Coffee Gold Mine

YESAB Project Proposal

Appendix 31-C Conceptual Reclamation and Closure Plan

VOLUME V

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AMP	adaptive management plan
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRCP	Conceptual Reclamation and Closure Plan
EBR	electrochemical biological reactor
EEM	environmental effects monitoring
EMR	Yukon Government Energy, Mines and Resources
EP	event pond
FoS	factor of safety
GCL	geosynthetic clay liner
Goldcorp	Kaminak Gold Corporation, a wholly owned subsidiary of Goldcorp Inc.
HDPE	high-density polyethylene
HLF	heap leach facility
LAA	local assessment area
LLDPE	linear low-density polyethylene
LSA	local study area
ML/ARD	metal leaching / acid rock drainage
MMER	metal mine effluent regulations
NAG	non-acid generating
NAR	Northern Access Route
PAG	potentially acid generating
PRB	permeable reactive barrier
Project	Coffee Gold Mine
ROM	run of mine
RSA	regional study area
SARA	*Species at Risk Act*
TSS	total suspended solids
VC	valued component
WAD	weak acid dissociable
WRSF	waste rock storage facility
YESAB	Yukon Environmental and Socio-economic Assessment Board
YISC	Yukon Invasive Species Council
YWB	Yukon Water Board
ZVI	zero-valent iron

UNITS AND MEASURES

Abbreviation	Measurement
µg	microgram
µS	micro-Siemens
%	percent
cm	centimetre
ha	hectare
km	kilometre
L	litre
M	million
m	metre
mg	milligram
NTU	nephelometric turbidity unit

1.0 INTRODUCTION

This Conceptual Reclamation and Closure Plan (CRCP or Plan) has been developed for the Coffee Gold Mine (Project) Project Proposal to be submitted to the Yukon Environmental and Socio-economic Assessment Board (YESAB) Executive Committee for screening under the *Yukon Environmental and Socio-economic Assessment Act*. This Plan is conceptual in nature and has been developed to provide the level of detail necessary for the assessment stage of the Project. Descriptions are based on Project details developed during and subsequent to the Project Feasibility Study (JDS 2016).

Kaminak Gold Corporation, a wholly-owned subsidiary of Goldcorp Inc. (Goldcorp) has retained SRK Consulting and Lorax Environmental Services to lead the development of this CRCP. Contributors to each CRCP section are listed at the beginning of this document.

The purpose of this Plan is to (1) provide the proposed approach to decommission mine features and reclaim landforms, and (2) outline a monitoring program to be conducted until mitigation and reclamation measures have achieved closure objectives. This Plan has been developed in accordance with current best practices and is based on the best information available at the present time. The general structure of this Plan and a brief description of the section content are as follows:

- **Section 1.0 Introduction** – Provides an overview of the proposed Project and the regulatory context for this CRCP, describes the strategies and objectives incorporated into reclamation and closure planning, presents the Project schedule, and briefly outlines the types of design criteria considered for the closure of mine infrastructure.
- **Section 2.0 Reclamation and Closure Planning** – Describes components of reclamation planning, including specific measures, practices and plans applicable to achieving closure objectives at the site, outlines the approach to adaptive management, and presents key objectives and activities for seasonal or temporary closure.
- **Section 3.0 Conceptual Reclamation and Closure of Mine Features** – Presents the measures and design criteria for decommissioning and closure of mine facilities and infrastructure to allow environmentally safe and responsible closure of the Project.
- **Section 4.0 Site Water Management** – Describes site water management and monitoring activities both during implementation of closure and after decommissioning and reclamation measures are completed.
- **Section 5.0 Monitoring and Surveillance for Closure Phases**– Outlines proposed monitoring and surveillance activities for the Reclamation and Closure Phase (including Post-mining Closure and Active Closure stages), and the Post-closure Phase.
- **Section 6.0 Reclamation and Closure Execution Strategy** – Describes the conceptual strategy for executing the reclamation and closure activities.
- **Section 7.0 Reclamation and Closure Liability** – Presents the cost estimate methodology and liability estimate for decommissioning and reclaiming the Project site at the end of the mine life.

1.1 Project Overview

Goldcorp proposes to develop the Project in the White Gold District of west-central Yukon, approximately 130 km south of the City of Dawson and 330 km northwest of Whitehorse (**Figure 1.1-1**). The Mine Site is located within Tr'ondëk Hwëch'in Traditional Territory (**Figure 1.1-1**). The Project will consist of an open pit heap leach gold mine using conventional shovel and truck mining methods with an ore production rate of five million tonnes per year over a 12-year operational mine life. Conceptual design indicates a total of 60.1 Mt of mined ore over the life of the mine, containing 2.5 million ounces of gold.

Goldcorp proposes to construct the Project over a 2.5-year period during the Construction Phase, commencing in mid-Year -3 of the Project. At the end of the Construction Phase (Year -1), pre-production mining of waste rock and ore will commence and the recovery of first gold will occur, triggering the Operation Phase. Mining and processing will continue over 12 years (Year 1 to the end of Year 12). During the Operation Phase, progressive reclamation activities will be ongoing, beginning as early as Year 2 when mining at the Double Double pit is completed. The Reclamation and Closure Phase (Years 13 to end of Year 23) will commence when all mining and processing have been completed, and will be followed by the Post-closure Phase from Year 24 onwards.

Access to the Project will be provided by airplane or helicopter or by an all-season 214 km all-season road referred to as the Northern Access Route (NAR). As described in detail in Section 2.0 Project Description of the Project Proposal, key Project components at the Mine Site will include:

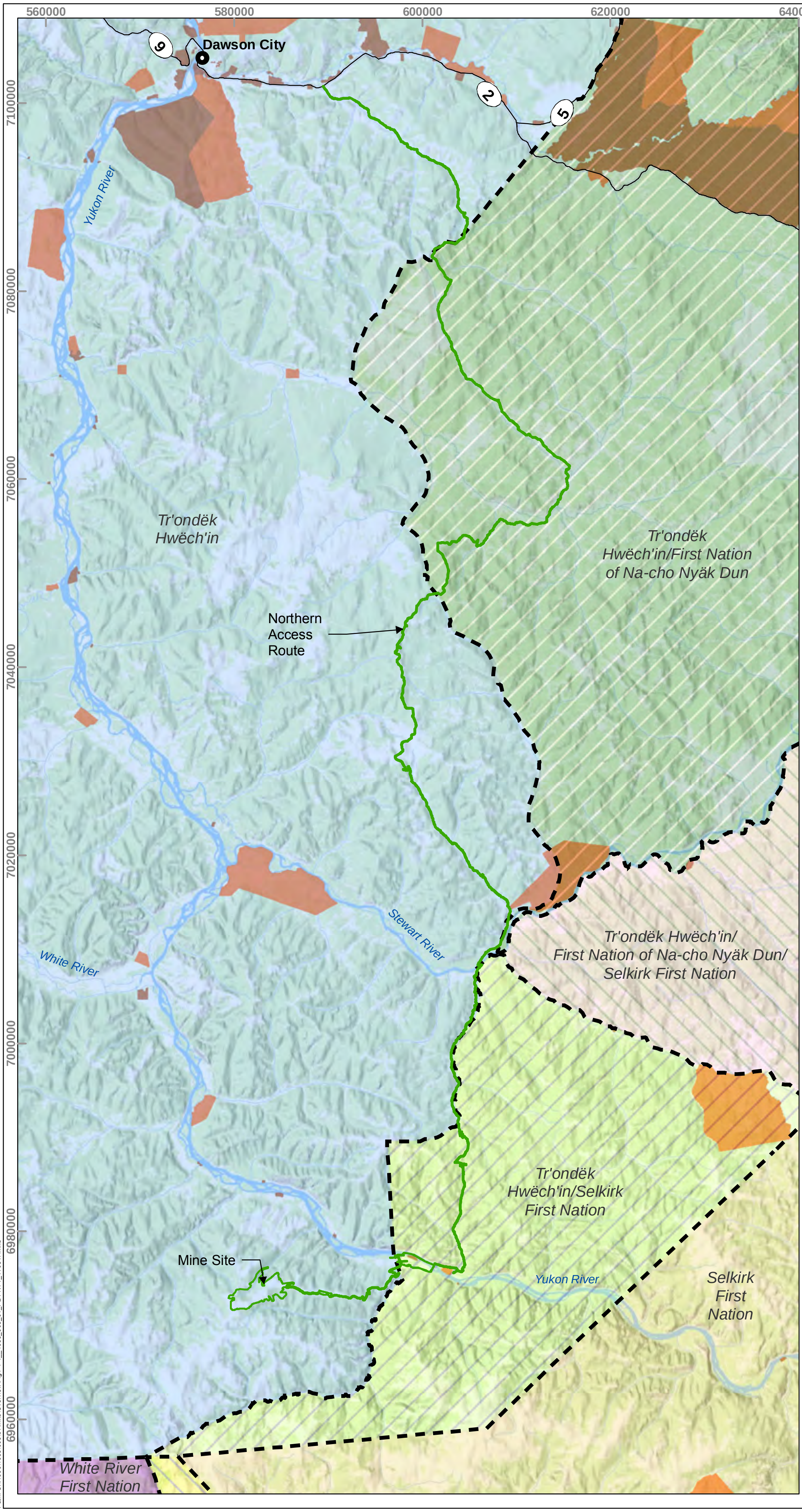
- Four open pits – Latte, Double Double, Supremo, and Kona
- Two waste rock storage facilities (WRSFs)– Alpha and Beta
- Stockpiles including a temporary organics stockpile, a frozen soil storage area, and a run-of-mine (ROM) stockpile
- Crusher system including crushing circuits and a crushed ore stockpile
- Heap leach facility (HLF) including lined heap leach pad, associated event ponds, a rainwater pond, and associated piping and water management infrastructure
- Plant Site including process plant, reagent storage area, laboratory, truck shop and warehouse building, power plant, and bulk fuel storage
- Camp Site including dormitories, kitchen, dining, and recreation complex buildings, mine dry and office complex, emergency response and training building, fresh (potable) water and fire water systems, sewage treatment plant, and waste management building
- Bulk Explosive Storage Area
- Mine Site roads and haul roads
- Site water management infrastructure (e.g., Alpha and Facility ponds, diversion structures, ditches).

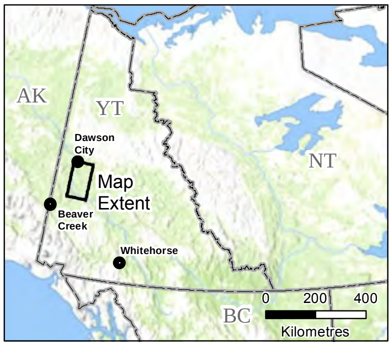
The layout of the Mine Site at the cessation of Operation Phase activities and commencement of Reclamation and Closure Phase activities in Year 13 is presented in **Figure 1.1-2**.

In 2010, Goldcorp initiated the collection of environmental data and heritage information to characterize existing conditions. The collection of environmental information, which is ongoing, includes the disciplines of water (surface and groundwater), hydrology (surface and groundwater), climate, air quality, vegetation, wildlife, and aquatic life. The data collected to date is reflective of undisturbed areas found in and around the Project area. Goldcorp has involved First Nations and other stakeholders including Yukon Government in the design, implementation and data collection of the characterization programs. The Project area was, and continues to be, used by First Nations and future use has and continues to be considered in Project planning.

COFFEE GOLD MINE

Coffee Gold Mine Location and First Nations Traditional Territories





Legend

- Highway
- Watercourse
- Settlement Lands - Category
- Settlement Lands - Category B

Traditional Territories

- Traditional Territory Boundary
- Traditional Territory of Selkirk First Nation
- Traditional Territory of Tr'ondëk
- Shared Traditional Territory of Tr'ondëk Hwëch'in, First Nation of Na-cho Nyäk Dun
- Shared Traditional Territory of Tr'ondëk Hwëch'in, First Nation of Na-cho Nyäk Dun, Selkirk First Nation
- Shared Traditional Territory of Tr'ondëk Hwëch'in, Selkirk First Nation
- Traditional Territory of White River First Nation
- Shared Traditional Territory of White River First Nation, Selkirk First Nation

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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Figure 1.1-1	Date: Mar 17, 2017	Drawn by: JS	Reviewed: DP

GOLDCORP

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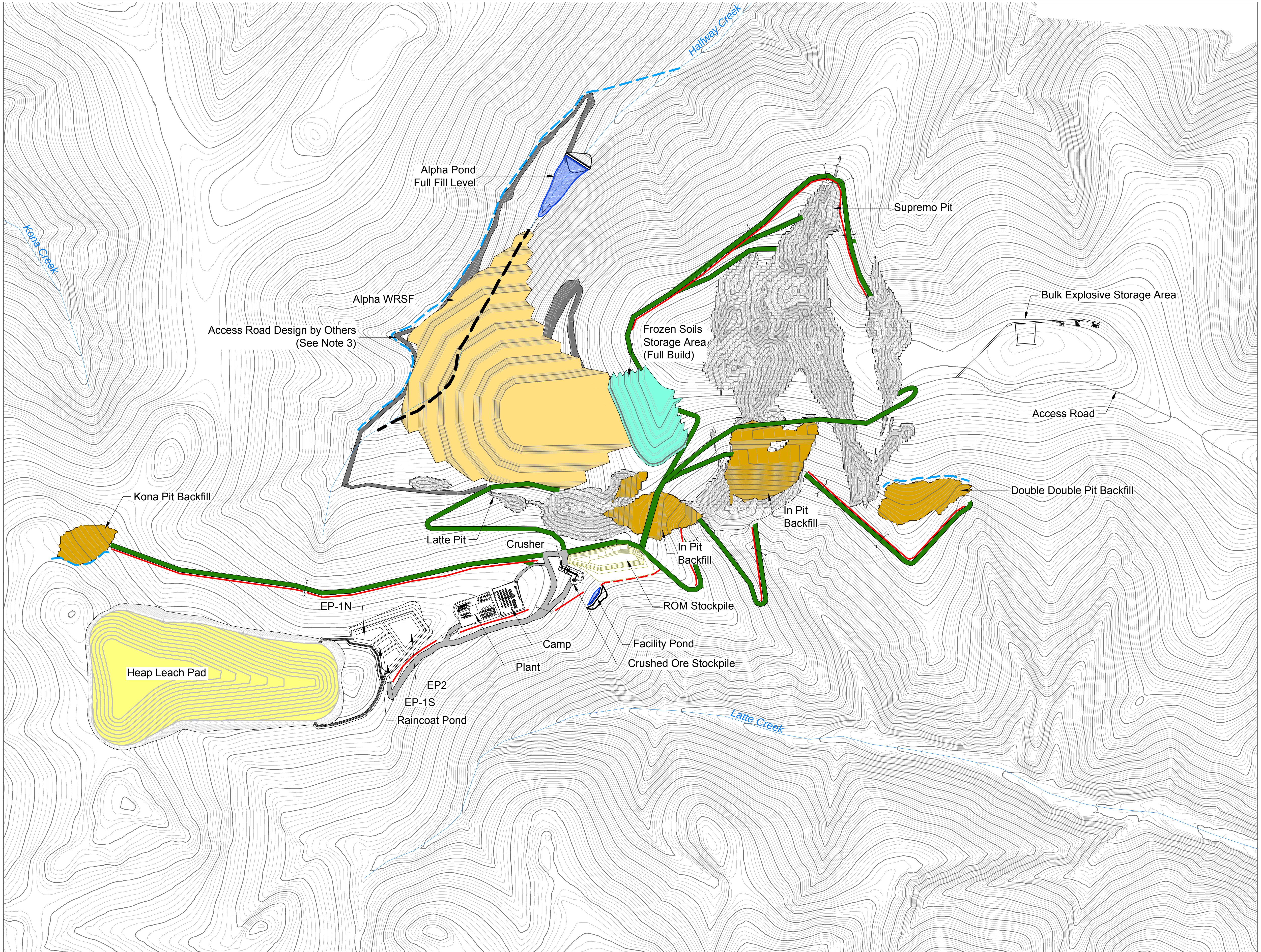

COFFEE GOLD MINE

Mine Site Layout at the Commencement of Reclamation and Closure Phase Activities in Year 13

Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

Notes

1. This figure is not intended to be a "stand-alone" document, but a visual aid to the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. Contours shown at a 5 meter contour interval.
3. Access Road design to be finalized in next phase.

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Figure 1.1-2	Date: Mar 29, 2017	Drawn by: TAH	Reviewed: DP/TS

GOLDCORP

1.2 REGULATORY CONTEXT

This CRCP has been developed in accordance with industry best practices (outlined in the **Sections 2.0** to **7.0**, where relevant), and was informed by Yukon regulatory, policy, and guidance requirements in these primary documents:

- *Reclamation and Closure Planning for Quartz Mining Projects (YWB and EMR, 2013)*
- *Yukon Mine Site Reclamation and Closure Policy (EMR, 2006), and*
- *Yukon Mine Site Reclamation and Closure Policy - Financial and Technical Guidelines (EMR, 2013).*

The Project is subject to assessment by the Executive Committee of YESAB under the *Yukon Environmental and Socio-economic Assessment Act*, and subsequently to license approvals under the *Quartz Mining Act* and the *Yukon Waters Act*. A more detailed plan, developed in accordance with the plan requirements and closure costing guidance of the *Reclamation and Closure Planning for Quartz Mining Projects* (YWB and EMR, 2013), will be submitted in conjunction with the application for a Type A Water Use Licence to the Yukon Water Board (YWB) and Quartz Mining License application to Yukon Government Energy, Mines and Resources (EMR). Over the life of the mine, successive iterations of the Reclamation and Closure Plan may be expected every two years, with each iteration providing more detail (from lessons learned through reclamation research programs, mine operation and monitoring programs) and greater certainty regarding the sequence of closure activities to occur progressively during operations and during closure.

1.3 CLOSURE STRATEGIES AND OBJECTIVES

The Yukon Water Board emphasizes the importance of robust reclamation and closure planning, stating that it will endeavour to "…issue licences only when there is a reasonable certainty that an acceptable level of reclamation of the site can be achieved during mining and/or following cessation of mining" (YWB 2012). A principal philosophy, therefore, followed during Project planning and development of this Plan was to work towards an eventual closure that requires minimal long-term monitoring and maintenance. Strategies and objectives to allow this closure philosophy to be realized are described below.

1.3.1 RECLAMATION AND CLOSURE STRATEGIES

Goldcorp intends to implement a technically feasible reclamation and closure plan that is environmentally sound, while respecting local laws, traditional land uses, and public interests. Several key strategies or principles to achieve this are as follows:

- Early and ongoing community and regulatory engagement;
- Designing for closure, including reclaiming disturbed areas progressively during the Operation Phase;
- Reducing affected water and controlling contaminants at source; and
- Planning for long-term monitoring and maintenance, while minimizing long-term operational activities.

Additional details on each of these strategies are provided below.

1.3.1.1 Community and Regulatory Engagement

Engagement with the community, including governments (First Nation, federal, territorial), local communities, assessment/regulatory authorities and non-government organizations has been an essential strategy from the onset of Project planning. Consultation is well underway to 1) gain an understanding of expectations and concerns for reclamation and closure of the Project, and 2) incorporate input into Project planning, design, implementation, and monitoring for activities or developments that are open to modification. Goldcorp has focused on building relationships into meaningful partnerships with stakeholders, and views consultation not as a single conversation but a series of conversations allowing the creation of capacity and understanding of the Project among potentially affected First Nations and communities. Section 3.0 of the Project Proposal provides additional information pertaining to consultation activities undertaken to date and topics discussed, and how Goldcorp has considered the views, expectations, and concerns regarding decommissioning and reclamation.

There is an expectation by all parties consulted that mine development will be undertaken in a responsible manner and that measures will be put in place for the protection of the environment and public health and safety. In addition, the parties look to see socio-economic benefits from the mine flowing to them, and that business opportunities accrue to the Yukon. As per Goldcorp's Sustainability Excellence Management System, Goldcorp will consult and work with communities on future detailed reclamation and closure plans, which will include mitigation measures and activities related to socio-economic aspects of closure (e.g., community contributions, partnerships).

1.3.1.2 Design for Closure Including Progressive Reclamation

The Project mine plan has and will continue to be designed with closure in mind by integrating closure considerations into the mine's planning and operational processes. Information specific to the closure of mine infrastructure and management of water is provided in **Sections 3.0** and **4.0**, respectively.

A key element in designing for closure is the incorporation of progressive closure activities including contouring, backfilling and re-vegetating areas no longer needed for mining during active operations, where practicable. Progressive reclamation will ultimately advance the return of disturbed areas to self-sustaining biological ecosystems, increase confidence in long-term reclamation success, and reduce the overall final cost of reclamation by taking advantage of operational efficiencies. Goldcorp intends to maximize all opportunities for operational implementation of progressive reclamation activities. Reclamation and re-vegetation studies were initiated in 2013; additional reclamation research activity information is provided in **Section 2.3**.

1.3.1.3 Reducing Affected Water and Contaminant Source Control

The Project has been designed to avoid mixing of unaffected water with mine-related contaminants. Unaffected water will be routed away from Project components at various locations around the Mine Site. Project design has also incorporated various measures for controlling contaminants, such as waste segregation, specific waste storage locations, liners, covers, water collection and treatment, surface diversions and others, as described further in **Section 3.0**.

1.3.1.4 Long-term Planning

The Project has been designed to minimize ongoing intervention or operating activities after completion of mine reclamation and closure activities, with anticipated activities consisting of periodic monitoring, inspections, and limited maintenance. Long-term monitoring and maintenance activities have been incorporated in the Post-closure Phase, as described in **Section 5.0**.

1.3.2 RECLAMATION AND CLOSURE OBJECTIVES

The overall objectives for the Project are to permanently close the mine with minimal intervention or ongoing requirements, except for periodic inspections and minimal maintenance, and to allow the mine site to be closed in accordance with the objectives listed in **Table 1.3-1**. These reclamation and closure objectives are intended to respect the values and expectations of future land users, and fulfill expectations of governments and regulators. These objectives have been incorporated into the closure measures described in **Section 3.0**.

Table 1.3-1 Fundamental Mine Reclamation and Closure Objectives

Value	Reclamation and Closure Objectives
Physical Stability	All mine-related structures and facilities are physically stable and performing in accordance with designs. All mine-related structures, facilities and processes can withstand severe climatic and seismic events.
Chemical Stability	Release of contaminants from mine related waste materials occurs at rates that do not cause unacceptable exposure in the receiving environment.
Health and Safety	Reclamation eliminates or minimizes existing hazards to the health and safety of the public, workers and area wildlife by achieving conditions similar to local area features. Reclamation and closure implementation avoids or minimizes adverse health and safety effects on the public, workers and area wildlife.
Ecological Conditions and Sustainability	Reclamation and closure activities protect the aquatic, terrestrial and atmospheric environments from mine-related degradation and restore environments that have been degraded by mine-related activities. The mine site supports a self-sustaining biological community that achieves land use objectives.

Value	Reclamation and Closure Objectives
Land Use	Lands affected by mine-related activities (e.g., building sites, chemical and fuel storage sites, roads, sediment ponds, tailings storage facilities, waste rock storage areas, underground workings, etc.) are restored to conditions that enable and optimize productive long-term use of land. Conditions are typical of surrounding areas or provide for other land uses that meet community expectations. Site access is consistent with community land use expectations.
Aesthetics	Restoration outcomes are visually acceptable.
Socio-economic Expectations	Reclamation and closure implementation avoids or minimizes adverse socio-economic effects on local and Yukon communities, while maximizing socio-economic benefits. Reclamation and closure activities achieve outcomes that meet community and regulatory expectations.
Long-term Certainty	Minimize the need for long-term operations, maintenance and monitoring after reclamation activities are complete.
Financial Considerations	Minimize outstanding liability and risks after reclamation activities are complete.

Source: YWB and EMR (2013)

1.4 CLOSURE STAGES AND SCHEDULE

Closure-related activities are anticipated to occur over a 22-year period from Year 2 to Year 23 in distinct stages, including:

- Operational Closure Stage during the Operation Phase,
- Post-mining Closure and Active Closure stages during the Reclamation and Closure Phase, and
- The Post-closure Phase.

The timing of these stages are illustrated in **Figure 1.4-1** and general requirements related to reclamation, closure, and monitoring activities for each stage are summarized in **Table 1.4-1**. Activities that are conducted during the Operational Closure Stage are typically referred to as progressive reclamation activities.

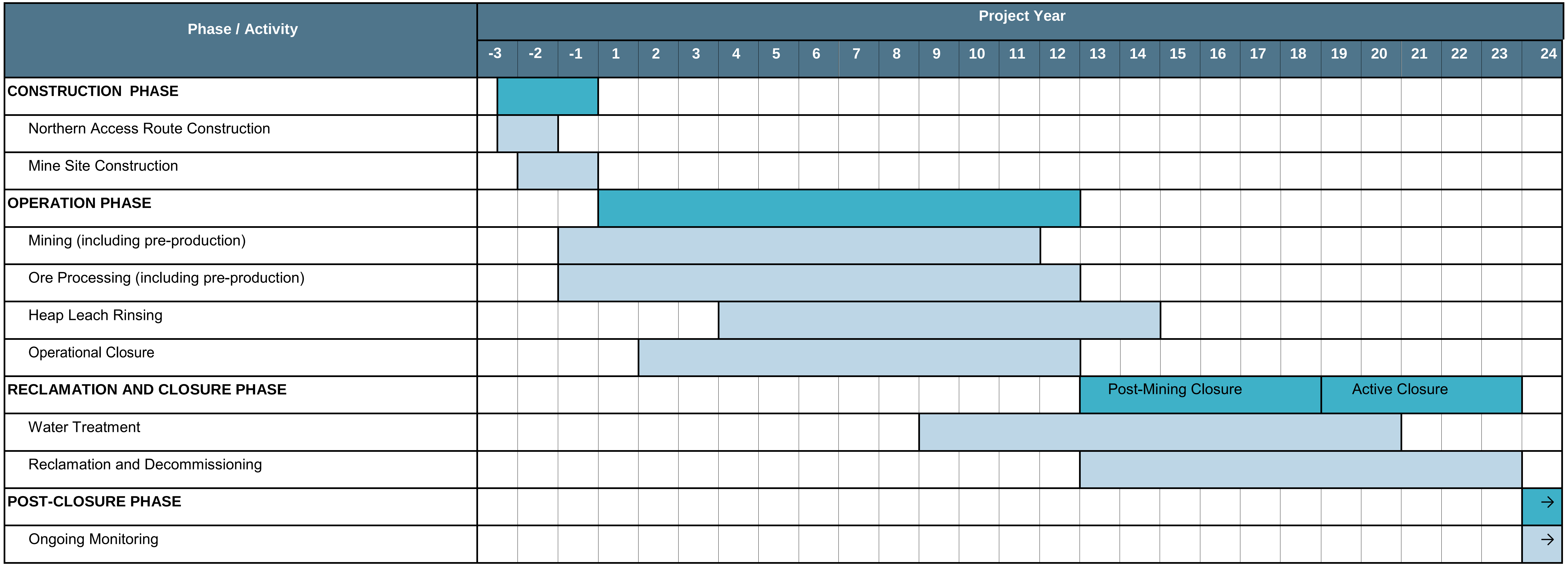


Figure 1.4-1 Schedule of Key Activities by Project Phase

Table 1.4-1 Closure and Monitoring Activities Planned during the Operation, Reclamation and Closure, and Post-closure Phases

Closure Period	Project Years	Planned Reclamation and Closure Activities	General Monitoring Activity Requirements
Operation Phase			
Operational Closure	Year 2 to end of Year 12	Reclamation and closure activities will be undertaken in a progressive manner when pits, WRSFs, and stages of the HLF are no longer required to support mine operations. Closure activities planned during the Operation Phase include the following: • Progressive reclamation of disturbed areas within the Mine Site footprint that are no longer required to support mine operations • Partial backfill of Latte and Supremo pits and closure of disused haul roads • Commence backfill of Kona and of complete backfill of Double Double pits and closure of disused haul roads • Progressive reclamation and closure of early stages of HLF • Installation of water treatment facility and commencement of water treatment of drain-down rinse water from closed HLF stages	Routine monitoring will occur in accordance with conditions of mine operating licenses.
Reclamation and Closure Phase			
Post-mining Closure Stage	Year 13 to end of Year 18	Reclamation and closure activities that are planned during the first stage of the Reclamation and Reclamation and Closure Phase include the following: • Complete backfill of Kona pit and closure of associated haul roads • Reclamation of disturbed areas within the Mine Site footprint that are no longer required to support closure activities • Equipment removed from service when no longer required to support closure activities • Excavation of contaminated soil followed by on-site treatment or temporary storage and off-site disposal • Reclamation of Latte pit and Supremo pit • Reclamation of Alpha WRSF, including frozen soil storage area, and Beta WRSF footprint area • Reclamation of the temporary organic stockpile area once stockpiled materials have been used and reclamation of the ROM stockpile area • Continued water treatment of drain-down rinse water from closed HLF stages, until rinsing of the heap is complete, then reclamation and closure of the HLF and water management structures • Dismantling and removal of process plant, reagent storage area, laboratory, truck shop and warehouse building, power plant, and bulk fuel storage at the Plant site, as well as the explosives storage facility at the bulk explosives storage area	Routine monitoring will continue, and reclamation of disturbed areas and subsequent monitoring of these areas will be undertaken.

		• Dismantling and removal or dormitories and kitchen, dining, and recreation complex buildings, mine dry and office complex, emergency response and training building, fresh (potable) water and fire water systems, sewage treatment plant, and waste management building at the Camp Site at the end of this stage • Decommissioning and reclamation of new sections along the NAR and the Project airstrip at the end of this stage	
Active Closure Stage	Year 19 to end of Year 23	Reclamation and closure activities that are planned during the second stage of the Reclamation and Reclamation and Closure Phase include the following: • Dismantling and/or removal of remaining infrastructure and equipment • Reclamation of remaining disturbed areas within the Mine Site footprint • Continued water treatment until HLF effluent is of suitable quality for discharge	Monitoring will be undertaken to observe progress towards the return of the Mine Site to pre-mining conditions.
Post-closure Phase			
Post-closure Phase	Year 24 onwards	Reclamation activities are complete.	Monitoring schedule frequency is reduced as performance criteria is met and reclamation and closure objectives are achieved.

Activities related to reclamation that occur (in whole or in part) in advance of the Post-mining Closure Stage include, but are not limited to the following:

- Salvaging and stockpiling of overburden material and soil (see **Section 2.2**)
- Installing sediment and erosion control measures (see **Section 2.2**)
- Monitoring and managing invasive plant species (see **Section 2.2**)
- Conducting reclamation field trials and research programs (see **Section 2.4**), and
- Completing progressive reclamation activities during the Operation Phase (see **Table 1.4-1**).

The primary focus of this CRCP is on reclamation and closure activities that commence in Year 13 following the cessation of mining and ore processing activities.

1.5 CLOSURE DESIGN CRITERIA

Reclamation and closure planning has been guided by many design criteria, ranging from regulatory and guidance-based criteria, constraints imposed by the Project location and local area characteristics, and criteria established through consultation with stakeholders. Design criteria that are relevant to closure are presented in **Section 3.0** by mine component, including the applicable geotechnical, hydrologic, and/or water quality criteria for that component.

2.0 RECLAMATION AND CLOSURE PLANNING

Reclamation and closure planning has been a primary consideration from the onset of mine planning and design. This section provides information on reclamation practices incorporated into the Project mine plan. Reclamation and closure planning has focused on the following goals:

- Achieving short- and long-term erosion control
- Ensuring that future land use is compatible with surrounding lands, and
- Leaving the area as a self-sustaining ecosystem.

As stated previously in **Section 1.3.1**, Goldcorp recognizes that closure is a process, not an event, and has implemented a 'design for closure' approach into mine design. Goldcorp has and will continue to work with stakeholders to integrate scientific, traditional and local knowledge in mine reclamation and closure planning and implementation for the Coffee Project. Goldcorp also intends to provide socioeconomic benefits from mine reclamation and closure activities (where feasible and practical) to local communities and First Nations, particularly those who have the potential to be most affected by the mine and its closure.

The following principles and strategies, as outlined by EMR (2006) and YWB and EMR (2013), have informed reclamation and closure planning for the Coffee Project:

- Progressive reclamation of the site during the Operation Phase (key activities are summarized in **Table 1.4-1**)
- Reclamation and revegetation of surface disturbances using the best practicable and "leading edge" technological and scientific measures, and
- Periodic re-evaluation, refinement, and improvement of reclamation and closure plans to incorporate, for example, changing site conditions, improved understanding of physical and chemical performance of project components, and results of ongoing reclamation research and monitoring programs.

Additional information pertaining to reclamation and closure planning is provided in the sections that follow, including:

- **Section 2.1 Post-mining Disturbance and Post-Closure Ecosystem Description** - summarizes the areas of mining-related surface disturbances, and describes reclamation target ecosystems
- **Section 2.2 Reclamation Measures and Practices** - details general measures and practices to minimize reclamation requirements during the Reclamation and Closure Phase, including soil and overburden management, erosion and sediment control, and invasive plant management
- **Section 2.3 Reclamation Research Programs** – describes revegetation reclamation research activities conducted from 2013 to 2015, and future research activities for revegetation as well as closure of the HLF
- **Section 2.4 Closure Adaptive Management Plan** – outlines the proposed approach towards adaptive management in order to achieve reclamation and closure objectives, and
- **Section 2.5 Seasonal or Temporary Closure** – presents measures and activities to be undertaken in the event of seasonal or temporary closure.

2.1 POST-MINING DISTURBANCE AND POST-CLOSURE ECOSYSTEM DESCRIPTION

The purpose of this section is to provide context for the level of effort required to reclaim the site by summarizing the spatial extent of disturbed areas anticipated from mining-related features and activities and describing the target ecosystems for the restoration of land use and wildlife habitat capabilities during the Reclamation and Closure Phase and beyond.

2.1.1 MINING-RELATED AREAS OF DISTURBANCE

The Project area encompasses 22,000 ha, and includes areas unaffected and potentially affected by the Project. The spatial extent of disturbance within the Project area has been estimated based on the footprint areas for Mine Site infrastructure and facilities and transportation infrastructure, as shown in **Figure 2.1-1** for the Mine Site, **Figure 2.1-2** for the Mine Site Access Route, airstrip, and southern portion of the NAR, and **Figure 2.1-3** for the NAR. The footprint areas shown in the figures represent the full extent of Project-related disturbance to permit a conservative approach[1].

Table 2.1-1 summarizes the estimated spatial extent of disturbance associated with specific mine features, and indicates whether reclamation activities will be conducted progressively or at the end of operations. The disturbance area estimates provided in **Table 2.1-1** include the following buffers to allow for modifications that may arise during detailed design:

- 10 m from the perimeter of mine site infrastructure and facilities, other than transportation corridors.
- 10 m either side of the centerline for the Mine Site Access Route (between the Project airstrip and the Mine Site)
- 10 m either side of the centerline for the Yukon River and Stewart River ice roads
- 50 m from the perimeter of the Project airstrip running surface
- 50 m either side of the centreline for the 37 km portion of the NAR (i.e., those sections that are newly constructed to support Project activities and will be reclaimed)
- 50 m from the perimeter of spoil and borrow sites along the NAR.

The total area of disturbance is approximately 1130 ha and approximately two-thirds of this area will be actively reclaimed (**Table 2.1-1**). Specific reclamation and closure details for these mine features are provided in **Section 3.0**.

