17. FEDERAL ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The Ajax Project falls under the transitional provisions of CEAA 2012, where it will continue to be assessed as a comprehensive study in accordance with regulated timelines, as if the former CEAA had not been repealed. The federal environment assessment will continue to follow the requirements of the former CEAA. As defined in the former CEAA Section 16 (2), every comprehensive study, mediation, or review panel must include consideration of factors in addition to those set out in Section 16 (1), including purpose of the project, alternative means of carrying out the project, need for a follow-up program, and the capacity of renewable resources that are likely to be significantly affected by the Project. These factors are discussed below.

17.1 ENVIRONMENTAL EFFECTS

The approach to assessing effects, as outlined in Chapter 5, and implemented in Chapters 6 through 10 of the Application/EIS has been developed to consider potential environmental effects of the Project, in a manner that is consistent with the CEAA definition, where 'environmental effect' means, in respect of the project:

- Any change that the project may cause in the environment (found in Sections 6 and 10), including any change it may cause to a listed wildlife species, its critical habitat or the residences of individual of that species, as those terms are defined in subsection 2(1) of the SARA (cross-references to where SARA-listed species are evaluated are listed in Table 17.2-1);
- Any effect of any change in the environment caused by the project on:
  - Health and socio-economic conditions (found in Sections 10, 7 and 8, respectively);
  - Physical and cultural heritage (found in Sections 8.5 and 9);
  - The current use of land and resources for traditional purposes by Aboriginal persons (found in Section 8.5); or
  - Any structure, site or thing that is of historical, archaeological, paleontological or architectural significance (found in Section 9).
- Any change to the project that may be caused by the environment (found in Section 17.5).

A summary of the findings of the assessment of environmental effects is provided in the next section.

17.2 FEDERAL COMPONENTS

For the federal components, as listed in the AIR/EIS Guidelines, Table 17.2-1 summarizes the residual effects, proposed mitigation measures, and significance of residual effects, as assessed in Sections 6 through 10. Appropriate cross references to the detailed assessments is provided in the table in order to minimize redundancy in the Application/EIS.

Table 17.2-1. Summary of Mitigation Measures, Residual and Cumulative Effects and Significance for Federal Components

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Migratory Birds						
Migratory Birds [6 SARA listed species: Common Nighthawk Lewis's Woodpecker Long-billed Curlew Olive-sided Flycatcher Rusty Blackbird Williamson's Sapsucker]	Habitat loss, particularly wetland and grassland habitat	Construction	• minimizing Project footprint; • *Wildlife/Vegetation Management Plan* (Section 11.27); • Habitat and wetland compensation; • Reclamation; and • Revegetation.	Not Significant (Moderate)	Not Significant (Minor)	Section 6.14

Migratory Birds
[6 SARA listed species:
Common Nighthawk
Lewis's Woodpecker
Long-billed Curlew
Olive-sided Flycatcher
Rusty Blackbird
Williamson's Sapsucker]
	Chemical Hazards	All phases	• Removal of suitable breeding habitat, vegetation and other attractants from around TSF and MRSFs;
			• Management Plans, including:
			  • a *Surface Water Quality Management and Monitoring Plan* (Chapter 11.23);
			  • a *Groundwater Quality Management and Monitoring Plan* (Chapter 11.24);
			  • a *Construction Waste Management Plan* (Chapter 11.4);
			  • a *Metal Leaching and Acid Rock Drainage Management and Monitoring Plan* (Chapter 11.5);
			  • a *Water Management and Hydrometric Monitoring Plan* (Chapter 11.7);
			  • a *Contaminated Sites Management Plan* (Chapter 11.8);
			  • a *Solid Waste Management Plan* (Chapter 11.9).
			  • a *Hazardous Waste Management Plan* (Chapter 11.10);
			  • a *Risk Management Plan (Accidents and Malfunctions)* (Chapter 11.12);
			  • a *Natural Hazards Management Plan* (Chapter 11.13);
			  • an *Emergency Response Plan* (Chapter 11.14); and
			  • a *Wildlife/Vegetation Management Plan* (Chapter 11.27).
				Not Significant (Minor)	Not Significant (Minor)	Section 6.14

Air Quality						
Air Quality	Change in CAC concentrations	Construction, Operation	• Minimize material drop heights. • Orient stockpiles to minimize wind exposure. • Watering road surfaces prone to generating fugitive dust. • Natural mitigation from precipitation. • Proper road maintenance. • If necessary implement wheel cleaning to prevent "track-out". • Minimize area of exposed rock and soil. • Reduce vehicle idling and rapid starts and stops. • Use multi-passenger vehicles to transport crews. • Operate vehicles within posted maximum speed limits. • Maintain vehicles in good operating condition. • Use low sulphur diesel per Environment Canada Sulphur in Diesel Fuel Regulation (Government of Canada 2015b). • Arch cover over conveyor from crusher to plant.	Not Significant (Moderate)	No Residual Effect	Section 10.1

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
			• Cover over the coarse ore and fine ore stockpiles. • Partially enclose the primary crusher. • Use covered and well-sealed concentrate transport trucks. • Use large trucks for ore and mine rock transport to minimize the number of trips. • Avoid blasting when wind speed and direction will potentially cause a safety concern. • Select best achievable technology for the mine fleet. • Adhere to all permits, authorizations and approvals related to air quality.			
Geology, Landforms and Soils						
Geology, landforms and soils	Alteration of Baseline Landforms	Construction, Operation, Decommissioning and Closure.	• Footprint minimization. • Decommissioning and Closure planning.	Not Significant (Minor)	No Residual Effect	Section 6.2
Rare and Sensitive Ecological Communities						
Rare and Sensitive Ecosystems	Habitat loss	Construction	• Reclamation, re-vegetation. • Avoidance. • Project footprint design. • Wildlife/Vegetation Monitoring Plan. • Compensation Program for wetlands.	Not Significant (Moderate)	Not Significant (Minor)	Section 6.9
Grasslands	Habitat loss	Construction	• Reclamation, revegetation and compensation.	Not Significant (Moderate)	Not Significant (Minor)	Section 6.10
Mammals						
Mammals	Habitat Loss (American Badger, Bats, Mule Deer).	Construction.	• Reclamation. • Revegetation.	Not Significant (Moderate)	Not Significant (Moderate)	Section 6.17
Mammals	Sensory Disturbance (American Badger).	Construction, Operations.	• Limit noise to certain windows (avoid sunrise/sunset).	Not Significant (Minor)	Not Significant (Minor)	Section 6.17
Mammals	Disruption of Movement (American Badger).	Construction, Operations, Closure.	• Maintain habitat across landscape where possible; continued monitoring.	Not Significant (Minor)	Not Significant (Minor)	Section 6.17
Mammals	Chemical Hazards (Bats).	Construction, Operations, Closure.	• Continued monitoring of water quality, buoys/netting.	Not Significant (Minor)	Not Significant (Minor)	Section 6.17
Surface Water, and Groundwater Quality and Quantity (note: changes in domestic water quality and quantity are assessed under 'human health')						
Surface water quality	Change in surface water quality in Humphrey Creek.	Decommissioning and Closure, Post Closure.	• Mine Site Water Management Plan. • SMRSF Pond – manage seepage and runoff from the southern extent of the SMRSF. • Reclamation on SMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff. • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. • Air Quality Management Plan.	Not Significant (Moderate)	No Residual Effect	Section 6.3

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Surface water quality	Change in surface water quality in Peterson Creek at PC02.3.	Construction, Operation, Decommissioning and Closure, Post Closure.	• Mine Site Water Management Plan. • Operations – interception of seepage from the EMRSF at EMRSF Pond, reclaimed to mill for Operations water demand. • Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff.	Not Significant (Minor)	No Residual Effect	Section 6.3
Surface water quality	Change in surface water quality in Peterson Creek at PC02.	Construction, Operation, Decommissioning and Closure, Post Closure	• Mine Site Water Management Plan. • Operations – interception of seepage from the EMRSF, reclaimed for Operations water demand. • Reclamation of EMRSF in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff.	Not Significant (Moderate)	No Residual Effect	Section 6.3
Surface water quantity	Change in surface water quantity (all metrics) in Kamloops Lake.	Construction, Operation.	• Water Management Plan.	Not Significant (Minor)	Not Significant (Minor)	Section 6.4
Surface water quantity	Change in surface water quantity (annual flow volume, low flow) in Peterson Creek (Lower).	Construction, Operation, Decommissioning and Closure, Post Closure.	• Water Management Plan. • Actively fill Open Pit with water from TSF as well as passive seasonal surficial runoff. • Cease dewatering activities.	Not Significant (Moderate)	No Residual Effect	Section 6.4
Surface water quantity	Change in surface water quantity (monthly flow distribution, peak flow) in Peterson Creek (Lower).	Construction, Operation, Decommissioning and Closure, Post Closure.	• Water Management Plan. • Actively fill Open Pit with water from TSF as well as passive seasonal surficial runoff. • Cease dewatering activities.	Not Significant (Minor)	No Residual Effect	Section 6.4
Groundwater quality	Change in groundwater quality in RES-2 Well.	Operation, Decommissioning and Closure, Post Closure	• Mine Site Water Management Plan. • TSF Design which includes an underdrain system in the embankment foundation, HDPE geomembrane liner with a woven geotextile underlay on the upstream face of the embankment overlying a low permeability glacial till basin liner. • Operations – North Embankment WMP 1 – interception of seepage from TSF and seepage and runoff from North Embankment and WMRSF, reclaimed for Operations water demand. • Operations – interception of seepage from SMRSF, WMRSF, EMRSF and low grade ore with associated WMPs, reclaimed to mill for Operations water demand. • North Embankment WMP 1 is converted to an evaporation pond in Closure and Post Closure. • Reclamation of MSRFs in Decommissioning and Closure with a low permeability till layer overlain with topsoil to reduce infiltration and maximize evapotranspiration and runoff. • Dry cover on TSF to reduce infiltration into the underlying tailings solids and increase non-contact runoff. • Air Quality Management Plan.	Not Significant (Minor)	Refer to Human Health VC (Section 10) and Surface Water Quality VC (Section 6.3)	Section 6.5
Groundwater quantity	Changes to magnitude or timing of groundwater recharge and discharge.	Operation, Decommissioning and Closure, Post Closure.	• Water Management Plan.	Not Significant (Moderate)	Not Significant (Moderate)	Section 6.6
Groundwater quantity	Changes to groundwater elevations, flow rates, or flow directions.	Operation, Decommissioning and Closure, Post Closure.	• Water Management Plan. • Monitor groundwater elevations.	Not Significant (Moderate)	Not Significant (Moderate)	Section 6.6

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Aquatic Environment (e.g. aquatic life, fish, fish habitat)						
Fish and fish habitat	Direct loss of habitat in NE arm of Jacko Lake from Open Pit Development affecting the productivity of the fish population.	Operation, Decommissioning and Closure, Post Closure.	• Footprint minimization • Offsetting Measures. • Fisheries and Aquatic Life Monitoring Plan.	Not Significant (Minor)	Not Significant (Minor)	Section 6.7
Fish and fish habitat	Direct loss of habitat in Peterson Creek from Open Pit Development affecting the productivity of the fish population.	Operation.	• Offsetting Measures. • Fisheries and Aquatic Life Monitoring Plan.	Not Significant (Minor)	No Residual Effect	Section 6.7
Fish and fish habitat	Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project Footprint and Contact Water.	Operation, Decommissioning and Closure, Post Closure.	• Water Management Plan. • Fisheries and Aquatic Life Monitoring Plan. • Surface Water Quality Management and Monitoring Plan.	Not Significant (Moderate)	No Residual Effect	Section 6.7
Fish and fish habitat	Fish mortality in Jacko Lake associated with changes in pressure from installation of the sheet pile dam for Open Pit Development.	Construction.	• Design in accordance with National Oceanic and Atmospheric Administration interim criteria for the onset of physical injury to fish.	Not Significant (Minor)	No Residual Effect	Section 6.7
Fish and fish habitat	Sub-lethal effects on fish populations in Peterson Creek downstream of the Project area associated with changes in primary productivity from reduced flows resulting from Project Footprint and Contact Water.	Construction, Operation, Decommissioning and Closure, Post Closure.	• Water Management Plan. • Fisheries and Aquatic Life Monitoring Plan. • Surface Water Quality Management and Monitoring Plan.	Not Significant (Minor)	Not Significant (Minor)	Section 6.7
Flora at Risk (as defined under and in accordance with the SARA)						
Rare Plants [1 SARA listed species (*Pterygoneurum kozlovii* (alkaline wing-nerved moss)]	Habitat loss	Construction	• Reclamation, revegetation.	Not Significant (Moderate)	Not Significant (Moderate)	Section 6.8

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Fauna at Risk (as defined under and in accordance with the SARA)						
Amphibians [2 SARA schedule 1 species: Great Basin spadefoot and western toad]	Habitat Loss.	Construction.	• Reclamation. • Revegetation. • Artificial diversion pools. • Enhancement. • Wetland Habitat Compensation Plan.	Not Significant (Moderate)	Not Significant (Minor)	Section 6.12
Amphibians [2 SARA schedule 1 species: Great Basin spadefoot and western toad]	Direct Mortality.	Construction, Operation.	• Translocation of individuals to areas of suitable habitat. • Avoid critical windows (April through August).	Not Significant (Moderate)	Not Significant (Minor)	Section 6.12
Amphibians [2 SARA schedule 1 species: Great Basin spadefoot and western toad]	Chemical Hazards.	Construction, Operation.	• Installation of artificial 'diversion pools'. • Clearing of emergent vegetation. • Amphibian Monitoring Program.	Not Significant (Minor)	Not Significant (Minor)	Section 6.12
Raptors [5 SARA species: Burrowing Owl Flammulated Owl Peregrine Falcon, anatum subspecies Short-eared Owl Western Screech-owl, macfarlanei subspecies]	Habitat Loss	Construction.	• Reclamation / revegetation. • Artificial nest creation.	Not Significant (Minor)	Not Significant (Minor)	Section 6.15
Raptors [5 SARA species: Burrowing Owl Flammulated Owl Peregrine Falcon, anatum subspecies Short-eared Owl Western Screech-owl, macfarlanei subspecies]	Sensory Disturbance.	Construction, Operation.	• Limit noise to certain windows (outside of breeding season).	Not Significant (Minor)	Not Significant (Minor)	Section 6.15

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Greenhouse Gas Management						
Greenhouse Gases	Increase in atmospheric GHG of up to 123 kt CO_2 eq/year during Construction and Operation due to Scope 1, 2 and 3 Emissions and Land Use Changes.	Construction, Operation.	• Greenhouse Gas Management Plan. • Access and haul roads designed to minimize distances. • Larger trucks for ore and waste transport to minimize number of trips. • Consider energy conservation in equipment procurement and selection. • Consider the use of alternate fuels. • Select the best achievable technology. • Maintain vehicles in good operating condition. • Utilize buses/multi-passenger vehicles to transport crews. • Train equipment and vehicle operators to reduce GHG emissions. • Operate vehicles within the posted maximum speed limits and reduce idling. • Land clearing will be minimized for the Project where practical and economically achievable. • Progressively re-vegetate or re-vegetate disturbed areas prior to Closure.	Not Significant (Minor)	Not Significant (Minor)	Section 6.1
Heritage and Archaeological Resources						
Archaeological Sites	Disturbance of Known Archaeological Sites	Construction	• Avoidance or systematic data recovery approved by the Archaeology Branch and, if necessary, affected First Nations community(s).	Not Significant (Minor)	No Residual Effect	Section 9.1
Archaeological Sites	Disturbance of Known Archaeological Site EdRc-25	Construction	• Avoidance or mitigation measures approved by the Archaeology Branch and, if necessary affected First Nations community(s). Mitigation could involve reconstruction of the petroforms at another location.	Not Significant (Moderate)	No Residual Effect	Section 9.1
Archaeological Sites	Disturbance of As-Yet Unknown Archaeological Sites	All phases	• Chance find procedure and avoidance or mitigation measures approved by the Archaeology Branch and, if necessary affected First Nations community(s).	Not Significant (Minor)	No Residual Effect	Section 9.1
Heritage Sites	Disturbance of Paleontological Sites	Construction	• Chance find procedure and avoidance or mitigation measures if the paleontological material is found to be of significance.	Not Significant (Minor)	No Residual Effect	Section 9.2
Heritage Sites	Disturbance of Aboriginal Heritage Sites	Construction and Operation	• Hunting Blind protected by the HCA and avoidance or mitigations approved by the Archaeology Branch and affected First Nations community(s) will be carried out.	Not Significant (Minor)	No Residual Effect	Section 9.2
Heritage Sites	Disturbance of Non-Aboriginal Heritage Sites	Construction and Operation	• Consultation with community stakeholders to determine if additional mitigation measures and/or preservation of the site is desired. • Should evidence of the Nicola Brigade Trail be discovered during construction, documentation and associated mitigation will be addressed under the Heritage Chance Find Procedure.	Not Significant (Minor)	No Residual Effect	Section 9.2

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Aboriginal Traditional Use (current and historic)						
Current Use of Lands and Resources for Traditional Purposes	Disruption of ceremonial use.	Construction; Operation; Closure.	• Develop an Access Management Plan in consultation with Aboriginal Groups • Develop an alternate road access and parking lot to Jacko Lake to facilitate access to Jacko Lake for fishing • Communicate with Aboriginal Groups regarding when blasting is likely to occur and demarcate those areas • Continue to support the permit system (provisions to allow Aboriginal users access to ranch lands) for accessing ranch or grazing leases owned by KAM and not within the Project footprint • Reduce traffic by implementing the Transportation Management Plan (Section 11.20) • Noise mitigation and noise management plan and Vibration management plan for blasting activities(Section 11.22) • Progressive re-vegetation of Project components and other disturbed areas (Section 3.17) • Surface Water Quality Management and Monitoring Plan (Section 11.23), a Groundwater Quality Management and Monitoring Plan (Section 11.3), and a Water Management and Hydrometric Monitoring Plan (Section 11. 7) • Protect harvested species from contamination by implementing a Construction Waste Management Plan (Section 11.4); a Metal Leaching and Acid Rock Drainage Management and Monitoring Plan (Section 11.5); a Contaminated Sites Management Plan (Section 11.8); a Solid Waste Management Plan (Section 11.9); a Hazardous Waste Management Plan (Section 11.10); a Risk Management Plan (Accidents and Malfunctions) (Section 11.12); a Natural Hazards Management Plan (Section 11.13); and an Emergency Response Plan (Section 11.14).	Not Significant (Moderate)	Significant	Section 8.5
Current Use of Lands and Resources for Traditional Purposes	Disruption of fishing use.	Construction; Operation; Closure.	• Meet the recommended flow threshold for BC streams, and as needed, work with the provincial government to manage releases from the Peterson Creek Downstream Pond to meet instream flow needs • Fisheries and Aquatic Life Monitoring Plan (Section 11.25) and Fish Habitat Offsetting Measures (Appendix 6.7-C) • Implement a Surface Water Quality Management and Monitoring Plan (Section 11.23); a Groundwater Quality Management and Monitoring Plan (Section 11.24); an Erosion and Sediment Control Plan (Section 11.2); a Metal Leaching and Acid Rock Drainage Management and Monitoring Plan (Section 11.5); Air Quality Monitoring and Dust Control Plan (Section 11.6); Water Management and Hydrometric Monitoring Plan (Section 11.7); Soil Salvage and Handling Plan (Section 11.3); Dark Sky Management and Monitoring Plan (Section 11.19); Noise and Vibration Management Plan (Section 11.22) • Develop an Access Management Plan in consultation with Aboriginal Groups • Develop an alternate road access and parking lot to Jacko Lake to facilitate access to Jacko Lake for fishing • Communicate with Aboriginal Groups regarding when blasting is likely to occur and demarcate those areas • Reduce traffic by implementing the Transportation Management Plan (Section 11.20) • Blast design to minimize disturbances to Jacko Lake and its users; noise mitigation and noise management plan; and Vibration management plan for blasting activities • Progressive re-vegetation of Project components and other disturbed areas on an ongoing basis during the Construction and Operations phases with larger Project components further re-vegetated at closure.	Not Significant (Minor)	Not Significant (Moderate)	Section 8.5
Current Use of Lands and Resources for Traditional Purposes	Disruption of hunting use.	Construction; Operation; Closure.	• Avoidance of wildlife habitat wherever possible through mine footprint redesigned • Mitigation and Best Management Practices with respect to vegetation clearing, noise and Project activities with potential to result in direct wildlife mortality • Habitat compensation as described in the Grassland Compensation Plan, Wetland Compensation Plan, and Vegetation and Wildlife Management Plan • Implement an Access Management Plan and the Transportation Management Plan (Section 11.21 and 11.20) • Air Quality Monitoring and Dust Control Plan (Section 11.6) • Soil Salvage and Handling Plan and the Landscape Design and Restoration Plan (Sections 11.3 and 11.26, respectively) • Continue to support the permit system (provisions to allow Aboriginal harvesters access to ranch lands) for accessing ranch or grazing leases owned by KAM and not within the Project footprint • Develop an Access Management Plan in consultation with Aboriginal Groups • Develop an alternate road access and parking lot to Jacko Lake to facilitate access to Jacko Lake for fishing	Not Significant (Moderate)	Significant	Section 8.5

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
			• Communicating with Aboriginal Groups regarding when blasting is likely to occur and demarcating those areas • Reducing traffic by implementing the Transportation Management Plan (Section 11.20) • Noise and Vibration Management Plan for blasting activities(Section 11.22) • To reduce visual disturbances, progressive re-vegetation of Project components and other disturbed areas on an ongoing basis during the Construction and Operations phases with larger Project components further re-vegetated at closure (Section 8.4) • implement a Surface Water Quality Management and Monitoring Plan (Section 11.23), a Groundwater Quality Management and Monitoring Plan (Section 11.24), and a Water Management and Hydrometric Monitoring Plan (Section 11.7) • Other management plans to protect harvested species from contamination include a Construction Waste Management Plan (Section 11.4); a Metal Leaching and Acid Rock Drainage Management and Monitoring Plan (Section 11.5); a Contaminated Sites Management Plan (Section 11.8); a Solid Waste Management Plan (Section 11.9); a Hazardous Waste Management Plan (Section 11.10); a Risk Management Plan (Accidents and Malfunctions) (Section 11.12); a Natural Hazards Management Plan (Section 11.13); and an Emergency Response Plan (Section 11.14)			
Current Use of Lands and Resources for Traditional Purposes	Disruption of plant gathering.	Construction; Operation; Closure; Post Closure.	• mine footprint redesign to ensure the minimum possible effects on the surrounding habitat during planning, and for those rare plant occurrences that cannot be avoided, transplantation of these rare plants will be considered based upon guiding principles • Implementation of the Wildlife/Vegetation Management Plan (Section 11.27); the Erosion and Sediment Control Plan (11.2); the Air Quality Monitoring and Dust Control Plan (Section 11.6); and the Access Management Plan and the Transportation Management Plan (Section 11.21, Section 11.20) • Compensation as described in the Grassland Compensation Plan and the Wetland Compensation Plan • The Soil Salvage and Handling Plan and the Landscape Design and Restoration Plan (Sections 11.3 and 11.26, respectively) as well as the Invasive Species Management Section in the Wildlife/Vegetation Monitoring Plan (Section 11.17) and a vehicle wash station at site entrance may also help to reduce the impact of invasive plants • Develop an Access Management Plan in consultation with Aboriginal Groups • Develop an alternate road access and parking lot to Jacko Lake to facilitate access to Jacko Lake for fishing • Communicating with Aboriginal Groups regarding when blasting is likely to occur and demarcating those areas • To reduce visual disturbances, progressive re-vegetation of Project components and other disturbed areas on an ongoing basis during the Construction and Operations phases with larger Project components further re-vegetated at closure (Section 8.4) • To minimize contamination of harvested species through potential ingestion of contaminated water, KAM will implement a Surface Water Quality Management and Monitoring Plan (Section 11.23), a Groundwater Quality Management and Monitoring Plan (Section 11.24), and a Water Management and Hydrometric Monitoring Plan (Section 11.7) • Other management plans to protect harvested species from contamination include: a Construction Waste Management Plan (Section 11.4); a Metal Leaching and Acid Rock Drainage Management and Monitoring Plan (Section 11.5); a Contaminated Sites Management Plan (Section 11.8); a Solid Waste Management Plan (Section 11.9); a Hazardous Waste Management Plan (Section 11.10); a Risk Management Plan (Accidents and Malfunctions) (Section 11.12); a Natural Hazards Management Plan (Section 11.13); and an Emergency Response Plan (Section 11.14)	Not Significant (Moderate)	Significant	Section 8.5

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Land and Resource Use						
Land and Resource Use	Presence of Project may limit the ability of City of Kamloops to continue to pursue various land use planning initiatives to full capacity.	All phases	• Ongoing engagement between KAM and City of Kamloops to discuss potential areas of interaction between Project and planning.	Not Significant (Moderate)	No Residual Effect	Section 8.4
Land and Resource Use	Presence of Project may limit the ability of the TNRD to continue to pursue various land use planning initiatives to full capacity.	All phases	• Ongoing engagement between KAM and City of Kamloops to discuss potential areas of interaction between Project and planning.	Not Significant (Moderate)	No Residual Effect	Section 8.4
Land and Resource Use	Potential changes to ranching operations	Construction, Operations	• Implementation of Project design and best management practices for air quality, noise and vibration, water quantity, traffic; adaptive management; communication and consultation	Not Significant (Minor)	No Residual Effect	Section 8.4
Outdoor Recreation (Navigation)						
Outdoor Recreation	Reduced opportunities as a result of changes in access.	Construction; Operation.	• Implementation of Project design and best management practices for air quality, noise and vibration, visual impacts and aesthetic features. • Adaptive management. • Access Management Plan will include signage and communications regarding temporary closures of Jacko Lake. • Establishment of angling working group to develop additional mitigation/offsetting measures, including potential to develop other lakes for angling.	Not Significant (Moderate)	No Residual Effect	Section 8.6
Outdoor Recreation	Diminished quality of experience.	Construction; Operation.	• Implementation of Project design and best management practices for air quality, noise and vibration, visual impacts and aesthetic features. • Adaptive management.	Not Significant (Moderate)	No Residual Effect	Section 8.6
Outdoor Recreation	Reduced opportunities resulting from changes to resources.	Construction; Operation.	• Implementation of Project design and best management practices for air quality, noise and vibration, visual impacts and aesthetic features. • Adaptive management.	Not Significant (Minor)	No Residual Effect	Section 8.6
Noise and Vibration						
Noise	Change in acoustic environment.	Construction, Operation.	• Locate noise emission inside gallery, enclosure, or buildings. • Reduce haul road distance. • Use large haul truck for ore and mine rock transport. • Mobile equipment fitted with exhaust mufflers. • Locate plant facilities further from City of Kamloops boundary. • Implement the Noise and Vibration Management Plan.	Not Significant (Minor)	Not Significant (minor)	Section 10.5
Vibration	Change in vibration environment.	Construction, Operation.	• Implement blast designs that were based on the damage threshold at the closest location (i.e. Jacko Lake). • Implement the Noise and Vibration Management Plan.	Not Significant (Minor)	No Residual Effect	Section 10.5

Valued Component	Residual Effect	Project Phase	Summary of Mitigation Measures	Significance of Residual Effect		Cross Reference
				Project	Cumulative	
Human Health						
Human health	Change in air quality that could result in a change in human health risk associated with inhalation exposures to CACs and particulate-bound metals.	Construction, Operation, Closure.	• Mitigation measures to control air and dust emissions outlined in the Air Quality Section 10.1.4.3, the Green House Gas Management Plan, and the Dust Management Plan will reduce Project emissions to levels that are protective of human health. • Additional mitigation measures specific to human health have not been recommended.	Not Significant (Minor)	No Residual Effect	Section 10.4
Human health	Changes in soil, surface water, groundwater, and country food quality could result in a change in human health risk associated with direct contact and ingestion exposures to metals.	Post Closure.	• Mitigation measures to control air and dust emissions outlined in the Air Quality Section 10.1.4.3, the Green House Gas Management Plan, and the Dust Management Plan will reduce Project emissions to levels that are protective of human health. • Mitigation measures to control surface water discharge/seepage outlined in the Water Quality Section 6.3.4.3 and the Water Management Plan will reduce Project related discharge/seepage to levels that are protective of human health. • Additional mitigation measures specific to human health have not been recommended.	Not Significant (Minor)	No Residual Effect	Section 10.4

17.3 NEED FOR, PURPOSE OF, AND ALTERNATIVES TO THE PROJECT

17.3.1 Introduction

The prosperity of Canada and British Columbia (BC) is linked to economic development opportunities in the natural resources sector. The purpose of the Project is to supply copper and gold to the global market while contributing to the country's economic growth and stability. KAM is committed to developing the Project in a manner that will contribute to the local, provincial, and national economies and create employment opportunities on a local, regional and national level.

The Operational Policy Statement titled *Addressing "Need for", "Purpose of", "Alternatives to" and "Alternative Means" under the Canadian Environmental Assessment Act* (CEA Agency 2007) makes reference to both "alternatives to" a proposed undertaking and "alternative means" of carrying out a proposed undertaking. The alternatives considered in the Application/EIS are based on guidance from the policy statement and from the AIR/EIS Guidelines (BC EAO 2015) for the Project. This section addresses the "alternatives to" the proposed Project, while Section 17.4 addresses the "alternative means" of carrying out the proposed Project.

17.3.2 Assessment

"Alternatives to" the Project are the different ways to meet the needs of the project and achieve the project purpose. Unlike other types of projects for which a number of alternatives to the project might be available, such as the development of transportation systems, mines such as the proposed Project are unique because ore bodies have a fixed location, and the only way to proceed with a mining venture is to mine the ore body in place. Alternatives to project advancement include:

- to proceed with the Project in the near term as planned to produce copper-gold for sale and provide a return on investment to shareholders;
- to delay the Project until market conditions improve; or
- to abandon the Project.

Three performance objectives apply to the evaluation of alternatives to the Project, namely:

- economic viability;
- natural environment acceptability; and
- human environment acceptability.

The technical feasibility performance objective does not apply to the alternatives evaluation since the expected technical performances of all alternatives are equal (i.e., the Project will only be built if it is technically feasible to do so).

17.3.2.1 Economic Viability

The proposed Project will create short-term employment during the construction phase and permanent positions during the operation phase. A discussion of the Project costs and benefits are presented in Section 2.7 of the Application/EIS.

A positive return was indicated (Wardrop 2011) from the near-term development of the Project, based on a copper price of US$2.75/lb, a gold price of US$1,085.00/oz, and an exchange rate of US$0.92: Cdn$1.00. The pre-tax financial results for a project with a 23-year mine life and 503 million tonnes of mineable ore are:

- 14.5% Internal Rate of Return;
- 7.8 year payback on US$795 million capital; and
- US$416 million Net Present Value at 8.0% discount rate.

Proceeding with the proposed Project in the near-term provides a competitive return on investment and is the preferred alternative.

Delaying the Project would only be an acceptable alternative if future economic conditions could be reliably predicted to be more favourable. However, future economic conditions are notoriously difficult to predict, increasing the economic risks of delaying the Project. Feasibility studies to date have considered the regulatory review and construction timeline costs based on developing the Project as planned in the near-term. In addition, mining is a capital intensive industry and relatively predictable short-term metal prices are critical to recover capital investments during the early payback period and to determine the overall feasibility of the Project. There is no assurance that future economic conditions would equally or more strongly support a decision to proceed with the Project, so the alternative of delaying does not meet the minimal acceptable criterion for economic viability.

Abandoning the proposed Project, or the "no development scenario", is also an unacceptable alternative as this option would not contribute to economic growth and stability, or meet the current and forecasted demand for copper and gold in global markets.

17.3.2.2 Natural Environment Acceptability

Proceeding with the Project as planned will displace Peterson Creek, infringe on Jacko Lake, temporarily remove land from the Agricultural Land Reserve, and potentially affect fish, vegetation and wildlife. As described in the VC assessments in Sections 6.1 to 6.17 of the Application/EIS, mitigation measures will be implemented to minimize adverse effects to the extent reasonably practicable, including offset measures and habitat restoration at closure. This option is considered acceptable since the effects on flora and fauna would be localized and are not expected to permanently affect habitat integrity.

The "delay project" alternative is considered acceptable as it would have the same effects as the "proceed alternative" but in the future. Abandoning the Project would be the preferred alternative from a natural environment perspective as there would be no changes to the current environment other than those effects that have already occurred as part of previous mining activities and other land uses.

17.3.2.3 Human Environment Acceptability

The Project will have benefits and disturbances for local communities. KAM is committed to developing the Project, throughout its lifecycle, in a socially responsible manner, and to upholding respectful and transparent relationships with neighbouring residents and other stakeholders. The company is confident that the Project can be developed in a way that minimises disturbance and other potential adverse effects, while maximising benefits for the community and region. KAM sees the proximity of the Project to the City of Kamloops as an opportunity to ensure best practices are used and benefits realized.

The Project will have positive socio-economic benefits for the local community from employment to supplying goods and services. There is support for the Project as local employment will improve livelihood; for example, families with fathers working outside of the area can be families again with the father working at home.

The Project has the potential to disturb or otherwise affect local residents. Displacement of certain agricultural, hunting and other local recreational activities will occur during the construction and operational phases of the Project. The community has also raised concerns regarding increased health risks related to reduced air quality, increased traffic, and increased noise. Where adverse effects are expected, the Project has (or will) offset or managed these effects through purchasing of private lands, providing alternate access, mitigating potential effects on water and air through project design, and establishing agreements with local government and Aboriginal groups. Significant changes to the general arrangement of the mine site have also been made in order to minimize effects on local residents.

Abandoning the Project would preserve the current human environment conditions and avoid potential effects to current land use and public health and safety in the area. However, economic opportunities—including employment and business opportunities, associated personal and business income, tax revenues, and contributions to local and regional economic development—would not be realized.[1] Abandoning the Project is unacceptable as this option would not contribute to economic growth and stability, or supply copper and gold to global markets.

Continuing or delaying the Project are both considered acceptable options. However, proceeding with the Project in the near-term is the preferred alternative since delaying the Project increases the uncertainty regarding the socio-economic benefits of the Project.

[1] As described in Section 2.7, the equivalent of approximately 450 full-time positions will be generated during mining operations. The Project will also provide economic opportunities for local business, increase tax revenues and support local events and activities.

17.3.3 Conclusion

Abandoning the proposed Project would fail to fulfill the need and purpose of the Project by foregoing employment opportunities for local communities, and potential tax and royalty revenues to the Government of BC and the Government of Canada. Project development will have positive socio-economics benefits for the local and regional economy through employment and supplying goods and services. The Project has the potential to cause disturbance to the local environment and some local residents as well as some displacement of some agricultural, hunting and other traditional and local recreational activities. Where adverse effects are expected, many such effects have been, or will be, minimized or offset through applying mitigation measures during operations and reclamation at closure.

Delaying or not developing the proposed Project is unsuitable because the current economic opportunities would not be realized and future Project economics are uncertain.

Proceeding with the proposed Ajax Project in the near-term is the preferred alternative.

17.4 ALTERNATIVE MEANS OF CARRYING OUT THE PROJECT

17.4.1 Introduction

The prosperity of Canada and British Columbia (BC) is linked to economic development opportunities in the natural resources sector. The purpose of the Project is to supply copper and gold to the global market while contributing to the country's economic growth and stability. KGHM Ajax Mining Inc. (KAM) is committed to developing the Project in a manner that will contribute to the local, provincial, and national economies and create employment opportunities on a local, regional and national level.

The Operational Policy Statement titled *Addressing "Need for", "Purpose of" "Alternatives to" and "Alternative Means" under the Canadian Environmental Assessment Act* (CEA Agency 2007) makes reference to both "alternatives to" a proposed undertaking and "alternative means" of carrying out a proposed undertaking. The alternatives considered in the Application/EIS are based on guidance from the policy statement (CEA Agency 2013) and from the AIR/EIS Guidelines (BC EAO 2015) for the Ajax Project (the Project). This section addresses the "alternative means" of carrying out the proposed Project, while Section 17.3 addresses the "alternatives to" the proposed Project.

This chapter describes the approach used to select preferred options from a variety of alternative means of developing the Project. The assessment of alternatives demonstrates the key decisions that KAM has made to undertake mining activities to minimize the potential adverse effects from the Project whilst maximizing beneficial environmental, cultural, and socio-economic effects, and remaining technically and economically feasible. For this section, "alternatives" refer to the different means of carrying out the Project including facility locations and methods for constructing, operating or closing the Project.

This evaluation of the alternative means of undertaking the Project meets the requirements of Section 16(2b) of the *Canadian Environmental Assessment Act* (1992) and the Comprehensive Study Scope of Assessment (CEA Agency 2010) as a factor to be considered in the scope of the comprehensive study environmental assessment, in addition to satisfying the information requirements as outlined in the British Columbia (BC) Application Information Requirements (AIR)/Environmental Impact Statement Guidelines (EISg) document (BC EAO 2011, 2015).

Throughout the process of development planning for the Project, KAM has made numerous decisions and taken steps to improve the Project's performance based on economic, technical, environmental, and social criteria. The concerns and preferences of Aboriginal groups and local community have been solicited and addressed to the extent possible. Major mine components and activities, including those identified in the AIR/EIS Guidelines, for which alternative assessment was carried out, include:

- General arrangement;
- Mining methods;
- Production rates;

- Open Pit limits;
- Mine rock storage;
- Tailings storage facility location;
- Tailings storage facility technology and management;
- Tailings storage facility closure;
- Water use and supply;
- Jacko Lake management;
- Peterson Creek diversion;
- Product transport method and route;
- Site access road;
- Explosives manufacture and storage facility;
- Blasting schedule; and
- Power supply and transmission line.

17.4.2 Approach to Assessment

The approach used in this assessment is based on an initial screening of the alternatives for technical and economic feasibility. Where there is more than one feasible alternative, assessment of the potential environmental effects, including the human and natural environment, were used to inform the selection of the preferred option. This approach follows the four steps recommended in the Operational Policy Statement (CEA Agency 2007) to determine the preferred alternative for each Project component:

1. Identify and screen technically and economically feasible alternative means;
2. List their potential effects on valued components;
3. Select the approach for the analysis of alternative means; and
4. Assess the environmental effects of alternative means.

These steps have generally been followed to assess the environmental effects for each Project component. A summary table is provided at the end of each section which provides an 'overall performance rating' based on a qualitative assessment of the merits of each option.

This assessment was carried out at a level sufficient to distinguish the relative merits of the different alternatives for developing, operating and closing the Project. The assessment includes consideration of the advantages and disadvantages of each alternative based on a series of performance objectives, evaluation criteria and considerations, to define the preferred alternative for each of the key Project components or activities.

Stakeholder input and consideration of the interests of Aboriginal Groups have been solicited through consultation as the Project has evolved (see Section 4.6 and 4.7). KAM was able to develop an understanding of key interests through consultation efforts, feedback received during technical working group meetings and community information sessions, and review of available documentation. As part of the engineering and design development, KAM environment and external affairs representatives and consultants participated in workshops and discussions with the larger Project team to ensure that interests identified through consultation were incorporated into the decision-making process for the alternatives means of carrying out the Project. Section 17.7 provides details of mitigation measures to address stakeholder and Aboriginal Group concerns.

Performance objectives are attributes considered essential to the Project success and these objectives facilitate assessment of the options. In addition to technical and economic feasibility, performance objectives include effects to the natural and human environment (i.e. 'environmental acceptability'). Criteria used in assessing technical feasibility include suitability, reliability and expected performance during operations and post-closure. Considerations used to assess the technical performance objective are provided in Table 17.4-1. The performance ratings are the outcome of the assessment and include: preferred, acceptable, challenging or unacceptable.

Table 17.4–1. Technical Feasibility Performance Objective and Rating

Performance Objective	
Criteria	Applicability, reliability, effectiveness and proven performance of a given alternative.
Considerations	Flexibility with regard to technical, operation, and environmental uncertainties.
	Proposed technologies and the advantages and disadvantages of the technologies considered (e.g., proven technology used elsewhere or new).
	Technical Risk (e.g., unforeseen geotechnical condition may require design modification).
	Availability of construction material and volume requirements.
	Post-closure risks and uncertainties (e.g., potential for perpetual treatment or maintenance).
Performance Rating	
Preferred	Proven effective with contingencies if the alternative does not perform as expected.
Acceptable	Appears effective based on modelling/theoretical results; contingencies are available if the alternative fails to perform as expected.
Challenging	Appears marginally effective based on modelling/theoretical results; contingencies may not be available if the alternative fails to perform as expected.
Unacceptable	Effectiveness appears dubious or relies on unproven technologies.

Criteria used in assessing economic feasibility include capital, operating and closure costs. Additional considerations and the performance rating are provided in Table 17.4-2.

When more than one feasible alternative was identified through the screening process (i.e. both technically and economically feasible), further assessment using 'natural environment acceptability' and 'human environment acceptability' was carried out. The following criteria and considerations were taken into account for the assessment of natural (Table 17.4-3) and human environment (Table 17.4-4) performance objectives.

An alternative was rejected if it was given an unacceptable rating for any single performance objective. A rationale for the selection of a preferred alternative is provided. In some cases, the alternative that received the greatest number of acceptable or preferred ratings is not necessarily the best or most preferred alternative. The terms 'alternative 'and 'option' are used synonymously in this Section.

Table 17.4–2. Economic Feasibility Performance Objective and Rating

Performance Objective	
Criteria	Total costs. Return on investment (ROI), Net present value (NPV)
Considerations	Capital, Operational, Decommissioning and Closure and Post-closure costs Economic benefits and risks. Construction timeline costs.
Performance Rating	
Preferred	Facilitates a competitive net present value
Acceptable	Facilitates an acceptable net present value.
Challenging	Marginal: may or may not facilitate an acceptable net present value.
Unacceptable	Cannot be financially supported by the Project.

Table 17.4–3. Natural Environment Performance Objective and Rating

Performance Objective	
Criteria	Overall environmental risks and effects of the Project. Ability to mitigate effects. Amenability to reclamation.
Considerations	Overall affected land footprint size. Potential effects to key valued components (VCs)that may include the following: greenhouse gas management; geology, landforms and soils; surface water quality; surface water quantity; groundwater quality; groundwater quantity; fish populations and fish habitat; rare plants; rare and sensitive ecological communities; grasslands; terrestrial invertebrates; amphibians; reptiles; migratory birds; raptors; non-migratory gamebirds; mammals. Considerations related to climate change adaptation (e.g., changes in water management). Amenability to reclamation (e.g., probability of achieving long-term reclamation goals).
Performance Rating	
Preferred	Minimizes risk for an adverse effect on the environment with standard mitigation.
Acceptable	Minimizes magnitude of adverse effects on the environment with reasonable mitigation.
Challenging	May cause substantial or irreversible adverse effects on the environment that may be difficult to reasonably mitigate.
Unacceptable	Likely to cause substantial or irreversible adverse effects on the environment that cannot reasonably be mitigated.

Table 17.4–4. Human Environment Performance Objective and Rating

Performance Objective	
Criteria	Overall socio-economic risks and effects of the Project. Ability to mitigate effects and/or enhance benefits.
Considerations	Benefits and relative preferences of community members, Aboriginal Groups, local governments (e.g., economic growth, employment and training, local business and property values). Preservation of Aboriginal and non-Aboriginal archaeological/cultural sites. Potential effects on health valued components including air quality, domestic water quality, country foods, noise and vibration, community health and well-being. Potential effects on asserted Aboriginal rights. Potential effects on infrastructure, public facilities and services; visual impacts /aesthetic features (shading); Land use and recreation. Safety considerations.
Performance Rating	
Preferred	Minimizes negative effects on the socio-economic environment with standard mitigation and provides positive benefits.
Acceptable	Minimizes negative effects on the socio-economic environment with reasonable mitigation.
Challenging	May cause substantial negative effects on the socio-economic environment that may be difficult to reasonably mitigate.
Unacceptable	Likely to cause substantial negative socio-economic effects that cannot reasonably be mitigated.

17.4.3 General Arrangement Alternatives

17.4.3.1 Introduction

The emergence of dominant themes of public input profoundly affected the development of the Ajax Project. The first iteration of the proposed Ajax Project, a plan set out in a feasibility study prepared by Abacus Mining and Exploration in 2012, was internally reviewed by KAM beginning in late 2012 and continuing into 2013.

Senior KAM management concluded that the first plan was untenable because of the proximity of key mine components to public infrastructure, and the public's growing concern about those components. In August 2013, KAM senior management publicly announced that the company would postpone submission of its Application/EIS as a result of an internal review of the proposed Ajax Project mine plan. The proponent had initially intended to submit its Application/EIS in September 2013. This decision had substantial cost implications for KAM.

In the months that followed, mine planners noted the public input gathered through the previously described consultation efforts and made key decisions about the future layout and operation of the Project.

On May 29, 2014, KAM announced the Ajax South General Arrangement (GA), which outlined an optimized Project design intended to address many of the concerns raised in earlier community engagement processes. Key changes to the Project included:

- relocating the Tailings Storage Facility more than five kilometers southeast, away from the Coquihalla Highway and farther from City neighborhoods;
- relocating the north mine rock storage facility and temporary ore stockpiles, the two closest site structures to Kamloops, an additional 3.5 kilometres southeast from their previous locations; and
- re-designing the Project to avoid impacts to Inks Lake, initially proposed to be used as a TSF seepage pond. The lake, an important natural resource for recreational users as well as for wildlife, will no longer be impacted by mine operations (note that Inks Lake is part of the fisheries offsetting plan for the Project)

Both the Ajax North and Ajax South general arrangements are considered to be technically and economically feasible. Further assessment of the acceptability with respect to the natural and human environments is therefore required. Sections 17.4.7 and 17.4.8 describe the alternatives considered in response to public concern.

17.4.3.2 Natural and Human Environment Acceptability

Both general arrangements include the same location for the Open Pit as this is fixed, and similar locations for transmission lines. The main difference between the arrangements is that Ajax South is entirely outside of the Kamloops City limits and most infrastructure, including the Tailings Storage Facility (TSF) and most of the Mine Rock Storage Facilities (MRSFs) are located a further distance from the city limits than the Ajax North arrangement. The Ajax South arrangement was a response to the engagement process and the community's preference for mine infrastructure to be relocated further from residential areas.

<u>Natural Environment</u>

The Ajax North arrangement is located within two watersheds: the TSF and North Waste Dump (NWD) in the Cherry Creek watershed, and the Open Pit and East Waste Dump, in the Peterson Creek watershed; whereas the Ajax South arrangement is all within one catchment (draining to Peterson Creek). For Ajax North there is loss of a small, unnamed lake beneath the NWD as well as alteration of Inks Lake for mine water management. Neither are fish bearing and do not have surface connections with any fish-bearing watercourses. For Ajax South Goose Lake would be inundated by the TSF. Goose Lake does not support fish and there is no surface connection with any fish-bearing watercourse (Appendix 6.7-B).

Both alternatives affect Jacko Lake as the northeast arm will be cut-off by a small dam to provide a safety setback zone between the Open Pit and the lake. Both alternatives require diversion of approximately 3.5 km of Peterson Creek but the creek will be re-established at closure. From an environmental acceptability perspective, the two alternatives are considered equal because they have the same Project components, require similar levels of mitigation for successful operation, and

the same closure objectives. However, the Ajax South arrangement has the advantage of being within one watershed and has a tighter footprint (i.e., TSF and MRSF closer together) than the Ajax North arrangement.

Human Environment

The general arrangement presented in Ajax North focussed on minimizing the footprint by positioning facilities near the open pit, in response to technical and economic considerations. Based on comments, concerns and suggestions provided by the community at town hall forums, face-to-face small group community sessions and through the KAM website, the Project General Arrangement was re-assessed. As a result of the input received, and ongoing engineering and design the general arrangement was revised in 2014 to Ajax South. The location of the Open Pit cannot change; however, the Ajax South arrangement locates the Project components and activities further away from Kamloops neighbourhoods to the south and east of the open pit. These areas include private land where ranching is the predominant land-use with limited areas within Crown land or Settlement Land (Figure 2.6-2).

Details of land use activities, community plans and communities potentially affected by the Project, including KAM's understanding of the traditional territories of the Aboriginal Groups, can be found in section 8.5 (Land and Resource Use) and in sections 14 and 12 (Background and Aboriginal Groups Setting). The SSN assert Aboriginal rights and title in the areas surrounding the Project, noting that the SSN lived in, used and supported their way of life on the lands surrounding the Project (SSN, 2015). The SSN also assert rights and title to particular areas such as the Jacko Lake and surrounding areas (also known as "Pipsell"), including Jacko Lake, Goose Lake, Peterson Creek (formerly Jacko Creek) and the Hunting Blind Complex. The SSN have advised KAM that they harvest wildlife (moose, mule deer and grouse in the areas surrounding the Project) for food, trade (trade amongst other Aboriginal families, divisions and nations), ceremonial, medicinal, and technological (e.g. antlers) used to tan hides, skins used to construct clothing.

Key location changes include:

- Processing plant, crushers and temporary ore stockpiles relocated south of the Open Pit and more than two kilometers away from Kamloops;
- The NWD relocated four and half kilometers away from the Aberdeen neighbourhoods; and
- TSF relocated five kilometers southeast from the previously proposed location at Inks Lake, close to the Coquihalla Highway.

These changes reduce the Project's visibility, noise and potential air quality effects on the local community and are more acceptable than the Ajax North arrangement. The Ajax South arrangement will remove Goose Lake and its access road.

17.4.3.3 Preferred Alternative

The resultant Ajax South general arrangement reflects location changes to many of the proposed Project facilities to be further away from local residents, the City of Kamloops, and the Coquihalla

Highway. This moves potential sources of noise and dust away from the local community and the facilities will be less visible from most prominent viewpoints. The assessment of general arrangement alternatives has shown that the Ajax North arrangement is "challenging" because of the challenging rating for human environment acceptability (Table 17.4-5).

Table 17.4-5. Natural and Human Environment Acceptability Ratings for General Arrangement Alternatives

Performance Objective	Ajax North	Ajax South
Natural Environment Acceptability	More widely spread footprint within two watersheds. Requires creek diversion but compensation and reclamation will mitigate effects. Overall considered similar to Ajax South because of similar project components and closure objectives.	Tighter footprint within one catchment. Requires creek diversion but compensation and reclamation will mitigate effects. Overall considered similar to Ajax North because of similar project components and closure objectives.
	Acceptable	Acceptable
Human Environment Acceptability	Concern about visibility and noise, due to proximity to Kamloops and TSF proximity to Highway and impact to Inks Lake. Loss of small (unnamed) lake	Increased distance from Kamloops and from the Coquihalla highway preferred by local community. Less visible and reduced potential for noise and dust effects on community receptors. Loss of Goose Lake.
	Challenging	Acceptable
Overall Rating	Challenging	Preferred

The Ajax South arrangement is the preferred alternative.

17.4.4 Mining Method Alternatives

17.4.4.1 Introduction

The mining method affects other aspects of mine development such as production rates, development schedules, and mine rock volume. The main methods for recovering ore from hard rock mines are open pit and underground mining. Both methods use drilling, blasting, and heavy equipment, but have different environmental, social, technical, and economic considerations. In-situ leaching is a method for extraction of metals from an ore body without the need for conventional mining. The process involves drilling of holes into the ore deposit, fracturing the rock, and pumping leaching solution into the deposit. The solution bearing the dissolved ore content is then pumped to the surface and processed.

17.4.4.2 Technical and Economic Feasibility

In BC, copper-gold porphyry deposits such as the Ajax deposit are commonly mined using open pit mining methods. Open pit mining is ideal for extraction of irregular shaped ore bodies that extend from the surface to considerable depths and have substantial horizontal dimensions with relatively little overburden. The method is flexible, allowing for large variations in production schedules at relatively short notice, and can be highly mechanized, making open pit mining the most productive mining method. For the Project, open pit mining produces ore at a fraction of the cost of

underground mining. There is also significant local experience in open pit mining and it has a lower incident frequency rate than underground mining.

Underground mining is generally more selective, producing less mine rock than open pit mining and less surface disturbance. However, underground mining is also associated with greater equipment needs, longer worker hours to retrieve ore, and additional expenditures for air ventilation, electricity, and water pumping, resulting in higher overall costs.

Open pit mining of the low grade, high tonnage deposit is the most cost-effective and technically viable alternative for the Ajax Project. Employment and business opportunities would be realized with development by all the mining method alternatives; however, underground mining requires more specialized training that may limit opportunities for the local and regional economies.

In-situ leaching is not technically feasible for sulphide deposits since reagent consumption is too high. This method is more suited to oxide and carbonate ore.

17.4.4.3 Preferred Alternative

The grade of the Ajax orebody is too low for underground mining methods alone. In-situ leaching of the ore body is not technically feasible. The deposit is located near surface and mining using proven open pit methods would be more cost efficient than underground mining methods (Wardrop 2011). Open Pit mining is preferred based on technical and economic feasibility (Table 17.4-6).

Table 17.4-6. Technical and Economic Feasibility Ratings for Mining Method

Performance Objective	Underground Mining	Open Pit	In-situ Leaching
Technical Feasibility	Typically for high grade deposits at depth. Greater equipment needs and lower production compared to open pit mining	Ideal for low grade ore bodies extending from surface to depth with little overburden. Flexible and highly mechanized allowing high production rates	Method is not suitable for sulphide ores
	Acceptable	Acceptable	Unacceptable
Economic Feasibility	Lower production and higher unit costs compared to open pit method would make Project uneconomic	Most cost effective and produces ore at a fraction of underground methods	Not assessed
	Unacceptable	Preferred	
Overall Rating	**Unacceptable**	**Preferred**	**Unacceptable**

Open pit mining is the preferred alternative

17.4.5 Production Rate Alternatives

17.4.5.1 Introduction

Optimizing the production rate is key to mining, as it influences cost per production unit, recovery, and grade, which in turn bear on other decisions pertaining to mine development scheduling, pit sequencing, mine design, and equipment requirements. Long-term mine planning is conducted iteratively as reserve estimates are refined and production rates are optimized as commodity prices change.

17.4.5.2 Economic Feasibility

Generally, economies of scale can be realized at higher production rates and lead to reduced unit operating costs. Higher production rates also enable capital costs to be recouped earlier, providing more assurance on return on investment, which improves the project net present value (NPV). However, higher tonnage throughputs also require more capital, and economies of scale can still apply where a given component of the asset has a high fixed cost regardless of the size of the project. In addition, rates of production are restricted by physical and operational constraints and flexibility issues (for example, power availability restrictions can limit the production of a mine).

Initial assessment for a 40 kilo-tonnes per day (ktpd) process facility was revised to 60 ktpd based on studies that showed an estimated net-present value (NPV) increase of 134% (Wardrop 2012). The resource model assumed a base case of 60 ktpd for the Preliminary Economic Assessment (PEA); providing an NPV of US$416 million at 8% discount rate, a 14.5% internal rate of return and 7.8 year pay-back period on a 23 year life of mine (Wardrop 2011). Following the PEA, mill throughput rates of 75 ktpd and 90 ktpd were considered but rejected because the NPV gains were relatively small, 9% and 6%, respectively, for the estimated capital cost increases of $136 million and $200 million, respectively.

The production rate is constrained not only by mill throughput but also potentially by mining, crushing, conveyance and mine rock management. Ongoing optimization studies have resulted in the nominal design throughput of 65 ktpd (Table 17.4-7).

Table 17.4-7. Economic Feasibility Ratings for Production Rate

Performance Objective	40 ktpd	60 ktpd[1]	65 ktpd[2]	75 ktpd	90 ktpd
Economic Feasibility	Lower capital cost but higher unit operating costs and lower cash flow. Unattractive NPV	Increases NPV from 40 ktpd mine plan and reduces financial risk	Provides improved return of investment based on optimization of 60 ktpd plan	Small NPV gains for large capital cost increase related to larger processing plant and vehicle fleet	Small NPV gains for large capital cost increase related to larger processing plant and vehicle fleet
Rating	**Unacceptable**	**Acceptable**	**Preferred**	**Acceptable**	**Challenging**

[1] Wardrop, 2011; [2] KGHM optimization, 2015.

17.4.5.3 Natural and Human Environment Acceptability

The low production rate (40 ktpd) is considered economically unviable. For the 60 ktpd, 65 ktpd, 75 ktpd and 90 ktpd production rates post-closure environmental effects will be the same; however, during the mine life, these alternatives would have different intensity levels.

Increased mining intensity (e.g. 75 ktpd) would result in higher peak demand for utilities (e.g., water, electricity, diesel), and increased sizing of equipment/facilities. However, all of the same equipment/facilities would be required, and utility availability (e.g., water, electricity) are not considered to be limiting factors in the Project design at these capacities.

Increased mining intensity would also result in increased emissions intensity (e.g. noise and dust from greater traffic levels), and higher employment, but all over a shorter mine life, while lower mining intensity would similarly lower emissions intensity. Based on review of differences between these alternative production rates, KAM did not identify any substantial differences in natural and human environment criteria that could not be managed through the implementation of the same mitigation measures (e.g., active dust control, blast measures, water management).

Based on engineering trade-offs, the preferred alternative is a processing plant with a nominal name plate capacity of 65 ktpd (Table 17.4-8). Ultimately, the mine will be operated with a pace/timing that is intended to optimize returns based on current market conditions of supply and demand. Functionally, this will mean that during periods of high metal prices, the production rate will consistently achieve full capacity, while during periods of lower prices; the facility may operate at less than capacity. For the purposes of the effects assessment, an average daily production rate of 65 ktpd is utilized as the basis of assumptions within the Project Description (Chapter 3), and numerical modelling (e.g., water balance, air quality, noise, etc.).

Table 17.4-8. Natural and Human Environment Acceptability Ratings for Production Rates

Performance Objective	Production Rate 60 to 65 ktpd	Production Rate 75 to 90 ktpd
Natural Environment Acceptability	Lower emissions intensity of longer duration is expected to have less adverse effect with reasonable mitigation. Similar post-closure effects to higher production rates.	Increased footprint for larger infrastructure. Higher emissions intensity of shorter duration may cause adverse effects that are more difficult to minimize with reasonable mitigation. Similar post-closure effects to lower production rates
	Acceptable	Challenging
Human Environment Acceptability	Lower employment but over a longer mine life is preferable over the opposite as it creates longer term jobs	Higher employment but over a shorter mine life is acceptable but less preferred compared to the lower production rate option
	Preferred	Acceptable
Overall Rating	Preferred	Challenging

17.4.5.4 Preferred Alternative

The previous 60 ktpd production rate has been optimized to 65 ktpd and is the preferred rate to economically support production for the life of the mine. KAM is of the view that a 65 ktpd throughput provides the most economical sense given their current assessment of the market.

The 65 ktpd production rate is preferred based on economic performance objectives.

17.4.6 Open Pit Limits Alternatives

17.4.6.1 Introduction

The Project's pit limits are constrained along its western extent due to the presence of Jacko Lake. The western parts of the deposit contain some of the highest grade ore at depth; however, to access all of this ore, the western pit limits would need to significantly intrude on Jacko Lake and Peterson Creek. The SSN assert rights and title to Jacko Lake and surrounding area (known as "Pipsell") for traditional land uses including food harvesting and maintenance of cultural values, practices and traditions. In developing alternatives to the pit extent, KAM has been attentive to Aboriginal concerns and community values associated with Jacko Lake and have selected a design that attempts to strike a balance between preserving the lake and maximizing the extraction of the in-situ resource.

The extent of the pit's limit is based on an optimal 'pit shell contour' that maximizes the material selected for extraction while satisfying operational requirements for safe pit wall slopes. The open pit limits were determined in this way for the Project and resulted in three technically feasible alternative pit designs (each extracting a different quantity of total ore):

- Alternative 1: unconstrained pit infringing on Jacko Lake;
- Alternative 2: constrained pit completely outside of Jacko Lake; and
- Alternative 3: constrained pit with minimal infringement on Jacko Lake.

The pit shell extents as it affects Jacko Lake are shown in Plate 17.4.-1.

17.4.6.2 Economic Feasibility

Constraining pit limits can substantially affect the size, shape and value of the Open Pit. The three alternatives are all technically feasible; however there is 'opportunity cost' associated with the alternatives. The unconstrained pit which infringes on Jacko Lake (Alternative 1) maximizes the resource and value of the pit. The opportunity cost for completely avoiding Jacko Lake completely (Alternative 2) compared to the maximized pit is approximately US$886M and reduces the mineral inventory by about 88 Mt and 3.7 years of mine life at 65 ktpd (KAM internal memo). Infringing on Jacko Lake by removing the northeast arm but preserving the southeast arm (Alternative 3) has an opportunity cost of approximately US$334M and reduces the mineral inventory by 44 Mt and 1.9 years of mine life at a processing rate of 65 ktpd (Table 17.4-9).

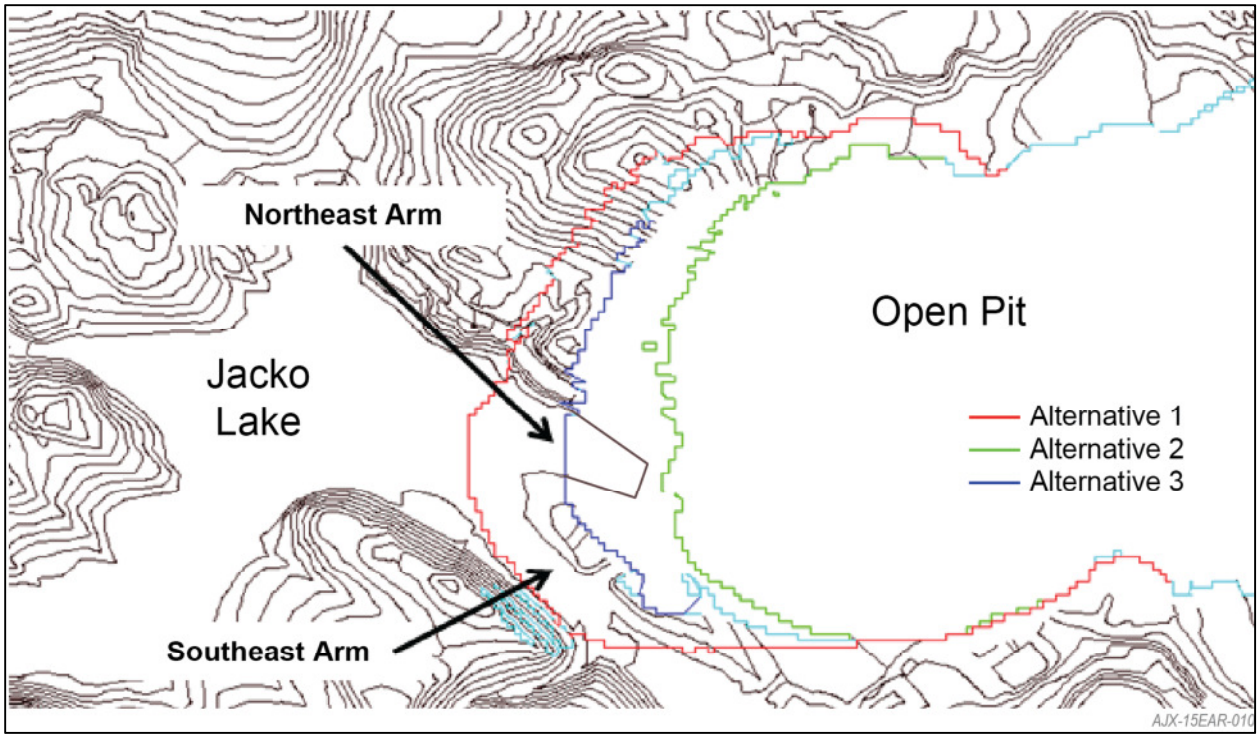


Plate 17.4-1. Pit Shell Extents

Table 17.4-9. Economic Feasibility Rating for Open Pit Limits Alternatives

Performance Objective	Alternative 1 - Unconstrained Pit Infringing on Jacko Lake	Alternative 2 - Constrained Pit, Completely Outside of Jacko Lake	Alternative 3 -Constrained Pit - Minimal Infringement on Jacko Lake
Economic Feasibility	Maximizes the return on the project by accessing all of the high grade zone on west of deposit	Not able to access high grade zone: opportunity cost of US$886M; considered economically unviable for Project	Optimizes return on the project where encroachment into Jacko Lake is a constraint to accessing some of the high grade zone on west of deposit. Opportunity cost of $334M
Overall Rating	Preferred	Unacceptable	Acceptable

A constrained Open Pit completely outside of Jacko Lake is not economically feasible for the Project. The unconstrained alternative is preferred from an economic perspective and the minimally constrained alternative is rated as "acceptable". The unconstrained and minimally constrained alternatives were carried forward for further assessment using 'natural environment and 'human environment' performance objectives.

17.4.6.3 Natural and Human Environment Acceptability

KAM recognizes local community and Aboriginal Group concerns and the values associated with Jacko Lake related to (among others) fish, recreation, water supply, archaeology, and Aboriginal Interests and that the SSN prefers the option that does not have an impact on Jacko Lake or Peterson Creek. KAM is seeking a balance of minimal disturbance to Jacko Lake and having an economically feasible project.

Natural Environment

The unconstrained pit (Alternative 1) will infringe further into Jacko Lake compared to a minimally infringing pit (Alternative 3) and result in greater effects on aquatic habitat as well as require additional fill materials to construct a dam to separate the pit from the lake. An unconstrained open pit implies increased production rates or a longer mine life with associated noise and air emissions. Relative to the other alternatives, this alternative has the greatest potential for aquatic and terrestrial effects and requires significant offsetting in the local area.

Human Environment

The unconstrained pit (Alternative 1) will have a longer mine life resulting in economic benefits for the local community and government. The unconstrained pit will infringe further into Jacko Lake compared to a partially constrained pit and result in greater effects on Aboriginal interests and on recreational users. Re-establishment of Peterson Creek would be more challenging for the unconstrained pit alternative and drainage from Jacko Lake may need to be routed to the west. This would be problematic for downstream users of water supplied by Jacko Lake.

The minimally-infringing pit option (Alternative 3) will result in the loss of the northeast arm of Jacko Lake but preserve the southeast arm. The southeast arm is the lake discharge location and reportedly popular with fishermen. Two small dams (< 5 m high) would be installed to hold the PMF and excess water diverted around the pit. At closure, the dams would remain and excess water will flow through the spillway on the southeast dam connecting to a re-established Peterson Creek. The Open Pit is not expected to fill to ground elevation and discharge to the environment. The area surrounding the Open Pit would be reclaimed. A rock berm would be constructed around the Open Pit perimeter to limit access. Constraining the pit boundaries, such that the infringement into Jacko Lake is minimized (Alternative 3), balances maximizing pit boundaries for safe and economical operations while minimizing the effects to local community / Aboriginal Groups and potential aquatic and terrestrial impacts (Table 17.4-10).

