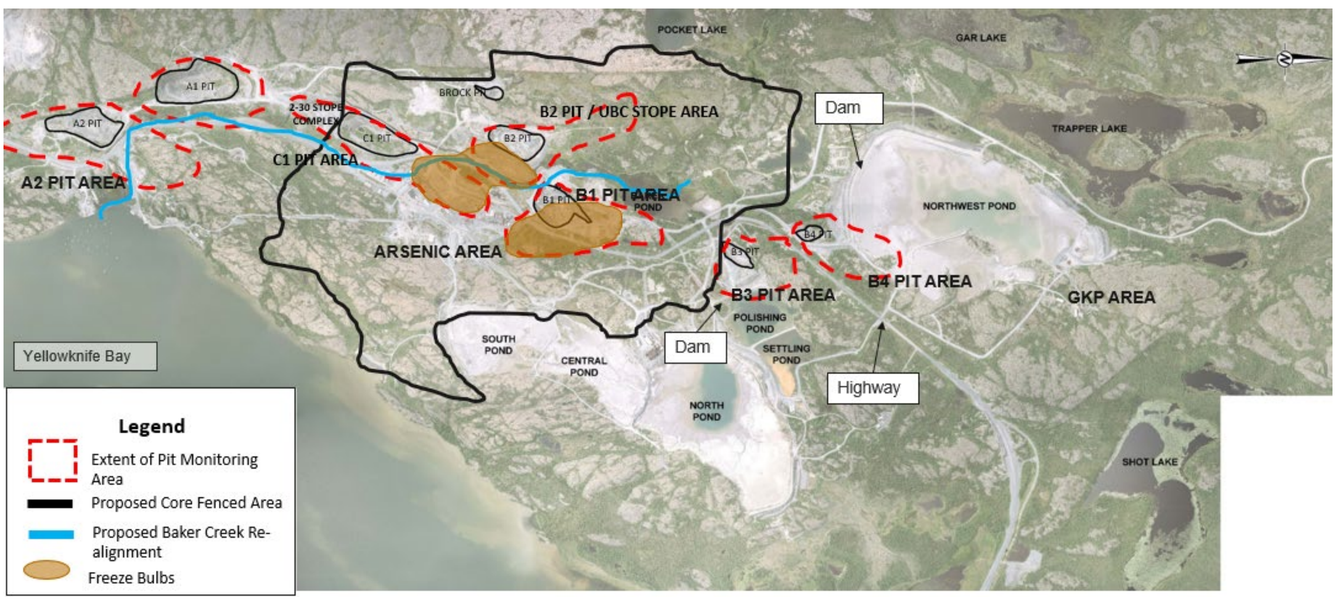


Plate 5-1: Underground Monitoring Locations on Surface

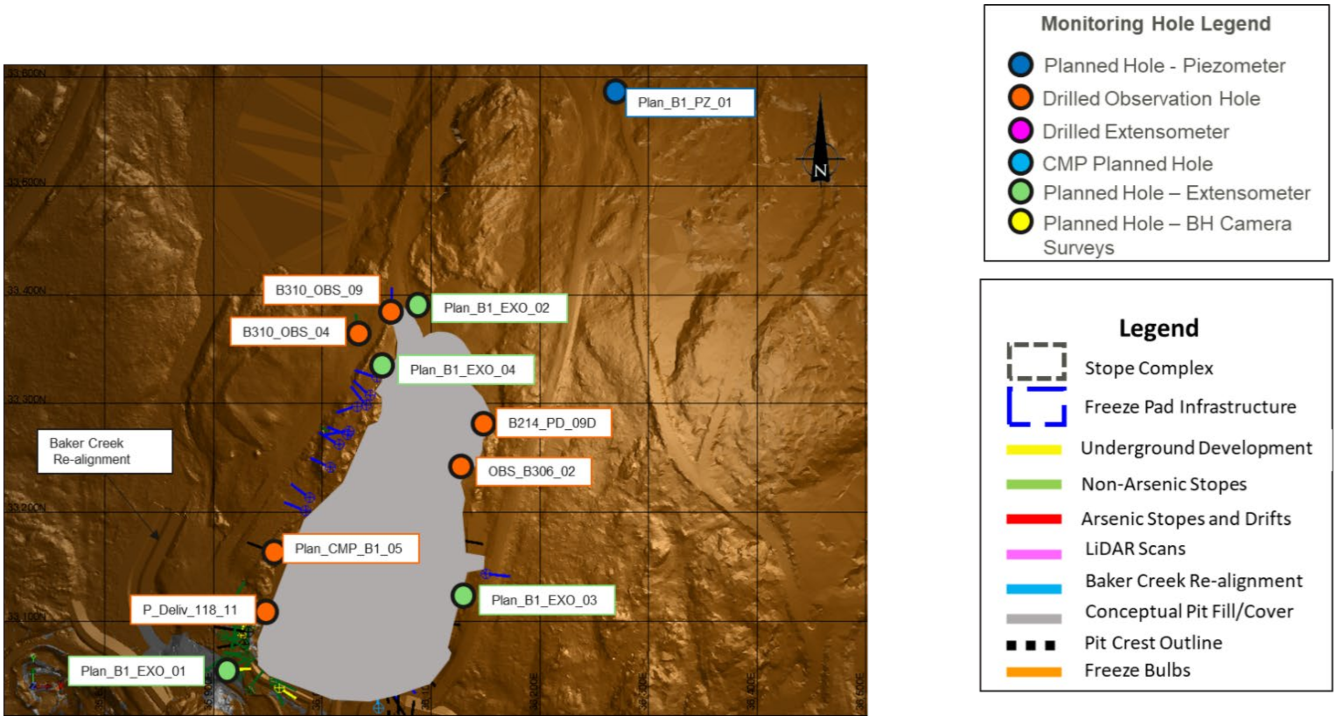


Plate 5-2: **Plan View of Planned Underground Monitoring Locations in B1 Pit Area**

