HARDROCK PROJECT
Final Environmental Impact Statement / Environmental Assessment

CHAPTER 22.0:
Assessment of Effects of Potential Accidents or Malfunctions

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22.1 INTRODUCTION

Under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), the environmental assessment of a designated project must address environmental effects of accidents or malfunctions that may occur in relation to the designated project. Accidents or malfunctions refer to events or upset conditions that are not part of normal activity/operation of the project as planned, and are related to the failure of project works. The risk of accidents or malfunctions can be reduced or eliminated through good planning and design, adoption of safety measures and emergency response planning.

22.2 APPROACH

The approach used to identify and assess potential accidents or malfunctions is described in this section. The process will include the following key steps:

1. Identify potential accidents or malfunctions, describe the general operating conditions that would lead to each accident or malfunction, and screen those accidents or malfunctions that warrant further investigation (based on consideration of the potential for residual adverse effects on valued components [VCs]).
2. For those accidents or malfunctions requiring further investigation, identify the safety measures that will be implemented to reduce or eliminate the risk of each accident or malfunction.
3. Identify the emergency response measures that could be implemented to manage the potential residual adverse effects of each accident or malfunction, should it occur.
4. Describe the potential residual adverse effects (after controls or safety measures have been applied) on VCs that would result from each accident or malfunction.
5. Assess the residual risk (after controls or safety measures have been applied) of each accident or malfunction based on the likelihood of the event occurring and the potential consequences of the event. Determinations of likelihood and severity consider the lifespan of each project component (as required by the EIS Guidelines).

22.2.1 Identification of Accidents or Malfunctions

Section 22.3 discusses each accident or malfunction key event scenario that was identified as having the potential to occur over the life of mine (LOM). Accidents or malfunctions were selected for further assessment based on a screening level analysis of the mechanisms that would lead to each accident or malfunction and the potential for that event to adversely affect the VCs identified in the Final Environmental Impact Statement/Environmental Assessment (EIS/EA).

22.2.2 Safety Measures

The Project is being designed, and will be constructed and operated, according to accepted standard practices for health, safety, and environmental management to reduce the risk of potential Project-related environmental effects, including those that could result from accidents or malfunctions. Safety measures will be put in place to reduce the potential for accidents or malfunctions by following these general principles:

- Use accepted standard management practices for carrying out the Project while controlling permitted or allowable releases to the environment and consequently limit environmental effects.
- Incorporate safety and reliability into the design of Project components, and application of principles and practices of process and mine safety management.
- Develop and apply procedures and training aimed at safe operation of the Project, that prevent or avoid the potential upset conditions that might lead to accidents or malfunctions.
- Provide training in operational procedures and environmental emergency response procedures, including safety measures to prevent accidents or malfunctions.
- Develop and implement an environmental management program for the Project to outline the proposed environmental protection measures and commitments to be carried out by Greenstone Gold Mines Inc. (GGM) and their contractors.

With regard to the tailings management facility (TMF), the design addresses the recommendations from the Independent Expert Engineering Investigation and Review Panel's *Report on the Mount Polley Tailings Storage Facility Breach* (2015), and a review of other recent project examples that inform a proactive approach to managing Project safety. GGM's commitment to quality assurance and safety includes staffing a senior geotechnical engineering position dedicated to TMF safety, and to fund an Independent TMF Review Board (ITRB) for the Project composed of three external experts.

22.2.3 Emergency Response Plan

The Conceptual Emergency Response Plan (ERP; Appendix M3) describes actions to be carried out in the event of an accident or malfunction, and procedures/protocols to provide rapid response to these events. The ERP will be advanced prior to construction and outline incident reporting and investigation.

Plans and procedures that will be developed include:

- training employees in operational procedures and environmental emergency response procedures including safety measures to respond to accidents or malfunctions
- preparing and maintaining an ERP.

Response procedures will include standard practices to be implemented for a range of scenarios based on the magnitude of potential risks. The priorities of the ERP will be 1) the protection of human life, 2) the protection of the environment, 3) the protection of property. The ERP will be developed prior to the initiation of relevant construction and operation activities.

The purpose of the ERP is to:

- facilitate prompt and efficient response actions for addressing emergencies or compliance issues
- identify the organization, responsibilities and reporting procedures of the emergency response team
- define appropriate communications protocols, including procedures to contact relevant regulatory agencies and Aboriginal communities related to an accident or malfunction event and follow up actions that will be taken
- provide site information on the facilities and contingencies in place should an emergency or compliance issue occur
- provide support and information on available resources, facilities and trained personnel in the event that an emergency occurs.

The United Nations Environmental Programme report titled *APELL for Mining: Guidance for the Mining Industry in Raising Awareness and Preparedness for Emergencies at Local Level* (UNEP 2001), which provides guidance for preventing accidents or limiting their effects, including through increasing community awareness and preparing coordinated response plans with industry, government and local communities, will be reviewed and considered during the development of the detailed ERP.

The ERP will be refined as the Project advances.

22.2.4 Effects Assessment

Section 22.4 provides a qualitative analysis of the potential residual adverse effects of each screened accident or malfunction. This analysis includes consideration of engineering and technical studies prepared as part of the Final EIS/EA, and relies on the expertise of the Project team.

The effects assessment focuses on the likelihood of each accident or malfunction and addresses safety measures and management approaches. The assessment focuses on environmental effects that have the potential to exceed the effects of regular operation of the Project. For example, emissions to the air from the operation of heavy machinery to clean up a spill would be considered within the regular operation of the Project, since heavy machinery is used on a daily basis.

For the purpose of the assessment of accidents and malfunctions, traditional knowledge and traditional land and resource use (TLRU) information was considered at a landscape level to determine where accidents or malfunctions would have the potential to affect traditional uses. Mapping, provided in Appendix J, was used to identify where potential effects may extend to Aboriginal sites or areas, and where community-specific information was not available, a general assumption was made on the potential to affect TLRU based on the potential to affect other VCs (e.g., disruptions to fish habitat could have a localized effect on Aboriginal fishing activity in that location). Due to the unique nature of accidents or malfunctions, each event has the potential to affect different VCs. The analysis focuses on the individual specific VCs that are most likely to be affected for each specific accident or malfunction. Significance thresholds that are used in this assessment are presented for each VC in Chapters 7.0 through 19.0.

22.2.5 Risk Assessment

Section 22.5 provides an assessment of the residual risk of each selected accident or malfunction. This is based on the potential residual adverse effects associated with each accident or malfunction (considering emergency response measures that will be implemented) and the likelihood of the event occurring (after safety measures are applied).

Risk is determined as a function of likelihood (frequency of occurrence) and severity (degree of consequence). Once the potential effects associated with each accident or malfunction scenario were identified, the level of residual risk (after controls or safety measures have been applied) was determined based on the method described below.

The likelihood and severity were based on experience and judgment of qualified professionals. Determinations of likelihood and severity considered the lifespan of each Project component (as required by the EIS Guidelines).

The potential likelihood of an event occurring is defined as follows:

- **Very Low:** Not expected to occur at any point over the life of the Project, with no or limited previous examples of occurrence in similar projects.
- **Low:** Limited potential to occur in exceptional circumstances over the life of the Project with limited but consistent occurrence in some similar projects.
- **Moderate:** Might occur over the life of the Project, with an established trend of regular occurrence in most similar projects.
- **High:** Expected to occur over the life of the Project, with frequent occurrence in similar projects.
- **Very High:** Almost certain to occur over the life of the Project.