17.4.6.4 Preferred Alternative

A constrained pit completely outside of Jacko Lake (Alternative 2) is not feasible as it renders the Project uneconomical. An unconstrained pit (Alternative 1) would have increased disturbance and loss of fish habitat and reduce the traditional land use and recreational use of Jacko Lake. Re-establishing Peterson Creek may be more difficult and the overall rating for an unconstrained pit is “challenging”.

The preferred alternative is a pit that minimally infringes on Jacko Lake (Alternative 3). Constraining the pit boundaries such that the infringement into Jacko Lake is minimized is considered to be acceptable as it balances maximizing pit boundaries for safe and economical operations and minimizing effects of the Project on the human and natural environments.

Table 17.4-10. Natural and Human Environment Acceptability Ratings for Open Pit Limits

Performance Objective	Alternative 1 - Unconstrained Open Pit	Alternative 3 - Constrained Open Pit - Minimal Infringement on Jacko Lake
Natural Environment Acceptability	Longer mine life with associated noise and air emissions. Increased loss of fish habitat and increased terrestrial habitat disturbance. Potential post-closure flow reductions to Peterson Creek.	Reduction of fish habitat limited to northeast arm of Jacko Lake and less terrestrial habitat disturbance compared to unconstrained open pit. Peterson Creek connection re-established at closure.
	Challenging	Acceptable
Human Environment Acceptability	Longer mine life resulting in economic benefits to local community and government. Greater loss of land and aquatic resources less acceptable to local community and Aboriginal Groups.	Minimizes effects to land and aquatic resource users and maintains an economical project.
	Challenging	Acceptable
Overall Rating	Challenging	Preferred

A minimally-infringing pit is the preferred alternative

17.4.7 Mine Rock Storage Alternatives

17.4.7.1 Introduction

The terms 'waste rock dumps' and 'mine rock storage facilities' are the same and MRSF are used in this section. Mine rock and overburden generated from the Open Pit operations will be transported to designated storage locations by haul truck or by conveyor system. Open pit mining operations will generate approximately 90 tonnes of mine rock and overburden on an annual average basis. From 10% to 13% of the mine rock is considered potentially acid generating (PAG) (Appendix 3-A).

The overall objective of the MRSF selection process was to minimize the distance from the pit, to minimize the footprint of the areas occupied by the mine rock, and to avoid areas sensitive to the natural and human environment. Constraints placed on MRSF locations included:

- The facilities should be placed on land and avoid water bodies and aquifers where practicable;
- Avoid archaeological sites and mitigate effects;
- The facilities should be located in proximity to open pits; and
- Maximize backfilling of open pit based on mine plan sequencing and economic trade-off.

Two potential mine rock storage areas were identified in the Feasibility Study (Wardrop 2012): the North Waste Dump (NWD) located several kilometers northwest of the Open Pit, and the East Waste Dump (EWD) to the east side of the Open Pit (Figure 17.4-1). These MRSFs were part of the 'Ajax North' general arrangement. For the 'Ajax South' general arrangement (Figure 17.4-2), which resulted from ongoing consultation and feasibility studies, four (4) additional MRSF areas were

identified by KAM with the intent of creating a tighter footprint whilst meeting the constraints listed above. Six (6) mine rock storage areas were assessed:

- North Waste Dump (NWD);
- East Waste Dump (EWD)
- South Mine Rock Storage Facility (SMRSF);
- East Mine Rock Storage Facility(EMRSF);
- West Mine Rock Storage Facility (WMRSF); and
- In-Pit Mine Rock Storage Facility (IPMRSF).

All of the MRSFs are considered economically and technically feasible and are carried forward for assessment using 'natural environment and 'human environment' performance objectives.

17.4.7.2 Natural and Human Environment Acceptability

North Waste Dump (NWD)

The proposed NWD area comprises a 450 ha footprint and storage capacity of 728 Mt with final design elevation of 1,084 m, and it is approximately 1.5 km from the pit. The NWD has the disadvantage of being within Kamloops City boundary and approximately 1.5 km from the community of Aberdeen. Visibility of the facility and the propagation of noise during mine operation and reclamation are less easily mitigated. From a natural environmental perspective, the facility does not cross or infringe on surface water bodies, however, it is located within two watersheds and therefore less preferable than the facilities located in one watershed (e.g., the SMRSF). The North Waste Dump location is closer to the highway and residential areas than other alternatives.

The MRSF's footprint in two watersheds and proximity to the Highway and location within Kamloops's city limits render this alternative "acceptable" from a natural environment perspective and "challenging" from a human environment perspective with an overall "challenging" rating (Table 17.4-11).

East Waste Dump (EWD)

The proposed EWD is located less than 500 m east of the Open Pit and has a 325 ha footprint (Figure 17.4-1). The EWD is approximately 1.5 km south of the community of Aberdeen and will be visible to the community. Potential air quality / noise effects could result from this MRSF during mine operation and reclamation. The footprint of the EWD is close to the aquifer associated with the glacio-fluvial deposits within the Peterson Creek corridor.

The size (footprint and height) of the EWD and proximity to the Peterson Creek aquifer and the community of Aberdeen render this alternative "challenging".

Figure 17.4-1
Ajax North General Arrangement

ERM

TTP Emergency Pond
Emergency Discharge Pipeline
TSF West Pond Water Reclaim Pipeline
Thickened Tailings Plant (TTP)
Oil Pipeline
North Waste Dump
TSF East Pond Water Reclaim Pipeline
TSF West Pond
Tailings Storage Facility (TSF) Final Footprint
Mill Tailings and Excess Water Return Pipelines
Processing Facility
East Waste Dump
Pit
TSF East Pond
Thickened Tailings Discharge and Flush Water Pipelines
Jacko Lake
Goose Lake
5
5,613,000
5,610,000
5,607,000
678,000
681,000
684,000
687,000

Legend
- City of Kamloops
- Peterson Creek Aquifer

Proposed Structures
- Pipeline
- Road
- Peterson Creek Diversion Discharge
- Pit Outline
- Water Management Ponds
- Waste Dump
- Tailings Storage Facility (TSF)
- Building Footprint

NOTES:
1. BASE MAP:
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:35,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.4 0.8 1.2 Kilometers

KGHM Ajax Mining Inc.

2015 March 19			
DATE			
LP	LP	PvL	JR
DESIGNED	DRAWN	CHK'D	APP'D
REF NO.	AJX-15-029		REV A

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Figure 17.4-2
Ajax South General Arrangement

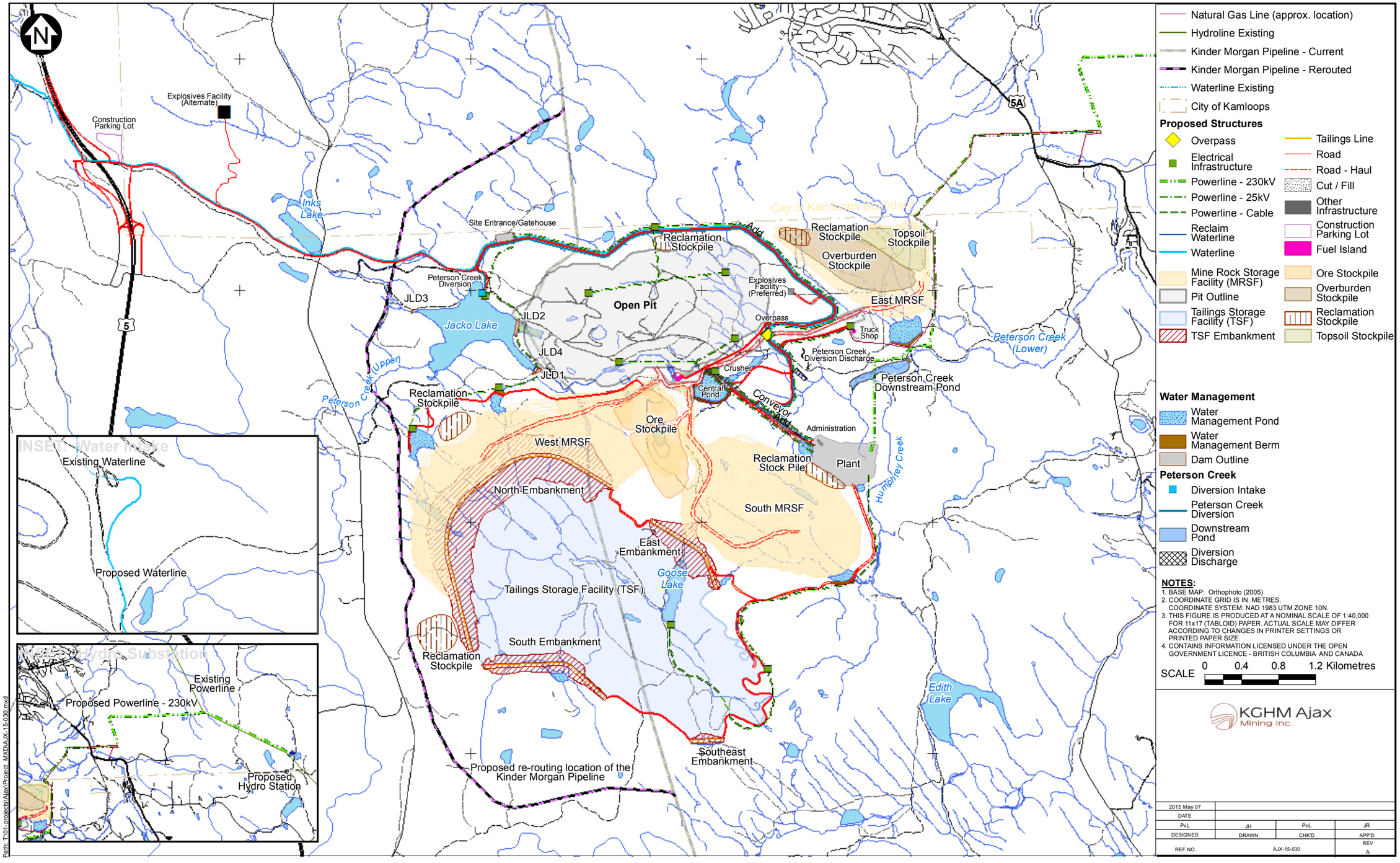


Table 17.4-11. Environmental Acceptability Ratings for Mine Rock Storage Alternatives

Assessment Criteria	Mine Rock Storage Alternatives					
	NWD	EWD	SMRSF	EMRSF	WMRSF	IPMRSF
Natural Environment Acceptability	Footprint in 2 watersheds. Not close to aquatic habitat.	Footprint in 1 watershed. Proximity to Peterson Creek aquifer.	Footprint in 1 watershed. Proximity to aquatic habitat; mitigation may be required.	Footprint in 1 watershed. Proximity to aquifer and aquatic habitat; mitigation may be required.	Footprint in 1 watershed. Not close to aquatic habitat. Post-closure contact water flows to pit.	Reduces surface footprint and potential water quality effects.
	Acceptable	Challenging	Challenging	Challenging	Acceptable	Preferred
Human Environment Acceptability	Within Kamloops City limits. Proximity to highway. Visibility and noise. Not favoured by community.	Proximity to community of Aberdeen. Visibility and potential air quality / noise effects. 1 archaeological site.	More distant from community implies fewer disturbances. 1 archaeological site.	Reduced elevation to EWD. Potential air quality / noise and visibility to local community. 1 archaeological site.	Distant from community but will be visible from Jacko Lake. 2 archaeological sites.	Less mine rock stored on surface.
	Challenging	Challenging	Acceptable	Acceptable	Acceptable	Preferred
Overall Rating	Challenging	Challenging	Preferred	Preferred	Preferred	Preferred

East Mine Rock Storage Facility (EMRSF)

The proposed EMRSF is in a similar location as the EWD but is further from Peterson Creek, has a smaller footprint (100 ha compared to 325 ha), and a lower design height (85 m) compared to the EWD. The EMRSF will accommodate temporary overburden and topsoil stockpiles that will be used during reclamation.

The EMRSF is approximately 1.5 km from the Aberdeen community but has less potential for air quality / noise effects and visibility compared to the EWD due to its reduced size. The EMRSF is rated as an acceptable location for rock storage compared to the EWD (Table 17.4-11). There is one archaeological site for which mitigation will be required. Water management will include collection of runoff and shallow seepage in a lined pond and diversion to the process plant during operations. Only NPAG rock will be stored in the EMRSF to mitigate potential effects of seepage on the Peterson Creek aquifer.

The reduced size of the EMRSF compared to the EWD means that it would be further from the Peterson Creek aquifer. Overall this alternative is rated as "acceptable" since mitigation (e.g. depositing only non-acid generating rock in the EMRSF, collection of run-off and seepage) is expected to limit the potential effects to aquatic habitat.

South Mine Rock Storage Facility (SMRSF)

The proposed South Mine Rock Storage Facility (SMRSF) is located furthest from Kamloops relative to the other MRSF alternatives. The facility has a footprint of 210 ha and a capacity of 358 Mt, a final height of approximately 270 m and is between 1 and 2 km south of the pit. Feasibility studies indicate that this location is technically feasible and that project economics remain positive with the development of this MRSF.

The benefit of the location is that it is within one watershed and is therefore preferred as it limits the potential distribution of runoff from mine rock piles. The location south of the pit and more distant from Kamloops compared to the North Waste Dump location implies fewer disturbances to the community including reduced opportunity for interactions with air and noise emissions. The location of this facility is within 200 m of Humphrey Creek, which drains from Edith Lake, southeast of the Project, northwards to Peterson Creek. Although Humphrey Creek is a short creek (4.6 km) with no reported fish presence, seepage from the SMRSF has the potential to affect water quality. Mitigation will include covers that limit infiltration through the rock and collect seepage and run-off at the toe of the dump.

There is one known archaeological site in the footprint of the SMRSF. Mitigation measures will be determined through KAM and the Archaeology Branch.

The SMRSF location has an overall rating of "acceptable" as the potential environmental effects can be minimized with reasonable mitigation (Table 17.4-11).

West Mine Rock Storage Facility (WMRSF)

The proposed WMRSF is located between 1 and 2 km south of the pit and further away from Kamloops than the NWD and EWD. The WMRSF will be constructed north of the North Embankment along most of its alignment; thereby providing added buttressing to the embankments of the TSF. The WMRSF is technically feasible with storage capacity of 200 Mt, an approximate height of 140 m and a footprint of 155 ha. A disadvantage of the location is that it requires relocation of the Kinder Morgan Trans Mountain Pipeline; however, the relocation is required regardless of the location of the WMRSF.

The location of the facility is limited to one watershed and preferred in order to limit potential distribution of runoff from mine rock piles. The geotechnical conditions in the footprint of the WMRSF are similar to the North Embankment and considered suitable for mine rock storage with appropriate foundation preparation. Most runoff and seepage will be collected in water management ponds. Any seepage infiltrating to depth is expected to flow through groundwater flow channels to the open pit. The location of the WMRSF, south of the Open Pit, is further from Kamloops compared to the NWD location; this implies fewer disturbances to the community including reduced opportunities for interactions with air and noise emissions. There is one known archaeological sites that will require mitigation.

The WMRSF location has been rated as "preferred" for rock storage (Table 17.4-11).

In-Pit Mine Rock Storage Facility (IPMRSF)

Mine rock can potentially be accommodated in mined out areas of the Open Pit. Re-handling mine rock from other MRSFs to backfill the Open Pit is not economically viable; however, backfilling the pit is feasible toward the end of mine life when storage capacity is available. Storage of up to 200 Mt of mine rock could potentially be stored in the pit over this period.

Backfilling the pit reduces the Project's footprint because it keeps mine rock in the Open Pit, most of which will ultimately be submerged by a pit lake. For this reason and the economic benefits of not hauling this material for storage in a MRSF, pit backfilling is considered the "preferred" method for storing mine rock.

17.4.7.3 Preferred Alternative

The NWD and EWD are approximately 1.5 km from Aberdeen neighbourhoods and will potentially have air quality / noise effects and would be visible to the community at full build. Moving the mine rock storage facilities south of the Open Pit (Ajax South option) moves a potential source of noise and dust away from Kamloops.

The best MRSF alternative is the IPMRSF; however there is insufficient capacity to manage the volume of mine rock generated as well as the timing of its generation. Other "preferred" MRSFs include the WMRSF, SMRSF and the EMRSF as their potential effects on the environment can be minimized with reasonable mitigation (Table 17.4-11). In addition to being technically and economically feasible, the proposed Ajax South MRSFs have human environment benefits when compared to the mine rock storage locations and attributes of the Ajax North options. The Ajax South MRSFs are closer to mine operations and therefore trucks will drive shorter distances, reducing emissions and dust generation. Reducing the footprint of the EMRSF compared to the EWD reduces the operation period of the facility and potentially reduces noise and air emissions.

The Ajax South rock storage facilities (EMRSF, SMRSF, WMRSF and IPMRSF) are the preferred alternatives for the Project.

17.4.8 Tailings Storage Facility Alternatives Assessment

17.4.8.1 Introduction

This section describes the steps taken to identify potential tailings storage locations and technologies for the Project. This section is intended to meet both the requirements of the AIR/EIS Guidelines, and the EAO's direction to KAM based on the findings of *Report on Mount Polley Tailings Storage Facility Breach* by the Independent Expert Engineering Investigation and Review Panel (IEEIRP 2015) (Panel Report). For proposed mining projects with new proposed tailings dams, Proponents must provide the following information:

- A description and assessment of alternative means of undertaking the proposed project with respect to options for tailings management that considers technology, siting and water balance.
- A presentation and comparison of best practices and best available technologies for tailing management for the project, along with options for managing water balance to enhance safety and reduce the risk (likelihood and consequence) of tailings dam failure during all phases of mine life (construction, operations, closure and post closure). The assessment must present and compare technically and economically viable engineering solutions that are available to adequately address site conditions.
- Provision of a clear and transparent evaluation of the factors that supported the selection of the most suitable option. Factors that will be taken into consideration in the evaluation include safety, technical and financial aspects, and implications for environmental, health, social, heritage and economic values. The assessment must consider these factors in relation to tailings management options in both the short and long-term context. Life cycle cost assumptions (construction, operations, closure and post closure) must be included in the analysis of options.

17.4.8.2 Tailings Alternative Assessment Studies for Ajax

The Project will produce approximately 275 Mm^3 of tailings over the life of the Project. As described in detail in Appendix 3-A, this material is predicted to be non-acid generating. KAM is committed to storing this material in the safest manner possible and has invested significant effort into evaluating options to determine the best available technologies and practices for tailings storage for the Project. Detailed site-specific studies/evaluations have been completed and have contributed to the decision-making process that led to the identification of the preferred alternative for the Project.

The Ajax North arrangement comprised a TSF location close to the Coquihalla highway that utilized a modified dry-stack technology (Section 17.4-3). This alternative was selected at the time based on available land, proximity to the mill, ease of water management, meeting the tailings storage requirement, and reasonable constructability (Wardrop 2012).

In 2012/2013, as part of the overall Project re-evaluation that led to the Ajax South arrangement (Section 17.4-3), an alternatives study was completed by Knight Piésold (Appendix 17.4-A) with the objectives of identifying the most appropriate alternative, which is technically and economically feasible; minimizing the area occupied by tailings; and avoiding environmentally and socially sensitive areas to the extent practicable.

The results of the Knight Piésold study represent an important contribution to the work undertaken by KAM in planning the Project. This study, and KAM's selection of the preferred TSF alternative for the Ajax South arrangement was completed prior to the incident at the Mt. Polley Mine. Subsequent to the Mt. Polley incident and associated investigation, KAM reviewed findings of the Knight Piésold study and confimed that they remained appropriate. This review was undertaken in accordance with guidance provided by the BC EAO, and the findings of the Mt. Polley investigation.

In 2015, KAM commissioned Norwest and M3 to further evaluate and confirm the most appropriate TSF location and technology alternative by undertaking a feasibility level engineering trade-off study. This study included a review and endorsement of the location for the TSF proposed previously by Knight Piésold and considered in more detail the following tailings management technologies (Appendix 17.4-B):

- Un-thickened (conventional) tailings;
- Thickened tailings;
- Paste tailings; and
- Filtered dry stack tailings.

The tailings management technologies cover the full continuum of alternatives for management of the water balance. The tailings water content is lowest for filtered dry stack tailings, followed in increasing order by paste tailings, thickened tailings and un-thickened (conventional tailings). While the content of water differs, the tailings in all alternatives, except for filtered dry stack, can be pumped and require embankments and similar facility layouts to store the tailings. Filtered dry stack tailings have lower water content so that the facility does not require the same level of embankments and the layout of the storage facility may be different.

Together, the Knight Piésold and the Norwest/M3 studies provide the background and rationale for how KAM has reached a preferred alternative considering the TSF location, technology and water balance in a manner that is consistent with the guidance provided by the government and required in the AIR/EIS Guidelines.

17.4.8.3 Aboriginal Interests

KAM's efforts to consult and engage with Aboriginal Groups are described in detail in Section 4.7 and Section 15 of the Application/EIS. KAM requested meetings with Aboriginal Groups to specifically discuss Project alternatives; though such meetings were not able to be scheduled. However, KAM was able to develop an understanding of key interests through broader consultation efforts and review of available documentation, including:

- consultation with Chief, Council, and community representatives;
- the SSN Cultural Heritage Study (Ignace 2014);
- the MNBC - KGHM/Ajax Mine Initial Project Report (MNBC 2014);
- correspondence between KAM (letters and email) and Aboriginal Groups;
- community open houses;
- site tours;
- primary research, such as interviews with Aboriginal community members and leadership;
- review of previous environmental assessments (EAs; Kinder Morgan Pipeline and affidavits) and legal cases;
- information package provided by SSN on July 8 2015 at the Working Group Meeting;
- letters and comments submitted to the CEA Agency and BC EAO; and
- secondary research that involved a range of historic and ethnographic studies.

The following are some of the key Aboriginal interests that KAM has identified through the above data sources, which KAM and its consulting team have taken into consideration throughout the evaluation of TSF location and technology alternatives:

- The Project lies within the Secwépemc traditional territory (see Figure 12.1-1 in Chapter 12 for more details). The Project also lies in the Nlaka'pamux Nation (LNIB and AIB) traditional territory (see Figure 12.1-2 in Chapter 12 for more details).
- A number of specific locations are important for the SSN. These include the Aboriginal trail, Cherry Creek, Inks Lake, Kamloops Lake, Jacko Lake area (Pípsell), Goose Lake, and the Hunting Blind. Further details on these are provided in Chapter 12.
- Jacko Creek and Peterson Creek are noted to be a valued trout fishery for the SSN.
- The oral history surrounding Jacko Lake and the surrounding area is said to be connected to the epistemological underpinning for Secwépemc stsq'ey (which means indigenous law) that explains the reciprocal and mutually accountable relationships between human beings and

the environment (e.g. fish, birds, animals, the atmosphere and the water cycle). This relationship is illustrated in a story called The Trout Children.

- SSN people continue to practice Aboriginal interests within the traditional territory including hunting, trapping, fishing, plant gathering, as well as conducting other uses (such as cultural and spiritual practices, use of trails, navigation on waterbodies). These activities are an important part of the seasonal round. Chief Ignace notes that current developments (road construction, ranching, mining, and pipelines) in the Jacko Lake area have had negative effects on the area.
- SSN are concerned about cumulative effects at the scale of the Thompson River watershed, and potential effects of water withdrawal from Kamloops Lake.
- SSN are concerned about effects of dust from the TSF in relation to air quality, water quality, and human health.
- SSN are concerned over the removal of Goose Lake.
- SSN are concerned over the interaction of the Afton properties TSF and the Project's TSF.

KAM has incorporated these concerns into this assessment by:

- Considering impacts to water bodies including Jacko Lake, Peterson Creek, Goose Lake, Inks Lake, Kamloops Lake, and Cherry Creek;
- Evaluating options for minimizing footprint;
- Evaluating potential impacts to watersheds;
- Evaluating closure options for restoration of disturbed land;
- Evaluating technologies to reduce water requirements from Kamloops Lake; and
- Evaluate the potential for dust generation;

17.4.8.4 Methodology

The methodology KAM developed and followed to determine best available technology/best available practices with respect to tailings management and storage for the Project is:

- **Step 1** - Identification of potential candidates (a combination of sites and technologies) for tailings management;
- **Step 2 –** Pre-screening (fatal–flaw) assessment of these candidates to eliminate any that did not meet basic technical, economic and environmental/human environment feasibility requirements for the Project;
- **Step 3 –** More detailed screening of the short-listed alternatives based on technical criteria, water balance, life cycle costs, environmental, and human environment, including socio-economic, heritage, health and Aboriginal interests to select preferred TSF for the Project;
- **Step 4 –** Application of a range of tailings technology against the preferred TSF to identify BAT for the Project. Criteria considered include technical, safety, project economics, environmental, socio-economic, heritage, health and Aboriginal interests.

- **Step 5 –** Identification of Best Available Practices (BAP) that reduce risk of tailings breach for the BAT for the Project

Steps 1 through 3 were conducted prior to the EAO's March 19 directive following the Mt. Polley failure. Steps 4 and 5 were conducted post-Mt. Polley to further re-evaluate BAT/BAP for the Project and to ensure that all recommendations and requirements resulting from the Mt. Polley investigation were fully considered.

17.4.8.5 Step 1 - Identification of Potential Locations and Technologies

KAM completed a high-level review of multiple potential locations and technologies for the TSF. Table 17.4-12 and Figure 17.4-3 provides an overview of the locations which were given consideration. This was initialized by reviewing contour mapping to evaluate potential sites for tailings disposal within a 10 km radius of the proposed plant site. For each location, consideration was given for both "pumpable tailings" including conventional slurry, thickened, and paste; and a stacked filtered tailings facility "stackable" (see section 17.4.8.2 for additional description). The locations were identified in the Knight Piésold study (Appendix 17.4-A) as well as KAM's ongoing assessment of potential TSF locations.

17.4.8.6 Step 2 – Pre-screening (Fatal-flaw) Assessment

The 12 candidates were screened against several "fatal-flaw" criteria; i.e., any factor that would eliminate a candidate from further consideration (Table 17.4-12). The following fatal-flaw criteria were used: topographical constraints, technical feasibility, sufficient capacity for life-of-mine tailings, and environmental/social acceptability. Any candidates that did not meet all of these criteria were excluded from further consideration in the assessment. Quantitative metrics were not used at this level of assessment, but general criteria are described below.

Topographical Constraints

Locations with good topography are those that provide natural containment support, and do not possess structural constraints such as steep hillsides or large outcroppings. Natural topographic containment reduces the required size of embankments; thus topographic constraints are more critical for pumpable technologies than for dry-stack. Flat-lying topography does not provide sufficient containment; while steep hillsides result in higher embankments, which also bear risks. Steep hillsides or large outcroppings should be avoided as they could pose challenging for foundation conditions of both pumpable and stackable systems.

Storage

A single site is preferred to store all tailings from the Project. Depending on the physical arrangement (e.g., natural topography, embankment layout, or stacking height), somewhere between 4 ha and 8 ha of contiguous land is required for a site to be able to viably provide the required capacity. It would be necessary for KAM to reasonably be able secure the rights to the land (e.g., private or Crown) in order to construct a TSF.

Figure 17.4-3

Initial Tailings Management Facility Locations Identified for the Ajax Project

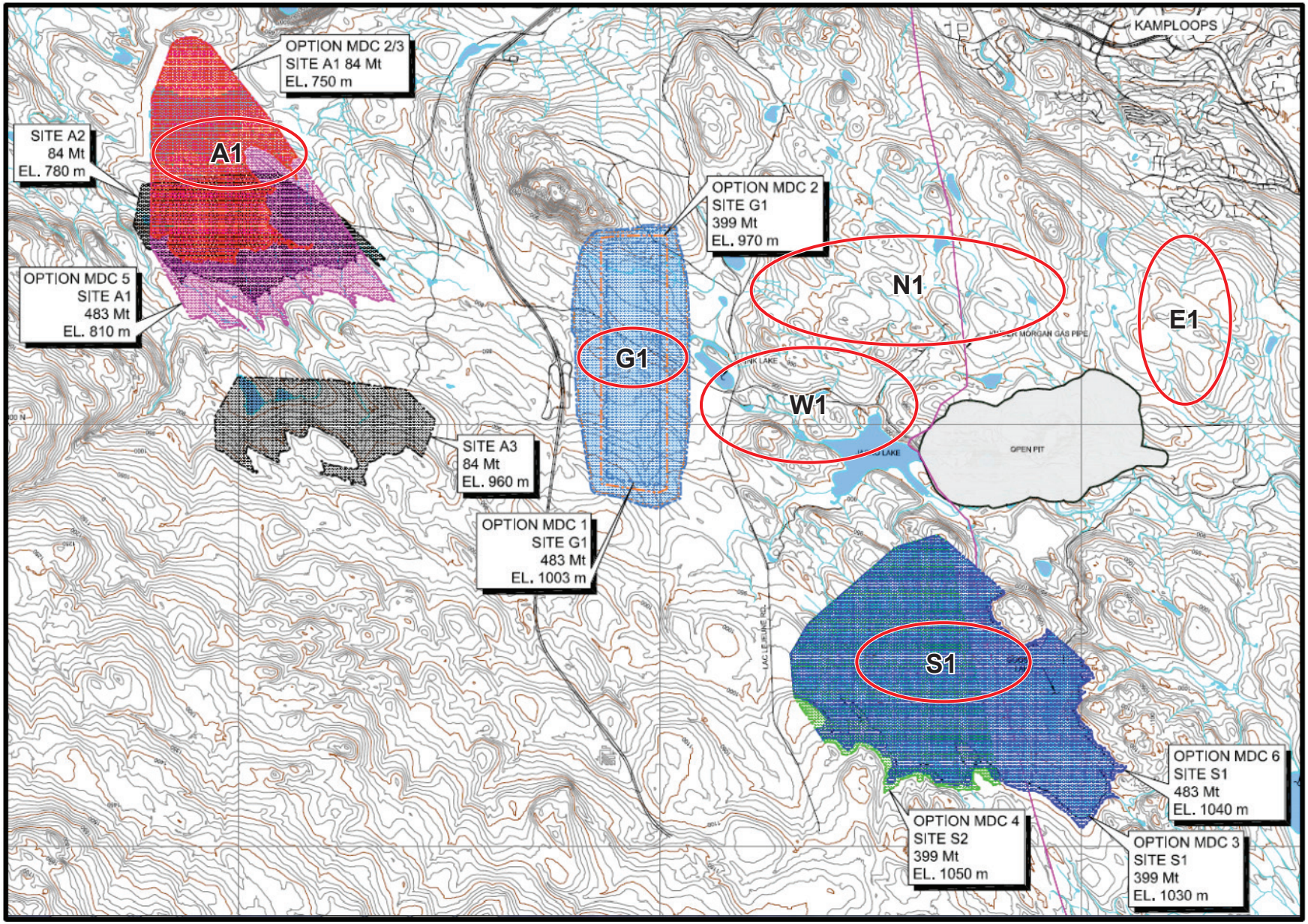


Table 17.4-12. Results of Pre-screening Assessment

Option	Site Location	Tailings Technology [1,2]	Topographically Supported[3]	Sufficient Potential Capacity	Technically Feasible	Environmental/Social Acceptability	EVALUATE FURTHER
A1	Old Afton TSF	Pumpable	✓	✓[4]	✓	✓	✓[4]
		Stackable	✓	×	×	✓	×
G1	Directly East of Coquihalla Highway	Pumpable	×	✓	✓	✓	×
		Stackable	✓	✓	✓	✓	✓
N1	North of Open Pit	Pumpable	×	✓	✓	×	×
		Stackable	✓	✓	✓	×	×
S1	South of Open Pit	Pumpable	✓	✓	✓	✓	✓
		Stackable	✓	✓	✓	✓	✓
E1	East of Open Pit	Pumpable	✓	×	✓	×	×
		Stackable	✓	×	✓	×	×
W1	West of Open Pit	Pumpable	✓	×	✓	×	×
		Stackable	✓	×	✓	×	×

Notes:
[1] "Pumpable" refers to tailings technology which requires an engineered containment structure and applies to conventional slurry, thickened tailings, and paste tailings
[2] "Stackable" has minimal containment requirements
[3] Topographically supported locations have natural containment support, and do not possess structural constraints such as steep hillsides or large out croppings
[4] The Old Afton TSF would require expansion or use of an additional location to provide sufficient potential capacity for tailings produced during the life of the project

Technical Feasibility

For the purposes of this fatal-flaw assessment, technical feasibility is related to conditions not captured by topographic constraints or storage capacity. This could include, for example, quality of foundation conditions, ability to pump/convey tailings to the site, distance required to transport material to construct the embankments, ability to work around existing infrastructure, or consequence of failure.

Environmental/Social Acceptability

KAM recognizes the challenges the Project faces due to proximity to Kamloops and other local residences. Fatal flaws for environmental/social acceptability are related to such things as: direct

impact to existing residences/infrastructure; ability to contain or manage seepages; and likelihood of successful reclamation/closure.

Site A1 – Old Afton TSF

The Old Afton TSF is located between Highway 5 and Highway 1, approximately 12 km to the south west of the City of Kamloops and 9 km west of the Ajax Project. The Old Afton TSF construction began in 1976, and since 1997 has been under care and maintenance. This facility has historically contained a large ponded area, but recently efforts have been made to reduce the amount of water in the facility.

Use of the Old Afton TSF to impound pumpable tailings (A1) was considered topographically supported because the construction of the existing facility utilized the surrounding topography to support the design. Although in order to meet the capacity requirements for the life of the project, the existing facility would require expansion or construction of an entirely separate facility. Utilizing A1 for pumpable tailings met the criteria for environmental/social acceptability as it would limit the TSF to an existing footprint for approximately 4 years before exceeding existing capacity. Although an expansion or additional facility would be required, the option was still considered technically feasible, and therefore carried forward for further evaluation.

The option of locating a stackable facility on the Old Afton TSF was deemed technically not-feasible as, from the perspective of geotechnical foundation conditions; it would be impractical to construct a stackable storage facility on the footprint of a conventional TSF impoundment.

Site G1 – East of Coquihalla

Site G1, located directly East of the Coquihalla Highway, is an area with little natural containment provided by the topography. As the lack of topographic support would require extensive dam construction to provide sufficient containment for pumped tailings, this location was considered not feasible for these forms of tailings.

This location is technically feasible for a stackable facility, and contains sufficient potential capacity for the Project as well as no topographic constraints for a stackable facility. As such, stackable at site G1 was carried forward for further evaluation.

Site N1 – North of the Open Pit

Areas to the North of the Open Pit have topographic constraints which limit opportunities for tailings storage and make these areas not-feasible from a technical perspective (i.e. the topography is such that an unacceptably large areal footprint or very high dyke structures would be required to store/impound the required volumes of tailings). While a dry-stack option may be potentially feasible, proximity to area residents was also a key factor that ruled-out consideration of TSF development in this area.

Site S1 – South of the Open Pit

The area South of the Open Pit was identified as having good topographic layout (natural containment partially provided by topography) and sufficient footprint area to support either a pumpable or a dry-stack facility. No environmental or social fatal flaws were identified for this site. This location was carried forward for further evaluation.

Site E1 – East of the Open Pit

Areas to East of the Open Pit were considered, but do not provide the sufficient capacity to contain tailings for the life of the Project. Additionally, proximity to the Peterson Creek Aquifer and the community of Knutsford were Environmental and Social constraints that contributed to the "fatal flaw" result of this location.

Site W1 – West of the Open Pit

The area to the West of the Open Pit does not contain sufficient potential storage capacity and would result in the complete loss of Jacko and Inks Lake which would be unacceptable to local stakeholders.

Results of "fatal-flaw" assessment

Four (4) of the alternatives passed the fatal-flaw assessment and were carried forward for screening assessment (Step 3) :

- A1 (Pumpable) - Old Afton TSF;
- G1 (Stackable) - Directly East of Coquihialla Highway;
- S1 (Pumpable) – South of the Open Pit; and
- S1 (Stackable) – South of the Open Pit.

17.4.8.7 Step 3 - Screening Assessment

To determine the best alternative of the four for the project, technical characteristics and proponent costs are characterized (Table 17.4-13).

Table 17.4-13. Technical and Financial Characteristics

TSF Site	A1 (pumpable)	G1 (Stackable)	S1 (pumpable)	S1 (Stackable)
Impoundment storage volume (Mm^3)	322	302	322	250
Dam crest elevation (masl)	810	1003	1040	986.5
Dam height (m)	110	183	110	112
Embankment volume (Mm^3)	35	31	60	n/a
Storage efficiency (impoundment volume / embankment volume	9.2	9.7	5.4	n/a
Impoundment footprint (km^2)	5.9	3.9	7.5	4.3

TSF Site	A1 (pumpable)	G1 (Stackable)	S1 (pumpable)	S1 (Stackable)
Distance from plant to TSF (km)	9	5	5	5
Water Catchment area (km²)	58	14	13	13
Capex ($M)	60	107	42	442
OPEX ($M)	332	333	179	430

Note: OPEX for Site G1 (Golder, 2011) has been doubled to account for volume of waste rock to address seismic stability issue. Site S1(Stackable) characteristics from Norwest / M3 Tailings Dry Stack Study (Appendix 17.4-B))

A ranking matrix was developed to allow for numerical ranking of technical (including constructability), environmental, social and proponent economic criteria. The ranking was based on subjective assessment of the relative impacts on a scale of one (1) to five (5) with five best (Table 17.4-14). In a manner similar to the other alternatives assessments described in this chapter, the criteria were further categorized as "challenging" (rank 1, 2); "acceptable" (rank 3, 4); and "preferred" (rank 5).

Ranking Criteria

The ranking matrix outlined in Table 17.4-14 utilized both quantitative and qualitative criteria. Quantitative criteria included items such as TSF height and pipeline length, while qualitative criteria included such items as seasonal constraints and access requirements. Some of the qualitative criteria warrant additional explanation, which is included below.

Terrain Hazard

Terrain hazards refer to the potential of natural hazards to affect the Facility including risk of a seismic event, snow avalanche and hazards associated with karst occurrences. Section 6.2 provides further discussion of terrain hazards around the Project.

ML/ARD Sensitivity

ML/ARD sensitivity refers to the potential for the tailings material to result in metal leaching or acid rock drainage. As discussed in Appendix 3-A, the tailings produced at the Ajax Project are predicted to be non-potentially acid generating (NPAG). Use of water as a cover for ML/ARD management during Operation or Post-Closure is not required or planned.

Access Requirements

Locations in closest proximity to the Project require the least amount of infrastructure to achieve necessary access to the TSF. The complexity of accessibility increases with distance of a facility from the Project site.

Seasonal Constraints

Seasonal constraints are applicable to the construction of the TSF at all locations for foundation preparation. From an operational perspective, changes in temperature are more detrimental to a stackable facility. Freezing conditions can result in depositional issues on a stackable facility, which are not as problematic for conventional facilities. Appendix 17.4- B includes additional discussion on seasonal constraints for the various TSF technologies.

Logistical Complexity

Logistical complexity includes factors such as use of more than one facility to store the waste; and the amount and complexity of the equipment/infrastructure requirements to transport and deposit tailings and reclaim water.

Location of TSF

The location of the TSF refers to the current land-use / land potential of the site and whether it is within a previously disturbed area or not.

Downstream Environmental Sensitivity

Sensitivity of the downstream environment refers to the sensitivity of the environment downstream of the site in relation to habitat type/quality, existing water use, or other environmental values.

Permitting Implications

Permitting implications refer to the perceived level of difficulty and the likelihood of achieving timely approvals for a facility at the proposed site. Permitting complexities can result from interaction with transportation corridors, service (pipeline corridors), easements, rights-of-way and multiple other potential considerations.

Property ownership

Property ownership refers to whether there are anticipated constraints or challenges associated with KAM acquiring ownership of the proposed site. Note: this rating is outdated for S1 since KAM has acquired ownership of the property at S1. This would increase the "total rating" for S1.

Table 17.4-14. Ranking Matrix for Technical, Cost, Natural and Human Environment Criteria

Alternative Locations	A1 (pumpable)	G1 (stackable)	S1 (pumpable)	S1 (stackable)
Technical and Cost Criteria				
TSF height	3	1	3	3
TSF storage efficiency	3	2	4	2
Expansion potential	2	1	4	4
Pipeline length	2	4	4	4 (conveyor)
Geotechnical risk	3	1	5	5
Water management complexity	3	3	4	4
Terrain hazard index	4	4	4	4
ML/ARD sensitivity	4	4	5	5
Access requirements	2	3	4	4
Seasonal constraints	3	2	3	2
Ease of temporary diversions	3	3	3	3
Logistical complexity	1	3	4	2

Alternative Locations	A1 (pumpable)	G1 (stackable)	S1 (pumpable)	S1 (stackable)
Initial CAPEX	4	2	5	1
Sustaining CAPEX and OPEX	4	3	5	1
Net Present Value (NPV)	4	2	5	1
Natural Environment Criteria				
Location of TSF	5	3	2	2
Downstream environmental sensitivity	3	1	4	4
Post closure reliability	3	3	3	3
Human Environment Criteria				
Permitting implications	2	3	2	2
Proximity to residents / visibility	4	1	3	3
Property ownership	3	4	2	2
Aboriginal interests	3	2	2	2
Total Rating	**68**	**55**	**80**	**61**
Ranking	**2**	**4**	**1**	**3**

Source of ratings: (Knight Piesold 2013)
Green (5) = preferred; Yellow (3, 4) = acceptable; Orange (1,2) = challenging

Alternative A1 (Conventional (impounded) tailings)

Site A1 is the existing Old Afton TSF. The existing facility has the capacity for approximately 56 Mm^3 of additional tailings. This would be volume would be produced by the Project in approximately 4 years, after which an alternate facility location would be required.

In order to utilize Site A1, tailings delivery pipelines, as well as process reclaim water from the TSF to the plant, would require large flow pumps and pipelines. These pipelines would be approximately 9 km in length.

For technical and proponent cost criteria, Site A1 is "challenging" (rating 1 and 2) for the criteria of pipeline length; expansion potential; access requirements and logistical complexity. The pipeline length, access requirements and logistical complexity are primarily a function of the distance of the facility from the Project. As the distance from the Project to the TSF location increases, so does the potential for additional land owners, infrastructure, natural barriers, or other added interactions and constraints.

The alternative is considered "acceptable" (rating 3 and 4) for all other technical and proponent cost criteria. This alternative was ranked "acceptable" from a cost perspective, as the sustaining capital and operational expenditures were less than all other options with the exception of S1 (pumpable). The cost estimates for this alternative are described in more detail in Appendix 17.4-A.

Downstream consequences in the event of a TSF failure would be associated with agricultural lands along Cherry Creek, and extending to Kamloops Lake. This is consistent with risks associated with the existing Afton TSF (Knight Piesold, 2014). For natural environment criteria, the location is

considered "preferable" as it utilizes an existing facility. This is seen as beneficial in terms of reducing potential new effects to terrestrial and wildlife habitats. However, if only used in the early years of the Project life, it would mean that two TSF sites are developed, potentially in different catchments, which has negative environmental consequences.

Site A1 has a total upstream catchment area greater than 50 km^2 which is significantly larger than the catchments associated with Sites G1 and S1 (14 km^2 and 13 km^2, respectively). Although detailed run-off modeling would be required to provide volumetric estimates of run-off for each location, it is expected that larger run-off volumes would be associated with this significantly larger catchment. Therefore, diversion structures with greater capacity and/or additional tailings impoundment freeboard and storage capacity would be required for TSF structures at Site A1. It is important to note that with installation of appropriate diversion structures, all three TSF site alternatives can be operated under a negative water balance due to the semi-arid nature of the region.

From a human environment perspective, Site A1 would be located in an area that is already disturbed. This would be expected to reduce, but not remove, potential effects associated with visual quality, and concerns driven by proximity to surrounding communities (e.g., related to dust, noise and health). It would also limit the potential for disturbance to heritage resources.

As with all evaluated locations, Site A1 lies within the SSN traditional territory. SSN have expressed safety concerns with re-opening the Old Afton TSF facility due to its proximity to the New Gold New Afton Project as well as potential dust concerns during operations and closure of the TSF. Additionally this alternative would have potential effects to the Alkali Creek watershed (including Cheery Creek) which has been identified as an important water body by Aboriginal Groups. Site A1 was given a "challenging" ranking for Aboriginal interests.

The option is rated "acceptable" for most of the natural and human environment criteria and overall is "preferred" based on the highest rating for all natural and human environment criteria.

Overall alternative A1 (conventional (impounded) tailings) is considered "Acceptable".

Alternative G1 (Stackable tailings)

Alternative G1 (Stackable tailings) is located between the Lac Le Jeune and Coquihalla highways, about 3.5km west of the Project site. During earlier stages of the Project, this location had been identified as potentially viable for the construction and operation of a modified paste/dry stack tailings storage facility (Golder, 2011). This facility would require transport of tailings to a thickening plant near the G1 location at which point the tailings would be thickened and deposited in a modified paste/dry stack approach. The height of the stack would be approximately 183m.

Among all alternatives, alternative G1 (stackable tailings) scored lowest on the technical criteria. The three primary factors for low technical ranking were: height, geotechnical risk, and expansion criteria. The height of this facility was a concern to stakeholders due to the close proximity to the Coquihalla highway as the stack height would be approximately 183m and clearly visible from the highway. Due to the unproven nature of constructing a stackable facility at unproven rates, and the potential consequence if a failure were to occur directly next to the Coquihalla highway, geotechnical risk was also ranked "challenging" for alternative G1. Additionally expansion potential

was limited in this location if capacity requirements ever needed to expand. For these reasons this alternative was rendered "challenging" from a technical perspective.

Alternative G1 had the highest sustaining capital and operating costs among all of the alternatives and was therefore considered "challenging" from a cost perspective.

From a natural and human environment perspective, proximity to residential areas and downstream environmental sensitivity are considered "challenging". Social concerns were expressed in relation to the proximity of the TSF to the Coquihalla Highway, and how it would become a prominent visual feature for visitors coming to Kamloops. Dust management and linkages to health were also strongly expressed in community consultations; however, it was recognized that active dust management will be required at all sites, and available mitigation methods are industry standard and effective. Water management for this alternative was ranked slightly lower than alternative S1 (dry-stack), as the watershed catchment area is slightly larger at this location.

Alternative G1 is within the SSN traditional territory. Concerns raised with this alternative by the SSN were primarily related to dust from a stackable facility. Additionally there were concerns with the loss of Inks Lake, which is considered a prominent hunting area by the SSN, and the potential for impacts to Alkali Creek Watershed (including Cherry Creek). These concerns resulted in a "challenging" ranking for Aboriginal interests.

Overall, alternative G1 (stackable tailings) is considered "Challenging".

Alternative S1 (pumpable)

Alternative S1 (pumpable) is located approximately 1 km to the southwest of the plant site, within an area bounded by natural topography. A tailings pipeline is required to transport tailings from the plant site to the TSF location. Construction of up to four embankments is required in order to contain the tailings within the impoundment.

Location S1 was considered the best option for geotechnical risk compared to the other alternatives. Downstream consequence in the event of a TSF failure leading to loss of tailings would be associated with agricultural lands along Peterson Creek, and runout could extend to the city of Kamloops before reaching Kamloops Lake. The close proximity of the TSF to the open pit provides a short haul distance for mine rock, and therefore more opportunity and flexibility for KAM to use mine rock buttressing as a highly effective means of reducing geotechnical risk (see further discussion in Section 17.6, and Appendix 17.6-B). Although buttressing of the TSF is conceptually possible at other locations, provision of the volumes of rock/fill required would be uneconomic either due to the haul distances from the Ajax pit or the costs of mining and placing locally sourced fill (excluding considerations of additional disturbance for provision of the buttress fill at the more distance sites). The placement of the buttress provides for a significant level of risk reduction to the facility in terms of potential breach events, both during Operations and Post-Closure, as noted in Appendix 3-D and Appendix 17.6-B. The integration of the tailings embankment with the MRSF structures, as well as the topographic containment of the tailings basin means that Alternative S1 provides the highest level of stability for the contained tailings long-term.

KAM completed a separate conceptual TSF closure alternatives assessment (as outlined in the CDA Guidelines) to evaluate the BAT for closure of the tailings facility at the Ajax Project (Appendix 17.4-C). The study included climatic considerations, design criteria, trade-off advantages and disadvantages, Rough Order of Magnitude (ROM) quantities, and associated costs for wet and dry closure options. As described in more detail in Section 17.4.10, the results from that study identified that the best alternative for the Ajax Project was a dry closure cover given climate and siting of the facility. Based on the proximity of the proposed MRSF locations, which will be used as a source of material for the dry cover, the Alternative S1 is the closest of any of the locations considered and is therefore the most economically viable from a closure perspective.

All other technical criteria were rated "acceptable". Alternative S1 were considered the overall "preferred" option for technical and economic criteria (Table 17.4-14). The ML/ARD sensitivity for alternatives at S1 was ranked more favourable than the other locations as S1 is closer to the open pit which will allow for non-acid generating material to be more easily transported to the TSF for construction of embankments.

"Challenging" natural and human environment criteria include the TSF location (i.e. in previously undisturbed area), property ownership and permitting implications. However, the adverse effects of these criteria could be mitigated through land reclamation, agreements with landowners and habitat offsetting.

From an environmental perspective, Alternative S1 would bring all major site infrastructure into a single watershed (Peterson Creek). A more compact site footprint allows for simpler water management and opportunities to more effectively collect and re-use water. From a long-term closure perspective, it maximizes the benefit of the open pit, which will be a long-term sink for groundwater seepage from the TSF (see Section 6.6).

From a human environment perspective, the TSF at S1 would be less visible to the general public than at Alternative G1, but it would be clearly visible to recreational users at places such as Jacko Lake and Coal Hill.

Heritage investigations have identified archaeological/heritage sites within the Project footprint but not directly related to the TSF location. KAM is working to develop appropriate mitigation measures (see Chapter 9).

As with all other options, Alternative S1 lies within the SSN traditional territory. With alternatives A1 and G1, multiple watersheds would be affected by the Project, which was a concern for SSN particularly with regards to Cherry Creek. By locating the TSF at the S1 site, all of the Project components are within a single watershed; however, this potentially concentrates effects closer to Jacko Lake and Peterson Creek.

Peterson Creek and Jacko Lake have been identified by Aboriginal groups as significant for hunting, fishing, plant gathering, and spiritual and ceremonial use. Alternate S1 has the potential to impact water quality in Peterson Creek and Jacko Lake, primarily through dust deposition. One benefit of the Peterson Creek diversion is that the portion of Peterson Creek which would be most susceptible

to dustfall from the TSF, will be diverted around the Project infrastructure until the Project closure phase.

Additionally, Goose Lake has been noted as an area of cultural importance to Aboriginal groups, primarily for hunting purposes. Alternative S1 (pumpable) would entirely encapsulate Goose Lake. In an effort to mitigate this, KAM is proposing improvements to other lakes in the area including Jacko Lake and Inks Lake. For these reasons alternate S1 has been considered "challenging" for Aboriginal interests.

Overall, alternative S1 (pumpable) is considered "Preferred"

Alternative S1 (stackable)

Alternative S1 (stackable) would utilize a filtration system to reduce the moisture content of the tailings to a point where it can be deposited using a stacker material handling system. Alternative S1 (stackable) would be located in the same area as alternative S1 (un-thickened).

A filtered stackable tailings facility at S1 was the subject of a feasibility level engineering trade-off study by Norwest and M3 (Appendix 17.4-B). Since the location is the same as S1 (pumpable), the technical rankings are similar to S1 (pumpable) (Table 17.4-14).

Water management is more complex for S1 (stackable) compared to S1 (pumpable) as it requires development of underdrains and a water storage facility to manage runoff from the facility. Goose Lake would need to be developed as a water pond with two dams to store up to 3Mm^3. The two dams will be earth fill construction, lined with a geosynthetic layer on the upstream face to prevent seepage through the structures. The pond would be reclaimed as wildlife habitat post-closure.

Operation of a filtered stackable facility is logistically complex involving operation of a filtration plant, conveyor system or fleet of trucks to transport the tailings and equipment to spread and compact; therefore ranked as "challenging".

Both CAPEX and sustaining CAPEX and OPEX are very high for S1 (stackable) and therefore rated as "challenging". For S1 (pumpable) costs are considerably less and therefore rated "preferred" (Table 17.4-14).

The natural environment criteria are considered "acceptable" for alternatives S1 (stackable) and S1 (pumpable) based on the criteria in Table 17.4-14. For both alternatives the human environment criteria are considered "challenging" because of proximity to residential areas, concerns around visibility and dust generation as well as loss of areas important to Aboriginal groups. Despite the human environment challenges for S1 (pumpable), it is overall most favourable based on "preferred" technical and life cycle cost performance and "acceptable" environmental performance. The overall rating for S1 (filtered stackable) is "challenging" however, it has been carried forward for assessment in Step 4 because it is considered to meet the principles for BAT identified in the Panel Report (IEEIRP, 2015); i.e., eliminate surface water from the impoundment; promote unsaturated conditions in the tailings with drainage provisions, and achieve dilatant conditions throughout the tailings deposit by compaction.

Concerns from SSN are similar to alternative S1 (pumpable) and include impacts to Peterson Creek, Jacko Lake, and Goose Lake. Although Goose Lake will be impacted by alternative S1 (stackable) there is a potential for reclamation of the lake during the closure phase, and it is not entirely encapsulated with tailings as with the un-thickened option. Due to the proximity to Jacko Lake and Peterson Creek, as well as dust concerns raised from the SSN for a stackable facility, this option is still considered "challenging" for Aboriginal interests.

Overall alternative S1 (stackable) is considered "Challenging".

Results of Screening

A comparative ranking of the four candidates is provided in Table 17.4-15. Alternative S1 (pumpable) is the overall "preferred" alternative based on storage efficiency (footprint versus volume stored); lowest geotechnical risk; simplicity for water management; least downstream environmental sensitivity; and the best economics compared to the other alternatives.

While Alternative S1 (stackable) was considered "challenging", it has physical stability benefits as described in the Panel Report (IEEIRP, 2015) and therefore both technologies for S1 were carried through to Step 4 for further detailed assessment.

Alternative A1 (pumpable) rates favourably for natural environment and human environment acceptability because it utilizes an existing TSF, however there are safety concerns because of proximity to the New Gold New Afton Project. In addition there are technical constraints because of the large distance from the plant. One of the more substantial downfalls to Alternative A1 is that the existing TSF's limited capacity would require the construction of a second facility, resulting in impacts at an additional location. These factors make Alternative A1 (pumpable) more challenging than the S1 location.

Table 17.4-15. Screening Assessment

Performance Objective	A1 - pumpable	G1 – Stackable	S1 - pumpable	S1- Stackable
Technical Feasibility	Large distance from plant with limited expansion potential. Comparatively difficult access and logistical complexity	High TSF height, low storage efficiency, lack of expansion potential, geotechnical risk and water management complexity, seasonal construction rates	Best location for geotechnical risk, water management, ML/ARD sensitivity; access and logistical complexity	Best location for geotechnical risk, water management, ML/ARD sensitivity; access and logistical complexity
	Challenging	Challenging	Preferred	Challenging

Performance Objective	A1 - pumpable	G1 – Stackable	S1 - pumpable	S1- Stackable
Life cycle costs	Low CAPEX $60M and high OPEX ($332M)	Moderate CAPEX $107M and high OPEX $333M	Low CAPEX $42M and moderate OPEX $179M	Very high CAPEX $442M and very high OPEX - $430M
	Acceptable	Challenging	Preferred	Challenging
Water balance + Water management	Largest upstream catchment requiring larger diversion structures or increased holding capacity in TSF impoundment. Limited capacity within historic impoundment.	Thickener reduces water losses, and thus water demand from Kamloops Lake. In very close proximity to Coquihalla Highway. Small upstream catchment limits need for water management structures.	High dam required to contain upstream run-off plus supernatant pond. Smallest upstream catchment of options considered minimizes requirements for water management.	Underdrains and external pond required for run-off and makeup water storage but could be developed by expansion of Goose Lake with moderate sized dams. Thickener reduces water losses, and thus water demand from Kamloops Lake. Smaller footprint would allow for greater diversion of non-contact water around facility. Water management of run-off from stack slopes could be challenging due to fine grained nature of tailings leading to high erosion; frequent ditch and channel maintenance required.
	Acceptable	Acceptable	Acceptable	Preferred
Natural Environment Acceptability	Use of existing facility (Afton TSF) has beneficial effects for wildlife habitat. Best rating for environmental criteria	Smallest impoundment footprint. Downstream environmental sensitivities but can be mitigated with standard methods	Least downstream sensitivity. TSF located in undisturbed area but reclamation will return to pre-existing land use. Limits Project footprint to single watershed	Least downstream sensitivity. TSF located in undisturbed area but reclamation will return to pre-existing land use. Limits Project footprint to single watershed
	Preferred	Acceptable	Acceptable	Acceptable

Performance Objective	A1 - pumpable	G1 – Stackable	S1 - pumpable	S1- Stackable
Human Environment Acceptability	Use of existing facility (Afton TSF) limits potential to disturbance of heritage resources. Visible to surrounding communities and potential issues related to dust, noise and health.	Concerns expressed by community on proximity to residential areas. Highly visible due to facility height and close to Highway. Potential dust issues and health	Location within ALR and visibility concerns. Heritage values associated with St. Peter's church. Aboriginal concerns for loss of Goose Lake. Property ownership and permitting implications mitigated by purchase of land owner agreements and habitat offsetting.	Location within ALR and visibility concerns. Heritage values associated with St. Peter's church. Aboriginal concerns for loss of Goose Lake but will be reclaimed post-closure Property ownership and permitting implications mitigated by purchase of land owner agreements and habitat offsetting.
	Acceptable	Challenging	Challenging	Challenging
Aboriginal Interests	SSN have expressed safety concerns with re-opening the Old Afton TSF facility due to its proximity to the New Gold New Afton Project as well as potential dust concerns during operations and closure of the TSF. Potential effects to the Alkali Creek watershed (including Cheery Creek).	SSN have expressed concerns related to dust from a stackable facility. Loss of Inks Lake, which is considered a prominent hunting area by the SSN, and the potential for impacts to Alkali Creek Watershed (including Cherry Creek).	SSN have expressed concerns related to Peterson Creek and Jacko Lake, which have been identified as important for hunting, fishing, plant gathering, and spiritual and ceremonial use. Goose Lake has been noted as an area of cultural importance, and it would be completely encapsulated by the TSF. Improvements to other areas may be required to offset loss.	SSN have expressed concerns related to Peterson Creek and Jacko Lake, which have been identified as important for hunting, fishing, plant gathering, and spiritual and ceremonial use. Goose Lake would be effected, but not completely lost, with potential for reclamation. Potential concerns related to dust from a stackable facility.
	Challenging	Challenging	Challenging	Challenging
Overall Rating	Acceptable	Challenging	Preferred	Challenging

Step 4 – Assessment of Tailings Storage Facility Management Technology AlternativesBased on the direction provided to KAM from the BC EAO on March 19, 2015, KAM commissioned Norwest and M3 to further evaluate and confirm the most appropriate TSF location and technology alternative by undertaking a feasibility level engineering trade-off study. This study included a review and endorsement of the location for the TSF and considered in more detail the following tailings management technologies at site S1 (Appendix 17.4-B):

- Un-thickened (conventional) tailings (unbuttressed)
- Un-thickened tailings (buttressed)
- Thickened tailings (buttressed)
- Paste tailings (buttressed) and
- Filtered dry stack tailings (buttressed).

The range of tailings management technologies evaluated represents a continuum of tailings water content, with highest water content for un-thickened tailings, and lowest water content for dry-stack tailings. There is a key geotechnical threshold that occurs between paste and dry-stack tailings. Paste tailings are pumpable (liquefiable) and therefore require an engineered embankment, whereas dry-stack tailings are not pumpable, and therefore can be self-supporting (e.g., do not require an embankment for containment) if a sufficiently low moisture content and suitable density is achieved during placement. As such, the TSF layout for un-thickened, thickened and paste tailings would be quite similar, while the layout for a dry-stack could be very different.

The progression of evaluation and technical planning that resulted in the decision for BAT for the Project is consistent with the intent of the recommendations of the Independent Expert Engineering Investigation and Review Panel on the Mount Polley failure. The Panel identified the need for mine developers to consider a full range of technologies and placement options for management of tailings in order to develop BAT and storage option for their specific site. Filtered tailings were singled out by the panel for recommendation as one of the BAT options that should be considered going forward.

A preliminary TSF design was completed for the un-thickened slurry tailings option and forms the basis for the trade-off comparison. Norwest and M3 worked from the preliminary un-thickened design to develop the trade-off for thickened and paste designs. They also developed a separate conceptual level engineering and design of the filtered dry stack tailings management system, including geotechnical design, water management and reclamation considerations.

Details of the trade-off study and layouts of the alternatives are provided as Figures 5.1 through 5.4 in Appendix 17.4-B. A summary of the results of the trade-off study are outlined below. The trade-off study assessed technical, environmental, social, economic and project risk. Criteria were chosen by the TSF design engineers with a group of KAM technical experts with knowledge in tailings management, environment, mine planning, ore processing, and geotechnical engineering. The criteria in table 17.4-16 were chosen by KAM and their TSF engineers as applicable measureable criteria. Evaluation criteria in Table 17.4-17 were based on feedback received from project stake holders, and an understanding of which valued components would potentially be impacted by the tailings technology used. The table indicates the assessment pillar, the VC and factor used to assess the alternatives. Only those VCs that were considered differentiating (i.e. an effect on the VC that distinctly differentiates one alternative from the other) between the tailings technologies were carried forward for assessment. The tailings technologies were rated from most to least favourable (Table 17.4-16 and 17.4-17).

Table 17.4-16. Assessment of Technical, Proponent Cost and Project Risks Criteria

Tailings Disposal Method[2]	Dewatering of Tailings[3]	Tailings Depsition[4]	Water Balance / Management	Physical Stability	Process Makeup Water (m^3/h)	Disturbed Surface Area (ha)		Risk of Breach Failure[5]	CAPEX	OPEX	Proven Technology at 65,000 tonnes/day	Regulatory Concern
						Tailings Surface Area (ha)	Total					
Conventional Unthickened (32% solids) Unbuttressed Facility	Most favourable	Most favourable	Least Favourable	Least Favourable	1,087	589 Beach 326 Pond 263	700	Least Favourable	$223 M	$123 M	Most Favourable	Less Favourable
Conventional Unthickened (32% solids) Buttressed Facility[6]	Most favourable	Most favourable	Least Favourable	Less Favourable	1,087	589 Beach 326 Pond 263	700	Less Favourable	$223 M	$123 M	Most Favourable	Less Favourable
Thickened (60% solids) Buttressed Facility [6]	More favourable	More favourable	More Favourable	More Favourable	764	550 Beach-450 Pond-100	690	More Favourable	$226 M [7]	$132 M [7]	Most Favourable	More Favourable
Paste (75% solids) Buttressed Facility [6]	Less favourable	Less favourable	More Favourable	More Favourable	730	461 Beach-411 Pond-50	603	More Favourable	Expected to be higher than thickened	Expected to be higher than thickened	Least Favourable	Least Favourable
Dry Stack (85% solids) Buttressed Facility [6]	Least favourable	Least favourable	Most Favourable	More Favourable	400	362	429	Most Favourable	$442 M	$430 M	Least Favourable	Most Favourable

Notes:

[1] Qualitative ranking in order of preferred option is: Most Favourable(green) -> More Favourable (blue) -> Less Favourable(yellow) -> Least Favourable (red)

[2] Percent solids are by weight.

[3] Relates to amount of dewatering required and potential issues that could occur during process.

[4] Relates to the ability and level of effort required to achieve design configuration (i.e., design slope for thickened or paste options).

[5] Downstream consequences related to mobility of the tailings flow if containment is lost.

[6] Assumes mine rock used for buttress and is primarily a mining cost

[7] Thickened costs are based on a rough order estimate relative to the conventional un-thickened tailings option.