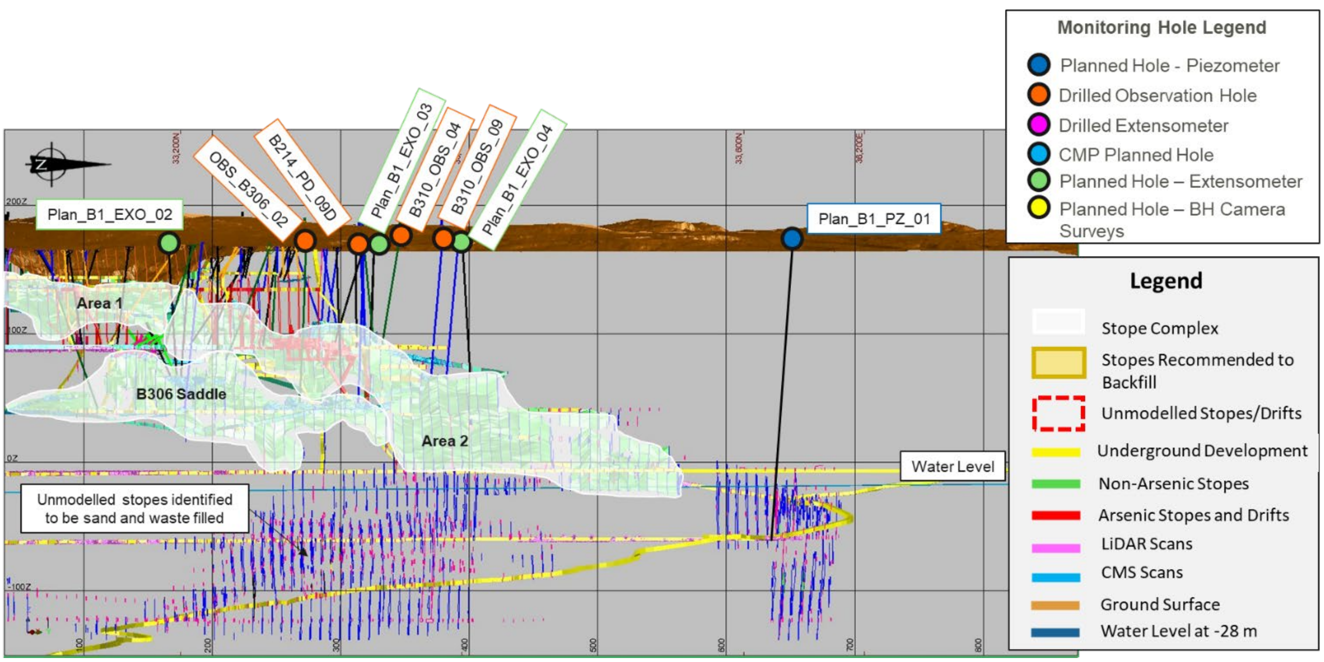


Plate 5-3: **Section View (looking west) of Planned Underground Monitoring Locations in B1 Pit Area**

5.2.2 Frequency and Duration

The frequencies, locations, and equipment that will be used for monitoring are presented in Table 5-2. Key monitoring equipment will consist of borehole cameras, which allow remote visual inspections of backfill condition and position in voids through boreholes; vibrating wire piezometers, which monitor water pressure and will be installed in flooded areas of the mine to monitor changes in water levels; and vibrating wire extensometers, which measure the displacement between two points cemented into a borehole drilled through the crown pillar of a stope. Extension of the points is interpreted to indicate potential instability of the crown pillar. Monitoring will be conducted at a decreasing frequency and spatial distribution with time, provided data suggest acceptable performance.

Note that surface subsidence monitoring for possible underground failures is done near the pit areas per Section 5.2.1. This is linked to the open pit closure criterion P2-4 about subsidence. The Open Pit Mine Workings Design Plan will provide information about the closure criterion for subsidence and achievement of this criterion. The monitoring is noted here for the sake of completeness because of its direct link to underground stabilization.

Table 5-2: Monitoring Frequency, Locations and Methods

Monitoring Program	Equipment	Locations	Measurement	Review Frequency (Data Logging Frequency)	Future Updates to Review Frequency
Minewater level	Vibrating wire piezometers with data logger	3 total across mine pool in areas with connections to deeper voids in B1, C1 and B4 areas.	Minewater level	Twice annual review in spring and fall. (Hourly)	15 years of acceptable data will demonstrate achievement of closure criteria. Ongoing monitoring after 15 years of acceptable data to be detailed in the Post-Closure Monitoring and Maintenance Plan
Crown pillar stability	Surface visual monitoring	Pit monitoring areas shown in Plate 5-1.	Changes in surface conditions, cracking or subsidence	Annual	N/A
	Satellite InSAR	Pit monitoring areas shown in Plate 5-1 and core fenced area.	Surface Displacement (subsidence)	Annual	N/A
	Vibrating wire extensometers – non-arsenic stopes	22 total across site in shallow stope areas	Displacement of crown pillar above residual void	Reviewed annually (Hourly)	15 years of acceptable data will demonstrate achievement of closure criteria. Ongoing monitoring after 15 years of acceptable data to be detailed in the Post-Closure Monitoring and Maintenance Plan

Table 5-2: Monitoring Frequency, Locations and Methods

Monitoring Program	Equipment	Locations	Measurement	Review Frequency (Data Logging Frequency)	Future Updates to Review Frequency
Crown pillar stability	Vibrating wire extensometers – arsenic stopes	16 total across site in arsenic storage areas	Displacement of crown pillar above residual void	Reviewed annually (Hourly)	15 years of acceptable data or acceptable data until establishment of freeze will demonstrate achievement of closure criteria. Ongoing monitoring after 15 years of acceptable data to be detailed in the Post-Closure Monitoring and Maintenance Plan
	Borehole camera surveys	43 total across site in all shallow stope areas (16 in Arsenic and 27 in Non-Arsenic stopes) 7 in deep backfilled non-arsenic stopes across 50 total including shallow and deep boreholes	Displacement of crown pillar and/or backfill	Annual	Reduce to every 5 years after 5 years of acceptable performance. 15 years total (2x5 year cycles) of stable data will demonstrate achievement of closure criteria. Ongoing monitoring after 15 years of acceptable data to be detailed in the Post-Closure Monitoring and Maintenance Plan

N/A = not applicable.

