July 2018

LUPIN MINES INCORPORATED
(A wholly owned indirect subsidary of Mandalay Resources Corporation)

LUPIN MINE SITE
Final Closure and Reclamation Plan - DRAFT

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Submitted to:
Nunavut Water Board
PO Box 119
Gjoa Haven NU X0B 1J0

Report Number: 1789942_003_Rpt_RevA

REPORT

Golder Associates

EXECUTIVE SUMMARY - ENGLISH

The Lupin Mine (Lupin or Lupin Mine or Site) is located approximately 285 kilometres (km) southeast of Kugluktuk, in the Kitikmeot Region of Nunavut and is owned by Lupin Mines Incorporate (LMI), a wholly owned indirect subsidiary of Mandalay Resources Corporation. It is an underground gold mine that was in operation from 1982 to 2005 with temporary suspensions of activities between January 1998 and April 2000, and again between August 2003 and March 2004. The mine resumed production in March 2004 until February 2005. Since 2005, the Site has remained in Care and Maintenance.

An important part of closing the mine will be ensuring that the site is returned to a condition that protects the health and safety of Nunavut residents and the environment around the Lupin Mine. LMI is committed to ensuring that this occurs through the preparation of a complete Final Closure and Reclamation plan (the Plan) for remediation of the Lupin Mine that considers the historic uses of this area by Inuit. Included in the document are:

- an overview of LMI and their approach to final reclamation
- a history of the site and reclamation completed to date
- a description of baseline (pre-mining) environmental conditions
- a description of mine operations and existing project facilities
- a description of current environmental conditions
- an overview of progressive reclamation and their associated post operational activities
- details of the permanent closure and reclamation activities for each mine facility or component including:
  - closure objectives
  - proposed remediation activities
  - scheduling
  - environmental conditions and assessment of post reclamation risks to human and environmental health
  - associated financial liabilities

In addition, LMI has submitted various documents in support of the FCRP which provide detailed accounts of scientific and engineering studies (i.e., Updated Phase I II Environmental Site Assessment).

The following highlights components of the FCRP:

1) **Regulatory Framework –** The property consists of five contiguous mining leases covering 6,758 hectares (ha) on crown land. LMI holds the mining leases under the *Territorial Lands Act*.

   LMI currently holds a Type A Water Licence 2AM-LUP1520 (Water Licence) for the Lupin Gold Mine. The Water Licence is valid until 18 August 2020 and in good standing. This FCRP is being submitted to the Nunavut Water Board (NWB or Board) in accordance with Part I, Item 6 of water licence 2AM-LUP1520.

LMI is, by way of submission of the FCRP, in accordance with Part I, Item 7, providing the Board in writing confirmation of intent to move to Final Closure and Reclamation phase for the Site.

This FCRP has been prepared based on the current site conditions and it provides the concepts and activities for the full closure and reclamation of the Site. Upon acceptance, this FCRP will supersede the existing ICRP.

2) **Global Objectives –** The overarching objective or purpose of this Plan is to return the Site and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. The overall closure goal is supported by the three closure principles of Physical Stability, Chemical Stability and Future Use and Aesthetics for each component of the Project.

3) **Physical Environment –** The area of the mine site is of sparse vegetation, in the barren land tundra of Nunavut. It is typified as having sparse low lying vegetation which is extremely tolerant and well adapted to the climatic conditions. Some of the more prevalent types of habitat that can be found throughout the area include upland and lowland tundra, wet meadows and gentle slopes.

Climate in this region is classed as semi-arid subarctic, with an average annual precipitation of approximately 300 millimetres (mm). August is the wettest month with average rainfall of 59.8 mm. The annual average temperature is -10.9 degrees Celsius (°C); July is the warmest month with average temperature of 11.7 °C, whereas January is the coldest month with a monthly average of -29.7 ºC.

The Site is located in the tundra zone of the Canadian Shield, in an area of continuous permafrost. Terrain in the vicinity of the Site is generally low and undulating, ranging between 470 and 505 m elevation. Numerous shallow lakes and streams occur in depressions throughout the area.

Much of the Site exhibits bedrock at surface, and it is typified by "tombstone" topography over some of its area. These "tombstone" features resemble grave markers and occur as a result of ice- jacking action in heavily jointed rocks where joints tend to be pseudo-vertical and near-horizontal. The frost heave blocks are of various sizes and are scattered in a chaotic fashion. Removal of a block raised by this action would reveal an underlying mass of permanent ice.

Contwoyto Lake is the major water body in the region, with a surface area of approximately 95,900 ha and a drainage area of 8,000 square kilometres (km^2). Contwoyto Lake has two outlets in the Burnside River, which flows from the northwest end of the lake towards Bathurst Inlet, and the Back River at the southeast end of the lake, which flows into Pellatt Lake. The main body of Contwoyto Lake lies to the east and south of the mine site. To the north of the mine, a portion of the lake extends to the west and south, terminating in a narrow bay (Sun Bay) which lies directly west of the mine site.

The aquatic habitat in the receiving environment immediately downstream of the tailings area is comprised of three shallow lakes, two streams (Seep Creek and Concession Creek), two shallow ponds, and two embayment areas of Contwoyto Lake (Inner and Outer Sun Bay). Most of the small lakes and ponds freeze to the bottom in winter. Due to low winter flows, both Seep Creek and Concession Creek freeze to the bottom in winter. As a consequence, over wintering habitat for fish is limited primarily to Outer Sun Bay and the main body of Contwoyto Lake.

4) **Overview Mine Operations –** The Lupin gold deposit is situated in an Archean metaturbidite sequence of the Contwoyto Formation, part of the Yellowknife Supergroup of supracrustal metasedimentary and meta-volcanic rocks of the Slave Geologic Province. The rocks have been subjected to both regional and contact metamorphism and to several phases of deformation and intrusion. The bedrock at the Site consists of a mixture of low grade metamorphosed argillite, siltstone, slate, greywacke, and quartzite, generally phyllite.

The Lupin ore unit is composed of the Centre Zone, East Zone, West Zone and L19 Zone, all of which are contained within a continuous, isoclinally folded, steeply dipping unit of amphibolitic iron formation within the Contwoyto Formation. This unit has been followed for a strike length of 3,000 m and a dip length of 1,500 m.

Initial geological information indicated enough ore reserves to provide six years of production, based on the potential to develop in excess of two million tons of ore with a mill designed to process an average of 950 tonnes per day.

In August 1980, the decision was made to proceed with development and construction of the Lupin Mine. Waste rock generated from the development of the underground workings was used to build the pad surrounding the mill and as roadbed material. Plant design was based on being able to air freight all the components to site. The transportation of personnel to the site was accomplished with a Convair 640, which also carried a total of 7 million pounds of supplies such as perishables and repair parts during construction.

The Lupin Mine was in operation from 1982 to 2005 with temporary suspensions of activities between January 1998 and April 2000, and again between August 2003 and March 2004.

From 1983 to 1993, the Lupin Mine underwent a number of other expansions and operational changes to increase the mining and milling capacity to a nominal 2,300 tonnes per day. The main production shaft was deepened on two separate occasions to a final depth of 1,210 m below surface and the old sinking compartment was converted into a cage compartment. In April 2001, a production winze was commissioned between the 1050 level and 1340 level. This infrastructure allowed mucking below the elevation of the crusher to be carried out more productively, thus extending the depth, and life, of the mine. The -15% decline drift, or ramp, which permits mobile equipment to access all the mine levels, extends from surface to the 1560 m level. The lowest developed level in the mine is at the 1550 m elevation. In December 1994, the paste backfill plant was completed, which provided critical ground support in production areas while reducing the amount of tailings reporting to the Tailings Containment Area (TCA).

The mine resumed production in March 2004 until February 2005. Mill throughput in these last years of operation, March 2004 to February 2005, averaged approximately 1,200 tonnes per day, significantly less than in previous years. Production ceased in 2005; at that time, the Site was put under care and maintenance. No active mining has since occurred.

5) **Decommissioning and Remediation –** This FCRP has been prepared on the assumption that all facilities and installations that comprise the Lupin Mine Operations will ultimately be decommissioned, removed, or reclaimed under the terms of the land lease and in accordance with the reclamation requirements set out in the Water Licence.

   a. **Mine Workings (Underground) –**

   The Lupin underground workings include a 1,210 m vertical shaft and a decline drift, or ramp, to a depth of 1,560 m. A secondary hoist system (Winze) was installed in 2001 allowing hoist access to 1,340 m. The current mine depth is 1,550 m. There are also two other shafts open to surface: a fresh air raise and an exhaust raise. Incorporated into the underground facility were maintenance shops, an electrical shop and a primary crushing station. The winze and underground mine equipment were removed from site when the mine entered care and maintenance in 2006. All hazardous materials were removed from the underground workings. Any equipment left (disposed of) in the underground workings was drained of fluids.

   Shafts will be backfilled to prevent animal or human entrance. Crown Pillars will be blasted down where required for stability or disposal. Contaminated soil and waste rock will be disposed of into open crown pillars. The combined volume available for underground disposal for the West Zone stope, the haulage shaft, the fresh air raise, and exhaust raise totals approximately 75,066 m^3 of underground storage volume. Crown pillars will be backfilled with rock fill (up to 1.5 m above surface to allow for settlement, then capped with 1.0 m of esker material.

   The Lupin Mine was also serviced by an access ramp, which has already been sealed with a soil and rock plug and a locked fence installed to prevent access during the current phase of care and maintenance.

   b. **Borrows and Quarries –**

   The sand and gravel used for road and dam construction as well for covering the TCA cells since 1995 was obtained from the Fingers Lake esker. The Fingers Lake esker will continue to provide the cover material for the remaining TCA cells and will also be used for the reclamation of the other components of the Lupin Mine as described in Section 4.0. During closure implementation, the Finger Lakes esker area will be contoured and esker material will be used in the placement of erosion protection in drainage paths.

   The two existing bedrock quarry areas; one within the TCA area and the other one near the Fingers Lake esker, are small and inactive and there are no plans to use these areas further during closure implementation.

   c. **Waste Rock–**

   Waste rock was generally used throughout the Site as pads, roadbed materials, in dam construction, airstrip stabilization, underground backfill, and laydown yards or for other purposes such as building foundation preparation. The estimated volume of waste rock on surface is about 1,000,000 m^3. Mine operations did not produce any stockpiles of overburden or unprocessed low grade ore.

Information on the geochemical characterization of the waste rock is provided in Section 2.2.2.2. Environmental site assessments in 2006 and 2017 indicated that up to 67% of the waste rock can be classified as Potentially Acid Generating (PAG) and that PAG samples were distributed across the site. Accordingly, the main objective of the reclamation of the waste rock is to limit the contact between the waste rock and surface water.

During closure implementation, waste rock containing high levels of As, CN, or P_bNO_3 will be disposed of in open shafts or crown pillars. Waste rock from perimeter areas will be disposed of into shafts or open crown pillars, into the landfill, or it will be consolidated into the central waste rock area. The waste rock remaining on surface will be contoured to shed water and then it will be capped with 1.0 m of esker material.

d. Tailings Containment Area –

As described in Sections 3.2.1 and 3.3.1, the tailings from Lupin milling operation were deposited within a number of cells in the Lupin TCA. In accordance with the approved TCA 2004 Final Abandonment and Restauration Plan (Final TCA ARP) (Kinross 2005), as of the end of the 2017 construction season, a 1.0 m esker material cover had been completed over approximately 1,311,500 m^2 of the exposed tailings. As of the end of 2017, there remained approximately 123,500 m^2 of exposed tailings in Cell 5 and 86,000 m^2 in Cell 3. LMI intends to complete the placement of the cover by the end of the summer of 2019 as part of the approved Care and Maintenance activities.

The tailings pipeline will be removed and buried in the landfill. The treatment plant will be demolished and rubble will be disposed of in the landfill. Permanent monitoring instrumentation will be installed for the continued monitoring of site conditions.

During closure implementation, the water inventory in the TCA ponds will be treated with lime and then released to lower the pond water levels. Permanent closure spillways will be constructed through Dam 1A and J Dam and lined with rip rap and geotextile. If any tailings are exposed when the ponds are lowered, the tailings will either be covered in place with 1.0 m of esker material or relocated to a covered area.

e. Mill Complex –

All metallurgical reagents used during operation in the Mill Complex, with the exception of lime, have been shipped off site during the current care and maintenance phase. The mill was given a complete wash down with the intent of gold recovery (visible gold that settles within the system) and any residual contaminants (from chemical use) were removed to the tailings impoundment prior to the current care and maintenance phase.

Mill buildings will be demolished; rubble will be disposed of in open crown pillars or landfill. Materials that can be economically salvaged will be consolidated and shipped off-site. Any concrete foundation slabs will be hoe-rammed, left in place and covered with 0.3 m of granular fill. Any asbestos containing materials will be safely disposed of in the landfill.

f. Landfill and Other Waste Disposal –

The waste management facilities used at the Site are: an incinerator, a temporary "boneyard" (for decommissioned tanks, buildings, and equipment), a solid non-hazardous waste landfill, a landfarm, two burn pits (annual applications to DIAND are required for open burning) and waste oil storage. Waste materials that cannot be disposed of in a management facility on site are appropriately segregated, stored such that they are inaccessible to wildlife and later shipped to a third party waste receiver in Yellowknife, NWT.

Recyclable containers, primarily food and beverage containers, will be segregated and shipped off-site for management by a third party waste receiver.

All non-hazardous wastes will be disposed of in the existing landfill, including ash which will be removed from burn pits. Waste rock will be used to infill voids and create a stable contoured surface which drains freely. All non-hazardous and non-burnable waste (scrap metal, plastics, residue from burning) historically will be disposed at the site landfill and buried with waste rock on a regular basis. The waste in the landfill will be covered progressively during use.

All hazardous materials that cannot be disposed at the landfill, such as paints, batteries, solvents, chemicals and glycols will be assembled in a staging area and then shipped off-site for disposal.

g. Support Infrastructure –

i. Accommodation Facilities

Accommodation facilities will be demolished; rubble will be disposed the landfill.

ii. Fresh Water Supply

The freshwater for the site is obtained from Contwoyto Lake approximately 1.5 km from the complex. A causeway/breakwater extending out into the lake supports a pump house building and docking facilities.

The fresh water supply pumps were decommissioned in 2006; as a care and maintenance requirement. Currently, freshwater is trucked from the breakwater on Contwoyto Lake to a water storage tank at the accommodation buildings. The water supply system will be removed for final closure; however the breakwater will be left in place for future use.

iii. Arsenic Treatment Facility

This facility, a steel frame/metal clad building, is located at the TCA between Ponds 1 and 2, at the south end of J-Dam. It was used for mixing of reagents (ferric sulphate and lime) for water treatment operations during the early 1990's and has been inactive since 1996. The facility has been partially decommissioned. All remaining components were flushed after use. The facility will be demolished and the rubble will be disposed in the landfill.

iv. Explosives Magazine

The explosives storage magazine is located 2 km west of the TCA and consists of 2 steel-frame/metal clad buildings for Ammonium Nitrate/Fuel Oil (ANFO) storage, and historically numerous Sea-Containers for the storage of stick powder and other blasting products. There are currently no explosives on-site and no Sea-Containers at the explosives magazine. The storage facility will be used temporarily for the blasting of the West Zone crown pillar and then it will be demolished and the rubble will be disposed of in the landfill.

v. Roads and Airstrips

Roadways were constructed in part with mine development waste rock. Roads will be rehabilitated for closure (scarified and graded, cut through access roads and removal of culverts).

The old airstrip that was used during construction had been used as a laydown area after the new airstrip was operational. This area was slowly phased out as a storage location and, in 1998, the gravel/esker fill strip was graded to conform to the natural landscape with cuts and backsloping applied where necessary to promote natural drainage and reduce erosion. The surface was scarified utilizing a grader with a ripping attachment.

The main airstrip is 1,950 m (6400 ft.) in length and it was constructed of crushed waste rock produced from development underground. The drainage course in the area has been altered slightly in a lateral direction; however all runoff from both the east and west sides of the strip report in a northerly direction, eventually to Contwoyto Lake. The airstrip fueling facility has been removed and the fuelling area has been reclaimed. The airstrip will be left in place for public use after closure.

vi. Sewage and Refuse Facilities

The sewage facilities consist of several lift stations within the camp and an 800 m long 6 inch diameter insulated steel pipeline to the first of two sewage lakes. Alternatively, when, during Care and Maintenance, camp capacity requirements do not warrant its use; sewage and grey water are collected in a sewage tank at the accommodation buildings. The tank is then hauled to the Upper Sewage Lake wherein waste is deposited. A sewage line to convey camp sewage directly to the Upper Sewage Lake may be utilized.

Grey water originating from log cabin (guesthouse or office cabin or manager's house) use may be deposited in an adjacent leach pit. All sewage is to be discharged to the Sewage Lakes Disposal Facilities.

A 'permeable' type dam with an emergency overflow and a syphon exists between the first and second lake. Discharge from the second lake is controlled by the use of syphons. Water accumulating in the Lower Sewage Lake is tested prior to discharge to the environment. Discharge procedures are described in the Liquid Waste Management Plan.

For closure, the upper and lower dams will be breached and the breaches will be lined with rip rap and geotextile. Other sewage facilities will be dismantled and removed for closure.

vii. Tailings Pipeline

The tailings line has been flushed thoroughly with clean water and then partially dismantled, but left in place. For closure, the piping will be disposed of in the landfill. The tailings line foundation will be generally left intact with the exception of areas where drainage is controlled by culverts. The removal of culverts and the backsloping of the openings will ensure that minimal erosion takes place and proper drainage is achieved. Any other areas of water pooling along the tailings lines during spring melt will be opened up to provide unlimited drainage. The management of PAG material in the tailings line foundation and elevated metal concentrations in the adjacent soil will be as described in Section 4.3.2.3.

viii. Fuel Storage

The fuel storage facilities at Lupin included a main tank farm (including a system of 14 diesel tanks, 1 jet A tank and 9 individual tanks), a satellite tank farm (STF) (including a system of 10 diesel tanks and 2 gasoline tanks and a waste oil tank farm which included 2 waste oil tanks). In addition, there were 5 glycol tanks on-site and various individual tanks. Geomembrane liners were used for containment purposes.

At the end of 2017, there was an ample inventory of diesel fuel in storage at the site and it had been tested and verified as still useable. Most of this fuel will be consumed in undertaking the closure measures; diesel fuel that remains after closure is completed will be burnt on site. After the tanks are emptied they will be purged according to regulations and then cut up and disposed of in the landfill.

In 2014 buried pipes were removed between the main tank farm and satellite tank farm. The fuel remaining in the satellite tank farm was used up in 2015. The STF was demolished in 2016. A total of about 500 m^3 of petroleum hydrocarbon contaminated soil associated with it was cleaned up and placed in the landfarm in 2017, where it is currently undergoing bioremediation. After treatment, the bioremediated soil will be used for site grading.

An updated Phase 1 and 2 Environmental Site Assessment carried out in 2017 indicated that there was a total of about 34,700 m^3 of petroleum hydrocarbon contaminated (PHC) soils present in a number of locations on the site. The PHC soils will be cleaned up and disposed of in the underground mine workings.

ix. Chemical Storage

During operations the mine had an inventory of chemicals which included: cyanide, lime, lead nitrate, zinc dust, flocculants, and ferric sulphate in major quantities and miscellaneous refinery reagents in much lesser quantities. Of the chemicals listed, only lime is held on-site during care and maintenance.

During closure implementation, any remaining paints, solvents, chemicals, glycols and hazardous materials will be drummed and shipped to off-site disposal; waste oil will be burned in burn pits; diesel fuel will mostly be consumed during closure operations, with any remaining fuel being burned in burn pits; fuel tanks will be purged and disposed in accordance with the Canadian Environmental Protection Act Regulation; hydrocarbon contaminated soils will be buried in the underground workings (i.e., in shafts or open crown pillar voids; soil currently in landfarm will be bioremediated for used for reclamation, and fluids from on-site equipment will be drained and disposed off in landfill or off-site.

6) **Long Term Community Values –** throughout the reclamation process, LMI will continue to identify and discuss potential forms of benefit to northern communities including: disposal of assets; contracts and employment. LMI began community engagement ……INSERT. Community meetings have been held to discuss this FCRP with INSERT.

7) **Post-Closure Management and Monitoring –** LMI will provide a project management team to oversee all remediation activities. Upon completion of active remediation, post-closure management of the site will be handled remotely by Discovery Mining Services (DMS) out of Yellowknife, Northwest Territories consistent with approach taken by LMI and DMS during the Care and Maintenance Phase. Post-Closure monitoring of the site will be conducted to confirm global objectives of physical stability, chemical stability, and future use and aesthetics are effective at the site after closure. A Post-Closure Monitoring plan has been developed and is provided in the FCRP (refer to Section 5.0). It is anticipated that active monitoring will occur for 2.5 years and passive monitoring will take approximately 5 years following completion of the reclamation work, or until the global objectives for the mine site can be confirmed.

8) **Implementation –** Remediation of the Lupin Mine site, as outlined in this plan, will require approval pursuant to the *Nunavut Project and Planning Assessment Act* and *Nunavut Waters and Nunavut Surface Rights Tribunal Act*. It is anticipated that this FCRP will be submitted to the Nunavut Water Board in July of 2018, as part of a water licence application.

   Throughout the licensing review process, LMI intends to continue public consultation on the FCRP. Reviews by the boards and regulatory agencies will also have formal requirements for public consultation.

   Although the schedule of the licensing process will ultimately be determined by the boards and authorizing agencies, it is anticipated the process will take 10 months from the date of submission to the regulatory agencies.

   Concurrent with the regulatory review process, LMI intends to continue implementation of the approved final closure of the TCA and ongoing care and maintenance measures to support full remediation.

Under the schedule provided in this Plan, LMI intends to commence implementation of the FCRP in 2018 and intends to complete the active closure period reclamation of all major surface infrastructure in 2.5 years with passive closure period monitoring to occur for an additional 5 years.

EXECUTIVE SUMMARY – INUKTITUT

Inuktitut translation of Final Exec. Summary will be required – assumption LMI will coordinate translation

EXECUTIVE SUMMARY – INNUINNAQTUN

Inuinnaqtun translation of Final Exec. Summary will be required – assumption LMI will coordinate translation

EXECUTIVE SUMMARY – FRENCH

French translation of Final Exec. Summary will be required – assumption LMI will coordinate translation

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LIST OF ACRONYMS, ABBREVIATIONS

ACM	Asbestos-containing Materials
ANFO	Ammonium Nitrate/Fuel Oil
ARD	Acid Rock Drainage
CIRNAC or Minister	Crown-Indigenous Relations and Northern Affairs Canada
CMP	Care and Maintenance Plan
DIAND	Department of Indigenous Affairs and Northern Development
DMS	Discovery Mining Services
ECCC	Environment and Climate Change Canada
EEM	Environmental Effects Monitoring
ESA	Environmental Site Assessment
FCRP or the Plan	Final Closure and Reclamation Plan
HHERA	Human Health and Ecological Risk Assessment
IARP	Interim Abandonment and Reclamation Plan
ICRP	Interim Closure and Reclamation Plan
IOL	Inuit Owned Lands
KIA	Kitikmeot Inuit Association
LMI	Lupin Mines Incorporated
Lupin or Lupin Mine or the Site	Lupin Gold Mine
Mandalay	Mandalay Resources Corporation
ML	Metal Leaching
MDMER	*Metal and Diamond Mining Effluent Regulations*
NIRB	Nunavut Impact Review Board
NWB or Board	Nunavut Water Board
NWNSRTA or Act	*Nunavut Waters and Nunavut Surface Rights Tribunal Act*
PAG	Potentially Acid Generating
PCB	polychlorinated biphenyls
PHC	Petroleum Hydrocarbons
QA/QC	Quality Assurance/Quality Control
STF	Satellite Tank Farm
TCA	Tailings Containment Area

LIST OF UNITS

°C	degrees Celsius
ha	hectare
km	kilometre
km^2	square kilometre
m	metre
m^2	square metre
m^3	cubic metre
mm	millimetre

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1.0 INTRODUCTION

1.1 Project and Company Information

Lupin Mines Incorporated (LMI), a wholly owned indirect subsidiary of Mandalay Resources Corporation (Mandalay), has prepared this Final Closure and Reclamation Plan (FCRP or the Plan) for the Lupin Gold Mine (Lupin or the Lupin Mine or the Site). The Mine is 100% owned by LMI. All rights, title, interests, liabilities, and obligation for the Site rest with LMI.

Mandalay is a Canadian based company focused on producing assets in Australia, Chile, and Sweden, a development project in Chile and the exploration and development of the past-producing Lupin Gold Mine and the Ulu gold project, both located in Nunavut, Canada.

Mandalay is committed to remediation of the site as evidenced in past performance. Since it acquired the Lupin site in 2014, Mandalay has completed numerous care and maintenance activities that are discussed in Section 3.0.

The Lupin Mine was in operation from 1982 to 2005 with temporary suspensions of activities between January 1998 and April 2000, and again between August 2003 and March 2004. The mine resumed production in March 2004 until February 2005. Since 2005, the Site has remained in Care and Maintenance.

This FCRP uses currently accepted management practices and appropriate mine closure techniques to comply with accepted protocols and standards. This Plan has been prepared based on the current site conditions and it provides the concepts and activities for the full closure and reclamation of the Site. This FCRP upon acceptance will supercede any Interim Closure and Restoration Plan (ICRP) or Care and Maintenance Plan (CMP).

General site maintenance and facilities upgrades have been undertaken at Lupin Mine since 2006 in accordance with the ICRP and CMP. These activities have been carried out to assess operational requirements in case the Lupin Mine would resume operations. The activities underway were screened by the Nunavut Impact Review Board (NIRB) under file 99WR053 and were approved by the Nunavut Water Board (NWB or Board) under the current Water Licence. LMI now intends to complete the full closure and reclamation of the Lupin Mine over the next 2.5 years.

1.2 Site Location and Access

The Lupin Mine is located in the Kitikmeot Region, 285 kilometres (km) southeast of Kugluktuk, Nunavut, 400 km and north of Yellowknife, Northwest Territories (NWT). The Site is on the western shore of Contwoyto Lake, approximately 60 km south of the Arctic Circle (Figure 1).

The Lupin Mine property is accessible by fixed wing or rotary aircraft from Yellowknife. The airport serving the Site is at 65° 46’ 00” N and 111° 14’ 41” W. A 1,950 metres (m) long gravel airstrip suitable for Boeing 737 and C-130 Hercules sized aircraft is located on the mine property. A facility to handle float-equipped aircraft is located on the shore of Contwoyto Lake.

The Site is also accessible via the Tibbitt to Contwoyto winter road, which could be operated between February and April. The winter road, it is approximately 570 km from the end of the Ingraham Trail, located near Yellowknife, NWT to the Site. Following the closure of the Jericho Mine (km 600) in 2008, construction of the winter road beyond the Ekati Diamond Mine (Km 405) has occurred periodically, not annually. The Lupin spur has been inactive for several years, but can be reactivated to allow for the delivery of bulk items. Winter road routing is shown on Figure 1.

1.3 Regulatory Requirements

The regulatory requirements for decommissioning, reclamation and closure of the Lupin Mine are outlined primarily in the Water Licence and federal land leases. It should also be noted that additional regulatory requirements related to the *Fisheries Act*, Inuit Water Rights under the Nunavut Agreement, and land use planning and environmental assessment requirements are also mandated. LMI has prepared this FCRP as the foundation for all regulatory requirements provided in this section.

For a full listing of applicable acts, regulation, guidelines, or policies that govern the Site refer to .

1.3.1 Water Licence Requirements

The original Water Licence for mining and milling at Lupin was issued by the Northwest Territories Water Board on 1 June 1981. Several Amendments and renewals have occurred since that time.

The Lupin Mine is currently licenced in accordance with the legislative requirement of the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA or Act) and *Nunavut Water Regulations* (NWR or Regulations) by the NWB under a Type A Water License 2AM-LUP1520 (Water Licence). The current Water Licence was issued by the Board on 19 August 2015, approved by the Minister of Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC or Minister) on 5 October 2015. The Licence expires on 18 August 2020. LMI has maintained the Water Licence in good standing and is in compliance with terms and conditions set out therein.

On 28 March 2017 the Board issued Amendment No.1 to the current Water Licence which was subsequently approved by the Minister on 12 May 2017 to amend the amount of reclamation security required under Part C of the Water Licence from $25.5 million to $34.65 million. Further, on 30 May 2018, the Minister approved Amenment No. 2 to amend the amount of reclamtion security to $29,305,000 million. For additional information including specific terms and conditions regarding Financial Security, refer to Section 7.0 of this document.

Part I and Schedule I of the Water Licence sets out the terms and conditions applying to abandonment and restoration as provided in APPENDIX B. Note: Appendix B provides a summary concordance of previous and current final closure reclamation requirements as required in the terms and conditions of the Type A water licence and associated land leases.

LMI, by way of submission of the FCRP, in accordance with Part I, Item 7, is providing the Board in writing confirmation of intent to move to Final Closure and Reclamation phase for the Site.

The FCRP considers all applicable terms and conditions provided in Part I and Schedule I of the Water Licence including: the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2007); the Mine Site Reclamation Policy (INAC 2002); an updated Environmental Site Assessment (ESA) including detailed rock characterization study; and the current ICRP as well as any approved technical supporting documents included in the ICRP (Care and Maintenance) plan dated March 2013. For a full list of supporting documents included in the ICRP refer to Appendix B and Appendix F list of Environmental Studies/Reclamation Research/Engineering Studies and Design Reports.

This FCRP has been prepared based on the current site conditions and it provides the concepts and activities for the full closure and reclamation of the Site. In October 2017, LMI submitted an updated ICRP to the NWB for review and acceptance in accordance with Part I, Item 2. Partial comments on the ICRP were submitted by ECCC, and provided to LMI by the Board in November, 2017 and responses from LMI were filed with the Board on 29 November 2017.

This FCRP has been developed from the ICRP and includes the responses provided in November, 2017 to the NWB and upon acceptance will supersede any ICRP or CMP.

1.3.2 Land Lease Requirements

In addition, LMI holds five mining leases under the *Territorial Land Act* for mining on crown lands administered by CIRNAC. A list of the surface land leases pertaining to the Lupin Mine is presented in Table 1 and shown on Figure 3.

