26. ENVIRONMENTAL EFFECTS OF ACCIDENTS AND MALFUNCTIONS

26.1 INTRODUCTION

This chapter of the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS) evaluates the potential effects to the environment of any Project-related accident or malfunction during the Construction, Operations, and Closure phases of the proposed Harper Creek Project (the Project).

The *Canadian Environmental Assessment Act* (CEAA; 1992) requires that every comprehensive study type environmental assessment (EA) include a consideration of the environmental effects of accidents or malfunctions that may occur in connection with the proposed project, the significance of the effects, and measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects.

For the purposes of this report, accidents and malfunctions are defined as follows:

- accident: an unexpected occurrence or unintended action; and
- malfunction: failure of a piece of equipment, a device, or a system to function normally.

While the possibility of accidents and malfunctions occurring exists, the objective of Harper Creek Mining Corporation (HCMC; the Proponent) is to minimize the probability of such incidents and the associated consequences that might affect people and the environment. The Project will be designed, constructed, and operated according to standard industry best management practices to minimize the risk of any accident or malfunction occurring. Best management practices, including appropriate environmental management plans, will be put in place and procedures for safe mine operations will be developed and adhered to. Moreover, employees will be trained for emergency responses (refer to Section 24.4, Emergency Response Plan, in Chapter 24, Environmental Management Plans and Reporting, for more detailed information on operational safety and best management practices).

26.2 SCOPE

26.2.1 Project Description

HCMC proposes to construct and operate the Project, an open pit copper mine near Vavenby, British Columbia (BC). The Project has an estimated 28-year mine life based on a nominal process plant ore throughput of 70,000 tonnes per day (25 million tonnes per year). Ore will be processed on site through a conventional crushing, grinding, and flotation process to produce a copper concentrate, with gold and silver by-products, which will be trucked from the Project Site along approximately 24 kilometres (km) of existing but upgraded access roads to a rail load-out facility located at Vavenby. The concentrate will be transported via the Canadian National Railway network to the

Vancouver Wharves storage, handling, and loading facilities located at Port Metro Vancouver for shipment to overseas smelters.

The Project infrastructure consists of an open pit mine, on-site processing facility, tailings management facility (TMF; for tailings solids, subaqueous storage of potentially acid-generating [PAG] waste rock, and recycling of water for processing), waste rock stockpiles, low-grade ore (LGO), overburden, and topsoil stockpiles, a temporary construction camp, ancillary facilities, mine haul roads, sewage and waste management facilities, a 24-km access road between the Project Site and a rail load-out facility located on private land owned by HCMC in Vavenby, and a 14-km 138 kV power line connecting the Project Site to the BC Hydro transmission line corridor in Vavenby. The Project infrastructure is shown in Figure 26.2-1.

26.2.2 Application Information Requirements

This chapter discusses unlikely events and situations that are not part of normal operations, but that could potentially occur during the life of the Project, even after prevention and mitigation measures have been applied. More specifically, this chapter discusses:

- the reasonably plausible potential accidents and malfunctions for each stage of the Project that could lead to environmental, economic, social, health, and/or heritage impacts; and
- the potential effects to the environment as a result of these potential accidents and malfunctions.

The likely economic, social, health, and heritage effects will be assessed for the higher-risk accidents and malfunctions (see Table 26.3-3).

The list of potential accidents and malfunctions that are being addressed in this chapter and their rationale for inclusion are discussed in Section 26.3.1.

As per the Application Information Requirements (AIR; BC EAO 2011) this chapter also discusses operational procedures and management measures to be implemented to reduce or eliminate the potential for accidents and malfunctions to occur, including:

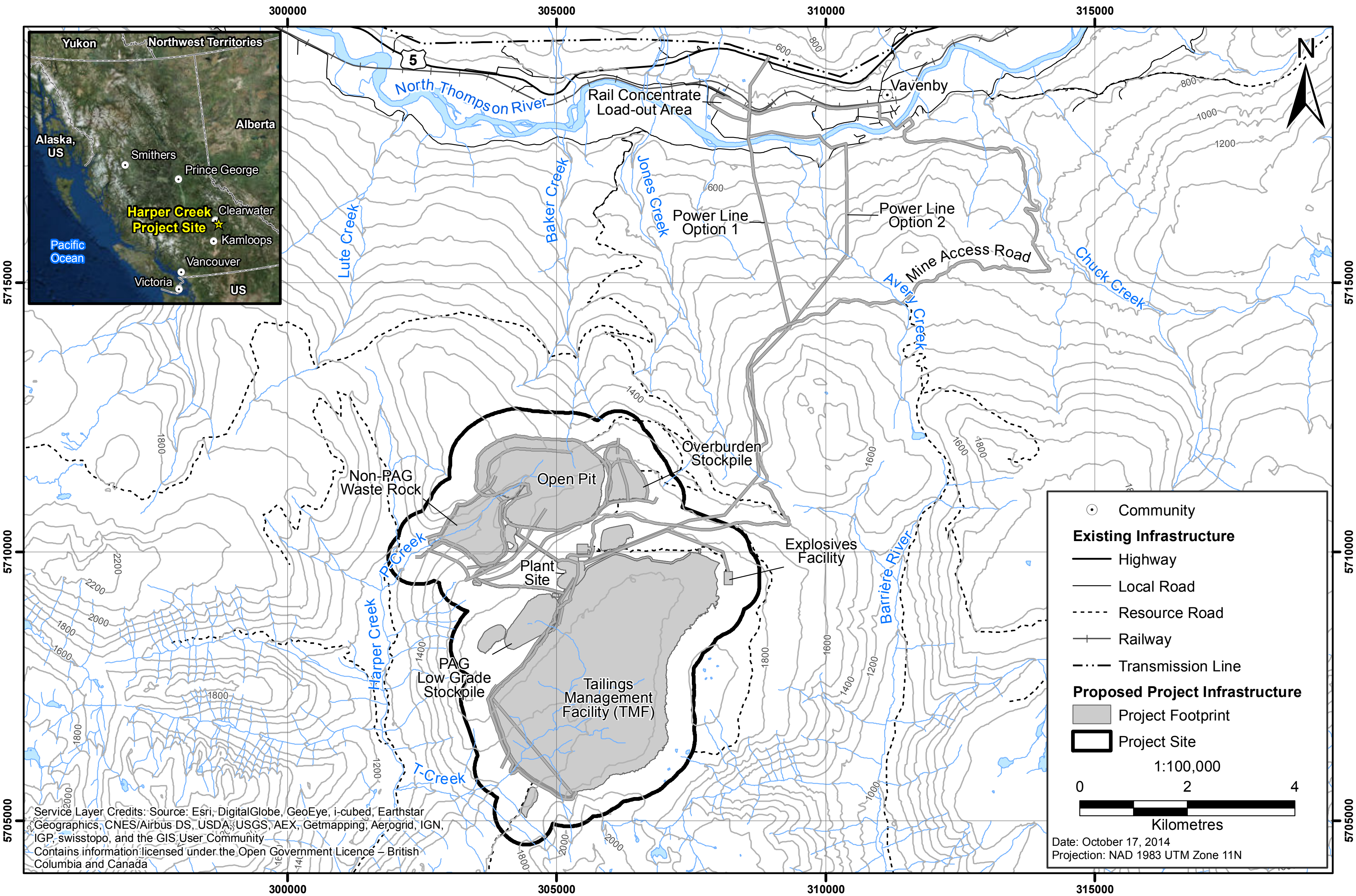
- location of and rationale for on-site storage for anticipated chemicals to be used;
- description of on-site containment features, such as pads and dikes for containment of spills; and
- proposed mitigation measures, including environmental management/contingency plans and on-site emergency response procedures.

26.3 Methodology

The methodology applied throughout this chapter and detailed below enables focusing on reasonably plausible accidents and malfunctions of the Project that could lead to significant adverse environmental, economic, social, health, or heritage effects.

Figure 26.2-1
Project Location and Infrastructure

ERM



26.3.1 Selection of Potential Accidents and Malfunctions

Potential accidents and malfunctions that may occur during the life of the Project were identified, assessed, categorized, and developed into worst-case scenarios.

26.3.1.1 Identification of Potential Accidents and Malfunctions

The identification of these accidents and malfunctions was carried out by considering the specificities of the Project's design, technology, location, and infrastructure; by using historical performance data for other similar projects; and by applying professional judgment and experience with similar types of projects and activities.

26.3.1.2 Assessment of Potential Accidents and Malfunctions

The assessment of these accidents and malfunctions was conducted by consideration of the following:

- Project phase in which the accidents and malfunctions may occur (e.g., Operations);
- type of accidents and malfunctions that may occur (e.g., oil or chemical spills);
- geographic extent of the potential accidents and malfunctions (e.g., local, regional);
- frequency with which these accidents and malfunctions may occur (e.g., once a month, once a year);
- duration of the potential accidents and malfunctions (e.g., day, months);
- impacts of natural events on potential accidents and malfunctions (e.g., weather, floods, fires);
- direct environmental effects as a result of accidents and malfunctions; (e.g., water contamination); and
- type of environment that may be affected by the accidents and malfunctions (e.g., water, soil).

26.3.1.3 Categorization of Potential Accidents and Malfunctions

Following their assessment, potential accidents and malfunctions were categorized into specific and distinct types of accidents and malfunctions that could occur on site and during transportation from the rail load-out facility to the Project Site. The categories identified are:

- spills and leaks, including fuel, concentrate, or other hazardous material spills;
- fires or explosions;
- failure of sediment and erosion control measures; and
- failure of the TMF containment dam.

26.3.1.4 Development of Worst-case Scenarios of Potential Accidents and Malfunctions

For each category listed above, a suite of potential scenarios from the Project that could lead to environmental, economic, social, health, or heritage impacts was developed. Each scenario development included a consideration of the following:

- whether the event occurs in isolation of other events. A series of accidents and malfunctions occurring one after the other, or combined with one another, is not considered plausible and therefore not evaluated; and
- whether the event represents a worst-case scenario and the focus of the assessment is on the accidents and malfunctions for which the resulting adverse residual environmental effects could potentially be significant.

The categories of potential accidents and malfunctions identified in the section above are presented in Sections 26.4, 26.5, 26.6, and 26.7 in this chapter, with the corresponding worst-case scenarios within each relevant section. The potential accidents and malfunctions for each phase of the Project are summarized in Table 26.3-1.

Table 26.3-1. Identification of Potential Accidents and Malfunctions per Project Phase

Potential Accidents and Malfunctions		Project Phase			
		Construction	Operations	Closure	Post-Closure
Spills and leaks	Fuel spill on land	x	x	x	
	Fuel Spill in water	x	x	x	
	Spill of hazardous substance on land	x	x		
	Spill of hazardous substance on water	x	x		
Fires or explosions	Fire or explosion on site	x	x		
	Fire or explosion causing a wildfire	x	x		
Failure of sediment erosion control measures	Failure of sediment erosion control measures	x	x		
Failure of the TMF containment dam	Overtopping of dam	x	x		
	Catastrophic Failure of TMF dam	x	x	x	x

As per the AIR, this chapter also identifies which routine activities may trigger the potential accidents and malfunctions identified above. These are identified in Table 26.3-2.

Table 26.3-2. Project Routine Activities that Could Lead to Potential Accidents and Malfunctions

Routine Activities	Spills and Leaks	Fires and Explosion	Failure of Sediment and Erosion Control Measures	Failure of the TMF Containment Dam
Construction				
Backfilling			x	
Blasting		x		
Clearing vegetation			x	
Crushing				
Delivery of equipment, materials and personnel	x	x		
Disposal of hazardous materials	x	x	x	
Drilling			x	
Dumping			x	
Excavating			x	
Extracting			x	
Hauling	x			
Heavy machinery and trucks use	x	x	x	
Logging of trees			x	
Refueling; servicing; maintenance	x	x		
Slashing and burning			x	
Stockpiling			x	
Storage of explosives		x		
Storage of hazardous materials		x		
Stripping topsoil			x	
Transportation of hazardous materials	x	x		
Water management construction			x	
Operations 1				
Blasting		x		
Clearing			x	
Delivery of equipment, materials and personnel	x	x		
Disposal of surplus materials			x	
heavy machinery and trucks use	x	x	x	
Loading of concentrate	x			
Ore crushing, milling, conveyance and processing				
refueling; servicing; maintenance		x		
snow stockpiling			x	

(continued)

Table 26.3-2. Project Routine Activities that Could Lead to Potential Accidents and Malfunctions (completed)

Routine Activities	Spills and Leaks	Fires and Explosion	Failure of Sediment and Erosion Control Measures	Failure of the TMF Containment Dam
Operations 1 *(cont'd)*				
Stockpiling			x	
Storage of explosives		x		
Storage of hazardous materials		x		
Surface water management			x	x
Tailings storage				x
Tailings transportation	x		x	
TMF water storage			x	x
Transportation of concentrate	x			
Transportation of hazardous materials	x			
Operations 2				
Ore crushing, milling, conveyance and processing				
Partial reclamation			x	
Surface water management			x	x
Closure				
Decommissioning			x	
Filling of open pit				
Reclamation			x	
Solid waste management			x	
TMF discharge				x
Water management			x	x
Post-Closure				
Maintenance of mine drainage, seepage and discharge			x	x

26.3.2 Effects Assessment

26.3.2.1 Screening and Analyzing Effects from Potential Accidents and Malfunctions

Potential interactions between the environmental valued components (VCs) of the Project and the potential accidents and malfunctions were assessed using the same ranking system as used for the Project environmental effects for the VC. Each scenario was screened against the VCs using a risk-based approach to filter potential effects into low-, moderate-, or high-risk ratings as a result of interactions between the accident or malfunction and the VCs. The potential interactions were ranked using past experience, guidance documents, and professional judgement for each of the VCs. All risks evaluated as "moderate" or higher were then screened in terms of the resultant impact on the receiving environment based on the proposed Project design and mitigation measures. In the following assessment, the term wildlife refers to terrestrial invertebrates, amphibians, migratory birds, raptors, bats, fur-bearers, large mammals and ungulates VCs, unless otherwise noted; the term vegetation refers to rare plant, ecological communities at risk (ECAR), wetlands and old-growth forest VCs unless otherwise noted.

Table 26.3-3 below summarizes the environment VCs that may be affected by the potential accidents and malfunctions of the Project. Spills on land could affect groundwater quality and quantity and wildlife, whereas spills on water could impact fish, fish habitat, and aquatic resources. Fires contained to the Project Site could have adverse impacts on air quality, while a wildfire could potentially have significant effects on all environmental VCs. Accidental release of off-specification effluent could adversely affect surface water, as well as fish, fish habitat, and aquatic resources.

26.3.2.2 Mitigation Measures

Generally, HCMC will apply the following prevention and mitigation measures throughout the life of the Project:

- use of standard industry best management practices for carrying out the activities of the Project;
- use of management plans specifically developed for the Project's operations;
- development and application of training measures aimed at safely operating the facilities and preventing any potential accident and malfunction; and
- implementation of effective emergency response procedures.

For the effects carried forward in each scenario (i.e., moderate or high risk), the relevant environmental management plans, project design measures to minimize risk and emergency response procedures are presented.

26.3.2.3 Potential Effects

The potential effects are those of greater importance that require preventative and/or mitigation measures for the effects to be minimized. Potential effects were analyzed using best practice methods to predict the nature and extent of environmental effects that could result from potential Project accidents and malfunctions. The duration of effects was assessed using the same ranking system used for Project environmental effects, as indicated in Table 26.3-4. These analyses are described for each category of potential accidents and malfunctions in the "potential effects" sections below.