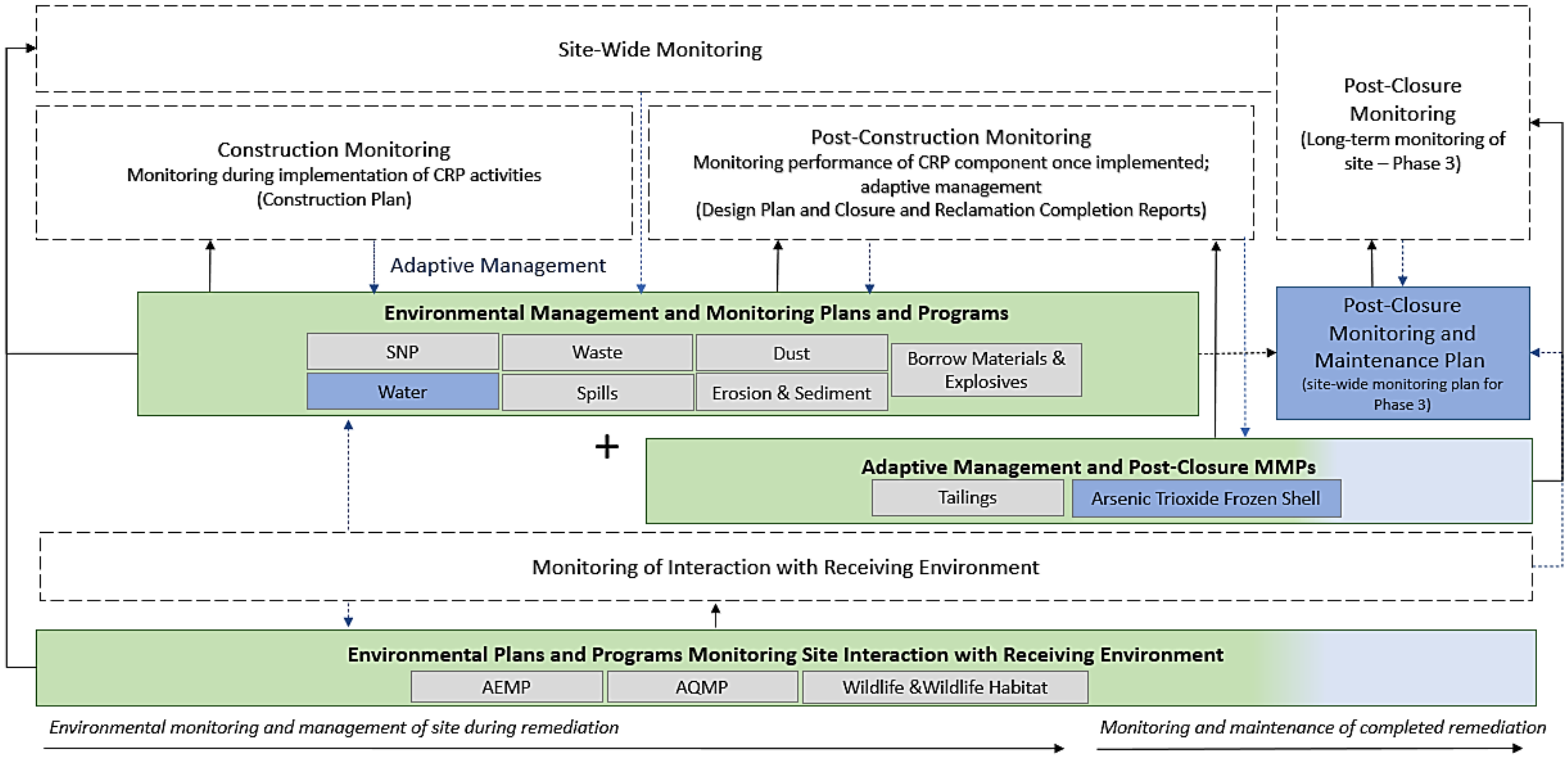
5.2.3 Updates to Site-Wide Monitoring and Management Plans

Once the monitoring and maintenance details in Section 5 are approved, they will be incorporated into management and monitoring plans as applicable, as per Part E, Condition 15 of the Water Licence. The linkages of the site-wide monitoring and management plans during various phases of remediation are provided in Figure 5-1 and the relevant management and monitoring plans are noted in blue.

The relevant site-wide monitoring and management plans and updates are listed below:

- Underground stabilization work and closure of openings to surface will not require update to the site-wide monitoring and management plans during construction.
- The Water MMP will require updating for the action levels for the minewater level once the WTP is installed and may require update after underground stabilization. There are currently action levels related to the minewater level in the Water MMP that cover the time period before the commissioning of the WTP and the covering of the Northwest Pond TCA, both of which will change the seasonal fluctuation in the underground requiring a new set of action levels. These action levels are not approved, and engagement is ongoing. Engagement will be scheduled in the fall/winter 2021. Following engagement, an update to the Plan will be submitted to the MVLWB for review and approval.
- Post-construction of the underground stabilization, the Arsenic Trioxide Frozen Shell MMP will be updated to include geotechnical stability monitoring and relevant action levels.
- Post-closure, it is anticipated that long-term stabilization monitoring of the underground will be required and would move to the Post-closure Monitoring and Maintenance Plan.

Figure 5-1 Linkages Between Environmental Management and Monitoring Plans, Construction and Design Plans for Giant Mine



5.3 Maintenance

Long-term (approximately 15 years) monitoring of the stability of the backfill is required to verify continued support to the crown pillar. Borehole casing materials may require replacement by installing a smaller diameter steel or HDPE casing through the existing borehole. In extreme circumstances, monitoring instruments such as extensometers and piezometers may fail or become damaged during the monitoring period. In these cases, new instrumentation holes would be drilled from surface to replace the instrument, if required.

Concrete caps for openings to surface have been designed with a service life of 100 years and will be inspected every four years and maintained as required. Caps which have been backfilled over top of can be inspected using the ventilation pipe. Maintenance is expected to be similar to other cast concrete structures such as bridge abutments with minor patching and replacement of weathered concrete although geotechnical issues such as eroding foundations will also be checked for. Similar to underground backfill, borehole backfill is not expected to require maintenance.

The ground support installed as part of the long-term access portal may have a shorter design life than the excavation itself and will require annual documented inspection and maintenance by qualified persons as long as the portal and decline are in use per NWT *Mine Health and Safety Act* requirements and the site Ground Control Management Plan. Following closure of the portal, maintenance will be discontinued.

5.4 Risks, Action Levels, and Response

The monitoring program outlined in Section 5.2 is designed to confirm that the closure criteria are being achieved upon completion of underground construction and associated activities. In general, should monitoring indicate that closure criteria are trending away from the target measurements, a series of actions would be initiated. An adaptive management approach is used to link monitoring results to actions with the purpose of achieving closure criteria as planned. This provides a systematic approach to responding to the results of the monitoring. This includes:

- a description of how the results will link to those actions necessary to verify that changes remain within an acceptable range
- definitions, with rationale, for tiered action levels
- a description of the rationale for each action level
- a description of how exceedances of action levels will be assessed
- a description of potential actions that may be taken if an action level is exceeded

Briefly, the process involves:

- Action levels are evaluated based on monitoring findings in a given frequency.
- When an action level is exceeded, the actions for the action level exceedance should be completed, as appropriate.
- Report exceedance to MVLWB.

Action levels include the following information:

- **Location/Item**: name or title of relevant location or topic for action level

- **Risk**: list the key item of concern around which actions levels relate
- **Key information:** summarizes which measurement endpoints are assessed for each assessment endpoint.
- **Low (Action Level):** the conditions under which the Low Action Level would be reached.
- **Moderate (Action Level):** the conditions under which the Moderate Action Level would be reached.
- **High (Action Level):** the conditions under which the High Action Level would be reached.