[1] The fullest extent of Project disturbance represents the total potential disturbance area over time and is irrespective of when disturbances occur. In areas where Project components overlap spatially over time, areas have not been corrected to account for such overlap. For the Project footprint area shown for the Mine site area in **Figure 2.1-1**, the overall footprint area incorporates a buffer to allow for potential disturbances beyond the infrastructure or facility footprint areas specified in **Table 2.1-1.**

Table 2.1-1 Summary of Estimated Areas of Disturbance within the Project Area

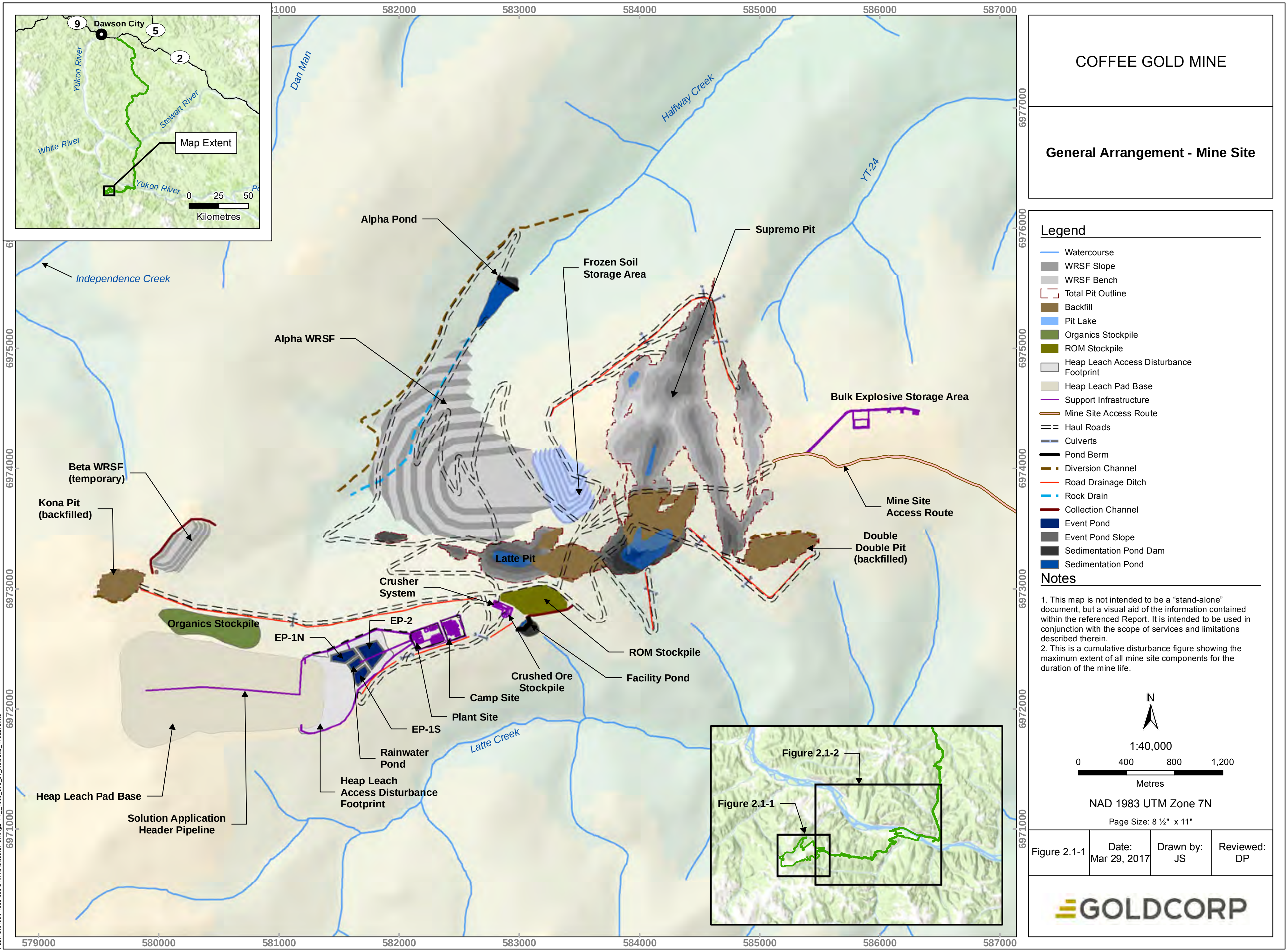
Mine Feature	Area (ha)	Area Reclaimed
Open Pits[a]	**213.3**	
Double Double	12.6	Yes*
Latte	31.0	No
Kona	34.3	Yes*
Supremo	7.6	No
Waste Rock Storage Facilities and Stockpiles[a]	**185.9**	
Alpha WRSF	148.1	No
Beta WRSF	11.3	Yes
Temporary Organics Stockpile	16.0	Yes
Run-of-Mine Ore Stockpile	9.5	Yes
Crusher and Crushed Ore Stockpile	1.0	Yes
Heap Leach Facility[a]	**150.3**	
Heap Leach Pad and Infrastructure	142.0	Yes
Event and Rainwater Ponds	8.3	Yes
Supporting Mine Infrastructure/Facilities[a]	**19.0**	
Plant Site and Camp Site	8.8	Yes
Bulk Explosive Storage Area	3.1	Yes
Alpha Sediment Pond	1.8	Yes
Facility Sediment Pond	1.7	Yes
Water Management Infrastructure	3.6	Yes
Roads and Airstrip	**560.7**	
Mine Site Access Route to Airstrip[a]	11.1	Yes
Mine Site Haul Roads[a]	94.9	Yes
Airstrip[b]	24.4	Yes
Northern Access Route – Project Portion[c]	375.0e	Yes
Potential Spoil and Borrow Sites along Access Route[b]	48.9	Yes
Yukon River and Stewart River Ice Roads[a]	2.1	Yes
TOTAL AREA OF DISTURBANCE	**1129.2**	

Notes: * Progressively backfilled (either completely or partially) as part of operational closure activities.

a. Area includes 10 m buffer from centreline of roads or from perimeter of mine features.

b. Area includes 50 m buffer the perimeter of the Project airstrip running surface and the perimeter of spoil and borrow sites along the NAR.

c. Area represents the 37 km portion of access route that is newly constructed to support mine development and operations and includes 50 m buffer either side of the centerline.



COFFEE GOLD MINE
General Arrangement - Mine Site
Legend
Watercourse
WRSF Slope
WRSF Bench
Total Pit Outline
Backfill
Pit Lake
Organics Stockpile
ROM Stockpile
Heap Leach Access Disturbance Footprint
Heap Leach Pad Base
Support Infrastructure
Mine Site Access Route
Haul Roads
Culverts
Pond Berm
Diversion Channel
Road Drainage Ditch
Rock Drain
Collection Channel
Event Pond
Event Pond Slope
Sedimentation Pond Dam
Sedimentation Pond
Notes
1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. This is a cumulative disturbance figure showing the maximum extent of all mine site components for the duration of the mine life.
N
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Metres
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Figure 2.1-1
Date: Mar 29, 2017
Drawn by: JS
Reviewed: DP
GOLDCORP
Dawson City
9
5
2
Yukon River
Stewart River
White River
Map Extent
Yukon River
0 25 50
Kilometres
Dan Man
Halfway Creek
YT-24
Independence Creek
Alpha Pond
Supremo Pit
Frozen Soil Storage Area
Alpha WRSF
Bulk Explosive Storage Area
Beta WRSF (temporary)
Kona Pit (backfilled)
Mine Site Access Route
Double Double Pit (backfilled)
Latte Pit
Crusher System
Organics Stockpile
EP-2
EP-1N
ROM Stockpile
Facility Pond
Crushed Ore Stockpile
Camp Site
Plant Site
EP-1S
Latte Creek
Rainwater Pond
Heap Leach Access Disturbance Footprint
Heap Leach Pad Base
Solution Application Header Pipeline
Figure 2.1-2
Figure 2.1-1
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6971000 6972000 6973000 6974000 6975000 6976000 6977000
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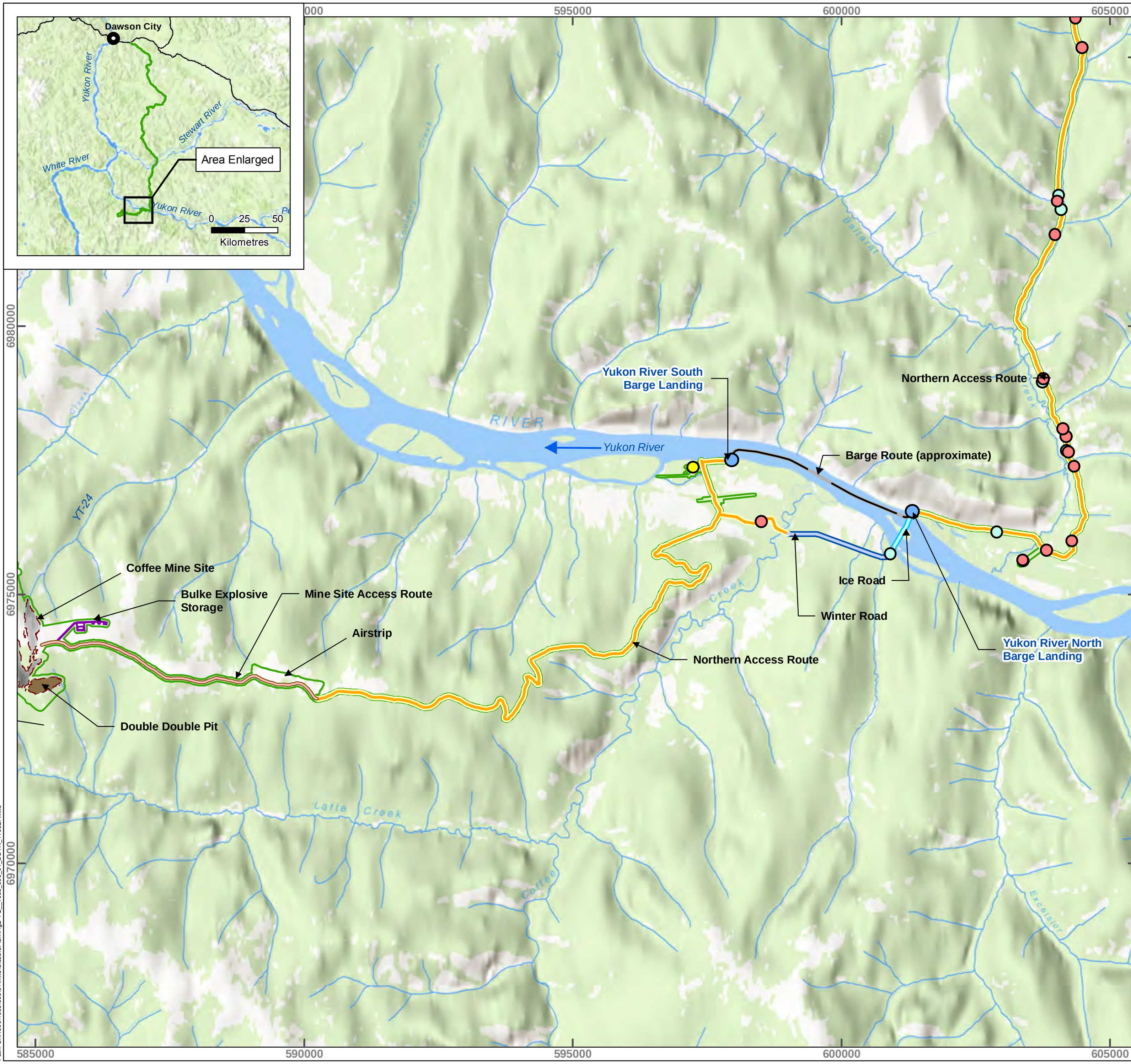

COFFEE GOLD MINE

General Arrangement - Mine Site Access

Legend

- Watercourse
- Flow Direction
- Project Footprint
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route
- Licensed Camps
- Potential Borrow Sources
- Potential Spoil Sites
- Barge Landing

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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Kilometres

NAD 1983 UTM Zone 7N

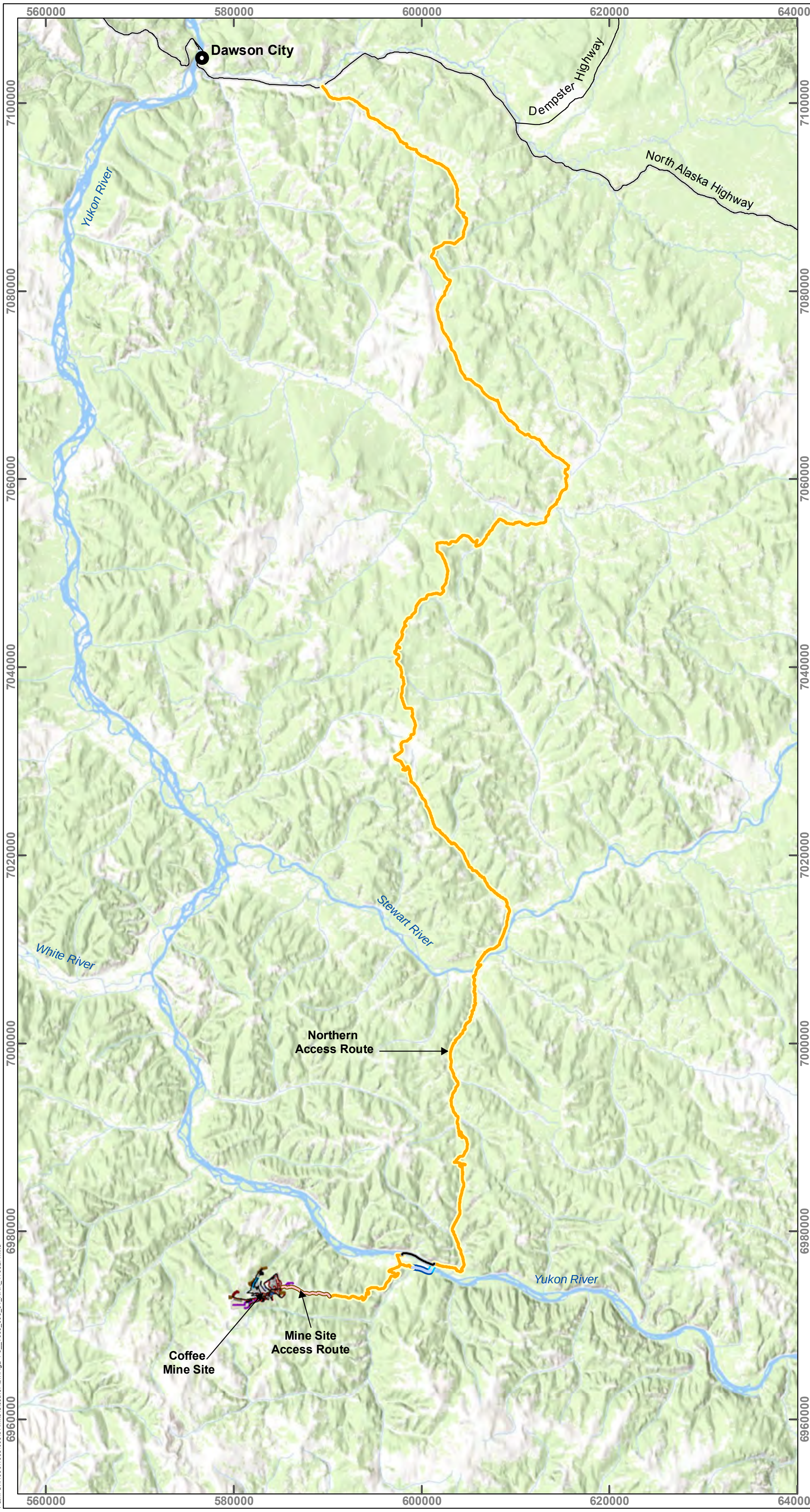
Page Size: 8 ½" x 11"

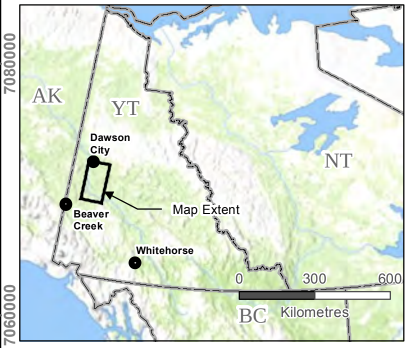
Figure 2.1-2	Date: Mar 28, 2017	Drawn by: JS	Reviewed: DP

GOLDCORP

COFFEE GOLD MINE

General Arrangement – Northern Access Route





Legend

- Highway
- Stewart River Ice and Barge Crossings
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access
- Northern Access

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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Kilometres

NAD 1983 UTM Zone 7N

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Figure 2.1-3	Date: Mar 28, 2017	Drawn by: JS	Reviewed: CPK

GOLDCORP

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2.1.2 POST-CLOSURE ECOSYSTEM DESCRIPTION

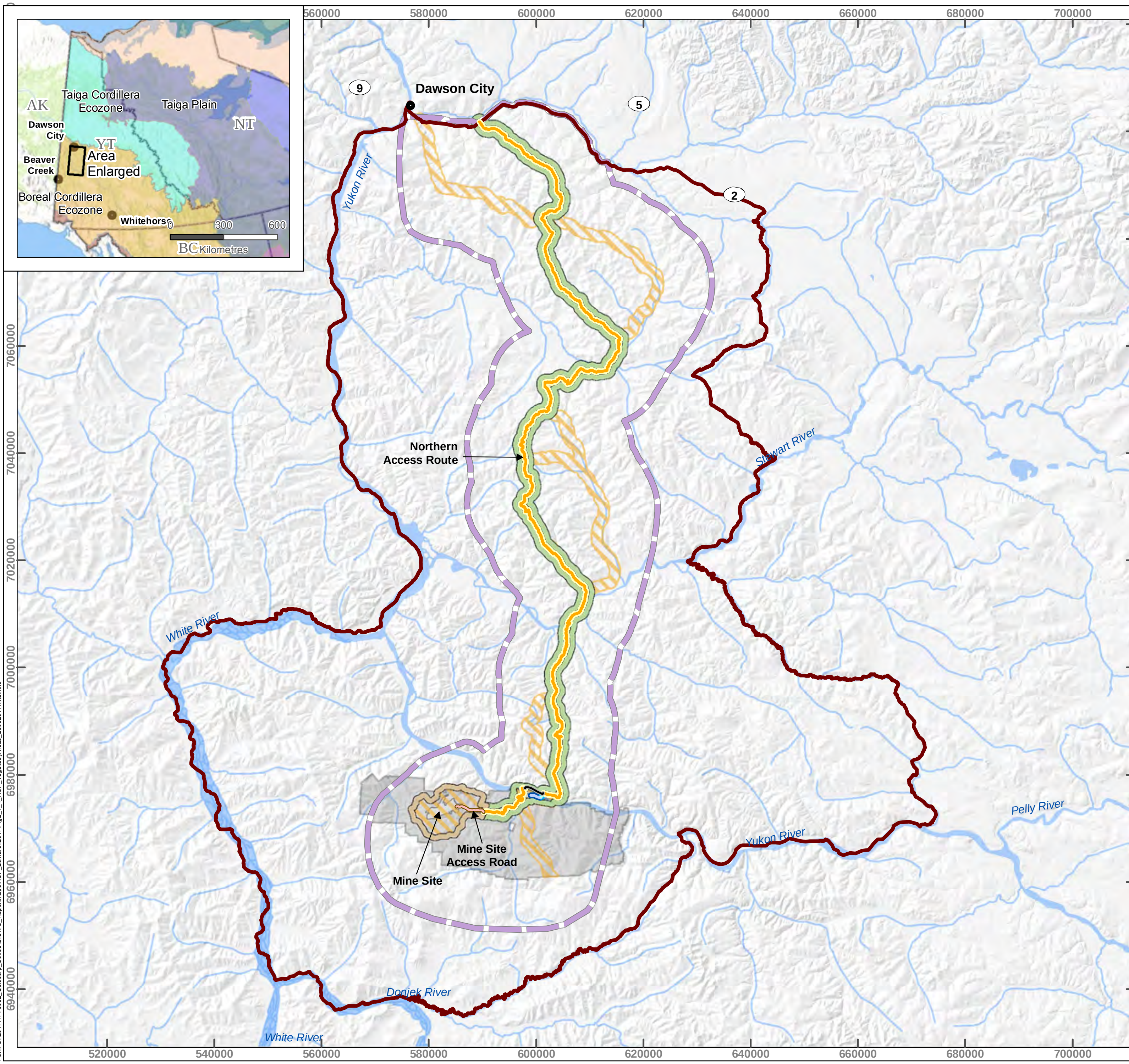
The term ecosystem is used to describe a natural system in which biotic and abiotic components interact and is often applied irrespective of any spatial scale (Ponomarenko and Alvo 2001). This section summarises pre-mining and Post-closure ecosystems within and adjacent to the Project area, including vegetation, bird and wildlife habitat components. In general, the target ecosystem units for the post-closure landscape are likely to be similar to those present in the pre-mining landscape. A summary description of the pre-mining ecosystem, including species of conservation concern, is provided below to support the post-mining characterization that follows, as well as provide context for the Reclamation and Closure Phase terrestrial monitoring programs described in **Section 5.3.**

Baseline studies and Project effects assessments for vegetation, birds and wildlife were conducted at different spatial scales depending on the species being studied and/or the nature of the assessment. The spatial boundaries for the areas referred to in the sections that follow are shown in **Figure 2.1-4**, including the local study area (LSA) assessed during baseline studies, local assessment area (LAA) for the Project area (including both the Mine Site and NAR areas), the regional study area (RSA) for vegetation and birds, and the RSA for wildlife.

2.1.2.1 Summary of Pre-Mining Ecosystem Characterization

Baseline studies completed in 2014 to 2016 to characterize vegetation within the LSA included ecosystem mapping, invasive plant surveys, trace metals analysis of vegetation and soils, and rare plant surveys (Appendix 15-A, Vegetation Baseline Report). Aspects of these surveys are summarized below to characterize the ecosystem as related to revegetation objectives, and information on invasive plants and trace metal levels is provided in **Sections 2.2.3** and **5.3.3**, respectively.

The Project is located within the Klondike Plateau Ecoregion of the Boreal Cordillera Ecozone. The ecoregion is considered uniform in character with smooth topped ridges dissected by deep, narrow, V-shaped valleys that have not been glaciated in the recent past. Many of the plant species found within the LSA are currently, or have been previously, used by local First Nations as a source of food, or for medicinal and spiritual use while others have more practical or decorative uses. Both Tr’ondëk Hwëch’in and White River First Nation members report harvesting berries and other edible plants from the Coffee Creek area (Tr’ondëk Hwëch’in 2012, Bates and DeRoy 2014). Past and current harvesting by First Nations of game birds (e.g., grouse and ptarmigan) and wildlife (e.g. moose) has been reported in the region.



COFFEE GOLD MINE

Local and Regional Study and Assessment Areas for Vegetation, Birds, and Wildlife

Legend

- Highway
- Stewart River Ice and Barge Crossings
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route
- Project Footprint
- Coffee Property
- Mine Site Local Assessment Area (VC Report)
- Northern Access Route Local Assessment Area (VC Report)
- Vegetation/Birds Regional Study Area (Baseline) & Vegetation/Birds Regional Assessment Area (VC Report)
- Wildlife Regional Study Area (Baseline) & Wildlife Regional Assessment Area (VC Report)

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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Kilometres

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Figure 2.1-4	Date: Mar 24, 2017	Drawn by: HG	Reviewed: AM

GOLDCORP

Ecosites and Vegetation

Baseline plant surveys completed from 2014 to 2016 documented 411 plant species, including seven tree, 60 shrub, 188 forb, 63 grass, 18 fern/horsetail/clubmoss, 2 aquatic, 36 mosses/liverworts, and 37 lichens (for a complete list of species, refer to Appendix 15-A, Vegetation Baseline Report). Based upon the Yukon Ecological Land Classification Framework (Flynn and Francis 2011), and according to Yukon bioclimate zone mapping, the pre-mining landscape in the LAA contains the Boreal and Subalpine bioclimate zones. These zones represent 92% and 8% of the LAA, respectively (Appendix 15-A). The LAA does not extend into the Alpine Bioclimate Zone and does not contain any alpine ecological communities.

Within the Boreal Bioclimate Zone, the vegetation patterns reflect the discontinuous distribution of permafrost throughout the region. This zone supports vegetation associations with taller trees, often consisting of either pure or mixed stands of White Spruce (*P. glauca*), Black Spruce, Alaska Birch (*Betula neoalaskana*), and Trembling Aspen (*Populus tremuloides*). The understory is characterized by Labrador Tea, Prickly Rose (*Rosa acicularis*), Lowbush Cranberry, Tall Bluebells (*Mertensia paniculata*), Bastard Toadflax (*Geocaulon lividum*), and feathermosses. Colder aspects with imperfect drainage and near surface permafrost support forests with stunted Black Spruce, Labrador Tea, sedges, and Cloudberry (*Rubus chamaemorus*). Wildfires are frequent in the region and have produced abundant stands of young, deciduous and mixedwood forest.

The Subalpine Bioclimate Zone is characterized by smooth topped ridges that have experienced a long history of weathering. Typical vegetation of the Subalpine landscape is dominated by well-developed moss and lichen layers and shrubs such as Scrub Birch (*Betula glandulosa*), Lowbush Cranberry (*Vaccinium vitis-idaea*), Labrador Tea (*Rhododendron groenlandicum*), Bog Blueberry (*Vaccinium uliginosum*), and Crowberry (*Empetrum nigrum*). A sparse conifer canopy begins to develop as the Subalpine nears the treeline and transitions to the Boreal High Bioclimate Zone. Stunted Black Spruce (*Picea mariana*) forest with Scrub Birch, Labrador Tea, sedges (*Carex* spp.), feathermosses, and peat mosses (*Sphagnum* spp.) are common on moderate, north-facing slopes that are underlain by permafrost and have imperfect to poor drainage.

Vegetation communities within the Boreal and Subalpine bioclimate zones are further described through ecosite[2] and vegetation association[3] designations in Appendix 15-A, Vegetation Baseline Report.

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2 Ecosites are the site-level 'building blocks' and are interpreted within the context of the bioclimate zone in which they occur. They represent vegetation potential and are relatively stable and enduring features that are defined by landscape position and characteristic site conditions, including soil moisture and nutrient regimes (Environment Yukon 2015a; Environment Yukon, 2015b).

3 Vegetation associations are ecosite subdivisions that incorporate the differences an ecosystem experiences through seral vegetation development.

Species of Conservation Concern

The identification of species of conservation concern within the LSA was a key focus of vegetation, bird, and wildlife baseline surveys.

No plant species of conservation concern listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)[4] or under the *Species at Risk Act* (*SARA)* were observed during the rare plant surveys. However, populations of four plant species on the Yukon Conservation Data Centre's Watch-list were observed within the LSA, including spotted lady's-slipper (*Cypripedium guttatum*), Coffee Creek scorpionweed (*Phacelia mollis*), small enchanter's nightshade (*Circaea alpina ssp. alpina*), and dry-spike sedge (*Carex siccata*) (Appendix 15-A, Vegetation Baseline Report).

To characterize the bird and wildlife communities, the results of studies within the LSA were combined with information from other studies (e.g. surveys by Environment Yukon), Traditional Knowledge, Project consultation, and available literature. The majority of waterbird, waterfowl, raptor, shorebird and upland bird species found within the LSA are widespread throughout much of the central Yukon (Appendix 17-A, Bird Baseline Report). The region provides breeding habitat for a variety of bird species including waterbirds, waterfowl, raptors, shorebirds and upland birds. Eighty-eight species have been documented to date, including seven at-risk species protected under the *SARA* or listed as species of conservation concern by the COSEWIC. Of these species, the Olive-sided Flycatcher (*Contopus cooperi*) has been documented within the Mine Site LAA, and a single Short-eared Owl (*Asio flammeus*) was observed in April 2016 near the eastern edge of the Mine Site LAA[5]. The Yukon Government has identified several Wildlife Key Areas that are used by wildlife for critical life functions (e.g. nesting raptors) within the RSA; however, the Mine Site LAA does not overlap any of these areas (refer to Appendix 17-A for more information).

Large mammal species found in the RSA that are considered to be of conservation concern or highly valued for hunting include Woodland Caribou (*Rangifer tarandus caribou*), Grizzly Bear (*Ursus arctos*), Wolverine (*Gulo gulo),* Cougar (*Puma concolouri),* and Moose (*Alces alces*) (Appendix 16-A, Wildlife Baseline Report). Collared Pika (*Ochonona collaris*) and Little Brown Myotis (*Myotis lucifugus*), federally protected at-risk small mammal species, also occur within the RSA, but neither species was found within the Mine Site LAA (Appendix 16-A, Wildlife Baseline Report).

2.1.2.2 Post-closure Ecosites and Vegetation

Describing post-closure ecosystems in terms of ecosites and vegetation associations allows for some flexibility in the planning of reclamation activities, particularly in areas with newly created (or altered) landforms. For example, the HLF will be a new landform with accompanying slopes, aspects, and parent

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4 The COSEWIC, an independent body of experts, is responsible for identifying and assessing plant and wildlife species considered at risk, which may then qualify for legal protection and recovery under *SARA*.

5 Given the timing of this observation, it is unknown whether this individual was establishing a nesting territory in the area or migrating through.

materials that, depending on the reclamation treatments applied, could support various ecosites and accompanying vegetation associations. Vegetation cover trials are proposed for the heap leach pad (**Section 2.3.3**) and depending on the outcome of these trials, areas may be targeted for the reintroduction of a specific vegetation association or a more general ecosite. Either approach should allow for the re-establishment of vegetation that is ecologically appropriate and tailored to local conditions and long term objectives for the HLF.

The ecosites and vegetation associations currently located within the LAA represent the most suitable candidates to target for re-establishment in the post closure landscape. These vegetation patterns inform reclamation planning and an understanding of how local conditions might influence the selection of candidate ecosites and vegetation associations used in reclamation. To support the end land use objective of leaving the area as a self-supporting ecosystem, the plant species selected for reclamation may, where appropriate, target preferred habitat and forage species for birds and wildlife. As the Project advances and reclamation research and monitoring programs provide a better understanding of the most effective way to achieve closure objectives, a more detailed post-closure landscape will be defined for the LAA.

2.2 RECLAMATION MEASURES AND PRACTICES

A number of reclamation measures and practices will be carried out during the life of the Project to facilitate the return of self-sustaining vegetation communities and specific habitat features to the reclaimed Mine Site and portions of the NAR. Proposed measures and practices include (but are not limited to) the following:

- From the onset of mine planning determine appropriate research strategies, as informed by reclamation research programs. Programs that are underway and proposed are described in **Section 2.3**.
- During the Construction Phase and Operation Phase, salvage and stockpile organic material and topsoil, and implement erosion and sediment control measures (see **Sections 2.2.1** and **2.2.2,** respectively, for more information);
- During the Operation Phase, progressively reclaim areas no longer needed for mining (see **Table 1.4-1** for more details on the timing of progressive activities), and revegetate disturbed sites to minimize erosion, sedimentation, and the establishment of invasive plant species (see **Section 2.2.3**); and
- At the onset of the Reclamation and Closure Phase, decommission mine infrastructure and facilities, dispose of waste materials in the landfill, and remove hazardous materials and wastes from site for proper disposal. The following activities may also be conducted as warranted:
    - Assess ground and surface water contamination and determine appropriate remedial measures (if required) in areas of potential risk;
    - Re-contour disturbed areas and scarify/rip compacted surfaces to improve plant root establishment, reduce surface water ponding, and minimize erosion potential; and
    - Place planting media then seed and/or plant as soon as possible at target revegetation sites to reduce the potential for erosion and the establishment of invasive species.

Closure measures specific to key mine infrastructure and facilities (e.g., open pits, HLF, WRSFs and stockpiles, roads and airstrip, and the plant site) are described in **Section 3.0**.

2.2.1 ORGANIC MATERIAL AND TOPSOIL MANAGEMENT

During construction, organic material and topsoil (an estimated average thickness of 30 cm) will be stripped from the footprints of the open pits, heap leach pad, and the foundations of other infrastructure, and subsequently stored in the temporary organics stockpile. The estimated total amount of organic material to be stripped from the Mine Site is approximately 1.5 Mm^3. The stockpile, located north of the heap leach pad (see **Figure 2.1-1**), has been designed with a maximum capacity of 2.1 Mm^3 within a footprint of approximately 16 ha. A summary of the key aspects of management of material removal and storage is provided below.

The temporary organics stockpile foundation will not be cleared or grubbed to avoid disturbing and exposing permafrost to thawing. Sediment and erosion control measures will be put in place down-slope of the stockpile prior to the placement of any materials. Organic material and topsoil will be stockpiled until it is progressively removed from the stockpile for site reclamation and revegetation activities as mine areas are closed. Frozen soil, which is not suitable for immediate use as fill during construction due to ice content or grain size, will not be stored in the temporary organics stockpile. It will be deposited in the frozen soil storage area located adjacent to the Alpha WRSF (see **Figure 2.1-1**), and may be used in site reclamation and revegetation activities. Appendix 31-D, Waste Rock and Overburden Management Plan, provides additional information on waste rock and soil overburden materials will be characterized, segregated, and stored to ensure long-term chemical and physical stability.

Erosion and sediment control measures, described below, will be employed as required to allow the stockpile to remain stable during its period of use. Details on sediment and erosion control measures are described below and the management of sediment-laden water during construction and operation relevant to the temporary organics stockpile are described in the Water Management Plan (Appendix 31-E).

2.2.2 EROSION AND SEDIMENT CONTROL

The closure of a quartz mine involves earth moving activities with the potential to induce surface erosion or sedimentation in watercourses, if adequate measures are not implemented within susceptible areas. Conservation of soil is very important and erosion and sediment control measures in all Project phases will focus on preventing soil loss by:

- Minimizing the size of the disturbed area (e.g., Project footprint)
- Maximizing the retention of natural vegetation cover and maintaining vegetation buffers (particularly near water)

- Avoiding or minimizing work in unstable areas and steep slopes and limiting disturbance of permafrost, and
- Scheduling construction activities and the installation of perimeter sediment controls to mitigate sedimentation in high risk areas[6].

In accordance with best management practices (Yukon Environment 2011), active erosion control measures may include covering and stabilizing disturbed areas as soon as possible, using appropriate erosion and sediment control products and methods (e.g., seed, mulches, geotextile materials, and other erosion control products), diverting runoff around erosion-prone areas, maintaining shallow (2:1 grade or flatter) and/ or short (e.g., terracing) slopes, and maintaining small drainage areas to minimize water accumulation and limit erosive energy. Active sediment control measures may include installing measures such as silt fences or sediment traps before starting any work that may result in sediment mobilization, and avoiding mixing clean water with sediment-laden water by diverting sediment-laden runoff water into sediment traps or basins and diverting clean runoff water from undisturbed areas around disturbed areas with high erosion potential.

Standard procedures and best management practices will be followed to minimize potential effects to the environment and to provide for the physical stability of exposed surfaces during the Construction and Operation phases, and monitoring requirements. For the Reclamation and Closure Phase, the protocols for identifying and responding to instances of sedimentation or erosion will be similar to those described for prior phases.

A risk-based approach to erosion and sediment control planning and response will be employed during the Reclamation and Closure Phase. The amount and complexity of employed measures will depend on the risk of erosion and potential consequences associated with a sediment release. In addition, a hierarchical approach to erosion and sediment control will be employed by first implementing clean water run-off controls where possible, followed by erosion control measures, then sediment control measures. Site-specific erosion and sediment control plans may be developed, if necessary. Descriptions of sedimentation and erosion prevention and control measures that could be used during access road construction and operation are provided in Appendices 31-A and 31-B, respectively.

2.2.3 Invasive Plant Management

According to the Yukon Invasive Species Council (YISC 2016) invasive plants can negatively affect an ecosystem by:

[6] As an example of construction sequencing and sediment control planning, clearing and stripping at waste rock storage facilities will be undertaken in as short a time period as practicable in advance of waste rock placement. This will minimize the exposure period of the cleared ground, thus limiting the potential for thawing of permafrost and erosion of the area. For these facilities, perimeter sediment controls will consist of diversion channels and sediment ponds (for more information refer to Appendix 31-E, Water Management Plan).

1. Permanently altering landscapes and ecosystem functions by reducing the quality and quantity of forage plants
2. Competing with native species for light, nutrients, and water, and
3. Increasing the potential for erosion and sedimentation (and subsequent changes to water quality).

The YISC promotes prevention and Early Detection and Rapid Response to proactively manage invasive species in Yukon. Preventing the introduction of invasive species is the most effective, economical, and ecologically sound approach for their management. The introduction and/or spread of invasive plants is commonly linked to the exposure of soil at salvage and stockpile areas to invasive seed sources, and the movement of vehicles or equipment. A key objective of Project closure is to minimize and manage the establishment and spread of invasive plant species within the LSA.

Invasive plant surveys conducted in the LSA identified populations of 18 invasive plant species, including five species categorized as highly invasive and considered to a management priority (see Appendix 15-A Vegetation Baseline Report for more information). In general, concentrations of invasive plants were less frequent in the southern portion (Coffee Camp, Coffee airstrip, Java Road, and the Mine Site) of the LSA that has limited vehicular access compared to the northern portion of the LSA that includes the NAR.

Goldcorp will implement prevention and control measures during all Project phases to reduce the potential for the establishment of invasive plant species. Prevention and control measures that are considered to be applicable to the Reclamation and Closure Phase are summarized in **Table 2.2-1**.

Table 2.2-1 Prevention and Control Measures for Invasive Plant Species

<table>
<tr><th>Prevention Measures</th><th>Control Measures</th></tr>
<tr><td>Confirm equipment inbound to the Mine Site is free of soil, invasive plant parts, and seed.</td><td rowspan="6">Mechanical treatment by hand pulling or mowing to physically remove invasive plants:
• Method of removal will depend on the species, size of the patch and location of the patch[a].
• For this to be effective, mechanical treatment will need to be applied a minimum of two times during the season, because some invasive species can regrow within the same season.
• Plants will be picked or mowed during early flowering and prior to seed set whenever possible[b]. Removal will depend on the biological characteristics of the plant (i.e., length of seed viability) and it may take a few years to remove seeds from the local seed bank.
• Plants will be bagged and incinerated.</td></tr>
<tr><td>Minimize disturbance of existing vegetation during decommissioning and reclamation activities</td></tr>
<tr><td>Where practicable, avoid disturbing high-risk sites to minimize the potential spread of invasive species (i.e., within or adjacent to existing infestations)</td></tr>
<tr><td>Periodically monitor along roads and at parking and staging areas for invasive species to detect invasive species early.</td></tr>
<tr><td>If sourcing offsite materials (e.g., aggregate, seed, mulch), confirm it is certified weed free</td></tr>
<tr><td>Establish a vegetation cover as soon as practicable after ground disturbance</td></tr>
</table>

Prevention Measures	Control Measures
If hand-pulling of invasive plants on-site is deemed an insufficient control measure through monitoring activities, a vehicle and equipment wash-station may be considered.	Targeted application of herbicide to kill species.
Improve effectiveness of prevention practices through education and awareness training	

Notes:

a. Mechanical removal is usually the first method used when evaluating invasive plant removal as it is cost effective, does not require special licensing, and does not introduce chemicals to the environment.

b. Timing is essential when considering mechanical treatment. Mowing of invasive species during seed set could cause the seeds to spread, increasing the infestation.

Ongoing monitoring efforts (see **Section 5.0** for a description of the Reclamation and Closure Phase monitoring program) will facilitate early detection of invasive plants to track known populations and direct management efforts. The YISC may be consulted as specific management actions may be required for certain species. Management efforts will be prioritized towards those invasive plants that have been categorized as highly invasive. Invasive plants will be destroyed and an investigation conducted to identify if the pathway of entry can be determined; if possible, changes will be made to reduce the possibility of further introduction.