The severity or consequence of that event was defined as follows:

- **Very Low:** Localized effect; readily remediated, recovery within days or weeks.
- **Low:** Localized effect; predictably remediated, recovery within the life of the Project.
- **Moderate:** Widespread effect; predictably remediated, recovery within the life of the Project
- **High:** Widespread effect; uncertain remediation, not recoverable within the life of the Project.
- **Very High:** widespread effect, unlikely to be completely remediated, not recoverable within the life of the Project, loss of a considerable portion of a VC.

The assessment of the potential risk of environmental effects resulting from accidents or malfunctions is provided in Section 22.5, and was determined based on the likelihood and consequence of that particular accident or malfunction based on the definitions above.

22.2.6 Influence of Consultation and Consideration of Aboriginal Information

Consultation has been ongoing prior to and throughout the EA process, and will continue with government agencies, local Aboriginal communities, and stakeholders through the life of the Project. Chapter 3.0 (community and stakeholder consultation) provides more detail on the consultation process covering open houses, site visits, targeted meetings, newsletters, questionnaires, presentations, and capacity funding for technical reviews and community-based studies among other areas. The record of consultation RoC (Appendix C) includes detailed comments received during the development of the Draft EIS/EA.

Consultation feedback related to accidents and malfunctions has been addressed through direct responses (in writing and follow up meetings) and in the Final EIS/EA, as appropriate. Information received has been considered by the Project team. An overview of the key comments that influenced the assessment of accidents and malfunctions between the Draft EIS/EA and the Final EIS/EA is summarized below.

Additional Detail Related to the Potential Effects of a TMF Dam Breach

Requests for more information related to the effects of a potential TMF dam breach were received from Biigtigong Nishnaabeg, the Ministry of Natural Resources and Forestry (MNRF), the Canadian Environmental Assessment Agency (CEA Agency), the Ministry of Northern Development and Mines (MNDM) and Fisheries and Oceans Canada (DFO).

Biigtigong Nishnaabeg noted the importance of considering effects on Long Lake and the Aguasabon River related to fish habitat because of the risk of downstream effects from a potential TMF dam failure. The MNRF requested the completion of a Dam Break and Inundation Study for each alternative. The CEA Agency requested information on the potential residual effects on VCs that could result from a structural failure of the TMF. The MNDM identified an interest in reviewing a dam breach analysis to support the TMF design. DFO identified the importance of providing an assessment of potential accidents and malfunctions related to a tailings dam breach on Kenogamisis Lake.

Further analysis of potential TMF dam breach scenarios was completed and incorporated into the effects assessment in Section 22.4.1.3 to address these comments. This included considering both 'fair weather' and 'wet weather' failures of the north and west (north cell), and southwest (south cell) dams. Information is provided regarding predicted quantities of water released and water levels for each breach scenario and this information is used to assess the potential for effects within the Project development area (PDA) and local assessment area (LAA).

Consideration of failure risk has also been included in the TMF alternatives assessment (Appendix G1).

Consideration of Flooding and Watercourse Failures Related to Extreme Weather Events

Requests for more information on how flood events were considered and how they may contribute to accidents or malfunctions were received from the Ministry of the Environment and Climate Change (MOECC), the MNRF, the CEA Agency and Aroland First Nation (AFN).

The MOECC and AFN identified the importance of considering catastrophic weather events and flood events in the effects assessment, and the MNRF requested further details on flood elevations for Kenogamisis Lake and the potential effects on Project components. Updates to the assessment provided further detail on how the Project will be designed to accommodate flood conditions through design and safety measures, and the effects assessment for Project components and VCs was updated to clarify how effects related to wet weather events were considered, where relevant. This includes further detail on how flooding would contribute to effects related to TMF or seepage and water collection system failures (Sections 22.4.1.3 and 22.4.2.3), and refinements to the assessment of TMF and Goldfield Creek failures related to design features for flood conveyance (Sections 22.4.1.1 and 22.4.5.1).

The CEA Agency requested further discussion of the capacity of the Goldfield Creek diversion related to the ability to withstand flooding events, including confirmation of how the design will account for the need to accommodate both floodwater and flows from the TMF emergency spillway, and mitigation and response measures that will be employed to manage the risk of failure of the TMF north cell dams. Sections 22.4.1.1 and 22.4.5.1 (TMF and Goldfield Creek diversion safety measures, respectively) were updated with additional detail on the approach to the design and sizing of the diversion to convey maximum anticipated flood events, incorporation of a diversion dam to protect the TMF north cell, and account for floodwater associated with both the upstream flows from Goldfield Lake and flows from the emergency spillway of the TMF.

AFN requested discussion on the detection and mitigation measures for a pipeline failure at the Southwest Arm Tributary, and the MNRF requested additional detail on the potential for road and water crossing structure failures. Section 22.3.1.4 was updated to clarify the safety and response measures related to a failure of the treated effluent discharge pipeline. Section 22.3.1.11 was also updated to specifically address the potential for a watercourse crossing failure related to roads or other infrastructure, considering the potential for a failure and the possible effects on the Project and VCs.

Characterization of Likelihood

The CEA Agency requested clarification on the approach used to define the likelihood of occurrence, and AFN requested clarification and additional justification to support the characterization of residual risk associated with accident and malfunction events. The likelihood characterization definitions were updated and included in Section 22.2.5 to provide clarification on how the probability of occurrence was applied, and updates were made to the effects assessment for each scenario to better align the results of the assessment with the risk definitions used.

Consideration of Archaeological and Heritage Resources

AFN requested further consideration of the potential effects on archaeological and heritage resources related to accident and malfunction events. The assessment was updated to directly consider archaeological and cultural heritage resources where the potential for effects on these resources may exist. In particular, the potential to disturb archaeological and heritage resources during a TMF failure was brought forward to the effects assessment in Section 22.4.1.3.

Environmental Management and Monitoring Plans (EMMPs)

GGM acknowledges that Aboriginal communities are concerned with the potential effects from accidents or malfunctions and the need to manage the potential for accident and malfunction events to occur. Based on the comments provided (with key comments summarized in Section 22.2.6), GGM has refined the ERP and other EMMPs, including associated communication protocols, to support the proactive management of Project components and the ongoing consultation with local Aboriginal communities during Project operation. The conceptual ERP and EMMPs are included in Appendix M.

22.3 SCREENING OF ACCIDENTS OR MALFUNCTIONS FOR ASSESSMENT

Based on professional judgment, experience with other mining projects, and in consideration of comments provided by agencies, Aboriginal communities and the public, the following key accidents or malfunction scenarios have been identified (Table 22-1) as having the potential to occur as a result of the Project. A description of the conditions that would lead to each accident or malfunction, and consideration of the potential for adverse effects on VCs are used to screen those accidents or malfunctions that warrant further assessment in Section 22.4.

Table 22-1: Potential Key Accidents or Malfunction Scenarios

Potential Accident or Malfunction	General Description
TMF Failure	Failure of the TMF dam could result in localized flooding and the release of tailings solids and water.
Tailings Pipeline Failure	Failure of the tailings delivery pipeline would result in the release of tailings.
Process Plant Failure	Failure of a component of the processing system could result in the release of liquids, reagents or gasses.
Effluent Treatment Plant, Sewage Treatment Plant or Pipeline Failure	Failure of the effluent treatment system or sewage treatment system would result in the release of untreated effluent, sewage, or reagents. A treated effluent discharge pipeline failure would result in the release of treated effluent.
Seepage and Contact Water Collection System Failure	Failure of the seepage and contact water collection system would result in the release of contact water.
Fuel Spill	Failure of the onsite storage and handling systems for gasoline and diesel fuels, and natural gas would result in the release of petroleum related products.
Hazardous Material Spill	Failure of the onsite storage and handling systems for hazardous materials would result in the release of these materials (e.g., mill reagents required for ore processing).
Open Pit Slope Failure	Failure of the open pit slope would result in areas adjacent to the open pit slumping into the open pit.