5.4.1 Risks Associated with Not Achieving Closure Criteria

The main risks of not achieving performance closure criteria that require long term monitoring for minewater elevation and backfill stability:

- Mine water rise (above -27 m amsl[2]) or fluctuations or, liquefaction due to seismic events that exceed the Projects design basis of a peak ground acceleration greater than 0.036g at a probability of 2% per 50 years (return period of 1 in 2,475 years) resulting in backfill destabilization.
- Sinkhole formation as a result of crown pillar instability.
- Arsenic escape as a result of crown pillar failure and loss of freeze containment.
- Natural, intentional or unintentional lit forest fires.

The potential outcome should the underground closure criteria not be met for the above scenarios is anticipated to be:

- an increase in void size and resulting reduction in stability condition and increased chance of caving to surface and sinkhole formation. It could also cause plugging of water flow pathways in the underground which may further destabilize fill due to pressure differentials in the minewater;

- sinkhole formation is most likely to pose a hazard to individuals and could also damage building foundations. Failure of rock between or above an arsenic stope or chamber could result in exposure of arsenic solids to the environment; however, if the sinkhole forms after freeze is established, the arsenic solids should not be mobile. As a worst case scenario, a sinkhole could result in some flow from Baker Creek entering the underground.

- arsenic escape would create loss of containment and a possible increase of arsenic concentrations in the minepool and the requirement to change the freeze configuration (e.g., freeze additional areas).

- Forest fires, although not anticipated to cause damage to the underground stabilization, could cause damage to or destroy the surface monitoring equipment requiring the instruments to be replaced.

[2] The GMRP acknowledges that the minewater action levels are not approved through this version of the Underground Design Plan and engagement will be scheduled in fall/winter 2021. Following engagement, an update to the Plan will submitted to the MVLWB for review and approval.

5.4.2 Action Levels and Response

Long-term Portal

Closure criterion UG 1-3 will be monitored by site personnel and confirmed after five years of long-term portal operation or upon backfilling when access to the underground is not possible, whichever is first. If at that time site personnel confirm that no unauthorized access was noted, the criteria will have been achieved. The five-year timer will reset if unauthorized access is observed after remedial actions such as fence repairs or modifications have been completed. No action levels are proposed for this criterion.

Minewater Level

As per closure criterion UG2-1, minewater level will be maintained at the 750 Level (-77 m amsl elevation) with potential maximum fluctuations of -5 m and +50 m, which correspond to GMRP elevations of -82 to -27 m amsl[3]. Closure criterion UG 2-1 will be monitored independently for each deep mining area according to Table 5-2. Action levels for this are found in Table 5-3. The piezometer data will be logged hourly and analyzed twice annually in the spring and fall. Any piezometer which exceeds an average measured minewater level of -27 m amsl for a 24--hour period or greater (i.e., the High action level in Table 5-3) is considered to not meet the closure criteria for the associated deep mining area (B1, C1 and B4). Actions and contingencies will occur to address exceedances. Once all three deep mining areas have independently achieved 15 years of piezometer data below the high action level, this criterion will have been achieved for the Site. The action levels in Table 5-3 include draw down rates (decreases in water level over a 24-hour period) in addition to water level elevations, as rapid fluctuations in minewater level can also impact backfill stability. Note, that these action levels and the description of monitoring are in relation to achievement of the closure criterion only. Minewater elevation is monitored daily on site through the Water MMP (Monitoring section).

Table 5-3: Minewater Level Action Levels to Address UG2-1

This table is under review. The action levels and potential actions and contingencies for minewater elevation will be resubmitted to the MVLWB for review and approval in a future version of the Water MMP and updated in the Underground Design Plan after engagement has occurred in fall 2021.

Item	**Minewater Elevation**	
Risk Item	Mine stope destabilization	
Key Information	Minewater elevation Rate of minewater rise or fall	**Types of Actions and Contingencies**
Low	Elevation:10 m above -77 m amsl OR Minewater Elevation Drawdown Rate[(a)]: greater than 0.5 m/day	• Investigate cause • Evaluate mitigation options such as: ▪ Increase pumping to surface during minewater level raise ▪ Reduce pumping rate during minewater reduction to limit destabilization (bring down slowly) ▪ Backup submersible pumps ▪ Bring in new pumps ▪ Contingency surface water storage
Moderate	Elevation: 25 m above -77 m amsl OR Minewater Elevation Drawdown Rate[(a)]: greater than 0.5 m/day	

[3] The GMRP acknowledges that the minewater action levels are not approved through this version of the Underground Design Plan and engagement will be scheduled in fall/winter 2021. Following engagement, an update to the Plan will submitted to the MVLWB for review and approval.

Table 5-3: Minewater Level Action Levels to Address UG2-1

This table is under review. The action levels and potential actions and contingencies for minewater elevation will be resubmitted to the MVLWB for review and approval in a future version of the Water MMP and updated in the Underground Design Plan after engagement has occurred in fall 2021.

Item	Minewater Elevation	
High	Elevation: Greater than 50 m above -77 m amsl (stope destabilization issues) OR Minewater Elevation Drawdown Rate[(a)]: greater than 1.0 m/day	Specific mitigations would be determined pending the cause of the change in water level. Types of actions include: ■ Install additional dykes or other on-surface measures to direct flow away from the underground. ■ Continue to pump and treat using the two treatment trains instead of deferring to a duty-standby configuration, therefore maintaining the higher pumping and treatment capacity to keep minewater at the approved level. ■ Use Northwest Shaft wells as backup if required. ■ Install a third intake in the C Shaft area, a new well could be developed in case of loss of one well. During this period, one well would still be in operation.

Note: The action levels can be triggered with elevation change or pumping rate change over time or both.

(a) Measured as water level change from previous 24h.

MVLWB = Mackenzie Valley Land and Water Board; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada.

Arsenic Crown Pillars

Closure criterion UG3-3 will be monitored independently for each arsenic stope and chamber per Table 5-2, and action levels are noted in Table 5-4. Any extensometer which exceeds an average measured extension of 1.5 m for a 24-hour period or greater is considered to not be meeting the closure criteria for the associated stope or chamber. The 15-year timer for this stope/chamber will be reset once the actions and contingencies have been enacted to remedy the situation. The timers are independent, so stopes/chambers which have not exceeded the 1.5 m extension may continue to progress towards closure completion. As the data are interpreted annually, an action level can be retroactively applied. Once all eleven arsenic stopes and chambers have independently achieved 15 years of extensometer data below the 1.5 m extension requirement, this criterion will have been achieved for the Site.