Table 17.4-17. Assessment of Environmental and Human Environment Criteria

Assessment Pillar	Valued Component	Factor	Conventional Unthickened (32% solids) Unbuttressed Facility	Conventional Unthickened (32% solids) Buttressed Facility[7]	Thickened (60% solids) Buttressed Facility [7]	Paste (75% solids) Buttressed Facility [7]	Dry Stack (85% solids) Buttressed Facility [7]	Differentiating
Environment	Vegetation and Terrestrial Ecosystems	Disturbed area (total footprint)	Least favourable – 700 ha total TSF footprint	Least favourable – 700 ha total TSF footprint	Less Favourable – 690 ha total TSF footprint	More Favourable – 603 ha total TSF footprint	Most Favourable – 429 ha total TSF footprint	Yes
Environment	Groundwater quality and quantity	Seepage	Least Favourable – large pond size and low initial tailings density produces more seepage (115 m^3/h). Long term seepage flows are to the Open Pit so not considered a strong differentiator	Least Favourable – large pond size and low initial tailings density produces more seepage (115 m3/h) Long term seepage flows are to the Open Pit so not considered a strong differentiator	Less favourable – smaller pond size and higher density tailings reduces seepage potential (36 m^3/h). Long term seepage flows are to the Open Pit so not considered a strong differentiator	More favourable - smaller footprint and higher density tailings imply less seepage potential (< 36 m^3/h). Long term seepage flows are to the Open Pit so not considered a strong differentiator	Most favourable - smallest footprint and almost no seepage.	Yes
Environment	Grasslands, rare and sensitive ecosystems and wildlife	Reclamation	Less Favourable – most challenging to reclaim because of largest footprint, trafficability and settlement issues	Less Favourable – most challenging to reclaim because of largest footprint, trafficability and settlement issues	More Favourable - thickened tailings potentially improves trafficability on beaches and settlement	Least Favourable – saturated tailings likely to limit trafficability and crust may affect reclamation success	Most Favourable as surface is trafficable and can be progressively reclaimed once the final outer slopes are constructed	Yes
Environment	Wildlife	TSF footprint	Least favourable - largest footprint (700 ha), and thus the largest loss of wildlife habitat.	Least favourable -largest footprint (700 ha), and thus the largest loss of wildlife habitat.	Less Favourable – large footprint (lost habitat); smaller supernatant pond that un-thickened (potential wildlife attractant)	More Favourable – moderate footprint (lost habitat); smaller supernatant pond than un-thickened or thickened.	Most Favourable – smallest footprint (lost habitat)	Yes
Environment	Surface water quantity & groundwater quantity	TSF footprint and makeup water requirement	Least favourable - larger footprint potentially intercepts more surface water and groundwater than smaller footprint and uses most make-up water	Least favourable - larger footprint potentially intercepts more surface water and groundwater than smaller footprint and uses most make-up water	Less favourable - slightly smaller footprint intercepts slightly less surface and groundwater and uses less makeup water	More favourable - slightly smaller footprint intercepts slightly less surface and groundwater and uses less makeup water	Most favourable - smallest footprint has least effect on surface and groundwater flow. Also least make-up water requirement	Yes
Environment	Surface water quality	Capacity to easily collect contact runoff and seepage	Collection of contact runoff and seepage unlikely to result in effects on downstream water quality	Collection of contact runoff and seepage unlikely to result in effects on downstream water quality	Collection of contact runoff and seepage unlikely to result in effects on downstream water quality	Collection of contact runoff and seepage unlikely to result in effects on downstream water quality	Collection of contact runoff and seepage unlikely to result in effects on downstream water quality	No
Social	Visual impact	Facility height and night lighting	Most Favourable – low embankment elevation (1,060 m) and does not require night lighting for tailings placement	Most Favourable – low embankment elevation (1,060 m) and does not require night lighting for tailings placement	Most Favourable – low embankment elevation (1,056 m) and does not require night lighting for tailings placement	Least Favourable – highest (1,095 m) elevation and requires night lighting for tailings placement	Least Favourable – low elevation (1,055 m) but requires night lighting for tailings placement	Yes
Social	Land and resource use	Non-traditional and recreational land-use	Not considered differentiating between the alternatives as the access to the public in the Project area will be controlled regardless of the alternative. Note – alternatives do not affect access to Jacko Lake	Not considered differentiating between the alternatives as the access to the public in the Project area will be controlled regardless of the alternative. Note – alternatives do not affect access to Jacko Lake	Not considered differentiating between the alternatives as the access to the public in the Project area will be controlled regardless of the alternative. Note – alternatives do not affect access to Jacko Lake	Not considered differentiating between the alternatives as the access to the public in the Project area will be controlled regardless of the alternative. Note – alternatives to not affect access to Jacko Lake	Not considered differentiating between the alternatives as the access to the public in the Project area will be controlled regardless of the alternative. Note – alternatives to not affect access to Jacko Lake	No

Assessment Pillar	Valued Component	Factor	Conventional Unthickened (32% solids) Unbuttressed Facility	Conventional Unthickened (32% solids) Buttressed Facility[7]	Thickened (60% solids) Buttressed Facility [7]	Paste (75% solids) Buttressed Facility [7]	Dry Stack (85% solids) Buttressed Facility [7]	Differentiating
Social	Current Use of Lands and Resources for Traditional Purposes	Habitat loss; lack of access and reduced quality of experience in harvesting or for cultural uses.	Effects to Aboriginal interests potentially including: loss of habitat (e.g. fish and animals); lack of access (for hunting, plant harvesting and ceremonial / cultural activities); reduced quality of experience due to noise. Mitigations including offsetting and reclamation to restore habitat for wildlife. Not considered differentiating for the alternatives	Effects to Aboriginal interests potentially including: loss of habitat (e.g. fish and animals); lack of access (for hunting, plant harvesting and ceremonial / cultural activities); reduced quality of experience due to noise. Mitigations including offsetting and reclamation to restore habitat for wildlife. Not considered differentiating for the alternatives	Effects to Aboriginal interests potentially including: loss of habitat (e.g. fish and animals); lack of access (for hunting, plant harvesting and ceremonial / cultural activities); reduced quality of experience due to noise. Mitigations including offsetting and reclamation to restore habitat for wildlife. Not considered differentiating for the alternatives	Effects to Aboriginal interests potentially including: loss of habitat (e.g. fish and animals); lack of access (for hunting, plant harvesting and ceremonial / cultural activities); reduced quality of experience due to noise. Mitigations including offsetting and reclamation to restore habitat for wildlife. Not considered differentiating for the alternatives	Effects to Aboriginal interests potentially including: loss of habitat (e.g. fish and animals); lack of access (for hunting, plant harvesting and ceremonial / cultural activities); reduced quality of experience due to noise. Mitigations including offsetting and reclamation to restore habitat for wildlife. Not considered differentiating for the alternatives	No
Economic	Labour force, employment and training	Economic-employment opportunities	Not considered differentiating for the alternatives	Not considered differentiating for the alternatives	Not considered differentiating for the alternatives	Not considered differentiating for the alternatives	Slightly more employment opportunities for 'dry stack' but not considered significantly differentiating for the alternatives	No
Heritage	Archaeological Sites	Identified archaeological sites	No identified sensitive archaeological sites within TSF footprints	No identified sensitive archaeological sites within TSF footprints	No identified sensitive archaeological sites within TSF footprints	No identified sensitive archaeological sites within TSF footprints	No identified sensitive archaeological sites within TSF footprints	No
Health	Air Quality	Dust Potential	Less Favourable – tailings are segregating but large areas of deposit remain saturated reducing dust potential; however dust generation off beaches similar to dry stack.	Less Favourable – tailings are segregating but large areas of deposit remain saturated reducing dust potential; however dust generation off beaches similar to dry stack.	More Favourable – tailings tend to be non-segregating and will form a crust that minimizes dust potential. Saturated areas reduce areas have less dust potential compared to beaches	Most Favourable – tailings tend to be non-segregating and will form a crust that minimizes dust potential. Most material remains saturated so less dust potential	Least Favourable – place in dry state and with equipment travelling over the material, is expected to generate dust sooner than other alternatives	Yes
Health	Noise and vibration	Equipment noise levels	Considered less noisy than dry stack option because tailings are pumped, but not significantly differentiating	Considered less noisy than dry stack option because tailings are pumped, but not significantly differentiating	Considered less noisy than dry stack option because tailings are pumped, but not significantly differentiating	Considered less noisy than dry stack option because tailings are pumped, but not significantly differentiating	Considered potentially more noisy because of equipment to construct TSF but not significantly differentiating.	No
Health	Human Health	Human Health Risk from air and drinking water quality	Not differentiating for water quality. More dust generated off beaches but with mitigation not expected to differentiate for human health risk between the alternatives	Not differentiating for water quality. More dust generated off beaches but with mitigation not expected to differentiate for human health risk between the alternatives	Not differentiating for water quality. More dust generated off beaches but with mitigation not expected to differentiate for human health risk between the alternatives	Not differentiating for water quality. More dust generated off beaches but with mitigation not expected to differentiate for human health risk between the alternatives	Not differentiating for water quality. More dust generated off beaches but with mitigation not expected to differentiate for human health risk between the alternatives	No

[1] *Qualitative ranking in order of preferred option is: Most Favourable (green) -> More Favourable (blue) -> Less Favourable (orange) -> Least Favourable (red); non-differentiating effects are shown in grey*

Technical Criteria

The alternatives were assessed against a number of technical criteria that focus on operational complexity (e.g., potential issues related to dewatering the tailings) and tailings placement, including transport and placement relating to the ability and level of effort to achieve design configurations (e.g. design slopes); as well as water balance and water management complexity and physical stability related to risk of breach failure.

Dewatering of tailings

The key difference between the various tailings technology alternatives is the water content of the tailings at the time of deposition. In general, the higher the water content in the tailings stream from the plant, the simpler the material is to distribute and deposit. Therefore conventional unthickened tailings are considered most favourable since there is no extra thickening or filtering required. Achieving lower water content in the tailings adds additional components, additives and systems to the processing system; which increases operational complexity and reduces system reliability and availability.

Tailings Deposition (i.e., transport and placement of tailings)

Tailings placement includes both the transport from the treatment facility to the TSF, and the ability to achieve the required design configuration within the TSF footprint. Conventional tailings is considered the most favourable as it is pumped to the TSF and discharged from spigots around the perimeter of the facility. Design configurations are more easily achieved because the range of possible beach deposition slopes is narrow (1-2%). Thickened and paste tailings have lower moisture contents than un-thickened tailings but can still be pumped, although more expensive pumps are required. The higher viscosity of thickened and paste tailings result in steeper beach slopes (2 – 5% for thickened and 3-10% for paste) and maintaining design slopes at full production, particularly for paste tailings, is considered more challenging.

The dry stack (filtered) candidate would involve filtering thickened tailings and using a conveyor to transport the filtered material to the TSF. A benefit of the dry stack is that the design configurations can be more easily achieved as the surface is trafficable for grading slopes and compacting. However, similar to the discussion on solids/water content, the increasing operational complexity when moving from un-thickened tailings technology to filtered tailings transport and placement brings with it issues of high maintenance and less system reliability. The filtered tailings technology is not proven at the planned processing rate of 65,000 tpd (the largest similar process known is operated at 30,000 tpd in Australia) creating a technology risk.

Process Makeup Water Requirement

Reducing the water demand on the Thompson River system is an important consideration for sustainable development, and has been clearly articulated as a value for Aboriginal Groups. From this perspective, filtered tailings are the most favourable option due to the shorter timeframe within which recycle water becomes available. This water is available immediately after filtering (reducing evaporative and seepage losses). The next most favourable options would be paste and thickened, respectively; due to the water recovered from the thickening processes. Un-thickened (conventional) tailings is the least favourable with regards to reducing makeup water requirements because it is

discharged at a high water content and releases its interstitial water slowly over time as consolidation of the tailings occurs. In addition, a higher volume of process water must be stored in the TSF to allow solids to settle and not be pumped back to the process facility, and as contingency in the event freshwater cannot be pumped from Kamloops Lake.

Water Balance and ManagementThere is an overall negative water balance for the Project because of the dry climate of the Kamloops area. An overall negative water balance does not mean that water will not be stored in the TSF but that over the course of a year, more water is required to be supplied to the site than is input from precipitation and snowmelt within the Project footprint. A reliable supply from Kamloops Lake is required to meet Project needs.

Following a precipitation or snow-melt event, additional water will be temporarily stored within the TSF and will be preferentially used within the process plant. This will allow for seasonal reductions in the pumping rate from Kamloops Lake. As an example, an extreme precipitation event (PMF)) would result in the collection of approximately 4 Mm^3 of water within the TSF. The operational water balance indicates that this water volume would be drawn down within 5 to 6 months of normal operations.

The tailings management technologies require different volumes of impounded water stored in the supernatant pond at start-up and during operations in order to provide sufficient recycled process water to the plant in addition to the water pumped from Kamloops Lake. Containment and maintenance of a supernatant pond requires that adequate freeboard be maintained for seasonal and operational variances. Therefore larger supernatant pond sizes result in larger containment facilities, more extensive water management/handling infrastructure, and higher seepage and evaporative losses. Un-thickened tailings require the largest supernatant pond volumes at start-up and during operations (estimated 5 – 7 Mm^3) and are therefore considered least favourable. Thickened and paste tailings are expected to have pond volumes in the range of 2 to 3 Mm^3 and are therefore considered more favourable. The filtered dry stack alternative is considered most favourable as it would not contain a supernatant pond but on-site water storage would be associated with the filtered tailings option with dams being placed around Goose Lake to increase its capacity to approximately 0.75 Mm^3.

Water management requirement around a TSF are influenced by the footprint size (level of surface water management) and the volume of water impounded (level of seepage control required). The level of seepage control would be expected to decrease as the impounded water volume decreased. Therefore un-thickened tailings would be the least favourable and filtered tailings the most favourable at it would require the lowest level of seepage control. The footprint of the un-thickened, thickened, and paste tailings alternatives are similar so they would have similar requirements for surface water management including diversion channels for non-contact water, ditches, sumps, containment dams for contact water and related infrastructure. The dry stack (filtered) tailings facility has the smallest footprint but would still require surface water management structures although there is more potential to divert non-contact water around the dry stack facility.

Physical Stability

The physical stability associated with the containment of each tailings type is affected by a number of factors some of which include:

- configuration/composition of impounding structure;
- volume of fluid and tailings contained;
- foundation conditions beneath the structure's footprint;
- seepage forces and pore pressure conditions within and around the facility; and
- erosion and external factors which could adversely affect the slopes.

Evaluation of factors affecting physical stability results in some overlap with other criteria considered (e.g. water balance, risk of breach) but is a useful criteria in evaluating BAT for the Project. As discussed in other sections, the un-thickened (conventional) tailings options impound the largest volumes of water at start-up and during operations so this is also unfavourable in terms of physical stability.

In terms of overall physical stability, the un-thickened (conventional), unbuttressed option is least favourable as it provides the lowest level of stability in containment due to the smaller physical size (specifically dam width) of the containment structure. This means the embankment is more potentially vulnerable to instability mechanisms including slope failures and high pore pressures leading to piping. The buttressed un-thickened option rates higher in terms of stability as the buttress lowers the risk of slope instability which could lead to loss of contents as well as decrease seepage gradients across the full width of the structure.

The buttressed thickened and paste tailings options would be comparable in terms of physical stability as both have similar external containment configurations and destabilizing factors related to contained water and seepage forces would be comparable. The outer slopes of these structures would be predominantly placed mine rock which is expected to have good resistance to large scale erosion by water or wind.

The dry stack (filtered) tailings structure is different in that only the western portion of the facility has external buttressing with mine rock while the other slopes are built of compacted filtered tailings material. Properly constructed filtered tailings slope would be expected to have good stability but would be sensitive to construction methods and water content of the stacked tailings. Since there is no impounded water within the dry stack, this technology would be favoured in terms of internal seepage forces. Given their fine grained nature, the exposed dry stack slopes would be vulnerable to water or wind erosion until covered by reclamation material but this effect should be limited to relatively small areas.

Risk of Breach Failure

Consideration of the risk of TSF failure has been an important consideration throughout Project design. Consequences of breach failure are related to the mobility of the tailings flow as well as the volume of water stored impounded within the TSF. The higher the water content of the tailings (and more water stored within the TSF), the greater the mobility of the tailings-water mixture and therefore the higher the consequence of a breach failure. Therefore, for the tailings technologies evaluated, the consequences of breach failure from lowest to highest are filtered dry stack (filtered), paste, thickened and un-thickened (conventional) tailings. At a site-specific level, the likelihood (probability) of breach failures can be significantly reduced by design elements such as removal of unsuitable materials (e.g. glacio-lacustrine till deposits) in the embankment footprint during foundation preparation and buttressing the embankments during Operation to increase the factor of safety. All options can be sufficiently buttressed to achieve an acceptable factor of safety that exceeds the guidelines for safe dam design. As described in Section 17.4.10, a "dry cover" closure where there is no final pond on the TSF also reduces the long-term risk (consequence and likelihood) of breach failure Post-Closure; this is possible for all alternatives.

Project Economic Criteria

Overall project economics (lifecycle costs) were evaluated for the various tailings management alternatives. The evaluation included initial and sustaining capital costs, operating and maintenance cost, and reclamation and salvage value (see Section 8 of Appendix 17.4-B). Clean-up costs associated with potential accidents and malfunctions have not been included in the cost estimates. Detailed estimates of capital (CAPEX) and operational (OPEX) expenditures were developed for the conventional unthickened (conventional) buttressed facility and the dry stack buttressed facility. Thickened tailings were evaluated on a relative basis with un-thickened tailings, while paste tailings are expected to be higher than thickened tailings.

On a high level, within the estimation of error, the capital requirement for thickened slurry was slightly lower than un-thickened (conventional) slurry. Although additional thickener capital was considered, smaller piping and pumping requirements compensated for costs in the un-thickened case. The tailings embankments are based on the same design standards. Operational costs are generally similar as well, because additional costs of power and flocculants to operate the thickener are offset by lower energy costs of reduced water pumping requirements.

Paste preparation is more capital intensive than un-thickened and thickened tailings options as the high viscosity of the material requires costly (positive displacement) pumps. Operational costs are affected by the mobility of these equipment sets which require regular moving to evenly distribute the paste. If the material is distributed effectively so it dries out, the capital investment of the tailings impoundment could be reduced as very little water would be released from the paste and therefore it is not treated as a fluid for design considerations.

The capital and operating costs of filtered dry stack tailings systems are substantially more than un-thickened slurry deposition. Filtration and the material handling systems required for dry stack tailings are significantly more expensive in terms of capital investment required and operating costs. Energy requirements for pressure filtration are substantial as multiple pumping and compressor systems are required to produce a dry product. The conveying and stacking systems are subject to

lower mechanical availabilities (i.e. downtime to move, maintain and repair) than the upstream mills and flotation systems of conventional tailings technology. The overall effect that incremental capital cost has on Net Present Value is much further reaching than the direct effect of operating cost. Incremental costs will impact the minable mineral reserves. Although cost was not the only consideration, the filtered dry stack tailings option is considered cost prohibitive as it would result in the Project being uneconomical in the current market.

The dry stack method is rated as "Least Favourable" whereas un-thickened tailings have the "Most Favourable" CAPEX and "More Favourable" OPEX whereas the opposite is true for thickened tailings. Paste tailings economics are rated "Less Favourable".

Project Risk

Proven Technology

Un-thickened and thickened tailings are proven technologies for surface tailings disposal at the Project throughput, climate and topography. Paste tailings is more commonly used for backfill of tailings in underground mines and considered difficult to design, build and operate a large scale surface storage facility. Dry stack (filtered) tailings are proven at lower processing rates but not at the planned processing rate of 65,000 tpd. The scale up factor can be a significant challenge in obtaining the desired throughput.

Proven Technology at 65 ktpd

Un-thickened (conventional) tailings are the most common surface storage method currently in use by the mining industry. Un-thickened and thickened tailings disposal are proven at the production rates proposed for the Project and are rated as "Most Favourable".

Dry stack (filtered) tailings facilities have been designed for similar production rates, but none have been constructed or operated, so there are operational risks associated with this scale-up. Most existing dry-stack operations are constructed in the range of 3,000 to 15,000 tonnes per day in gold and silver mining operations. The largest similar process known is a 30,000 tonne per day iron ore process plant located in an arid part of Australia. At a production rate of 65,000 tonnes per day, Ajax would clearly be the largest tailings filtration plant in the world.

Although the technical risks of unit operations of filtered dry stack are believed to be manageable there remains a considerable operational risk. In comparison to smaller, existing operations, the process design offers little operational buffer in the process chain from mill through tailings discharge. Storage tanks, surge tanks, and thickeners would have the capacity to absorb only a few minutes of process upset conditions or conveyor downtime in the downstream filter operations and material handling. Although difficult to quantify, risks in safety mishaps, environmental discharges, mineral recovery loss, and energy consumption all increase dramatically in unplanned plant shutdown and frequent restart operating conditions. These issues and risks are much lower in a continuous operating plant. Although the risk could be mitigated with additional storage tanks, the high production rates could fill the largest storage tanks in the industry in only a few minutes. For these reasons the dry stack (filtered) method is rated as "Least Favourable".

Regulatory Concerns

From safety, environmental and social perspectives it is expected that lower moisture content tailings facilities which result in reduced tailings mobility in the event of a breach failure will be considered more favorably. Taking into consideration the recent failure of the slurry tailings dam at the Mount Polley Mine, it is expected that the un-thickened tailings option will be perceived as the greatest risk to project stakeholders and would require demonstration of a robust design with risk mitigation measures in place. Buttressing on the tailings embankments is inherent to each option and significantly reduces the likelihood (probability) and consequences from breach failure. Note that a detailed analysis of the potential for breach failure for the preferred alternative is provided in Appendix 17.6-B. Included in that analysis is a discussion of how the Project is planning to manage the volume of water stored within the TSF, particularly during start-up, and how mine rock buttressing will be sequenced over the mine life to always maintain a high factor of safety and reduce the probability of failure.

Natural Environmental and Human Environment Criteria

Natural and human environment criteria are considered together because there is overlap around issues such as water demand, dust generation and disturbance areas. The following criteria were considered differentiating for the alternatives (Table 17.4-17):

- Dust potential;
- Disturbed area (total and tailings surface area);
- Seepage;
- Reclamation
- Wildlife;
- Visual impact; and
- Water Quantity.

The following criteria were also considered by KAM's team, but were not found to result in meaningful differentiation between alternatives and were therefore not included in the assessment summarized in Table 17.4-17:

- Water quality;
- Noise;
- Human health risk;
- Non-traditional and recreation land use
- Archaeological resources;
- Employment opportunities; and,
- Current use of lands and resources for traditional purposes.

Disturbed Area

Placement of tailings at steeper slope angles and reducing the size of the containment structures results in a smaller footprint being needed to store a given volume of tailings. It does not necessarily result in a lower TSF elevation. For example, the un-thickened (conventional), thickened and filtered dry stack TSF designs have similar ultimate crest elevation designs and the conceptual paste option has a slightly higher ultimate crest elevation. Although a dry stack (filtered) TSF does not include an internal water storage pond (unlike the other options), an outside pond is required to store diverted run-off from the TSF. Based on the design slopes and the disturbed surface area, the filtered dry stack tailings option is considered the most favourable (33% deposit slope; 429 ha total disturbance area) followed by paste (3-10%; 603 ha); thickened (2-5%; 690 ha) and un-thickened slurry (1-2%; 700 ha). It should also be noted that the un-thickened, thickened and filtered dry stack TSF designs are similar in ultimate crest height (un-thickened (conventional) is 1060 m, thickened is 1056 m and filtered is 1055 m). The conceptual level paste option has an ultimate crest elevation of 1095 m.

For the Ajax project, it is proposed that dams be constructed as required at Goose Lake to provide this water storage for the filtered option. In comparison, Goose Lake is absorbed into the overall TSF footprint for the un-thickened, thickened and paste options due to their larger footprints. Although, not fish-bearing, Goose Lake has been identified by the SSN as part of "Pipsell" and it supports their traditional land use in the area. Although the filtered dry stack tailings has a smaller footprint, Goose Lake would still be substantially affected, as it would be need to be used as a water storage and seepage collection facility, both during Operation, and into Post-Closure.

From a sustainable development perspective, minimizing project footprint is recognized as a positive goal. However TSF site selection (as described in Section 17.4.3 and Section 17.4.8), has already resulted in a more compact Project footprint. The differences in footprint area between TSF technologies identified above would not be expected to substantially change the conclusions of an assessment of potential environmental or social effects, for example, when considering, loss or alteration of habitat for various wildlife species, or current ranching and recreational land use in the headwaters of Peterson Creek.

Dust Potential

These comments relating to dust generated from the TSF alternatives during Operations are provided without the benefit from specific air quality modelling and should be treated as general in nature. It is expected that the paste and thickened tailings options, respectively, would be the most favourable regarding dusting. This is because the paste and thickened tailings tend to be non-segregating (i.e., fines do not migrate to the top of the deposition surface) and tend to form a crust as the surface desiccates. The un-thickened (conventional) and filtered dry stack options are expected to be comparable with regards to dust generation. Un-thickened (conventional) tailings beaches are saturated during initial deposition on the beach, however, fines in the slurry tend to segregate and migrate to surface where they are more readily available to generate dust as the beach surface dries.

Dry stack (filtered) tailings are placed at lower moisture content meaning dust will be generated sooner than with slurry tailings. However, the fines do not segregate in the filtered option. It is difficult to state one tailings disposal method will be significantly better than another with regards to dusting without site specific air quality modelling. However, it is recognized that active dust

management will be required for all alternatives. Engineering solutions to mitigate dust generation include maintaining tailings saturation and use of water trucks or spray on amendments that suppress dust. Such dust management techniques have proven to be effective at other mines locally and globally.

Dust potential would be similar for each of the alternatives after the facilities are reclaimed during Post Closure.

Seepage

Seepage to the TSF foundation has been assessed based on the pond size and the initial tailings placement density. A larger pond and lower initial tailings placement density would result in greater seepage volume. The seepage volumes are therefore greatest for the buttressed unthickened (conventional) tailings facility and least for the dry stack (filtered) buttressed. Seepage estimates are provided in Appendix 17.4-B and range from near zero for dry-stack, to 36 m^3/h for thickened tailings, to 115 m^3/h for un-thickened tailings. It is important to note that groundwater modelling studies (see Section 6.6 and Appendix 6.6-D) indicate that the long-term seepage flow path from the TSF is to the open pit. This flow path would be the same for all of the alternatives considered. As such, seepage is not considered a strong differentiator for Project-specific BAT.

Wildlife

The unthickened (conventional) tailings would result in the largest footprint (700 ha), and thus the largest loss of wildlife habitat. It would also have the largest supernatant pond, which could potentially be an attractant for wildlife species such as migratory birds, amphibians and bats. Moving along the tailings continuum, footprint and supernatant pond size decrease with reduced tailings water content. Filtered dry-stack would have the smallest footprint (429 ha), and a smaller supernatant pond, which is seen as more favourable.

Visual Impact

The visual impact considered the overall facility height of each TSF as well as expected lighting required during nighttime operation. In general, the TSF embankments for each option will be visible from a number of locations, including for recreational users on Jacko Lake and Coal Hill. The paste alternative has an ultimate crest elevation of 1095 m. This is higher than un-thickened (conventional), thickened and filtered options which have ultimate crest elevations of 1060 m 1056 m and 1055 m respectively. However, at the distances from which members of the public would view these embankments, the height difference would not be expected to make a substantial difference, especially as the embankment height would increase in stages over the mine life.

In the case of paste and dry stack (filtered) methods there would also be greater visual impact associated with illumination required for continuous safe placement of the material whereas the slurry tailings require minimal lighting for spigotting from the TSF perimeter. Therefore the paste and dry stack (filtered) options are rated as “Least Favourable”. However, potential effects from light sources can be effectively mitigated, for example, by directing beams, using LED lights which are dimmed when not in use, and different coloured light to reduce glare.

Reclamation

Reclamation is planned to allow return of land to a capability that would support current ranching practices as well as traditional land use activities. Reclamation of a filtered dry stack TSF is considered the easiest ("Most Favourable") of the technology alternatives because the surface is immediately trafficable and can be progressively reclaimed as the final outer slopes are constructed. There is also a smaller footprint compared to the other options. Reclamation of paste and thickened tailings is expected to be somewhat more difficult. Opportunities for progressive reclamation during Operation would be limited to the embankments, as the TSF surface area behind the embankments would be continually growing and evolving. After mining is complete, in comparison to the filtered dry stack alternative, there may be challenges associated with vehicle access and tailings settlement, which can cause problems with constructing and contouring the final cover. Un-thickened (conventional) tailings would have the same limitations for progressive reclamation, and would be expected to have even greater challenges associated with trafficability and settlement. The un-thickened (conventional) TSF also has the largest footprint. It is expected that the potential challenges associated with trafficability on the TSF surface can be managed; however, it will increase the closure costs, and may require more time to allow for natural consolidation of the tailings before final reclamation objectives are achieved. Additional details regarding TSF closure alternatives are discussed in Section 17.4.10.

Water Quantity

Water quantity effects are a function of the disturbed area (total disturbed area in Table 17.4-16) as a larger footprint and upstream catchment area would potentially reduce flow to creeks and intercept or alter groundwater flow path. The un-thickened (conventional) and thickened tailings are less favourable as they would potentially divert more runoff from creeks whereas the paste and dry stack (filtered) facilities would be more favourable as they have smaller footprints. The un-thickened tailings also have the greatest make-up water requirements and therefore have the greatest effect on water quantity outside of the Project area (Table 17.4-16).

Water Quality

Downstream water quality effects are considered not differentiating between the alternatives during Operations and Post-Closure because design measures to collect seepage from the TSF during Operations and the "dry cover" closure would result in similar downstream water quality.

Noise

Noise generated from operating a dry stack (filtered) tailings would potentially be higher than for un-thickened (conventional), thickened or paste tailings because of the equipment (conveyors and equipment) to convey and spread / compact the material. However, within the context of an operational mine site where blasting, hauling and other construction activities are ongoing, the incremental noise generated from the TSF is not considered significant or differentiating between the alternatives.

Human Health

Human health risk is predominantly related to dust generation and drinking water quality. Based on the discussion above regarding seepage and water quality, the technology options are not expected

to have differentiating effects to drinking water quality during Operations and Post-Closure, therefore potential dust generation is the most important health criterion and was included in the assessment (Table 17.4-16). The paste and thickened tailings alternatives are expected to have the least human health risk due to dust generation; however, as discussed above, with implementation of dust control measures, the differences between alternatives are not considered strongly differentiating.

Non-traditional land use and recreational land use

Non-traditional land use and recreational use were taken into consideration, but were found to not be differentiating factors during Operations and Post-Closure for the alternatives and were therefore not carried forward in the assessment. Visual effects were considered most differentiating because of the ultimate height of the TSF and were included in the assessment (Table 17.4-17).

Heritage – archaeology

There are no identified archaeological sites within the TSF footprints; therefore heritage was not considered differentiating for the alternatives and not carried forward in the assessment. Heritage values associated with Saint Peter's church would be affected by the Project in all scenarios, but not directly impacted by the TSF footprint, and will be mitigated appropriately.

Economic – employment opportunities

While the selection of tailings technology could have large implications for Project economics (as discussed below), with respect to resultant effects to economic valued components (e.g., labour, income, business opportunities, etc.), the differences in tailings management were not seen as key differentiating factors. Employment opportunities would be slightly greater for the dry stack alternative, with approximately 20 additional staff needed to operate the filter plant and conveyor / placement of tailings (compared to conventional tailings). However, such differences in total employment could easily be offset by other Project economics, for example, the flexibility for KAM to continuously operate the mine over a range of market conditions.

Current Use of Lands and Resources for Traditional Purposes

Indicators selected for the assessment of Current use of Lands and Resources for Traditional Purposes (CULRTP) include: fishing; hunting and trapping; plant gathering; and ceremonial or other cultural uses (e.g., cultural and spiritual practices, trails, habituation sites, navigation (Section 8.5)).

Fishing has been identified as a current use of the lands and resources for traditional purposes in the area where the Project is located. This activity could be affected by potential losses of fish habitat (e.g. availability), access restrictions to fishing areas, sensorial disturbances such as noise and potential changes to the quality of the fish that is harvested for human consumption. However, the differences between the various tailings technology alternatives are not expected to change potential effects to fishing activities on Jacko Lake or Peterson Creek.

Hunting has been identified as a current use for traditional purposes in the area where the Project is located. This activity could be affected by potential losses of habitat used by animals (e.g. availability), access restrictions to hunting areas, sensorial disturbances such as noise and

potential changes to the quality of the animals that are harvested for human consumption. While the dry-stack facility would result in a smaller footprint, and therefore less direct loss of wildlife habitat, the differences in footprint area are not expected to substantially change the choices of individuals to exercise traditional practices in the headwaters of Peterson Creek upstream of the TSF.

Plant harvesting has been identified as a current use for traditional purposes in the area where the Project is located. This activity could be affected by potential losses to habitat for plants harvested, access restrictions to harvesting areas, sensorial disturbances such as noise and potential changes to the quality of the plants harvested for human consumption. While the dry-stack facility would result in a smaller footprint, and therefore less direct loss of habitat that could support plant harvesting activities, the differences in footprint area are not expected to substantially change the choices of individuals to exercise traditional practices in the headwaters of Peterson Creek upstream of the TSF.

Ceremonial or other cultural uses have been identified in the area where the Project is located, particularly associated with Jacko Lake and Peterson Creek. These activities could be affected by potential losses to sites of ceremonial or cultural importance (e.g. trails, navigation, habituation sites, prayer locations), access restrictions, sensorial disturbances such as noise or visual effects from Project activities. The differences between the various tailings technology alternatives are not expected to change potential effects to access or use of Jacko Lake or Peterson Creek.

Based on these considerations, Current Use of Lands and Resources for Traditional Purposes was not considered differentiating for the alternatives and not carried forward in the assessment.

17.4.8.8 Best Available Technology

The trade-off study compared the advantages and disadvantages of dry stack (filtered) tailings method to un-thickened (conventional; buttressed and un-buttressed), thickened and paste technologies. The study provided a framework to evaluate the BAT for the Project. Overall Project economics within the evaluation included initial and sustaining capital costs, operating and maintenance cost, and reclamation and salvage value. These financial aspects of the tailings management options were evaluated in conjunction with the full project economics to determine the cost impact to the project economic return, or not, in the case of dry stack tailings. Un-thickened (conventional) tailings was used as the base case for comparison against thickened and filtered cases.

Un-thickened (conventional) tailings are considered "acceptable" particularly where mitigation of the breach risk is carried out through buttressing of the TSF embankments. Although it has the greatest water makeup requirements and disturbance area, it has the lowest level of operational complexity and risk and potentially the lowest cost.

The paste option is rated favourable with regard to a number of environmental criteria (disturbed surface area, process make-up water requirement and dust potential) but is considered high risk for the Project throughput and unfavourable for technical, cost, visibility and reclamation.

A filtered dry stack facility is rated as favourable for six (6) of the eight (8) environmental / social criteria. It is rated unfavourable for dust potential and visual impact. For technical and economic criteria it is rated as least favourable. The feasibility study for a filtered "dry stack" TSF concluded:

- Continuously producing filtered tailings at the design specification moisture content is challenging but limited volumes of off-specification material can be managed.
- The technology is proven but has not been implemented at the proposed production rates therefore there is an operational risk factor to be considered.
- It is expected that scaling up to these production rates is achievable but would likely result is significant operational and cost implications.
- Overall costs of this option is considered cost prohibitive as it would result in the Project being uneconomical in the current market.

For the thickened tailings buttressed facility, risk of breach failure, dust potential, reclamation and visual impact were evaluated as "more" or "most favourable" compared to the other methods. Thickened tailings are also considered more favourable for technical and economic criteria with less project risk of the alternatives. In the trade off study, thickened tailings scored "More Favourable" and "Most Favourable" in 10 categories compared to seven (7) for the dry stack tailings.

The progression of engineering feasibility carried out for the Project, which included the technology trade-off study determined that a buttressed, thickened tailings facility, is the best option for the Project. The benefits of thickened tailings include:

- Requires less make-up water resulting in a smaller volume of water stored in an impoundment, less fresh water taken from Kamloops Lake and lower pumping costs.
- Lower risk of breach failure than un-thickened tailings, this risk includes both the consequence and probability as the lower water content results in reduced mobility of the tailings mass. The significantly smaller supernatant pond means there is also less water available to transport tailings material. The probability of a breach failure is reduced for each tailings disposal option, including thickened tailings, due to the inclusion of the mine rock buttressing in the design.
- Less impounded water and higher initial placement density reduces seepage.
- Improved dust control over un-thickened or filtered options. Thickened tailings tend to be non-segregating due to the addition of flocculent during the thickening process. This flocculent binds the fine particles to coarser particles which results in less fine particulate at surface available for transport as dust.
- Lower visual impact as limited lighting is required for nighttime operation of the facility (versus filtered dry stack tailings).
- Reduced challenges and costs associated with placement of a final dry cover (versus un-thickened) due to the higher initial solids content and lower segregation potential.
- Proven technology both in general and at high production rates similar to the 65,000 tonnes per day proposed for Ajax.

The trade-off study identified thickened tailings as the BAT and preferred option for the Project.

17.4.8.9 Step 5 - Best Practices

The Mt. Polley Independent Investigation and Review Panel (the Panel) report recommended proponents employ best practices to reduce operational and post-closure risk for tailings facility failure. The best practices recommendations include:

1. Use of the best available technologies (BAT);
2. Corporations operating a TSF should be required to become a member of the Mining Association of Canada (MAC) or commit to an equivalent tailings management program (including auditing);
3. Expansion of corporate design commitments including a detailed evaluation of potential failure modes, cost/benefit analysis of BAT tailings and closure options and the establishment of detailed Quantitative Performance Objectives; and
4. Utilization of an Independent Tailings Review Board.

KAM has put forth every effort in identifying the BAT for the Project. KAM is a member of MAC and commits to the high standard of tailings management to which MAC holds its members. KAM has, and will continue to evaluate the potential failure modes and continue to evaluate BAT tailings and closure options. KAM recently engaged industry experts to create an Independent Tailings Review Board, which will review the KAM TSF design and associated site investigations. KAM intends to maintain the Independent Review Board throughout the development of the TSF design and into construction.

KAM has incorporated the following TSF design elements which can be considered best practices and significantly lowers the risk of tailings failure during operation and post-closure:

- Buttressing of the tailings embankments around their entire extent around the TSF: this provides additional stability and risk of a tailings breach;
- Limiting the water stored on the TSF by reclaiming the water for use in the process;
- Maintaining the TSF supernatant pond against natural ground so that it does not encroach on the TES embankments;
- Thickening the tailings to increase the density and improve consolidation rate and strength;
- Reclaiming the TSF with 'dry cover' so there is no supernatant pond after closure (see following section).

KAM is committed to staying up to date on any changes in regulation, guidelines, policies, and best practices to ensure that the design, mitigation, inspection, and monitoring of the Project TSF meets or exceeds all requirements for dam safety and operation.

17.4.8.10 Conclusion

KAM has undertaken multiple studies to arrive at a determination of Project-specific BAT/BAP for the TSF design. Key aspects of alternatives assessment for TSF design include siting location and deposition technology. The range of tailings management technologies evaluated represents a continuum of tailings water content, with highest water content for un-thickened tailings, and lowest water content for dry-stack tailings. The key distinction is that un-thickened, thickened and paste systems are all pumpable, and require embankments to contain the tailings. Filtered dry stack tailings are not pumpable, and therefore can be self-supporting if a sufficiently low moisture content and suitable density is achieved during placement. As such, the TSF layout for un-thickened (conventional), thickened and paste tailings would be quite similar, while the layout for a dry-stack (filtered) could be very different.

A systematic approach to assessment was undertaken, which considered technical and economic criteria; environmental, economic, social, heritage, health criteria; and Aboriginal interests.

At the highest level, an initial assessment considered a matrix of 12 potential alternatives - six potential siting locations/areas, and at each location, two layouts: one pumpable; and one dry-stack. This initial assessment screened the analysis to four potential options (A1 (pumpable); G1 (dry-stack); S1 (pumpable); and S1 (dry-stack).

Further assessment of these four options, considering a more detailed set of criteria, determined that Site S1 was best suited for the Project. S1 (pumpable) was rated "preferred", with the highest rating, while S1 (dry-stack) was considered "challenging". Site A1 was considered "acceptable" and G1 was also rated as "challenging".

KAM carried both S1 options forward for a further, even more detailed, assessment of tailings technology at Site S1. Despite a "challenging" rating in the screening level assessment, filtered dry stack tailings technology at site S1 was carried forward in response, in part, to the recommendations of the Independent Expert Engineering Investigation and Review Panel on the Mount Polley failure. The Panel singled out filtered dry stack tailings as one of the BAT options that should be considered going forward.

Based on the detailed technology assessment, KAM identified thickened tailings at Site S1 to be BAT for the Ajax Project. Key aspects of the thickened tailings design include:

- Requires less make-up water resulting in a smaller volume of water stored in an impoundment, less fresh water taken from Kamloops Lake and lower pumping costs.
- Lower risk of breach failure than un-thickened (conventional) tailings, this risk includes both the consequence and likelihood, as the lower water content results in reduced mobility of the tailings mass. The significantly smaller supernatant pond means there is also less water available to transport tailings material. The probability of a breach failure is reduced for each tailings disposal option, including thickened tailings, due to the inclusion of the mine rock buttressing in the design.
- Less impounded water and higher initial placement density reduces seepage.

- Improved dust control over un-thickened (conventional) or dry stack (filtered) options. Thickened tailings tend to be non-segregating due to the addition of flocculent during the thickening process. This flocculent binds the fine particles to coarser particles which results in less fine particulate at surface available for transport as dust.
- Lower visual impact as limited lighting is required for nighttime operation of the facility (versus filtered dry stack tailings).
- Reduced challenges and costs associated with placement of a final dry cover (versus un-thickened) due to the higher initial solids content and lower segregation potential.
- Proven technology both in general and at high production rates similar to the 65,000 tonnes per day proposed for Ajax.

17.4.9 Tailings Storage Facility Closure Alternatives

17.4.9.1 Introduction

Tailings closure options for different technologies were considered as part of the Tailings Technology Alternative Assessment (see Section 7 of Appendix 17.4-B). The conventional tailings options include reclamation challenges associated with the drawdown of the supernatant pond. The dry stack option offers the best opportunity for progressive reclamation, but the benefit of this may be reduced as a result of steep slopes which are subject to erosion.

Based on the selection of thickened tailings as BAT for the Project, a number of TSF closure alternatives have been considered to further evaluate the site-specific BAT for safe and sustainable closure of the TSF.

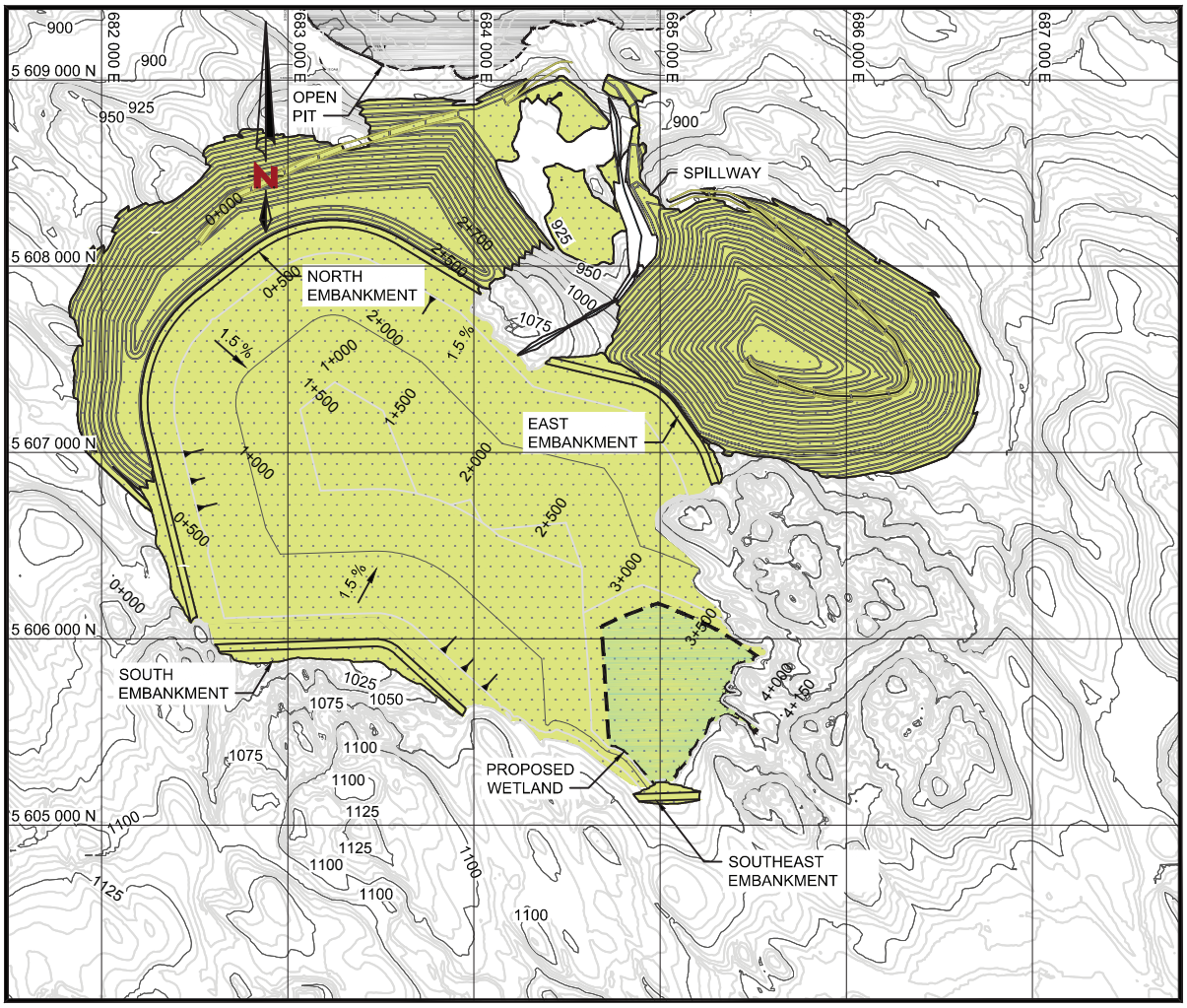
Preliminary considerations assumed a seasonal pond and wetland in the southeast corner of the facility. KAM also evaluated 'dry closure' as potential BAT for the reclaimed tailings surface. The main objectives of 'dry closure' are to prevent water ponding on the reclaimed surface of the tailings facility and to transform the TSF into an integral component of the surrounding ecosystem (Appendix 17.4-C).

Three options for closing the preferred TSF option have been considered:

<u>Option 1 – Small Pond/Wetland and Discharge to Open Pit</u>

At closure, supernatant tailings process water will be pumped to the pit and the beach areas of the TSF covered with approximately 1 m of mine rock to provide a trafficable surface. An earth fill cover approximately 1 m thick would be installed across the entire TSF except in the pond area where a seasonally fluctuating pond and wetland would remain in perpetuity in the location of the final supernatant pond. An engineered channel will direct any runoff to the Open Pit (Figure 17.4-4). There are many precedents for this type of closure in BC, including Afton Mine, Island Copper Mine and Brenda Mine and the recently permitted Kitsault and Mt. Milligan mines.

Figure 17.4-4
Closing TSF with a Pond and Wetland



Source: Norwest (2015).

LEGEND

- TOPSOIL / REVEGETATION
- WETLAND
- SLIME ZONE

1000m 500 0 1000 2000m

SCALE 1:40,000

Option 2 - Dry Closure with Discharge to Humphrey Creek

The tailings surface will be covered and recontoured with an earth fill cover to minimize ingress of surface water and to pass runoff (upon meeting water quality requirements) into an engineered channel towards the south of the TSF and into Humphrey Creek (Figure 17.4-5). Once appropriate tailings consolidation has occurred and water quality in the TSF pond is suitable for discharge to the environment (otherwise pumped to the Open Pit), an engineered channel will be excavated through natural ground to connect with Humphrey Creek. This dry closure option will be designed to minimize ponded water within the TSF footprint and infiltration into the tailings in perpetuity.

Option 3 - Dry Closure with Discharge to Open Pit

The entire tailings surface will be covered and recontoured with an earth fill cover to minimize ingress of surface water and to pass runoff through a spillway along the abutment of the east embankment (similar to Option 1) and into the open pit. This dry closure option will be designed to minimize any ponded water within the TSF footprint and infiltration into the tailings in perpetuity. There are two tailings management plans considered to meet this dry closure option:

- Option 3a – using the current tailings deposition plan (i.e. in option 1 and 2) with a southerly sloped beach but at closure to use construction materials to regrade the surface to promote drainage towards an engineered channel near the east embankment (and then to the open pit)
- Option 3b – revise the tailings deposition plan so that the deposit slopes towards a spillway on the abutment of the east embankment. This option minimizes the high costs for construction that would be incurred in option 3a.

The options were first assessed for their technical and economic feasibility

17.4.9.2 Economic and Technical Feasibility

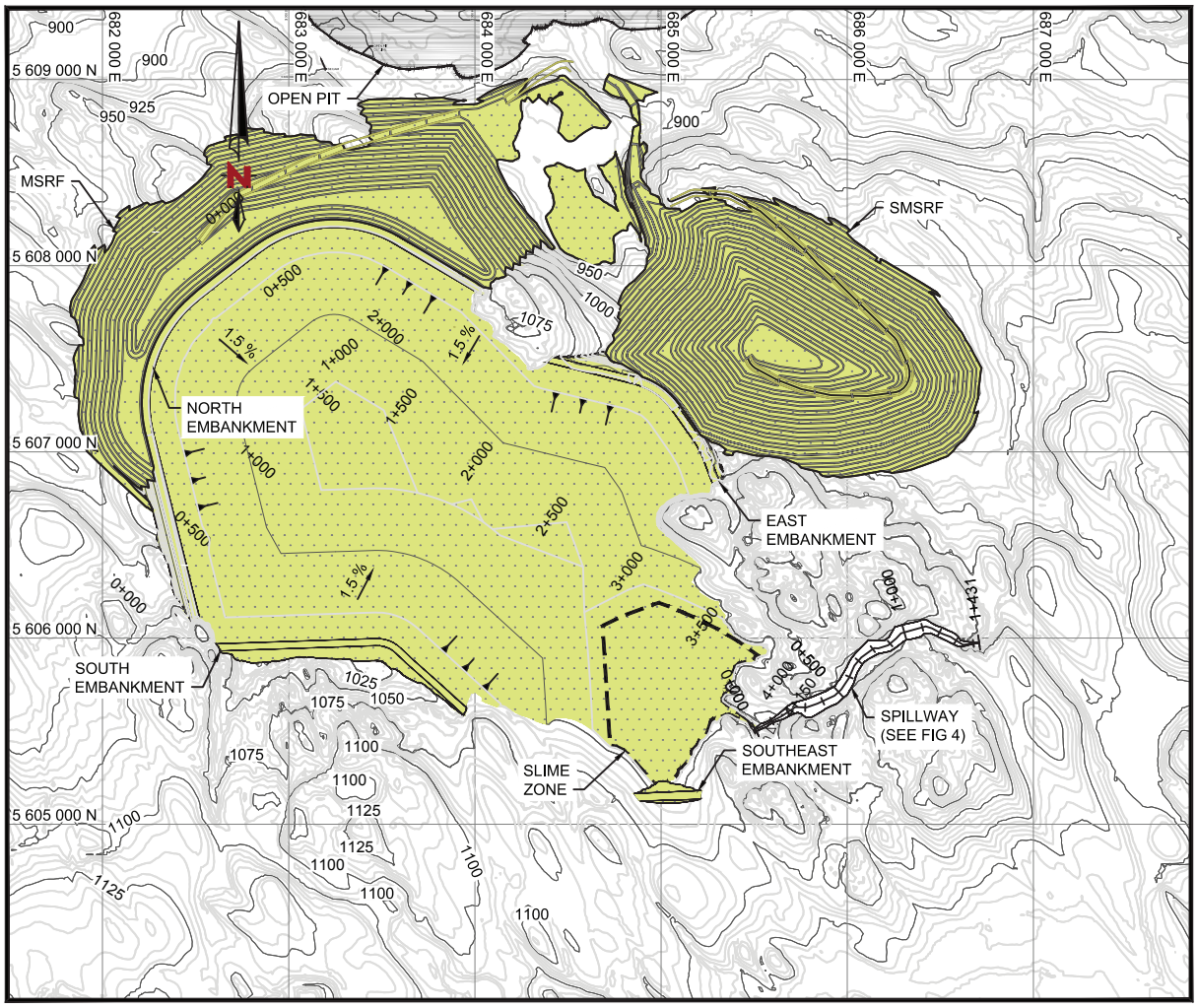
Option 1 - Small Pond/Wetland and Discharge to Open Pit

The technical and economic advantages of a small pond/wetland and discharge to Open Pit include:

- Less expensive compared to dry cover closure as it requires significantly less cover material because the high fines tailings area (i.e. final supernatant pond) is left under a shallow water cover; reclamation could be carried out in a shorter time than for the dry closure;
- Easier to construct as soil cover only required over the more competent and trafficable beach areas;
- The location of the ultimate pond along natural ground on the southeast of the facility, would reduce the risk of saturated conditions near any embankments;
- Long term consolidation effects within the softer deposits (high fines tailings) that can cause surface deformation have little effect on the long term performance;
- Recontouring of the TSF is not required;
- Modifications to existing water courses are not required;
- Use can be made of part of the existing water management infrastructure to convey water to the Open Pit

Figure 17.4-5

Dry Closure with Runoff to Humphrey Creek



Source: Norwest (2015).

LEGEND

TOPSOIL / REVEGETATION

SLIME ZONE

1000m 500 0 1000 2000m

SCALE 1:40,000

The technical and economic disadvantages of a small pond/wetland and discharge to Open Pit include:

- The engineered channel over the east embankment will be challenging to construct due to the steep slopes, rock cuts, channel lining and energy dissipation measures needed to convey water from the TSF into the pit
- If the long term water balance changes and water begins to accumulate in the area of the TSF, the entire surface of the TSF would be covered in water before excess water is routed through the engineered channel towards the pit
- The area of soft sediments may pose a hazard for animal and human land users and may require additional provisions to secure the area
- The uncapped area of softer sediments will take longer to consolidate compared to the dry closure options in which loading of the sediments decreases the consolidation period.

Option 2 - Dry Cover with TSF Runoff to Humphrey Creek

The technical and economic advantages of a dry cover with TSF runoff to Humphrey Creek include:

- There is more confidence in achieving the tailings deposition strategy for closure (with drainage to the south) with this option than the other options, which drain to the Open Pit
- The hazards associated with a pond of standing water or uncapped tailings area are mitigated
- The dry cover option has lower embankment stability risk post-closure as no water is impounded. Therefore, the risks and costs associated with long-term maintenance and monitoring of the embankments are reduced.

The technical and economic disadvantages of a dry cover with TSF runoff to Humphrey Creek closure include:

- Development of a channel requiring excavation up to 40 m deep to connect the covered TSF area to Humphrey Creek will be costly but some of these costs may be offset by using this material for reclamation
- Should the reclaimed TSF runoff quality not be suitable for release to Humphrey Creek, an engineered wetland or other mitigation options (pumping to Open Pit) may be required to remove contaminants before surface water can be discharged.

Option 3 - Dry Closure with Discharge to Open Pit

Option 3 has two different tailings management plans. Option 3a maintains the current tailings deposition plan that establishes sloped beaches to the south and a supernatant pond away from the embankments. The surface of the TSF would require re-grading to promote positive drainage toward a spillway and engineered channel located near the east embankment (similar to Option 1) using mine rock to lift the south end of the TSF. Option 3b considers an alternate tailings deposition plan that develops sloped beaches to the east and establishes a supernatant pond near the east embankment. This tailings deposition plan is currently at a conceptual level only.

Option 3a is not economically feasible and rated "unacceptable". The technical feasibility of Option 3b is uncertain because a revised tailings deposition plan would be needed and the ability to develop sloped beaches to the east is uncertain over the mine life; Option 3b is rated "challenging" for technical feasibility (Table 17.4-18).

17.4.9.3 Natural and Human Environment Acceptability

Options 3a and 3b have been screened based on 'challenging' or 'unacceptable' technical and economic feasibility. Options 1 and 2 have been assessed for environmental acceptability.

Option 1 - Small Pond/Wetland and Discharge to Open Pit:

Advantages of a small pond/wetland and discharge to Open Pit

- Although classified as NPAG, maintaining the submergence of fine-grained tailings and saturation in the pond and wetland areas is good practice to mitigate the risk for metal leaching;
- Modifications to existing water courses are not required.

Disadvantages of small pond/wetland and discharge to Open Pit

- Surface water ingress into the tailings deposit is not prevented as the lower impermeable till layer does not cover the softer sediments beneath the supernatant pond
- Increased seepage from the TSF reduces water quality in the water management ponds and potentially downstream;
- A stagnant pond at closure can result in concentration of contaminants as the pond evaporates;
- Soft sediment areas may pose risk for animals and humans and require additional provisions to secure the area;
- Land-use impaired over the area of soft sediments, cannot be returned to pre-mining use;
- Less runoff to the environment because of retention and evaporation on the TSF; and,
- Potentially long term management commitments.

Option 2 - Dry Closure with Discharge to Humphrey Creek

Advantages of the dry closure with discharge to Humphrey Creek include:

- The low permeability till cover layer isolates surface water from the tailings and minimizes infiltration into the tailings deposit;
- Hazards to animal and humans associated with a pond of standing water or uncapped soft tailings are mitigated;
- Improved discharge water quality is expected due to elimination of standing water and reduced infiltration;
- Entire surface area can be returned, as close as practical, to pre-mining conditions and the ALR;

- Fits better with the surrounding landscape; and,
- Runoff from the reclaimed surface returns directly to creeks.

Disadvantages of the dry closure with discharge to Humphrey Creek include:

- Excavation of post-closure channel will disturb terrestrial and aquatic habitat;
- Reinforcement of the Humphrey Creek natural channel may be required to manage flow from an increased catchment area.

17.4.9.4 Preferred Alternative

A quantitative trade-off comparison (Appendix 17.4 C) indicated that dry closure with discharge to Humphrey Creek (Option 2) asis BAT for the Project. The trade-off comparison used eight (8) attributes and ranked Option 2 better than Option 1 for: ponded water; water infiltration; terrestrial landscape and discharge water quality. Option 1 was ranked better for channel earthworks, long-term consolidation and cost; the options were ranked similar for tailings deposition during operations. The key challenge associated with Option 2 would be the development of the channel to connect the covered TSF area to Humphrey Creek and potential reinforcement of the creeks natural channel. The size of the cut, side slope configuration, and amount of channel reinforcement are not expected to be technically challenging and are outweighed by the operational and long-term environmental benefits of this option.

From an environmental acceptability standpoint, the dry closure with discharge to Humphrey Creek has significant benefits (Table 17.4-19). Major benefits include reduced hazards associated with a surface pond; improved water quality; return of the entire TSF surface to pre-mining land-use and reduced long-term management commitment. The human environment acceptability of closure with a small pond/wetland and discharge to Open Pit (Option 1) is considered 'challenging' given the concern associated with potential hazards of a post-closure TSF pond. Although both closure options are overall considered 'acceptable'; the dry closure option is considered a better option as it provides significant improvement for the natural environment and reduces long-term risk.

A dry closure with discharge to Humphrey Creek is the preferred alternative

17.4.10 Water Supply Alternatives

17.4.10.1 Introduction

Water needs during construction can initially be met by using approximately 0.5 Mm^3 of water ponded within the historic Ajax pit with additional water required to complete construction. The design requirement for the Project during operations will be largely met by recycling water from the TSF. However, additional make-up water is required due to the losses of water in the tailings voids, evaporation losses, and, ice formation within the TSF during the winter months. In addition, freshwater will be required for dust control, reagent preparation, gland sealing water, potable, process water make up and for firefighting purposes.

Table 17.4-18. Economic and Technical Feasibility Ratings for TSF Closure Alternatives

Performance Objective	Option 1 – Small Pond/Wetland and Discharge to Open Pit	Option 2 – Dry Cover with TSF Runoff to Humphrey Creek	Option 3a –Dry Cover with Current Tailings Deposition Plan and Runoff to Open Pit	Option 3b – Dry Cover with Revised Tailings Deposition Plan and Runoff to Open Pit
Economic Feasibility	Lowest cost attributed to less reclamation material as pond not covered ($95 M). Higher costs associated with long-term maintenance and monitoring.	Does not require very large amounts of material as option 3a as utilizes natural slope for tailings deposition ($105 M). Reduced costs associated with long-term maintenance and monitoring	Most expensive as large volumes of mine rock required for contouring the TSF towards the east embankment ($631 M). Reduced costs associated with long-term maintenance and monitoring	Similar cost to Option 2 ($105 M)
	Acceptable	Acceptable	Unacceptable	Acceptable
Technical Feasibility	Easiest to construct. Can make use of some of existing water management system. Consolidation of tailings does not affect long term performance. Safety concerns mitigated by buttressing of embankments and pond location along natural ground in southeast of TSF	Reduces hazard associated with ponded water and uncapped tailings. Lowers embankment stability risks post-closure as no water is impounded. Large excavation to connect to Humphrey Creek and potential reinforcement of creek to manage increased flow. Runoff quality may be unsuitable for release to Humphrey Creek and require mitigation (engineered wetland or divert to open pit)	Engineered channel over the east embankment will be challenging to construct due to steep slopes, rock cuts, channel lining and energy dissipation measures needed to convey water from the TSF into the pit	Uncertainly on whether sloped beaches to the east could be practicality achieved over the life of mine. Engineered channel over the east embankment challenging for similar reasons as option 3a o
	Acceptable	Acceptable	Challenging	Challenging
Overall Rating	Acceptable	Acceptable	Unacceptable	Challenging

Table 17.4-19. Environmental Acceptability Ratings for TSF Closure Alternatives

Assessment Criteria	Tailings Storage Facility Closure Alternatives	
	Option 1 - small pond/wetland and discharge to Open Pit	Option 2 - dry closure with discharge to Humphrey Creek
Natural Environment Acceptability	Increased infiltration to TSF and seepage affecting water quality in management ponds. Poor supernatant pond water quality. Reduced land-use in pond area. Loss of runoff water. Reduces potential for ML/ARD. Modifications to water courses not required.	Low permeability cover isolates tailings and minimizes infiltration thereby improving discharge water quality Return of entire surface to pre-mining land-use. TSF runoff returns to creeks.
	Acceptable	Preferred
Human Environment Acceptability	Closure simpler but inconsistent with surrounding land-use; regulatory and community concern related to hazards associated with supernatant pond. Land use impaired in pond area. Potentially long term management commitment. Loss of runoff water.	Better fit with surrounding landscape; consistent with surrounding land use. Improved discharge water quality with runoff returned to creek for downstream users. Reduced long-term management commitment. Reduced concern related to dam hazard (e.g. breach risk). Disturbance of terrestrial and aquatic habitat from engineered channel to connect to Humphrey Creek and in-stream works to reinforce the natural creek channel.
	Challenging	Preferred
Overall Rating	Acceptable	Preferred

Water supply alternatives are limited to extending to the existing system that supplies the New Afton mine or developing a new source and distribution system. Groundwater supply was initially considered but not assessed further because of the limited resource. Potential alternatives considered include:

- upgraded system from Kamloops Lake;
- run-off within the TSF catchment; and
- treated effluent from the City of Kamloops.

17.4.10.2 Assessment

Upgraded System from Kamloops Lake

An intake system and existing steel pipeline is currently operated by New Gold Inc. to supply water to the New Afton mine, located to the northwest of the Project. The pipeline was oversized at the time of construction to allow for future expansion. A new pipeline will be required to deliver water from the New Afton Mine site to the Project. The new pipeline will largely follow alongside the haul road route.

Infrastructure for the Project's water supply includes:

- a new intake and pumping station at Kamloops Lake,
- the existing New Afton water pipeline between Kamloops Lake and the New Afton Mine,
- approximately 16 km of new pipeline from a booster station at New Afton to the Ajax processing plant and,
- two new booster stations along the pipeline.

The freshwater pipeline will supply water to the explosives facility, primary crusher, truck shop, plant site and other buildings and facilities as required. A portion of the water delivered will be treated for potable use during all project phases and stored in a potable water storage tank prior to delivery to various service points. Other water uses include diamond drilling activities and use within maintenance/vehicle facilities.

A water pipeline from Kamloops Lake is the only alternative that provides the quantity of water required for the Project; it is a reliable water source and is the "preferred" alternative (Table 17.4-20).

Table 17.4-20. Technical Feasibility of Water Supply Alternatives

Assessment Criteria	Water Supply Alternatives		
	Upgrade System from Kamloops Lake	Capturing Runoff within TSF catchment	Treated Effluent from the City of Kamloops
Technical feasibility	New intake, booster pumps and additional 16 km pipeline to Project. Only alternative that can meet all Project needs	Small volumes only during freshet insufficient to meet Project needs	Could potentially meet some of Project needs but freshwater still required for non-process requirements. Challenging to route beneath CP track. Potentially quality constraints for use in processing. Merits further investigation
	Preferred	Acceptable	Challenging

Capturing Runoff within the TSF catchment

This alternative collects run-off from within the TSF catchment that would otherwise be diverted around the TSF. The anticipated flow entering the TSF from the undisturbed catchment is small, on average 7 m^3/hr and peaking during freshet (Appendix 3-F). This rate is not sufficient by itself to supply all of the Project water demand.

Treated Effluent from the City of Kamloops

The possibility to augment the mine's water supply using treated effluent from the City of Kamloops has been raised but it would need to make economic sense for construction of a pipeline. Approximately 1,600 m^3/h could be available based on current discharge of treated effluent to the Thompson River (pers. Comm. City of Kamloops); however, freshwater would still be required for potable and other needs and therefore the intake at Kamloops Lake would still be required. The treated water undergoes clarification and ultraviolet disinfection, however, the effluent may not be suitable for some applications in the plant and further assessment would be required to determine if

it meets specifications. The distribution pipeline would need to route beneath the CP Rail track. KAM will conduct further investigation and discussions with the City to determine the viability of this option.

17.4.10.3 Preferred Alternative

Capturing run-off, recycling contact water or using City of Kamloops treated sewage effluent can supplement the Project's demand but cannot meet the entire Project's water quantity and water quality requirements. There are also quality constraints for applications such as gland seal, reagent make-up and potable water that limit using recycled water.

Upgrading the existing system from Kamloops Lake is the preferred alternative. Other water sources do not guarantee the operational requirements, and whilst every effort will be made to recycle and conserve water, a secure supply of fresh water is required.

Water supply from the Kamloops Lake is the preferred option.

17.4.11 Jacko Lake Management Alternatives

17.4.11.1 Introduction

Jacko Lake provides recreational activities including fishing from shore and boat, and wildlife and bird watching. It is also a source of irrigation water for downstream water licence holders and contributes to flows in Peterson Creek. KAM understands the importance of Jacko Lake to local communities and Aboriginal Groups and has committed to maintaining the lake as an important outdoor recreation location. Jacko Lake is considered a component of "Pipsell" (a site or location with high cultural significance and playing an important role in people's cultural identity) for the SSN. With the understanding of the importance to Aboriginal Groups and community members, KAM has undergone a thorough process of evaluating the potential options for the addressing the Project's proximity to Jacko Lake. Options considered included the potential for closure of the lake, but this was ruled out in favor of preserving access for the continued use and recreational enjoyment of the lake.

The outlet of Jacko Lake is currently controlled by the Jacko Lake Dam located at the southeast arm of the lake. Discharge currently occurs through an overflow spillway and a low level outlet controlled by a manually operated gate, which allows for water releases from Jacko Lake to Peterson Creek during periods when there is no flow over the spillway. The low level outlet is controlled by the water steward, who releases water to the downstream users as required.

KAM will manage the blasting schedule in proximity of Jacko Lake to protect aquatic life and minimize blasting impacts in the surrounding communities. Blasting schedule and design has been modified to protect aquatic life in Jacko Lake based on the overpressure and vibration guidelines by Wright and Hopky (Appendix 10.5-A). Although no longer endorsed by the Department of Fisheries and Oceans, Canada (DFO) and given the lack of replacement criteria, KAM will operate in accordance with these criteria and monitor fish populations.

The Open Pit extent has been constrained in an effort to maintain the value of Jacko Lake whilst achieving a balance between a viable project and minimizing the impact to the lake (section 17.4.6). The Open Pit will impinge on the northeast arm of the lake and the Kinder Morgan pipeline, which will require relocation. Four (4) engineered dams, less than 5 m high and crest length ranging from 30 m to 175 m, will be required within Jacko Lake to contain the PMF since there will no longer be a spillway and for removal of the Kinder Morgan pipeline which runs beneath the northeast arm of the lake (Appendix 3-H).

The outflow from Jacko Lake will be diverted around the Open Pit as the existing channel will be removed by pit excavation. The diversion and the Peterson Creek downstream pond (PCDP) will allow for continued access for the water bailiff to regulate the release of Jacko Lake water for the use of downstream water license holders.