2.3 RECLAMATION RESEARCH PROGRAMS

A Revegetation Reclamation Research Program with the overall objective of developing successful reclamation protocols has been initiated. Goldcorp proposes to continue this program through Construction and Operation phases and commence with pilot testing of the water treatment plant and vegetation cover trials for the HLF during the Operation Phase.

As stated previously, reclamation measures will be refined based on the outcomes of reclamation research programs to allow reclamation and closure plans to be successful in achieving closure objectives when implemented. Goldcorp will continue to work with specialist consultants, First Nations, and other technical groups to address potential constraints to achieving these objectives. Key elements of each of these three programs are described below.

2.3.1 REVEGETATION RECLAMATION RESEARCH PROGRAM

Revegetation helps to achieve a variety of closure objectives by reducing water infiltration, providing habitat, limiting erosion, and meeting aesthetic expectations (YWB and EMR 2013). The overall goal of the Revegetation Reclamation Research Program is to identify appropriate measures that can be employed during reclamation to prepare the site so that the vegetation returns to a state as near as possible to that in existence prior to mining activities.

From 2013 to 2015, Goldcorp initiated this program alongside exploration activities to start testing the effectiveness of various revegetation reclamation techniques under different site conditions. Summaries of the annual campaigns of this program are provided below, along with results if available, and additional details pertaining to study methodology, participants, and details are provided in **Appendix A** of this CRCP. Outcomes from the Revegetation Reclamation Research Program are intended to inform future closure measure decisions and implementation strategies for the site, as well as increase the level of confidence that closure objectives will be met.

2.3.1.1 Reclamation Demonstration Site Program

In 2013, reclamation studies investigated basic site prescriptions in disturbed areas where exploration activities had occurred. The objective was to assess and compare regeneration of vegetation through mechanical reclamation[7] and seeding at established demonstration sites. The sites were seeded with Tickle Grass (*Agrostis scabra*), Alpine Bluegrass (*Poa alpina*), Glaucous Bluegrass (*Poa glauca*), Rocky Mountain Fescue (*Festuca saximontana*), and Tufted Hairgrass (*Deschampsia caespitosa*), obtained from a seed supplier.

Reclamation studies were expanded in 2014 to include monitoring plots at additional exploration sites and cut slopes. The objectives were to test and monitor various site prescriptions within 1 m^2 monitoring plots and determine the most effective techniques for reclamation and revegetation of the Mine Site. The prescriptions involved various combinations of mechanical reclamation, raking pre- or post-seeding, seeding, and bio-engineering[8]. The native seed mix obtained from onsite sources included Alpine Bluegrass, Glaucous Bluegrass, Rocky Mountain Fescue, Tufted Hairgrass and Boreal Wormwood (*Artemisia norvegica* ssp. *saxatilis*).

In 2015, percentage cover of germinating plants was measured at demonstration sites and monitoring plots to assess early establishment in relation to site prescriptions. At cut slope monitoring plots, the percent of live stakes and bundles was also measured. Additional monitoring is planned for 2017 and results of all monitoring campaigns at demonstration sites and monitoring plots will be summarized following this work.

2.3.1.2 Seed Program and Candidate Reclamation Species

Goldcorp recognizes the importance of sourcing indigenous northern plant species for its reclamation activities. A Seed Collection, Inventory and Mapping Program was implemented in 2015 to determine target plant species for site restoration. In conjunction with this program, Goldcorp supported the development and implementation of two training programs in partnership with Tr’ondëk Hwëch’in and the Yukon College, including the Centre for Northern Innovation in Mining and the Yukon Research Centre. These training

[7] Mechanical reclamation involved the use of machinery and manual labor to replace the original vegetation layer from where it was removed.

[8] Bioengineering involved the insertion of local cuttings either horizontally as bundles or vertically as stakes in slopes with higher erosion potential.

programs (Introduction to Environmental Monitoring Pilot Project and Northern Terrestrial Restoration) were provided to local First Nations students to promote awareness and understanding of environmental monitoring requirements and to offer students the opportunity to gain experience in experimental design, field sampling techniques, and native seed collection[9].

Yukon College scientists, specialist consultants, and Tr’ondëk Hwëch’in students and elders surveyed disturbed and undisturbed vegetation communities in Boreal Low, Boreal High and Subalpine Bioclimate Zones to identify species naturally recolonizing disturbed areas within the LSA. A seed source map for target revegetation species was created[10] that integrated both scientific knowledge as well as traditional ecological knowledge from Tr'ondek Hwech'in elders.

Seed collection sites were selected in Boreal High and Subalpine ecotypes (ecotypes in which the Mine Site is located, as described previously in **Section 2.1**). Early successional species colonizing disturbed areas within the Boreal High and Subalpine ecotypes, included Prickly Rose (*Rosa acicularis*), Red Raspberry (*Rubus idaeus*; Boreal High only), Fireweed (*Chamerion angustifolium*), Bitter Fleabane (*Erigeron acris*), Tall Lungwort (*Mertensia paniculata*; Boreal High only), Blue-joint Reedgrass (*Calamagrostis canadensis*) and *Poa* grass species. This suggests that these species are good indicators of disturbed areas in these ecotypes and may be appropriate candidates for reclamation and revegetation.

Native grasses and nitrogen-fixing forbs were collected, as well as shrub species for bio-engineering bundles and stakes, such as Willow (*Salix* spp.), Alder (*Alnus viridis*), Balsam Poplar (*Populus balsamifera*), and Scrub (or Dwarf) Birch (*Betula glandulosa*). More than 30 candidate species were harvested by hand from 26 locations then dried and stored in the temporary nursery located onsite at the Coffee exploration camp.

A preliminary list of potential native grasses, nitrogen-fixing forbs, and shrubs species for reclamation at the Coffee Project was compiled as shown in **Table 2.3-1**. The list was developed with consideration of the local availability of plant species and those species recommended for use in the Yukon by the *Yukon Revegetation Manual* (Matheus & Omtzigt 2013). Candidate native species could be used for progressive or interim reclamation (e.g. to control surface erosion), to prevent or minimize the establishment of invasive plants, and final reclamation of the site. In some areas, plant species selected for final reclamation will target preferred wildlife forage species to enhance wildlife habitat.

[9] The Northern Terrestrial Restoration course offered local First Nations students the opportunity to gain research experience and provide a foundation for future local community involvement in restoration and horticulture of native plants. Through directly integrating research and education, the goal is to not only identify, preserve and test materials for restoration of the Coffee Gold Project, but also to determine effective restoration protocols and build capacity for native plant horticulture in Yukon communities.

[10] The Plants of Coffee Creek Seed Source Map is available at:
http://yrc-c.maps.arcgis.com/apps/MapJournal/index.html?appid=30b9ade6ce39467d8bb503fbfe4147b5

Table 2.3-1 Preliminary List of Candidate Native Grass, Forb, and Shrub Species for Revegetation

Native Grass Species		Native Forb and Shrub Species	
Common Name	**Species Name**	**Common Name**	**Species Name**
Alpine Bluegrass[1]	Poa alpina	Alpine Bearberry[1]	Arctous alpina
Alpine Sweetgrass[1]	Hierochloe alpina	Alpine Sweet-vetch[2]	Hedysarum alpinum
Bluejoint Reedgrass[1,2]	Calamagrostis canadensis	Arctic Lupine[1]	Lupinus arcticus
		Arctic Willow[1]	Salix arctica
Fowl Bluegrass[1,2]	Poa palustris	Bog Bilberry[1,2]	Vaccinium uliginosum
		Canada Buffalo-berry[1,2]	Shepherdia canadensis
Glaucous Bluegrass[2]	Poa glauca	Scrub Birch[1]	Betula glandulosa
Northern Rough Fescue[1]	Festuca altaica	Gray-leaved Willow[1]	Salix glauca
Ticklegrass[2]	Agrostis scabra	Lowbush Cranberry[1,2]	Vaccinium vitis-idaea
Tufted Hairgrass[2]	Deschampsia caespitosa	Mountain Avens[1]	Dryas spp.
		Northern Bedstraw[1,2]	Galium boreale

Notes: 1. Typical in subalpine areas; **2**. Typical in boreal areas.

Plant species are intended to be sourced from an onsite native plant nursery, as described in **Section 2.3.2**.

2.3.1.3 Revegetation and Soil Amendment Trials

Effective ecosystem processes include below-ground processes, such as nutrient cycling, water cycling, decomposition, and energy flow that support the production of plant matter. In consideration of this, the Yukon Research Centre established revegetation and soil amendment trials in 2015 to test various reclamation techniques in different ecotypes present onsite. These trials were conducted onsite in conjunction with the Northern Terrestrial Restoration course. Except for the control site (for which no amendments were made), the trials used various combinations of reclamation techniques including the addition of Boreal Low or Subalpine Bioclimate Zone organic matter applied as a soil amendment, fertilizer, and/or seed. Plots were seeded in June with a seed mix from the Alaska Seed Bank that included local species (Alpine Bluegrass, Glaucous Bluegrass, Rocky Mountain Fescue, Tufted Hairgrass and Boreal Wormwood) and germination rate and percent cover were measured in August. Key findings are as follows:

- Overall organic matter and fertilizer amendments had little to no effect on germination rates of the native seed mix for either the Boreal Low or Subalpine ecotypes;
- The addition of fertilizer either alone or in addition to organic matter affected the percent cover of vegetation found growing at sites within these ecotypes, suggesting that aboveground biomass production can be promoted by the use of commercial fertilizers (at least in the first growing season); and
- Total percent cover for all species was three times higher in the Boreal Low (18%) than the Subalpine (6%) ecotype, which was in part driven by the recruitment of native local volunteer species establishing in the research plots.

Further monitoring is needed to determine the effectiveness of these amendments over time. It is evident that different approaches will likely be required in different ecotypes. High recruitment from the seed bank at the Boreal Low site indicates that natural revegetation will likely occur with minimal intervention. The low aboveground cover and lack of recruitment from the seed bank at the Subalpine ecotype, however, indicates that a more extensive revegetation strategy may need to be developed. This will be incorporated into future reclamation research.

2.3.1.4 Greenhouse Trials

Greenhouse trials using Arctic Lupine (*Lupinus arcticus* - a common native species found at the Project site) were conducted in 2015 at the Yukon Research Centre by trained staff as a laboratory experiment. The purpose of the trials was to test the relationship between soil amendments and the recovery of ecosystem processes using Arctic Lupine. This plant was selected for the trials because it can fix nitrogen to assist growth, development, and reproduction of plants in the surrounding soil and promotes ecosystem processes.

In a controlled growth chamber, eight types of growth media were tested to determine ethylene production (as an indicator of nitrogen-fixation rates) in Arctic Lupine after three months of growth. Ethylene production from Arctic Lupine was markedly different between Boreal Low and Subalpine soils within some treatments, while pH adjustment of peat led to higher rates of nitrogen-fixation. Details are provided in **Appendix A** of this CRCP.

2.3.2 NATIVE PLANT NURSERY

Sourcing sufficient seed stock of native plant species will be a critical component of the revegetation program.

In 2014 and 2015, Goldcorp initiated plans to operate a basic nursery onsite as part of a pilot project. Environmental Monitors and students from the Northern Terrestrial Restoration program established a temporary nursery at the Coffee exploration camp and participated in native seed potting trials and target species transplants. Goldcorp will continue to explore options for establishing a nursery onsite.

Goldcorp will seek opportunities to work with local or Yukon First Nation businesses interested in establishing a nursery to grow native species for use in reclamation research and ultimately to cultivate seed and plants for use in reclamation activities (i.e., species that are adapted to the growing and climatic conditions that occur at the Mine Site).

2.3.3 FUTURE RESEARCH

Goldcorp is committed to continuing reclamation research and monitoring as part of reclamation and closure planning. The following sections summarize aspects of reclamation research that may be included in future versions of the Reclamation Research Program.

2.3.3.1 Revegetation

The development of successful restoration practices to establish beneficial conditions for the early establishment and long-term development of any given plant community relies on the understanding of how plant species interact with soil. The objectives of proposed future work are to characterize the rhizosphere (i.e., plant-root interface) of northern native plants that are potential candidates for restoration and to understand the mechanistic linkages between the composition and structure (diversity and abundance) of plant roots, soil bacteria, fungi, and archaea and critical ecosystem functions (soil nitrogen and carbon cycling and storage) as restoration proceeds. Additional information is provided in **Appendix A**.

2.3.3.2 Heap Leach Facility - Water Treatment Plant Pilot Program

Water treatment of rinse drain-down water derived from those stages of the HLF that have been closed will commence in Year 9. It is anticipated that the rinse water will exceed Metal Mine Effluent Regulations water quality standards for discharges to the environment with respect to cyanide and arsenic, and possibly uranium and nitrates. As described in **Section 3.2.2**, Goldcorp proposes to treat collected rinse drain-down water using a combination of chemical and biological processes. Bench-scale treatment testing of metallurgical cyanide leach solutions has been performed at the University of Utah, and the ultimate water treatment system design to determine optimal operating characteristics (e.g., flow rates and nutrient amendments) will be determined through a field-scale pilot program during the Operation Phase. This research will not only refine plant operating requirements, but will also provide greater certainty in achieving water quality criteria in the timeline proposed for closure of the HLF. Details of this program will evolve through the Operation Phase.

2.3.3.3 Heap Leach Facility - Vegetation Cover Trials

The HLF will be progressively reclaimed in stages during rinsing of the heap, as detailed in **Section 3.2**. Following the cessation of heap rinsing, approximately in Year 15, the primary closure objectives for the HLF are to maintain physical stability (e.g., stable and erosion-resistant slopes, limiting infiltration into the heap to 20% to 30% of average precipitation, etc.), and provide a growth medium to sustain native plants to achieve end land-use objectives. In order to achieve these objectives, the slopes and crest of the heap will be regraded and the top 1 m compacted. The flat areas of the heap (crest and benches) will then be capped with a geosynthetic clay liner (GCL), compacted low permeability soil, an integral GCL/geomembrane product, or equivalent low permeability infiltration barrier; then covered with 500 mm of overburden material. For both flat and sloped surfaces, the establishment of vegetation will further reduce infiltration and erosion potential.

Goldcorp proposes to conduct a revegetation field trial program commencing after Year 6 on the reclaimed Stage 1 of the HLF, if operational conditions allow. The design of these field-based trials will be informed by results obtained from other current and proposed onsite and greenhouse/lab revegetation research programs (see **Section 2.3.1** for program descriptions). Revegetation plans for the HLF will be refined based on the results of these revegetation cover trials.

2.4 Closure Adaptive Management Plan

2.4.1 Purpose of Adaptive Management

Adaptive management is a systematic approach of identifying, evaluating, and addressing performance uncertainties, with the goal of reducing these uncertainties over time and ensuring adequate long-term performance. The adaptive management framework will evolve through the Construction, Operation, and Reclamation and Closure phases as conditions change and some uncertainties are addressed and new ones emerge. In the context of closure planning, adaptive management is primarily focused on the performance of closure measures, including monitoring potential differences between likely and actual performance and implementing changes to address any issues that may arise.

A detailed closure adaptive management plan (Closure AMP) will be developed to support Project licensing. The key components of AMPs for closed mine sites typically address issues relating to water quality, physical stability, and revegetation. The Closure AMP will include information on monitoring locations, frequencies, and methods; data analysis and interpretation; identification of potential indicators; and a range of management responses to changing conditions.

Brief overviews of the overall adaptive management approach for these three themes are provided in the following subsections. For each theme examples of aspects that may have to be managed, example performance indicators, and potential responses in the event of inadequate performance are provided.

2.4.2 Closure AMP Themes

2.4.2.1 Water Quality

Chemical stability is a fundamental mine reclamation and closure objective (**Table 1.3-1**), as it is necessary to limit release of contaminants from mine wastes and avoid unacceptable exposure in the receiving environment. The water quality of the HLF, the pit lakes, and creeks draining the Mine Site are key aspects of the Closure AMP that relate to chemical stability.

Heap Leach Facility

The HLF will be progressively closed and reclaimed starting in Year 4 (**Section 3.2**). Some example aspects of the HLF that may require adaptive management are described in **Table 2.4-1**.

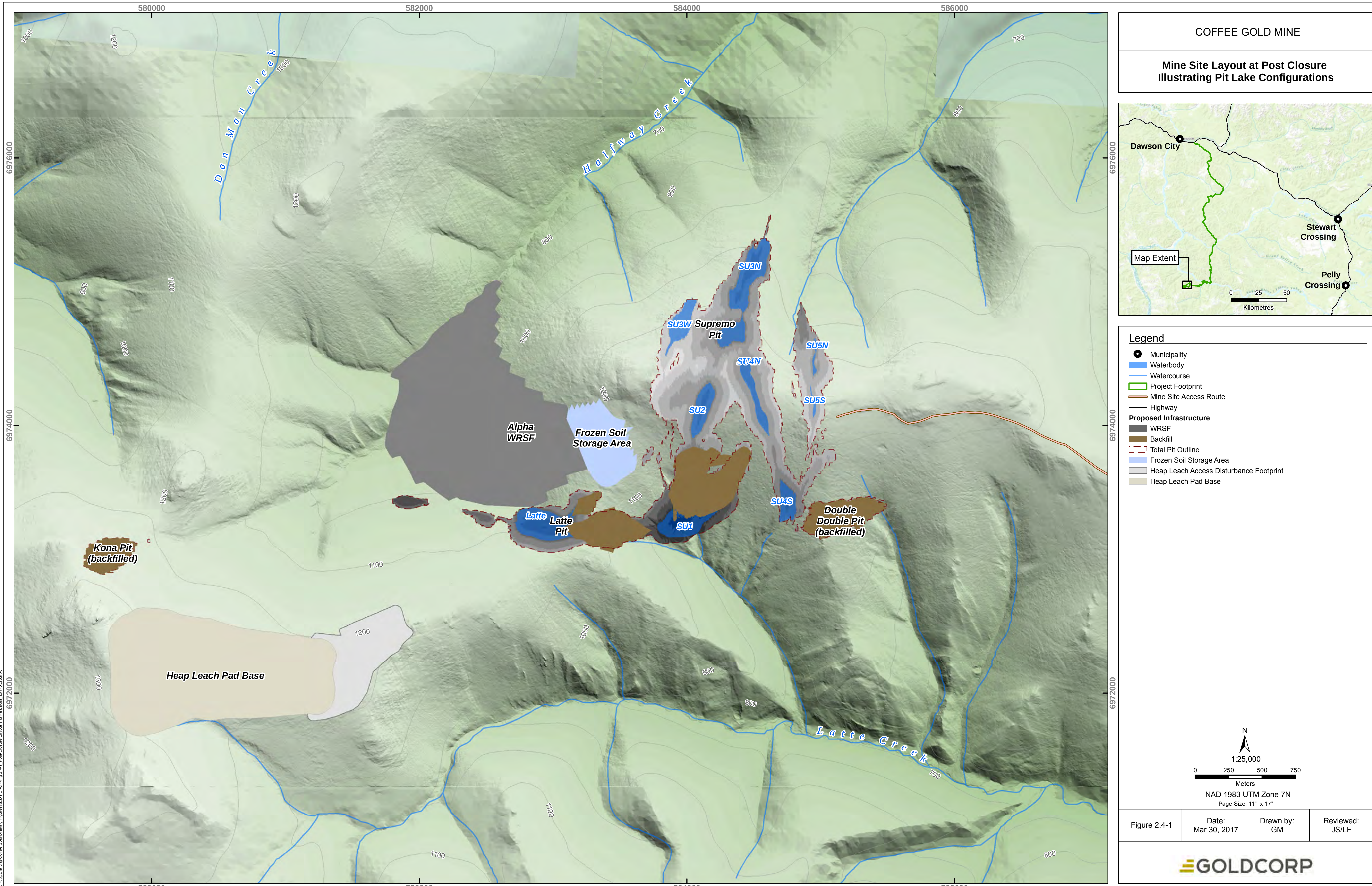
Table 2.4-1 Heap Leach Facility Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Water treatment less effective than expected	Concentrations of water quality parameters in effluent	Evaluate upgrades to water treatment system and implement as appropriate.
Rinsing of HLF less effective than expected	Concentrations of water quality parameters in heap rinse water	Extend duration of water treatment operations Extend duration of active rinsing.

Pit Lakes

Nine pit lakes projected to develop over time within the mined-out Latte and Supremo pits include the following pit lakes: Latte, SU1, SU2, SU3W, SU3N, SU4N, SU4S, SU5N, and SU5S, as shown in **Figure 2.4-1**. No pit lakes will occur within Kona and Double Double pits as both will be backfilled with waste rock as part operational closure activities (**Section 3.1**).

Upon complete filling, some of the pit lakes will passively overflow into the receiving environment and include Latte pit (overflowing into upper Halfway Creek drainage); SU1 and SU4S (overflowing to upper Latte Creek); SU3W (overflowing to Halfway Creek); and SU3N and SU5N (overflowing to YT-24) (see **Figure 2.4-1**).



COFFEE GOLD MINE
Mine Site Layout at Post Closure
Illustrating Pit Lake Configurations
580000
582000
584000
586000
6976000
6974000
6972000
Dan Man Creek
Halfway Creek
Latte Creek
Alpha WRSF
Frozen Soil Storage Area
Supremo Pit
SU3N
SU3W
SU4N
SU5N
SU5S
SU2
SU4S
SU1
Latte
Latte Pit
Double Double Pit (backfilled)
Kona Pit (backfilled)
Heap Leach Pad Base
Dawson City
Stewart Crossing
Pelly Crossing
Map Extent
0 25 50
Kilometres
Legend
Municipality
Waterbody
Watercourse
Project Footprint
Mine Site Access Route
Highway
Proposed Infrastructure
WRSF
Backfill
Total Pit Outline
Frozen Soil Storage Area
Heap Leach Access Disturbance Footprint
Heap Leach Pad Base
N
1:25,000
0 250 500 750
Meters
NAD 1983 UTM Zone 7N
Page Size: 11" x 17"
Figure 2.4-1
Date: Mar 30, 2017
Drawn by: GM
Reviewed: JS/LF
GOLDCORP

Water quality modeling of pit lake chemistry has indicated that pit lake water quality will be suitable for direct discharge to the environment without deleterious effects to receiving water quality (Appendix 12-C). While unlikely, an example of potential adaptive management for pit lakes at closure is provided in **Table 2.4-2**.

Table 2.4-2 Pit Lake Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Pit lake water quality is worse than predicted	Concentrations of water quality parameters in pit lakes	Increase groundwater monitoring downgradient of the pit lakes Investigate potential sources and possible improvement measures

Surface Water and Groundwater Quality

The Mine Site is within the catchments of Latte Creek, Halfway Creek, and YT-24 and indirectly in the catchments of Coffee Creek and Yukon River. Eighteen surface water monitoring locations on these creeks as well as on Coffee Creek, Independence Creek, and the Yukon River were established for baseline environmental monitoring purposes (Appendix 12-A, Baseline Water Quality Report), and 17 groundwater monitoring wells were installed within these catchments (Appendix 7-B, Numerical Groundwater Model Report). Many of these locations will continue to be monitored during the Construction, Operation, and Reclamation and Closure phases. Some example aspects of closure water quality that may require adaptive management are described in **Table 2.4-3**.

Table 2.4-3 Water Quality Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Water quality in Alpha or Facility pond discharge exceeds threshold concentration values	Concentrations of water quality parameters in pond discharge	Evaluate performance of closure measures Implement improvements to closure measures as needed to meet surface water quality objectives.
Water quality in groundwater monitoring wells exceeds threshold concentration values (as determined through steady state water quality modelling) that could lead to exceedance of acceptable concentration limits in downgradient surface water in the future	Concentrations of water quality parameters in sentinel groundwater monitoring wells	Review surface water quality model to identify whether refinement based on operational groundwater monitoring results is warranted Review estimates of time for the groundwater zone exceeding threshold concentrations to report to surface water, and refine if appropriate Evaluate performance of closure measures Implement improvements to closure measures as needed to protect groundwater quality.

2.4.2.2 Physical Stability

Physical stability is a fundamental mine reclamation and closure objective (**Table 1.3-1**), which requires that all mine-related structures and facilities will remain physically stable under the range of potential future site conditions (including static loading and seismic loading conditions). The waste storage facilities, the open pits, and the water management infrastructure are key components of the Closure AMP related to physical stability.

Waste Rock Storage Facilities

The Alpha WRSF will be constructed as described in **Section 3.3.3**. Minor re-sloping may be completed to promote long-term physical stability at the end of active waste dumping. The Alpha WRSF will not be covered or actively revegetated (**Section 3.3**). Some example aspects of WRSF stability at closure that may require adaptive management are described in **Table 2.4-4**.

Table 2.4-4 Waste Rock Storage Facilities Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Movement within WRSF or underlying foundation	Visual or surveyed indicators such as distress of external slopes, development of tension cracks on WRSF surfaces or crests, sloughing or deformation at WRSF toes Instrumentation results such as excess pore pressures in foundation piezometers.	Undertake geotechnical investigation to assess mitigation requirements, and undertake any necessary mitigations (could include flattening of slopes or buttress construction).

Pits

At closure, Supremo and Latte pits will remain mostly open (with limited backfill of waste rock in specified areas), while Double Double Pit and Kona Pit will be completely backfilled. Boulder fences will be placed around each pit to form a substantial visual indicator of a change in landscape that will act as a warning sign to humans and wildlife and there will be appropriate egress points to reduce the potential for entrapment. The pits will be allowed to passively accumulate natural runoff and precipitation, creating one pit lake in Latte Pit and eight pit lakes in Supremo Pit (**Section 3.1**). Aspects of the physical stability of the pits at closure that may require adaptive management are described in **Table 2.4-5**.

Table 2.4-5 Pit Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Pit crests ravel back more than expected	Footprint of pit expands during closure to engulf a section of boulder fence	Monitor condition of boulder fence and undertake maintenance, relocation or replacement as appropriate

Example Performance Issues	Example Indicators	Potential Responses
		Replace affected section of boulder fence further away from pit crest.

Water Management Infrastructure

Water management infrastructure will be left in place until the water quality entering Alpha Pond and Facility Pond routinely meets effluent criteria (**Section 5.2**). Once effluent criteria are routinely being met, the ponds will be decommissioned.

A permanent diversion channel will be constructed along the western margin of the Alpha WRSF which will replace the operations diversion channel, and be built in such a way to ensure long term performance and minimal maintenance. . The conveyance underdrain of the Alpha WRSF will also remain as a permanent water management structure. Aspects of the physical stability of the permanent water management infrastructure that may require adaptive management are described in **Table 2.4-6**.

Table 2.4-6 Water Management Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Erosion in diversion channels	Scour of channel base or embankments	Conduct maintenance and/or undertake upgrades as appropriate.
Settlement along diversion channel alignment	Changes to as-built graded profile of channels	Conduct maintenance and/or undertake upgrades as appropriate

2.4.2.3 Revegetation

Revegetation is related to several fundamental mine reclamation and closure objectives (**Table 1.3-1**), including ecological conditions and sustainability, land use, and aesthetics. The main aspects that require attention from an AMP perspective are aspects that relate to areal coverage and species mix (including invasive plants and non-native plants). Aspects of the physical stability relevant to revegetation that may require adaptive management are described in **Table 2.4-7**.

Table 2.4-7 Revegetation Adaptive Management Overview

Example Performance Issues	Example Indicators	Potential Responses
Colonization by invasive plant species	Presence of invasive plants	Implement control measures appropriate to species and population.
Areal vegetation coverage lower than target density in reclaimed areas	Low plant density, high proportion of bare ground	Implement enhancement measures (e.g., over-seeding, direct planting, application of fertilizer, re-evaluation of target species mix).
Natural colonization is slower than target performance thresholds	Low rates of colonization by native species	Implement enhancement measures (seeding or direct planting of native species).

2.5 Seasonal or Temporary Closure

In accordance with the *Yukon Mine Site Reclamation and Closure Policy* (EMR 2006), this section describes the measures and activities that will be undertaken for the Project in the event of a seasonal or temporary closure, including monitoring and reporting activities[11].

For purposes of this CRCP, seasonal closure refers to the cessation of activities in a specific season (e.g., winter season), while temporary closure refers to a closure in which operations activities cease with the intent of resuming activities in the near future.

To minimize outstanding liability and risks while the site is in seasonal or temporary closure, the primary objectives during such a period are to:

- Confirm that all mine-related infrastructure and facilities are physically and chemically stable and performing in accordance with designs
- Confirm that all mine-related infrastructure and processes can withstand severe climatic and seismic events
- Eliminate or minimize health and safety hazards to site personnel and area wildlife by achieving conditions similar to local area features or preventing access to areas that are not reclaimed that pose a risk, and,
- Confirm that mine-related disturbances (e.g., building sites, hazardous materials storage sites, roads, etc.) are not going to adversely affect aquatic and terrestrial environments to prevent future long-term uses or a self-sustaining ecosystem.

[11] The *Yukon Mine Site Reclamation and Closure Policy* states that: 1) “Every approved reclamation and closure plan will provide for measures to be taken in the event of a temporary and/or seasonal closure”; and 2) “These plans will include among other things a monitoring and reporting program for the duration of the temporary closure period.”

Prior to the onset of care and maintenance activities during a seasonal or temporary closure, it is likely that operations personnel would complete all necessary outstanding repairs; winterize water collection and diversion systems, mobile equipment, buildings and other site infrastructure; and transport waste materials stored in waste transfer areas to appropriate disposal, recycling, or salvage facilities.

Details pertaining to care and maintenance activities during seasonal or temporary closure are provided below in **Sections 2.5.1** and **2.5.2**, respectively.

2.5.1 Seasonal Closure

A seasonal closure is most likely to occur prior to the Construction Phase or early in the development of the mine (Year -3 or Year -2), and in conjunction with a suspension of NAR operation when the Stewart and Yukon Rivers is freezing-up in the fall through early winter.

A care and maintenance program during a seasonal closure would require a reduced workforce to conduct the following activities:

- Inspect and maintain property assets
- Maintain site security and restricted access to authorized personnel only
- Confirm that barriers and warning signs are in place around hazardous areas (e.g., excavations and open pits)
- Confirm that hazardous materials and explosives are safely stored
- Secure machinery and mobile equipment when not required
- Implement measures outlined in management plans (provided in Appendix 31)as necessary, and
- Continue with inspection, monitoring, and reporting activities as per licence and permit requirements.

During a seasonal closure that occurs late in the Construction Phase or early in the Operation Phase, additional activities may be required to achieve primary objectives. Such activities applicable to a more developed mine site are likely to be similar to those described below for temporary closure (e.g. recirculation of heap leach process solutions if the HLF has been commissioned).

2.5.2 Temporary Closure

A temporary suspension of operation activities could result with a change in market conditions or mine-related factors, and could be either planned or unplanned. For the purposes of this CRCP, temporary closure is assumed to occur at the commencement of the Operation Phase (Year 1), with the suspension of operations occurring for more than a continuous six month period but less than three years[12].

[12] The duration of temporary closure will ultimately be defined by conditions specified in water use and mining licences.

The key measures to be undertaken during a temporary closure period are associated with ensuring that the site is secure and safe to minimize health and safety risks, and ensuring compliance with all regulatory and licensing requirements to manage risks associated with potential abandonment of a site. As shown in **Figure 2.5-1**, the Mine Site area includes the following mine infrastructure and facilities at commencement of the Operation Phase in Year 1:

- Latte and Double Double open pits
- Heap leach facility including Stage 1 of the pad and EP-1N and EP-1S event ponds
- Alpha WRSF including the frozen soil stockpile area
- Temporary organics stockpile, ROM stockpile, and the crusher system and crushed ore stockpile
- Camp and Plant sites (including waste management areas), and the bulk explosive storage area,
- Water management infrastructure, and
- Mine Site Access Route, and mine site and haul roads.

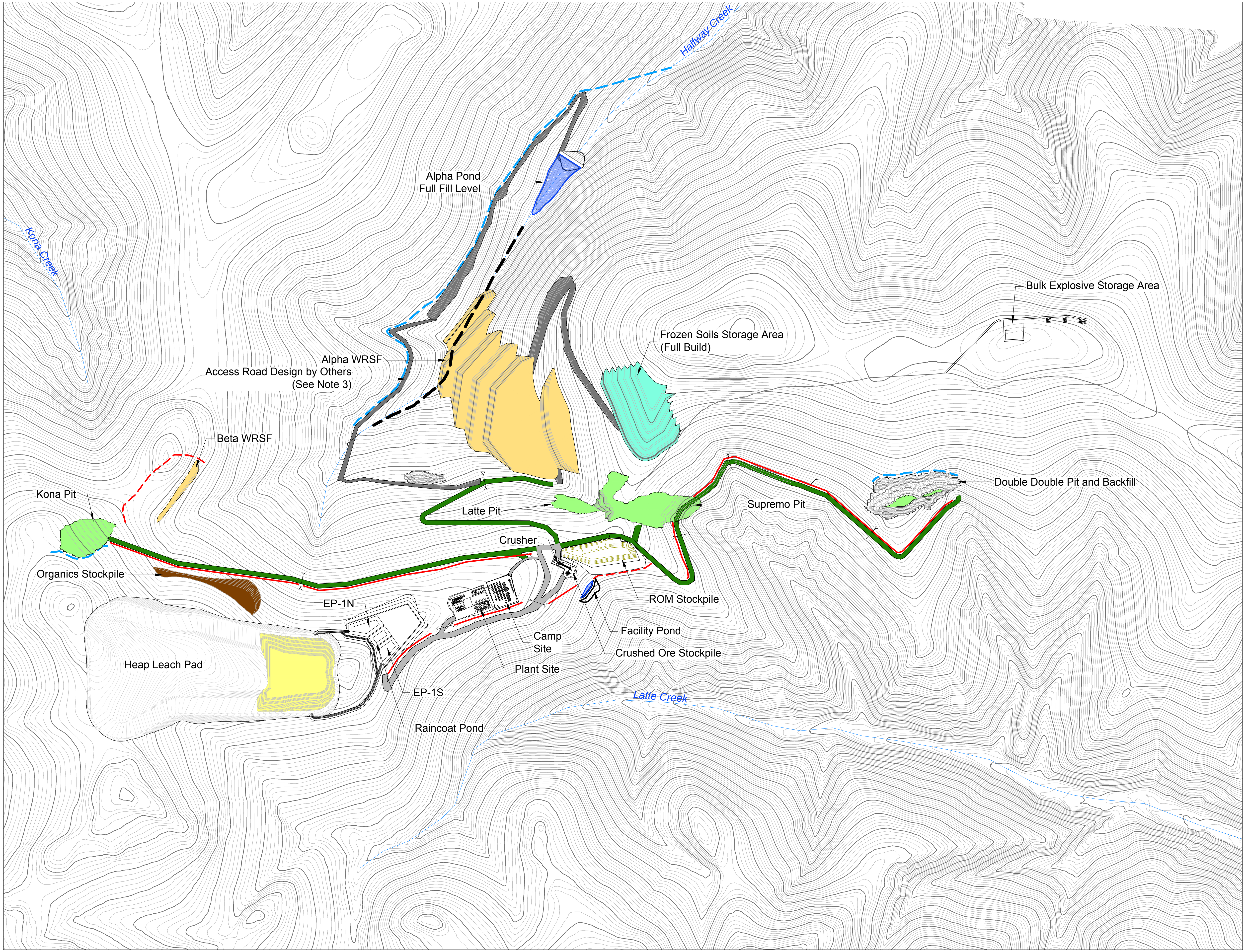
2.5.2.1 Care and Maintenance Program

At the onset of temporary closure, a care and maintenance program will be implemented to a level such that all mining infrastructure and processes are in operable condition for a period of up to three years so that full operations can resume in a timely manner should the decision be made to recommence production. Temporary closure activities would continue until mining resumes or until the decision is made to permanently close the mine (i.e., prevailing conditions for the resumption of operations are not favorable).

General measures and activities that are likely to be undertaken during temporary closure are described below, along with specific activities for Year 1 infrastructure and facilities. A more detailed plan for temporary closure, developed in accordance with the plan requirements and closure costing guidance of the *Reclamation and Closure Planning for Quartz Mining Projects* (YWB and EMR 2013), will be submitted in conjunction with the YWB application for a Type A Water Use Licence.

COFFEE GOLD MINE

Mine Site General Arrangement at Start of Operation Phase (Year 1)



Legend

- Diversion Berm
- Rock Drain
- Road Drainage Ditch
- Waste Rock Collection Channel
- Active Pit
- Frozen Soils Storage Area
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility
- Heap Stack
- Access Road
- Haul Road
- Culvert

Notes

1. This figure is not intended to be a "stand-alone" document, but a visual aid to the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. Contours shown at a 5 meter contour interval.
3. Access road design to be finalized in next phase.

N

1:25000

0 2500 5000 7500 10000

Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 2.5-1	Date: Mar 29, 2017	Drawn by: TAH	Reviewed: DP/TS

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Path: P:\01_SITES\Coffee Gold\!040_AutoCAD\Yearly Buildouts\Year 1.dwg

2.5.2.2 General Requirements

It is anticipated that Goldcorp will undertake the following reporting activities after temporary closure has commenced:

- Submission of a notice of closure within a specified period (as dictated by licenses) to the appropriate regulators and stakeholders, which describes the following:
  - Reasons for and anticipated duration of the suspension of operations
  - Actions that will be taken to maintain compliance with Project licenses and permits, and
  - Any event which would reasonably be anticipated to result in the resumption of mining or the permanent closure of the mine.
- Submission to the appropriate authorities of an updated Reclamation and Closure Plan, including consideration of any increases in liability associated with temporary closure, or costs incurred for implementing temporary closure.

