



## WOLVERINE MINE

# RECLAMATION AND CLOSURE PLAN

VERSION 2012-04

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# 1 Introduction

This document contains updates to the Reclamation and Closure Plan (Plan) for the Wolverine Mine, Yukon that was originally submitted in June 2006 (Version 2006-01) and updated in March 2008 (Version 2008-02) and April 2010 (Version 2009-03).

This Plan incorporates requirements of *Quartz Mining License QML-0006* and *Type A Water Use Licence QZ04-065* for the mine site as a whole, and *Type B Water Use Licence QZ01-051* and *Quartz Mining Land Use Approval LQ00140* for the temporary waste rock and ore storage facility constructed in 2005. Requirements of the Yukon Mine Site Reclamation and Closure Policy (January 2006) have also been considered in preparing cost estimates for decommissioning and closure.

As per *QML-0006 Section 8.0* and *QZ04-065 Part E*, this document addresses care and maintenance of the mine site during a temporary closure period, and decommissioning of operations and reclamation of the site at final closure. The Plan has been developed to address two possible scenarios for permanent decommissioning:

1. The mine site in its current state (Existing Condition), or
2. The mine after ore reserves are exhausted (Life of Mine).

## 1.1 Glossary of Terms

The requirements of the *QML-0006*, *Type A Water Use Licence (QZ04-065)* and the *Yukon Mine Site Reclamation and Closure Policy* (January 2006) have been reviewed and incorporated into this Plan. For consistency in interpretation of the contents contained herein, the following terms are defined:

- **Decommissioning** - the period following the cessation of operations involving the removal of equipment from active service.
- **Temporary Closure** - unless otherwise agreed to in writing by the Chief, Dept. of Energy, Mines and Resources:
  1. The cessation of development or production that extends for more than a continuous two week period; or
  2. Any closure after the start-up date where no ore is mined or ore or tailings milled for a period exceeding two consecutive months.
- **Closure or Permanent Closure**
  1. The period in which decommissioning and reclamation activities are completed for the purpose of returning the mine site to pre-mining conditions (estimated to be a three year period for the Wolverine Mine to meet water discharge standards in the tailings facility); Monitoring frequency is quarterly for groundwater sampling and monthly for surface water sampling during closure.
  2. Where temporary closure exceeds three continuous years in duration.
- **Post Closure** – The period following closure where all reclamation activities are complete and the monitoring schedule frequency is reduced to annual assessments.

## 2 Project Description

The Wolverine Mine, owned and operated by Yukon Zinc Corporation (YZC), is a zinc-silver-copper-lead-gold underground mine, with on-site milling capabilities of 1,700 t/d to produce copper, lead and zinc concentrates. The current life-of-mine (LOM) is nine years, based on a 5.2 M tonne mineable reserve. YZC completed major site construction throughout 2009 and 2010. Mill commissioning commenced in 2011 and commercial production of 1,020 t/d or 60% of rate mill capacity over a 30 day period was achieved on March 1, 2012. Production is currently increasing towards 1,700 t/d capacity.

The Wolverine Mine is located in the south-eastern Yukon near the headwaters of the Wolverine Lake watershed within the Kaska Nation traditional territory (Figure 2-1). Site access is via air or a 24 km long all season access road that connects with the Robert Campbell Highway at km 190.



**Figure 2-1: Location of the Wolverine Mine within the Yukon and Kaska Nation Traditional Territory**

Exploration of the area commenced in the early 1970s, and in early 2005, a *Type B Water Use Licence (QZ01-051)* and a *Mining Land Use Permit (LQ00140)* were issued to allow for advanced exploration activities. Under these approvals, Yukon Zinc completed test mining and detailed infill diamond drilling programs. *Quartz Mining License QML-0006* and *Type A Water Use Licence QZ04-065*, to allow for the development and operation of the mine, were issued in December 2006 and October 2007, respectively.

The Wolverine Mine area climate is cold with a mean daily summer temperature of 15°C and a mean daily winter temperature of -25°C. Precipitation falls fairly evenly throughout the year, predominantly as rain from May to September and snow for the balance of the year. The mean annual precipitation is 570 mm, with total snowfall of less than 2 m. Maximum wind speeds are less than 40 km/hr and the annual average is 15 km/h. The project site elevation is approximately 1,350 masl.

The Wolverine Lake area is sparsely populated, and is used primarily for harvesting, gathering, and trapping by the Kaska First Nation bands from the Yukon, the Ross River Dena Council (RRDC) and the Liard First Nation (LFN). In July 2005, YZC signed a Socio-Economic Participation Agreement with the RRDC, on behalf of the Kaska Nation, that provides a basis for participation by all Kaska Nation members in project exploration and mine development and operations activities. This has and will include the review of environmental, social, and economic matters related to activities which support mine development, operation, and closure.

The Wolverine Mine has been planned and will be operated and reclaimed in accordance with the *Kaska Socioeconomic Participation Agreement* and the *RRDC Traditional Knowledge Protocol Agreement* as well as the Terrestrial Performance Standards outlined in *QML-0006* Schedule D (including terrain hazards, erosion control, re-vegetation, watercourses, contaminated soils, roads and trails, buildings and infrastructure, rock dumps, underground openings and workings, acid mine drainage concerns, tailings impoundment, and water control structures).

The overall project timeline from construction through to post closure is provided in Table 2-1.

**Table 2-1: Wolverine Mine Project Timeline**

<b>Period</b>	<b>Year(s)</b>
<b>Construction Phase</b>	<b>2009 to 2010</b>
<b>Production Ramp-Up</b>	<b>2011</b>
<b>Operations Phase</b>	<b>2012 - 2020</b>
Year 1	<b>2012</b>
Year 2	<b>2013</b>
Year 3	<b>2014</b>
Year 4	<b>2015</b>
Year 5	<b>2016</b>
Year 6	<b>2017</b>
Year 7	<b>2018</b>
Year 8	<b>2019</b>
Year 9	<b>2020</b>
<b>Permanent Closure Phase</b>	<b>2021 to 2023</b>
Year 1 (Decommissioning)	<b>2021</b>
Year 2	<b>2022</b>
Year 3	<b>2023</b>
<b>Post Closure Phase</b>	<b>2023-2029</b>

Information pertaining to infrastructure and current activities for Wolverine Mine operations is provided below. For additional information, please refer to *Wolverine Mine General Site Plan 2011-05 (October 2011)*.

## 2.1 Wolverine Mine Operations

The Wolverine Mine is an underground mine with surface ramp access, designed for 1700 t/day of mill feed ore. The Wolverine Mine operates 365 days per year, 24 hours per day. At the end of July 2012, there were approximately 363 staff at the mine on rotation for two weeks per month, including YZC employees and contractors, with approximately 26% being Yukon-based employees.

Following production ramp-up in 2011, commercial production was achieved on March 1, 2012 and full production at 1,700 t/d is anticipated in early 2013. The underground mine will ultimately extend from approximately 1345 masl, at the portal entrance, to 1080 masl at the bottom stope, with a main access ramp, and a ventilation raise that includes an evacuation route.

Figure 2-2 illustrates the overall mine site layout, and Figure 2-3 and Figure 2-4 provide the layouts for the industrial complex and tailings facility areas, respectively. The surface facilities and infrastructure for mine operations include the following:

- site access road;
- airstrip;
- fuel storage and dispensing;
- power generation and distribution;
- process buildings;
- assay laboratory;
- wet shotcrete plant;
- waste rock storage pads;
- tailings facility;
- truck shop;
- mining office complex;
- administration, first aid and mine rescue buildings, dry; and
- camp

The road is a private, single-lane road with passing bays, has restricted access and is operated under radio control. The road is used year-round with minimal load restrictions.

The on-site gravel airstrip is 1,340 m long with 280 m of runway at the south end of the airstrip required to provide for an emergency stop way to allow an aircraft to land on the airstrip with a full passenger load. The airstrip is intended for restricted use only by day during good visual meteorological flight conditions.

Diesel fuel is supplied from six diesel fuel storage tanks (75,000 L capacity each) and an 8,500 L gasoline tank. Storage is based on two weeks of reserve in the event of road problems and/or use restrictions. A fuel truck transports diesel fuel and lubricants to mobile equipment as required.