KAM intends to enhance Inks Lake as an off-setting measure to lost fish habitat in Jacko Lake. Inks Lake will be developed as a stocked fishery with quick/easy access from town and provide similar characteristics to what Jacko Lake offers. This section describes the management alternatives considered for Jacko Lake including:

- Partial containment or release of the Probable Maximum Flood (PMF)
- Peterson Creek Diversion route

17.4.11.2 Partial Containment or Release of the Probable Maximum Flood (PMF)

As the Peterson Creek Diversion will result in a loss of the spillway from the southeast arm of Jacko Lake during Construction and Operations, it was necessary to evaluate how management of a large storm event resulting in flood water entering Jacko Lake would occur. Two options were considered to manage the Probable Maximum Flood (PMF): containment of the PMF within Jacko Lake, or an engineered berm and spillway which would allow a portion of the PMF to flow into the Open Pit. The release option requires gravity drainage through a spillway whereas containment of the PMF requires the installation of several dikes for containment, and utilizes the Peterson Creek diversion system to gradually divert flow from Jacko Lake for release into Peterson Creek downstream of the project (Appendix 3-H).

Assessment

To contain the PMF, four (4) dikes, not exceeding a height of 5 m, are required around Jacko Lake whereas only two (2) on dams are required for the release option on the east side of Jacko Lake to safely discharge a portion of the PMF to the Open Pit (Appendix 3-F). These structures will be required early in the construction phase of the Project, during operations and remain in place post-closure. Upon closure, Peterson Creek will be re-established and a spillway from the southeast arm of the lake release water back into the creek channel. The containment and release of PMF options are considered technically and economically feasible but have different effects to the natural and human environment; these are summarized in Table 17.4-21.

The option that releases the PMF to the Open Pit results in flow reduction for downstream users whereas the containment option does not as the PMF would be retained and diverted (pumped)

around the Open Pit. In this option there would be no spillway required, however, a contingency spillway could be provided to route PMF to the Open Pit. The release of the PMF to the Open Pit has safety risks associated with flood flows potentially affecting mining activities. The potential reduction of flow from Peterson Creek would affect downstream water users. For these reasons, release of the PMF to the Open Pit is rated "challenging".

Containment of the PMF is the "preferred" option for managing Jacko Lake as it allows for better utilization of water by downstream license holders as the water received in a storm event can, for short periods of time, remain stored in Jacko Lake and gradually released to downstream users as-needed, rather than all at once (which would currently happen during a storm event). Although changes in lake flow may potentially affect fish habitat and the recreational fishery, these effects can be mitigated if this turns out to be the case (e.g. see the following section).

Table 17.4-21. Environmental Acceptability for Partial Containment or Release of Probable Maximum Flood from Jacko Lake

Performance Objective	Containment of PMF Flood	Release of PMF to Open Pit
Natural Environment Acceptability	Requires 4 small dikes < 5 m high. Does not result in loss of flow to downstream users. Interruption of lake flow through may affect aquatic habitat and may require mitigation	Requires 2 dams < 5 m high. Results in loss of flow to downstream users.
	Acceptable	Challenging
Human Environment Acceptability	Potential change in lake flow through may affect recreational fishery but can be mitigated. Flows can be managed from Peterson Creek Downstream Pond. Public perception of reduced value of lake	Safety risk to Open Pit and potential disruption of mining activity. Release of PMF to Open Pit would reduce flow in Peterson Creek catchment
	Acceptable	Challenging
Overall Rating	Preferred	Challenging

Preferred Alternative

Containing the PMF within Jacko Lake, and utilizing the Peterson Creek Diversion system to pump excess water downstream is the preferred option.

17.4.11.3 Peterson Creek Diversion Route Alternatives

A section of Peterson Creek will need to be diverted around the Project facilities, as a portion of the current creek configuration will be lost during excavation of the Open Pit. A flow diversion system is therefore required to maintain flow in Peterson Creek downstream of the mine site.

Multiple options were considered for the re-routing or diversion of Peterson Creek including gravity flow through the Peterson Creek corridor, both through an open diversion channel and through a gravity pipeline as well as options for pumping flows around the northern perimeter of the open pit.

Four pipeline diversion alternatives of varying lengths from about 3.5 km to 10.3 km were considered as alternative routes (Appendix 17.4-D). In addition, an open channel diversion along the South Route (Peterson Creek corridor) was assessed as it is preferred by the SSN (Appendix 17.4-E):

- Alternative A – pipeline along north route: The intake would be located on the northeast end of Jacko Lake for conveyance of flows north of the Open Pit along the main access road.
- Alternative B – pipeline along south route: The intake would be located on the southeast arm of Jacko Lake for conveyance of flows south of the Open Pit through the Peterson Creek corridor.
- Alternative C – pipeline along southwest route: The intake would be located on the southeast arm of Jacko Lake for conveyance of flows around the west perimeter of Jacko Lake and connecting with the main access road.
- Alternative D – pipeline along southeast route: The intake would be located on the southeast arm of Jacko Lake for conveyance of flows around the east perimeter of Jacko Lake and connecting with the main access road.
- Alternative E – open channel along south route: an upgraded spillway on the southeast arm would connect to an engineered channel between the Open Pit and MRSF and convey flow through the mining area (Peterson Creek corridor). The channel would follow a similar alignment to that for the re-established Peterson Creek at the end of mine life and require extensive cut and fill to assure gravity drainage through the channel.

The pipeline diversions and associated infrastructure would be removed at mine closure whereas an open channel would remain and suitably reclaimed to enhance riparian habitat. In the case of a pipeline diversion, a new channel would have to be built in the Peterson Creek corridor before the pipeline diversion can be decommissioned. The Jacko Lake dams will remain at closure and the spillway connected to the new channel (Appendix 3-H).

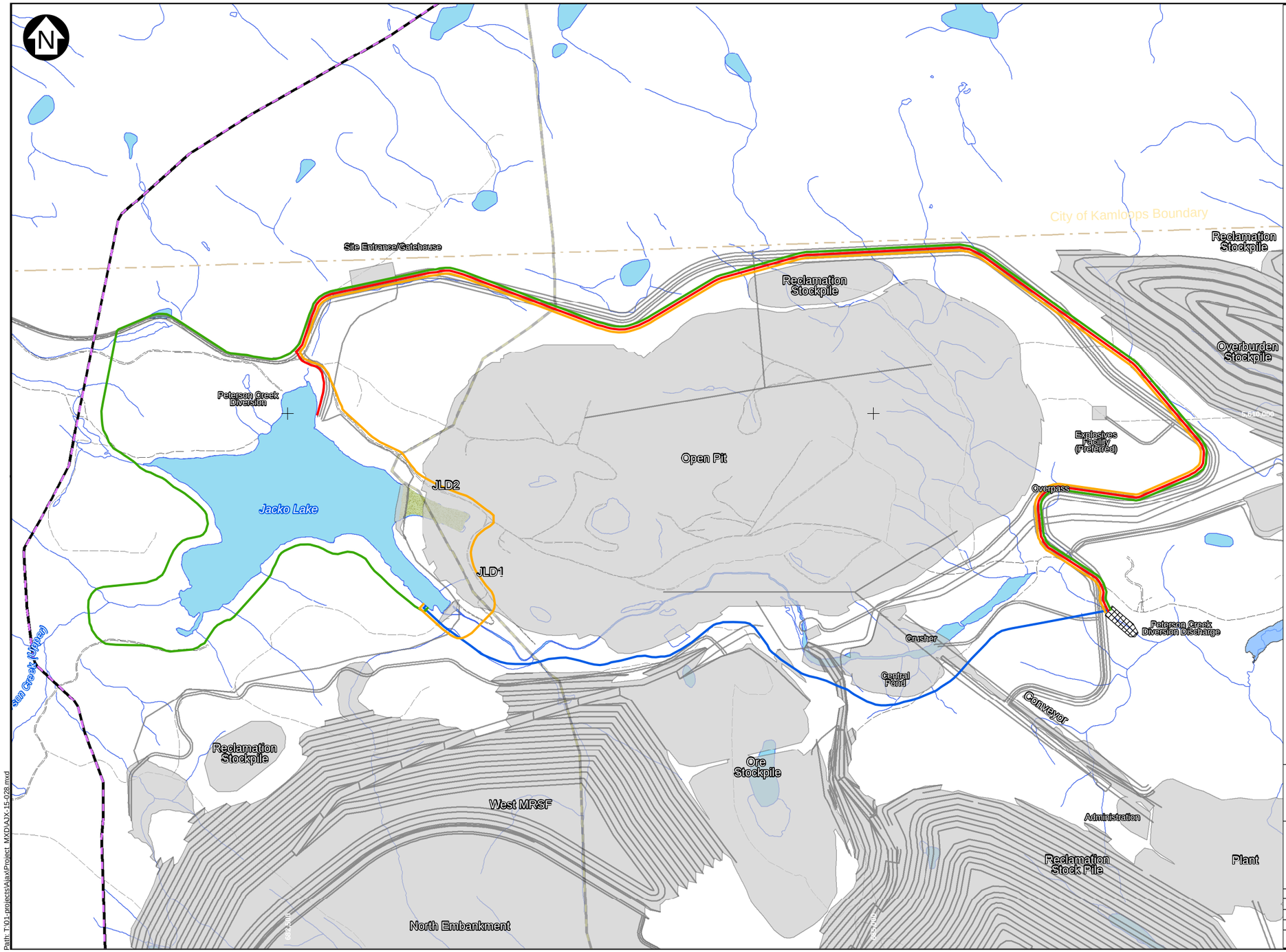
Assessment

Four route alternatives were identified based on different routes around Jacko Lake and reconnecting with Peterson Creek downstream of mining activities (Figure 17.4-6).

Alternative A – Pipeline along North Route

This route is preferred because it is the simplest and least expensive to construct. The intake would be located in the northeast end of Jacko Lake and convey flow north of the Open Pit along the main access road within the same corridor as the water supply pipeline from Kamloops Lake. Because of concerns around changes to circulation in the southeast arm of Jacko Lake from the intake location, a pump and pipeline on Jacko Lake shoreline to preserve circulation has been proposed as a potential mitigation measure that would be based on monitoring during operations (Table 17.4-22).

Figure 17.4-6
Peterson Creek Diversion Alternatives



Peterson Creek Diversion Alternatives
- Alternative A
- Alternative B
- Alternative C
- Alternative D
- Highway
- Paved Road
- Gravel Road
- Rough Road
- Recreational
- Kinder Morgan Pipeline - Current
- Kinder Morgan Pipeline - Rerouted
- City of Kamloops

Proposed Structures
- Downstream Pond
- Diversion Discharge
- Proposed Structures

NOTES:
1. BASE MAP: Topographic (TRIM)
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD83 UTM, ZONE 10 NORTH, METER.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:17,500 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

SCALE 0 0.15 0.3 0.45 Kilometres

KGHM

KGHM Ajax Mining Inc.

2015 September 03			
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Table 17.4-22. Performance Ratings for Peterson Creek Diversion Alternatives

Performance Objective	Alternative A - North Route Piped	Alternative B -South Route Piped	Alternative C -Southwest Route	Alternative D -Southeast Route	Alternative E – South Route Open Channel
Technical Feasibility	Short leg from Jacko Lake to route conveyance along main access corridor north of pit. Simplest to construct with intake in northeast of lake	Complex construction as route within mine infrastructure corridor. More complex intake in southeast arm of lake	Routes around west perimeter of Jacko Lake. Long access road. More complex intake in southeast arm of lake	Complex construction as routes north between Open Pit and Jack Lake and requires realignment post construction of Jacko Lake dams. More complex intake in southeast arm of lake	Alignment is within narrow corridor between Open Pit and MRSF and would interfere with mining infrastructure. Requires extensive excavation that could affect infrastructure
	Acceptable	Challenging	Challenging	Challenging	Challenging
Economic Feasibility	Low cost $2.1M	High cost $5.6M	High cost $6.5M	Moderate cost $3.3M	Moderate Cost $3.4M
	Acceptable	Challenging	Challenging	Acceptable	Acceptable
Natural Environment Acceptability	Does not maintain lake circulation Low disturbance as routed along main access corridor	Intake location maintains lake circulation. Route would be within disturbed mining area	Most disturbance from long road and pipeline and potential environmental effects	Intake location maintains lake circulation. Route would be within disturbed mining area and then along main access corridor	Open channel would not constitute viable habitat and be vulnerable to contamination from contact-water and sedimentation.
	Acceptable	Acceptable	Unacceptable	Acceptable	Challenging
Human Environment Acceptability	Intake in deep part of lake and construction provides least disturbance to Jacko Lake.	Disturbance within mining area	Most disturbance from road & pipeline construction	Disturbance within mining area	Would meet preference of SSN but potential contamination of creek or safety risk from interaction with mining infrastructure
	Acceptable	Acceptable	Unacceptable	Acceptable	Challenging
Overall Rating	Preferred	Challenging	Unacceptable	Acceptable	Challenging

Alternative B – Pipeline along South Route

A south route with an intake in the southeast arm of Jacko Lake that conveys flow in a pipeline through the Peterson Creek corridor would be challenging because of the interaction of the alignment with mine infrastructure in the narrow corridor. The capital cost is high ($5.6M) because of measures needed to avoid major mine infrastructure including protection from the haul road and the overland conveyor. Design details associated with routing could also cause delays in project development. The south route is considered "challenging".

Alternative C – Pipeline along a Southwest Route

A southwest route conveys flow around the west perimeter of Jacko Lake connecting with the main access road. A 3.5 km access road to connect the pipeline to the main access road would be required along the shoreline and outside of the 10-year maximum water level of Jacko Lake. The capital cost is estimated at $6.5M and the pipeline would have to bypass a dam construction site on the west arm of Jacko Lake and cross the access road for a boat launch. The terrain is quite steep around the shoreline requiring large volumes of material to be excavated for construction. A substantial water management plan would be needed for protection from sediments entering Jacko Lake. Apart from the high cost, there are likely to be concerns from users of Jacko Lake regarding disturbances to the natural environment from construction of the pipeline. The southwest route is "unacceptable" because of high cost as well as potential environmental effects.

Alternative D – Pipeline along a Southeast Route

A southeast route has the intake in the southeast arm of Jacko Lake and routes the pipeline between the Open Pit and Jacko Lake around the north side of the Open Pit along the main access road. The pipeline would initially be placed through the footprint of the Open Pit to allow for construction of dams on the southeast and northeast arms of Jacko Lake and relocated on completion of the dams. The total pipeline length including realignment is approximately 4.5 km and cost to construct around $3.3M (excluding the realignment). The construction timing of the Peterson Creek diversion and the two dams would need to be carefully planned for this alternative. Overall, this alternative is considered "Acceptable"

Alternative E – Open Channel along South Route

The assessment of gravity flow versus pumped flow diversion alternatives demonstrated that the Peterson Creek diversion by gravity flow in an open trench would require a large amount of excavation (approximately 200,000 m^3 of cut and 107,000 m^3 of fill) and would expose the water in the creek to potential contaminants from the Project due to close proximity to facilities and activities. Collection ditches would be required adjacent to the diversion channel to keep mine contact water out of Peterson Creek. A safety offset of from 30 m to 40 m from the perimeter of the final Open Pit would be required potentially interfering with mine infrastructure. A cost of approximately $3.4M is estimated to construct the engineered channel (Appendix 3-H).

A piped gravity flow system, although protecting the water from potential contaminates, would also require extensive excavation due to topographic issues and the potential for damage to the pipeline from mining activities would be high. For these reasons, diverting the flow around the Project was identified as the preferable option.

Preferred Alternative

The pipeline and open channel alignments considered in combination with the two intake locations either followed a northern route outside of the active mine site, or a southern route through the active mine site. The southern route through the active mine site was discounted as it would infringe on mining infrastructure such as the WMRSF and haul roads, potentially affect water quality in Peterson Creek as well as constitute a safety risk for Open Pit operations. The diversion alignments outside of the active mining site are simpler to construct but longer, especially in the case of routing around the western perimeter of Jacko Lake. The construction of a new access road for the pipeline is the major cost component in each of the alternatives assessed. Diversion infrastructure will be removed during the closure period once Peterson Creek is reconnected to Jacko Lake by an engineered channel.

Two intake locations were considered in the alternatives assessment: the northeast arm and southeast arm (existing dam) of Jacko Lake. Locating the intake in the southeast arm of the lake maintains the existing flow circulation but is more complex due to the shallow water. An intake located at the northeast end of the lake is preferred as it allows for a relatively simple intake structure with fish protection screens in combination with larger centrifugal pumps on the shore. A simple and inexpensive pumping system that circulates water in the southeast arm of Jacko Lake will mitigate the potential effects of the Peterson Creek diversion if monitoring indicates an adverse effect.

The preferred option for diversion of Peterson Creek is around the northern perimeter of the open pit (Alternative A)

17.4.12 Product Transport Method Alternatives

17.4.12.1 Introduction

Truck, rail and a multi-modal truck/rail combination are three modes of transportation that could suitably deliver ore concentrate from the mine site to a port facility. In the Kamloops area, there are experienced hauling companies such as Arrow and Trimac, who service the mining industry locally and across Canada. Rail service is well established and available from two national carriers, CN Rail and CP Rail, with experience handling bulk materials.

17.4.12.2 Technical and Economic Feasibility

The trucking of concentrate is an accepted standard practice in the industry and provides service flexibility for the Project. An advantage of using truck transportation is that it requires less material handling. Trucking transit time is more favourable than the other options, being 11 hours round trip from the mine site to delivery at the Port of Vancouver. Costs provided by transportation companies range from C$ 37/t to C$ 40/t based on a 50 tonne payload.

The major disadvantages of rail include the multiple handling requirements, inconsistent scheduling of rail cars, and lengthier transit times. Transit times take approximately four days from Kamloops to the Port of Vancouver and are not as favourable as trucking. Additional time will also be required for loading and unloading product. Within CN Rail's Kamloops rail yard, a reload facility currently does not exist so a dedicated loading facility would be required to facilitate unloading of trucks, provide storage and the capability for reloading concentrate into railcars. This reload facility would

require to store up to 8,000 t taking up a 2 ha footprint with an approximate construction time of four months.

From an operating cost perspective, the rail alternative is more effective than trucking. Costs for railing to the Port of Vancouver are estimated at C$ 28.47/t in the first year, escalating to C$ 31.41/t in the sixth year. These costs include trucking from the mine to delivery to a terminus in North Vancouver (Wardrop 2012). It is expected that current prices for railing would be higher than quoted previously, but would remain lower than current trucking cost. A combined truck and rail alternative would use established trucking companies and a national rail carrier with an existing rail reload facility that is situated at Ashcroft, BC, approximately 100 km to the west of the mine site. This option would use trucks to transport the concentrate from the mine site to Ashcroft, and then rail the concentrate to the Port of Vancouver. The rate per tonne from Ashcroft to the Port of Vancouver (C$ 62.39/t) is approximately double from Kamloops, therefore this option is considered uneconomical.

17.4.12.3 Natural and Human Environment

The choice of transportation method will have environmental effects, specifically for air quality. Use of truck and rail transport is accepted standard practices; however, rail transport would have a slight advantage with respect to higher fuel efficiency and therefore lower air emissions. In the trucking option the mineral concentrate is handled only once from loading at the mine site to final delivery at the port, providing operational efficiencies and less potential for spillage. Construction of a new rail reloading area in Kamloops increases the Project footprint and increases the potential of environmental effects. The effects of the product transport alternatives on the natural and human environment are rated as "acceptable "(Table 17.4-23).

17.4.12.4 Preferred Alternative

In comparing the modes of transportation, trucking is the preferred alternative because it provides operational service flexibility, less material handling requirements, and the most favourable transit times.

Trucking is the preferred mode of product transportation.

17.4.13 Transport Corridor Route Alternatives

17.4.13.1 Introduction

Concentrate from the mine site will need to be transported to market for further smelting and copper/gold recovery. This market is outside Canada and concentrate will need to be delivered to a port for shipment. Two port locations, the Port of Vancouver and the Port of Stewart, are used by the mining industry as BC's southern and northern logistics gateways, respectively. Both port facilities have the mineral shipping facilities for bulk concentrate, are ice free and provide good anchorage.

Table 17.4-23. Performance Ratings for Product Transportation Alternatives

Performance Objective	Trucking	Rail	Combined Truck / Rail
Technical Feasibility	Standard industry practice. Advantages are more efficient as there is less material handling. Shorter transit time. Disadvantages are higher vehicle traffic and emissions	Multiple handling requirements. Lengthier transit time than trucking. Requires new loading facility at rail yard. Inconsistent scheduling of rail cars	Trucking to existing loading facility 100 km from mine and rail to Port of Vancouver. Multiple handling and lengthier transit times than trucking
	Preferred	Challenging	Acceptable
Economic Feasibility	C$ 37/t to C$ 40/t	Approximately $30/t	$ 62.39/t
	Acceptable	Acceptable	Unacceptable
Natural Environment Acceptability	Higher air emissions. Less potential for spillage	Lower air emissions. Surface disturbance for 2 ha loading facility	Some air emissions but lower than trucking
	Acceptable	Acceptable	Acceptable
Human Environment Acceptability	Increased use of highway for haul trucks from mine site to Port of Vancouver	Increased use of highway from mine site to rail siding in Kamloops	Increased use of highway for haul trucks between mine site and Ashcroft
	Acceptable	Acceptable	Acceptable
Overall Rating	Preferred	Acceptable	Unacceptable

17.4.13.2 Technical and Economic Feasibility

The transport corridor route from the mine to the Port of Vancouver is via the Coquihalla Highway. The transport corridor to the Port of Stewart would be north on Highway 97 to Prince George and then west on Highway 16 to Prince Rupert. Both the Port of Vancouver and the Port of Stewart have the technical capabilities to service the Project's shipping needs. The lower costs associated with hauling to a closer port location makes the Port of Vancouver the preferred location.

The Port of Stewart is not considered viable due to the great distance from the Project (1,218 km) and therefore uneconomical in terms of transportation costs. The Port of Vancouver is within reasonable proximity (352 km) of the Project and is the preferred route for exporting concentrate.

17.4.13.3 Preferred Alternative

Transport to the Port of Vancouver is the preferred corridor route

17.4.14 Site Access Road Alternatives

17.4.14.1 Introduction

The Project is located to the south of the City of Kamloops and within the Thompson Nicola Regional District. Highway 5 (Coquihalla Highway) is the main provincial highway that connects Kamloops with the towns of Merritt, Hope and through to Vancouver via Highway 1. The highway is an all-season road operated and maintained under the jurisdiction of the British Columbia Ministry of Transportation and

Infrastructure (MOTI). Most of the highway is comprised of two lanes of traffic per direction but widens up to six travel lanes where there are steep gradients to allow faster moving vehicles to pass. At the Inks Lake Road Interchange, approximately 10 km west of the Project, the highway is a divided and has two lanes in the northbound direction and three lanes in the southbound direction.

The Lac Le Jeune Road is an undivided, 2-lane paved public road, approximately 5 km west of the Project, and connects with the highway northwest of the Project (Copperhead Drive interchange). The road provides access to a small industrial park near Kamloops, private agriculture lands and recreation lands. Road users are primarily passenger vehicles and commercial vehicle traffic near the existing industrial development. Traffic accessing the Project from the highway will cross the Lac Le Jeune Road on an overpass (Figure 17.4-7).

The Ajax South general arrangement allows use of the historic mine haul road as primary access to the site; this was not possible with the Ajax North arrangement because of the location of the TSF. This road is locally known as the "haul road" and was constructed to provide access to the historic Afton mine. The haul road includes a highway underpass and provided access between the historic Afton mine and the historic Ajax pits. For the purposes of this assessment, this existing road is referred to as the main access road. Upgrades to the main access road will include asphalt paving, design curves, design super elevations, drainage improvements, and signage and traffic safety control measures. Access from the highway to the Project will be required to transport personnel, equipment, materials and concentrate. This alternatives assessment considers the location of the entrance/exit from the mine access road to the highway and whether a new interchange would be needed to accommodate traffic levels.

17.4.14.2 Assessment

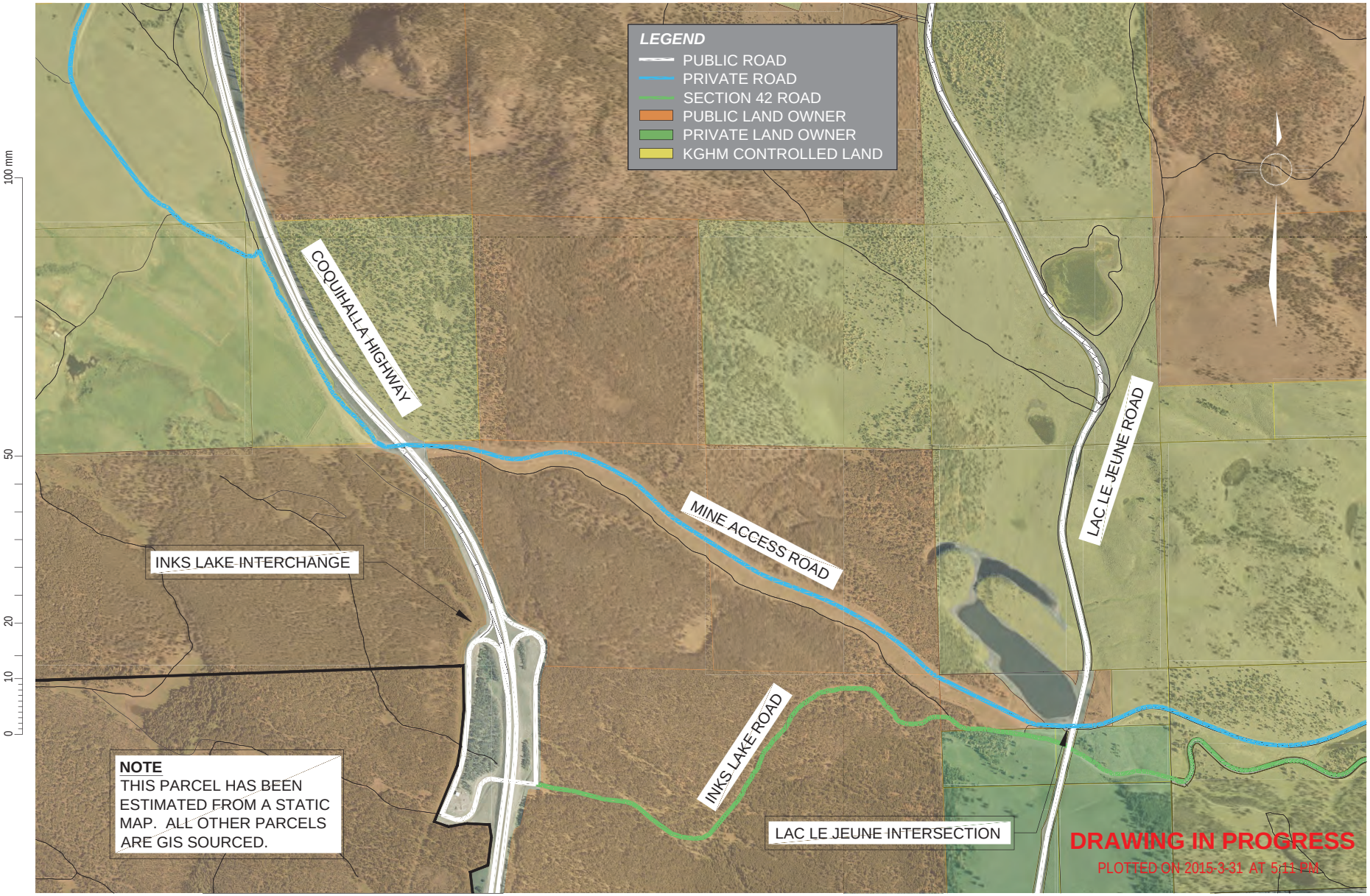
Alternatives considered for site access to the Project include upgrades to the existing Inks Lake Road interchange or a new interchange. Eight (8) options were identified (Appendix 17.4-F) and ranked based on technical and economic criteria; these included ease of access between the highway and mine facilities; lane balance and function (i.e., weaving, speed change lanes, ramp alignments and way finding); traffic operations (delays, level of service and queuing) and costs based on the length of new or rebuilt roadways, structure expansion and length of new lanes. Vehicle safety was also considered in this assessment.

In this assessment, options were screened out if they did not meet national design guidelines for design speed differences between the highway and the controlling curves on the ramps. Options were also excluded where considered challenging for complexity in way finding or there is undesirable merging and diverging on ramps, which is not favoured by MOTI. Options carried forward for assessment are:

- Option 1 – New (Diamond) Interchange includes new ramps connecting to the Mine Access Road (Figure 17.4-8)
- Option 2 – Full upgrade off the Inks Lake Interchange including new ramps and connectors to the Mine Access Road (Figure 17.4-9)

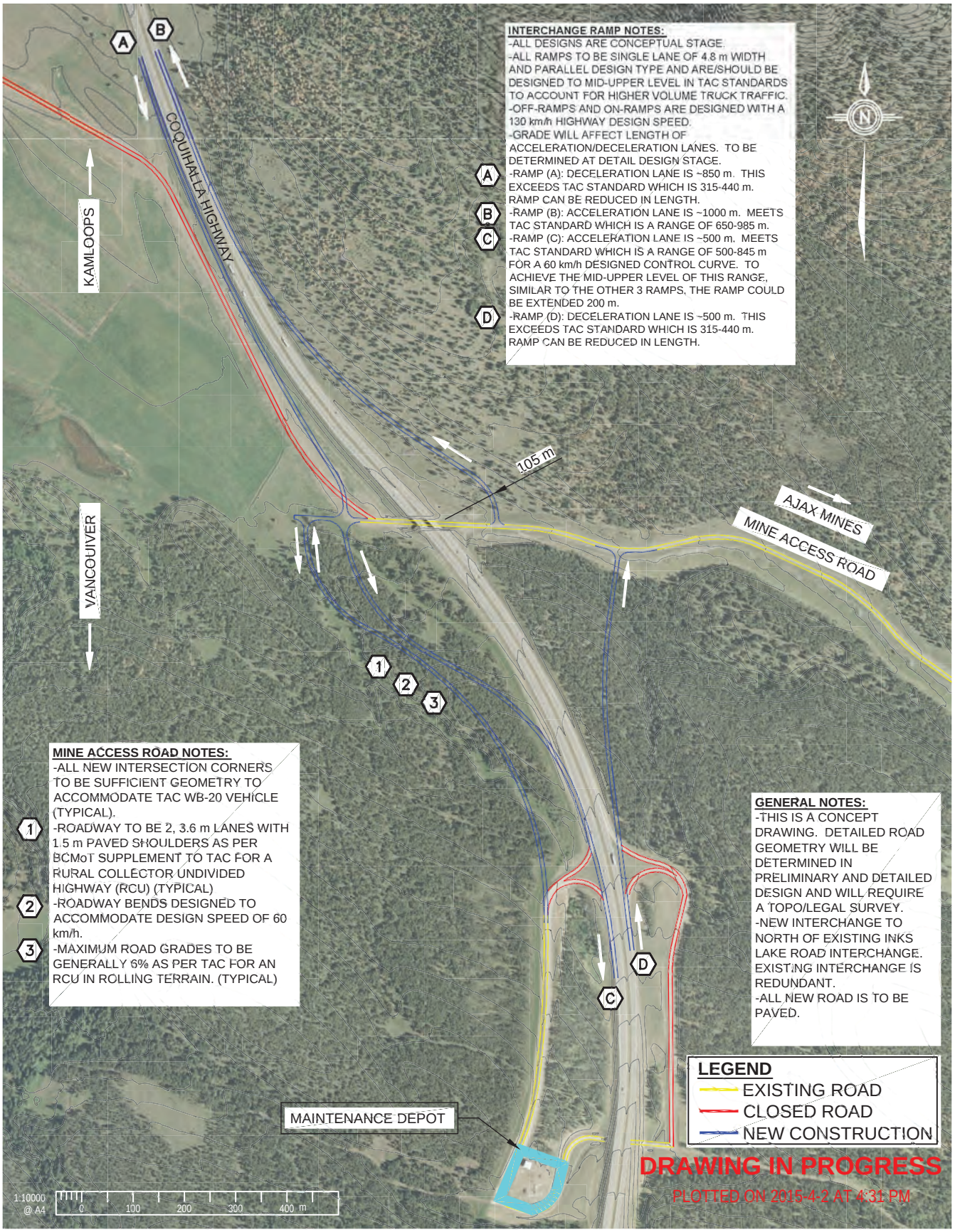
Figure 17.4-7

Existing Roads to the West of the Project



Source: Opus (2015).

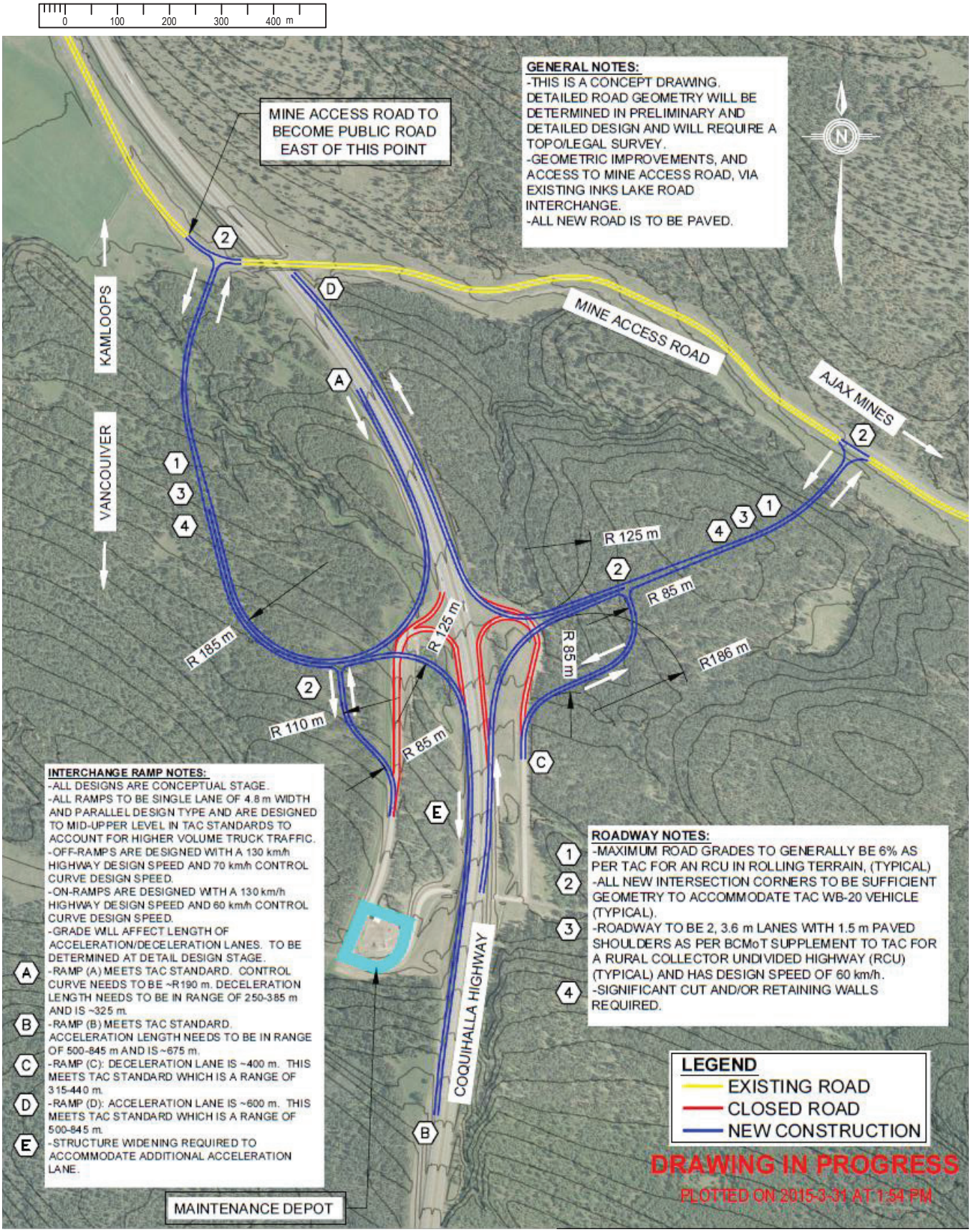
Figure 17.4-8
Option 1: New Interchange at Mine Access Road



Source: Opus (2015).

Figure 17.4-9

Option 2: Upgrade Inks Lake Interchange and Connections to Mine Access Road



Source: Opus (2015).

These options were scored overall highest for economic and technical criteria and are further assessed for natural and human environment acceptability.

From a natural environment perspective, using a new network of roads and a new access interchange would result in effects to previously undisturbed areas. Both options have similar footprint areas but for the new interchange, the ramps extend north and south of the interchange with the mine access road, whereas for the upgraded Inks Lake interchange the new ramps are all south of the mine access road. The area around the Inks Lake interchange does not contain any rare ecosystem or listed species but is considered winter range for deer (Appendix 6.8-A). The options are considered equivalent for environment performance objectives. Potential environmental effects associated with construction of roads include soil erosion and sedimentation of water courses from disturbed surfaces; these can be addressed through implementation of best management practices.

17.4.15 Explosives Supply Alternatives

Safety is considered the most important objective in terms of human environment acceptability. A new interchange (option 1) will provide better vehicle safety because all intersections are one-way and off ramps end in a stop control prior to intersection conflict points. In the upgraded interchange (option 2), there is potential for confusion between the two-way connector roads and one-way ramps potentially leading motorists to use the off ramp to access the highway in the wrong direction. Option 1 provides superior safety performance (Appendix 17.4-F).

Disturbance during construction such as increased noise emissions are considered equivalent for both options. Option 1 will close the mine access road to the west of the new interchange (Figure 17.4-8) as well as the existing ramps at Inks Lake interchange. The latter changes may inconvenience people using Inks Lake Road to access, for example, Jacko Lake. However, access will be provided via the upgraded mine access road. There will also be a longer route to the highway maintenance depot for option 1, but it has been suggested that it may be possible to relocate the maintenance depot and provide recreational parking at the current depot location.

17.4.15.1 Preferred Alternative

An all new interchange connecting the Project to the highway is the preferred option based on superior safety performance. The route does not use existing public roads and proposes new ramps connecting to an upgraded mine access road (Figure 17.4-8). Potential environmental effects will be short term during construction and mitigation measures would be implemented to minimize any impacts. The new road links would serve to improve connectively and improve highway safety and operations. Table 17.4-24 summarizes the natural and environmental performance objectives and the preferred option.

An all new interchange connecting to the highway to the mine access road is the preferred option.

Table 17.4-24. Environmental Acceptability of Highway Interchange Alternatives

Performance Objective	Option 1 - All new interchange	Option 2 – Full upgrade of Inks Lake Interchange
Natural Environment Acceptability	Similar footprint to option 2 but in previously undisturbed area for north ramp. No sensitive environments	Upgrade is in the same location as existing interchange. No sensitive environments
	Acceptable	Acceptable
Human Environment Acceptability	Considered safer because all intersections are one-way and off-ramps end in stop control.	Safe but possible confusion over highway connectors (two way) and ramps (one way)
	Acceptable	Challenging
Summary Ratings	Preferred	Acceptable

17.4.15.2 Introduction

Explosives are required for blasting during mine operations and potentially to a limited amount during construction. Mining operations require a relatively large quantity of explosives on a reliable, ongoing basis throughout the operational mine life. Potential alternatives considered an offsite explosive facility operated by a third party supplier, or explosives manufacture onsite. Two sites have been identified as alternatives for the onsite location: one between the Open Pit and EMRSF and the other off the haul road, approximately 4.5 km northwest of the Pit.

17.4.15.3 Assessment

Onsite manufacture of explosives or contracting to an offsite third party supplier of explosives are both accepted, standard practices in industry. An onsite facility has the advantage of supplying explosives, as needed, as mixing is carried out onsite. The Project has greater control on supply requirements and would not be dependent on a daily delivery of explosive supplies, which has the potential to be interrupted or delayed due to inclement weather.

From an economic performance objective, capital costs will be required to construct the onsite explosive storage and mixing area infrastructure. This would be offset by lower anticipated operating costs over the life of the Project compared to using a third party supplier.

From an environmental and human environment objective, using a third party supplier requires the transportation of prepared explosives to site. A higher risk is associated with this alternative due to the potential for accidental spills and releases during transportation. Onsite manufacturing results in a safer transportation method because the individual components are non-explosive materials and potential spills can be adequately managed by incorporating into the site management plans.

17.4.15.4 Preferred Alternative

For explosives manufacturing, the preferred alternative is onsite manufacturing. While higher capital costs are associated with constructing the explosive storage and mixing area infrastructure, operating costs are anticipated to be lower than for an offsite third party supplier. Greater control is

afforded to the site as explosive supplies can be prepared onsite, on an as needed basis. The preferred alternative has a safer transportation method because onsite manufacturing requires the transport of the individual components (non-explosive material) to site and any spills can be incorporated into the site management plans.

17.4.15.5 Explosives Facility (Magazine) Location

The siting of explosive facilities is prescribed by standard S05-01: the Quantity-Distance Principle (NRCan 1995), and depends in part on the location of other site facilities. The preferred location does not meet the standard for distance from mine infrastructure (about 150 m to Open Pit high wall) and may require a permit variance (Figure 17.4-2). The advantages of the preferred location include less transportation to the point of use therefore fewer disturbances to terrestrial habitat and dust generation compared to the location 4.5 km northwest of the Pit. The preferred option is within the mine's working area (i.e., behind the mine access gate) and therefore has the advantage of better security compared to a more remote location (Table 17.4-25).

Two potential locations have been identified for an explosives facility. The preferred location is between the Open Pit and EMRSF but this will require a permitting variance. Both locations are carried through to assessment in the Application/EIS.

Table 17.4-25. Performance Ratings for Explosives Facility Location Alternatives

Performance Objective	Location between Open Pit and EMRSF	Location 4.5 km Northwest of Pit
Technically Feasible	Proximity to mine infrastructure requires permit variation.	No permit variation required.
	Acceptable	Acceptable
Natural Environment Acceptability	Closer to point of use therefore less transportation. Less dust and disturbance to terrestrial habitat from shorter access road.	Requires longer road; more disturbance to terrestrial habitat and dust generation.
	Acceptable	Acceptable
Human Environment Acceptability	Better security as behind mine access gate. Disadvantage is proximity to the Open Pit (150 m).	Potentially less secure as more distant from mine operations.
	Acceptable	Acceptable
Overall Rating	Preferred	Acceptable

17.4.16 Blasting Schedule Alternatives

17.4.16.1 Introduction

Blasting of the ore and waste material within the Open Pit is required as the geologic material is too hard to allow ripping. Overburden materials will be removed using excavators. Through ongoing feasibility studies it has been determined that the blasting schedule will include:

- production blasting averaging once every two days but at times up to once per day to ensure efficient use of explosives to provide the desired fragmentation for mill feed; and

- adjusted blasting, in particular in the areas approaching Jacko Lake, to reduce potential adverse effects from vibration and increased air pressure.

In addition, assessment of controlled year round blasting and winter only blasting schedules were considered. Both alternatives are considered technically feasible but have different economic implications and potential environmental effects.

17.4.16.2 Economic Performance

From an economic performance objective, winter only blasting will increase the capital and operating expenses associated with providing a consistent mill feed for the Project due to the increased vehicle fleet needed to mine and transport the material and the need for a larger stockpile area. This would render many mining jobs seasonal in nature, which is undesirable. Operations would also be at risk of delays if winter conditions impeded access to the area.

17.4.16.3 Natural and Human Environment Performance

Blasting optimizes explosives use such that the ore material is broken to an appropriate size and volume. This optimization also considers resultant vibrations and air pressures such that the standard approach can be adjusted to meet operational needs and expected standards for the natural and human environment. Adjusted blasting is a deviation from the standard blasting approach near the Jacko Lake area to reduce adverse effects from vibration and overpressure on fish. Reducing the amount of explosives, using explosive decks and/or smaller diameter blast holes will be required to achieve these levels in Jacko Lake (Appendix 10.5-A).

Of the two blasting schedules considered, a controlled year round blasting schedule has the operational advantage of providing continuous feedstock to the mill. A winter only blasting schedule would reduce the risk of dusting on Jacko Lake and impact to fishing experience but would require a greater frequency of blasting/day and larger stockpiling of feedstock for the mill. Both alternatives will generate noise and vibration from mining activity (drilling and blasting) but the winter only blasting schedule will mean a greater frequency of noise generation per day over a shorter duration. Winter only blasting would potentially result in more dust because of atmospheric inversions that tend to trap low-level air. The winter blasting schedule is considered "unacceptable" from a human environment perspective.

17.4.16.4 Preferred Alternative

To meet economic performance objectives, year round blasting is the preferred alternative. Year round blasting allows for the efficient planning of blasting and stockpiling of feedstock for the mill. Winter only blasting would increase the capital and operating expenses associated requiring a larger stockpile of material and rated as "unacceptable". Winter only drilling and blasting would have a higher potential of increasing the Project footprint and a blasting schedule that results in a greater frequency of noise and sound generated per day, this is considered "challenging" for human environment acceptability, and is therefore overall rated as "unacceptable" (Table 17.4-26).

Table 17.4-26. Performance Ratings for Blasting Schedule Alternatives

Performance Objective	Year Round Blasting	Winter Only Blasting
Economic Feasibility	Less expense due to smaller vehicle fleet. Less schedule risks from winter conditions	Increased expense due to larger vehicle fleet. Schedule risks due to winter conditions
	Preferred	Challenging
Natural Environment Acceptability	Smaller stockpile area. Increased risk of dusting on Jacko Lake	Larger stockpile area. Reduced risk of dusting on Jacko Lake
	Acceptable	Acceptable
Human Environment Acceptability	Less frequent blasting. Consistent employment (no seasonal jobs).	Increased noise due to greater frequency of blasting. Potentially limits number / seasonality of jobs.
	Preferred	Unacceptable
Overall Rating	Preferred	Unacceptable

Standard production blasting with average daily frequency will be carried out to meet economic performance objectives; however, to meet environmental performance objectives, blasting adjustments will be made in proximity to Jacko Lake to protect fish. A ground vibration/air blast monitoring program will be implemented to ensure compliance within specified levels.

Year round blasting is the preferred option with an adjusted blasting approach around Jacko Lake.

17.4.17 Power Supply Alternatives

17.4.17.1 Introduction

The Project will require a power supply of up to 110 MW during construction and operations. Among the primary power demands of the Project, a large power draw will be required for in-pit rock handling equipment and for the mill processing plant grinding circuits.

A scoping study (energy trade-off study) was completed in 2014 to assess the power supply alternatives for the Project including supply from BC Hydro and alternative energy sources such as natural gas, wind and solar (Appendix 17.4-G). The primary reference used in assessing the options was BC Hydro's 2013 Integrated Resource Plan (IRP) which is a flexible long-term strategic plan to meet BC's growth in electricity demand over the next 20 years. The following alternative energy sources were considered:

- natural gas;
- diesel;
- geothermal;
- wind;
- solar;
- small hydro; and

- biomass.

The technical and economic feasibility of the power supply options is discussed below.

17.4.17.2 Technical and Economic Feasibility

BC Hydro

Due to its meshed transmission network and adequate generation resources, it is expected that BC Hydro would meet the mine's electricity requirements with a very high reliability level. The electric power could be supplied from BC Hydro's existing 230 kV transmission line (2L265), which is some 9 km east of the Project area. The line will be constructed within a corridor approximately 10 m wide from the tie-in location to the process plant along the eastern boundary of the Project. This Power Line will be constructed using single wooden poles although some H-frame structures will be required. The power supply will be stepped down to 25 kV at a substation adjacent to the plant for distribution to Project infrastructure.

Alternative Energy Sources

Most alternative energy power options are technically unsuitable as they provide intermittent power (for example when the sun shines or wind blows) and typically cannot be relied on to provide the required base load power supply for the Project. There are examples of alternative energy power in the mining sector; however this is often as a small, supplementary component of the overall base load power supply.

The findings of a study on potential new supply options are summarized below:

- Natural gas –This supply option could provide firm and backup power to the Project. It is also possible that it would only provide firm power and the BC Hydro grid would provide backup power, depending on the expected reliability level and economics. This option would increase the Project's atmospheric emissions, particularly CO_2.
- Diesel – Power supply using diesel generators has higher operating costs associated with the fuel costs, fuel delivery system and maintenance, making the option economically unsuitable to meet all of the Project needs. Use of diesel would increase atmospheric emissions but could be considered as backup power.
- Geothermal – Although a geothermal power plant can provide continuous supply to its electricity consumers, the total estimated resources available in the region are very limited (only some 20 MW). If a potential power plant site is relatively far away from the Project, a transmission or distribution line would also be required, which may not be cost effective.
- Wind – There are adequate wind resources and there are likely to be suitable wind power plant sites in the region to provide the peak electricity demand of the Project. However, due to its intermittent nature, wind power plants alone could not meet the electricity requirements of the mine. It must be backed up by other firm on-site generation, BC Hydro grid, energy storage plant, or a combination of these technologies;

- Solar – There are adequate solar resources and there are likely to be suitable solar power plant sites in the region to provide the peak electricity demand of the Project. As solar power could only be generated during day time and the output from a solar power plant is dependent upon sunlight being available, solar PV power plants alone could not meet the electricity requirement of the mine. It must be backed up by other firm on-site generation, BC Hydro grid, energy storage plant, or a combination of these technologies.
- Biomass – A biomass power plant can provide continuous electricity supply to its consumers. The supply of biomass resources available in the region could only meet the fuel requirement of a power plant with an installed capacity of some 60 MW.
- Small hydro – The potential small hydro resources in the region could supply the peak electricity demand of the Project, however, because the power output depends on the water flow, small hydro plants could not meet the continuous supply requirement of the mine without energy storage plants. The location of the small hydro plants is important as a transmission would have an impact on the economics of supply.

Alternative energies are generally technically unfeasible because they cannot deliver the power needs for the Project; they have a greater risk for power disruption due to the intermittent nature of alternative power supplies are ranked "unacceptable". Alternative energies that have high costs per megawatt hour (MWh) are ranked "unacceptable"; however if there is potential for the power source to provide backup supply at a moderate cost they are ranked "acceptable" (Table 17.4-27).

Natural Gas Phase 2 Study

The results of the scoping study concluded that grid supply would be the most economical way to provide the project's power requirements. The study identified a natural gas fired Combined Cycle Gas Turbine (CCGT) power plant as the second ranked option. In view of this, KAM proceeded with a more detailed assessment of the CCGT option (Appendix 17.4-G).

A gas turbine generator is a type of internal combustion engine and there are two main types: aero-derivative and industrial combustion turbines. A CCGT Power Plant requires addition of a heat recovery steam generator (HRSG) to the back-end of the gas turbine (GT) to capture the high grade heat from the gas turbine exhaust gas. Steam generated in the HRSG is used to drive a steam turbine generator (STG) to produce additional electricity.

A water cooling tower with freshwater makeup is required. The cooling tower and air-cooled condenser can be a significant source of noise. A design feature in order to mitigate and reduce noise to acceptable levels is required with some engineering design and increase in the capital cost but was not included in the capital cost estimates.

Table 17.4-27. Technical and Economic Feasibility Ratings for Power Supply Alternatives

Assessment Criteria	BC Hydro[2]	Power Supply Alternatives						
		Natural Gas	Diesel Gas	Geothermal	Wind	Solar	Biomass	Small Hydro
Technical Feasibility	Could be supplied; consistent and reliable	Could provide adequate power to meet Project needs or as backup	Could not provide all Project needs but could be used to provide backup power	Limited regional resource (20 MW)	Intermittent supply and could not meet Project needs	Photovoltaics cannot meet Project needs	Limited regional resource (60 MW)	Intermittent supply and cannot meet Project needs
	Acceptable	Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Economic Feasibility[1]	Lowest Cost $35/ MWh	Moderate Cost $58-$92/MWh	Moderate Cost use for backup power	High Cost $141/MWh	High Cost $122-$164/MWh Firming supply by using energy storage or BC Hydro would increase cost.	Very High Cost $290/MWh	High Cost $141/MWh	High Cost $97-$494/MWh Firming supply by using energy storage or BC Hydro would increase cost.
	Preferred	Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Overall Rating	Preferred	Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable

[1] *Costs from BC Hydro 2013 IRP and support document. Costs calculated to point of delivery without consideration of firming requirement.*
[2] *Wardrop, 2011.*

Gas turbines are one of the cleanest types of commercially available fossil-fuelled power generation equipment. The primary emissions from gas turbine engines are nitrogen oxides (NO_x) and carbon dioxide (CO_2). Carbon monoxide and volatile organic compounds (VOCs) are also produced albeit in smaller amounts. Nitrogen oxide formation is strongly dependent on the high temperatures developed in the combustor. Carbon monoxide and VOC are primarily the result of incomplete combustion. The operating load also has a significant effect on the primary pollutant generation. Each turbine supplier generally has a technology for controlling the emissions as part of the combustion process with the fuel-air ratio or with water or steam injection. Present gas turbine technologies will allow the emissions to remain within acceptable limits (IFC emission guideline) from full load to a designated part load condition of approximately 50 -55 % of the rated output for a single machine.

The Phase 2 study assumed an average annual availability of approximately 94%. During planned or forced outages when the power generation from the onsite power plant is not sufficient, it was assumed that the power supply from the electrical grid could be used to meet the project power demands (and that the electrical grid has 100% availability to supply power to the Project, if needed). A number of configurations were considered that included different power demands (165 MW and 110 MW) and one or more GTs and HRSGs. The footprint area of the power plants is from 3.5 ha to 5.8 ha depending on the configuration.

Total costs of a 110 MW load demand for three different scenarios were estimated:

- BC Hydro grid supply only: $502 Million;
- Self-generation using natural gas fired CCGT for base load and backed up by BC Hydro grid - $747 Million, and;
- Self-generation using natural gas fired CCGT for base load and natural gas fired gas turbines for standby/backup - $795 Million

The natural and human environment performance indicators are considered below.

17.4.17.3 Natural and Human Environment Acceptability

Natural gas power generation will have air quality effects resulting from the combustion of natural gas, however, these effects can be mitigated with add on pollution control technology to reduce emissions. The source of power for BC Hydro is predominantly hydropower which does not have the air quality effects of natural gas power generation. Although the cleanest means of fossil-fuel power generation, greenhouse gas (GHG) emissions would be considerable. Air quality impacts from the transmission line alternative will be minimal and limited predominantly to dust generation from the use of equipment during the construction phase. There will be noise emissions from the cooling towers and condenser of the natural gas power plant but these can be readily mitigated although it will increase the cost. There is no significant noise effect associated with the grid connection.

The natural gas power plant will require freshwater make-up for cooling whereas the grid supply will have limited water demand. The natural gas power plant will have a footprint of approximately 5 ha compared to less than 1 ha for a sub-station for the grid supply. Both options require a utility corridor for road and transmission line / pipeline from closest source and are expected to have an

equivalent footprint. Terrestrial habitat impacts from the utility corridor can be minimized by optimizing the route length to limit the amount of vegetation clearing required.

Diesel power generation will have air quality and noise impacts resulting from the combustion of diesel fuel and the delivery of fuel to the site. However, the effects from these can be minimized with reasonable mitigation such as engineered-controls to reduce emissions (Table 17.4-28).

Table 17.4-28. Environmental Acceptability Ratings for Power Supply Alternatives

Performance Objective	Connection to BC Hydro	Natural Gas Fired Power Plant	Diesel Generators
Natural Environment Acceptability	Very low air emissions with effects limited to construction of transmission line; can be minimized with standard mitigation. Less than 1 hectare footprint excluding transmission line	Freshwater make-up for cooling tower. Air emissions (including GHG) but effects can be mitigated with reasonable mitigation. Five hectare footprint excluding pipeline corridor.	Air emissions (including GHG) but effects can be mitigated with reasonable mitigation
	Preferred	Acceptable	Acceptable
Human Environment Acceptability	Disturbance during construction of transmission line but effects can be minimized with standard mitigation.	Increased air emissions and noise from gas turbines and cooling towers but effects can be minimized with reasonable mitigation.	Increased air emissions and noise from generators but effects can be minimized with reasonable mitigation
	Preferred	Acceptable	Acceptable
Overall Rating	Preferred	Acceptable	Acceptable

17.4.17.4 Preferred Alternative

The use of on-site power generation using natural gas or diesel has increased air, noise emissions, GHG and water demand in the case of a natural gas generator. However these can be minimized with reasonable mitigation (e.g. engineering controls) and are ranked as "acceptable" particularly as they would be used on an intermittent basis for backup power supply. Construction of a gas pipeline will create disturbance including vegetation clearance, road construction and pipeline excavation. However, impacts to terrestrial habitat can be mitigated by optimizing the route to minimize the amount of clearing required and implementing best management practices in construction.

The Project site is not remotely located and has a nearby connection point to the existing BC Hydro grid network. The Project site is located in an area with sufficient electrical capacity and a short transmission line would provide a reliable, proven technology with relatively stable prices The BC Hydro grid has minimal environmental impacts related to construction activities. From an economic and environmental standpoint, connection to the local BC Hydro grid is the "preferred alternative".

A transmission line connection to the existing BC Hydro grid is the preferred option to provide the Project. Backup power will be provided by diesel or natural gas generators.

17.4.18 Transmission Line and Gas Pipeline Alternatives

The transmission line corridor will connect from a-BC Hydro sub-station, approximately 9 km to the east of the Project area, to the plant site using overhead cables on wooden poles. The transmission line route follows property boundaries to complete the shortest distance to reach the Project (Figure 17.4-10). The transmission line has been routed in an effort to minimize the amount of property crossings. The transmission line will be constructed within a disturbance corridor of approximately 10 m wide. Alternatives to this routing were considered, but were rapidly determined to be unviable due to topographic and property boundary constraints.

The natural gas pipeline would connect with the existing Fortis pipeline in the community of Knutsford to the east of the Project area. The buried pipeline is proposed to initially be routed to the north to the transmission line corridor and then follow this corridor to the Project boundary. The pipeline will deviate from the transmission line corridor within the Project area and follow a westerly route before crossing Peterson Creek and connect to the plant via an alignment parallel to the plant access road and conveyor. The pipeline would have a similar corridor width as the transmission line.

Post-closure, the transmission line would be removed and the right of way reclaimed through natural vegetation growth. The natural gas pipeline would be-decommissioned as per direction from Fortis BC.

The most direct route to nearby electrical grid / gas pipeline that avoids population centres is preferred.

Figure 17.4-10
Natural Gas Line and Transmission Line Corridor

ERM



NOTES:
1. BASE MAP: Orthophoto (2005)
2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:30,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - BRITISH COLUMBIA AND CANADA

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KGHM Ajax Mining Inc.

2015 June 30			
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17.5 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

17.5.1 Introduction

This chapter assesses the potential for the environment to affect the Ajax Project (the Project), a proposed open pit copper-gold mine located at the historic Afton Mining Camp, south-west of the City of Kamloops, British Columbia (BC). This chapter provides an assessment consistent with section 2(1) of the *Canadian Environmental Assessment Act* (CEAA; 1992) which describes environmental effects in subsection (c) as "any change to the project that may be caused by the environment."

In accordance with CEAA 1992 and the Project Application Information Requirements (AIR; BC EAO 2015), the following topics are considered in this assessment:

- extreme weather events, including:
  - lightning,
  - heavy precipitation,
  - extreme temperatures,
  - flooding and drought,
  - wind,
- fires;
- geophysical events, including:
  - natural seismic events and associated effects such as liquefaction and subsidence;
  - slope stability and mass wasting events; and
- climate change.

17.5.2 Climate and Meteorology

17.5.2.1 Climate

Extreme weather events occur in many forms, including windstorms, thunderstorms, and heavy precipitation. Of the extreme weather events likely to occur in the future, this section focuses on heavy precipitation (also referred to as intense or extreme precipitation). Heavy precipitation occurs as a consequence of the variability in weather conditions. Weather refers to atmospheric conditions on time scales ranging from days to weeks, whereas climate refers to longer-term atmospheric conditions. Long-term climatic conditions are important to consider in the context of extreme weather events, since future variability is expected to change as a consequence of climate change.

This section provides a brief description of factors controlling weather and climate in the region, including drivers affecting large-scale natural climate variability. The concept of future climate variability and extremes is then presented in Section 17.7. A discussion on heavy precipitation will explain trends and projections reported in the literature, as well as those obtained for the Project area. Possible effects from heavy precipitation on various mine infrastructure components will follow, along with mitigation measures.

Regional Climate

The climate of the Thompson region is continental with strong seasonal variations. The chief characteristic is the cold winter, liable to intense cold when continental polar air moves in from the north. Springs are mild, with large precipitation events in May and June. While summers are reasonably long and hot, snow generally accumulates as early as late October, peaking in February with melting occurring up to April.

The topography of the region plays a large role in the region's climate and contributes to local variations in climate patterns. Climate elements such as temperature, precipitation, snow depth and wind show significant variations with elevation. The region is frequently influenced by moist air from the Pacific, as well as drier continental air masses.

The Project is located in the Central Interior between the Southern Coast Mountains and the Northern Columbia Mountains, southwest of Kamloops, BC. The Project lies within the Fraser Plateau hydrologic zone (BC MoE 1998). This zone is demarcated by hot dry summers and cold winters.

As air masses migrate over the Coast Mountains, much of the moisture in these air masses condenses out, creating a semi-arid climate on the lee side of the Coast Mountains. As such, precipitation increases with elevation due to moisture-laden air moving up slope; as the air rises it cools and is less capable of holding moisture and may release it as rain or snow. However, complexities of topography and air movement create a high degree of spatial and temporal variability in precipitation.

Regional Climatic Variability

The winter climate of the region is affected by the strength of the Aleutian Low, which is a low-pressure cell that forms in winter over the North Pacific Ocean and Aleutian Islands. The Aleutian Low migrates spatially along the coast of BC and Alaska and it advects warm, moisture-laden air into the jet stream. The strength of the Aleutian Low is directly linked to the phase and strength of the Pacific Decadal Oscillation (PDO).

The PDO is a measure of the difference in sea level pressure between the Aleutian Low and the Hawaiian High pressure cell (Mantua et al. 1997). The PDO is characterized by positive phases (1925 to 1946, 1977 to 2005) and negative phases (1947 to 1976, 2005 to present). The phase and strength of the PDO have been shown to influence changes in river flow, glacial mass balance, and salmon abundance throughout Oregon, BC, and Alaska (Dettinger et al. 1993; Mantua et al. 1997; Hodge et al. 1998; Bitz and Battisti 1999; Gedalof and Smith 2001; Neal, Walter, and Coffeen 2002).

The PDO was in a negative phase from approximately 1942 to 1977, and then transitioned to a positive phase from approximately 1977 to 2005, when it transitioned back to a negative phase and has remained in this phase until present. The specific phase of the PDO has been demonstrated to have a moderating effect on the strength and state of the El Niño Southern Oscillation (ENSO). In practice, during a positive phase of the PDO there is a greater propensity of El Niño events to occur. Conversely, during a negative phase of the PDO there is a greater propensity of La Niña events. This temporal clustering of El Niño (positive PDO phase; 1925 to 1946, 1977 to 2005) and La Niña (negative PDO phase; 1946 to 1976, 2005 to present) events has substantial effects on regional hydroclimatology.

The ENSO phenomenon is a measure of difference in sea surface temperatures (SSTs) between northern Australia and the coastal upwelling zone off western Ecuador. The significance of this phenomenon is that the SST anomalies generated by ENSO migrate from the equator up the west coast of North America and eventually pool off the coast of BC and Alaska. These SST anomalies are spatially expansive and, off the coast of northern BC, reside directly below the Aleutian Low. As such, warm (El Niño) phases of ENSO result in above-average SST off the north coast of BC, which then result in greater advection, and therefore more moisture-laden air masses rising into the Aleutian Low pressure cell and then into the jet stream to be transported inland.

The significance of the PDO and ENSO for the Project area is how each affects air temperature, precipitation, and streamflow. For example, since positive phases of the PDO tend to result in clustered El Niño events, it can be expected that the extreme events commensurate with El Niños will also be clustered during positive phases of the PDO. Similarly, since negative phases of the PDO tend to result in clustered La Niña events, it can then also be expected that extreme events commensurate with La Niñas will also be clustered during negative phases of the PDO. This was evidenced during the last positive phases of the PDO (1977 to 2005), and specifically in the 1980s and 1990s when numerous clustered El Niño events were responsible for extreme precipitation events including both rainfall and snowfall. These events closed ski resorts, flooded out communities and highways, and shut down schools.

Local Climate

Elevation at the proposed Project site ranges from 800 to 1,100 metres above sea level (masl). In August 2010, the AJAXMET climate station was installed by Knight Piésold Ltd. at an elevation of 950 masl. Prior to that in 2006, Golder Associates installed the Goldmet Climate station near the Project Mine Site at an elevation of 940 masl. However, data from Goldmet station was not used other than to fill data gaps in the AJAXMET station data. Details of the AJAXMET meteorological station's sensors and site layout are provided in the 2014 Climatology Report (Knight Piésold 2012, 2014a).

In addition to the AJAXMET station which has been collecting data since 2010, a further meteorological station was added to the Project in 2014 (AJAXAQ-1) at the proposed TSF at an elevation of 1,050 masl. Data from this station have not been used in this chapter as it does not contain a full year of data at this point. Details of the AJAXAQ-1 meteorological station and sensors can be found in the 2014 Climatology Report (Knight Piésold 2014a).

In the following sections, local climate is summarized using data from three sources.

- **The on-site AJAXMET and Goldmet climate stations**. These data provide site-specific information since 2006.

- **The computer program ClimateWNA**. ClimateWNA provides 30-year "climate normal[1]" data for western North America on a 2.5 by 2.5 arcminute grid. ClimateWNA data are interpolated and adjusted for elevation effects based on gridded climatic datasets (from the Climate Research Unit and Global Historical Climatology Network; Wang et al. 2006; Wang et al. 2012).
- **Climate data from regional meteorological stations**. These data are used here to assess air temperature and precipitation extremes from stations close to the Project area. Data from these stations are also summarized in the hydrometeorology baseline report (Knight Piésold 2012, 2014a).

17.5.2.2 Precipitation

Typical Precipitation

Precipitation data were recorded on site from 2010 to present at the AJAXMET Station. Analysis conducted using data collected at the AJAXMET Station and at Kamloops Airport was used to determine long-term estimates for mean annual precipitation for the Project. The mean annual precipitation for the Project area is estimated to be 336 millimetres (mm). Approximately 70% of annual precipitation falls as rain (235 mm) and 30% as snow, with a snow water equivalent, i.e., the amount of water contained within the snowpack, of 101 mm. Precipitation occurs throughout the year, although the largest precipitation events occur in June and July within the Project area, due to convective storm activity (Table 17.5-1) (Knight Piésold 2012, 2014a).