Table 1: Mineral and Surface Leases, Lupin

Name	Type	Description	Expiry	Area (ha)
2428	Mineral Lease	Lot 1 Group 1216 Quad 76E/14	27- Jul- 2033	2,831.59
3275	Mineral Lease	Lot 1003 Quad 76E\11	27- Sep- 2030	927.13
3276	Mineral Lease	Lot 1002 Quad 76E\11	27- Sep- 2030	891.92
3277	Mineral Lease	Lot 1004 Quad 76E\11	27- Sep- 2030	959.10
3278	Mineral Lease	Lot 1001 Quad 76E\11	27- Sep- 2030	1,148.09
76E/14- 1- 9	Surface Lease	Minesite, Tailings Containment Area	31-Mar-2012[(a)]	1,035.79
76E/14- 2- 10	Surface Lease	Airstrip	31- Mar- 2012[(a)]	53.16
76E/11- 2- 3	Surface Lease	Fingers Lake Quarry, access road	31- Mar- 2012[(a)]	137.80
76E/11- 3- 4	Surface Lease	Fingers Lake Waterlot - dock	31- Mar- 2012[(a)]	0.43
76E/14- 10- 3	Surface Lease	VOR Navigation aid site	31- Mar- 2012[(a)]	0.09

a) LMI has filed renewal application and all fees through 2017 have been paid for the leases that expired March 2012. LMI has been advised by DIAND Lands department that the Lupin surface leases will be issued by September 30, 2017. LMI has recently been advised leases pending final approval from Justice Canada.

For additional information related to closure and reclamation requirements provided in the Leases refer to APPENDIX B.

1.3.3 Fisheries Act Requirements (Metal Diamond Mining Effluent Regulation Requirements)

Environment and Climate Change Canada (ECCC) is responsible for the *Canadian Environmental Protection Act*, the *Fisheries Act* – pollution prevention measure and the Fisheries Act – *Metal and Diamond Mining Effluent Regulations* (MDMER). Note: LMI does not hold any stand-alone Fisheries Authorizations for the mine.

The MDMER under the *Fisheries Act* came into force on 1 June 2018 (Government of Canada 2002). The MDMER stipulates the conditions under which deleterious substances may be discharged to the aquatic environment by metal and diamond mines (EC 2012). Specifically, these regulations impose limits on the release of deleterious substances, which include: cyanide, arsenic, copper, lead, nickel, zinc, radium-226, and total suspended solids, as well as prohibiting the discharge of effluent that is acutely lethal to fish.

While operations at the Lupin Mine ceased in 2005, it has not been officially designated as having “closed mine status” under the MDMER. Therefore, the regulatory requirements outlined by the MDMER are applicable to the Mine.

To be officially designated as having “Closed Mine Status”, LMI is required to

- provide written notice of that intention to the authorizing officer designated under the MDMER
- maintain the mines rate of production at less than 10% of its design rated capacity for a continuous period of three years starting on the day that the written notice is received by the authorization officer
- conduct a biological monitoring study during the three-year period referred to above and in accordance with Division 3 of Part 2 of Schedule 5

If LMI has complied with all of the requirements set out above, the mine becomes a recognized closed mine after the expiry of the three-year period.

When the mine is discharging effluent, monitoring requirements under the MDMER include:

- Weekly, or less frequently as per the MDMER, sample effluent from the final discharge point and analyze for deleterious substances;
- Monthly, or less frequently as per the MDMER, sample effluent from the final discharge point and analyze for acute lethality;
- Four times per calendar year, but not less than one month between sampling events, sample effluent for chemical characterization and sub lethal toxicity testing; and
- Four times per calendar year, but not less than one month between sampling events, sample receiving environment (exposure and reference areas) water quality for chemical characterization.

The other requirement of the MDMER is to conduct the Environmental Effects Monitoring (EEM) program. The objective of the EEM program, as defined in the Metal Mining Technical Guidance for EEM document (EC 2012), is to evaluate the effects of mine effluent on fish, fish habitat, and use of fisheries resources by humans. The guiding principles of the EEM program are that it be scientifically defensible, cost-effective, and flexible around site-specific requirements, without subjecting field crews to unsafe sampling conditions. The EEM program is comprised of:

- Biological monitoring of fish and fish habitat (i.e., benthic invertebrate communities) in the receiving environment (exposure area) and in the reference area(s). More specifically, an EEM program consists of four key elements:
  - effluent and water quality monitoring and reporting
  - development and submission of a study design for biological monitoring
  - implementation of the study design in the field
  - data assessment, interpretation, and submission of an interpretative report

Five phases of EEM have been conducted at Lupin Mine. Phase 1 was conducted as a Periodic Monitoring – Surveillance program in 2005 (Golder 2006). Phase 2 EEM was conducted as a Periodic Monitoring – Confirmation program in 2008 (AECOM 2009). Both the Phase 1 and Phase 2 EEM programs identified significant differences in benthic invertebrate community and fish endpoints between the exposure and reference areas. As such, Phase 3 was conducted as an Investigation of Cause study in 2010 to determine cause for the differences (AECOM 2011). Following Investigation of Cause, the next phase of EEM was conducted as a Periodic Monitoring – Surveillance program. A Phase 4 EEM Study Design was developed and submitted to Environment Canada, but the biological investigation was not completed as all activities at the Mine were suspended in August 2013.

The Phase 5 EEM program was designed as a Periodic Monitoring – Surveillance program involving fish and benthic invertebrate community surveys (Golder 2017d). Results indicated that there was no difference in the benthic invertebrate community between the exposure and reference areas but there was a difference in fish size between areas. Based on results from the Phase 5 study, and the EEM guidance document, the next regular EEM study should be completed as a Periodic Monitoring – Surveillance program, designed similar fashion to Phase 5.

Once LMI provides notice to ECCC on the closure of Lupin, the final study design must be submitted not less than six months after providing the notice. The final study shall be conducted not sooner than six months after the final study design has been submitted.

For additional information related to the EEM program and monitoring for the Site refer to Section 5.0.

1.3.4 Land Use Planning and Environmental Assessment Requirements

Consistent with the Boards Reasons for Decision dated 11 May 2015, correspondence is on the NWB public registry from the Nunavut Planning Commission (i.e., email dated 26 February 2014) indicating that as the project is located outside the boundaries of the two approved land use plans in Nunavut, no conformity determination was required and not further review by the Nunavut Planning Commission would be required as it relates to the current Water Licence.

In 1999, the NIRB screened the renewal application to determine whether it had significant impact potential and whether it required review prior to processing by the NWB. The NIRB Screening decision indicated that the project proposal could be processed without review under the Nunavut Agreement. Since 1999 and following several amendments and/or renewals NIRB determined the Project had not been significantly modified and the application was exempt from requirements from further screening. In addition, the NIRB reminded LMI that the activities proposed (including final closure of the site) remain subject to the terms and conditions recommended by NIRB in their original Screening Decision Report (NIRB 99WR053) issued 16 November 1999. NIRB clearly states their decision "is based on specific consideration that reflect the primary objectives of the Land Claims Agreement. Our consideration in making this decision included: [ ] clean up/restoration of the site upon abandonment. Terms and Conditions related to reclamation are outlined in Section 55 to 58 of the report, as follows:

55. The Licensee shall remove all scrap metal, discarded machinery and parts, barrels and kegs, building and building material upon abandonment.

56. The Licensee shall undertake ongoing restoration for any land or improvements, which are no longer, required for the Licensee's operation on the land.

57. The Licensee shall cap all drill holes and cut off any drill casings that remain above ground to ground level upon abandonment of the operation.

58. The Licensee shall complete all clean up and restoration of the lands used prior to the expiry date of the permit.

In addition, the NIRB report also requires LMI to "*submit to the NWB and NIRB a summary report of activities undertaken and any abandonment and restoration of the site*." (NIRB Report, Section 62)

LMI assumes the final closure of the Lupin Mine does not constitute a significant modification requiring further review under the Nunavut Agreement and that the original NIRB Screening Decision Report (NIRB 99WR053) and reconfirmed by NIRB in 2011 for the project apply. This assumption and approach is consistent with the determination made for final closure of the Polaris Mine and Nanisivik Mine, both located in Nunavut, projects originally screened under *Canadian Environmental Assessment Act*, grandfathered in the Nunavut Agreement and subsequently screened by NIRB.

1.3.5 Inuit Water Rights under the Nunavut Agreement

The Lupin Mine is entirely on crown land administered by CIRNAC. Inuit Beneficiaries of the Kitikmeot Region are represented by the Kitikmeot Inuit Association (KIA). The KIA is the entity responsible for defending, preserving, and promoting social, cultural, and economic benefit to Inuit in the Kitikmeot Region.

In accordance with Article 20 of the Nunavut Agreement Inuit have the exclusive rights to the use of water on, in or flowing through Inuit Owned Lands (IOL). The project is entirely on Crown Lands. The Lupin Mine does not adversely affect the change in quality, quantity, or flow of water on IOL and has to date never been requested by the KIA to pay compensation related to mining at the Site. As confirmed in the most recent public hearing, on October 31st, 2014, KIA provided confirmation to the NWB that there is no outstanding water comensation issues regarding the Lupin site relating to Section 63 of the NWNSRT Act. (NWB 2015b)

1.3.6 Consultation

1.3.6.1 Government Consultation

LMI presented a "Working Draft" of the FCRP to the NWB in Edmonton in February 2018. Subsequent to this meeting a Draft was formally presented to officials from the federal government (CIRNAC, ECCC, and Fisheries and Oceans Canada), the Government of Nunavut and the NWB in [LOCATION] in [DATE]. The issues and concerns that were raised during these meeting was considered in the planning and completion of this FCRP.

1.3.6.2 Community Consultation

LMI recognized the importance of maintaining on-going dialogue with the local communities most affected by the forthcoming closure and reclamation of the Lupin Mine Site.

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1.4 Purpose of the Final Closure and Reclamation Plan

The overarching objective of this Plan is to return the Site and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. The overall closure goal is supported by the three closure principles of Physical Stability, Chemical Stability and Future Use and Aesthetics for each component of the Project.

The overarching objective of the Plan follows the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2007) and the Mine Site Reclamation Policy (INAC 2002). These guidelines will be adhered to ensure that the closure principles are met.

Furthermore, all applicable legislation will be complied with to confirm that, to the extent possible once closure and reclamation has been completed:

- Type A Water Licence requirements are met
- Mining lease obligations are met
- *Fisheries Act* obligations are met
- Traditional values are protected including Inuit Water Rights
- Responsible reclamation practices are used to protect public and employee health, safety, and welfare
- Potential impacts from contaminants are minimized or prevented
- The requirement for long-term maintenance and monitoring associated with the Project components are minimal or nil
- The cumulative degradation of abandoned areas affected by the mining activities is prevented, and natural recovery of disturbed lands is enhanced
- The affected areas will be returned to a condition that is compatible with the surrounding, original undisturbed area with respect to its future potential/productivity uses
- Shareholder value is protected
- LMI and shareholder goals are met

Progressive reclamation at the Lupin Mine has been on-going since 1988. The main progressive reclamation activities carried out on-site include:

- the placement of a 1 m thickness esker material cover on the majority of the exposed tailings at the Tailings Containment Area (TCA)
- the installing thermistors strings installation for monitoring purposes
- reclamation work at the underground mine workings, at unused roads, at the original Twin Otter airstrip and at unused equipment storage areas

- a landfarm was also constructed and commissioned in 2017 to allow bioremediation of petroleum hydrocarbon impacted soils from the cleanup of the Satellite Tank Farm (STF)

Details on the progressive reclamation activities carried out at the Site are provided in Section 3.0.

The hiring of Inuit beneficiaries is a priority for LMI. Discovery Mining Services works to hire support workers from Kuglugtuk and other Kitikmeot communities whenever possible. The data and information collected during the operations stage of the Lupin Mine and during the current state of care and maintenance have been used in the preparation of this Plan.

1.5 Approach to Development of the Final Closure and Reclamation Plan

Concurrent with the regulatory review process, LMI intends to continue implementation of the approved final closure of the TCA and ongoing care and maintenance measures to support full remediation. LMI is committed to responsible closure and reclamation practices for the protection of human, wildlife and aquatic life health, and for minimizing impacts on the environment. This commitment is in agreement with the three closure principles listed in the INAC (2007) guidelines for mine closure and on which the overall closure objective of this Plan is supported:

- **Physical stability:** The components of the reclaimed site should be constructed or modified at closure so that they do not erode, subside or move under extreme design events, and therefore do not pose a threat to humans, wildlife, or environmental health and safety;
- **Chemical stability:** The components of the reclaimed site should be chemically stable so as to prevent adverse soil, water and air quality effects that might pose a risk to humans, wildlife or environmental health and safety; and
- **Future use and aesthetics:** The reclaimed site should be compatible with the surrounding lands at the completion of the reclamation activities.

These principles and their broad objectives were used to support the identification of closure objectives that are specific to each the Project components which are presented in this Plan.

1.6 Closure and Reclamation Planning Team

The Proponent of the Project:	Lupin Mines Incorporated (LMI)
The address for the Proponent is:	Lupin Mines Incorporated Mandalay Resources Corporation 76 Richmond Street East, Suite 330 Toronto, Ontario M5C 1P1 Canada
The primary contact person for the Project is:	Karyn Lewis General Administration, Mandalay Resources Inc. M: 778-368-7340 Email: klewis@elginmining.com
Acting on behalf of the Proponent:	Lead Consultant Golder Associates Ltd. (Golder) 16820 107 Avenue Edmonton, Alberta T5P 4C3 Canada
	Underground Mine Works, TCA, Landfarm Consultant Norwest Corporation 1900, 555-4th Avenue, SW Calgary, Alberta T2P 3E7

	Canada

1.7 Definition of Terms

A glossary of commonly used terms in this Plan is included in Appendix C. A list of acronyms and abbreviation along with units and symbols was provided above.

1.8 Approach to Inclusion of Long-Term Community Values

LMI is committed to maintaining the highest level of integrity in its corporate responsibilities toward resource development and environmental stewardship. LMI is committed to environmental protection throughout the exploration, development, operation, and eventual closure and rehabilitation of each of its projects by applying sound judgment, by meeting or exceeding legislative requirements and by minimizing adverse impacts its activities may have on the environment.

LMI is committed to the sustainable development of the Kitikmeot region and will strive to maximize the benefits of the Project for all parties involved while minimizing or eliminating any negative impacts or long-term influences on the environment and local communities.

LMI is committed to keeping the communities impacted by the Mine informed of the final closure of the Site, advancements or setbacks, and to create constructive dialogue between all parties. Consequently, numerous mine elements have been planned based on community input. This practice of information sharing will continue through development of the FCRP and will provide a framework for addressing future opportunities and concerns.

LMI is committed to the following:

- Supporting the local community for procuring resources and personnel wherever possible.
- Maintaining open lines of communication between all parties involved.
- Understanding and integrating the Project within a context of ecosystem integrity, social health, and economic stability. LMI's objective is to minimize disturbance to the local environment during operations, and leave the site in as natural a state as possible after closure. Post-closure monitoring will be a key component in ensuring this objective is realized.

To achieve these goals, LMI will:

- Be responsible for its actions and their consequences on the environment.
- Instill the ethics of environmental responsibility through education and communication with all employees, contractors, consultants and suppliers.
- Instill in all employees the recognition that environmental management is an important priority of the Company and integrate environmental considerations into all mine closure planning.
- Implement and maintain ethical business practices and an effective risk management system, including an up-to-date timeline of all permits, expiration dates, and planned permit renewal activities.

- As part of its design and operating philosophy, to the extent practicable and commercially reasonable, minimize potential adverse impacts on the natural environment, for example, including, but not limited to: minimizing land disturbances in the design, construction and operation of our projects with the goal, to the extent practicable and commercially reasonable, of remediating disturbed areas in such a way that they can revert to their original state or to some other beneficial use.
  - maximizing energy efficiency of our mining and process equipment to reduce absolute energy needs per unit of output
  - reviewing options and alternatives to utilize renewable energy and low-carbon energy sources
  - minimizing water use and recycling water as much as possible
  - minimizing discharges (reportable or otherwise) and conducting prompt remediation and required regulatory reporting should they occur
  - reducing use of consumables and reusing or recycling them where practical
  - reducing degradation of equipment through wear and damage that causes needs for premature capital equipment replacement
- Evaluate environmental performance by conducting operational and environmental monitoring programs required by law, as well as audits and other monitoring activities not necessarily required by law but that may be useful in measuring our performance and identify opportunities for improvement.
- Keep up-to-date with changes and potential changes to environmental regulations and evolving government guidelines.
- Keep up to date on technological developments that could be used to mitigate or avoid impacts.
- Encourage conservation and pollution prevention measures by requiring contractors and suppliers to provide operational guidelines that outline their own procedures and responsibilities to reduce, recycle and reuse materials when working on Mandalay-related activities.
- Assess environmental conditions regularly at all stages of mine development and closure to identify issues or areas in need of attention and to establish strategies for their management.
- Be consistent with the current state of practice in the industry for environmental protection and management.
- Implement effective and transparent engagement and communication with our stakeholders when significant environmental issues arise. Respond to concerns in a timely and productive manner, identifying concerns, and where Mandalay activities are the cause, taking corrective measures to alleviate the concerns and prevent their recurrence.
- LMI will ensure that it maintains feasible reclamation plans at each site as well as adequate financial reserves to reclaim each site after completion of commercial activities.

There are two potential forms of benefit to northern communities, may including:

- Disposal of assets; and
- Decommissioning contracts and employment.

1.9 Approach to Inclusion and Management of Information

To assist the NWB in review of the FCRP, LMI has compiled a concordance assessment to all applicable final closure terms and conditions for Type A water licences issued by the Board and land leases administed by CIRNAC. All available information including data, research and studies required for the development and/or implementation of closure and reclamation measures have where appropriate been incorporated in this FCRP. Links to Type A water licence documentation for final closure are accessable through links provided in the concordance assessment which link directly to the documents on the NWB public registry. A supplemental list of Environmental Studies/Reclamation Research/Engineering Studies and Design Reports is provided in Appendix F.

This FCRP has been prepared based on the current site conditions and it provides the concepts and activities for the full closure and reclamation of the Site. This FCRP upon acceptance will supercede the ICRP. For detailed history of closure plan development refer to APPENDIX D.

2.0 PROJECT DESCRIPTION

2.1 Environmental Setting

2.1.1 Geology

2.1.1.1 Bedrock Geology and Mineralogy

The Lupin gold deposit is situated in an Archean metaturbidite sequence of the Contwoyto Formation, part of the Yellowknife Supergroup of supracrustal metasedimentary and metavolcanic rocks of the Slave Geologic Province. The rocks have been subjected to both regional and contact metamorphism and to several phases of deformation and intrusion. The bedrock at the Site consists of a mixture of low grade metamorphosed argillite, siltstone, slate, greywacke, and quartzite, generally phyllite (Geocon 1980).

The Lupin ore unit is composed of the Centre Zone, East Zone, West Zone and L19 Zone, all of which are contained within a continuous, isoclinally folded, steeply dipping unit of amphibolitic iron formation within the Contwoyto Formation. This unit has been followed for a strike length of 3,000 m and a dip length of 1,500 m. Several phases of deformation have resulted in steeply plunging fold noses and steeply dipping fold limbs. The resulting pattern is ‘M’ shaped, consisting of a northerly-plunging syncline and adjacent anticlines to the west and east. The West Zone forms the west limb of the west anticline, the Centre Zone the west limb of the syncline and the East Zone the east limb of the syncline. Most of the gold occurred in the West Zone and Centre Zone. A lesser amount was found in the East Zone. The L-19 Zone did not contain economic concentrations of gold and was not mined.

The iron formation is a well laminated unit and consists of both silicate facies and sulphide facies metamorphosed to an amphibolite and quartz rich rock. The gold is found primarily within the sulphide rich iron formation. The ore at Lupin consists of amphibole, quartz, garnet, pyrrhotite, arsenopyrite, minor pyrite and traces of chalcopyrite. The gold is fine grained (generally less than 100 microns in diameter) and is associated mainly with the pyrrhotite and arsenopyrite. Although not common, visible gold is sometimes found and is usually in close proximity to quartz veining. Also found in trace amounts are scheelite, apatite, epidote, calcite, tourmaline, and some arsenides (notably loellingite). Arsenopyrite occurs as metacrysts, up to 2 centimetres (cm) in diameter, which often have loellingite cores. Much of the gold associated with these arsenides occurs at the arsenopyrite - loellingite boundaries within these metacrysts. Gold is also finely disseminated within pyrrhotite and silicates, and is rarely visible to the naked eye.

The McPherson Zones (M1 and M2) are in iron formation lenses separate from the main Lupin ore unit, contain economic quantities of gold, and were mined. They trend parallel to the West Zone at approximately 60 m and 80 m east of it near the latitude of the shaft. The M1 and M2 Zones contain a higher proportion of pelitic beds than the main Lupin ore unit. Gold is locally present in the pelitic beds, and visible gold is more common in the M1 and M2 Zones than in mineralized zones of the main ore body.

2.1.1.2 Surficial Geology

Where bedrock is not present at surface, the ground surface typically consists of glacial till which is occasionally overlain by glacio-fluvial and glacio-lacustrine sand and gravel deposits (in the form of eskers and lake shore deposits). The till is a silty sand with gravel and boulder content and is underlain by weathered and competent low grade clastic metamorphosed bedrock of the Yellowknife Supergroup. The esker material used for progressive reclamation is described further in Section 2.4.2.

2.1.2 Climate

Climate in this region is classed as semi-arid subarctic, with an average annual precipitation of approximately 300 millimetres (mm). August is the wettest month with average rainfall of 59.8 mm. The annual average temperature is -10.9 degrees Celsius (°C); July is the warmest month with average temperature of 11.7 °C, whereas January is the coldest month with a monthly average of -29.7 ºC. Table 2 shows the monthly temperature at the Lupin Mine, as measured at the weather stations.

Table 2: Monthly Average Temperature at Lupin (1982-2015)

	Mean Monthly Temperature (ºC)												
Date[(a)]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
1982	-36.0	-28.5	-27.5	-19.8	-5.6	4.9	11.5	7.3	0.9	-7.2	-26.0	-29.8	-13.0
1983	-30.9	-33.4	-28.8	-17.2	-14.0	5.2	10.3	9.3	2.4	-9.4	-14.0	-27.1	-12.3
1984	-32.2	-25.8	-25.2	-12.0	-3.9	8.1	12.7	9.7	-0.1	-9.2	-21.8	-32.4	-11.0
1985	-27.7	-34.7	-26.5	-19.6	-1.6	6.5	7.8	6.3	0.8	-10.0	-23.5	-25.0	-12.3
1986	-31.8	-26.9	-27.6	-19.0	-5.7	3.0	10.5	7.0	1.5	-9.6	-24.1	-24.9	-12.3
1987	-24.7	-25.1	-26.0	-15.2	-6.9	5.4	10.1	5.4	4.1	-8.1	-21.2	-19.6	-10.2
1988	-31.6	-31.7	-22.7	-15.4	-10.1	7.1	11.5	10.4	3.7	-8.3	-25.5	-27.4	-11.7
1989	-33.4	-22.5	-29.7	-15.3	-8.2	7.9	12.3	12.7	1.6	-7.9	-26.0	-29.2	-11.5
1990	-32.8	-34.6	-21.3	-14.6	-7.4	4.3	10.9	6.1	1.0	-9.3	-24.9	-31.3	-12.8
1991	-31.5	-30.6	-28.1	-13.9	-1.8	7.5	11.4	10.1	0.0	-10.7	-22.7	-27.8	-11.5
1992	-29.2	-29.0	-23.0	-17.5	-5.8	4.3	11.0	8.2	-1.2	-8.4	-18.6	-26.0	-11.3
1993	-25.7	-28.3	-21.4	-17.1	-5.7	4.8	10.4	9.2	0.5	-8.9	-21.9	-29.0	-11.1
1994	-34.4	-33.6	-21.7	-17.5	-2.4	8.1	13.9	10.6	2.2	-5.0	-18.5	-23.5	-10.2
1995	-25.0	-28.3	-25.6	-15.2	-7.1	7.6	8.9	8.9	0.8	-9.3	-20.6	-29.9	-11.2
1996	-31.7	-26.7	-25.9	-16.3	-5.8	9.7	14.3	7.6	5.1	-9.5	-20.4	-26.9	-10.5
1997	-30.3	-27.5	-27.6	-16.0	-6.5	6.0	13.4	9.7	4.7	-10.6	-15.1	-23.0	-10.2
1998	-33.4	-25.6	-22.1	-10.7	-0.4	8.3	13.9	11.4	3.6	-4.1	-12.8	-22.2	-7.8
1999	-28.6	-23.3	-19.6	-13.3	-4.8	6.9	8.4	8.8	2.3	-8.9	-16.9	-24.8	-9.5
2000	-26.8	-24.9	-22.3	-16.1	-3.9	7.3	15.1	9.0	1.0	-8.7	-18.8	-29.5	-9.9
2001	-25.4	-27.7	-23.8	-15.8	-4.7	3.8	12.4	8.5	5.9	-9.6	-20.5	-23.2	-10.0
2002	-28.3	-30.1	-25.5	-19.9	-8.4	7.4	12.0	8.1	2.8	-9.0	-17.3	-20.2	-10.7
2003	-27.2	-32.0	-26.7	-13.5	-5.4	5.6	13.4	10.3	3.7	-4.3	-18.9	-25.1	-10.0
2004	-33.0	-29.1	-29.6	-19.3	-11.2	5.2	11.6	6.5	0.8	-10.6	-22.0	-29.7	-13.4
2005	-29.1	-29.5	-23.9	-11.4	-8.7	4.8	9.4	8.7	0.2	-7.0	-17.4	-20.6	-10.4
2006	-26.1	-23.3	-18.5	-13.4	-0.1	10.2	11.2	11.3	4.5	-6.0	-20.9	M	-7.7
2007	M	-28.3	-27.8	-14.3	-6.5	5.3	12.8	7.0	-0.8	-7.6	-22.1	-27.0	M
2008	-27.6	M	M	-15.8	-4.1	5.9	12.2	8.3	0.2	-6.0	-18.4	M	M
2009	M	M	M	M	M	M	M	M	4.3	-9.3	-17.0	-25.3	M
2010	-27.5	M	M	-8.8	-8.7	6.6	12.6	9.7	2.4	-5.6	-16.3	-24.4	M
2011	M	M	M	-19.7	-2.8	5.4	13.3	10.7	3.7	-5.4	-19.9	-24.6	M
2012	-28.6	M	M	-15.3	-1.1	9.4	13.5	10.3	6.4	-6.6	-21.3	-29.2	M
2013	-31.6	M	M	-17.9	-5.1	10.8	9.9	11.2	3.8	-3.6	M	-29.3	M
2014	M	M	M	-16.3	-3.0	9.4	13.5	7.9	0.6	-7.4	-20.5	-25.4	M
2015	-27.5	M	M	-17.5	-1.9	7.9	10.4	11.1	3.2	-10.0	M	-24.6	M
Avg[(b)]	**-29.7**	**-28.5**	**-24.9**	**-15.8**	**-5.4**	**6.7**	**11.7**	**9.0**	**2.3**	**-8.0**	**-20.2**	**-26.2**	**-10.9**

a) Between 1982 and 2006 data was collected from station 23026HN and between 2007 to 2016 data collected from station 230N002
b) Averaged precipitation values do not include missing or invalid data
M = Missing or invalid data from weather stations

Based on years with complete records, the mean annual temperature at Lupin is about -10.9 ºC. According to Boyd (1973), the freezing index in the area was about 3300 ºC-days. Because of climate change, predictions are that the mean annual temperature will increase about 4 to 5 ºC over the next century. Notwithstanding this predicted increase, continuous permafrost will still persist at the Lupin site.

Snowfall represents about 46% of the total annual precipitation. Snowfall can occur during any month, although heaviest snowfalls generally occur in October. The prevailing winds in the Lupin Mine area are from the northwest.

Snowmelt is generally complete by the end of June. Break-up on Contwoyto Lake begins in mid-July, although in some years the lake is not ice-free until early August. Small lakes in the region are ice free by early July. Ice starts to reform on small lakes of the surrounded area in late August or early September. Complete freeze-over of Contwoyto Lake occurs in October.

The winter climate at this latitude is severe in intensity and duration and is followed by a short, warm summer. In winter, between 1 and 3 m of ice develop on the surface of the lakes and it is the rate of melting of this ice that greatly influences summer conditions. The interaction between climate and morphology of the individual lakes gives rise to great differences in the thermal regime of the lakes.

Table 3 shows the monthly precipitation from snow and rain, as measured at the Lupin Mine weather station, between 1982 and 2006. Precipitation readings were taken manually until 2006 when an automated system was installed by Environment Canada. The automated system does not separate measured precipitation into snowfall or rainfall, making it difficult to interpret. The automated system does record temperature and wind speed.

Table 3: Monthly Precipitation at Lupin Mine Weather Station (1982-2006)

	Total Monthly Precipitation mm (1 cm of snow = equivalent to 1 mm of water)												
Date	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
1982	0.8	3.0	M	13.2	12.8	44.9	36.0	62.4	36.6	21.3	14.1	15.0	260.1
1983	24.6	5.5	16.8	16.5	18.0	10.4	77.7	75.2	77.0	41.8	10.8	6.0	380.3
1984	6.8	19.4	16.2	19.3	17.8	60.0	69.6	53.7	19.8	25.4	13.2	9.2	330.4
1985	9.2	11.6	10.4	25.8	10.2	19.4	89.0	46.6	44.7	24.0	9.4	6.6	306.9
1986	20.0	9.2	5.2	19.7	29.2	17.5	18.0	100.8	30.0	28.0	13.6	12.8	304.0
1987	11.6	6.6	5.6	6.6	8.6	67.8	41.8	47.1	35.0	34.1	45.0	25.4	335.2
1988	1.8	3.6	4.2	6.0	10.8	50.3	32.4	18.7	43.4	32.2	22.2	8.2	233.8
1989	20.0	4.0	10.2	3.1	36.1	6.3	35.0	27.5	33.7	11.7	14.4	16.5	218.5
1990	11.8	6.0	12.0	8.3	2.4	23.4	23.3	54.0	48.5	20.1	9.2	14.7	233.7
1991	7.9	13.2	12.4	26.1	14.0	12.4	42.8	76.2	46.5	26.4	17.6	19.4	314.9
1992	17.6	8.6	9.8	20.4	21.4	21.2	14.8	47.0	31.2	43.8	15.4	4.2	255.4
1993	6.1	19.2	13.2	6.2	28.4	24.0	87.0	28.8	29.9	19.4	14.8	12.0	289.0
1994	3.4	2.2	22.0	8.2	15.4	39.2	13.8	47.2	43.4	29.2	11.0	14.8	249.8
1995	5.2	3.4	38.8	6.6	11.2	20.8	40.2	79.0	49.4	37.0	7.4	23.8	322.8
1996	5.6	18.4	4.4	8.0	24.8	53.2	57.7	156.0	68.8	12.4	13.6	6.6	429.5
1997	6.6	6.6	6.8	12.8	27.2	21.2	18.2	58.6	25.4	46.2	12.6	17.8	260.0

Table 3: Monthly Precipitation at Lupin Mine Weather Station (1982-2006)

	Total Monthly Precipitation mm (1 cm of snow = equivalent to 1 mm of water)												
Date	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
1998	5.2	7.2	5.6	17.8	19.2	38.4	32.2	57.4	61.8	51.7	17.0	21.6	335.1
1999	9.6	6.6	14.4	25.0	25.2	19.6	62.4	57.2	85.2	23.8	13.4	30.8	372.8
2000	3.8	5.4	7.0	12.4	18.6	5.0	27.2	49.2	58.6	43.4	14.0	7.8	252.4
2001	6.4	7.0	24.6	30.2	40.2	6.4	44.4	46.4	9.4	20.0	27.6	12.0	274.6
2002	7.6	2.2	6.4	15.8	4.4	35.6	67.0	92.8	52.2	14.2	20.2	11.2	329.6
2003	3.8	0.4	19.8	3.4	22.2	18.4	44.0	69.2	36.0	28.4	31.3	15.6	292.5
2004	10.8	12.4	9.2	18.4	6.0	21.2	12.2	111.0	61.2	29.2	30.2	3.4	325.2
2005	14.2	6.2	12.6	18.8	11.2	59.4	28.8	64.2	26.6	33.2	20.2	12.4	307.8
2006	14.6	6.8	16.8	16.8	9.2	63.7	21.6	35.4	11.2	20	M	M	M
Avg.	***9.4***	***7.8***	***12.2***	***14.6***	***17.8***	***30.4***	***41.5***	***62.5***	***42.6***	***28.7***	***17.4***	***13.7***	***300.6***

M = Missing data; not used on average calculation

The Climate Normals, climate averages and extremes for the Lupin site compiled by Environment Canada at Station 23026HN for the 1981 to 2010 period are listed in Table 4.