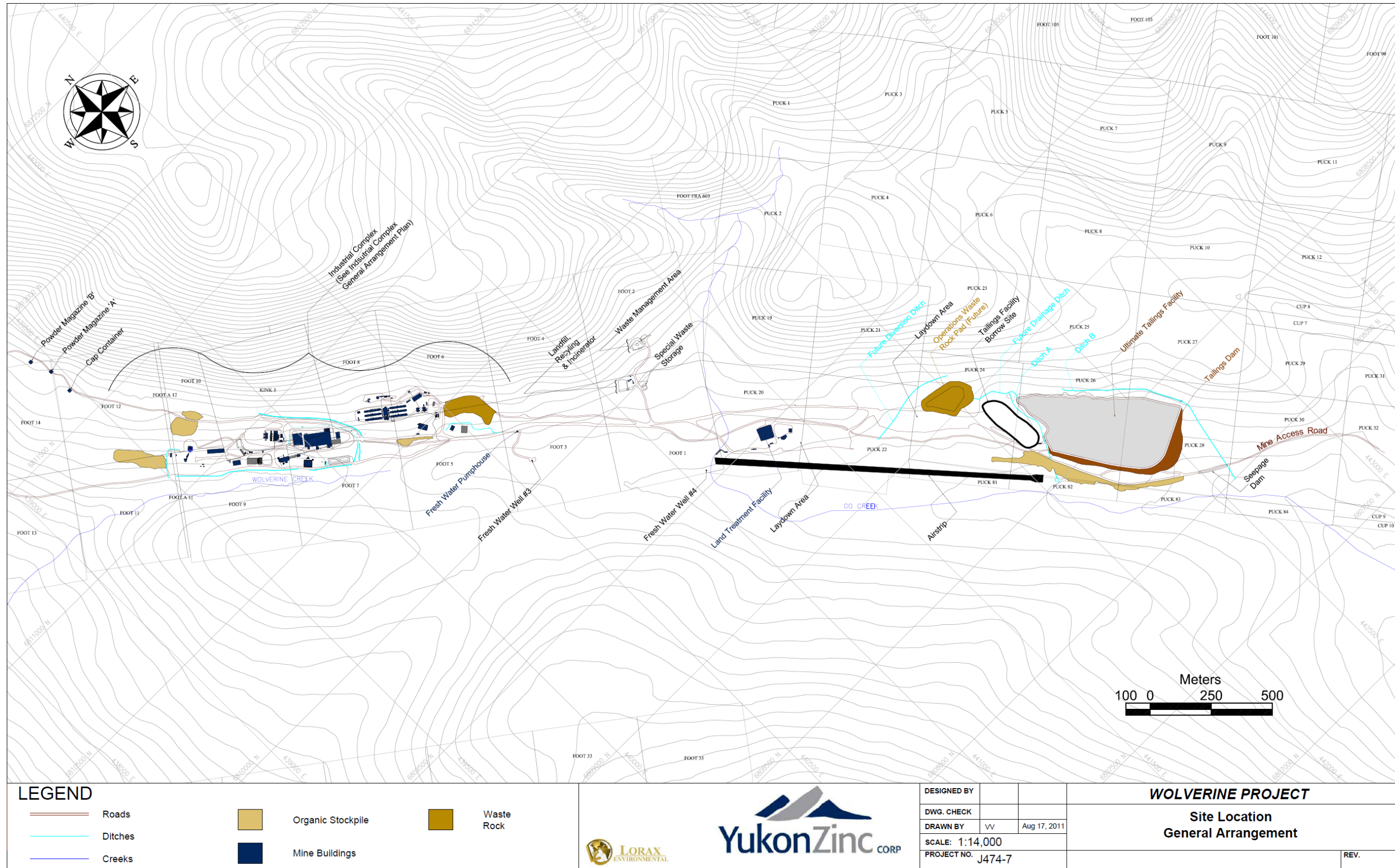


Figure 2-2: General Site Layout – Wolverine Mine Area

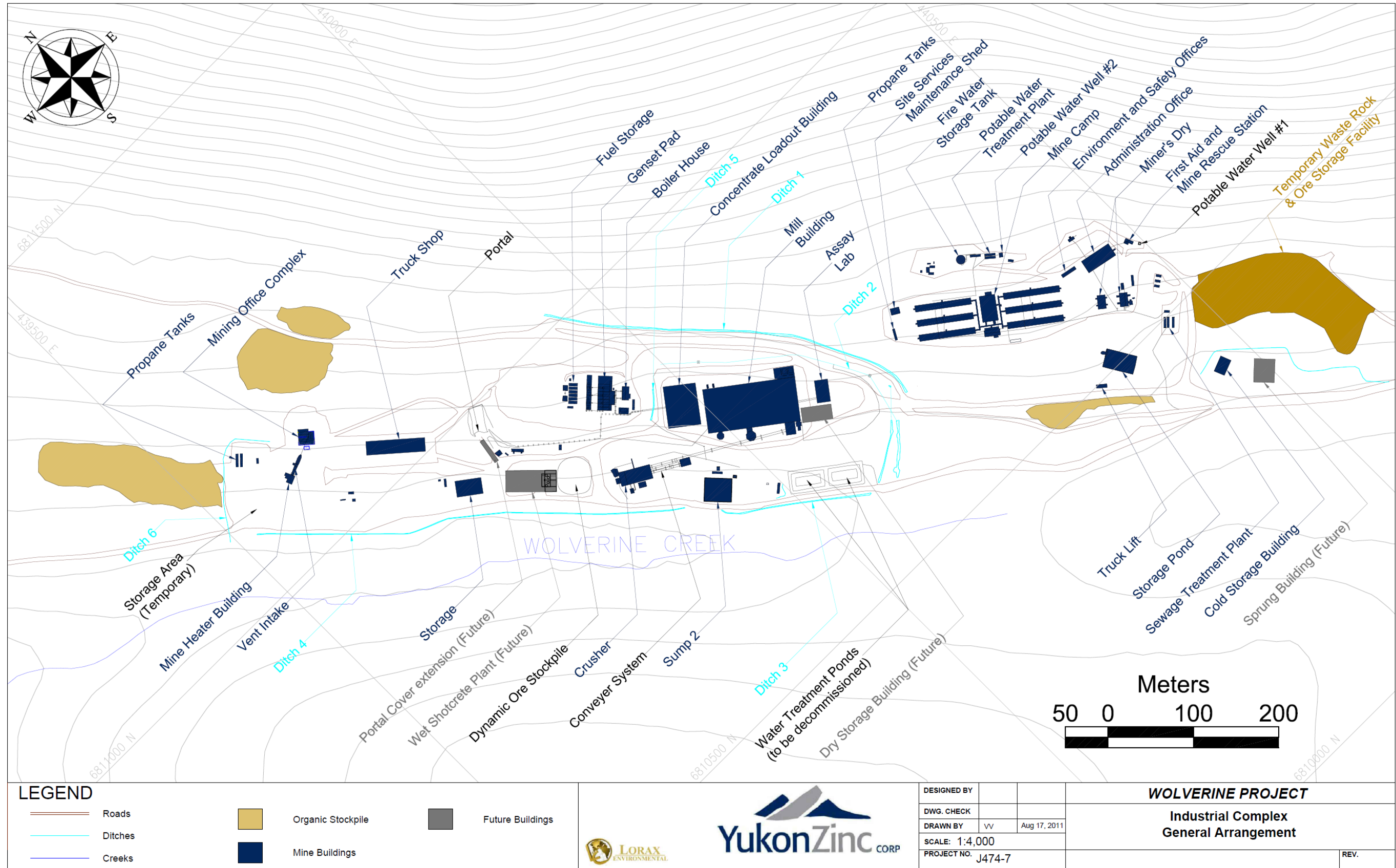


Figure 2-3: General Site Layout – Industrial Complex Area

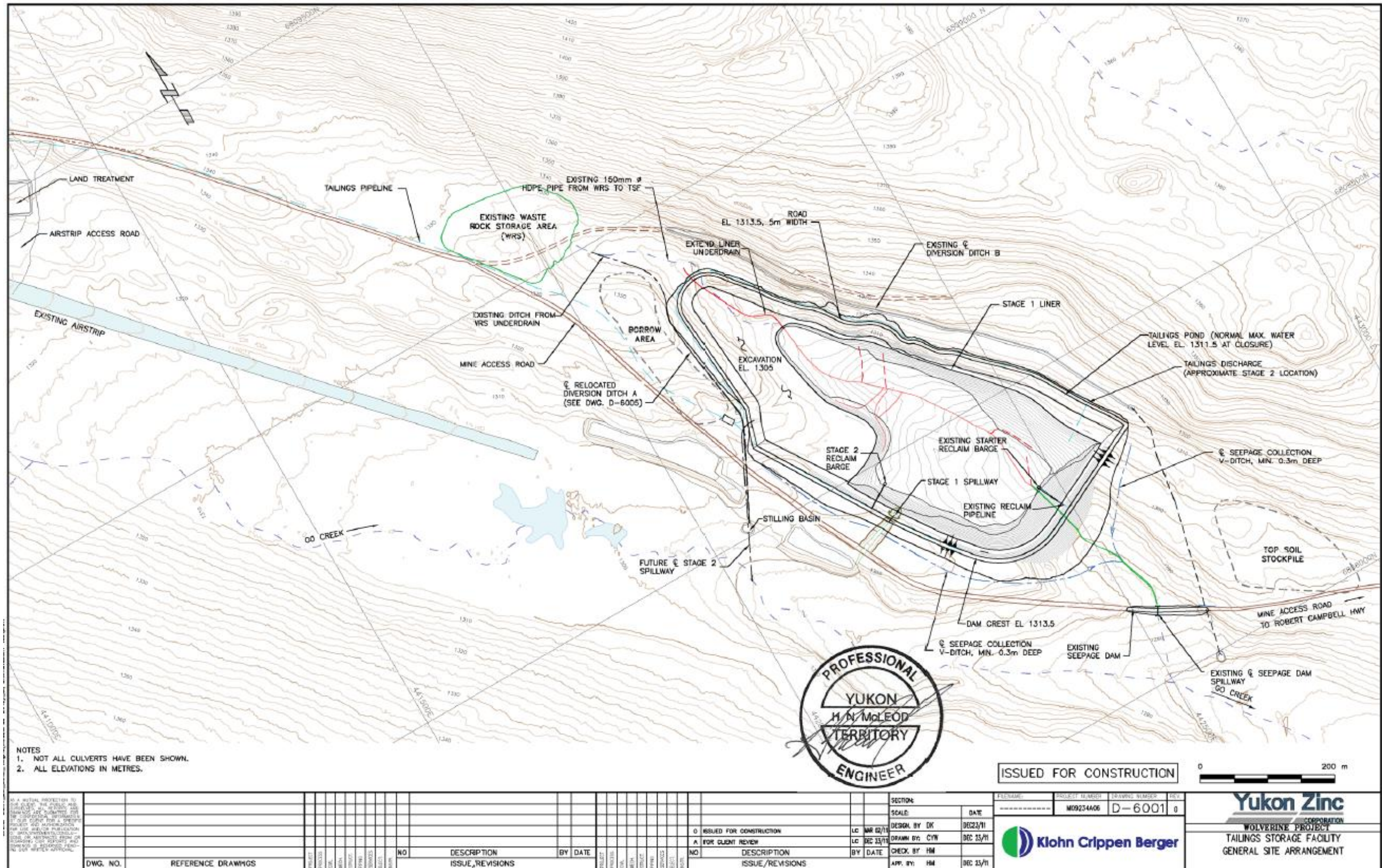


Figure 2-4: General Site Layout –Tailings Facility Area

On-site power generation is provided by eight diesel generator sets, each rated 1,200 rpm, 1.26 MW continuous, 1.45 MW prime power generating at 4,160 V for a total installed generating capacity of 10.08 MW continuous, 11.60 MW prime power.

The process facilities consist of a crusher building, mill building and concentrate load-out building. Feed conveyors connect the crusher building to the mill and transport crushed ore to the rod and ball mills. Ancillary facilities include a wet shotcrete plant, assay laboratory, mining office complex, truck shop and camp.

Camp infrastructure at the Wolverine Mine consists of six, 41-man dormitories, a kitchen, recreation hall, administration office, first aid office, mine rescue station and dry facilities. Additional support infrastructure includes a maintenance shed, training room, firewater tank, potable water treatment plant, communication station, and sewage treatment plant.

Water from the underground workings and the tailings slurry from the milling process are pumped to the tailings facility, then back to the mill for process water use. Approximately half of the tailings solids are designated for paste backfill operations. A water treatment plant is being designed to treat the excess tailings supernatant stored in the tailings facility. Final design and plant construction of the water treatment plant is scheduled for 2013 to allow for the treatment of tailings water commencing in spring 2014. All treated water from mine operations will be discharged to Go Creek according to *Water Use Licence QZ04-065*.

Waste rock from the mine is stored temporarily on two waste rock pads. The first pad, located southeast of the camp, was constructed in 2005 and the second pad located north of the tailings facility was constructed in 2011. Material from both pads will be hauled underground to the mined-out stopes over a four year period (late 2012 to 2016) and encapsulated with paste backfill.

Metal concentrates are predominantly trucked south along the Robert Campbell Highway through Watson Lake to the Stewart Bulk Terminal in Stewart, BC for transportation via ocean freighter to various smelters in Asia.

### 3 Temporary Closure

This section describes activities required during a temporary closure period (see Section 1.1 for definition). A temporary suspension of mining and processing activities could result with a change in market conditions or mine-related factors occur, and could be either a defined or indefinite period of suspension. A state of inactivity may evolve into a state of permanent closure if prevailing conditions for the resumption of operations are not favourable. If temporary closure exceeds three continuous years, the site will be considered permanently closed and the final closure plans will be implemented as required by *QML-0006*.

Closure activities for a temporary shutdown have been planned to ensure that all safety and environmental standards are achieved. During a temporary closure, YZC intends to be a responsible steward of the site and demonstrate its commitment to re-opening the site by continuing to:

- Ensure physical and chemical stability of the site;
- Monitor and maintain buildings and facilities;
- Maintain the site and main access roads;
- Maintain security and access protocols;
- Dewater the mine to prevent flooding of the underground workings;
- Collect site runoff from the industrial complex and waste rock pad; and

- Operate and maintain water management structures and treatment facilities to ensure no uncontrolled discharges occur.

Therefore, surface facilities will only be accessible to YZC personnel, or designated representatives, and equipment and facilities will remain essentially intact on site.

### **3.1 General Requirements**

Measures that will be taken during a temporary closure period include:

- Mining equipment will be left in no load condition. All surface equipment not required for site maintenance or operating activities during this period will be stored in appropriate areas.
- Depending on the anticipated closure period, chemicals or reagents that are deemed to have short shelf life will be returned to suppliers/manufacturers, and those chemicals that cannot be returned will be disposed of in a proper manner as per manufacturer's requirements.
- If required, a fuel distribution agent or a waste management contractor will pump the contents of storage tanks. Tanks that will not be reused will be removed and offered for sale or scrap, following appropriate procedures and protocols.
- The mine access road will remain operational with restricted access (locked gate located at km 0.1), monitored on a regular basis, and maintained as required.

### **3.2 Underground Workings**

During a temporary closure period, the priorities are to ensure public safety and protection of wildlife, prevent flooding of the mine to maintain the integrity of the workings, and prevent uncontrolled discharge of groundwater at the portal.

The portal will be gated to restrict access to the mine when access is not routinely required. Water collected in levels in underground sumps will be pumped to the tailings facility. The following infrastructure and equipment will remain operational or onsite to support water management activities:

- main access road and onsite roads;
- light duty vehicles;
- tailings and reclaim pipelines and pumps;
- fuel storage facility;
- tailings facility water treatment plant (once operational);
- power generating facility with adequate capacity to power the water pumping systems and camp;
- small maintenance workshop; and
- communication system.

### **3.3 Monitoring and Management Activities**

During temporary closure, regular inspections will be conducted to ensure compliance with applicable regulations and permits/licenses. Structures such as the waste rock pads, water collection sumps, land treatment farm, diversion and collection ditches, tailings facility, fuel and storage tanks, pipelines and roadside ditches and culverts will be inspected to ensure physical stability and integrity.

Water management activities during temporary closure will consist of dewatering of the underground workings, and collection of surface runoff from the temporary waste rock pads, land treatment farm and the industrial complex area. For structures designed to collect contact water runoff or effluent, monitoring will be conducted to ensure that all runoff is captured and treated as necessary. Depending on when the period of temporary closure occurs and the capacity of the tailings facility, treatment may not be required during the closure period.

Surface water quality and flow monitoring will be conducted on selected surface water sampling stations as summarized in Table 3-1.

**Table 3-1: Selected Surface Water Quality Monitoring Stations – Temporary Closure**

Station	Watershed	Frequency (# samples/yr)
W82	Wolverine Creek	Monthly (12)
W9		Monthly (9)
L1	Little Wolverine Lake	Monthly (12)
W31		Monthly (8)
W80	Go Creek	Monthly (6) & daily during discharge (184)
Retention Pond		daily during discharge (184)
W22	Money Creek	Monthly (12)
W71	Access Road Route	Monthly (12)
W72		Monthly (12)
W73		Monthly (12)

Based on the past two years of sampling, stations W9 and W31 cannot be sampled during the coldest winter months due to frozen conditions. Groundwater quality monitoring will be conducted quarterly on all monitoring well installations (numbers of samples for some well have been reduced based on frozen conditions observed in past two years of sampling). For additional information with respect to station locations and analytical parameters, refer to *Wolverine Mine Monitoring and Surveillance Plan 2011-03*.

All wastes will be handled, stored, managed and disposed of in a proper manner as outlined in the *Wolverine Mine Waste Management Plan Version 2011-03*. Domestic waste will be the primary source of waste during temporary closure.

### 3.4 Temporary Closure Cost Estimate

An estimate of the annual temporary closure costs for the Wolverine Mine is presented in Table 3-2. The cost estimate includes a contingency of 10%. Several assumptions have been used to develop the estimate including personnel requirements, maintenance and security, environmental monitoring and water treatment requirements.

On-site personnel will include a site manager, an environmental technician and a ticketed underground mine foreman, who will work on shift rotations to ensure coverage. Support staff will not be required as the tasks and activities are not extensive. Specialist personnel, such as mechanics or electricians will be onsite on an as needed basis. During this type of closure, corporate involvement is assumed and inclusion of third party closure personnel has not been included.

The water treatment cost estimate has been developed assuming an excess water balance of approximately 184,200 m<sup>3</sup> to be treated over a six month period. This volume of water accumulating in

the tailings facility has been calculated using average climate conditions as well as assuming 12 m<sup>3</sup>/h (~3 L/s) from mine dewatering activities that would continue during the temporary closure. As stated previously, active water treatment may not be required during the temporary closure period should sufficient storage capacity exist in the tailings impoundment.

**Table 3-2: Annual Temporary Closure Cost Estimate**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Organization, Security and Overhead</b>					
Site Manager	Management	months	12	\$ 8,800	\$ 105,600
Underground Mine Foreman	Management	months	12	\$ 10,500	\$ 126,000
Corporate	Management and oversight	L.S.			\$ 20,000
Camp Cost <sup>1</sup>	per person day	days	599	\$ 85	\$ 50,915
Vehicle for security and technician	light-duty vehicle	months	24	\$ 1,400	\$ 33,600
Flights	1 flight/week for shift rotations, specialist visits, supplies	flights	52	\$ 1,300	\$ 67,600
Site maintenance costs	maintenance, fuel, supplies	months	12	\$ 1,500	\$ 18,000
<b>Sub Total</b>					<b>\$ 421,715</b>
<b>Compliance Monitoring and Reporting</b>					
Environmental Technician	responsible for sampling and monitoring	months	12	\$ 6,000	\$ 72,000
Water Quality Analytical	Surface water (when not frozen)	samples	95	\$ 400	\$ 38,000
Water Quality Analytical	Groundwater (when not frozen)	samples	69	\$ 270	\$ 18,630
Water Quality Analytical	Monitoring of treatment discharges	samples	368	\$ 400	\$ 147,200
Hydrological Monitoring		L.S.			\$ 10,000
External Consulting Services		L.S.			\$ 20,000
Geotechnical Inspections		annual	1	\$ 20,000	\$ 20,000
<b>Sub Total</b>					<b>\$ 325,830</b>
<b>Water Treatment of Excess Tailings Water</b>					
Biotreatment of excess tailings water	Annual treatment volume	m <sup>3</sup>	184,200	\$ 0.40	\$ 73,680
<b>Sub Total</b>					<b>\$ 73,680</b>
					<i>10% Contingency</i>
					<b>\$ 82,123</b>
<b>Total</b>					<b>\$ 903,348</b>

1: Camp person days calculated assuming 3 persons for 183 days (on 2 week in, 2 week out rotation) plus 50 days for specialist personnel

Based on the plans presented herein, the total annual cost of temporary closure is estimated at approximately \$903,348 including contingency. Temporary closure for a three-year period is approximately \$2,713,044 including contingency (note that this total is based on a three-year period not a five-year period as required by QML-0006 (Part 8.3 h) as temporary closure is considered to be permanent after a three year continuous period).

## 4 Reclamation and Closure Research Programs

Yukon Zinc Corporation will conduct further research programs in 2013-14, including a Reclamation Research Program and pilot testing of the Biopass treatment system as described below.

### 4.1 Reclamation Research Program

The overall goal of the Reclamation Research Program at the Wolverine Mine is to prepare the site so that the vegetation returns to a state as near as possible to that in existence prior to mining activities. The short and long term objectives of land reclamation and re-vegetation are to provide erosion control, to ensure land use compatible with surrounding lands, and to leave the area as a self-supporting ecosystem. YZC will work with consultants, Kaska First Nation and other technical groups to address potential environmental constraints and issues of concern for the overall site. In conjunction with other Yukon mining companies, YZC has initiated work with the Yukon Research Centre, Yukon College's dedicated research arm, to initiate the development of research programs that may include:

- Assessing the availability of natural seed or the availability of productive seed material from local surroundings;
- Undertaking vegetation trials using native plant species;
- Assessing nutrient level deficiencies in available soils to determine necessary amendments;
- Determining appropriate seed mixes, fertilization and growth media through experimental test plots; and
- Establishing performance standards to measure re-vegetation success.

In addition, YZC will inventory all organic stockpile areas created during the exploration and construction periods to determine the availability of soils for reclamation cover and will undertake clean borrow material investigations to determine potential sources of inert, non-acid generating material for the tailings cover material for the tailings facility at closure.

To date in areas of disturbance, stockpile areas and along the access road, YZC has used a 'Roadside Reclamation' seed mix originating from western Canada, the Yukon and/or Alaska containing 40% Violet wheat grass (*Agropyron violaceum*), 25% Arctic Red Fescue (*Festuca saximontana*), 20% Sheep Fescue (*Festuca ovina*), 10% Slender wheat grass (*Agoropyron paucifloru*), and 5% Tickle Grass (*Agrostis scabra*). The mix was specified to meet the following purity and germination requirements:

- Species must not exceed the following limits for noxious weeds per 25 grams: 0 primary, 5 secondary, 25 total, and 0 sweet clover;
- Minimum percent of pure living seed must be 70%.

## 4.2 Biopass Pilot Testing

Reclamation of the mine underground workings involves the construction of hydraulic plugs (Section 6.3.2) within the decline to prevent the discharge of water from the underground workings via the mine portal and subsequently to Wolverine Creek. The possibility remains that the hydraulic plugs will not be completely effective at preventing discharge of mine-affected water from the portal. To account for and mitigate this potential risk, a passive biological treatment system (termed Biopass) is proposed for the treatment of mine-affected discharge. More details on the conceptual design of the Biopass system are provided in Section 6.3.4.

The initial part of development and testing of the Biopass was completed as part of a Royal Roads University Master of Science thesis in early 2012, with supervision provided by Dr. Jack Adams of the University of Utah. The M.Sc. thesis involved a lab-based up-flow column experiment to examine the passive treatment of simulated mine impacted effluent to remove selenium and other parameters of concern, including sulphate, ammonia, nitrate, nitrite, aluminum, arsenic, cadmium, iron, manganese and zinc. Five columns were filled with varying compositions of gravel and Wolverine Creek substrate organics, and were un-amended (control column) or amended with manure, sewage sludge, zero-valent iron, or wood chips and alfalfa. The up-flow columns were operated at expected base-flow volumes of approximately 1 L/s. Selenium, sulphate and the other parameters of concern were lowered most effectively by the control column and by the columns amended with sewage sludge. Sewage sludge greatly increased the rate at which the columns became reducing, thereby increasing sulphide precipitation and cadmium and zinc co-precipitation. The addition of zero-valent iron increased the sulphate and selenium removal to almost 100%. The addition of wood chips and alfalfa did not appear to greatly influence the removal mechanisms in the columns, but could affect the long-term success of a treatment system.