26.3.2.4 Risk Assessment

Risk is derived from the product of probability and consequences, and therefore the risk assessment of accidents and malfunctions consists of an evaluation of the probability (i.e., the likelihood of occurrence) of a scenario happening, and an evaluation of the consequences (i.e., the severity of occurrence) of the effects of a mishap on the environment, assuming that emergency planning and management controls are in place.

Table 26.3-3. Risk Ratings of Plausible Accidents and Malfunctions on Environmental Project Valued Components

Accidents and Malfunctions Category	Reasonably Plausible Scenario	Air Quality	Noise	Groundwater Quality	Groundwater Quantity	Surface Water Quality	Surface Water Quantity	Fish	Fish Habitat	Aquatic Resources	Rare Plant	Ecological Communities at Risk	Wetlands	Old-growth Forest	Terrestrial Invertebrates	Amphibians	Migratory Birds	Raptors	Bats	Fur-bearers	Large Mammals	Ungulates
Spills	Fuel spill on land	yellow	green	yellow	yellow	green	green	green	green	green	yellow	red	yellow	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
	Fuel spill in water	green	green	green	green	red	green	red	red	red	green	yellow	yellow	green	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
	Hazardous substances spill on land	yellow	green	yellow	yellow	green	green	green	green	green	yellow	red	yellow	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
	Hazardous substances spill in water	green	green	green	green	yellow	green	red	red	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Fires	Fire or explosion on-site	red	red	yellow	yellow	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
	Fire or explosion causing a wildfire	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	red	red	red	red	red	red	red	red	red	red	red	red
Failure of sediment and erosion control measures	Failure of sediment and erosion control measures	green	green	green	green	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	green	green	green	green	green	green	green	green
Failure of the TMF containment dam	Overtopping of dam	green	green	green	green	yellow	red	red	red	red	yellow	yellow	yellow	yellow	green	red	green	green	green	green	green	green
	Catastrophic Failure of TMF dam	green	green	green	green	red	red	red	red	red	red	red	red	red	red	red	red	red	red	red	red	red

● (green) = *Low risk interaction: a negligible to minor adverse effect could occur; no further consideration warranted.*

● (yellow) = *Moderate risk interaction: a potential moderate adverse effect could occur; warrants further consideration.*

● (red) = *High risk interaction: a key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

Table 26.3-4. Duration of Effects of an Accident or Malfunction

Duration	
Short-term	Effect lasts less than 2 years (i.e., during the Construction Phase of the Project)
Medium-term	Effect lasts from 2 to 30 years (i.e., encompassing both stages of the Operations Phase)
Long-term	Effect lasts from 30 to 37 years (i.e., effects last into the Closure Phase)
Far Future	Effect lasts more than 37 years (i.e., effects last into the Post-Closure Phase and beyond)

The probability of an accident and malfunction is determined according to the attributes identified in Table 26.3-5. These attributes have been developed according to professional judgement and environmental assessment best practice in BC.

Table 26.3-5. Attributes of Probability of an Accident or Malfunction

Probability Rating	Quantitative Threshold	Description of Threshold
Negligible	< 0.1% chance of occurrence; 1:1000 years	Doubtful it could happen
Low	0.1 – 1% chance of occurrence; 1:1000 – 1:100 years	Unlikely to happen
Moderate	1 – 10% chance of occurrence; 1:100 – 1:10 years	It could happen
High	10 – 50% chance of occurrence; 1:2 – 1:10 years	Has or probably will happen
Very high	> 50% chance of occurrence; 1:2 years	Will happen

The severity of consequences for credible accidents and malfunctions is determined according to the definitions presented in Table 26.3-6. Likewise to Table 26.3-4, these attributes have been developed according to professional judgement and environmental assessment best practice in BC.

Table 26.3-6. Consequence Severity of an Accident and Malfunction

Category Rating	Consequence on Valued Component
Negligible	No measurable impact
Low	Minor, reversible impact on VC
Moderate	Significant, reversible impact on VC
High	Significant, irreversible impact on VC
Severe	Catastrophic, irreversible impact on VC

The determination of the overall risk is done with the support of a risk matrix, presented in Table 26.3-7, which combines the probability of an accident and malfunction with its potential consequences. All moderately high or higher risk accidents and malfunctions will undergo an assessment of potential economic, social, health, and heritage effects. The outcomes of the risk assessments are shown graphically on a risk matrix in the summary section of this chapter (see Table 26.8-1).

Table 26.3-7. Risk Matrix

Probability	Consequence				
	Negligible	**Low**	**Moderate**	**High**	**Severe**
Negligible	Negligible	Very Low	Low	Moderately Low	Moderate
Low	Very Low	Low	Moderately Low	Moderate	Moderately High
Moderate	Low	Moderately Low	Moderate	Moderately High	High
High	Moderately Low	Moderate	Moderately High	High	Very High
Severe	Moderate	Moderately High	High	Very High	**Critical**

26.4 SPILLS AND LEAKS

The transportation, storage, and use of hydrocarbons, hazardous materials, and concentrates have associated risks for the unintended release of these compounds into the environment. Accidents and malfunctions include vehicle accidents, failures of tanks and containment systems, spills during maintenance or refuelling operations, or releases associated with other failures such as fires. It was determined that during the life of the Project, the worst-case scenario would be the direct spill of an entire load of hydrocarbon, hazardous material, or concentrate load. Fuel spills are discussed in Sections 26.4.1 and 26.4.2, and hazardous material spills (which include concentrate spills) are discussed in Sections 26.4.3 and 26.4.4.

The inventory of hydrocarbons and hazardous materials that will be found on site, along with their storage locations are identified in Table 26.4-1.

The worst-case spills and leaks scenarios considered in this assessment are:

- fuel spill on land;
- fuel spill in water;
- hazardous material spill on land; and
- hazardous material spill in water.

26.4.1 Scenario 1: Fuel Spill on Land

A dedicated fuel truck (bowser) will transport diesel to the mining equipment operating in the pit, while replenishment of the four 75,000-litre (L) diesel storage tanks near the truck shop will be a daily occurrence from an off-site terminal. A fuel spill into the terrestrial environment could occur as a result of an accident that releases some or all of a load of fuel along the main access road during transportation. Fuel trucks will travel from Southern Yellowhead Highway (Highway 5) along a 24-km network of Forest Service Roads (FSRs), and then to the fuel storage facilities. This scenario assumes the entire load of a standard tri-drive fuel truck (48,000 L) to be deposited into the terrestrial environment along the transport route. Such a fuel spill on land scenario is applicable during the Construction, Operations, and, to a lesser extent, Closure phases of the Project; no significant fuel transport is expected in the Post-Closure phase.

Table 26.4-1. Harper Creek Inventory of Dangerous Goods and Hazardous Materials and Storage Locations

Product	Storage		
	Storage Location	Estimated Maximum Volume	Concentration
Diesel fuel	Diesel fuel storage will be located near the truck shop and away from the stockpile and processing plant.	4 tanks of 75,000 L	-
Domestic products	Domestic products will be stored in the warehouse away from main mining activities, from the camps and from the explosives facility.	-	-
Ethylene glycol	Maintenance shop will be located near the truck shop and away from main mining activities and the explosives facility.	205 L	-
Explosives	Explosives will be stored in the explosives facility, located east of the Project Site, and far away from all mining activities, fuel storage and processing plant.	-	-
Flocculent	Flocculant will be stored near the processing plant for easy access and to minimize risks of spills.	-	Dilute solution of less than 0.5% solution strength
Gasoline	Gasoline storage will be located near the truck shop and away from main-frame construction activities.	Unknown	-
Laboratory chemicals	The Laboratory will be located in the processing plant for easy access and to minimize risks of spills or leaks.	5 L	-
Lime	The lime silo will be located near the processing plant for easy access and to minimize risks of spills and leaks.	30 t	Lime content will be 15% by weight
Lubricating oil	Maintenance shop will be located near the truck shop and away from main mining activities and the explosives facility.	205 L	-
Process Plant reagents	Reagent solutions will be stored in separate holding tanks. Each reagent will have its own preparation system, including a bulk handling system and mixing and holding tanks. These will be located in the processing plant, for easy access and to minimize risks of spills and leaks.	-	Diluted reagent solutions for PAX will be 20% by weight
Propane	Propane storage will be located near the truck shop and away from main mining activities and the explosives facility.	-	-
Solvents	Maintenance shop will be located near the truck shop and away from main mining activities and the explosives facility.	205 L	-

26.4.1.1 Low-risk Effects

As per Table 26.3-3, a fuel spill on land is unlikely to affect noise, surface water quality, surface water quantity, fish, fish habitat, and aquatic resources.

26.4.1.2 Mitigation Measures

Environmental Management Plans

HCMC has developed the following environmental management plans (see Chapter 24) to prevent and mitigate potential fuel spills on land:

- Emergency Response Plan;
- Fuel and Hazardous Materials Management Plan;
- Groundwater Management Plan;
- Sediment and Erosion Control Plan;
- Spill Prevention and Response Plan;
- Traffic and Access Management Plan;
- Vegetation Management Plan; and
- Wildlife Management Plan.

Project Design Measures to Minimize Risk

The Project has been designed to include the following considerations and best management practices to prevent and decrease the likelihood of a fuel spill on land.

- Transportation, storage, dispensing and use of fuels at the site will be conducted in compliance with all relevant government laws and regulations, i.e., all storage and handling of petroleum and allied products will be in accordance with the Canadian Council of Ministers of the Environment (CCME) *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products* (2003).
- Containers will be appropriate for the material being shipped and will be properly secured.
- Containers and trucks will be properly marked, labelled, and placarded, and construction fuel tanks will be installed in suitably lined containments at site.
- Prior to transporting or positioning fuel tanks at the Project Site, the fuel supplier(s) will be required to provide a copy of their fuel spill contingency plan.
- Fuel storage facilities will be located away from the stockpile and processing plant, and be inspected on a regular basis to ensure compliance with regulations.
- Fuel tanks will be double walled or be positioned over an impervious pad surrounded by an impervious dike, and will be positioned where spills, should they occur, are least likely to enter the substrate.

- Refuelling hoses will have a design pressure rating of at least 150% of the maximum head of the system, and refuelling operators will be in attendance for the duration of the fuelling operation.
- Site-wide procedures dictating how refuelling and servicing activities are to occur outside of a service facility.
- A supply of spill response and clean-up equipment will be available on site in appropriate quantities throughout the various Construction and Operations sites.
- Any fuel supplies and chemicals required for decommissioning will be stored within contained areas and products no longer required will be removed from the site once milling ceases.
- Diesel fuel pipelines will be equipped with leak detection systems and automatic shut-off valves, and such safety provisions will use conventional, proven technologies that will be consistent with regulations governing petroleum product pipelines.
- Tanks and sumps will have high-level alarms and all transfers from tanker trucks to tanks at the fuel storage facilities will be done using enclosed lines, hoses, and pumps.
- Inspection schedules will be developed for each fuel storage site, taking into account the volume of fuel stored at each site and the respective risks related to that storage.
- Access roads will be properly maintained.
- Speed limits will be enforced for all mine traffic on roads.
- Vehicles will be adequately maintained and undergo regular inspection.
- Drivers will undergo training and will be equipped for spill first response, containment, and communication.

<u>Emergency Response Procedures</u>

In the event of upset conditions related to fuel spill on land, an on-site staff member tasked with the responsibility of coordinating the Emergency Response Plan described in Section 24.4 will launch an investigation of the incident and the following emergency response approach will be initiated:

- ensuring the safety of the employees, site personnel, and the public;
- mobilizing the necessary equipment and crews to contain and clean up the spill and rehabilitate the site to protect the environment. Contaminated soil will be temporarily stockpiled in a waste handling and transfer area, either until it can be removed from site by a licensed hazardous waste contractor or placed in the purpose-designed landfarm for on-site bioremediation, depending on the approach adopted. The waste handling and transfer area will consider storage measures and containment, and its design will minimize any potential for erosion and runoff;
- notifying the appropriate stakeholders, including government agencies (e.g., the BC Provincial Emergency Program and Environment Canada Emergencies), and any nearby communities or landowners; and
- reporting the spill as per the Spill Reporting Regulation (BC Reg. 263/90).

If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent's overall Emergency Response Plan. Statutory reporting of spills of more than 100 L of fuel to provincial authorities is also necessary, and any spills will be documented in a Spill Report that will be submitted within 24 hours to the BC Provincial Emergency Program.

A site-wide communication system (including access roads) will ensure rapid notification of any observed spills. The site will have a trained Emergency Response Team with resources to contain and recover spills, to reduce the size of any spill and thus reduce any potential adverse environmental or health effects. On-site equipment will include absorbent pads and dike materials as part of spill recovery kits for deployment to any spill scene. The kits will be easily transferable to enable delivery by helicopter, if required.

26.4.1.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, should a fuel spill on land occur, a few VCs risk being affected, as per Table 26.3-3.

<u>Air Quality</u>

Air quality may be affected, as an accidental event that exposes fuel to the open air would release volatile organic compounds. Changes in the air quality due to a spill will be local in geographic extent, affecting only the immediate vicinity. Pollutant emissions from the clean-up activities themselves will be sporadic in frequency and short in duration, and will likely not be detectable above emissions from other Project activities involving the use of heavy equipment. Any minor adverse environmental effects on air quality will cease once the cleanup is complete. Contaminant emissions are expected to be within all pertinent standards and guidelines and no significant residual environmental effects are predicted.

<u>Groundwater Quality and Groundwater Quantity</u>

A fuel spill along the transport route could introduce fuel constituents into groundwater, with subsequent decreases in the quality and utility of groundwater resources. The rate and extent of infiltration of fuel constituents depend on the soil and environment conditions, including soil moisture and temperature, as well as the composition of fuel. Soluble constituents are relatively mobile in soil matrices and may migrate considerable distances under certain conditions.

In the event of a spill, the clean-up and restoration measures will start as soon as feasible. The close proximity of the spill to the transport route, in this scenario, will facilitate the rapid response and deployment of containment and recovery equipment. It is expected that a significant portion of the spilled fuel will be removed from the terrestrial environment with the rapid implementation of clean-up efforts. The potential effects from the spill to groundwater will therefore be minimized, and the quantity of fuel constituents infiltrating into groundwater will be limited. A monitoring and follow-up program will be implemented to determine the extent and concentration of residual fuel constituents, and to track any further infiltration and movement away from the immediate vicinity of the spill site. Further mitigation measures, including the removal and on-site bioremediation at the landfarm of additional source materials, would be implemented as necessary, and also in response to the information collected in the monitoring program.

Residual fuel constituents would possibly remain in the groundwater environment after the restoration and clean-up efforts. The clean-up efforts are expected to recover and remove the majority of the spilled fuel, but the remaining material may remain for years to decades as it is naturally degraded and dispersed. To be conservative, the duration of the effects from a spill along the transport route on groundwater is assessed to be medium-term (e.g., 2 to 30 years) but reversible because of the implementation of clean-up measures, follow-up monitoring and management, and natural degradation.