The Canadian climate normals represent average climate variables (air temperature, precipitation, etc.) over a period of three decades for many cities across Canada. At the end of each decade the Canadian government updates the climate normals and provides online access for public use. ClimateWNA[2] is a web-interface software tool developed by the University of British Columbia to provide online mapping tools for climate data. ClimateWNA uses the climate normal datasets (1961 to 1990, 1971 to 2000, and 1981 to 2010) and provides spatially explicit interpolation for any point in BC.

Annual precipitation extracted from ClimateWNA for the 1981 to 2010 climate normal period predicts that 410 mm of precipitation is expected at the Project site (915 masl). Annual precipitation for the 1981 to 2010 climate normal period ranged from 277.6 mm to 505.1 mm at the Kamloops Airport and Red Lake climate stations, respectively (Table 17.5-1). ClimateWNA predicts that 21% of the total annual precipitation falls as snow at the Project site.

Typical intensity, duration, and frequency of precipitation events in the Project area are low, and will not have substantial effects on Project infrastructure in the short- to medium-term, i.e., during the active life of the mine. However, over longer time periods, and in the absence of proper maintenance, the cumulative effects from "typical" precipitation events could cause erosion of roadways, sedimentation in drainage lines, and flooding of ditches and roadways. Access to and from the Project site, and utility delivery, could be affected.

[1] Figures derived from the observations of meteorological data calculated from the average over a 30-year period.
[2] http://climatewna.com/

Table 17.5-1. Ajax Project Regional and Project Precipitation Values (mm)

Month	Project Site (AJAXMET) Long Term Estimate (2010-2014) (950 masl)	50°36′ N, -120°24 W Climate Normal - ClimateWNA (1981-2010) (915 masl)	Kamloops Airport Climate Normal (1981-2010) (345 masl)	Criss Creek Climate Normal (1981-2010) (1,122 masl)	Red Lake Climate Normal (1981-2010) (1,162 masl)
Jan	23.4	30	21.1	30.8	35.5
Feb	14.5	18	12.4	17.7	23.5
Mar	11.9	18	12.8	26.7	31.5
Apr	19.2	25	14.2	31.7	37.9
May	32.8	44	27.3	50.2	50.1
Jun	43.4	56	37.4	68.5	69.9
Jul	42.4	49	31.4	52	51.5
Aug	32.0	33	23.7	46.2	41.3
Sep	35.8	42	29.4	34.7	38.8
Oct	15.5	25	19.4	34.1	35.5
Nov	28.0	34	23.3	39	43.3
Dec	37.0	36	25.4	38.6	46.3
Annual Total	**336**	**410**	**277.6**	**470.2**	**505.1**

Extreme Precipitation

Many studies suggest, on a theoretical basis, that increases in mean global temperature should lead to increases in precipitation intensity (i.e., heavier or more extreme) (Cubash and Meehl 2001; Allen and Ingram 2002). A warmer atmosphere can hold more moisture, resulting in a more energetic system. This means that in regions where precipitation occurs, the potential would exist for more precipitation to fall during any given event. This process is summarized as the intensification of the global hydrologic cycle (Douville et al. 2002).

Concurrent with gradual global warming, the historical record reveals an increase in mean and extreme precipitation across many regions nationally and globally. For the period of 1910 to 2001 in BC, total annual precipitation increased by 7.2%. At the same time, heavy precipitation events increased by 16% around the world (Groisman et al. 2005). For the Project, heavy precipitation was defined by the threshold depth of the top 5% of all observed events, or 26 mm. The increases in observed total and heavy precipitation were linked to precipitation changes simulated by Global Circulation Models (GCMs) for overlapping time periods. Given that GCMs incorporate the intensification of the hydrologic cycle, GCMs may be useful tools for predicting future changes in heavy precipitation for the Project area.

Heavy precipitation measured at regional meteorological stations can provide insight into the expected precipitation extremes. Nearby weather stations with records sufficiently long for 30-year climate normals are included in Tables 17.5-1 and 17.5-4. Extremes of precipitation and air temperature data are available for these sites (Environment Canada 2014) over a longer period of time than the climate normal data and are provided in Tables 17.5-2 and 17.5-5 respectively. Extreme high-magnitude rainfall and snowfall events, represented by the threshold depth of the top 5% of all observed events as described above, do not occur frequently in this region, although moderate storms occur frequently. For the Project, a 1:2 year return period 24-hour precipitation event was determined to be 27.6 mm. Estimated extreme 24-hour precipitation events include 43 mm (1:10), 51 mm (1:25) and 69 mm (1:200) storm events. The probable maximum precipitation is estimated to be 221 mm over 24 hours (Knight Piésold Ltd. 2014a).

Table 17.5-2. Ajax Project Regional Extreme Daily Precipitation Values (mm)

	Kamloops Airport (1953-2014) (345 masl)	Criss Creek (1988-2014) (1,122 masl)	Red Lake (1974-2014) (1,162 masl)
Extreme Rainfall (mm)	48	42.8	40.5
Date	16-Aug-76	22-Jul-00	5-Jun-04
Extreme Snowfall (cm)	33.8	31.4	31
Date	7-Jan-62	22-Apr-92	29-Jan-04

Effects of Heavy Precipitation on the Project (Flooding)

High-magnitude rain and snow events are infrequent in the Project area. However, severe rainstorms in Project catchments could trigger flooding events, especially if they coincide with periods of peak snowmelt. Precipitation-related (flood) effects could include damage to buildings, site infrastructure, and the access roads, in addition to inundation of the open pit.

Containment Structures

Extreme precipitation could cause overtopping of containment structures such as the tailings storage facility (TSF), sediment control ponds, and seepage collection ponds. Containment structures will be designed to appropriate engineering design flows. For example, a culvert may be designed to 1:100 year 24-hr precipitation events, while the TSF will be designed to a higher return period such as the 1:200 year 24-hr precipitation event, or the probable maximum precipitation (PMP) for a 24-hr event. Emergency procedures will be developed for events when infrastructure design flows are exceeded, or in the worst-case scenario, when catastrophic failure of impoundment embankments occurs.

Buildings and Infrastructure

Increased precipitation in solid forms, such as sleet or hail, may damage building roofs, cause temporary blockages in diversion channels and create unsafe working conditions. Extreme, or sustained, rainfall could include erosion of diversion or containment structures, stream channels, bridge footings and drainage infrastructure, and undermining of the foundations of buildings and pads. Construction design criteria will vary with infrastructure and be sufficient to withstand extreme precipitation events. For example, culverts may have design flows equivalent to the

1:100 year precipitation event; whereas, the TSF will use a more conservative design flow such as the 24-hr PMP along with the 1:100 year snowpack.

Roads

Extreme precipitation events can reduce visibility, increasing travel hazards during storms. Greater potential for large snowfall amounts during the winter could result in periods of high snow accumulation on roads. Heavy precipitation events could lead to road damage and/or erosion. Increased maintenance could be required to access various Project locations in winter and maintain road integrity. The design criteria for roads will vary with the frequency of use of the roads. Appropriate standards and regulations will be followed for road design (MoF 2002; APEG 2012) to ensure road design and drainage systems are sufficient to accommodate extreme precipitation events.

Effects of Low Precipitation on the Project (Drought)

Effects of low precipitation are much more likely in the Project area as compared to heavy precipitation. Low precipitation generally manifests as low streamflow (Section 17.3.3). Prolonged periods of low precipitation could also increase the risk of wildfires (Section 17.5) and reduce available water for processing plant operational needs.

Mitigation Measures

Precipitation-related risks to the Project and consequent mitigation measures are presented in Table 17.5-3 and discussed in detail in Section 17.2.2, Flooding and Drought. Mitigation measures for the effects of low precipitation, and therefore low streamflow, on the Project are also addressed in Section 17.2.2.

Containment Structures

Increasing the design flow criteria is the easiest but most costly way to mitigate against extreme precipitation events. In lieu of increased design flow, the most effective method to mitigate against extreme precipitation events is to have a purpose-designed plan in place that includes clear communication of the steps involved. For example, overtopping of a containment structure is not problematic when the downstream catchment, routing and containment structures are sufficient to deal with this increased capacity and personnel understand the steps required to maximize the free board across all containment structures. The Natural Hazards Management Plan in Section 11.15 of the Application for an Environmental Assessment Certificate/Environment Impact Statement addresses floods, inter alia, and will provide the required specifications for the management of containment structures. The TSF will also be designed, constructed, operated, closed and reclaimed according to the Canadian Dam Association's (CDA) Dam Safety Guidelines (Canadian Dam Association 2007 (Revised 2013)).

Buildings and Infrastructure

Roadways will be cleared during or after snow events, and will be repaired and maintained on a continuous basis as needed. Ditches and culverts will be cleared of debris and monitored. Snow should be shovelled off roofs after heavy snowfalls to prevent roof collapse from excessive loads. Buildings will be constructed to withstand periods of heavy precipitation.

Table 17.5-3. Precipitation-related Risks and Mitigation Measures

Project Component	Area Affected	Risks to Project	Mitigation Measures	Likelihood	Severity
Transportation	Road surface, ditches, culverts and diversions	Infrastructure effects: erosion, sedimentation, flooding.	Maintenance of drainage and crossing structures	High	Low
		Access effects: reduced access to Project site due to downed trees, snow drifts, damaged roads.	Snow clearing, roadway repair, ditch and culvert clearing	High	Low
Site Infrastructure	Containment Structures	Overtopping of containment structures or catastrophic failure of TSF embankment.	Use appropriate design flows, building code and / or regulations	Low	Low
	Buildings, stockpiles, processing plant, equipment and fuel storage facilities, explosive storage facilities, overburden and soil storage areas, sedimentation pond(s), sewage treatment and disposal facilities, truck wash, waste rock management facility	Flooding, erosion and sedimentation, snow loading. Leading to damage of infrastructure and reduced mine productivity.	Flooding and drought-related mitigation measures are discussed in Section 17.3	Low	Medium
	Transmission line	Erosion at footings, damage due to downed trees, leading to reduced mine productivity.	Periodic monitoring and repair as needed.	Low	Low

Contingency Plans

Although the mitigation measures above will significantly reduce the risk of extreme precipitation on the Project, it is possible that such an event may occur within the life cycle of the Project. In this case, the Emergency Response Plan (Section 11.16), and the management measures it contains, will be followed. Within this plan, when extreme precipitation presents health and safety concerns, the situation will qualify as an emergency, the risk will be assessed, and activities modified or curtailed as appropriate. The Emergency Response Plan will also outline procedures, communications protocols, and responsible personnel in the case of an extreme precipitation incident.

17.5.2.3 Air Temperatures

Long-term estimates of temperature were determined for the Project site based on data collected at the AJAXMET climate station between 2010 and 2014, and concurrent regional data. Long-term mean annual temperature for the Project was determined to be 6.4°C. The coldest months were December and January, with the mean monthly air temperatures of -4.9°C and -4.5°C, respectively.

The warmest months were July and August, when the mean monthly air temperatures were 18.7ºC and 17.8ºC, respectively (Knight Piésold Ltd. 2012, 2014a).

Typical Air Temperature

Climate normal air temperature data extracted from ClimateWNA for the Project site suggest that mean annual air temperature in the Project site is 5.8ºC, based on the 1981 to 2010 and 1961 to 1990 climate normal datasets.

Local and regional air temperature has historically been collected at several locations surrounding the Project site. These regional weather stations include Kamloops Airport (7 km to the north), Red Lake (41 km to the northwest) and Criss Creek (45 km to the northwest). Table 17.5-4 provides a monthly summary of air temperature measured at these regional weather stations as well as at the AJAXMET Project station.

Table 17.5-4. Ajax Project Regional and Project Air Temperature Values (ºC)

Month	Project site (AJAXMET) Long-Term Estimate (2010-2014) (950 masl)	Kamloops Airport Climate Normal (1981-2010) (345 masl)	Criss Creek Climate Normal (1981-2010) (1,122 masl)	Red Lake Climate Normal (1981-2010) (1,162 masl)
Jan	-4.5	-2.8	-7.5	-6.3
Feb	-2.4	0.1	-5.2	-4.1
Mar	1.5	5.2	-1.4	-0.2
Apr	6.5	9.9	3.7	4.6
May	11.1	15.0	8.0	9.0
Jun	14.7	18.0	11.0	13.0
Jul	18.7	22.0	14.0	16.0
Aug	17.8	21.0	13.0	15.0
Sep	12.9	16.0	9.0	11.0
Oct	5.6	8.5	3.4	4.5
Nov	-0.1	2.1	-3.0	-2.8
Dec	-4.9	-2.7	-7.2	-6.1
Average	6.4	9.3	3.2	4.3
Max	18.7	22.0	14.0	16.0
Min	-4.9	-2.8	-7.5	-6.3

Extreme Air Temperature

Long-term data from nearby regional weather stations reveal a wide range between extreme warm and extreme cold air temperatures. Air temperatures as warm as 40.6ºC, and as cold as -41ºC, have been recorded near the Project area (Table 17.5-5). The potential for extremes in cold and warmth is characteristic of the continental interior climate of the Project site.

Table 17.5-5. Ajax Project Regional Extreme Air Temperature Values (°C)

	Kamloops Airport (1953-2014) (345 masl)	Criss Creek (1988-2014) (1,122 masl)	Red Lake (1974-2014) (1,162 masl)
Extreme Maximum (°C)	40.6	33.0	35.0
Date	31-Jul-71	24-Jul-94	27-Jul-98
Extreme Minimum (°C)	-37.2	-41.0	-37.5
Date	29-Jan-69	20-Dec-94	27-Nov-85

Note: years represent full extent of data available from station.

Given the climatic setting of the Project site, effects on the Project might be expected from both extreme cold and extreme warm air temperature. These extreme temperatures may affect workers, infrastructure, or machinery.

Freeze-Thaw Cycles

At high elevations in BC (over 1,000 masl), freeze-thaw is likely a concern in spring, summer, and fall; at lower elevations in BC (under 1,000 masl), freeze-thaw is more of a concern in the spring, fall, and winter. The Project site is located in the range of 800 to 1,100 masl. Freeze-thaw cycles are a causal factor of cracked pavement and road surfaces, and can cause damage to power and transmission lines, if left unchecked.

Effects of Extreme Cold on the Project

- Extreme low air temperatures could adversely affect workers' health, causing frostbite and hypothermia. Workers can become distracted and prone to accidents under extreme low temperatures.
- Equipment and machinery is more likely to malfunction or become damaged during extreme low temperatures, increasing the potential for worker-related exposure and accidents. Extreme low temperatures may be accompanied by blowing snow, which could affect surface transport of materials and personnel, and could temporarily slow mine operations.
- Increased heating requirements on site would result from extreme low temperatures, increasing power demands.
- Extended cold temperatures could result in an extended winter and increased snow accumulation. As a result, access roads, haul roads, and diversion channels would require more frequent maintenance.
- Cold spells could cause later melting of the winter snowpack, delaying spring runoff.
- Freezing temperatures could cause ice dams to form in diversion channels. Ice jams cause the water levels to rise and can result in water overtopping the diversion channels which can then potentially damage infrastructure and disrupt operations.

Effects of Extreme Warmth on the Project

- Extreme high air temperature may also adversely affect workers' health, potentially causing heat exhaustion, dehydration, and heat stroke. Workers can become distracted and more prone to accidents under extreme high temperatures.
- Equipment and machinery is more likely to malfunction during extreme high temperatures, increasing the risk of worker-related exposure and accidents.
- Increased air conditioning requirements on site would result from extreme high temperatures, increasing power demands.
- With sustained warm air temperatures, more precipitation would fall as rain than as snow, and earlier melting of the snowpack could cause increases in runoff during the late winter and early spring. Storms where precipitation falls as rain rather than snow could cause more rapid runoff, potentially increasing the erosive capabilities of flows. Costs of maintaining diversion channels and access roads could increase during periods of extended warm temperatures.
- Extreme high temperatures coinciding with dry periods could increase the likelihood of wildfire occurrence in the area (discussed in Section 17.5).
- As the TSF is designed to be a zero-discharge facility during operations, extreme heat would not have any effects on discharge during this time. At closure however when the TSF discharges, extreme temperatures could increase evaporation and therefore decrease discharge which may result in more concentrated chemical load and decreased water quality.
- High temperatures in the spring could cause ice jams to form if ice melts rapidly and runoff increases.

Effects of Freeze-Thaw Cycles on the Project

Given that air temperatures in winter can range above and below the freezing point, freeze-thaw cycles and frost heave in winter are likely. Frost heaving could affect transportation and utilities components of the Project. Warm temperature cycles in the winter can also act to increase the density of snow, and therefore the force on buildings and infrastructure. Both examples would result in increased maintenance costs.

Mitigation Measures

Weather forecasts will be monitored, which will provide time to prepare for air temperature extremes. Health and safety policies will be implemented, and risk assessments will be undertaken before working in adverse weather conditions. Staff will be educated through formal training programs to ensure they understand the risks of working under extreme high or low temperatures, and to ensure they have good knowledge of the related procedures. Daily job safety analysis will be conducted. Personnel will be required to wear appropriate personal protective equipment, including cold weather gear, while working outdoors. Radio communication will be maintained with anyone working away from the Project site.

Suitable equipment and design systems will be purchased and implemented for the Project to enable operation under both extreme high and extreme low temperatures. Equipment will be maintained to ensure reliable operation. Potentially vulnerable infrastructure will be designed and built to withstand freeze-thaw cycles, especially infrastructure related to transportation and utilities where layer works or foundations may be affected.

The TSF will be designed, constructed, operated, closed and reclaimed according to the CDA's Dam Safety Guidelines (Canadian Dam Association 2007 (Revised 2013)).

Air temperature-related risks to the Project and mitigation measures are presented in the Table 17.5-6. These include the project component, area affected and mitigation required to reduce risk to the Project.

Contingency Plans

Although the mitigation measures above will significantly reduce the risk of extreme temperatures on the Project, it is possible that extreme temperature events may occur within the life cycle of the Project. In this case, the Emergency Response Plan (Section 11.16), and the management measures it contains, will be followed. Within this plan, when extreme temperature presents health and safety concerns, the situation will qualify as an emergency, the risk will be assessed, and activities modified or curtailed as appropriate. The Emergency Response Plan will also outline typical procedures, communications protocols, and responsible personnel in the case of an extreme temperature event.

17.5.2.4 Wind

Wind speeds recorded at the local AJAXMET climate station are variable over the period of record (2010-2014). In the summer the wind direction is predominantly north-westerly and in the winter it is predominantly south south-easterly (Knight Piésold Ltd. 2012, 2014a). This indicates persistent high pressure systems in the summer and low pressure systems in the winter. Monthly mean wind speeds for the period of record ranged from 1.6 m/s to 3.1 m/s. The mean annual wind speed for the period of record was 2.3 m/s.

Effects of Wind on the Project

Overall, as described above, winds in the Project area are generally of low velocity and are unlikely to have significant effects on the Project. However, low frequency, high magnitude wind events can occur. High winds could cause access and haul roads to become blocked with downed trees, increase fire severity and interrupt power. Power lines, communication towers, and buildings could be susceptible to damage by high winds. Electrical blackouts could occur if power lines were damaged during high wind events. High winds during summer months may increase fire intensity (Section 17.5). High winds during winter when below-freezing air temperatures occur would contribute significant wind chill causing more extreme freezing. Blowing snow could cause deep snow drifts and reduce visibility, thereby limiting access to and from the Project; whereas blowing dust may present an occupational safety risk.

Table 17.5-6. Air Temperature-related Risks and Mitigation Measures

Project Component	Area Affected	Project Effects	Mitigation Measures	Likelihood	Severity
Transportation	Road surface, ditches, culverts and diversions	Blowing snow, frost heave.	Frequent snow clearing. Use of appropriate design standards to minimize frost heave.	High	Negligible
Surface infrastructure	Buildings, processing plant, equipment and fuel storage facilities, sewage treatment and disposal facilities, washing plant	Effects to workers from cold: frostbite, hypothermia, distraction, accidents.	Staff will wear appropriate clothing, and be trained in risks and risk-mitigation relating to extreme temperatures.	Medium	Low
		Effects to infrastructure from cold: increased heating and power demands, freeze-thaw damage.	Suitable equipment will be used in mine infrastructure to withstand extremes of heat and cold.	High	Low
		Effects to workers from warmth: heat exhaustion, dehydration, heat stroke.	Staff will wear appropriate clothing, and be trained in risks and risk-mitigation relating to extreme temperatures.	Medium	Negligible
		Effects to infrastructure from warmth: increased air conditioning and power demands.	Suitable equipment will be used in mine infrastructure to withstand extremes of heat and cold.	Medium	Negligible
	Transmission line	During extreme cold temperatures, ice accumulation may damage the conductors which could in turn result in electrical supply failure.	Towers and conductor specifications should be appropriate for expected climate extremes. Additionally, routine inspections should be performed to monitor potentially problematic sections of the power line.	Low	Medium
	TSF	Increased evaporation due to extended extreme temperatures.	Water balance model updated during construction and operation phases to reflect as-built parameters and current met data.	Medium	Negligible

Mitigation Measures

Onsite meteorological stations will continue to operate during construction and operations. Data from the onsite station will be used to guide construction techniques necessary to mitigate potential damage by wind. Weather forecasts will be monitored to anticipate and prepare for severe winds. During blackouts, non-essential machinery will be shut down until power is re-established. In the event of a blackout an alternative power source will be needed.

17.5.3 Surface Water Flows

17.5.3.1 Typical Surface Water Flows

Local Hydrology

Baseline hydrometric monitoring was initiated in 2008 to collect and analyze hydrologic data for streams within the Project area. From 2008 to 2014, a network of four to five hydrometric gauging stations was operated within the Project area. The natural drainage areas around the Project have been altered by previous mining activity, and streamflow at certain monitored stations is affected by surface water and groundwater withdrawals by local residents, beaver dams and maintenance works.

Regional Hydrology

Detailed results from the regional hydrometric program are provided in the 2012 Hydrometeorology Report (Knight Piésold Ltd. 2012) and the 2014 Baseline Hydrology Report (BGC Engineering Inc. 2014). The regional hydrometric baseline program involved assessing a network of hydrometric stations near the Project to provide synthetic (estimated) hydrologic data for Project streams (Table 17.5-7). This involved analyzing long-term datasets from regional Water Survey of Canada (WSC) stations. This regional analysis allowed prediction of recurrence intervals for floods and low-flows within the Project area (see Table 17.5-8).

The flow regime in the area is closely related to the seasonal distribution of temperature and precipitation. Rivers in this region are predominantly fed by spring and early summer snowmelt (freshet) and low flows during the remainder of the year. Low flows persist through the autumn rainfall season, likely due to soil water deficits that absorb precipitation rather than causing large runoff events. High stream discharge occurs from mid-April through July, with a low flow period starting in early autumn and continuing until early spring. Mean annual runoff is the amount of water running over the land surface throughout the year (volume/watershed area) and is estimated to be 26 mm for the Project area (Knight Piésold Ltd. 2012).

Regional watersheds are larger than the Project watersheds. The most notable difference in the hydrologic regime of these larger catchments is an increased quantity of runoff occurring in winter.

Table 17.5-7. Mean Monthly Discharge at Water Survey of Canada Stations in the Baseline Study Area

WSC Station Name	WSC Station ID	Drainage Area (km²)	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual Discharge
North Thompson River Near Mclure	08LB064	19,600	m³/s	93	87	95	238	890	1334	923	528	343	261	198	118	427
Salmon River Above Salmon Lake	08LE075	143	m³/s	0.1	0.1	0.2	0.6	3.1	2.7	0.8	0.3	0.2	0.2	0.2	0.2	0.7
Criss Creek Near Savona	08LF007	479	m³/s	0.2	0.2	0.3	1.6	8.1	5.9	1.7	0.5	0.4	0.5	0.4	0.3	1.7
Deadman River at Criss Creek	08LF027	878	m³/s	0.5	0.5	0.6	1.9	7.1	4.2	2.3	1.1	0.8	0.6	0.6	0.5	1.2
Guichon Creek at Outlet of Mamit	08LG041	871	m³/s	0.2	0.2	0.2	0.6	2.6	2.4	1.2	0.7	0.4	0.3	0.2	0.2	0.7
Nicola River above Nicola Lake	08LG049	1,500	m³/s	1.0	1.1	1.4	3.8	18.3	14.4	4.9	1.6	0.9	0.7	0.9	0.9	4.1

17.5.3.2 Flooding

An understanding of flood potential is an important consideration for the Project site, as it could affect the design characteristics of infrastructure such as roads, bridges, ditches, dams, and dykes. Floods in southeastern BC are typically produced through two main mechanisms:

- rapid snowmelt during freshet conditions in spring and early summer; and
- rain falling on melting snow during freshet conditions in spring and early summer, or during early winter.

Based on analysis of the regional WSC stations, high-flow events are regularly generated by both mechanisms. Thus, floods in the Project area can be caused by both rapid spring snow melt and rain on snow events; however, due to the terrain in the Project area, rapid snowmelt is the dominant mechanism for generating peak flow.

Return period estimates are used to identify the expected frequency and magnitude of extreme (peak and low) flow events. For example, an event with a return period of 1:100 has a 1% chance (1/100) of occurring at any given time. Similarly, an event with a 1:5 return period has a 20% chance (1/5) of occurring at any given time. To conduct a frequency analysis, a long-term data record (i.e., over 10 years) is required; therefore, a long-term synthetic flow series (JACINF gauging station) and a regional flow series (Guichon Creek (08LG041)) were used. Return periods at the JACINF gauging station for mean monthly discharge and instantaneous peak flow estimates are listed in Tables 17.5-8 and 17.5-9 respectively.

Table 17.5-8. Regional Analysis of Return Period Streamflow at the JACINF Gauging Station

	Return Period Ratio of Mean Monthly Discharge (m^3/s) within Project Area						
	Dry				Wet		
Month	1:20 Year	1:10 Year	1:5 Year	Mean	1:5 Year	1:10 Year	1:20 Year
Jan	0.000	0.000	0.000	0.001	0.001	0.001	0.002
Feb	0.000	0.000	0.000	0.001	0.001	0.002	0.002
Mar	0.010	0.011	0.011	0.017	0.02	0.026	0.032
Apr	0.012	0.014	0.016	0.038	0.05	0.079	0.123
May	0.021	0.047	0.076	0.129	0.174	0.202	0.229
Jun	0.026	0.031	0.040	0.08	0.114	0.144	0.172
Jul	0.000	0.001	0.002	0.027	0.033	0.068	0.119
Aug	0.000	0.000	0.001	0.005	0.008	0.011	0.014
Sep	0.000	0.000	0.000	0.002	0.004	0.005	0.007
Oct	0.000	0.000	0.000	0.001	0.002	0.003	0.003
Nov	0.000	0.000	0.000	0.001	0.002	0.003	0.004
Dec	0.000	0.000	0.000	0.001	0.002	0.003	0.003

Notes:
Values calculated using @RISK decision tools statistical modelling software (Palisade Corporation).
Source: Knight Piésold Ltd., 2012

Table 17.5-9. Instantaneous Peak Flow Return Periods for the JACINF Gauging Station

Description	Drainage Area (km^2)	Peak Instantaneous Flows (m^3/s)					
		Mean	1:2 year	1: 10 year	1:50 year	1:100 year	1:200 year
Statistical Estimate	31.1	0.24	0.29	0.62	1.08	1.35	1.68
Regional Estimate		0.72	0.69	1.14	1.82	2.19	2.61

Notes:
Statistical and regional estimate calculations are based on the synthetic flow series using the generalized extreme value distribution in Environment Canada's CFA software.
The statistical estimate is based on the peak flows from the long-term synthetic flow series, adjusted by a factor of 1.5 to account for the difference between instantaneous and daily flows.
The regional estimates are based on an index flood approach (Obedkoff, 2003) and use a scaling exponent of 0.7.
Source: Knight Piésold Ltd., 2012.

To minimize the potential effects from floods on the Project, most of the key Project components (e.g., diversions ditches and road stream crossings) will be designed to accommodate appropriate return periods into engineering design flows.

In addition to the event return period presented for the Project area, climate change should be considered while assessing flood risk. Projections show an increase in median precipitation in the future, with the possibility of increased high magnitude events. These issues are discussed in Section 17.7.

Effects of Flooding on the Project

Floods can cause overtopping of, and damage to, containment structures, in addition to damaging river crossing structures, including bridges and culverts. Floods can cause streams to erode and deposit sediment, negatively affecting water quality. Floods can cause rapid channel avulsion, and could cause damage to any infrastructure within the new channel. They can also trigger mass wasting events, when stream beds undercut steep banks.

Containment Structures

Containment structures such as seepage collection ponds, sediment control ponds, and TSF will be engineered to a specific design flow event according to the appropriate return intervals and guidelines (Canadian Dam Safety Guidelines 2013). The direct risks to choosing a design flow are low frequency, high magnitude events. Extreme surface water flows beyond the design flows can cause overtopping of containment structures (sediment control ponds, diversions, TSF, etc.).

Diversion Ditches

Non-contact water diversion ditches are intended to manage the volume of water collected within the Project site. The ditches will be designed to accommodate appropriate design flow and return periods. Should design flows be exceeded, the ditches will overflow, causing excess water to flow through the Project site. Such an occurrence could have consequence for Project infrastructure.

Project Access Roads and Haul Roads

Floods occurring at the Project site could result in road closures caused by excess water on the road surface, erosion of the road surface, damage to stream crossings, or debris blocking the roads. Under the most extreme flood events there is the potential for drainage structure washouts (bridges, culverts, and cross-drains).

For floods in excess of the design criteria, it is likely that road closures would be put in effect as there is potential for crossings to partially obstruct flows, resulting in elevated upstream water levels (backwatering) and overtopping onto the road surface. Road closures under these conditions would be temporary and the road would re-open once water levels recede and inspections of the structural integrity of the crossings have been made.

Mitigation Measures

Project infrastructure will be designed to withstand extreme flood events. Specific mitigation measures for extreme streamflow are presented in Table 17.5-10. General mitigation measures employed to reduce impacts will include:

- monitoring weather forecasts to anticipate and prepare for large rainfall events;
- slowing or stopping work if rainfall runoff is anticipated to cause flooding and unsafe working conditions;
- placing Project-related infrastructure above high-water flood levels wherever possible; and
- appropriately reinforcing stream channels at road crossings to minimize erosion of the substrate.

Containment Structures

Containment structures will be designed to accommodate appropriate design flows. Specifically, the TSF will be designed, constructed, operated, closed and reclaimed according to the CDA's Dam Safety Guidelines (Canadian Dam Association 2007 (Revised 2013)) or other appropriate engineering standards. However, there is a statistical possibility that at any time, precipitation and streamflow events may exceed engineering design flow limits. A regular inspection and maintenance program will be established and include monitoring sediment build-up in collection ponds and the TSF. This information will be used to update the water balance model.

Diversion Ditches

The diversion ditches will be designed to accommodate appropriate design flow and return periods. A regular inspection and maintenance program will be established to ensure that the ditches are free of obstructions and able to convey design flows efficiently. This will be especially important during early spring before freshet conditions, in early fall ahead of potential fall rain storms, and following any major flood event.

Table 17.5-10. Streamflow-related Risks and Mitigation Measures

Project Component	Area Affected	Project Effects	Mitigation Measures	Likelihood	Severity
Transportation	Road surface, ditches, culverts and diversions	Floods: erosion and sedimentation at ditches, culverts, and road surface. Negative effects on water quality if sediment concentrations increase. Delay of materials and personnel if access to Project site is limited.	Floods: Constructing infrastructure to withstand extreme flood events; monitoring weather forecasts to anticipate and prepare for large rainfall events; slowing or stopping work if rainfall runoff is anticipated to cause unsafe working conditions; placing Project-related infrastructure above 100 year flood level.	High	Low
		Droughts: negative effects on water quality through decreased dilution.	Drought: maintain separation between contact and non-contact water; hold back as much discharge as possible for potential recirculation to processing needs.	High	Negligible
Surface infrastructure	Buildings, stockpiles, processing plant, equipment and fuel storage facilities, explosive storage facilities, overburden and soil storage areas, sedimentation pond(s), sewage treatment and disposal facilities, washing plant, waste rock management facility	Floods: erosion and sedimentation around infrastructure. Water damage to infrastructure. Trigger of mass wasting events. Negative effects on water quality if sediment concentrations increase. Delay of materials and personnel if access to Project site is limited.	Floods: Development of appropriate water balance model, water management plan, and environmental management plans.	Low	High
		Drought: reduction in water quality in receiving environment. Reduction in water available for use in process, resulting in slowed production.	Drought: Maintaining water quality by limiting sediment erosion, and reducing inputs of contaminated material.	Low	Negligible
	Transmission line	Floods: erosion or sedimentation where power lines are near streams or areas prone to flooding.	Floods: Constructing infrastructure to withstand extreme flood events.	Low	Medium
	Containment Structures	Overtopping of TSF or catastrophic failure of TSF embankment	TSF will be designed to meet all current CDA Dam Safety Guidelines (Canadian Dam Association 2007 (Revised 2013)). Engineering design flood is the 24-hour PMF.	Low	High

Project Access Roads and Haul Roads

Stream crossings on site roads will be designed to accommodate appropriate design flow and return periods. Appropriately sized riprap will be placed at the inlet and outlet of bridges and culverts to protect structures from erosion. A regular inspection and maintenance program will be established to ensure that stream crossings are free of obstructions and able to convey design flows. This will be especially important during early spring before freshet conditions, in early fall ahead of potential fall rain storms, and following any major flood events.

17.5.3.3 Drought

An understanding of drought potential is important to consider at the Project site, as it could affect aquatic communities and the operation of the Project. Drought is the occurrence of persistently below normal precipitation which may cause below normal soil moisture and a decrease in groundwater and surface water supplies.

The climatic moisture deficit extracted from ClimateWNA for the Project site is 379 mm. This corresponds to a potential evaporation that exceeds the amount of precipitation in the area (Table 17.5-1). Since a deficit in soil moisture already exists, the area is more susceptible to a decrease in groundwater and surface water supply when there are prolonged periods without precipitation.

Effects of Extreme Low Streamflow on the Project

Low flows are an important consideration for the Project because they could affect aquatic communities and downstream water users. While the annual low flow will occur during winter months, flow volumes during the summer season (June to September) are also important as they can strongly influence species presence. Low flows at the JACINF gauging station are characterized for return periods of dry years in Table 17.5-8. As the annual low flows occur in the winter months, it was further necessary to calculate flows for each month during dry years.

A drought could reduce water available for diluting flows, resulting in a water quality decline in the receiving environment. Biota dependant on water quality could therefore also be affected. Maintenance of water quality during low flows is particularly important at discharge locations.

An extreme low streamflow event may cause a decrease of surface water within the TSF, potentially reducing the size of the decant pond within the TSF. As the TSF is designed to be a zero discharge facility, extreme low flows would not have any effects on discharge.

Prolonged periods of low precipitation around the Project area could also reduce available water for operating the process plant. Reduced availability of water for capture and use on-site would increase reliance on supply from Kamloops Lake during a period when the Thompson River may also be experiencing lower than normal flow conditions.

During extremely dry periods there is an increase the risk of dust accumulation and wildfires (Section 17.5).

Mitigation Measures

Project infrastructure will be designed to accommodate drought events. Specific mitigation measures for extreme low streamflow are presented in Table 17.5-10 and, specifically, mitigation measures relating to reducing drought-induced water quality declines include:

- separating hazardous waste from non-hazardous waste to maintain water quality and transporting it off site for disposal;
- constructing storage areas to minimize spills of fuel and other hazardous materials;
- diverting non-contact water around Project site;
- constructing drainage ditches to maximize the collection of Project site contact water;
- developing a water management plan that accounts for low-runoff years; and
- developing and implementing an environmental management plan for waste that describes waste sources, waste types, and waste streams (recycling, re-use, off-site disposal).

Contingency Plans

Although the mitigation measures above will significantly reduce the risk of extreme temperatures and drought on the Project, it is possible that such events may occur within the life cycle of the Project. In such cases, the Emergency Response Plan (Section 11.16), and the management measures it contains, will be followed. Within this plan, when extreme temperature and drought presents health and safety concerns, the situation will qualify as an emergency, the risk will be assessed, and activities modified or curtailed as appropriate. The Emergency Response Plan will also outline procedures, communications protocols, and responsible personnel in the case of extreme temperatures and drought events.

17.5.4 Lightning

Lightning generally occurs in thunderstorms due to turbulent wind conditions that separate electric charges within a cloud. Similarly, lightning can also occur in dust storms or forest fires when particulates in the air become electrically charged. Lightning flashes occur more often in the summer months with June to August having the highest number of flashes and are less likely to occur in the morning. The annual average of days with thunderstorms at the Environment Canada Kamloops Airport climate station is 10 days. The interior of BC has a long lightning season; however, it has relatively low lightning density compared to parts of Alberta, southern Saskatchewan and southern Manitoba.

17.5.4.1 Effects of Lightning on the Project

Lightning due to thunderstorms may be accompanied by hail and damaging winds (Sections 17.4 and 17.2.4). Lightning could cause forest fires under dry conditions (Section 17.5), and damage infrastructure such as buildings and power lines (Environment Canada 2014b). Lightning can also create unsafe outdoor working conditions and could affect production if work is stopped as a consequence.

17.5.4.2 Mitigation Measures

Mitigation of lightning strikes primarily includes maintaining compliance with appropriate building codes (electrical standards and fire suppression systems) to prevent fire or withstand lightning strikes. The building codes that are applicable in BC will ensure that electrical failsafe and fire suppression systems are adequate for the protection of the structures. Appropriate fire suppression equipment will be readily available to personnel in buildings, in and around site infrastructure, and in and around plant and machinery.

Local and regional weather will be monitored for lightning forecasts and warnings in the Project area. In addition to this the Project will also employ lightening monitoring devices and suspend work activities during lightening prone times. Outdoor activities requiring work at high elevations, near tall buildings, in water, or in forested areas will be suspended when there is a risk of lightning strikes. The use of electrical equipment will be avoided during a lightning storm and personnel will be informed of relevant emergency procedures.

17.5.5 Wildfires

Wildfires are common landscape disturbances throughout forested and grassland ecosystems in BC. On average, 1,900 wildfires occur in BC every year; approximately 39% are caused by human activity and 61% by lightning ignition (BC MFLNRO 2012). The probability of wildfire occurrence is dependent on fire behaviour, ignition potential, and suppression capability.

Fires are one of the most significant natural disturbances in BC, and the characterization of fire history aids in predicting fire frequency and severity. Natural disturbance frequencies and types have been identified for ecosystems across BC, and five types have been created and assigned to Biogeoclimatic Ecosystem Classification (BEC) zones. These Natural Disturbance Types (NDTs) summarize the dominant disturbances for each BEC zone and provide an indication of the disturbance type, extent, and frequency (BC MOF 1995). The BECs in the Project's Biophysical Effects Local Study Area (LSA) are assigned to NDT 4 (ecosystems with frequent stand-maintaining fires) and comprise the Nicola Very Dry Warm Bunchgrass Variant (BGxw1), the Thompson Very Dry Hot Bunch Grass Variant (BGxh2), the Thompson Ponderosa Pine Very Dry Hot Ponderosa Pine Variant (PPxh2), and the Thompson Very Dry hot Interior Douglas-fir Variant (IDFxh2), as illustrated in Table 17.5-11.

Table 17.5-11. Natural Disturbance Types in the Local Study Area and Fire Return Intervals

Natural Disturbance Type	BEC Zone	Stand Replacement Disturbance Cycle	Area in LSA (ha)	Description
NDT 4	BGxw1, BGxh2 PPxh2 IDFxh2	4 - 50 years	7,167	Ecosystems with frequent stand maintaining events. Low intensity fires occur frequently and limit encroachment of woody trees and shrubs, and fire-resistant species are common. Stand initiating events occur in the IDFxh2 BEC but are not common or large. Stands tend to be uneven aged.

All these BEC zones occur in NDT 4, which historically had lower intensity fires. Due to changing climate, the effects of forest health pathogens, increasing fuel loading due to historic fire suppression efforts, and human-caused ignitions, there has been a general increase in fire intensity and severity in these BEC zones. This elevates the risk posed to Project infrastructure in comparison with historical fire regimes.

Although much of the Project is located in grassland ecosystems, forest health is also a consideration when addressing fire hazard. Extensive mortality associated with the mountain pine beetle (*Dendroctonus ponderosae*; pest species code IBM) has occurred in the LSA. While other forest health agents are also present, the mountain pine beetle is the most prevalent agent. Tree mortality caused by the beetle can result in increased ignition potential and fire behaviour due to cured standing and downed fuels. Fire behaviour is highest during the red-attack phase (1 to 4 years) and decreases in grey-attack phases as fine fuels (less than 7.5 cm in diameter) decrease over time (2 to 10 years) [3]. As the standing grey-attack trees fall, they contribute to surface fuels. These surface fuels, in combination with tree regeneration during this stage, can result in an increase in expected fire behaviour during this stage (approximately 10 to 30 years). As these fuels decay, fire behaviour decreases. Adjacent to valued infrastructure components, fuel mitigation measures in beetle-attacked stands are important to consider reducing the likelihood of fire-related losses or impacts.

To provide a more locally specific assessment of fire history, the use of fire ignition records is pertinent. The BC Government Wildfire Management Branch maintains a spatial database of fires back to 1950 (BC WMB 2014). The database indicates fire location, date, and cause (human or lightning), and is useful in determining wildfire probability for an area. In the 158,415 hectare (ha) Biophysical Effects Regional Study Area (RSA), 75% of the fires were human caused; 17% started by lightning, and 7% were unknown causes (Table 17.5-12). The number of human caused fires is high compared to the provincial average of 38%. Since 1951, there have been 2,011 fires recorded in the RSA.

Table 17.5-12. Fire Occurrences for Each Decade by Cause in the Local Study Area and Regional Study Area

	Number of Fires by Cause in the LSA				Number of Fires by Cause in the RSA			
Decade	Lightning	Human	Unknown	Grand Total	Lightning	Human	Unknown	Grand Total
1950	2	4		6	18	170		188
1960	3	8		11	55	203		258
1970		2		2	52	196		248
1980		3		3	70	124		194
1990	5	7		12	76	167		243
2000	1	42	11	54	75	563	131	769
2010	1	11	1	13	14	80	17	111
Grand Total	**12**	**77**	**12**	**101**	**360**	**1,503**	**148**	**2,011**

[3] Red- and grey-attack phases are indications of the percentage of tree volume killed by beetles.

In the LSA, which is 6,324 ha in size, human ignitions are responsible for 76% of all fires and lightning and unknown causes each account for 12% of fires. There have been 101 fires recorded in the LSA since 1951. Ignition potential is considerable in the region and supports the characterization of the high fire probability in the Project area. Combined with vulnerable Project infrastructure such as the power line and the number of staff working on site, wildfire risk is considerable. The proximity to Kamloops and the Kamloops Fire Centre and accessible terrain adjacent to the Project, means that suppression efforts will be rapid. Early detection and reporting of fires is essential to halting spread and potential impacts on the Project.

17.5.5.1 Effects on the Project

Linear infrastructure, such as the power line to the Project, is vulnerable to damage by wildfire. The power line also has the potential to act as an ignition source in the event of a flash-over from a tree strike or growth of vegetation into the clearance zones around energized conductors or other components. A vegetation maintenance and hazard tree removal program is key to reducing power line-caused fires. Although it is recognised that the area is largely grassland, a precautionary approach requires that trees that do occur are subject to a potential hazard evaluation.

In the event of a wildfire, egress using the access roads may become vulnerable and wildfire evacuation planning that considers other existing Forest Service Roads is critical to ensuring mine personnel safety.

Human safety is one of the key focuses in developing mitigation measures for effects that the environment may have on the Project. Reducing the probability of fire spreading to or from Project infrastructure, ensuring suppression training and equipment is adequate, and developing wildfire-relevant evacuation planning are all important measures to consider in reducing risk to workers.

Adequate setbacks from coniferous fuels should be maintained to help reduce the probability of fire spreading to or from Project infrastructure. Grass adjacent to or within 10 m of infrastructure where ignition sources such as trucks will be operating, should be maintained in a low state to reduce fire ignition potential and spread rates. Conducting a fire hazard assessment after construction is recommended. Potential costs due to shutdowns or losses to infrastructure related to wildfire can be mitigated through fire risk reduction measures, which are detailed below.

A wildfire could also have secondary effects related to the loss of surface vegetation cover in the local catchment area. Increased amounts of runoff with elevated levels of total suspended solids would report to the diversion channels, requiring increased maintenance.

General mitigation measures, operating procedures, training and educational considerations are provided below. The City of Kamloops Community Wildfire Protection Plan (City of Kamloops 2008) provides additional information regarding wildfire risk mitigation and planning. Consultation with the City of Kamloops and the Wildfire Management Branch in regards to wildfire planning is recommended.

17.5.5.2 Mitigation Measures

To reduce the chance of infrastructure loss and/or damage due to wildfires, the Project will employ a Fire Hazard Abatement Plan in addition to implementing the following mitigation measures:

- contacting the City of Kamloops to identify opportunities for collaboration and coordination regarding wildfire, especially actions and measures identified in their community wildfire protection plan;
- conducting FireSmart Canada Industry Partner assessments to reduce fire risk (https://www.firesmartcanada.ca/become-firesmart/industry-partners/);
- incorporating FireSmart vegetation management and building design where possible;
- creating buffer zones around all structures where vegetation is maintained in a low hazard state;
- implementing a hazard tree inspection program for the power line to ensure the right-of-way is maintained in a condition that reduces the risk of tree failure;
- training for designated employees (e.g., Provincial S100 Basic Fire Suppression and Safety training) and ensuring sufficient trained personnel are on site during the fire season to action a fire response;
- ensuring employees have access to appropriate personal protective gear to action a wildfire response;
- developing an evacuation plan to address egress of personnel in the case of wildfire;
- identifying safe zones for workers at the Project site in the event that evacuation is not possible;
- erecting fire danger signs in visible locations that are updated throughout the fire season to ensure personnel are aware of current fire hazard conditions;
- ensuring water sources have adequate volumes to action fires and that pumps or other water delivery systems can provide sufficient pressure for the effective use of hoses, sprinklers, and other fire suppression tools;
- locating water pumps and fire-fighting equipment strategically around the Project to help contain/extinguish any fire;
- equipping appropriate vehicles with firefighting tools (shovels, pulaskis, and axes), water, and portable pumps to supply initial attack to accessible fires;
- using mining equipment such as dozers in the case of a fire to remove vegetation around the infrastructure, thus removing fuel for the fire;
- providing backup generators for use in the event of power line loss. The generators will have enough power capacity to operate essential equipment (e.g., ventilation, fire suppression);
- properly storing flammable materials, banning heat and flame in these areas, and providing proper signage;

- training personnel in fire response and containment, including:
  - use of fire extinguishers for small fires in buildings; and
  - raising an alarm and seeking assistance;
- train employees to use the Report a Wildfire number: 1-800-663-5555 or *5555 from a cellular phone, and of the importance of calling fires in quickly along with posting the numbers and calling instructions in appropriate areas at the mine;
- monitoring BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO) fire alerts; and
- complying with all relevant legislation in the BC *Wildfire Act* (2004).

17.5.5.3 Contingency Plans

Although the mitigation measures above will significantly reduce the risk of wildfires to the Project, it is possible that such an event may occur over the life of the Project. In this case, specific information regarding wildfire safety and evacuation is included in the Emergency Response Plan (Section 11.16) and Fire Hazard Abatement Plan (Section 11.17) which will be followed if wildfires could potentially have an effect on the Project. These plans also outline procedures, communications protocols, and responsible personnel in the case of a fire incident. The Erosion and Sediment and Erosion Control Plan (Section 11.4) and Wildlife/Vegetation Monitoring Plan (Section 11.21) outline measures that would minimize the effects of a wildfire on the Project, as well as treatment measures to restore and wildfire-generated areas of erosion.

17.5.6 Geophysical Effects

17.5.6.1 Baseline Summary/Existing Conditions

This section discusses effects and mitigation measures associated with geophysical activity, as it relates to slope stability and mass wasting events such as debris slides, erosion, rockfalls and avalanches, which may have an influence on the Project.

Relatively little evidence of mass movement and soil erosion has been noted in the Project area. Two landslides were noted near the Project area and were comprise debris slides along with some gully erosion (Knight Piésold 2014b). The overall Project area is characterized by landforms that reflect a history of glaciation. Glacial till is the predominant surficial geology unit across the study area. There are kame complexes adjacent to Peterson Creek and to the south and west of Goose Lake, and aeolian sediments were identified on broad terrain with northwest-southeast aspects. Fluvial deposits were also found in the active channel of Peterson Creek.

Terrain stability mapping was conducted by Knight Piésold Ltd. (2014b) based on original mapping of the area undertaken in 2010 by Polar Geoscience Ltd. The potential for landslides to affect the Project area was assessed based on terrain stability maps which provide a relative assessment of stability but provide no indication of the expected frequency, magnitude, or consequence of failure. Terrain stability as defined in the mapping refers to the likelihood of a landslide initiating in a

terrain polygon following timber harvesting and road construction for mine development. The following three terrain stability classes were used in mapping the study area:

- Stable (S) – Identified as terrain with a 'negligible' to 'low' likelihood of landslide initiation following timber harvesting and road construction for mine development;
- Potentially unstable (P) – Expected to contain areas with a 'moderate' likelihood of landslide initiation following timber harvesting and road construction for mine development; and
- Unstable (U) – Expected to contain areas where there is a 'high' likelihood of landslide initiation following timber harvesting and road construction for mine development.

Terrain stability mapping indicated that there were few area with 'unstable' terrain identified for the Project area (Knight Piésold Ltd. 2014b). Small, isolated areas of 'potentially unstable' terrain were identified within the footprints of the proposed mine facilities and along the transmission line alignment and no areas of 'potentially unstable' terrain were identified along the water supply pipeline alignment (Knight Piésold Ltd. 2014b). Each of these areas are presented and discussed in the effects assessment (Section 6.2).

17.5.6.2 Debris Flows

Effects on the Project

Two recent debris slides were identified in the study area (Knight Piésold 2014b). A shallow debris slide was identified on natural terrain within the East Mine Rock Storage Facility and a second slide was found in natural terrain on the east side of the Project area. This demonstrates that debris slides can occur within the Project area and mitigation measures will be required.

Mitigation Measures

An assessment of slope stability and debris slide potential should be made before construction begins on any slope that may potentially be prone to mass wasting ($\geq$ 37 degrees). Particular attention should be given at road crossings for bridge and culvert design. Such an assessment would allow for appropriate mitigation measures to be developed.

17.5.6.3 Surface Erosion

Effects on the Project

Gully erosion was observed in the study area, predominantly in the west part of the Project area. Areas of unconsolidated sediments were also identified to be particularly prone to erosion once vegetation has been removed during the Construction phase of the Project. Erosion will affect the planning of any roadwork, culvert design and mine infrastructure where the removal of vegetation may result in erosion.

Mitigation Measures

Erosion and sediment control plans have been developed and will be implemented prior to the removal of vegetation on sloped terrain. Gully erosion potential should be assessed and attention given at road crossings for bridge and culvert design. Erosion control plans and site assessments at recognized crossing where gully erosion is present would allow appropriate mitigation measures to be developed.

17.5.6.4 Rockfalls

Effects on the Project

No specific potential hazard associated with rockfalls was identified in the study area. Rockfalls occur as a result of mechanical action on unstable (or occasionally stable) rock. In the Project area, rockfalls would likely be the result of seismic activity, freeze-thaw activity, or unsecure overhead hazards.

Seismic activity could result in the release of small or large sections of rock, as further described in Section 17.5.6 below. Freeze-thaw is a mechanical trigger for rock with existing cracks and fissures. When water or snow is introduced into cracks and fissures of rocks (cliffs and outcrops primarily), and is then exposed to free-thaw cycles, the contraction and expansion of solid state water acts to progressively ratchet the rocks loose. This process could be relatively fast or occur over a long period of time, dependent on the specific circumstances.

Mitigation Measures

The most effective way to mitigate risks to the Project from rockfalls is to locate Project site buildings, infrastructure, plant, and work zones away from overhead hazards. Should work be required where overhead hazards exist, risk and occupational safety management plans will be used to mitigate worker exposure.

17.5.6.5 Snow Avalanches

Effects on the Project

The risk of snow avalanches within the study area is anticipated to be low as the moderately steep and steep slopes are relatively short. Avalanches are classified as either "point release" (when a small amount of snow sets more snow in motion) or "slab avalanches" (when a plate or slab of cohesive snow begins to slide as a unit before breaking up) (Jamieson 2011). Although the potential for avalanches is low there is the potential risk of small (size 1) "point release" avalanches occurring on short steep slopes in the Project area. Canadian classification for avalanche size describes "size 1" avalanches as "sluff" of snow that slides less than 50 m of slope distance regardless of snow volume, and the destructive potential of "size 1" avalanches as "relatively harmless to people" (Jamieson 2011).

Mitigation Measures

Although there is not expected to be significant avalanche risk within the study area, assessment of potential avalanche areas should be continued throughout the Construction and Operations phases of the Project. Such assessments are able to consider current conditions, Project layout and worker exposure.

17.5.6.6 Seismic Activity

The Pacific Coast is the most earthquake-prone region of Canada due to the presence of active faults, particularly dominated by the northwestward motion of the Pacific Plate relative to the North American Plate. However, the Project is distant from these faults (more than 200 km) and earthquake frequency and size decrease moving inland from the coast. As a result, seismic activity is relatively low in the region the Project is located within.

A probabilistic seismicity assessment in the immediate vicinity of the Project was carried out by Klohn Crippen Berger Ltd. in 2011, for a tailings impoundment for the historic New Afton Project. The findings indicated that shallow crustal earthquakes in the southeastern region of BC would be the predominant seismic hazard for the Project.

Peak Ground Acceleration (PGA) is a measure of how vigorously the earth shakes during an earthquake, and is measured in units of acceleration due to gravity (g). PGA was calculated for three return periods within the vicinity of the Project area (KCBL, 2011) and for four return periods using the Natural Resources Canada Hazard Calculator (NRCan, 2014; Table 17.5-13). Both methods calculated a 1:2,475 year PGA which ranged from 0.138 g (NRCan, 2014) to 0.163 g (KCBL, 2011). The range of all results indicates that the Project area could experience PGA associated with earthquakes which range between 0.034 g (1:100 year event) and 0.293 g (1:10,000 year event; Table 17.5-13). Events of these magnitudes in turn could be expected to result in "none" (1:100 year event) to "light" (1:10,000 year event) potential damage (USGS 2014).

Table 17.5-13. Exceedance Probability and Peak Ground Acceleration for Seismic Events at the Project

Event	Mean Peak Ground Acceleration[2] (g)	Mean Peak Ground Acceleration[3] (g)	Probability for Any Single Year (%)	Probabilities for Project Phases[1] (%)			
				Construction (YR-2 to YR1)	Operation (YR1 to YR23)	Reclamation and Closure (YR24 to YR29)	Post Closure (TBD)
1 in 100 yr	-	0.034	1.0	2.0	20.6	4.9	-
1 in 476 yr	-	0.072	0.21	0.4	4.7	1.0	-
1 in 1,000 yr	-	0.097	0.10	0.2	2.3	0.50	-
1 in 2,475 yr	0.163	0.138	0.04	0.08	0.93	0.20	-
1 in 5,000 yr	0.222	-	0.02	0.04	0.46	0.10	-
1 in 10,000 yr	0.293	-	0.01	0.02	0.23	0.05	-

[1]The probabilities of events occurring during Project phases are calculated using the hydrology frequency analysis formula: Probability (risk) = 1 – (1 – P)^n.
[2]Data derived from the Afton Tailings Impoundment Seismic Hazard and Seismic Stability Assessment (KCBL, 2011).
[3]Data from National Building Code interpolated seismic hazard values at location 50.61 N, 120.41 W (NRCan, 2014).

The above analysis points towards the Project being at low risk of a damaging seismic event. For example, for the entire life cycle of the Project there is a 0.32% chance of a 1 in 1,000 year event occurring, with a PGA of 0.293, which would cause "light" structural damage at the surface (USGS 2014). However, where infrastructure is not built on firm ground, or where unconsolidated material is deposited on slopes, damage to infrastructure and risk to workers could be greater. Liquefaction can also be caused by seismic activity.

Effects on the Project

Liquefaction

Liquefaction is defined as the transformation of granular material from a solid state into a liquid state as a consequence of increased soil saturation. Liquefaction is the primary cause of landslides and other ground failures associated with earthquakes. Earthquakes catalyze liquefaction by shaking the ground and altering the pore water pressure of the surficial material. The risk of liquefaction is greatest in steep terrain with unconsolidated substrate and saturated soils.

A study conducted in the immediate vicinity of the Project site concluded that liquefaction was not a concern in foundation soils (KCBL 2011) of a nearby tailing impoundment due to the presence of very stiff, fine grained soil.

Subsidence

Subsidence is the motion of a surface (usually, the Earth's surface) as it shifts downward relative to a datum. Ground subsidence may be caused by seismic activity and could potentially affect project infrastructure. The seismic hazard and seismic stability assessment conducted in the immediate vicinity of the project (KCBL, 2011) was unable to identify subsidence as a potential concern for the area.

Mitigation Measures

Identify areas with potential for liquefaction or subsidence, and avoid such areas for construction (KCBL 2011). Appropriate assessments and engineering design criteria will be closely adhered to.

Site infrastructure will be located in areas that avoid or minimize exposure to weak, unconsolidated soils or soils that are assessed to be potentially liquefiable or prone to subsidence, where practical. Where infrastructure is to be built on weak, compressible, or potentially liquefiable soils, appropriate modifications will be incorporated into the design. All structures will be thoroughly assessed for stability and integrity after seismic events.

An Emergency Response Plan (Section 11.16) will be developed. The plan will ensure that there are always trained first response personnel on site whenever there are workers active in the Project site. The number and type of first responders depends on the number of active workers. There will also be on-site personnel trained in first aid, firefighting, and hazardous material handling and clean up. Appropriate emergency equipment will be maintained and made available on site.

Contingency Plans

The most effective method of mitigating against geohazard impacts is to locate site infrastructure outside of high risk zones. When Project activities must occur in hazardous zones, the primary mechanism for mitigating such risks is the application of the relevant Environmental Management and Monitoring Plans contained in Chapter 11 of the Application/EIS.

Although the mitigation measures described above will significantly reduce the risk of geohazards on the Project, it is possible that such events may occur within the life cycle of the Project. In this case, the Emergency Response Plan (Section 11.16), and the management measures it contains, will be followed. Within this plan, when geohazards are presenting health and safety concerns, the situation will qualify as an emergency, the risk will be assessed, and activities modified or curtailed as appropriate. The Emergency Response Plan will also outline typical procedures, communications protocols, and responsible personnel in the case of an incident related to geohazards.

17.5.7 Climate Change

17.5.7.1 Climate Change Regulatory Context

The BC government is currently drafting policy regarding climate change adaptation and how to mainstream adaptation considerations into other regulatory and guidance documents (BC MOE 2010). As yet, there is no specific legislation applicable to adapting Project components to climate change risk. Infrastructure design for water structures in BC is currently regulated for a wide variety of meteorological risk factors (i.e., temperature extremes, storms, and floods), but these provisions are based on analyses of past climate and so do not currently explicitly address climate change projections that may differ from past ranges (APEGBC 2012).

With regards to the effect of the environment on the Project in relation to climate change, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (CEA Agency 2003) recommends that:

> *Potential risks to the project, providing they do not affect the public, public resources, the environment, other businesses or individuals, may be borne by the project proponent and are not generally a concern for jurisdictions.*

It is believed that climate change in the Project area will not increase risks to the public, public resources, the environment, other businesses, or individuals. However, recognising that extreme weather events resulting from climate change can disrupt operations, damage assets, disrupt energy provision or supply chains, and threaten water availability, this chapter discusses the likely effects of climate change on the Project and the related mitigation measures in a manner that should allow for informed decision-making.

17.5.7.2 Climate Change Adaptation and Contingency Planning

Climate change adaptation is the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). It is distinct from climate change mitigation, which is the reduction in the magnitude and rate of climate change itself (West Coast Environmental Law 2012). Planning for adaptation is difficult, given unknowns in the timing and magnitude of climate change, and the environmental effects of this change.

Planning and decision making will take climate change into account wherever possible. This includes obtaining relevant climate information, assessing likely effects, considering infrastructure vulnerability, and adopting a cooperative approach with governments, stakeholders, and Aboriginal groups. Recommendations and position statements from relevant scientific literature, institutions (e.g., AMS 2012; IPCC 2013), and professional associations will be followed wherever applicable or possible (e.g., APEGBC 2010, 2012; BCWWA, 2013a, 2013b).

To respond to the known uncertainties surrounding climate change impacts, an adaptive management approach to climate change will be taken. Adaptive management involves using learning to continuously improve policies and practices. Adaptive management is useful because it allows for flexible responses to early signals of change when timing and magnitude are not known. Adaptive management has six components: assess the problem, design a solution, implement the solution, monitor the results, evaluation, and adjustment (BC MOFR 2013; CEA Agency 2013). Employing adaptive management to the likely effects of climate change may iteratively bridge the gap between GCM projections and the actual climate impacts experienced in the Project area, thereby allowing the Project to adapt to such effects by formulating appropriate mitigation to the extent possible.

17.5.7.3 Climate Change Projections for the Project Area

Global climate is unequivocally warming, and will continue to warm in the future (APEGBC 2010; AMS 2012; BCWWA 2013a; IPCC 2013). Heavy precipitation events have become more intense and frequent globally, and will continue to do so, although confidence in the direction and amount of change in precipitation is lower than that of air temperature (AMS 2012). Uncertainty increases when considering local effects, and the effects of climate change on the biophysical environment, such as vegetation, glaciers, streamflow, and wildfires.

As noted in Section 17.2.1.2, several cyclical climatic patterns influence the climate of the Project area, including the PDO and ENSO. The effects of global warming on these patterns are poorly understood. However, in a review of GCM results from the IPCC AR4 (2007) report, it was found that the negative phase of the PDO will increase in frequency, especially after 2050. Overall, the climate of the Project area is expected to become warmer and experience more precipitation in the future. However, if the PDO were to increasingly experience a negative phase, then these effects would be dampened, but not reversed. As global sea-surface temperatures continue to warm, the ENSO is expected to experience an "El Niño-like" mean state change, but no change in amplitude (Lapp et al. 2012).

Extreme weather in the Project area is correlated with both the PDO and ENSO, including each phase. For example, during a negative phase of the PDO (2005 to present) there is a greater propensity for La Niña events, and during La Niña events the interior of BC tends to experience colder winters and drier summers. Conversely, during a positive phase of the PDO (1977 to 2005) there is a greater propensity for El Niño events, and during El Niño events the interior of BC tends to experience warmer winters, and record high snowpack, increased rainfall, and extensive flooding. Given this understanding of local weather conditions, climate change in the Project area will likely continue to result in extreme weather from both the PDO and ENSO cycles. According to climate change projections, both the frequency and magnitude of these events are likely to increase.

17.5.7.4 Project-related Adaptation and Mitigation Measures

Climate change impacts are unique in that they cannot be predicted by extrapolating from historical measurements and return periods (BCWWA 2012). Climate change impacts are also unique due to the sustained nature of change, and an increase in the frequency and magnitude of extreme events.

By analyzing extreme return period events for temperature, precipitation, and streamflow, climate change impacts are implicitly considered in the Project's engineering design. As noted above, most extreme weather in BC is the result of ENSO conditions. Thus, by considering extreme events through the 1:50, 1:100, and 1:200 year return periods, the direct impacts of ENSO phases on possible extremes in air temperature, precipitation, and streamflow are accounted for within the scope of the assessment. For example, climate change projections are currently suggesting an annual increase in precipitation of 6% by 2050 (Environment Canada 2014a). Whereas when considering extreme precipitation return periods, the 1:200 year dry return period precipitation is 50% below baseline; and the 1:200 year wet return period precipitation is 26% above baseline. This demonstrates that by examining extreme events, the Project's engineering design is inherently including the projected effects of climate change.

Components of the environment and Project affected by climate change are listed below. Each component is discussed and categorized in terms of the severity of its anticipated impacts. Categories are **negligible, low, moderate,** and **high**. Each are defined relative to the likelihood of change in interaction, risk of effects to the Project, and consequent effects to the environment, human health, and safety.

Air Temperature

Project components will be designed to withstand a wide range of air temperatures, including the temperature ranges for extreme events (Table 17.5-14). Increasing the number of freeze-free days would be beneficial to the Project in some respects, such as reducing heating costs, and reducing exposure of personnel to extreme cold. Climate change is predicted to induce milder winters in this region, which would likely produce more freeze-thaw cycles. If improperly designed, this increase would accelerate roadway deterioration, and increase maintenance costs.

More frequent freeze-thaw cycling also has the potential to compromise the structural integrity of other site infrastructure, including power lines and building foundations. As such, roadways and transportation corridors have **moderate** sensitivities and all other Project components have **negligible** to **low** sensitivities to increased or decreased air temperature due to climate change (Table 17.5-14), given that a changed air temperature regime is factored in to the Project's engineering design.

Precipitation

Project components will be either designed to handle all forms of precipitation, or have management plans in place for handling snow and rain. It is predicted that extreme precipitation events will increase in frequency and magnitude (IPCC 2007, 2013). Engineering systems will be put in place that can handle increases in precipitation from current climate projections, as climate projections are approximately proportional to less than a 1:10 year wet year return period and Project components are often designed to withstand the 1:100 year or 1:200 year events. Increases in the frequency and magnitude of extreme snow and rain may occasionally limit travel on access roads. Overall, Project components have a range of sensitivities to increased precipitation due to climate change (Table 17.5-14).