In summary, column effluent metal and sulphate concentrations provided evidence that co-precipitation, adsorption and microbially mediated redox reactions were the predominant biogeochemical mechanisms operating within the columns. Based on this research, recommendations made to further the design of a semi-passive treatment system, included:

- Comparison of a control (containing creek substrate and gravel) to a zero-valent iron/wood chip/alfalfa amended column (an alternative control column containing only gravel could also be tested);
- Replicate columns to allow for statistical analysis;
- An influent with relatively constant concentrations of parameters of concern that has been oxygen depleted to better simulate contaminated groundwater;
- A longer treatment time (*e.g.*, >500 days) to examine the potential for increased reducing conditions and subsequent precipitation of iron and co-precipitation of arsenic; and
- If increased treatment time does not achieve the desired water quality for all parameters, it may be necessary to test a secondary treatment mechanism or addition of bacterial inoculum.

These recommended studies, followed by a field trial, will allow for the design of a robust system for the long term treatment of potentially contaminated groundwater emanating from the Wolverine Mine.

## 5 Progressive Reclamation

The preferred approach to returning the site to a productive land-use state is to conduct progressive reclamation throughout the life of the project. Areas considered for progressive reclamation throughout the operational phase of the mine include:

- Construction phase laydown areas;
- Footprints where temporary structures and redundant components were located;
- Borrow sites;
- The downstream face of the tailings dam; and
- Selected areas along road corridors.

At the end of the summer construction seasons in 2009 and 2010, several exposed areas were seeded and re-vegetation has been successful (Picture 5-1). Based on the early success of this seeding program, a plan and implementation schedule for a revegetation program will be developed for implementation in 2013. Monitoring locations will include randomly allocated plots located within representative areas.



**Picture 5-1: Example of revegetation success two years after seeding along the access road near km 16 (July 18, 2012).**

## 5.1 Mine Access Road

The 24km long all-weather access road was initially constructed in 2007 and improvements were made in 2010 and 2011 to allow for concentrate haulage. In summer 2010 and 2011, several improvements were made including the extension or addition of pull out bays, flattening of steeper road sections, re-contouring of cut and fill slopes, placement of organic matter along the corridor, and seeding of some borrow areas, areas of potential erosion, and areas paralleling the road corridor (Picture 5-2). The road running surface ranges from 6 m to 10 m, and averages approximately 7 m with 3 m side slopes. Once additional progressive reclamation activities are completed, the area remaining for reclamation during closure will total 31.2 ha (24 km length by 13 m width).

Progressive reclamation plans for disturbed areas outside of the road operating surface including borrow sites, staging areas and/or cut and fill slopes, will be prepared in 2013.



**Picture 5-2: Example of revegetation (natural and from seed) along road corridor near km 3 (July 18, 2012)**

## 5.2 Tailings Facility

Following completion of the tailings facility ultimate dam raise from 19.5m to 26.5m in late 2012, seeding of the dam slopes will be conducted in spring 2013 to limit erosion. Seeding with 12 x 25kg bags of the Roadside Reclamation Mix of the starter dam slope, Ditch A, Ditch B as well as construction/borrow sites was completed in fall 2009. Vegetation became established on the starter dam face (Picture 5-3) and in most areas around the facility, including those areas lined with coarser material to limit erosion (Picture 5-4).



**Picture 5-3: Construction of ultimate tailings dam; note seeding on the starter dam face has resulted in ~50% grass cover between the crest and construction zone (July 17, 2012)**



**Picture 5-4: Looking north at established vegetation in coarser material along Ditch B (August 2011)**

### 5.3 Temporary Waste Rock and Ore Storage Pads

The initial Temporary Waste Rock and Ore Storage Facility was constructed in 2005 (Phase 1) and extended in fall 2007 (Phase 2) to accommodate test mine and pre-production development rock generated in 2005 and 2009, respectively. Ore stored on the pad was used to commission the mill in 2010, and the current volume of waste on the pad from a survey completed on July 24, 2012 is 91,000 m<sup>3</sup> (Picture 5-5). The pad is at capacity and the facility will be progressively reclaimed during the operations phase, with waste rock being placed underground as backfill starting in late 2012.



**Picture 5-5: Test mine and pre-production waste rock on temporary waste rock storage pad located east of camp (Sept. 12, 2012)**

Due to updates in 2010-11 to the underground mine plan, a second waste rock pad was constructed in late 2011 to accommodate waste rock generated from mine ramp development during the production phase. The lined area is approximately 20,000 m<sup>2</sup> and current volume of waste on the pad from a survey completed on July 24, 2012 is 19,500 m<sup>3</sup> (Picture 5-6).

For both sites, activities to be undertaken in approximately operating Year 4 or 2016 when all rock has been placed within the mine will include:

- Granular till and clay components of the pad liners will be hauled to underground, and encapsulated with paste backfill;
- Geo-synthetic components of the Enviro Liners will be cut into manageable segments, then hauled underground, and encapsulated with paste backfill;
- Sumps will be backfilled with fine-grained materials, and any pipelines removed; and

- Footprints will be recontoured, covered with stockpiled topsoil and organic stripping, and re-vegetated.

Assuming that the waste rock storage pads will be decommissioned by the end of Year 4, life-of-mine cost estimates have been adjusted accordingly. Should the mine enter into permanent closure prior to the end of the projected operations phase, all waste rock and granular till will be placed within the tailings facility and the liner will be removed and disposed of within the underground workings.



**Picture 5-6: Operations phase waste rock pad looking east (July 17, 2012)**

## 6 Decommissioning and Closure Phase Activities

### 6.1 Introduction and Overview

During the operations phase, additional information will be collected from site-specific research and environmental monitoring and testwork in order to develop and revise comprehensive closure plans for target areas that will be cost effective, and environmentally and technologically feasible. To ensure that reclamation activities have the greatest chance for success, the results from the reclamation research programs described in Section 4 will be incorporated into the plan.

The timing of facility closures is dependent on a number of factors including the purpose of the facility and its future use and environmental considerations. Site decommissioning activities are anticipated to commence during the final stages of operations after Year 9.

Table 6-1 provides a list of anticipated activities that will be required during the decommissioning and closure period. Decommissioning of the waste rock pad is not included as these activities are scheduled for Year 4.

A number of personnel will be required onsite to implement the various decommissioning, closure and reclamation tasks. The water treatment plant will remain in operation to treat excess water accumulating in the tailings facility during the early closure phase until tailings pond water meets discharge criteria. The following infrastructure and equipment will remain operational or onsite to support water treatment plant operations:

- onsite roads to the camp, industrial complex, tailings facility and airstrip;
- main access road and associated light duty vehicles;
- discharge pipelines and pumps;
- fuel storage facility;
- power generating facility with adequate capacity to power the water treatment plant, pumping systems, and camp;
- small maintenance workshop; and
- communication system.

During decommissioning and the early closure period, soils will be tested for contaminants in all areas where ore, concentrate, waste rock, solid wastes, special wastes, fuel and chemicals were stored or handled at the site. If contamination is found, the contaminated soil will be removed from the area and either temporarily disposed of in the land treatment farm near the airstrip or hauled directly offsite to an approved facility. The selected disposal method will be in accordance with the Yukon Environment Act and Contaminated Sites Regulation, and Special Waste Regulation. Costs for potential soil contamination have not been included in the closure costs directly; however, any such costs are considered addressed through the incorporation of contingencies in the closure cost analysis.

Once infrastructure is removed, slopes will be stabilized by contouring and leveling to provide land forms that conform to the surrounding terrain and provide suitable seedbeds. Erosion features will be minimized on re-sloped surfaces, runoff will be diverted away from steep slopes, and settling ponds and diversion ditches will be used as necessary.

**Table 6-1: Activities Associated with the Decommissioning and Closure Phases**

Component	First Year of Closure and Decommissioning	Year 2 to Year 3 of Closure and Decommissioning Phase
Mine workings	<ul style="list-style-type: none"> <li>▪ Install hydraulic plugs as main ramp is backfilled to stratify underground water</li> <li>▪ Cement/grout ventilation opening</li> <li>▪ Install portal barrier</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cap portal barrier and revegetate</li> </ul>
Industrial complex area	<ul style="list-style-type: none"> <li>▪ Dismantle and remove buildings and supporting infrastructure, including buried tanks, pipes and underground services</li> <li>▪ Cover concrete foundations with overburden and re-vegetate</li> <li>▪ Market mining and mill equipment</li> <li>▪ Transport explosive and cap magazines offsite</li> <li>▪ Deactivate most gensets leaving adequate power for the camp and water treatment facility</li> <li>▪ Conduct remediation programs</li> <li>▪ Recontour, replace organic layer and seed disturbed areas</li> </ul>	<ul style="list-style-type: none"> <li>▪ Construct portal discharge ditch to Biopass</li> <li>▪ Remove site runoff collection ditches once area is reclaimed and vegetated</li> <li>▪ Remove remaining gensets and transmission lines once all activities are complete</li> <li>▪ Remove demolition waste or dispose of in authorized landfill.</li> <li>▪ Remove all hazardous waste from site</li> <li>▪ Market and dispose of all assets once support for water treatment and reclamation activities are no longer needed</li> </ul>
Tailings facility	<ul style="list-style-type: none"> <li>▪ Dismantle tailings discharge pipeline and dispose of in tailings facility</li> <li>▪ Decommission diversion ditches A and B and underdrain pipes upstream of facility</li> <li>▪ Cover tailings with 0.5 m coarse inert material (CIM) during winter</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cover tailings with 0.5 m CIM (winter placement)</li> <li>▪ Dismantle tailings reclaim &amp; discharge lines only after water quality in pond meets criteria</li> </ul>
Water treatment plant	<ul style="list-style-type: none"> <li>▪ In use for treatment of excess water from tailings facility</li> </ul>	<ul style="list-style-type: none"> <li>▪ Decommissioned only after tailings pond water meets discharge criteria</li> </ul>
Camp	<ul style="list-style-type: none"> <li>▪ Remove modular components not required to support ongoing activities.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Progressively remove all buildings</li> <li>▪ Market sewage treatment plant</li> <li>▪ Decommission and seal water wells</li> </ul>
Airstrip	<ul style="list-style-type: none"> <li>▪ Will not be decommissioned</li> </ul>	<ul style="list-style-type: none"> <li>▪ Will not be decommissioned</li> </ul>
Onsite and access road	<ul style="list-style-type: none"> <li>▪ In use for removal of material and import of supplies; road access and traffic control maintained</li> </ul>	<ul style="list-style-type: none"> <li>▪ Access and traffic controls in place until the end of the closure period; roads deactivated and reclaimed once water treatment is no longer required</li> </ul>
Land treatment farm	<ul style="list-style-type: none"> <li>▪ Operational to remediate soils excavated during early stages of decommissioning</li> </ul>	<ul style="list-style-type: none"> <li>▪ Use soil in reclamation activities if deemed remediated; haul offsite if contaminated</li> </ul>
Landfill, incinerator, waste storage areas	<ul style="list-style-type: none"> <li>▪ Operational</li> </ul>	<ul style="list-style-type: none"> <li>▪ Remove incinerator from site</li> <li>▪ Close landfill and storage areas by contouring, capping and seeding</li> </ul>

## 6.2 Estimated Areas of Disturbance at Life-of-Mine

Estimated areas of disturbance were calculated from Figure 2-3 and Figure 2-4. Specific components and total estimated areas disturbance for the Wolverine Mine are summarized in Table 6-2. The total disturbed area is approximately 89 ha.

**Table 6-2: Summary of Estimated Areas of Disturbance at Life of Mine**

Mine Area/Component	Subtotal Area (ha)	Total Estimated Area (ha)
<b>Industrial Complex Area</b>		<b>22.2</b>
<i>Mill Buildings, Truck Shop, Offices</i>	14.5	
<i>Diversion Ditches</i>	0.5	
<i>Organic Stockpiles</i>	2.4	
<i>Camp and Support Facilities</i>	2.8	
<i>Explosives Magazine</i>	0.1	
<i>Land Treatment Farm</i>	0.4	
<i>Landfill</i>	1.5	
<b>Tailings Facility Area</b>		<b>28.1</b>
<i>Impoundment</i>	16.6	
<i>Dam Face</i>	2.4	
<i>Diversions</i>	0.5	
<i>Seepage Recovery Pond</i>	0.8	
<i>Tailings Lines Corridor</i>	1.8	
<i>Organic Stockpiles and Borrow Areas</i>	6.0	
<b>Access Road</b>		<b>31.2</b>
<b>Mine Site Roads</b>		<b>7.0</b>
<b>TOTAL ESTIMATED DISTURBANCE</b>		<b>88.5</b>

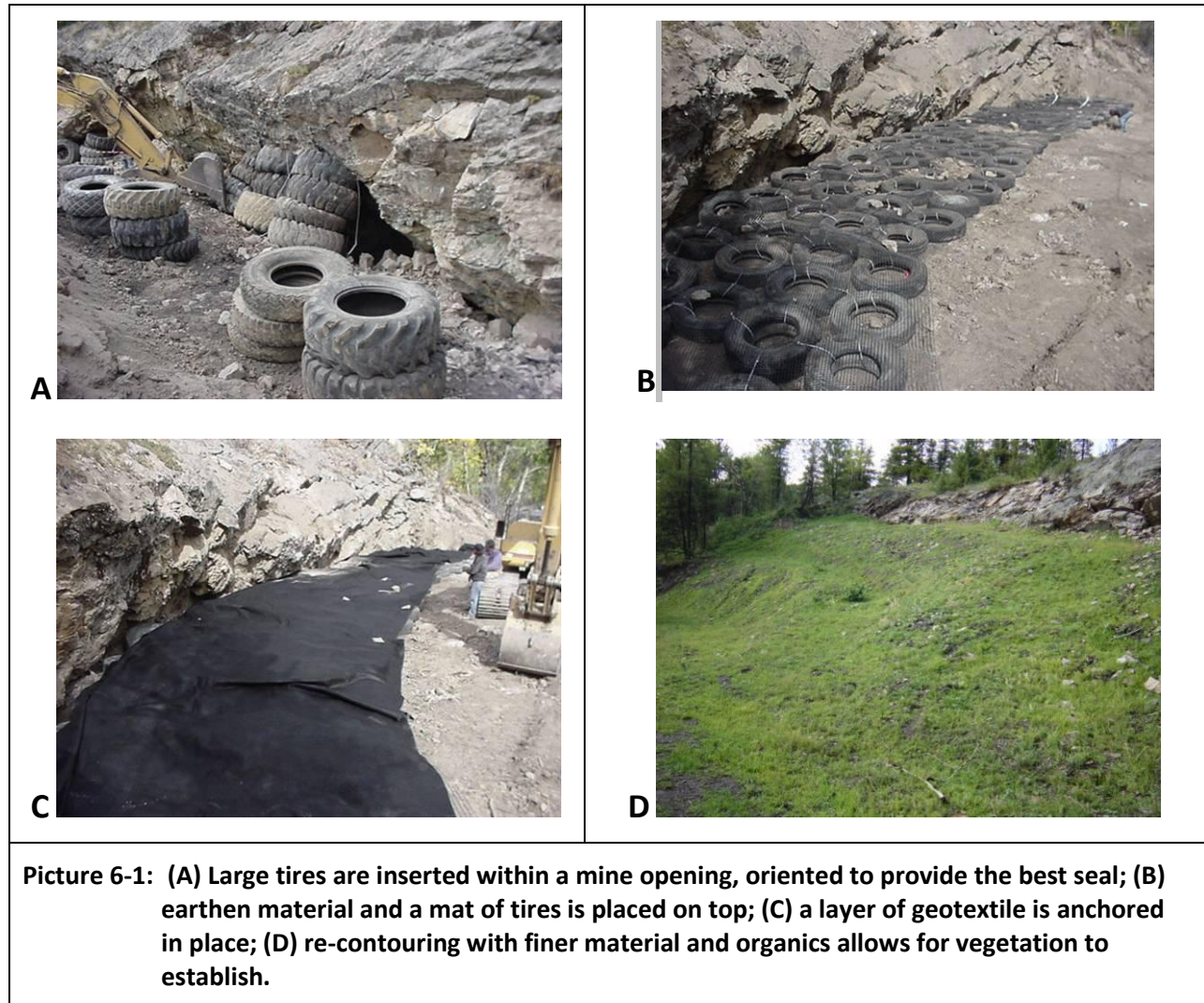
## 6.3 Portal and Underground Mine

### 6.3.1 Mine Backfill

Throughout operations, backfill of the mine stopes will occur. Near the end of the mine life, when mining along the main ramp, paste backfill of the ramp will occur. The backfill serves primarily as structural support for the mining operation but has an added benefit of limiting exposure of mine walls to oxidative conditions.