Vegetation

In the event of a fuel spill, ECAR and old growth forest could be affected since they are found along the transport route. Lethal effects to vegetation would occur from direct contact with the spilled fuel, and further effects to growth, metabolism, and reproduction may occur from exposure to fuel constituents. However, the clean-up and restoration activities would be implemented rapidly, and are expected to mitigate the effects of fuel constituents on vegetation to an acceptable level. Contaminated soil would be removed for appropriate treatment and disposal. The restoration activities in the affected area may include:

- replacing fill or topsoil where required, including measures to minimize erosion prior to the establishment of ground cover;
- re-vegetation with appropriate vegetation types; and
- weed control measures, if required, to ensure the re-growth of a suitable plant community.

A monitoring and follow-up program would be implemented to ensure the restoration and re-vegetation efforts are successful. Additional mitigation measures, such as the removal of additional fuel residues or the application of soil amendments to foster vegetation growth, would be applied as necessary. As a result of the clean-up and restoration activities, the effects of a fuel spill on vegetation and the terrestrial ecosystem are expected to be restricted to the spill site, short-term in duration and reversible.

Wildlife

A fuel spill along the transport route could interact with wildlife through direct contact, alteration, degradation or loss of habitat, and the availability of prey and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. Migratory birds could be affected to a larger extent if the event was to occur during breeding or nesting season. The potential for effects from direct contact with fuel constituents would likely be minor; most wildlife species are mobile and would immediately avoid the vicinity of the spill and clean-up activity. The direct effects would be expected to be local and short-term, and would be reversible due to the natural processes of dispersion and degradation combined with recovery of any accessible spilled fuel. Likewise, sensory disturbance from volatile fuel constituents and restoration activities would have local and short-term effects; odours would dissipate and the clean-up activities would be short-term. Monitoring and follow-up programs for soil quality would assess the longer term effects and recovery of these indicators, and would be used to assess the significance of indirect effects to wildlife, as well as identify and plan further mitigation and management measures.

Indirect effects to wildlife could occur because of effects to terrestrial ecology. Decreases in ecosystem productivity could reduce the availability of food sources for some wildlife species. However, the availability of food and habitat would increase with the re-vegetation and restoration of the habitat and the effects to wildlife are predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible but, to be conservative, the recovery may occur over the medium-term (greater than two years). Furthermore, the road right-of-way is not likely a significant habitat for wildlife species because of the traffic and existing effects from human activities.

26.4.1.4 Risk Assessment

Since the Project will put in place several prevention and response procedures to minimize or eliminate the potential for a fuel spill on land, a probability rating of **Low** has been allocated, notwithstanding that there will be continuous transport of fuel to the Project Site during the Construction and Operations phases.

With the implementations of emergency response procedures and mitigation measures, it is anticipated that the initial fuel spill response would begin within a few hours following the spill and would enable the recovery of a portion of the spill; the Potential Effects would then be short-term, reversible, and contained to the area of the spill. As a result, a consequence rating of **Low** was allocated.

As per Table 26.3-7, the overall risk assessment for a spill on land is **Low.**

26.4.2 Scenario 2: Fuel Spill in Water

Liquid fuels will be transported to the Project Site by truck and a fuel spill into the freshwater environment is possible as a result of a vehicle accident that releases some or all of a load of fuel into a waterbody. Fuel trucks will travel along Highway 5 and then via a network of existing FSRs to the fuel storage facilities at the plant site. The route traverses the North Thompson River over the Vavenby Bridge and/or the Birch Island Lost Creek Bridge. This scenario assumes the entire load of a standard tri-drive fuel truck (48,000 L) to be deposited into a freshwater environment. The high-flowing North Thompson River or a low-flowing tributary to Harper Creek are potentially the most likely receiving environments. This scenario is applicable during Construction, Operations, and Closure phases; no significant fuel transport is expected in the Post-Closure phase.

26.4.2.1 Low-risk Effects

As per Table 26.3.3, a fuel spill in water is unlikely to affect air quality and noise. Moreover, since the North Thompson River and Harper Creek are groundwater discharge zones, minimal interaction is expected between fuel constituents and groundwater quality, groundwater quantity, and surface water quantity.

26.4.2.2 Mitigation Measures

Environmental Management Plans

HCMC developed the following environmental management plans and operational management plans to prevent and mitigate potential fuel spills in water:

- Emergency Response Plan;
- Fish and Aquatic Effects Monitoring and Management Plan;
- Fuel and Hazardous Materials Management Plan;
- Sediment and Erosion Control Plan;
- Spill Prevention and Response Plan; and
- Traffic and Access Management Plan.

Project Design Measures to Minimize Risk

The Project design measures to minimize the risk of a fuel spill in water occurring are the same as for the fuel spill on land scenario. Refer to Section 26.4.1.2, Mitigation Measures, above.

Emergency Response Procedures

The emergency response approach is the same as for the fuel spill on land scenario in Section 26.4.1.2, with the addition that if fish and fish habitat are affected by the spill, the spill would also be reported to Fisheries and Oceans Canada (DFO). Moreover, if the release of fuel cannot be fully mitigated in clean-up and restoration, a program would be implemented to monitor any residual effects in the freshwater environment, including water quality, sediment quality, aquatic resources, fish, and fish habitat.

26.4.2.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, should a fuel spill on water occur, a few VCs risk being affected, as per Table 26.3-3.

Surface Water Quality and Aquatic Resources

A fuel spill in the North Thompson River or a low-flow tributary creek may have substantial effects on water quality, sediment quality, and aquatic resources. The flowing waters in the river will disperse and mix the fuel, which could lead to decreases in water quality for several kilometres downstream. Some fuel constituents, like polycyclic aromatic hydrocarbons (PAH) are hydrophobic and would likely move from the water to the sediment environment. Natural processes of dispersion and volatilization will immediately decrease the concentrations of fuel constituents in the water and clean-up efforts will remove any remaining accessible fuel. Natural degradation processes, mediated by microbes and other organisms, use hydrocarbons as substrates for growth and metabolism (Singer, Thompson, and Bailey 2004). As a result, the effects to water quality are expected to be short-term and reversible in the short-term (i.e., less than two years).

The distribution of fuel constituents to the sediments will depend on the conditions within the receiving environment. Depositional environments, such as eddies, will preferentially accumulate sediments and hydrophobic fuel constituents, whereas the flow rate within the river will determine the dilution and distance of travel. It is likely that sediment quality will be degraded at some locations downstream of the spill. Natural processes of volatilization and degradation will act on the fuel constituents in the sediments and will naturally reduce the concentrations of constituents over time. However, the process is dependent upon temperature and oxygen supply, and may take significantly longer than the processes that act in the underlying river water. To be conservative, the effects of the spill on sediment quality are assessed to be reversible in the medium-term (i.e., 2 to 30 years).

The dispersion of the spilled fuel in the freshwater environment would expose aquatic organisms to potentially toxic constituents. Primary producers, which are aquatic plants and algae, and secondary producers, which are aquatic invertebrates and zooplankton, are potentially susceptible to acute toxic effects from fuel constituents (Shales et al. 1989; Lewis and Pryor 2013). A spill of 48,000 L would likely cause acute toxicity in primary producers and aquatic invertebrates in the immediate vicinity of the spill. Benzene, toluene, ethylbenzene, and xylenes (BTEX) are significant components of fuels and are potentially toxic to aquatic organisms. Provincial and federal water quality guidelines have been established for BTEX compounds for the protection of aquatic life based on the known toxicity of BTEX (BC MOE 2014; CCME 2014).

Short-term effects on primary producers would likely occur as a result of the fuel spill scenario into North Thompson River. The high concentrations in the plume of fuel constituents would likely result in lethal and sublethal effects to aquatic plants and periphyton, which would reduce ecosystem primary production and provide less energy to higher trophic levels. Furthermore, shifts in the composition of the primary producer community would likely occur due to the differences in tolerance to fuel constituents between organisms (Lewis and Pryor 2013). The acute lethal effects would likely continue for a short period of time (hours to days) due to the natural dispersion and volatilization processes that reduce the concentrations of fuel constituents. The primary producer community would likely start to recover as the concentrations of fuel constituents decrease. Longer-term effects, associated with more persistent fuel constituents like PAHs, may continue to occur on the scale of months-to-years.

Secondary producers could similarly be affected by the fuel spill. Lethal and sublethal effects to aquatic invertebrates could occur from direct contact with the plume of fuel constituents (Lytle and Peckarsky 2001; Smith et al. 2010). Significant aquatic invertebrate mortality has been reported to occur immediately after a fuel spill, and lethal effects have been observed at least 5 km downstream from diesel spills (Lytle and Peckarsky 2001). Sublethal effects include changes in the composition of the secondary producer community; for example, more hydrocarbon-tolerant beetles were observed downstream of a diesel spill in the United Kingdom (Smith et al. 2010). The natural dispersion, degradation, and volatilization of fuel constituents reduce the lethal and sublethal effects on the scale of months-to-years. It would be expected for the abundance and diversity of the secondary producer community to return to pre-spill levels within five years.

Follow-up water quality, sediment, and aquatic organism monitoring would be conducted to assess short- and long-term effects and to identify any additional mitigations required. Surveillance of sediment PAH concentrations would measure the accumulation and persistence of those potentially harmful compounds, and potentially identify depositional areas that could be dredged and de-contaminated.

Fish and Fish Habitat

A fuel spill into the North Thompson River would be expected to have effects on fish and fish habitat because of the potential lethal and sublethal effects of fuel constituents on fish and the indirect effects on fish prey and habitat. As discussed for primary and secondary producers, fuel constituents such as BTEX and PAH have known effects on the behaviour, metabolism, growth, and reproduction of fish (Shales et al. 1989; CCME 2014). Some fish mortality would be expected in the immediate vicinity of the spill, where fuel constituent concentrations are high enough to be toxic. Fish would also avoid habitats with elevated concentrations of fuel constituents, which would lead to local decreases in fish community abundance and diversity. The decreases in primary and secondary production, due to fuel effects on those lower-food-web organisms, would have indirect effects on fish by reducing the availability of food and habitat (Section 26.4.1.3). The geographic extent of the effects would likely be similar to the effects to secondary producers, and may extend more than 5 km downstream of the spill site.

The active efforts to recover spilled fuel along with the natural processes of dispersion, volatilization, and degradation are expected to reduce the concentrations of fuel constituents substantially in the freshwater environment. As a result, the effects to fish are expected to be short-term (e.g., less than five years). The fish community is expected to recover; fish would recolonize affected habitats as water and sediment quality improves and the communities of prey (e.g., primary and secondary producers) recover back to their natural state.

Follow-up monitoring programs would measure the recovery of the ecosystem and identify any further opportunities for restoration. Fish community and fish habitat studies would be conducted to measure the rate and extent of recovery.

Vegetation

Vegetation can be affected by fuel spills by direct damage from the hydrocarbon constituents; fuel can chemically burn vegetation and disrupt nutrient cycling processes. In this scenario, the fuel would either be entering the freshwater environment of the high-flowing North Thompson River or the low-flowing tributary to Harper Creek. In the case of a fuel spill in the North Thompson River, there would be little immediate contact with the terrestrial environment. Riparian vegetation downstream of the spill would be potentially vulnerable to the spill constituents; however, the potential effects would be attenuated by dispersion and dilution in the high-flowing water of the North Thompson River, by evaporation of volatile fuel constituents and the microbially mediated breakdown of hydrocarbons. If the fuel spill were to occur in slower moving water area, riparian vegetation could come into direct contact with the hydrocarbon constituents. Effects are anticipated to be local, short-term, and reversible over time due to the natural processes of dispersion and degradation combined with the recovery of any accessible spilled fuel. Containment measures and cleanup are expected to be implemented rapidly.

Wildlife: Terrestrial Invertebrates, Amphibians, Migratory Birds, Raptors, and Bats

A fuel spill in water could result in direct loss or displacement of amphibians and the disruption of stream habitat. Indirect effects to some wildlife species may occur due to adverse effects on fish, fish habitat, and aquatic resources. Decreases in ecosystem productivity and prey abundance could reduce the availability of food for some wildlife species feeding on invertebrates and fish in these areas. It is anticipated, however, that as the availability of food recovers, the effects to wildlife would decrease. As a result, the indirect effects to wildlife are predicted to be reversible but the recovery may occur over the medium-term (i.e., greater than two years) because of the potential for slower recovery for aquatic resources.

Wildlife: Fur-bearers, Large Mammals, and Ungulates

A fuel spill into the North Thompson River could interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. However, most wildlife species, e.g., fur-bearers, large mammals, and ungulates, are mobile and would immediately avoid the vicinity of the spill.

26.4.2.4 Risk Assessment

Although a fuel spill in water is improbable, a probability rating of **Low** has been allocated since the transport of fuel to the Project Site during the Construction and Operations phases will be a daily occurrence.

Despite the implementation of emergency response procedures and mitigation measures, a fuel spill on water could result in severe impacts on fish, fish habitat, and aquatic resources over a short and large period of time. As a result, a consequence rating of **High** was allocated.

The overall risk assessment for a spill in water is **Moderate.**

26.4.3 Scenario 3: Spill of Hazardous Substances on Land

Various potentially hazardous materials including reagents, used oil, dust suppression chemicals, and other miscellaneous commodities will be transported to and from the Project Site, stored, and utilized during the Construction and Operations phases, as indicated earlier in Table 26.4-1.

For this scenario, a spill of copper concentrate has been considered. While copper concentrate is not flammable or combustible or otherwise hazardous under normal conditions of transport and storage, it has the potential for impacts due to its inherent physical and chemical properties. When heated strongly, copper concentrate will burn, releasing toxic and irritating sulphur dioxide gas, as well as possible copper and iron oxide fumes. A spill into the terrestrial environment is possible as a result of an accident along the access road to the rail load-out facility that could release part or all of a load of copper concentrate.

The scenario of a spill of a hazardous substance is applicable during the Construction and Operations phases of the Project; no significant transport of hazardous materials is expected in the Closure and Post-Closure phases.

26.4.3.1 Low-risk Effects

As per Table 26.3-3, a spill of hazardous substances on land is unlikely to affect noise, surface water quality, surface water quantity, fish, fish habitat, and aquatic resources.

26.4.3.2 Mitigation Measures

Environmental Management Plans

HCMC has developed the following environmental management plans to prevent and mitigate potential spills of hazardous substances on land:

- Air Quality Management Plan;
- Emergency Response Plan;
- Fuel and Hazardous Materials Management Plan;
- Groundwater Management Plan;
- Mine Waste and ML/ARD Management Plan;
- Sediment and Erosion Control Plan;
- Spill Prevention and Response Plan;
- Traffic and Access Management Plan;
- Vegetation Management Plan;
- Waste Management Plan; and
- Wildlife Management Plan.

Project Design Measures to Minimize Risk

The preferred manner to deal with the potential for spills is by avoidance through appropriate storage, handling, and transportation measures. The Project has been designed to include the following considerations and best management practices to prevent and decrease the likelihood of a hazardous materials spill on land:

- clear labelling of packaging and rigorous storage policies through a Workplace Hazardous Materials Information System (WHMIS), the latter outlines the protocols for labeling and documenting these hazardous materials. Recommendations regarding worker education programs and addressing the handling of hazardous materials will also be provided;
- appropriate containment of all dangerous or hazardous products, with protective barriers where there is potential for impact from vehicles;
- separate storage and sump systems for storage areas of incompatible products;

- reagent solutions will be stored in separate holding tanks and added to the addition points as required by processes using metering pumps;
- documented operational procedures and site-specific work instructions for tasks that have an identified risk, such as explosives manufacturing and handling, and waste management;
- certification of vehicles and drivers for transportation of dangerous goods;
- ensuring that vehicle cargos are adequately contained and secured;
- a high level of preventative maintenance of vehicles, equipment, storage containers, etc.;
- regular housekeeping of facilities to ensure maximum protection is in place;
- a risk assessment program for identifying vulnerabilities and management of improvements; and
- documented inspection schedules and procedures for dangerous goods and hazardous materials stored on site.