Table 17.5-14. Potential Project Component Sensitivities Arising from Climate Change

Project Component	Area Affected	Air Temperature			Precipitation		Streamflow		Wind	Wildfires
		Increase from Mean Climate Normal	Freeze-Thaw Cycles	Extreme Heat	Increase from Mean Climate Normal	Extreme Rain and Snow	Flooding	Drought	Increased Velocity	Increased Wildfires
Transportation	Road surfaces, ditches, culverts	Low	Low	Low	Moderate	High	Moderate	Low	Low	Moderate
Surface Infrastructure	Buildings, stockpiles, processing plant, equipment and fuel storage facilities, explosive storage facilities, overburden and soil storage areas, sedimentation pond(s), sewage treatment and disposal facilities, waste rock management facility	Low	Low	Low	Low	Moderate	Moderate	Low	Low	High
	Transmission line	Low	Low	Low	Low	Moderate	Moderate	Low	Low	High
	TSF	Low	Low	Moderate	Moderate	High	Moderate	Low	Low	Low
	Sediment control ponds, diversion channels, etc.	Low	Low	Moderate	Moderate	High	Moderate	Low	Low	Low

Flooding and Drought

As precipitation extremes unfold, the Project will likely experience long return period streamflows (1:50 to 1:100) for both dry and wet conditions. Given the relationship between the PDO and ENSO it is probable that the Project will experience both extreme low flows (PDO negative, La Niña) as well as extreme high flows (PDO positive, El Niño). Water management systems within the Project area will be designed to withstand floods with long return periods (1:50, 1:100, and 1:200 year). Containment structures (TSF, diversions, etc.) and site access roads will have the most exposure and will likely require increased maintenance during high streamflow years (and thus high precipitation). The road systems are ranked as **moderate** in terms of climate sensitivity for the Project, due to increased streamflow. All other Project components are ranked as having **negligible** to **low** sensitivities to increased or decreased streamflow due to climate change (Table 17.5-14).

Wind

Project components will be designed to handle extreme winds. The anticipated effects of climate change with respect to wind will likely be secondary effects. For example, wind is a primary component of evaporation, since as wind increases so too does evaporation. Thus, the likely effects of climate change on the Project will be increased evaporation of water in the TSF. A possible implication of this would be less water available for processing. In low water years this may present a constraint if the Project is highly reliant upon recovered tailings water for processing. However, the Project components as a whole are believed to have **low** sensitivities to increased or decreased wind velocities due to climate change (Table 17.5-14).

Wildfire

As wildfire extremes as a consequence of climate change emerge over time, the Project area may experience increased fire behaviour. Given the relationship between the PDO and ENSO it is probable that fire occurrences will increase during the current (negative) phase of the PDO, which have resulted in frequent La Niña events between 2005 and 2014. On the Fraser Plateau, the coupling of negative PDO phases with La Niña events has been demonstrated to significantly increase both fire weather as well as wildfire occurrences (Daniels 2002). As such, Project components have a range of sensitivities to increased wildfire due to climate change (Table 17.5-14).

17.6 ACCIDENTS AND MALFUNCTIONS

17.6.1 Introduction

17.6.1.1 Approach to Risk Management

Risk is an inherent part of the development of any large mining project. KAM actively utilizes management systems to identify and assess risks, and establish the controls needed to effectively manage them. Risk mitigation may come in the form of engineering controls, training requirements, operating standards, contingency planning, monitoring programs, compliance evaluation and audit and inspection requirements.

Risk management processes are currently being applied as part of Project design. They will continue to be implemented throughout the Project lifecycle and are a critical component to continual improvement of environmental performance. Risks and opportunities are assessed, prioritized, and managed as appropriate according to the nature, scale, and impacts of the Project's operations and activities. Environmental risks are recorded and maintained in a risk register. The register is reviewed and updated regularly, including when operational and management changes are applied, and when post-incident investigations are undertaken.

The management of risks and preparedness for unplanned events such as accidents and malfunctions are important elements within KAM's corporate policies and approaches to Project development. The broad approach adopted by KAM with respect to Project risk is as follows:

- proactively identify major risks of concern starting at the design phase and continuing through all Project phases;
- fully assess material risks using a methodological analysis, including estimating the probability, potential magnitude, and consequence(s) of accidents and/or malfunctions associated with the Project;
- develop management plans, training, and education, and facilitate a culture of risk awareness designed to prevent accidents and/or malfunctions associated with the Project;
- develop and maintain emergency preparedness plans and other management plans to ensure the protection of the environment, workers, and public in case of accidents and/or malfunctions associated with the Project;
- where elimination, avoidance, or transfer of risk is not possible, reduce the risk to as low as reasonably practicable by applying loss control and other strategies to minimize the effect on the environment, workers, and public; and
- employ adaptive management techniques to ensure continual appraisal and improvement for all risk awareness, management, mitigation and response plans, and training associated with the Project.

17.6.1.2 Requirements for Environmental Assessment

Accidents and malfunctions that may occur in connection with the Project require an assessment of the environmental effects. As outlined in the AIR/EIS Guidelines, the following scenarios are required to be evaluated:

- fire;
- pit failure;
- contamination of soils and/or water due to spill, leaks, etc. (e.g., fuel spills, reagents);
- failure of Tailings Storage Facility (TSF), seepage collection and runoff ponds;
- leakage from TSF, seepage collection and runoff ponds;
- failure of the mine rock storage facilities;
- Kinder Morgan Pipeline leakage or failure;
- accidental leakage of effluent;
- power outages;
- flying rock from blasting;
- motor vehicle/transportation accidents;
- flooding, erosion and/or burial due to containment structure failures;
- metal leaching and acid rock drainage;
- sediment transport into watercourses; and
- accidental explosion.

The requirement to assess the above scenarios has been fulfilled through three evaluations:

The first evaluation was a Failure Modes and Effects Analysis (FMEA) workshop covering all activities and components of the Project, except TSF failure, which was evaluated separately. FMEA is a semi-quantitative methodology that provides a structured and transparent analysis of:

- the likelihood of hypothetical failure of structures, equipment, or processes, and variation from assumptions made during design and estimates; and
- the effects or consequences of such failures on external systems should they occur.

For the purposes of this chapter, the term "failure mode" is synonymous with "accidents and malfunctions." These terms are applied interchangeably.

KAM hosted a formal FMEA workshop over two days in February 2015. ERM Consultants Canada Ltd. facilitated this workshop. The FMEA included the identification of potential effects of a hypothetical failure on health and safety, environment, and the surrounding communities. The FMEA also included possible environmental consequences associated with different failure modes of mine activities and components during Construction, Operation, Decommissioning and Closure,

and Post-Closure. The FMEA workshop findings are summarized in Section 17.6.2; the detailed results of the FMEA workshop are included in Appendix 17.6-A.

The second risk evaluation addresses the potential for catastrophic failure of the dams associated with the TSF. The dam failure modes assessment and dam breach inundation evaluation was completed in three stages:

- Stage 1: Screening Level Study;
- Stage 2: Potential Failure Modes Analysis; and
- Stage 3: Dam Breach and Inundation Study.

The dam breach inundation study was completed in accordance with the Canadian Dam Association (CDA) Dam Safety Guidelines (the Guidelines; CDA 2007).

Potential Failure Modes Analysis (PFMA) is a systematic, proactive method for evaluating a structure or system to identify where and how it might fail (potential failure modes) and assessing the likelihood of the failure and the effects (consequences) of such failure. The purpose of the dam breach study is to evaluate potential consequences of dam failure in order to classify the dam and to map out potential inundation zones for emergency preparedness measures. The PFMA precedes the dam breach study in order to identify credible failure mechanisms that could lead to breach and inundation.

Norwest Corporation (Norwest) has been engaged as the engineering design consultant for the TSF, and carried out this risk evaluation. The risk assessment methodology and findings are summarized in Section 17.6.3; a detailed technical report from Norwest is included as Appendix 17.6-B.

The third evaluation used the results of the Norwest study to consider the potential downstream environmental effects associated with the inundation models created for each of the credible failure modes. The analysis was completed by ERM Consultants Canada Ltd. The assessment methodology and results are described in Section 17.6.4.

17.6.2 Failure Modes and Effects Analysis

17.6.2.1 Workshop Overview

A workshop was held on February 19 and 20, 2015 to support, in part, the requirements of the Application/EIS to identify and assess potential accidents, malfunctions, and unplanned events that could occur during any phase of the Project. The workshop was based on a FMEA approach in accordance with the requirements of the AIR/EIS Guidelines. [Note: an assessment of failure modes associated with the TSF was excluded from the scope of this workshop and considered in a detailed stand-alone assessment.]

The workshop was attended by a multi-disciplinary team from KAM and its consultants. Workshop participants are listed in Table 17.6-1 and were selected based on their knowledge of the Project as well as their technical expertise and ability to apply previous knowledge and experience gained regionally and globally in the mining industry to the scenarios being evaluated. The workshop was

facilitated by Ms. Mireille Busque (ERM Global Risk Practice), a trained facilitator for qualitative and semi-quantitative risk assessments.

Table 17.6-1. KAM Project FMEA Workshop Participants

Name	Organization	Role
Mireille Busque	ERM	Facilitator
Rebecca D'Onofrio	ERM	Scribe
Kate Parsons	KGHM	Environmental Manager
Nicola Banton	KGHM	EA and Permitting Manager
Dene McGunigle	KGHM	Safety Superintendent
Carlos Penunuri Yepiz	KGHM	Health and Safety Manager
Clyde Gillespie	KGHM	Project Development Manager
Wayne Fong	KGHM	Process Manager
Yves Lacasse	KGHM	External Affairs Manager
Sheila Kluck	KGHM	Manager Geotechnical Engineering
Michal Wypych	KGHM	Chief Mine Engineer
Daniel Lefebvre	KGHM	Manager of Engineering
Les Galbraith	Knight Piésold	Geotechnical Engineering
Mediha Hodzic	Knight Piésold	Water Management
Trevor Crozier	BGC	Groundwater, Water Management
Mark Bietting	Klohn Crippen Berger	Hydrogeology
Derek Chubb	ERM	Environmental Assessment
Elizabeth Sherlock	ERM	Environmental Assessment
Jason Rempel	ERM	Environmental Assessment
Chris Klassen	Norwest	Geotechnical Engineering
Bruce Mattson	Lorax	Geochemistry

17.6.2.2 Failure Modes and Effects Analysis Methodology

Overview

FMEA was originally developed for the United States Armed Forces in 1949, and is now widely used in reliability engineering and early on in the project lifecycle to identify and address potential issues. Useful guidance related to FMEA for mining is outlined in an Infomine E-Book titled Mine Closure (Robertson and Shaw, n.d.). FMEAs are an essential part of any ongoing risk and liability reduction program.

The term "risk" is a function of:

- the expected severity of consequences; and
- the likelihood of such consequences to materialize if such an event (i.e., the failure modes) were to occur.

Through the FMEA process a risk profile is developed for each scenario. Failure modes with high and medium risk are identified, and opportunities for further prevention and mitigation or alternative designs to reduce risk are considered. It is important to note that the current controls operating as designed and intended (adequate and effective) are taken into account when estimating the potential severity of consequences and the likelihood of occurrence.

The failure modes considered during the February 2015 FMEA workshop were focussed on hypothetical failure modes involving what participants considered worst-case scenarios with the potential for off-site environmental effects. The workshop briefly evaluated the health and safety consequence associated with each scenario; however, for the purposes of fulfilling the requirements for environmental assessment, the focus was on external risks (i.e. risks to facilities and habitat outside the Project area). KAM has other mechanisms/processes in place for evaluating and managing internal risks (e.g., occupational health and safety).

FMEA Components

The results of the February 2015 FMEA workshop are documented in Appendix 17.6-A. Definitions of key components that were evaluated during the workshop are provided in the following sections.

Failure Mode

The Failure Mode provides a scenario of the event and/or type of system failure being evaluated. A failure mode can be initiated naturally (e.g., "Natural Perils" including a seismic or meteorological event), by failure of an engineered subsystems (e.g., instability due to design limitation), or from operational failure linked to ineffective or inadequate control measures (e.g., neglecting to close a valve and subsequent release of a contaminating substance). Due to the large number of potential failure modes that could be included in an FMEA, only the failure modes with a potentially material impact (human health & safety, environment, community) were assessed in the February 2015 FMEA workshop.

Consequence/Severity

Consequence/Severity is the "expected" severity of consequences related to the defined failure mode – while giving due consideration to the current level of control, and effectiveness. For each defined failure mode, the consequence in the FMEA is assessed separately with respect to each of the three areas of concern used in this FMEA approach:

- *Environment* (includes biological and regulatory consequences);
- *Community* (includes public mistrust consequences); and
- *Human health and safety* (includes community and public but not occupational consequences [which were considered internal risks]).

Various threshold scales apply for each area of concern such as severity of injury, community expressions of mistrust, and environmental impact. The consequence severity categories used for the workshop are defined in Table 17.6-2. The severity ranking is typically classified using a five-level system, from "Minor" to "Catastrophic".

Table 17.6-2. Severity of Consequence Definitions

Severity Definitions	Minor	Moderate	Serious	Major	Catastrophic
Environment	Events with no negative impact on the environment in the local study area	Events with small reversible impact on the environment in the local study area	Events causing reversible damage outside of the local study area but not dysfunction of ecosystems.	Events causing reversible damage to the environment and temporary dysfunction of ecosystems	Events causing irreversible damage to the environment and permanent dysfunction of ecosystems
Community	Tangible expressions of mistrust among a handful of community members with no influence on public opinion and decision-makers.	Tangible expressions of mistrust among a few community members with some influence on public opinion and decision-makers.	Tangible expressions of mistrust among some community members with moderate influence on public opinion and decision-makers.	Tangible expressions of mistrust among most community members with significant influence on decision-makers.	Widespread loss of trust across the community setting the agenda for decision-makers and key stakeholders.
Health and Safety	First aid required	Lost time injuries	Disabling injuries	Single fatality	Multiple fatalities

Controls – Prevention and Mitigation

For each of the defined failure modes, *prevention* (pre-event) controls (e.g., design measures or operating controls) that are/will be implemented and effective to prevent the failure mode are identified. These prevention strategies and measures function to prevent and/or detect the failure mode by reducing the likelihood of occurrence.

For each of the defined failure modes, *mitigation* (post-event) strategies and measures (e.g., design measures, operating procedures, and response plans and recovery measures) that will be implemented and effective to reduce the effect of the failure mode are identified. These mitigation measures function to reduce the severity of the consequences related to an event should failure occur.

Likelihood

Likelihood indicates the probability that the identified outcome (i.e., severity of consequences) will occur relative to the defined failure mode. Likelihood has been classified using a five-level rating system, ranging from "Almost Certain" to "Rare" as defined in Table 17.6-3. The likelihood rating considers the current controls (prevention and mitigation) operating as designed and intended (adequate and effective).

Table 17.6-3. Likelihood Rating Criteria

Likelihood Rating	Criteria
Almost Certain	1:1 year or 100% chance of occurrence
Likely	1:10 years or >10% chance of occurrence
Possible	1:100 years or <1.0% chance of occurrence
Unlikely	1:1,000 years or <0.1% chance of occurrence
Rare	1:10,000 years or <0.01% chance of occurrence

For the purposes of this FMEA, it is important to note that the likelihood related to the defined failure mode was estimated based on the environmental consequences only.

Risk Ranking

The risk ranking associated with a failure mode is a function of the severity of consequences and the likelihood of the failure mode. Using a procedure known as "binning", each combination of likelihood and severity assigns a rank categorized as Low, Medium, or High across a Risk Matrix (Table 17.6-4). The level of risk increases with greater likelihood and severity. A failure mode with a likelihood of "almost certain" and a "major" or "catastrophic" severity is a high risk (red). In contrast, a failure mode with a "rare" likelihood with a "minor" severity is a low risk (green). Risk increases diagonally on the Risk Matrix from the bottom left to the top right (Table 17.6-4). The workshop required consensus amongst the team members to assign a ranking for a failure mode.

Table 17.6-4. FMEA Risk Matrix

Likelihood	Consequence Severity				
	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain 1:1 year or 100%	*LOW*	*MEDIUM*	*HIGH*	*HIGH*	*HIGH*
Likely 1:10 years or >10%	*LOW*	*MEDIUM*	*MEDIUM*	*HIGH*	*HIGH*
Possible 1:100 year or <1.0%	*LOW*	*LOW*	*MEDIUM*	*HIGH*	*HIGH*
Unlikely 1:1,000 years or <0.1%	*LOW*	*LOW*	*MEDIUM*	*MEDIUM*	*HIGH*
Rare 1:10,000 years or <0.01%	*LOW*	*LOW*	*MEDIUM*	*MEDIUM*	*HIGH*

Uncertainty in assigning the likelihood of failure and/or the severity of consequences needs to be considered in discussing the results of the risk categorization. Factors such as lack of data, lack of system understanding, and future advances in project design or operating procedures may alter the confidence in a risk assessment. As circumstances change surrounding a failure mode, the risk assessment needs be periodically reconsidered.

17.6.2.3 FMEA Risk Evaluation Summary

While KAM recognizes the importance of all risk categories, the remainder of this chapter will focus on the potential environmental effects of accidents and malfunctions. A total of 38 failure modes with potential effects on the environment were assessed, capturing each of the topics identified in the AIR/EIS Guidelines [ID corresponds to the risk register in Appendix 17.6-A]:

- Fire [ID32];
- Pit failure [ID01, ID02];
- Contamination of soils and/or water due to spill, leaks, etc. (e.g., fuel spills, reagents) [ID34, ID35, ID36];

- Failure of Tailings Storage Facility, seepage collection and runoff ponds [ID26, ID30, ID31, Appendix 17.6-B];
- Leakage from Tailings Storage Facility, seepage collection and runoff ponds [ID27, ID28, ID29, Appendix 17.6-B];
- Failure of the waste rock storage facilities [ID08, ID09, ID10, ID11, ID12];
- Kinder Morgan Pipeline leakage or failure [ID10, ID37];
- Accidental leakage of effluent [ID27, ID28, ID29];
- Power outages [ID20];
- Flying rock from blasting [ID03];
- Motor vehicle/transportation accidents [ID17, ID18, ID19];
- Flooding, erosion and/or burial due to containment structure failures [ID11, ID12, ID31];
- ML/ARD [ID13];
- Sediment transport into watercourses [ID11, ID31]; and
- Accidental explosion [ID21, ID22, addendum to Appendix 17.6-A].

The number of Project failure modes at each risk level was:

- High risk (red) – 2
- Medium risk (yellow) – 23
- Low risk (green) – 13

Table 17.6-5 summarizes the distribution of risk within the FMEA Risk Matrix.

Table 17.6-5. Environmental Risk Distribution within the FMEA Risk Matrix

Likelihood	Consequence Severity				
	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain 1:1 year or 100%					
Likely 1:10 years or >10%	2				
Possible 1:100 year or <1.0%	2	2	1		
Unlikely 1:1,000 years or <0.1%	1	4	8	8	
Rare 1:10,000 years or <0.01%	1	1	1	5	2

17.6.2.4 Assessment of Potential Environmental Effects

All 38 failure modes considered during the FMEA workshop are described in Appendix 17.6-A, and will continue to be carried forward on the Project risk register to be re-evaluated at subsequent stages of Project development. For the purposes of this assessment, the 25 high risk and medium risk failure modes identified through the FMEA workshop were carried forward to an evaluation of potential environmental effects. This was completed through two steps:

1. Failure modes were screened against the list of Valued Components (VCs) to identify which VCs would be most directly influenced by the failure mode. Similar to the methodology outlined in Chapter 5, an interaction matrix approach was used, and interactions were ranked as follows:
   - Red — primary/direct interaction between failure mode and VC;
   - Yellow — secondary/moderate interaction between failure mode and VC;
   - Green — tertiary/minor interaction between failure mode and VC; or
   - White — no interaction anticipated.
2. Failure modes were characterized against the following assessment criteria:
   - Severity:
     - See Table 17.6-2.
   - Duration:
     - *Short Term*: an effect that lasts approximately 1 to 5 years.
     - *Medium Term*: an effect that lasts between 6 to 25 years.
     - *Long Term*: an effect that lasts between 26 and 50 years.
     - *Far Future*: an effect that lasts more than 50 years.
   - Spatial Extent:
     - *Local*: an effect is limited to the Project footprint.
     - *Landscape*: an effect extends beyond the Project footprint to a broader area.
     - *Regional*: an effect extends across the regional study area.
     - *Beyond Regional*: an effect that extends possibly across or beyond the province of BC.
   - Likelihood:
     - See Table 17.6-3.
   - Reversibility:
     - *Reversible Short Term*: an effect that can be reversed relatively quickly.
     - *Reversible Long Term*: an effect that can be reversed after many years.
     - *Irreversible*: an effect that cannot be reversed (i.e., is permanent).

- Resiliency:
  - *High*: the component is considered to be highly resilient following the failure mode
  - *Moderate*: the component is considered to be moderately resilient following the failure mode.
  - *Low*: the component is considered to be of low resiliency following the failure mode.

17.6.2.5 Risk Profiles

Using the results of the FMEA workshop and the assessment of potential environmental effects, this section provides a risk profile for each of the 25 failure modes identified as high or medium risk.

Overall, KAM and its consulting team are of the opinion that the risks identified through the FMEA workshop are similar to those associated with typical open-pit mining. It is not possible to remove all risks. However, the preventative measures that are planned are standard within the mining industry, and KAM is actively implementing such measures at its active mining operations globally.

The most unique aspect of the Ajax Project highlighted during the workshop is the location of Jacko Lake relative to the Open Pit. To date, KAM has undertaken detailed investigations to understand current hydrogeological and geotechnical conditions between the lake and the proposed pit. As detailed geotechnical monitoring plans are developed, they will be focused on effectively managing this risk. With the implementation of the above measures, workshop participants rated the likelihood of this failure scenario as "Rare" (the lowest category), yet the risk remains High, because the consequences of loss of Jacko Lake remain "Catastrophic" (the highest category). However, it is important to note that this failure mode (propagation to Jacko Lake) is not considered credible at the start of Operation, when the pit rim is the furthest from Jacko Lake. The risk will increase through the first few years of Operation as the pit rim advances toward the lake; however, this will be balanced by a robust system monitoring the geotechnical and hydrogeologic conditions and adjustments to the mining operation based on the results of the monitoring programs. The risk will then decrease again during the later stages of the Operation as the IPMRSF is developed, with lower risk conditions carried into Post-Closure. KAM recognizes the many environmental, social, and cultural values associated with Jacko Lake, and is committed to developing, operating, and closing the Project in a manner that retains these values.

The risk register and risk profiles that have been developed through the FMEA workshop have been incorporated into KAM's internal risk management systems. Actions have been initiated against the recommendations identified during the workshop. The results of some of studies have already been incorporated into this Application/EIS; others are longer-term actions that are on-going to support continued engineering design and development of the Project.

17.6.3 Dam Breach Inundation Study

A dam breach inundation study was used to evaluate the likelihood of potential accidents, malfunctions and unplanned events, and to develop mitigation strategies. The following section provides an overview of the TSF and its development, as well as the three-step approach used to screen and evaluate risks.

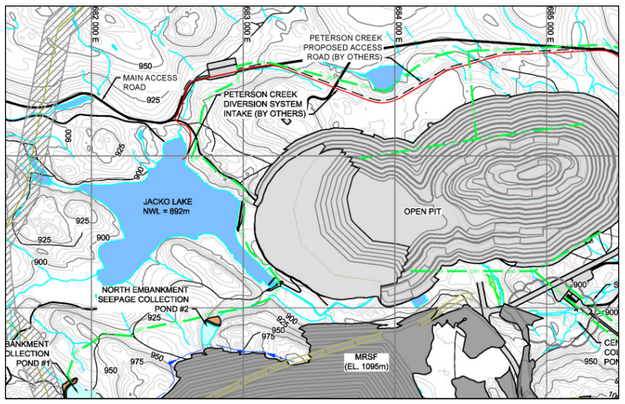
Failure Modes Effects Analysis Risk Profile – ID-01

ID:	01	Title:	Open pit high wall failure (Operations)

Description:

Operations phase highwall failure that propagates into Jacko lake resulting in a significant volume of water transferring into the mine pit. This failure mode would be a rapid one-time event with a local footprint. Potential impacts would include: loss of fish and wildlife habitat (extending downstream of the lake); Potential of loss of life (fishermen on the lake, workers in the pit); Loss of recreational and cultural value.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations and design, including a minimum factor of safety of 1.6 (see Appendices 3-D; 6.2-C; 6.2-D);
- De-pressurization of the pit wall during Operation through installation of horizontal drains (see Section 3.5.1);
- Active, continuous monitoring of pit stability (Section 11.2);
  - Slope stability will be constantly monitored through a combination of Automated Total Station Networks, Non reflective LIDAR (Light Detection and Ranging) scanning, Slope Stability Radar (SSR) and/or Global Positioning System (GPS). Monitoring will be done on a daily basis to allow for real-time identification of stability issues that can be rectified in a timely manner through adaptive management.
- An adaptive response will be implemented based on monitoring observations, which will include escalation as appropriate (e.g., reinforcement of wall, evacuation of pit, evacuation of Jacko Lake);
- The mine plan will be continuously optimized and refined through Operation to ensure long-term stability; and
- In-pit MRSF (Section 3.9.1) will buttress high-wall and reduce residual risk.

Mitigation Response:

- Implement Emergency Response Plans (Section 11.14) to ensure safe conditions are established as quickly as possible;
- Site investigations:
  - Evaluate the new geotechnical conditions in the immediate vicinity of the failure and of remaining pit wall sections; and
  - Evaluate resultant effects to environmental/cultural resources around the lake.
- Re-establishment of lake:
  - Construct new dam(s) and grout/seal potential new seepage pathways that were developed;
  - Re-fill lake (with original lake water, or with supply from Kamloops Lake); and
  - Re-establish water supply to downstream users and stocked fish population.
- Re-establishment of stability monitoring to incorporate new site conditions.

Follow-up Monitoring:

- Monitoring of new dams to support the re-established Jacko lake;
- Monitoring success of lake re-establishment (e.g., fish, recreational use).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

While it would be possible to physically re-establish the lake (reversible long-term), it is recognized that that this failure mode has the potential to irreversibly erode cultural values related to the story of Jacko Lake.

Risk Characterization:

Likelihood \ Severity	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare					H, C, E

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Ensure that pit slope stability analysis and design incorporates conservative information (for example how voids are addressed);
- Engage a third-party geotechnical expert to review the slope design;
- Re-evaluate magnitude of consequences based on the distance between pit crest and the cut-off wall considering the most likely pit failure plane;
- Ensure that the monitoring program of the high wall stability is robust and that the area close to Jacko Lake is subject to more stringent review.

Status at time of EA Submission:

- Action against the first two recommendations has been initiated and incorporated into the results presented in this Application (e.g., see Appendices 3-D; 6.2-C; 6.2-D); and
- Recommendations continue to be tracked in the risk register, and are being implemented as part of Detailed Design.

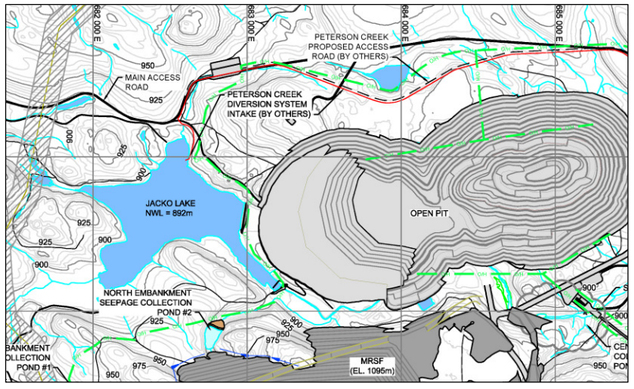
Failure Modes Effects Analysis Risk Profile – ID-02

ID:	02	Title:	Open pit high wall failure (Post Closure)

Description:

Post-closure phase highwall failure that propagates into Jacko lake resulting in a significant volume of water transferring into the mine pit. This failure mode would be a rapid one-time event with a local footprint. Potential impacts would include: loss of fish and wildlife habitat (extending downstream of the lake); Potential of loss of life (fishermen on the lake); Loss of recreational and cultural value.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations and design, including a minimum factor of safety of 1.6 (see Appendices 3-D; 6.2-C; 6.2-D);
- De-pressurization of the pit wall during Operation through installation of horizontal drains (see Section 3.5.1);
- Understanding of geotechnical conditions developed through the monitoring program during Operation will inform final closure planning; and
- In-pit MRSF (Section 3.9.1) will buttress high-wall and reduce residual risk.

Mitigation Response:

- Implement Emergency Response Plans (Section 11..14) to ensure safe conditions are established as quickly as possible;
- Site investigations:
  - Evaluate the new geotechnical conditions in the immediate vicinity of the failure and of remaining pit wall sections ;
  - Evaluate resultant effects to environmental/cultural resources around the lake;
- Re-establishment of lake:
  - Construct new dam(s) and grout/seal potential new seepage pathways that were developed,
  - Re-fill lake (with original lake water, or with supply from Kamloops Lake),
  - Re-establish water supply to downstream users and stocked fish population;
- Re-establishment of stability monitoring to incorporate new site conditions.

Follow-up Monitoring:

- Monitoring of new dams to support the re-established Jacko lake;
- Monitoring success of lake re-establishment (e.g., fish, recreational use).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

While it would be possible to physically re-establish the lake (reversible long-term), it is recognized that that this failure mode has the potential to irreversibly erode cultural values related to the story of Jacko Lake.

Risk Characterization:

Likelihood	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare	H				C, E

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Ensure that pit slope stability analysis and design incorporates conservative information (for example how voids are addressed);
- Engage a third-party geotechnical expert to review the slope design;
- Re-evaluate magnitude of consequences based on the distance between pit crest and the cut-off wall considering the most likely pit failure plane;
- Ensure that the monitoring program of the high wall stability is robust and that the area close to Jacko Lake is subject to more stringent review.

Status at time of EA Submission:

- Action against the first two recommendations has been initiated and incorporated into the results presented in this Application (e.g., see Appendices 3-D; 6.2-C; 6.2-D);
- Recommendations continue to be tracked in the risk register, and are being implemented as part of Detailed Design.

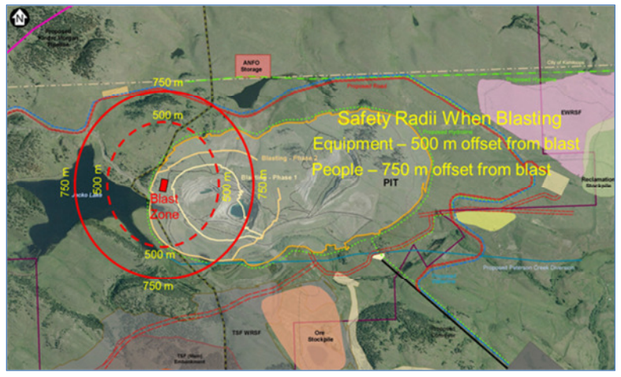
Failure Modes Effects Analysis Risk Profile – ID-03

ID:	03	Title:	Overloading Blast Holes

Description:

Inappropriate loading of blast holes resulting in flyrock travelling further than expected leading to personal injuries; noise, vibration and dust impact on local community; distress to fish and wildlife due to noise and vibration. This failure mode would occur as a result of operator error by blasting technicians. The risk would be highest early in the mine life, when blasting activity is near surface. This failure mode would be a one-time occurrence, with very short-term duration.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

Implementation of an explosives management plan (see Section 11.11):

- Appropriate training/certification for contractors/employees handling explosives;
- Use of appropriate stemming and decking, drill patterns, blast charge weights per delay, and blast hole diameter;
- Quality control procedures to ensure proper loading of blast holes and minimization of contamination to the explosive from the stemming; and
- Communication of blast scheduling and blast radius to personnel and users of Jacko Lake.

Managing access on Jacko Lake during blasting (see Section 11.21).

Mitigation Response:

- Emergency response plan (Section 11.14; for injuries), including extended search zones;
- Aquatic and wildlife habitat assessment; and
- Incident investigation, including review of blasting procedures and contracting.

Follow-up Monitoring:

- Increased auditing/oversight of blasting activities.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely			E	H,C	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- No new recommendations were identified (beyond what is already planned).

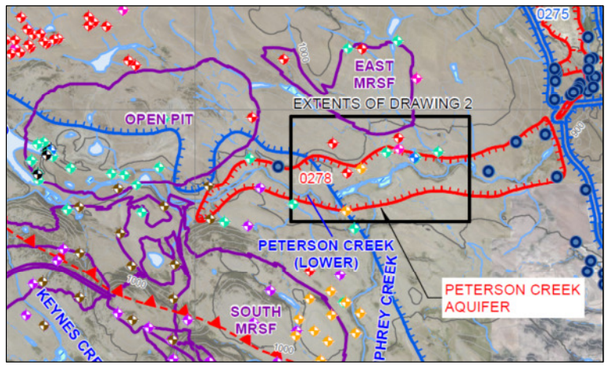
Failure Modes Effects Analysis Risk Profile – ID-04

ID:	04	Title:	Peterson Creek Aquifer Delineation

Description:

Incorrect delineation of Peterson Creek Aquifer, which results in increased groundwater flow to the pit, and thus greater reduction of groundwater flow within Peterson Creek Aquifer to support other ecological or water supply values. This failure mode would occur as a variation from assumptions made during design. It is a chronic condition that would develop over time, as opposed to a one-time event.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

Detailed hydrogeological and geotechnical baseline investigations as (see Appendices 3-D; 6.2-B; 6.2-C; 6.2-D; 6.6-A; 6.6-B, 6.6-C), including pump test of Peterson Creek Aquifer.

Monitoring programs (see Section 11.7, 11.25) that will track:

- Water levels in Peterson Creek aquifer during Operation and into Post-Closure;
- Water levels in the pit lake during Post-Closure; and
- Dam stability at Jacko Lake during Operation and into Post-Closure.

Mitigation Response:

Specific response would be based on site investigation, but generally could include activities such as:

- Consolidation grouting or interception wells to cut off groundwater flow into the pit;
- Temporarily supplementing Jacko Lake or Peterson Creek with water from Kamloops Lake.

Follow-up Monitoring:

- Continuation of monitoring programs (per Preventative Controls);
- Increase sampling frequency at existing wells, and/or install new wells at targeted locations (as appropriate).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Severity: Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely	H		C	E	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Conduct additional surveys to understand hydraulic conductivity to increase confidence of distance between the open pit and Peterson Creek Aquifer.

Status at time of EA Submission:

- Peterson Creek Aquifer pump test (Appendix 6.6-C) completed.

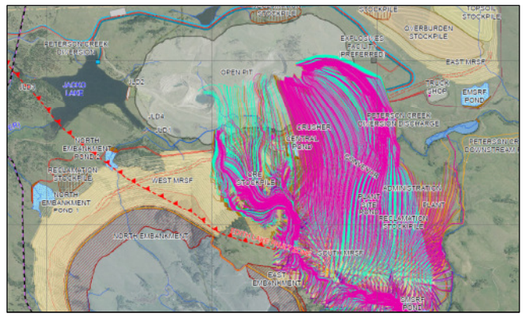
Failure Modes Effects Analysis Risk Profile – ID-05

ID:	05	Title:	Groundwater Seepage Post Closure

Description:

Groundwater seepage of potentially contaminated water from the open pit to the local aquifer during Post Closure. For this failure mode to occur, there would need to be a hydraulic gradient that could drive seepage from the pit toward the Aquifer. Modelling work completed to date (see Appendix 3-C) indicates that the pit lake is anticipated to fill very slowly, and that the pit lake level will be established at approximately 760 masl (124 m below the pit perimeter). In this case, the pit lake remains a groundwater sink throughout Post Closure, with hydraulic gradients flowing into the pit lake rather than out of it.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

Detailed hydrogeological and geotechnical baseline investigations as (see Appendices 3-D; 6.2-B; 6.2-C; 6.2-D; 6.6-A; 6.6-B, 6.6-C), including pump test of Peterson Creek Aquifer

Monitoring programs (see Sections 11.7, 11.25) that will track:

- Water levels in Peterson Creek aquifer during Operation and into Post-Closure; and
- Water levels in the pit lake during Post-Closure.

Mitigation Response:

Specific response would be based on site investigation, but generally could include activities such as:

- Managing pit lake level (through discharge) to maintain a desired hydraulic gradient;
- Installing pumping wells to control groundwater transport from pit lake along specific flow paths of interest.

Follow-up Monitoring:

- Continuation of monitoring programs (per Preventative Controls);
- Increase sampling frequency at existing wells, and/or install new wells at targeted locations (as appropriate).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Severity: Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely	H			E,C	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Further validate water model and adapt the water management plan as required (for example: fault mapping during pit operations).

Status at time of EA Submission:

- Investigations of Peterson Creek Aquifer (pump test) (Appendix 6.6-C) and Edith Lake Thrust Fault (Appendix 6.2-B) completed to date.

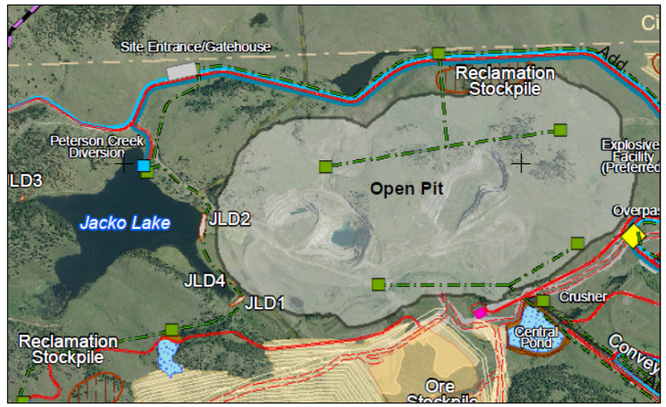
Failure Modes Effects Analysis Risk Profile – ID-06

ID:	06	Title:	Jacko Lake Water Retention failure

Description:

Operations or Post-Closure phase incremental failure in water-retention from Jacko Lake resulting in the progressive infilling of the the pit and leading to loss of fish and wildlife habitat in and around Jacko Lake; with effect on downstream water users and water license holders.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

Detailed hydrogeological and geotechnical baseline investigations as (see Appendices 3-D; 6.2-B; 6.2-C; 6.2-D; 6.6-A; 6.6-B, 6.6-C)

- Pit design to higher Factor of Safety in proximity to the lake and dykes to protect lake and dams;
- Adherence to blasting management protocols established to preserve fish health and minimize vibration in proximity to the lake and dams;
- Performance monitoring of the dams including third-party review and inspection in accordance with established guidelines.

Mitigation Response:

Specific response would be based on site investigation, but generally could include activities such as:

- Modifications to dams on Jacko Lake;
- Sheetpiles/grouting to prevent further seepage;
- Pumping wells;
- Termination of operations at the western pit limit if deemed unsafe; with a case-specific re-evaluation of pit wall and water management methodologies moving forward.

Follow-up Monitoring:

- Continuation of monitoring programs (per Preventative Controls).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely				H,C,E	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Third party expert review of dam design basis and engineering design.

Status at time of EA Submission:

- Third party reviewer engaged and supporting detailed design.

Failure Modes Effects Analysis Risk Profile – ID-07

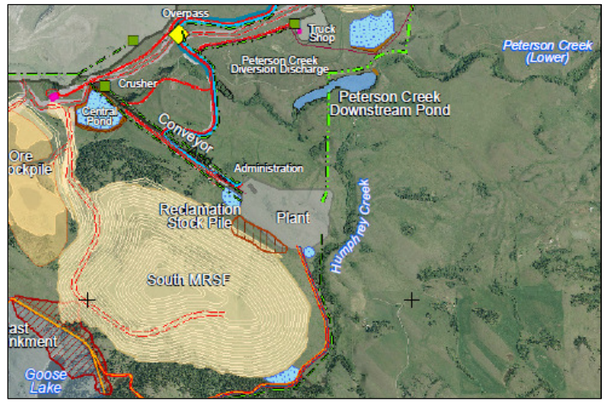
ID:	08	Title:	Slope Failure of SMRSF (1)

Description:

Slope failure of SMRSF leading to potential rupture of the Tailings and Reclaimed pipelines which would naturally drain to Humphreys Creek, and towards Peterson Creek (but contained by Peterson Creek Downstream Pond).

Note: see also ID14

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Geotechnical investigations and stability analyses (Appendix 3-F);
- Conservative design for slope angles (2.4H:1V);
- Routine (monthly) monitoring of slope movements during Operation (Section 11.2), including vibrating wire piezometers, slope inclinometers, and surface movement monuments.

Mitigation Response:

- Cease plant operations until the problem is solved
- Implement response protocol for spills (see Section 11.16):
  - identification and control of immediate dangers to human life or health;
  - identification and control of release source;
  - elimination of additional potential release sources;
  - containment of release;
  - notification of authorities, as appropriate;
  - recovery and cleanup; and
  - incident investigation and reporting.

Follow-up Monitoring:

- Increase water sampling frequency in Humphrey Creek post clean-up (as appropriate).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood \ Severity	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely	H		C	E	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Evaluate means to protect the pipelines from a potential slope failure of the SMRSF.

Status at time of EA Submission:

- Recommendation continues to be tracked in the risk register, and will be actioned as part of detailed design.

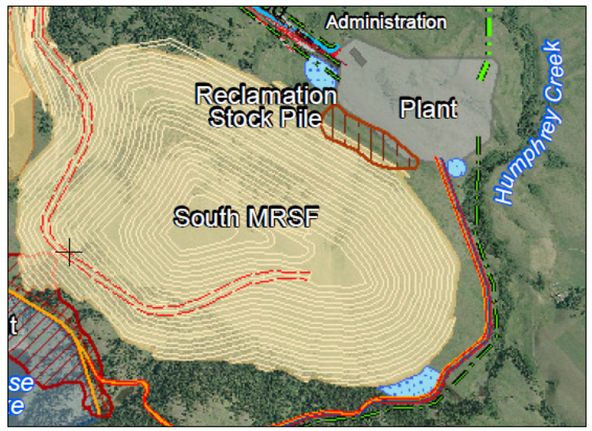
Failure Modes Effects Analysis Risk Profile – ID-08

ID:	09	Title:	Slope Failure of SMRSF (2)

Description:

Slope failure of SMRSF, with potential impact to plant site resulting in damage to the chemical storage areas within the process plant.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Geotechnical investigations and stability analyses (Appendix 3-F);
- Conservative design for slope angles (2.4H:1V);
- Routine (monthly) monitoring of slope movements during Operation (Section 11.2), including vibrating wire piezometers, slope inclinometers, and surface movement monuments.

Mitigation Response:

- Cease plant operations until the problem is solved
- Implement response protocol for spills (see Section 11.16):
  - identification and control of immediate dangers to human life or health;
  - identification and control of release source;
  - elimination of additional potential release sources;
  - containment of release;
  - notification of authorities, as appropriate;
  - recovery and cleanup; and
  - incident investigation and reporting.

Follow-up Monitoring:

- Targeted water sampling in area of Plant Site post clean-up (as appropriate).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood \ Severity	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare				E,C	H

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Further investigate the likelihood that a slope failure from the SMRSF would result in catastrophic impacts at the Plant site (i.e., validate the spatial extent of the slope failure.

Status at time of EA Submission:

- Siting of chemical storage areas will be reviewed by H/S as part of detailed design.

Failure Modes Effects Analysis Risk Profile – ID-09

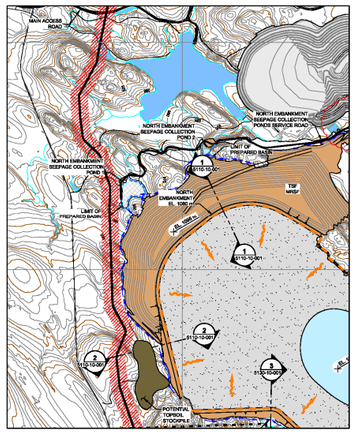
ID:	10	Title:	Slope Failure of WMRSF

Description:

Slope failure of the WMRSF leading to impact to Kinder-Morgan pipeline, which in-turn releases hydrocarbons in the environment; potential impacts to Lac Le Jeune and mine roads, and Jacko Lake.

Note: see also ID37

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations and stability analysis (Appendix 3-F);
- Conservative design of slope angles (2.4H:1V);
- Minimum 90 m offset from edge of MRSF to Kinder-Morgan pipeline;
- Monitoring of slope movements in MRSFs (see Section 11.2), including vibrating wire piezometers, slope inclinometers, and surface movement monument; and
- Kinder-Morgan pipeline is buried, less susceptible to damage than an above-ground pipeline.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Work with Kinder-Morgan as appropriate to ensure a coordinated response.

Follow-up Monitoring:

- Implement enhanced monitoring of surface water and groundwater quality in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood \ Severity	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare	H			E,C	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Evaluate if a slope failure of the WMRSF can reach the pipeline, Lac Le Jeune or Jacko Lake.

Status at time of EA Submission:

- Recommendation continues to be tracked in the risk register, and will be actioned as part of detailed design.

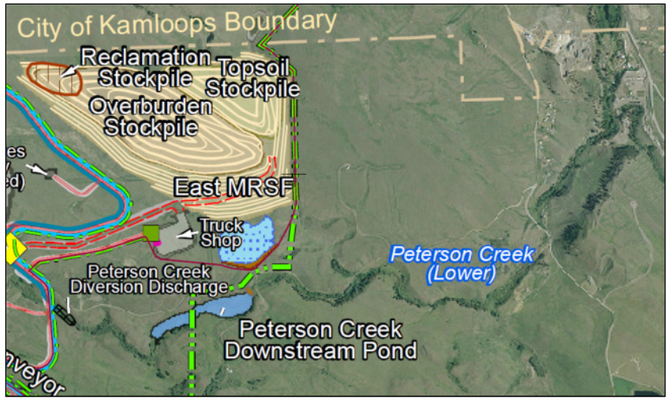
Failure Modes Effects Analysis Risk Profile – ID-10

ID:	11	Title:	Slope Failure of EMRSF

Description:

Slope failure of the EMRSF (50 metre height) leading to loss of containment of EMRSF water management pond (198,000 m^3 storage capacity) with subsequent impact on Peterson Creek due to poor quality of the water released.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations (Appendix 3-F);
- Conservative design of slope angles (2.4H:1V) and total storage volume;
- Only NPAG material stored in EMRSF;
- Monitoring of slope movements in MRSFs (see Section 11.2), including vibrating wire piezometers, slope inclinometers, and surface movement monuments;
- Lining of EMRSF management pond to prevent/reduce infiltration to Peterson Creek Aquifer;
- Limit volume of water stored in EMRSF seepage collection pond by regularly pumping to Central Pond.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Contain runoff from immediate failure zone and retain within site water management system, wherever possible;
- Remediate failure slope; re-contour and revegetate as appropriate.

Follow-up Monitoring:

- Increase water sampling frequency in Peterson Creek post clean-up (as appropriate).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely					
	Rare	H			E,C	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Evaluate if the slope failure of the EMRSF can reach Peterson Creek if the height is limited to 50 m.

Status at time of EA Submission:

- Recommendation continues to be tracked in the risk register, and will be actioned as part of detailed design.

Failure Modes Effects Analysis Risk Profile – ID-11

ID:	12	Title:	Slope Failure of PAG Material

Description:

Slope failure of the SMRSF or WMRSF (which include PAG material) leading to soil erosion and sedimentation in the downstream environment with impact on aquifer and surface water due to acid generation and metals leaching.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations (Appendix 3-F);
- Conservative design of slope angles (2.4H:1V) and total storage volume;
- Monitoring of slope movements in MRSFs (see Section 11.2);
- Implement ML/ARD management (see Section 11.5):
  - blending of PAG and NPAG materials;
  - sampling during Operation to ensure blending criteria are being met;
  - updating and revising geochemical source terms during Operation.

Mitigation Response:

- Implement erosion and sediment control measures (see Section 11.2);
- Contain runoff from immediate failure zone and retain within site water management system, wherever possible;
- Remediate failure slope; re-contour and revegetate as appropriate.

Follow-up Monitoring:

- Implement enhanced monitoring of surface water and groundwater quality in immediate vicinity of event;
- Increase water sampling frequency in Peterson Creek (as appropriate).

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely					
	Rare	H			E,C	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- No new recommendations were identified (beyond what is already planned).

Failure Modes Effects Analysis Risk Profile – ID-12

ID:	13	Title:	Mine Rock Management

Description:

Failure in mine rock management (inappropriate placement of mine rock) leading to poor water quality exceeding guidelines in the receiving environment during Operations or Post-Closure.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geochemical characterization (Appendices 3-A, 3-B);
- Water management plan (see Section 11.7) includes no direct discharge to receiving environment;
- Implement ML/ARD management plan (see Section 11.5):
  - maintain detailed, QA/QC'd geochemical inventory,
  - update and revise geochemical source terms during Operation, and
  - blending of PAG and NPAG materials;
- Surface water and groundwater monitoring programs to provide early detection.

Mitigation Response:

- Re-handle material (as appropriate) to remediate mine rock placement to achieve appropriate blend of material(s);
- Evaluate options for progressive reclamation; and
- Review water management system to capture runoff and direct to controlled area (Central Pond during Operation; Open Pit Post Closure).

Follow-up Monitoring:

- Implement enhanced monitoring of surface water and groundwater quality in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood \ Severity	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely	H			E,C	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Revisit the consequence rating once the water quality modeling has been done;
- Revisit the water balance for the pit at closure (to consider a pump scenario for the Peterson Creek aquifer).

Status at time of EA Submission:

- Water quality modelling complete (see Appendix 6.3-C). Consequence rating unchanged;
- Updated water balance shows pit as sink during Post Closure (see Appendices 3-I, 3-C).

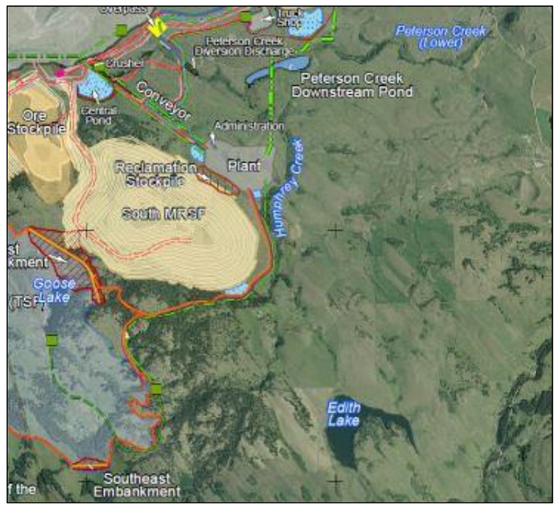
Failure Modes Effects Analysis Risk Profile – ID-13

ID:	14	Title:	Tailings/Reclaim Pipeline

Description:

Containment failure of the tailings or reclaim pipeline leading to tailings and reclaim water released to Humphreys Creek and Plant Site.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Design change to thickened tailings has reduced required flow rate for reclaim water, and tailings viscosity (thus run-out distance);
- Containment ditching along the pipeline;
- Pipeline integrity monitoring.

Mitigation Response:

- Pressure sensors at strategic locations on pipeline will allow operations to detect leakage and act;
- Implement response protocol for spills (see Section 11.16);
- Remediation/clean-up.

Follow-up Monitoring:

- Implement enhanced monitoring of surface water and groundwater quality in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely	H		C	E	
	Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Investigate means of automating pump shutdown on tailing and reclaim lined if leakage is detected using the process parameters;
- Quantify potential volume of discharge in case of a pipeline failure.

Status at time of EA Submission:

- Automation options to be investigated as part of detailed design.

Failure Modes Effects Analysis Risk Profile – ID-14

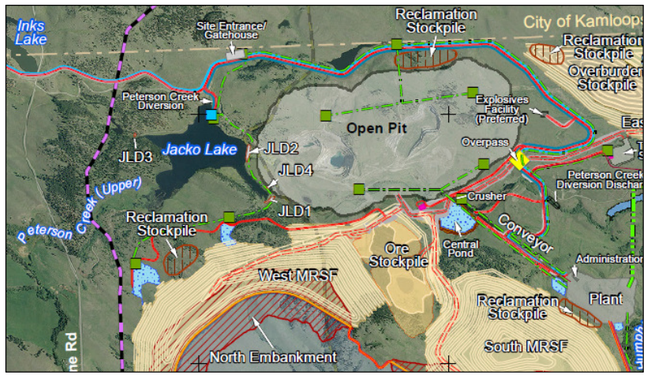
ID:	17	Title:	Concentrate Truck Accident and Spill

Description:

Concentrate Truck Accident/Spill leading to concentrate released in the environment (Peterson Creek into downstream pond and localized soil contamination); fatality (truck driver); leakage into the groundwater reaching Jacko Lake.

Note: it is recognized that the failure mode extends all the way to port of Vancouver; however, FMEA Workshop focused on area within direct KAM control (e.g., to Hwy 5).

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Site orientation for new drivers/contractors;
- Transportation Management Plan (including speed limits and seat belts; see Section 11.20);
- Road design appropriate for vehicle size and turning radius;
- Vehicle inspection prior to accessing site;
- Road maintenance;
- Safety berms on the road at portion adjacent to Peterson Creek.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16):
- Implement emergency response plan (for injuries; Section 11.14);
- Remediation activities to clean-up spill.

Follow-up Monitoring:

- After spill cleanup and excavation of the spoil, ensure that soil testing and proximal water testing is performed as appropriate to ensure Cu rich material has been removed and there is no danger of Cu bearing effluent leaching into the environment.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Minor	Moderate	Serious	Major	Catastrophic
	Severity				
Almost Certain					
Likely					
Possible					
Unlikely			E,C	H	
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Add berms and ditching along road near Jacko Lake;
- Extend Traffic Management to Lac le Jeune Road for all suppliers and employees.

Status at time of EA Submission:

- Size/location of berms and ditching will be actioned as part of detailed design.

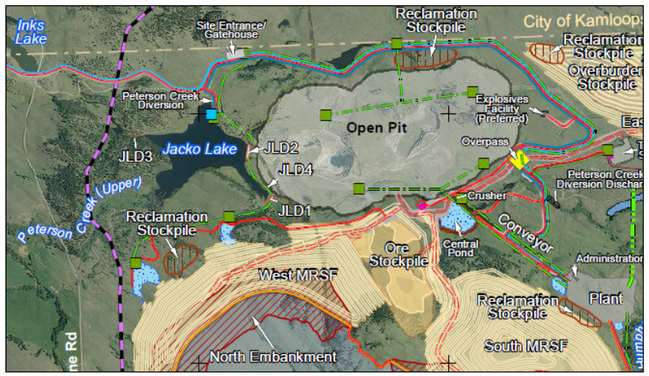
Failure Modes Effects Analysis Risk Profile – ID-15

ID:	18	Title:	Fuel Truck Accident and Spill

Description:

Fuel Truck Accident/Spill leading to fuel release in the environment (Jacko Lake, localized soil contamination); fatality (truck driver). The largest single volume of fuel will be contained in the b-train tankers coming to site. These tankers have a capacity of 53,000 L. Fuel tanks on the haul trucks have a standard capacity of 5,300 L, and on a typical pick-up truck are 140 L.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Site orientation for new drivers/contractors;
- Transportation Management Plan (including speed limits and seat belts; see Section 11.20);
- Road design appropriate for vehicle size and turning radius;
- Vehicle inspection prior to accessing site;
- Road maintenance;
- Safety berms on the road at portion adjacent to Peterson Creek.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Implement emergency response plan (for injuries; Section 11.14);
- Remediation activities to clean-up spill.

Follow-up Monitoring:

- After spill cleanup and excavation of the spoil, soil testing and proximal water testing will be performed as appropriate to ensure hydrocarbon rich material has been removed and there is no further danger of fuel bearing effluent leaching into the environment.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	Moderate	Serious	Major	Catastrophic
Likelihood	Almost Certain					
	Likely					
	Possible					
	Unlikely				H, C, E	
	Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Add berms and ditching along road near Jacko Lake;
- Extend Traffic Management to Lac le Jeune Road for all suppliers and employees.

Status at time of EA Submission:

- Size/location of berms and ditching will be actioned as part of detailed design.

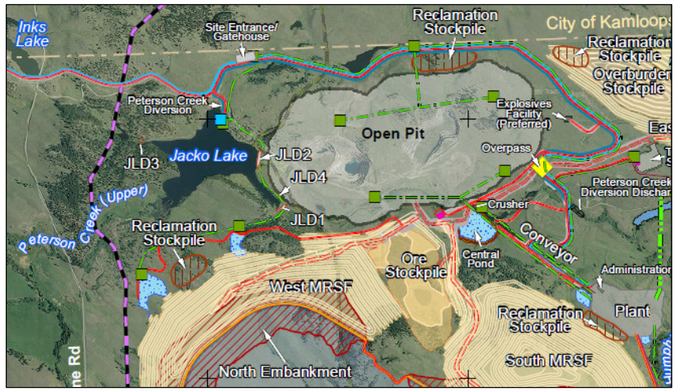
Failure Modes Effects Analysis Risk Profile – ID-16

ID:	19	Title:	Hazardous Goods Truck Accident and Spill

Description:

Hazardous Goods Truck Accident/Spill leading to hazardous material (ammonium nitrate) release in the environment with the potential for the material to reach Jacko Lake during a rain event; fatality (truck driver).

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Site orientation for new drivers/contractors;
- Transportation Management Plan (including speed limits and seat belts; see Section 11.20);
- Road design appropriate for vehicle size and turning radius;
- Vehicle inspection prior to accessing site;
- Road maintenance;
- Safety berms on the road at portion adjacent to Peterson Creek.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Implement emergency response plan (for injuries; Section 11.14);
- Remediation activities to clean-up spill;
- Offsite disposal of contaminated soil as per Hazardous Waste Regulations.

Follow-up Monitoring:

- After spill cleanup and excavation of the spoil, soil testing and proximal water testing will be performed as appropriate to ensure hazardous material (ex AN) has been removed and there is no further risk of hazardous material leaching into the environment.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely					
	Rare				H, C, E	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Add berms and ditching along road near Jacko Lake;
- Extend Traffic Management to Lac le Jeune Road for all suppliers and employees.

Status at time of EA Submission:

- Size/location of berms and ditching will be actioned as part of detailed design.

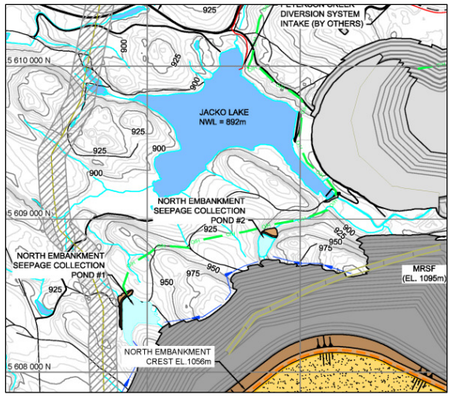
Failure Modes Effects Analysis Risk Profile – ID-17

ID:	26	Title:	Potential release of contact water into Jacko Lake

Description:

Structural failure of one of the TSF seepage and collection ponds leading to release of contact water into Jacko Lake. Based on current engineering designs the storage capacity of the seepage collection North Embankment Pond 1 is 120,000 m^3; and the North Embankment Pond 2 is 130,000 m^3.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Appropriate design of seepage collection pond embankments and pond capacity to accommodate probable flood conditions;
- Monitoring program to track water level and water quality in ponds;
- Limit volume of water stored in seepage collection ponds by regularly pumping to Central Pond.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Implement temporary control berms and diversion of surface flows to containment areas. Re-build embankment;
- Reclaim area between embankment and Jacko Lake to prevent erosion/sedimentation.

Follow-up Monitoring:

- Implement enhanced monitoring of surface water and habitat in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely	H		C,E		
	Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Consider having a third party expert review the dam design basis and engineering design.

Status at time of EA Submission:

- Third party reviewer engaged and supporting detailed design.

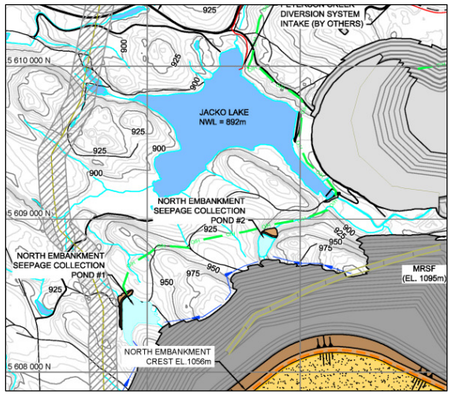
Failure Modes Effects Analysis Risk Profile – ID-18

ID:	27	Title:	Seepage of contact water via groundwater into Jacko Lake

Description:

Leakage from one of the seepage and collection ponds up-gradient of Jacko Lake leading to leakage into the groundwater reaching Jacko Lake. This failure mode would occur as a variation from assumptions made during design. It is a chronic condition that would develop over time.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Appropriate design of seepage collection pond embankments and pond capacity to accommodate probable flood conditions;
- Ponds are lined facilities;
- Monitoring program to track water level and water quality in ponds;
- Limit volume of water stored in seepage collection ponds by regularly pumping to Central Pond.

Mitigation Response:

- Identify source of leakage;
- Repair pond liner system;
- Implement temporary control berms and divert surface flows to containment areas.

Follow-up Monitoring:

- Implement enhanced monitoring of surface water and groundwater in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely	H		C,E		
	Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- No new recommendations were identified (beyond what is already planned).

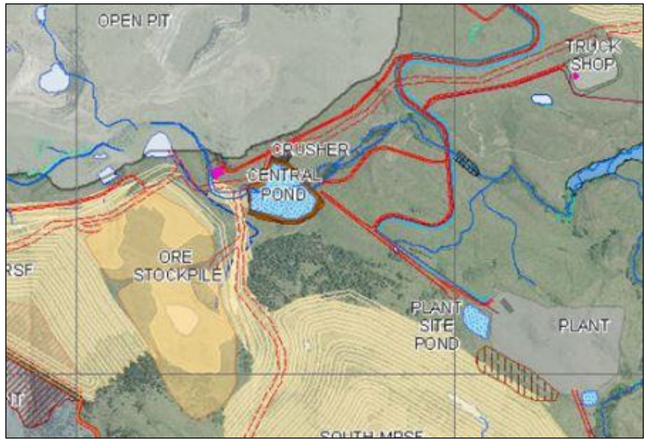
Failure Modes Effects Analysis Risk Profile – ID-19

ID:	28	Title:	Failure of Central Collection Pond

Description:

Failure of the Central Collection pond liner leading to release of contact water into Peterson Creek and Peterson Creek Aquifer. Based on current engineering designs the storage capacity of the Central Pond is anticipated to be in the range of 100,000 m^3 to 400,000 m^3.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Engineering design of ponds to accommodate probable flood conditions;
- Ponds are lined facilities;
- Limit volume of water stored in Central Pond by regularly pumping to Plant and/or TSF; and
- Peterson Creek Downstream Pond provides potential for containment before full release to receiving environment.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Use Peterson Creek Downstream Pond to help attenuate release of water further downstream;
- Temporary control berms and diversion of surface flows to containment areas; Identify source of leakage; and
- Repair pond liner system.

Follow-up Monitoring:

- Implement enhanced monitoring (e.g., frequency of sampling) of surface water and groundwater in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely	H		C,E		
	Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Revisit the consequence description once the groundwater modeling flow-path assessment is complete.

Status at time of EA Submission:

- Groundwater modelling completed (Appendix 6.6-D). Potential for consequence to Peterson Creek Aquifer for this scenario remains very low.

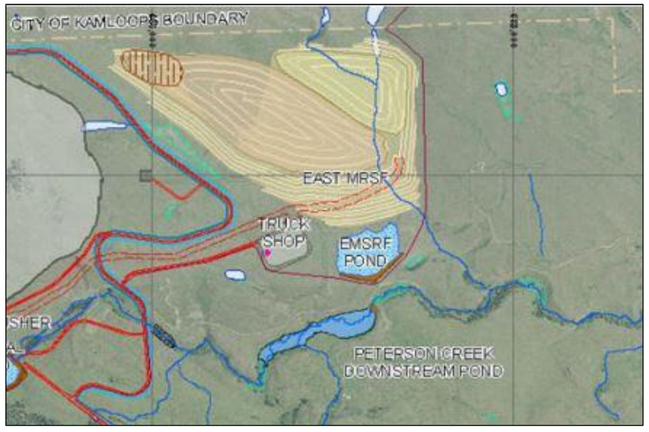
Failure Modes Effects Analysis Risk Profile – ID-20

ID:	29	Title:	Failure of EMRSF Collection Pond (1)

Description:

Failure of the EMRSF collection pond liner leading to release of contact water into Peterson Creek and Peterson Creek Aquifer. This failure mode would occur as a variation from assumptions made during design, or a liner defect. It is a chronic condition that would develop over time.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Engineering design of ponds to accommodate probable flood conditions;
- Ponds are lined facilities;
- Limit volume of water stored in EMRSF collection pond by regularly pumping to Central Pond.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Establish temporary containment;
- Identify source of leakage;
- Repair pond liner system.

Follow-up Monitoring:

- Implement enhanced monitoring (e.g., frequency of sampling) of surface water and groundwater in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Severity: Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely	H	C	E		
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- No new recommendations were identified (beyond what is already planned) – for example, see ID3.

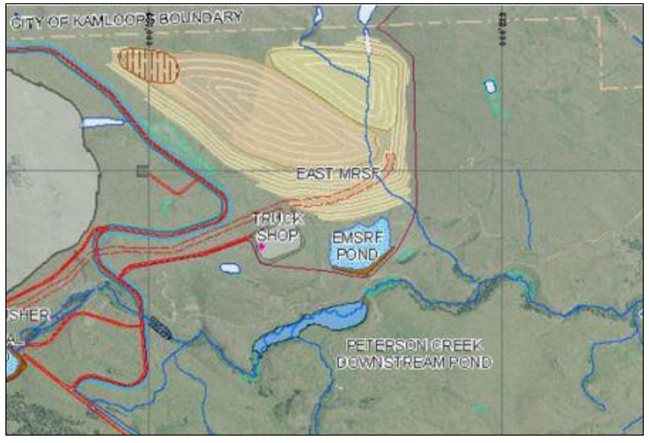
Failure Modes Effects Analysis Risk Profile – ID-21

ID:	30	Title:	Failure of EMRSF Collection Pond (2)

Description:

Structural failure of the EMRSF collection pond leading to impact to Peterson Creek and Peterson Creek aquifer. Based on current engineering designs the storage capacity of the EMRSF Pond is 198,000 m³.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations to inform design and placement of the EMRSF collection pond;
- Appropriate design of seepage collection pond embankments;
- Monitor the storage of water in the EMRSF collection pond; and
- Limit volume of water stored in EMRSF collection pond by regularly pumping to Central Pond.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Establish temporary containment;
- Re-build embankment; and
- Reclaim area between embankment and Peterson Creek to prevent erosion/sedimentation.

Follow-up Monitoring:

- Implement enhanced monitoring (e.g., frequency of sampling) of surface water and groundwater in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely	H	C	E		
	Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Consider having a third party expert review the dam design basis and engineering design.

Status at time of EA Submission:

- Third party reviewer engaged and supporting detailed design.