In addition to backfill, the mine openings must also be capped or blocked to ensure the safety of public and wildlife, and to limit portal discharge of groundwater.

The portal will be sealed off by a barrier constructed of tires and earthen material, a technique used in Alberta and British Columbia. As per the example shown below<sup>1</sup> in Picture 6-1 A-D, the tires will be forced into the opening with an excavator (A). The rubber will expand to make a tight seal, and will remain elastic and resilient for hundreds of years when kept away from ultraviolet radiation. Smaller riprap and a mat of tires (B) will be placed on top of the tires inserted in the opening to form a second protective barrier and to provide support for mesh and geotextile (C). The site will then be recontoured with finer material and organics to allow for seeding (D).

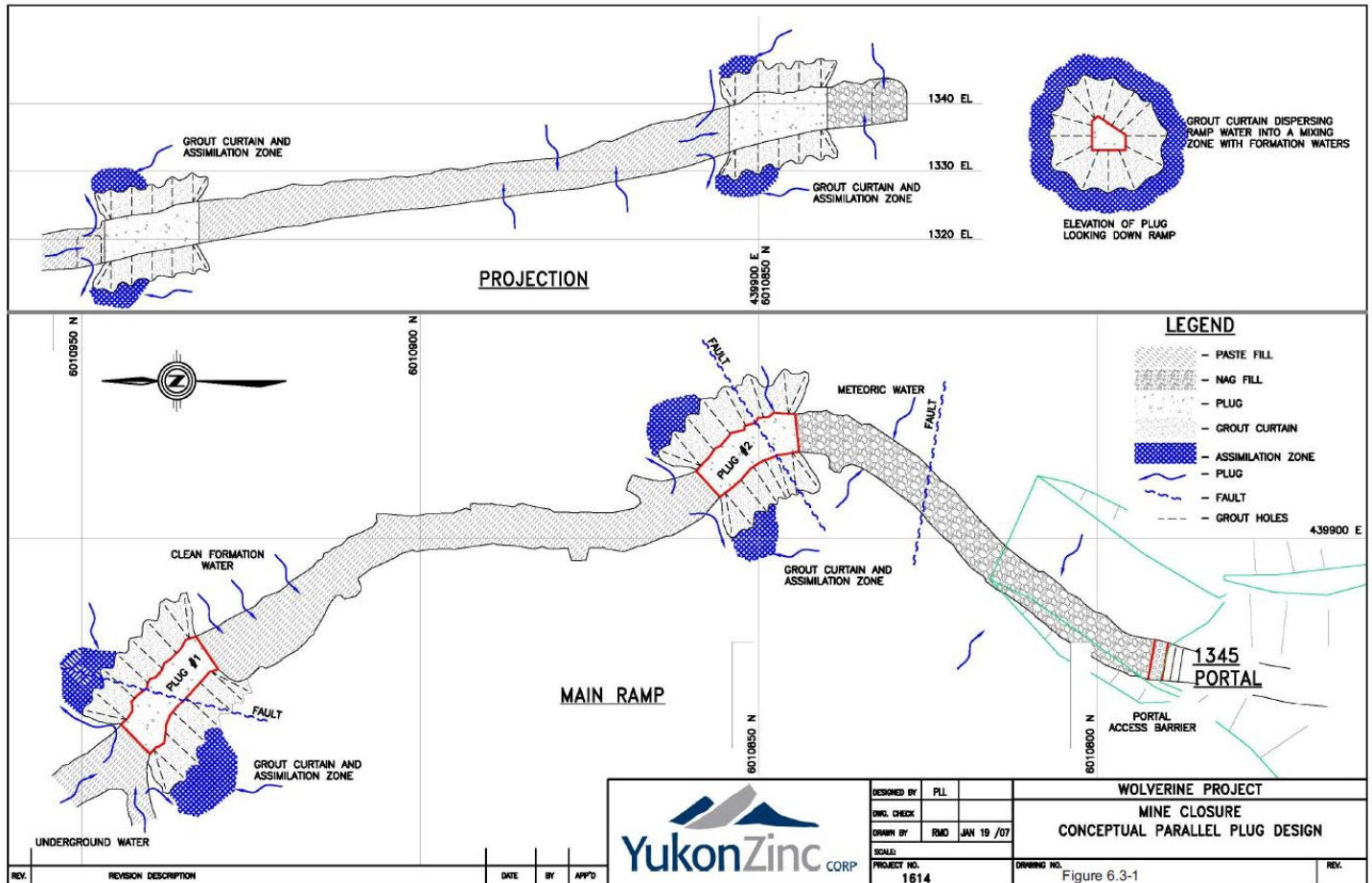


### 6.3.2 Hydraulic Plugs

Preventing or greatly limiting the potential for discharge of groundwater from the mine workings is an important focus of the Wolverine Mine closure plan. While most of the underground mine

<sup>1</sup> N. Tribe & Associates Ltd Geological Consultants. Mining Subsidence Reclamation Consultants. Information from: <http://members.shaw.ca/nta/nltribe/>. Accessed September 4, 2012

workings will contain paste backfill, it will be necessary to install hydraulic plugs at strategic locations within the main access ramp. A conceptual plan of the parallel plugs is provided in Figure 6-1. The purpose of the plugs is to stratify the water within the mine workings, so that only meteoric water is present in the upper part of the main ramp. Plug location must be carefully selected with regard to the mechanical and hydraulic characteristics of the rock, and a site-specific knowledge is necessary for detailed design.



**Figure 6-1: Mine Closure Conceptual Parallel Plug Design**

The ventilation opening will also be plugged with a concrete plug to minimize the potential for groundwater discharge and prevent public or wildlife safety hazards.

Some portal discharge is expected at closure. Monitoring data from the upper reaches of the underground test mine indicates that there is a likelihood that water stratified in the upper portions of the ramp may be of acceptable quality to directly discharge to the environment. In the event that this water is of poorer quality than expected, a contingency measure will be in place. Specifically, YZC will construct a drainage ditch from the portal to the Biopass biotreatment system as a contingency measure in the event of unexpectedly poor quality water passively discharging from the portal. Details pertaining to the Biopass system are provided in Section 6.3.4 below.

### 6.3.3 Underground Mine Water Quality Predictions

The quality of groundwater following the flooding of mine workings has been an important focus of the Wolverine Mine. AMEC Earth & Environmental (AMEC) has developed an underground water quality model utilizing the static and kinetic geochemical testing database for mine rock types at Wolverine. The primary objective has been to develop predictions of water quality of flooded mine workings at closure. A detailed assessment and prediction was included in *Wolverine Mine Reclamation and Closure Plan V2008-02 (Appendix B)*, and annual updates on humidity cells testing of mine rock, ore, neutralization potential depleted ore, dense media separation float and cemented paste backfill are provided in Wolverine Mine Monitoring and Surveillance Plan annual reports.

Underground water quality predictions will be updated when the mine has been developed to depth and additional site-specific data is collected from the mine to update the model. A summary of key predictions from the initial water quality model are provided below.

The chemical composition of the mine water was modeled with the geochemical equilibrium model MINTEQA2 to develop estimates of chemical composition of the groundwater following flooding of the mine workings.

Groundwater that floods the mine will dissolve the soluble weathering products accumulated on the exposed surfaces of mine rock and paste backfill. Estimates of the accumulated weathering products on the mine surfaces were based on the humidity cell tests with mine rock, ore and paste backfill. Measured release rates from humidity cells with the six major rock types were used for non-ore bearing rock surfaces to develop mass loading estimates.

Mass loadings to the total water volume in the flooded mine were estimated by scaling mass loadings ( $\text{mg}/\text{m}^2/\text{wk}$ ) derived from humidity cell tests to the estimated surface area exposed in the flooded mine. The weathering products were assumed to accumulate on the mine surfaces throughout the mine operation without losses due to ongoing leaching. The water quality of the mine water was estimated by dissolving the total mass (mg) of accumulated weathering products in the total volume of groundwater (L) that is predicted to flood the mine.

The predicted metal release rates were incorporated into the underground water quality model to evaluate the potential impacts due to rate changes. A summary of the predicted water quality for groundwater at closure in the mine workings is provided in Table 6-3.

**Table 6-3: Predicted Concentrations of Key Parameters in Groundwater in Mine Workings at Closure**

Parameter	Predicted Concentration (mg/L)
Sulphate	238
Aluminum	0.64
Antimony	0.07
Arsenic	0.06
Cadmium	0.24
Copper	0.033
Iron	1.16
Lead	0.12
Molybdenum	0.009
Nickel	0.016
Selenium	0.38
Silver	0.088
Zinc	7.7

#### 6.3.4 Contingency Water Management and Treatment

Closure planning includes a contingency plan for mitigating the potential for poor quality groundwater from the underground workings discharging into Wolverine Creek. Based on baseline water quality sampling programs prior to mine operation, it is known that a portion of the groundwater that contributes to the flow in Wolverine Creek is naturally elevated in zinc, cadmium and selenium. For the treatment of metals and selenium in groundwater that contributes to Wolverine Creek, a passive biological treatment system (Biopass) is being developed and tested. The Biopass system represents passive biological treatment where dissolved metals are precipitated as metal sulphides and dissolved selenium (selenate, selenite) is reduced to solid phase elemental selenium through microbial reduction.

The Biopass system will be constructed in the Wolverine Creek channel along the stretch of the creek that is known to contain higher metal concentrations (e.g. 400 m long) and could potentially receive groundwater with high selenium and other metal concentrations derived from mine water (Figure 6-2). Clean water in Wolverine Creek, upstream of the Biopass channel, will be diverted along the western margin of Wolverine Creek in a lined channel and re-introduced into Wolverine Creek in the lower reach that is not adversely affected by poor quality groundwater.

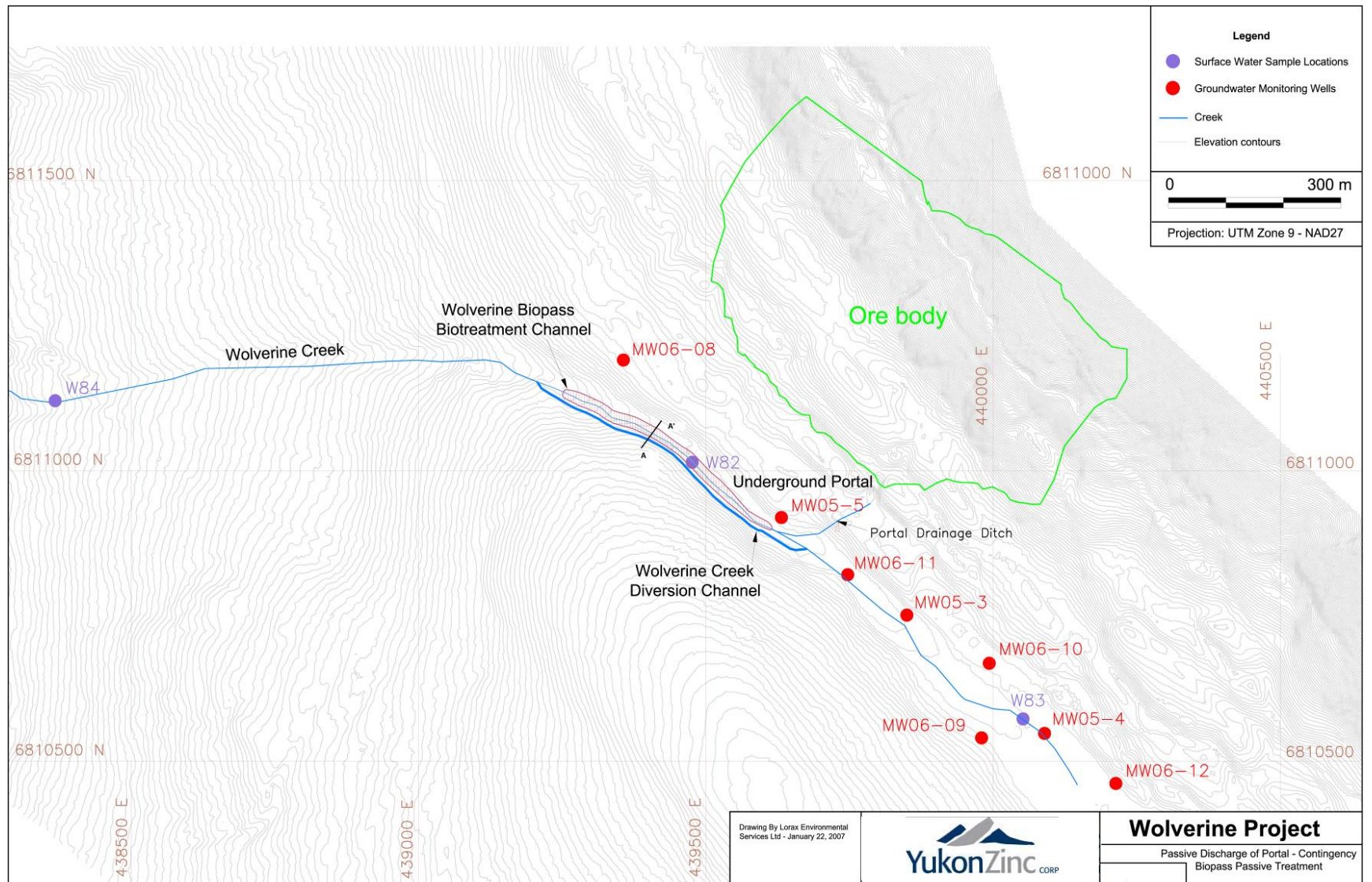


Figure 6-2: Location of Wolverine Creek Biopass System and Diversion Channel

The Biopass will be approximately 2.5 m deep and 3 m wide and will collect groundwater that naturally discharges to Wolverine Creek (Figure 6-3). Deep groundwater that does not enter into Wolverine Creek will flow towards Little Wolverine Lake where no impacts to water quality are predicted to occur. The excavated channel that intercepts groundwater will be filled with an organic substrate and amendments (see Section 4.2) to support the sulphate reducing bacteria and microorganisms that reduce dissolved selenium to solid phase elemental selenium. A gravel layer (0.15 m) will cover the organic substrate to facilitate (lateral) drainage of the upward flowing treated water. The drainage layer will be sealed at the top by an impermeable geomembrane liner to limit exchange of water and gas with the overlying cover (0.25 m) of topsoil to protect the liner. Rainfall and surface runoff that infiltrates into the cover layer will be collected in lateral sand drains and removed to prevent water saturation of the topsoil cover.

The groundwater that discharges into the more permeable organic substrate will be biologically treated while moving in a down-slope direction. Collected groundwater will flow upwards and through the organic substrate where treatment will occur. Before joining the non-diverted section of Wolverine Creek, the Biopass system will merge into a french drain that discharges into Wolverine Creek. While the water exiting from the Biopass system is expected to be depleted of oxygen, this water will be combined with the diverted well-oxygenated water from upper Wolverine Creek. Moreover, this combined flow will then traverse steep terrain for approximately 1000m before reaching the mouth of Wolverine Creek and is expected to be fully oxygenated by the time it reaches this fish-bearing reach.

The groundwater discharge rates that can be treated will depend on the porosity of the organic substrate layer and the total length of the Biopass. For example, by using a Biopass with a total length of 400 m, it will be possible to treat groundwater at discharge rates of approximately 2 L/s; groundwater discharge rates in the treatment area are expected to be on the order of 0.5 L/s to 1 L/s, following installation of the hydraulic plugs in the portal.