Table 4: Climate Normals 1981-2010 for Station 23026HN

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Temperature												
Daily Avg. (°C)	- 29.9	- 28.5	- 24.8	- 15.8	- 5.9	6.4	11.5	8.8	2.1	- 8.4	- 20.4	- 26.2
Standard Deviation	3.2	3.5	3.1	2.6	3.3	1.9	1.9	1.8	1.9	1.9	3.7	3.6
Daily Max. (°C)	- 26.3	- 24.9	- 20.9	- 11.5	- 2.1	10.8	16.3	12.6	4.8	- 5.8	- 16.9	- 22.6
Daily Min. (°C)	- 33.4	- 32.1	- 28.7	- 20.1	- 9.6	1.9	6.7	5	- 0.6	- 10.9	- 23.9	- 29.7
Extreme Max (°C)	- 5	- 5	0.5	6	17.5	27.5	31	27.5	21	13	0	- 4.5
Precipitation												
Rainfall (mm)	0	0	0	0.4	5.3	26.8	41.1	59.8	25.5	1.6	0	0
Snowfall (cm)	9.4	7.8	12.2	14.3	12.5	3.6	0.4	2.6	17.1	27.1	17.4	13.7
Precipitation (mm)	9.4	7.8	12.2	14.6	17.8	30.4	41.5	62.5	42.6	28.7	17.4	13.7
Extreme Daily Rainfall (mm)	0	0	0	5.8	10.2	36.8	41.8	38.6	34.2	10.8	0.2	0
Date (yy/dd)	82/01	82/01	82/01	05/22	92/26	87/13	83/09	86/29	99/10	88/08	87/02	82/01
Extreme Daily Snow Fall (cm)	11.6	14.2	10	13.8	14.3	13.4	3.4	8.8	17	31.8	14	10
Date (yy/dd)	92/02	93/01	03/14	91/08	89/11	92/15	85/18	85/19	83/27	98/28	87/09	87/08
Extreme Daily Precipitation (mm)	11.6	14.2	10	13.8	14.3	36.8	41.8	38.6	34.2	31.8	14	10
MNDate (yy/dd)	92/02	93/01	03/14	91/08	89/11	87/13	83/09	86/29	99/10	98/28	87/09	87/08

Source: Environment Canada Website

The Hydrologic Atlas of Canada indicates that the annual evaporation in the area of the Lupin Mine is about 105 to 110 mm per year.

2.1.3 Topography

The Site is in the tundra zone of the Canadian Shield, in an area of continuous permafrost. It was glaciated multiple times during the Pleistocene age. The most recent glaciation was the late Wisconsin glacial stage, which reached a maximum extent about 14,000 years BP and disappeared about 6,000 years BP. Terrain in the vicinity of the Site is generally low and undulating, ranging between 470 and 505 m elevation. Numerous shallow lakes and streams occur in depressions throughout the area.

While the Site area is predominantly bedrock at surface, it is typified by "tombstone" topography over some of its area. These "tombstone" features resemble grave markers and occur as a result of ice- jacking action in heavily jointed rocks where joints tend to be pseudo-vertical and near-horizontal. The frost heave blocks are of various sizes and are scattered in a chaotic fashion. Removal of a block raised by this action would reveal an underlying mass of permanent ice (Geocon 1980; Golder 1990).

2.1.4 Vegetation

The Lupin Mine is located within an area of sparse vegetation, in the barren land tundra of Nunavut. It is typified as having sparse low lying vegetation which is extremely tolerant and well adapted to the climatic conditions. Some of the more prevalent types of habitat that can be found throughout the area include upland and lowland tundra, wet meadows and gentle slopes.

Throughout the Site there is diverse types of vegetation consisting of grasses and sedges; ground cover such as mosses, Labrador tea, cranberry, bilberry, bearberry, and arctic white heather. In wet areas, predominant species include cotton grass, bog rush, and other aquatic grasses. Dwarf birch and willows populate trenches, and colourful flowering plant species include fireweed, Lapland rosebay, azalea and saxifrage to list a few.

2.1.5 Hydrology

Contwoyto Lake is the major water body in the region, with a surface area of approximately 95,900 hectares (ha) and a drainage area of 8,000 square kilometres (km^2). Contwoyto Lake has two outlets in the Burnside River, which flows from the northwest end of the lake towards Bathurst Inlet, and the Back River at the southeast end of the lake, which flows into Pellatt Lake. The main body of Contwoyto Lake lies to the east and south of the mine site. To the north of the mine, a portion of the lake extends to the west and south, terminating in a narrow bay (Sun Bay) which lies directly west of the mine site.

As shown on Figure 3, aquatic habitat in the receiving environment immediately downstream of the tailings area is comprised of three shallow lakes (colloquially referred to as Dam 2 Lake, Dam 1a Lake, and Unnamed Lake), two streams (Seep Creek and Concession Creek), two shallow ponds, and two embayment areas of Contwoyto Lake (Inner and Outer Sun Bay). Dam 2 Lake is a small lake (maximum depth of 7 m), bordered on the north by a gravel pit and the east by the TCA (AECOM 2011). With the exception of Dam 2 Lake, all of the small lakes and ponds freeze to the bottom in winter. Much of Inner Sun Bay also freezes to the bottom. Due to low winter flows, both Seep Creek and Concession Creek freeze to the bottom in winter. As a consequence, over wintering habitat for fish is limited primarily to Outer Sun Bay and the main body of Contwoyto Lake (RCP/RL&L 1985).

Concession Creek drains Concession Lake via Unnamed Lake to Inner Sun Bay. Seep Creek enters the Sun Bay drainage system along the east side of Unnamed Lake. Lower Concession Creek (i.e. that section between Unnamed Lake and Inner Sun Bay) varies in width between 25 and 75 m, depending on seasonal discharges. Side channels are active during spring freshet. Stream depth generally is less than 1 m, except during spring freshet when depths approach 1.5 m. The substrate is primarily large boulders with large and small cobbles occupying the interstices.

Seep Creek is approximately 6.5 km in length, flowing from its source in Dam 2 Lake and Dam 1a Lake (via separate branches which join about 2 km downstream) to Unnamed Lake. The stream channel in upper Seep Creek generally is poorly defined, often flowing through marshy areas, or between large boulders or through bedrock fractures. This section of the creek generally is less than 0.5 m in depth and less than 2 m wide. The dominant substrate type is boulders, although localized areas of cobble and gravel are present. Lower Seep Creek (i.e. the 400 m section upstream of Unnamed Lake) is characterized by a well-developed channel varying in width from 1 to 4 m, although during freshet, maximum wetted width was about 20 m. The dominant substrate type is boulders, with localized areas of cobbles and gravel (RCP/RL&L 1985).

Inner Sun Bay (approximate area of 150 ha) is primarily shallow (mean depth of 1.7 m), with a maximum depth of about 6.5 m. Over 91% of the surface area is shallower than 3 m, and much of the bay freezes to the bottom in winter. Outer Sun Bay is deeper (greater than 10 m).

2.1.6 Water Quality

2.2 Site Environmental Conditions

2.2.1 Environmental Site Assessment

Schedule I of the Water Licence, conditions applying to abandonment, reclamation, and closure planning require the FCRP to address ESA plans in accordance with Canadian Standards Association criteria (Item k).

Canadian Standards Association criteria for Phase I ESA's establishes a consistent framework for preparing for and undertaking an investigation and interpreting and reporting the information gathered. Phase I framework does not involve selection or implementation of any measuring, sampling, analytical, or remediation activities.

Criteria for Phase II ESA establishes a framework for developing a sampling plan, preparing for and undertaking an investigation for sampling and measuring and interpreting and reporting the information gathered.

According to the 2006 Annual Report filed with the NWB, the final report on the Phase 1 and Phase 2 ESAs for the Lupin Mine site, conducted during July 2005 by Morrow Environmental was provided to the Board in August 2006. Part I, Item 9 of the Water Licence required LMI to update the ESA conducted for the project in 2006. Further Item 10, requires that the updated ESA include a detailed rock characterization study or program to determine the total quantity (inventory) of PAG material associated with the site and identification of any potential contamination that may be linked to such material. For additional details on the rock characterization study refer to Section 2.2.2.2.

LMI conducted an updated Phase I and II ESA in 2017 with the results provided to the NWB on October 18, 2017.

In summary, the updated Phase II ESA identified approximately 35,200 cubic metres (m^3) of petroleum hydrocarbon impacted soil at 13 historical maintenance, fueling, and fuel storage locations across the Site. In addition, approximately 400 m^3 of lead nitrate and/or cyanide impacted soils was identified at three historical cyanide storage locations and approximately 16,300 m^3 of arsenic impacted "hot spots" were identified at two locations. The updated Phase I and II ESA recommends that an updated Human Health and Ecological Risk Assessment (HHERA) be considered for the Site to develop site specific remediation criteria for metals.

As part of the ESA update, an asbestos-containing materials (ACMs) assessment at the Lupin Mine was carried out in 2017 (Golder 2017c). The assessment was carried out to evaluate the ACMs that may be impacted by future operation of the mine or demolition of the mine buildings. A total of 299 samples (non-intrusive sampling method) of suspect asbestos-containing building materials were collected and tested for asbestos content during the assessment, 46 of the samples were found to contain asbestos, mostly in vinyl flooring, duct mastic, window caulking and fire stop; location details are provided in Golder (2017c).

In addition to the asbestos assessment, it was noted that additional common hazardous building materials are likely present, including: lead-based paint, lead containing materials, polychlorinated biphenyls (PCB) in fluorescent light ballasts, potentially mercury soil contamination, mercury in thermostats and mercury vapour in fluorescent light tubes or bulbs, ozone-depleting substances in items or systems such as refrigerators and air conditioning units, potentially naturally occurring radioactive materials, radioactive materials in smoke detectors and exit signs, and miscellaneous building maintenance chemicals.

The ACM study included a recommendation that an intrusive hazardous building materials assessment be completed prior to any demolition activities to properly identify and quantify potentially hidden and additional potential hazardous building materials.

2.2.2 Geochemistry

2.2.2.1 Tailings

Tailings are primarily composed of the gangue minerals amphibole and quartz, which account for over 80% of the volume. Pyrrhotite and arsenopyrite make up an additional 17% (Klohn 1995). The tailings have been shown through various studies to be capable of generating acid upon oxidation. The tailings are a fine grained material with 80 to 87% less than 75 µm (SRK 2015). Solid phase arsenic concentrations range from 6,750 to 8,410 mg/kg (SRK 2015).

Extensive studies completed in the past have shown that the Lupin tailings, given the proper conditions, will oxidize and produce the by-products necessary for the formation of acidic runoff. Typical Lupin tailings contain approximately 3% sulphur (total) and have a Neutralizing Potential to Maximum Potential Acidity (NP/MPA) ratio of less than three.

Included in these studies were a 1991-1992, 30 week column leach program (kinetic test) and a follow- up 16 week leaching program in 1993 on mitigative measures for Cell 5 (then known as Area 3) tailings (Klohn 1992a). In addition, a 1992 study was completed on the assessment of water chemistry and remedial measures for the Lupin Tailings Management System with regard to the effects of the (formerly) exposed tailings within Pond 2 (Klohn 1992b and Klohn 1993). One of the results of this study was the decision to build M Dam, which now separates Cell 5 from Pond 2, and prevents the inflow of raw tailings into the pond.

2.2.2.2 Waste Rock

In 2004 samples were collected from waste rock deposited in roadbeds, tailings dams, the airstrip and the mill complex pad. The material sampled was generally the coarse cobble fraction of the waste rock. About 30% of the waste rock samples had sulphide concentrations above 0.3%; however, only one of these samples had an acidic paste pH. The results of the 2004 program indicated that a portion of the Lupin waste rock had the potential for acid generation. The alkaline pH values of the waste rock indicated acid generation had not yet occurred, even in those samples considered potentially acid generating (URS 2005). The median concentration of arsenic in the development waste rock was 1,140 mg/kg. The study also noted that approximately 35% of the development rock was capped with sand and gravel cover 0.15 m or thicker (Morrow 2006). The data set evaluated included the analysis of coarse rock fragments. The analysis of coarse rock fragments does not directly indicate what impacts the waste rock may have on the receiving environment.

An assessment to evaluate the water quality of seepage from waste rock at the mill/mine complex was conducted in 2005. The ESA detected groundwater and seepage with depressed pH and elevated metal concentrations in isolated locations. Forty (40) percent of the seeps sampled in 2005 were acidic (Morrow 2006).

An update to the Phase I and Phase II ESA at the Lupin Mine was carried out by Golder in 2017 (Golder 2017a). The scope of this update included the collection of development/waste rock and overburden grab soil samples for the purpose of completing an updated Acid Rock Drainage / Metal Leaching (ARD/ML) evaluation. The results of the ARD/ML investigation indicated that approximately 67% of the combined (2006 and 2017) waste rock dataset are classified as Potentially Acid Generating (PAG). The PAG samples were not concentrated in one or more specific areas; rather the PAG samples were distributed throughout the Site. Direct measurement of acidic pH values in groundwater and seepage water confirmed that acid generation was occurring after several decades of waste rock exposure.

2.3 Overview of Mine Development and Operations

Figure 2 provides a timeline which summarizes the history of the development, operation and post-operational care and maintenance of Lupin Mine. The Lupin Mine was discovered in 1960 as a result of reconnaissance sampling and mapping programs conducted by the Canadian Nickel Company Ltd, a subsidiary of Inco Limited. Between 1961 and 1964 the Canadian Nickel Company Ltd. conducted exploration in the Lupin area, which included geological mapping, geophysical surveying, trenching, stripping and channel sampling.

In February 1979, Echo Bay Mines obtained an option on the Lupin property from Inco and proceeded with an underground exploration program. The geological information indicated enough ore reserves to provide six years of production, based on the potential to develop in excess of two million tons of ore with a mill designed to process an average of 950 tonnes per day.

In the summer of 1980, prior to a production commitment, a 1,960 m long gravel landing strip capable of handling a C130 Hercules was prepared. In August 1980, the decision was made to proceed with development and construction of the Lupin Mine. Waste rock generated from the development of the underground workings was used to build the pad surrounding the mill and as roadbed material. Plant design was based on being able to air freight all the components to site.

Engineering, procurement and construction management of the surface facilities was contracted to Bechtel Canada Limited, while the contract for mine development and underground construction was awarded to J.S. Redpath Limited. The Lupin Mine was constructed and commissioned for a total cost of $135 million dollars.

Mine site construction started in August 1980 and was completed on schedule in March 1982 when pre-production commissioning began. The transportation of personnel to the site was accomplished with a Convair 640, which also carried a total of 7 million pounds of supplies such as perishables and repair parts during construction. During the twenty-month construction period, the Hercules aircraft made some 1,100 flights, carrying 25 tonnes of construction material per trip. This material included all the contained machinery and construction equipment, 2,200 tonnes of structural steel and the cement required to mix 7,300 m^3 of concrete. The floor area of the main complex was 9,290 square metres (m^2). During peak periods, the construction crew numbered up to 400 people on-site.

From 1983 to 1993, the Lupin Mine underwent a number of other expansions and operational changes to increase the mining and milling capacity to a nominal 2,300 tonnes per day. The main production shaft was deepened on two separate occasions to a final depth of 1,210 m below surface and the old sinking compartment was converted into a cage compartment. In April 2001, a production winze was commissioned between the 1050 level and 1340 level. This infrastructure allowed mucking below the elevation of the crusher to be carried out more productively, thus extending the depth, and life, of the mine. The -15% decline drift, or ramp, which permits mobile equipment to access all the mine levels, extends from surface to the 1560 m level. The lowest developed level in the mine is at the 1550 m elevation. In December, 1994, the paste backfill plant was completed, which provided critical ground support in production areas while reducing the amount of tailings reporting to the TCA.

Operations were temporarily suspended at Lupin between January 1998 and April 2000, and again from August 2003 to March 2004. Mill throughput in the last year of operation, March 2004 to February 2005, averaged approximately 1, 200 tonnes per day, significantly less than in previous years. Production ceased in 2005; at that time, the Site was put under care and maintenance. No active mining has since occurred.

2.4 Description of Mine Facilities

Figure 3 shows the general arrangement of the Lupin Mine Site. Other than the transportation requirement for materials and supplies necessary to sustain the workforce and industrial operations, the Lupin Mine site is completely self-contained and relatively compact.

Figure 4 shows the current conditions of the mine / mill / camp complex. There are two main areas: the residential complex consisting of accommodations, kitchen and recreation center; the industrial complex comprised of milling and maintenance areas, head frame, hoist room, powerhouse, and warehouse and office facilities. The freshwater pump house is situated approximately 1.6 km northwest of the camp, on the shore of Contwoyto Lake.

In association with the above, there are a number of support areas consisting of: shops and yards (maintenance, surface, backfill, and carpentry), storage/laydown areas (cold storage buildings), the main fuel tank farm; camp sewage facilities, mill tailings line, a recently constructed landfarm and a weather/aircraft control office with exploration shack. Only the main tank farm is currently being used for the storage of bulk fuel. In 2016, the former satellite tank farm was demolished and in 2017, the petroleum contaminated soils associated with it were cleaned up and relocated to the landfarm for bioremediation.

The TCA (Figure 5) is situated approximately 3 km south of the mine site. As shown on Figure 3, the only physical connections between the TCA and the mine site are a road and the 8 inch diameter insulated tailings line, used to transport the tailings slurry from the mill to the deposition point in the tailings cells. The explosives magazine is located approximately 2 km west of the TCA and is accessible by road from the TCA road network. There are currently no explosives on-site.

2.4.1 Underground Mining

The Lupin underground workings include a 1,210 m vertical shaft and a decline drift, or ramp, to a depth of 1,560 m. A secondary hoist system (Winze) was installed in 2001 allowing hoist access to 1,340 m. The current mine depth is 1,550 m. Incorporated into the underground facility were maintenance shops, an electrical shop and a primary crushing station. A surface projection of the underground mine workings is shown on Figure 6.

Shaft sinking began in 1982 to an original depth of 370 m below the surface collar. The shaft was deepened twice since then, first to the 780 m elevation during 1984-86 and the second time to its final depth of 1,210 m during 1988-90. The 2-drum ASEA production hoist, originally installed in 1987, was upgraded to 1,720 hp in 1992. This allowed 10-tonne capacity skips to be hoisted in the two skipping compartments. In 1992, the manway compartment above the 250 m level and the sinking compartment below the 250 m level were converted to a cage compartment. The hoistroom was modified to accommodate a fully automated cage hoist. After the end of operations, the doors to the shaft were welded shut to prevent inadvertent access.

The Lupin Mine is also serviced by an access ramp, which extends from surface to the bottom of the mine. For the most part, the ramp is a closed spiral and is located under the plunging south nose of the ore body. The 5 m wide x 3.5 m high ramp grades at -15% over its entire length. The termination of the ramp is at the 1,560 m level horizon. The ramp provided for movement of men and materials within the mine and allowed for efficient deployment of resources as required. The ramp has been sealed with a soil and rock plug and a locked fence installed to prevent access during the current phase of care and maintenance.

A 1,000 hp, 84 inch diameter Joy axivane fan mounted on surface, supplied fresh air to the mine via a 3 m diameter fresh-air raise. A similarly sized Joy fan is also mounted on surface, over a 3.4 x 3.4 m raise, and helps exhaust contaminated air from the mine.

Almost all of the lateral and ramp development at the Lupin Mine was accomplished with electric - hydraulic drills and diesel scoop trams. A number of sublevels were developed with pneumatic drills and slushers during the last few years of operation.

Standard mechanized drift dimensions were as follows:

- Ramp: 5.0 m wide x 3.5 m high, -15%
- Access Drifts: 4.6 m wide x 3.5 m high
- Central Zone (CZ) Ore Drifts: 4.0 m wide x 3.5 m high +2% grade
- West Zone (WZ) Ore Drifts: 2.0 m wide x 3.2 m high +2% grade

Raises up to 20 m in length (stope slots, mill holes, and vent raise extensions) were driven by conventional open raising methods, longhole drop raises or longhole inverse raises. Longer raises were driven with an Alimak or raise boring machine.

Production at the Lupin Mine began with sublevel longhole open stoping in the Centre and East Zones. Stope heights were typically 80 m and were as long as the strike of the ore body. Every fourth sublevel was developed as an extraction horizon complete with a haulage way, draw points, ore pass and waste pass. All of the mining above 810 m in these two zones was done by this method. The West Zone is the narrowest zone at Lupin. It was first mined by shrinkage and later by a ‘Raise Platform Mining’ method, which involved driving closely spaced raises and then breasting between them from an Alimak raise climber. This method was in turn replaced with sublevel longhole stoping similar to the Centre Zone but utilizing much smaller equipment.

As mining progressed to greater depths and the accumulated volume of stope excavation increased, rock stress and ground control issues became an increasing concern. The stoping method was modified to integrate both waste and paste backfill into the mining cycle. Stope dimensions were decreased in both height and strike length as one technique used to control dilution. The method involved longitudinal retreat mining 20 m high panels over a relatively short strike length (20 m maximum in the Centre Zone and 15 m in the West Zone), remote mucking the stope empty, and then filling with paste before mining the adjacent panel. This mining method was used at the mine since 1995.

The paste backfill plant was commissioned in October 1994 and was one of the first such systems operating in Canada at that time. The process involved taking the filter cake from the second stage filters in the mill (tailings), conveying it to the paste plant where it was mixed in a pan mixer with cement and water to create the paste. The paste was pumped to the shaft utilizing one of two positive placement pumps. Once delivered to the shaft, the paste flowed by gravity through the 6 inch diameter fill line and was distributed throughout the mine. Design capacity of the paste system was 120 short tonnes per hour. Between January 1995 and December 2004, over 1.8 million tonnes of paste backfill, equating to more than 30% of all tailings produced by the mine in that time period, were placed in the underground stopes. The paste backfill plant was decommissioned and removed from site following 2004. There are no paste backfill holes to the underground workings.

During the last few years of mining, several of the crown pillars of the Lupin Mine orebody were recovered. The crown pillars were the portions of the East, Centre and West zones between surface and 27 m level that were left behind when the initial mining was carried out. The East Zone crown pillar was recovered in 1997 and completely backfilled with waste rock and non-hazardous waste material in 1998. Mining of most of the Centre Zone crown was completed in 2003 and it was backfilled with pastefill that same year. A small portion of the Centre Zone crown pillar was mined during 2004 and remains open for the deposition of waste material. The West Zone crown pillar was mined between 1996 and 2004, and has been left open for the future disposal of demolition debris and soils. The crown pillar openings will be completely filled in, and the surface capping material contoured, during reclamation activities at the mine site.

The winze and underground mine equipment were removed from site when the mine entered care and maintenance in 2006. All hazardous materials were removed from the underground workings. Any equipment left (disposed of) in the underground workings was drained of fluids.

During operations, mine water from the underground workings was discharged either into the TCA or into the sewage lakes system in accordance with Part E(12) of the Water Licence. Underground working water chemistry was reported to the NWB prior to any discharge to the environment.

2.4.2 Borrow/Quarries

Figure 5 and Figure 7 show the locations of borrow pits and quarries on the property. The sand and gravel used for road and dam construction as well for covering the TCA cells since 1995 was obtained from the Fingers Lake esker, which is located approximately 10 km south of the mine (4 km southeast of the TCA). The Finger Lakes esker borrow area is the largest area that has been disturbed by borrowing activities. The other borrow areas within the TCA area are small and they have been inactive for a number of years.

The Fingers Lake esker will continue to provide the cover material for the remaining TCA cells and will also be used for the reclamation of the other components of the Lupin Mine as described in Section 4.0. The frozen nature of the material within the esker dictates that only shallow layers of material can be removed during excavation and hauling. In general, this “thaw scrape” approach results in a larger area of the esker surface being disturbed but allows for easier restoration work upon cessation.

The two existing bedrock quarry areas; one within the TCA area and the other one near the Fingers Lake esker, are small and inactive and there are no plans to use these areas further during closure implementation.

The range of metal concentrations of potential chemicals of concern in the esker material placed on Cell 3 of the TCA are listed in Table 5 (SRK 2015).

Table 5: Range of Metal Concentration of Potential Chemicals of Concern in Esker Material

Metal	Minimum (mg/kg)	Maximum (mg/kg)
Arsenic	8	12.8
Cadmium	0.036	0.79
Cobalt	5.02	190
Copper	16.8	188
Lead	1.04	1.27
Molybdenum	0.17	0.33
Nickel	16.7	493
Selenium	<0.02	<0.02
Zinc	20.7	178

Esker Material Properties

Part I, Item 1 (d) in the previous Water Licence (No. NWB1LUP0008) required ‘a comprehensive assessment of material suitability, including geochemical and physical characterization and availability for restoration needs, with attention to top-dressing materials, including maps, where appropriate, showing sources and stockpile locations of all borrow materials‘. The information resulting from that assessment is included below, for the purposes of reference and information.

A comprehensive assessment of the properties of the esker material was conducted by Golder Associates in 2004 (2004a). The following laboratory tests were completed on representative samples of the esker material:

- Grain size distribution and maximum and minimum density to generally characterize the esker material
- Cyclic wetting and drying to assess the physical stability of the esker material
- Chemical analysis of the tailings decant water
- Chemical analysis of leachate fluid from a mixture of esker material and tailings decant water to assess the chemical stability of the esker material

The following conclusions were reported by Golder in 2004:

- The results of sieve analyses indicate that the esker material is classified as gravely sand according to the Modified Unified Soil Classification System.
- The results of 20 cycles of wetting and drying indicate that the percentage of mass lost by the specimen over the course of the test was 0.31%. This value is considered to be within the accuracy of the testing method; consequently, the results indicate that the esker material is physically stable.
- Comparisons of the results of chemical analysis of the tailings decant water with that of the tailings decant water after it was leached through the esker material show negligible change in metals content. Based on these results, it does not appear that the esker material will physically degrade on exposure to the tailings decant water. Further, it appears that the chemistry of the tailings decant water will change relatively little if this fluid leaches through the esker material. It is, therefore, concluded that the esker material is a suitable cover material for the tailings deposition cells.

The details of this study are contained in the report *Studies Related to Water Licence Requirements and in Support of Reclamation Planning*, completed by Golder Associates (Golder 2004a). This report was filed with the NWB during the last licence renewal process.

Rip Rap Quarry Material Properties

A rip rap quarry was developed within the footprint of the TCA to provide the coarse broken rock needed to enhance dam stability, provide additional armour for the faces of the embankments, and for use as inert cover material. Approximately 15,000 m^3 of broken rock were sourced from the quarry. The quarry is located just north of Cell 3 and east of the perimeter road (Figure 5). The quarry was located on a on a hilly barren outcrop of phyllite. The quarry is inactive and there is no plans to use this area further during closure implementation.

Four rock samples were taken from the quarry area and tested for ARD potential. Table 6 lists the results of this testing. All samples showed that the rock was well suited to be used as cover material and would not be a concern for possible ARD generation.

Table 6: Riprap Quarry Sample ARD Potential Test Results

Sample	Fizz	NNP	NP	pH	MPA	NP:MPA	S%
50133	1	3	5	7	1.6	3.20	0.05
50134	1	14	15	8.6	0.6	24.00	0.02
50135	1	5	5	7.8	0.5	16.00	0.01
50136	1	8	8	8.1	0.5	26.88	0.01

An area of approximately 6,000 m^2 (78 m x 78 m) was excavated by blasting to a depth of 2.5 m. There was little to no overburden in the footprint of the quarry area, so stripping was not required. Access to the quarry site was immediately off the road to the west of K Dam, so any effect on the tundra was minimized.

As the quarry location was originally on a hill top, there is a little depression remaining after completion of the quarry operation. The quarry essentially removed the top of the hill. All drainage off the former hill drained into Pond 2. The quarry was configured such that this drainage pattern did not change.

As shown on Figure 3, a second bedrock quarry was developed just north of the esker borrow area. A small area of a bedrock outcrop has been blasted at this location. Use of this quarry has apparently been limited to date.

2.4.3 Waste Rock

The production of waste rock was considerable during the early development stages of the mine. Excess waste rock was brought to surface where it was either stockpiled or used as construction material at the Site. In the latter stages of the mine life, excess waste rock generation was reduced and the waste rock produced was normally moved to other areas of the underground workings as backfill material.

Waste rock was generally used throughout the Site as roadbed materials, in dam construction, airstrip stabilization, underground backfill, and laydown yards or for other purposes such as building foundation preparation. Approximately 1,000,000 m^3 of rock was placed on surface (URS 2005).

Mine operations did not produce any stockpiles of overburden or unprocessed low grade ore.

Information on the geochemical characterization of the waste rock is provided in Section 2.2.2.2.

2.4.4 Tailings Containment Area

Figure 5 shows the current conditions in the TCA. The TCA is located approximately 6 km south of the Lupin Mine, and covers an area of about 361 ha within the 750 ha lease. The containment is divided into three main components: solids retention cells (cells 1 through 5), polishing ponds (Pond 1 and Pond 2) and the End Lake area (not used). The tailings cover approximately 1,521,000 m^2 of the TCA. Since 1995, as further described in Sections 2.4.4 and 3.2.1, an esker material cover has been placed over approximately 1,311,500 m^2 of the tailings. The esker material cover serves to eliminate wind dispersal of dry tailings, to protect against contact with exposed tails by fauna, and the embedded moisture layer prevents oxidation of the underlying tails.