Table 22-1: Potential Key Accidents or Malfunction Scenarios

Potential Accident or Malfunction	General Description
Waste Rock Storage Area (WRSA) or Overburden Storage Area Slope Failure	Failure of a WRSA or overburden storage area slope would result in the release of waste rock, overburden or topsoil outside the storage areas.
Historical MacLeod Tailings Failure	Failure of the historical MacLeod tailings may result in damage to a portion of the realigned Highway 11 or overburden storage area and release of tailing outside the storage area.
Goldfield Creek Diversion or Watercourse Crossing Failure	Failure of the Goldfield Creek diversion would result in erosion, the release of sediment to downstream watercourses and lakes, and potential damage to downstream road and utility crossings.
Overblasting	Uncontrolled or unmanaged blasting would result in excess noise and vibration or damage resulting from fly rock extending beyond defined boundaries.
Fire	A fire may result in the destruction of Project infrastructure and vegetation and natural features within or beyond the PDA, and the release of smoke, combustion gases and ash.
Spill from Vehicle Collision or Mechanical Failure	A vehicle collision or mechanical failure involving Project equipment or transport trucks may result in the release of hazardous materials such as mill reagents, hydraulic fluid and fuel, or other non-hazardous materials such as construction material.

22.3.1 Description of Potential Accidents or Malfunctions

22.3.1.1 Tailings Management Facility Failure

An engineered TMF will be built to store mine waste in the form of tailings from the process plant, as outlined in Appendix K1 (TMF Design Reports). The TMF site selection process has been carried out in accordance with Environment and Climate Change Canada's *Guidelines for the Assessment of Alternatives for Mine Waste Disposal* (2011) (Appendix G1, Alternatives Assessment Report: Hardrock Project – Tailings Management Facility and Waste Rock Storage Areas.

The TMF related infrastructure (including perimeter road and seepage collection ditches) has a minimum setback of 120 m from Kenogamisis Lake with the TMF dams located at a minimum of 200 m from Kenogamisis Lake. The TMF will be formed using embankment dams raised in stages using mine rock with a till core to reduce seepage. Tailings will be discharged in the TMF, allowing the tailings solids to separate from the liquid effluent and be deposited to form wide beaches to enhance dam safety and limit seepage under or through the dams.

The TMF design has been selected considering the proximity to Kenogamisis Lake and proven design specifications in accordance with relevant guidelines and legislation:

- Rockfill embankment dams:
  - raised by the downstream method (for increased stability)
  - foundation filter beneath rockfill.
- Wide tailings beaches:
  - enhanced dam safety and seepage mitigation.
- Pond which abuts natural ground:
  - safer during operation and closure and reduces seepage.
- Dams and spillways designed for maximum credible earthquake and Probable Maximum Flood (PMF).

Under normal design conditions there will be no releases to the environment directly from the TMF as the TMF water is recycled back to the mill for use in processing. In the event of precipitation above the 1:100 storm design event, an emergency spillway will pass the excess flow beyond the maximum storm that can be fully contained in the TMF (known as the Environmental Design Flood [EDF]) to maintain dam stability. This design feature has been incorporated to reduce the potential for failure of the TMF and meet industry and regulatory design requirement.

In the unlikely event of a TMF dam failure, the potential may exist for residual adverse effects on infrastructure, surface water, fish and fish habitat, groundwater, vegetation communities and wildlife habitat. The potential also exists for subsequent residual adverse effects on land and resource use (LRU), including traditional uses, and archaeological or cultural heritage resources where they exist. The evaluation of potential effects is provided in Section 22.4.

22.3.1.2 Tailings Pipeline Failure

The pipeline used to transfer tailings from the process plant to the TMF is composed of three separate sections to address varying pressure requirements. The first section leaving the process plant is an approximately 230 m long buried rubber lined pipe. The second section is an approximately 4.6 km long double walled high-density polyethylene line or a line with similar safety features, installed along the haul road. The last section, installed within the TMF itself, will consist of a high-density polyethylene distribution network along the TMF berm.

A pipeline rupture or leak due to the structural failure of a portion of the first two sections of the pipeline could result in a spill of tailings within the PDA. A failure along the third portion will be contained within the TMF. A pipeline leak may involve a large rupture, but could also involve a small release over an extended period of time.

GGM will develop a safety and surveillance plan that includes routine visual inspection of the pipeline. The line includes a pump pressure monitoring system to trip an alarm in the event of a loss of pressure in the line. The line includes a lined safety pond, which is large enough to contain 110% of the total pipeline volume. The calculated volume is approximately 1,000 m^3. To drain the tailings pipeline in the case of a pipeline rupture, a fail-safe valve will be installed to open the line. In a malfunction event, the tailings slurry from the pipeline would be pumped back to the process plant until such time as the pipeline is repaired and pumping of tailings slurry to the TMF can resume. The safety pond will be maintained empty by a level controlled sump pump that will direct water that collects within the pond to pond M1.

Where the tailings pipeline crosses the Southwest Arm Tributary, the crossing is located above ground and is designed with secondary containment. The pipe will be equipped with a wireless leak detection system. Should issues with the pipe be detected, pumping would stop and, if required, the pipe could be drained to the safety pond. Secondary containment would prevent a release to the Southwest Arm Tributary while the pipe is drained. A failure of the TMF pipeline would be contained through these measures to avoid release of tailings to the environment.

A Spill Prevention and Response Plan (SPRP) will also be developed to address onsite spill scenarios, including prevention, contingency planning and reporting practices for the timely and effective response to pipeline spills. A Conceptual SPRP is provided in Appendix M8.

No releases to the environment or residual adverse effects on VCs are anticipated, and therefore no further effects assessment is required.

22.3.1.3 Process Plant Failure

The Project will extract gold from the ore using gravity separation and standard cyanide leaching. Cyanide will be shipped to the Project site and stored in a solid phase (sodium cyanide briquettes). It will be used in the mill in both a liquid phase (as free cyanide and in complex with metals) and in the gaseous phase (as hydrogen cyanide). The tailings remaining after the gold is extracted from the ore will undergo SO_2/air cyanide detoxification treatment in the process plant before being pumped to the TMF. An accident or equipment malfunction in this process may release cyanide, in its various forms, or SO_2 into the environment.

Solid cyanide will be transported to the Project by a supplier and handling the material will be done in designated areas with appropriate storage containment. In its solid form, the potential for a release to the environment is very limited, and clean-up would be manageable.

The mixing of the solid cyanide to create a liquid solution will be done in the controlled and self-contained reagent mixing area of the process plant, thereby preventing a spill from exiting the reagent area.

The potential for cyanide solution to exit the process plant area would be limited to the simultaneous rupture of more than one leach tank into the containment pad. The containment pad is designed to contain approximately 130% of the volume of one leach tank with supplemental volume available to manage additional volumes from the cyanide detox pad and mill.

Cyanide gas could be released into the environment if the pH of the leach solution or cyanide preparation solution is allowed to fall below pH 9. As the pH decreases below 9, increasing amounts of cyanide would be volatilized from solution into a gaseous form. For this to occur there would need to be a prolonged (several hours) failure of the lime feed to the mill, while continuing to feed cyanide into the leach tanks. This could occur through either a rupture in the lime feed or multiple prolonged valve failures. However, a failure of the lime supply would force a mill stoppage before the solution would be affected to such an extent as to cause the release of cyanide gas.

During the SO_2/air detoxification of cyanide in the tailings, a process logic control (PLC) device will adjust the required air input into the chamber to obtain generation of SO_2. The gas will then be cooled prior to direct injection into the treatment tanks. Flow, temperature, and pressure controls on inputs and outputs of the system control the SO_2 production. The system can be placed into a standby mode by feeding fresh sulfur or air into the system.