During a temporary closure period, Goldcorp will be a responsible steward of the site and demonstrate its commitment to re-opening the site by continuing to retain full-time care and maintenance and operations (for the HLF) staff. It is anticipated that onsite personnel will include a site manager, environmental technicians, HLF operation staff, and supporting personnel (for site maintenance and camp operation) who will work on shift rotations to provide adequate coverage. Onsite staff will be responsible for a variety of measures including, but not limited to, the following:

- Inspecting the site on a regular basis to observe and document the condition of any changes to site security, safety measures, and mine infrastructure
- Monitoring and reporting as per regulatory requirements (**Section 2.5.3** provides additional information on site inspection and monitoring activities)
- Documenting potential environmental or health and safety issues and response to any security/safety breaches as required
- Implementing and supporting safety and security controls, first aid, emergency and spill response, and communications
- Coordinating specialist contractors such as mechanics, electricians, biologists, and engineers to assist with requirements on an as needed basis
- Providing for snow removal and dust control for roads and the airstrip, as necessary (and other applicable measures (see for example, Appendix 31-B,Access Route Operational Management Plan for applicable measures for the NAR), and
- Supporting water management and process activities at the HLF.

Care and maintenance activities have been planned to adhere to all safety and environmental standards. Anticipated care and maintenance activities in Year 1 for open pits, the HLF, WRSFs, stockpiles, roads and the airstrip, Camp and Plant sites, surface equipment, and the management of waste and hazardous materials are described below. In addition to relevant requirements outlined in Project Proposal Volumes II to V for specific components, activities pertaining to water management and wildlife protection would continue where applicable, in accordance with the Water Management Plan (Appendix 31-E) and Wildlife Protection Plan (Appendix 31-F), respectively.

2.5.2.3 Open Pits

The development of Latte and Double Double pits will cease during temporary closure. The primary goal for these open pits during temporary closure relates to the protection of human health and safety. Site access control is a key measure to minimize this risk, in addition to the placement of boulder fences and warning signs in areas of concern. Boulder fences are intended to create a visual aid to suggest a change in landscape to act as a warning sign for both humans and large mammals.

Chemical stability is not a concern for Latte and Double Double pits as geochemical characterization (based on static and humidity cell testing, acid-base accounting, and trace element analyses by Lorax (JDS 2016)) of these deposits indicates that they are non-acid generating.

Open pits will fill with water during temporary closure. Depending on pit capacity, infilling rate, and geotechnical requirements relevant to the resumption of mining activity, pits may naturally decant or be pumped to maintain a desired water level once it is determined that water quality criteria have been met. Appropriate erosion protection measures will be installed at the overflow or discharge location to adequately manage suspended sediments. The necessary infrastructure and equipment (e.g., pipelines, pumps, and a power generating facility with adequate capacity to power water pumping systems) to allow for this pumping activity will remain in operable condition.

2.5.2.4 Heap Leach Facility

The HLF consists of a conventional free-draining lined leach pad, event ponds, access roads, and leachate solution distribution and collection piping. As water management and leaching from the HLF are concerns during temporary closure, process solutions will be recirculated. The heap water balance is designed to minimize make-up water demand from external sources and avoid the need to treat surplus water until near the end of the mine life.

A small operations crew will continue to irrigate the heap with barren solution, collect and store pregnant solution, operate gold recovery facilities, and maintain the facility as a zero discharge facility. The site caretaker will assist with maintenance of HLF infrastructure (e.g., process equipment) as required during temporary closure.

To avoid freezing of the heap leach pad and to facilitate year-round HLF operation during temporary closure, operating requirements will be similar to those currently proposed during January through March of each year for routine operations. The following activities will be conducted, as required:

- Barren solution will be heated November through March of each year;
- Pregnant, barren and wash water will be stored in tanks at the plant (rather than ponds, which will only being used in upset conditions); and
- Temporary geomembrane covers (or raincoats) will be used to:
    - Maintain ore and solution temperatures;
    - Eliminate dust generation in windy conditions;
    - Minimize precipitation infiltration to avoid a chronic surplus of water and the associated need to treat for discharge; and,
    - Maximize runoff for storage for later use as make-up water or discharge as non-contact water depending on operational water needs.

The recirculation of process solutions and recovery of gold would continue until operations resume or a decision is made to cease recirculation. The latter may occur if all economically recoverable gold has been processed or the mine progresses towards permanent closure. Depending on the circumstances, a small water treatment plant may be required to treat collected process solution and drain-down rinse water. Treated water will either be used in additional rinsing of the heap or discharged to the environment (i.e., Halfway Creek). .

2.5.2.5 Waste Rock Storage Facilities and Stockpile Areas

Waste Rock Storage Facilities

Waste rock from the Latte and Double Double open pits is planned to be deposited in the Alpha WRSF. As stated previously, the stockpiled material from these pits is not likely to be a geochemical concern. The focus of temporary closure for the Alpha WRSF is to provide for physical stability to minimize erosion, subsidence or slope failure, and collect and route runoff through Alpha Pond to settle total suspended solids (TSS). The storage capacity within the pond is likely to provide retention time to settle the majority of TSS, to allow for discharge that meets water quality criteria.

Stockpiles and Crusher System

Organic material and topsoil from the pre-stripping from the footprints of each pit, and foundations of the Alpha WRSF and other infrastructure will be stored in a temporary organics stockpile located immediately north of the HLF. There are no concerns with this stockpile during temporary closure, and the material is available for use as needed for reclamation activities.

The physical and chemical stability of the ROM or crushed ore stockpiles may be a concern during temporary closure, if any ore material accumulated over the months of January through March (i.e., when ore transport to the heap pad is likely to cease) prior to the commencement of temporary closure. Depending on the period of temporary closure, stockpiled material may be transported to the HLF, prior to the installation of raincoats on the heap.

There are no anticipated issues associated with the crusher system during temporary closure.

2.5.2.6 Supporting Infrastructure and Equipment

Care and maintenance activities during temporary closure for supporting infrastructure and equipment are focused on maintaining all necessary services and equipment to support the activities described above and to minimize health and safety risks.

Roads and Airstrip

The NAR will remain operational to allow for camp and plant supplies and fuel to be delivered. Access will be restricted at the crossing points on the Yukon River and Stewart River. The NAR will require periodic visual inspections to monitor for physical stability and operational safety concerns, and to minimize potential risks to the surrounding environment in the event of a washout. For additional details pertaining to NAR inspection and maintenance requirements, refer to the Access Route Operational Management Plan (Appendix 31-B). Site roads and the airstrip will also be regularly inspected and maintained. Care and maintenance personnel will conduct routine maintenance tasks (e.g., snow removal) as required. Private contractors may be retained to complete maintenance of surface drainage infrastructure or grading as conditions warrant.

Camp and Plant Sites

A portion of the main camp complex will be utilized throughout temporary closure. To support personnel during temporary closure, site services such as the potable water treatment, sewage treatment, power plant, and communications, will be maintained. All site buildings not in use will be kept locked and secured and structural inspections and maintenance will be provided by care and maintenance staff as necessary.

Domestic waste from camp operations will be the primary source of waste during temporary closure. All wastes will be handled, stored, managed, and disposed of as per standard procedures..

The Plant Site will remain operational during temporary closure to support the activities outlined above for the HLF and gold recovery. Routine operating protocols will apply and tanks and storage areas containing hazardous materials such as chemicals and reagents will be secured, with containment provisions complying with applicable regulations.

Depending on the nature of temporary closure, other hazardous materials will either be removed from the Mine Site (e.g., coolants and lubricants) and/or stored in a safe and secure manner with primary and secondary containments, as required. Tanks may be drained and stabilized for temporary closure based on recommendations from mechanical and chemical suppliers, contractors and engineers. The bulk explosives inventory will be removed from site and explosives storage containers and facilities will be inspected regularly.

Mobile Equipment

Vehicles and mobile equipment will be kept onsite to support care and maintenance activities. Mining equipment will be left on site in no load condition, and mobile equipment not required for site maintenance during this period will be stored in appropriate areas. All hazardous fluids will be drained from non-essential mobile equipment based on recommendations from mechanical and chemical suppliers, and handled and disposed of as per standard procedures.

2.5.3 MONITORING AND REPORTING ACTIVITIES

During temporary closure, regular inspections will be conducted to confirm compliance with applicable permits and licenses. Infrastructure such as the Alpha WRSF, HLF, open pits, water management infrastructure, fuel and storage tanks, and the NAR will be inspected to confirm physical stability and integrity. Care and maintenance personnel will coordinate follow-up investigations by appropriate professionals as necessary.

Annual geotechnical inspections of the HLF, Alpha WRSF, open pit walls, all contact and non-contact water management infrastructure, and any other surface infrastructure elements possibly affecting permafrost will be carried out by a qualified geotechnical engineer licensed to practice in the Yukon. Any repairs or maintenance of the infrastructure or facilities, or improvements to runoff, erosion and sediment control will be undertaken on recommendation from the inspections.

Surface water quality, hydrology, and groundwater will be monitored at designated stations in accordance with the license criteria. Monitoring of climatic conditions at the onsite weather station will continue. Care and maintenance personnel will coordinate and support professionals in conducting some elements of the monitoring program such as non-routine water quality and biological monitoring, as necessary. Care and maintenance staff will submit inspection and monitoring reports according to the reporting requirements of applicable licenses and permits.

3.0 CONCEPTUAL RECLAMATION AND CLOSURE OF MINE FEATURES

The general arrangement of Project components within the Mine Site area at the commencement (Year 13) and end (Year 23) of the Reclamation and Closure Phase are shown in **Figure 1.1-2** and **Figure 4.1-1**, respectively. The following sections describe the various components and summarize the conceptual reclamation and closure measures proposed. The major activities are summarized graphically in **Figure 3.1-1.**

3.1 OPEN PITS

For open pits, the performance targets for closure are to meet water management objectives, protect humans and wildlife from topographic hazards, and prevent subsidence (YWB and EMR 2013).

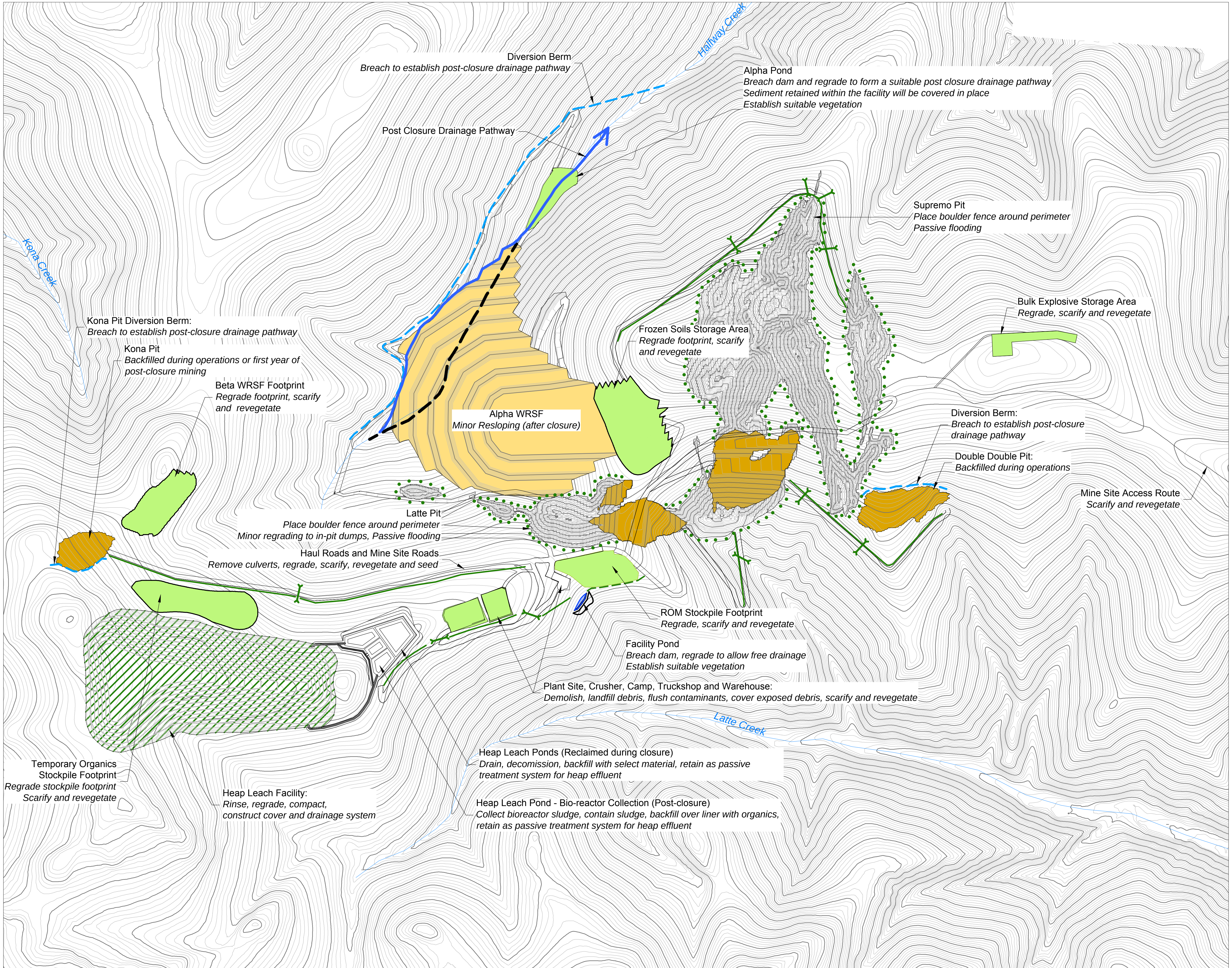
Water management objectives are addressed in **Section 4.0**. Protection of humans and wildlife from topographic hazards will be provided through the placement of boulder fences, retention of some egress from each pit to reduce the potential for wildlife entrapment, and prevention of subsidence will be accomplished by adhering to pit designs that either meet or exceed the acceptable safety factor of 1.3 (JDS 2016). Pits that may eventually fill and spill will have appropriately engineered spillway channels to prevent erosion and sediment from entering the drainages around the mine site. The individual open pits that will be formed by the project are described in the respective sections below, along with the proposed reclamation and closure measures.

3.1.1 LATTE PIT

3.1.1.1 Description

Latte pit will be developed during the preproduction period concurrently with Double Double pit. Mining will continue until Year 3 of operations. The Latte pit will be developed through two phases of mining, with initial development followed by a pushback to the final pit extent. Production from Latte pit will be completed second (after Double Double pit and before Kona and Supremo pits). At completion, Latte pit will be approximately 1,500 m long, 300 m wide, and 150 m deep and will produce a total of 15 Mt of ore.

Most of the waste rock produced from Latte pit will be placed in the Alpha WRSF, but some waste rock will be backfilled into the pit to create causeways to shorten ore haulage routes to the crusher. At closure, approximately 6.9 Mt of waste rock will be left in Latte pit.



COFFEE GOLD MINE

Major Reclamation and Closure Activities (Year 13 - 18)

Legend
- Diversion Berm
- Rock Drain
- Reclaimed Road Diversion Ditch
- Reclaimed Waste Rock Collection Channel
- Reclaimed Footprint
- Reclaimed Heap Leach Pad
- Pit Backfill
- Pit Footprint
- Sedimentation Pond
- Waste Rock Storage Facility (WRSF)
- Removed Culvert Alignment
- Boulder Fence

Other Infrastructure (not shown)
- Power Plant
- Fuel Storage Farm
- Utilities
- Laydown and Storage Areas
- Waste Management Infrastructure

Other Reclamation Areas

Airstrip: Lighting, navigation equipment, and culverts will be removed.
Regrade to promote positive drainage to eliminate potential hazards.
Scarify and revegetate.

Exploration Airstrip: Lighting, navigation equipment and culverts will be removed
Regrade to promote positive drainage to eliminate potential hazards
Scarify and revegetate.

Northern Access Route: Decommissioned at closure.
Culverts and bridges removed, regrade to maintain pre-construction surface drainage.
Remove barge landings
Regrading to promote positive drainage.
Scarify road.

Notes
1. This figure is not intended to be a "stand-alone" document, but a visual aid to the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. Contours shown at a 5 meter contour interval

N

1:25,000

0 2500 5000 7500 10000
Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 3.1-1	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DBM

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3.1.1.2 Closure Measures

Pit sumps and associated pumps and pipelines will be removed as each open pit is mined out. If the pumps are not going to be reused, the pumps will be placed in the designated landfill. Associated pipelines, if not being reused, will be cleaned if necessary and also placed in the landfill.

Boulder fences will be placed around each open pit as it is mined out. Boulders will be placed back from the final pit crest- the intention is not to prevent access, but instead to be a visual aid suggesting a change in landscape that will act as a warning sign to both humans and large mammals. In addition, egress from the pit will be retained, where deemed appropriate and practical to reduce the potential for wildlife entrapment.

The open pits will be allowed to passively fill with natural runoff and precipitation. Latte pit is likely to flood to an elevation of 1009 masl (Appendix 7-B, Numerical Groundwater Model Report). The water quality of the pit lake is likely to be acceptable for release to the closure water management system, which will subsequently report to the receiving environment (Appendix 12-B Surface Water Quality VC Assessment Report).

3.1.1.3 Reclamation Activities

No additional reclamation activities for Latte pit are planned.

3.1.1.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.1.2 DOUBLE DOUBLE PIT

3.1.2.1 Description

Double Double pit will be developed during the preproduction period concurrently with Latte pit. No pushbacks were included in the mine plan because of the relatively small footprint of the pit. At completion, Double Double pit will be approximately 600 m long, 250 m wide, and 100 m deep and will produce a total of 1.5 Mt of ore.

Waste rock produced from Double Double pit will be placed in the Alpha WRSF or used as backfill for the Latte causeway. Later, waste rock from adjacent areas of the Supremo pit will be backfilled into the mined-out Double Double pit. By the end of the Operation Phase (Year 12), approximately 8.8 Mt of waste rock will be stored in the backfilled Double Double pit (JDS 2016).

3.1.2.2 Closure Measures

As the Double Double pit will be fully backfilled during operations, it will not be necessary to construct a boulder fence around the pit perimeter unless it is deemed necessary for the period between the end of pit excavation and the completion of backfilling. Closure measures for the backfilled pit will be as described in **Section 3.2** for WRSFs.

3.1.2.3 Reclamation Activities

No additional reclamation activities for Double Double pit are planned.

3.1.2.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.1.3 KONA PIT

3.1.3.1 Description

Kona pit will be developed during Year 1 of operations, and mining will continue until Year 3. No additional pushbacks were included in the mine plan because of the relatively small footprint of the pit. At completion, Kona pit will be approximately 380 m long, 220 m wide, and 90 m deep and will produce a total of 1.6 Mt of ore.

Although the waste rock from the Kona pit is non-acid generating (NAG), a small area of ore exposed in the completed pit wall has weak potentially acid generating (PAG) tendencies. In order to limit exposure of this ore seam to potential oxidation, the Kona pit will backfilled with waste rock prior to closure. Backfill will be sourced from the temporary the Beta WRSF, which will be constructed next to the pit during mining. Backfilling of Kona pit will be complete by the end of the Operation Phase or during the first year of the Post-Mining Closure Phase. Approximately 3.2 Mt of waste rock will be used as backfill.

3.1.3.2 Closure Measures

As the Kona pit will be fully backfilled, it will not be necessary to construct a boulder fence around the pit perimeter unless it is deemed necessary for the period between the end of pit excavation and the completion of backfilling. Closure measures for the backfilled pit will be as described in **Section 3.2** for WRSFs.

3.1.3.3 Reclamation Activities

No additional reclamation activities for Kona pit are planned.

3.1.3.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.1.4 SUPREMO PIT

3.1.4.1 Description

Supremo pit is located northeast of the Plant Site and the southernmost extent of Supremo pit intersects the eastern wall of the Latte pit. Supremo pit is the largest proposed open pit in the Project and it will be the only producing pit in the final years of the Operation Phase. A total of five phases or pushbacks are planned to optimize the mine schedule and maximize value from the pit. At completion, Supremo pit will be approximately 2,100 m long, 500 m wide, and 140 m deep and will produce a total of 42 Mt of ore.

Most of the waste rock produced from Supremo pit will be placed in the Alpha WRSF, but some waste rock will be backfilled into the pit to create causeways to shorten ore haulage routes to the crusher. At closure, approximately 29 Mt of waste rock will be left in Supremo pit.

3.1.4.2 Closure Measures

Pit sumps and associated pumps and pipelines will be removed as each open pit is mined out. The pumps and associated pipelines, if not intended for reuse will be placed in the designated landfill.

Boulder fences will be placed around the perimeter of Supremo pit during mining; if areas of boulder fence remain to be constructed at the end of the Operation Phase, these will be completed during the Post-Mining Closure Stage. Boulders will be placed back from the final pit crest. . The intention is not to prevent access, but instead to be a visual aid suggesting a change in landscape that will act as a warning sign to both humans and large mammals. In addition, egress from the pit will be retained, where deemed appropriate and practical to reduce the potential for wildlife entrapment.

The open pits will be allowed to passively fill with natural runoff and precipitation. Supremo pit is likely to develop several pit lakes in local depressions in the final pit floor, with projected long term water elevations ranging from 939 masl to 1194 masl (Appendix 7-B, Numerical Groundwater Model Report). The water quality of the Supremo pit lakes is likely to be acceptable for release to the closure water management system, which will subsequently report to the receiving environment (Appendix 12-B Surface Water Quality VC Assessment Report).

3.1.4.3 Reclamation Activities

No additional reclamation activities for Supremo pit are planned.

3.1.4.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.2 HEAP LEACH FACILITY AND PROCESS PONDS

For the HLF, the performance targets for closure are to effectively control transitional solution management and draindown, to achieve suitable final heap quality conditions, and to ensure long-term physical stability (YWB and EMR 2013).

Control of transitional solution management is addressed through rinsing of the heap and collection and treatment of rinse fluids. Suitable final heap quality conditions will be achieved through the combined effects of heap rinsing, chemical stabilization of the heap through rinsing with bioreactor treated solutions and nutrient additions to foster in situ cyanide and nitrogen removal and metal insolubility, construction of low infiltration covers to limit infiltration and reduce heap seepage volumes and provision to implement (if necessary) passive treatment using permeable reactive barriers (PRBs) for “polishing” of heap solutions within event ponds prior to final release to the environment. Long term physical stability of the heap will be provided for through siting the facility on a stable foundation and constructing it according to a geotechnically-stable design that meets or exceeds minimum long term safety factors. The following sections provide a summary description of the HLF and the proposed reclamation and closure measures.

3.2.1 DESCRIPTION

The HLF will be located on the ridgeline to the west of the process plant, with the eastern edge of the leach pad located about 2 km west of the Latte Pit (**Figure 1.1-2**). The HLF will consist of a conventional heap leach pad, three event ponds, a rainwater pond, solution distribution (for delivery of barren solution to the heap), and collection piping (of pregnant solution and rinse water to the event ponds and process plant).The heap leach pad will be a conventional, relatively level pad, directly on bedrock or structural fill after the removal of topsoil and ice-rich material by grading the local terrain and using competent waste rock for fill that supports a multi-lift, free-draining heap.

The heap leach pad design is based on staged construction with initial capacity of approximately 7.2 Mt expanding to the ultimate capacity of 67.3 Mt in five stages. Since only 60.1 Mt of ore are currently planned to be loaded on the HLF, the design capacity is greater than anticipated ore tonnage (**Figure 3.2-1**). The heap leach pad will be lined as described in the Project Proposal (Section 2.5.7 Heap Leach Pad Construction). The leach pad liner system was designed to collect process and rinse solutions and protect surface and groundwater quality through the operating life and after HLF closure.

The average heap height will be 50 m with a typical maximum heap height of 60 m and local maximums reaching approximately 80 m in some areas (as measured vertically above the leach pad liner). The liner and drainage systems are designed for much higher loads and thus the 80 m height is not a firm limit but rather a convenience of the geometry; principally, to provide ample room on the crest of the last lift for haul trucks to operate. As the heap is stacked, the side slopes will be benched such that the face of each lift is stacked at the angle of repose of the crushed ore (1.3H to 1.5H:1V), and benches between each lift will create an overall toe-to-crest slope angle of 2.5H:1V. Bench widths will vary between 12.0 m and 14.4 m depending on the angle of repose.

Because the heap will be free-draining with no in-heap solution storage, there will be no dams or embankments associated with the leach pad. Small embankment dams will be used to create four ponds: the south event pond (EP-1S), north event pond (EP-1N), event pond 2 (EP-2), and the rainwater pond (**Figure 3.2-1**). The event ponds are designed to contain a combination of upset conditions including:

- Heap draining during an extended power or pumping outage
- Extreme precipitation and freshet events
- Cumulative water storage during wet years or temporary shut downs.

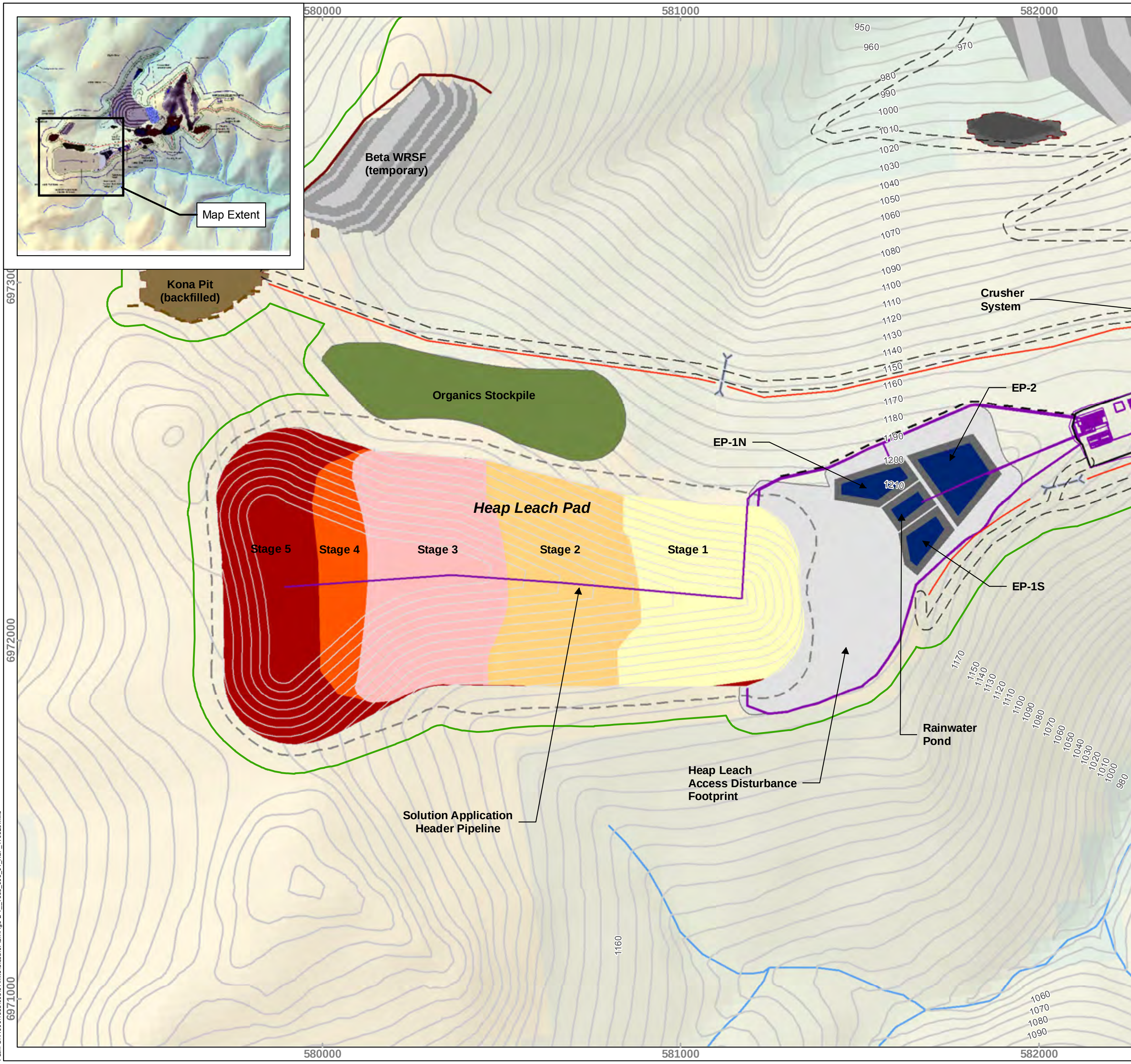
The rainwater pond is designed to temporarily store clean water diverted by the raincoats (described below) for use as makeup water during drier periods as well as freshwater for rinsing during progressive reclamation of the pad stages.

The leach pad will have a liner system comprising a 2.0 mm-thick linear low density polyethylene (LLDPE) geomembrane over a reinforced geosynthetic clay liner (GCL) liner. The bottom side of the LLDPE liner will be aggressively textured to provide a close bond with the GCL. A 500 mm thick drainage layer composed of crushed gravel and drainage pipes will be installed over the synthetic liners. Under the liner system will be graded natural ground (thaw stable rock) and structural rock fill, along with a leak detection system. The total surface area of the heap leach pad with 67.3 Mt of ore stacked will be 971,700 m^2 (Project Proposal- Section 23.5 Heap Leach Facility)

Event ponds 1S and 1N will have two HDPE geomembranes, separated by a drainage layer and underlain by a GCL. Event pond 2 and the rainwater pond will have a single geomembrane liner over a GCL. The capacity of the ponds is summarized in **Table 3.2-1**.

Table 3.2-1 Capacities of the Event and Rainwater Ponds

Pond	Storage Capacity to Free Board Elev., m^3	Storage Capacity to Pond Crest Elev., m^3	Placed in Service
EP-1N	112,349	122,183	Year -1
EP-1S	89,777	97,810	Year -1
EP-2	222,873	240,468	Year +6
Rainwater	51,925	57,074	Year +3



COFFEE GOLD MINE

Heap Leach Facility Illustrating Stages of Heap Pad & Heap Development

Legend

- Watercourse
- Project Footprint
- Heap Leach Pad Stage 1
- Heap Leach Pad Stage 2
- Heap Leach Pad Stage 3
- Heap Leach Pad Stage 4
- Heap Leach Pad Stage 5
- Heap Leach Pad Ultimate Footprint

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. This is a cumulative disturbance figure showing the maximum extent of all mine site components for the duration of the mine life.

N

1:15,000

0 150 300 450

Metres

NAD 1983 UTM Zone 7N

Page Size: 8 ½" x 11"

Figure 3.2-1	Date: Mar 29, 2017	Drawn by: JS	Reviewed: DP

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The average heap height at full construction will be 50 m, with a typical maximum heap height of 60 m, and local maximum heights reaching approximately 80 m in some areas (as measured vertically above the leach pad liner). The liner and drainage systems are designed for much higher loads and thus the 80-m height is not a firm limit but rather a convenience of the geometry; principally, to provide ample room on the crest of the last lift for haul trucks to operate. As the heap is stacked, the side slopes will be benched such that the face of each lift is stacked at the angle of repose of the crushed ore (1.3H to 1.5H:1V), and benches between each lift will create an overall toe-to-crest slope angle of 2.5H:1V. Bench widths will vary between 12.0 m and 14.4 m depending on the angle of repose.

During the Operation Phase and early in the Reclamation and Closure Phase, geomembrane covers (referred to as raincoats) will be used over the heap to reduce the volume of meteoritic water infiltrating into the heap and entering the process solution, and to increase heat retention in the heap during the winter. The raincoats will remain in use over portions of the heap until completion of the Reclamation and Closure Phase. Progressive reclamation of the heap leach pad will entail rinsing individual sections of the heap leach ore once they have undergone the complete gold recovery cycle. The heap will be rinsed (via solution from the rinse pipelines) and capped in stages; as each stage is capped, the raincoats for that area will be removed and used in other areas or incorporated as part of the closure capping.

3.2.2 Closure Measures

In general, the closure activities for the heap include the following (which are discussed in more detail in the following sections). The heap geometry at closure is shown in **Figure 3.2-2** and **Figure 3.2-3**.

- Rinsing the leached ore and management and treatment of surplus solutions
- Grading the heap, and
- Capping the heap.

For two or three of the four ponds, the closure activities will include:

- Drain the pond and wash the pond liner, with the wash water then used in the preliminary heap rinsing
- Perforate the liner at the bottom of the pond
- Fold the liner from the slope and anchorage into the pond, and,
- Fill the empty pond with selected material (e.g. zero valent iron, coarse organic composted wood chips from tree clearing, suitable geologic materials) to serve as contingency final polishing and passive treatment of heap seepage waters following completion of active treatment.

One pond will be used for the duration of the water treatment period (anticipated to be to Year 15, but may extend to Year 20) for disposal of the likely small volumes of sludge from the water treatment plant. It will then be closed as described above for the other three ponds except that the liner will not be perforated, and when the liner is folded down over the sludge the laps will be properly welded to produce water-tight seams. A second pond may also remain open and in use for some or all the water treatment period, and there is consideration to use it in the long term (after Year 20 or sooner, depending on the treatment circuit performance) as part of the passive treatment polishing system for heap effluent as described above.

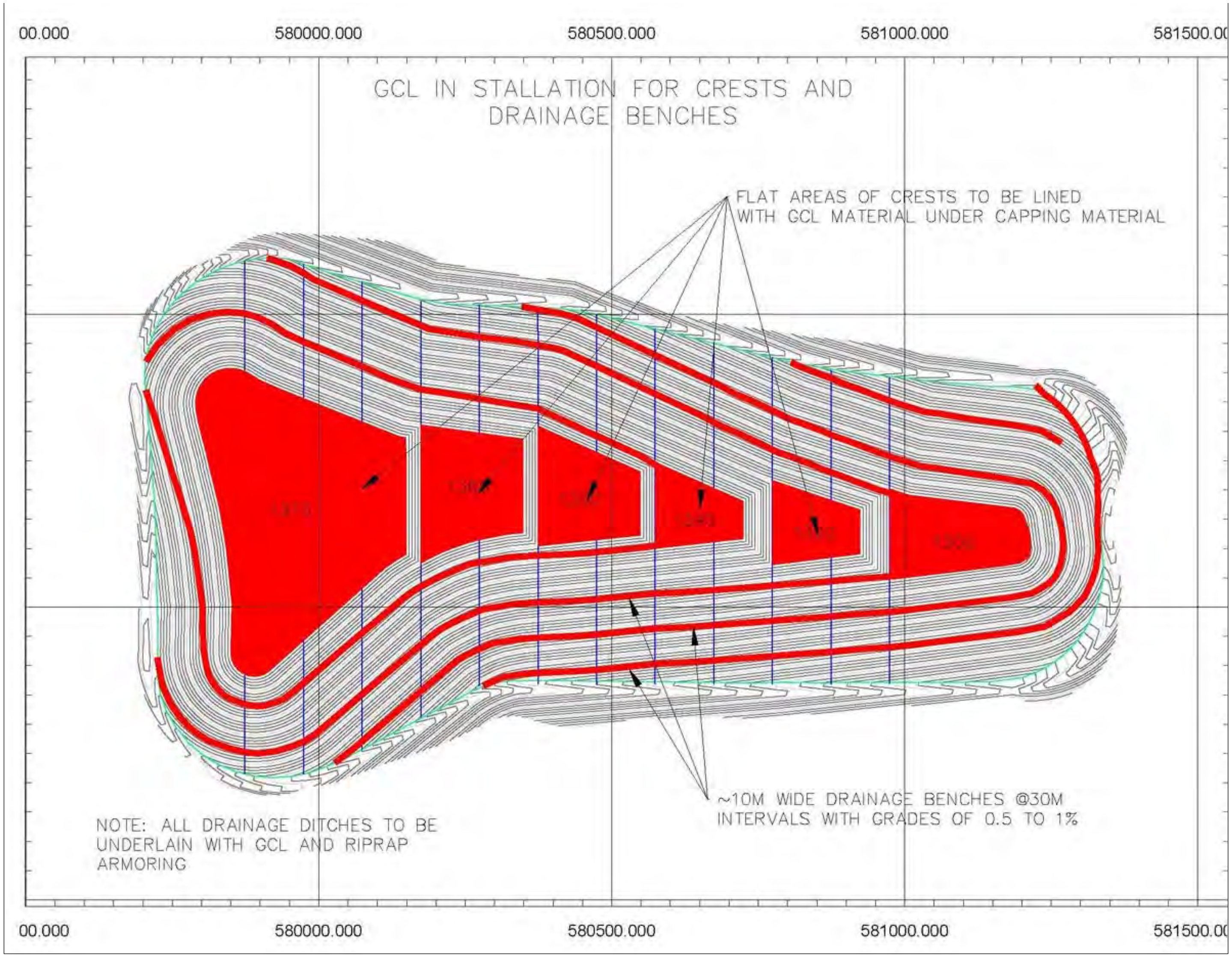


Figure 3.2-2 Heap at Closure Showing Areas to Receive GCL in Capping System (in red)

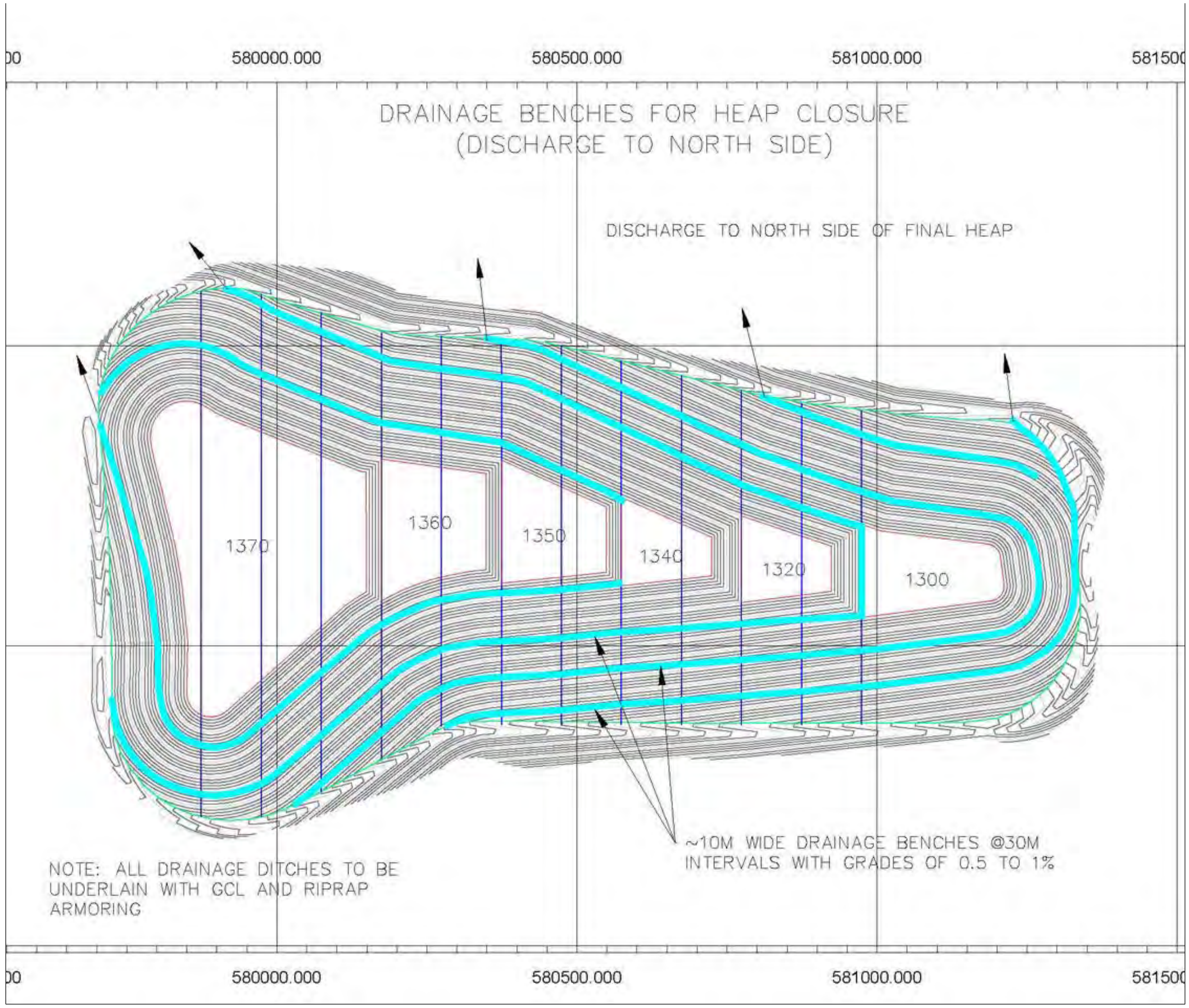


Figure 3.2-3 Heap at Closure Showing Final Surface Drainages (in blue)

3.2.2.1 Heap Rinsing

The north and south halves of the leach pad are separated hydraulically; the south half slopes and drains to the southeast while the north half slopes and drains to the northeast. The design also includes hydraulic separation of the leach solutions by cell (approximately every 100 m of pad in the east-west or long axis direction) and by stage (Stages 1 through 5). Each cell will be separated by a drainage ditch or berm, preventing solution from one cell from entering the adjacent cell (**Figure 3.2-3**). The stages will be separated in a similar way but with a larger berm to provide more definitive separation. Because there is always some lateral spreading of solution within the heap during irrigation, there will be some solution cross over from a cell under irrigation to an adjacent cell, but this will be limited to a horizontal distance of under half the width of a cell. Thus, the first cells of Stage 1 of the heap can begin rinsing when active leaching has moved at least 1 cell away. The first area to enter rinsing will be the first cells of Stage 1, and this is likely to begin by mid-Year 4. Thereafter the rate of advancement of rinsing will closely follow the movement of the active leaching.