A detailed history of the design and operation of the TCA is contained in the approved TCA 2004 Final Abandonment and Restauration Plan (Final TCA ARP) (Kinross 2005). The tailings facility consists of multiple frozen core perimeter dams.

Table 7 provides a summary of perimeter and internal dams associated with the TCA. During active operations, the tailings management philosophy involved discharge of tailings into a closed system that allowed for solids accumulation and some supernatant water storage within five main cells, and also for the treatment of water prior to discharge into the environment. The cells within the impoundment allowed for separation of the liquid from the solid tailings as well as provided treatment through natural degradation.

Table 7: Perimeter and Internal Dams

Perimeter Dams	Internal Dams
Dam 1A	Dam 3D
Dam 1B	J-Dam
Dam 1C	K-Dam
Dam 2	L-Dam
Dam 3	M-Dam
Dam 4	N-Dam
Dam 5	Divider dyke
Dam 6	

Cells 1 and 2 have been filled and covered and retain ponded precipitation only in low lying areas of the cover. Contouring of the cover on Cell 1A directs run-off and precipitation from Cell 1A to a surface water conveyance ditch across Dam 3. Cell 3 has capacity for a small amount of run-off and precipitation and is directed into Cell 4. Cell 4 has acted as a water management pond, retaining water within the system prior to releasing it into Pond 1. Cell 5 retains run-off and precipitation, with water directed into Pond 1. Supernatant water and runoff storage occurs within one of two ponds – Pond 1 and Pond 2. Pond 1 acts as a buffering pond to manage the water chemistry. A water treatment plant (see Section 2.4.7) is located on J-Dam between Ponds 1 and 2, and was used during operations to treat the water in Pond 1 prior to discharge into Pond 2. Pond 2 is the last point of control prior to discharge into the receiving environment. Water is managed in Cell 3 and Cell 5 and Pond 1 through pumping and the use of syphons, while Cell 4 maintains a gated culvert. Syphons are used to discharge water from Pond 1 into Pond 2, and from Pond 2 into the receiving environment. Pond 2 currently has no flood overflow structure, but is required to maintain a minimum 1.0 m of freeboard at all times.

The TCA is impounded through natural terrain relief together with a series of engineered retaining structures. The main water retaining perimeter dams are Dam 1A and Dam 2, which contain Pond 2, and J-Dam which retains Pond 2 and Dam 4 in Cell 4. Dams 5 and 6 within Cell 3 are low level dams. No tailings have been impounded against Dams 1B, 1C, or 5. A design to raise Dam 6 was completed in 2003 (BGC 2003) to increase the tailings capacity in Cell 3; however this raise was never constructed.

All perimeter dams have been designed with a geomembrane liner for initial control of seepage and to promote the establishment of permafrost within the dams. K-Dam, which is an internal structure, was also designed with a synthetic liner for initial seepage control. A tailings beach, approximately 10 m in depth, has been placed on the upstream side of this dam.

Tailings Cells 1 and 2 are separated from Pond 1 by Dam 3D. The stability of this esker fill dam was enhanced in 1995 by the addition of a 10 m wide downstream berm, constructed of 75,000 m^3 of quarried waste rock, placed at a slope between 1.5H:1V to 2.0H:1V. The addition of this waste rock has also increased the erosion protection of the dam.

Ponds 1 and 2 are separated by J-Dam, which was constructed with esker material and mine development waste rock. Buried HDPE pipes in J-Dam currently act as an overflow structure from Pond 1 into Pond 2, reducing the risk of overtopping should the dam freeboard be encroached.

The frequency of water discharge from TCA into the receiving environment has been variable over the life of the mine. Discharge occurred annually between 1985 and 1997, and then every two to four years until 2015. Since the Site entered care and maintenance in 2005, there have been five water treatment campaigns to reduce the volume of water within the facility. These campaigns have occurred in 2005, 2009, 2012, and 2015. The annual reports illustrate the annual volume of water discharged to the environment.

The details of the many investigations in support of the saturated zone cover design are contained in the approved Final TCA ARP (Kinross 2005). The partially saturated granular cover design key features are summarized below:

- A basal saturated layer of esker material that inhibits oxidation of the underlying tailings by limiting the oxygen flux through the saturated zone.
- A surface layer that restricts the rate of evaporation of the saturated esker and tailings materials.

The esker cover serves to eliminate wind dispersal of dry tailings, protect against contact with exposed tails by fauna, and the embedded moisture layer prevents oxidation of the underlying tails. A study conducted to assess the presence of recent windblown tailings adjacent to the TCA detected no deposition of tailings material on surface (SRK 2015).

2.4.5 Mill Complex

The Lupin Mine milling process remained basically unchanged throughout the life of the mine. It utilized the Merrill-Crowe process for gold recovery, whereby a powdered zinc mixture was added to a gold bearing cyanide solution to precipitate out the gold. Lead nitrate was used in low doses to activate the zinc. The gold precipitate was then dried and melted in a furnace, and poured into doré bars. All metallurgical reagents, with the exception of lime, have been shipped off site during the current care and maintenance phase. The mill was given a complete wash down with the intent of gold recovery (visible gold that settles within the system) and removal of any residual contaminants (from chemical use) to the tailings impoundment prior to the current care and maintenance phase.

2.4.6 Landfill and Other Waste Disposal Areas

The waste management facilities used at the Site are: an incinerator, a temporary “boneyard” (for decommissioned tanks, buildings, and equipment), a landfill, a landfarm, two burn pits (annual applications to DIAND are required for open burning) and waste oil storage. Waste materials that cannot be disposed of in a management facility on site are appropriately segregated, stored such that they are inaccessible to wildlife and later shipped to a third party waste receiver in Yellowknife, NWT.

The waste management facilities are operated in accordance with the *Waste Management Plan (Solid and Hazardous).*

Recyclable containers, primarily food and beverage containers, are segregated and shipped off-site for management by a third party waste receiver.

The landfill is licenced under the Type A Water Licence (NWB, 2015) to dispose of "relevant inert, non-hazardous and non-combustible waste generated at the Project." The licence refers to the Landfill Management Plan (LMI, 2016).

All hazardous materials that cannot be disposed at the landfill, such as paints, batteries, solvents, chemicals and glycols are assembled in a staging area and then shipped off-site for disposal.

2.4.6.1 Incinerator

An incinerator has been used to incinerate combustible, inert solids throughout the life of the Lupin Mine. A new incinerator was installed in 2012 to replace the outdated site incinerator. The incinerator is a cinder block building that is secure from wildlife. The Inciner8 Model A600X incinerator is a dual stage forced air commercial incinerator that operates on diesel fuel or kerosene. The incinerator is operational and is currently used to burn the domestic and kitchen waste. The Operations and Maintenance Procedure for the incinerator is appended to the *Waste Management Plan (Solid and Hazardous).*

The types of materials that are acceptable for incineration include: organic waste (such as kitchen waste), wood, paper, cardboard, air filters, domestic waste, light plastics (bags, thin plastics), cooking waste oil (small amounts, used as incinerator fuel) and poor grade diesel fuel (small amounts, used as incinerator fuel).

Ashes from the incinerator are placed in drums and disposed at the onsite landfill. Incinerator ash samples can be collected and tested for metals to confirm suitability for landfilling in accordance with Part E(27) of the Water Licence. In the event ash is not suitable for landfilling, drums are shipped to a licensed waste disposal facility in the south. The shipment is typically as backhaul on aircraft supplying the site.

2.4.6.2 Landfill

The refuse disposal area used at the Site (the landfill) is located to the southeast of the mine and north of the second lower sewage lake. The landfill has been used since the Mine started operations. All non-burnable waste (scrap metal, plastics, residue from burning) and non-hazardous materials were historically disposed of and buried with waste rock on a regular basis. A portion of this facility is utilized in accordance with the *Waste Management Plan (Solid and Hazardous)* (LMI, 2016) and it's Appendices: *Landfill Management Plan* and the *Liquid Waste Management Plan*. The waste in the landfill is covered progressively during use. The waste items accepted for landfilling are listed in the *Landfill Management Plan*.

2.4.6.3 Landfarm

As part of the care and maintenance activities at Lupin in 2016 and 2017, the NWB permitted the use of a double-containment landfarm facility with a leakage detection pipe under Motion No. 2017-A1-013, Modification No.1 to License No. 2AM-LUP1520. LMI submitted as-built documentation of the initial landfarm design and operational procedures to the NWB in the summer of 2017, as part of the license modification requirements. This landfarm is located on the foundation of the former paste backfill building and remediated soil will be re-used on-site during closure activities. The landfarm was put into operation in August 2017 when it was loaded with about 500 m^3 of petroleum hydrocarbon contaminated soil from the cleanup of the dismantled Satellite Tank Farm. This soil is currently undergoing bioremediation in the landfarm.

The facility is operated in accordance with the *Waste Management Plan (Solid and Hazardous)* and it's Appendix: *Landfarm Management Plan* and the *Liquid Waste Management Plan*.

2.4.6.4 *Burn Pits*

One burn pit is located on site adjacent to the landfill, and a second one is at the north end of the Site. Permits to open burn are applied for on an annual basis through INAC. The waste items accepted for open burning are listed in the *Lupin Mine Landfill Management Plan* (Appendix B).Non-hazardous oversized materials, including untreated wood products, were historically burned in the burn pits to reduce the volume of waste entering the landfill.

2.4.7 Support Infrastructure

2.4.7.1 *Accommodation Facilities*

The major component of the accommodations is the sleeping and eating quarters which consist of over 200 modular units and separately framed areas to form the complex. In 2012 and 2013, 150 rooms were refurbished. The other components consist of recreation and gymnasium facilities which are steel frame/metal clad construction.

2.4.7.2 *Fresh Water Supply*

The freshwater for the site is obtained from Contwoyto Lake approximately 1.5 km from the complex. A causeway/breakwater extending out into the lake supports a pump house building and docking facilities.

The fresh water supply pumps were decommissioned in 2006; as a care and maintenance requirement. The pumps are currently stored at the mine site and were refurbished in 2013 in preparation for reinstallation. When the pumps are not in place, freshwater is trucked from the breakwater on Contwoyto Lake to a water storage tank at the accommodation buildings.

2.4.7.3 *Arsenic Treatment Facility*

This facility, a steel frame/metal clad building, is located at the TCA between Ponds 1 and 2, at the south end of J-Dam. It was used for mixing of reagents (ferric sulphate and lime) for water treatment operations during the early 1990's and has been inactive since 1996. The facility has been partially decommissioned. All remaining components were flushed after use.

2.4.7.4 *Explosive Magazine*

The explosives storage magazine is located 2 km west of the TCA and consists of 2 steel-frame/metal clad buildings for Ammonium Nitrate/Fuel Oil (ANFO) storage, and historically numerous Sea-Containers for the storage of stick powder and other blasting products. There are currently no explosives on-site and no Sea-Containers at the explosives magazine.

2.4.7.5 *Roads and Airstrips*

A considerable amount of roadway exists at the TCA, with the largest portion being the access to the explosives magazine and the access to the Fingers Lake esker (Figure 3). The roadways were constructed in part with mine development waste rock.

The old airstrip that was used during construction had been used as a laydown area after the new airstrip was operational. This area was slowly phased out as a storage location and, in 1998, the gravel/esker fill strip was graded to conform to the natural landscape with cuts and backsloping applied where necessary to promote natural drainage and reduce erosion. The surface was scarified utilizing a grader with a ripping attachment.

The main airstrip is 1,950 m (6400 ft.) in length and it was constructed of crushed waste rock produced from development underground. The drainage course in the area has been altered slightly in a lateral direction; however all runoff from both the east and west sides of the strip report in a northerly direction, eventually to Contwoyto Lake. The airstrip fueling facility has been removed and the area has been reclaimed.

2.4.7.6 Sewage and Refuse Facilities

The sewage facilities consist of several lift stations within the camp and an 800 m long 6 inch diameter insulated steel pipeline to the first of two sewage lakes. Alternatively, when, during Care and Maintenance, camp capacity requirements do not warrant its use; sewage and grey water are collected in a sewage tank at the accommodation buildings. The tank is then hauled to the Upper Sewage Lake wherein waste is deposited. A sewage line to convey camp sewage directly to the Upper Sewage Lake may be utilized.

Grey water originating from log cabin (guesthouse or office cabin or manager's house) use may be deposited in an adjacent leach pit. All sewage is to be discharged to the Sewage Lakes Disposal Facilities.

A 'permeable' type dam with an emergency overflow and a syphon exists between the first and second lake. Discharge from the second lake is controlled by the use of syphons. Water accumulating in the Lower Sewage Lake is tested prior to discharge to the environment. Discharge procedures are described in the *Liquid Waste Management Plan*.

The refuse landfill was discussed in Section 2.4.6.

2.4.7.7 Tailings Lines

A steel tailings line exists between the mill complex and the Tailings Containment Area. The initial 6 inch line was removed in 2001. The newer 8 inch line extends the entire 6 km distance to the impoundment. The line extends further within the impoundment for an additional 2.5 km. Various small buildings along the line house valves for either dumping of the line to controlled sumps or switching flow direction. Development waste rock was used to construct part of the tailings line foundation.

2.4.7.8 Fuel Storage

The fuel storage facilities at Lupin included a main tank farm (including a system of 14 diesel tanks, 1 jet A tank and 9 individual tanks), a satellite tank farm (STF) (including a system of 10 diesel tanks and 2 gasoline tanks and a waste oil tank farm which included 2 waste oil tanks). In addition there were 5 glycol tanks on-site and various individual tanks. Geomembrane liners were used for containment purposes.

In 2014 buried pipes were removed between the main tank farm and satellite tank farm. The fuel remaining in the satellite tank farm was used up in 2015. The STF was demolished in 2016. A total of about 500 m^3 of petroleum hydrocarbon contaminated soil associated with it was cleaned up and placed in the landfarm in 2017.

2.4.7.9 Chemical Storage

During operations the mine had an inventory of chemicals which included: cyanide, lime, lead nitrate, zinc dust, flocculants, and ferric sulphate in major quantities and miscellaneous refinery reagents in much lesser quantities. Of the chemicals listed, only lime is held on-site during care and maintenance.

3.0 PROGRESSIVE RECLAMATION AND POST OPERATIONAL ACTIVITIES

3.1 Summary

By definition, Progressive Reclamation is a closure related activity that is undertaken while a mine is still in operation. At Lupin Mine, there are several examples of closure activities that were undertaken before the mine shut down in 2005. Progressive reclamation at the Lupin Mine started in 1988.

Since the shut down in 2005, the Site has been continuously under care and maintenance; it has never been in an abandoned condition. Furthermore, a substantial number of closure activities have been undertaken since 2005. Herein, these activities are described as “post-operational activities”.

Table 8 provides a summary of progressive reclamation and post-operational activities that have been undertaken to date on the Site. These activities are described further in subsequent sections.

An estimate of the costs associated with the closure and reclamation of underground workings was previously presented in the Closure Cost Update provided in October 2017 (Golder 2017b). This estimate incorporated changes in the quantities considering the work that had been completed as part of progressive reclamation and post-operational activities. For further information related to financial security refer to Section 7.0.

Table 8: Summary of Progressive Reclamation and Post-Operational Activities

Period	Description
Completed Progressive Reclamation	
Tailings Containment Area (TCA)	
1988	A test portion of Cell 1 (Cell 1A) was covered with esker material as final cover layer with thermistor strings installed.
1995	1 m layer of esker material was placed on Cell 1 and on a portion of Cell 2 with thermistor strings installed.
1994 and following years	Thermistors data collected, analyzed and interpreted.
1997	Additional cover work was completed on Cell 2 (¾ complete with a 1 m cover of esker material).
2003	Designated Cells 3A and 3B of Cell 3, were covered by approximately 1 m of esker material. Total area covered of approximately 62,350 m^2.
2003	Additional site information accumulated in support of the ‘Partially Saturated Granular Cover’ program for tailings reclamation.
2004	Major portion of Cell 3, the remainder of Cell 2, and a small portion of Cell 5 were covered by a minimum of 1 m of esker material. Total area covered of approximately 328,794 m^2.
2004	Additional site information was accumulated in support of the ‘Saturated Granular Zone Cover’ program for tailings reclamation.
2005	Major portion of Cell 5 and another portion of Cell 3 were covered by a minimum of 1 m of esker material. Total area covered of approximately 383,001 m^2, bringing the total of exposed tails covered to approximately 1,280,000 m^2.
Other Areas	
to 2005	The following components were reclaimed: - unused roads - equipment storage areas - original Twin Otter airstrip - all associated piping removed from the original construction camp water supply lake - piping roadway also reclaimed - fueling station at the main airstrip - arsenic treatment facility partially decommissioned (all remaining components were flushed after use)
Regular basis to 2005	All non-burnable waste (scrap metal, plastics, residue from burning) was disposed at the site landfill and buried with waste rock.
1998	Reclamation work was completed where the East Zone and Centre Zone was mined from the surface. The Crown Pillar area was reclaimed to the extent possible through filling in the mined out areas of the East Zone and Centre Zone.
2003	The Centre Zone Crown Pillar open stope, which was previously open from the 27 m level to surface, was filled with cemented tailings paste backfill and then topped with surface material.
Completed Post-Operational Activities	
Tailings Containment Area (TCA)	
2006	Final report on the Phase 1 and Phase 2 ESA of the Lupin Mine Site was provided to the NWB
Monthly basis until 2006	Data from the TCA thermistor strings was collected on a monthly basis until October 2006.

Table 8: Summary of Progressive Reclamation and Post-Operational Activities

Period	Description
Annual basis	Dam safety inspections were carried out and continue.
2013 - ongoing	Repairs to Dam M, Dam N and covering Cell 5 with esker material were carried out and continue.
2016 - ongoing	Covering of Cell 5 was resumed in 2016, currently ongoing. The total of exposed tails covered in Cell 5 to 2017 was approximately 1,311,500 m^2. There remains approximately 123,500 m^2 in Cell 5 and 86,000 m^2 in Cell 3 of exposed tailings. Minor cover repairs were made to existing tailings cover where required in 2016 and 2017.
Other Areas	
Following cessation of operations	The mill portion of the complex was given a complete wash down with the intent of gold recovery. Any residual contaminants (from chemical use) were removed and buried in the tailings impoundment.
	All metallurgical reagents, with the exception of lime, were shipped off site.
	The steel frame structure of the paste backfill building was removed along with the equipment from the plant and a cold storage building.
2006	The winze and underground mine equipment were removed from site. All hazardous materials were removed from the underground workings. Any equipment left (disposed of) in the underground workings was drained of fluids.
2006 - 2013	The underground mine workings ramp was sealed with a soil and rock plug and a locked fence installed to prevent access. The fresh water supply pumps were decommissioned in 2006. The pumps are currently stored at the mine site.
2011	Important maintenance was conducted on the main fuel tank and satellite tank farms.
2012 - 2015	Significant reclamation activities were resumed with the shipment of hazardous materials and other waste off-site for disposal at approved facilities. The shipment of significant quantities of hazardous materials and other waste off-site continued in 2013 and was resumed in 2015.
2014	Numerous fuel tanks and buried pipes were decommissioned and removed.
2014 - 2015	Repairs were completed to the upper and lower sewage lagoon dams.
2015 - 2016	Hazardous waste materials were consolidated and shipped of site for disposal. During 2015 and 2016 a total of 139,363 kg were shipped out. During 2017, an additional 15,345 kg were shipped.
2016 - 2017	A pilot landfarm to remediate hydrocarbon soil from the Satellite Tank Farm was constructed. The Landfarm was put into operation in late August 2017.
2016	Dam 5 repairs and upgrades were completed on the upper and lower sewage lagoons.
2017	The Phase 5 EEM Cycle was completed and filed with Environment Canada.
2017	As per the Water License, an updated Phase I and II ESA was completed. As part of the ESA update, an asbestos-containing materials (ACMs) assessment at the Lupin Mine was also completed.

3.2 Completed Progressive Reclamation

3.2.1 Tailings Containment Area

As part of ongoing restoration activities, and as described in the 1988, 1995, 2003, 2004, and 2005 Annual Reports to the NWB, exposed tailings in completed cells has been progressively covered with between 1.0 to 2.0 m of esker material.

In 1988, a test portion of Cell 1, referred to as Cell 1A, was filled and covered with esker material as a final cover layer. Temperature monitoring thermistor strings were installed at various depths in this area to provide an indication of the amount of esker material needed to maintain the tailings frozen and allow the active thaw zone to be restricted to the esker cover.

In 1994, Echo Bay Mines Ltd. retained the services of Klohn-Crippen Consultants Ltd. for the engineering, geophysical and data interpretation of a test plot area on Cell 1 (Klohn 1995). Results of the geophysical portion of the study were inconclusive; however considerable background information was generated with regard to the chemistry of the tailings prior to covering.

In 1995, a continuation of the 1994 study incorporated the more standard physical measurement techniques of thermistors, frost probing and frost tubes at the study area. The scope was broadened when the decision to expand the esker cover program was made and Cell 1 was covered. These data, along with those generated by the additional thermistors installed in the following years, provided excellent information of the thermal response of the covered tails. The thermistor readings generally indicated that permafrost has re-established within the tailings cells and the thermistors located within Cell 1 indicated that the maximum annual depth of thaw was between 1.5 and 2 m. 3.2.1

In 1995, a 1 m layer of esker material was placed on Cell 1 and a portion of Cell 2 with thermistor strings installed to monitor the temperature below the ground surface. In 1997, additional cover work was completed on Cell 2 (¾ complete with a 1 m cover).

Progressive reclamation activities in the TCA during 2003 saw two areas within Cell 3, designated cells 3A and 3B, covered by approximately 1 m of esker material. The work was carried out between 5 August and 23 September 2003, with a total area covered of approximately 62,350 m^2.

In 2003, additional site information was accumulated in support of the 'Partially Saturated Granular Cover' program for reclamation of the TCA. Monitoring of pore water quality and the saturation status of the esker cover in Cell 1 continued from the previous year. Further to this work, a test pad was constructed in Cell 1 by effectively isolating a 20 m by 40 m area from the rest of the cell. This was accomplished by installing an impermeable liner in a 2.4 m deep trench surrounding the area, anchored well below the active zone. A thermistor and 2 water sample pipes were installed within the test pad area.

Progressive reclamation activities in the TCA during 2004 saw a major portion of Cell 3, the remainder of Cell 2, and a small portion of Cell 5 covered by a minimum of 1 m of esker material. The work was carried out between July 6 and September 19, 2004, with a total area covered of approximately 328,794 m^2.

In 2004, additional site information was accumulated in support of the 'Saturated Granular Zone Cover' program for reclamation of the TCA. Monitoring of pore water quality and the saturation status of the esker cover in Cell 1 continued from the previous two years. Further to this work, a series of 9 pits were excavated through the esker cover in Cells 1, 1A, 2 and 3 to check for cover thickness, moisture content, and condition of tails/cover interface. This work confirmed that a saturated zone exists at the base of the esker cover which effectively isolates the underlying tailings from an oxidizing environment. A detailed description of this program and data from of the many investigations in support of the saturated zone cover design are contained in the Final TCA ARP (Kinross 2005). See Section 3.2.1.

Progressive reclamation activities in the TCA during 2004 saw a major portion of Cell 3, the remainder of Cell 2, and a small portion of Cell 5 covered by a minimum of 1 m of esker gravel. The work was carried out between July 6 and September 19, 2004, with a total area covered of approximately 328,794 m^2.

Reclamation activities in the TCA during 2005 saw a major portion of Cell 5 and a small portion of Cell 3 covered by a minimum of 1 m of esker gravel. The work was carried out between 23 June and 28 September 2005, with a total area covered of approximately 383,001 m^2. General site maintenance and facilities upgrades were completed with a view to potentially resume production, which would have involved resuming disposal of tailings in the TCA. Covering ceased after 2005 because the remnant areas of exposed tailings were saturated for most of the year and the exposed areas would have been available to be used if the mine restarted. By 2005, approximately 1,280,000 m^2 of exposed tails had been covered

3.2.2 Other Progressive Reclamation

In addition to the work in the TCA, progressive reclamation has taken place in numerous other areas including many unused roads, and equipment storage areas. This included the original Twin Otter airstrip located south of the mine site parallel with the second sewage lake. All associated piping was removed from the original construction camp water supply lake and the roadway taken out of service by re-grading and scarifying the roadbed to promote natural re-vegetation of the ground. The fueling station at the main airstrip was also decommissioned and removed. The arsenic treatment facility was partially decommissioned. All remaining components were flushed after use.

All non-hazardous and non-burnable waste (scrap metal, plastics, residue from burning) historically were disposed at the site landfill and buried with waste rock on a regular basis. The waste in the landfill is covered progressively during use.

In 1998, while under care and maintenance, further reclamation work was completed where the East Zone and Centre Zone had been mined from the surface. The Crown Pillar area, the area where the ore zone is present near the surface, was reclaimed to the extent possible through filling in the mined out areas of the East Zone and Centre Zone.

The Centre Zone Crown Pillar open stope, which was previously open from the 27 m level to surface, was filled with cemented tailings paste backfill during 2003. Approximately 100,266 dry short tonnes of paste, at a cement content of close to 1%, were placed in the opening. Once the paste dried, it was then topped with surface material that had been stored when the original ground cover was removed to obtain access for mining. This activity has served a dual purpose by backfilling of one of the open crown pillars at surface as a step towards reclamation of the Site, and by reducing the amount of tailings directed towards the surface TCA impoundment.

3.3 Completed Post-Operational Activities

3.3.1 Tailings Containment Area

The Lupin property was sold to a new operator in 2005 and the mine has remained in care and maintenance since 2005. In 2006, the final report on the Phase 1 and Phase 2 ESA of the Lupin Mine Site was provided to the NWB (Morrow 2006). Aside from relocating a surface water conveyance ditch on Dam 3 in 2010, measures for final closure and reclamation of the TCA were halted until 2016 when Lupin Mines resumed covering of Cell 5. Measures for final closure and reclamation of the TCA were halted until 2016, when Lupin Mines resumed covering of Cell 5. Since 2016, activities have included: repairs to Dam M, Dam N and covering Cell 5 with esker material. Minor cover repairs we made to existing tailings cover where required in 2016 and 2017. Covering of Cell 5 continued during the 2017 season bringing the total of exposed tails covered to approximately 1,311,500 m^2.

Collection of data from all thermistor strings installed at the TCA continued on a monthly basis until October 2006. The information collected to 2006 indicated that sub-zero temperatures continued to be maintained at depth with no indications of warming (BGC 2006). Results obtained between 1995 and 2005 showed that October is usually the month when the active layer has penetrated the deepest and significant cooling has begun on surface (BGC 2006).

The geotechnical conditions and routine maintenance of the perimeter dams has been reported in the annual geotechnical inspection reports current to 2017. Commencing with the 2012 annual geotechnical report, the geotechnical conditions of the internal dams has additionally been reported. Temperature monitoring of the dams (based on installed thermistors) indicates that the cores remain frozen year-round (actively monitored thermistors are shown on Figure 5). The 2017 dam frozen core thermistor readings indicated that the thaw depth of the dams (active layer) ranged from 2.0 m to 3.0 m and varied between TCA locations (Norwest 2017a).

Data collected from the groundwater monitoring pipes, installed in 2002 and monitored up to 2004, indicated that the saturated zone thickness within the cover ranged from 0.2 m to 0.6 m, measured upwards from the tailings to cover contact surface. The water level readings and water quality results and are presented in the report “Studies Related to Water License Requirements and in Support of Reclamation Planning” (Golder 2004a).

Between 2005 and 2016, no esker material cover was placed and the data collection to access the performance of the soil covers was been infrequent. In 2016, LMI reinitiated the monitoring cover performance data by the engineers responsible for the annual geotechnical inspections, and this, including new instrumentation outlined in Section 5.0, will continue as part of the on-going annual inspections. The 2016 and 2017 cover performance data indicated that the cover active layer (thaw depth) ranged from 1.0 m to 1.5 m, and varied between reporting years and TCA locations.

As of 2017, there remained approximately 123,500 m^2 to cover in Cell 5 and 86,000 m^2 to cover in Cell 3.

3.3.2 Other Post-Operational Activities

Following cessation of operations, the mill portion of the complex was given a complete wash down with the intent of gold recovery (i.e., the recovery of visible gold that settles within the system). Any residual contaminants (from chemical use) were removed and buried in the tailings impoundment.

All metallurgical reagents, with the exception of lime, have been shipped off site.

The steel frame structure of the paste backfill building has been removed and equipment from the plant was removed for resale or salvage. A cold storage building has also been removed.

The winze and underground mine equipment were removed from site in 2006. All hazardous materials were removed from the underground workings. Any equipment left (disposed of) in the underground workings was drained of fluids.

The underground mine workings ramp has been sealed with a soil and rock plug and a locked fence installed to prevent access.The fresh water supply pumps were decommissioned in 2006. The pumps are currently stored at the mine site. The pumps were refurbished in 2013, but they remain in storage.

In October 2011, important maintenance was conducted on the main fuel tank and satellite tank farms. Significant reclamation activities resumed in June 2012 with the shipment of hazardous materials and other waste off-site for disposal at approved facilities. The shipment of significant quantities of hazardous materials and other waste off-site continued in 2013 and resumed in 2015. The volume and types of materials shipped off-site for disposal are reported in the 2012 and 2013 monthly reports to the NWB and also in the 2015 and 2016 annual reports.

Reclamation activities during 2014 consisted of the decommissioning and removal of numerous fuel tanks and buried pipes as reported in the 2014 annual report. Repairs were also completed to the upper and lower sewage lagoon dams in 2015. Hazardous waste materials have been consolidated and shipped of site for disposal. During 2015 and 2016 a total of 139,363 kg were shipped out. During 2017, an additional 15,345 kg were shipped.

In 2016, reclamation included construction of a pilot landfarm to remediate hydrocarbon soil from the STF. The Landfarm was put into operation in late August 2017. Dam 5 repairs and upgrades were completed on the upper and lower sewage lagoons.

As per the Water Licence, an updated Phase I and II ESA was completed in 2017 (Golder 2017a). The objective of the updated Phase I ESA was to identify potential sources of soil and groundwater quality impairment based on the historical activities. The scope of work for the updated Phase II ESA was developed to assess current soil and groundwater quality based on the 2006 assessment results (Morrow 2006) and then refined based on the findings of the updated Phase I ESA and the current site conditions.

As part of the ESA update, a ACMs assessment at the Lupin Mine was carried out by Golder in 2017 (Golder 2017c). The assessment was carried out to evaluate the ACMs that may be impacted by future demolition of the mine buildings.