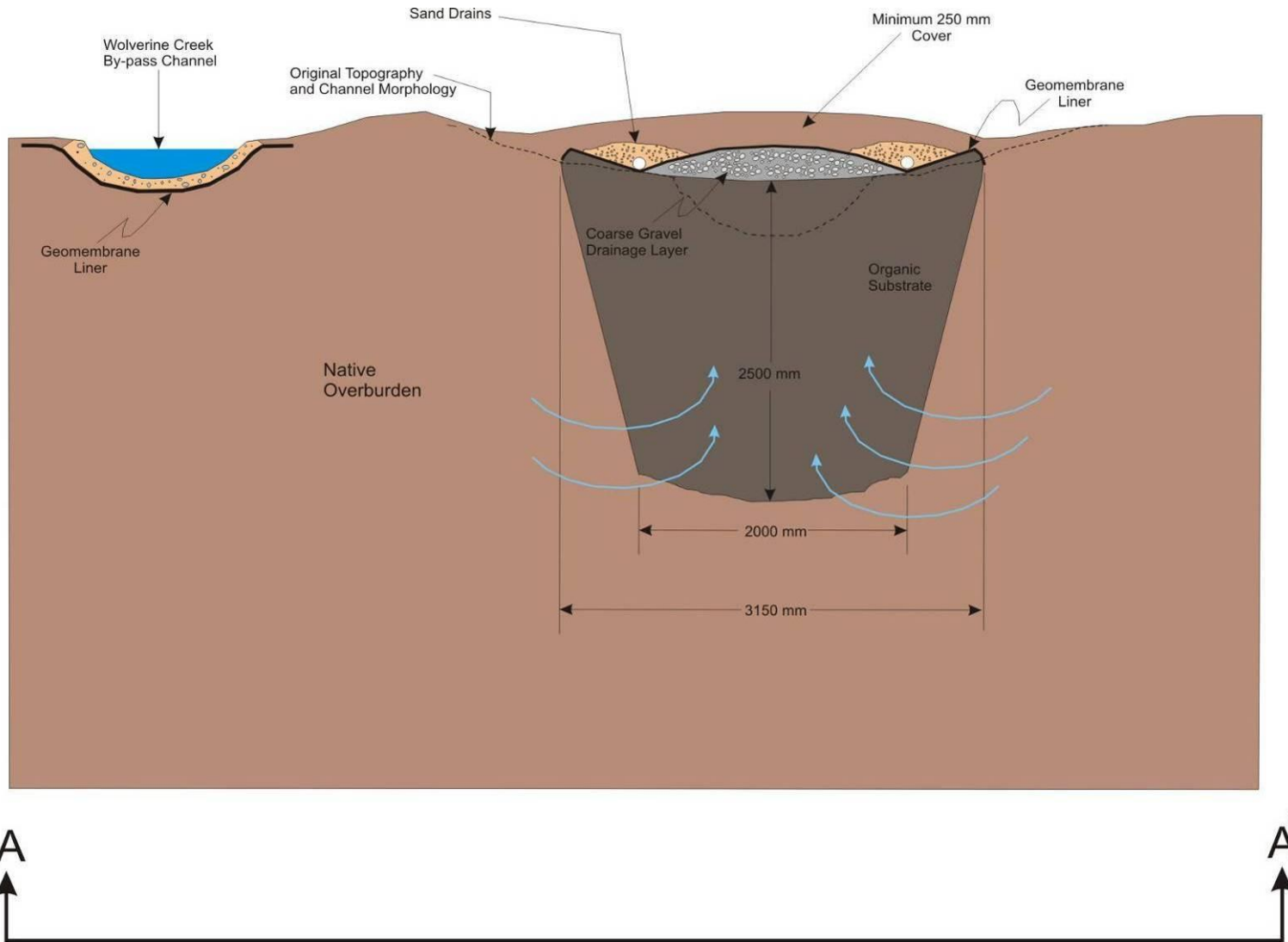


Figure 6-3: Cross-Section along Wolverine Creek Illustrating Biopass Design and Diversion Channel

### **6.3.5 Reclamation**

Limited residual reclamation activity will be required in the areas immediately adjacent to the mine workings and the portal apron. Soil placement and reseeded of these areas are largely addressed as part of the industrial complex reclamation. Minor reclamation and revegetation along the discharge channel corridor from the portal to the Biopass will be completed.

## **6.4 Industrial Complex Infrastructure**

Closure issues related to infrastructure include public health and safety, site stabilization, aesthetics, and restoration of disturbed lands. The industrial complex buildings (mill, crusher, concentrate load out, truck shop, assay lab, offices, and camp) and support facilities will be decommissioned in stages, with the water treatment plant supporting infrastructure removed last.

By the end of the closure period (post water treatment) all materials from industrial complex buildings will be completely removed with the exception of concrete foundations, which will be buried *in situ*.

Equipment with marketable value will be sold, and the remaining assets will be disposed of through demolition and salvage contracts. In the event that it is uneconomical to remove non-hazardous materials from the site, such material will be buried in the landfill.

Following demolition and dismantling of the industrial complex area, approximately 22 ha of area will require soil placement and reseeded. Closure costing has assumed recontouring of the area followed by placement of 250 mm of salvaged topsoil.

### **6.4.1 Power Generation Infrastructure**

During the initial closure stage, power requirements will be reduced and only those generators required for ongoing activities will remain operational to support the water treatment plant, pipeline pumps and auxiliary facilities. Excess gensets will be deactivated and removed from the site. Power poles and distribution lines to facilities no longer in use will be salvaged or buried in the landfill.

At the end of the closure phase when water treatment is no longer required, the remaining gensets will be removed from the site, and the distribution lines will be re-spoiled for salvage or buried in the landfill if in poor condition. Poles will be removed and if the poles are treated with a preservative such as creosote, the contaminated portion of the poles will be disposed of in accordance with Yukon Special Waste Regulations.

### **6.4.2 Explosives and Magazines**

Unused explosives and detonation devices will be checked for condition and either returned to the supplier for credit, shipped to another third party user, or destroyed through appropriate procedures. In all cases the explosives will be handled, transported and disposed of in compliance with the Explosive Act. The explosives magazines will be returned to the supplier or to a third party.

### **6.4.3 Fuel Storage Tank Area**

Fuels and lubricants required during the three-year closure phase will only be ordered on an as-needed basis with the objective of reducing the inventory of remaining fuels during decommissioning. Fuels remaining at the end of the active closure phase will be either returned to the original supplier or possibly sold to a third party user. All tanks will be emptied of their contents in accordance with the Yukon Environment Act. Excess fuel storage tanks will be hauled away for salvage.

Propane tanks used for underground heating will be removed by a qualified contractor once underground operations cease. Associated fuel delivery lines will be removed and disposed of in an appropriate manner.

### **6.4.4 Equipment**

All fixed and mobile equipment with marketable value, including equipment from the underground mine workings, will be removed and sold. Materials within the mine without any marketable value and that are non-hazardous, such as piping, wood, and concrete, etc. will be left in place. Electric installation cables will be left in place unless it is determined that they contain hazardous materials. Equipment that cannot be sold or is deemed to be hazardous will be disposed of in a proper manner.

### **6.4.5 Industrial Reagents and Hazardous Products**

Chemicals, reagents and hydrocarbon products will be consumed as mine operations are brought to a close. Any remaining materials will be removed from the mine site and returned to the original supplier for credit and reuse, or sold to a third party user subject to the appropriate regulatory requirements. For specialized products, disposal options may include disposal through a licensed waste disposal firm. It is anticipated that such material will be small in volume.

### **6.4.6 Water Management Structures**

Drainage structures within the industrial complex area (Collection Ditches 2, 3 and 5) consist of geomembrane-lined open channels to transport storm water to a collection pond (Sump #2) prior to being pumped to the tailings impoundment (Figure 2-3). The Collection Ditches and Sump #2 will be decommissioned following the removal of all industrial complex structures. Liners will be removed and the ditches and sump backfilled with coarse material.

Ditch 1 upslope of the industrial complex (Figure 2-3), used to divert non-contact surface runoff around the area, will be decommissioned once infrastructure footprints and collection ditches have been reclaimed.

### **6.4.7 Miscellaneous Materials**

All salvageable material will be sold and removed from the site. Material that has no scrap value will be disposed of in the landfill site. Materials will be examined to ensure that all hazardous materials have been removed for proper disposal.

## 6.5 Tailings Facility Area

The current status of the tailings impoundment is shown in Picture 6-2 in July 2012 and the general arrangement of the tailings impoundment at life of mine is provided in Figure 6-4. The lined area in Picture 6-2 is the current operational starter dam impoundment. Decommissioning, reclamation and closure requirements for the tailings facility and supporting infrastructure are provided below. Reclamation of the downstream dam face will be completed as part of the progressive reclamation program.



**Picture 6-2: Tailings facility area during ultimate dam construction; lined area is starter impoundment (July 6, 2012)**

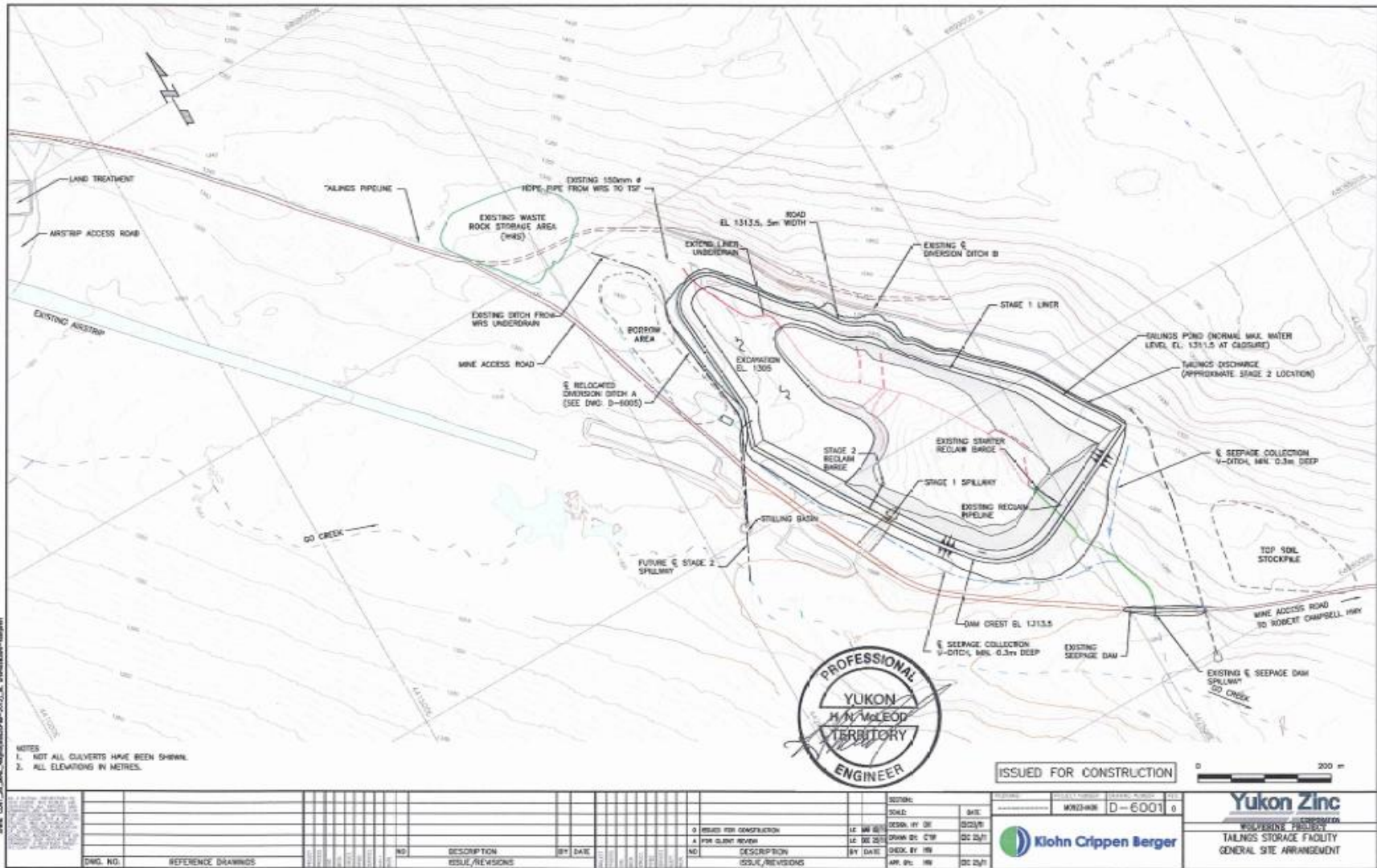


Figure 6-4: Issued for Construction Tailings Facility General Arrangement – Ultimate Dam

### 6.5.1 Tailings Impoundment

Ore processing will result in a total of 4.07 M tonnes of tailings over the life of mine, with approximately 2.1 M tonnes stored within the tailings impoundment. Process effluent from the grinding and flotation circuits is also stored in the tailings impoundment prior to being recycled back to the process plant.

The tailings comprise a sand-silt mixture with a relatively low permeability. Static testing (acid base accounting) of composite tailings samples indicated that the tailings contain significant quantities of sulphide-sulphur and lesser quantities of neutralization potential. As such, Wolverine tailings are characterized as potentially acid generating. Kinetic testing of two tailings samples in laboratory humidity cells, overseen by Marsland Environmental Associates, ceased in February 2012 after operating for over 340 weeks each. Humidity cell tests have indicated that the onset of acid generation in lab conditions could take five years for the diluted ore tailings sample, the most representative sample of actual Wolverine tailings. Laboratory humidity cells are accelerated weathering tests with conditions that are notably different than the conditions found in the tailings facility; nevertheless, for closure planning purposes, tailings are assumed to be potentially acid generating. Closure mitigation strategies have focused on eliminating the potential for tailings oxidation within the impoundment.

To prevent oxidation of the tailings solids and subsequent acid generation, the tailings impoundment has been constructed as a water retaining structure underlain with an impermeable liner. This will permit the tailings to remain completely saturated, both during operations and at closure, and will eliminate the potential for acid drainage from the facility. Moreover, the liner also greatly reduces the potential for seepage of tailings water and the concomitant potential for groundwater contamination occurring both during operations, closure and at post-closure. The tailings closure strategy involves the placement of an inert cover material over the tailings solids and the maintenance of a water cover over the entire facility to provide a stable cover for the tailings and reduce the potential for remobilization and re-suspension of tailings solids from wind induced wave action. YZC currently proposes to quarry coarse inert material (CIM) for use in covering the tailings. The borrow location for this CIM will be evaluated and full acid rock drainage testing (e.g. acid-base accounting and shake flask testing) will be performed to confirm there is no potential for acid generation and/or metal leaching from the material.

Upon cessation of operations, the CIM cover will be placed over the surface of the tailings in two lifts. During the first winter of the closure period, a 0.5 m thick layer of CIM will be placed on the ice within the tailings pond. As the ice melts, the material will gradually settle over top of the submerged tailings. The objective is to place the cover with minimal disturbance to the tailings interface. Following complete settling of the material, an underwater survey will be conducted to ensure adequate and consistent cover material over the tailings. During the second winter, a second 0.5 m thick layer of material will be laid over the ice to complete the 1.0 m material cover.

Ultimately, the tailings facility will be closed as a saturated deposit with a combined cover of 1.5 m over the tailings consisting of the approximately 1.0 m of material and 0.5 m of water (Figure 6-5; note vertical scale = 5x horizontal scale).

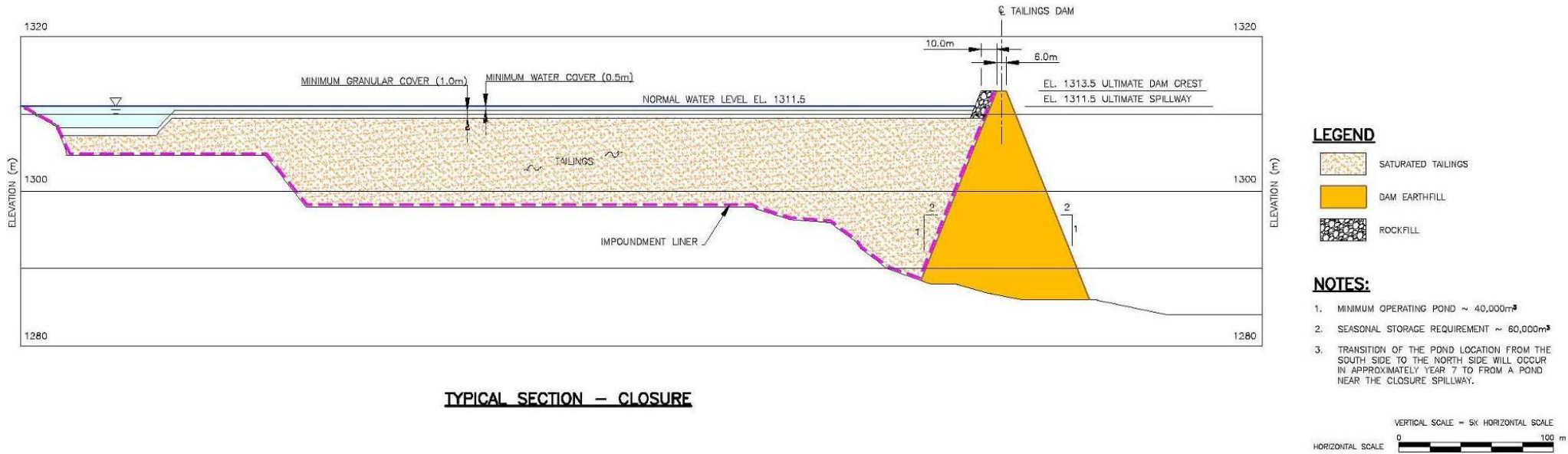


Figure 6-5: Typical Section through Tailings Facility at Closure (vertical scale = 5x horizontal scale)

The potential effects of climate change have been evaluated and duly considered in the design and closure management of the tailings impoundment. Wide-ranging precipitation conditions (e.g. 100-year dry and 100-year wet) were evaluated in water balance modeling for the facility in support of this plan. Continued monitoring of site meteorological conditions (e.g. precipitation and evaporation) will also provide the necessary supporting data to ensure all tailings design criteria for extreme events, including climate change, are adequate and comprehensive.