The transport of dangerous goods and hazardous materials will necessitate the following:

- Material Safety Data Sheets (MSDS) will accompany all designated goods and materials, and only qualified employees will handle these substances;
- non-compatible materials will be transported in separate shipments;
- fire extinguishers and fire prevention materials will be adequate and appropriate for the material being transported;
- containers will be appropriate for the material being shipped;
- containers will be properly secured;
- containers and trucks will be properly marked, labelled, and placarded;
- manifests will be maintained in accordance with federal and provincial regulations;
- spill response materials will be adequate and appropriate for the materials being transported;
- drivers will be adequately trained and equipped for spill first response, containment, and communication;
- access roads will be properly maintained;
- speed limits will be enforced for all mine traffic on roads; and
- vehicles will be properly maintained.

Emergency Response Procedures

The spill response procedures for hazardous substances are the same as those for a fuel spill discussed in Section 26.4.1.2.

26.4.3.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, should a spill on land occur, a few VCs risk being affected, as per Table 26.3-3.

<u>Air Quality</u>

Air quality may be affected since an accidental event that exposes copper concentrate to the open air would release dust and particulate matter. Changes in the air quality due to a spill will be local in geographic extent, affecting only the immediate vicinity. Pollutant emissions from the clean-up activities will be sporadic in frequency, short in duration, and will likely not be detectable above emissions from other Project activities involving the use of heavy equipment. Any minor adverse environmental effects on air quality will cease once the cleanup is complete. Contaminant emissions are expected to be within all pertinent standards and guidelines and no significant residual environmental effects are predicted.

<u>Groundwater Quality and Groundwater Quantity</u>

A spill of copper concentrate has the potential for infiltration into groundwater with subsequent decreases in the quality and quantity of groundwater resources. The rate and extent of infiltration depend on the solubility of the substance in water, the soil and environment conditions, including soil moisture and temperature. Copper concentrate is relatively insoluble in water, and therefore its constituent metals have low direct bioavailability. Extended exposure of the copper concentrate in terrestrial environments, however, can lead to the release of the constituent metals in more bioavailable forms.

In the event of a spill, the clean-up and restoration measures would start as soon as feasible. The close proximity of the spill to the transport route, in this scenario, would facilitate the rapid response and deployment of containment and recovery equipment. It is expected that a significant portion of the spilled copper concentrate would be removed from the terrestrial environment with the rapid implementation of clean-up efforts. The potential effects from the spill to groundwater would therefore be minimized, and the quantity of copper concentrate infiltrating into groundwater would be minimized. A monitoring and follow-up program would be implemented to determine the extent and concentration of spilled-related copper, and to track any further infiltration and movement away from the immediate vicinity of the spill site. Further mitigation measures, including the removal of additional source materials, would be implemented as necessary based on the information collected in the monitoring program.

To be conservative, the duration of the effects from a spill along the transport route on groundwater quantity and groundwater quality is assessed to be medium-term (i.e., 2 to 30 years) but reversible because of the implementation of clean-up measures, follow-up monitoring and management, and natural dispersion.

<u>Vegetation</u>

Vegetation could be affected by a hazardous substance spill along the transport route. Extended exposure of copper concentrate in terrestrial environments can lead to the release of the constituent metals in more bioavailable forms; these forms have the potential to cause adverse effects to growth, metabolism, and reproduction. ECAR and old-growth forest can be found in some areas along the transport route and therefore have the potential to be affected. Clean-up and restoration activities would be implemented as soon as feasible after a spill and are anticipated to mitigate the effects of hazardous substances on vegetation to an acceptable level. Contaminated soil would be removed for appropriate treatment and disposal. The restoration activities in the affected area may include:

- replacing fill or topsoil where required, including measures to minimize erosion prior to the establishment of ground cover;
- re-vegetation with appropriate vegetation types; and
- weed control measures, if required, to ensure the re-growth of a suitable plant community.

The extent of the effects of a spill would be expected to be localized because of the restoration activities. Monitoring and follow-up programs would be implemented to assess the performance of the mitigation and restoration measures. Additional mitigation measures, such as the removal of metal residues or the application of soil amendments to foster vegetation growth, would be applied as necessary. As a result of the clean-up and restoration activities, the effects of a copper concentrate spill on vegetation and the terrestrial ecosystem are expected to be restricted to the spill site, short-term in duration, and reversible.

Wildlife

A copper concentrate spill along the transport route could interact with wildlife through direct contact, alteration, degradation or loss of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. Migratory birds could be affected to a larger extent if the event was to occur during breeding or nesting season.

The effects from direct contact with metal constituents would likely be minor; most wildlife species (i.e., migratory birds, raptors, bats, fur-bearers, large mammals, and ungulates) are mobile and would immediately vacate the vicinity of the spill and clean-up activity. The direct effects would be expected to be local and short-term, and would be reversible due to the natural processes of dispersion and degradation combined with the recovery of any accessible spilled copper concentrate. Likewise, sensory disturbance would have local and short-term effects; any odours would dissipate rapidly and the clean-up activities would be short-term. Monitoring and follow-up programs for soil quality would assess the longer-term effects and recovery of these indicators, and would be used to assess the significance of indirect effects to wildlife. These monitoring measures would be used to identify and plan further mitigation and management measures, if required.

Indirect effects to wildlife could occur because of effects to terrestrial ecology. Decreases in ecosystem productivity could reduce the availability of food sources for some wildlife species. However, the availability of food and habitat would increase with the re-vegetation and restoration of the habitat and the effects to the wildlife would be predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible but, to be conservative, the recovery may occur over the medium-term (i.e., greater than two years). Furthermore, the road right-of-way is not likely a significant habitat for wildlife species because of the traffic and existing effects from human activities.

26.4.3.4 Risk Assessment

The Project will put in place several prevention and response procedures to minimize or eliminate the potential for a spill of hazardous substances on land. However, there will be continuous transport of hazardous substances to the Project Site during the Construction and Operations phases and therefore a conservative probability rating of **Low** has been allocated.

The VCs that have potential to be affected are groundwater quality, ECAR and old-growth forest. Potential effects resulting from a hazardous substance spill are expected to be local in geographic extent, affecting only the immediate vicinity, and short in duration as the clean-up measures would remove most of the spill. While the effects are anticipated to be local and short, they may adversely affect ECAR and old-growth forest, resulting in a consequence rating of **Moderate**.

The overall risk assessment for a hazardous substances spill on land is **Moderately Low.**

26.4.4 Scenario 4: Spill of Hazardous Substances in Water

For this scenario, a spill of copper concentrate in a waterbody is considered. More specifically, this scenario assumes the entire load of copper concentrate to be deposited into a freshwater environment along the transport route, i.e., the North Thompson River. This scenario is applicable during the Construction and Operations phases of the Project; no significant transport of hazardous materials is expected in the Closure and Post-Closure phases.

26.4.4.1 Low-risk Effects

As per Table 26.3-3, no effects are anticipated on air quality or noise. A spill in the North Thompson River would be expected to have minimal interaction between metal constituents and groundwater quality, groundwater quantity, and surface water quantity since both the North Thompson River are groundwater discharge zones.

26.4.4.2 Mitigation Measures

The mitigation measures (including management plans, project design measures to minimize risk, and emergency response procedures) for a spill of hazardous substances in water are the same as the mitigation measures for a spill of hazardous substances on land outlined in Section 26.4.3.2 above.

26.4.4.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, should a spill in water occur, a few VCs risk being affected, as per Table 26.3-3.

Surface Water Quality

Hazardous substances may have direct effects on surface water quality. In the case of copper concentrate, it is relatively insoluble in water in the short-term. However, extended exposure of the concentrate in aquatic environments can lead to the release of the constituent metals in more bioavailable forms. The mobility of the constituent metals in more soluble forms is media-dependent; they can bind with inorganic and organic ligands, reducing their mobility and bioavailability in water. Bioavailability is also mediated by other factors (e.g., pH, hardness, total organic carbon) in the aquatic environment. Guidelines have been established for the protection of aquatic life for copper (BC MOE 2014; CCME 2014). Concentrations of copper would be expected to be greater than the applicable water quality guidelines immediately following a spill into the North Thompson River. The concentrations would be expected to decrease with the recovery efforts, and the dilution and dispersion of the spilled copper concentrate. The effects to water and sediment quality are anticipated to be short-term (i.e., less than two years) and reversible due to the natural dispersion processes.

Fish and Fish Habitat

A spill of a hazardous substance would be anticipated to have effects on fish and fish habitat. The effects would be greatest in the immediate vicinity of the spill, and would be mitigated by active recovery and natural dispersion. As a result, the effects to fish would be expected to be short-term (i.e., less than two years). The fish community would be expected to recover; fish would recolonize affected habitats as water and sediment quality improves and the communities of prey (e.g., primary and secondary producers) recover back to their natural state.

Aquatic Resources

Aquatic organisms would be expected to be affected by significant increases in copper concentrations in the vicinity of a concentrate spill. Lethal and sublethal effects to communities of prey would be expected, with substantial decreases in the abundance, diversity, and productivity in the immediate vicinity of the spill. The effects would be expected to be attenuated with distance from the spill with dilution and dispersion. The acute effects of the spilled copper concentrate would decrease over time and aquatic organisms would re-colonize the affected areas of the North Thompson River. The effects on aquatic resources are expected to be short-term (i.e., less than two years) and reversible.

Vegetation

Vegetation could be affected by the lethal and sublethal effects from a copper concentrate spill. In this scenario, the spill would enter the freshwater environment of the North Thompson River and would have little immediate contact with the terrestrial environment. Riparian vegetation downstream of the spill would be potentially vulnerable to the spilled copper concentrate. However, the potential effects would be attenuated by dispersion and dilution in the flowing waters. Furthermore, riparian areas with significant accumulation of material would be targeted for clean-up and remediation efforts.

The effects from a spill of hazardous substances in water is predicted to be local to the spill and short-term because of the natural processes of dispersion and the directed efforts of spill recovery and cleanup. The effects to the terrestrial environment are expected to be reversible after restoration and with the natural processes of dispersion and degradation.

Wildlife: Amphibians

Amphibious organisms could have a higher likelihood of exposure but the natural process of dispersion will decrease the concentrations of copper concentrate and thus decrease the wildlife exposure over time. The direct effects would be expected to be local and short-term, and would be reversible due to the natural processes of dispersion combined with the recovery of any accessible spilled copper concentrate. Likewise, sensory disturbance from restoration activities would have local and short-term effects; odours would dissipate rapidly and the clean-up activities would be short-term.

Wildlife

A spill of copper concentrate could interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. The effects from direct contact with the spill would likely be minor; most wildlife species (e.g., terrestrial invertebrates, migratory birds, raptors, bats, fur-bearers, large mammals, and ungulates) are mobile and would immediately avoid the vicinity of the spill. Indirect effects to wildlife could occur because of effects to surface water and aquatic resources and fish. Decreases in ecosystem productivity and prey abundance could reduce the available food for some wildlife species. However, as those receptor VCs recover, the effects to wildlife would be predicted to decrease. Moreover, copper concentrate is relatively insoluble in water, and therefore, its constituent metals have low direct bioavailability on the short-term.

26.4.4.4 Risk Assessment

The Project will put in place several prevention and response procedures to minimize or eliminate the potential for a spill of hazardous substances on water. However, there will be continuous transport of potentially hazardous substances to the Project Site during the Construction and Operations phases, and from the Project Site to the rail load-out area, and therefore a conservative probability rating of **Low** has been allocated.

Several VCs could be affected, and there is potential for significant fish mortality and immediate loss of fish habitat, aquatic resources and prey. As a result, a consequence rating of **Moderate** was allocated for potential effects resulting from a spill of hazardous substance in water.

The overall risk assessment for a hazardous substance spill in water is **Moderately Low.**

26.5 FIRES AND EXPLOSIONS

A fire or explosion could be caused by a number of failure modes, including equipment or machinery malfunction, improper use or storage of explosives, combustion of inflammable materials, or careless human activity. Fire or explosion scenarios are applicable during the construction and operations phases when equipment, machinery, fuel and hazardous materials are present on site. Environmental factors such as dry summer weather, high winds, and lightening can increase the risk of fires; these are discussed in Chapter 27, Effects of the Environment on the Project.

The Project's truck shop is comprised of five regular service bays, two welding bays, and a preventative maintenance bay. The diesel fuel storage facility is located on site away from the stockpile and processing plant, and consists of four aboveground 75,000-L capacity diesel fuel storage tanks and one gasoline storage tank, and loading and dispensing equipment.

The proposed explosives manufacturing and storage facility is shown in Figure 26.2-1.

Two possible fire and explosion scenarios are considered in this assessment:

- a fire or explosion that is contained to the Project Site; and
- a fire or explosion that causes a wildfire.

26.5.1 Scenario 1: Fire or Explosion on Site

A fire or explosion occurring on site is possible as a result of an accident at or near the fuel storage facility, which will cause on-site combustible materials to ignite. The fuel storage facility is comprised of four aboveground 75,000-L capacity diesel fuel storage tanks and one gasoline storage tank, which is the volume of fuel needed for four days of operations.

26.5.1.1 Low-risk Effects

As per Table 26.3-3, a fire or explosion on site is unlikely to affect surface water quality, surface water quantity, fish, fish habitat, and aquatic resources. Moreover, interactions with rare plants, ECAR, wetland and old-growth forest are expected to be minimal as the fire would be contained within the Project Site, and vegetation at the Project Site would have been cleared during mine establishment. Similarly, effects to wildlife and wildlife habitat are expected to be minimal as limited wildlife is anticipated to be within the Project Site boundaries as the area would have been cleared during Project construction.

26.5.1.2 Mitigation Measures

<u>Environmental Management Plans</u>

HCMC has developed the following environmental management plans to prevent and mitigate potential fires or explosions on site, or to contribute to the overall better management of the Project:

- Air Quality Management Plan;
- Emergency Response Plan;
- Explosives Handling Plan;
- Fuel and Hazardous Materials Management Plan;
- Site Water Management Plan;

- Spill Prevention and Response Plan;
- Traffic and Access Management Plan; and
- Waste Management Plan.