Following final leaching for gold recovery, heap closure will consist of three steps, as summarized below. Grading of the heap to the final closure geometry can occur seasonally during any of these three steps, and may continue through all three.

Phase I – Preliminary Rinsing

Preliminary rinsing of the heap will occur using detoxified barren solution with the pH adjusted to below about 8 to facilitate the removal of cyanide through volatilization. The high vapor pressure of hydrogen cyanide causes free cyanide to volatilize where conditions favor a significant concentration of this species (pH below approximately 10) and therefore volatilization increases with decreasing pH (Johnson, 2014). The preliminary rinsing will continue until the chemistry of the heap effluent reaches approximate equilibrium with the rinse solution. Preliminary rinsing will begin in Year 4 and then occur annually until about two years after cessation of active leaching for gold recovery. Preliminary rinsing will advance along the heap in the same direction as ore stacking (east to west) and, once started, will progress at approximately the same rate as the westward advancement or stacking of the heap.

Phase II – Final Rinsing

Final rinsing is designed to dramatically reduce contaminant levels in heap solutions with the ultimate objective of reducing contaminant concentrations to levels acceptable for direct discharge to the environment. Final rinsing of the heap will be performed using fresh water (surface runoff water that is collected and stored in the rainwater pond), and treated process solution from the Electrochemical Biological Reactor (or EBR, as described in Section 3.2.2.4) or a combination of the two. The effluent from final rinsing will then be used as either rinse water from preliminary rinsing, or makeup water for the process circuit until active leaching for gold recovery is completed.

Rinsing with treated heap leach solutions is designed to foster *in situ* treatment of the heap and reduce the overall time for chemical stabilization of the heap leach pad. The concept is to rinse with bioreactor treated solutions as this water will be both free of contaminants and contain microbes from the bioreactor adapted to treating heap chemistry. Nutrients and soluble carbon (e.g. methanol, molasses and phosphate) will likely be added to the treated solutions prior to rinsing of the heap. The proposed process is similar to what was done at the Brewery Creek Heap Leach Facility to detoxify the solution inventory to close the heap.

The addition of microbes, carbon and nutrients to the heap will foster reducing conditions within the heap pore waters allowing for *in situ* denitrification and ultimately reductive precipitation of metals. It is anticipated that following Phase I rinsing that the heap drain down water will be elevated in nitrate, metalloids (As and Sb) and metals (Cd, Cu, Hg, U and Zn) and these parameters will require treatment prior to release to the environment. This phase of *in situ* treatment is designed to treat constituents within the heap, as well as decreasing metals concentration to sufficient levels to either directly discharge, or at least provide water that is of sufficiently good quality to only require polishing in a passive treatment system (described below). Final rinsing will continue until the chemistry of the effluent has reached the target.

Final rinsing will begin one year after preliminary rinsing (about Year 5) and will continue until the entire heap has been rinsed, approximately Year 15, and may extend to Year 20. Beginning in about Year 9, the system will produce surplus water. The water treatment plant will be commissioned before Year 9, and will treat the excess water to concentrations acceptable for discharge to Halfway Creek. Treated water will be discharged to the Alpha underdrain and report to the Alpha Pond prior to release to Halfway Creek during operations and early closure while the water treatment plant is in operation.

Phase III – Final Capping of the Heap

Following final rinsing and once heap draindown is complete, a cover runoff control system will be constructed on the heap. This activity will occur immediately following final rinsing and will require one summer season. This will advance progressively each year starting in about Year 5.

3.2.2.2 Heap Grading and Engineered Cover Design

The heap will be graded to provide proper drainage for runoff and freshet. The surface of the heap will be compacted and an engineered cover system installed. On the flat areas, the cover will include both an infiltration barrier (e.g., geosynthetic clay liner (GCL) or similar) and a store-and-release component overlying the GCL with provision for drainage of water overlying the GCL. For the slopes, only a store-and-release system will be included due to the complexities of creating a stable slope with a low-permeability barrier. The goals of the cover system are:

- Provide for physical stability of the heap including stable slopes and erosion resistance
- Provide for positive drainage to minimize the creation of saturated zones

- To route runoff away from the heap and into the nearby natural drainage channels in a manner that prevents erosion or other ill effects, and,
- Reduce infiltration of precipitation and freshet 20 to 25% (typical) and 30% (maximum) of mean annual precipitation.

Beginning in about Year 5 and continuing annually until Year 15 to 18, the slopes and crest of the heap will be graded to achieve the following:

- The slopes of the heap will be smoothed and some of the benches will be removed to provide a flatter inter-bench slope. Generally, one 10- to 15-m wide bench will remain for every 20 to 30 m in vertical slope height. The slopes below and above each bench will be approximately 2.3H:1V, and the overall slope from the toe to the crest of the heap will be 2.5H:1V or flatter;
- The crest will be graded to provide a gentle but positive slope to armored drainage channels along the crest and down the slopes, to route the water off of and away from the heap;
- All areas that are flat or have a slope of not greater than about 6%, including the crest of the heap and the benches on the slope, will be capped with the following infiltration barrier and store-and-release cover system (from bottom to top):
    - Compacted rinsed ore to provide a firm, non-yielding base
    - GCL, compacted low permeability soil, an integral GCL/geomembrane product, or equivalent low permeability infiltration barrier
    - Drainage layer (gravel, geonet, or equivalent)
    - 500 mm storage layer comprised of finely-graded waste rock (i.e., confirmed to be of limited metal leaching potential), soil or other suitable material, and
    - Natural revegetation will be encouraged where appropriate and according to site-specific testing to be performed during the operating life of the facility.

The slopes of the heap will be capped with a store-and-release system as follows (from bottom to top):

- Compacted rinsed ore to provide a firm, non-yielding base and to function as part of the store-and-release system
- 500 mm storage layer comprised of finely-graded waste rock (i.e., confirmed to be of limited metal leaching potential), soil or other suitable material, and
- Natural revegetation will be encouraged where appropriate and according to site-specific testing to be performed during the operating life of the facility.

3.2.2.3 Closure Schedule

Closure activities will span the latter part of the Operation Phase and the initial part of the Reclamation and Closure Phase. Subject to operational variations, activities will proceed along the following general timeline:

- Years 3 and 4
    - Raincoat placement starts on Stage 1 of the heap in Year 3

  - Preliminary rinsing starts by Year 4, using detoxified barren solution to reduce the pH and cyanide levels in the effluent. As each area approaches target water chemistry the detoxified solution will be replaced or supplemented with fresh make-up water for the final rinse cycle
  - Treatment goals for this period are only to reduce cyanide concentrations of the heap and effluent and to lower the pH of the heap to values less than pH 9.0; treatment is not designed to meet environmental discharge criteria. No water discharged to environment occurs during this period and all rinse water is reused in the circuit
  - Begin pilot testing of closure concepts and EBR for treatment (see **Section 3.2.2.4**) as well as recycling of EBR effluent onto heap for in situ stabilization and nitrate removal, and,
  - Continue geotechnical monitoring.
- Year 5 to Year 9
  - Raincoat placement continues through the remaining life of the operation
  - *In situ* detoxification using organic carbon and nutrient inoculation will be field (pilot) tested in the early cells of Stage 1 or 2
  - Effluent detoxification continues, lowering the pH to remove cyanide and the biologically mediated oxidation of total cyanide, ammonia oxidation (nitrification) and nitrate removal (denitrification)
  - Heap covering commences in Year 5 with GCL covered by soil or rock on flat areas, soil or rock only on sloped areas. The cover system is to reduce infiltration and begin revegetation, and,
  - Continue geotechnical monitoring.
- Years 9 to 14
  - As above
  - Focus closure technologies on those that have been field-proven during pilot testing program
  - Surplus water production is expected in Year 9. Commissioning the water treatment plant to meet effluent requirements for discharge to Alpha WRSF underdrain and ultimately Halfway Creek (full water treatment plant commissioning will occur before Year 9).
  - Average treatment rate will be 4 L/s starting in Year 9, increasing to 10 L/s over the duration of the final rinsing process. Treatment duration will average about 6 months annually (May through October).
  - Continue active management of the site, providing annual grading and cover upgrading, routine maintenance of covering and drainage layers for the heap and active management of the water treatment plant, and,
  - Continue geotechnical monitoring.
- Year 15 to 23
  - Water treatment will continue until about Year 15 (it may extend to Year 20 depending on treatment circuit performance) after which water will either be directly discharge to Latte pit, or directed to passive treatment cells for final polishing and then discharged to Latte pit.

- Most active management functions will have concluded and beginning in about Year 15 and the only active management will be the water treatment plant (if required).
- Site wind-down including demobilization of most personnel and equipment in preparation for passive closure beginning in Year 24, and,
- Continue geotechnical monitoring.

- Years 24 and beyond
  - Regular monitoring according to a schedule to be developed. Monitoring frequency should decline over time; and,
  - Adapt the geotechnical monitoring program to the closed conditions and monitor as planned.

3.2.2.4 Water Treatment

As described in **Section 3.2.2.1**, progressive reclamation of the HLF will entail rinsing of individual sections of the HLF that have completed the gold recovery cycle. As such, potential parameters of concern have been identified as those elements in heap leach rinse solutions that are predicted to be at concentrations unacceptable for direct discharge to the receiving environment and will therefore require treatment prior to release.

The processing of heap leach ore at Coffee will entail the use of dilute cyanide solutions under pH conditions ranging between pH 10.5 and 11.0. While the dissolution of gold is the primary chemical process occurring during cyanide leaching, other metals are liberated during the leaching process, both as a result of complexation reactions with cyanide (e.g. Cu-CN, Cd-CN, Zn-CN) and increased solubility under elevated pH conditions (e.g. As and U). In addition, natural degradation of CN in situ within the heap leach facility results in elevated concentrations of nitrogen species in heap leach solutions. Collectively, leaching of Coffee heap leach ores is predicted to produce leaching solutions with chemical characteristics as summarized in **Table 3.2-2** below as determined through metallurgical column leach testing. This process solution will only report to the ADR (adsorption, desorption, and recovery) plant and will not be directed to water treatment.

Table 3.2-2 Summary of Expected Heap Leach Process Solution Chemistry Prior to Rinsing

Parameters of Concern	Expected Concentration (mg/L)*
pH	9.0 – 11.0
CN_{Total}	130 -170
CN_{WAD}	100 - 160
Sulphate	100 - 1000
Ammonia-N	50 - 90
Nitrite-N	1 – 10
Nitrate-N	25 - 200
As	1 - 5
Sb	0.05 – 1
Cd	0.0003 – 0.01
Cu	1 – 3
Fe	0.5 – 5
Hg	0.0005 – 0.01
Ni	0.05 – 0.13
U	0.1 – 0.5
Zn	0.2 – 1.5

Note: * All units in mg/L except pH

Active water treatment will only occur on heap leach rinse solutions. As discussed previously, rinsing will comprise two stages:

1. Phase I - Preliminary rinsing of the leached ore using pH adjusted (e.g., pH 7.5 to 8.0) barren solution, which will continue until the chemistry of the heap effluent reaches approximate equilibrium with the rinse solution.
2. Phase II - Final rinsing of the heap will be performed using fresh water, stored in the rainwater pond, and/or treated rinse solution. The heap effluent from final rinsing will then be used as either rinse water for preliminary rinsing, or as makeup water for the process circuit until active leaching for gold recovery is completed.

Heap rinse solutions resulting from Phase I rinsing are anticipated to have water quality characteristics as summarized in **Table 3.2-3**.

Table 3.2-3 Summary of Expected Heap Rinse Solution Water Quality following Initial Rinsing

Parameters of Concern	Expected Range of Concentrations (mg/L)*	MMER Limits[1] (mg/L)*
pH	8.0 – 9.0*	6.5 – 9.0
Total Suspended Solids	1 - 10	15
CN_{Total}	1 - 5	1
CN_{WAD}	0.2 - 1	
Sulphate	100 - 500	
Ammonia-N	5 - 20	
Nitrite-N	1 - 10	
Nitrate-N	100 - 300	
As	1 - 2	0.5
Sb	0.05 – 1	
Cd	0.0005 – 0.001	
Cu	0.01 - 1	0.3
Fe	0.5 – 5	
Hg	0.0005 – 0.001	
Pb	0.001 – 0.02	0.2
Ni	0.05 – 0.13	0.5
U	0.1 – 0.5	
Zn	0.1 - 1	0.5

Notes: * All units in mg/L except pH

1: Metal Mining Effluent Regulation Limits for maximum authorized monthly mean concentration

As illustrated, a number of parameters are predicted to remain elevated in rinse solutions and therefore require further treatment prior to release to the environment. The most notable of these parameters include CN_{Total}, CN_{WAD}, nitrate, nitrite, As, Sb, Cd, Cu, Hg, Ni, U and Zn. While some of the above parameters are readily removed using chemical treatment processes, nitrate and U are more amenable to biological treatment using microbial reduction techniques.

Discharge of water from the water treatment plant will commence in Year 9. The treatment plant will be constructed prior to this time and used in treatment of rinse solutions as described previously. Currently, the water treatment plant is expected to operate through the end of the Operation Phase to Year 15 of the Reclamation and Closure Phase (and possible to as late as Year 20, depending on the chemistry of the final rinse solution over time). The water treatment plant will operate for the approximately eight months of the year that flowing water is present. As described above, treated water from the water treatment plant will either be discharged to the environment or used in additional rinsing of the heap. Water discharged to the environment be released to the Halfway Creek drainage.

The proposed water treatment system is a two-stage process. The first stage of the treatment process is to oxidize residual cyanide using hydrogen peroxide. The products of this process are cyanate and/or ammonia and carbon dioxide. The second stage of the process utilizes a biological reactor system termed Electrochemical Biological Reactor or EBR. The overall water treatment system is designed to treat 34 m^3/hour (10 L/s).

The EBR treatment system has been designed by Inotec of Salt Lake City, Utah. A description of the EBR process and fundamentals is provided below.

3.2.3 EBR TREATMENT PROCESS

Microbes mediate the removal of metal and inorganic contaminants through electron transfer (redox processes). For example, nitrate reduction can be described by the following redox reaction:

$$NO_3^- + 5e^- + 6H^+ \rightarrow 0.5N_2 + 3H_2O \quad (1)$$

The biotransformation shown in reaction 1 occurs under anaerobic, reductive conditions, and thus requires low dissolved oxygen levels and a negative oxidation-reduction potential environment. Five electrons are needed to reduce one molecule of nitrate to nitrogen gas. Other co-contaminants, such as arsenic and uranium, etc., would add to the electron demand. One molecule of glucose, often used as a cost-effective nutrient in the form of molasses, can provide up to 24 electrons under optimal conditions and complete glucose metabolism (usually measured in hours). In environmental applications, this efficiency or the amount of electrons actually realized is usually considerably less; only a few of these electrons are available within 4 to 6 hours.

In conventional biological treatment systems, electrons are supplied from excess nutrients added to the system. Excess nutrients/chemicals are typically required to compensate for inefficient and variable electron availability needed to adjust the reactor chemistry, microbial growth, contaminant removal, and to compensate for system sensitivity. However, these excess nutrients lead to additional capital and operating expenditures, due to higher nutrient consumption and excessive biomass production. The Electro-Biochemical Reactor (EBR) technology overcomes these shortcomings by directly supplying needed electrons to the reactor and microbes, using a low applied potential across the reactor cell (1-3 V). For a comparison with a conventional nutrient electron donor, the current of 1 mA provides 6.2×10^{15} electrons per second. These electrons replace and supplement the electrons normally supplied to the reactor/microbial system by excess nutrients, at a considerable monetary savings and reactor, microbial, and environmental benefits. The directly supplied electrons are readily available to the microbes in a consistent controllable manner without metabolic energy expenditure. The excess electron provision in the EBR systems allows for a better control of the oxidation-reduction potential conditions, without the need to add chemicals, such as bisulfide to adjust the oxidation-reduction potential. Moreover, those "free electrons", from the microbes' metabolic standpoint, make the EBR bioreactors more robust and less sensitive to wide fluctuations in water chemistries than the past generations of biotreatment systems.

3.2.4 Bench-Scale Performance Testing of Treatment Process – Proof of Concept

Bench-scale testing of the proposed EBR treatment system was performed on Coffee Gold metallurgical leach solutions. Microbial isolation and screening tests were conducted on solutions received and initial column materials at 5ºC and 20 ºC. Microbes isolated from the Coffee heap solution waters and spent ore materials were tested for their ability to remove arsenic, uranium, and nitrate from solution. These isolates were tested in direct comparative screening tests alongside Inotec's repository microbes in order to select a site-specific inoculum for removal of contaminants of interest. These tests provided the microbes for the EBR treatability assessment. A microbial population screened to be effective at removing arsenic, uranium, and nitrate were grown into an inoculum for the EBR testing.

The bench-scale setup consisted of a two-stage, up-flow, fixed bed EBR system. The tests were conducted under continuous flow conditions, i.e., the water was treated 24 hours per day. The system was operated using a total hydraulic retention time of 44 hours. The EBR column tests were conducted continuously for two months for process assessment and validation testing.

Prior to the EBR treatment, the cyanide in the leachate solutions was oxidized using hydrogen peroxide treatment. To confirm that the treatment process could remove anticipated concentrations of nitrate, leach solutions were spiked with nitrate to provide treatment feed solutions of at least 150 mg/L NO_3-N.

Results of the bench-scale testing indicated that the proposed two stage treatment process for heap leach rinse solutions is highly effective at removal of contaminants of concern. **Table 3.2-4** provides a summary of the water treatment results using the EBR. As illustrated, water quality exiting the EBR water treatment system is of high quality with removal efficiencies for most parameters over 99%. Nitrate and Nitrite-N removal via denitrification was highly effective. Uranium removal in the EBR system was also highly effective and achieved treated water concentrations of less than 0.002 mg/L and well below receiving water quality objectives.

Table 3.2-4 Summary of Bench-Scale Water Treatment Performance for EBR System

Parameters of Concern	Feed to Water Treatment Plant (mg/L)*	Treated Effluent (mg/L)*	MMER Limits[1] (mg/L)*
pH	8.0 – 9.0	7.0 – 8.0	6.5 – 9.0
Total Suspended Solids	1 – 10	< 5	15
CN_{Total}	1 – 5	0.08 – 0.3	1
CN_{WAD}	0.2 – 1	0.007- 0.01	
Sulphate	100 - 500	50 - 100	

Parameters of Concern	Feed to Water Treatment Plant (mg/L)*	Treated Effluent (mg/L)*	MMER Limits[1] (mg/L)*
Ammonia-N	5 – 20	0.1 – 0.25	
Nitrite-N	1 – 10	0.02 – 0.05	
Nitrate-N	100 - 300	0.1 – 0.25	
As	1 – 5	0.01 – 0.015	0.5
Sb	0.05 – 1	<0.005	
Cd	0.0005 – 0.001	<0.00001	
Cu	0.01 – 1	<0.003	0.3
Fe	0.5 – 5	<0.5	
Hg	0.0005 – 0.001	<0.00005	
Pb	0.001 – 0.02	<0.0005	0.2
Ni	0.05 – 0.13	<0.002	0.5
U	0.1 – 0.5	<0.0015	
Zn	0.1 – 1	0.03 – 0.05	0.5

Notes: * All units in mg/L except pH
1: Metal Mining Effluent Regulation Limits for maximum authorized monthly mean concentration

Based on the above, treated water from the water treatment plant will either be discharged to the environment or used in additional rinsing of the heap. Water discharged to the environment will occur either directly to Halfway Creek

As introduced previously, progressive reclamation of the heap leach facility will also evaluate the efficacy of accelerating the detoxification of the heap through in situ stabilization as successfully employed at Brewery Creek. For Coffee, the closure concept is to use treated water from the EBR in the rinsing process. Treated effluent will provide an "inoculum" from the EBR containing microbes that denitrify and remove soluble metals (e.g., As and U) to the heap. Nutrients will also be added to the treated effluent and discharged onto the heap during the rinsing. The addition of nutrients and inoculum is designed to promote *in situ* detoxification of the heap and will further improve rinsing efficiencies and geochemical stabilization of the spent heap ore for closure.

3.2.5 Reclamation Activities

At this stage of the Project, it is difficult to determine if *in situ* stabilization of the Coffee heap pad will be sufficiently successful to allow direct discharge of heap seepage solutions to the environment. As such, additional contingency reclamation efforts will be afforded to providing for passive treatment polishing of heap seepage solutions prior to release to the environment. Permeable reactive barriers have been a successful passive treatment technology for treating mine waste solutions containing elevated nitrogen species, metalloids such as arsenic and metals including uranium.

A PRB is a passive, *in situ* technology that, under certain conditions, has a high potential to treat waters at a lower cost than traditional pump-and-treat methods (Blowes *et al.,* 2000). In these systems, a permeable barrier is constructed to intercept contaminated water, with the barrier amended with one or more materials to create a reactive matrix for contaminant removal. A PRB is designed to be more permeable than the surrounding media, such that water can easily flow through the reactive zone without significantly altering the natural flow system. PRBs have been extensively used in groundwater systems.

In PRBs, the reactive zone includes a permeable matrix (*e.g.*, gravel) amended with one or more materials that serve to create conditions conducive to contaminant removal. For example, zero-valent iron (ZVI) and/or carbon-based organic materials (e.g., straw, sawdust, wood chips, etc.) have been successful in treating both inorganic and organic contaminants (USEPA, 2005).

PRBs have been used for the treatment of groundwater contaminants since the 1980s, and there are numerous reports and publications available that summarize the extensive research, field trials and full-scale implementations (*e.g.*, USEPA 1998 and 2005; Blowes *et al*., 2000; ITRC 2005 and 2011). There are multiple examples of successful full-scale PRB installations that have been operating in excess of five to ten years. In this regard, PRBs are acknowledged as an appropriate and cost-effective technology for the treatment of mine-influenced water (ITRC, 2013). Site-specific considerations dictate the selection of a PRB as a treatment option, and a comprehensive understanding of site hydrogeochemistry is required for barrier design, placement configuration, and selection of reactive materials to effectively treat solutions.

Given that PRBs are contained within the subsurface environment, they are minimally influenced by atmospheric temperature, and have been shown to function well in cold-interior climates (Benner *et al*., 1997). Performance failures of some PRB systems have generally been related to the buildup of mineral precipitates, loss of pore space (*i.e.,* decrease in PRB permeability), development of preferential flow paths, and general loss of hydraulic control. Research efforts indicate that contaminant behavior in PRB systems is complex, as biogeochemical processes in the reactive medium govern contaminant removal and are closely linked to processes that govern fluid flow through porous media. These factors must be better understood on a contaminant-specific basis in order to optimize the design and implementation of PRBs for groundwater remediation (Wilkin *et. al.*, 2009).

For the Coffee heap leach facility, nitrate (NO_3^-), arsenic (As) and uranium (U) represent the parameters of potential environmental concern. Nitrate represents a residual product of cyanide degradation, while As and U represent leached components from the ore.

Arsenic is a well-characterized toxic element that is present in a variety of chemical forms, with As(III) generally considered to be more mobile and toxic that As(V). There has been considerable research focused on ZVI-type PRBs and its potential for removing As from water (*e.g.*, Bain *et al.*, 2006, Wilkin *et al.*, 2009). Results of these studies indicate that As removal occurs via adsorption onto corrosion products of

ZVI, including iron hydroxides, oxyhydroxides, and mixed valance Fe(II)-Fe(III) green rusts (USEPA, 2008). The precipitation of As as secondary arsenic sulfide minerals (*e.g.*, orpiment) and co-precipitation with pyrite also represent likely removal processes within PRB systems (USEPA, 1998).

Nitrate is a common groundwater contaminant related to agricultural activity, wastewater disposal, leachate from landfills, septic systems, and industrial processes (*e.g.*, use of cyanide in gold extraction). Treatment methods designed to foster microbially-mediated nitrate reduction (denitrification), such as PRBs, have been applied in a variety of forms and settings. In this regard, organic materials can provide an effective reactive media in PRBs to produce conditions conducive to bacterial denitrification (USEPA, 1998).

Uranium contamination in the environment can pose an ecological risk due to chemical toxicity of bioavailable U. At circum-neutral pH, U exists in two major oxidation states: U(VI) and U(IV). The U(VI) species are highly soluble and therefore mobile, whereas U(IV) species are sparingly soluble at near-neutral pH. Since reduction of U(VI) to U(IV) results in a significant decrease in the solubility of U, reduction of U(VI) is a potential remediation strategy to sequester U(IV) in U-contaminated waters (Basu, 2013).

Remediation of contaminants using PRBs may be achieved through abiotic reduction, biotic reduction, chemical precipitation, or adsorption processes and numerous case studies exist demonstrating successful treatment of nitrate, arsenic, uranium and other metals (e.g., Cu, Co, Cd, Ni, and Zn) (Ludwig et. al., 2002).

3.2.6 Remaining Issues and Investigations

During Years 4 to about 6, various pilot programs will be commissioned and provide both optimization and proof of concept for further development. The programs that will be pilot tested are likely to include the following:

- In situ detoxification using organic carbon and nutrient inoculation similar to what was done at Brewery Creek
- Freezing the top or core of the heap to reduce infiltration and effluent flows in the short- and/or long-term
- Passive treatment of heap seepage solutions using permeable reactive barrier system for final polishing;
- Use of raincoat geomembrane and the lateral extent of GCL as part of the closure capping system;
- Various schemes for revegetation and erosion control, and,

Optimizing effluent treatment methods for mid- and long-term scenarios with focus on passive and semi-passive systems. As Project engineering and closure planning continue and advance, and Project performance is better understood during operations, revisions to water treatment technologies and approaches may be considered.

3.3 WASTE ROCK STORAGE FACILITIES AND STOCKPILES

For WRSFs and stockpiles, the performance targets for closure are to ensure physical stability, avoid unacceptable release of contaminants to the receiving environment, and avoid risks to humans and wildlife. (YWB and EMR 2013).

Water management objectives are addressed in **Section 4.0**. Physical stability will be acceptable and risks to humans and wildlife will be avoided by adhering to facility designs that either meet or exceed acceptable safety factors for long term stability of the dump surface (minimum Factor of Safety (FoS) = 1.2), and long term deep seated stability for static and pseudo-static conditions (minimum FoS of 1.5 and 1.3, respectively) (JDS 2016).

The individual WRSFs and stockpiles that will be formed by the Project shown in **Figure 1.1-2** are described in the respective sections below, along with the proposed reclamation and closure measures.

3.3.1 ALPHA WASTE ROCK STORAGE FACILITY

3.3.1.1 Description

The Alpha WRSF is north of Latte pit and west of Supremo pit. The facility will be constructed and maintained to meet closure criteria (including final slope angles) and will not require extensive re-sloping during the Reclamation and Closure Phase. Waste rock will be placed on the Alpha WRSF from preproduction through the duration of active mining. Details of the planned configuration of the Alpha WRSF are provided in the Project Proposal (Section 2.3.2- Waste Rock Storage Facilities).

3.3.1.2 Closure Measures

The Alpha WRSF be constructed and maintained to meet closure criteria and will not require progressive resloping. At the end of active waste dumping in Year 12, minor resloping may be completed to achieve long-term physical stability and appropriate water conveyance for closure. . Given the limited material available and suitable for covers, the Alpha WRSF will not be covered or actively revegetated.

3.3.1.3 Reclamation Activities

No additional reclamation activities for the Alpha WRSF are planned.

3.3.1.4 Remaining Issues and Investigations

The need to segregate waste materials in the Alpha WRSF will be determined during the first years of operation.

3.3.2 BETA WASTE ROCK STORAGE FACILITY

3.3.2.1 Description

Geochemical characterization work indicates that the exposed pit walls of Kona pit are potentially acid generating, so waste rock from Kona will be temporarily stored in the Beta WRSF next to the pit during mining and then will be backfilled into the mined-out pit. Waste rock will be placed in the Beta WRSF from Year 1 through Year 3.

3.3.2.2 Closure Measures

The Beta WRSF will have been consumed in backfilling Kona pit in the final year of the Operations Phase or the first year of the Post-Mining Closure Stage. During Post-mining Closure, the footprint of the former temporary WRSF will be generally graded as required for routing of surface runoff as appropriate. Once grading is complete the footprint will be scarified, top-soiled as necessary, and seeded.

3.3.2.3 Reclamation Activities

No additional reclamation activities for the Beta WRSF footprint are planned.

3.3.2.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.3.3 PIT BACKFILL WITH WASTE ROCK

3.3.3.1 Description

Most waste rock will be placed in the WRSFs, but some waste rock will be backfilled into Latte, Double Double, Kona and Supremo pits as described in **Section 3.1**. Double Double and Kona pits will be completely filled, while the Latte and Supremo pits will only be backfilled to the extent required for construction of efficient haulage routes to transport ore form various portions of the Supremo pit to the crusher. The Supremo and Latte pit backfills will be constructed with flat tops, angle of repose side slopes and safety berms as required.

3.3.3.2 Closure Measures

No closure measures are planned for the pit backfill components.

3.3.3.3 Reclamation Activities

No additional reclamation activities for the pit backfills are planned.

3.3.3.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.3.4 Temporary Organics Stockpile and Frozen Soil Storage Area

3.3.4.1 Description

Soil stripped from the footprints of the open pits, the HLF, and the WRSFs will be placed in a temporary stockpile located immediately north of the HLF or in a Frozen Soil Storage Area located immediately east of the Alpha WRSF. This stockpiled material will be used during reclamation or (in the case of the Frozen Soil Storage Area) reclaimed in place if the final material is not suitable for use in reclamation.

3.3.4.2 Closure Measures

The Temporary Organics Stockpile will be consumed during the Post-mining Closure Stage and no further closure measures will be required. The Frozen Soil Storage Area will either be used during reclamation or reclaimed in place.

3.3.4.3 Reclamation Activities

The remaining base of the stockpiles and any remaining stockpiled material will be graded as required, scarified, and seeded or otherwise treated in accordance with the final revegetation plan.

3.3.4.4 Remaining Issues and Investigations

No additional investigations to address remaining issues or uncertainties are anticipated.

3.4 Roads and Airstrips

For roads and airstrips, the performance targets for closure are to establish conditions that support future land use objectives, ensure public safety, and eliminate risks to wildlife while providing for long-term operations, monitoring and maintenance requirements (YWB and EMR 2013).

3.4.1 Northern Access Route

3.4.1.1 Description

The all-season NAR will be used throughout the life of the Project. Road construction will start in Year -3, with substantial completion prior to the start of Mine Site construction in Year -2.

The road will start 16 km outside of City of Dawson, Yukon, at the junction of Hunker Creek Road. The road will initially follow existing government-maintained roads up to Sulphur Creek. Once past Sulphur Creek, the road will generally follow existing roads utilized by placer miners, with some upgrades and realignments required to meet design criteria and make the road suitable for year-round access. The access road will cross two major rivers (the Stewart River and the Yukon River).

There will be two distinct operating seasons for the road: one during periods of open water flow in the two major rivers and the other during the winter months when the rivers are frozen. During the open water period, barges will be utilized to ferry transport trucks delivering fuel and dry freight across the Stewart and Yukon Rivers. During the winter months, when the rivers are frozen, ice crossings will be constructed to allow transport trucks to drive across the rivers. The winter ice road construction of river crossings will begin in early December of each year. Once the road is constructed and deemed suitable for hauling, the road will be monitored and maintained to provide safe and continuous operation until the end of April.

No river access will be possible during the spring thaw and fall freeze-up periods each year. Logistics and storage of fuel and consumable materials during these periods has been considered with respect to storage and laydown areas.

3.4.1.2 Future Use Requirements

If it is determined that it would be beneficial to leave some or all of the access road in serviceable condition for future use, then that will be done. The benefits of future access road use are not likely to be determined until later in the Project life.

3.4.1.3 Reclamation Activities

The NAR will be operational during the Post-mining Closure Stage to permit the transport of equipment, fuel, and consumables to the Mine Site, and the removal of hazardous materials and other wastes (e.g., recyclables) and equipment. The NAR will be decommissioned at the end of this stage, unless otherwise directed by First Nations or regulators Decommissioning of the new portions of the NAR that are purpose-built for the Project will entail the removal of culverts and bridges to maintain pre-construction surface drainage, removal of the barge landings, and general grading of the road surface to promote runoff shedding. Once grading is complete, the road surface will be scarified. Once the NAR has been decommissioned, the annual resupply of consumables and materials required during the Active Closure Stage will be transported to site by barge campaigns on the Yukon River.

3.4.2 HAUL ROADS

3.4.2.1 Description

The primary haulage roads are required between the various open pit deposits and the primary ore crusher, WRSFs, construction areas and maintenance facilities. Roads are planned to be, as far as practical, constructed using all-fill techniques utilizing non-acid generating waste rock sourced from the open pits to achieve design alignment and grade. Dust control on the roads will be done using water trucks, with the addition of chemical suppressants as needed.

The main in-pit haul roads and ramps are designed to be 27 m in width. The selected road allowance is adequate for accommodating three times the width of the largest haul truck (144 t), with additional room for drainage ditches and safety berms. Ramps are designed with a maximum grade of 10%, steepened to 12% for final access to lower portions of the open pits.

Ex-pit roads are designed to allow access to roads connecting the pits to the crusher and WRSFs and are planned to be a maximum of 30 m wide. The site will have 25 km of external pit haul roads.

3.4.2.2 Future Use Requirements

If it is determined that it would be beneficial to leave some or all of the haul roads in serviceable condition for future use then that will be done. Final determination of the benefits of future haul road use are not likely until later in the Project life.

3.4.2.3 Reclamation Activities

Haul roads and service roads that are no longer required once Operation Phase activities are complete will be decommissioned. This will entail removal of any culverts to reestablish pre-construction surface drainage, and general grading of the road surface to promote water runoff. Once grading is complete, the areas will be scarified, top-soiled and seeded.