### 6.5.2 Water Quality at Closure and Treatment Requirements

During closure, the dominant inflow to the tailings impoundment water balance is runoff originating from the tailings area as a result of decommissioning of diversion ditches and the underdrains. During the initial three years following closure, excess tailings water will be treated through the water treatment plant and water levels in the impoundment will be maintained below the spillway elevation of 1311.5 m.

At cessation of operations, it is anticipated that roughly 80,000 m<sup>3</sup> of tailings water will exist in the tailings pond in the impoundment. Upon removal of the diversion ditches and underdrains, annual clean water inflows of runoff and precipitation to the facility are expected to be on the order of 170,000 m<sup>3</sup>. Accordingly, approximately two tailings water volume replacements are expected to occur for each year. By the end of year-3 closure, approximately 5 to 6 complete volume replacements would have occurred with clean runoff water. The impoundment water quality should return to near 'baseline' conditions following treatment and removal of the excess water at closure and upon replenishing the pond with fresh water from annual inflows of clean runoff. As such, the anticipated three-year closure treatment phase is dictated by the amount of time required to flush tailings influenced water from the impoundment to achieve overflow water quality below discharge limits. The tailings impoundment will be closed as a 'wet' facility with water cover over the tailings and a permanent spillway to manage discharge as well as flood flows through the impoundment. Because the tailings are to be covered with approximately 1 m of cover material, diffusion of tailings porewater to the overlying water column will be attenuated and the influence of tailings porewater on overlying water is anticipated to be minimal.

As previously discussed, the water treatment plant will remain in operation to treat the tailings facility overflow water during the early phases of closure. For the purposes of estimating current closure costs, it has been assumed that the water treatment plant has been constructed and is operational for the Existing Condition scenario (it will be constructed in 2013 and operation in 2014).

The following infrastructure and equipment will remain operational or onsite to support water treatment plant operations:

- onsite roads to the camp, water treatment plant, tailings facility, and airstrip;
- Retention pond associated with water treatment plant;
- main access road;
- light duty vehicles;
- reclaim and discharge pipelines and pumps;
- fuel storage facility;
- power generating facility with adequate capacity to power the water treatment plant, pumping systems, and camp;

- small maintenance workshop;
- laboratory for analysis and reagent storage facility; and
- communication system

The water treatment plant and seepage dam will be decommissioned when the effluent quality from tailings facility is in compliance with *Type A Water Use Licence QZ04-065* requirements and suitable for passive discharge to the receiving environment.

Long-term groundwater quality beneath the tailings impoundment following closure is expected to remain at baseline conditions owing to the fact that the tailings facility is completely lined.

### **6.5.3 Water Management Structures**

#### **6.5.3.1 Pipelines**

Once the mill is no longer operational, the tailings and water reclaim pipelines will be dismantled and disposed of in the tailings impoundment. The tailings pipeline will be removed and disposed of within the tailings impoundment prior to the cover material being added in Year 1 of closure. The reclaim pipeline will be removed and disposed of offsite once water treatment is no longer required (Year 3 of closure). The pipeline corridor will be seeded as barren ground is exposed with pipeline removal.

#### **6.5.3.2 Diversion Ditches and Underdrains**

Diversion Ditches A and B (see Figure 6-4) and up-gradient underdrains will be decommissioned and clean runoff will be permitted to enter directly into the tailings impoundment to facilitate the replacement of tailings-affected water with clean runoff. Ditches will be backfilled and re-contoured consistent with the original topography. Disturbed areas along the ditch alignments will be revegetated.

#### **6.5.3.3 Spillway**

The spillway on the tailings impoundment will not be removed at closure as this structure serves as the natural overflow of the impoundment once tailings water is of acceptable quality for direct discharge. Routine maintenance of the spillway will be required to ensure that the structure can freely transport water. It is expected that any maintenance will be required prior to the onset of the snowmelt period.

#### **6.5.3.4 Seepage Recovery Dam**

Once the tailings impoundment water quality is of acceptable discharge water quality, the seepage recovery dam will be decommissioned in conjunction with access road closure activities as dam is formed by a section of the road.

### **6.5.4 Dam Safety and Monitoring**

The tailings dam is designed with a minimum factor of safety of 1.15 for the Maximum Credible Earthquake. Consequently, the main concerns with dam safety on closure are associated with erosion of the dam or blockage of the spillway. Accordingly, a long term care

and maintenance plan will be prepared to confirm that erosion is not occurring and that the spillway is clear. Measures to mitigate these potential concerns include the following:

- The downstream slope of the dam will be revegetated during the operations phase to minimize erosion.
- 10 m wide neutral rockfill will be placed adjacent to the upstream crest of the dam. The rockfill will keep the “free water” away from the dam crest, further reducing the potential for water release even with a significant erosion event.
- The ultimate dam spillway, located at the end of the impoundment away from the dam, will consist of an excavated channel lined with large riprap with discharge capacity for the routed peak flow resulting from the 10,000-year rainfall plus snowmelt event.

The physical and seepage conditions in the dam and area directly downstream of the dam will be monitored during closure as follows:

- Routine: visual monitoring by mine personnel every second month until safe long term trends are indicated
- Intermediate: visual monitoring by the site dam engineer and annual review of monitoring data and dam performance by the design engineer
- Comprehensive: Dam safety review by dam engineer prior to decommissioning and otherwise routinely every five years (even after decommissioning); and
- Special Reviews: site visit and review of monitoring data are required after the occurrence of any potentially damaging events (e.g., floods, earthquakes) or unusual observations (e.g., cracks, sinkhole formation).

Details pertaining to these monitoring requirements as well as the monitoring of inclinometers, piezometers, survey monuments, climate conditions, pond level and groundwater wells are included in the Wolverine Mine Tailings Facility Operation, Maintenance and Surveillance Manual V2010-01.

### **6.5.5 Water Quality Monitoring**

Water quality monitoring of the surface stations and excess water discharge during the ice-free months represents the most significant closure monitoring requirement of the Wolverine Mine.

Monitoring frequency will be in accordance with Water Use Licence QZ04-065. During the first three years of closure, 19 surface water quality sites (including the tailings pond location T1) will be monitored monthly and groundwater quality monitoring at 24 wells will occur annually. During the discharge period from May to October (approximately 184 days), daily monitoring of the discharge quality at the retention pond (R1) and at the compliance point in Go Creek (W80) will occur. Based on sampling of the surface and well sites over the past two years, it is not possible to sample all sites year-round due to frozen/no flow conditions or safety issues that limit access. As summarized in Table 6-4, incorporating this site-specific knowledge, the total analytical load for water quality monitoring is approximately 1773 samples over the initial three year closure period.

Once tailings pond water is demonstrated to be routinely within permitted discharge limits, annual monitoring in the summer of the 18 surface water, T1 and 24 groundwater well locations is proposed for the next seven years (Closure Years 4-10).

**Table 6-4: Surface Water and Groundwater Quality Sampling Frequency During Closure (Year 1 to 3)**

Surface WQ Station	Monthly Samples			Daily During Discharge	Well Station	Annual Sample
	2010	2011	Projected			
W82	11	12	12		MW05-1A	1
W9	10	8	9		MW05-1B	1
W1	8	7	8		MW05-2A	1
L1	10	12	11		MW05-2B	1
W21	12	12	12		MW05-3A	1
W8	10	8	9		MW05-3B	1
W31	8	8	8		MW05-4A	1
W16	11	12	12		MW05-4B	1
W15	11	12	12		MW05-5A	1
W81	11	12	12		MW05-5B	1
W80	9	10	4	184	MW05-6A	1
W12	10	8	9		MW05-6B	1
W14	10	8	9		MW05-7B	1
W22	12	12	12		MW06-8S	1
W40	12	12	12		MW06-8M	1
W71	12	12	12		MW06-8D	1
W72	12	12	12		MW06-9S	1
W73	12	12	12		MW06-9M	1
T1	12	12	12		MW06-10S	1
R1				184	MW06-10M	1
					MW06-10D	1
					MW06-11S	1
					MW06-12S	1
					MW08-13	1
<b>Total Samples</b>			<b>199</b>	<b>368</b>		<b>24</b>
<b>Total Samples per Year</b>	<b>591</b>			<b>3-Year Total</b>	<b>1773</b>	

## 6.6 Temporary Waste Rock Storage Pads

Waste rock currently contained on the two waste rock pads totals 110,500 m<sup>3</sup> and is designated for use in mine backfill. Should permanent closure of the site occur prior to all waste rock being hauled underground, the material will be hauled and disposed of within the tailings facility. It is assumed that there is adequate capacity for the entire volume of rock stored on surface should this be required, and an early closure would mean that less tailings will be deposited in the facility.

## 6.7 Mine Access Road

During mine access road design, Yukon Engineering Services assessed road closure requirements based on completion of the Phase 2 road. The closure requirements will be reviewed upon completion of road construction to Phase 2 level and as-built drawings. Closure of the access route will involve both access control during the initial closure phases and decommissioning and access control when the road is no longer required.

### 6.7.1 Access Control

During the initial closure phase (year 1 to year 3) vehicular access from the Robert Campbell Highway will be controlled remotely on 24-hour basis from the gate located at km 0.1.

Once all decommissioning activities have been completed and use of the access road is no longer required, another access control gate will be installed near km 14. This location has been selected on a 10% ascending gradient, some 3 km north of the glaciofluvial plateau that separates the upper Money Creek and Go Creek drainages. The location will deny access to highway vehicles, all-terrain vehicles and snowmobiles, should they proceed along the reclaimed road corridor from the highway.

### 6.7.2 Access Road Decommissioning and Closure

Road closure will involve the removal of the culverts and drainage structures and decommissioning of the roadbed. The roadbed will be contoured and rounded throughout its length, and will include the following activities:

- In smaller cuts and fills, ditches will be filled in, and the soils shaped to match the surrounding topography
- In large cuts and fills, the embankment or excavation footprint will be reshaped to a lesser extent, but all slopes will be flattened or rounded to better suit the surrounding terrain
- Organic stripping materials placed at the toe of fills during the original construction phase, will be re-contoured along the downhill side to act as a sediment filter, and to re-establish vegetation, and
- Surfaces of gradients less than 25% will be scarified where necessary using scarifiers on bulldozers, excavators and graders to better accept seeding.

All culverts, bridges, and drainage structures will be removed and disposed of off-site at an appropriate location. The following activities are planned:

- Trenches resulting from the removal of culverts will be swaled or contoured to match the surrounding terrain
- Where warranted due to fine grain soils, erosion protection will be installed within the remaining swales, to a point where the reclaimed watercourse meets with its original path in undisturbed soil
- Where ditches are to be left intact (some steeper sections) existing ditch erosion protection may be left in place, and
- The Bunker Creek Bridge at km 10 will be removed, and the abutments will be excavated to the level of the rip-rap placed during construction.

All remaining borrow sources will be stabilized and contoured to prevent surface erosion, then seeded as per the guidelines developed from the Reclamation Research Program.

## **6.8 Camp**

Portions of the modular camp facilities will be progressively removed as onsite personnel requirements decrease. Facilities will remain for care and maintenance staff and for reclamation crews and monitoring crews until all closure objectives have been met.

Once all closure activities have been completed, remaining modular structures will be removed. Sewage treatment facilities will also be decommissioned and salvageable material removed from site. The water supply wells will be decommissioned once the potable water treatment and camp facilities are no longer required. The pump houses and the buried distribution system will be removed for salvage and or if deemed appropriate, the distribution system will remain in situ to minimize subsequent surface disturbance associated with removal. Water wells will be backfilled throughout their entire length with a combination of concrete and grout, and the top 5 m will be completely cemented.

Following decommissioning, the camp area will be recontoured, soil growth medium will be placed and the area seeded.

## **6.9 Waste Management Areas**

Waste management areas include the landfill, special waste storage pad, solid waste storage area, and land treatment facility (Figure 6-6).

### **6.9.1 Landfill and Waste Storage Areas**

Decommissioning and demolition activities will generate some non-hazardous waste material that will be disposed of in the landfill area. Waste that cannot be buried in the landfill will be temporarily stored at the solid waste or special waste storage areas prior to transportation for disposal offsite. At the end of closure activities, the landfill and storage areas will be covered with a 250 mm thick layer of compactable soil material and graded to encourage the shedding of water. The sites will then be seeded.

### **6.9.2 Land Treatment Facility**

Soils present in the land treatment facility during the final year of operation will be tested to determine if material is acceptable for use in reclamation programs around the industrial complex. Depending on the level of contamination, contaminated soils excavated during decommissioning may be placed in the land treatment facility for remediation for subsequent use in reclamation activities in the closure phase. If the various soils are found to contain residual contamination that does not permit use in reclamation, they will be hauled off site to an approved facility.

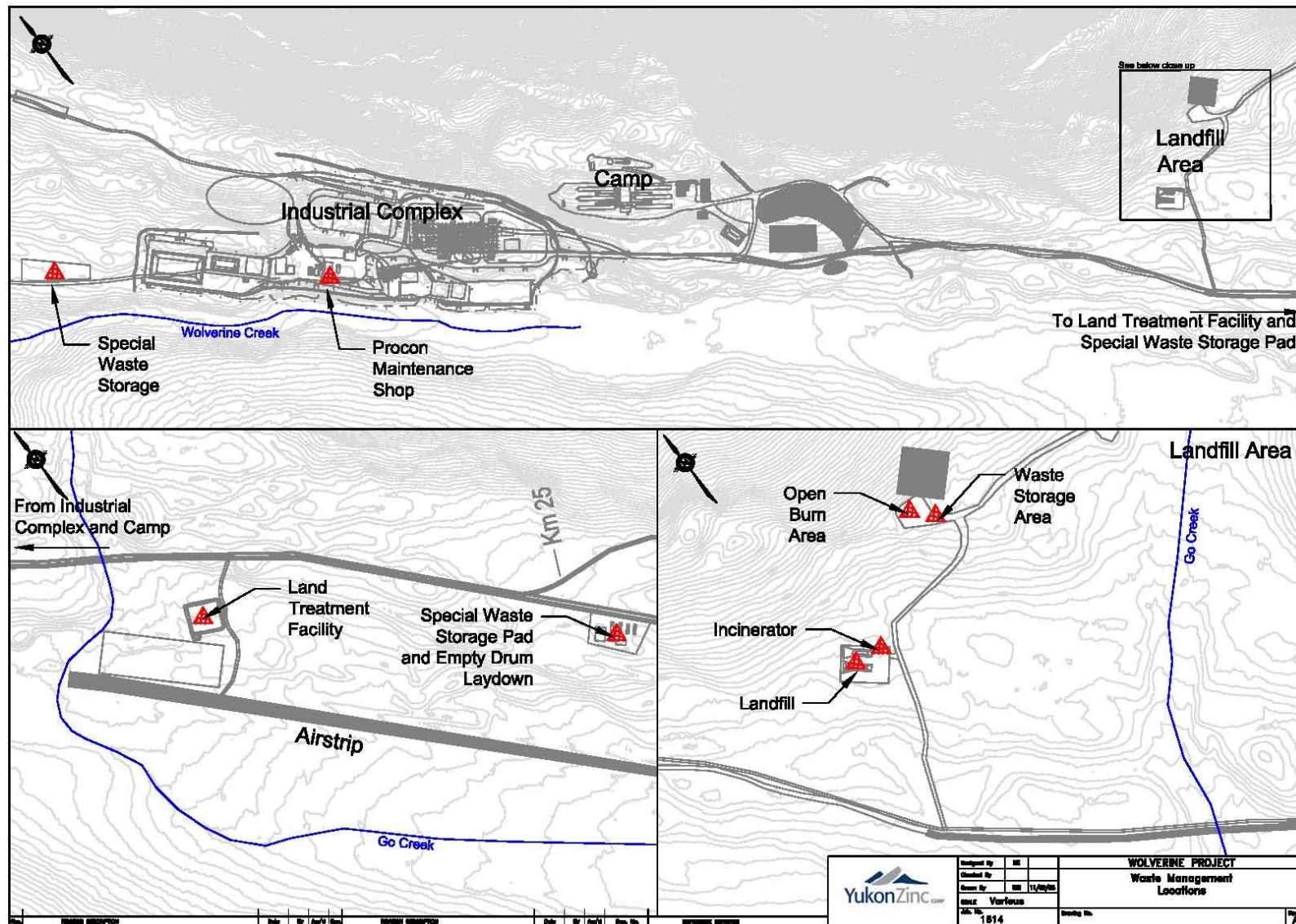


Figure 6-6: Location of Special Waste Storage, Landfill, Incinerator, Land Treatment Facility, Waste Storage and Open Burn Areas



## 6.10 Closure Manpower

A number of personnel will be required onsite to implement the various decommissioning, closure and reclamation tasks. The majority of these activities will be undertaken on a seasonal basis (May–October) and directed by an onsite manager. A caretaker will remain onsite following seasonal closure of the site.