Project Design Measures to Minimize Risk

The Project has been designed to include the following considerations and best management practices to prevent and decrease the likelihood of an accidental fire or explosion occurring on site:

- A federally (Natural Resources Canada) licensed contractor will be hired to handle explosives sourcing and handling.
- Prior to blasting, per standard mine safety procedures, the open pit and areas within the range of fly rock will be cleared, access roads blocked and all mine staff warned when a blast will occur. A sweep of all areas within the blast zone will be done by the pit foreman or designate prior to the blast. Regulations also require signage on all roads leading into the blast zone the day blasting will occur, giving the time of the blast. Typical warnings for all staff with radio contact (which would include all mine vehicles) will include a two-hour, half-hour, and two-minute warning before the blast is set off, as per regulations.
- The explosives manufacturing and storage facility will be set back the required distance from working areas and accommodations. The explosives storage area will be restricted to authorized employees only and the access road signed per regulations.
- The explosives manufacturing and storage facility will be appropriately climate-controlled, dry, well-ventilated, and will have appropriate fire and safety protection.
- The licensed explosives contractor will provide measures to address potential environmental effects and health and safety considerations.
- To reduce the severity of impacts of any potential accidents, the minimum necessary amount of explosives will be used.
- Only certified employees will undertake the charging of drill holes and setting off of blasts.
- No mine facilities other than equipment working in the pit would be within the blast zone.
- Most of the proposed blasting for the Project will be away from fish and fish habitat.
- All site forestry clearing operations will comply with the terms of the Forest Fire Prevention and Suppression Regulation (BC Reg. 169/95), which forms part of the *Forest Practices Code of British Columbia Act* (1996a).
- All personnel handling dangerous goods will be trained and provided with appropriate personal protective equipment.
- Chemical storage areas will be designated as non-smoking areas, smoking will be strictly prohibited during refuelling operations, and operators will be required to be in attendance for the duration of the fuelling operation.
- Fire extinguishers and fire prevention materials will be adequate and appropriate for the material being transported.

- Fuel will be stored in appropriately sized tanks with secondary containment.
- Areas will be kept clean and free of clutter and unused equipment.
- All project facilities, once in operation, will have a fire safety installation (e.g., monitoring, emergency shutdown, and fire-control systems) to identify and control any problems if they arise.
- All buildings will be equipped with fire alarms, fire suppression, and firefighting equipment including hose reels and fire extinguishers as required by regulation.
- Employees will be trained in fire prevention, early detection, and effective firefighting techniques to assist in protecting the proposed Project Site and surrounding area from fire.

Emergency Response Procedures

Should a fire or explosion occur on site, despite the above mentioned mitigation and preventative measures, the following emergency response approach will be initiated:

- Small-scale fires such as equipment, kitchen, and machinery fires will be extinguished by individuals on site, with the appropriate equipment (e.g., chemical and water extinguishers, fire hoses, sand).
- In the event of an accidental explosion, an alert would be issued throughout the mine and the immediate area evacuated. The emergency coordinator would take charge and decide when it is safe to enter the explosion area. Any explosion in the mine area would be handled by the trained mine rescue crew required under mine regulations.
- Injuries would be handled as a medical first aid or emergency, depending on the situation. Medivac would be initiated if required. Fatalities would be reported immediately to the Mines Health and Safety Inspector and RCMP as required by law.
- All accidental explosions at a Project Site must be investigated by the Chief Mines Inspector. The mine health and safety committee would investigate from the mine's side and provide a report to the mine manager and HCMC'S corporate head office.
- Employees would be designated to remain in close contact with the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO) fire control staff during the fire season to identify any fire threats that may occur at or near the proposed Project Site.
- Immediate action will be taken to minimize the environmental effects should accidental fires or explosion occur.

26.5.1.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, should a fire or explosion occur on site, a few environmental VCs risk being affected, as per Table 26.3-3.

Air Quality

A fire or explosion could affect the air quality through the volatilization of particulate matter and combustion gases (i.e., carbon monoxide, carbon dioxide, nitrous oxides, sulphur oxides, and other products of incomplete combustion). Any fire, whether it would be from fuel combustion or burning of organic matter, would release particulate matter and combustion gases into the atmosphere. However, these effects would be short-term and immediately local to the Project Site.

Noise

An explosion would potentially change the noise and vibration levels. However, it would solely occur during the blast or detonation itself, and be very short term. The noise and vibration levels would return to pre explosion levels once the explosion is contained.

Groundwater Quality and Groundwater Quantity

Water used to extinguish a fire could be sourced from the TMF reclaim pond in an emergency and has the potential to transport metals or other soluble compounds (including fire retardant, nitrogen compounds, and sediment) and infiltrate the soil, therefore potentially affecting groundwater quality and groundwater quantity. However, the extent of the infiltration will be the immediate vicinity of the fire (i.e., limited to the Project Site) and will be restricted to the duration of the fire-fighting operations. Moreover, the run-off water within the Project Site would be contained on site by the mine contact water collection system. As a result, any potential interaction with groundwater will be very limited.

26.5.1.4 Risk Assessment

Even though the Project will put in place several prevention and response procedures to minimize or eliminate the potential for a fire or explosion occurring, a conservative probability rating of **Moderate** has been allocated since there will be inflammable materials used throughout the life of the Project.

Due to the response mitigation, extent, and magnitude of potential effects, it is not anticipated that a fire or explosion on site would permanently alter the receiving environment. Moreover, the event would be detected within a relatively short timeframe and responded to, and the impacts would be of low magnitude and temporary. As a result, a conservative consequence rating of **Low** was allocated.

The overall risk assessment for a fire or explosion on site is **Moderately Low**.

26.5.2 Scenario 2: Fire or Explosion Causing a Wildfire

A forest fire caused by a fire or explosion on the Project Site could expand outside the boundaries of the Project and therefore cause a wildfire. A wildfire could also arise from an off-site vehicle accident. In this case, there are substantially greater effects and the potential extent of the fire is regional in scale, and could have a significantly longer duration. A large-scale wildfire has substantial effects on the landscape, and can alter terrain and surface water flows, with potential effects on groundwater resources.

26.5.2.1 Low-risk Effects

As per Table 26.3-3, a fire or explosion causing a wildfire is anticipated to affect all environmental VCs. No low-risk effects are expected.

26.5.2.2 Mitigation Measures

HCMC has developed the following environmental management plans to prevent and mitigate potential fires or explosions causing a wildfire:

- Emergency Response Plan;
- Explosives Handling Plan;
- Fuel and Hazardous Materials Management Plan;
- Site Water Management Plan;
- Spill Prevention and Response Plan;
- Traffic and Access Management Plan; and
- Waste Management Plan.

Project Design Measures to Minimize Risk

The Project has been designed to include the following considerations and best management practices to prevent and decrease the likelihood of a fire or explosion causing a wildfire:

- all site forestry clearing operations will comply with the terms of the Forest Fire Prevention and Suppression Regulation (BC Reg. 169/95), which forms part of the *Forest Practices Code of British Columbia Act* (1996a);
- all operations will comply with fire hazard ratings, and activities could be postponed if they were to occur during high-risk periods;
- activities will be carefully managed to minimize the risk of fire, especially during construction clearing activities;
- brush fires caused by an escaped slash burn would be minimized to the extent possible by ensuring slash is burned only in clearings and not at times when the forest fire hazard is high; slash burns would be carefully monitored;
- all personnel handling dangerous goods will be trained and provided with appropriate personal protective equipment;
- there will be constraints on refuelling in areas in the proximity of inflammable vegetation;
- chemical storage areas will be designated as non-smoking areas;
- smoking will be strictly prohibited during refuelling operations and operators will be required to be in attendance for the duration of the fuelling operation;
- fire extinguishers and fire prevention materials will be adequate and appropriate for the material being transported;
- fuel will be stored in appropriately sized tank with secondary containment; and
- employees will be trained in fire prevention, early detection, and effective firefighting techniques to assist in protecting the proposed Project Site and surrounding area from fire.

Emergency Response Procedures

Should a fire or explosion be at risk of causing a wildfire, despite the above-mentioned mitigation and preventative measures, the following emergency response approach would be initiated, in addition to those for a fire or explosion on site:

- any forest fires that pose a risk to humans or Project infrastructure would be extinguished by professionally trained personnel as soon as possible;
- employees will be designated to remain in close contact with the BC MFLNRO fire control staff during the fire season to identify any fire threats that may occur at or near the proposed Project Site; and
- it is expected that wildfire suppression would be coordinated through the Kamloops office of the BC MFLNRO.

26.5.2.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, should a fire or explosion cause a wildfire, all environmental VCs risk being affected, as per Table 26.3-3.

Air Quality

Wildfires can have significant impacts on local air quality, visibility, and human health through the volatilization of particulate matter and combustion gases. Emissions from forest fires can travel large distances, affecting air quality and human health far from the originating fire. Direct effects can include injury or fatalities, as well as wider effects through the reduction of air quality in the regional area. The smoke from forest fires can adversely affect the health of people outside the immediate area of the wildfire and may lead to respiratory issues for certain people. Fire-fighting personnel may be injured or killed during fire-fighting operations, and the potential spread of forest fires to residential areas increases the probabilities of civilian injuries. In the case of a fire following an off-site vehicle collision, the burning of fuel could result in a smoke plume. However, it is anticipated that the effects will be short-term and in close proximity to the fire, provided that measures are put in place to stop the fire rapidly.

Noise

A wildfire caused by an explosion would momentarily increase the noise and vibration levels during the blast or detonation. However, these levels would return to pre-fire or explosion levels once the fire or explosion is contained. Emergency response and clean-up measures are expected to increase the noise levels in the area, but this would be limited to the duration of the immediate response and clean-up measures.

Groundwater Quantity and Groundwater Quality

A large-scale wildfire can have substantial effects on the landscape and can alter terrain and surface water flows, with the potential for effects to groundwater resources. Fire also causes chemical changes in the soil that increase soil hydrophobicity, which reduces infiltration rates and can result in increased overland flow and associated soil erosion, especially in association with fine-textured soils. As a result, no significant effects to groundwater quality are expected. However, groundwater quantity could be affected for a short period of time if groundwater is sourced for fighting the fire.

Surface Water Quantity, Surface Water Quality, and Aquatic Resources

Wildfires have immediate effects on surface water quality, including increasing water temperature, altered water chemistry from absorption of smoke and deposition of ash, volatile organic compounds and other burning residuals, increased sedimentation, and reduction in dissolved oxygen. Aquatic resources, such as aquatic invertebrates, may experience direct mortality as well as indirect effects from changes to surface water quality and flows.

Stream ecosystems tend to recover from fire-related disturbances in the short-term, although the recovery is dependent on complex interactions between hydrology, the deposition of coarse woody debris into the freshwater environment, and biological re-colonization from unaffected areas (Minshall 2003; Mellon, Wipfli, and Li 2008; Arkle, Pilloid, and Strickler 2010). Active restoration measures are known to enhance the recovery from the effects of wildfires of the aquatic ecosystems (Minshall 2003).

Fish and Fish Habitat

Fire may cause direct mortality in affected reaches, as well as longer-term effects due to habitat loss, disruption of foodwebs, as well as disruption of flow and movement (Dunham et al. 2003). Run-off from fire water could enter the aquatic environment and potentially cause harmful alteration to fish habitat in adjacent watercourses due to increases in suspended particulate matter and possible traces of hydrocarbons.

The resiliency of fish and fish habitat to the effects of forest fires is dynamic and dependent on a complex web of biotic and abiotic factors (Rieman and Dunham 2000; Dunham et al. 2003). The recovery of fish populations after a fire can extend into the medium-term (i.e., between 2 and 30 years; Dunham et al. 2003) if there are barriers to migration and re-colonization.

Vegetation

Wildfires have substantial effects on the landscape, resulting in large-scale changes to forest vegetation composition, wetlands, and soils. The consumption of tree and understory vegetation cover and humus can expose soils to precipitation and elevated rates of soil erosion. Fire also causes chemical changes in the soil that increase soil hydrophobicity, which reduces infiltration rates and can result in increased overland flow and associated soil erosion, especially in association with fine-textured soils. The resultant effects to rare plants, ECAR, wetlands, and old-growth forest may be of higher magnitude, longer duration, and regional in extent.

Wildlife

A wildfire that would burn uncontrollably would significantly affect wildlife habitat and potentially result in direct mortality to wildlife populations, especially those with low mobility, or during breeding or nesting season. Wildlife habitat may also be degraded through fragmentation and ash deposition into areas not directly affected by the fire.

26.5.2.4 Risk Assessment

Even though the Project will put in place several prevention and response procedures to minimize or eliminate the potential for a Project-induced fire or explosion to cause a wildfire, a probability rating of **Low** has been allocated since a few distinct Project-related events could potentially cause a fire or explosion to spread into a wildfire. Such events may include a fire due to a fuel spill that may extend to outside the Project Site or a fire caused by an off-site vehicle collision (fires caused by external sources, such as environmental factors, are discussed in Chapter 27, Effects of the Environment on the Project).

Despite considering the emergency response procedures and mitigation measures, a wildfire could impact several VCs over a large period of time and geographical extent. As a result, a consequence rating of **High** was allocated.

The overall risk assessment for a fire or explosion causing a wildfire is **Moderate.**

26.6 FAILURE OF SEDIMENT AND EROSION CONTROL MEASURES

During the Construction and Operation phases, certain activities will require diversion channels and sediment ponds at strategic locations to prevent sediment-laden water from active zones entering nearby water courses. Water management (sediment control) ponds are used to detain runoff from disturbed areas so that sediment can settle out and be captured. These ponds will be situated downstream of the TMF embankment, PAG LGO stockpile, non-PAG waste rock stockpile. The ponds will provide a collection point for surface runoff and infiltration from the stockpiles as a result of precipitation in these areas, and for seepage. All water collected will be pumped to the TMF supernatant pond for long-term storage and use as reclaim water for process purposes.

26.6.1 Scenario 1: Failure of Sediment and Erosion Control Measures

A number of factors can affect erosion, namely the amount of vegetative cover, the slope length, velocity and volume of runoff, and extant erosion control measures. The release of sediment-laden water into the downstream receiving environment could occur from the open pit (Post-Closure), waste rock and overburden stockpiles, ore stockpiles, and TMF. This scenario assumes a failure of the sediment and erosion control measures, which will lead to increased surface erosion from disturbed areas, increased sediment load to downstream receiving environments, and siltation or erosion of downstream watercourses or waterbodies.

26.6.1.1 Low-risk Effects

As per Table 26.3-3, failure of sediment and erosion control measures is unlikely to affect air quality, noise, groundwater quality, and groundwater quantity.

26.6.1.2 Mitigation Measures

HCMC has developed the following environmental management plans to prevent and mitigate a failure of sediment and erosion control measures:

- Emergency Response Plan;
- Fish and Aquatics Effects Monitoring and Management Plans;
- Mine Waste and ML/ARD Management Plan;
- Groundwater Management Plan;
- Sediment and Erosion Control Plan;
- Site Water Management Plan;
- Soil Salvage and Storage Plan;
- Spill Prevention and Response Plan; and
- Vegetation Management Plan.

Project Design Measures to Minimize Risk

The Project has been designed to include the following considerations and best management practices to prevent and decrease the likelihood of a failure of the sediment and erosion control measures:

- sufficient supply of erosion prevention and sediment control materials will be kept at site for the spring melt through the autumn period;
- records of mitigation of erosion events will be kept to improve future management techniques (adaptive management);
- sediment control measures will be inspected routinely to ensure they are installed and operating correctly;
- all temporary sediment and erosion control features will undergo regular maintenance;
- the pipelines and pumping systems for the water management ponds have been designed to convey peak mean monthly runoff, which occurs during the month of June; and
- all major dams will be inspected annually by an independent geotechnical engineer, as required by the Mines Act (1996b) permit. Any problem areas would be repaired immediately. Water will be controlled in a manner that minimizes erosion in areas disturbed by construction activities and prevents the release of sediment-laden water to the receiving environment. This includes the collection and diversion of surface water runoff, sediment control ponds, and pump-back systems.