3.4.3 MINE SITE ROADS

3.4.3.1 Description

Mine Site roads will be constructed with embankment fills. The embankment material will be rock material sourced from infrastructure earthwork activities or from open pit waste material. Appropriate thicknesses of road bed material will be utilized according to the existing ground conditions. The site will have 3 km of service roads (not including the all-weather site access road and the haul roads) for smaller vehicles (i.e., light trucks) to access the various components of the mine infrastructure. The Mine Site roads are designed for light and medium trucks, with a minimum traveling surface width of 8 m and a maximum grade of 8%.

3.4.3.2 Future Use Requirements

If it is determined that it would be beneficial to leave some or all of the site roads in serviceable condition for future use, then that will be done. Final determination of the benefits of future site road use are not likely until later in the Project life.

3.4.3.3 Reclamation Activities

All site roads not required for post-closure maintenance and monitoring will be decommissioned and reclaimed at the end of the Active Closure Stage. The remaining roads will be reclaimed at the end of active closure monitoring. Decommissioning will entail removal of any culverts to reestablish pre-construction surface drainage, and general grading of the road surface to promote water runoff. Once grading is complete, the areas will be scarified, top-soiled and seeded.

3.4.4 EXPLORATION CAMP ACCESS ROAD

3.4.4.1 Description

A 20 km light vehicle access road runs from the barge landing at the exploration camp to the Project area. It is likely that the NAR will be built along the same alignment, and the existing exploration camp access road will not exist at the beginning of the Reclamation and Closure Phase as it will be largely within the footprint of the NAR.

3.4.4.2 Future Use Requirements

The exploration camp access road will not exist in the Reclamation and Closure Phase as described above. The NAR will be available for consideration of future use as described in **Section 3.4.1.2**.

3.4.4.3 Reclamation Activities

No additional reclamation activities for the exploration camp access road are planned, as the road is unlikely to remain in the Reclamation and Closure Phase.

3.4.5 PROJECT AIRSTRIP

3.4.5.1 Description

Air transportation is the primary means for mine personnel and incidental freight transportation. The Project airstrip was designed to handle turboprop passenger aircraft similar in size to a Hawker Siddeley 748 and cargo aircraft up to a de Havilland DHC-5A Buffalo.

The airstrip will be 1,220 m long and will be 35 m wide. The taxiway to the apron area is 10 m wide with 6 m graded areas along each side. The apron is suitably sized for two aircraft to maneuver and park. The airstrip is to be constructed from cut-and-fill material local to the airstrip.

3.4.5.2 Future Use Requirements

If it is determined that it would be beneficial to leave the Project airstrip in serviceable condition for future use, then that will be done. The benefits of future Project airstrip use are not likely to be determined until later in the Project life.

3.4.5.3 Reclamation Activities

The airstrip will be reclaimed near the end of the Post-mining Closure Stage. Lighting, navigation equipment, and culverts will be removed, and contouring will be undertaken to eliminate potential hazards to wildlife. Reclamation will involve scarifying, top-soiling and seeding. Once the airstrip is reclaimed, the existing airstrip at the exploration camp will be used instead.

3.4.6 EXPLORATION AIRSTRIP

Prior to the completion of the Project airstrip, the site activities will be supported by the existing exploration airstrip.

3.4.6.1 Future Use Requirements

Once the Project airstrip is reclaimed, the exploration airstrip will be used during the Active Closure Stage and the Post-closure Phase.

3.4.6.2 Reclamation Activities

Once the exploration airstrip is no longer needed to support Post-closure Phase monitoring activities, lighting, navigation equipment, and culverts will be removed, and contouring will be undertaken to eliminate potential hazards to wildlife. Reclamation will involve scarifying, top-soiling and seeding.

3.5 CRUSHER SYSTEM AND ROM AND CRUSHED ORE STOCKPILES

The Crusher System and ROM and Crushed Ore stockpiles include a Run-of-Mine ore stockpile that will be used to feed the crusher, a two-stage crushing system, and a Crushed Ore stockpile to temporarily store the crushed product that is awaiting transfer to the HLF. Performance targets for closing the Crusher System and ROM and Crushed Ore stockpile infrastructure are to ensure physical stability, remove potential threats to public health and safety and provide for appropriate future land use (YWB and EMR 2013).

3.5.1 CRUSHER SYSTEM

The crusher facility will be decommissioned following completion of mining activities in Year 12. Any potentially hazardous materials (e.g. hydrocarbons) will be removed and prepared for suitable on- or off-site disposal.

All Crusher System infrastructure and equipment will be dismantled and disposed of in the inert materials disposal site. Specific materials will be handled as follows:

- Concrete foundations and floor slabs will be broken down to original ground level and demolition rubble disposed in the landfill.
- Any buried piping will be removed to just below grade and ends will be capped. Any buried fuel and glycol lines will be flushed with water, removed, and buried in the landfill. Surface piping will be flushed, if necessary, removed, and buried in the landfill.

- Any buried electrical cables will be cut approximately 1 m below grade at surface terminations and left intact. The remaining above-ground cable will be removed and disposed of in the landfill.
- All other inert materials not suitable for reuse or salvage, such as metal cladding, wallboard, and insulation, will be disposed of in the landfill.

3.5.2 ROM AND CRUSHED ORE STOCKPILES

The ROM and Crushed Ore stockpiles will be located south of Latte pit and east of the Plant site. Both stockpiles will be consumed by the end of the Operation Period (Year 12). During the Active Closure Stage, the remaining stockpile footprint areas will be minimally graded, then scarified and revegetated.

3.6 PLANT SITE

The Plant Site includes the process plant, reagent storage area, laboratory, truck shop and warehouse building, power plant, and bulk fuel storage. Performance targets for closure Plant Site infrastructure are to ensure physical stability, remove potential threats to public health and safety and provide for appropriate future land use (YWB and EMR 2013).

3.6.1 PROCESS PLANT AND REAGENT STORAGE AREA

The process plant and reagent storage area will be decommissioned after the final rinsing of the heap is complete and the solution has been processed to extract the contained gold. Once all the ore and solution has been processed, the various circuits will be cleaned with water and the final washings will be treated prior to discharge. All potentially hazardous materials such as hydrocarbons, chemicals, and reagents will be removed and prepared for suitable on- or off-site disposal. Reagent tanks will be drained and cleaned prior to demolition. Any potentially hazardous materials will be drained from the process equipment. In addition, all utilities and services, including air, glycol, power, and water, will be shut off, de-energized, and drained as necessary to permit demolition to proceed safely and without compromising services to other areas in use.

All Plant Site buildings and equipment will be dismantled and disposed of in the inert materials disposal site. Specific materials will be handled as follows:

- Concrete foundations and floor slabs will be broken down to original ground level and demolition rubble disposed in the landfill.
- Any buried piping will be removed to just below grade and ends will be capped. Any buried fuel and glycol lines will be flushed with water, removed, and buried in the landfill. Surface piping will be flushed, if necessary, removed, and buried in the landfill.
- Any buried electrical cables will be cut approximately 1 m below grade at surface terminations and left intact. The remaining above-ground cable will be removed and disposed of in the landfill.
- All other inert materials not suitable for reuse or salvage, such as metal cladding, wallboard, and insulation, will be disposed of in the landfill.

3.6.2 TRUCK SHOP AND WAREHOUSE BUILDING

The truck shop and warehouse building will be decommissioned, cleaned, and dismantled during the Post-mining Closure Stage once it is no longer required. The building will be inspected and all potentially hazardous materials will be removed and packaged for off-site shipment and disposal. The remaining equipment and the building will be dismantled, demolished, and transported to the landfill site.

All buildings and equipment will be dismantled and disposed of in the inert materials disposal site. Specific materials will be handled as follows:

- Concrete foundations and floor slabs will be broken down to original ground level and demolition rubble disposed in the landfill.
- Any buried piping will be removed to just below grade and ends will be capped. Any buried fuel and glycol lines will be flushed with water, removed, and buried in the landfill. Surface piping will be flushed, if necessary, removed, and buried in the landfill.
- Any buried electrical cables will be cut approximately 1 m below grade at surface terminations and left intact. The remaining above-ground cable will be removed and disposed of in the landfill.
- All other inert materials not suitable for reuse or salvage, such as metal cladding, wallboard, and insulation, will be disposed of in the landfill.

3.6.3 POWER PLANT

The power plant is a modular system capable of continuously generating at least 3.5 megawatts of electrical power to allow for reliable operations. The power plant will consist of the electric generators, electrical switchgear, control systems, and waste heat recovery equipment, which will be decommissioned, dismantled and reclaimed when no longer required, using measures similar to those described for the process plant (**Section 3.5.2**).

3.6.3.1 Bulk Fuel Storage Area

Before dismantling the diesel tanks and liquefied natural gas bullet tanks in the Active Closure Stage, any remaining fuel will be withdrawn. Steel plate sections and distribution system components will be washed and disposed of in the landfill site, pursuant to regulatory approval. The containment berm and liner materials will be removed and the area regraded. Once the tanks are removed, appropriately sized portable fuel storage tanks will be used as required to store diesel for equipment and power generation during the Active Closure Stage.

3.6.4 CAMP SITE

Infrastructure at the Camp Site will be utilized to the end of the Post-mining Closure Stage, then decommissioned. Once decommissioning is complete, the Coffee exploration camp adjacent to the Yukon River will house personnel during the Active Closure Stage and Post-closure Phase.

All Camp Site buildings and equipment will be dismantled and disposed of in the inert materials disposal site. Specific materials will be handled as follows:

- Concrete foundations and floor slabs will be broken down to original ground level and demolition rubble disposed in the landfill.
- Any buried piping will be removed to just below grade and ends will be capped. Any buried fuel and glycol lines will be flushed with water, removed, and buried in the landfill. Surface piping will be flushed, if necessary, removed, and buried in the landfill.
- Any buried electrical cables will be cut approximately 1 m below grade at surface terminations and left intact. The remaining above-ground cable will be removed and disposed of in the landfill.
- All other inert materials not suitable for reuse or salvage, such as metal cladding, wallboard, and insulation, will be disposed of in the landfill.

3.7 OTHER INFRASTRUCTURE

3.7.1 BULK EXPLOSIVE STORAGE AREA

The remaining inventory of explosives, comprising ammonium nitrate and emulsion product, at the end of mining will either be returned to the supplier or transferred to another licensed user. The pad areas and earthen berms will be regraded to blend with the surrounding topography then scarified, top-soiled and seeded.

3.7.1.1 Utilities

Site powerlines will be deconstructed or demolished, with salvageable materials shipped off site and materials with no salvage value disposed in the landfill. Any buried piping will be removed to just below grade and ends will be capped. Any surface or buried fuel and glycol lines will be flushed with water, removed, and buried in the landfill. Surface piping will be flushed, if necessary, removed, and buried in the landfill.

3.7.1.2 Laydown and Storage Areas

Stored materials and equipment will be shipped offsite or disposed in the landfill. Areas of contaminated soils will be addressed as described in **Section 3.4.5**, and remaining areas will be generally graded as required for routing of surface runoff as appropriate. Once grading is complete the areas will be scarified, top-soiled and seeded.

3.7.1.3 Waste Management Infrastructure

Non-hazardous materials from site buildings, structures, and equipment will be dismantled and deposited in the landfill. Appropriate authorization for this non-hazardous waste disposal site will need to be obtained before starting closure and reclamation activities.

Potentially hazardous structures, equipment, materials and fluids will be transported from site. Hazardous materials are generally likely to include waste oil, glycol, lubricants, solvents, paints, batteries, and miscellaneous chemicals. Some of these materials may be suitable for recycling if appropriate facilities are available in reasonable proximity (e.g. Yukon, Alberta or British Columbia) at the time of mine closure and if recycling can be done at reasonable cost.

3.7.2 Contaminated Soils

The potential for ground contamination at the various facilities will be assessed. This will include the airstrip area, fuel tank farm, process plant, power plant, accommodations complex, service complex, waste management facilities, and storage facilities. This site investigation will be completed using a direct push drill rig (or other appropriate method) down to 5 m below surface, focused on parking bays, fuel storage, wash bays, truck shops, maintenance areas, and generator areas, as well as along roads and in areas where spills have been known to occur. Soils will be analyzed for contaminants such as hydrocarbons and glycol. The volumes of contaminated soils will be estimated from this investigation.

Any contaminated soils will be excavated and either treated on site to an acceptable standard or transported off-site for disposal. If the volumes of contaminated soils are large, the materials will be remediated with on-site land farms constructed specifically for this purpose. If the volumes are small, the material will be shipped off-site for disposal at a licensed facility.

4.0 SITE WATER MANAGEMENT

The water management system includes diversion channels, diversion berms, underdrains in WRSFs and sedimentation ponds. The site-wide water management system was developed for each year of the Project, from the Construction through Reclamation and Closure phases (Appendix 31-E)..

4.1 SITE WATER MANAGEMENT INFRASTRUCTURE

The design, operation and monitoring of water management infrastructure is described in the Water Management Plan (Appendix 31-E). Water management at the Project area consists of multiple conveyance components and sedimentation ponds. Water management infrastructure components include:

- Underdrains
- Diversion Channels
- Drainage Ditches
- Diversion Berms
- Sedimentation Ponds
- Water Treatment Plant.

This section of the Conceptual Reclamation and Closure Plan describes the sequence of and how these water management infrastructure will be decommissioned.

Pit lakes are expected to develop in portions of the completed pits that have not been backfilled as discussed in **Section 3.1**. Some of these lakes may ultimately serve some water management function (e.g. settling of TSS) but they have not been designed to act as part of the formal post-mining water management system. Water management features during the Reclamation and Closure Phase and the Post-Closure Phase are summarized in **Table 4.1-1**.

Table 4.1-1 Summary of Site Water Management Features during Closure

Stage/ Phase	Years	Active Water Management Features	Features Decommissioned during Stage/ Phase	Water Treatment
Post-Mining Closure Stage	Years 13 to end of Year 18	All conveyances, Alpha Pond, Facility Pond, Water Treatment Plant.	Culverts are removed when no longer necessary toward the end of the Post-Mining Closure Stage.	Water Treatment Plant. TSS settling in the existing ponds
Active Closure Stage	Years 19 to end of Year 23	All conveyances, Alpha Pond, Facility Pond, Water Treatment Plant (through Year 20).	At the end of Active Closure, all conveyances and sedimentation ponds. Water Treatment Plant decommissioned after Year 20	Water Treatment Plant (through Year 20). TSS settling in the existing ponds

Stage/ Phase	Years	Active Water Management Features	Features Decommissioned during Stage/ Phase	Water Treatment
Post-Closure Phase	Year 24 onward	Passive treatment within the former footprint of the sedimentation ponds.	None (decommissioning complete by start of phase)	Passive TSS removal in vegetated swales and/or stilling pools constructed in reclaimed footprint of former sedimentation ponds.

4.1.1 ACTIVITIES DURING MINE CLOSURE STAGES

This section describes how mine water management infrastructure will be operated and then decommissioned in the different mine closure stages.

4.1.1.1 Reclamation and Closure Phase, Post-Mining Closure Stage

During the Post-mining Closure Stage, the mine surface water management system will be operated and monitored as it was during the Operation Phase (Appendix 31-E). **Figure 4.1-1** shows the water management infrastructure that will be present at the beginning of the Post-Mining Closure Stage. Water management for the HLF during the Post-Mining Closure Stage is described in **Section 3.2**.

Pit sumps and associated pit dewatering systems (pumps and pipes) will be removed from Supremo Pit (and any other pits where pipes and pumps have not been removed during the Operation Phase). The pumps will be recycled or placed in the designated landfill. Associated pipelines, if not being reused, will be cleaned if necessary and also placed in the landfill.

Some of the pits may form pit lakes over the long term. Spillways will be constructed at the pour point of these pits to direct the overflow to:

- Natural drainage courses
- Channels constructed over the top of waste rock facilities
- Underdrains
- Other discharge locations dictated by the final mine layout

4.1.1.2 Reclamation and Closure Phase, Active Closure Stage

During the Active Closure Stage, roads, pads, processing equipment and other mine infrastructure will be decommissioned and areas will be reclaimed. Closure of the heap leach pad is described in **Section 3.2.**

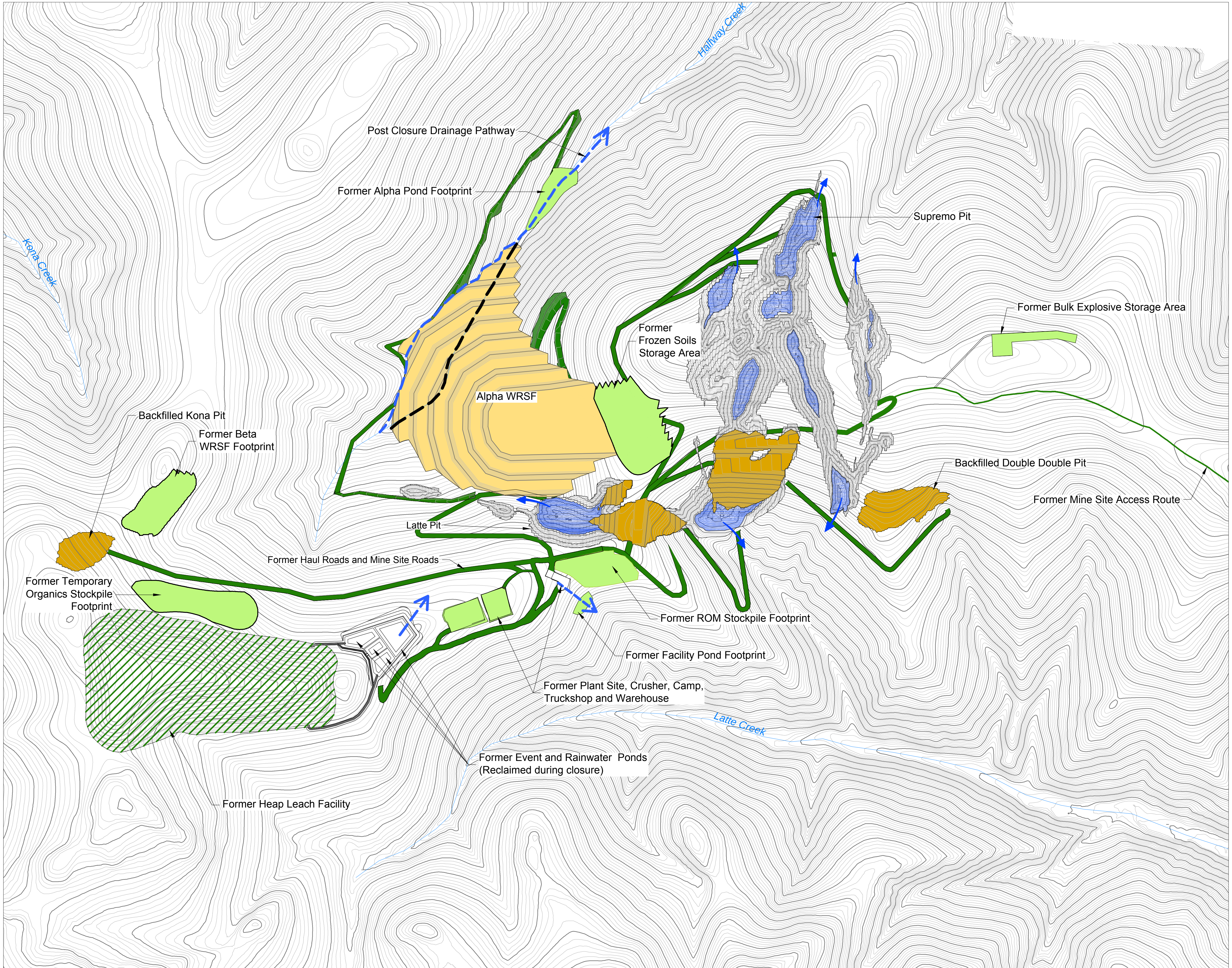
Sedimentation ponds and conveyance structures will continue to operate as designed until the water quality in the ponds meets the post closure water quality objectives, at which point each pond can be decommissioned. This decommissioning process of water management infrastructure (and supporting components such as access roads) will be the final step in the Active Closure Stage.

Decommissioning of the sedimentation ponds will be accomplished according to the following sequence of concepts. First, the sedimentation ponds will be drained. Sediment that has accumulated in the ponds will either be covered in place or will be removed and disposed of in the pits, in dedicated disposal areas in the waste rock dumps or in other appropriate locations. The sedimentation pond dams will be breached, with the majority of the excavated material used to backfill pond excavations (if present), to cover the inundation footprint of the ponds, and in construction of a suitable post closure drainage pathway through the footprint of the former dam and pond. The breach design may include leaving a lower portion (~1-2 m) of the dam to form a shallow sediment retention basin that would serve to trap some sediment in the immediate period following decommissioning, and which would be likely to fill in as sediments accumulate over time. The basin may be seeded or planted with native vegetation and/or allowed to revegetate naturally by the encroachment of the surrounding vegetation (e.g. *Salix* spp.).

Ponds and conveyance structures will be graded as required to provide adequate drainage. Disturbed areas will be covered as needed with soil or organic layer material stockpiled during mine development (to the extent available).

4.1.1.3 Post-Closure Phase

The Post-closure Phase will start when post closure water quality objectives are met and subsequently the remaining decommissioning of water management infrastructure has occurred. This phase will consist of monitoring for water quality at the post closure water quality monitoring locations. Error! Reference source not found. shows the water management infrastructure that will be present at the beginning of the Post-Closure Phase.



COFFEE GOLD MINE

Site Water Management Features
Beginning of Post-Closure Phase (Year 23)

Legend

- Rock Drain
- Reclaimed Footprint
- Reclaimed Heap Leach Pad
- Reclaimed Haul and Mine Site Roads
- Pit Backfill
- Pit Footprint
- Pit Lake
- Waste Rock Storage Facility (WRSF)
- Pit Outflow Direction
- Flow Direction

Notes

1. This figure is not intended to be a "stand-alone" document, but a visual aid to the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. Contours shown at a 5 meter contour interval

N

1:25,000

0 2500 5000 7500 10000
Metres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 4.1-1	Date: Mar 30, 2017	Drawn by: TAH	Reviewed: DBM

GOLDCORP

4.1.2 Monitoring Requirements

The following structures will require monitoring at the frequency shown in **Table 4.1-2**. Monitoring will be the responsibility of the site's surface superintendent and environmental monitoring staff.

4.1.2.1 Physical Monitoring

During the Post-mining and Active Closure stages, the water management system will be monitored as during Operation. The purpose of the monitoring is to confirm the system is operating as designed. **Table 4.1-2** describes physical monitoring during the Post-mining and Active Closure stages.

Table 4.1-2 Reclamation and Closure Phase Physical Monitoring Requirements

Phase	Year	Facility	Frequency
Post-Mining Closure Stage	13 - 18	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Weekly- during open water seasons for 2 years then monthly for remaining 4 years
Post-Mining Closure Stage	13 -18	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Kona Pit Diversion, Haul Road Ditches, Access Road Ditches	Weekly- during open water seasons for 2 years then monthly for remaining 4 years
Active Closure Stage	19-23	**Sedimentation Ponds:** Alpha Pond and Facility Pond	Monthly- during open water seasons
Active Closure Stage	19-23	**Conveyance Structures:** Halfway Creek Diversion, Alpha WRSF Perimeter Ditches, Double Double Pit Diversion, Kona Pit Diversion, Haul Road Ditches, Access Road Ditches	Monthly- during open water seasons

The decommissioning of all water management infrastructure (conveyance structures and sedimentation ponds) will be the final step in the Active Closure Stage of the Reclamation and Closure Phase. Therefore, physical monitoring should be included with broader Project geotechnical inspections, and there will be no other physical monitoring requirements for water management infrastructure during the Post Closure Phase.

4.1.2.2 Surface Water Monitoring

Water quantity and quality monitoring will be required for all effluent discharge points associated with the project. The proposed surface water monitoring plan is summarized in **Section 5.2.1**.

4.2 REMAINING ISSUES AND INVESTIGATIONS

Decommissioning of the sedimentation ponds and related dams, and reestablishment of adequate post-closure surface water drainage will require additional investigations to be conducted and designs to be prepared. Based on the Project plan (including closure periods), the designs for decommissioning will not be required until the end of the Active Closure Stage, and the designs would be improved by considering the performance monitoring data collected during the Operation Phase and the Post-Mining Closure Stage. For this reason, it is recommended that the design work be deferred until early in the Active Closure Stage.

5.0 MONITORING AND SURVEILLANCE PROGRAM FOR CLOSURE PHASES

The environmental assessment process and subsequent permitting processes required under the *Quartz Mining Act*, the *Yukon Waters Act*, the *Fisheries Act* and its Metal Mining Effluent Regulations (MMER), and the *Yukon Environment Act* will ultimately identify specific program requirements for monitoring and surveillance. The objectives of environmental monitoring, surveillance, and reporting activities with respect to the eventual closure of the Project are to:

- Track the effects of the Project on the environment relative to predicted outcomes
- Assess the effectiveness of mitigation measures and inform amendments to management and mitigation plans, as necessary
- Assess the effectiveness of reclamation and closure measures, and
- Inform reclamation and closure plan adjustments, as required.

Closure activities are defined by four specific closure stages: Operational Closure, Post-mining Closure, Active Closure, and Post-closure (as outlined in **Section 1.4**). Monitoring requirements during the Operational Closure Stage, during which progressive reclamation activities are undertaken, are described in component-specific sections (e.g., for surface water quality, fish and aquatic environment) contained in Volumes II to IV. Monitoring requirements described in this section refer to requirements from the commencement of the Reclamation and Closure Phase to the end of the Post-closure Phase. The intensity of monitoring is likely to decrease with the progression of the Project into subsequent stages, and in general, monitoring programs will continue until predicted Project-related effects are confirmed or the success of reclamation efforts has been ascertained. The proposed program to monitor meteorological conditions is provided in **Section 5.1.** Proposed Reclamation and Closure Phase monitoring programs for the aquatic environment are described in **Section 5.2** for surface water monitoring and **Section 5.2.3** for fish and aquatic habitat monitoring. The proposed terrestrial environment monitoring program is described in **Section 5.3**. Reporting requirements for all programs are outlined in **Section 5.4**.

5.1 METEOROLOGICAL MONITORING PROGRAM

Meteorology monitoring since 2012 has resulted in the collection of high-quality and site-specific climate data including air temperature, precipitation, wind speed and direction, relative humidity, atmospheric pressure, and solar radiation at a central weather station and the sampling of snow at snow courses across the Coffee Property. A second research grade weather station will be installed at the elevation of the heap leach facility during the Construction Phase to support water management decision-making at the heap leach facility and plant and camp sites.

The implementation of the Meteorology Monitoring Plan is likely to remain consistent throughout the Project phases as the collection of meteorological data is sensitive to site-scale changes (vegetation growth, shading, ground cover changes, etc.) and to changes in instrumentation and maintenance activities. As a result, the protocols and practices implemented during the Reclamation and Closure Phase are expected to remain consistent with requirements outlined since the collection of baseline data. During Post-mining and Active Closure stages, routine climate monitoring as well as surveillance monitoring will be conducted, and reporting will be conducted in the context of both site-specific and regional climate data. Meteorology monitoring is not proposed for the Post-closure Stage.

Key elements of this monitoring program include the following:

- Climate data will be manually downloaded from the central weather station datalogger on a monthly basis and from the heap leach facility weather station as conditions and activities at the facility dictate.
- On a monthly basis, instrumentation and any wiring will be inspected for damage due to weathering or animals, gauges will be checked, and seasonal maintenance activities will be conducted, as appropriate.
- Measurements will be taken at established snow courses within a 12-day window, centered around the start of each month for the period of January 1 to April 1, to quantify the maximum snow water equivalent and determine the relative magnitude of runoff that must be managed at site prior to the spring freshet.
- Surveillance monitoring will be conducted while water management infrastructure is still operational to inform potential water management actions.
- An annual interpretive report, anticipated to be a permit/licence requirement for the proposed Project, will be prepared that summarizes the data collected for the previous year.

5.2 Aquatic Environment Monitoring – Water Monitoring Program

To evaluate Project-related effects and the effectiveness of implemented mitigation measures, requirements for environmental effects monitoring (EEM) under MMER will include the characterization of effluent (including sublethal toxicity testing), as well as water quality monitoring and biological monitoring (including sediment and biota) in the receiving environment.

The program for water monitoring during the early part of the Reclamation and Closure Phase incorporates hydrology, surface water quality, and groundwater components (including groundwater quality and quantity). Water management will strive to separate contact from non-contact water to the extent practical, maximize the use of contact water for heap leach rinsing requirements, and suppress dust in disturbed areas, while the site is being reclaimed, as with the Operation Phase. These practices will reduce the volume of contact water that must be managed, and therefore, potential downstream effects on water quality and streamflow volumes.

The Reclamation and Closure Phase water monitoring program will be focused on:

1. Meeting EEM requirements such that the Coffee Gold Mine becomes a "recognized closed mine" as defined in MMER;
2. Meeting requirements pursuant to permits and approvals issued by the Yukon Government (as per the Quartz Mining License and Water Use Licence, and others that may apply); and
3. Conducting Post-closure Stage monitoring to verify that the site is stable.

The surface water and groundwater monitoring programs during Post-mining Closure and Active Closure stages are structured to provide early indication of potential changes in flow sources and chemistry at the Mine Site, and potential effects down-gradient. Efforts will address three types of monitoring:

1. Mine Site - monitor the quantity and quality of both surface and groundwater that may be potentially affected by the various mine facilities, to confirm that water management systems are effective.
2. Effluent - monitor the quantity and quality of contact water that accumulates in sediment control ponds located downgradient of mine infrastructure and effluent from the water treatment plant to verify compliance for waters to be discharged to the environment (discharges will be subject to regulatory requirements).
3. Receiving Environment - monitor the quantity and quality of surface water upstream and downstream of points of discharge in the receiving environment to confirm compliance with applicable regulatory requirements. A system of groundwater monitoring wells will be used to verify groundwater flow paths, and discharge rates and quality within these watersheds.

The surface water and groundwater monitoring programs for these components will be implemented in a systematic manner during the Reclamation and Closure Phase to obtain reliable and consistent data for comparison to previous results.

5.2.1 SURFACE WATER MONITORING

Monitoring of surface water during the Reclamation and Closure Phase includes both hydrologic (flow) monitoring and water quality sampling.

5.2.1.1 Hydrologic Monitoring

The current hydrologic regime and flow path distribution at the Project site is well understood, and there is a high-degree of confidence in the planned alterations to existing flow paths from the placement of engineered water management structures. However, it will be necessary to implement a strategic and flexible water monitoring program at the mine site for the following reasons:

- Enhance baseline understanding of local hydro-meteorological processes;
- Verify the accuracy of the residual change and residual cumulative change predictions;

- Assess the efficacy of proposed mitigation measures and the need for modifications to those measures;
- Identify analysis discrepancies that may arise related to the surface hydrology, and;
- Implement additional mitigation measures as per adaptive management plans as required.

The relevant monitoring and management plans that will inform adaptive management and future water monitoring program at the Coffee Gold Project are:

- Access Route Construction Management Plan (Appendix 31-A);
- Access Route Operational Management Plan (Appendix 31-B);
- Conceptual Reclamation and Closure Plan (Appendix 31-C);
- Waste Rock and Overburden Management Plan (Appendix 31-D); and
- Water Management Plan (Appendix 31-E).

During Closure Phases additional water specific monitoring initiatives may be required to inform mitigative actions. Following successful reclamation and closure of the mine site, water monitoring directives for Post-closure are envisioned, albeit with reduced scope compared to preceding mine phases. Design and delivery of future monitoring activities will require the involvement of the regulatory agencies that have jurisdiction over water related issues, First Nations, and coordinated efforts by mine site staff.

Closure mine site monitoring is intended to record the quantity and quality of surface water that is affected by the various mine facilities. It is required primarily to verify geochemical ‘source terms’, (quantitative assumptions and predictions made to anticipate the effects of bedrock disturbance that will occur in the course of mine development, that underlie the ML/ARD Management Plan), and to confirm that site-wide water management systems are effective and functioning as intended at closure.

Effluent monitoring is intended to record the quantity and quality of surface water that collects in sediment control ponds and sumps, located downgradient of mine infrastructure, and is discharged to the receiving environment. Effluent water quality and flow monitoring will also occur on water treatment plant effluent. Surplus rinse water from the heap leach facility will continue into closure require discharge and therefore treatment starting in Year 9 and is anticipated to continue into the Active Closure Stage. Monitoring to ensure compliance with appropriate discharge limits for treated effluent pond discharges are important components of the plan and are expected to be subject to certain regulatory requirements. Following reclamation and drain-down of the HLF, seepage from the closed facility is proposed to be directed to Latte Pit. Measuring discharge volumes and water quality prior to and exiting this future pit lake will be a requirement following spillover.

Hydrologic receiving environment monitoring includes monitoring intended to record the quantity and quality of water in the receiving environment, downstream of mine inputs. Surface water monitoring will include monitoring at selected stations on Latte Creek, Coffee Creek, YT-24, Halfway Creek, and on the Yukon River, as well as Independence Creek, the latter of which serves as the undisturbed control drainage, as noted above (**Figure 5.2-1**). Flows in the receiving environment downstream of the mine will reflect the ultimate effects of the mine on the relevant intermediate and valued components. Receiving environment water quantity is also expected to be subject to specific regulatory requirements.

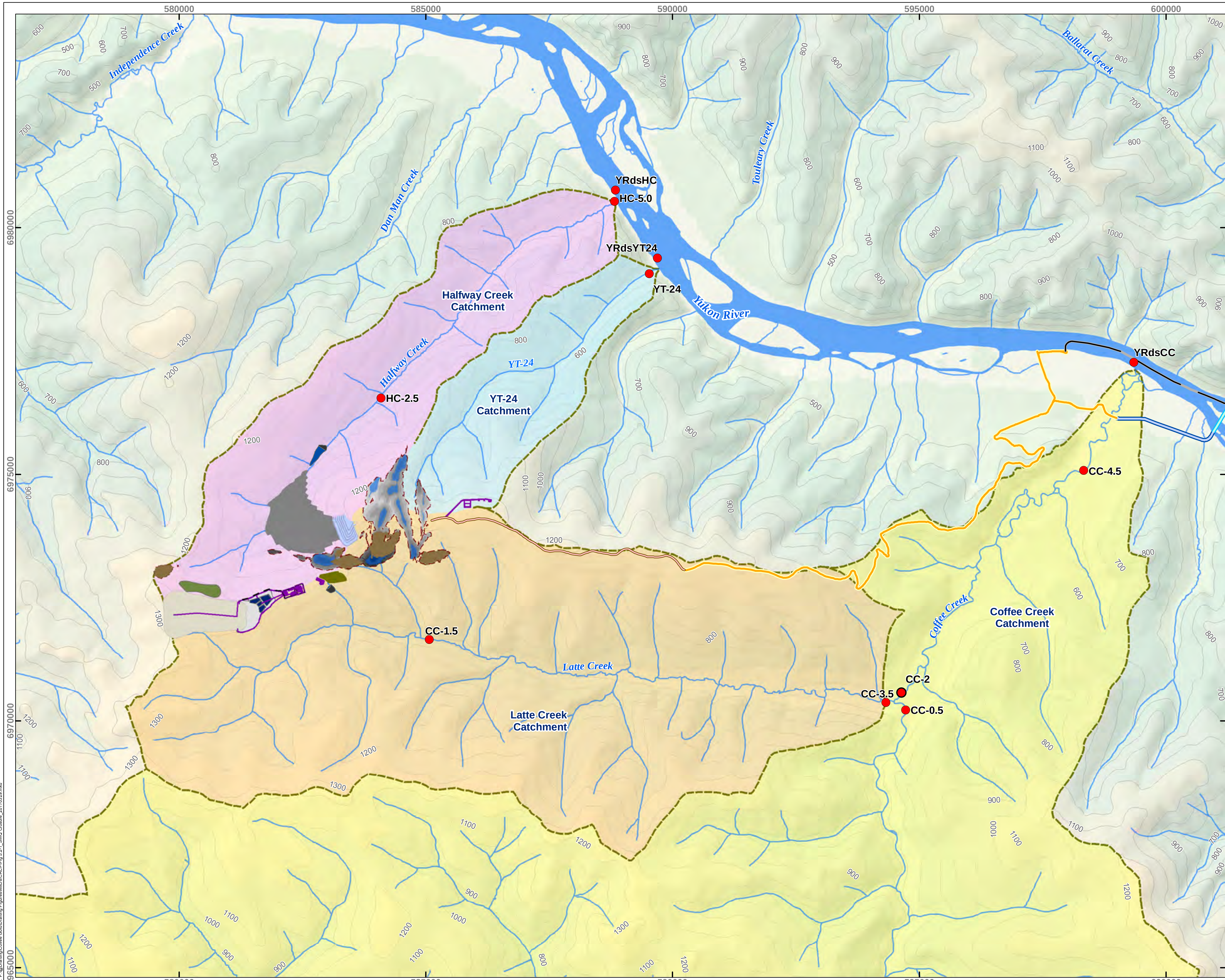
Flow monitoring will ultimately be undertaken to measure surface water discharge from mine facilities, from sediment control ponds, and to measure flows in the receiving environment. This section provides an overview of current monitoring methods employed at the Project, which focuses currently on receiving environment monitoring and collection of baseline data. Flow measurement procedures and key findings associated with baseline climate and hydrology studies are described in detail in Appendix 8-A, Hydro-meteorology Baseline Report.