For the purposes of achieving closure criteria, arsenic crown pillar failure is defined as a 1.5 m or greater reduction in thickness through ravelling, spalling, or other failure mechanisms. In the event that an arsenic crown pillar fails in this manner, following mitigation of the failure, the timer for that stope or stope complex would reset such that an additional 15 years of acceptable (as defined in Table 5-1) monitoring data are required before the closure criteria can be said to have been met. In the meantime, closure criteria for other arsenic stopes and chambers that have continued to exhibit acceptable performance can be met. Monitoring action levels related to crown pillar stability (Table 5-4) have been designed to provide early warning and allow for action prior to failure of the crown pillar. The high action levels are therefore, conservatively set below the amount of failure allowed by the associated closure criterion to provide this early warning. Crown pillar spalling and failure tends to be a progressive process and it is desirable to maintain as much of the current thickness of each crown pillar as possible as the nature of rock masses does not provide opportunity to repair the rock mass, only support or react to an instability occurrence.

Table 5-4: Arsenic Crown Pillar Condition Level Action Levels to address UG3-3

Item	**Crown Pillar Condition**	
Risk Item	Surface Impact or Arsenic Release	
Key Information	Crown Pillar Thickness/Condition	**Types of Actions and Contingencies**
Low	**Vibrating Wire Extensometers**: 10 to 50 mm of total cumulative movement.	Immediate action to be taken: Increase monitoring frequency to weekly. Data to be interpreted within 24 h of receipt of data and assessment provided interpretation of results to Mine Manager/GMRP staff. Responses are expected to be similar for each action level, but the effort is expected to increase with Moderate and High. **Responses to be taken for all categories include:** ■ Complete a risk assessment for underground access. ■ Complete root cause analysis to determine if fill has migrated from void. ■ Install temporary fencing on surface. ■ Place additional backfill. ■ Underground construction to limit further fill migration/void spanning backfill. ■ Adjust minewater management. ■ Conduct surface mitigation such as geogrid and backfilling and regrading ■ Structural reinforcement for overlying infrastructure.
Moderate	**Vibrating Wire Extensometers**: 50 to 500 mm of total cumulative movement.	
High	**Vibrating Wire Extensometers**: >500 mm total cumulative movement.	

Non-Arsenic Crown Pillars

Closure criterion UG4-4 will be monitored independently for each non-arsenic stope according to Table 5-2, and the actions levels may be found in Table 5-5. The extensometer data will be logged hourly and analyzed annually using a 24-hour rolling average to smooth out potential electronic noise. Borehole camera surveys will be conducted annually (Table 5-1) and interpreted to coincide with extensometer interpretation. Stopes which have both monitoring holes and extensometers can be placed in a given action level or be shown to not be meeting the closure criterion based on either instrument. Any extensometer or borehole camera survey that indicates the crown pillar has failed to a thickness of less than 5 m is considered to not be meeting the closure criteria for the associated stope or stope complex. The 15-year timer for the triggering stope or stope complex will be reset once the actions and contingencies have been enacted to remedy the situation. The timers are independent so stopes/stope complexes which have maintained the minimum 5 m thick crown pillar may continue to progress towards closure completion. As the data are interpreted annually, an action level can be retroactively applied. Once all non-arsenic stopes and stope complexes have independently achieved 15 years of extension data below the high action level, this criterion will have been achieved for the Site.

For the purposes of achieving closure criteria, non-arsenic crown pillar failure is defined as a measurable surface subsidence greater than 1 m or reduction in thickness through ravelling, spalling, or other failure mechanisms to less than 5 m thick. The zone of influence of this surface subsidence could be highly variable depending on the rock mass between the top of the stope and the top of bedrock as well as the properties of the overlying overburden materials, as is therefore not practical to predict in advance of an event occurring. In the event that a non-arsenic crown pillar fails in this manner, following mitigation of the failure, the timer for that stope or stope complex would reset such that an additional 15 years of acceptable (as defined in Table 5-1) monitoring data are required before the closure criteria can be said to have been met. In the meantime, closure criteria for other non-arsenic stopes and stope complexes that have continued to exhibit acceptable performance can be met. Monitoring action levels related to non-arsenic crown pillar stability (Table 5-5) have been designed to provide early warning and allow for action prior to failure of the crown pillar. The high action levels are therefore, conservatively set below the amount of failure allowed by the associated closure criterion to provide this early warning. Crown pillar spalling and failure tends to be a progressive process and it is desirable to maintain as much of the current thickness of each crown pillar as possible as the nature of rock masses does not provide opportunity to repair the rock mass, only support or react to an instability occurrence.

Table 5-5: Non-arsenic Crown Pillar Condition Level Action Levels to Address UG4-4

<table>
<tr><th>Item</th><th colspan="2">Crown Pillar Condition</th></tr>
<tr><td>Risk Item</td><td>Surface Impact</td><td></td></tr>
<tr><td>Key Information</td><td>Crown Pillar Thickness/Condition</td><td>Types of Actions and Contingencies</td></tr>
<tr><td>Low</td><td>Vibrating Wire Extensometers (all depths):
10 to 50 mm of total cumulative movement.</td><td rowspan="3">Immediate action to be taken: Increase monitoring frequency to weekly. Data to be interpreted with 24 h of receipt of data and assessment provided interpretation of results to Mine Manager/GMRP staff.

Responses are expected to be similar for each action level, but the effort is expected to increase with Moderate and High.

Responses to be taken for all categories include:
■ Complete a risk assessment for underground access.
■ Complete root cause analysis to determine if fill has migrated from void.
■ Install temporary fencing on surface.
■ Place additional backfill.
■ Underground construction to limit further fill migration/void spanning backfill.
■ Adjust minewater management.
■ Conduct surface mitigation such as geogrid and backfilling and regrading
■ Structural reinforcement for overlying infrastructure.
■ .</td></tr>
<tr><td>Moderate</td><td>Vibrating Wire Extensometers or borehole cameras 5 mbgs or shallower:
50 to 100 mm total cumulative movement.

Vibrating Wire Extensometers or borehole cameras between 5 and 10 mbgs:
50 to 500 mm total cumulative movement.

Vibrating Wire Extensometers or borehole cameras deeper than 10 mbgs:
50 to 1,000 mm total movement.</td></tr>
<tr><td>High</td><td>Vibrating Wire Extensometers or borehole cameras 5 mbgs or shallower:
>100 mm total cumulative movement.

Vibrating Wire Extensometers or borehole cameras between 5 and 10 mbgs:
>500 mm total cumulative movement.