Sediment mobilization and erosion will be managed throughout the site by:

- installing sediment controls prior to construction activities;
- limiting the extents of disturbance as much as is practical;

- reducing water velocity across the ground, particularly on exposed surfaces and in areas where water concentrates;
- progressively rehabilitating disturbed land and constructing drainage controls to improve the stability of rehabilitated land;
- protecting natural drainages and watercourses by constructing appropriate sediment control devices such as collection and diversion ditches, sediment traps and sediment ponds;
- restricting access to rehabilitated areas; and
- constructing surface drainage controls to intercept surface runoff.

Emergency Response Procedures

Should a failure of the sediment and erosion control measures occur, despite the above-mentioned mitigation and preventative measures, the following emergency response approach would be initiated:

- immediately after a sediment control failure is noticed, silt screens would be deployed to intercept as much of the silt as possible before it enters any watercourse. If possible, upslope water would be diverted to an alternate location. Silt screens would be placed on the upstream side of the failed sediment pond's dike to aid in filtering out sediment while the dike is repaired;
- a report would be filed with the Mine Manager and the incident reviewed by the Mine Environmental Supervisor and the HCMC executive team to determine what preventative actions are appropriate to prevent a repeat; and
- restoration actions appropriate to the incident will be carried out according to the Sediment and Erosion Control Plan, including monitoring for sediment intrusion into waterbodies until the risk is ameliorated.

26.6.1.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures, several environmental VCs risk being affected by a failure of the sediment and erosion control measures, as per Table 26.3-3.

Surface Water Quantity, Surface Water Quality, and Aquatic Resources

Potential effects on surface water quality, surface water quantity, and aquatic resources include increases in the concentration of suspended material, alteration of sediment quality, and mortality of aquatic biota due to smothering by sediment. Deposition of sediment into a watercourse would increase concentrations of suspended material and decrease water quality. These effects could alter surface water quality, surface water quantity, and aquatic resources for considerable distances downstream. Once the source of the sediment is removed, aquatic resources are generally resilient to the effects of increased suspended material. The potential effects of a large sediment transport event into a watercourse could include the temporary alteration of water quality, both during the event and after cleanup as storm events remobilize deposited sediment, increasing turbidity. The geographic extent and magnitude of the environmental effects of a major sediment release to a watercourse could be significant. However, the temporal effects can be reduced and managed with the application of well-defined emergency response procedures, complemented by additional mitigation and compensation measures as identified in a follow-up and monitoring plan. Mitigation and clean-up measures would begin with containing the sediment, both at the source and at accessible downstream locations. Immediate removal of sediment from the watercourse may be required to prevent further damage from avulsions or debris flows.

Monitoring the residual effects on surface water and aquatic resources would begin during the clean-up phase and would include collection of downstream water quality samples and characterizing aquatic resources in affected areas.

Fish and Fish Habitat

Major sedimentation events, such as landslides, may affect fish and fish habitat by altering or destroying in-stream habitat, increasing concentrations of suspended material, smothering substrates that are used for food production and spawning, and causing direct or indirect mortality of fish.

A mass wasting event into a stream may block flow, which can lead to flooding upstream, avulsions, and scouring. In addition, the increased sediment in the stream may cause sediment deposition in fish habitat. These events may alter the suitability of habitat for various fish life stages. The effects of such habitat alterations may be evident for some distance downstream. Prompt removal of the constriction reduces the potential for long-term habitat alteration and destruction; however, sediment deposition in critical habitats may take several years to be flushed out by natural floods.

Characterizing the effects of a major sediment transport event on fish and fish habitat would occur during the clean-up phase. Effects to fish habitat would be characterized through habitat surveys upstream and downstream of the release site. These surveys would document changes to stream morphology, substrate quality, and habitat availability. Habitat surveys would be repeated periodically to monitor the recovery of habitat and to recommend adaptive management strategies.

Effects on the fish community are more difficult to determine; however, a fish sampling program would be initiated to compare fish populations in downstream areas to those in unaffected streams of similar size. Any observed mortalities would be documented.

The potential effects of a major sediment release to a watercourse could include the loss or alteration of fish habitat and direct or indirect mortality of fish. The temporal extent of these effects could range from temporary (up to four years) to permanent, depending on the scope of the sediment release and the potential secondary impacts from debris flows and avulsions. The most likely outcome would be a temporary alteration of in-stream habitat that could see fish move from the area until it stabilizes.

Vegetation

Vegetation could be affected by a major sediment release to a watercourse by direct damage to riparian vegetation. Sediment may smother vegetation, particularly if there are flooding or debris flows associated with the sediment transport. Mitigation measures to limit the extent of the impact to terrestrial ecosystems include re-vegetation of disturbed areas and monitoring of the success of planted vegetation.

The effects from a major sedimentation event into a watercourse would be predicted to be local and short-term because of the natural processes of dispersion and regrowth, as well as the re-vegetation efforts applied as mitigation. The effects to the terrestrial environment are expected to be reversible after restoration and due to the natural processes of dispersion.

Wildlife

Wildlife could be affected by major sedimentation events such as landslides, through alteration, degradation or loss of habitat and the availability of prey, and sensory disturbance due to the eroded soil. Decreases in ecosystem productivity could reduce the availability of food sources for some wildlife species. However, the availability of food and habitat would increase with the re-vegetation and restoration of the habitat and the effects to the wildlife are then predicted to decrease. As a result, the effects to wildlife are predicted to be reversible but, to be conservative, the recovery may occur over the medium-term (i.e., greater than two years).

26.6.1.4 Risk Assessment

Even though the Project will put in place several prevention and response procedures to minimize or eliminate the potential for failure of sediment and erosion control measures, a probability rating of **Low** has been allocated since there will be several sediment ponds and erosion control measures throughout the site.

Despite considering the emergency response procedures and mitigation measures, a failure of sediment and erosion control measures could impact several environmental VCs over a short period of time, in the vicinity of the sediment release. As a result, a consequence rating of **Low** was allocated.

The overall risk assessment for a failure of sediment and erosion control measures is **Low.**

26.7 FAILURE OF THE TMF CONTAINMENT DAM

The TMF has been designed to provide for secure and permanent storage for 585 million tonnes (Mt) of tailings and 237 Mt of PAG waste rock and an anticipated surplus water volume of up to 180 Mm^3 from the proposed mining operation (Knight Piésold Ltd. 2014). The balance of the tailings (low grade ore processed in Years 24 to 28) will be deposited into the open pit. The main (south) TMF embankment will be developed in stages throughout the life of the Project using a combination of suitable non-PAG overburden and waste rock from the open pit and/or local borrow sources. The south embankment will be raised on an annual basis.

The TMF is located in a bowl-shaped basin in the upper reaches of an un-named tributary to Harper Creek (T-Creek). The upper reaches of the tributary in the vicinity of the TMF are classified as non-fish habitat and is isolated from migratory fish by a natural fish gradient barrier. The catchment is hydraulically contained by topography on three sides and will be confined by constructing an earthen dam on the fourth side to create the TMF. The TMF has been sited in the preferred location after an examination of potential alternatives, as discussed further in Chapter 4, Project Design and Alternatives Assessment.

The tailings dam will be constructed in several stages to provide the necessary storage capacity over the life of the Project. The dam will consist of a cofferdam and an initial starter embankment (Stage 1) constructed during the Construction phase, an embankment raise during the first year of Operations, and annual staged expansions thereafter over the life of the Project using the centreline method of construction. The ongoing annual raises of the embankment crest to support the staged expansion will be carried out during the summer months of Operations (Knight Piésold Ltd. 2014).

The final stage of the main embankment is designed to reach an elevation of 1,836 metres (m), which is approximately 185 m in height at the maximum dam section. It will be capable of securely storing the tailings and PAG waste rock, as well as the site contact water, and the inflow design flood (IDF) with at least 1 m of freeboard for wave run-up (Knight Piésold Ltd. 2014). The general arrangement (site plan) of the ultimate embankment is shown on Figure 5.8-4 of the Project Description.

This assessment considers the effects of two potential accidents or malfunctions: a flood caused by overtopping of the embankment and a catastrophic failure. By focusing the assessment on these scenarios, it is intended to cover the range of potential effects of such accidents or malfunctions.

The residual effects from both an overtopping of the TMF and from a catastrophic TMF dam failure would likely be significant, and many effects could endure into the far future. A preliminary and conservative qualitative assessment of the temporal and geographical extent of the effects of a these two scenarios is discussed here.

A Dam Breach Inundation Study will be prepared by the qualified design engineers for incorporation into the Emergency Response Plan. This will be done in conjunction with development of the TMF Final Design Report which will be completed prior to construction of the TMF, and the Operation, Monitoring and Surveillance (OMS) Manual which will be completed prior to operation of the TMF.

26.7.1 Scenario 1: Overtopping of Dam

This scenario assumes that an unknown volume of water overtops the larger, south embankment. The wash of water may carry some tailings and embankment material along with it. Although it is possible that an overtopping event may occur on the smaller, north embankment, the south embankment will be constructed earlier in the Project and the time period over which effects could be experienced would thus be considerably greater. This scenario would most likely be a discrete event (i.e., with a definite start and end time), which would release a wave of water into the downstream environment. Despite the fact that TMF dam will be designed to meet all current Canadian Dam Association (CDA) *Dam Safety Guidelines* (2007 (Revised 2013)) and handle the inflow design flood (IDF) while maintaining a minimum 1 m of freeboard between the water level and the dam crest, dam overtopping could conceivably be caused by an extreme hydrologic event, such as an unprecedented rain storm during the spring melt (i.e., a rain-on-snow event). In such an event, as the pulse of water travels down into the receiving environment, it would most likely scour streambeds, and potentially interact with any vegetation or human structures (e.g., cabins, bridges, roads) that occur in close proximity to affected waterbodies. This effect could occur during Project Construction and Operations. It is unlikely this event would occur during Project Closure or Post-Closure as a spillway will be constructed that would minimize the risk of an overtopping failure.

The TMF drains to T-Creek, which drains to Harper Creek and then to the Barrière River, and ultimately to the North Thompson River 61 km downstream (Figure 26.7-1). As the resultant pulse of water would be dependent on the volume and conditions of the failure, it is impossible to predict how far downstream the pulse of water would travel before being attenuated. However, for the sake of this analysis, it is assumed that the pulse would reach the North Thompson River before being fully attenuated.

The Project's TMF is located in a non-fish bearing area and is isolated from migratory fish by a natural fish barrier 2.3 km downstream of the south embankment. Bull Trout habitat exists immediately downstream of the fish barrier. At 4.5 km downstream of the TMF there is another fish passage barrier, below which exists habitat for multiple fish species in the lower reaches of Harper Creek. A number of fish species exist within the Barrière River, including Coho Salmon, Sockeye Salmon, Chinook Salmon, Rainbow Trout, Bull Trout, Kokanee Salmon, Steelhead, Burbot, Longnose Dace, Redside Shiner, Mountain Whitefish, Dolly Varden, and Sculpin. Chinook, Coho, and Sockeye Salmon spawn in the Barrière River. These fish species are also present in the North Thompson River. As well, Chinook, Coho, Pink, and Sockeye Salmon spawn in the North Thompson River.

The waterbodies downstream of the TMF also occur within the traditional territories of Simpcw First Nation (refer to Figure 22.1-1), and Neskonlith Indian Band, Adams Lake Indian Band, and Little Shuswap Indian Band (as part of the Lakes Division Secwepemc traditional territory; refer to Figure 22.1-2). Simpcw First Nation has identified subsistence/fishing places downstream of the TMF dam in Harper Creek, Barrière River, and North Thompson River (see Figures 18.4-10). Simpcw First Nation has also identified trails along those waterbodies (Figure 18.4.-11), and the Harper Creek corridor as a culturally important landscape (Figures 18.4-11 and 18.4-12).

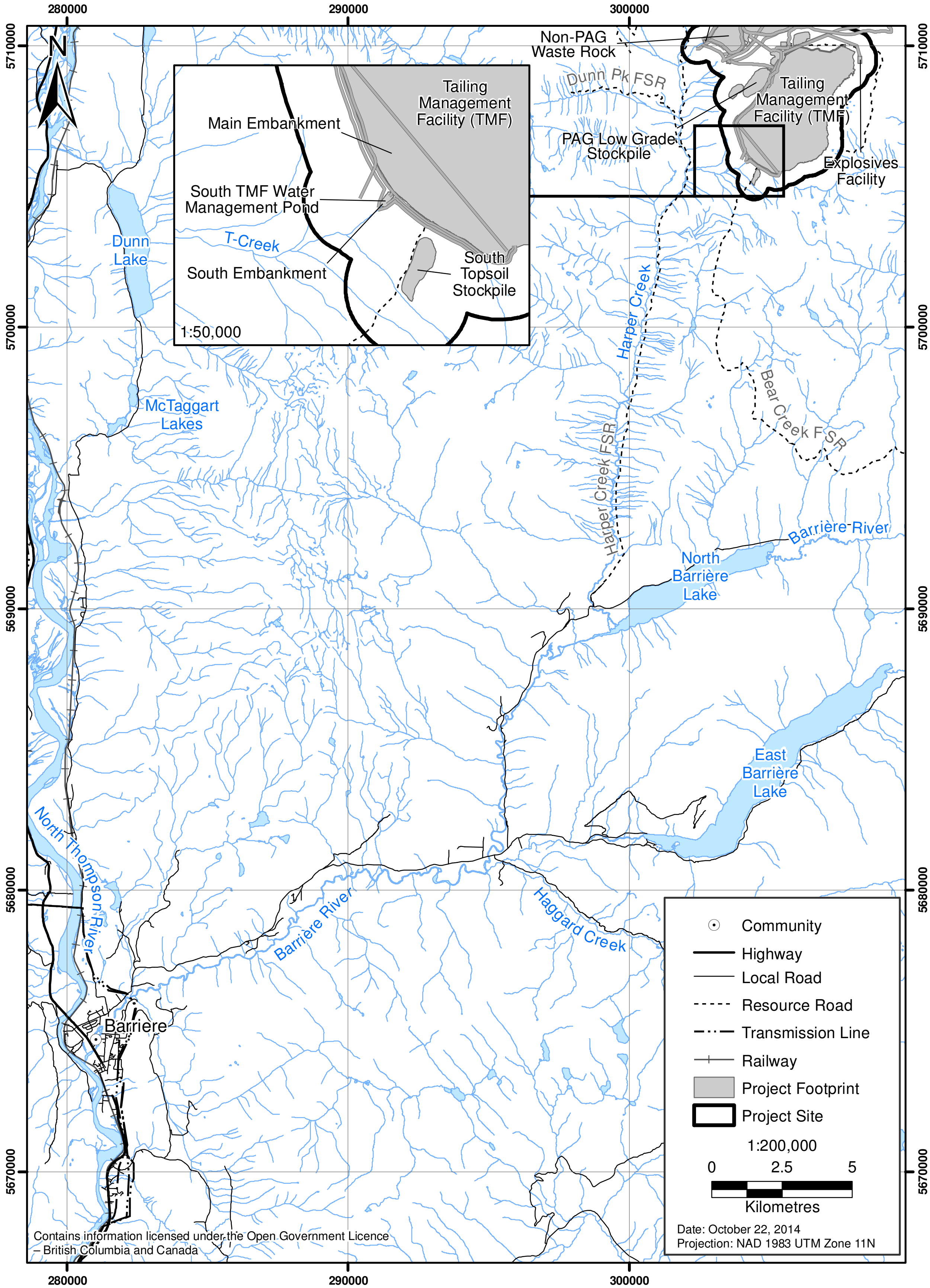
The eastern edge of the Dunn Creek Protected Area lies downstream of the confluence of T-Creek and Harper Creek (see Figure 18.4-6). The closest recreation sites downstream of the TMF are a campground and the North Barrière Lake Resort along the north edge of North Barrière Lake. Although these sites may or may not be directly affected by any TMF-related incidents (Figures 18.4-6 and 18.4-7), their value as recreational sites may be negatively affected under this scenario by impacts to Harper Creek and North Barrière River. Otherwise, the closest recreation site downstream of the TMF is located in the community of Barriere. Several environment, conservation, and recreation tenures exist downstream of the TMF along the Barrière River (see Figure 18.4-7).