To safeguard against potential processing failures or malfunctions, processing facilities will be designed according to the highest engineering standards for safe operation, with appropriate ventilation systems. Employees will be properly trained, with an emphasis on safety and accident prevention. This process is a technically-proven and well-established technology with high reliability during normal operations.

GGM also intends to become a signatory to the International Cyanide Management Code, and will abide by code criteria for the safe and responsible use, transport and management of cyanide products.

Cyanide handling activities will be limited to the process plant, and undertaken following the highest standard management practices. Releases would be contained within a facility designed with the capacity to manage a conservative case scenario failure. No releases to the environment or residual adverse effects on VCs are anticipated, therefore no further effects assessment is required.

22.3.1.4 Effluent Treatment Plant, Sewage Treatment Plant or Pipeline Failure

Contact water and sanitary sewage will be treated in separate treatment facilities such that the respective effluents meet applicable requirements which will be confirmed during the permitting period (see Appendix M1). In the event of a mechanical or instrument failure in the treatment plants, or a rupture or leak in one of the pipes within the plants, effluent not meeting discharge standards may be released within the treatment plant area. However, the treatment plants will be built on pads and surrounded by ditching to control potential releases.

Effluent from the sewage treatment plant will be co-discharged with treated effluent from the effluent treatment plant to Kenogamisis Lake via a single pipeline. A leak or spill from the discharge pipeline will release effluent that has already been treated to meet discharge standards. Such releases would be detected and addressed rapidly, including the shutdown of treatment plants. In addition, the assimilative capacity of the Southwest Arm of Kenogamisis Lake is high, further reducing the potential for adverse effects (Appendix F6). A large volume release from the discharge pipeline may also result in localized erosion and potential sedimentation to the Southwest Arm Tributary or Kenogamisis Lake, depending on the location of the failure. However, vegetated setbacks will be maintained along the watercourse to stabilize banks and limit erosion. Such an event would be of short duration and addressed through regular maintenance activities.

No residual adverse effects on VCs are anticipated, and therefore no further effects assessment is required.

22.3.1.5 Seepage and Contact Water Collection System Failure

The seepage and contact water collection systems will be designed to capture contact water and seepage from various Project components, including the ore stockpile, overburden storage areas WRSAs, TMF, and historical MacLeod high tailings.

Perimeter contact water collection ditches and ponds will be constructed to collect and store surface water runoff and seepage from the WRSAs, ore stockpile and overburden storage areas. A subsurface seepage collection system consisting of a French drain system will be installed at the toe of the historical MacLeod high tailings and will drain by gravity to two subsurface seepage collection ponds located on the west and east side of the historical MacLeod high tailings. Water from collection ponds will be directed by gravity or pumped to the main Project water management pond, M1, which also receives runoff from the process plant area. Under a normal operating condition, the ditches and ponds will be generally dry (with the exception of pond M1). The ponds, which include emergency spillways, are designed to hold the 1:100 year, 24-hour storm event without release and safely manage and pass the regulatory storm event (Timmins Storm, also known as the regional storm event) through the emergency spillways. The regulatory storm event is larger than a 1:500 year storm event.

For the TMF, an integrated seepage collection system has been designed with seepage collection ditches and ponds that will capture runoff and seepage, with water from the ponds pumped back to the TMF. The seepage collection ponds for the TMF have been designed to contain runoff from the downstream slopes of the TMF dams corresponding to the 1:100 year, 24-hour storm event. Water that collects in the seepage collection ponds and ditches will be pumped back to the TMF reclaim pond to maintain pond capacity and positive inflow of groundwater. A failure may occur from a localized breach in the ditching/pond system.

If overtopping were to occur during an extreme precipitation event, this would be conveyed by the emergency spillways as per the intended design. A failure resulting from a localized breach in a ditch or collection pond (except for pond M1) would likely not result in a release, as ponds and ditches are designed to remain dry.

Pond M1 will be designed to permanently store water for use in the mill to meet reclaim demand with excess water directed to the ETP. A breach of pond M1 may result in a localized release of contact water within the PDA to the Southwest Arm Tributary, potentially affecting surface water quality, and/or fish and fish habitat.

A breach of pond M1 would result in a limited volume release along a narrow flow path to the Southwest Arm Tributary, affecting a small area within the PDA, with the potential to effect surface water quality within the Southwest Arm Tributary and Southwest Arm of Kenogamisis Lake. Vegetation communities would be cleared around the pond during construction and wildlife access would be limited in the PDA, so that a release would not have an effect on this VC. Potential effects to LRU and TLRU would be limited since a breach would be limited to the PDA where LRU and TLRU will not occur during construction and operation. A release would have limited potential to affect groundwater as the release would be conveyed downstream, or confined to the soils within the timeframe of a cleanup response and appropriately contained and remediated before migrating to the groundwater table. No disturbance to archaeological resources would be expected as the PDA will have been cleared of potential resources prior to construction. No disturbance to cultural heritage resources would be expected, as no cultural heritage resources have been identified near Pond M1.

Based on the potential for residual adverse effects on surface water and fish and fish habitat, further effects assessment is provided in Section 22.4 below.

22.3.1.6 Fuel Spill

Diesel and, potentially, liquefied natural gas (LNG) will be stored on site in tanks, and used for power generation and fueling equipment. These petroleum products may be accidentally released during storage and handling; transportation is discussed in Section 22.3.1.14.

Fuel storage and refueling activities will be within designated areas within the PDA. Fuel storage will be guided by the Environment and Climate Change Canada's *Code of Practice for Above Ground Storage* and the *National Fire Code*. Fuel will be stored in double walled tanks on a concrete slab drained to an oil / water separator, and delivery trucks and mining equipment will park on the concrete slab for fuel transfer. Some large equipment may require refueling by fuel truck, but control devices and procedures will be put in place to prevent spills. No refueling will occur outside of the PDA. Should a spill occur, the spill will be immediately contained and cleaned up using spill kits available onsite. Soils in the vicinity of a spill location will be tested for hydrocarbons and excavated as required. No releases to the environment or residual adverse effects on VCs are anticipated, and therefore no further effects assessment is required.

22.3.1.7 Hazardous Material Spill

Hazardous materials and reagents required for Project operation will be transported to and from, and stored at, the Project site following applicable federal and provincial regulations (e.g., Transportation of Dangerous Goods Regulations), as appropriate. Some reagents will be delivered in bulk, such as lime, sodium hydroxide, elemental sulphur, and hydrochloric acid, while other reagents will be delivered in smaller containers, depending on the application. Hazardous waste (such as batteries and used oils) will be separated from the waste stream and stored, handled and transported following applicable federal and provincial regulations. Storage of hazardous material will occur within buildings, in secure and contained areas, and secondary containment and alarms will be used as appropriate. Applicable regulations and Material Safety Data Sheets for material handling and storage will be complied with including for reagents, explosives components and other hazardous materials. Hazardous material handling and storage requirements are noted in the Conceptual SPRP (Appendix M8). Hazardous waste management is included in the Conceptual Waste Management Plan (Appendix M4). Storage facilities will be sited in locations that represent a relatively low risk and afford an opportunity for containment during emergency response.

The storage and handling of hazardous material will be limited to the PDA, and spills will be immediately cleaned up using appropriate absorbent materials. Spills would have limited potential to affect groundwater, as they would be confined to the soils within the timeframe of a cleanup response and be appropriately contained and excavated before migrating to the groundwater table. No releases to the environment or residual adverse effects on VCs are anticipated, and therefore no further effects assessment is required.