Vibrating Wire Extensometers or borehole cameras deeper than 10 mbgs:
>1,000 mm total movement.</td></tr>
</table>

mbgs = metres below ground surface; MVLWB = Mackenzie Valley Land and Water Board; CIRNAC = Crown-Indigenous Relations and Northern Affairs Canada.

Closure criterion UG4-5 will be monitored indirectly using remote sensing methods, i.e., LiDAR and/or InSAR surveys, to check that the criterion of less than 1 m of differential settlement over a 3 m baseline within the surface influence zone of stopes and chambers has been achieved. This monitoring will be conducted from surface as part of the effort to monitor closure criterion P2-4, which will be monitoring the entire area of pit backfill and cover, regardless of whether the area is undermined.

Reporting on Monitoring and Action Levels

Reporting on closure and post-closure monitoring and maintenance will be done per the requirements of the relevant Water Licence, Land Use Permit, or other authorizations in force at the time of reporting, either under the current Water Licence or, if required, future licences. Associated risks noted during monitoring, if any, will be reported at the time of observation or during regular reporting, depending on the risk level identified. Monitoring results will be reported in annual reports under the Water Licence unless instability requiring investigation is identified in the interim.

6 REFERENCES

6.1 Acts and Regulations

Mine Health and Safety Act. SNWT 1994 c 25. In force 15 December 1995, amendments to SNWT 2010 C 16. https://www.justice.gov.nt.ca/en/files/legislation/mine-health-and-safety/mine-health-and-safety.a.pdf

Mine Health and Safety Regulations. R-125-95 under the *Mine Health and Safety Act*. Amendments to R-123-2018. https://www.canlii.org/en/nt/laws/regu/nwt-reg-125-95/latest/nwt-reg-125-95.html

6.2 Literature Cited

CIRNAC (Crown-Indigenous Relations and Northern Affairs Canada). 2019. RE: Giant Mine Remediation Project – MV2007L8-0031 and MV2019X007 – Removal of the Partial Minewater Raise Reclamation and Research Plan. Letter from Natalie Plato, Deputy Director, Crown-Indigenous Relations and Northern Affairs Canada to Mavis Cli-Michaud, Mackenzie Valley Land and Water Board, 14 August 2019.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2013. Report of environmental assessment and reasons for decision – Giant Mine Remediation Project. EA0809-001. Yellowknife, NWT, Canada. 20 June 2013.

Wood (Wood Environment & Infrastructure Solutions). 2020. Quantitative risk assessment report. Version 1.0. Prepared for Crown Indigenous Relations and Northern Affairs Canada. 28 May 2020.

APPENDIX A

CONFORMITY TABLE

Conditions of the Type A Water Licence MV2007L8-0031 are summarized in Table A-1, along with section references to this design plan where each condition is addressed. A comparison of the approved closure criteria from the Closure and Reclamation Plan (CRP) and changes made through the design plan are shown in Table A-2. Two deletions of redundant criteria in development were made, and the criteria that were previously in development were finalized.

Table A-1: Water Licence MV2007L8-0031 Conditions

Water Licence MV2007L8-0031 Condition	Corresponding Section in Design Plan
Part E: Construction **Schedule 3, Condition 1**: The **Design Plans** referred to in Part E, condition 10 shall include, but not be limited to:	
a) A detailed description, with appropriate maps or diagrams, of the location and design of the Project Component, including:	
i. Summary of existing condition, including an erosional site assessment, stability analysis, and any site investigation details and how it influences design;	Section 2 and 1.2, Appendices B1, B2, Section 5.1.2.2 of the CRP
ii. Identification of any other critical assumptions for design;	N/A
iii. Proposed engineering work including a description of the processes and facilities that will support final design and closure conditions, including:	Section 4.5
As an appendix, design drawings and specifications for the Engineered Structures, stamped and signed by a Professional Engineer including final thermal, geotechnical, and stability criteria as appropriate;	Appendices C, D, E, F
iv. Discussion of design criteria that consider any unforeseen events that exceed design criteria (i.e., seismic activity or forest fire);	Section 3.4
v. A description of any linkages to the design and schedule of other Project Components;	Section 1.3
vi. Identification of the Closure Objectives and Closure Criteria from the Giant Mine Remediation Project Closure and Reclamation Plan that implementation of the engineered design is to satisfy in whole or in part;	Section 4.1
vii. Identification of new or updated Closure Objectives, Closure Activities, and/or Closure Criteria being proposed including rationale;	Section 4.1; Appendix A, Table A2
viii. Discussion on how the design addresses site-wide Closure Objective SW3-1 to “minimize perpetual care requirements”;	Section 4.3.1
ix. A description of long-term operational requirements and any anticipated maintenance, as applicable; and	Section 5.1 and 5.3
x. Any other design specific information.	Section 4, Appendices B1, C, D, E, F
b) A description of how implementation of the design will support meeting approved EA0809-001 measures, as applicable;	Section 3.1
c) A description of any engagement activities undertaken to inform the development of the Design Plan;	Section 3.2
d) Relevant background information used to inform the design, including, as is relevant:	
i. Data from geotechnical and geochemical investigations, as applicable;	Section 2, Appendices B1, B2

Table A-1: Water Licence MV2007L8-0031 Conditions

Water Licence MV2007L8-0031 Condition	Corresponding Section in Design Plan
ii. A description of the results or recommendations from any site-specific or Project Component-specific studies, research, modelling or testing and how they are addressed by the proposed design including, but not limited to:	Section 2, Appendices B1, B2
a. The results of programs to characterize soil, rock, geochemistry, Groundwater, ground ice or permafrost, and ground temperature conditions to the depth expected to be affected by the proposed activity, beneath the footprint of all containment and Contact Water control structures, as deemed adequate by the Professional Engineer responsible for the design; and	
b. Recommendations or conclusions from relevant Reclamation Research Plans.	N/A
iii. Discussion of how results of the Quantitative Risk Assessment have been incorporated into the design, as applicable;	Section 3.4
iv. Any other data collected to help inform development of the engineered design or specification; and	Section 3.4 and 4, Appendices B1, B2
v. Any other background information specific to the Project Component.	1.2
e) Activity-specific monitoring and mitigation details for the post-Construction phase, including:	
i. Monitored components;	Section 5.2
ii. Linkages to existing Site-Wide Management and Monitoring Plans, including any applicable updates and rationale;	Section 5.2.3
iii. Details and rationale for sampling locations, including a map to scale, types of instrumentation, including Surveillance Network Program updates, Operational Monitoring Program stations, parameters measured, sampling frequency, and where data will be reported;	Section 5.2.1
iv. Duration of monitoring to confirm Closure Criteria will be met and rationale to support that Closure Criteria are expected to remain met;	Section 5.2.2
v. An explanation of how proposed monitoring will consider the results of the Stress Study, as applicable; and	N/A (completion of stabilization of the underground and monitoring of the underground will be communicated to public and communities to relieve concerns about the Underground risks; the stress study results will not affect the monitoring of the underground but could influence communication in relation to completed closure activities)
vi. Any other monitoring details required to monitor and mitigate impacts to the Receiving Environment.	Section 5.2
f) A description of contingency activities that will be undertaken if monitoring results show that Project Components are not meeting Closure Criteria, or are not trending towards meeting Closure Criteria, this includes:	
i. Risks that have been identified related to not achieving the Closure Criteria;	Section 5.4.1