Hydrology methods observe the standards and procedures outlined in the *Manual of British Columbia Hydrometric Standards – Version 1.0* (RISC, 2009). This document defines standards and detailed procedures for the acquisition of water quantity data, and provides specific direction on monitoring site selection, station construction and benchmarking, recording discharge measurements, developing stage-discharge relationships, and reporting and presenting hydrometric data.

These standard methods have been employed since 2010 as part of the baseline monitoring program, and will continue to be used through the construction and operation phases of the Coffee Gold Project.

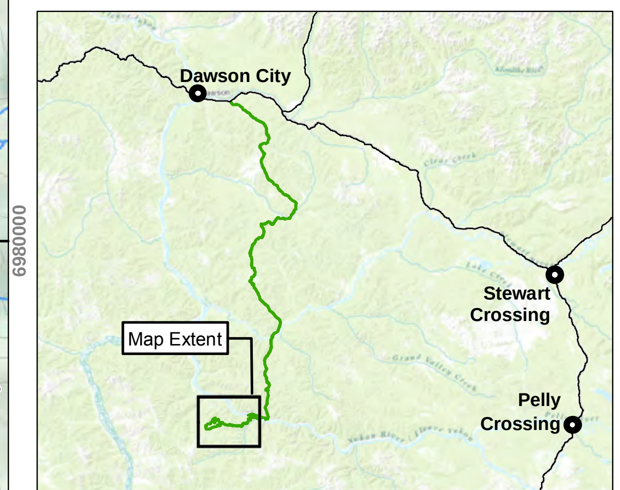
A robust and spatially representative hydrometric monitoring program is currently in place, and a high-quality baseline dataset exists from which to measure Project-related changes to streamflow and to confirm the predictions of the water-balance-modelling exercise. The monitoring program is currently structured to provide high-resolution data that will allow potential changes to all indicators used in this change assessment to be robustly measured and re-evaluated. Monitoring locations are provided in **Figure 5.2-1**.

Hydrologic monitoring will be complimented by a high-elevation climate station (air temperature, precipitation, relative humidity, solar radiation, wind speed and direction, barometric pressure) and stand-alone tipping bucket rain gauges and snow courses established at various elevations.



COFFEE GOLD MINE

Hydrology and Surface Water Monitoring Locations during Closure Phases



Legend

- Water Quality Model Node
- Municipality
- Project Footprint
- Catchment Boundary
- Waterbody
- Watercourse
- Elevation Contours (100m)
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route

Pre-Mine Catchment Area

- Halfway Creek
- Latte Creek
- YT-24 Creek
- Coffee Creek

Proposed Infrastructure

- WRSF
- Backfill
- Total Pit Outline
- ROM Stockpile
- Organics Stockpile
- Frozen Soil Storage Area
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure

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Kilometers

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Figure 5.2-1	Date: Mar 30, 2017	Drawn by: GM	Reviewed: AS

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5.2.1.2 Surface Water Quality Monitoring

Surface water quality monitoring is required to verify water quality predictions, and to identify any unanticipated effects on surface water quality that may occur through life of mine and, in particular, closure. Monitoring will include surface water quality within the mine site, at effluent discharge points, and in the receiving environment. The surface water quality monitoring program is intended:

- To verify and update water quality predictions for all phases of the Project, based on monitoring results, as necessary.
- To assess compliance with applicable water quality discharge limits for mine site effluent, and
- To assess whether any mitigation or adaptive management is required.

A generic surface water quality monitoring program is discussed below for the Coffee Gold Project, with a focus on monitoring concepts as they relate to Mine Site monitoring, Effluent Monitoring and Receiving Environment Monitoring during closure. It is anticipated that surface water quality monitoring requirements will be reduced following successful reclamation and closure of the mine site. Design and delivery of future monitoring activities will require the involvement of First Nations partners, regulatory agencies that have jurisdiction over water-related issues, and coordinated efforts by mine staff.

Mine site monitoring will be undertaken to assess the quality of surface water that is affected by the various mine facilities. Surface water quality monitoring will include monitoring at selected stations on Latte Creek, Coffee Creek, YT-24, Halfway Creek, and on the Yukon River, as well as Independence Creek, the latter of which currently serves as the undisturbed control drainage. Key closure monitoring locations are outlined in **Figure 5.2-1**. Water quality in the receiving environment downstream of the mine will reflect the ultimate effects of the mine on the relevant intermediate and valued components.

The methods employed for the existing program will continue through operations and the post-mining phase. Water quality sampling is undertaken in accordance with the *British Columbia Field Sampling Manual* (BC Ministry of Environment, 2013). A YSI Sonde handheld instrument is used to obtain *in situ* measurements of temperature, pH, specific conductance, dissolved oxygen, and oxidation-reduction potential at the time and location that water quality samples are taken. Samples are collected and Samples are shipped to an accredited laboratory and are analyzed for physical parameters, major ions, nutrients, total and dissolved organic carbon, weak acid dissociable (WAD) cyanide, and total and dissolved metals. The full list of parameters that are analyzed, and detection limits, are provided in **Table 5.2-1**.

Table 5.2-1 Analytical Parameter List and Reportable Detection Limits

Analysis		Reportable Detection Limit
Physical Parameters	**Unit**	
Conductivity	µS/cm	1.0
Hardness (as $CaCO_3$)	mg/L	0.5
pH	pH	0.01 unit
Total Suspended Solids	mg/L	1.0
Total Dissolved Solids	mg/L	10.0
Turbidity	NTU	0.1
Major Ions and Nutrients		
$Alkalinity_{Total}$ (as $CaCO_3$)	mg/L	0.5
$Alkalinity_{PP}$ (as $CaCO_3$)	mg/L	0.5
Bicarbonate (HCO_3)	mg/L	0.5
Cabonate (CO_3)	mg/L	0.5
Chloride (Cl)	mg/L	0. 5
Sulphate (SO_4)	mg/L	0.5
Fluoride (F)	mg/L	0.01
Nitrate (as N)	mg/L	0.002
Nitrite (as N)	mg/L	0.002
Total Ammonia (as N)	mg/L	0.005
Nitrate plus Nitrite (as N)	mg/L	0.002
Total Phosphorus as P	µg/L	0.002
Cyanide		
Weak acid dissociable cyanide (CN_{WAD})	mg/L	0.0005
Organic Carbon		
Total Organic Carbon	mg/L	0.5
Dissolved Organic Carbon	mg/L	0.5
Total and Dissolved Metals		
Aluminum (Al)	µg/L	0.5
Antimony (Sb)	µg/L	0.02
Arsenic (As)	µg/L	0.02
Barium (Ba)	µg/L	0.02
Beryllium (Be)	µg/L	0.02
Bismuth (Bi)	µg/L	0.01
Boron (B)	µg/L	10
Cadmium (Cd)	µg/L	0.005
Calcium (Ca)	mg/L	0.05

Analysis		Reportable Detection Limit
Physical Parameters	**Unit**	
Chromium (Cr)	µg/L	0.1
Cobalt (Co)	µg/L	0.005
Copper (Cu)	µg/L	0.05
Iron (Fe)	µg/L	1.0
Lead (Pb)	µg/L	0.005
Lithium (Li)	µg/L	0.5
Magnesium (Mg)	mg/L	0.05
Manganese (Mn)	µg/L	0.05
Mercury (Hg)	µg/L	0.002
Molybdenum (Mo)	µg/L	0.5
Nickel (Ni)	µg/L	0.02
Potassium (K)	mg/L	0.05
Selenium (Se)	µg/L	0.04
Silicon (Si)	mg/L	50
Silver (Ag)	µg/L	0.005
Sodium (Na)	mg/L	0.05
Strontium (Sr)	µg/L	0.05
Thallium (Tl)	µg/L	0.002
Tin (Sn)	µg/L	0.2
Titanium (Ti)	µg/L	0.5
Uranium (U)	µg/L	0.002
Vanadium (V)	µg/L	0.2
Zinc (Zn)	µg/L	0.1

5.2.2 GROUNDWATER MONITORING

Both groundwater flows (which recharge local streams) and groundwater quality will be monitored during the Post-mining Closure and Active Closure stages to detect any changes in groundwater pressure (i.e., water table elevations), or groundwater quality, that may be caused by mine operation and closure activities. Groundwater monitoring is not proposed for the Post-closure Stage.

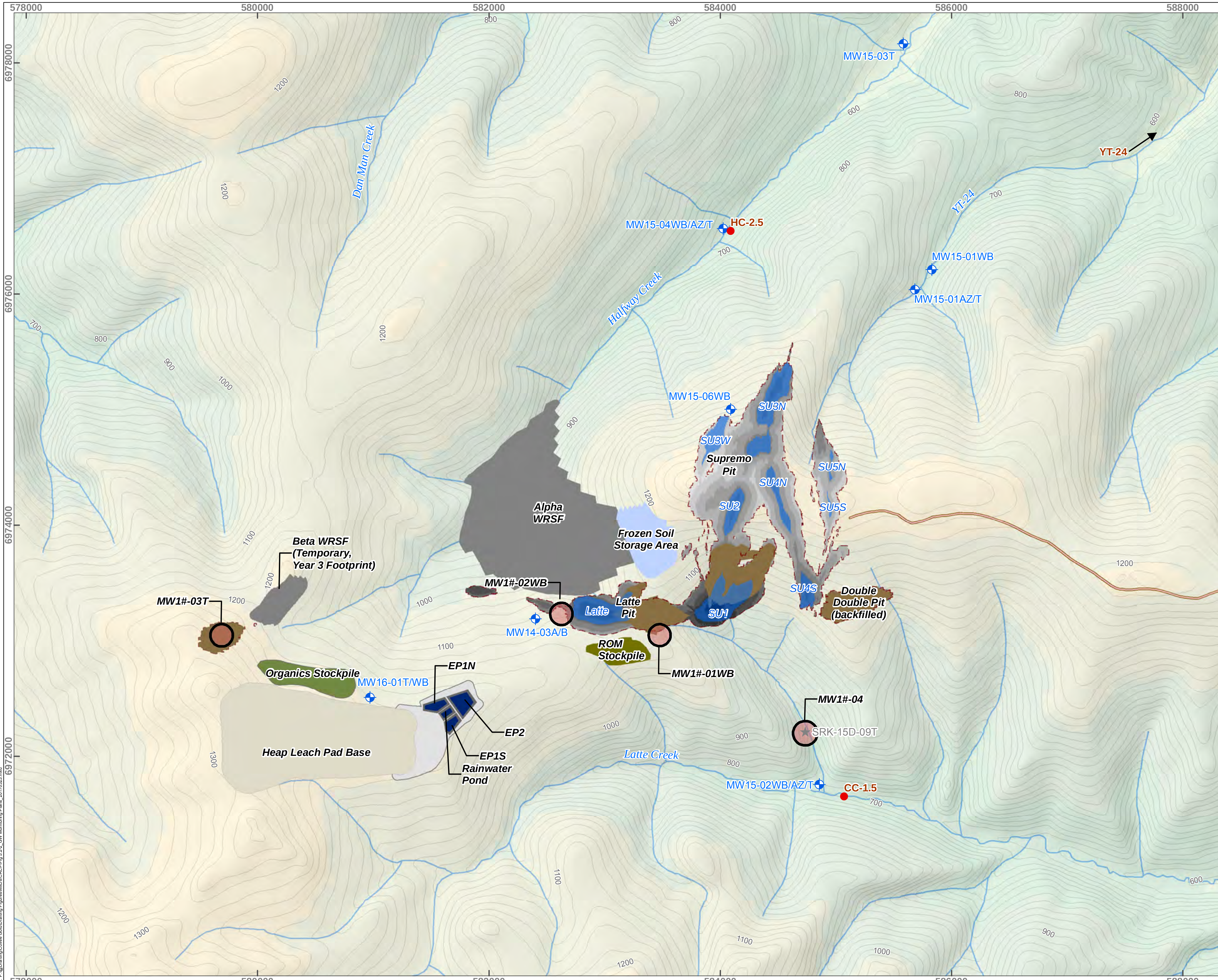
The groundwater monitoring system includes thermistor strings to measure ground temperature, vibrating wire piezometers to measure depth to groundwater, and a series of shallow and deep groundwater monitoring wells. Hydrogeological monitoring locations and monitoring frequency specific to the Post-Mining Closure and Active Closure stages are described below and illustrated in **Figure 5.2-2**.

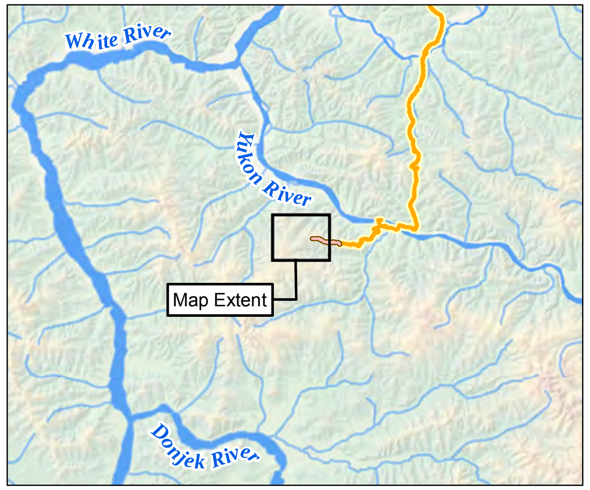
For the Post-mining and Active Closure stages, ground temperature and groundwater levels will be monitored continuously (except quarterly at Westbay wells), while groundwater quality adjacent to, and immediately down-gradient from mine facilities will be sampled quarterly, with receiving environment locations to be sampled quarterly or semi-annually, depending on proximity to mine facilities. A thermistor string will be installed in the backfilled Kona Pit to verify that the waste rock remains frozen (permafrost aggrades into the backfilled pit).

During the Active Closure Stage, surface water quality will be used as the key indicator of changes in groundwater as no groundwater discharge from the heap leach facility is likely, noting that this is the only facility (in conjunction with the water treatment plant) that requires active management in the Active Closure Stage. The two Westbay wells on either side of Latte Pit will be sampled, as well as the three Westbay wells, to assess groundwater down-gradient of the Mine Site in each of three catchments (**Figure 5.2-2**). While monitoring frequencies will be determined during the licensing phase of the project, it is envisioned that these wells would be monitored a minimum of twice per year in the Active Closure Stage.

COFFEE GOLD MINE

Groundwater Monitoring Locations for Reclamation and Closure Phase





Legend

Approximate Location of Additional GW Monitoring	*WB = Westbay* *T = Thermistor String*
Monitoring Well	AZ = Active Zone WB = Westbay, A = Deep Conventional (200+m) B = Shallow Conventional (150+m) T = Thermistor String
SWQ Monitoring Station	
Thermistor/VMP (SRK 2015)	
Mine Site Access Route	
Northern Access Route	

Proposed Infrastructure

- WRSF
- Backfill
- Total Pit Outline
- ROM Stockpile
- Organics Stockpile
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base

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0 500 1,000 1,500 2,000

Meters

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Figure 5.2-2	Date: Mar 30, 2017	Drawn by: (A.L.)	Reviewed: (J.H.)

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5.2.3 AQUATIC ENVIRONMENT MONITORING – FISH AND AQUATIC HABITAT MONITORING PROGRAM

Both the Water Use Licence (pursuant to the *Yukon Waters Act*) and MMER of the *Fisheries Act* will require monitoring of the aquatic environment to identify Project-related effects, if any, on fish and fish habitat. Potential Project-related effects in downstream fish bearing watercourses may include increased sediment loading and changes in water quality, which could result in changes to habitat quality and usage by fish[13]. Potential adverse effects can be mitigated by implementing prevention and control measures (see **Section 2.2.2**) that minimize erosion and sediment mobilization from the Mine Site downstream into aquatic environments, and through compliance with discharge limits and water quality objectives for receiving environments to confirm that releases are within acceptable limits to protect fish, fish habitat, and use of fisheries resources downstream of the Mine Site.

To determine Project-related effects and the effectiveness of implemented mitigation measures, EEM requirements will include effluent and water quality monitoring (as described above in **Section 5.2.1**) as well as monitoring of sediment and biota in the receiving environment. The program will be designed and implemented according to the requirements outlined in MMER Schedule 5 for biological monitoring studies including reporting[14]. Since EEM is an iterative system of monitoring and interpretation phases, monitoring plans will evolve over the life of mine. Goldcorp will continue to engage with regulators and Project stakeholders in order to further develop the details of the EEM Plan.

The proposed monitoring program[15] for the Reclamation and Closure Phase is outlined in **Table 5.2-2**. Proposed receiving environment monitoring locations include Latte, Coffee, Halfway and YT-24 creeks, and reference area locations include Coffee Creek upstream of the Latte Creek confluence, Independence Creek, and Los Angeles Creek. For EEM, an effect is determined by a statistically significant difference in fish or benthic invertebrate community indicators between receiving environment watersheds and reference areas. Aquatic effects monitoring during Post-closure will only be conducted in the event that site specific water quality criteria are not achieved and adaptive management measures are triggered.

Previous fish capture data indicates that the watersheds in the LAA support relatively small populations of fish (Appendix 14-A, Fisheries and Aquatic Resources Baseline Update 2015). As such, electrofishing (a non-lethal fish capture method) will be used to monitor fish abundance, diversity, growth rate, condition, and age class distribution. Baseline sampling data also indicates that the minimum sample size[16] required

13 Arctic Grayling (*Thymallus arcticus*), juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) and Slimy Sculpin (*Cottus cognatus*) have been identified in watercourses that have the potential to be affected by Project-related changes (Appendix 14-A Fisheries and Aquatic Resources Baseline Update 2015).

14 Details available at http://laws-lois.justice.gc.ca/eng/regulations/SOR-2002-222/FullText.html.

15 This program was developed based in part on the following predictions and MMER Schedule 5 (paragraph 9) requirements: 1) That since the concentration of effluent in the exposure area is greater than 1% in the area located within 250 m of a final discharge point, a fish population survey will be required; 2) That since the concentration of total mercury in the effluent is below than 0.10 µg/L, fish tissue sampling is not required.

16 Sampling requirements outlined in Metal Mining Technical Guidance for Environmental Effects Monitoring (ECCC 2016).

for use of non-lethal sampling techniques is unlikely to be achieved at many sampling stations within the LAA, and as such, modifications will be made to the program as necessary.

Goldcorp will assign the monitoring activities and reporting of results to qualified environmental professionals. In years when monitoring activities are undertaken, annual reports will present the data collected for the monitoring indicators presented in **Table 5.2-2** (in conjunction with results of effluent characterization, sublethal toxicity testing, and water quality monitoring (see **Section 5.2.1**)), and describe any effects on the fish population and the benthic invertebrate community. A comprehensive report will be prepared periodically that presents comparisons between data collected over time (baseline, Construction Phase, Operation Phase, and Reclamation and Closure Phase data) and the results of analyses to discern whether changes, if any, are attributable to Project-related effects or natural variation.

Table 5.2-2 Summary of Proposed Fish and Fish Habitat Monitoring - Reclamation and Phase

Indicator	Objective	Scope of Monitoring[a]
Fish Abundance and Species Diversity	Evaluate how the Project may influence habitat use by fish species in streams downstream of the Project by calculating fish catch-per-unit-effort and density (fish/m²), and number of fish species present	Fish sampling via electrofishing in receiving environment watersheds and reference sites
Fish Habitat Quality	Evaluate how the Project may influence habitat in fish bearing streams downstream of the Project by evaluating pool frequency and average pool depth	Detailed habitat assessment in receiving environment watersheds and reference sites
Fish Growth Rates, Condition Factors and Survival	Evaluate how the Project may influence fish species health and population age structure in streams downstream of the Project by measuring fish length at age (fork length), condition factor, and age class composition	Fish sampling via electrofishing (and other methods if required to increase the fish sample size at each monitoring station) in receiving environment watersheds and reference areas
Chinook and Chum Salmon Spawning	Quantify the extent of Chum and Chinook salmon spawning within the LAA by enumerating observed spawning salmon and salmon redds	Surveying periodically for salmon spawning activity via helicopter during the summer and fall for Chinook and Chum Salmon, respectively, in habitat areas where are likely to spawn in the LAA[b]
Benthic Invertebrate Community Structure	Evaluate how the Project may influence benthic invertebrate community structure by assessing abundance and taxonomic richness, and measuring diversity and evenness (i.e., Simpson's indices)	Collecting and analyzing benthic invertebrate communities in receiving environment watersheds and reference areas
Primary Productivity - Chlorophyll a and Periphyton Abundance and Diversity	Evaluate how the Project may influence aquatic primary productivity in streams downstream of the Project	Collecting and analyzing primary producers and productivity in receiving environment watersheds and reference areas

Indicator	Objective	Scope of Monitoring[a]
Sediment Quality	Evaluate how the Project may influence sediment quality by analyzing for grain size, total organic carbon, and total metals concentrations.	Collecting then analyzing sediment samples in receiving environment watersheds and reference areas

Notes:

a. Proposed receiving environment monitoring locations include Latte, Coffee, Halfway and YT-24 creeks and reference area locations include Coffee Creek upstream of the Latte Creek confluence, Independence Creek, and Los Angeles Creek.

b. Proposed spawning survey areas include approximately 30 km of the Yukon River from approximately 4 km upstream of Coffee Creek to the confluence with Independence Creek, and the lower 5 km of both Coffee Creek and Independence Creek. Surveys will be discontinued if no evidence of spawning has been documented after several monitoring campaigns.

5.3 Terrestrial Environment Monitoring

The Quartz Mining License, Water Use Licence, and permits issued under the *Environment Act* are expected to outline the requirements to monitor potential Project-related effects on the terrestrial environment during closure. These requirements are likely to include surveillance monitoring of the site in general and specific activities related to the monitoring for 1) the presence of invasive plants, 2) trace metal uptake in soil and vegetation[17], 3) effectiveness of reclamation activities, and 4) wildlife protection. Surveillance and monitoring activities proposed during the Post-mining Closure and Active Closure stages are described below.

5.3.1 Surveillance Monitoring

Surveillance monitoring of the Mine Site will continue during the Reclamation and Closure Phase, including routine, annual, and event-driven inspections. Details for monitoring will be refined throughout the Operation Phase to inform subsequent requirements, and modifications to Closure monitoring will be adapted as necessary to changing site conditions.

Routine inspections will be conducted by Goldcorp personnel to confirm the proper operation and maintenance of waste management facilities (i.e., wastewater treatment, incinerator, landfill, land farm, and waste storage areas), on-site power generation and distribution, and hazardous materials storage facilities (e.g., cyanide and other reagents) that could pose a risk to the terrestrial environment. Routine monitoring will be conducted according to a schedule (to be developed), and the monitoring frequency is likely to decline over time.

Visual observations and the review of collected data by a qualified geotechnical engineer (licensed to practice in the Yukon) of physical (geotechnical) performance will be conducted annually during summer months to identify apparent physical changes, and corrective measures to be taken prior to an instability occurring. Key areas for monitoring include water management infrastructure, HLF infrastructure,

[17] Trace metals are elements that occur in small amounts in natural and perturbed environments that, when present in sufficient bioavailable concentrations, are toxic to living organisms (Adriano 2001).

stockpiles, WRSFs, open pits, roads, and the airstrip. Surveillance monitoring programs will be revised based on site conditions, and monitoring requirements modified as necessary.

Event-driven inspections will be dictated by specific performance requirements outlined for key facilities or in response to site conditions (e.g., severe storm event). Details pertaining to event-based inspections will be incorporated into facility- or component-specific management plans (to be developed) as the Project progresses.

5.3.2 INVASIVE PLANT MONITORING PROGRAM

During the Reclamation and Closure Phase, Goldcorp will continue to monitor for the presence of invasive plant species on both revegetated and barren areas. The scope of monitoring and management activities will be similar to that implemented during the Operation Phase. Previously disturbed areas within and adjacent to the Mine Site area will be assessed to determine recolonization by both invasive and native plant species, and invasive plant species (if any) will be quantified and managed as conditions dictate.

It is anticipated that surveys will be conducted during Post-Mining Closure by Goldcorp's Environmental Department staff annually or as triggered by observations of invasive plant species. The need for surveys during Active Closure or Post-closure will depend on the results of previous monitoring and treatment activities. Surveys will be timed to facilitate invasive species identification and allow for removal of invasive species prior to seed set, wherever possible. Once ground cover has established on previously disturbed areas and revegetation efforts are considered to be complete (see **Section 5.3.5** for information on reclamation effectiveness monitoring), monitoring for invasive plants will cease.

5.3.3 METAL UPTAKE MONITORING PROGRAM

Trace metals uptake in soil and plants was identified as a potential concern for the Project with respect to risks to humans and wildlife that may consume potentially affected plant material. Increased trace metal uptake in plants can result from the direct deposition of dust on tissues or through increased metal concentrations in soil, which are then taken up by roots; therefore, dust suppression[18] during land disturbance and traffic activities will be important for mitigating potential effects during closure phases. Over the duration of the Project, Goldcorp proposes to implement a monitoring program to quantify trace metals in soils and plants in order to characterize baseline concentrations and assess potential Project-related effects on vegetation.

[18] Additional information on measures to mitigate fugitive dust dispersal and potential effects on soil and vegetation are provided in the Appendix 31-A Access Route Construction Management Plan and Appendix 31-B Access Route Operational Management Plan.

Monitoring program activities proposed during the Post-mining Closure Stage include monitoring of metal concentrations in soil and target vegetation species near the Mine Site, evaluating any changes in concentrations from baseline conditions[19], and if required, ascertaining whether any trends identified in metal uptake are attributable to the Project. Target species are likely to include reindeer lichens (*Cladina mitis* and *Cladina rangiferina*), willow (*Salix* spp.), and Lowbush Cranberry (*Vaccinium vitis-idaea*). These candidate species were selected for monitoring based on importance to First Nations (Mishler and Simeone 2004, Bates and DeRoy 2014), value as wildlife forage, and comparability to other studies. Monitoring will focus on metals that were selected based on the level of risk associated with each element and baseline metal concentrations in soils and plants. The proposed metals and associated threshold levels for the Project for soil and vegetation are presented in **Table 5.3-1**. The threshold values determined for vascular plants and lichen are provided as a guideline of potentially harmful trace metal concentrations. If Project monitoring activities identify an increase in trace metal concentrations in plants and lichen over time, adaptive management activities will be initiated before trace metal concentrations approach the identified thresholds.

Monitoring will be conducted by Goldcorp's Environmental Department staff every two years or as determined by increases in trace metals concentrations and adaptive management plans to mitigate effects to vegetation health. At this time, metal uptake monitoring is not proposed during Active Closure Stage or Post-closure Phase.

Table 5.3-1 Proposed Project Thresholds Identified for Trace Metals in Soils and Plants

Trace Metals	Proposed Thresholds (mg/kg)[a]	
	Soils	Vascular plants and Lichens (dry weight)
Arsenic	12	13
Cadmium	1.4	10
Copper	63	40
Lead	70	55
Mercury	6.6	2
Selenium	1	5
Uranium	23	-
Zinc	200	250

[19] In baseline samples, there were no correlations or trends between trace metal concentrations in soil or vegetation and proximity to the Mine Site, although approximately 40% of the soil samples taken within and around the Mine Site had arsenic concentrations above Canadian Council of Ministers of the Environment (CCME) agricultural soil guidelines.

5.3.4 Wildlife Monitoring Program

Activities associated with the closure of Mine Site infrastructure and facilities and use and closure of the NAR have the potential to affect wildlife and wildlife movement. Wildlife monitoring will continue during the Reclamation and Closure Phase to determine whether Project-related effects are occurring and if mitigation and management measures are adequate to minimize any observed effects. Anticipated activities include monitoring within the Mine Site, monitoring of Project activities including traffic and waste management activities, and recording wildlife observations and Project-related mortality. **Table 5.3-2** summarizes the wildlife monitoring program elements that are proposed for the duration of the Post-mining Closure and Active Closure stages, until facilities and infrastructure are decommissioned and areas are reclaimed (where applicable). The monitoring will be conducted by Goldcorp's Environmental Department staff.

Proposed species-specific monitoring programs to be carried out during the Construction Phase and the initial part of the Operation Phase are detailed in Appendix 31-F Wildlife Protection Plan. Continued monitoring in the latter years of Operation and in the Reclamation and Closure Phase will be subject to the analysis of the survey results and consultation with Project regulators and working groups; however, it is anticipated that some species-specific monitoring will continue until activity levels decrease.

Table 5.3-2 Proposed Mine Site Feature and Wildlife Monitoring – Reclamation & Closure Phase

Monitoring Element	Proposed Frequency	Description
Building Assessment	Monthly	Mine Site buildings will be inspected for use by nest predators (e.g. foxes, ravens etc.), nesting structures, or as a haven for potential problem wildlife until decommissioned.
Waste Management	Monthly	Regular surveillance of Project facilities and waste disposal sites will be conducted to confirm that wildlife are not frequenting these areas. Audits will be performed periodically to assess the effectiveness of waste management practices.
Wildlife Observations	Ongoing	Goldcorp employees and contractors will be required to report all wildlife sightings along the road and in the Mine Site area. Collected data will include wildlife species, date, time, location, and other details relevant to assessing potential Project-related effects such as wildlife behaviour, interaction with Project activity or personnel (i.e., collisions and near misses), etc.
Project-related Wildlife Mortality	Ongoing	Goldcorp will document Project-related wildlife mortalities and subsequent investigations will be conducted as necessary to determine contributing factors. Corrective measures will be implemented and management plans revised as necessary to mitigate future Project-wildlife interactions or mortalities.

5.3.5 Reclamation Effectiveness Monitoring Program

A monitoring program to assess the effectiveness of reclamation efforts will be developed as reclamation research programs progress and reclamation plans and revegetation prescriptions and methodologies are defined during the Construction and Operation phases. In general, reclamation effectiveness will be determined by the following:

- Measuring revegetation success by monitoring several parameters: plant species percent cover, species composition and diversity, species survival, and vegetation structure. Specific thresholds, such as the percent cover of vegetation deemed necessary to provide suitable erosion control, will vary by site and will be developed based on the results from revegetation trials and/or monitoring of areas that have been progressively reclaimed;
- Measuring percent ground cover (living and dead plant material on and within 2 cm of the ground surface) to assess the amount of soil being held in-place by plants and debris (i.e., a measure of erosion potential); and
- Assessing site stability based on site surface preparation (e.g., contouring, hard surfacing with rip rap) and/or vegetation establishment.

Reclamation monitoring will occur annually for the first four years following revegetation, including the year of planting, and then will decrease depending on the monitoring results until areas are considered to be self-sustaining. Additional treatments will be completed if site reclamation or revegetation efforts do not provide necessary erosion control or are not developing into self-sustaining communities where prescribed. Monitoring activities will occur mid-summer (July – August) during the peak growing season when plants are easily identifiable. Measured parameters, including the percent cover, composition and structure of vegetation, will be compared over time to assess revegetation success and achievement of the closure objective of developing into self-sustaining communities.

5.4 Reporting

Reporting will be conducted in accordance with Project permits and licenses. At a minimum, Goldcorp anticipates the submission of an annual report to regulatory agencies. The annual report will include:

- Summaries of Project activities completed and mitigation measures implemented;
- Results of monitoring programs and interpretation of findings related to programs outlined above;
- Details of any investigations that were conducted and any corrective actions taken;
- A summary of engagement with regulators, Project-related working groups, First Nations, or Project stakeholders regarding that status of monitoring programs; and
- A description of any proposed changes to mitigation and monitoring plans.

Every three years, or as appropriate based on data collection, Goldcorp will review the results of annual monitoring and develop a detailed report that evaluates monitoring indicator trends. This interpretive report will include a retrospective analysis of monitoring data from baseline to current conditions to assess trends and compliance with Project-specific objectives and thresholds. Statistical analysis of the monitoring results will be performed where appropriate.

6.0 RECLAMATION AND CLOSURE EXECUTION STRATEGY

The reclamation and closure execution strategy is integrated with the operational development schedule to promote progressive reclamation and closure activities and maximize efficiencies. Similar to the project execution plan, the reclamation and closure execution strategy is based on principles tested and proven in the development of remote, logistically-challenged projects in northern Canada, including:

- Safety in design, construction, operations, and closure;
- Simple, passive environmental solutions minimizing disturbance footprint;
- Fit-for-purpose design, construction, operation, and closure;
- Consolidated operational and closure activities; and
- Common equipment fleet purchased by owner at the outset and used for construction, operations, and closure needs.

6.1 SEQUENCING

There are four well-defined periods of mine closure planned for the Project: Operational Phase (progressive reclamation), Reclamation and Closure Phase, Post-mining Closure Stage; Reclamation and Closure Phase, Active Closure; and Post-Closure Phase. This CRCP addresses only those aspects of reclamation and closure that occur after mining is complete (i.e., from the Reclamation and Closure Phase, Post-mining Closure Stage onward). **Table 6.1-1** summarizes the duration and objectives of the respective post-mining stages and lists major activities that are planned.

Table 6.1-1 Stages of Closure

Phase	Timing	Objective	Typical Major Activities
Reclamation and Closure Phase			
Post-Mining Closure Stage	Year 13 to end of Year 18 Begins with the end of ore processing Ends with the decommissioning of the process plant and infrastructure	Completion of major closure activities related to ending heap leach rinsing, dismantling infrastructure, establishing final water conveyance network, and reclamation	Rinsing of the HLF until Year 15 Ongoing treatment of HLF drain-down rinse water Decommissioning of crusher, the bulk explosives storage facility, ROM stockpile area Contaminated soil investigation and cleanup
Active Closure Stage	Year 19 to Year 23 Begins with closure of remaining facilities Ends with the end of water treatment	Maintenance, monitoring, and closure of remaining facilities	Water treatment will continue until it is no longer required (estimated to be Year 20) and treatment sludge removal from site Decommissioning of remaining facilities in Year 18, including camp Decommissioning of site roads and access road Demobilization of equipment Contaminated soil investigation and cleanup Decommissioning of the Alpha Pond and the Facility Pond
Post-closure Phase			
Post-Closure Phase	Year 24 onwards Begins with the end of water treatment Continues until all license conditions are met	Monitoring only	Geotechnical inspections of the HLF, WRSF, and the pit walls Water quality monitoring for the pits and WRSF Aquatic effects monitoring Terrestrial animal monitoring

6.2 LOGISTICS

Activities conducted during the Operation and Post-Mining Closure stages will have been completed while the camp and the NAR are still in place, so many of the same logistical considerations as for the Operation Phase will still apply. By the end of Year 18, the NAR, Project airstrip, and most Mine Site facilities will have been decommissioned. Active Closure Stage and Post-closure Phase activities will be supported via the exploration airstrip and the Coffee Exploration Camp. Access to the site during Post-Closure will be primarily by aircraft.

6.2.1 ACCESS LOGISTICS

Access logistics include considerations of aircraft access, road access, barge access, and seasonality.

6.2.1.1 Post-mining Closure Stage

During the Post-mining Closure Stage, the NAR, including barge crossing facilities on the Yukon and Stewart Rivers will remain operational about one month per year for the transport of equipment, fuel, and consumables to the Mine Site. At the end of the Post-Mining Closure Phase, sections of the NAR and the barge crossing facilities built for the Project will be decommissioned.

The Project airstrip will be used by fixed wing aircraft to deliver select materials, perishables, and passengers during the Post-Mining Closure Stage on an as-needed basis and when the NAR is closed. At the end of this phase, the Project airstrip will be decommissioned.

6.2.1.2 Active Closure Stage

Access to the site during Active Closure will be during the summer. During Active Closure, the annual supply of equipment, fuel, and consumables will be transported to site by barge campaigns on the Yukon River. The exploration airstrip will be used on an as-needed basis and when barge campaigns are not possible.

6.2.1.3 Post-Closure Phase

Access to the site during Post-Closure will be during the summer. During Post-Closure, access to the site will be primarily by aircraft using the exploration airstrip.

6.2.2 SITE LOGISTICS

Site logistics include considerations of accommodations, power, fuel storage, and seasonality.

6.2.2.1 Post-Mining Closure Stage

During Post-Mining closure, most of the main camp complex will be kept in place. Personnel will be housed in the same camp used during the Operation Phase. Potable water treatment, sewage treatment, and communications will all be kept in place through the end of Post-Mining closure. At the end of the Post-Mining closure period, the camp complex will be decommissioned.

Three of the four generators will be decommissioned at the end of the Operation Phase. The remaining generator will be used until closure activities are complete.

Fuel storage during Post-Mining Closure will use the same storage facility that was used during the Operation Phase. The fuel storage facility will be decommissioned at the end of the Post-Mining Closure period.

6.2.2.2 Active Closure Stage

During Active Closure, personnel will be housed at the exploration camp. Smaller, temporary facilities will be used for fuel storage, potable water treatment, sewage treatment, and communications. Power will be supplied by the remaining generator.

6.2.2.3 Post-Closure Phase

During Post-Closure, personnel will be housed at the exploration camp. Smaller, temporary facilities will be used for fuel storage, potable water treatment, sewage treatment, and communications. Power will be supplied by the remaining generator. These facilities will be decommissioned when post-closure monitoring is complete.

6.3 REGULATORY CONSIDERATIONS

It is likely that a Water Use Licence or amendment will be required for the Active Closure and Post-Closure stages. The continued need for a Water Use Licence following the decommissioning phase will be dependent on site conditions, performance of closure measures in achieving stated objectives, and legislated requirements. Post-closure management and monitoring of the site will be guided to some extent by the Water Use Licence, quartz mining licence or other permit requirements, the performance of physical structures remaining on site, and the ability of achieving and demonstrating long-term compliance with existing license terms.

Once overall closure performance has been demonstrated for all aspects of decommissioning, the necessity of maintaining licences or permits will be re-examined. At an appropriate time, a Certificate of Closure under the Quartz Mining Act would be requested.