22.3.1.8 Open Pit Slope Failure

The open pit will be developed in rock characterized as good to very good rock mass quality, and geotechnical conditions are well understood. Follow-up analysis will take place during operation to monitor slope performance.

There is the potential for open pit slope failure to occur at the open pit walls as a result of improper open pit design, unanticipated geologic conditions, or operational procedures such as blasting.

Slope failure could result in a loss of approximately 75 m from the open pit crest toward the WRSAs located around the perimeter of the open pit (assuming 45 degree failure slope). This would cause slumping into the open pit, and may affect the access road around the open pit or the edges of the surrounding WRSAs or historical tailings.

Since the open pit is located within the PDA, a failure of the open pit wall may affect Project operation or infrastructure, but will not have a residual adverse effect on VCs, therefore no further effects assessment is required.

22.3.1.9 WRSA or Overburden Storage Areas Slope Failure

Failure of the WRSAs and overburden storage areas could occur as a result of inadequate consolidation and soil shear strength, incorrect stockpile placement or grading, uncontrolled erosion, inappropriate design considerations, improper geotechnical monitoring and unknown soil/foundation characterization.

The WRSAs and overburden storage areas range from approximately 5 to 100 m in height above ground level with slopes ranging from 2:1 to 4:1. Details regarding the stability of the WRSAs are discussed further in Section 22.4

Should a failure occur, a slump or slough of the storage areas could result in material entering areas adjacent to the mine site including Highway 11, the Kenogamisis golf course, Kenogamisis Lake, the Goldfield Creek diversion/Southwest Arm Tributary, the residential property boundary located in proximity (approximately 150 m) to WRSA A or the open pit. A release of material could potentially damage infrastructure or a release of sediment or waste rock into surface water and fish habitat. Potential effects to fish and fish habitat may, by extension, also affect local LRU, including traditional uses. No disturbance to archaeological resources would be expected as the PDA will be cleared of potential resources prior to construction. No disturbance to cultural heritage resources would be expected, as those found within the PDA will be removed to accommodate Project development and those outside the PDA are located outside the area that would be affected by a failure.

Based on the potential for residual adverse effects on surface water, fish and fish habitat, community services and infrastructure, LRU and TLRU, further effects assessment is provided in Section 22.4.

22.3.1.10 Loss of Stability of Historical MacLeod Tailings

The historical MacLeod tailings deposits are comprised of loose sand and silt, which provides less stable geotechnical conditions than native soils found within the PDA. Project development will include the construction of Highway 11 and the placement of overburden material over the historical Macleod high tailings and as a result the potential for failure from these activities exists without further design and mitigation.

Determination of the hazard potential classification (HPC) of the historical MacLeod high tailings was completed in accordance with the Ministry of Natural Resources and Forestry (MNRF) *Lakes and Rivers Improvement Act* (LRIA) bulletins (2011), and the Canadian Dam Association's (CDA) *Dam Safety Guidelines* (2013/2014). Based on these guidelines a design earthquake of 1 in 6,250 years was adopted to assess the seismic stability of the historical MacLeod high tailings. The evaluation identified that there was the potential for instability of the tailings under the design earthquake and the potential for adverse effects on Highway 11. To address these instabilities, the design has incorporated toe berms and buttresses to address the stability concerns. These berms and buttresses have been incorporated into Project layout.

Design recommendations will be taken into account to maintain the stability of the Highway 11 realignment over the historical MacLeod tailings to address the potential for failure (Appendix H; Highway 11 Realignment Preliminary Design Report [PDR]). With implementation of mitigation measures as recommended, there is limited potential for failure of the historical tailings, but a conservative case failure has the potential to affect surface water, fish and fish habitat, and groundwater. Effects on surface water and fish and fish habitat could also extend to effects on LRU, including traditional uses. No disturbance to archaeological resources would be expected as the PDA will be cleared of potential resources prior to construction in communication with relevant government agencies and interested Aboriginal communities. No disturbance to cultural heritage resources would be expected, as those found within the PDA will be removed to accommodate Project development and those outside the PDA are located outside the area that would be affected by a failure.

Based on the potential for residual adverse effects on surface water, fish and fish habitat, groundwater, LRU and TLRU, further effects assessment is provided in Section 22.2.4.

22.3.1.11 Goldfield Creek Diversion or Watercourse Crossing Failure

The Goldfield Creek diversion will involve excavation and clearing along new and existing channels, and will be susceptible to erosion during construction before the channel is stabilized. The diversion will connect with the existing Southwest Arm Tributary, potentially resulting in downstream effects to that watercourse as well. Failure of the diversion channel or related works could result from a precipitation or snowmelt event that exceeds the design capacity, causing the loss of channel form due to erosion, or damage to watercourse crossings downstream of the diversion along the Southwest Arm Tributary.

A failure of the Goldfield Creek diversion would result in erosion of the constructed channel and related habitat features, and sedimentation to downstream water bodies. This would result in potential adverse effects on surface water features and fish and fish habitat. The potential also exists for effects on LRU, including traditional uses. No disturbance to archaeological resources would be expected as the PDA will be cleared of potential resources prior to construction.

Based on the potential for residual adverse effects on surface water, fish and fish habitat, LRU and TLRU, further effects assessment is provided in Section 22.4 for a failure of the diversion.

Flows through the diversion channel may also affect road and utility crossings downstream of the diversion (leading into the Southwest Arm Tributary), if the flows exceed the design for those crossings. Crossings downstream of the diversion channel include: a construction access road west of SWP3 and a haul road (and tailings delivery, reclaim and treated effluent discharge pipelines) crossing the Southwest Arm Tributary. These crossings will be designed to accommodate appropriate design storms to limit the potential for effects. In addition, the design includes two valley-wide grade control structures within the existing Southwest Arm Tributary to impound and attenuate flows, and reduce water velocity to address erosion potential. One grade control structure is located upstream of the haul road and pipeline crossing.

In the case of extreme weather events, the construction access and haul roads may flood, limiting or restricting access to the TMF, WRSA D and aggregate sources S4 and T2 until repairs are made. Crossings will be constructed as culverts (no bridges required), so downstream deposition of debris from an infrastructure failure would be limited and would be removed as part of rehabilitation works. A road crossing failure would contribute a limited amount of sediment in comparison to the sediment that would be produced from runoff and erosion along the full length of the channel in such a scenario.

In the case of the tailings delivery, reclaim and treated effluent pipelines, the crossing will be located above ground so flooding will not disrupt pipeline operation. As noted above, the tailings delivery pipe will be equipped with a wireless leak detection system; should issues with the pipe be detected (e.g., damage from debris conveyed during flooding), pumping would stop and, if required, the pipe would be drained to the safety pond. This is considered in more detail as part of the tailings pipeline failure scenario in Section 22.3.1.2.

The effects of a Southwest Arm Tributary crossing failure would be limited primarily to disruptions to process plant operation (i.e., it would not affect outside users), and are not assessed further.

22.3.1.12 Overblasting

Explosives needed for the Project will be prepared in a dedicated explosives manufacturing facility, which will be sited in accordance with Natural Resources Canada (NRCan) requirements by the explosives contractor. Specifications for the manufacturing plant and the explosives storage magazines and the locations of these facilities must adhere to the *Explosives Act* and regulations as published by the Explosives Safety and Security Branch (ESSB) of NRCan. The location of the manufacturing plant and the explosives magazines are determined by NRCan's Quantity-Distance criteria (NRCan 1995), which specifies required distances to features such as roads and buildings. The location of the manufacturing plant and explosives magazines will be reviewed and approved by NRCan.