The closest guide outfitting tenure (i.e., Guiding Territory Certificate) downstream of the TMF lies just to the south of Kamloops, which is approximately 130 km downstream. It is not expected that any failure of the dam would affect use of tenure. Multiple range tenures exist downstream of the TMF (Figure 18.4-3). Multiple water licenses exist downstream of the TMF, particularly near the Barrière and North Thompson rivers (see Figure 18.5-4).

Figure 26.7-1

Harper Creek Project: Tailing Management Facility Dam Failure Scenario - Potentially Affected Waterbodies

ERM



26.7.1.1 Low-risk Effects

Low-risk effects from a TMF overtopping event would include effects to air quality, noise, groundwater quality and quantity, and terrestrial invertebrates.

26.7.1.2 Mitigation Measures

Environmental Management Plans

HCMC has developed the following environmental management plans to prevent and mitigate an overtopping of the dam:

- Emergency Response Plan;
- Fish and Aquatic Effects Monitoring and Management Plan;
- Mine Waste and ML/ARD Management Plan;
- Sediment and Erosion Control Plan;
- Traffic and Access Management Plan;
- Vegetation Management Plan; and
- Wildlife Management Plan.

Project Design Measures to Minimize Risk

The Waste and Water Management Facilities Feasibility Study Report included as Appendix 5-D identifies design measures that were taken to prevent and mitigate overtopping of the dam (Knight Piésold Ltd. 2014). The design and location of the TMF has taken into account the following general design requirements:

- situating the TMF away from sensitive environmental features including fish bearing drainages;
- clustering the facilities to minimize the overall footprint;
- permanent, secure, and total confinement of all solid waste materials within engineered disposal facilities;
- control, collection, and removal of free-draining liquids from the tailings facilities during operations for recycling as process water to the maximum practical extent;
- prevention of acid rock drainage (ARD) and minimization of metal leaching from reactive tailings and waste rock; and
- staged development of the facility over the life of the project (Knight Piésold Ltd. 2014).

As well, the TMF has been designed to meet all current Canadian Dam Association (CDA) *Dam Safety Guidelines* (the Guidelines; Canadian Dam Association 2007 (Revised 2013)). As per the Guidelines, each structure is assigned a "Dam Class" based on the incremental losses that would result from failure of the dam with respect to loss of life, environmental and cultural values, as well as infrastructure and economic losses. The Dam Class determines the required IDF and earthquake design ground motion (EDGM) for the design of the dam structure and water management systems. The dam classification for the Project tailings dams is **very high**. A description of the dam safety consideration that contributes to dam classification is provided in Table 26.7-1. The following suggested design flood and earthquake levels were adopted from the Guidelines for the Project (Knight Piésold Ltd. 2014):

- IDF – 2/3 between 1 in 1,000 year return period and probable maximum flood (PMF); and
- EDGM – 1/2 between the 1 in 2,475 year return period and maximum credible earthquake (MCE).

A recent report released by the CDA, entitled *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (2014), suggests that in closure of the TMF, a mining dam should be designed for the probable maximum flood (PMF) and maximum credible earthquake (MCE) regardless of dam classification. Thus, the following design event levels were adopted for closure of the TMF (Knight Piésold Ltd. 2014):

- IDF – PMF (1 in 10,000 year return period); and
- EDGM – MCE (1 in 10,000 year return period).

A tailings deposition strategy will be implemented to selectively develop tailings beaches along the embankments, thereby producing an extensive low permeability zone that facilitates seepage control and maintains the operational supernatant pond away from the crest of the embankment. Selective tailings deposition will ensure that the beaches are saturated, thus reducing the potential for dust generation (Knight Piésold Ltd. 2014)

As described in the Mine Waste and ML/ARD Management Plan (Chapter 24.9), after the initial staging of the starter TMF embankment in Year 1, the annual staging of the TMF dam lifts will allow for each successive year of tailings (as well as PAG waste rock, operational pond volume, and storage of the inflow design flood to provide freeboard for wave run-up). Given that annual dam lifts will occur on an on-going basis for a period of approximately 22 years, the importance of comprehensive monitoring of the physical conditions pertaining at the TMF is clear.

Volumes of tailing deposited in the TMF will be monitored by reference to the records kept as part of the mine plan. These records will provide a basis for the purpose-designed monitoring of the performance of the TMF, which will also include visually checking the condition of embankment slopes and surface water control structures. The monitoring program will also include the installation of geotechnical instrumentation for the collection of data to confirm design assumptions, to evaluate stability performance, and to warn of potential failure mechanisms or deformation of slopes.

Table 26.7-1. Canadian Dam Association (2007) Dam Safety Guidelines – Dam Classification Categories

Dam Class	Population at Risk[1]	Incremental Losses		
		Potential for Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat. Restoration or compensation in kind impossible.	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances).
Very High	Permanent	100 or fewer	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).
High	Permanent	10 or fewer	Significant loss or deterioration of important fish or wildlife habitat. Restoration or compensation in kind highly possible.	High economic losses affecting infrastructure, public transportation, and commercial facilities.
Significant	Temporary Only	Unspecified	No significant loss or deterioration of fish or wildlife habitat. Loss of marginal habitat only. Restoration or compensation in kind highly possible.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes.
Low	None	0	Minimal short-term loss. No long-term loss.	Low economic losses; area contains limited infrastructure or services.

[1] *Definition for "population at risk:"*

- ***None*** *– there is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.*
- ***Temporary*** *– people are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).*
- ***Permanent*** *– the population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent resident); three consequences classes (high, very high, extreme) are proposed to allow for more detailed estimate of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).*

[2] *Implications for "loss of life:"*

- ***Unspecified*** *– the appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.*

The results of the monitoring program will be used to measure the success of the management strategies and to identify where additional mitigation may be necessary. Monitoring will continue for a period of time after mine closure to confirm that reclamation objectives are being achieved and to identify repair or maintenance requirements. Inspection and monitoring may include:

- visual inspection of embankments, crests, and slopes to check for signs of cracking, settlement, or bulging;
- visual inspection of the TMF embankment toe areas to check for signs of ground heave or seepage;
- installation of slope inclinometers during operation to monitor foundation deformation;
- installation of surface survey monuments during TMF construction; and
- deployment of wireline extensometers as required.

Monitoring and responding to any deformation of TMF embankments is critical to maintaining their stability. Slope inclinometers and wireline extensometers are appropriate instrumentation for such monitoring and HCMC will investigate their use or the use of similar instrumentation.

A schedule for routine inspection and instrumentation monitoring (OMS Manual) will be developed in conjunction with mine permitting based on the mine construction and operation schedule.

Instrumentation monitoring will be routinely completed during Construction and Operations (Knight Piésold Ltd. 2014). Measurements during construction will be taken and analysed on a routine basis to monitor the response of the embankment fill and the foundation from the loading of the embankment fill. The frequency of monitoring for the piezometers and inclinometers may be decreased once the effects of initial construction have dissipated. Surface monuments will be surveyed at least twice per year during Operations. The OSM Manual will be prepared following initial construction and prior to commissioning of the TMF, and will provide comprehensive operating instructions and monitoring frequencies for the TMF and related facilities.

During Closure and Post-Closure, the TMF closure spillway becomes active and excess site water is discharged via the spillway to the downstream receiving environment (Knight Piésold Ltd. 2014).

In addition to the instrumentation monitoring described above, the TMF dams would be inspected annually by the design geotechnical engineer-of-record, as would be required by the *Mines Act* (1996b) permit. The reviewer would be Qualified Professional Engineer as required in APEGBC's (2014) *Professional Practice Guidelines - Legislated Dam Safety Reviews in BC.* Any problem areas identified would be repaired immediately. Independent Dam Safety Reviews (DSR) to further monitor operation, maintenance, surveillance, and performance of the dams during Operations and Closure will be conducted. DSR frequencies will meet or exceed regulatory requirements.

Going forward, a Dam Breach Inundation Study will be prepared by the design engineers for incorporation into the Emergency Response Plan. This will be done in conjunction with development of the TMF Final Design Report which will be submitted prior to construction of the TMF, and the OMS Manual which will be submitted prior to operation of the TMF.

<u>Emergency Response Procedures</u>

In the event of upset conditions related to the overtopping of the TMF embankment, an on-site staff member tasked with the responsibility of coordinating the Emergency Response Plan described in Section 24.4 would launch an investigation of the incident and the following emergency response approach will be initiated:

- ensure the safety of the employees, site personnel, and the public;
- notify the appropriate stakeholders, including government agencies (e.g., the BC Provincial Emergency Program and Environment Canada Emergencies), and any nearby communities or landowners;
- mobilize the necessary equipment and crews to contain and clean up the incident and rehabilitate the site to protect the environment; and
- report the spill as per the BC provincial Spill Reporting Regulation (BC Reg. 263/90) and DFO (if the spill affected fish and fish habitat).

A site-wide communication system (including access roads) will ensure rapid notification of dam overtopping. The site will have a trained Emergency Response Team with resources to contain and recover spills, or to reduce the size of a spill if complete containment and recovery is not possible.

In the case of a dam overtopping incident, a program would be implemented to monitor any residual effects in the freshwater environment, including water quality, sediment quality, aquatic resources, fish, and fish habitat.

26.7.1.3 Potential Effects

Despite rigorous application of the mitigation measures and emergency response procedures listed above, should an overtopping of the TMF embankment occur, a few VCs risk being affected, as per Table 26.3-3.

<u>Surface Water Quality and Quantity</u>

The release of a pulse of water as a result of overtopping would likely have direct effects to surface water quality, including potential increases in metal concentrations, and increases in sedimentation. These effects would likely be local, short-term and reversible, with the exception of potential sedimentation effects. An extreme flood event capable of resulting in a dam overtop would also likely result in dilution of the TMF supernatant and extreme high flows in the downstream aquatic environment providing additional dilution. This highly diluted water would flow into Harper Creek, mixing with creek water and continue downstream. However, as this water would be heavily diluted, it is possible that there would be only minor effects due to metal concentrations. The most persistent effect to surface water quality would most likely be sedimentation caused by the scouring of creek beds and deposition of any released tailings material. Persistent effects from elevated metal levels in tailings deposited by the pulse outside the TMF footprint are possible in the absence of adequate assessment and restoration. The duration of sediment suspension in the water column would be dependent on the force and duration of the pulse of water. Post-event water quality studies would inform the need for adaptive mitigation. Over the long-term, this effect would most likely be fully reversible.

The release of a pulse of water from the TMF would likely have direct, short-term effects to water quantity downstream of the TMF. Depending on the force and duration of the pulse, the sudden release of water would scour streambeds and alter stream morphologies. After the cessation of the flood event, the water volumes downstream of the TMF would return to pre-disturbance levels, although stream morphology may be permanently altered. Even after mitigation and clean-up measures are applied, these effects would likely be irreversible.

Fish and Fish Habitat and Aquatic Resources

A sudden release of water from the TMF due to overtopping would likely have direct and indirect effects to fish and fish habitat. The rush of water, dependent upon volume and duration, may wash fish, fish habitat, and aquatic resources out of Harper Creek and potentially further downstream while scouring the creek beds and changing channel morphology. The scouring of the creek beds would cause sediment to become suspended in the water column. Sedimentation can clog fish gills and smother eggs. Fish, fish habitat, and aquatic resources would be affected by increased sedimentation for as long as it takes the sediment to settle out of the water column. Direct and indirect effects to fish and fish habitat and aquatic resources may also include effects from any tailings or dam material released in the event, which may smother fish or aquatic resources and cause alternations to water quality due to elevated metal levels. Fish habitat could also be permanently altered through changes in stream morphology and subsequent changes to aquatic resources. If such an event were to occur, HCMC would initiate an immediate assessment of the effects to fish and fish habitat, and would initiate clean-up and potential offsetting measures. Effects to fish, fish habitat, and aquatic resources would be expected to be local to the affected waterbodies and would likely be fully reversible over the medium- to long-term. Offset measures could be implemented to ensure no overall net loss of fish habitat.

Vegetation

Rare plants, ECARs and other sensitive ecosystems are often spatially correlated, occurring in areas where unusual environmental conditions create niche habitats. These habitats commonly are found in and adjacent to riparian areas. A pulse of water released from the TMF could result in the loss of vegetation VC adjacent to or within riparian areas due to scouring. Direct loss of plants and ecosystems could occur during the initial flooding. The duration and volume of water released would determine the severity of the flooding and effects on plants and ecosystems in the flood path.

Alteration of site conditions associated with a flood could have negative effects on the soils, light conditions, and successional pathways. Changes to the site conditions that support plants and ecosystems could include changes in soil quantity through deposition or erosion, changes in soil quality, and changes in site productivity associated with soil pH, moisture or nutrient regimes. Depending of flood severity, changes in canopy closure could result in changes to microclimate conditions including light availability, temperature, wind, and increased precipitation reaching the ground surface. These changes may be negative or positive depending on the plants or ecosystems affected. Individual plant species respond based on how well adapted they are to the new conditions. These responses can result in changes in vegetation community composition that favour pioneer species that displace other less competitive plants or communities.

Recovery of vegetation after a flood would be dependent on flood severity. Low severity events would typically have the least impact and recovery would often occur rapidly. However, for plant species sensitive to disturbance or with small populations, even low severity events could potentially result in loss of the species or community at that location. Recovery to pre-disturbance conditions becomes more uncertain as severity increases. In the case of very severe flooding, recovery may occur only over the long-term or may never occur. Due to the unique conditions required for many rare plants, ECARs and other sensitive ecosystems, restoration efforts are generally not successful. Establishment of vegetation communities that stabilize the riparian zone to reduce erosion and restore riparian functions should be the primary goal in the event of a flood.

Wildlife

A sudden release of water into the downstream environment from overtopping of the TMF would interact with wildlife through direct contact, alteration, degradation or loss of habitat, the availability of prey, and sensory disturbance due to subsequent clean-up and restoration efforts. Migratory birds could be affected to a larger extent if the event was to occur during breeding or nesting season.

The effects from direct contact with the pulse of water would likely be minor; direct mortality could occur if any individuals were caught in the rush of water. With the notable exception of amphibians (discussed below), the direct effects would be expected to be local and short-term, and would be reversible due to the discrete nature of the event. Likewise, sensory disturbance from clean-up and restoration activities would have local and short-term effects as these activities would occur over the short-term. Monitoring and follow-up programs would assess the longer-term effects and recovery of key indicator wildlife species, and would be used to assess the significance of indirect effects to wildlife, and identify and plan further mitigation and management measures.