7.0 RECLAMATION AND CLOSURE LIABILITY

7.1 COST ESTIMATE METHODOLOGY

Preparation of the closure cost estimate for the Project has been developed by JDS (2016) with input by various other contributors including The Mines Group (MINES), SRK, and Onsite Engineering Ltd. (Onsite).

The closure cost estimate was developed using first principles, applying directly-related Project experience, and the use of general industry factors and was based on feasibility level engineering design. The Project has relied on inputs obtained from engineers, estimators, contractors, and suppliers who have provided similar services to existing operations and have demonstrated success in executing the plans set forth in this study.

Progressive reclamation and closure activities will begin as soon as mining at the Double Double pit has been completed and will continue through the rest of the mine life.

There are four Project periods that pertain to mine closure:

- Operational closure – Years 2 to 12: completed pits, WRSF and stages of the HLF are decommissioned they will be closed
- Post-mining closure – Years 13 to 18: closure activities relating to terminating the mining operation, dismantling infrastructure and reclamation
- Active closure – Years 19 to 23: maintenance, monitoring and closure of remaining facilities; and
- Post-closure – Year 24 onwards: monitoring only.

Mine closure and reclamation activities are described in **Section 6.0** and include the following:

- Heap leach rinsing and re-sloping and capping
- Managing hazardous waste
- Dismantling and disposing of all structures and equipment
- Landfilling all inert waste, including equipment drained of all oils and hazardous materials;
- Transporting all hazardous waste from the Project sites
- Disposing all liners and pipelines
- Collecting and treating all contaminated soils
- Re-contouring the site areas to provide positive drainage, and
- Scarifying, placement of re-vegetation layer and seeding of disturbed surfaces.

The following assumptions were used to build up the closure cost estimate and are summarized in **Table 7.1-1**:

- Mobile equipment required for closure was assumed to be rental or third party equipment
- Labour was assumed to be provided by the owner using fully burdened labour rates
- Unit cost estimates were based on the rental equipment fleet, and
- No salvage recovery was included in the closure cost estimate.

Table 7.1-1 Basis of Closure and Reclamation Estimate Summary

Category	Estimate Basis
Open pit	Open pit closure costs were estimated by applying unit costs from first principles and quantities based on current designs.
Heap leach closure	Heap leach closure costs were estimated by applying unit costs from first principles and estimated quantities based on current designs. Liner placement was based on vendor quotes.
Water management structures	Water management structure closure costs were estimated by applying unit costs to material quantities estimated on current designs.
Buildings and equipment	Buildings and equipment closure costs were estimated using previous project-closure production data which was scaled by area and material quantities.
Site pads, roads and airstrip	Infrastructure pads, roads and airstrip closure costs were estimated by applying unit costs from first principles and quantities based on the current design for restoring drainage, scarifying and revegetation layer. Seeding and fertilizing units' costs were based on vendor quote from previous projects.
Access road	Access road closure costs were estimated by applying unit costs from first principles and quantities based on the current design for restoring drainage, scarifying and revegetation layer.
Water treatment	Water treatment plant capital costs were based on previous projects. Treatment costs were based on reagent costs for similarly sized equipment. Labour costs were based on owner provided labour.
Contaminated Soil	Soil investigations were based on unit costs per meter drilled at the required intervals over the testing footprint.
Post mining and active closure Monitoring	Cost allowances were based on similar projects.
Indirects	Indirect costs were based on the required man-days to complete post mining and active closure activities and associated accommodation, fuel, site services, tool, transportation and supply costs. Indirect costs also include allowances for project management, general and administrative, helicopter support and a 12% contingency.

7.2 CLOSURE LIABILITY ESTIMATES

The total estimated closure costs are provided in **Table 7.2-1**. These costs are provided in undiscounted 2015 Canadian Dollars and include progressive reclamation, active closure monitoring activities, water treatment operation, and monitoring.

Table 7.2-1 Estimated Closure and Reclamation Costs

Closure Item	Sub-total	Total Cost
Direct Costs		
Open Pits		**$200,000**
Heap Leach		**$15,300,000**
On-Site Infrastructure		**$4,800,000**
Site Roads		**$2,000,000**
Water Management Structures		**$500,000**
Access Road		**$800,000**
Water Treatment		**$10,700,000**
Contaminated Soil		**$600,000**
Closure Monitoring		**$700,000**
Sub-Total - Direct Costs		**$35,600,000**
Indirect Costs		
Mobilization-Demobilization		**$500,000**
Site Logistics (barge, road maintenance, camp, travel, etc.)		**$12,400,000**
Management, Admin, and Office costs		**$5,500,000**
Contingency (12% of above costs)		**$6,500,000**
Sub-Total - Indirect Costs		**$24,400,000**
Total Cost		**$60,000,000**

Note: Source – JDS (2016)

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APPENDIX 31-C-A

Revegetation Reclamation Research and Monitoring

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1.0 INTRODUCTION

Northern soils present challenges for reclamation and revegetation practices. Factors such as a cold, semi-arid to subarctic climate, near surface permafrost, and limiting nutrients create unique conditions that require an understanding of site conditions to develop strategies and overcome these challenges.

There is a growing trend in the industry to seed or transplant locally collected native species to advance natural regeneration (Matheus & Omtzigt 2013). Native species are species indigenous to a given area. Native species indigenous to the north naturally occur in northern climates and possess unique adaptations to survive northern climates and soils. Native species are favored and are now required or regulated in many circumpolar regions for reclamation, because native species are:

- Adapted to the climate; therefore, have high survival rates
- Adapted to the local photoperiod; therefore, have a greater reseeding potential
- Prolific seed producers and natural colonizers; therefore, do not require intense fertilization, and
- Native to the local area; therefore, do not introduce non-native invasive species.

Reclamation programs that utilize native species in natural regeneration processes reduce the cost of revegetation by promoting self-sustaining ecosystems (Polster 2003).

Kaminak Gold Corp., a wholly owned subsidiary of Goldcorp Inc. (Goldcorp or Proponent), proposes to develop the Coffee Gold Mine (Project), in west-central Yukon, approximately 130 kilometres (km) south of the City of Dawson and 330 km northwest of Whitehorse. The Mine Site area is located on Crown Land within the traditional territory of Tr’ondëk Hwëch’in and the asserted area of White River First Nation. The Project will consist of a new open pit heap leach gold mine using conventional shovel and truck mining methods with an ore production rate of five million tonnes per year over a 12-year operational mine life. The Proponent proposes to construct the Project over a 2.5-year period, referred to as the Construction Phase of the Project. Since mining of waste rock and ore will begin during Construction, this phase also includes the pre-production period. After recovery of first gold at the end of Year –1, the mine will enter the Operation Phase. Mining will continue over 12 years. During the Operation Phase, progressive reclamation activities will be ongoing, beginning as early as Year 2 when mining at the Double Double pit is completed. The Project’s active Reclamation and Closure Phase (Years 13 to 23) will commence when all mining and processing have been completed, to be followed by a Post-closure Phase from Year 24 onwards.

In anticipation of the eventual requirements for reclamation of the Project site and in support of the Project Proposal to be submitted to the Yukon Environmental and Socio-economic Assessment Board (YESAB) Executive Committee for screening under the Yukon Environmental and Socio-Economic Assessment Act (YESAA), and applications to be submitted for a Quartz Mining Licence from Yukon Government Energy, Mines and Resources and a Type A Water Licence from the Yukon Water Board, Kaminak initiated studies to develop site-specific restoration materials and protocols for the Project. This work began in 2013 with reclamation studies at existing drill sites/fences conducted by Kaminak Environmental Monitor Derek Scheffen. In 2014, this work was expanded under the guidance of Randy Lewis of Arctic Alpine Reclamation Group, with support by EDI Environmental Dynamics Inc. (EDI). In 2015, in addition to ongoing work by Randy Lewis and Kaminak Environmental Monitors, Kaminak partnered with the Yukon College, Yukon Research Centre (YRC), to conduct additional studies of the use of local native plant species and soil amendments for use in the restoration of the Project site. The 2015, research was led by Katherine Stewart with the YRC; Katherine has since taken an Assistant Professorship with the University of Saskatchewan, Department of Soil Science, but continues to be involved in reclamation research for the Project. The 2015 research also incorporated information from Tr'ondëk Hwëch'in (TH) Elders, Angie Joseph-Rear and Julia Morberg, so that both scientific and traditional ecological knowledge were reflected. All reclamation studies were overseen by Allison Rippin Armstrong, former Kaminak Vice President of Sustainability.

The Project provides an opportunity to test various techniques of reclamation, revegetation, and natural regeneration of mine disturbed areas within a unique northern environment. The Project also provides the opportunity to combine science and traditional knowledge (TK) with education. In conjunction with the 2015 research program, Kaminak supported the development and implementation of two training programs in partnership with TH and the Yukon College, including the Centre for Northern Innovation in Mining (CNIM), and the YRC. These training programs, Introduction to Environmental Monitoring Pilot Project (IEMPP) and Northern Terrestrial Restoration (NTR), were provided to local First Nations students to promote awareness and understanding of environmental monitoring requirements and offer students the opportunity to gain experience in experimental design, field sampling techniques, and native seed collection. This report summarizes reclamation research and monitoring activities conducted on site from 2013 to 2015, including the following components:

- Plants for reclamation
- Reclamation demonstration sites and monitoring
- Seed collection, inventory, and mapping and
- Nursery planning.

2.0 RECLAMATION RESEARCH AND MONITORING

Since the inception of mine exploration associated with the Project, areas disturbed for drilling have been mechanically restored using machinery to replace the vegetation mat. From 2013 to 2015, Kaminak initiated progressive reclamation research alongside exploration activities to test the effectiveness of various reclamation techniques under different site conditions.

2.1 PLANTS FOR RECLAMATION

Not all species have equal weight in providing ecosystem services to the environment (Lawton 1994); therefore, identifying northern plant species that promote effective ecosystem processes is crucial for reclamation. Effective ecosystem processes include below-ground processes, such as nutrient cycling, water cycling, decomposition, and energy flow that support the production of plant matter. In consideration of this, a preliminary list of potential native species for reclamation at the Project was developed by looking at the local availability of plant species recommended for use in the Yukon by the Yukon Revegetation Manual (Matheus & Omtzigt 2013).

Field investigations were conducted in conjunction with baseline rare plant surveys carried out by EDI from July 5 to 9, 2014. Native species considered for reclamation studies were selected based on moderate to high distribution and abundance within the Project area. Abundance was rated on a scale from 1 to 9 based on the British Columbia Ministry of Forests Weed Density Distribution Classes (Luttmerding et al. 1990). These guidelines provide a density distribution for plants growing in a 20 m x 20 m area and take into consideration continuous occurrence and clumped distribution. Locations were marked with a GPS and categorized into broad regional areas.

Candidate native species for reclamation studies identified as having moderate or high abundance included grasses, nitrogen-fixing forbs, and shrubs. **Table 2-1** and **Table 2-2** provide a preliminary list of native grass species and native forb and shrub native grass species, respectively, that may be considered for reclamation and studies**.**

Table 2-1 Native Grass Species Considered for Coffee Gold Mine Reclamation Studies

Common Name	Species Name	Ecotype	Abundance[a]	Latitude	Longitude
Alpine bluegrass	*Poa alpina*	Subalpine	4	62.8743	-139.4360
Alpine sweetgrass	*Hierochloe alpina*	Subalpine	7	62.7664 62.8743 62.8878	-139.0063 -139.4360 -139.3299
Bluejoint reedgrass	*Calamagrostis canadensis*	Boreal	8	62.9142	-139.0837
		Subalpine	4	62.8878	-139.3299
Fowl bluegrass	*Poa palustris*	Boreal	7	62.8882 62.9142	-139.0784 -139.0837
		Subalpine	4	62.8878	-139.3299
Glaucous bluegrass	*Poa glauca*	Boreal	7	62.8882 62.8804	-139.0784 -139.1018
Northern rough fescue	*Festuca altaica*	Subalpine	7	62.7986 62.8743 62.8878	-139.0282 -139.4360 -139.3299
Ticklegrass	*Agrostis scabra*	Boreal	5-7	62.8806 62.9084	-139.1002 -139.0697
Tufted hairgrass	*Deschampsia caespitosa*	Boreal	7	62.9144	-139.0868

Note: a. Abundance was rated on a scale from 1 to 9 based on the British Columbia Ministry of Forests Weed Density Distribution Classes to provide a baseline value for abundance and distribution (Luttmerding et al. 1990).

Table 2-2 Native Forb and Shrub Species Considered for Coffee Gold Mine Reclamation Studies

Common Name	Species Name	Notes
Alpine bearberry	*Arctous alpina*	Found in open subalpine not dominated by high shrubs > 2 m tall, such as scrub birch.
Alpine sweet-vetch	*Hedysarum alpinum*	Found in the low boreal forest along the Yukon river. Nitrogen fixing plant.
Arctic lupine	*Lupinus arcticus*	Found in open subalpine not dominated by high shrubs > 2 m tall, such as scrub birch. Nitrogen fixing plant.
Arctic willow	*Salix arctica*	Found in open subalpine not dominated by high shrubs > 2 m tall, such as scrub birch.
Bog bilberry	*Vaccinium uliginosum*	Found in moist subalpine and boreal forest
Canada buffalo-berry	*Shepherdia canadensis*	Found in dry subalpine and boreal forest. Nitrogen fixing plant.
Dwarf birch	*Betula glandulosa*	Widespread in subalpine
Gray-leaved willow	*Salix glauca*	Widespread in subalpine
Lowbush cranberry	*Vaccinium vitis-idaea*	Widespread at all elevations
Mountain avens	*Dryas* spp.	Found in open subalpine not dominated by high shrubs > 2 m tall, such as scrub birch.
Northern bedstraw	*Galium boreale*	Found in subalpine and boreal forest

2.2 RECLAMATION DEMONSTRATION SITES

Mine exploration involves surface disturbance where the vegetation mat is removed for drilling core samples. The outcome of drilling activities is commonly referred to as drill sites/fences.. As exploration activities progress, these disturbances create a need for progressive reclamation and revegetation. Additional disturbances which present an opportunity to test methods of reclamation and revegetation onsite are cut slopes along the existing access road between the Coffee exploration camp and the deposit (i.e., Java road). These areas are prone to erosion; therefore, various methods of reclamation and revegetation (i.e., site prescription) must be tested to determine the most effective solution to reduce erosion and stabilize slopes. Kaminak Environmental Monitors conducted preliminary research at reclamation demonstration sites in 2013. In 2014, Kaminak, in collaboration with Arctic Alpine Reclamation Group, expanded reclamation demonstration sites to include data collection and monitoring, as well as new sites).

2.2.1 YEAR 2013

In 2013, reclamation studies tested basic site prescriptions at existing drill sites/fences. The objective was to test natural regeneration through mechanical reclamation and seeding. To conduct mechanical reclamation, machinery is commonly used to replace the original vegetation layer from where it was removed. A combination of machinery and manual labor was used to conduct this work. Kaminak Environmental Monitors used shovels and rakes to replace soil, vegetation, and boulders in an effort to emulate a well-known reclamation technique referred to as “rough and loose”. Rough and loose surface treatments provide ecosystem benefits by minimizing compaction, controlling erosion, and creating conditions that promote revegetation of the site (Polster 2009). The rough and loose approach promotes a diversity of habitats by creating topographic heterogeneity, which supports early and successful establishment of pioneering species (Holling 1973).

In 2013, sites were seeded with native seed from Arctic Alpine Reclamation Group, including 20% tickle grass (*Agrostis scabra*) 20% alpine bluegrass (*Poa alpina*), 20% glaucous bluegrass (*Poa glauca*), 20% Rocky Mountain fescue (*Festuca saximontana*), and 20% tufted hairgrass (*Deschampsia caespitosa*) at a rate of 1500 pure live seeds per square metre (PLS/m^2). The seed was applied with a manual seed spreader and raked into the soil materials.

2.2.2 YEAR 2014

In 2014, reclamation studies expanded to include long-term monitoring plots at existing and new reclamation demonstration sites including drill sites/fences and cut slopes.

The objective was to test and monitor various site prescriptions at reclamation demonstration sites to determine which prescriptions are most effective for reclamation and revegetation for the Project. The following site prescriptions were applied to new disturbed sites in 2014 including drill sites/fences, and cut slopes along the Java road:

1. Mechanical Reclamation (MR)
2. Mechanical Reclamation + Seeding (MRS)
3. Mechanical Reclamation + Raking + Seeding + Raking (MRRSR). and
4. Mechanical Reclamation + Bio-engineering + Seeding + (MRBS).

Drill sites/fences were treated with site prescriptions one (MR), two (MRS) or three (MRRSR) which included mechanical reclamation, seeding, and/or raking. For those site prescriptions that included seeding, in 2013, seed was sourced from Arctic Alpine Reclamation Group. In 2014 and 2015, seed was locally collected onsite and included a mixture of grasses, nitrogen-fixing forbs, and shrubs (for details on seed collection refer to **Section 3.0 Seed Collection, Inventory, and Mapping)**.

Site prescription four (MRBS) was only applied at selected cut slopes along the Java Road and tested local seed mixtures and bio-engineering techniques. Bio-engineering techniques involved staking and bundling cuttings from local shrubs including willow (*Salix* spp.), alder (*Alnus viridis*), balsam poplar (*Populus balsamifera*), and birch (*Betula glandulosa*). Native seed was also applied to the cut slopes; the seed mix included alpine bluegrass (*Poa alpina*), glaucous bluegrass (*Poa glauca*), Rocky Mountain fescue (*Festuca saximontana*), tufted hairgrass (*Deschampsia caespitosa*), and boreal wormwood (*Artemisia norvegica* ssp. *saxatilis*). Seed was applied at a rate of 1500 PLS/m^2.

Demonstration sites along the Java road focused on cut slopes. Cut slope site prescription trials focused on three main sites located at KM 1.6, 3.2, and 7.2. Cut slope sites were different in size; site one at KM 1.6 was 35 m x 2.5 m (87 m^2), site two at KM 3.2 was 195 m x 3 m (585 m^2) and site three was 285 m x 90 m (25,650 m^2). Site three was further divided into eight, 30 m plots. For all sites, native species cuttings were inserted horizontally (bundles) and vertically (stakes) into the soil. Willow, alder, balsam poplar, and Labrador tea (*Rhododendron groenlandicum*) were used as cuttings for bioengineering. All erosion sites were treated with site prescription four (MRBS), which included soil bioengineering techniques. Soil bioengineering is the use of living plant materials to perform specific engineer functions (Schiechtl 1980). To test the effectiveness of site prescriptions at demonstration sites, four 1 m^2 long-term monitoring plots were established at selected demonstration sites.

2.2.3 YEAR 2015

Reclamation demonstration sites established in 2013 and 2014 were monitored in 2015. To determine the effectiveness of site prescriptions at drill sites/fences, the percent cover of germinating plants were measured at all four 1x1 m plots within a site. At cut slope sites, the percent cover of vegetation was also recorded, as indicated by the percent of live stakes and bundles. Results for the reclamation demonstration sites will be provided following future onsite monitoring activities that will be undertaken by Randy Lewis and Environmental Monitors.

2.3 Yukon Research Centre Studies

In 2015, the Yukon Research Centre (YRC) established seeding trials to test various reclamation techniques in different ecotypes present onsite at the Project site. In addition, greenhouse trials were conducted to test the relationship between soil amendments and the recovery of ecosystem processes (i.e., nitrogen-fixation). Seeding trials were conducted onsite at the Project site in conjunction with the NTR course. Greenhouse trials were conducted at the YRC by trained staff, as a laboratory experiment. Both trials support reclamation research and monitoring activities as part of the Project.

2.3.1 Seeding Trials

Seeding trials were conducted to determine germination rate and percent cover of native seed applied to different ecotypes using various reclamation techniques. Using a randomized block design, trials were established at both boreal low and subalpine sites. At each site ten blocks each with seven different reclamation techniques were installed for a total of 140 plots. The reclamation techniques were applied in 1 m^2 plots and randomly assigned within each block. At a minimum, all plots were situated 1 m apart and 1 m from the edge of the site. The following seven reclamation techniques were tested:

- Boreal low, organic matter and seed (BOS)
- Subalpine, organic matter and seed (SOS)
- Boreal low, organic matter, fertilizer and seed (BOFS)
- Subalpine, organic matter, fertilizer and seed (SOFS)
- Fertilizer and seed (FS)
- Seed only (S), and
- Control, no addition (C).

The two types of organic matter applied as a soil amendment were Boreal low (BO) and Subalpine (SO). The BO amendment was harvested from a low-lying bog underlain by permafrost at approximately 50 to100 cm located near the airstrip. The SO amendment was harvested from the top 50 cm of the soil profile in subalpine birch heath located adjacent to a subalpine drill site/fence. Kaminak Environmental Monitors, NTR students, and YRC researchers applied organic matter at 5% (v/v) to the top 5 cm of soil and fertilizer (19:19:19 NPK) was added at 160 kg/ha. A native seed mix was applied at a rate of 1500 PLS/m^2.The native seed mix included alpine bluegrass (*Poa alpina*), glaucous bluegrass (*Poa glauca*), Rocky Mountain fescue (*Festuca saximontana*), tufted hairgrass (*Deschampsia caespitosa*) and boreal wormwood (*Artemisia norvegica* ssp. *saxatilis*). Plots were seeded from June 15 to 16, 2015 and measured for germination and percent cover from August 17 to 18, 2015. Although the seed used in this initial trial was not from site, all species in the mix were found to occur naturally on-site and was sourced from the Alaska Seed Bank to maintain regional continuity. For additional information on local seed collections that were carried out concurrently to this trial please refer to **Section 3.0 Seed Collection, Inventory and Mapping.**

2.3.2 GREENHOUSE TRIALS

To test the relationship between soil amendments and the recovery of ecosystem processes a greenhouse trial was conducted at the Yukon Research Centre (YRC) using a common native species found at the Project site. Arctic lupine (*Lupinus arcticus*) is an understory species that possesses natural nitrogen-fixing abilities. Through a symbiotic relationship with a strain of bacteria known as rhizobia, lupine can fix nitrogen to assist growth, development and reproduction of plants in the surrounding soil and promotes ecosystem processes. This process occurs in tiny, round nodules on the roots and is a good indication of site conditions that will support natural regeneration.

In a controlled growth chamber, eight treatments were tested to determine ethylene production in lupine after three months of growth. Ethylene is a natural plant hormone that is produced as a by-product during all stages of tissue development. It is produced from all parts of higher plants, including leaves, stems, flowers, fruits, roots, tubers and seeds. The amount of ethylene produced (ppm/h) by individual lupine plants growing in a medium was measured for each of the following treatments:

- Inoculum peat and seed (IP-S)
- pH adjusted, inoculum peat and seed (pHIP-S)
- Inoculum seed (IS)
- Peat and seed (P-S)
- pH adjusted, peat and seed (pHP-S)
- Seed only (S)
- Inoculum peat and inoculum seed (IP-IS)
- pH adjusted, inoculum peat and inoculum seed (pHIP-IS).

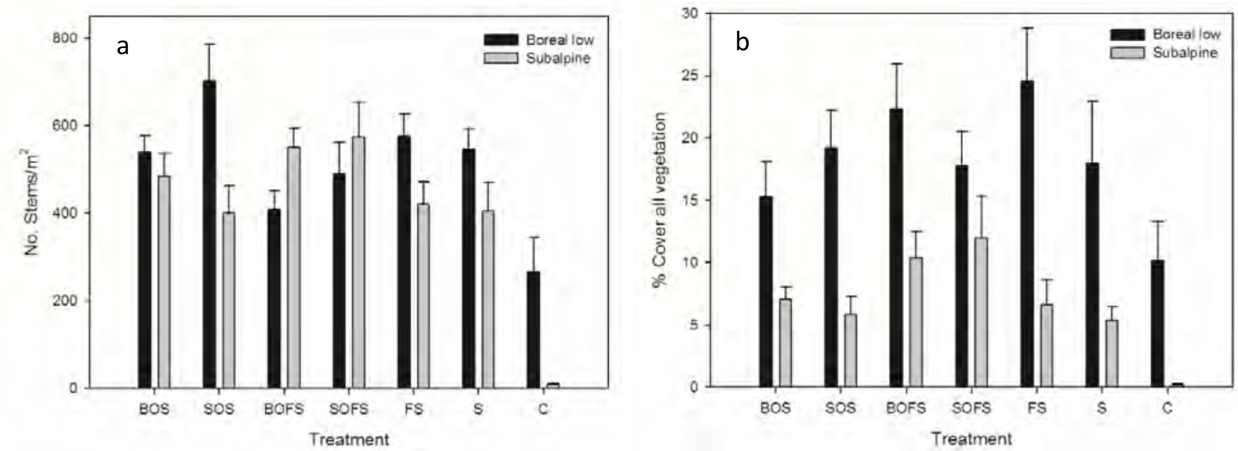
Lupine root nodules were harvested onsite June15-16, 2015. Root nodules were kept in a cool, dark fridge until processing on June 26, 2015. Both roots and nodules were washed with a small brush to remove soil, rinsed with deionized (DI) water, sterilized with ethanol by submersing it in the liquid for 30 seconds then rinsed by DI water six times. Nodules were separated from the roots using a sterile scalpel, weighed and then ground with a mortar and pestle. Ground nodules were added to a yeast sucrose broth (YSB; Vincent 1970). The YSB was made by mixing 100 g of baker's yeast with one litre of cold DI water. The mixture sat at room temperature for one hour then was autoclaved at 120°C for 40 min. Following this it was left to settle before adjusting the pH to 6.10 with calcium carbonate ($CaCO_3$). The mixture was left to stand for 24 hours at room temperature, then was diluted to 1500 ml with DI water to create enough broth for all treatments.

Potting soil and organic peat were collected from two locations onsite June 14, 2015 from the boreal low (62º54.267’, -139º04.666’) and subalpine (62º53.043’, -139º17.429’) areas. The peat was processed for the potting trials by sieving, air drying, sterilizing in an autoclave at 120 º C for one hour, then grinding the material in a food processor. It was neutralized with $CaCO_3$ at a rate of 10 km/m^3 (12 g added to 1200 ml of peat). Sterilized peat was then mixed with the YSB to achieve 50% moisture v/v (700 ml peat was mixed with 700 ml YSB). Finally, both peat and lupine seeds were soaked in the YSB for 24 hours or DI water. Two lupine seeds were planted per tube of 150 ml of soil and watered to field capacity with DI water. After approximately three months soils were measured by ARAs-acetylene reduction assays to determine amount of ethylene produced (ppm/h).

2.3.3 RESULTS: 2015 YUKON RESEARCH CENTRE STUDIES

Seeding Trials

Overall organic matter and fertilizer amendments had little to no effect on germination rates of the native seed mix for either the boreal low or subalpine ecotypes (Panel a in **Figure 2-1**); However, the addition of fertilizer either alone or in addition to organic matter affected the percent cover of vegetation found growing at sites within these ecotypes (Panel b in **Figure 2-1**). In general aboveground cover was higher in all plots with fertilizer amendments in both the boreal low and subalpine ecotypes. This suggests that at least in the first growing season aboveground biomass production can be promoted by the use of commercial fertilizers. Further research is needed to determine the long term effectiveness of fertilizer addition on plant growth. Total percent cover for all species was three times higher in the boreal low (18%) than the subalpine (6%), which was in part driven by the recruitment of native local volunteer species (6%) establishing in the research plots (see **Table 2-3**). While further monitoring is needed to determine the effectiveness of these amendments over time it is evident that different approaches will likely be required in different ecotypes. High recruitment from the seed bank at the boreal low site indicates that natural revegetation will likely occur with minimal interventions; however, the low aboveground cover and lack of recruitment from the seed bank at the subalpine ecotype indicates that a more extensive revegetation strategy will likely need to be developed.



Note: Germination rate (number of stems/m^2) is on the left (a) and percent cover (%) is on the right (b);
Source: Stewart 2015a.

Figure 2-1 2015 Seeding Trial Results from Boreal Low and Subalpine Ecotypes at the Coffee Gold Mine Project

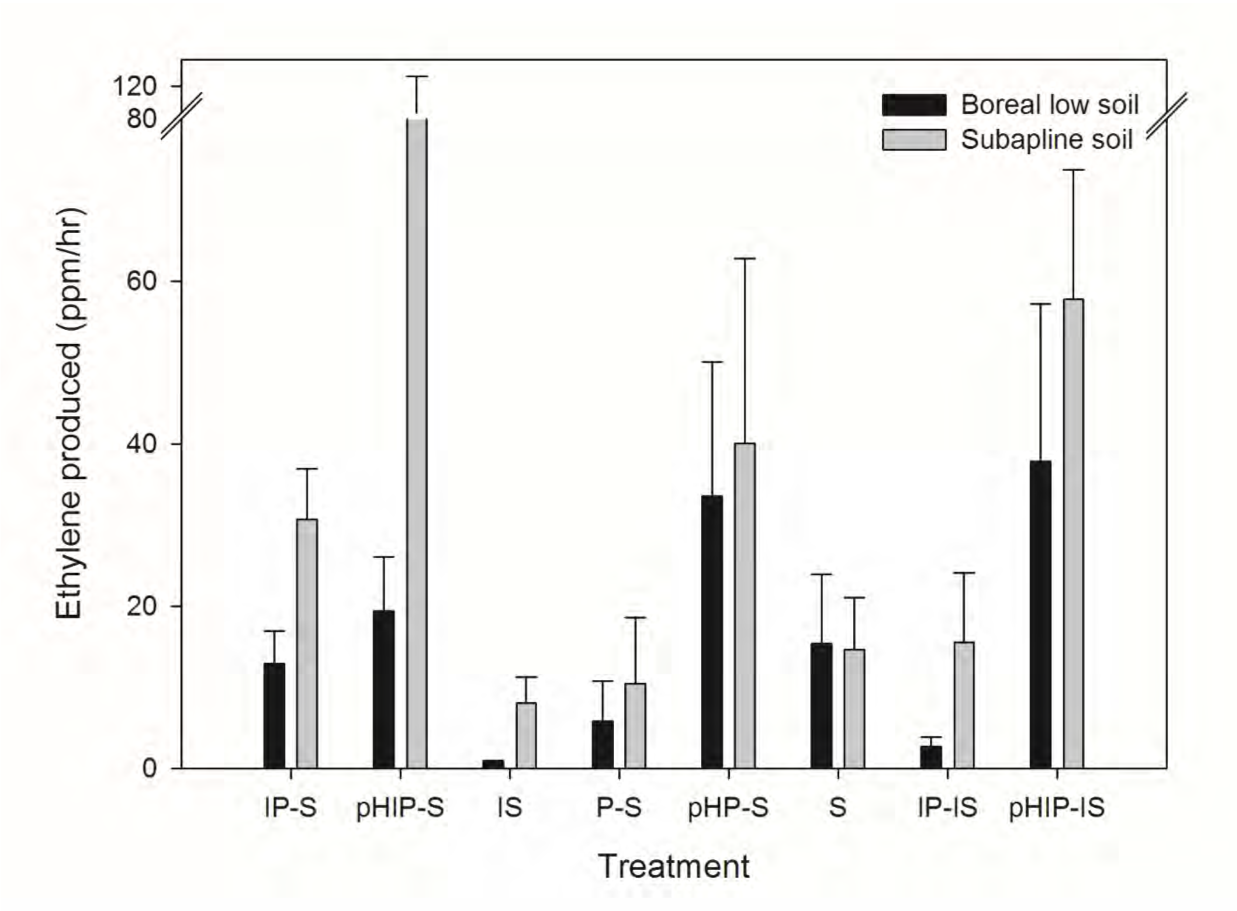
Table 2-3 Total Percent Cover for all Species in Boreal Low and Subalpine Ecosites

Ecotype	Total Cover (%)	Grass Cover (%)	Volunteer Species (%)
Boreal low	18	12	6
Subalpine	6	6	0

Greenhouse Trials

Ethylene production (i.e., nitrogen-fixation) from lupine was significantly different between boreal low and subalpine soils within some treatments (**Figure 2-2**). Nitrogen fixation was higher in subalpine than boreal low soils for the following treatments: IP-S (Inoculum peat and seed), pHIP-S (pH adjusted, inoculum peat and seed, IS (Inoculum seed) and IP-IS (Inoculum peat and inoculum seed). There was no difference in nitrogen fixation between subalpine and boreal low soils for the following treatments: P-S (Peat and seed), pH-S (pH adjusted, peat and seed), S (Seed only), and pHIP-IS (pH adjusted, inoculum peat and inoculum seed).

Between treatments, pH adjustment of peat led to higher rates of nitrogen-fixation. This may be due naturally low acidic/high alkaline subalpine soil or a naturally high number of rhizobium in the soil. Quantification of the rhizobium associated with each treatment could determine if rhizobium colonization rates were higher in the above treatments or if higher alkaline conditions only increased nitrogen-fixation activity, while maintaining similar colonization rates.



Source: Stewart 2015a.

Figure 2-2 2015 Greenhouse Trials using Arctic Lupine and Boreal Low and Subalpine Soils from the Project Site

3.0 SEED COLLECTION, INVENTORY AND MAPPING

In 2014, Kaminak initiated onsite seed collection and inventory for use in reclamation studies based on the preliminary list of potential species for reclamation (see **Section 2.1 Plants for Reclamation)**. This was expanded in 2015 through the work with the Yukon Research Centre. Disturbed and undisturbed vegetation communities in the boreal low, boreal high and subalpine ecotypes were surveyed to identify species naturally recolonizing disturbed areas. Due to higher rates of natural recovery and the reduced adverse effects expected in the boreal low ecotype (i.e. no Project mining operations in the boreal low), seed collection sites were selected in the boreal high and subalpine ecotypes. Seed collection sites also considered the availability of native species for bio-engineering bundles and stakes. Native seed was collected during the fall of 2014 and 2015 from KM zero (i.e., old airstrip) to KM 20 (i.e., Java road). Detailed locations are provided online as part of an interactive seed source map available at:

http://yrc-c.maps.arcgis.com/apps/MapJournal/index.html?appid=30b9ade6ce39467d8bb503fbfe4147b5

More than 30 candidate species were collected from 26 locations including grasses, nitrogen-fixing forbs, and shrubs. Seed collection considered plant phenology according to species. Plant phenology refers to the timing of plant growth and development. This can vary by season and is dependent on factors such as climate, elevation, and aspect. All seed was harvested by hand then dried and stored in the temporary nursery located onsite at the Coffee exploration camp.

Early successional species colonizing disturbed areas within the boreal high and subalpine ecotypes included prickly rose (*Rosa acicularis*), red raspberry (*Rubus idaeus*; boreal high only), fireweed (*Chamerion angustifolium*), bitter fleabane (*Erigeron acris*), tall lungwort (*Mertensia paniculata*; boreal high only), blue-joint reedgrass (*Calamagrostis canadensis*) and *Poa* grass species. This suggests that these species are good indicators of disturbed areas in these ecotypes and may be appropriate candidates for reclamation and revegetation.

4.0 NURSERY PLANNING

Using native species for northern reclamation is a challenge due to lack of available seed stock. In 2014 and 2015, Kaminak initiated preliminary plans to examine the basics of operating a nursery onsite. As part of this pilot project, Environmental Monitors and students from the NTR program established a temporary nursery at the Coffee exploration camp and participated in native seed potting trials and target species transplants. To prepare seeds for planting in nursery pots all seeds were cleaned by sieving to separate the seed from the husk and outer covering and then dried on a mesh rack. Following this, seeds were planted in nursery pots with soil collected onsite and watered to examine survival. Target species transplants were potted as soon as possible to prevent drying or damage to the root system.

Goldcorp will seek opportunities to work with local or Yukon First Nation businesses who are interested in establishing a nursery to grow native species for use in reclamation research and ultimately to cultivate seed and plants for use in reclamation activities (i.e., species that are adapted to the growing and climatic conditions that occur at the Mine Site).

5.0 FUTURE WORK

Goldcorp has committed to continue reclamation research and monitoring as part of reclamation and closure planning. Future work aims to increase the scope and depth of research to find innovative restoration techniques that are Project specific. One way that this can be achieved is by understanding rhizosphere (i.e., plant-root interface) properties of boreal plants and their potential to restore belowground processes (Iversen et al. 2015). This is important because understanding how these plant species interact with soil is fundamental to the development of sound and successful restoration practices that not only promote predictability of plant community assemblages, but also ensure restoration of key ecosystem processes in soils that support these communities over the long-term (Kardol and Wardle 2010; Quideau et al. 2013). It has been identified that more knowledge is needed on the use of local peat as a soil amendment during restoration and to address the management of a large ice-rich peat deposit overlying one of the major proposed pits onsite (i.e., Supremo). In addition, understanding the relationship between soil biological community development, carbon and mineral nutrient availability, and ecosystem function will provide important information for the reclamation and closure plan. To fulfill these knowledge gaps, Goldcorp has committed to a three year (2016 to 2018) reclamation research program with Katherine Stewart (Assistant Professor, University of Saskatchewan) to:

1. Characterize the rhizosphere of northern native plants that are potential candidates for restoration to understand the relationship between the diversity and abundance of plant roots, soil bacteria, fungi, and archaea with ecosystem functions (i.e., soil nitrogen and carbon cycling and storage).
2. Examine the use of local peat as a soil amendment during restoration and the potential impact of stockpiling on above and belowground plant-soil systems.
3. Investigate the interaction of peat soil amendments with northern plant species and rhizospheres.
4. Establish a three year field trial to evaluate the restoration of plant-soil materials on existing disturbance (e.g., drill fences) in subalpine areas.

This work will result in the training of two technicians, two masters' students, and three undergraduate student assistants. It will also engage Goldcorp's environmental monitoring team by involving the Environmental Monitors in field trial establishment and monitoring.

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