The work force requirements for the decommissioning or initial closure period (Year 1 to Year 3) and the late closure phases (Year 4 to Year 10) are provided in Table 6-5.

**Table 6-5: Site Decommissioning, Closure and Reclamation Work Force Requirements**

Personnel	Decommissioning Period	Late Closure Period
	Year 1 to Year 3	Year 4 to Year 10
Project Manager (Corporate)	1	1
Project/Mine Engineer	1	
Environmental Monitor	1	1
Construction Supervisor	1	
Equipment Operators	2	1
Mechanics/Welders/Electricians	2	
General Laborers	2	1
Camp Support Staff	2	
<b>Total Seasonal</b>	<b>12</b>	<b>4</b>
<b>Total Off-Season (Caretaker)</b>	<b>1</b>	

## 7 Reclamation and Decommissioning Cost Estimates

Decommissioning and closure costs for implementing the Wolverine Mine closure plan have been prepared for the existing condition (August 2012) and Life of Mine (LOM) at end of 2020.

The cost summaries provided below include costs associated with project shutdown, the decommissioning of facilities and support infrastructure, reclamation activities, and compliance and reclamation monitoring. The estimated cost is based on the following assumptions, rationale and information:

- No salvage value is included in the estimate.
- No discounting has been included in the estimate.
- Reclamation costs are based on the cost of having the work completed by a third party contractor.
- Unit rates for equipment for dry conditions were obtained from Government of Yukon Third Party Equipment Rental Rates (2011/2012) and focused on contractors and rates published out of Whitehorse, Ross River and Watson Lake. A summary of the unit rates employed in the cost evaluations are provided in Table 7-1.
- Costs associated with closure monitoring and in particular surface water quality and groundwater quality analytical are based on current costs incurred by YZC. The number of samples for analysis over the total closure period is based on monitoring requirements set forth in Water Use Licence QZ04-065.
- Contingencies, ranging from 10% to 15%, have been included in the cost estimate for each closure component based on the level of uncertainty in the assessment and the degree of risk associated with each component.
- Decommissioning, reclamation and closure (including post-closure) phases are assumed to be complete 10 years after the cessation of mining.
- The closure phase water balance for the tailings facility will have a net positive balance and the water will require treatment before being discharged to Go Creek for an estimated 3-year period. No funds for treatment have been allocated beyond this 3-year closure phase.
- Closure water treatment costs have been estimated from similar operating biological reduction water treatment systems with a minimum of 10 years operating cost experience. The water treatment costs range from \$0.07/m<sup>3</sup> to \$0.39/m<sup>3</sup> (Dr. Jack Adams, pers. comm.). For the Wolverine Mine, a closure water treatment cost of \$0.40/m<sup>3</sup> (includes power supply and amendment costs) have been assumed.
- Non-acid generating fill and rock will be available within the project area for closure activities.

**Table 7-1: Unit Rates for Closure Cost Estimates**

Equipment	Rate	
	Hourly	Monthly
Cat D8N Dozer (1991)	\$245	
Volvo A30D Rock Truck (2006)	\$197	
Compactor - Cat CS563 84" (2006)	\$140	
Cat 320CL Excavator (2004)	\$125	
Cat 320 Excavator + Hammer (2004)	\$170	
Cat 14G grader (2000)	\$160	
Cat 950H Loader (2009)	\$150	
Drill Rig	\$190	
Crane 30 ton	\$160	
Light-duty vehicle		\$2,500
Labourer	\$50	
Tradesman	\$80	
Site Supervisor	\$95	
Design Engineer	\$130	
Project Engineer	\$140	
Project Manager		\$9,700
Site Caretaker		\$6,100
Environmental Monitor		\$6,000

Contractor Unit Rates; Misc Costs	Rate	
	Units	Cost
Excavation of Soil in Stockpile	m <sup>3</sup>	\$5
Supply and place geotextile	m <sup>2</sup>	\$12
Load, haul and place topsoil	m <sup>3</sup>	\$5
Load, haul and place tailings cover (CIM)	m <sup>3</sup>	\$7
Load, haul and place rock cover, organics, granular till and clay	m <sup>3</sup>	\$8
Drill, Blast and Haul Rip Rap	m <sup>3</sup>	\$22
Place Rip Rap	m <sup>3</sup>	\$14
Camp Costs	day/person	\$75
Surface water quality analyses	sample set	\$420
Groundwater quality analyses	sample set	\$290
Water Treatment Cost	m <sup>3</sup>	\$0.40
Revegetation Seed Mix	kg	\$13.00
Fertilizer	kg	\$1.00
Seed and Fertilizer Application	ha	\$1,500
Concrete	m <sup>3</sup>	\$85
Culvert Removal (<1200mm)	each	\$1,500
Culvert Removal (>1200mm or multiple/location)	each	\$5,000
Flights (Whitehorses-Wolv + commercial connections)	weekly	\$3,000
Erosion barrier	per linear km	\$3,000

A summary and comparison of the estimated costs to implement the reclamation and closure plans described above are presented in

Table 7-2 for the Existing Condition and LOM. Detailed cost breakdowns are provided in Appendix A for LOM closure costs and additional costs prior to the completion of larger progressive reclamation activities relevant to the Existing Condition scenario are included in Appendix B.

Each closure cost scenario provides detailed costing associated with the following mine components:

- Mine workings
- Tailings facility
- Infrastructure
- Access road
- Reclamation and revegetation; and
- Site Management and Monitoring.

The total closure cost estimated for the Existing Condition scenario is approximately \$9.0 million. By comparison, LOM costs are lower due to completed progressive reclamation programs on the tailings dam face, at the waste rock pads, and adjacent to the road corridor. The total closure cost estimated for the LOM scenario is approximately \$8.0 million, with the most significant costs being associated with Site Monitoring and Maintenance (~\$4.0 million), closure of the tailings facility (~\$1.7 million), and infrastructure decommissioning (~\$1.1 million).

**Table 7-2: Summary of Estimated Costs to Execute Decommissioning, Closure and Reclamation Plans for the Existing Condition and LOM Closure Scenarios**

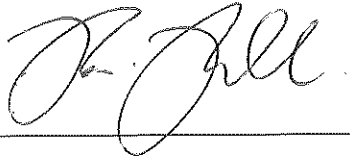
Work Item Description	Existing		LOM	
	Sub-Total Costs	Total Costs	Sub-Total Costs	Total Costs
<b>Mine Workings</b>		\$ 442,249		\$ 442,249
1345 Portal and Vent Raise Closures	\$ 75,664		\$ 75,664	
Installation of Hydraulic Plugs in Access Ramp	\$ 185,800		\$ 185,800	
Installation of Hydraulic Plug in Ventilation Raise	\$ 123,100		\$ 123,100	
15% Contingency	\$ 57,685		\$ 57,685	
<b>Tailings Facility</b>		\$ 1,719,828		\$ 1,682,868
Reclaim Tailings Dam Face	\$ 33,600		\$ -	
Reclaim Seepage Recovery Dam	\$ 15,120		\$ 15,120	
Decommission Diversion Ditches	\$ 24,370		\$ 24,370	
Remove Tailings and Reclaim Pipelines	\$ 129,300		\$ 129,300	
Cover Tailings with Coarse Inert Material (CIM)	\$ 1,138,000		\$ 1,138,000	
Water Treatment and Plant Decommissioning	\$ 223,090		\$ 223,090	
10% Contingency	\$ 156,348		\$ 152,988	
<b>Infrastructure</b>		\$ 2,045,953		\$ 1,106,696
Buildings	\$ 571,801		\$ 571,801	
Waste Rock Pads	\$ 853,870		\$ -	
Power Supply - Gensets	\$ 54,700		\$ 54,700	
Reclaim Site Diversions	\$ 31,500		\$ 31,500	
Water Supply Wells	\$ 10,346		\$ 10,346	
Camp and Facilities	\$ 39,580		\$ 39,580	
Explosive Magazine	\$ 5,150		\$ 5,150	
Miscellaneous Buildings and Structures	\$ 110,910		\$ 110,910	
Industrial Reagents and Fuels	\$ 40,000		\$ 40,000	
Spill Cleanup	\$ 32,100		\$ 32,100	
Demolition Overheads	\$ 110,000		\$ 110,000	
10% Contingency	\$ 185,996		\$ 100,609	
<b>Access Road</b>		\$ 590,214		\$ 519,126
Lower road grade and slope stabilization	\$ 71,080		\$ 71,080	
Remove culverts	\$ 138,500		\$ 138,500	
Bunker Creek rehabilitation	\$ 77,000		\$ 77,000	
Scarify Road Surface	\$ 62,400		\$ 62,400	
Recountour staging, spoil and borrow areas	\$ 47,350		\$ -	
Revegetation, maintenance	\$ 84,450		\$ 73,050	
Barrier installations	\$ 7,000		\$ 7,000	
Engineering and surveying	\$ 48,778		\$ 42,903	
10% Contingency	\$ 53,656		\$ 47,193	
<b>Reclamation and Revegetation</b>		\$ 115,071		\$ 115,071
Stockpile Footprints	\$ 12,600		\$ 12,600	
Mine Site Roads	\$ 92,010		\$ 92,010	
10% Contingency	\$ 10,461		\$ 10,461	
<b>Site Management and Monitoring</b>		\$ 4,101,791		\$ 4,101,791
Organization, Security and Overhead	\$ 1,724,325		\$ 1,724,325	
Document Control	\$ 55,200		\$ 55,200	
Compliance Monitoring and Reporting	\$ 1,463,120		\$ 1,463,120	
Closure Maintenance	\$ 100,000		\$ 100,000	
Wolverine Creek Biopass Contingency	\$ 224,130		\$ 224,130	
15% Contingency	\$ 535,016		\$ 535,016	
<b>Estimated Total Closure Costs</b>		\$ 9,015,105		\$ 7,967,801

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## **Appendix A: Detailed Closure Cost Estimates – Life of Mine**

## Mine Workings - LOM

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>1345 Portal &amp; Vent Raise Closures</b>					
Plug portal and ventilation raisewith tires	Cat 320CL Hoe	hrs	30	\$ 125	\$ 3,750
Place waste rock cap over tires	Cat 320CL Hoe	hrs	20	\$ 125	\$ 2,500
	A30D Rock truck	hrs	40	\$ 197	\$ 7,880
Supply broken rock at base of plug and discharge channel riprap	Cat 320CL Hoe	hrs	20	\$ 125	\$ 2,500
	A30D Rock truck	hrs	40	\$ 197	\$ 7,880
Construct rock drain at base of plug	Cat 320CL Hoe	hrs	10	\$ 125	\$ 1,250
Supply fill to seal discharge channel	Cat 320CL Hoe	hrs	10	\$ 125	\$ 1,250
	A30D Rock truck	hrs	20	\$ 197	\$ 3,940
Construct lined open channel for discharge from portal to biopass system; 300 m length	Cat 320CL Hoe	hrs	20	\$ 125	\$ 2,500
	Compactor	hrs	10	\$ 140	\$ 1,400
Stabilize and vegetate area around channel	Seed and Fertilize	ha	0.09	\$ 1,500	\$ 135
Labour for channel construction	Labourer	hrs	30	\$ 50	\$ 1,500
Labour to assist with placing tires & cap	Labourer	hrs	80	\$ 50	\$ 4,000
Design of rock drain and channel (Engineering)	Design Engineer	hrs	40	\$ 130	\$ 5,200
Interim Portal Discharge Treatment	Water Treatment (1 L/s x 2 years)	m <sup>3</sup>	63072	\$ 0.40	\$ 25,229
Supervision to design & install tires and cap	Site Supervisor	hrs	50	\$ 95	\$ 4,750
<b>Sub Total</b>					<b>\$ 75,664</b>
<b>Install Hydraulic Plugs in Access Ramp</b>					
Drill and grout	grouting 10 m into wall; 20 m length x 2 plugs	hours	300	\$ 190	\$ 57,000
Install concrete plugs	20 m length x 5 m x 5 m x 2 plugs	m <sup>3</sup>	1000	\$ 85	\$ 85,000
Labour for plug installation	Labourer	hours	300	\$ 50	\$ 15,000
Engineering	Design of plugs	hours	60	\$ 130	\$ 7,800
Supervision	Project engineer	hours	150	\$ 140	\$ 21,000
<b>Sub Total</b>					<b>\$ 185,800</b>
<b>Install Hydraulic Plug in Ventilation Raise</b>					
Install concrete plug	75 m length x 4 m x 4 m x 1 plug	m <sup>3</sup>	1200	\$ 85	\$ 102,000
Labour for plug installation	Labourer	hours	150	\$ 50	\$ 7,500
Engineering	Design of plug	hours	40	\$ 130	\$ 5,200
Supervision	Project engineer	hours	60	\$ 140	\$ 8,400
<b>Sub Total</b>					<b>\$ 123,100</b>
<i>15% Contingency</i>					<b>\$ 57,685</b>
<b>Total</b>					<b>\$ 442,248</b>

**Tailings Management Area - LOM**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Reclaim Seepage Recovery Dam</b>					
Seepage Dam Regrade	Cat D8N Dozer - regrade and contour	hours	16	\$ 245	\$ 3,920
Load Haul and Place topsoil	Area of 8000 m <sup>2</sup> with 0.25 m depth	m <sup>3</sup>	2000	\$ 5	\$ 10,000
Revegetate	Seed and Fertilize	ha	0.8	\$ 1,500	\$ 1,200
<b>Sub Total</b>					<b>\$ 15,120</b>
<b>Decommission Diversion Ditches</b>					
Decommission Diversion Ditches A&B	Cat D8N Dozer - regrade and contour	hours	60	\$ 245	\$ 14,700
Decommission Diversion Ditch B	Cat 320CL Excavator for steep slopes	hours	20	\$ 125	\$ 2,500
Revegetate and Stabilize	Seed and Fertilize area 1.56 km x 5 m	ha	0.78	\$ 1,500	\$ 1,170
Culvert removal (800 mm)	Uncovering and removal	Ea.	4	\$ 1,500	\$ 6,000
<b>Sub Total</b>					<b>\$ 24,370</b>
<b>Remove Tailings Pipeline</b>					
Remove Pipeline	Cat 320CL Excavator	hrs	150	\$ 125	\$ 18,750
	A30D Rock Truck	hrs	150	\$ 197	\$ 29,550
	Labour	hrs	300	\$ 50	\$ 15,000
Revegetation	Seed, fertilize - 3km length x 3 m corridor	ha	0.9	\$ 1,500	\$ 1,350
<b>Sub Total</b>					<b>\$ 64,650</b>
<b>Remove Reclaim Pipeline</b>					
Remove Pipeline	Cat 320CL Excavator	hrs	150	\$ 125	\$ 18,750
	A30D Rock Truck	hrs	150	\$ 197	\$ 29,550
	Labour	hrs	300	\$ 50	\$ 15,000
Revegetation	Seed, fertilize - 3km length x 3 m corridor	ha	0.9	\$ 1,500	\$ 1,350
<b>Sub Total</b>					<b>\$ 64,650</b>
<b>Cover Tailings with Coarse/Inert Material (CIM)</b>					
Load Haul and Place Tailings Cover	Place and level CIM on ice in winter	m <sup>3</sup>	145,000	\$ 7	\$ 1,015,000
Load Haul and Place Rockfill	Erosion control on dam face	m <sup>3</sup>	15,000	\$ 8	\$ 120,000
Revegetate CIM stockpile area	Seed and Fertilize	ha	2	\$ 1,500	\$ 3,000
<b>Sub Total</b>					<b>\$ 1,138,000</b>
<b>Water Treatment of Excess Tailings Water</b>					
Biotreatment of excess tailings water	Treatment for 3 years; ~170,000 m <sup>3</sup> /yr	m <sup>3</sup>	510,000	\$ 0.40	\$ 204,000
Decommissioning and Dismantling of water treatment plant	Labour	hours	230	\$ 50	\$ 11,500
Dismantle WTP infrastructure - Industrial Complex	Cat 320CL Excavator	hours	30	\$ 125	\$ 3,750
	Crane	hours	24	\$ 160	\$ 3,840
<b>Sub Total</b>					<b>\$ 223,090</b>
					<i>10% Contingency</i>
					<b>\$ 152,988</b>
<b>Total</b>					<b>\$ 1,682,868</b>