Blasting will be a regular part of the Project, occurring approximately twice weekly during construction, and several times per week in the daytime during operation throughout the LOM. An uncontrolled explosion may occur as an unmanaged or inadvertent detonation. An unmanaged explosion would be related to open pit operation, where proper safety measures were not applied as required (e.g., blast mats not used despite management requirements to do so), whereas an inadvertent explosion may be the result of error or malfunction.

The ESSB of NRCan is responsible for administering the *Explosives Act* and regulations and pursuing the advancement of explosives safety and security technology. ESSB's main priority is the safety and security of the public and the workers involved in the explosives industry in Canada. This includes providing necessary authorizations for any explosive that is to be imported into or manufactured, transported, stored, handled or used in Canada, and licensing for the acquisition, storage and sale of explosives. Blasting operations will be carried out by qualified and certified blasting personnel in accordance with strict operating procedures. Explosive components will be supplied by a distributer certified under Canadian regulations. In addition, the explosives facility will be located according to the guidelines set out in NRCan's *Quantity Distance Principles User's Manual* (NRCan 1995), which provides the minimum permissible distance between a site containing explosives and nearby sites requiring protection.

GGM will develop operating procedures to carry out blasting safely during operation. This will include standards related to employee responsibilities, notification, inspections, signage, clean-up and the safe use of materials and equipment. An Explosives and Blasting Management Plan (EBMP) will also be developed to provide direction for the safe storage, handling and use of explosives and explosive components at the Project site, to address the safety of the public and Project personnel, and protection of both the environment and Project components. A Conceptual EBMP is provided in Appendix M11.

Although an uncontrolled explosion would create a larger blast and more noise than a controlled explosion (since regular blasting in the open pit would be performed by drilling and blasting successive benches with appropriate controls in place). Noise and vibration effects from an uncontrolled explosion would be short in duration. Although blasting operations will be carried out in such a manner and in accordance with necessary regulations to limit the potential for an uncontrolled explosion, the PDA was developed to include a 500 m safety limit around the open pit to isolate VCs from the potential effects of fly rock, and the explosives facility will be located based on minimum distance requirements as noted above. No residual adverse effects on VCs are anticipated, and therefore no further effects assessment is required.

22.3.1.13 Fire

A fire may occur as the result of an accident associated with the activities of the Project, including equipment malfunction, human error, or uncontrolled explosion. Fires arising from non-Project causes such as lightning strikes, offsite forest fires or undefined causes, are assessed as an effect of the environment on the Project in Chapter 21.0.

Although a Project-related fire could spread beyond the PDA, all reasonable precautions will be taken to avoid fires and limit the potential spread of fires beyond the PDA. Employees, as appropriate, will be trained in fuel handling, equipment maintenance and fire prevention and response measures. Fire prevention and suppression systems will be maintained onsite, including water supplies, sprinklers, fire extinguishers and other firefighting equipment, and GGM will pursue an agreement with municipal fire services for additional fire support in the event of an emergency. Flammable material (such as fuels and explosives) will be carefully controlled within the PDA. Emergency response measures will also be in place for a timely and effective response to fires, and containment within the PDA.

No residual adverse effects beyond the PDA or adverse effects on VCs are anticipated, and therefore no further effects assessment is required.

22.3.1.14 Spill from Vehicle Collision or Mechanical Failure

Vehicle traffic will occur during all phases of the Project as a result of the movement of equipment, supplies, materials, and personnel to and from the Project site. A vehicle collision or mechanical failure could occur on the road transportation network leading to or from the Project site (such as Highway 11), or within the Project site.

Fuel and other hazardous materials will be periodically transported to the Project and a vehicle collision could result in a spill of these materials. In addition, vehicles such as large mining equipment may have mechanical failures, resulting in a release of hydraulic fluid. A spill within the PDA would be captured and treated by the seepage and contact water collection system around the perimeter of the PDA. Spills would have limited potential to affect groundwater, as they would be confined to the soils within the timeframe of a cleanup response and appropriately contained and remediated before migration to the groundwater table could occur. No releases to the environment or residual adverse effects on VCs are anticipated in the case of a vehicle collision within the PDA, and therefore no further analysis is required.

A vehicle collision or mechanical failure outside the PDA may have the potential for a residual adverse effect. A spill on land would be localized to the soils and readily remediated. If the collision or mechanical failure took place near a waterbody, there would be a higher potential for parameters of potential concern (PoPC) to affect surface water, and fish and fish habitat. Potential effects to fish and fish habitat may by extension also affect local LRU, including traditional uses.

Based on the potential for residual adverse effects on surface water, fish and fish habitat, LRU and TLRU, further effects assessment is provided in Section 22.4.

22.3.1.15 Summary of Accidents or Malfunctions Screened for Further Assessment

A total of six accident and malfunction events were identified as having the potential to cause a residual adverse effect on VCs, if they occurred, and will be assessed further in this Chapter. These events and the potentially affected VCs are identified in Table 22-2.

Table 22-2: Summary of VCs with the Potential for Residual Adverse Effects from an Accident or Malfunction

Accident or Malfunction Event with the Potential to Cause Residual Adverse Effects	Surface Water	Fish and Fish Habitat	Groundwater	Vegetation Communities	Wildlife and Wildlife Habitat	Community Services and Infrastructure	Archaeological and Heritage Resources	Land and Resource Use	Traditional Land and Resource Use
Tailings Management Facility Dam Failure	✓	✓	✓	✓	✓	-	✓	✓	✓
Seepage and Contact Water Collection System Failure	✓	✓	-	-	-	-	-	-	-
WRSA or Overburden Storage Area Slope Failure	✓	✓	-	-	-	✓	-	✓	✓
Loss of Stability of Historical MacLeod Tailings	✓	✓	✓	-	-	✓	-	✓	✓
Goldfield Creek Diversion or Watercourse Crossing Failure	✓	✓	-	-	-	-	-	✓	✓
Spill from Vehicle Collision or Mechanical Failure	✓	✓	-	-	-	-	-	✓	✓

NOTES:
✓ Potential for a residual adverse effect.
– No potential for a residual adverse effect.

22.4 EFFECTS ASSESSMENT OF SCREENED ACCIDENTS OR MALFUNCTIONS

22.4.1 Tailings Management Facility Failure

22.4.1.1 Tailings Management Facility Safety Measures

A feasibility level geotechnical and hydrologic design of the TMF was prepared by Amec Foster Wheeler (AMECFW; Appendix K1 [TMF Design Reports]). The TMF for the Project is designed to contain 140,000 kt of tailings, with an additional allowance of 5,000 kt of historical tailings for a total of 145,000 kt. The TMF will be constructed using perimeter embankment dams raised using the downstream construction method in stages. Mine rock will be used to construct the dams with a relatively low-permeability till core used to limit seepage through the dams. The TMF design criteria are provided in Tables 1 through 3 of Appendix K1.2 (Greenstone Gold Mines Tailings Management Facility Design Hardrock Feasibility Study Geraldton, Ontario).

The TMF is expected to cover 518 ha at ultimate configuration. The maximum starter dam section is about 10 m high with the ultimate dams raised to a maximum section height of about 35 m above surrounding ground level.

The TMF will be constructed using proven design specifications in accordance with relevant guidelines and legislation. Containment structures will be designed in accordance with:

- site conditions – climate (precipitation, temperature) and seismic risk (refer to Appendix K1.2 – TMF Design report)
- tailings operating data – production rate and discharge slurry density (refer to Appendix K1.2 – TMF Design report)
- Technical Bulletin – Geotechnical Considerations for Dam Safety (CDA 2007)
- Technical Bulletin – Application of Dam Safety Guidelines to Mining Dams (CDA 2014)
- *Lakes and Rivers Improvement Act* - Administrative Guide (MNR 2011).