4.0 PERMANENT CLOSURE AND RECLAMATION

4.1 Definition of Permanent Closure and Reclamation

Permanent closure is defined as the final closure of a mine site with no foreseeable intent by the existing proponent to return to either active exploration or mining. Permanent closure indicates that the proponent intends to have no further activity on the site aside from post-closure monitoring and potential contingency actions. Permanent closure does not, however, preclude the proponent or another party from pursuing opportunities at the existing site or in the area at a time beyond the foreseeable future.

Lupin Mines Incorporated has decided to commence with the permanent closure and reclamation of the Site.

4.2 Permanent Closure Objectives and Criteria

There are a number of environmental and safety considerations to address when mines are closed. Environment Canada's *Environmental Code of Practice for Metal Mines* summarizes the key objectives of mine closure as follows (adapted from EC 2009):

- Ensure public and wildlife safety by preventing inadvertent access to mine openings and other infrastructure
- Provide for the stable, long-term storage of waste rock and tailings
- Ensure that the site is self-sustaining and prevent or minimize environmental impacts
- Rehabilitate disturbed areas for a specified land use (e.g., return of disturbed areas to a natural state or other acceptable land use)

While the general objectives above apply to the project as a whole, there are also closure considerations specific to the different mine components. A summary of potential aspects is shown in **Error! Reference source not found.**. (It should be noted that Table 9 provides a general list and that some of these considerations do not specifically apply at Lupin Mine.) Additional detail is provided in the sub-sections of Section 4.3.

Table 9: Mine Components and Closure Considerations

Mine Components	Closure Considerations
Quarries	▪ Slope and bench stability ▪ Groundwater and rainwater management ▪ Security and unauthorized access ▪ Wildlife entrapment ▪ Effects of drainage into and from the pit/quarry
Waste Rock Storage Facilities	▪ Slope stability ▪ Effects of leaching and seepage on surface and groundwater ▪ Dust generation ▪ Visual impact
Tailings Storage Facilities	▪ Embankment stability ▪ Changes in tailings geochemistry ▪ Effects of seepage

Table 9: Mine Components and Closure Considerations

Mine Components	Closure Considerations
	▪ Surface water management and discharge ▪ Dust generation ▪ Access and security
Water Management Facilities	▪ Restoration or removal of dikes, settling ponds, sumps, pumps, pipelines, and/or culverts which are no longer needed ▪ Site surface water drainage and discharge ▪ Maintenance of closure water management facilities
Infrastructure at Mill and Camp	▪ Removal of buildings and foundations ▪ Clean-up of workshops, fuel and reagents ▪ Removal of power and water supply ▪ Removal of haul and access roads ▪ Disposal of scrap and waste materials ▪ Re-profiling of site
Landfill/Waste Disposal Facilities	▪ Disposal or removal from site of hazardous wastes ▪ Disposal and stability of treatment sludge ▪ Removal of sewage and water treatment plants ▪ Prevention of groundwater contamination

Source: adapted from EC 2009, Table 3.4

Closure criteria are used to measure the success of meeting closure objectives. The following are examples of the types of criteria that will be applied:

- Applicable water quality criteria or guidelines
- Target surface water and/or permafrost levels
- Evidence of post-closure wildlife and fish use
- Satisfactory inspections related to drainage and slope stability

4.3 Permanent Closure and Reclamation Plan

4.3.1 Reclamation Principles

Further to the approach to the development of the FCRP presented in Section 1.5, the goal of specific restoration practices is to minimize, or preferably eliminate, degradation of disturbed areas and to initiate, encourage and accelerate the natural recovery. The facilities and specific disturbed areas of concern with regard to the Lupin Mine that require permanent reclamation and closure activities and special management are covered in the following sections.

4.3.2 Reclamation Components

Figure 10 shows the planned configuration of the mine and mill site area after permanent closure has been implemented. Figure 11 shows the planned configuration of the TCA after permanent closure has been implemented. Table 10 lists the measures that will need to be implemented to achieve permanent closure at both locations. The following subsections provide descriptions of the measures for each component.

Table 10: Summary of Measures for Final Closure

Component	Description	Preparatory Work	Closure Phase		Post-Closure Phase				
		2018	2019	2020	2021	2022	2023	2024	2025
			Active Stage		Passive Stage				
Underground Mine	Backfilling of shafts to prevent animal or human entrance		X						
	Blasting down crown pillars where required for stability or disposal – to be carried out under approved care and maintenance plan	X	X						
	Disposing of contaminated soil, waste rock and demolition rubble into open crown pillars – to be carried out under approved care and maintenance plan		X						
	Backfilling of crown pillars with rock fill (to 1.5 m above surface to allow for settlement) – to be carried out under approved care and maintenance plan		X						
	Capping rock fill in crown pillars with 1.0 m of esker material								
Waste Rock	Excavate waste rock from perimeter areas and dispose in the open crown pillars, landfill or central waste rock area[a] – to be carried out under approved care and maintenance plan	X	X						
	Excavate waste rock containing high levels[b] of As, CN or P_bNO_3 and dispose in shafts or crown pillars to be carried out under approved care and maintenance plan		X						
	Contouring remaining waste rock and capping with 1.0 m of esker material		X						
Tailings Containment Area	Removal of tailings pipeline; bury in landfill		X						
	Remove any tailings from emergency dump and dispose in crown pillar	X							
	Complete covering of remaining tailings area with 1.0 m of esker material – to be carried out under approved Final TCA Closure Plan	X	X						
	Demolish treatment plant; dispose in landfill		X						
	Installation of permanent monitoring instrumentation – to be carried out under approved Final TCA Closure Plan	X							
Buildings and Equipment	Removal of asbestos containing materials, disposal in landfill	X							
	Remove salvageable materials; consolidate for shipment off-site	X							
	Removal of above-ground mechanical and electrical equipment	X							
	Demolition of ancillary buildings (shops, storage, camp); disposal of rubble in open crown pillars or landfill		X						
	Demolition of mine and mill buildings; disposal of rubble in open crown pillars or landfill		X						
	Hoe ram concrete foundation slabs; leave in place and cover		X						
	Removal of fresh water supply system pumphouse; cap pipeline and leave in place		X						
	Placement of 0.3 granular fill over slabs		X						
	Rehabilitation of roads (cut through access roads and removal of culverts scarify and grade)								
	Dismantling and removal of sewage facility								
	Disposal of unsalvageable / un-recyclable non-hazardous waste in landfill – to be carried out under existing approved management plan		X						
	Burn combustible material – to be carried out under existing approved licence/permit	X	X						
Borrow and Quarry Areas	Contouring esker area and placement of erosion protection in drainage paths		X						
Chemicals	Decontaminate: oil, fuel and glycol systems	X	X						
	Drum paints, solvents, chemicals, glycols, and hazardous materials for shipment to off-site disposal								
	Remove ashes from burn pit and bury in landfill > 2m below final grade – to be carried out under existing approved licence/permit								
	Burn waste oil – to be carried out under existing approved licence/permit		X						
	Consume most of diesel fuel for closure operations	X	X						
	Burn excess fuel at end of closure activities – to be carried out under existing approved licence/permit								
	Empty and purge fuel tanks and dispose in accordance with the Canadian Environmental Protection Act Regulation	X	X						
	Excavation of hydrocarbon contaminated soils, consolidate into containers and bury in open crown pillars		X						
	Bioremediate soil currently in landfarm; use remediated soil for reclamation – to be carried out under existing approved management plan licence/permit	X	X						

Table 10: Summary of Measures for Final Closure

Component	Description	Preparatory Work	Closure Phase		Post-Closure Phase				
		2018	2019	2020	2021	2022	2023	2024	2025
			Active Stage		Passive Stage				
Machinery and Mobile Equipment	Drain fluid from equipment to be left on-site and dispose in landfill								
	Drain fluid from equipment used for long-term maintenance (e.g., excavators)[c] and dispose in landfill or off-site								X
Landfill	Place wastes into existing landfill – to be carried out under existing approved management plan		X						
	Use waste rock to infill voids and create a stable contoured surface which drains freely								
	Cover contoured landfill with 1 m of esker material								
Site Roads	Scarify all-weather roads; remove culverts								X
Water Management Facilities	Treat water inventory with lime and release to lower water level – to be carried out under existing approved licence/permit	X							
	Construction of spillways in Dam 1A and J Dam; place geotextile and rip rap to 2 m depth								X
	Excavation of spillways on Upper and Lower Sewage Lakes								
Mob/Demob	Move Mobile equipment from Ulu to Lupin		X						
	Operate Winter Ice Road for salvage removal		X						

a) The waste rock from the perimeter of the Mill Site Area (shown in Figure 10) will be removed and disposed into the open crown pillars, shafts, landfill or the central waste rock area. Waste rock which will stay on place will be contoured to drain freely and then capped with 1.0 m of esker material.

b) Refer to text for levels of As, CN, or P_bNO_3 requiring disposal in shafts or crown pillars, rather than covering in place.

c) Assumed 5 years after closure; however Closure schedule depends on monitoring results. Activities will occur until contact water quality satisfies water license criteria for direct discharge to the environment.

4.3.2.1 Acid Rock Drainage and Metal Leaching

Project Description

The related studies describing the potential of ARD are identified in Section 2.2.2.

The results of the recent ARD/ML investigation (Golder 2017a), indicated that approximately 67% of the waste rock can be classified as PAG. The PAG samples were not found to be concentrated in one particular area; rather PAG samples were distributed throughout the waste rock deposits around the Site. In addition, much of the sulphur present was in the form of sulphate rather than sulphide, indicating that oxidation of the waste rock was well advanced. The updated Phase I and II ESA recommended evaluation of options for dealing with the acid generation and metal leaching potential of waste rock.

Reclamation Objectives and Closure Criteria

The approved plan for the reclamation of the TCA includes covering all exposed tailings with a 1.0 m layer of esker material. This layer will prevent any contact between the tailings and the surface environment and the saturated zone at the cover/tailings interface will provide an effective barrier to oxidation.

Given the advanced state of oxidation of the waste rock, the main objective of the reclamation should be to limit the contact between the waste rock and surface runoff (as opposed to limiting oxygen flux to the waste rock).

Closure and Reclamation Options

The reclamation plan for the TCA has been approved and, as discussed in Section 3.3.1, most of the exposed tailings have already been covered as part of post-operational activities. Placement of the 1.0 m thick esker material cover will be completed over the remaining area. More details of the tailings cover are provided in Section 4.3.2.8.

In principle, the objective of limiting the contact between waste rock and surface runoff can be achieved by relocating some of the waste rock into the open crown pillar voids, the shafts or the landfill. The space available in these locations is insufficient to hold the estimate 1,000,000 m^3 of waste rock, so the remainder of the waste rock will be left in place, contoured to shed water and covered with a 1.0 m layer of esker material. More details of the activities for the closure of the waste rock are provided in Section 4.3.2.7.

4.3.2.2 Revegetation

Listing and Assessment of Possible Reclamation Activities

The areas at the Lupin Mine site which are candidates for revegetation enhancements are limited in type (covered tailings, covered waste rock, abandoned roadways etc.), most being raised above the surrounding terrain, windswept and dry. The lack of suitable growth medium and unavailable soil amendments for post use reclamation make it much more difficult. The esker deposit is the major material type that would be used in restoration activities and it lacks the organic/nutrient content that the surrounding vegetation has established. Nonetheless, the tailings cells that were covered by esker material in 1988 and 1995 have both started to re-vegetate on their own.

The procedure of scarifying reclaimed surfaces, (as was carried out successfully on Cell 1A, the old airstrip, and the East Zone crown pillar cover), will be continued in order to provide a microclimate for natural plant growth. Providing a rough surface enhances seed entrapment, moisture retention and wind protection.

A potential alternative to natural re-establishment and alien species use is the practice of native sod transplanting. This procedure would involves the transplanting of blocks of soil to the restoration area which contain both the plant species and associated microflora. These ‘sod islands’ would provide a nuclei that plants and microorganisms could emigrate from. Many plant species produce rhizomes, suckers or shoots that are responsible for propagation. This is especially true in harsh, northern conditions where seed production may be minimal due to the short (and variable) growing season, lack of moisture and other constraints.

Sod transplanting may be a viable method of revegetation; however, in an area with minimal growth medium in combination with a shallow active surface layer, the placement of sod for the restoration of one site does not justify the removal of sod from another established area.

For areas that have been restored with the use of esker material, the most practicable technology available is to provide the most suitable substrate by surface preparation to promote natural revegetation. This includes addition of heavy (large grain sized quarry material), surface scarification and contouring to provide proper drainage patterns to avoid erosion and ponding of water.

4.3.2.3 Contaminated Soils

Project Description

Approximately 25 years of mining operations at the Site have resulted in the widespread contamination of surficial soils. The primary contaminants of concern at the Site are arsenic and petroleum hydrocarbons (PHCs). Secondary contaminants have been identified (i.e., lead nitrate, cyanide); however, they are localized and coincide with the primary contaminants. The following paragraphs provide further discussion of the two primary sources of contaminated soils at the Site.

Approximately 1,000,000 m^3 of waste rock was historically placed on surface at the Site for the development of roadways, laydown yards, and building foundations (URS 2005). Historical analysis of waste rock identified elevated arsenic concentrations (i.e., median concentration of 1,140 mg/kg) exceeding the applicable criteria (Morrow 2006). The deposition/blending of this arsenic rich waste rock with surficial soils has resulted in wide spread shallow arsenic impairment across the developed portions of the Site. Historical analysis has also confirmed that arsenic concentrations are naturally elevated at the Site. Background arsenic concentrations in soil range from 9 mg/kg to 189 mg/kg (Morrow 2006). Based on this dataset, a background total arsenic concentration was established at 179 mg/kg (Morrow 2006). Recent investigations have identified approximately 418,000 m^3 of arsenic impacted soil exceeding the background concentration at the Site (Golder 2017a). A sub-set of this volume (approximately 16,300 m^3) has been classified as heavily arsenic impacted (i.e., arsenic concentrations greater than 4,000 mg/kg). This heavily arsenic impacted shallow soil is a result of mill processing and potentially the surface release of ore.

Approximately 35,200 m^3 of PHC impacted soil has been identified at 13 historical maintenance, fueling, and fuel storage locations across the Site (Golder 2017a). Multiple above ground storage tanks were used in historical operations for fuelling vehicles and machinery, heating buildings, and fuel storage. Historical spills have resulted in PHC impacts to surficial soils. Areas of PHC impacted surficial soils have been identified based upon historical investigations, including reviews of mine records relating to spills and storage. The areas of PHC impacts typically coincide with areas of arsenic impacted soil.

Reclamation Objectives and Closure Criteria

The primary goal of the closure and reclamation of contaminated soils is to minimize the release of contaminants from the Site to the surrounding environment. Based on this goal, the following objectives have been identified:

- Manage contaminated soils in-situ or relocate them to final disposal locations in order to reduce unacceptable risk to humans and terrestrial ecosystems.
- Impacts to humans, environment, and wildlife within risk managed areas are minimized.
- Human and wildlife exposure to soil contaminant concentrations above criteria for the designated land use is minimized.

A summary of the measurable criteria to meet these objectives are presented below.

- Contaminated materials will either be ex-situ remediated or risk managed in-place with an engineered cover to reduce human health and ecological risks. Verification sampling will be completed to confirm that the appropriate soil remediation criteria are met for the areas that will be ex-situ remediated. The engineered cover will be designed to reduce human health and ecological risks. Design specifications will be verified in the field.
- For the risk managed areas, the engineered cover will consist of a minimum of 1.0 m of esker material to minimize the impact to humans, environment, and wildlife. Technical specifications for the engineered cover (i.e., acceptable gradations and compaction) will be established prior to placement.
- Contaminated soils will be either ex-situ remediated or risk managed in place to comply with industrial land use criteria specified within the Nunavut Environmental *Guideline for Contaminated Site Remediation* (GN, 2009). The engineered cover is designed to reduce human and wildlife exposure to soil contaminants left in place above the applicable criteria.

Post-Closure Reclamation Options

Various remedial options are available to address the shallow soil quality impairment at the Site. Options were selected based on: (i) feasibility to remediate or risk manage these areas; and (ii) experience and review of recent studies/case studies. The potential remedial options were combined/segregated into four "general response actions" which included: risk management – administrative controls; risk management – engineered controls; in-situ remediation; and ex-situ remediation. A summary of the potential remedial options for each of the four general response actions is provided in Table 11.

Table 11: Potential Remedial Alternatives

General Response Action	Remedial Options	Process Description
Risk Management – Administrative Controls	Administrative Measures	Restricting potential receptors or controlling potential exposure pathways through administrative measures (e.g., signage). Requires long term monitoring and restricted land use.
	Land Use Management Restrictions	Land use restrictions may be imposed to restrict specific types of development and activities. Land use zoning restrictions are typically intended allow management of the land in an efficient manner and/or to protect future land users from potential environment and safety hazards. The restrictions are typically legislated by government.

Table 11: Potential Remedial Alternatives

General Response Action	Remedial Options	Process Description
	Public Awareness	This control typically involves the use of public information sessions, schools, and/or libraries to provide information to local communities and the public concerning potential hazards.
Risk Management - Engineered Controls	Physical Barriers	The construction of physical barriers or fences is a commonly used measure to restrict public access and thereby potentially reduce risk to the public.
	Engineered Cover	Engineered covers typically involve the placement of a coarse-grained material to prevent public and wildlife direct soil contact.
	Vegetated Engineered Cover	Similar to Engineered Cover, complete with topsoil and seed. Vegetative barriers may be used to minimize potential exposure and stabilize contaminants. Revegetation using native plants will promote “self-healing” by initiating and enhancing natural processes such as biological degradation and soil development.
In-situ Remediation	In Situ Treatment - Stabilization	Reduce the mobility of the contaminant in the soil through addition of chemical agents or adsorptive additives.
	In situ Treatment - Phytoremediation	Encourage plant growth for stabilization and removal of metals from soil.
Ex-situ Remediation	Landfarming	Excavated soils are typically placed in a lined cell and treated through mixing (i.e., aeration) and/or the addition of soil amendments to promote microbial degradation of contaminants (i.e., PHCs).
	Excavation of Contaminated Soil using Specialized Techniques	Removal of contaminated soil using specialized excavation techniques, including small scale equipment, dental excavation, and/or hand excavation.
	Excavation of Contaminated Soil using Conventional Techniques	Removal of contaminated soil using conventional excavation techniques, including backhoes, haul trucks, and/or dozers.

Northern Considerations

The work season is typically restricted to three or four months. As a result, potential remedial options which require a significant timeframe to implement were not considered as they were deemed impractical.

The remote location of the Site limits the remedial options. As discussed in Section 1.2, the Site is located approximately 400 km north of Yellowknife, NWT and can only be accessed by aircraft or winter roads. Potential remedial options requiring off-Site disposal of contaminated soils were deemed impractical.

Listing and Assessment of Possible Reclamation Activities

Some of the developed areas of the Site are characterized by arsenic rich waste rock distributed over a large area. These materials are typically located in areas which are accessible to construction equipment. The presence of existing infrastructure (i.e., buildings) represents a constraint to access in some areas. As previous interim closure and reclamation plans have committed to remediate the Site to industrial land use standards, potential remedial options unable to achieve this end land use (i.e., administrative controls, physical barriers, and in-situ remediation) were not considered practical. As a result, the remedial options for the Site were restricted to either conventional soil removal (i.e., ex-situ remediation) or risk management (i.e., engineered covers). As discussed in Section 4.3.2.12, a small pilot landfarm has been constructed on-site and it is currently being used to remediate about 500 m^3 of hydrocarbon contaminated soils that were excavated for the previously completed cleanup of the STF. It is expected that it will take 2 to 3 years to complete the bioremediation.

Selection of Preferred Reclamation Activities

Contaminated soils at the Site are typically shallow (i.e., less than 2.0 m thick); however they are laterally extensive (approximately 275,000 m^2). As a result, it was recognized that due to the significant volume of contaminated soils at the Site (approximately 450,000 m^3), completing ex-situ remediation of all contaminated soils is impractical. In addition, as discussed in Section 2.4.2, a substantial coarse-grained borrow source is available at the Fingers Lake esker located approximately 10 km south of the mine. This esker material is a well graded gravelly sand, composed of 59% sand, 38% gravel, and 3% silt on average (Holubec 2005) and has been historically used for closure activities at the TCA. Given these factors, it was determined that a combination of remedial options will be implemented based on contaminant type and concentration. The remedial options selected for the Site include ex-situ remediation using conventional techniques (i.e., excavators, haul trucks, and dozers), and risk management with a coarse-grained engineered cover. The capacity of the existing landfarm is too small to remediate the estimated 35,200 m^3 of PHC contaminated soils in a realistic time frame. It is also impractical to construct enough additional landfarm capacity to bioremediate the PHC soils within the planned 2 to 3 year closure period. For this reason, PHC contaminated soil will be excavated and moved into the open crown pillar voids for isolation.

Synthesis of Preferred Activities into a Reclamation Plan

Approximately 418,000 m^3 of arsenic impacted soil, exceeding the background concentration, has been identified (Golder 2017a). A sub-set of this volume (approximately 16,300 m^3) has been classified as heavily arsenic impacted (i.e., arsenic concentrations greater than 4,000 mg/kg). Heavily arsenic impacted shallow soil is located adjacent to the transfer/screen house, conveyors, and crushing building portions of the mill complex and is likely the result of mill processing and potentially the surface release of ore. The heavily arsenic impacted shallow soil will be ex-situ remediated using conventional techniques (i.e., excavators, haul trucks, and dozers). This material will be excavated and disposed of within the shafts or open crown pillars for isolation. Afterwards, the areas of excavated heavily arsenic impacted shallow soil will be regraded to support surface water management and then covered with coarse-grained borrow material from the Fingers Lake esker. In some cases the regrading of excavated depressions will be achieved by bringing in waste rock from the perimeter areas.

The remainder of the arsenic impacted soil that is left in place will be managed using a risk-based approach in accordance with the Nunavut *Guideline for Contaminated Site Remediation* (GN, 2009). A HHERA will be completed during final reclamation and closure planning to develop Site-specific soil quality remediation objectives for metals (i.e., arsenic). Upon completion of the risk assessment, soils exceeding the Site-specific total arsenic guideline will be risk managed with the placement of a coarse-grained engineered cover. It is anticipated that the engineered cover will consist of approximately 1.0 m of coarse-grained borrow material from the Fingers Lake esker and will be graded to support surface water management.

Approximately 35,200 m^3 of PHC impacted soil has been identified at 13 historical maintenance, fueling, and fuel storage locations across the Site (Golder 2017a). These locations include: the STF and Powerhouse, the Mill and Office Emergency Tanks, the Main Tank Farm Loaders, the Main Tank Farm Bedding Sand, the Emergency Powerhouse, the South Burn Pit, the Landfill, the RTL Shop, the North Burn Pit, the Incinerator, Cold Storage #1, the Former Airstrip Fuelling Area, and the former Ball Field. This material will be ex-situ remediated using conventional techniques (i.e., excavators, haul trucks, and dozers) and disposed of in the shafts or open crown pillars. The areas that have been excavated will be regraded to ensure drainage and then covered with 1.0 m of coarse-grained borrow material from the Fingers Lake esker.

As discussed in Section 3.3.2, a landfarm cell was constructed in 2016 to treat PHC impacted soil from the STF. The landfarm cell was constructed at the south end of the former Paste Backfill Building footprint. The PHC impacted soil currently in the landfarm cell (about 500 m^3) will be remediated according to the Nunavut *Guideline for Contaminated Site Remediation* (GN, 2009).

Management and Accountability Structure

As part of the remedial activities, a quality assurance/quality control (QA/QC) program will be implemented. The purpose of the QA/QC program will be to verify that the remedial activities are implemented as planned. The scope of the QA/QC program will be developed prior to implementing the remedial activities; however, it is anticipated that it will generally include the following tasks:

- Monitoring remedial excavations and collecting confirmatory soil samples from the limits of the excavations
- Monitoring the disposal of PHC impacted soil in the shafts or open crown pillars
- Monitoring the disposal of heavily arsenic impacted soil in the shafts or open crown pillars
- Monitoring the regrading of the excavated areas
- Monitoring the placement and grading of the engineered cover over the arsenic impacted soil that is left in place
- Documenting the results of the remedial works, along with the QA/QC program, in a report

Uncertainties and Information Needs

The actual volume of contaminated soils requiring remediation and/or risk management is uncertain. It is possible that additional contaminated soils will be encountered as remedial works are completed. However, a contingency allowance has been developed within the disposal strategy in order to accommodate additional materials. In addition, as previously discussed, a HHERA will be completed during final reclamation and closure planning to develop Site-specific soil quality remediation objectives for metals. These objectives may result in modification to the area of arsenic impacted soil to be risk managed. Finally, the heavily arsenic impacted shallow soil will be disposed of within the shafts or open crown pillars. .

Monitoring, Maintenance, and Reporting Program

The purpose of post-closure monitoring is to verify the attainment of closure objectives and criteria. Contaminated soils will require limited post-closure monitoring activities. Post-closure monitoring activities associated with the landfarm are discussed in Section 4.3.2.12. The following post-closure monitoring activities will be completed related to contaminated soils:

- **Engineered Cover Monitoring:** An engineered cover will be placed over a large portion of the Site in order to risk manage arsenic impacted soil. In order to confirm that the cover does not deteriorate over time, regular maintenance and monitoring will be required. Annual visual inspections will be completed and documented and maintenance activities will be undertaken if and as needed (e.g., regrading or the placement of additional granular material to repair erosion).
- **Groundwater and Seepage Water Monitoring:** After the completion of remedial activities, a new shallow groundwater monitoring well network will be established within the active zone to confirm that remedial activities have been successful. Annual monitoring and sampling of this new groundwater monitoring network, along with the current seepage water sample network, will be completed and documented to confirm the remedial objectives have been achieved.

Contingency Program

Should the post-closure monitoring identify a significant deficiency with the engineered cover, a more robust engineered cover could be implemented. This work may include the localized placement or erosion protection over geotextile to minimize erosion/deterioration of cover materials. In addition, should the groundwater and seepage water monitoring program identify that the remedial objectives were not achieved, additional ex-situ remedial excavation would likely be required.

Costs

An estimate of the costs associated with the closure and reclamation of contaminated soils was previously presented in the Closure Cost Update provided in October 2017 (Golder 2017b). The current plan for dealing with contaminated soils will have the effect of reducing the costs, due to several factors:

- It is no longer planned to construct additional landfarm cells to bioremediate PHC contaminated soils; rather the excavated soils will be disposed of in open crown pillars for isolation; and
- The costs of disposing of excavated PHC contaminated soils into the open crown pillars will be less than managing them in landfarm cells.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.4 Underground Workings

Reclamation Objectives and Closure Criteria

The reclamation objectives for the underground workings include the following:

- Backfilling underground and surface expression voids with materials including waste rock resulting from mining operations, contaminated soils (as discussed in Section 4.3.2.3) and hydrocarbon contaminated soils that are unable to be treated by ex-situ remediation with landfarming.
- To collapse or fill any remaining crown pillar voids to reduce the risk of geotechnical instability following permanent closure.
- To ensure that all openings to surface (i.e., the shaft, ventilation raises and the ramp portal) are backfilled or sealed off to prevent access to underground.
- To place a final cover over the crown pillar and sealed areas.
- To grade the areas over the crown pillars and sealed areas to avoid ponding and to conform with surrounding landforms.

The permanent closure criteria will be met when all underground access points and related surface voids and expressions are filled and graded for geotechnical stability and long-term safety for humans and wildlife.

Post-Closure Reclamation Options

Waste-rock from surface will be placed above the backfilled surface voids to form a free draining surface which is graded to conform to surrounding landforms. Additional fill will be placed to account for potential post-closure subsidence. Finally, a 1 m layer of esker material will be placed on top of the waste rock surface to form the final cover. Post-closure geotechnical monitoring will include observations on landform stability and drainage and, if required, recommendations will be made for repairs.

Northern Considerations

The northern climate will result in a limited work season and the inability to execute materials handling and underground disposal work year-round. If required, dewatering activities will be staged to align with the work to be completed per work season.

As discussed in Section 1.2, the Site is located approximately 400 km north of Yellowknife, NWT and can only be accessed by aircraft or winter roads. Post-closure monitoring and the ability to perform repairs will additionally be impacted by the seasonality of the site access and work season.

Listing and Assessment of Possible Reclamation Activities

Two options were considered for underground disposal of site waste materials and equipment, heavily arsenic impacted soil and waste rock, and hydrocarbon contaminated soils that are unable to be treated by ex-situ remediation with landfarming. These include:

- **Ramp Access Disposal:** Disposal of materials in the underground workings by re-accessing the underground workings through the ramp. This would involve removing the portal bulkhead cover and working through the historically noted ramp ice plug. This approach would involve examining and stabilizing the underground workings for safety, dewatering the required areas for disposal, rehabilitating the ventilation system and using site equipment to haul materials underground.
- **Surface Access Disposal:** Re-access the underground workings from surface through open stopes, open shafts and collapsed crown pillars. All surface expressions of the underground workings and collapsed crown pillars would be filled to surface, crowned and capped with materials to account for subsidence and to facilitate post-closure surface water drainage.

Selection of Preferred Reclamation Activities

In late 2005 - early 2006, Kinross applied to dispose of contaminated soils in the open stope in the West Zone portion of the Lupin orebody, as shown on Figure 12. Plan explanations (Kinross, 2006b) and responses to information requests (Kinross, 2006a) were submitted in August 2006. The open stope to the West Zone 87 Level varies in width between 2.0 and 4.0 m. The stope is open to the surface in two locations, and three additional surface pits approximately 7.0 m deep were developed in the West Zone crown pillar (approximately 17 to 20 m thick). This plan projected dumping into the two openings, developing three drop raises in the longest surface pit to access the open portion of the stope, and then filling the remaining pits. The plan projected 44,750 m^3 of contaminated material could be stored in these areas with voids projected in the upper level of the open stope due to angle of repose of the stored material.

For the FCRP, it is proposed to modify the previous plan for the West Zone disposal as shown on Figure 14. The modified plan would address the void areas and increase the storage capacity. Instead of developing additional drop raises in the remaining crown pillar for disposal, the new plan would be to blast down the remaining crown pillar, creating an open slope trench approximately 260 m in length and approximately 72 m deep. The bank volume of the remaining crown pillar is approximately 9,250 m^3. Assuming a 20% swell of this material, the West Zone open stope would have approximately 11,100 m^3 of crown material collapsed into the void. Using the projected material volumes from the 2006 Kinross underground storage plan, an average stope width of 3.5 m is projected. The new void combining stope areas 2, 3, 4, and 5 (from the 2006 Kinross plan) is projected to contain approximately 66,266 m^3, plus the volume in Area 1 (open to the 27 Level) of approximately 4,000 m^3

when filled to the surface, minus the 11,100m^3 of crown pillar swelled material, for a projected total area of 59,166 m^3 for the disposal of contaminated soil, waste rock and building materials. This updated plan provides 14,400 m^3 of additional storage, removes the large void areas under the remaining crown pillar, and effectively stabilizes the West Zone crown pillar.