Indirect effects to wildlife could occur because of effects to terrestrial ecology. Decreases in ecosystem productivity could reduce the availability of food sources for some wildlife species. However, the availability of food and habitat would increase with the re-vegetation and restoration of the habitat and the effects to wildlife are predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible but, to be conservative, the recovery may occur over the medium-term.

With respect to amphibians, the sudden release of water from the TMF could wash amphibians out of Harper Creek, depending upon the volume and duration of the event, and potentially further downstream. Direct effects could also include sedimentation and effects from any tailings or dam material released in the event, which could smother amphibians and their eggs. Changes to stream morphology could cause alteration or permanent loss of amphibian habitat. Indirect effects could include changes to habitat due to changes in stream morphology and decreases in available aquatic resources (i.e., food supply). These effects are predicted to be reversible over the medium- to long-term, as cleanup and restoration would restore habitat functionality for amphibians.

Land Use

Land use could be affected if the overtopping of the dam were to wash out any roads or bridges, or changes the navigability of any affected waterbodies. As scouring of the stream beds could alter stream morphology, the navigability of these waterways may be likewise affected. It may become difficult for Aboriginal peoples to access traditional use sites. Traditional land use may also be affected by changes to fish and fish habitat, and wildlife.

Mitigation measures would involve reconstruction of any affected bridges or roads and an assessment of any changes to the navigability of water ways. Changes to land use would be expected to be fully reversible over the medium-term, as clean-up and restoration efforts, and potential offsetting measures would restore the functionality of fish habitat. Changes to access would be expected to be fully reversible over the short-term as the Project area is networked with FSRs that could be used for alternate access to a particular site. Changes to navigation could potentially be irreversible, depending on the changes to stream morphology.

26.7.1.4 Risk Assessment

Even though TMF embankments will be designed to meet the CDA's Guidelines and the embankments will be designed and operated to contain most weather events, it is still remotely possible that a dam overtopping event may occur if an unprecedented extreme weather event were to occur. As per Table 26.3-5, a probability rating of **Negligible** has been allocated since the TMF embankments have been designed to store an IDF equal to a PMF (Knight Piésold Ltd. 2014).

Despite considering the emergency response procedures and mitigation measures, a dam overtopping event could impact several VCs into the far future, although the geographic extent would be limited to the downstream receiving environment. However, due to the potential permanent alteration to several VCs, particularly to stream morphology, a consequence rating of **High** was allocated.

As per Table 26.3-7, the overall risk assessment for a TMF embankment overtopping event is **Moderately Low.**

26.7.2 Scenario 2: Catastrophic Failure of TMF Dam

This scenario assumes that a catastrophic failure of the main (southern) embankment would cause a large volume of tailings and supernatant water to flow downstream, primarily into Harper Creek. This scenario would most likely be a discrete event (i.e., with a definite start and end time). Although catastrophic dam failures are extremely rare and the majority are caused by issues surrounding water, failure can also be caused by operational error or an unexpected seismic event (Engels 2014). Note that the effects of a seismic event are addressed in Section 27.5.3 in Chapter 27, Effects of the Environment on the Project, where the opinion is offered that the proposed Project would be at low risk of a damaging seismic event.

The scenario of a catastrophic failure of the main TMF embankment assumes that the tailings and supernatant water would discharge suddenly from the TMF, fanning out to an unknown distance downstream. Although it is unknown exactly how far downstream the receiving environment would be affected, for the purposes of this scenario assumes that the downstream environment to the community of Barriere would be directly affected. Indirect effects further downstream are also assumed from potential changes to water quality. To be conservative, it is assumed that this effect may occur during any Project phase.

26.7.2.1 Mitigation Measures

The design, mitigation, monitoring measures, and emergency response approach which will be implemented to prevent an overtopping of a dam are the same as for a catastrophic TMF dam failure. These measures are presented in Section 26.7.1.

26.7.2.2 Residual Effects

The residual effects from a catastrophic TMF dam failure would be significant, and many effects could endure into the far future. A preliminary and conservative qualitative assessment of the temporal and geographical extent of the effects of a catastrophic dam break is presented here for downstream receptors, including surface water quality and quantity, aquatic resources, fish and fish habitat, rare plants and ecological communities, wildlife, traditional land use, and social and economic receptors.

A Dam Breach Inundation Study will be prepared by the design engineers for incorporation into the Emergency Response Plan. This will be done in conjunction with development of the TMF Final Design Report which will be submitted prior to construction of the TMF, and the OMS Manual which will be prepared prior to operation of the TMF.

<u>Surface Water Quantity and Quality</u>

A catastrophic dam failure would have high magnitude, direct and potentially irreversible effects to the aquatic environment. Potential effects on surface water quality include increases in the concentration of suspended material through direct sediment loading from tailings release as well as from scouring of streambeds, altered chemical composition of the water, and altered sediment quality. ARD lag times of any residual exposed PAG material are likely long enough that full capping and clean-up efforts could be completed prior to any ARD generation. The geographic extent would be regional and would include directly affected waterbodies and downstream aquatic environments (i.e., beyond North Barrière Lake). Mitigation and clean-up measures would begin with containing the tailings, both at the source and at accessible downstream locations. Persistent effects from elevated metal levels in tailings solids and waste rock material deposited outside the TMF footprint are likely in the absence of adequate assessment and restoration.

The release of a pulse of water from the TMF would likely have direct and immediate effects to water quantity downstream of the TMF. The deposition of tailings would likely alter stream morphologies. The sudden release of supernatant water would also scour streambeds and alter stream morphologies. After the cessation of the event, the water volumes downstream of the TMF would likely return to pre-disturbance levels, although stream morphology would likely be permanently altered. Even after mitigation and clean-up measures are applied, stream morphology effects would likely be irreversible. As well, removal of tailings deposits from the watercourse, to the degree possible, may be recommended to prevent further damage from avulsions or debris flows.

Characterizing the effects of a catastrophic dam failure on the aquatic environment would occur during the clean-up phase. Effects to surface water quality and quantity would be characterized through ongoing surveys. These surveys would be repeated periodically, as needed, to monitor the recovery of the aquatic environment and to recommend adaptive management strategies.

Fish and Fish Habitat, and Aquatic Resources

A catastrophic dam failure would have direct and indirect effects to fish and fish habitat, and these effects would likely be regional to the directly affected waterbodies and those downstream through potential decreases in water quality. The sudden release of water and tailings would directly affect fish and fish habitat, and aquatic resources by washing or smothering fish and aquatic organisms out of the downstream environment and scouring the creek beds. TMF supernatant water would flow into Harper Creek, mixing with and displacing creek water and likely continue downstream and beyond. If a large enough volume of tailings were released, the Harper Creek bottom would be partly or completely covered, potentially affecting or eliminating more fish habitat. The released tailings could lodge in the tributary streams of Harper Creek, covering fish habitat. Indirect effects on fish and other aquatic organisms could potentially be acute and chronic toxicity. Chronic toxic effects could be expected to last until elevated contaminants had leached out of the tailings for as long as it would take metals to leach out of the deposited material. Chronic toxic effects may extend for a longer duration due to the persistence of some metals in the food web.

Characterizing the effects of a catastrophic dam failure on fish and fish habitat would occur during the clean-up phase. Effects to fish habitat would be characterized through habitat surveys. These surveys would document changes to stream morphology, water quality, and habitat availability. Habitat surveys and fish tissue analysis would be repeated periodically, as needed, to monitor the recovery of habitat and potential toxicities to fish, and to inform adaptive management strategies, which may include offsets for affected habitat. Any observed fish mortalities would be documented.

Although these effects would be significant in the medium-term, they are expected to be fully reversible in the far future, particularly through the implementation of adaptive mitigation measures, one of which may include habitat offsetting.

Vegetation

Vegetation could be affected by a catastrophic tailings dam failure to watercourses by direct damage to riparian, wetlands, or any other vegetation communities or rare plants occurring downstream of the TMF. As the tailings flow downstream, they would most likely create a fan, smothering any vegetation in the fan's footprint. Indirect effects on vegetation VCs could potentially be acute and chronic toxicity.

Characterizing the effects of a catastrophic dam failure on vegetation would occur during the clean-up phase through surveys. These surveys would document changes to community composition and the presence vegetation VCs. These surveys would also include metals analysis of indicator plant species. These surveys and analyses would be repeated periodically, as needed, to monitor the recovery of communities and potential toxicities to vegetation, and to inform adaptive management strategies.

The direct effects from a catastrophic dam failure are be predicted to be regional and long-term because of the natural processes of dispersion and regrowth, as well as the re-vegetation efforts applied as mitigation. These effects are expected to be partially reversible after clean-up and restoration efforts, as by their nature, sensitive ecosystems and rare plants require particularly unique conditions. The indirect effects due to toxicity, while still primarily being local to the affected area, would occur over the long-term and would be expected to occur until the tailings had been cleaned up or contaminants had leached out of the tailings. Chronic toxic effects may extend for a longer duration due to the persistence of some metals in the biotic environment.

Wildlife

A catastrophic dam failure would have direct effects to any wildlife caught in the outflow event, as these individuals could be killed by the event itself. However, this event would most likely be limited to a few occurrences. The more prominent and persistent effect would be the indirect effect of loss and degradation of wildlife habitat, particularly for any species that are highly dependent on wetland and riparian areas (e.g., waterbirds or moose). Food resources such as aquatic invertebrates, fish, or plants could be affected through acute or chronic toxicity. Clean-up and restoration efforts may present sensory disturbances to wildlife in the area.

Characterizing the effects of a catastrophic dam failure on wildlife would occur during the clean-up phase through surveys. These surveys would document changes to wildlife habitat and tracking wildlife use of the area over time. These surveys would also include metals analysis of target plant species, such as berries, or other food resources, such as fish, which are consumed by wildlife. These surveys and analyses would be repeated periodically, as needed, to monitor the recovery of wildlife and their habitat, potential toxicities to food resources, and to inform adaptive management strategies.

These effects are expected to be local to the affected area and may persist into the far future, although they would be reversible over time. Wildlife recovery may be enhanced through potential fish habitat offsetting efforts, which would provide appropriate habitat for some wildlife species.

Current Use of Lands and Resources for Traditional Purposes

A catastrophic dam failure would have direct effects to traditional land use, as fish resources downstream of the TMF dam would be unavailable after the event. Fish and fish habitat would be affected over the long-term. As well, even if the fish and fish habitat recover fully from the event, perceived potential contamination concerns could limit their use in the longer term.

Traditional use trails and current access roads may also be affected if they are washed out from the event.

As the Harper Creek corridor has been identified by Simpcw First Nation as a culturally important landscape, a catastrophic dam failure would have significant and irreversible effects on this cultural use.

Characterizing the effects of a catastrophic dam failure on traditional use would occur during the clean-up phase. Effects to fish and fish habitat would be characterized through surveys, which would include chemical analyses of fish tissue. These surveys would also include surveys of traditional trails and current access roads. These surveys and analyses would be repeated periodically, as needed, to monitor the recovery of fish and fish habitat, and potential toxicities to food resources, and to inform adaptive management strategies.

These effects would be expected to last into the far future, but would be at least partially reversible due to clean-up and restoration efforts, which may include repairing any access roads. Changes to access are expected to be fully reversible over the short-term as the Project area is networked with FSRs that could be used for alternate access to a particular site. It is difficult to predict the reversibility of the use of fish resources as the perception of contamination may persist even if analyses show the fish are safe for human consumption.

Economic

A catastrophic TMF failure would likely cause the Project to be put on care and maintenance, at least temporarily. This could cause HCMC to lay off staff, although significant numbers could be retained to undertake restoration measures. Such an event could have significant economic consequences for the regional economy. This effect would be regional in extent and would be reversible if the Project can restart, which would most likely occur over the medium-term.

The resort and campsite located on North Barrière Lake would also be likely affected by a catastrophic TMF failure. Access to these sites could become blocked and recreational users could be less likely to use these facilities due to potential water quality concerns in North Barrière Lake. Although site access is expected to be a short-term reversible effect, as any roads would be repaired as soon as possible after the event, the overall effect could be potentially irreversible, as the economic viability of the resort would be immediately affected.

Social

A catastrophic TMF failure could have effects on several social components, including the navigability and the use of water licenses in the downstream environment, and to community health and well-being.

Characterizing the effects of a catastrophic dam failure on the social environment would occur during the clean-up phase. Effects to navigation and water licenses would be characterized through surveys, which would include water quality analyses. These surveys and analyses would be repeated periodically, as needed, to monitor the recovery of water quality and any changes to the navigability of water ways, and to inform adaptive management strategies.

Changes to the use of water licenses would likely be local and potentially extend into the far future, but ultimately reversible as cleanup and restoration would ultimately restore water quality downstream. Changes to navigation would be local and extend into the far future, but could be irreversible, depending on the changes to stream morphology.

Community health and well-being would be affected by any Project shut-down. The Project is predicted to be a major employer in the region, and any shut-down would cause an economic downturn in regional communities. This effect would be regional in extent and would only be reversible once the Project can restart, which would most likely occur over the medium-term.

26.7.2.3 Risk Assessment

Even though TMF embankments will be designed to meet the CDA's Guidelines and the embankments will be designed and operated to contain most extreme weather events, it is still remotely possible that a catastrophic dam failure could occur in the event of an extreme weather event or an operational error. As per Table 26.3-5, a probability rating of **Negligible** has been allocated since the TMF embankments have been designed to store an IDF equal to a PMF, as well as an EDGM equal to a MCE. (Knight Piésold Ltd. 2014). During closure, the risk of such an event is lower, since the TMF has been designed for and IDF of the PMF and an EDGM of the MCE (Knight Piésold Ltd. 2014).

Despite considering the emergency response procedures and mitigation measures, a catastrophic dam failure would have severe effects impacting several VCs into the far future. Due to the potential permanent alteration to several VCs, particularly to stream morphology, current use of lands and resources for traditional purposes, and the economic environment, a consequence rating of **Severe** was allocated.

As per Table 26.3-7, the overall risk assessment for a catastrophic TMF dam failure event is **Moderate.**

26.8 SUMMARY

HCMC will implement a number of preventative features, mitigation measures and operational and best management practices intended to minimize the probability of accidents and malfunctions occurring, and the consequences of such events if they were to occur. Even with these in place, some accidents and malfunctions may occur at some time throughout the life of the Project.

Table 26.8-1 summarizes the environmental risk predicted for each accident and malfunction scenario.

By undertaking as part of the Application/EIS an evaluation of potential effects to the environment of any potential accidents or malfunctions during the Construction, Operations, and Closure phases of the Project, and incorporating the outcomes into the consideration of environmental risk effects, an evaluation of their potential implications for the viability of the Project has been possible.

The accidents and malfunction scenarios that emerge as possibly having a moderately-low to moderate environmental risk are a fire or explosion causing a wildfire, a fuel spill in water, and a catastrophic TMF dam failure. None of these are believed to pose constraints on the decision-making process regarding the proposed Project.

Table 26.8-1. Summary of Risk for the Potential Accidents and Malfunctions

Probability	Consequence				
	Negligible	Low	Moderate	High	Severe
Negligible			TMF embankment overtopping.		Catastrophic TMF dam failure.
Low		Fuel spill on land. Failure of sediment/erosion control measures.	Spill of hazardous substances on land. Spill of hazardous substances in water.	Fire or explosion causing a wildfire. Fuel spill in water.	
Moderate		Fire or explosion on site.			
High					
Severe					

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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