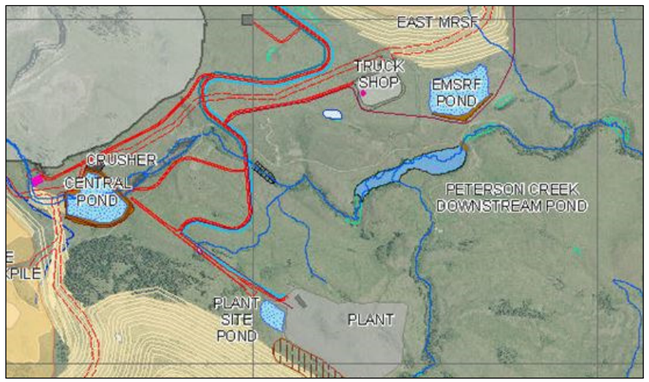
Failure Modes Effects Analysis Risk Profile – ID-22

ID:	31	Title:	Peterson Ck Downstream Pond

Description:

Failure of the Peterson Creek Downstream Pond dam (5 metre height; 60,000 m^3 storage) leading to silting and erosion downstream of Peterson Creek into the City of Kamloops due to the unexpected water flow. Would be equivalent to large storm event (e.g., less than Probable Maximum Flood for Peterson Creek).

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Detailed geotechnical investigations; and
- Appropriate design of pond embankment.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16);
- Shut down pumping from Jacko Lake (if operating at time of failure);
- Re-build embankment; and
- Reclaim downstream reach of Peterson Creek to prevent erosion/sedimentation.

Follow-up Monitoring:

- Implement enhanced monitoring (e.g., frequency of sampling) of surface water and habitat conditions in Peterson Creek.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely					
	Rare	H		E	C	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Consider having a third party expert review the dam design basis and engineering design.

Status at time of EA Submission:

- Third party reviewer engaged and supporting detailed design.

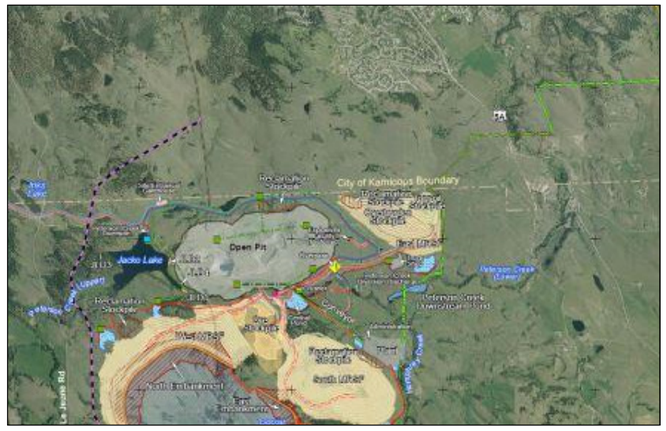
Failure Modes Effects Analysis Risk Profile – ID-23

ID:	32	Title:	Grassland/Forest Fire

Description:

Grassland/forest fire (e.g., cigarette or road incident) leading to fire on site and extending to Aberdeen or Knutsford with impact on the community because of smoke and poor air quality.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Implement Fire Hazard Abatement Plan (Section 11.15); and
- Training of employees re: no smoking policies.

Mitigation Response:

- On-site fire response;
- Coordinate response with BC Forest Service and municipal fire department; and
- Reclamation of areas disturbed by fire.

Follow-up Monitoring:

- Monitoring of reclamation success.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely					
Rare		H	C	E	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Conduct an annual review of fire-safety to minimize the likelihood of such an event.

Status at time of EA Submission:

- Incorporated in Fire Hazard Abatement Plan (Section 11.15).

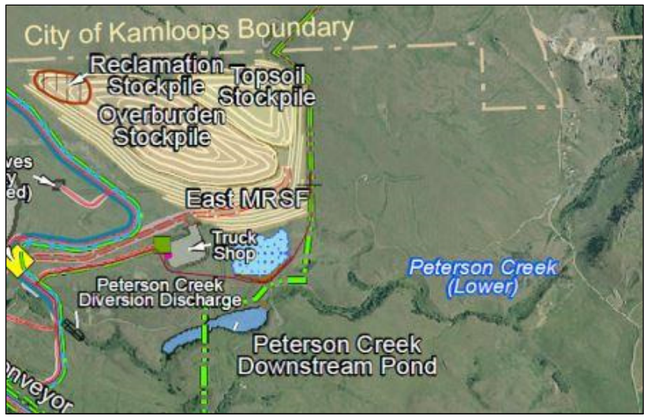
Failure Modes Effects Analysis Risk Profile – ID-24

ID:	34	Title:	Fuel Spill at Truck Shop

Description:

Fuel spill at the truck shop fuel storage location (up to 20,000 litre spill) due to tank and associated equipment failure leading to soil contamination; contamination of Peterson Creek; groundwater contamination; fire; employee injury.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Appropriate design of fuelling site, including:
  - secondary containment;
  - barriers to protect pumps and tanks from impact;
- Training of employees regarding appropriate fueling protocols.

Mitigation Response:

- Implement response protocol for spills (see Section 11.16):
  - identification and control of immediate dangers to human life or health;
  - identification and control of release source;
  - elimination of additional potential release sources;
  - containment of release;
  - notification of authorities, as appropriate;
  - recovery and cleanup; and
  - incident investigation and reporting.

Follow-up Monitoring:

- Implement enhanced monitoring (e.g., frequency of sampling) of surface water and groundwater in immediate vicinity of event.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible					
Unlikely		H,C	E		
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- No new recommendations were identified (beyond what is already planned).

Failure Modes Effects Analysis Risk Profile – ID-25

ID:	36	Title:	Repetitive Small Leaks

Description:

Repetitive small leaks from fuel stations over the life-time of the Project leading to soil and groundwater contamination.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Preventative Controls:

- Appropriate storage and handling of all fuels;
- Water management procedures around fueling areas;
- Training of employees regarding appropriate methods to reduce likelihood of spills from occurring; and
- Training of employees regarding spill response protocols.

Mitigation Response:

- Immediate and appropriate clean-up of small spills;
- Reclamation activities to remove contaminated materials to landfarm;
- Site investigation to evaluate cause and extent of potential contamination; and
- As appropriate, reporting of fuel spills to regulatory agencies.

Follow-up Monitoring:

- Auditing of training effectiveness;
- Environmental monitoring as necessary to close off site investigation.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

Likelihood	Severity: Minor	Moderate	Serious	Major	Catastrophic
Almost Certain					
Likely					
Possible	H		C,E		
Unlikely					
Rare					

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Conduct periodic soil sampling around fueling stations to identify hydrocarbon contamination early.

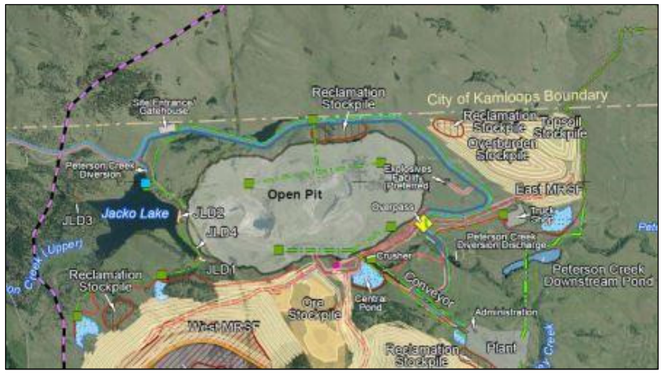
Failure Modes Effects Analysis Risk Profile – ID-26

ID:	37	Title:	Kinder Morgan Pipeline

Description:

Failure of Kinder Morgan pipeline near Jacko Lake. Large release of hydrocarbons in Jacko Lake that KAM could subsequently pump through the Peterson Creek Diversion to the downstream pond; soil contamination, water contamination.

Location:



VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Note: The likelihood of this event is rare as it would require a series of events to occur. This includes failure of the Kinder Morgan Pipeline in the area of Jacko Lake/access road to occur undetected and no response, the material spilling into Jacko Lake a distance of ~1 km and hilly and water (also undetected and no response) before reaching water intake location, and because the water intake on Jacko Lake is located on the lake bed and fuel floats, it would take a significant lake drawdown to occur undetected for the fuel to be withdrawn from Jacko Lake and discharged downstream to Peterson Creek.

Preventative Controls:

- Communications protocol in place for Kinder Morgan to quickly informs KAM of any changes in the status of the pipeline particularly those that would require an emergency response by KAM including a release in proximity to Jacko Lake.

Mitigation Response:

- Shut-off of Peterson Creek Diversion pump system;
- Implement response protocol for spills (see Section 11.16); and
- KAM to support Kinder Morgan response, as appropriate.

Follow-up Monitoring:

- Monitor water quality in Jacko Lake prior to re-initiating Peterson Creek Diversion pump system.

Environmental Effects Characterization:

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Risk Characterization:

		Severity				
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
Likelihood	**Almost Certain**					
	Likely					
	Possible					
	Unlikely					
	Rare	H	E		C	

H = Health/Safety; C = Community; E = Environment

Recommendations from FMEA Workshop:

- Continued dialogue with Kinder-Morgan as both projects advance.

17.6.3.1 TSF Design

The principal design objectives for the TSF are to provide containment for tailings and supernatant water during Operations, long-term containment (Post-Closure), and to achieve effective reclamation at mine closure. The TSF design requirements include the following key criteria:

- provide permanent, secure and total confinement of all tailings materials within an engineered disposal facility;
- control seepage through the basin and embankments and remove free-draining liquids from the TSF during Operations for recycling as process water to the maximum practical extent;
- apply Best Available Technology (BAT) and Best Available Practices (BAP) for tailings containment; and
- no surface water discharge to the environment over the life of the project.

A design has been completed (Appendix 3-D), and more detailed design work is on-going to support further advancement towards permitting and construction.

The TSF will comprise of four zoned earth-rockfill dams (referred to as the North Embankment, East Embankment, South Embankment, and Southeast Embankment) and will be constructed using the downstream method of construction. The TSF filling schedule is designed to ensure that dam crest elevations are sufficient to contain the cumulative tailings volumes, freeboard for Probable Maximum Flood (PMF) and wave run-up.

Integral to the embankment's downstream construction design will be the use of mine rock storage facilities adjacent to the TSF, which are incorporated in the tailings embankment designs to buttress these structures. The West Mine Rock Storage Facility (WMRSF) will buttress the North Embankment while the South Mine Rock Storage Facility (SMRSF) will buttress the East Embankment. The development schedule of these MRSF structures are planned to match the development schedule of the TSF embankments, and enhance the overall stability and performance of the TSF.

KAM is planning a thickened tailings strategy using 60% solids content tailings material, based on results from a recent trade off study completed by Norwest and M3 to identify the Best Available Technology (BAT) for the Project (Appendix 17.4-B). Thickened tailings technology has higher solids content to improve physical stability of the tailings deposit and minimizes water requirements within the facility as compared to the unthickened tailings containment.

As described in Section 3.17, closure of the TSF includes a dry closure cover. At the end of mining, the TSF supernatant pond will be located at the southeast corner of the facility. Through the course of the Decommissioning and Closure phase the water in the TSF will be pumped to the Open Pit. Mine rock will be hauled from the South MRSF and deposited on the TSF surface to accelerate tailings compaction and to provide a trafficable surface for reclamation equipment. The TSF cover system includes a low-permeability layer and overlain by a growth medium layer. There will be no ultimate closure pond and after reclamation, excess water will shed via a channel connecting the TSF to Humphrey Creek (in the Post-Closure phase).

17.6.3.2 Approach

The Application Information Requirements/EIS Guidelines require an evaluation of the likelihood of potential accidents, malfunctions, and unplanned events, including a failure of the TSF that could occur in any phase of the Project, and a description of how each potential accident, malfunction, or unplanned event would be managed or mitigated. A dam breach inundation study was completed by Norwest Corporation (Appendix 17.6-2) to accomplish these objectives. The work was completed in three stages as follows:

- Stage 1: Screening Level Study: Collect available information related to the TSF design and staging of the dams, and highlight failure scenarios that could lead to a dam breach during Construction, Operations, Decommissioning and Closure, and Post-Closure. Screen these scenarios to obtain a set of critical scenarios to highlight appropriate "sunny" and "rainy" day failure modes for further failure mode assessment. The Canadian Dam Safety Association (CDA 2007) provides guidelines that define these terms as:
  - "Sunny-day" failure – a sudden dam failure that occurs during normal operations. It may be caused by internal erosion, piping, earthquakes, mis-operation leading to overtopping, or another event.
  - "Rainy-day" failure (or flood-induced) – a dam failure resulting from a natural flood of a magnitude that is greater than what the dam can safely pass.
  - SMRSF failure – potential impacts (if any) on the physical integrity of the TSF due to a failure of the SMRSF, including, but not limited to, the potential for an induced wave in the TSF.
- Stage 2: Potential Failure Modes Analysis: Complete a Potential Failure Modes Analysis (PFMA) of the highlighted cases identified in the Screening Level study (Stage 1) to identify potential mechanisms that could lead to a dam breach; generally assess the likelihood of the failure occurring and the effects (consequences) of such failure; and identify potential risk reduction measures that could reduce breach potential. A generalized consequence category was applied to each Potential Failure Mode (PFM) as follows:
  - Category I – PFM with potential for a breach and subsequent inundation with potential for significant impact beyond the property boundary. These mechanisms typically involve water only or tailings and water as the mobile fluid. This is the highest consequence category.
  - Category II – PFM with potential for a breach with inundation zone likely to be maintained within the property or results in limited impacts beyond the property boundary.
  - Category III – PFM's leading to a structural failure that is unlikely to cause a breach and loss of contents.
  - Category IV – PFM's that may be ruled out because the physical possibility does not exist or the PFM is so remote a possibility as to be non-credible or not reasonable to postulate.
- Stage 3: Dam Breach and Inundation Evaluation: Complete a dam breach/inundation analyses on the credible cases (Category I or II) that could lead to a potential dam breach

scenario resulting from the PFMA in Stage 2. Assessment of the breach flows was completed for evaluating the possible inundation and potential consequences of dam failure.

17.6.3.3 Screening Study

The TSF will be developed throughout Operations, and there are different failure modes and related potential dam breach scenarios that occur at different stages of Operation and Construction. In order to evaluate these different time periods, a series of scenarios were developed to provide a basis for a screening evaluation (Table 17.6-6). Scenarios considered to be "Critical" were highlighted for further consideration in a PFMA. Key aspects considered when identifying the critical scenarios included:

- impounded contents (e.g., water only or tailings and water);
- the amount of water stored in the impoundment (2 Mm^3 at start-up);
- available freeboard;
- mine rock buttress sequencing; and
- the distance that tailings beach separates the embankment from the supernatant pond.

Table 17.6-6 Screening Study for Potential Dam Failure Scenarios

End of Year	Crest Elevation (m)	Impounded Contents	TSF Embankments		
			North	East	South
-2		Water Only	Not Critical	Not Built	Not Built
-1	971		Case #1		
1	984	Tailings and Water	Case #2	Not Critical	
2	992		Not Critical	Not Critical	
5	1,012		Not Critical	Not Critical	
10	1,031		Not Critical	Not Critical	Not Critical
20 (ultimate)	1,056		Case #3	Case #4	Case #5
Closure	1,056		DRY CLOSURE – No impounded water. Consolidated thickened tailings deposit.		

Given that the TSF has been designed for containment of the PMF, it was found that all the cases carried forward were not driven by "rainy day" or flood induced factors but were instead "sunny day" events related to sudden failure events related to seismic, internal erosion, or elevated internal pore pressures.

The development of the TSF embankment has been integrated with the placement of rock in the SMRSF. During the initial years of operations, the dyke crest and rock pile are raised at the same rate. Once the rock lifts exceed the elevation of the ultimate dyke crest (approximately 1,056 m), the rock is placed in low lifts (20-25 m) at an overall slope of 2.5H:1V and the stability of the overall rock fill slope meets or exceeds design criteria.

In addition, the presence of the TSF dyke and favourably dipping bedrock foundation all interact to increase the stability of the rock pile slopes and mitigate failures which would affect the tailings

dyke and the tailings deposition area. The configuration, sequencing and overall slope of the SWRSF above the 1,075 m elevation mitigate the risk of flowslides above the TSF basin.

The period during, and shortly after, first filling is the most critical from a dam breach and inundation perspective, as water is impounded directly against the embankment.

17.6.3.4 Potential Failure Modes Analysis

Potential Failure Modes Analysis (PFMA) is a systematic, proactive method for evaluating a structure or system to identify where and how it might fail (potential failure modes) and generally assess the likelihood of the failure occurring and the effects (consequences) of such failure.

As described in Appendix 17.6-B, the Southeast Embankment is intended to provide containment if the PMF event occurs during the latter stages of the mine life. The PMF modeling shows that at maximum footprint (Year 20), the elevation of water within the TSF footprint would reach approximately 946 m elevation (combined pond volume plus PMF inflow). In the event of a breach, only supernatant water would be released and would be contained by the natural topography at approximately the 946 m elevation. This would mean the water level would not extend beyond the footprint of the Southeast Embankment dyke as the elevation at the downstream dyke toe is 1,052 m elevation, therefore the Southeast Embankment for further evaluation of failure.

The PFMA was carried out in the following steps:

1. Identify and define Potential Failure Modes (PFM's) in terms of the broad type of failure (overtopping, structural failure, and piping), the initiating mechanism and the sequence of events that follow. Differentiate between those events that could subsequently lead to a breach and partial or complete loss of contents.
2. For each PFM, list the factors that were considered to make the failure mode more likely and conceivable (adverse factors) or less likely and remote (positive factors).
3. Assign PFM's to generalized consequence categories (Category I to IV as defined above).
4. Provide a list of risk reduction measures that mitigate the failure mode by lowering probability of failure and/or reducing or eliminating the consequence altogether. These measures are especially important for managing the risk of a breach event with subsequent downstream inundation potential. As the design advances to the next level of detail, some of these measures may be subsequently adopted.

In total, 19 PFMs were identified and evaluated for the five Cases identified in the screening assessment. A detailed summary of the PFMA analysis and findings is provided in Appendix 17.6-2.

<u>Category I</u>

The PFMA indicated that there was no Category I failure mode identified for any of the five potential dam failure scenarios. The TSF design includes several design features that substantially improve embankment stability and provide additional support to protect against slope failures that could lead to a breach:

1. A MRSF is included downstream of the embankment to increase the Factor of Safety (FOS) against a breach several times higher than the minimum design requirement.
2. Additional freeboard allowance for a PMF and wave run-up for all stages of dam development.
3. Except for the start-up condition, the design calls for the supernatant pond to be maintained at several hundred meters from the dam crest.

Category II

Of the 19 identified PFMs, the results of the PFMA identified four Category II cases, which would be a breach leading to an inundation zone maintained within the property, or resulting in limited impacts beyond the property boundary. These cases were:

- PFM #3 – Case #1: North Embankment at End of Year -1: Upstream failure of the till blanket, triggered by a seismic event, rapid drawdown, differential settlement and cracking, poor construction and/or high pore pressures. These triggers could result in failure leading to uncontrolled seepage.
- PFM #4 – Case #1: North Embankment at End of Year -1: Excessive and/or preferential seepage flows through the foundation leading to progressive internal erosion or piping.
- PFM #8 – Case #2: North Embankment at End of Year 1: Excessive and/or preferential seepage flows, inadequately designed filter material or internally unstable soils, seepage through embankment or foundation that leads to progressive internal erosion of fill or foundation material starting from the downstream side of the dam.
- PMF #18 – Case #5: South Embankment at End of Year 20: Large catastrophic failure triggered by a seismic event and/or high pore pressures leading to deep seated foundation failure and subsequent breach and a release of tailings downstream.

Category III & Category IV

The remaining 14 PFMs were either Category III or Category IV and were not considered further (see Appendix 17.6-2) for the purposes of this evaluation.

17.6.3.5 Dam Breach Inundation Evaluation

The recently issued CDA Technical Bulletin titled "Application of Dam Safety Guidelines to Mining Dams" does not prescribe procedures for conducting dam breach analyses, but is instead limited to identifying "some specific issues that should be considered during the design and safety evaluation of mining dams" (CDA 2014). Accordingly, the choice of which methodology is selected for tailings dam breach analyses, including simplifying assumptions about the mode of failure and its defining characteristics, is largely based on the judgment and experience of the professional engineer.

The PMFA identified four cases involving potential for breach and partial/complete loss of mobile contents (water and/or liquefied tailings) behind the dam structures. Three of these cases (PFM #3, PFM #4, and PFM #8) would each result in very similar effects. Of these scenarios, PFM #3 is

considered the dominant mechanism for excessive seepage and is therefore the worst-case event carried forward. PFM#18 is a large and sudden failure, and is also carried forward. Two "critical" cases (Case #1 - PMF#3, and Case #5 - PFM#18) form the basis for bounding the inundation risks based on the preliminary design.

Case #1 (PFM#3) – North Embankment at the End of Year -1

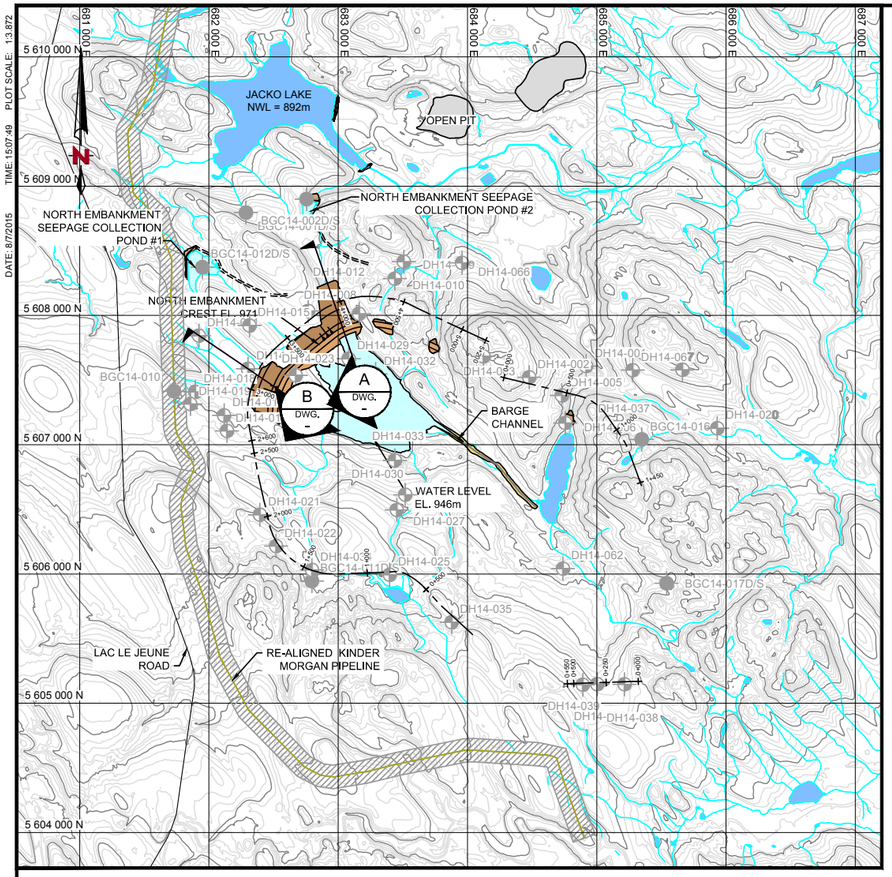
This case has a potential for releasing uncontrolled seepage flows through the North Embankment in the final year of Construction, and would result in drawing down the starter pond. The critical flow path is through the section where the pond is 12 m deep and in contact with the starter embankment over a length of approximately 115 m (Figure 17.6-1). The length of the rock buttress, which is over 500 m at the critical failure section assessed, is such that the excessive seepage is very unlikely to lead to piping failure that washes away the embankment and releases flow through an open channel or enlarged pipe. Rather, it is assumed that a relatively large, uncontrolled seepage flux through the face of the embankment in contact with the pond will occur. Flow through this section will collect at the North Embankment Seepage Collection Pond #2. Based on modelling analysis, an estimated average daily flow of 38,000 m^3 would discharge during the first week. The discharge rate would gradually reduce, and the estimated total time for the stored 2 Mm^3 to completely empty is about 4.5 months, assuming no interim interventions are made. North Embankment Collection Pond #2 will be designed for a storage volume of approximately 130,000 m^3. There are pumps planned for emptying the ponds and the evaluation assumes that they will be largely empty at the onset of an "uncontrolled discharge". Based on the estimated initial discharge rates, the North Embankment Seepage Collection Pond #2 would fill after about 3 days following the onset of excessive seepage. Pumps are to be installed within the North Embankment Seepage Collection Pond #2 to manage regular seepage through the facility. Under this PFM scenario, additional emergency pumping would be required to transfer the excessive seepage flows, and prevent the pond from overtopping. Over the filling duration of more than 3 days, it is considered that the mine can adequately deploy additional pumping to draw down the collection pond, and transfer the seepage water elsewhere within the site, such as to the open pit. With emergency pumping deployed and storage available and able to be utilized, excessive seepage flow from the TSF can be contained within the mine property.

The period of exposure to a risk of a significant release of water is brief, occurring just prior to production and shortly thereafter. Once tailings deposition commences, the slope of the tailings surface will push the pond away from the dam crest. Most of the North Embankment will include a large MRSF, placed downstream of the embankment, and constructed as the mine is developed. These conditions cause the potential for a water release to be very remote and beyond current consideration, shortly after production begins (within 1 to 2 years).

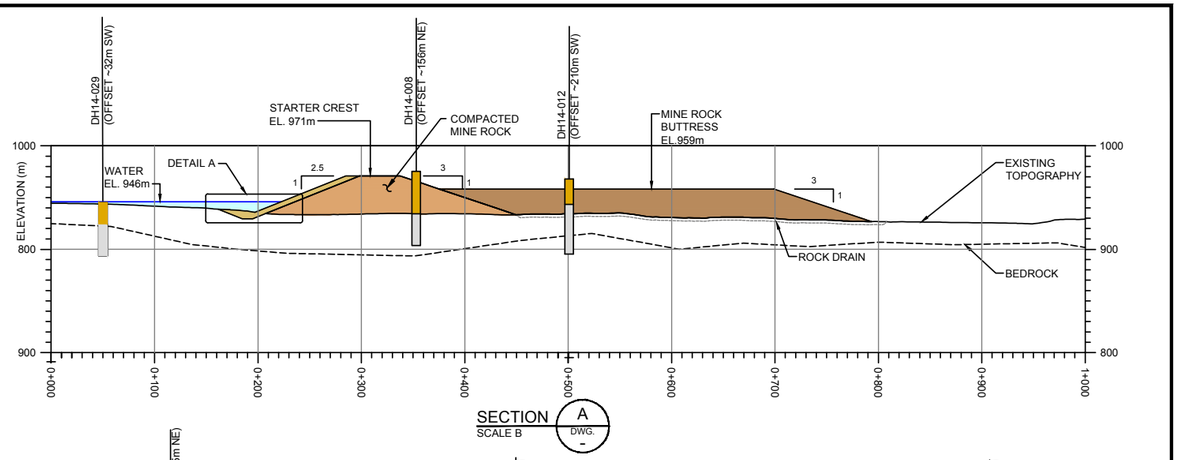
Case #5 (PFM #18) – South Embankment at End of Year 20

This case applies to the end of tailings deposition when the TSF is at full capacity. The South Embankment dam is a small structure compared to the North and East Embankments. The South Embankment will be constructed at the end of year 10 to provide tailings control to manage the supernatant pond at the TSF and contain the tailings deposit within the mine boundary limits.

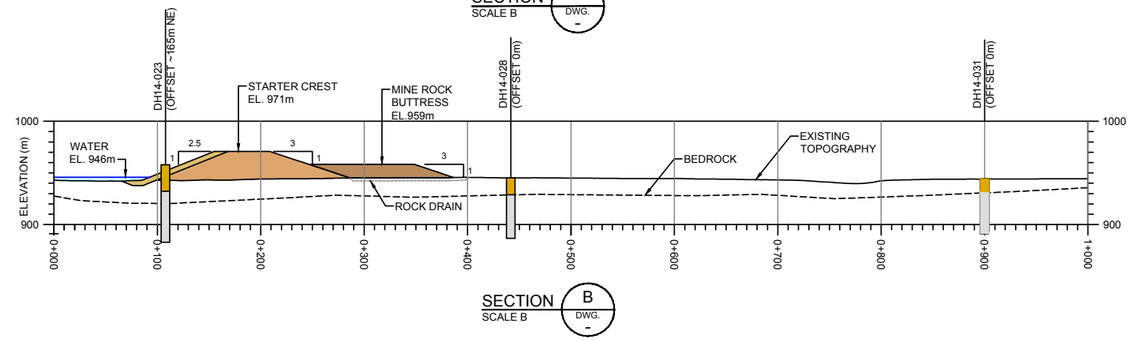
Figure 17.6-1
Tailings Storage Facility Starter (North) Embankment Sections End of Year -1 - Case #1



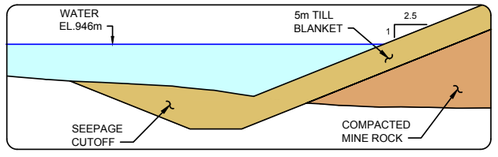
PLAN
SCALE A



SECTION A
SCALE B



SECTION B
SCALE B



DETAIL A
SCALE C

SCALE C
10m 0 10 20 30 40 50m
SCALE 1:1000

SCALE B
100m 50 0 100 200 300m
SCALE 1:5000

SCALE A
1000m 500 0 1000 2000m
SCALE 1:40,000

LEGEND:

- BEDROCK
- UNCONSOLIDATED OVERBURDEN
- TILL BLANKET
- COMPACTED MINE ROCK
- MINE ROCK BUTTRESS
- SUPERNATANT POND
- EXISTING WATER BODIES
- 0+000 CHAINAGE
- RE-ALIGNED KINDER MORGAN PIPELINE (BY KGHM)

REFERENCES:

1. ALL DESIGN DATA COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON LIDAR PROVIDED BY KGHM (APRIL 2013).
3. KINDER MORGAN PIPELINE ALIGNMENTS PROVIDED BY KGHM ON NOVEMBER 4, 2014.
4. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.
5. ACCESS ROADS PROVIDED BY KGHM ON JUNE 23, 2015.

Source: Norwest (2015).
Drawing No. C180-KA39-5100-00-006

The potential for structural failure is unlikely due to the large consolidated tailings mass upstream that provides structural support. The embankment foundation is relatively compact to very dense, adding further stability. However, the dam is not buttressed with a MRSF and was therefore considered for the dam breach evaluation. A dam breach of the South Embankment would release tailings only, as the supernatant pond is located a safe distance away from the dam crest. The maximum inundation extent downstream of the embankments was estimated to be the same tailings elevation stored within the TSF, as the topography will contain any tailings and water that are released in the event of a breach (Figure 17.6-2). It is assumed that the tailings will liquefy and flow as a fluid with very low strength. Immediately south of the embankment, the terrain is steep; therefore the runout distance will be limited. Inundation could extend as far as 300 m from the toe of the South Embankment.

17.6.3.6 Recommendations

As part of preliminary design, KAM and Norwest have implemented a number of design criteria that are intended to minimize the risk of inundation or breach of the TSF. As KAM continues to develop the design toward permitting and construction, a number of recommendations have been identified, which KAM is committed to undertaking, to further evaluate and reduce risks associated with the TSF. Recommendations include:

- Additional site investigations in support of detailed design are planned during 2015 to build upon previous investigations and further assess foundation conditions and the quality of available construction materials.
- Additional mitigation measures identified in the PFMA will be evaluated for inclusion in the TSF design.
- A Quantitative Risk Assessment (QRA) will be completed to evaluate dam breach risk following the next stage of design.

17.6.4 Downstream Effects of Dam Breach Scenarios

While it is recognized that the likelihood of TSF failure is very low, the consequences of such failure modes can be extreme. As such, an assessment of downstream effects of the dam breach scenarios is a requirement included in the AIR/EIS Guidelines.

The assessment of downstream effects focuses on the two critical cases evaluated by Norwest, as described above: Case #1 and Case #5. The assessment is completed in the following steps:

1. Identify Valued Components (VC's) that may be affected by each dam breach scenario;
2. Identify preventative controls and mitigation response; and
3. Characterize the environmental effects that would result from the failure mode.

17.6.4.1 Valued Component Matrix

Case #1 and Case #5 were screened against the list of VCs to identify those VCs that would be most directly influenced by the failure mode (Table 17.6-7). Similar to the methodology outlined in Chapter 5, an interaction matrix approach was used, and interactions were ranked as follows:

- Red — primary/direct interaction between failure mode and VC;
- Yellow — secondary/moderate interaction between failure mode and VC;
- Green — tertiary/minor interaction between failure mode and VC; or
- White — no interaction anticipated.

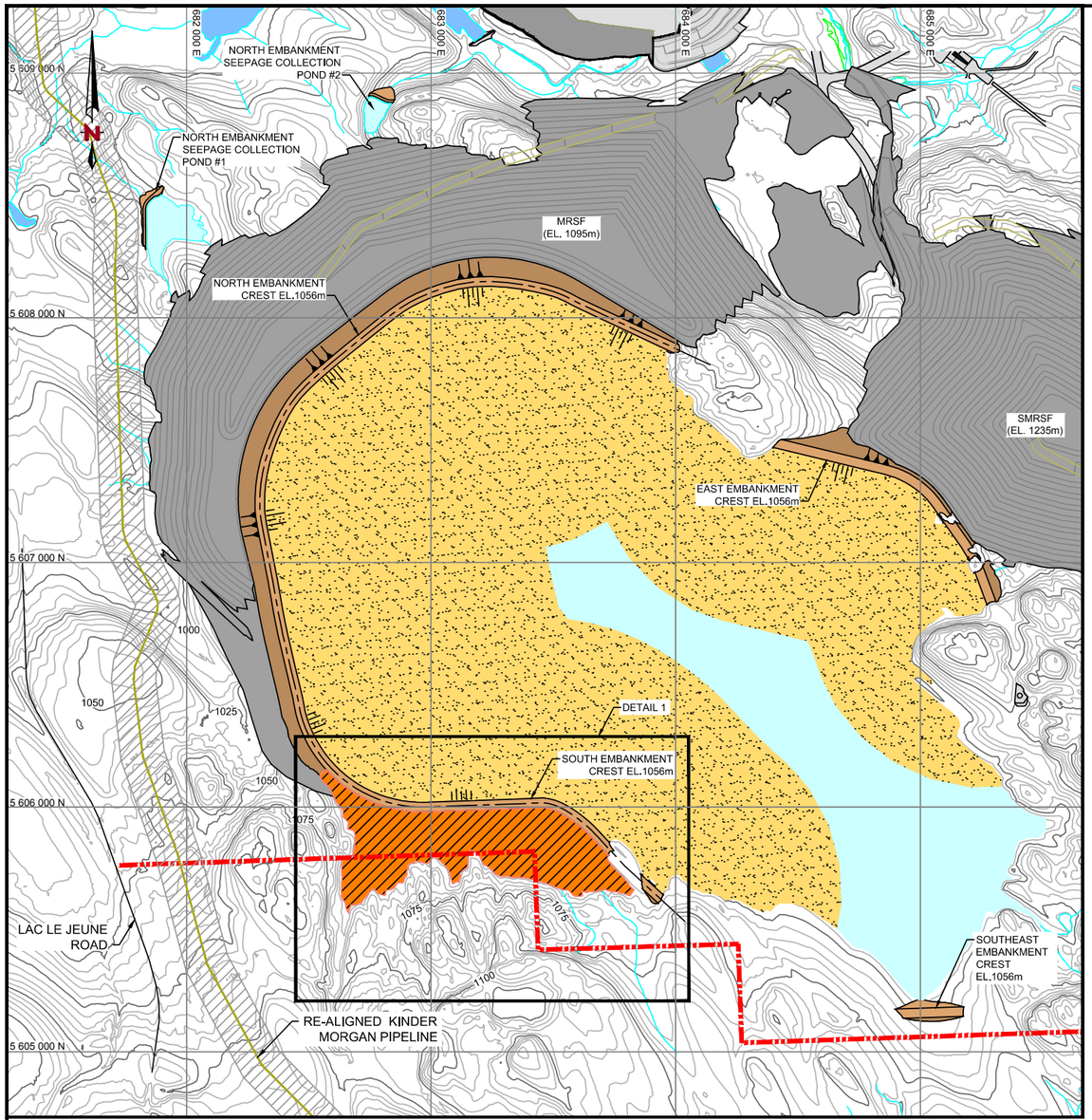
Table 17.6-7. Valued Component Interaction Matrix with Potential Dam Breach Scenarios (Case #1 and Case #5)

Valued Component	Case #1	Case #5	Valued Component	Case #1	Case #5
Greenhouse Gases			Economic Growth		
Geology, Landforms			Labour/Employment		
Surface Water Quantity			Income		
Surface Water Quality			Business		
Groundwater Quantity			Property Values		
Groundwater Quality			Economic Diversification		
Fish & Aquatics			Infrastructure/Services		
Rare Plants			Dark Sky		
RSEC			Visual Quality		
Grasslands			Land and Resource Use		
Terrestrial Invert.			CULRTP		
Amphibians			Outdoor Recreation		
Reptiles			Air Quality		
Migratory Birds			Domestic Water		
Raptors			Country Foods		
Non-Migratory Birds			Human Health		
Mammals			Noise		
Archaeological Sites			Healthy Living		
Heritage Sites			Community Health/WB		

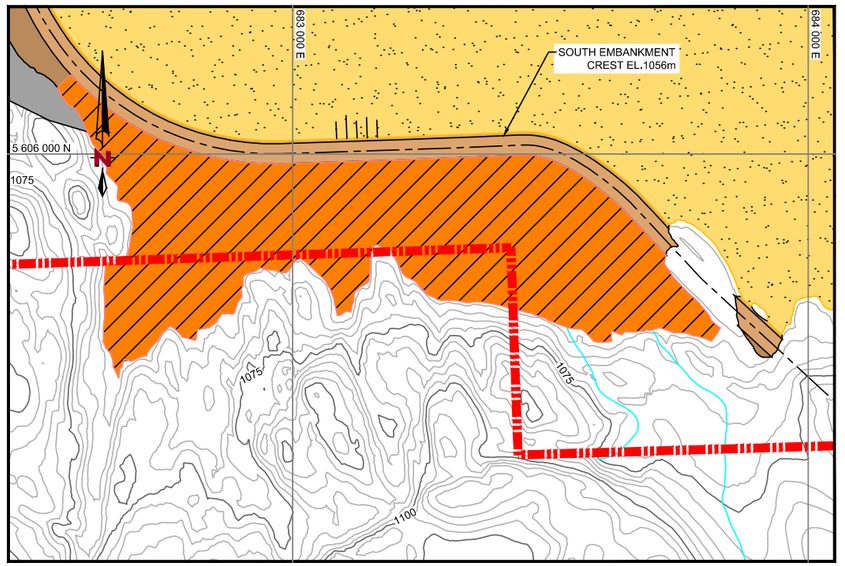
Case #1

Case #1 is a water-only failure mode due to seepage. Potential effects associated with such a failure mode would most directly be associated with surface water and groundwater VCs, with potential secondary effects to the Fish and Aquatics VC, and tertiary effects to the Current Use of Lands and Resources for Traditional Purposes (CULRTP) and Human Health VCs. Start-up water stored in the TSF will be derived from a combination of local rainfall and runoff, as well as supplemental water from Kamloops Lake, and so the quality of the water is anticipated to be reflective of baseline/present/existing conditions. Potential effects would be associated with flooding and subsequent erosion/deposition, and potential effects to downstream infrastructure.

Figure 17.6-2
Case #5 Inundation Extents



PLAN
SCALE A



DETAIL 1
SCALE B

LEGEND:

- COMPACTED MINE ROCK
- MINE ROCK BUTTRESS
- MINE ROCK STORAGE FACILITY (BY KGHM)
- TAILINGS
- SUPERNATANT/CONTACT WATER POND
- EXISTING WATER BODIES
- BREACH INUNDATION AREA
- MINE PROPERTY BOUNDARY
- RE-ALIGNED KINDER MORGAN PIPELINE (BY KGHM)

REFERENCES:

1. ALL DESIGN DATA COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON LIDAR PROVIDED BY KGHM (APRIL 2013).
3. KINDER MORGAN PIPELINE ALIGNMENTS PROVIDED BY KGHM ON NOVEMBER 4, 2014.
4. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.
5. ACCESS ROADS PROVIDED BY KGHM ON JUNE 23, 2015.

SACLE B
100m 0 100 200 300 400 500m
SCALE 1:10,000

SACLE A
500m 0 500 1000m
SCALE 1:20,000

Source: Norwest (2015).
Drawing No. C180-KA39-5130-00-002

Case #5

Case #5 is a tailings runout only; no supernatant water would be released. The extent of tailings runout is confined by the surrounding topography. Surface runoff from subsequent precipitation events, which could conceivably re-mobilize exposed tailings, would be contained within the TSF catchment, and would not connect to the local stream network. Potential effects associated with such a failure mode would most directly be associated with inundation of grazing lands (Grasslands, and Land and Resource Use VCs), and burial of soils adjacent to the Project (Geology, Soils and Landforms VC); secondary effects would be associated with loss of habitat, in particular for species that are not very mobile (e.g., Amphibians VC, compared to migratory birds). Such a failure scenario may affect perceptions of the suitability of using the area for conducting traditional practices (CULRTP VC).

17.6.4.2 Preventative Controls

As described in Section 17.6.3, the TSF design includes a number of preventative controls to reduce the likelihood and consequence of TSF failure. Beyond TSF design, construction and operation of the TSF will be implemented in accordance with an Operation, Maintenance and Surveillance (OMS) manual as required by Section 10.5.2 of the Health, Safety and Reclamation Code (BC MEMPR 2008). The OMS manual will outline principles for the safe operation of the TSF and include details for monitoring, training, and inspections associated with dam safety. The OMS manual will be developed based on CDA Guidelines and the associated CDA Technical Bulletins, as well as guidance from the Mining Association of Canada and the Toward Sustainable Mining program.

A program of visual and instrumentation monitoring for the TSF will include:

- inspection of the dam crests and slopes for signs of cracking, slumping, settlement, seepage or piping;
- inspection of pumps and piping systems;
- inspection of surface water diversion channels and structures to identify sections where repairs may be required;
- inspection of diversion channels to identify damage or blockages attributable to snow accumulation, and to identify excessive erosion during spring runoff;
- installation of piezometers to measure pore water pressures in the dams and dam foundations and establishment of limits and action plans based on allowable variations in pore water pressures;
- installation of survey monuments to measure dam fill settlement and surface displacement and establishment of limits and action plans based on allowable variations in displacements;
- monitoring of pond water levels;
- monitoring of tailing beach widths;
- monitoring of seepage water quantity and quality downstream of the dams and establishment of limits and action plans based on allowable variations in seepage rates;

- monitoring of flows in the diversion channels; and
- monitoring of geohazards.

A schedule for routine inspection and instrumentation monitoring will be developed at the time of mine permitting based on the mine construction and operation schedule. Threshold values (warning levels) for each instrument and response criteria will be established and included in the OMS manual.

Consistent with the requirements of the BC Dam Safety Regulation, the TSF will be subject to regular Dam Safety Reviews (DSRs) over the life of the Project. A DSR is a comprehensive formal review carried out by a Dam Safety Engineer at scheduled intervals to determine whether an existing dam is safe, and if it is not safe, to determine what improvements are required. KAM will respond to the findings of the DSRs by reviewing identified concerns and implementing appropriate safety improvement measures, for example adapting and updating monitoring and inspection procedures.

17.6.4.3 Mitigation Response

In the unlikely event of an emergency situation at any of the embankments, the Emergency Response Plan (ERP) would be triggered (see Section 11.14). KAM's top priority is the health and safety of workers and the public, and an effective ERP is a key element in meeting that priority. The ERP will ensure that the Project site is resourced with appropriate equipment, procedures, and trained staff to respond quickly and effectively to every potential event throughout the life of the Project.

For Case #1, the monitoring programs will identify increasing seepage rates, as evidenced by the rate of filling at North Embankment Collection Pond #2. This will trigger response by the Mine Manager to identify options for on-site storage of excess seepage (e.g., other on-site ponds, re-circulation to the TSF; or the open pit), and to deploy additional pumps to ensure containment of the seepage within the site.

For Case #5, the immediate mitigation response would be focussed on ensuring safety for personnel and the public. Interim measures to minimize potential environmental effects (e.g., sediment and erosion control, dust control) would be implemented in a manner consistent with existing plans at the site. Response would then shift to reviewing the stability of the resultant runout, and identifying appropriate remediation measures, which could include returning material to the TSF and re-constructing the embankment, or reclaiming the runout in place (given that it will be topographically constrained). Reclamation would include implementing necessary repairs to the closure cover, and may include extending the TSF closure cover to incorporate the runout area.

In the event of an emergency, KAM will notify all relevant federal, provincial, regional, and municipal government agencies, and Aboriginal Groups, as soon as practicable after the occurrence and work with agencies to ensure appropriate responsive action is taken, including communication to the public. Written documentation describing the emergency and response measures taken and preventive mitigation shall also be submitted.

17.6.4.4 Characterization of Environmental Effects

Case #1

Case #1 is associated with a potential effects pathway related to release of contact water (TSF start-up water), which, were it to occur, would have subsequent effects to VCs associated with Jacko Lake and Peterson Creek (Surface Water Quantity, Surface Water Quality, Fish and Aquatics, Human Health, CULRTP). The estimates of seepage rates calculated by Norwest indicate that there is a minimum 3-day window where KAM will be able to identify and respond to increased seepage rates, and deploy sufficient mitigation measures to retain all contact water onsite. Given the proximity of the Project to equipment suppliers in Kamloops and Vancouver, the mine can adequately deploy additional emergency pumping within this time frame to support the Project's on site equipment.

Based on the failure mode and the associated mitigation, it is expected that seepage can be controlled on site and would not be discharged into adjacent or downstream surface waters of Jacko Lake and Peterson Creek. Therefore, there are no downstream effects to Valued Components.

Case #5

Case #5 results in tailings inundation that covers an area close to 32 ha (Figure 17.6-2).

Mine infrastructure that includes seepage collection ponds and water management ditches would be buried in tailings, however, the tailings would be contained by topography and prevented from mobilizing to other catchments by surface runoff. This would be augmented by a mitigation response, which would include stabilization of the tailings to prevent remobilization from subsequent precipitation events. As such, potential downstream effects related to the aquatic environment (e.g., surface water quantity/quality, fish and aquatics) are not expected.

Until mitigation is implemented, the exposed tailings runout could lead to generation of dust; however, this would be for a very short interval, and the mitigation measures required to manage dust would be the same as what the mine applied on the tailings beach throughout Operation. As such, residual effects to air quality and human health from dust are not expected.

Overall, the area of inundation would increase the direct footprint of the Project (assessed as 1,705 ha; see Section 3.17) by less than 2%. Some unavoidable losses would be incurred. This includes loss of the soil resource in this 32 ha area as a result of burial by tailings. Also, some direct mortality may be incurred for individual amphibians or other small animals that may not be able to escape the inundation. However, given the relatively small area of inundation, this would not be anticipated to affect local or regional populations.

The majority of the inundated area (24 ha) would be within the mine property boundary on privately owned (KAM) lands; 8 ha would be outside the mine property boundary. This 8 ha is on crown land, which is associated with grazing license RAN 077241 and Trapline TR0320T001. Based on Vegetation Resource Inventory Data, the area that would be inundated is forested with primarily Douglas-fir (*Pseudotsuga menziesii*) and minor amounts of trembling aspen (*Populus tremuloides*) that are approximately 120 years old and 22 m high. The specific area of inundation is anticipated to see

limited trapping or ranching activity due to the natural topography and close proximity to the Project. As such, effects to other land uses/users are anticipated to be negligible, particularly after reclamation measures are implemented.

The assessment of Current Use of Lands and Resources for Traditional Purposes (CULRTP; Section 8.5) recognizes that the presence of the Project may result in losses of available habitat for hunted species or traditional use plant species and of potential ceremonial use sites, including sites associated with Pípsell. The area of inundation would expand the total area of loss. A dam breach scenario could also cause effects associated with the perceived quality of land in the proximity of the Project to support CULRTP. The 32 ha area of inundation would increase the direct footprint of the Project by less than 2%. The specific area of inundation is anticipated to see limited CULRTP activity due to the natural topography and close proximity to the Project. The inundation area, at the upstream end of the TSF, is not known to contain particularly unique habitat or ceremonial features. KAM would work with Aboriginal Groups to communicate about the failure event, the mitigation response and the results of reclamation efforts. This would help to ensure that members practicing traditional land uses near the Project are able to make informed decisions related to the quality of the land to support CULRTP activities.

17.6.4.5 Risk Profiles

The results of the TSF potential failure modes assessment and downstream effects analysis for Case #1 and Case #5 are summarized in risk profiles.

17.6.5 Conclusion

Consistent with the requirements outlined in the AIR/EIS Guidelines, an evaluation of accidents and malfunctions has been completed to support the environmental assessment process. The evaluation has employed the Failure Modes Effects Analysis, and focussed on the identification of worst-case failure modes, characterization of their risk, and evaluation of the associated environmental effects. At the environmental assessment stage, this information allows for an evaluation of the implications of these risks for the viability of the Project.

Risk is an inherent part of the development of any large mining project, and it is not possible to remove all risk. However, as part of a successful global mining company, KAM has the experience necessary to appropriately manage these risks. KAM will implement risk management systems that are consistent with its active mining operations globally and with industry standards. KAM is committed to active risk management through all phases of the Project to ensure that the Project is constructed and operated safely, and to consistently fulfill the company's commitment to "Zero Harm" to the environment.

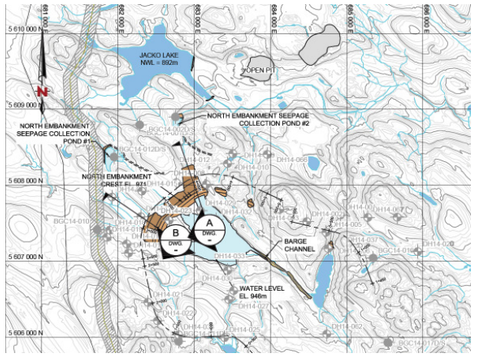
Potential Failure Modes Risk Profile – Case#1

ID:	Case #1	Title:	North Embankment at the End of Year -1

Description:

Upstream failure of the till blanket, triggered by a seismic event, rapid drawdown, differential settlement and cracking, poor construction and/or high pore pressures. These triggers could result in failure leading to uncontrolled seepage.

Location:



Risk Characterization:

Positive Factors	- Factor of Safety exceeds design criteria. - Very long seepage path that minimizes flow velocities that reduces internal erosion and potential for piping. - Rock fill material is not susceptible to erosion and piping. - Spatial and limited time of contact over a relatively small area. Startup pond has limited contact with the upstream face of the starter embankment.
Adverse Factors	- Limited by seasonal construction period. - Borrow areas are not well defined. - Rapid construction of till blanket that may lead to increased pore pressures and differential settlement.
Mitigation Opportunity	- Use geotechnical instruments and construction monitoring to monitor performance, prior to filling of the TSF. - QA/QC of material construction specification of processed engineered fill. - Use additional seepage control, thicker upstream blanket, and internal core zone as a design contingency.
Consequence Category (I to IV)	Category II

Preventative Controls:

- Construction and operation of the TSF will be implemented in accordance with an Operation, Maintenance and Surveillance (OMS) manual.
- Visual and instrumentation monitoring program for the TSF.
- Regular Dam Safety Reviews (DSRs) over the life of the Project.
- Use of Quantitative Performance Objectives (QPO) to establish adequate limits of measurable indicators that define the TSF performance (i.e., filling schedule, trigger levels for response to instrumentation, performance data gathering intervals).

Mitigation Response:

- Early response triggered by visual and instrumentation monitoring program results (e.g., on-site storage options; deploy additional pumps). Minimum 3-day window for response to be implemented.
- Emergency Response Plan (see Section 11.14).

Follow-up Monitoring:

- Monitor water quality in wells and receiving environment downstream of embankment.

VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Environmental Effects Characterization:

Based on the failure mode and the associated mitigation, it is expected that seepage can be controlled on site and would not be discharged into adjacent or downstream surface waters of Jacko Lake and Peterson Creek. Therefore, there are no downstream effects to Valued Components.

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Recommendations:

- Additional site investigations in support of detailed design were completed during 2015 to build upon previous investigations and further assess foundation conditions and the quality of available construction materials.
- Additional mitigation measures identified in the PFMA will be evaluated for inclusion in the TSF design.
- A Quantitative Risk Assessment (QRA) will be completed to evaluate dam breach risk following the next stage of design.

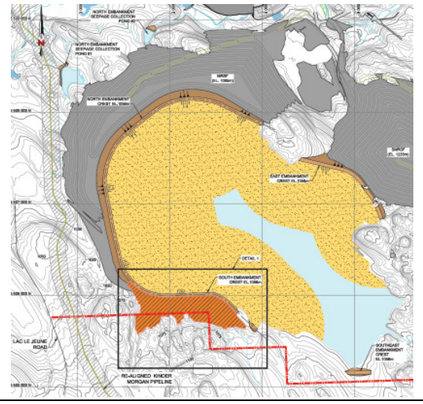
Potential Failure Modes Risk Profile – Case#5

ID:	Case #5	Title:	South Embankment at End of Year 20

Description:

Large catastrophic failure triggered by a seismic event and/or high pore pressures leading to deep seated foundation failure and subsequent breach and a release of tailings downstream. Results in tailings inundation that covers an area close to 32 ha, which is controlled by topography.

Location:



Risk Characterization:

Positive Factors	- Factor of Safety is several times higher than design criteria. - 13 m of pond water freeboard. - Foundation geology consists mostly of compact to very dense glacial deposits overlying competent bedrock. - Most weak layers were identified at shallow depth (<5m), which will be excavated out. - Continuous weak layers at depth were not identified.
Adverse Factors	- Shallow weak unit identified beneath foundation approximately 5 m deep.
Mitigation Opportunity	- Add rock buttress or reduce overall downstream slopes to improve stability. - Provide performance monitoring program to monitor to confirm that no movements within the foundation.
Consequence Category (I to IV)	Category II

Preventative Controls:

- Construction and operation of the TSF will be implemented in accordance with an Operation, Maintenance and Surveillance (OMS) manual.
- Visual and instrumentation monitoring program for the TSF.
- Regular Dam Safety Reviews (DSRs) over the life of the Project.
- Use of Quantitative Performance Objectives (QPO) to establish adequate limits of measurable indicators that define the TSF performance (i.e., filling schedule, trigger levels for response to instrumentation, performance data gathering intervals).

Mitigation Response:

- Emergency Response Plan (see Section 11.14).
- Ensure safety for personnel and the public.
- Interim measures to minimize potential environmental effects (e.g., sediment and erosion control, dust control).
- Review the stability of the resultant runout, and identify appropriate remediation measures (e.g., return material to the TSF and re-construct the embankment, or reclaim the runout in place).
- Reclamation activities.

Follow-up Monitoring:

- Monitor success of clean up and subsequent reclamation activities.

VC Interaction Matrix:

Greenhouse Gases	Terrestrial Invert.	Business	Archaeological Sites
Geology, Landforms	Amphibians	Property Values	Heritage Sites
SW Quantity	Reptiles	Economic Divers.	Air Quality
SW Quality	Migratory Birds	Infrastructure/Services	Domestic Water
GW Quantity	Raptors	Dark Sky	Country Foods
GW Quality	Non-Migratory Birds	Visual Quality	Human Health
Fish & Aquatics	Mammals	Land and Resource Use	Noise
Rare Plants	Economic Growth	CULRTP	Healthy Living
RSEC	Labour/Employment	Outdoor Recreation	Community Health/WB
Grasslands	Income		

Environmental Effects Characterization:

The majority of the inundated area (24 ha) would be within the mine property boundary; 8 ha would be outside the mine property boundary on crown land. The specific area of inundation is anticipated to see limited activity due to the natural topography and close proximity to the Project.

Duration:	Short-term	Medium-Term	Long-Term	Far Future	
Spatial Extent:	Local	Landscape	Regional	Beyond Regional	
Likelihood:	Rare	Unlikely	Possible	Likely	Almost Certain
Reversibility:	Reversible Short-term	Reversible Long-Term	Irreversible		
Resiliency:	High	Moderate	Low		

Recommendations:

- Additional site investigations in support of detailed design were completed during 2015 to build upon previous investigations and further assess foundation conditions and the quality of available construction materials.
- Additional mitigation measures identified in the PFMA will be evaluated for inclusion in the TSF design.
- A Quantitative Risk Assessment (QRA) will be completed to evaluate dam breach risk following the next stage of design.

17.7 MITIGATION MEASURES

The Application/EIS discusses the availability and implementation of mitigation measures to avoid, minimize, control, restore on-site, compensate, or offset adverse effects to Valued Components (VCs). A mitigation hierarchy is followed as described in the BC EAO's *Guidelines for the Selection of Valued Components and Assessment of Potential Effects* (BC EAO 2013). The hierarchy to mitigate potential effects include:

1. **Optimizing Alternatives**: Preventing or reducing adverse effects by changing an aspect of the Project.
2. **Design Changes**: Preventing or reducing adverse effects by redesigning aspects of the Project, or changing the timing of an activity.
3. **Best Achievable Control Technology (BACT):** Eliminating, minimizing, controlling, or reducing adverse effects through the use of technological applications.
4. **Management Practices**: Eliminating, minimizing, controlling, or reducing adverse effects on VCs through management practices.
5. **Restoration**: Restoration focuses on establishing appropriate composition, structure, pattern, and ecological processes necessary to make systems sustainable, resilient, and healthy under current and future conditions. Restoration is different from avoiding and minimizing residual effects because it can be implemented at a later date.
6. **Compensation**: Offsetting remaining effects that cannot be prevented or reduced through remedial or compensatory actions, so that the net effect on the community or ecosystem is neutral or beneficial.

Section 17.4 of the Application/EIS describes alternative means of carrying out the Project for a substantial list of design alternatives. The change from 'Ajax North' to 'Ajax South' is a good example of Optimizing Alternatives to reduce environmental effects. The 'Ajax South' GA reduces effects at the source by consolidating the project footprint and conducting activities in a single watershed. Consistent with the Operational Policy Statement (CEA Agency 2007), the assessments in Section 17.4 evaluate alternatives based on both technical and economic feasibility, as well as consideration of effects to the natural and human environment. Rationale for identifying the preferred alternative (and rejecting other alternatives) is provided in this section.

Once a preferred alternative was selected, a number of further Design Changes have been implemented for the Project through the course of the environmental assessment process. Key examples of this include:

- Reducing the volume of start-up water required to be stored in the TSF;
- Shifting the footprint of the EMRSF to increase setback from the Peterson Creek aquifer;
- Modifying the timing/scheduling of buttressing along the TSF embankments to increase the factor of safety; and

- Modifying the closure cover prescriptions for the EMRSF and SMRSF to reduce infiltration and seepage pathways toward the receiving environment (Peterson Creek and Humphrey Creek).

Examples of BACT include the selection of TSF technology (conventional thickened tailings, see Section 17.4.8) and blasting design prescriptions as the pit moves toward Jacko Lake (see Section 3.12.4).

The above examples of mitigation are 'mitigation through design', and are built into the Project as assessed. KAM's engineering team will continue to seek opportunities to improve the design and reduce potential environmental effects as the Project advances through detailed design, permitting, and toward Construction.

Further down the hierarchy of mitigation are Management Practices. These are specific practices that will be adopted by the Project to reduce or eliminate potential effects to Valued Components. These management practices will be implemented through an Environmental Management System, which is described in Section 11.1. An important component of the EMS is a set of Environmental Management Plans (EMPs) that will be implemented for the Project. The EMPs are managed collectively under the umbrella of the EMS and its defined management processes. Individual EMPs describe management practices which are aligned with the Plan-Do-Check-Act model of the EMS, including guidance on addressing risks, identifying objectives, implementing processes and procedures, monitoring and measurement activities. Three types of EMPs have been identified within the EMS:

- **Operational Management and Monitoring Plans** address management and/or monitoring Project environmental effects related to activities occurring within the mine site footprint. Examples include: soil salvage and handling (Section 11.3); dust control (Section 11.6); spill response (Section 11.16); and waste management (Section 11.9).
- **Environmental Effects Monitoring Plans** address management and/or monitoring Project environmental effects from mine site activities that have the potential to extend effects off-site. Examples include: surface water and groundwater quality monitoring (Sections 11.23 and 11.24, respectively), and ambient air quality monitoring (Section 11.6).
- **Biodiversity Management Plans** address planning, management and/or monitoring activities, over the mine lifecycle, related to biodiversity conservation and protection measures necessary to achieve an appropriate end land-use objective. Examples of these include fish habitat offsetting (Section 11.25), wetland compensation (Section 11.27), and reclamation planning (Sections 11.26 and 11.28).

The EMS is the overall framework within which EMPs and other environmental programs are developed, implemented, and maintained during the Construction, Operations, Decommissioning and Closure and Post-Closure stages of the Project. KAM is committed to developing, implementing, maintaining and continually improving an EMS that is in accordance with the internationally recognized ISO 14001 standard for environmental management systems, as well the Mining Association of Canada's *Towards Sustainable Mining* requirements.

The majority of the proposed management practices outlined in the Application/EIS are derived from existing field sampling manuals, guidance documents, and best management practices, which are referenced as appropriate within each of the EMPs. When appropriately implemented (e.g., through EMS oversight), there is a relatively high degree of confidence in the effectiveness of these mitigation measures to reduce or eliminate potential effects to levels that are considered not significant.

Technology will also be used to support effective implementation of the mitigation measures and monitoring programs. This includes, for example, specialized monitoring equipment (e.g., vibrating wire piezometers, continuous air quality monitoring equipment, automated water level recorders). While this type of equipment requires oversight and quality control from trained specialists, it is also standard practice for mining projects in Canada, and globally. As such, there is confidence that the proposed measures will support effect environmental management.

It is recognized that there are some areas where there is uncertainty associated with the effectiveness of proposed mitigation measures. An example of this is the proposed creation of new lek sites to replace those that will be lost due to the Project footprint. As described in Section 6.16, because the success of lek creation is not well known, KAM plans to create two lek sites for every known lek removed. A similar conservative approach is used for wetland compensation (Section 11.27) to increase the confidence that restoration/offsetting will be successful. Section 17.12 outlines proposed Follow-up Programs that are intended to track the effectiveness of proposed mitigation and monitoring for areas where there is higher uncertainty associated with the success of proposed mitigation and monitoring.

KAM also recognizes a number of opportunities for reclamation research that can be undertaken during Operation to test, refine, and optimize proposed reclamation techniques before their implementation (Section 11.26), such as:

- native grassland restoration using native hay as a seed source and/or use of traditional plants;
- planned grazing systems, including fencing and stock watering options for mine sites;
- agricultural irrigation and diversification (crops and livestock);
- soil amendments, including methods to develop an organically enriched surface layer;
- salvage and propagation of locally adapted native grass, forb and shrub species, particularly those useful for tailings, wetland and riparian zone reclamation;
- salvage, relocation and propagation of biological soil crusts (cryptogams);
- wildlife habitat enhancement techniques;
- fish and aquatic habitat enhancement; and
- opportunities for traditional land use by Aboriginal Groups.

As described in Section 15, KAM has undertaken efforts to engage and consult with Aboriginal Groups in the development of the Project. This has included a range of engagement techniques, such as:

- supporting development of TK/TLU studies;
- participating in community meetings;
- participating in meetings with leadership;
- facilitating opportunity for review of appropriate EA sections prior to submission (e.g., Part C and CULRTP); and
- providing Project updates regularly.

In particular, KAM provided capacity funding to SSN to support preparation of a Cultural Heritage Study (CHS) and Preliminary Mitigation Report. Review of these reports, and subsequent meetings, have helped KAM to gain a better understanding of SSN interests; however, to date it has not resulted in the identification of specific mitigation measures. The Preliminary Mitigation Report does not provide mitigation suggestions, noting that there is a lack of information from effects assessments and a lack of understanding about Project design changes. However, in the Report, the SSN noted most of its concerns cannot be mitigated.

KAM remains committed to on-going consultation and engagement with Aboriginal Groups through the Application Review stage. It is anticipated that the Application/EIS will provide Aboriginal Groups with a better understanding about the proposed Project and predicted effects, which will facilitate more detailed discussion related to appropriate mitigation measures.

17.8 RESIDUAL ENVIRONMENTAL EFFECTS

Residual effects are those that remain following the implementation of mitigation measures. Residual effects are evaluated for each Valued Component in Sections 6 through 10 of the Application/EIS. A summary of residual effects is provided in Tables 18.2-1 to 18.2-5.

17.9 SIGNIFICANCE ASSESSMENT/ANALYSIS

A significance assessment is completed for each of the identified residual effects for each Valued Component in Sections 6 through 10 of the Application/EIS. As described in Section 5, significance is determined by characterizing the residual effect based on a set of standard criteria (magnitude, duration, frequency, geographic extent, reversibility, resiliency and ecological context). The significance of effects then ranked according to the three categories:

- **Not Significant (Minor):** Residual effects have no or low magnitude, local geographic extent, short- or medium-term duration, and occur sporadically if at all. The effects on the VC (e.g., at a species or population level) are indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes). Land and resource management plan objectives will be met.
- **Not Significant (Moderate):** Residual effects have medium magnitude; have local, watershed, or regional geographic extent; are short-term to chronic (i.e., may persist into the far future); and occur at all frequencies. Residual effects on the VC may be distinguishable at the population, community, and/or ecosystem level. The ability to meet land and resource management plan objectives may be impaired.
- **Significant (Major):** Residual effects have high magnitude; have regional or beyond regional geographic extent; are chronic (i.e., persist into the far future); and occur at all frequencies. Residual effects on the VC are consequential (i.e., structural and functional changes in populations, communities, and ecosystems are predicted). The ability to meet land and resource management plan objectives is impaired.

Tables 18.2-1 to 18.2-5 provide a summary of the significance rating for each residual effect.

17.10 CUMULATIVE ENVIRONMENTAL EFFECTS

As described in Section 5, and Figure 5.3-1, each residual effect that is identified in the Project-specific assessment is also carried forward to a cumulative effects assessment. The cumulative effects assessment identifies other past, present, and reasonably foreseeable future projects and human activities that have caused, or may cause, effects and that could interact with the residual effects of the Project on each Valued Component being assessed.

A list of project/activities for consideration in the cumulative effects assessment is summarized in Table 5.3-1, and the spatial locations for most (represented where possible) are presented in Figure 5.3-2.

Where cumulative residual effects are identified, these are characterized against the standard assessment criteria (magnitude, duration, frequency, geographic extent, reversibility, resiliency and ecological context), and significance is rated (not significant (minor); not significant (moderate); significant).