Additional openings available for material storage include the mine haulage hoist shaft, fresh air raise, and the exhaust raise. The mine description from historic reports includes these three shafts. The hoisting shaft being 3.4 m by 3.4 m developed to a depth of 1,210 m. The fresh air raise being a 3.0 m diameter raised from the 890 Level to the surface from a ventilation drift in most of the upper haulage levels. This fresh air raise is projected to have 630 m available for disposal material. The exhaust raise being 3.4 m by 3.4 m developed in raises from the 890 Level to the surface from a ventilation drift in most of the upper haulage levels. The exhaust raise is mostly vertical from the 87 Level to the surface and angled in the range of 64° to 77° in the levels from the 650 level to the 87 Level, where availability for material disposal is likely from the surface for approximately 595 m down to the 650 Level. The extent of internal shaft support structures is not detailed for a more accurate estimation of potential storage capacity, so a conservative projection is estimated to be 80% of the shaft volume. The projected outer wall volume of the shaft and raises accessible from surface is approximately 19,873 m^3; projecting an 80% storage factor conservatively lowers the shaft and raise storage of soils and building materials to 15,900 m^3.

The combined underground disposal for the West Zone stope, the haulage shaft, the fresh air raise, and exhaust raise totals approximately 75,066 m^3 of underground storage volume.

Requirements to collapse the West Zone crown pillar include the pumping of water contained in the crown pillar surface pits. Pits 2, 4, and 5 are projected to have approximately 5,250 m^3 of open storage containing approximately 5,250 m^3 of water. The quality of this water will be sampled to ensure compliance with water license discharge criteria prior to discharge at a controlled rate to the environment release. If this water is not suitable for release it will be returned to the mine void via the main haulage shaft or exhaust shaft, or pumped to the Upper Sewage Lake for treatment.

Explosives required to collapse the West Zone crown pillar were projected based on a 2.56 specific gravity (SG) ore body crown pillar and a powder factor of 0.44 (kg/tonne) to determine the kilograms (kg) of explosives required. Approximately 9,260 m^3 of West Zone crown pillar volume was estimated from the 2006 Kinross underground storage plan and the back calculation of stope width based on the area of the projected backfill volumes. The projected explosives required are approximately 10,400 kg to collapse the West Zone crown pillar.

Capping material required to cover the West Zone newly opened and backfilled stope will require approximately 3,300 m^3 of waste rock fill to prepare a 1.5 m thick mound over the backfill material in the stope with 3:1 side slopes. The waste rock fill will be covered with an additional 1.0 m of esker, requiring approximately 6,200 m^3. The final cover will be graded to a minimum of 2% slope to shed runoff, to avoid ponding and to conform to the surrounding landforms

Synthesis of Preferred Activities into a Reclamation Plan

The remaining West Zone crown pillar will be collapsed to provide additional disposal capacity and to prevent future post-closure stability problems. The main haulage shaft, fresh air raise, and the exhaust raise will be completely backfilled to prevent access. Site materials and equipment, waste rock, and hydrocarbon contaminated soils will be disposed of in these areas.

The ramp portal has already been sealed with a soil and rock plug and a locked fence has been installed to prevent access. The areas above the shaft and raises, and all remaining surface expressions of the underground workings, (including the portal area depression if additional backfill material is needed), will be backfilled to above grade with waste-rock from surface and then capped with esker material.

Mobile equipment from the former mining operation was left underground. Any hazardous materials (e.g., batteries, fuel, lubricants etc.) were removed from the mine for disposal when the mine entered care and maintenance in 2006.

Management and Accountability Structure

As part of the underground disposal activities, a QA/QC program will be implemented. The purpose of the QA/QC program will be to verify that the disposal activities are implemented as planned. The scope of the QA/QC program will be developed prior to implementing the underground disposal activities; however, it is anticipated that it will generally include the following tasks:

- Monitoring the disposal of the PHC impacted soil and contaminated soil (Refer to Section 4.3.2.3) into the underground workings
- Monitoring the placement and grading of the waste rock to form the mounds over the backfilled crown pillar or surface openings
- Monitoring the placement and grading of the engineered cover over backfilled areas
- Documenting the results of the remedial works, along with the QA/QC program, in a report

Uncertainties and Information Needs

The current water levels within the West Zone pits and the chemistry of the water is not known at this time. It is therefore not known if the water could be displaced to surface. The water levels and chemistry will be confirmed once crews are on-site to execute FCRP activities to confirm the water management plan. The water levels within the open shafts will additionally be measured relative to the levels in the areas to be dewatered, to confirm that the water can be transferred to the underground workings.

The actual volume of waste rock, contaminated soils requiring underground disposal and the volume of building and site waste materials is uncertain and will require field confirmation. However, a contingency allowance has been developed within the various disposal strategies, including underground, in order to accommodate additional materials. In addition, estimates for swell, compaction and void space have resulted in an assumed fill factor of 80% when placing materials underground.

Underground disposal capacity volume estimates are based on historical mine plans and Lupin Mines reports that have not been independently verified. These reports indicate that lower portions of the stopes have likely accumulated bridged material; however it is uncertain at what depth and volume. Disposal volume uncertainties have been factored into the disposal plans.

Monitoring, Maintenance, and Reporting Program

Geotechnical visual inspections will continue for a period of 3 years to ensure that the caps and fill materials remain in satisfactory condition and continue to effectively shed water.

Contingency Program

Mine water will be managed so that it is not displaced to surface and allowed to runoff overland. If necessary, the crown pillar depression will be pumped down sufficiently before waste materials are placed. This would involve pumping water out of the crown pillar to be transferred into one of the shafts.

Costs

An estimate of the costs associated with the closure and reclamation of underground workings was previously presented in the Closure Cost Update provided in October 2017 (Golder 2017b). The current plan for the underground workings will result in changes to the previous cost estimate as follows:

- Rather than constructing concrete caps in the shaft and raises as previously proposed, these openings will now be backfilled to above grade with waste rock and then covered with 1.0 m of esker material. This will reduce the costs.
- It was previously planned to access the underground workings through the portal. This would have required the backfilling of the portal once closure activities in the underground workings were completed. It is no longer planned to use the portal for access, so the existing portal plug will simply be left in place, so the costs of re-plugging will be eliminated.
- The previous cost estimate did not allow for the blasting down of the crown pillars. The costs will increase to cover the drilling and blasting of West Zone crown pillar rock. The blasting volume is estimated to be about 9,250 m^3. This will increase the costs.
- It may, as a contingency, become necessary to pump water out of the crown pillars prior to placing waste. This could involve costs for pumping the water into the shaft.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.5 Borrow/Quarry

Project Description

The various borrow and quarry facilities are described in Section 2.4.2. The Finger Lakes esker borrow area is the largest area that has been disturbed by borrowing activities, and this area will increase in size due to its future use for the implementation of closure measures. The other borrow areas within the TCA area are small and they have been inactive for a number of years. The two existing bedrock quarry areas are small and inactive and there are no plans to use these areas further during closure implementation.

Reclamation Objectives and Closure Criteria

The objectives for reclamation of the borrow and quarry areas are: to establish physical stability, to remove hazards to wildlife, and to encourage the eventual restoration of natural habitat.

Northern Considerations

Ponding in borrow areas should be avoided because it could result in degradation of the permafrost in the underlying soils. Near vertical slopes in bedrock quarries could present a hazard to caribou, so these slopes should be flattened. Considerations regarding revegetation are discussed in Section 4.3.2.2.

Listing and Assessment of Possible Reclamation Activities

The reclamation activities for borrow areas and quarries are a matter of implementing standard good practice. Section 4.3.2.2 discusses the possible approaches to revegetation in the harsh barren lands environment.

Synthesis of Preferred Activities into a Reclamation Plan

After completion of restoration plans at the mine and tailings impoundment, the final contour of the esker borrow areas will be regraded to be compatible with the natural topography and to control potential erosion through sloping. The bases of the borrow areas will be graded so that they do not pond water. The surfaces will be ‘roughed’ with dozer cleats or otherwise scarified to enhance the natural re-establishment of indigenous vegetation.

For the small bedrock quarries, excavators will be used to make the backslopes gentler. This will involve mechanically pulling down loose rock off the backslopes and arranging it in the bottom of the quarries. Because these areas are bedrock outcrops, there will be no need to encourage revegetation.

Management and Accountability Structure

Earthworks contractors who are using the borrow areas, for example to complete the gravel covers in the TCA and mill areas, will be required to regrade the borrow area at the end of their contract. This requirement will be written into the project specifications, and compliance will be verified as part of the contract completion inspection.

Monitoring, Maintenance, and Reporting Program

It is possible that and concentrated surface runoff could result in localized erosion of the regraded surface in the borrow areas. As part of post-closure site inspections, the former borrow areas will be inspected. Observations will be included in the general inspection report.

Contingency Program

If, during post-closure inspections, minor erosion features are observed, these will be repaired, for example by back blading with a dozer. If more severe or persistent erosion features are noted, then appropriate repairs will be implemented, such as redirection of runoff by constructing berms and swales, localized placement of rip rap, etc.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) did not include any specific allowance for the reclamation of borrow and quarry areas. A cost allowance for this work will be added in a future estimate. These costs are expected to be small because, as discussed above, contractors using the borrow areas will be required to regrade the pits at the end of their usage.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.6 Open (Crown Pillar) Mine Workings

The discussion of Open Mine Workings has been integrated into Section 4.3.2.4.

4.3.2.7 Waste Rock

Project Description

As discussed in Section 2.4.3, about 1,000,000 m^3 of waste rock was brought up from underground during mining and most of this rock was used for construction of pads around the mine and mill area. Mine operations did not produce any stockpiles of overburden or unprocessed low grade ore.

The geochemical characterization of the waste rock is discussed in Section 2.2.2.2. Geochemical testing to date indicates that approximately 67% of the combined (2006 and 2017) waste rock dataset are classified as PAG. The PAG samples were not concentrated in one area; rather, the PAG samples were distributed throughout the site. In addition, much of the sulphur present in the waste rock was in the form of sulphate rather than sulphide, indicating that oxidation of the waste rock was well advanced.

Objectives Reclamation Objectives and Closure Criteria

Given the advanced state of oxidation of the waste rock, the main objective of the reclamation should be to limit the contact between the waste rock and surface runoff (as opposed to limiting oxygen flux to the waste rock).

Northern Considerations

Given the deep permafrost conditions at the Site, materials (including waste rock) that are placed into the mine workings through the shafts or open crown pillars can be expected to freeze back. Once they are frozen, there will be little or no interaction with surface water or groundwater.

Waste rock that is left in place, and waste rock that is placed in the landfill will remain frozen for most of the year. By the end of each summer, the thaw depth will extend through the 1.0 m thick esker cover. Nonetheless, most of the surface runoff will occur around the time of the spring freshet, while the cover is still at least partially frozen. With grading for positive drainage, the amount of infiltration through the cover will be small.

Listing and Assessment of Possible Reclamation Activities

The objective of limiting the contact between waste rock and surface runoff can be achieved by relocating the waste rock into the shafts or open crown pillar voids. Such backfilling would not only isolate the waste rock, but it would also serve to infill and stabilize the crown pillars and open stopes.

The space that can be made available in the crown pillar voids is however insufficient to accommodate the estimated 1,000,000 m^3 of waste rock. The realistic options for the remainder of the waste rock are as follows:

- To relocate it to the landfill where it would later be covered by 1.0 m of esker material; or
- To leave it in place, where it would be contoured to shed water and covered with a 1.0 m layer of esker material.

Selection of Preferred Reclamation Activities

There is not sufficient space available in the shafts and open crown pillars to accommodate all of the remaining waste rock. An adequate degree of isolation can be achieved by covering the waste rock in place or placing it into the landfill and covering it there.

Synthesis of Preferred Activities into a Reclamation Plan

The waste rock pads that are on surface in the mine and mill area will be remediated using a combination of two measures:

- As shown on Figure 10 the waste rock will be removed from some areas (generally around the perimeter of the mine mill area). The waste rock will be excavated, transported and then some of the excavated waste rock will be disposed of into the shafts, open crown pillars or the landfill. The remainder of the excavated waste rock will be relocated into the central area and used the grade the surface of the waste rock that is being left in place. Waste rock placed into the landfill will be covered by at least 1.0 m of esker material. The 1.0 m esker material cover will also be placed on top of any waste rock that is used to infill tops of the open crown pillars, and also on top of any rock that is left in place in the central areas. Waste rock which is not removed will be left in place, general in the central areas. The surface of the waste rock will be contoured to drain freely and then it will be capped with 1.0 m cover of esker material.

The general intention is to remove the waste rock from the perimeter areas where it is thin (i.e.,typically 1.0 m or less) and to leave thicker deposits in place. In some cases, it may be expedient to consolidate "islands" of thicker waste rock into the central covered area.

Section 4.3.2.3, includes a provision to excavate an estimated 16,300 m^3 of soil which has been classified as heavily arsenic impacted (i.e., arsenic concentrations greater than 4,000 mg/kg).and to dispose of it into the shafts or open crown pillars. These impacted areas will generally occur within the central waste rock area, and will likely involve soil and waste rock that are inter-mixed. In such a case, the two activities (i.e. contaminated soil cleanup and waste rock management) will be integrated. Once the excavation is completed, the area will be brought up to the desired final grade by relocating and regrading local waste rock. Then the regraded area will be capped with a total of 1.0 m esker material cover.

Management and Accountability Structure

Engineering drawings and specifications will be prepared to control the waste rock management activities. The contractor will be required to comply with these.

Uncertainties and Information Needs

The best estimate for the volume of waste rock is about 1,000,000 m^3; however this is uncertain. The in place density and final volume of the waste rock in the open crown pillars is also uncertain. These uncertainties in the mass balance can be dealt with by designing flexibility into the final grading plan for the Site.

Monitoring, Maintenance, and Reporting Program

A QA/QC program will be implemented to verify that the relocation, regrading and covering of the waste rock are implemented as planned. The scope of the QA/QC program will be developed prior to implementing the remedial activities; however, it is anticipated that it will generally include the following tasks:

- Monitoring the complete removal of waste rock from the applicable areas
- Monitoring the placement of waste rock into the shafts, open crown pillars or landfill to the correct grade
- Monitoring the final grading of the waste rock that is left in place to ensure proper drainage
- Monitoring the placement of the esker material cover with respect to thickness, gradation and compaction

Contingency Program

The area for waste rock removal shown on Figure 10 is only an estimate. The actual boundary will be established in the field based on the actual thicknesses of waste rock that are encountered. Similarly, the actual volume of waste rock is uncertain. This can be accommodated by adjusting the final grading plan for the waste rock left in place, while still providing for positive drainage.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included provisions for relocation of waste rock, for grading material that is left in place and for capping with esker material. These allowances are consistent with the approach described in this FCRP.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.8 Tailings Impoundment and Containment Systems

Project Description

As described in Sections 3.2.1 and 3.3.1, the tailings from Lupin milling operation were deposited within a number of cells in the Lupin TCA. In accordance with the approved TCA 2004 Final Abandonment and Restauration Plan (Final TCA ARP) (Kinross 2005), as of the end of the 2017 construction season, a 1.0 m esker material cover had been completed over approximately 1,311,500 m^2 of the exposed tailings. As of the end of 2017, there remains approximately 123,500 m^2 of exposed tailings in Cell 5 and 86,000 m^2 in Cell 3. LMI intends to complete the placement of the cover by the end of the summer of 2019 as part of the approved Care and Maintenance activities.

Several other actions are required to complete the permanent closure of the TCA. These include the permanent closure Water Management actions described in Section 4.3.2.13, treating and releasing water to permanently lower the water levels in Pond 1, Pond 2 and Cell 4, removing siphons and culverts, and constructing permanent open channel spillways through Dam 1A and J Dam to re-establish natural drainage through the TCA watershed. It is possible that lowering the water levels may expose small beaches of tailings below the former water level. The newly exposed areas will be examined and if any tailings are exposed, they will either be covered in place with a 1.0 m esker material cover, or they will be picked up and transported to another location in the TCA which will eventually be covered. While the closure water elevations have been designed to remain above placed tailings (Kinross 2005), additional volumes of esker cover will be available to account for any minor topographic highs or residual exposed tailings. A study conducted to assess the presence of recent windblown tailings adjacent to the TCA detected no deposition of tailings material on surface (SRK 2015), however if any are identified, they will be similarly covered with esker materials..

Post-Closure Reclamation Options

The closure options for the TCA have already been identified and considered. The initial Lupin Mine TCA Abandonment and Restoration plan, submitted in 2004, contemplated encapsulating the tailings within permafrost upon closure of the mine. The subsequent and currently approved Final TCA ARP (Kinross 2005) modified the tailings ARD mitigation strategy to encapsulation beneath a partially saturated granular cover. The detailed rationale for the selection is presented in a report titled Closure Plan for Lupin Tailings Containment Area, completed by Igor Holubec Consulting (Holubec 2005); included as Appendix 2 in the Final TCA ARP.

Following technical review with stakeholders LMI provided responses and the final TCA ARP was approved by the Board on August 19, 2015 on issuance of the Water Licence. (Refer to Part I, Item 1, b).

Synthesis of Preferred Activities into a Reclamation Plan

The key features of the Final TCA ARP partially saturated granular cover design are summarized below:

- A basal saturated layer of esker material that inhibits oxidation of the underlying tailings by limiting the oxygen flux through the saturated zone.
- A surface layer that restricts the rate of evaporation of the saturated esker and tailings materials.

The details of the many investigations in support of the saturated zone cover design are contained in the Final TCA ARP (Kinross 2005) and Closure Plan for Lupin Tailings Containment Area (Holubec 2005) reports.

The initial tailings cover program started in 1988. As summarized in Sections 3.2.1 and 3.3.1, much of the reclamation of the TCA has already been completed as Progressive Reclamation or Post-Operational activities.

TCA activities for permanent closure that still need to be completed include:

- Removal of the tailings pipeline and disposal in the landfill
- Examine the emergency dump pond area to see if any tailings are still present. If so, remove the tailings and transport them to the TCA in an area to be covered
- Complete the covering of the remaining exposed tailings with the 1.0 m esker material cover
- Inspect to see if any small areas of tailings are exposed when the water levels are lowered. If so, either cover the tailings in place or move them to locations which will eventually be covered
- Demolish the treatment plant and dispose of the debris in the landfill
- Install additional instrumentation to complete the permanent monitoring system

Management and Accountability Structure

As part of the TCA closure activities, a QA/QC program will be implemented. The purpose of the QA/QC program will be to verify that the Final TCA ARP closure activities are implemented as planned. The scope of the QA/QC program will be developed prior to implementing the TCA closure activities; however, it is anticipated that it will generally include the following tasks:

- Monitoring the performance of the tailings cover using the existing instrumentation together with new instruments to be installed in 2018
- Continued implementation of Care and Maintenance QA/QC procedures to ensure the cover is constructed according to the Final TCA ARP, which includes construction spot checks and survey controls
- Inspection and monitoring of the existing instruments to ensure the tailings dams are performing according to the Final TCA ARP
- Monitoring of TCA contained water prior to discharge to the environment

Monitoring, Maintenance, and Reporting Program

LMI collected data during mine operations to monitor the tailings cover performance. The collected data included ground temperatures, water levels within the cover, water quality within the cover, slopes of the tailings surfaces, thicknesses of tailings deposition, moisture contents of the cover materials, and particle size analyses of the tailings and cover materials. During the Care and Maintenance period, TCA monitoring activities, as described in Section 3.2.1, were carried out appropriate to the resources and time available on-site.

The thermistors are currently being monitored in the summer months during maintenance activities and during the annual TCA geotechnical dam safety inspections; current to 2017.

As outlined in Section 5.0, Phase 1 Active Closure Period monitoring will include installation of new thermistors and soil moisture and temperature probes in 2018 and TCA monitoring will be carried out for a period of 2.5 years, as follows:

- All thermistors will be read monthly
- Discharge water quality monitoring will be in accordance with water license requirements
- As observed during the most recent annual dam safety inspection (Norwest 2017a), the thermistors indicate that the frozen cores of the dams are intact and performing in a satisfactory condition. Groundwater seepage is not anticipated under permafrost conditions. LMI will complete a one-time geophysical survey along selected dams to confirm the lateral condition of the frozen cores. The existing thermistors could be paired with soil moisture sensors (discussed below), which would indicate any potential seepage to the environment;
- Soil moisture sensors will be installed in the tailings cover to provide additional monitoring of the saturation level and groundwater quality above the permafrost within the cover. The sensors will measure volumetric water content, ground temperature, pH, and electrical conductivity. Multiple sensors will be installed in a string at different depths and paired with data loggers for daily measurement collection. Porewater samples will be collected during initial installation to correlate key water quality parameters with the collected data. The sensor will allow the determination of the depth of the saturation zone and the porewater water quality (i.e., pH and conductivity) above the permafrost within the cover. Qualified personnel will review the soil sensor data to monitor the cover performance; and
- The existing groundwater monitoring pipes will be evaluated to determine their existing condition and their performance in 2018. If these pipes are in satisfactory condition, groundwater sampling and quality monitoring will be carried out monthly during site activities. However, if the pipes are deemed in non-satisfactory condition, they will be decommissioned.

Uncertainties and Information Needs

As shown on Figure 5, there are a number of areas within Cells 1, 2, 3 and 5 which are labelled as “Tundra”. It is understood that there are no tailings in these areas of exposed tundra; therefore it is not necessary to construct the cover over them. While the closure water elevations have been designed to remain above placed tailings (Kinross 2005), it is possible that lowering the water level in Cell 4 may expose small beaches of tailings or topographic highs. No tailings have been placed in Pond 1 or Pone 2, however all tundra and newly exposed areas will be examined and if any tailings are exposed, they will either be covered in place with a 1.0 m esker material cover, or they will be picked up and transported to another location in the TCA which will eventually be covered.

A study conducted to assess the presence of recent windblown tailings adjacent to the TCA detected no deposition of tailings material on surface (SRK 2015), however if any are identified, they will be similarly covered with esker materials.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included provisions for all of the closure measures listed above, except for the cleanup of the emergency dump pond, should this be found to be necessary. These allowances are consistent with the approach described in this FCRP.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.9 Buildings and Equipment

Reclamation Objectives and Closure Criteria

The goal of specific restoration practices is to minimize, or preferably eliminate degradation of disturbed areas and to initiate, encourage and accelerate the natural recovery. All buildings (except as required for ongoing monitoring) will be demolished and the Site will be regraded to resemble the regional terrain.

Post-Closure Reclamation Options

There is equipment in the mill that could, in principle, be re-used at another mine site. Also, there are materials, such as steel, copper and stainless steel that potentially have value as scrap. LMI will support salvage of equipment and recovery of scrap wherever it is economical to do so. Unfortunately, because the Site is so remote, these opportunities are expected to be limited. Equipment and materials that cannot be economically removed from the Site will be disposed of on-site.

Listing and Assessment of Possible Reclamation Activities

Demolition of the buildings on-site will produce a substantial volume of non-hazardous solid waste. Because of the long winter road access, it would not be feasible to haul this waste material to off-site disposal in Yellowknife, so it must be disposed of on-site. The options for onsite disposal are to deposit the waste into the shafts or open crown pillars or to deposit it into the existing landfill. To provide sufficient capacity, both options will be used together. An esker material cap will be constructed over the landfill and also over the backfilled crown pillars.

Synthesis of Preferred Activities into a Reclamation Plan

Mobile Equipment

Mobile equipment associated with the underground mining activities were previously drained of fluids and left underground. All hazardous waste was removed from the underground workings before the portal was backfilled. This equipment will be left underground.

There is an existing fleet of surface mobile equipment, including: pickup trucks, busses, haul trucks, excavators and dozers. This equipment has been maintained for ongoing use in care and maintenance and it will continue be used to support the active closure measures. Additional mobile equipment will be brought from Ulu Mine to add to this fleet. After active closure is completed, a small subset of this equipment fleet, (possibly just a single excavator, haul truck, and dozer), will be left on-site in case repairs are necessary in the future. All other mobile equipment will be demobilized over the winter road where it is economical to do so. Equipment that cannot be economically demobilized, will be drained of fluids and then disposed of into the shafts, open crown pillars or into the landfill.

Hazardous Building Materials

Golder (2017c) completed a survey of ACM in the buildings on-site. The survey included obtaining and testing 299 samples. ACM was identified in 46 of the samples taken from a number of buildings, mostly in vinyl flooring, duct mastic, window caulking and fire stop. ACM will be removed by a HazMat crew before general demolition proceeds and it will be buried safety in the landfill. Disposal of waste asbestos is specifically permitted under the Waste Management Plan (LMI, 2016).

As discussed in Section 2.2.1, it was noted that additional common hazardous building materials are likely present. An intrusive hazardous building materials assessment will be completed prior to any demolition activities to properly identify and quantify potentially hidden and additional potential hazardous building materials. These materials will be removed by a HazMat crew before general demolition proceeds. Materials, (such as fluorescent light tubes, ozone depleting substances, etc.), which are not permitted to be disposed in the landfill will be shipped off site for disposal.

Mill Complex

The existing buildings and equipment are described in Sections 2.4.5 and 2.4.7.

Following cessation of operations, the mill portion of the complex was given a complete wash down with the intent of gold recovery (visible gold that settles within the system) and removal of any residual contaminants (from chemical use) to the tailings impoundment. The crusher area was normally washed down on a regular schedule while operating, and a wash down will also be completed prior to demolition.

All equipment and internal components inside the mill will be dismantled and removed from the building. These will either be transported off-site for use at other facilities or sold as scrap where possible. Non-hazardous materials with no practical value as salvage or scrap will either be deposited into a shaft or an open crown pillar or buried in the landfill. The metal frame structure will be dismantled and sold as scrap where possible. Below grade concrete foundations will remain in place. The floor slabs will be punched with a hoe ram and then covered with esker material and contoured to provide positive drainage. All concrete footwalls which interfere with final grading of the soil surface cover will be collapsed.

Paste Backfill Building

Equipment from the former paste plant has already removed for resale or scrap. The steel frame structure has been removed. The residual waste cement has been disposed within the mine workings. The concrete floors and footwalls were left in place and were used in the construction of the landfarm.

Administration/Warehouse

These areas will have all salvageable/hazardous materials removed prior to dismantling. Demolition will take place in a similar fashion to the mill building and all materials that cannot be salvaged or sold as scrap will be disposed of into the open crown pillars or into the landfill.

Power House

The powerhouse facility is now redundant. The emergency power house will remain to provide power requirements during later stages of reclamation. The camp generators located adjacent to the 600 wing of the accommodation buildings will provide sufficient power generation during final closure. An emergency back-up generator for the camp generator is in place during care and maintenance.

Power distribution throughout the site is both above and below ground. Above ground power lines would all be removed for salvage or disposal. Transformers containing low level PCBs were transported off site in 1994. No other oil containing PCB material is known to be present at Lupin.

Maintenance and Shops

All outbuildings will be evacuated, inspected for hazardous materials and dismantled for salvage or disposal. These include the: carpentry shop, surface storage garages, mobile maintenance shop, and warm and cold storage shops.

Explosives Magazine

The explosives storage magazine consists of a steel frame/metal clad building. During care and maintenance ANFO was removed from the Site. The numerous Sea-Containers used for the storage of stick powder and other blasting products have also been removed from the Site. The former explosives storage magazine will be dismantled.

A new temporary explosives magazine will be set up on-site to support the crown pillar blasting. After that work is completed, any residual blasting products will be removed from site and the new magazine will be cleaned up and dismantled.

Any debris will be disposed of in the shafts, in the open crown pillars or in the landfill.

Accommodation Facilities

The steel frame buildings will be dismantled and the debris will be disposed of in the shafts, open crown pillars or in the landfill.

Arsenic Treatment Facility

The steel frame/metal clad building will be removed from the TCA and disposed of within the surface landfill located at the mine site. All remaining components will be rewashed and salvaged, if economical, or disposed of in the surface landfill.

Fuel Storage

The amount of usable fuel that is required to complete closure is currently available at site in the Main Tank Farm. Any fuel that remains on-site after the completion of closure will be burned. The empty tanks will then be withdrawn from service and disposed of in accordance with the *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations (2008) under the Canadian Environmental Protection Act.*

The STF was dismantled in 2016. In 2017, about 500 m^3 of PHC contaminated soil associated with it was placed into the landfarm where it is currently undergoing treatment. The treatment comprises volatilization through aeration and bioremediation with nutrient amendments of nitrogen and phosphorus. The Federal Guidelines for

Landfarming Petroleum Hydrocarbon Contaminated Soils (Government of Canada, 2006) will be consulted during the bioremediation process.

The Main Tank Farm area will be stripped of any fuel laden sand to be deposited into the shafts or open crown pillars.

The underlying geomembrane liner material will either be disposed of into the open crown pillars or utilized below a soil cover disposed in the landfill. Foundation material will be surveyed for hydrocarbon contamination. The remainder of the Site would be graded to conform to the surrounding natural topography and to provide positive drainage.

As discussed in Section 2.2.1, approximately 35,200 m^3 of hydrocarbon impacted soil was identified at 13 locations across the Site. These areas comprise historical maintenance, fueling, and fuel storage areas. The development of site-specific soil quality remediation objectives for petroleum hydrocarbons, such as those approved for by the NWB at the Nanisivik Mine in 2015, will be considered (Hemmera 2015). All impacted areas will be remediated according to the Nunavut *Environmental Guideline for Contaminated Site Remediation* (GN, 2009).

In addition to impacted material located within fuel storage areas, any on-site areas identified as impacted during abandonment and restoration (i.e., visible staining due to petroleum spillage) will be remediated according to these same contaminated site remediation guidelines.

Where the results of spills or incidents pose an immediate or ongoing risk to the environment, LMI will employ the *Spill Contingency Plan* and clean up or remediate soils or other species in a timely manner, prior to final reclamation.

Chemical Storage

During operations, the mine site carried an inventory of chemicals which include; cyanide, lime, lead nitrate, zinc dust, flocculants and ferric sulphate in major quantities, together with miscellaneous refinery reagents in much lesser quantities. Except for lime, (which is still used for water treatment), all of these chemicals have since been removed from the site.

The environmental site assessments (Morrow 2006; Golder 2017a) have delineated areas of chemical contamination of soils related to chemical storage and use. Section 4.3.2.3 describes the methods proposed to deal with this contamination.