The TMF dam is designed to provide containment (without discharge) of the EDF, which has been set as the 1:100 year, 24-hour return period hydrologic event. An emergency spillway will pass flows in excess of the EDF to maintain dam stability while controlling releases to the environment. The emergency spillway is designed to safely pass the PMF, which is the largest possible flood based on an analysis of the maximum possible precipitation in a given area (corresponding to a precipitation event of 360.7 mm within a 24-hr period, which is roughly equal to half the average annual precipitation occurring in a 24-hour period). The TMF is also designed to withstand the maximum credible earthquake (which is the largest earthquake that is capable of occurring based on the tectonic characteristics of an area).

A diversion of Goldfield Creek is required as a result of the TMF location. A diversion dam will be located north of the TMF to direct water away from the TMF and toward the new diversion channel. The dam will be designed to withstand the PMF conveyed through Goldfield Creek. This approach will effectively convey maximum expected flow volumes through the diversion channel keeping upstream water away from the TMF.

The perimeter dams are rockfill embankments that do not depend on the support of deposited tailings for stability. The tailings deposition plan involves discharging tailings from the dams to form wide beaches against the perimeter of the TMF dams. This allows the TMF pond to be maintained against natural ground well away from the dams, limiting seepage under or through the dams and reducing the risk of dam failure. The TMF perimeter configuration enhances the use of natural topography for containment which results in reduced dam length and heights. The downstream dam construction methodology (gradually expanding the perimeter dam downstream over the life of the mine) using mine rock provides for the safest construction approach for the facility. An emergency spillway is also provided for all stages of dam raising so that the PMF can be safely passed maintaining adequate freeboard to the dam crest. This is also an important dam safety measure. The ultimate emergency spillway for operation and closure will be located in natural ground further reducing the risk of embankment failure.

GGM is committed to staffing a senior geotechnical engineering position dedicated to TMF safety and to fund an Independent TMF Review Board (ITRB) for the Project composed of three external experts. The purpose of the ITRB is to review and advise on the design, construction, operation, performance, and closure planning for the TMF, with the objective of long-term safety and environmental protection. The ITRB will be in place prior to construction and provide review and advice through closure. ITRB reports and actions undertaken by GGM to address ITRB feedback will be made available to interested stakeholders.

The process of conducting site investigations, design, review, construction, operation, closure, and monitoring of a TMF in Canada is well established under guidelines developed by the CDA and by the International Commission on Large Dams. Along with general oversight provided by the ITRB, a qualified engineering firm will be engaged to conduct site investigations, develop designs, monitor construction, and inspect ongoing operations to confirm that appropriate standards are met including the following:

- Design for geotechnical stability under static and seismic conditions, when the facility is subject to the Maximum Design Earthquake, during operation and closure.
- Design for safe containment of rainfall and runoff resulting from the EDF during operation.
- Design for attenuation and safe passage of rainfall and runoff in excess of the EDF during operation and closure.
- Quality assurance and inspections by the design engineers during initial and ongoing construction of the TMF.

- An Operation, Maintenance and Surveillance (OMS) manual will be developed to facilitate training of staff for safe operation of the TMF dams. The manual will include guidelines for daily, weekly, monthly and quarterly inspection of the TMF by operational personnel.
- Annual dam safety inspections will be performed by a qualified geotechnical engineer, with more thorough Dam Safety Reviews on five year intervals by a qualified geotechnical engineer independent of the design engineer to assess TMF performance and to identify conditions that differ from those assumed during the design.
- Dam instrumentation to allow monitoring of the phreatic surface, seepage flows, and deformation conditions of the dams.

Procedures for monitoring and routine surveillance will be set out in the OMS manual to provide the operators with background on the indicators and warning signs that would require corrective action well in advance of a dam failure. Geotechnical dam instrumentation will be used to: (a) measure the depth to the water table at key locations, and (b) detect movements through survey measurements. Both of these types of instrumentation allow advanced warning and time for corrective action.

TMF dams are subject to permitting under the LRIA by the MNRF. Authorizations under the LRIA (i.e., Location Approval and Plans and Specifications Approval) to construct the TMF dam requires the determination of the HPC for each TMF dam. The HPC is determined through an incremental assessment of dam failure effects arising from a wet weather breach event, and is used to provide guidance on dam safety standards and requirements. Other breach scenarios considered include a dry weather (sunny day) and seismically sourced dam failure events. Acknowledging the existing infrastructure and number of water bodies in the Project area, the preliminary HPC for the TMF dams has been set at very high to achieve the highest design standards including a more robust spillway design and greater dam safety.

The likelihood of a partial or complete failure of the TMF dams is considered very low with these design measures.

22.4.1.2 Tailings Management Facility Emergency Response Measures

The initial response in the event of a TMF dam failure would include:

- shut down pumping of tailings to the TMF
- notification of authorities, emergency responders, local residents and local Aboriginal communities
- initiate pumping of tailings water to the open pit if needed
- deploy turbidity curtains within affected watercourses

- deploy earthwork equipment to repair the dam and establish additional containment as needed
- develop a remedial action and monitoring plan specific to the event.

22.4.1.3 TMF Failure Effects Assessment

The release of water and tailings solids would result in increased water levels and effects on water quality, with the potential for erosion and sedimentation due to high velocity flows from the breach location. Water would be contained by and directed along topographic lows, so that effects would be experienced primarily downstream of the failure. A release of solids would be more localized at the breach location, with tailings solids and dam material spreading out from the breach location.

The amount of tailings solids and water that would be released during a dam failure is dependent on the volume of water and climatic conditions at the time of failure. Both 'fair weather' and 'wet weather' dam breach scenarios have been considered by AMECFW as described below. A 'fair weather' scenario was assumed to release the contents of the dam under normal water levels with no additional runoff from a storm event, resulting in a release volume of 1.0 million cubic metres (m^3). A 'wet weather' scenario was assumed to release the contents of the dam under high water levels plus runoff from the 24-hour Probable Maximum Precipitation storm event, resulting in a release volume of 16.2 million cubic metres.

The wet weather scenario represents the conservative case related to the highest extent of potential effects, as it would release the highest volume of stored water. The failure scenarios considered breaches of the west and north dams of the north cell and the southwest dam of the south cell.

In the event of a wet weather failure of the west dam (north cell), the infrastructure within the PDA would be affected. The small lakes upstream of the TMF would be flooded with released tailings (diluted from heavy precipitation) as well as the Goldfield Creek diversion, the Southwest Arm Tributary, the process plant site, the wetland and roads to the north and west of the WRSA D and a portion of the Kenogamisis Lake shoreline extending from the TMF to WRSA B.

In the event of a wet weather failure of the north dam (north cell), the extent of increased water levels would cover a large area north and west of WRSA D as well as flooding along the Southwest Arm Tributary to Kenogamisis Lake.

Either a west or north dam (north cell) failure would result in increased flows into the Goldfield Creek diversion or downstream portions of the existing connecting watercourse, increasing the potential for erosion or a failure of the channel. The increased water levels would result in disruption of operations and potential damage along the haul road between the TMF and WRSA D, and infrastructure crossings of the Southwest Arm Tributary (including the tailings and effluent pipelines), but would not extend further into the PDA or north outside the PDA where the highway and provincial and municipal infrastructure is located.