Tables 18.2-1 to 18.2-5 provide a summary of the significance rating for each cumulative residual effect.

In a number of cases, while Project-specific residual effects were identified, cumulative residual effects were not. This was because other past and present human activities are already incorporated into the baseline condition and thus the Project-specific assessment. For example, the air quality modelling completed for the Project (Section 10.1) explicitly incorporates all existing licenced emission sources in the Kamloops area as part of the Base Case condition, such that the Construction Case and Operation Case already essentially represent a cumulative analysis (see Section 10.1.6 for more detailed discussion).

17.11 ABORIGINAL ENGAGEMENT AND CONSULTATION

17.11.1 Aboriginal Groups Consultation Requirements

The CEA Agency identifies the Stk'emlupsemc te Secwépemc Nation (SSN), which is comprised of the Tk'emlúps te Secwépemc (TteS) and Skeetchestn Indian Band (SIB), the Lower Nicola Indian Band (LNIB), Ashcroft Indian Band (AIB), the Whispering Pines/Clinton Indian Band and the Métis Nation British Columbia (MNBC) as the Aboriginal Groups that KAM is required to consult with. Table 17.11-1 identifies the Aboriginal Groups for which consultation was mandated by either the provincial (i.e., BCEAO) and federal (i.e., CEA Agency) agencies.

Table 17.11-1. Aboriginal Groups Consultation Requirements

Aboriginal Group	BCEAO's Section 11 and Section 13 Orders	CEA Agency Consultation Depth
Stk'emlupsemc te Secwépemc Nation	First Nation	High
Ashcroft Indian Band	Working Group First Nation	Moderate
Lower Nicola Indian Band	Working Group First Nation	Moderate
Whispering Pines/Clinton Indian Band	Notification First Nation	Moderate
Métis Nation British Columbia	Not mentioned	Low

The MNBC is the only Aboriginal Group that is not identified by the BC EAO but recognized by the CEA Agency. With respect to the MNBC, KAM collected background information and assessed effects on MNBC interests (i.e. rights including title) and other aboriginal interests in Part C of the Application/EIS as follows:

- Background Information: Section 12.4;
- Aboriginal Interests (Rights and Title): Section 13.9;
- Other Potential Effects: Section 14.6; and
- Procedural Aspects of Aboriginal Consultation: Section 15.3.6.

17.11.2 Summary of Consultation with Aboriginal Groups

Section 15 of the Application/EIS presents the results of consultation with all Aboriginal Groups. Appendix 15-A presents the summary of communications with each Aboriginal Group and Appendix 15-B presents the Aboriginal Groups Issues Tracking Tables which include KAM responses and the status of resolution for the issues identified by each Aboriginal Group. A summary of consultation is also presented in Section 16 and is repeated below.

The main concerns expressed by SSN during the consultation process include, but are not limited to, the following:

- potential loss of SSN traditional territory, including loss of land to support cultural activities and harvesting by community members;

- potential effects to Aboriginal title including the right to benefit economically from the land, effects on Aboriginal economies, shared decision making, governance and the Trout Children Story;
- changes to rights and title in relation to Jacko Lake, Goose Lake, and Kamloops Lake;
- potential effects on cultural/ceremonial sites, particularly Jacko Lake and surrounding areas (also known as *Pípsell*), including Jacko Lake, Goose Lake, Jacko Creek (upper Peterson Creek) and the Hunting Blind Complex;
- potential effects on cultural resources:
  - potential burial sites and burial cairns; and
  - sacred sites at Mount Lolo;
- potential effects on water quality and quantity in the Peterson Creek watershed, Jacko Lake, Kamloops Lake, Cherry Creek, and the Thompson River including effects from dust and/or seepage from the mine site;
- potential effects on fish, including habitat, movement and availability;
- potential effects on wildlife and wildlife habitat, including effects on non-migratory game birds, displacement of ungulates as a result of disruption in movement, and effects on other small mammals in the Project vicinity;
- destruction of grasslands which also support biodiversity;
- changes in access to and use of preferred harvesting locations (e.g., Jacko Lake, Goose Lake, Peterson Creek);
- potential effects on berry and wild root vegetation, as well as other medicinal and food plant gathering sites (in the vicinity of the Project and around Jacko Lake);
- potential effects on human health, as a result of contamination of country foods, or domestic drinking water, air quality changes (e.g. dust) as well as effects from noise and vibration (e.g., blasting) ;
- potential negative effects on social conditions such as increased pressure on health services, and additional social problems from increases in disposable income due to population increases;
- interest in support for economic opportunities, such as training and skills development for members and employment and contracting opportunities;
- accidents and malfunctions including potential failure of the Tailings Storage Facility (TSF);
- potential contamination during the Post-Closure phase (i.e., adequate reclamation); and
- cumulative effects on traditional land use resulting from interactions with other industries and developments in the Project area; and
- consultation concerns such as a lack of capacity funding and participation in the environmental assessment process, and consideration of the Cultural Heritage Study (CHS) as a result of changes to the General Arrangement (GA).

The main concerns expressed by AIB, LNIB, WP/CIB, and MNBC include, but are not limited to, the following:

- potential effects on fishing, hunting, and gathering practices;
- potential effects on water quality and quantity as a result of contamination, dust deposition, acid rock drainage, or overuse of water resources;
- potential effects on fish and fish habitat (e.g., from blasting and vibration);
- potential effects on land and resource use such as ranching;
- potential effects on wildlife and wildlife habitat, as a result of Project activities (e.g., light);
- potential soil contamination from fugitive dust emissions (affecting plants and sensitive ecological communities);
- effects on cattle, wildlife, country food, and medicinal plants due to dust, noise, and vibration;
- accidents and malfunctions, including potential failure of the TSF, particularly on fish, fish habitat, and human health;
- effects on human health from air pollution;
- potential negative effects on economic conditions such as property values, tourism and unemployment (due to boom and bust periods);
- potential negative effects on social conditions as a result of population changes or increased pressure on health services;
- cumulative effects resulting from interactions with other industries and developments in the Project area;
- potential use of temporary foreign workers for the Project;
- support for additional consultation;
- interest in contracting, training, and employment opportunities; and
- interest in development of traditional use studies to better understand potential Project effects.

17.11.3 Effects on Current Use of Land and Resources for Traditional Purposes by Aboriginal Groups

Section 16.1 of the *CEA Act* in Section 16.1 requires that every comprehensive study (i.e., Application/EIS) include a consideration of the environmental effects of a project, including effects of changes to the environment on current use of lands and resource for traditional purposes by Aboriginal peoples. Section 8.5 of the Application/EIS titled Current Use of Land and Resources for Traditional Purposes (CULRTP) presents the results of the assessment of effects for all the Aboriginal Groups identified.

Four indicators (i.e., fishing, trapping/hunting, plant harvesting and ceremonial use were selected for the assessment of effects on CULRTP. Table 17.11-2 summarizes the mitigation measures, residual effects, and cumulative effects for the four indicators for each Aboriginal Group. Residual effects are anticipated for all Project phases and for all Aboriginal Groups, and range from Not Significant (negligible) to Not Significant (moderate). Cumulative effects were also identified for all current use indicators, ranging from Not Significant (moderate) to Significant, with the Significant rating for Ceremonial Uses relating only to SSN. These rankings are driven by the degree of present disturbance to current use resources and sites in the LSA. Key mitigation measures include implementation of management plans including the Fish Habitat Mitigation and Offsetting Plan, the Transportation Management Plan and the Closure and Reclamation Plan as well as the implementation of No Fishing, Hunting, and Plant Gathering Policies.

Table 17.11-2. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Current Use of Lands and Resource Use for Traditional Purposes

Residual Effects	Project Phase	Mitigation Measures	Residual Effect Significance	Residual Cumulative Effect Significance
Disruption of Fishing Uses	All	Fish Habitat Mitigation and Offsetting Plan, No fishing policy, Transportation Management Plan	Not Significant (Negligible to Minor)	Not Significant (Moderate)
Disruption of Hunting Uses	All	Transportation Management Plan, Firearms and Hunting Policy, Closure and Reclamation Plan	Not Significant (Negligible to Moderate)	Significant
Disruption of Plant Gathering	All	Closure and Reclamation Plan, Invasive Species Management Plan, No plant gathering policy, Transportation Management Plan	Not Significant (Negligible to Moderate)	Significant
Disruption of Ceremonial Uses (SSN only)	All	Closure and Reclamation Plan	Not Significant (Moderate)	Significant

17.11.4 Effects on Aboriginal Interests

The assessment of the effects of the Project on Aboriginal interests (i.e. rights including title) is presented in Section 13 of the Application for all of the Aboriginal Groups as follows:

- Section 13.5 Stk'emlupsemc te Secwépemc Nation;
- Section 13.6 Ashcroft Indian Band;
- Section 13.7 Lower Nicola Indian Band;
- Section 13.8 Whispering Pines/Clinton Indian Band; and
- Section 13.9 Métis Nation BC.

Finally, Section 16.3 presents a summary of the assessment of project effects on Aboriginal interests for all Aboriginal Groups. The summary in Section 16.3 concludes that the seriousness of the effects of the Project on SSN's practice of fishing hunting and trapping, plant harvesting is considered to be minor. The seriousness of the effects on ceremonial and cultural practices is considered moderate.

The seriousness of the effects of the Project on AIB, LNIB, WP/CIB and MNBC's practice of fishing, hunting and trapping, and plant harvesting isTo date, research conducted by KAM and consultation with AIB, LNIB, WP/CIB and MNBC has not identified ceremonial and cultural practices within the vicinity of the Project for these Aboriginal Groups although these activities likely occur closer to key harvesting locations.

Mitigation and accommodation measures for Aboriginal Interests for each Aboriginal Group are summarized in Tables 16.3-1, 16.3-3, 16.3-5, 16.3-7, and 16.3-9.

17.11.5 Effects on Other Aboriginal Interests

The assessment of the effects of the Project on Other Aboriginal interests that were identified through consultation is presented in Section 14 of the Application for all of the Aboriginal Groups as follows:

- Section 14.2 Stk'emlupsemc te Secwépemc Nation;
- Section 14.3 Ashcroft Indian Band;
- Section 14.4 Lower Nicola Indian Band;
- Section 14.5 Whispering Pines/Clinton Indian Band; and
- Section 14.6 Métis Nation.

Finally, Section 16.3 presents a summary of the assessment of project effects on other aboriginal interests for all Aboriginal Groups. Tables 17.11-3 to Table 17.11-7 summarize the findings of the assessment relating to other aboriginal interests for each Aboriginal Group.

Table 17.11-3. Residual Effects and Mitigation for Other Aboriginal Interests of SSN

Other Aboriginal Interest	Residual Effect	Project Phase	Mitigation Measures
Economic Conditions	Decreased employment and income for SSN members after Project closure.	Decommissioning and Closure	Implementation of a communications and transition program.
	Increase in costs caused by staff turnover and the need to compete for staff against the Project.	Construction and Operations	The effect was characterized as negligible and did not required mitigation.

Other Aboriginal Interest	Residual Effect	Project Phase	Mitigation Measures
Social Conditions	Reduction in access for SSN members to health services.	Construction and Operations	Establish a Socio-economic Monitoring Advisory Committee. Implementing a Socio-economic Monitoring Plan. Keep health service providers informed about Project workforce requirements. Contracting a family physician to be the designated medical resource for the construction workforce. Contributing financially or in-kind to physician recruitment efforts and the new residency program for family physicians currently in place in Kamloops
	Increases in social problems (i.e. substance abuse) in SSN communities due to spending of additional income	Construction and Operations	Offer counseling services to employees if needed. Provide money management training as required. Implement a zero tolerance policy with respect to drug and alcohol at the Project site for Project employees and contractors. Work with local agencies to monitor Project socio-economic effects and to take corrective actions as appropriate. Establish a Socio-economic Monitoring Advisory Committee. Implementation of a Socio-economic Monitoring Plan.
Physical and Cultural Heritage Resources	Disturbances to the availability, access and experience of sites associated with Pípsell including the Hunting Blind Complex, Goose Lake, portions of Peterson Creek and minor portions of Jacko Lake	All	Systematic data recovery. Mitigation measures approved by the Archaeology Branch and the SSN. Develop an Access Management Plan in consultation with Aboriginal Groups. Provide support to the SSN to participate in accessing, harvesting, and/or documenting plants or other resources of cultural value prior to the Project footprint disturbance. Work with the SSN to identify opportunities to support cultural heritage programming for SSN members. Implement a site disturbance policy. Mitigation measures to mitigate effects on CULRTP outlined in Section 8.5. Mitigation measures to control noise and vibration emissions outlined in Section 10.5 Mitigation measures to control air and dust emissions outlined in Section 10.1. Mitigation measures described in Section 8.3, Visual Impact/Aesthetic Features.

Other Aboriginal Interest	Residual Effect	Project Phase	Mitigation Measures
Health Conditions	Health effects associated to exposure (i.e. inhalation or ingestion) to contaminants generated by the project.	All	Mitigation measures to control air and dust emissions outlined in the Air Quality section (Section 10.1). Mitigation measures to control surface water discharges outlined in the Surface Water Quality section (Section 6.4).

Table 17.11-4. Other Interests and Concerns Expressed by AIB

Other Interests or Matters of Concern	AIB Issue/Concern/Comment	Valued Component / Section of Application/EIS
Economic conditions	Interest expressed in contracting, employment, training and procurement opportunities.	Labour Force, Employment and Training
	Concern about the potential use of temporary foreign workers as employees for the Project.	Labour Force, Employment and Training
Health conditions	Potential effects on cattle from metals	Human Health
Water quality and quantity	General concerns about changes to water quantity and quality.	Surface Water Quality Surface Water Quantity Groundwater Quality Groundwater Quantity
	Potential effects on Thompson River.	Surface Water Quality Surface Water Quantity
Cumulative effects	Concern about cumulative effects (including the Kinder Morgan pipeline).	Multiple VCs as appropriate

Table 17.11-5. Other Interests and Concerns Expressed by LNIB

Other Interests or Matters of Concern	LNIB Issue/Concern/Comment	Valued Component / Section of Application/EIS
Economic conditions	Interest in potential education, training, and employment opportunities.	Labour Force, Employment and Training
	Interest in developing economic and business opportunities.	Business
	Interest in creation of economic diversification.	Economic Diversification
Water quantity and water quality	Potential downstream effects from changes in water quantity and quality.	Surface Water Quality Surface Water Quantity Groundwater Quality Groundwater Quantity
Accidents and malfunctions	Potential failure of the TSF, including potential effects on the Kinder Morgan pipeline, which is located under the proposed mine rock and TSF.	Accidents and Malfunctions (Section 17.6)

Table 17.11-6. Other Interests and Concerns Expressed by WP/CIB

Other Interests or Matters of Concern	WP/CIB Issue/Concern/Comment	Value Component / Section of Application/EIS
Economic conditions	Potential effects on tourism opportunities from sensory disturbances such as effects to aesthetic and visual resources and noise.	Business Outdoor Recreation
	Potential increase of unemployment and poverty due to mine activities.	Community Health and Well-being
	Potential effects of boom and bust periods on employment, including spillover effects.	Labour Force, Employment and Training Community Health and Well-being
Social conditions	Potential effects on access to health care facilities and medical practitioners (i.e., loss of physicians and health personnel) due to mine operations.	Infrastructure, Public Facilities, and Services Community Health and Well-being
Health conditions	Potential effects of air pollution on human health including: • effects from chemicals in blast emissions (including uranium) • effects from transportation-related emissions (large diesel generators, heavy equipment) on nearby Indian Reserves and traditional use areas • effects from chemicals in fugitive dust on nearby traditional use areas • potential for dust to be distributed at considerable distance from the mine site including to WP/CIB Reserve No 4	Human Health Air Quality
	Potential contamination of plants, wildlife, and country foods, including through soil contamination and dust emissions	Human Health Country Foods
	Potential sensory disturbances (noise and vibration effects) for those residing on the WP/CIB Indian Reserves.	Noise and Vibration
Water quantity and water quality	Effects on water quality from acid rock drainage and other potential contamination during and after production.	Surface Water Quality Groundwater Quality
	Concern about the significant amount of water that will be used by the Project from Kamloops Lake and the Thompson River, which could deplete water resources available for the community and other uses including cattle and hay ranching.	Surface Water Quantity
	Potential effects on water quality due to dust deposition on nearby waterbodies.	Surface Water Quality
Reclamation and closure	Potential for contamination during the post-closure phase.	Reclamation and Closure Plan
	Potential use of contaminated soil in reclamation programs.	Geology, Landforms and Soils
Accidents and malfunctions	Potential effects on traditional resources from a spill or accident along the transportation corridor.	Accidents and Malfunctions (Section 17.6)
	Potential failure of mine facilities (in particular the TSF and the MRSF, as well as potential accidents/malfunctions associated with the Kinder Morgan pipeline	Accidents and Malfunctions (Section 17.6)
Cumulative effects	Potential cumulative effects of various mining operations on traditional land use.	Multiple VCs as appropriate

Table 17.11-7. Other Interests and Concerns Expressed by MNBC

Other Interests or Matters of Concern	AIB Issue/Concern/Comment	Valued Component / Section of Application/EIS
Economic conditions	Interest expressed in potential employment and economic opportunities.	Labour Force, Employment and Training
	Interest expressed in training and skills development.	Labour Force, Employment and Training
	Concern about the use of foreign labour force.	Labour Force, Employment and Training
Social conditions	Potential effects on property values such as increases in housing costs.	Infrastructure, Public Facilities, and Services
	Potential effects from transportation of ore and increased truck traffic.	Infrastructure, Public Facilities, and Services
Health conditions	Potential noise effects from blasting and crushing activities on local residents.	Noise and Vibration
Water quantity and water quality	Potential effects on water quality in Jacko Lake as well as other waterbodies (such as the Thompson River).	Surface Water Quality
	Changes in water quantity to nearby waterbodies	Surface Water Quantity
Accidents and malfunctions	TSF safety and potential malfunctions.	Accidents and Malfunctions

17.12 FOLLOW-UP PROGRAMS AND ADAPTIVE MANAGEMENT

The *Operational Policy Statement for Follow-Up Programs under the Canadian Environmental Assessment Act* (CEA Agency 2011) provides the following definition for follow-up programs from the *Canadian Environmental Assessment Act* (1992):

- to verify the accuracy of the conclusions of the EA process for a designated project; and
- to determine the effectiveness of any measures taken to mitigate the adverse effects of the project.

As per the policy, the results of the follow-up programs will be used to adaptively manage for any previously unanticipated adverse environmental effects of the Project, and/or to modify necessary mitigation measures as needed. Adaptive management is a planned, systematic process for continuously improving environmental management practices by learning about their outcomes (CEA Agency 2009). Following the *Operational Policy Statement Adaptive Management Measures under the Canadian Environmental Assessment Act* (CEA Agency 2009), decisions to adopt specific adaptive management measures can be identified later during the project life-cycle as a result of the analysis of data generated by a follow up or monitoring program.

Indicators, action thresholds, predictions and triggers for adaptive management will be developed for each of the proposed follow-up programs in consultation with appropriate government agencies. Adaptive management options will also be identified if mitigation measures do not function as intended. If needed, once adaptive management measures have been implemented, monitoring will continue in order to verify the effectiveness of the follow-up program and learn from its results.

The EMPs provided in Sections 11.2 to 11.29 include mitigation measures that will be implemented to reduce and manage possible environmental effects in a systematic manner. EMPs are in part based on the principle of adhering to recognized best management practices and achieving an acceptable level of mitigation of identified environmental effects.

The following sections provide overviews of the follow-up programs proposed for the Project. In most cases, the follow-up programs are designed to rely on established management and monitoring programs to provide the necessary data for the follow-up program. Each of these programs will be funded by KAM. Details of the specific needs for these programs will continue to be developed through the Application/EIS Review phase based feedback received from reviewers, with final programs anticipated to be complete prior to the start of Construction.

17.12.1 Groundwater Follow-up Program

A long-term groundwater monitoring plan has been developed as a routine part of the Groundwater Quality Management Plan (Section 11.24) to monitor the potential effects on groundwater levels and groundwater quality in the area surrounding the major mine components. Monitoring results will be compared with established baseline levels and water quality guidelines. The purpose of the Follow-up Program will be to verify accuracy and conclusions from the groundwater modeling and to provide the data necessary to determine the effectiveness of mitigation measures related to water management.

The follow-up program will be designed to ensure an accurate understanding of the hydrogeological connectivity between Jacko Lake and the open pit, as well as confirming hydrogeological assumptions related to the Edith Lake Fault Zone and the Peterson Creek Aquifer.

An adaptive management plan will be initiated if the monitoring results show that the effect in the receiving groundwater environment is significant enough to warrant further attention.

The monitoring program proposed as part of this Follow-up Program will ultimately be part of compliance monitoring requirements of a permit(s) under the *Environmental Management Act* (EMA), with additional monitoring locations and sampling as required. The permit is expected to have annual reporting requirements. Reporting requirements for the Follow-up Program will be fulfilled by providing a copy of the annual permit report(s) to the CEA Agency and to Aboriginal Groups.

17.12.2 Surface Water Quality Follow-up Program

A program for surface water quality monitoring (Section 11.23) will be developed to gauge effectiveness of the mitigation measures outlined in the Surface Erosion and Sediment Control Plan (Section 11.2), the best management practices outlined in the Explosives Handling Plan (Section 11.11), and the overall effectiveness of the Metal Leaching and Acid Rock Drainage Management Plan (Section 11.5). Monitoring locations will focus on water management/seepage collection ponds, potential seepage pathways, Jacko Lake, and Peterson Creek. The monitoring program proposed as part of this management plan will ultimately be part of compliance monitoring requirements of a permit(s) under the *Environmental Management Act,* with additional monitoring locations and sampling as required.

The monitoring program will allow for comparison of results to established baseline conditions, predicted water quality from modelling studies, proposed science based environmental benchmarks, and water quality guidelines. If it is determined from the compliance monitoring results that trends toward significant effects to surface water quality are noted from any project component, then targeted mitigation measures will be initiated. Adaptive management measures will be applied if the follow-up monitoring program suggests the effects on water quality cannot be efficiently mitigated by the measures outlined in the effects assessment.

The EMA permit is expected to have annual reporting requirements. Reporting requirements for the Follow-up Program will be fulfilled by providing a copy of the annual permit report(s) to the CEA Agency and to Aboriginal Groups.

17.12.3 Terrestrial Ecology Follow-up Program

17.12.3.1 Rare Plants and Ecosystems at Risk Surveys

The confidence in the characterization of the residual Project effects to rare plants was considered to be low (Section 6.8). Based on the current information, rare plants will experience a non-significant moderate effect. However, this is likely an artifact of a lack of regional knowledge and detailed studies in regional micro-habitats.

Although the general predictions of adverse effects to rare plant are sound, the distribution of rare plants outside of the survey areas is unknown. As such, it is difficult to determine the scale of the effect of the Project on rare plant abundance and distribution. A field program to enable the establishment of the distribution and extent of additional rare plant occurrences within the regional study area will help better characterize the regional impacts of the Project and verify the conclusions reached in the Application/EIS. Field surveys will include investigation for additional occurrences of Red-listed ten-cent tarpaper, Red-listed powder-lined rock-olive, and Blue-listed goldnugget sulphur for example and investigations should target representative species of each category of rare plant including mosses, lichens and vascular plants.

Following the completion of regional surveys, a report will be prepared by the rare plant botanist and a research program on translocation of rare plants will be initiated. If necessary, additional mitigation measures will be identified through the research, and implemented. A copy of the report will be submitted to the CEA Agency and to Aboriginal Groups. Also, the location of any newly identified rare plants will be communicated to provincial agencies for incorporation into their tracking database.

17.12.3.2 Wetland Compensation Follow-up Program

Loss of wetlands is a concern to both provincial and federal governments. Environment Canada has identified the goal of maintaining wetland functions and values through a policy of no net loss of wetland function (Government of Canada 1991). Within the RSA less than 0.4 % of wetlands will be impacted as a result of the Project. This is considered a negligible effect regionally, however loss of wetlands within the LSA as a result of the Project is considered a residual effect.

Reclamation efforts upon closure of the mine may reduce the total wetlands lost, but will not be able to mitigate the habitat loss of saline wetlands, creek shore, and marsh habitat wetlands completely and a compensation plan will be developed.

The compensation plan will be developed and overseen by a qualified professional with experience in wetland restoration. A Follow-up Program will be designed to confirm the effectiveness of the wetland compensation plan. The program will include monitoring that will ensure compensatory habitats are constructed in accordance with the compensation plan, and effectiveness monitoring and/or detailed wetland mapping to ensure that restored, enhanced and/or created wetlands are functioning as intended after construction. The effectiveness monitoring is intended to guide adaptive management actions to promote the long term performance of the wetland habitat compensation measures established for the Project.

A Follow-up Program to re-map the wetlands affected by the Project will also be conducted at regular intervals through the life of mine. This information will refine the estimate of wetland loss caused by the Project, assist in evaluating the conclusions of the effects assessment, provide insight as to the effectiveness of the compensation plan, and inform reclamation.

Reporting for this Follow-up Program will include annual monitoring summaries for the first five (5) years after the initiation of compensation activities. The need for continued monitoring and reporting would be determined based on the results of five years of monitoring. Reports will be submitted to the

CEA Agency, to Aboriginal Groups and to provincial agencies (e.g., Ministry of Environment; Ministry of Forest Lands, Natural Resources) for review and comment.

17.12.4 Fish and Aquatic Resources Follow-up Program

17.12.4.1 Fish Habitat Offset Plan

The fish habitat offset plan has been developed to date with engagement and input from Fisheries and Oceans Canada (DFO), the Ministry of Environment (MOE), Forest Lands and Natural Resources (FLNR), SSN, as well as local angling groups. Further development of the plan, and further engagement, will occur to support application for a Fisheries Authorization.

A follow-up program that monitors the environmental performance of the fish habitat offsetting plan will be undertaken to determine the effectiveness of the offsetting measures.

Monitoring will be established for:

- water quality of Inks Lake and Alkali Creek;
- water quantity at Inks Lake to verify inflow and outflow assumptions; and
- fish health and productivity in Inks Lake and Jacko Lake including tissue analysis.

Adaptive management strategies will be employed if the monitoring program reveals that the fish habitat offsetting plan is not meeting the projected expectations.

Reporting for this Follow-up Program will include annual monitoring summaries for the first five (5) years after the initiation of compensation activities. The need for continued monitoring and reporting would be determined based on the results of five years of monitoring. Reports will be submitted to Fisheries and Oceans Canada, CEA Agency and to Aboriginal Groups. Copies will also be provided to provincial agencies (e.g., Ministry of Environment; Ministry of Forest Lands, Natural Resources) for review and comment.

17.12.5 Heritage Sites Follow-up Program

While avoidance is always the preferred recommendation for archaeological and heritage sites, this is not always possible. A total of 28 known archaeological sites are located in, or within 50 metres of, Project developments. Mitigation measures will be determined in consultation with the Archaeology Branch and SSN. It is anticipated that mitigation measures at these sites will include systematic data recovery or preservation through site capping. In particular additional mitigation measures will be required for cultural features associated with Jacko Lake and the Hunting Blind Complex, and the potential for a burial at the St. Peter's Church location.

The Follow-up Program will be designed to provide a mechanism for supporting engagement and consultation in the development of mitigation measures to ensure that environmental effects on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance are appropriately addressed and implemented. Prior to the disturbance of any archaeological site, a report will be provided to the CEA Agency summarizing the result of engagement between KAM, SSN and the Archaeology Branch.

17.13 CAPACITY OF RENEWABLE RESOURCES

17.13.1 Regulatory Context

This chapter presents an assessment of the capacity of renewable resources that are likely to be affected by the Ajax Project (the Project) to meet the needs of the present and those of the future, in accordance with section 16 (2) (d) of the *Canadian Environmental Assessment Act* (CEAA; 1992), and section 17.3 of the Project Application Information Requirements/ Environmental Impact Statement Guidelines (AIR/EIS Guidelines). The AIR/EIS Guidelines requires the Application/EIS to "identify those resources likely to be significantly affected by the project, and describe how the project could affect their sustainable use."

Section 6 of this Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS) evaluates the potential Project-related effects on valued components (VCs), as well as the potential cumulative effects. In many cases, VCs can be considered renewable resources from a biological or land use perspective, and are used as the basis for identifying renewable resources. This assessment considers the potential effects of the Project on the capacity of renewable resources during the Project Construction, Operations, Decommissioning and Closure and Post-Closure phases, to assess whether the capacity of these resources for current and future needs could be affected by the Project.

17.13.2 Methodology

The Application/EIS presents the VCs that may be affected as a result of the Project and the significance of Project-related and cumulative residual effects.

This chapter incorporates the results of the VC effects assessment and integrates the findings into an assessment of the effect of the Project on the capacity of renewable resources. The chapter uses the following methods:

- identification of renewable resources – identify VCs which could act as renewable resources for which "not significant (moderate)" or "significant (major)" potential Project-related residual/cumulative adverse effects are predicted as a result of the Project, either alone, or acting cumulatively with other projects;
- identification of parties - identify the parties that use and value the identified renewable resources in the LSA/RSA currently and who likely will continue to use them in the future; and
- assessment of capacity of renewable resources – determination of whether the sustainable use of the identified renewable resources will potentially be impaired by the Project. The sustainability of use determined based on the Application/EIS significance findings, focusing on magnitude, duration, extent, reversibility, resiliency of Project effects of the potentially affected renewable resources as indicators of continued productive capacity.

17.13.3 Spatial and Temporal Boundaries

Spatial boundaries are determined based on the anticipated magnitude and spatial extent of Project related effects. They are determined by the location and distribution of VCs and can be defined as the

anticipated zone of influence between the Project component/activity and the VC being studied. There are three zones of influence between the Project and the VC being studied: the Project Site, the local study area (LSA), and the regional study area (RSA). The spatial boundaries for the capacity for renewable resources assessment include the RSA boundaries for each VC, as defined in the applicable assessment in Section 6.

Temporal boundaries are the time periods considered in the assessment for various Project phases and activities. Temporal boundaries should reflect those periods during which planned Project activities are reasonably expected to potentially affect a VC. These boundaries are adjusted as appropriate to reflect seasonal and annual variations, or biophysical constraints related to a VC.

The temporal boundaries considered for each phase of the Project are described in Table 17.13-1.

Table 17.13-1. Temporal Boundaries for the Capacity of Renewable Resources Assessment

Phase	Duration	Years
Construction	2.5 years	Years -2 and -1
Operations	23 years	Year 1 to 23
Decommissioning and Closure	5 years	Year 24 to 29
Post-Closure	5+ years	

17.13.4 Identification of Renewable Resources

Based on a review of the VCs assessed in the Application/EIS, renewable resources for which "not significant (moderate)" or "significant (major)" potential Project-related residual/cumulative adverse effects are predicted were scoped in and listed in Table 17.13-2. They include: groundwater quantity, fish and fish habitat, rare and sensitive ecosystems, grasslands, migratory birds, and non-migratory gamebirds. The VCs rare plants, amphibians, and mammals are excluded from this assessment, even though there were assessed not significant (moderate) residual effects because human use of these VCs is expected to be minimal (i.e., they are not considered to be a renewable resource). Deer and moose are important to Aboriginal peoples. The rating is not significant (minor) for deer and negligible for moose. Rare plants and amphibians have limited human recreational or consumptive use. With respect to non-migratory gamebirds, not significant (moderate) residual effects were assessed for sharp-tailed grouse and ruffed grouse - loss of suitable habitat and known lek sites, and decreased lek usage or abandonment of nests due to sensory disturbance. However, sharp-tailed grouse are a managed species under Wildlife Management Unit 3-19, and hunting of this species is not currently permitted. Thus, the consumptive use of this species is unlikely in the Project area and this species is not considered a renewable resource. With respect to mammals, a not significant (moderate) residual effect was assessed for American badger habitat loss. This species is red-listed in BC, is considered endangered by the Committee on the Status of Endangered Wildlife in Canada, and is listed as Schedule 1 under the *Species at Risk Act* (1985). Thus, consumptive use of this species is generally prohibited and it is not considered a renewable resource.

Table 17.13-2. Summary of Residual Effects on Renewable Resources

Renewable Resources	Residual Effect	Timing of Effect	Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Residual Effects Significance
Jacko Lake groundwater balance	Seepage from Jacko Lake toward the mine pit	Operations, decommissioning and closure, and post closure	Medium	Long-term	Regular	Landscape	Irreversible	Neutral	High	Not Significant (moderate) Not Significant (moderate) Cumulative Residual Effects
Changes to the local groundwater balance	Increase in groundwater discharge to the open pit footprint, reduced recharge through the MRSFs and stockpile, increased recharge through the TSF.	Operations, decommissioning and closure, and post closure	Medium	Long-term	Regular	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate) Not Significant (moderate) Cumulative Residual Effects
Changes to the local groundwater levels	Permanent groundwater level changes within ~2 km of mine infrastructure	Operations, decommissioning and closure, and post closure	Medium	Long-term	Regular	Landscape	Irreversible	Neutral	Neutral	Not Significant (moderate) Not Significant (moderate) Cumulative Residual Effects
Fish and Fish Habitat	Indirect habitat loss in Peterson Creek downstream of the Project area from flow reductions associated with Project	Operations, decommissioning and closure, and post closure	Minor	Medium-term	Once	Regional	Irreversible	High	Low	Not Significant (moderate) Not Significant (minor) Cumulative Residual Effects
Rare and Sensitive Ecosystems	Habitat Loss	Construction	Medium	Far Future	Sporadic	Local	Reversible Long-term	Low	High	Not Significant (moderate) Not Significant (minor) Cumulative Residual Effects
Grasslands	Habitat Loss	Construction	Medium	Long-term	Sporadic	Local	Reversible Long-term	Low	Neutral	Not Significant (moderate) Not Significant (minor) Cumulative Residual Effects
Migratory Birds	Habitat Loss	Construction	Medium	Long-term	Sporadic	Local	Reversible Long-term	Low	Low	Not Significant (moderate) Not Significant (minor) Cumulative Residual Effects

17.13.5 Present and Future Use of Renewable Resources

Land and resource use often involves consideration of the present and future use of renewable resources. The Project is located within the Thompson-Nicola Regional District (TNRD), an area that includes both urban and rural landscapes. This combination of characteristics results in a diversity of land and resource uses to consider with respect to the Project. Community land use (including consideration of future plans) occurs to the north and east of the Project, where the City of Kamloops and rural community of Knutsford are located, respectively. Both the City of Kamloops and TNRD have undertaken land use planning processes related to these areas.

The Project is also in the traditional territories of several Aboriginal groups, including the Secwepmec Nation (including the Tk'emlúps te Secwepemc, the Skeetchestn Indian Band, and the Whispering Pines/Clinton Indian Band), the Nlaka'pamux Nation (including the Lower Nicola Indian Band and Ashcroft Indian Band), and Métis Nation BC.

The parties who presently use or have rights to renewable resources are identified in Chapter 8.4, Land and Resource Use, of the Application/EIS. Current Use of Land and Resources for Traditional Purposes are described in Chapter 8.5. Aboriginal Groups with interests (and rights) in the Project area are described in Chapter 15.

17.13.6 Groundwater Quantity

Groundwater quantity is identified as a VC, and as a renewable resource for its contribution to humans for drinking water, and livestock and irrigation water in the Project area. Changes to groundwater quantity as baseflow to streams or groundwater discharge to lakes may affect fish, fish habitat, vegetation, wetlands, and wildlife drinking water sources. Chapter 6.6 of the Application/EIS assesses in detail the Project's residual effects on groundwater quantity.

The identified not significant (moderate) residual effects on groundwater quantity in Chapter 6.6 include the potential changes to the Jacko Lake groundwater balance, local groundwater balance and local ground water levels. The Project-related residual effects relating to groundwater quantity are assessed as not significant (moderate) and are summarized below.

Jacko Lake Groundwater Balance

The assessment in Chapter 6.6 describes changes to the Jacko Lake groundwater balance indicating that Jacko Lake is a gaining lake under existing conditions. Development of the open pit is anticipated to cause seepage from Jacko Lake to the open pit during operations, decommissioning and closure, post closure, and into the future. The Project's residual effect on Jacko Lake groundwater balance is summarized in Table 17.13-3.

Changes to the Local Groundwater Balance and Groundwater Levels

Other primary potential effects on groundwater quantity are changes in the local groundwater balance and the resulting changes in the local groundwater levels (Table 17.13-4). Development of the TSF provides additional groundwater recharge to the groundwater flow system within the TSF and the development of the open pit provides groundwater discharge. As a result, the local

groundwater levels are expected to increase over time beneath the TSF and predicted to decline through time within the open pit footprint and near the open pit in response to pit excavation, pit slope depressurization and dewatering activities.

Table 17.13-3. Summary of Residual Effects on Jacko Lake Groundwater Balance

Characterization Criteria	Description
Residual Effect(s)	Water balance changes due to the potential for seepage between Jacko Lake and the open pit
Magnitude	Medium, based on the local hydraulic properties of the rock between Jacko Lake and the open pit
Duration	Operations, closure, and post closure phase
Extent	Localized
Reversibility	Irreversible
Resilience	Neutral resiliency, meaning a neutral ability to respond and adapt to the effect
Significance	Not significant (moderate)

Table 17.13-4. Summary of Residual Effects on Local Groundwater Balance and Groundwater Levels

Characterization Criteria	Description
Residual Effect(s)	Increase in groundwater discharge to the open pit footprint and increased recharge beneath the TSF
Magnitude	Medium
Duration	Continuous during the operations, closure, and post closure phase
Extent	Local, greatest within the project footprint near the open pit and TSF, and extent is up to approximately 2 km away
Reversibility	Permanent, irreversible
Resilience	Neutral resiliency, receiving environment will be able to adapt to the groundwater quantity changes
Significance	Not significant (moderate)

Under existing conditions, Jacko Lake is a gaining lake. Development of the open pit will cause seepage from Jacko Lake to the open pit during operations, decommissioning and closure, post closure. Seepage rates will vary depending on the local hydraulic properties of the rock between Jacko Lake and the open pit. The magnitude of the effect is considered to be medium, based on the expected seepage rate compared to the overall Jacko Lake water balance, whereby the lake will continue to be gaining. The effect will be continuous, local, and irreversible. Jacko Lake is considered to have neutral resiliency, based on the managed flows in the Jacko Lake watershed.

Changes to the local groundwater balance and local groundwater levels are an inevitable consequence of the Project development and include discharge and recharge zones. The open pit is predicted to be a permanent terminal groundwater discharge zone with groundwater level changes greater than 100 m with the mine footprint. The TSF will be a groundwater recharge zone with a

groundwater mound more than 100 m higher than existing conditions due to tailings deposition. The geographic extent of changes are limited to within the LSA.

With respect to the RSA, three activities are identified to have the potential to contribute to cumulative groundwater quantity effects: domestic groundwater use, agriculture, and ranching. Groundwater supply can locally lower groundwater levels due to pumping. Agricultural irrigation is common in the region. Irrigation can affect groundwater quality in two ways: by contributing groundwater recharge in the case of excessive irrigation and by removing water from the groundwater flow system by pumping wells. Ranching can impact groundwater quantity by groundwater abstraction for human consumption and for livestock watering. These three activities are ongoing in the area.

The Project is predicted to have not significant (moderate) Project-residual effects on groundwater. While the Project is expected to alter groundwater levels, patterns of groundwater recharge and discharge, and patterns of groundwater flow, the changes are associated within 2 km of the Project footprint and localized. Mitigation measures may include potentially deepening or replacing groundwater supply wells within approximately 2 km of the open pit due to the lower groundwater level. Based on the assessment of effects in Chapter 6.6, the Project is not expected to affect the long-term renewable capacity on groundwater quantity.

17.13.7 Fish and Fish Habitat

Fish and fish habitat are identified as a Project VC because of their scientific, ecological, Aborignal and socio-economic importance. Fish are an important renewable resource in the Project area due to their recreational (angling) and consumptive use by humans. Project activities and components that have the potential to affect fish and fish habitat include direct habitat loss, indirect habitat loss, mortality and sub-lethal effects (i.e. change in water temperature and change in water chemistry on fish).

The identified not significant (moderate) residual effect on fish and fish habitat described in Chapter 6.7 include the indirect habitat loss for rainbow trout that could occur in areas downstream of Project components in Peterson Creek as a result of flow alterations. Flow alterations affect water velocity, water depth, and wetted width, thereby influencing the quantity and quality of habitat available for fish. This Project-related residual effect relating to fish and fish habitat is assessed as not significant (moderate).. Rainbow trout are stocked in Jacko Lake and migrate downstream into the creek.

The Project's residual effect on indirect habitat loss in Peterson Creek downstream is summarized in Table 17.13-5.

Based on the assessment of effects, the potential indirect habitat loss in Peterson Creek downstream due to flow reduction is characterized with a minor magnitude and not anticipated to have impacts on the renewable use of fish resources in the Project area. The expected magnitude of this residual effect on the productivity of the rainbow trout population in this area of Peterson Creek is characterized as minor for the Construction and Operation phases and negligible during the Post-Closure phase. KAM has committed to maintaining the fishery in Jacko Lake, and has developed a conceptual fish habitat offsetting plan that addresses fish habitat losses in both Jacko Lake and

Peterson Creek (Section 11.9). The offsetting will support the development of new location (Inks Lake) that could also support a similar stocked fishery. Thus, the Project is therefore not expected to affect the long-term sustainability of the renewable fisheries resources.

Table 17.13-5. Summary of Residual Effects on Fish and Fish Habitat

Characterization Criteria	Description
Residual Effect(s)	Potential indirect habitat loss of Rainbow Trout in Peterson Creek downstream of the Project area from flow reductions associated with the Project
Magnitude	For productivity of Rainbow Trout population in the Peterson Creek area, minor during construction and operation phase and negligible during post closure phase
Duration	Construction, operation, closure and will continue into the post closure phase
Extent	Regional, effects will be within the Peterson Creek watershed
Reversibility	Irreversible, reduced flows will continue into the post closure phase
Resilience	High, water depths and velocities are suitable for the small bodied rainbow trout that inhabit this section of the creek. The resiliency means the population is anticipated to respond and adapt to the effect.
Significance	Not significant (moderate)

17.13.8 Rare and Sensitive Ecosystems

Rare and sensitive ecosystems were selected for inclusion as a Valued Component for their scientific and ecological importance. Rare and sensitive ecological communities and habitats are defined as wetlands, alkali ponds, old-growth forests, rock outcrops, and ecological communities at risk (ECAR). Chapter 6.9 of the Application/EIS assesses in detail the Project's residual effects on rare and sensitive ecosystems. Rare and sensitive ecosystems, particularly wetlands, are considered to be renewable resources primarily because of their importance to wildlife resources that may be hunted (e.g., waterfowl, see Section 17.13.10), and their water filtration function. The Project's residual effect on rare and sensitive ecosystems is summarized in Table 17.13-6.

Table 17.13-6. Summary of Residual Effects on Rare and Sensitive Ecosystems

Characterization Criteria	Description
Residual Effect(s)	Habitat loss and reduction in the amount of rare and sensitive ecosystems due to construction vegetation clearing
Magnitude	Moderate effects in LSA and minor in RSA
Duration	Long-term
Extent	Local
Reversibility	Effects may be reversible in the long-term; however, it is uncertain whether rare and sensitive ecosystems will successfully recolonize the reclaimed habitat
Resilience	Low
Significance	LSA: Not significant (moderate) RSA: Not significant (minor)

Chapter 6.9 identified habitat loss due to Project construction, specifically vegetation clearing associated with the Project footprint. Mitigation measures include impact avoidance and designing the project mine footprints to minimum the possible impact on the surrounding environment. During construction, the Project footprints will be kept to the minimum size required. At the end of mine life, during closure, reclamation and revegetation measures will be taken. However, there is recognition that uncertainty exists whether rare and sensitive ecosystems will successfully recolonize the reclaimed habitat.

The primary effect of habitat loss of Red- and Blue-listed ecological communities in the RSA as a result of Project construction will be approximately 7 % of the total ECAR and is assessed as a minor magnitude. The amount of total wetland habitat lost from the Project construction is 0.4% and is minimal relative to the total area. Lost wetland will also be compensated (Section 11.21-A). With the implementation of mitigation measures described in Chapter 6.9, the anticipated habitat loss due to construction vegetation clearing associated with the Project footprint is characterized as a not significant (minor) residual cumulative effect.

Based on the assessment of effects of the Project on rare and sensitive ecosystems summarized above, it is expected that the long-term sustainability of rare and sensitive ecosystems will not be affected.

17.13.9 Grasslands

Grasslands were selected for inclusion as a VC because the Project is situated in the grasslands ecosystem and considered for its scientific and ecological value. Chapter 6.10 of the Application/EIS assesses in detail the Project's residual effects on grasslands. Grasslands are considered a renewable resource because of their potential agricultural (grazing) use in the Project area.

Chapter 6.10 identified a residual effect resulting from grassland habitat loss due to Project construction vegetation clearing. The residual effect is summarized in Table 17.13-7.

Table 17.13-7. Summary of Residual Effects on Grasslands

Characterization Criteria	Description
Residual Effect(s)	Habitat loss due to construction vegetation clearing
Magnitude	Moderate
Duration	Long-term, effect will last beyond the length of the Project. Revegetation and reclamation of these areas will occur over several years
Extent	Local
Reversibility	Reversible in the long-term; however, it is uncertain whether Red and Blue-listed grassland communities can be effectively re-established as reclaimed habitat
Resilience	Low
Significance	LSA: Not significant (moderate) RSA: Not significant (minor)

Mitigation measures include avoiding sensitive habitats, revegetation and reclamation. A residual effect is still anticipated as mitigation measures are insufficient to reduce the direct loss of habitat. The Project-related residual effect on grasslands is considered not significant (moderate). Regionally, habitat loss is considered not significant (minor) for cumulative residual effects as less than 3 % of the priority grassland areas within the RSA will be lost, and suitable habitat still exists within the region. Based on the assessment of the Project effect on grasslands, on a cumulative residual effects basis, the magnitude is minor. Project-related habitat loss represents a small area relative to the broader region. It is expected that the capacity of grasslands as a renewable resource will not be affected and continue to be available for current and future generations.

17.13.10 Migratory Birds

Migratory Birds were selected for inclusion as a VC for their scientific and ecological importance. Chapter 6.14 of the Application/EIS assesses in detail the Project's residual effects on migratory birds. Migratory birds are considered a renewable resource because they include waterfowl (ducks and geese), which may be hunted in the Project area (see Chapter 8.6).

Chapter 6.14 identified habitat loss as a Project-related residual effect and is summarized below (Table 17.13-8).

Table 17.13-8. Summary of Residual Effects on Migratory Birds

Characterization Criteria	Description
Residual Effect(s)	Habitat loss for all the indicator species, though the greatest effect will be to wetland and grassland habitat and the associated species
Magnitude	Moderate, limited ability for reclamation and enhancement of the habitat and mitigation measures will not fully mitigate the anticipated habitat loss
Duration	Long-term
Extent	Local
Reversibility	May be reversible in the long-term through the implementation of revegetation and reclamation
Resilience	It is anticipated that Waterfowl, Great Blue Heron and Sandhill Crane indicators have a low resilience to the loss of wetlands, and will not easily adapt to this habitat loss
Significance	Not significant (moderate)

Habitat loss will only occur sporadically, during clearing and grubbing and earthworks activities, and the extent is restricted to within the LSA. Reclamation of grasslands and creation of wetlands could reverse this habitat loss in the long-term, but will not fully mitigate the loss. A considerable amount of suitable habitat occurs within the RSA providing migratory stop-over habitat and waterfowl breeding habitat. Less than 0.4% of wetland will be potentially lost as a result of Project construction. This is characterized as a minor magnitude effect, though the duration of impacts may last into the far future, and could be reversible if reclamation of various sites occurs. Migratory birds are somewhat resilient to habitat loss, and are able to move to other suitable habitat in the surround area. Regionally, habitat loss is anticipated to have a not significant (minor) effect on migratory birds

within the RSA. The loss of suitable migratory bird habitat, particularly wetlands (for waterfowl, great blue herons, and sandhill cranes), and grasslands (for long-billed curlews and common nighthawks) could impact populations locally, but is not expected to impact populations regionally. Based on the assessment of Project-related residual effects and cumulative effects on migratory birds in the LSA and RSA, it is expected that the long-term sustainability of migratory birds will not be affected.

17.13.11 Conclusion

Five renewable resources were evaluated to determine the capacity of renewable resources. As summarized in Table 17.13-9, the capacity of renewable resources to meet the needs of the present and the future are not anticipated to be significantly affected by the Project for groundwater quantity, fish and fish habitat, rare and sensitive ecosystems, grasslands, non-migratory gamebirds, and mammals.

Table 17.13-9. Effects of Ajax Project on the Capacity of Renewable Resources

Renewable Resources	Current Capacity of Resource Impaired (Life of Mine)	Future Capacity of Resource Impaired
Groundwater Quantity	No	No
Fish and Fish Habitat	No	No
Rare and Sensitive Ecosystems	No	No
Grasslands	No	No
Migratory Birds	No	No

17.14 BENEFITS TO CANADIANS OF THE FEDERAL ENVIRONMENT ASSESSMENT PROCESS

17.14.1 Introduction

The Ajax Project is predicted to result in substantial benefits to the region (Regional District of Thompson-Nicola, Electoral Areas J, K and P) and the province, as well as Canada as a whole. Benefits will be realized through employment and business opportunities to supply goods and services directly and indirectly to the Project, as well as other spin-off economic benefits associated with workers spending their incomes within their communities and within Canada. In addition, the Project will contribute tax revenues to local, provincial, and federal governments. A description of the anticipated Project Benefits, including economic impacts, labour force and employment requirement, income, business opportunities, economic diversification, healthy living and health education, and community development, is provided in Section 2.7 of this Application/EIS.

The communities in the economic effects assessment area (Chapter 7, Assessment of Potential Economic Effects) include incorporated and unincorporated communities as well as Aboriginal communities and Indian Reserves. The Project is expected to create employment opportunities for local workers directly at the Project Site. Moreover, direct project spending on local goods and services will support businesses enhancing the economic development in the communities. The additional spending will drive job creation by local businesses leading to a higher level of general employment and, consequently, higher personal income.

The project is also expected to provide benefits to Canadians in the following areas:

- prevention or reduction of environmental effects and maximized environmental benefits;
- technology innovations;
- reduction in Project costs;
- protection of Aboriginal interests;
- increases in scientific knowledge;
- increase in community and social benefits; and
- protection of public health and safety.

These benefits are discussed below.

17.14.2 Prevention or Reduction of Environmental Effect and Maximization of Environmental Benefit

Project redesign, relocation and mitigation measures that prevent negative impacts to the environment, or reduce the Project's overall environmental footprint can be considered a benefit to Canadians. As described in Section 3.2 of this Application/EIS, a number of considerations in Project design, operational safeguards, and contingency plans have been incorporated to mitigate potential

impacts. Highlights of the mitigation measures incorporated into Project design intended to prevent or reduce direct and indirect environmental effects include:

- Minimizing project footprint, thus minimizing the loss of habitat and reduction of habitat effectiveness.
- Locating facilities to minimize interaction with populated areas.
- Designing infrastructure to meet the highest quality standards to minimize effects of noise and dust on the environment.
- Designing blasting configurations in the open pit to minimize effects to Jacko Lake and fish and fish habitat due to blasting in proximity to Jacko Lake.
- Locating facilities to avoid or minimize interaction with sensitive environmental sites.
- Maintaining a 30-metre buffer from streams and waterways where possible.
- Maximizing sourcing of aggregate and borrow materials from the open pit.
- Maximizing storage of mine rock within the open pit.
- Selecting water sources in which Project water withdrawals will minimize the potential for drawdown and effects to fish habitat and the aquatic environment.
- Maximizing water recycling to minimize freshwater requirements.
- Implementing dust suppression measures to reduce dust generated along the road corridors, the crusher and conveyor, and the Tailings Storage Facility (TSF).
- Implementing noxious weed and invasive plant control to mimimize effects to the environment on encroachment of native species.

As well, at the end of the mine life, during the Decommissioning and Closure phase, habitat will be restored through reclamation and revegetation processes. Reclamation will attempt to restore habitat to reflect baseline conditions and to incoroporate, where possible, inclusion of plant species that have been identified by Aboriginal Groups.

The Project will also incorporate dry cover closure of the Tailings Storage Facility with discharge of runoff to Humphrey Creek through an engineered spillway during the Project's Closure phase. This technology is not standard closure practice in BC, but will have the following environmental Project advantages:

- the low permeability till cover layer isolates surface water from the tailings and minimizes infiltration into the tailings deposit;
- hazards to animal and humans associated with a pond of standing water or uncapped soft tailings are mitigated;
- improved discharge water quality is expected due to elimination of standing water and reduced infiltration; and,
- entire surface area can be returned, as close as practical, to pre-mining conditions.

Prevention and reduction of environmental effects will also be achieved through the implementation of the Project's Environmental Management System (EMS; Chapter 11). Relevant Environmental Management Plans include:

- Erosion and Sediment Control Plan;
- Soil Salvage and Handling Plan;
- Construction Waste Management Plan;
- Acid Rock Drainage Management Plan;
- Contaminated Site Management Plan;
- Hazardous Waste Management Plan;
- Explosives Management Plan;
- Accidents and Malfunctions Plan;
- Natural Hazards Management Plan;
- Emergency Response Plan;
- Fire Hazard Abatement Plan;
- Spill Contingency Plan;
- Invasive Plant Management Plan;
- Archaeological Sites Management Plan;
- Dark Sky Management and Monitoring Plan;
- Transportation Management Plan;
- Access Management Plan;
- Noise Management Plan;
- Jacko Lake Management Plan;
- Water Management and Hydrometric Monitoring Plan;
- Surface Water Quality Management and Monitoring Plan;
- Groundwater Quality Management and Monitoring Plan;
- Air Quality Management Plan;
- Fisheries and Aquatic Life Monitoring Plan ;
- Conceptual Landscape Restoration and Reclamation Plan; and
- Wildlife/Vegetation Monitoring Plan.

17.14.3 Technology Innovations

Project technological innovations may be considered benefits to Canadians through reduction in overall Project impacts, which may also contribute to improvements and reduced impacts of other projects utilizing the same technologies.

Innovative design has been applied in the formulation of the blasting plan for the western extremity of the pit excavation in order to mitigate Project potential effects on fish and fish habitat in Jacko Lake. This innovation primarily involves a purpose-design reduction in the volume of explosives fired per dey, according to defined blast zones. In the zone closest to Jacko Lake, smaller blast hole diameters and multiple explosives decks, with larger separation distances and longer in-hole charge delays between the decks, are specified. Timing of blasting will avoid sensitive windows for breeding birds and amphibians. Stipulating these control measures in the blasting plan for the Project will ensure compliance with the maximum recommended ground vibration and airblast levels.

KAM undertook a number of Best Available Technology (BAT) trade off studies to aid decision making regarding mine components including the:

- tailings storage facility (TSF): KAM compared the advanatages/disadvantages of the following technologies: un-thickened tailings, thickened tailings, paste tailings, and filtered dry stack tailings. Each technology was evaluated for technical, environmental, social and Aboriginal, Project economics, and risk consderations. This assessment, detailed in Section 17.4.9, led to KAM adopting thickened tailings for the preferred disposal methodology over standard un-thickened tailings, which reduces water consumption, footprint and energy consumption.
- open pit: a study to minimize pit boundaries to ensure safe and economically feasible operations, as well as minimizing effects to Jacko Lake and allowing for the re-establishment of Peterson Creek at Closure. Steeper pit walls to reduce the amount of setback of the pit edge, resulting in more efficient extraction of the ore with limited changes to the surface perimeter of the pit. The inclusion of in-pit mine rock storage also provides additional buttressing on the western edge of the Open Pit to improve Jacko Lake stability and reduce the Project footprint from mine rock storage areas.
- Peterson Creek diversion route: studies showed that re-routing Peterson Creek during operations will prevent water contamination and water temperature changes, as well as provide protection from erosion. Location of pumping was selected to reduce circulation effects on the southeast arm of Jacko Lake. The Creek would be re-established during mine Closure.
- fish habitat offsetting: studies led to the decision to abandon an offsetting option that involved raising water levels in Jacko Lake due to geotechnical concerns relating to the elevated water level and the setback of the pit required in the vicinity of the southeast arm of Jacko Lake.

17.14.4 Reduction in Project Costs

Modifications in Project design can reduce Project costs and increase efficiency, resulting in economic benefits to the Project and benefits to Canadians. KAM has undergone the process of Project design and optimization, with the ultimate intent of developing a project that balances both technical and economic feasibility. This process will set up the Project for success, such that the Project has the best chance of continuously operating over the intended mine life and bring the best value to Canadians. Project cost tradeoffs (see Section 17.4 of the Application/EIS) were evaluated for:

- mining methods (underground vs. open pit) and pit size determination;
- production rates;
- mine rock storage facility alternatives determined based on haulage distances and road grade;
- TSF location and closure which considered pipeline distances from the plant site to the TSF, and the cost of closure in dry configuration;
- Peterson Creek diversion alternate routes;
- product transport (trucking vs. rail vs. combined transport);
- blasting schedule evaluations, which considered seasonal vs. year round blasting, as well as fleet type and size of fleet required; and
- power supply tradeoffs compared natural gas, diesel, gethermal, wind, solar, biomass and small hydro power generation.

17.14.5 Protection of Aboriginal Interests

Benefits to Canadians resulting from the Project include the protection of Aboriginal interests. KAM has engaged potentially affected Aboriginal groups and will continue to do so throughout the life of the Project. KAM considers itself part of the communities in which it operates. Success is dependent on the collaborative, team-oriented, partner-style working relationships with employees, contractors, local and indigenous communities, and other stakeholders.

Specifically regarding Aboriginal interests, KAM is committed to building strong and lasting relationships and will continue to consult and collaborate with local Aboriginal groups about the Project and its design. This will include continued consultation and negotiations towards a Project-related agreement that supports the interests and concerns of the Stk'emlupsemc te Secwépemc Nation (SSN). Through this consultation, information and decisions which help avoid or reduce potential effects on the current use of lands and resources for traditional purposes are likely to result.

A summary of mitigation measures with respect to affected Aboriginal interests (fishing, hunting and trapping, plant harvesting, and ceremonial use) include:

- The Fish Habitat Mitigation and Offsetting Plan (FHMOP) measures to offset habitat losses in Jacko Lake and Peterson Creek.

- Construction of an access road and additional parking lot at Jacko Lake to maintain and facilitate access to the Lake.
- Measures to minimize traffic congestion on public roads.
- Decommissioning and Closure Plan that will aim to reverse habitat losses and re-established the land to a similar condition to prior to Project development, where feasible. Implementation of progressive re-vegetation activities beginning during the Operations phase and most importantly during the Decommissioning and Closure phase. Post-closure land use objectives in the Plan include allowing access to the mine site consistent with current practice (e.g. by obtaining permission from land owner) for fishing or for plant gathering purposes along Peterson Creek where appropriate.
- implementation of management plans including the Air Quality and Dust Control Plan, Noise Management Plan and Dark Sky Management Plan.
- Continued efforts negotiate and conclude Project agreements with SSN and other Aborigianl Groups.

Further details can be found in Part C of the Application/EIS.

17.14.6 Increases in Scientific Knowledge

The Project has provided benefits to Canadians through the historic and continued increases in scientific knowledge. KAM has pursued baseline studies in the Project area since 2007. Baseline studies are described in the relevant effects assessment chapter, but highlights include:

- A baseline hydrometeorological report was produced in 2013 that incorporated local and regional hydrology assessments to provide estimated long-term water quantity values. Surface water monitoring was also conducted in 2014.
- Modelling studies conducted for Air Quality in 2014 and 2015 have increased the knowledge of the local air shed and can be used by the city and TNRD for planning in relation to air quality objectives for the region.
- Soil Characterization studies were conducted in 2014 to understand soil types and quantities in the area. A Vegetation Productivity assessment to understand background levels in vegetation consumed by livestock were also completed.
- Geology and landforms studies were conducted in 2014 to understand the stability of the Aberdeen neighbourhood and potential effects of the Project. These studies provide a better understanding for the City regarding groundwater modelling in relation to stability concerns.
- Baseline studies for fish and aquatic resources were initiated in 2007 and a revised report, based on monitoring undertaken in 2014, was produced in 2015.
- Baseline studies were conducted for rare plants in the spring and summer of 2007, 2008, 2010, 2011, 2012, and 2014. Fifteen rare plant taxa were found including five vascular plants, two mosses, and eight lichens.

- Baseline studies were conducted for terrestrial invertebrates in 2010, 2011, and 2014. Additional baseline studies are planned for 2015. These surveys identified 77 invertebrate species, including 21 dragonfly/damselfly taxa, and 56 butterfly taxa.
- Baseline studies were conducted for amphibians in 2008, 2010, and 2014. These studies confirmed breeding populations of Blue-listed Great Basin spadefoot toads and western toads in the LSA.
- Baseline studies were conducted for reptiles in 2008, 2010 and 2014. The reptile surveys conducted in 2014 targeted potentially suitable habitat south of Jacko Lake and east of Goose Lake Road that had not been previously surveyed.
- Baseline studies were conducted for mammals from 2007 to 2014, excluding 2009. Surveys for badger dens, small mammals, and bats were undertaken in and around the LSA to:
  - establish presence of target species and key habitat features within the LSA;
  - collect data on the location and timing of use of the LSA by target species;
  - confirm habitat ratings used to develop wildlife habitat suitability models; and
  - provide information to KAM to use during the Project design phase to avoid or minimize impacts to target species.
- Baseline ungulate winter surveys were also completed during the winter of 2014/2015 to determine presence of ungulates and use of ungulate winter ranges in the vicinity of the Project.
- A baseline socio-economic study was produced in 2015, based on the outcomes of consultation undertaken between 2011 and 2015. The study provides a comprehensive understanding of the social and economic conditions pertaining in the area potentially affected by the Project.

Management plans that will be implemented under the Project's EMS that will increase scientific knowledge include:

- Archaeological Sites Management Plan;
- Socioeconomic monitoring plan;
- Surface Water Quality Management and Monitoring Plan;
- Groundwater Quality Management and Monitoring Plan;
- Fisheries and Aquatic Life Monitoring Plan;
- Wildlife/Vegetation Monitoring Plan; and
- Jacko Lake Management Plan.

17.14.7 Increase in Community and Social Benefits

As previously described, KAM is committed to building lasting relationships with the communities in which they operate. KAM will continue to actively engage in activities and events that support

community enhancement and/or environmental sustainability, and through enhancing educational and recreational benefits within the community. The Project will result in benefits to Canadian through improvements in community and social benefits.

The Project is expected to make a positive contribution to social and economic conditions in the City of Kamloops and the surrounding area, as well as within the Province of British Columbia (BC). The magnitude and nature of these benefits will differ between the Project phases (i.e., construction, operation, decommissioning and closure, and post-closure). Throughout all Project phases, the Project is expected to create substantial employment, business activity, and income around Kamloops and in the Thompson-Nicola Regional District (TNRD). As described in Section 2.7.2, during the Operations phase, the Project is estimated to contribute an average of $222 million to the GDP[1] of BC, and $67 million to the Canadian GDP annually; in addition to providing an average FTE Employment[2] of 1,450 in BC and 540 FTE employment within Canada each year.

Aboriginal Groups in the vicinity of the Project, including Tk'emlups te Secwepemc and the Skeetchestn Indian Band (jointly known as Stk'emlupsemc te Secwépemc Nation [SSN]), also stand to benefit from employment, training, and other economic aspects of the Project.

Other Aboriginal groups in the broader region, including the Ashcroft Indian Band, the Lower Nicola Indian Band, and the Whispering Pines/Clinton Indian Band, could benefit from access to Project-related opportunities. Similarly, citizens of Métis Nation BC could benefit from Project-related opportunities.

17.14.8 Protection of Public Health and Safety

KAM is commited to the protection and improvement of public health and safety. As described in Section 2.7.7 of the Application/EIS, KAM will implement a range of health and wellness programs for mine employees, including supporting a culture of safety, the company-wide Particip*action* plan, and implementation of a company-wide employee wellness program.

KAM will protect and enhance public health and safety throughout the life of the Project by adopting a comprehensive Environmental, Health, and Safety Policy and by implementating and continually improving upon health, safety and environemtnal management plans, such as the Spill Contingency and Emergency Response plans.

Project design changes and analyses that will result in increased protection of public safety include:

- the undertaking of a qualitative trade-off study of alternatives for tailings management that considered conventional, thickened, paste, and filtered dry stack tailings;

[1] GDP: The total "value-added" generated in the economy after the value of intermediate inputs are removed from Total Output. It is consequently smaller than Total Output, but is a better measure of the true dollar impact on the economy.
[2] FTE: Expressed as person-years of FTE employment (assuming 2,000 hours per year per position). Includes direct employment (including contractors) as well as indirect and induced employment related to goods and services. Total estimated employment impacts have been divided by the number of years to generate average annual employment estimates.

- Upgrades to Lac Le Jeune Road and the Inks Lake Interchange, and the provision of a parking lot and new access to Jacko Lake;
- to further enhance public and occupational safety, procedures, roles and responsibilities related to the environmental management of the TSF will be clearly documented and revised as needed throughout the mine operations and mine closure phases;
- relocating the processing plant, crushers, and temporary ore stockpiles more than 2 km away from Kamloops;
- relocating mine rock storage facilities 4.5 km away from the Aberdeen neighbourhoods; and
- relocating the TSF 2.5 km away from the Coquihalla Highway.

Management plans that will be implemented under the Project's EMS that will protect public health and safety include:

- Erosion and Sediment Control Plan;
- Soil Salvage and Handling Plan;
- Construction Waste Management Plan;
- Acid Rock Drainage Management Plan;
- Contaminated Site Management Plan;
- Hazardous Waste Management Plan;
- Explosives Management Plan;
- Accidents and Malfunctions Plan;
- Natural Hazards Management Plan;
- Emergency Response Plan;
- Fire Hazard Abatement Plan;
- Spill Contingency Plan;
- Archaeological Sites Management Plan;
- Dark Sky Management and Monitoring Plan;
- Transportation Management Plan;
- Access Management Plan;
- Noise Management Plan;
- Jacko Lake Management Plan;
- Water Management and Hydrometric Monitoring Plan;
- Surface Water Quality Management and Monitoring Plan;
- Groundwater Quality Management and Monitoring Plan;
- Air Quality Management Plan;

- Fisheries and Aquatic Life Monitoring Plan ;
- Conceptual Landscape Restoration and Reclamation Plan; and
- Wildlife/Vegetation Monitoring Plan.

17.15 REFERENCES

Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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