Tailings Lines

The tailings line has been flushed thoroughly with clean water and then partially dismantled, but left in place. If salvageable, the pipe will be sold and shipped off-site with equipment back haul. If salvage is not viable, the piping will be disposed of in the landfill.

The tailings line foundation will be generally left intact with the exception of areas where drainage is controlled by culverts. The removal of culverts and the backsloping of the openings will ensure that minimal erosion takes place and proper drainage is achieved. Any other areas of water pooling along the tailings lines during spring melt will be opened up to provide unlimited drainage. The management of PAG material in the tailings line foundation and elevated metal concentrations in the adjacent soil will be as described in Section 4.3.2.3.

Management and Accountability Structure

An intrusive survey of hazardous materials will be carried out. Materials that are identified, together with ACM, will be removed for safe disposal by a qualified HazMat contractor.

The demolition of buildings will be carried out by a qualified demolition contractor. LMI will hire an independent supervisor to oversee the demolition process and to verify the proper disposal of the demolition waste.

Uncertainties and Information Needs

The quantities of ACM and other hazardous materials discussed in Section 2.2.1 are estimates only based on the results of the Phase I and Phase II environmental site assessments. The actual quantities will vary. The post-demolition volume of the demolition debris is not known, and it will vary depending on the extent of salvage and scrap removal.

Monitoring, Maintenance, and Reporting Program

The LMI appointed supervisor will oversee the actions of the Hazmat and demolition contractors. He will also document the quantities and disposition of the waste materials. He will also verify that the final granular cover surface meets specifications in terms of: grading, minimum thickness and gradation. The results will be documented in annual Reclamation Completion Reports.

Contingency Program

If the quantity of hazardous materials and demolition debris exceeds predicted volumes, the existing solid waste landfill will be extended and/or raised to accommodate the actual volumes.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included provisions for all of the closure measures listed above. These allowances are consistent with the approach described in this FCRP.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.10 Transportation and Infrastructure Support

Reclamation Objectives and Closure Criteria

The main objectives will be to restore the drainage pattern that existed prior to mining activities and to encourage the natural revegetation of transportation and infrastructure components.

Listing and Assessment of Possible Reclamation Activities

It would be possible to remove all fill materials that were placed for the construction of roadways. However, this would make it difficult to access the TCA and the esker borrow area if emergency repairs became necessary at some time in the future. Also, permafrost will have aggraded up into the roadway fills. Removing the roadway fills could result in degradation of the underlying tundra landform.

Synthesis of Preferred Activities into a Reclamation Plan

A considerable amount of roadway exists at the mine with the largest portion being the access to the explosives magazine and the access road to the Fingers Lake esker. The roadways were constructed in part with mine development waste rock. The management of PAG material in the roadways is described in Section 2.2.2.2. The ESA conducted in 2005 indicated that the median arsenic concentration in the roadways was 136 mg/kg and that the background concentration for the Lupin area was 179 mg/kg (Morrow 2006). Based on the preceding, the site roads will be reclaimed without a soil cover. In order to gain a better understanding of the ecological implications of this reclamation strategy, a risk assessment will be conducted to evaluate the likelihood of adverse ecological/environmental effects occurring based on future use of the property. The risk assessment will be completed during final reclamation and closure planning. Site-specific soil quality remediation objectives for metals would be derived from the ecological risk assessment.

Roadways that are currently active will be generally left intact so that construction equipment could access the TCA and the esker borrow area should emergency repairs become necessary in the future. Future access notwithstanding, culverts will be removed and the resulting openings will be backsloped to ensure that minimal erosion takes place and proper drainage is achieved. Any other areas of water pooling along the roads during spring melt would be opened up to provide unlimited drainage.

The roadways are probably the third most prominent feature change (next to the TCA and Mine Site) at the mine and will remain clearly visible for an indefinite period of time. In order to promote natural growth of vegetation, the road surfaces would be scarified to provide microclimate sites for seed deposition.

The main airstrip will not be removed; however access roads will be cut and backsloped to allow uninhibited drainage along its parallel. All ancillary equipment including signs, marker lights, strobes (associated wiring) and weather station/traffic control building will be dismantled and removed. The major components consisting of the radio beacon VOR (VHF Omni Range) and tower (Non-direction Beacon) will be removed unless other arrangements are made through the appropriate governmental agency.

Fresh Water Supply

Upon closure the building, electronics, pumps and approximately 1.5 km of six inch insulated pipeline will be removed and salvaged where possible. The docks will be removed, however the breakwater and causeway will be left in place due to the increased disturbance that the lake would incur during removal and because of its potential for post-closure use. Non-salvageable materials would be disposed of either into the open crown pillars or in the landfill.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included provisions for all of the closure measures discussed above. This includes a provision for a final treatment of 1.786 Mm^3 of pond water.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.11 Landfills and Other Waste Disposal Areas

Project Description

The waste management facilities used at the Site are described in Section 2.4.6, the facilities include: a landfill, an incinerator, two burn pits, a waste oil storage, and a boneyard. There is also a landfarm onsite. The proposed reclamation for the landfarm is provided in Section 4.3.2.12.

The sewage facilities are described in Section 2.4.7.6.

The proposed reclamation for the waste oil storage is provided in Section 4.3.2.9.

Reclamation Objectives and Closure Criteria

The objectives for the reclamation of the landfill and other waste disposal areas are: to control erosion, to remove hazards to wildlife, and to encourage the eventual restoration of natural habitat.

The landfill will be covered with inert esker material and graded to promote positive drainage of surface runoff, to prevent water ponding on the surface, to provide erosion control around the perimeter and to prevent future human or animal contact with the covered wastes. If ashes from burned material are encountered elsewhere on the Site, the ashes will be transported and disposed of at the landfill and covered as described.

Listing and Assessment of Possible Reclamation Activities

The reclamation activities for landfill and other waste disposal areas are a matter of implementing standard good practice. Section 4.3.2.2 discusses the possible approaches to revegetation in the harsh barren lands environment.

Synthesis of Preferred Activities into a Reclamation Plan

Sewage Facility

Upon closure of the sewage facilities, the steel pipeline will be flushed with clean water, dismantled and disposed of within the open crown pillars or in the surface landfill. The dam structure between the upper and lower sewage lakes will be breached at the culvert location (lowest natural location) and backfilled with rip-rap to provide erosion control. Backslopes in the dam cut will be graded to reduce erosion at the water level. A spillway will be constructed in the dam at the lower lake.

Incinerator

The incinerator will continue to be used to incinerate combustible, inert solids during closure and reclamation in accordance with the *Waste Management Plan (Solid and Hazardous)*. Ash from the burning operations will be placed in drums as per current practices and buried in the landfill. The incinerator will be dismantled for salvage or disposed of with other scrap metal. The concrete block building will be dismantled and disposed of on-site.

The burned material (ashes) in the landfill will be covered with 2 m of ash free non-hazardous waste material and finally capped with 1 m of inert esker material. If ashes from burned material are encountered elsewhere on the site, the ashes will be placed in drums, transported and disposed of at the landfill and covered as described.

Landfill

The volume of waste generated by closure, especially building rubble, will exceed the volume that can be disposed of in the landfill with its current footprint. The landfill footprint will therefore be expanded. The landfill will be utilized for waste disposal until closure is near completion. At that time, waste rock will be used to infill any voids in the waste and then more waste rock will be placed on top of the waste to form a stable final surface contour, which is graded to promote positive drainage of surface runoff, to prevent water ponding on the surface, to provide erosion control around the perimeter and to prevent future human or animal contact with the covered wastes. The waste rock cover already placed over the closed areas of the landfill will also be capped with 1 m of inert esker material as some of the waste rock material could be PAG.

The burn pits and boneyard areas will be regraded to promote positive drainage of surface runoff.

Management and Accountability Structure

Engineering drawings and technical specifications will be prepared for the final grading of the landfill and for the construction of the landfill cover.

Monitoring, Maintenance, and Reporting Program

As part of post-closure site inspections, the reclaimed areas will be inspected. Observations will be included in the general inspection report.

The landfill does not require a full-time attendant. A landfill inspector will be appointed to undertake periodic inspections of the landfill operations to identify deposition sequencing based on volumes of waste, verify compliance with the *Landfill Management Plan*, including observations of unsuitable materials and corrective actions, wildlife sign, evidence of erosion, ponding or unusual landfill settlement, and adequacy of safety measures.

It is expected that the volume of leachate from the landfill after closure will be small because the grading of the landfill and the use of the esker cover will reduce infiltration. This is particularly so because much of the runoff will occur during the freshet while the bottom part of the granular cover is still frozen. Monitoring requirements for seepage from the landfill are described in the *Liquid Waste Management Plan.*

Contingency Program

If, during post-closure inspections, minor erosion features are observed at the regraded areas and/or landfill cover, these will be repaired, for example by back blading with a dozer. If more severe erosion features are noted, then appropriate repairs will be implemented, such as redirection of runoff by constructing berms and swales, localized placement of rip rap, etc.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included provisions for all of the closure measures listed above. These allowances are consistent with the approach described in this FCRP. The current cost estimate includes a lump sum allowance for the operation and capping of the landfill. The next cost estimate will include a more detailed estimate of the landfill closure cost taking into account its increased footprint.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.12 Landfarm

Reclamation Objectives and Closure Criteria

As described in Section 2.4.6, LMI submitted as-built documentation of the pilot landfarm design and operational procedures to the NWB in the summer of 2017, as part of the license modification requirements. The objective of the pilot landfarm facility is to provide a contained facilities to utilize biological treatment and volatilization to remediate the PHC impacted soils which was removed from the STF in 2017. A secondary objective is to create soil for site maintenance and closure soil cover. The closure criteria for the landfarm treated soil will be met when the soil is sampled and analyzed as compliant with the treatment objectives outlined in the Lupin Water License.

Northern Considerations

The harsh climate at the site limits the period of time each year that the bioremediation process is effective. Monitoring is in place to determine when bioremediation will be completed.

Selection of Preferred Reclamation Activities

As discussed in Section 4.3.2.3, the existing pilot landfarm is currently being used to bioremediate about 500 m^3 of PHC contaminated soil from the STF. This will continue until the soil meets its objectives. The capacity of the existing landfarm is too small to remediate the estimated 35,200 m^3 of PHC contaminated soils in a realistic time frame. It is also impractical to construct enough additional landfarm capacity to bioremediate the PHC contaminated soils within the planned 2 to 3 year closure period. For this reason, PHC contaminated soil will be excavated and moved into the open crown pillar voids for isolation.

Synthesis of Preferred Activities into a Reclamation Plan

The PHC impacted soil currently in the pilot landfarm cell will continue to be remediated according to the Nunavut *Guideline for Contaminated Site Remediation* (GN, 2009). The remainder of the PHC contaminated soil that will be excavated will be deposited into the shafts or open crown pillar as discussed in Section 4.3.2.3.

Management and Accountability Structure

A QA/QC program was in place during the construction of the existing pilot landfarm. Norwest (2017b) provided as-built documentation for the pilot landfarm.

Monitoring, Maintenance, and Reporting Program

The general operational procedures after placement of the PHC impacted soil within the landfarm include aeration, moisture content adjustment as necessary, application of fertilizer as necessary, and monitoring. The treated soil will be sampled and analyzed for compliance with the treatment objectives outlined in the Lupin Water License. Additional details regarding operation of the landfarm facility and leakage detection pipe are included in the Norwest document titled “As-built Document for the Pilot Landfarm at Lupin Mine”, submitted to the NWB in November 2017.

It is expected that the PHC contaminated soil currently undergoing treatment in the pilot landfarm will meet objectives within about two years. At that time, the treated soil will be removed and used for site remediation. Specifically, it may be used for site regrading or for localized capping. Once it has been emptied, the landfarm cell will be demolished, hoe rammed and capped in the same manner as the other buildings on-site (Section 4.3.2.9).

Contingency Program

If the soils the pilot landfarm do not meet the treatment objectives within two to three years, the soils will be removed and deposited into the open crown pillars.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included a provision to treat 32,500 m^3 of PHC contaminated soils in landfarms on the site. Under the FCRP, only the 500 m^3 currently in the pilot landfarm cell will be bioremediated; the remainder will be deposited into the open crown pillars. This will have the effect of reducing the closure costs.

Closure and reclamation costs are discussed further in Section 6.0.

4.3.2.13 Water Management Systems

Reclamation Objectives and Closure Criteria

The closure objectives are to re-establish passive drainage from the TCA watershed while meeting closure water quality objectives.

Selection of Preferred Reclamation Activities

Water management in the TCA currently relies on human intervention to syphon water over J Dam and over Dam 1A. When required, treatment currently consists of adding slurried lime into Pond 2 before syphoning the water over Dam 1A. As the tailings cover is completed, there will no longer be contact between the tailings and surface runoff and acid generation will be controlled by the saturated zone near the base of the tailings cover. Once it has been documented that ongoing treatment is no longer required, water management it the TCA will be made passive by building spillways to re-establish natural drainage through the TCA watershed.

Synthesis of Preferred Activities into a Reclamation Plan

In the TCA, the total watershed area is such that accumulation of spring meltwater takes place. Even though the climate is such that the rainfall and the lake evaporation are in near balance, the relatively the relatively large watershed results in an average annual increase in pond water elevation of approximately 0.5 m.

At final closure, two riprap spillways will be constructed, one through J Dam and one through Dam 1A, to permit passive water flow to the environment. Typical water elevations in the ponds, prior to and after annual discharge, are shown in Table 12.

Table 12: TCA Water Elevation

Facility	Before Discharge (m)	After Discharge (m)
Cell 4	486.8	485.0
Pond 1	484.6	481.0
Pond 2	483.0	480.0

Currently, a gated culvert located within the north arm of the Divider Dyke controls the flow of water between Cell 4 and Pond 1. The topographic channel between these two ponds is at 485 m elevation and will provide a natural gradient when the culvert is permanently removed during closure activities.

Ponds 1 and 2 are separated by J Dam, and water is presently transferred between from Pond 1 to Pond 2 using a syphon. After the final transfer of water into Pond 2, J Dam will be breached and a spillway will be constructed at an elevation of 481.0 m to permit controlled flow of water into Pond 2. Limiting maximum water level to this elevation will reduce the impoundment of water against Dam 3D and maintain a natural gradient for flow from the Cell 4 watershed. The final elevation of the water in Pond 2, following the syphon discharge to the environment, will be at a maximum of 480 m elevation. After final syphon discharge, the syphons will be removed and a spillway will be constructed through Dam 1A at an elevation of 480.0 m. This would allow any runoff from the spring freshet or from seasonal rain storms to drain passively from the impoundment area and flow through its original natural course via Seep Creek and eventually into Inner Sun Bay of Contwoyto Lake. At a maximum water elevation of 480 m, no water will be impounded against the sides of Dam 1A, Dam 2, or M Dam.

To reduce the water level in Cell 4 to 485.0 m, the existing gated culvert through the Divider Dyke will be removed and rip rap on geotextile will be placed in the resulting swale to protect against erosion.

Prior to construction of the two spillways, an evaluation of the water chemistry will be made to ensure that when outflow occurs, all water quality guidelines will be met. The outflow would amount to an estimated annual average water volume of approximately 250,000 m^3, with the majority of flow occurring in June and early July. As there is an elevation difference of approximately 3 m from the planned outflow to the receiving stream, the channel will be easily designed to prevent the migration by fish species (e.g. arctic grayling) into the tailings containment area through the use of a natural vertical barrier.

Management and Accountability Structure

Current water quality monitoring in the TCA will continue and the data will be analyzed to establish that treatment will no longer be required in the future. Only then will the two spillways be constructed.

Engineering drawings and technical specifications will be prepared for the two spillways.

QA/QC monitoring will be carried out while the spillways are constructed and the construction will be documented in an "as-built" report.

Contingency Program

If the water quality monitoring fails to establish that water treatment will no longer be required, then the construction of the spillways will be deferred and the current water management practice will be continued.

Costs

The Closure Cost Update provided in October 2017 (Golder 2017b) included provisions for all of the planned TCA water management measures discussed above.

Closure and reclamation costs are discussed further in Section 6.0.

4.4 Material Balance

Table 13 provides an estimation of the volumes of wastes that will be produced by the implementation of the final closure plan. It also provides the estimated disposition of the various waste materials into each of the following locations: the shafts and open crown pillars, the landfill and the central mass of waste rock which will be left in place and covered.

Table 13: Mass Balance for Disposal of Waste Materials

Volume Balance				
Waste		Disposal		
Description	Volume (m3)	Storage Available in Shafts and Crown Pillar (m3)	Underground Storage Left after Disposal (m3)	Disposal in Landfill (m3)
PHC Contaminated Soils	34,700	75,066	40,366	-
Contminated Soils (As Hotspots, PbNO3, CN)	16,700	40,366	23,666	-
Waste Rock from Mill Laydown Area	21,700	23,666	1,966	-
Waste Rock from Lumber Yard & Bone Yard	48,727	1,966	(46,761)	-
Asbestos Containing Materials	100	-	-	100

Volume Balance

and other HazMat				
Demolition Rubble	30,000	-	-	30,000
Mobile Equipment	540	-	-	540
Waste Rock for Contouring Landfill	10,650	-	-	10,650
Esker Material for Capping Landfill	13,500	-	-	13,500
Waste Rock for Infilling Voids in Landfill	500	-	-	as required
Waste Rock Left in Central Area to be Covered				965,184

4.5 Implementation Schedule

The proposed closure schedule for the Project is presented in Table 10. In order to meet the proposed schedule, some of the proposed closure activities should be carried out in 2018 and mainly during the warmest months; which normally occurs from June to September. These activities are identified under the “Preparation Work” Stage in Table 10. The majority of these activities, as also identified in the table, will be carried out under existing approved management plans, the Final TCA Closure Plan or in general the approved licences/permits. Table 10. The majority of these activities, as also identified in the table, will be carried out under existing approved licences/permits.

The schedule will be updated during the execution of the closure activities but will generally follow the present outline.

5.0 MONITORING

Post-closure monitoring of the Site will be required to confirm that the reclamation measures completed return the Site and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. The overall closure goal is supported by the three closure principles of Physical Stability, Chemical Stability and Future Use and Aesthetics for each component of the Project. The intent of the monitoring program is to collect sufficient information to assess the effectiveness of the remediation measures to achievement of overall closure goals and principles.

Monitoring of the site post-closure will progress in two distinct phases:

- Phase 1 – Active Closure Period
- Phase 2 – Passive Closure Period

The Active Closure Period (Phase 1) refers to the 2.5 year period during which active on-site reclamation work is completed. LMI projects the manpower presence at the Site will increase marginally during care and maintenance for active reclamation work. The increased presence of personnel on-site is anticipated for the reclamation period. Monitoring programs will be carried out by on-site personnel under the supervision and direction of Discovery Mining Services (DMS).

The Passive Closure Period (Phase 2) refers to the period of (5) years following the completion of active reclamation work. Environmental monitoring will be conducted to determine the success of the reclamation measures and confirm objectives have been achieved. Consistent with the Care and Maintenance phase, LMI does not project continuous manpower presence on-site during this Phase. Monitoring programs will be carried out during site visits under the supervision and direction of DMS.

Phase 1

LMI intends to continue implementation of closure measures already approved for the TCA and subject to approval of this FCRP forecasts Phase 1 monitoring to begin in the summer of 2018 and conclude in 2021.

Monitoring on-site during Phase 1 will include:

a) General Monitoring

The Water Licence (2AM-LUP1520) under Part J and Schedule J, specifies the conditions applying to monitoring that is required at the site until the current licence expires.

LMI commits to general monitoring include monitoring requirements established under the approved Lupin Care and Maintenance Plans dated March 2013, approved IARP (March 2013) and recent updates and recommendation related to monitoring addressed in the November 2017 IARP.

Water monitoring at the site will be conducted following the procedures outlined in the *Water Quality Monitoring Plan and Quality Assurance/Quality Control Plan* (LMI 2013). Water monitoring falls under General Monitoring and also included Environmental Effects Monitoring as defined in Section b) below.

Water quality monitoring stations, and frequency of monitoring are outlined in Table 14. Detailed parameters to be monitored are outlined in Table 15. Water monitoring stations are illustrated in Figure 12.

Field measurements of specific conductivity, pH, and temperature will be recorded whenever samples are collected by using a multi-meter (e.g., YSI 6-Series Multimeter). Water quality samples will be collected from specific sampling stations using a grab sampler or directly into bottles provided by an accredited analytical laboratory. Water quality samples will be analyzed by an accredited laboratory to appropriate detection limits (DLs). Samples from receiving waterbodies will be analyzed to DLs less than aquatic life guidelines while samples from on-site water may be analyzed to higher DLs. The specific limits will be provided once the analytical laboratory has been selected.

Samples will be collected following standard sampling protocol (LMI 2013). Samples will be collected by qualified personnel using suitable sampling equipment. Water samples for laboratory analysis will be filtered and preserved (as required), and stored in a cool environment before shipping to the laboratory. Quality control samples (i.e., blanks and duplicates) will be collected at a quantity of 10% of all samples collected.

Summaries of monitoring events will be provided in as outlined in Section e) below.

b) Environmental Effects Monitoring

In accordance with the requirements of the Metal Diamond Mining Effluent Regulations, LMI is required to complete a final EEM study. Based on the MDMER and requirements for the final study, and based on results of the Phase 5 EEM (summarized in Section 1.3), the next EEM field program should be conducted in 2019 with the study design submitted within six months of providing notice to ECCC.

c) Geotechnical Verification Monitoring (Temperature/Thermistor)

As discussed in Sections 4.3.2.4 and 4.3.2.8, geotechnical verification monitoring will continue at the TCA and take place at the mine site at all locations where waste has been deposited. Table 16 outlines the TCA existing and future (including planned 2018 installations) instrumentation monitoring. Instrumentation locations are shown in Figure 5.

d) Remediated Soils Verification Sampling

Confirmatory monitoring of soil quality will be conducted in areas where contaminated soils are to be excavated as part of remediation efforts. This sampling program will be design to confirm that the soil quality remediation objectives have been achieved.

e) Reporting of Results

Reporting of Results during Phase 1 with be as directed under the current Water Licence or as required by legislation. Consistent with current requirements LMI will summarize monitoring results in the Annual Report to the Board due March 31st each year for the previous calendar year. The Annual Report to regulatory agencies would include interpretation of all data collected including: water quality, ground temperatures, geotechnical inspections and a summary any other reclamation/closure studies completed by LMI during the previous calendar year.

Phase 2

Monitoring during the Passive Closure Period will be undertaken monthly as a series of brief site inspection expected to last 3-4 days each from June to September. LMI intends for these site inspections to coincide where possible with regulatory site inspection completed by any Inspector designated under federal legislation. LMI will provide 30 days notice of each monitoring inspection event to be undertaken.

Site inspections will be conducted similarly to those undertaken during Care and Maintenance (i.e. Monthly).

LMI proposes gradually decreasing the frequency of site inspections and or specific monitoring requirements as testing results obtained confirm predictions of chemical, physical stability. If results are not as predicted, additional monitoring, and/or remediation works will be undertaken by LMI.

Any additional information produced following the submission and acceptance of this FCRP will be incorporated into the Annual Report required under the Type A Water Licence and to other regulatory agencies (i.e. ECCC, DIAND, and KIA).

Table 14: Water Quality Monitoring Stations

Station	Description of station	Preparatory Work	Closure Phase		Post-Closure Phase					Parameter Group Code[see Table 14]: Frequency of Sample Collection in a Given Year
		2018	2019	2020	2021	2022	2023	2024	2025	
			Active Stage		Passive Stage					
LUP-01	Freshwater Intake from Contwoyto Lake	Yes	Yes	Yes	Only if still active					Volume: monthly totals Field, conventionals, metals, and biological: annually
LUP-10	Pond 2 discharge at Dam 1A	Yes	Yes	No	No	No	No	No	No	Volume, field, conventionals, metals, nitrate, nitrite and cyanide: daily during discharge Other (visible sheen Oil & Grease): daily during discharge Nutrients, radium: weekly during discharge Bioassay and Total Cyanide: monthly
LUP-10 (LUP-102)	Internal station in TCA Pond 2, approximately 100 m upstream from siphon intake	Yes	if water present	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium, and bioassay: prior to start of decant and termination of decant
LUP-14	Decant structure from the Sewage Lakes Disposal Facilities	Yes	Yes	Yes	Only if still active					Volume: monthly total Field, conventionals, nutrients, metals, biological, and other (biochemical oxygen demand): first day of discharge and monthly during periods of low flow
LUP-20	West end of Seep Creek before discharge into Unnamed Lake	Yes	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: weekly during discharge starting on day 1 of discharge
LUP-21	North end of Concession Creek before discharge into Unnamed Lake	Yes	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: weekly during discharge starting on day 1 of discharges Nitrate and ammonia: weekly at mid-depth Metals cyanide and radium: monthly at mid-depth and when bioassay sample is collected at LUP-10 just prior to termination of decant
LUP-22	Inner Sun Bay near center and midway between end of peninsula and west shore	Yes	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: weekly at mid-depth commencing one week prior to discharge and concluding two weeks after cessation of the discharge
LUP-24	Inner Sun Bay near narrows	Yes	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: weekly at mid-depth commencing one week prior to discharge and concluding two weeks after cessation of the discharge and when bioassay sample is collected at LUP-10 just prior to termination of decant Nitrate and ammonia: weekly at mid-depth Metals cyanide and radium: monthly at mid-depth
LUP-25	Outer Sun Bay (Total Rather than specific metals)	Yes	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: weekly at mid-depth commencing one week prior to discharge and concluding two weeks after cessation of the discharge
LUP-27	Bulk Fuel Storage Facility	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): prior to discharge and weekly during discharge
LUP-28	Discharge from the Landfarm Facility	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): prior to discharge and weekly during discharge
LUP-29	Landfarm Facility Monitoring Well – Up gradient	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly (June to September) when flow observed
LUP-30a	Landfarm Facility Monitoring Well – Down gradient	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly (June to September) when flow observed
LUP-30b	Landfarm Facility Monitoring Well – Down gradient	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly (June to September) when flow observed
LUP-31	Seepage from the Landfill Facility	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly when flow observed
LUP-32	Landfill Facility Monitoring Well – Up gradient	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly when flow observed

Table 14: Water Quality Monitoring Stations

Station	Description of station	Preparatory Work	Closure Phase		Post-Closure Phase					Parameter Group Code[see Table 14]: Frequency of Sample Collection in a Given Year
		2018	2019	2020	2021	2022	2023	2024	2025	
			Active Stage		Passive Stage					
LUP-33a	Landfill Facility Monitoring Well – Down gradient	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly when flow observed
LUP-34b	Landfill Facility Monitoring Well – Down gradient	Yes	Only if still active							Field, conventionals, nutrients, metals and other (oil and grease, benzene, toluene, ethyl benzene, xylene): monthly when flow observed
SCP-1	Seep Creek Pond EEM Station 1	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
SCP-3	Seep Creek Pond EEM Station 3	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
SCP-5	Seep Creek Pond EEM Station 5	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
FL-1	Fingers Lake EEM Station 1	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
FL-3	Fingers Lake EEM Station 3	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
FL-5	Fingers Lake EEM Station 5	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
R2-1	Reference Lake 2 EEM Station 1	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study
R2-3	Reference Lake 2 EEM Station 2	No	Yes	No	No	No	No	No	No	Field, conventionals, nutrients, metals, cyanide, and radium: once during final EEM study

Note: EEM = Environmental Effects Monitoring; FL = Fingers Lake; MDMER = Metal Diamond Mining Effluent Regulations; R2 = Reference Area 2; SCP = Seep Creek Pond; TCA = Tailings Containment Area

Table 15: Water Quality Monitoring Parameter Groups

Parameter Group Code	Specific parameters
Volume	Volume per day (discharged to the environment or withdrawn from the environment for use)
Field	Field measurements (pH, temperature, conductivity, dissolved oxygen[a])
Conventionals	pH, total suspended solids, alkalinity, hardness
Nutrients	Total ammonia, nitrate, and nitrite
Metals	Total aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, uranium, and zinc
Cyanide	Total cyanide
Radium	Radium-226
Biological	Fecal coliform
Bioassay	Acute toxicity tests (rainbow trout and Daphnia)
Other	Specified by station

Note: a - only measured at receiving environment stations

Table 16: Existing and Future Instrumentation Monitoring

Station	Location	Instrument Type	Approved Final Reclamation Work	Phase 1 (Active Closure Period)	Phase 2 (Passive Closure Period)
D1A-00-01S	Dam 1A	Thermistors	Monthly from 2000 through 2006, annually in the summer from 2009 through 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
D2-00-2N	Dam 2		Monthly from 2000 through 2006, annually in the summer from 2010 through 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
D3D-1	Dam 3D		Monthly from 2004 through 2006, once in the Summer of 2009 and annually in the summer from 2014 through 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
D4-1	Dam 4		Monthly from 1995 through 2006, annually between 2009 and 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
D4-2			Monthly from 1995 through 2006, annually between 2009 and 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
D4-3			Monthly from 1995 through 2006, annually between 2009 and 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
D4-4			Monthly from 1995 through 2006, annually between 2009 and 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
DK-3	Dam K		Monthly from 2004 through 2006, once in the Summer of 2009 and annually in the summer from 2014 through 2017	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
TC1-3	Cell 1 Cover		Monthly from 1995 through 2006, once in the Summer of 2009 and twice in 2015	Monthly during closure activities on site	Concurrent with site inspection (i.e June – September)
TC1-6			Monthly from 2003 through 2006, once in the Summer of 2015	Monthly in during closure activities on site	Concurrent with site inspection (i.e June – September)
TC1-7			Monthly from 2004 through 2006, once in the Summer of 2009 and thrice in summer of 2015	Monthly in during closure activities on site	Concurrent with site inspection (i.e June – September)
TC3-1	Cell 3		Monthly from 2004	Monthly in during	Concurrent with site

Table 16: Existing and Future Instrumentation Monitoring

Station	Location	Instrument Type	Approved Final Reclamation Work	Phase 1 (Active Closure Period)	Phase 2 (Passive Closure Period)
	Cover		through 2006, thrice in summer of 2015	closure activities on site	inspection (i.e June – September)
TC2-1*	Cell 2 Cover	Soil Moisture and Temperature Probes	N/A (to be installed in 2018 (Closure Year 1))	Weekly throughout the closure period via datalogger	Weekly throughout the closure period via datalogger (downloaded during site inspections)
TC3-2*	Cell 3 Cover			Weekly throughout the closure period via datalogger	Weekly throughout the closure period via datalogger (downloaded during site inspections)
TC5-1*	Cell 5 Cover			Weekly throughout the closure period via datalogger	Weekly throughout the closure period via datalogger (downloaded during site inspections)

* Instrument to be installed in summer of 2018. Location and station name are not yet confirmed.