Table A-1: Water Licence MV2007L8-0031 Conditions

Water Licence MV2007L8-0031 Condition	Corresponding Section in Design Plan
ii. A threshold or Action Level which defines the point at which monitoring indicates a response is necessary; and	Section 5.4.2
iii. The proposed response to be implemented if a threshold is exceeded.	Section 5.4.2
g) A description, including frequency of the inspections for Engineered Structures, including geotechnical inspections; and	Section 4, Table 4-1, and Section 5.2
h) Any other information required by the Board.	N/A
Schedule 3, Condition 2: Board Directives for Specific Engineered Component Design Plans referred to in Part E, condition 10 of this Licence shall include, but not be limited to, the following:	
1. Underground Mine Workings a) Infrastructure details related to the decommissioning of the high-test line.	Section 4.5.6
2. Arsenic Trioxide Frozen Shell a) An explanation of how the results of the Freeze Optimization Study satisfy approved EA0809-001 measure 18 and the requirements of approved EA0809-001 measure 19, including a summary of recommendations from the Freeze Optimization Study; and b) Operational requirements and any anticipated maintenance, as applicable.	N/A
3. Borrow/Quarry Sources a) Linkages between pit filling and borrow requirements; b) A rationale supporting the choice in borrow sources including aesthetics, health and safety, cultural significance, and environmental considerations including source quantity and quality; c) A description of borrow requirements, sources, methods for quarrying, and storage of borrow materials, including: i. Closure Activities that require borrow materials for completion including estimated volumes; ii. Closure Activities that create borrow materials which contribute to overall volumes needed for Closure Activities, including estimated volumes; iii. Borrow sources that will provide the anticipated deficit in borrow material required to complete the activities described in Schedule 3, condition 2, item 3(c)(i), including the criteria used to select on-site borrow sources and the estimated volumes of each source; and iv. Location and description of any temporary storage areas for borrow materials on site, prior to use in support of Reclamation activities identified in Schedule 3, condition 2, item 3(c)(i). d) Information regarding Reclamation of borrow source locations including: i. Description of methods of reclamation for coarse and fine borrow sources including linkages to the Giant Mine Remediation Project Closure and Reclamation Plan; and ii. Identify the Closure Objectives and Closure Criteria as indicated in the Giant Mine Remediation Project Closure and Reclamation Plan that Reclamation of borrow sources is to satisfy in whole or in part.	N/A
4. Open Pit Mine Workings a) Linkage between pit filling and borrow requirements.	N/A
5. Water Treatment Plant and Outfall Systems a) Include details of monitoring Water Treatment Plant residuals; and b) Discuss the consideration of heat tracing (or incorporation, if appropriate) into the design.	N/A

Table A-1: Water Licence MV2007L8-0031 Conditions

Water Licence MV2007L8-0031 Condition	Corresponding Section in Design Plan
6. Contaminated soils and sediment a) Details of soil washing, if applicable.	Section 4.5.2 (information included herein in lieu of the contaminated soil and sediment design plan)
7. Baker Creek and Surface Water Drainage a) Include specific subsidence mitigation measures for the Baker Creek re-alignment; b) Include re-evaluated climate change assumptions; c) Review updated climate forecasts to reduce uncertainty in the probable maximum flood prediction and then review which pits, if any, require additional Freeboard, as well as possible scour protection; d) Include the development of specified design criteria for berms/diversions that will be developed during detailed design; and e) Information about the establishment of one sediment sampling location in Baker Creek once remediation is complete in Baker Creek.	a) Section 4.4.2 (supporting information to the forthcoming Baker and Surface Water Design Plan) b) N/A c) N/A d) N/A e) N/A
8. Tailings Containment Areas a) Identify acceptable limits of differential settlement in the cover that are needed to protect liner integrity; b) Identify mitigation or repair measures to be undertaken if differential settlement exceeds these limits; and c) Include any quantifiable performance objectives and criteria identified by the Engineer of Record, as required by Part E, condition 5, including how annual reviews will be reported	N/A
9. Constructed wetlands a) A description of the design and operation of constructed wetlands, if implemented, including: i. Information regarding the long-term operation of the constructed wetlands; ii. Predicted performance values based on design; iii. A summary, with appropriate maps or diagrams, of the location of the constructed wetlands and its components; iv. A description of the process and facilities intended for the purposes of maintaining the constructed wetlands in the long-term, including the frequency of dredging, and the quality and disposal location of any dredged sediment; v. Linkages to any Closure Objectives and Closure Criteria from the approved Giant Mine Remediation Project Closure and Reclamation Plan or Design Plan(s) that are satisfied in whole or in part by the management systems detailed in this Plan; vi. Any other information required to describe how the constructed wetlands will be managed and maintained to continue to meet the Closure Criteria; and vii. Any other information about the monitoring that will be performed to verify that the constructed wetlands are being managed to continue to meet the final design criteria for the structure	N/A

N/A = not applicable.

Table A-2 Concordance of the Closure and Reclamation Plan Underground Closure Criteria (Section 5.1) versus the Design Plan (Section 4)

Closure Objective	Closure Criteria in Section 5.1 of the CRP[a]	What change was made in this Design Plan?	Updated Criterion as in Table 4-1/Rationale
UG1. Access to underground workings from surface openings is restricted for the safety of humans and wildlife	**UG1-1** All existing openings to surface that are connected to the underground are secured in a manner that meets the NWT *Mine Health and Safety Act*.	No change from approved criterion	--
	UG1-2 Design engineering drawings are signed and stamped by a Qualified Professional and the specifications outlined therein are met, such that access to the underground is restricted.	No change from approved criterion	--
	UG1-3 There is no unauthorized access to the underground via the new portal. Refer to Surface Infrastructure 3-2 regarding post-closure access	No change from approved criterion	--
UG2. Minewater elevation will be managed to maintain mine physical stability and chemical stability	**UG2-1** Maintain minewater level at or below approximately the 750L which is equivalent to -77 m[b] above mean sea level (amsl) ± seasonal fluctuation (refer to Water Management and Monitoring Plan)	No change from approved criterion	--
	UG2-2 Minewater drawdown will not be faster than an amount that could destabilize the mine	Removed	**Rationale:** GMRP can meet the objective of managing the mine physical and chemical stability (UG2) by maintaining the mine water level at the range defined in UG2-1. The design for stabilization of the near surface non-arsenic stopes (revised criteria in development UG4-4) has been completed in a way that the stability of the backfill in the near surface stopes will be maintained, and the potential that fluctuations in mine water level will impact stability has been minimized. This will be supplemented by additional monitoring and adaptive management approaches in the case that issues are detected (also described with the revised criteria UG4-4).