**Infrastructure Decommissioning - LOM**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Industrial Complex + Office Buildings</b>					
Remove salvageable equipment	General Labour	hours	1152	\$ 50	\$ 57,600
	Trades Labour	hours	1128	\$ 80	\$ 90,240
Dismantle Building - Manpower	General Labour	hours	1152	\$ 50	\$ 57,600
Dismantle Building - Manpower	Trades Labour	hours	576	\$ 80	\$ 46,080
Dismantle Building - Equipment and Loading	Cat 320CL Excavator	hours	160	\$ 125	\$ 20,000
	Crane	hours	80	\$ 160	\$ 12,800
Concrete Demolition	Cat 320CL Excavator with Hammer	hours	80	\$ 170	\$ 13,600
Misc. Supplies & Tools	Misc.	L.S.	L.S.		\$ 10,000
Scrap haul to landfill	A30D Rock Truck	hours	208	\$ 197	\$ 40,976
Reslope and contour and bury	Cat D8N Dozer	hours	80	\$ 245	\$ 19,600
Load, Haul and place topsoil	Area of 145244 m <sup>2</sup> x 0.25 m depth	m <sup>3</sup>	36311	\$ 5	\$ 181,555
Revegetate	Seed and Fertilize	ha	14.5	\$ 1,500	\$ 21,750
<b>Sub Total</b>					<b>\$ 571,801</b>
<b>Power Supply - Gensets</b>					
Remove salvageable equipment	General Labour	hours	180	\$ 50	\$ 9,000
	Trades Labour	hours	108	\$ 80	\$ 8,640
Salvage and remove powerline and poles		L.S.	L.S.		\$ 25,000
Dismantle Building - Manpower	General Labour	hours	96	\$ 50	\$ 4,800
	Trades Labour	hours	48	\$ 80	\$ 3,840
Dismantle Building - Equipment	Cat 320CL Excavator	hours	12	\$ 125	\$ 1,500
	Crane	hours	12	\$ 160	\$ 1,920
<b>Sub Total</b>					<b>\$ 54,700</b>
<b>Reclaim Site Diversions</b>					
Decommission 1500 m of diversion ditches	Cat 320 CL Excavator	hours	150	\$ 125	\$ 18,750
Remove culverts (<1200 mm)		L.S.	8	\$ 1,500	\$ 12,000
Revegetate	1.5 km x 3 m	ha	0.5	\$ 1,500	\$ 750
<b>Sub Total</b>					<b>\$ 31,500</b>
<b>Water Supply Wells</b>					
Remove salvageable equipment - pipeline/pumps and tank	General Labour	hours	24	\$ 50	\$ 1,200
	Trades Labour	hours	24	\$ 80	\$ 1,920
Remove pipeline and haul to tailings or underground	A30D Rock Truck	hours	8	\$ 197	\$ 1,576
	Cat 320CL Excavator	hours	8	\$ 125	\$ 1,000
Decommission water supply wells	fill with concrete	Ea.	2	\$ 2,000	\$ 4,000
Misc. Supplies & Tools	Misc.	L.S.	L.S.		\$ 500
Revegetate	Seed and Fertilize	ha	0.1	\$ 1,500	\$ 150
<b>Sub Total</b>					<b>\$ 10,346</b>



**All Weather Access Road - LOM**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Decommission and Reclaim Access Road</b>					
Lower road grade	Cat 14G Grader	Hrs	100	\$ 160	\$ 16,000
	Cat 320CL Excavator	Hrs	140	\$ 125	\$ 17,500
	A30D Rock Truck	Hrs	140	\$ 197	\$ 27,580
Stabilize cut/fill slopes	Cat 320CL Excavator	Hrs	80	\$ 125	\$ 10,000
Culvert Removal (<1200mm)	Removal to offsite for re-use, resloping banks and amoring wetted section	Each	69	\$ 1,500	\$ 103,500
Culvert Removal >1200mm or multiple at 1 location	Removal to offsite for re-use, resloping banks and amoring wetted section	Each	3	\$ 5,000	\$ 15,000
Culvert Crossing restoration work	Installation of environmental protection measures	L.S.	1	\$ 20,000	\$ 20,000
Bunker Creek Bridge Removal	Removal of bridge complete with bin-wall, resloping of banks	L.S.	1	\$ 75,000	\$ 75,000
Bunker Creek habitat restoration	Restoration in riparian zone and re-seeding	L.S.	1	\$ 2,000	\$ 2,000
Scarify road surface	To encourage re-vegetation (24 km x 13 m) - Cat D8N Dozer	Ha	31.2	\$ 2,000	\$ 62,400
Corridor re-vegetate	Using ATV mounted applicator for seed and fertilizer	Ha	31.2	\$ 1,500	\$ 46,800
Maintenance S&F-after 1 year	Assume coverage of 50% with seed & fertilizer alone	Ha	17.5	\$ 1,500	\$ 26,250
Permanent barrier at highway	Install trench and barricades	L.S.	1	\$ 3,500	\$ 3,500
Permanent barrier at Km 14	Install barricade to prevent interior access	L.S.	1	\$ 3,500	\$ 3,500
<b>Sub Total</b>					<b>\$ 429,030</b>
Engineering 5%	For major components, particularly removal of bridge				21,452
Surveying 5%	For final as-builts of new contours and stream crossings				21,452
<i>10% Contingency</i>					<b>47,193</b>
<b>Total</b>					<b>\$ 519,126</b>

**Remaining Land Reclamation - LOM**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Stockpile Footprints</b>					
Stabilize Slopes	Unit Cost Basis	km	3	\$ 3,000	\$ 9,000
Revegetate	Seed and Fertilize	ha	2.4	\$ 1,500	\$ 3,600
<b>Sub Total</b>					<b>\$ 12,600</b>
<b>Mine Site Roads</b>					
Lower road grade	Cat 14G Grader	hours	60	\$ 185	\$ 11,100
	Cat 320CL Exavator	hours	80	\$ 125	\$ 10,000
	A30D Rock Truck	hours	80	\$ 197	\$ 15,760
Stabilize slopes	Cat 320CL Exavator	hours	40	\$ 125	\$ 5,000
Culvert Removal (<1000m)	uncover, remove and stabilize	Ea.	15	\$ 1,500	\$ 22,500
Scarify	Cat D8N Dozer	hours	70	\$ 245	\$ 17,150
Revegetate	Seed and Fertilize	ha	7	\$ 1,500	\$ 10,500
<b>Sub Total</b>					<b>\$ 92,010</b>
<i>10% Contingency</i>					<b>\$ 10,461</b>
<b>Total</b>					<b>\$ 115,071</b>

## Site Management and Monitoring - LOM

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Organization, Security and Overhead</b>					
Pre closure planning and organization	Project Manager	months	6	\$ 9,700	\$ 58,200
Site Manager	Project Manager	months	36	\$ 9,700	\$ 349,200
Camp Costs <sup>1</sup>	per diem	days <sup>1</sup>	5751	\$ 75	\$ 431,325
Site caretaker	Security, camp operation, general maintenance	months	36	\$ 6,100	\$ 219,600
pre closure environmental assessment	contract	L.S.			\$ 75,000
post closure environmental cleanup confirmation	contract	L.S.			\$ 75,000
vehicles for security and manager	light-duty vehicle	months	72	\$ 2,500	\$ 180,000
site maintenance costs	general maintenance	year	3	\$ 10,000	\$ 30,000
Flights - Whitehorse charter and commercial connections	weekly	flights	52	\$ 3,000	\$ 156,000
miscellaneous office/supply/costs	miscellaneous	year	10	\$ 15,000	\$ 150,000
<b>Sub Total</b>					<b>\$ 1,724,325</b>
<b>Document Control</b>					
document reviews and storage	miscellaneous	monthly	120	\$ 200	\$ 24,000
final as built drawings	manhours	hours	240	\$ 130	\$ 31,200
<b>Sub Total</b>					<b>\$ 55,200</b>
<b>Compliance Monitoring and Reporting</b>					
Environmental Monitor	Sampling and monitoring	months	48	\$ 6,000	\$ 288,000
Water Quality Analytical (Closure Phase Yr 1 to Yr 3)	Surface water quality analytical (20 sites, incl. T1 & R1)	samples	1773	\$ 420	\$ 744,660
	Groundwater quality analytical (24 sites)	samples	72	\$ 290	\$ 20,880
Water Quality Analytical (Post-Closure Phase Yr 4 to Yr 10)	Surface water quality analytical (19 sites, incl. T1)	samples	133	\$ 420	\$ 55,860
	Groundwater quality analytical (24 sites)	samples	168	\$ 290	\$ 48,720
Hydrological Monitoring		L.S.			\$ 15,000
EEM Monitoring requirements		annual	3	\$ 30,000	\$ 90,000
External Consulting Services		L.S.			\$ 50,000
Geotechnical Inspections Closure Phase		annual	3	\$ 15,000	\$ 45,000
Geotechnical Inspections Post-Closure Phase		annual	7	\$ 15,000	\$ 105,000
<b>Sub Total</b>					<b>\$ 1,463,120</b>
<b>Closure Maintenance</b>					
Tailings Closure Spillway	twice per year inspection/maintenance	annual	10	\$ 10,000	\$ 100,000
<b>Sub Total</b>					<b>\$ 100,000</b>
<b>Wolverine Creek Biopass Contingency</b>					
Construction of Biopass Channel	Cat 320CL Excavator	hrs	60	\$ 170	\$ 10,200
Construction of diversion channel	Cat 320CL Excavator	hrs	80	\$ 170	\$ 13,600
Placement of liner in channel	Labour and materials	m	600	\$ 200	\$ 120,000
Source, haul and place organics	400 m x 2.5 m x 2.6 m	m <sup>3</sup>	2600	\$ 8	\$ 20,800
Organics and fill placement	Labour	hrs	432	\$ 50	\$ 21,600
Engineering, Construction Management and Survey Control	15% of capital cost				\$ 27,930
Maintenance	twice per year for 5 years	bi-annual	10	\$ 1,000	\$ 10,000
<b>Sub Total</b>					<b>\$ 224,130</b>
<i>15% Contingency</i>					<b>\$ 535,016</b>
<b>Total</b>					<b>\$ 4,101,791</b>

1: Camp-person days: assumed 12 persons for 6 months (183 days) in Year 1 (2196 days); 6 persons for 6 months in Year 2 (1098 days); 4 persons for 6 months in Year 3 (1095 days) and 1 Caretaker for 365 days for 3 years (1095 days), and for Years 4 to 10 - 3 persons for 30 days per year during sampling and monitoring (630 days)

## **Appendix B: Additional Closure Costs for Existing Condition**

**Tailings Facility Area - Existing Condition**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Reclaim Tailings Dam Face</b>					
Load Haul and Place topsoil	Area of 24000 m <sup>2</sup> with 0.25 m depth	m <sup>3</sup>	6000	\$ 5	\$ 30,000
Revegetate	Seed and Fertilize	ha	2.4	\$ 1,500	\$ 3,600
<b>Sub Total</b>					<b>\$ 33,600</b>
					<i>10% Contingency</i>
					<b>\$ 3,360</b>
<b>Total</b>					<b>\$ 36,960</b>

**Infrastructure Decommissioning - Existing Condition**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost
<b>Temporary Waste Rock Storage Areas</b>					
Load and haul rock and granular till layer	For disposal in tailings facility	m <sup>3</sup>	110,500	\$ 7	\$ 773,500
Remove liners and encapsulate in mine	2 liners	L.S.	2	\$ 8,000	\$ 16,000
Regrade and contour	Cat D8N Dozer	hours	30	\$ 245	\$ 7,350
Load Haul and place topsoil	33585 m <sup>2</sup> x 0.25 m	m <sup>3</sup>	8,396	\$ 5	\$ 41,980
Engineering and Survey Control		L.S.			\$ 10,000
Revegetate	Seed and Fertilize	ha	3.36	\$ 1,500	\$ 5,040
<b>Sub Total</b>					<b>\$ 853,870</b>
					<i>10% Contingency</i>
					<b>\$ 85,387</b>
<b>Total</b>					<b>\$ 939,257</b>

**All Weather Access Road - Existing Condition**

Work Item Description	Description	Units	Quantity	Unit Cost	Total Cost	Sub-unit Total
<b>Decommission and Reclaim Access Road</b>						
Lower road grade	Cat 14G Grader	Hrs	100	\$ 160	\$ 16,000	\$ 71,080
	Cat 320CL Excavator	Hrs	140	\$ 125	\$ 17,500	
	A30D Rock Truck	Hrs	140	\$ 197	\$ 27,580	
Stabilize side slopes	Cat 320CL Excavator	Hrs	80	\$ 125	\$ 10,000	
Culvert Removal (<1200mm)	Removal offsite for re-use, resloping banks and amoring wetted section	Each	69	\$ 1,500	\$ 103,500	\$ 138,500
Culverts >2400	Removal offsite for re-use, resloping banks and amoring wetted section	Each	3	\$ 5,000	\$ 15,000	
Culvert Crossing restoration work	Installation of environmental protection measures	L.S.	1	\$ 20,000	\$ 20,000	
Bunker Creek Bridge Removal	Removal of bridge complete with bin-wall, resloping of banks	L.S.	1	\$ 75,000	\$ 75,000	\$ 77,000
Bunker Creek habitat restoration	Restoration in riparian zone and re-seeding	L.S.	1	\$ 2,000	\$ 2,000	
Scarify road surface	To encourage re-vegetation (24 km x 13 m) - Cat D8N Dozer	Ha	31.2	\$ 2,000	\$ 62,400	\$ 62,400
Recontour staging and roadside stockpile areas	Cat 320CL Excavator, Cat 14G Grader	L.S.		\$ 20,000	\$ 25,000	\$ 47,350
Borrow Sources-stabilize slopes	Stabilize the slopes of the excavations - Cat D8N Dozer	Hrs	30	\$ 245	\$ 7,350	
Borrow Sources- revegetate	Using ATV mounted applicator for seed and fertilizer	Ha	10	\$ 1,500	\$ 15,000	
Revegetation of road surface + disturbed areas	Using ATV mounted applicator for seed and fertilizer	Ha	37.5	\$ 1,500	\$ 56,250	\$ 84,450
Maintenance after 1 year	Assume coverage of 50% with seed & fertilizer	Ha	18.8	\$ 1,500	\$ 28,200	
Permanent barrier at highway	Trenching and barricading using natural materials in the area, to dissuade casual access	L.S.	1	\$ 3,500	\$ 3,500	\$ 7,000
Permanent barrier at Km 14	Barricading to provide ultimate barrier to more interior access	L.S.	1	\$ 3,500	\$ 3,500	
					<b>\$ 487,780</b>	
Engineering 5%	For major components, particularly removal of bridge					24,389
Surveying 5%	For final as-builts drawings					24,389
					<i>10% Contingency</i>	<b>53,656</b>
<b>Total</b>					<b>\$ 590,214</b>	