6.0 POST REMEDIATION SITE AND ENVIORNMENTAL CONDITIONS

6.1 Post Remediation Site Conditions

Upon completion of the permanent closure and reclamation works described in Section 4.0, the physical status of the Lupin Mine site will be as shown on Figure 10 and Figure 11. The main points are as follows:

- All tailings in the TCA will be covered with 1.0 m of esker material and permanent monitoring instrumentation will be installed for the continued monitoring of site conditions.
- Water ponded in the TCA will be at long-term lowered water levels described in Section 4.3.2.13 and water will drain passively through spillways through J Dam and Dam 1A,
- The current buildings in the Mine and Mill area will have been removed.
- The mine and mill area will have been contoured to drain freely without ponding.
- All waste rock on surface will have been removed or covered with 1.0 m of esker material.
- All three mine shafts and open crown pillars will be backfilled to surface.
- The landfill witll be countoured to drain freely and it will be covered with 1.0 m of esker material.
- PHC contaminatwed soil will have been removed and disposed of into the mine workings.
- Contaminated soil (Arsenic hotspots and soils contaminated with lead nitrate or cyanide) will have been removed and disposed of into the mine workings.
- Borrow and quarry areas will have een remediated as described in Section 4.3.2.5.
- Roadways will have been scarified and culverts will have been removed to restore natural drainage.
- Except for a small fleet for maintenance purposes, all surface mobile equipment will have been removed or buried in the landfill.
- The PHC contaminated soil currently in the landfarm will be removed after treatment is completed and the landfarm will be demolished as descried in Section 4.3.2.12.

After closure, the former Lupin Mine site will resemble the lanform that existed before mining, except that the following facilities will remain:

- The TCA will remain in the form described above.
- The airstrip will be left in place for future use.
- The breakwater on Contwoyto Lake will be left in place for future use.
- Minor facilities will be left in place to facilitate future site monitoring and maintenance should this become necessary, likely including: the guest house, a small fleet of construction equipment and a temporary equipment shed/workshop.
- While the roads to the TCA and the esker borrow area will be scarified, the road beds will be left in place to facilitate maintenance should this become necessary in the future.

6.2 Post Remediation Environment Conditions/Post Remediation Risks to Human and Environmental Health

7.0 FINANCIAL SECURITY

7.1 Basis of Financial Security

On March 28, 2017 the Board issued Amendment No.1 to the Water Licence which was subsequently approved by the Minister on May 12, 2017 to amend the amount of reclamation security required under Part C of the Water Licence from $25.5 million to $34.65 million.

An updated estimate of the costs associated with the closure and reclamation was previously presented in the Closure Cost Update provided in October 2017 (Golder 2017b). This revised estimate is currently under review and no comments or questions have been received to date.

This FCRP contains several changes in approach relative to the updated cost estimate of October 2017. The current plan will result in changes to the previous cost estimate as follows:

- Rather than constructing concrete caps in the shaft and raises as previously proposed, these openings will now be backfilled to surface with waste rock and then covered with 1.0 m of esker material. This will reduce the costs.
- It was previously planned to access the underground workings through the portal. This would have required the backfilling of the portal once closure activities in the underground workings were completed. It is no longer planned to use the portal for access, so the existing portal plug will simply be left in place, so the costs of re-plugging will be eliminated.
- The previous cost estimate did not allow for the blasting down of the crown pillars. The costs will increase to cover the drilling and blasting of crown pillar rock. The blasting volume could vary between xxx and yyy m^3, depending on the requirements for stability and underground storage. This will increase the costs.
- It may, as a contingency, become necessary to pump water out of the crown pillars prior to placing waste. This could involve costs for pumping the water into the shaft Depending on the actual water levels, this could increase the costs.
- It is no longer planned to construct additional landfarm cells to bioremediate PHC contaminated soils; rather the excavated soils will be disposed of in open crown pillars for isolation; and
- The costs of disposing of excavated PHC contaminated soils into the open crown pillars will be less than managing them in landfarm cells.

7.2 Cost Liability

(Closure and reclamation cost liability schedule through the mine life)

7.3 Key Project Milestones

(Schedule of key project milestones for financial security planning refunds, recovery of security from Minister)

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FIGURES

APPENDIX A

List of Permits, Licenses, and Authorizations Required for Project

Table A-1: List of Permits, Licenses, and Authorizations Required for Project

Responsible Authority	Legislation	Authorization	Project Activity	Permitting Strategy/Timeline
Nunavut Impact Review Board	Nunavut Agreement Article 12 Nunavut Planning and Project Assessment Act (S.C. 2013, c. 14, s. 2)	Project Certificate – not applicable	Required to obtain requisite permits and approvals to proceed with Project	NIRB Screening Decision (NIRB 99WR053) issued 16 November 1999.
Kitikmeot Inuit Association	Nunavut Agreement Article 26	Inuit Impact and Benefits Agreement	Required to proceed with Project	Not Applicable – project entirely on Crown Lands
	Nunavut Agreement Article 20	Inuit Water Rights Compensation Agreement	May be required	
	Nunavut Agreement Article 6	Wildlife Compensation Agreement		
	Nunavut Agreement	Inuit Owned Lands - Commercial Land Use Lease	Access surface IOL to develop mine	
		Inuit Owned Lands - Quarry Concession Licenses	Extract aggregate on IOL	
Nunavut Water Board	Nunavut Agreement Article 13 *Nunavut Waters and Nunavut Surface Rights Tribunal Act* Nunavut Waters Regulations	Type A and B Water Licenses	Required for water use and waste disposal	Type A -Amendment for Final Closure to be filed concurrent with FCRP Type B – Camp Operations to support Closure 2BE-LEP1217 Pending Renewal)
Crown Relations and Indigenous and Northern Affairs Canada	*Territorial Lands Act* Canadian Mining Regulations- Territorial Land Use Regulations	Crown Land - Land lease and Water lot lease	Access surface Crown lands for the Project life	Lease Renewal Application filed pending determination from CIRNAC
	Territorial Quarrying Regulations	Crown Land - Quarry Lease/Permit	Extract aggregate on Crown Land	
Fisheries and Oceans Canada	*Fisheries Act* (Section 35(2))	Authorization under Paragraph 35(2)(b) of the *Fisheries Act*; required if serious harm to fish cannot be avoided. In instances in which serious harm to fish can be avoided,	Project activities directly removing or altering fish habitat: full lake dewatering, culvert installations, dam construction in watercourses, stream flow reductions and	General Application of DFO environmental protection measures No Authorization for the Project.

Table A-1: List of Permits, Licenses, and Authorizations Required for Project

Responsible Authority	Legislation	Authorization	Project Activity	Permitting Strategy/Timeline
		DFO may provide a letter of authorization in addition to compliance with Measures to Avoid Causing Harm to Fish and Fish Habitat.	potential water and sediment quality changes.	
Environment Canada	*Fisheries Act (Section 36)* Metal Mining Effluent Regulations	Notice of Closed Mine Status	Notice to be provided; Final Study design required not less than 6 months following notice.	Notice Pending
		Environmental Effects Monitoring	Implement EEM program	EEM initiated in 2005. Phase 5 complete
Natural Resources Canada	*Explosives Act* and Regulations Blasting Permits Explosive Magazine Permits Radio Licensing	Licence for a Factory and Magazine	Required for construction of explosives factories and magazines and storage of explosives	
GN Culture and Heritage	Nunavut Archaeological and Palaeontological Sites Regulations (Nunavut) *Nunavut Historical Resources Act*	Archaeology Permit	Required to conduct archaeology surveys and to mitigate cultural/heritage resources	Not required at this time.
Nunavut Research Institute	*Scientist Act* (Nunavut)	Scientific Licenses: Land and Water Social and Traditional Knowledge	Undertake non-biological and non-cultural heritage baseline and monitoring studies	Historical/TBD is this required for Final Study Design note one last summer for EEM work/Phase 1/2
GN Environment	*Environmental Protection Act* (Nunavut) Spill Contingency Planning and Reporting Regulations(Nunavut)	Approval of Spill Contingency Plan		
	Environmental Protection Act (Nunavut)	Hazardous Waste Generator		Generator No. XX
	Wildlife Act (Nunavut)			
GN Health and Social	*Public Health Act* (Nunavut)	Approval of camp facilities	Construction and operation of	

Table A-1: List of Permits, Licenses, and Authorizations Required for Project

Responsible Authority	Legislation	Authorization	Project Activity	Permitting Strategy/Timeline
Services	Camp Sanitation Regulations (Nunavut)		camp, medical facilities, buildings and propane storage	
	Emergency Medical Aid Act (Nunavut)	Medical facilities approval		
GN Community and Government Services	Building Codes (Nunavut)	Building Permits	Construction and operation of camp, medical facilities, buildings and propane storage	
	Fire Prevention Act (Nunavut) Fire Prevention Regulations (Nunavut) Propane Cylinder Storage Regulations	Approval of camp facilities and propane storage		
Worker's Safety and Compensation Commission of Nunavut - Mine Health and Safety	*Explosives Use Act* (Nunavut) Explosive Use Regulations (Nunavut)	Authorization to store and use explosives	Required to store detonators in a magazine	
	Mine Health and Safety Act (Nunavut) Mine Health and Safety Regulations (Nunavut)	Authorization to store and use explosives	Required to store detonators in a magazine	
	Worker's Compensation Act (Nunavut) Workers Compensation Regulations (Nunavut)	Authorization for Activities	Required to proceed with Project activities	Permit No. XX

IOL = Inuit Owned Land

APPENDIX B

Type A Water Licence and Land Lease Condition Concordance

Lease 76E/14-1-9 (Minesite, Tailings Containment Area) Section XX to XX of the lease document requires the lessee to:

- Lease 76E/14-2-10 (Airstrip) requires the lessee to XXXX
- Lease 76E/11-2-3 (Fingers Lake Quarry and access road) requires the lessee to XXXX
- Lease 76E/11-3-4 (Fingers Lake Waterlot – dock) requires the lessee to XXXX
- Lease 76E/14-10-3 (VOR Navigation aid Site) requires the lessee to XXXX

APPENDIX C

Glossary of Terms and Definitions

Glossary of Terms and Definitions

Term	Definition
Acid Base Accounting (ABA)	Acid base accounting; a static test that defines the amounts, and relative balance, of potentially acid-generating and acid-neutralizing (or base) minerals in a sample.
Active layer	The layer of ground above the permafrost which thaws and freezes annually.
Acid rock drainage (ARD)	Acidic pH rock drainage due to the oxidation of sulphide minerals that includes natural acidic drainage from rock not related to mining activity; an acidic pH is defined as a value less than 6.0.
Advanced mineral exploration	Any appurtenant undertaking in which the proponent requires a Type A or Type B water License in order to carry out the proposed activities.
Quarries and Granular Borrow Sites	Site from where soils and aggregates are obtained for use in earthworks construction.
Care and maintenance	The status of a mine when it undergoes a temporary closure.
Closure goal	The guiding statement that provides the vision and purpose of reclamation. Attainment of the closure goal happens when the proponent has satisfied all closure objectives. By its nature, the closure goal is a broad, high-level statement and not directly measurable.
Closure principles	The four core closure principles are 1) physical stability, 2) chemical stability, 3) no long-term active care requirements, and 4) future use (including aesthetics and values). The principles guide the selection of closure objectives.
Closure objectives	Statements that describe what the selected closure activities are aiming to achieve; they are guided by the closure principles. Closure objectives are typically specific to project components, are measurable and achievable, and allow for the development of closure criteria.
Closure options	A set of proposed alternatives for closing and reclaiming each mine component. The closure options are evaluated to determine the selected closure activity, which must be approved by the NWB.
Closure criteria	Standards that measure the success of selected closure activities in meeting closure objectives. Closure criteria may have a temporal component (e.g., a standard may need to be met for a pre-defined number of years). Closure criteria can be site-specific or adopted from territorial/federal or other standards and can be narrative statements or numerical values.
Contaminant	1) any physical, chemical, biological or radiological substance in the air, soil, or water that has an adverse effect; and 2) any chemical substance with a concentration that exceeds background levels or which is not naturally occurring in the environment.
Effluent	Contact water flows that may or may not require treatment prior to being discharged to the environment.
Engagement	The communication and outreach activities a proponent undertakes with affected communities and Aboriginal organizations/governments prior to and during the operation of a project, including closure and reclamation phases.
Environmental Site Assessment (ESA)	Phase I ESA: A review of available information to determine the likelihood of actual or potential environmental impacts. Phase II ESA: An intrusive investigation involving sampling and testing to better define the nature and scope of any environmental impacts.
Explosives	Gunpowder, blasting powder, nitroglycerine, gun-cotton, dynamite, blasting gelatine, gelignite, fulminates of mercury or of other metals, ANFO and every other substance made, manufactured or used with a view to producing an explosion.

Glossary of Terms and Definitions

Term	Definition
Humidify cell test (HCT)	A type of kinetic test in which a small sample (about 1 kg) is placed in an enclosed chamber in a laboratory, alternating cycles of moist and dry air is constantly pumped through the chamber, and once a week the sample is rinsed with water; chemical analysis of rinse water yields concentrations of elements and other parameters used to calculate reaction rates.
Kinetic test	A geochemical procedure for characterizing the chemical status of a sample through time during continued exposure to a known set of environmental conditions, such as a humidity cell.
Landfarm	Infrastructure that uses biological and physical processes to treat (remove contaminants) contaminated soil.
Land owner	The responsible authority with administrative control and ownership of a type of land classified as crown land, commissioners land or Inuit Owned Land. a. Crown land is land belonging to Her Majesty or in respect of which Government has the power of disposition. In Nunavut, this power rests with the Department of Indigenous Affairs and Northern Developemnt (DIAND). b. Commissions land is land belonging to the Commissioner for the Government of Nunavut; which typically is land within an established municipality administered by a Municipal Corporation and/or the Department of Community Government and Services (CGS) c. Inuit Owned Land (IOL) are those lands vested in the Designated Inuit Organization (DIO) pursuant the Nunavut Agreement. For this Project the DIO is the Kitikmeot Inuit Association.
Land use permit	a. For Crown land a Class A Permit or Class B Permit as required by the Territorial Land Use Regulations SOR/82-217, s.1; SOR/88-169, s.2 administered by DIAND Lands Department. b. For IOLs- Land Use License I, II or III or Commercial Lease I, II, III as defined by the DIO. c. For Commissioners land - a permit or lease as required by the Municipal Land Administration Policy.
Leachate	Water or other liquid that has washed (leached) from a solid material, such as a layer of soil or water; leachate may contain contaminants.
Long-term active care	A post-closure mine site is in long-term active care when sustained monitoring and maintenance of active facilities is required (e.g., for more than 25 years). This should be avoided whenever possible.
Metal leaching (ML)	The release of a metal from its solid-phase mineral into mine site drainage; described by concentrations in static tests and by metal release rates obtained from kinetic tests.
Passive long-term care	Occasional monitoring, coupled with infrequent maintenance or repairs that takes place following reclamation in the post-closure phase of the mine site. Many mine sites require ongoing passive care, which can be an acceptable practice.
Ore	Rock that is considered economic according to the parameters used in the ore reserve estimate.
Overburden	A general term referring to soil and broken rock, lying above ore and mine rock, that can usually be removed without blasting; at mines in soft sedimentary rock like coal, overburden can be synonymous with mine rock.
Potentially acid generating (PAG)	Rock with an NP/AP ratio less than 2 as determined by static tests, as defined by MEND (2009). PAG rock can also be operationally defined based on the results of static testing such as ABA and NAG testing.

Glossary of Terms and Definitions

Term	Definition
Permafrost	Bedrock or soil that maintains a temperature at or below 0º C for a continuous period of two years or more.
Progressive reclamation	Selected closure activities that can be taken at advanced mineral exploration and mine sites before permanent closure. Progressive reclamation takes advantage of cost and operating efficiencies by using the resources available from an operation to reduce the overall reclamation costs incurred. It enhances environmental protection and shortens the timeframe for achieving the closure objectives.
Proponent	Applicant for, or a holder of, a water License and/or land use permit.
Reclamation	The process of returning a disturbed site to its natural state or which prepares it for other productive uses that prevents or minimizes any adverse effects on the environment or threats to human health and safety.
Reclamation research	Literature reviews, laboratory or pilot-scale tests, engineering studies, and other methods of resolving uncertainties. Proponents conduct reclamation research to answer questions pertaining to environmental risks; the design of reclamation research plans aims to provide data and information which will reduce uncertainties for closure options, selected closure activities, and/or closure criteria.
Remediation	The removal, reduction, or neutralization of substances, wastes, or hazardous material from a site in order to prevent or minimize any adverse effects on the environment and public safety now or in the future.
Risk assessment	Analysis of potential threats and options for mitigation for a given site, component, or condition. Risk assessments consider factors such as risk acceptability, public perception of risk, socio-economic impacts, benefits, and technical feasibility. It forms the basis for risk management.
Salvageable Materials	Decommissioned materials which can be sold or reused elsewhere.
Security deposit	Funds held by the Crown (DIAND) or land owner that can be used in the case of abandonment of an undertaking to reclaim the site or carry out any ongoing measures that may remain to be taken after the abandonment of the undertaking.
Selected closure activity	The closure and reclamation activity chosen from the closure options for each Project component.
Stakeholders	Industry, federal agencies, the territorial government, Aboriginal organizations/governments, land owners, affected communities, and other parties with an interest in the Project.
Talik	Unfrozen ground surrounded by permafrost.
Traditional Knowledge	Accumulative, collective body of knowledge, experience, and values built up by a group of people through generations of living in close contact with nature. It builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual, and political change.
Type A water License	A Type A water License is required if the use is of a type set out in column 2 of Schedule 2 and satisfies a criterion set out in column 5 in respect of an undertaking set out in column 1 of the Nunavut Water Regulations SOR/2013-69 *(Note: despite definition of Type B water License item a), a Type A License is the appropriate License for a use of waters if a Type A License is required for another use of waters, or a deposit of waste, in respect of the same undertaking.)*

Glossary of Terms and Definitions

Term	Definition
Type B water License	A Type B water License required if a. The use is of a type set out in column2 of Schedule 2 and satisfies a criterion set out in column 4 in respect of an undertaking set out in column 1, or b. The use satisfies the criterion set out in paragraph 4(1)(a) but does not satisfy one or more criterion set out in paragraphs 4(1)(b) to (d) of the Nunavut Water Regulations SOR/2013-69
Waste rock	All unprocessed rock materials that a mining operation produces.

APPENDIX D

Detailed History of Closure Plan Development

The following provides background on the closure and reclamation planning requirements for the Lupin Mine since construction/production began.

Date	Description
1983	Commercial production began and the first 'conceptual' Abandonment and Restoration Plan was submitted to DIAND to fulfill requirements of Water Licence N7L2-0925 and Land Lease No.'s 3593 and 3594. Revisions were requested clarifying certain areas of the plan.
1984	In December, the IARP was re-submitted in two parts
	Part 'A' was prepared by consultants Reid Crowther and Partners Ltd. and contained a review of current technologies for reclamation applicable to the Lupin Mine, as well as potential problems and conditions that may develop as a result of the operation.
	Part 'B' was prepared by Echo Bay Mines Ltd. and outlined the plan of action with respect to the conditional requirements outlined in the Water Licence and the Federal Land Leases
1985	The IARP was resubmitted to include revisions required under the amended Water Licence and was accepted apart from the plans for the TCA. Regulatory authorities indicated that it would be unwise to commit to a specific plan of action at that time due to advancing technology and the anticipated mine life.
1987 to 1995	Annual updates and revisions to the IARP were submitted for approval along with the results of various studies/reports undertaken during operations. A complete revision of the plan incorporating new information/changes in scope was not requested until the 1995 Water Licence renewal.
1995 to 2000	Licence renewal granted on June 1, 1995 by the NWT Water Board and a revised 'Interim' Abandonment and Restoration Plan was submitted in January 1996. Annual updates and revisions to the Plan were submitted to the Board for approval along with results of various studies completed to date. Transfer of authority to the Nunavut Water Board.
2000	Licence renewal granted on June 1, 2000 (NWB1LUP0008) by the NWB, with expiry on June 30, 2008.
2001	Approval of revised Interim Abandonment and Reclamation Plan.
2001 to 2005	Annual updates on progressive reclamation activities, and the results of various studies completed to date, were provided to the NWB.
2005 to 2006	Final Abandonment and Restoration Plan for the TCA was submitted June 2005. Response to technical comments on the TCA Plan submitted March 31, 2006. Outstanding issues were identified by regulatory authorities in April and May 2006 following a technical meeting. Due to the sale of LMI, no further revisions to the TCA Plan were made.
2006	After sale of LMI, the Site continued under care and maintenance and final reclamation activities were halted while future mining and milling options were explored. An annual update on progressive reclamation activities was provided to the NWB.
2007	A revised ICRP Plan was submitted December with the renewal application.
2008	Annual update on progressive reclamation activities was provided to the NWB.
2009	Licence renewal granted on February 25, 2009, as amended May 25, 2009 (2AM-LUP0914) by the NWB, with expiry on March 31, 2014. An updated ICRP Plan was submitted June 2009 along with various studies completed to date.
2010	A revised ICRP Plan was submitted March 2010 that addressed deficiencies in the 2009 Plan along with various studies completed to date.
2011	Annual update on progressive reclamation activities was provided to the NWB.
2012	Update to the ICRP Plan was submitted to the Board for approval along with results of various studies completed to date.
2013	Revised Plan(s) were submitted to the NWB for approval along with the results of studies completed

Date	Description
	to date in advance of the Water Licence renewal process April 2013. [See Appendix B for full list of Plan(s)].
2014	An application to renew the water Licence was submitted to the NWB February 28, 2014. The Plan(s) were reviewed during the Technical Meetings held on October 22 and 23.
2015	Comments were received about the Plan(s) at the Public Hearing held February 4 and 5. Licence renewal granted October 5, 2015 (2AM-LUP1520) with expiry of August 18, 2020.
2016	ICRP was updated to reflect comments and recommendations made during the renewal process as required under the renewed Water Licence.
2017	ICRP updated to address Amendment #1 requirements to update the IARP. Progressive reclamation included: construction of a landfarm in 2016 (which began operation in 2017) to remediate the satellite tank farm area, Dam M repairs, Cell 5 tailings cover, minor repairs to Cell 1 cover, repairs to the upper and lower sewage lagoon dams. Updated to include information from the updated ESA completed in 2017 and includes a copy of the Environmental Effects Monitoring Phase 5 study completed in 2017.

IARP = Interim Abandonment and Restoration Plan; NWB = Nunavut Water Board; TCA = Tailings Containment Area

APPENDIX E

Consultation Record

Stakeholder engagement activities "consultation record" conducted by LMI commenced in third quarter 2011 to the current date are summarized in Table E-1 .

Table E-1: Stakeholder Consultation Record

Date	Stakeholder Group	Description
9 August 2011	Kugluktuk KIA	▪ Introduction of Elgin Mining/LMI to the KIA
16 November 2011	Yellowknife KIA	▪ Introduction of new team members to KIA ▪ Provided project update ▪ Discussed contact person for employment ▪ and training ▪ Discussed preferred method and timing of ▪ engagement activities
2011	Internal Consultation Measures	▪ Development of a Stakeholder Map, a tool for internal use by LMI to understand the various ▪ stakeholder groups and provide rationale for engagement activities; ▪ Ongoing engagement with relevant stakeholder groups; ▪ Commencement of consultation plan, strategic plan and communications plan development; ▪ Procurement of a facilitator to provide Inuit cultural awareness training to LMI management ▪ team; and ▪ Initiated working relationship with KIA employment and training coordinator.
16 January 2012	KIA Board	▪ Update on status of Lupin and Ulu mines
23 January 2012	KIA Representatives	▪ Follow up meeting update on status of Lupin and Ulu Mines at Mineral Exploration Roundup Vancouver, BC.
6 March 2012	KIA Representatives	▪ Follow up meeting update on status of Lupin and Ulu Mines at Prospectors and Developers Association of Canada, Toronto, ON.
29-31 May 2012	Kugluktuk: KIA, Elders and Community Representatives	▪ Community session to update on status of Lupin and Ulu Mines
15-20 April 2012	Nunavut Mining Symposium	▪ Presentation made at the Symposium in Iqaluit
2012	Kitikmeot Trade Show; Kugluktuk Recreation Frolics; Kugluktuk Summer Games; Kugluktuk Christmas Events; and Kugluktuk Hockey Team	▪ Community Sponsorship Engagement
2013	General	▪ No specific community engagement general touch base as needed with regulators. Also, commitment to engage communities if desired

22-23 October 2014	Kugluktuk: Community and Regulators	▪ A Pre-Hearing Conference, a Technical Session, and a Community Information Session to facilitate regulatory review process of NWB
4-5 February 2015	Kugluktuk: Community and Regulators	▪ Public Hearing and Community Information Session to facilitate regulatory review process of NWB
14 July 2015	KIA	▪ LMI hosted KIA on site tour of Lupin site.
6-7 October 2017	NWB, DIAND and Consultants*	▪ Site Tour Lupin Mine site.
2017	X	
2018		

* Specific participants included: Dave Hohnstein (NWB), Ian Parsons (DIAND), Eva Paul (DIAND) (part-time), Charles Gravelle (Arcadia-NWB), Regan McIssac (Knight Piesold- DIAND), Amber Blackwell (Knight Piesold- DIAND), Ken Booking (Golder- LMI), Patrick Downey (LMI), Karyn Lewis (LMI), and Dave Vokey (LMI)

Additional engagement was undertaken to support Inspectors as provided Table E-2 below.

Table E-2: Additional Consultation Record

Date	Inspection Lead	Description
2009/2010	INAC	No Inspections
2011	AANDC	Inspection July 2011
2012	AANDC	Water Use Inspection July 2012
	Environment Canada	September 25, 2012
2013	ECCC	Three inspectors on site July 25, 2013 to inspect fuel storage and TCA.
2014	ECCC	Inspector on site September 16 to inspect fuel storage and TCA.
2014	AANDC	Water Resources Inspector on Site July 15, 2014 and August 17, 2014.
2015	ECCC	Inspector on site September 27 to obtain water samples for treated tailings discharge
2015	AANDC	Water Resources Inspector on Site July 14, 2015 and September 27, 2015. Manager of Field Operations also participated in September site visit.
2016	AANDC and ECCC	Water Resource Inspector, Land Inspector and Environment Canada were at site on June 14, 2016 to complete site inspections.

Table E-2: Additional Consultation Record

Date	Inspection Lead	Description
2017	X	
2018		

APPENDIX F

Environmental Studies/Reclamation Research/Engineering Studies and Design Reports

AECOM; Lupin Gold Mine Environmental Effects Monitoring – Cycle 3 Interpretative Report; Project Number 60147160; May 2011.

BGC Engineering; Dam 6 Site Investigation and Raise Design (Draft); Project No. 0256-006-01; June 2003.

BGC Engineering; 2006 Annual Geotechnical Inspection Perimeter Tailings Dams. Lupin Mine Nunavut; Project No. 0256-12-01; October 2006.

EcoMetrix Incorporated; Geochemistry and Water Quality, Volume III of Seepage and Water Quality for Reclaimed Tailings Containment Area, Lupin Operations; March 2006.

Geocon; Geotechnical Report on Proposed Plant and Residential Sites, Lupin Project, Contwoyto Lake, N.W.T; Report. File No. A1147; July 1980.

Golder Assoc.; Detailed Design Recommendations for Tailings Area K Dam Lupin Mine. Contwoyto Lake,NWT; File No. 892-2404; May 1990.

Golder Assoc.; Studies Related to Water Licence Requirements and in Support of Reclamation Planning (Lupin Mine); December 2004a.

Golder Assoc., Ecological Risk Assessment for Lupin Mine Tailings Containment Area; December 2004b.

Golder Assoc.; Updated Phase I and II Environmental Site Assessment, Lupin Mine, Nunavut; October 2017.

Hemmera; Addendum to the Lupin Mine 2011 EEM Interpretative Report – Response to Technical

Advisory panel and Environment Canada Comments; May 2012.

Holubec, I. and Hohnstein, D.; Partially Saturated Granular Cover for Reactive Tailings in Permafrost; paper presented at 7th International Symposium of Mining in the Arctic, Iqaluit, NU; April 2003. [Appendix C to 2004 TCA Management Report]

Holubec Consulting; Covers for Reactive Tailings Located in Permafrost Regions Review (Draft); prepared for Mine Environment Neutral Drainage (MEND) Program; May 2004

Holubec Consulting; Lupin Operation – Closure Plan for Tailings Containment Area; January 2005.

Holubec Consulting Inc.; Geotechnical, Seepage and Water Balance, Volume I of Seepage and Water Quality for Reclaimed Tailings Containment Area, Lupin Operations; March 2006a.

Holubec Consulting Inc.; Water Management After Closure, Volume II of Seepage and Water Quality for Reclaimed Tailings Containment Area, Lupin Operations; March 2006b.

Klohn Leonoff; Acid Rock Drainage Study, Lupin Mine, Northwest Territories; March 1992a.

Klohn Leonoff; Assessment of Water Chemistry and Remedial Measures for the Lupin Tailings Effluent System; July 1992b.

Klohn Leonoff; Column Leaching Study, Evaluation of ARD Control Measures; December 1993.

Klohn-Crippen; Tailings Reclamation Test Cover Program, 1994 Report of Activities; August 1995.

Kinross Gold Corporation; Supplement to Lupin Tailings Containment Area, 2005 Abandonment and Restoration; March 2006b.

Li, M.G., Aubé, B., and St-Arnaud, L.; Considerations in the Use of Shallow Water Covers for Decommissioning Reactive Tailings, Proceedings - Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Canada; May 1997.

MEND 2.21.1; Development of Laboratory Methodologies for Evaluating Effectiveness of Reactive Tailings Covers; Univ. of Waterloo and Noranda Technology Centre; March 1992.

MEND 6.1; Preventing AMD by Disposing of Reactive Tailings in Permafrost; Geocon; March 1993.

Morrow Environmental Consultants Inc., a member of the SNC-Lavalin Group; Phase 1 and 2 Environmental Site Assessment, Lupin Mine Site, Nunavut Territory; January 2006.

Reid, Crowther & Partners: RL&L Environmental; Report on Aquatic Studies Program for Echo Bay Mines Ltd; February 1985.

SRK Consulting (Canada) Inc.; Results of the 2015 Lupin Mine Windblown Tails Survey at Dam 6; December 2015.

TBT Engineering Consulting Group; 2010 Annual Geotechnical Inspection Perimeter Dams Tailing Containment Area, Lupin Mine, Nunavut; November 2010.

URS Corporation; ARD/ML Assessment of Waste Rock at Lupin Mine; February 2005.

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
16820 107 Avenue
Edmonton, Alberta, T5P 4C3
Canada
T: +1 (780) 483 3499

Golder Associates