Table A-2 Concordance of the Closure and Reclamation Plan Underground Closure Criteria (Section 5.1) versus the Design Plan (Section 4)

Closure Objective	Closure Criteria in Section 5.1 of the CRP[(a)]	What change was made in this Design Plan?	Updated Criterion as in Table 4-1/Rationale
UG3. Structures, controls, and adaptive management approaches used for the remediation of the arsenic trioxide meet appropriate design levels required for long-term care	**UG3-1** Meets the NWT *Mine Health and Safety Act* for plugging underground openings and backfilling voids and the establishment of the new long-term underground mine access	No change from approved criterion	--
	UG3-2 Design engineering drawings are signed and stamped by a Qualified Professional and the specifications outlined therein are met, so that the voids and backfill provide stabilization.	No change from approved criterion	--
	UG3-3 *Stabilizing backfill stays in place.* **(Criteria in Development)**	Criterion finalized	**Final criterion:** No more than 1.5 m of the rock in the crown pillar of an arsenic stope or chamber, or in the top of an adjacent non-arsenic stope separated by a boundary pillar, can fall into void spaces, such that subsidence does not damage critical infrastructure **Rationale:** The goal was to protect three arsenic stopes with adjacent non-arsenic voids that could destabilize if the backfill in those non-arsenic voids moved. The revised criterion sets an overarching quantitative goal, one that reflects the design approach and is applicable at all arsenic stopes and chambers. Not allowing more than 1.5m of crown pillar or boundary pillar failure will meet the overall objective UG3 – specifically as it relates to the design levels required for long term care. Action levels identifying what would constitute excessive displacement of the bottom of the crown pillars will be set in the design plan.
	UG3-4 *Potentially unstable crown pillar voids are backfilled such that subsidence does not cause damage to critical infrastructure* **(Criteria in Development)**	Removed	**Rationale:** Combined with 3-3, see rationale for 3-3

Table A-2 Concordance of the Closure and Reclamation Plan Underground Closure Criteria (Section 5.1) versus the Design Plan (Section 4)

Closure Objective	Closure Criteria in Section 5.1 of the CRP[a]	What change was made in this Design Plan?	Updated Criterion as in Table 4-1/Rationale
UG4. Underground is stabilized (geotechnically and physically) to reduce risks for public, workers, and wildlife safety	**UG4-1** Design engineering drawings for underground backfill are signed and stamped by a Qualified Professional and the specifications outlined therein are met	No change from approved criterion	--
	UG4-2 Drifts connected to arsenic stopes will be filled to the extent of the frozen shell (see F1-2 related to definition of shell)	No change from approved criterion	--
	UG4-3 Paste backfill meets minimum 100 kPa specification to prevent liquefaction during seismic event	No change from approved criterion	--
	UG4-4 *Stabilizing backfill stays in place* ***(Criteria in development)***	Criterion finalized	**Final criterion**: A minimum crown pillar rock thickness of 5 m (thickness of intact bedrock below overburden and above void) will be maintained where initial crown pillar thickness permits. **Rationale:** The revised criterion sets an overarching quantitative goal, one that reflects the design approach and is applicable at all stopes. Maintaining a minimum thickness of rock in the crown pillar (5 m) will meet the overall objective UG4. The underlying technical basis for this revised criterion was identified through the development of the monitoring and mitigation program. The monitoring and mitigation program provides an approach to identify potential instabilities in such a way that early remedial actions can be taken.
	UG4- 5 *Voids under potentially unstable crown pillars will be filled to the extent practicable (dependent on void geometry and access) such that no more than 1 m subsidence would occur at ground surface.* ***(Criteria in development)***	Removed	**Rationale:** This criterion is now redundant with revised UG 4-6.

Table A-2 Concordance of the Closure and Reclamation Plan Underground Closure Criteria (Section 5.1) versus the Design Plan (Section 4)

Closure Objective	Closure Criteria in Section 5.1 of the CRP[(a)]	What change was made in this Design Plan?	Updated Criterion as in Table 4-1/Rationale
UG4. Underground is stabilized (geotechnically and physically) to reduce risks for public, workers, and wildlife safety	**UG4- 6** *Voids under pits will be filled to the extent practicable (depending on void geometry and access) to prevent no more than 1 m subsidence of the fill in the pits and to prevent damage to pit covers, where installed.* ***(Criteria in development)***	Criterion finalized	**Final criterion:** Voids under pits and Stope DWC will be filled so that no more than 1 m subsidence would occur at ground surface. **Rationale:** The revised criterion informs the design of underground non-arsenic stopes where there are portions of the void that break through to surface. This includes non-arsenic stopes within open pits, as well as stope DWC which is located outside of the pits. This criterion recognizes that zero movement of the stabilizing backfill is not practical.

(a) Closure and Reclamation Plan (Version 2.0) submitted to the MVLWB in December 2020.

(b) Number has been rounded to the nearest metre.

CRP = Closure and Reclamation Plan; MVLWB = Mackenzie Valley Land and Water Board; kPa = kilopascal.

APPENDIX B

SITE INVESTIGATION REPORT COMPLETED SINCE CLOSURE AND RECLAMATION PLAN

APPENDIX B1

SITE INVESTIGATION REPORTS COMPLETED SINCE CLOSURE AND RECLAMATION PLAN – UNDERGROUND STABILIZATION DESIGN BASIS

APPENDIX B2

SITE INVESTIGATION REPORTS COMPLETED SINCE CLOSURE AND RECLAMATION PLAN – BENCH SCALE TESTING OF SHALLOW HEAVILY IMPACTED SOIL NEAR FORMER ROASTER COMPLEX, GIANT MINE REMEDIATION PROJECT, NT

APPENDIX C

UNDERGROUND STABILIZATION DRAWINGS

APPENDIX D

SOIL EXCAVATION DRAWINGS

APPENDIX E

OPENINGS TO SURFACE DRAWINGS

APPENDIX F

LONG-TERM PORTAL DRAWINGS

APPENDIX G

DRILLING DRAWINGS

APPENDIX H

MONITORING LOCATIONS ACROSS SITE