In the event of a wet weather failure of the southwest dam (south cell), the release would travel along the Goldfield Creek Tributary and extend as far south as the upstream end of Kenogamisis Lake, but there would be no increased water levels at Project components northeast of the TMF, beyond natural flooding from the precipitation event. Additional flows in the Goldfield Creek Tributary would increase the potential for channel erosion. Effects on infrastructure within the PDA would be limited to flooding along the southern haul road surrounding the TMF. Released tailings would follow the natural topography, directing flows through the PDA and into Kenogamisis Lake. A dam breach would affect the water levels in Kenogamisis Lake. In a 'wet weather' scenario, a release would result in an increase in water level of 0.6 m over the 'wet weather' water level. Although the dam breach would result in an increased water level, the PMP storm event would already be of such a high magnitude that the incremental increase from the dam breach would likely not be perceptible. Water levels would also be affected downstream of Kenogamisis Lake as flows are conveyed through the system.

For 'fair weather' breach scenarios, the extent of the released tailings would be more contained within topographic lows such as valleys and shorelines, and water levels would be less due to the absence of flooding from precipitation. However, the quality of water released to Kenogamisis Lake would have higher concentrations due to the lack of dilution from increased precipitation. In a 'fair weather' failure scenario, the water level in Kenogamisis Lake would be expected to rise 0.4 m. Water levels along the shores of Kenogamisis Lake would increase nominally above normal variation and quickly dissipate back to normal operating levels and the flows equalize.

In the event of a TMF dam failure, tailings would be released to the environment affecting the waterways within the PDA and ultimately reach the Southwest Arm of Kenogamisis Lake. Solids could also be deposited along the failure pathway, extending from the breach location, potentially causing localized infilling of vegetated areas, watercourses or the shoreline of Kenogamisis Lake.

Depending on the timing and location of a potential failure, effects to surface water, fish and fish habitat, groundwater, vegetation communities, and wildlife habitat, may occur. Effects on these VCs if widespread, could affect local land uses and archaeological and heritage resources. A TMF failure would therefore have a potential high consequence as described in Section 22.2.5, and is characterized below for each potentially affected VC.

Surface Water

A TMF dam breach would have the potential to affect nearby waterbodies including the Goldfield Creek diversion and Southwest Arm Tributary, Goldfield Creek Tributary, and the Southwest Arm of Kenogamisis Lake, depending on the location of the breach.

Water quality modelling (Appendix F05) identified that within the TMF near the end of operations under climate normal conditions cyanide is the only parameter to potentially exceed the MMER Schedule 4 criteria. Cyanide, un-ionized ammonia, arsenic, aluminum, cobalt, copper, phosphorus and antimony may exceed the provincial water quality objective (PWQO) and nickel and uranium concentrations are expected to be at or just above the PWQO. The concentration of these parameters will be dependent on the volume of water within the TMF reclaim pond, which will vary seasonally and in response to operational demands. A TMF failure would result in the release of water with elevated concentrations for these parameters together with tailings solids.

A failure could also result in siltation, and the infilling of the watercourses or a portion of the lake with eroded material from the dam and tailings beaches. This may result in localized effects on natural flow patterns or alterations to the shoreline of Kenogamisis lake. Solids deposition into Kenogamisis Lake may result in long term water quality effects; however, clean-up activities would limit the long-term potential for effects to water quality.

Residual adverse effects on surface water would be of high magnitude, potentially extending beyond the local assessment area (LAA) (with an increased potential for effects if a failure was to occur near the end of mine life when higher volumes are contained in the TMF and dry weather conditions exist), long-term and potentially irreversible within the PDA, with the magnitude of effects diminishing outside the PDA.

Fish and Fish Habitat

A variety of habitats exist within the waterbodies surrounding the TMF. Failure of a TMF dam and release of water and tailings into these waterbodies could result in changes in water quantity and quality as well as sediment deposition within existing fish habitat.

The primary causes of effects on fish and fish habitat would be the direct overprinting of natural substrates and changes in water quality. Solids deposition in fish habitat could potentially smother existing fish eggs, if present, or cause a change in physical substrate characteristics that would render substrates unsuitable for spawning. There would be a loss of benthic and aquatic plant communities that may take a long time to fully recover or require rehabilitation of disturbed areas. Solids deposition would be limited to a localized area around the dam breach, but may have the potential to affect the productivity of fish and fish habitat, depending on the magnitude and location of the release. In addition, there is also the potential for shorter term effects and localized chronic effects (i.e., surrounding the deposited tailings). Potential short-term effects may include fish toxicity due to physical (e.g., concentration of suspended solids) and chemical changes. Long-term effects may cause sublethal effects on fish due to an alteration of food availability or chronic toxicity, if concentrations did not dissipate over time.

Although the potential for effects on fish and fish habitat would vary with the location and magnitude of the TMF dam failure, a conservative case scenario would result in residual adverse effects on fish and fish habitat that would be of high magnitude, extend to the LAA, and be medium-term and potentially irreversible.

Groundwater

A TMF dam failure would have the potential to affect groundwater quality depending upon the size of the failure and the timeframe of the cleanup response. Topography and the horizontal hydraulic gradient in the area of the TMF, slope toward Kenogamisis Lake and it may be expected that the effect on groundwater quality, as a result of a TMF failure, would extend from the TMF and spill area toward Kenogamisis Lake. Localized infiltration would be limited due to surface flow toward Kenogamisis Lake. Tailings solids may be deposited near the breach location, but will be cleaned up where possible to limit infiltration and long term effects to groundwater. If land areas cannot effectively be remediated due to the potential damage of natural vegetation (i.e., forested areas) the potential for long-term effects to groundwater quality exist.

Residual adverse effects on groundwater would be confined to the LAA, and mainly within the PDA, but could potentially be high magnitude, long-term and potentially irreversible if tailings cannot be effectively removed from the ground surface.

Vegetation Communities

The release of tailings from a dam failure would result in the overprinting of local vegetation communities.

Affected vegetation or wetlands would be addressed by the implementation of spill containment measures and either stabilization and covering in place, or restoration of affected areas and the cleanup of released material if feasible. Over time, vegetation in the portions of affected wetlands would reestablish through natural dispersion from unaffected portions of either the same community, or adjacent wetland communities, usually within one to two growing seasons, depending on the scale of the TMF breach.

Changes in water levels would have a limited effect on vegetation, as water level increases would be temporary.

Residual adverse effects on vegetation communities would be confined to the LAA, and mainly within the PDA, but would be considered moderate to high magnitude, medium to long-term and potentially irreversible depending on reclamation success.

Wildlife and Wildlife Habitat

Effects of a TMF breach on wildlife and wildlife habitat would depend upon the scale of the breach. Wildlife would not be expected to be close to the PDA, due to the presence of Project activities. This would reduce the risk of wildlife mortality as a result of TMF failure. The sustainability or abundance of regional wildlife populations would not be expected to be affected by a TMF failure, and uptake of PoPC through vegetation would be limited as communities reestablish over one or two growing seasons. Flooding or infilling of wildlife habitat could occur near the TMF, particularly at the breach location, but effects would be localized and generally within the PDA.

Changes in water levels would have a limited effect on wildlife and wildlife habitat, as water levels increases would be temporary.

Residual adverse effects on wildlife and wildlife habitat would be confined to the PDA and to a lesser extent the LAA, and would be considered moderate magnitude, medium to long-term and potentially irreversible.

Archaeological and Heritage Resources

The potential for effects on archaeological and heritage resources would depend upon the scale of the TMF breach and the local presence of resources.

Stage 1 and 2 archaeological assessments did not identify any archaeological resources within a study area that extended over 1 km west and south of the TMF (beyond Lake A322 and the Goldfield Creek Tributary), and beyond Marron Lake to the north. In the unlikely event of a failure of the TMF, there would be temporary flooding and sedimentation, but this would not result in substantial disturbance to existing ground conditions beyond surficial erosion, localized near the TMF. Effects on archaeological resources would only be expected in a case where a breach led to ground disturbance (as a direct effect from a tailings release, or from excavation to clean up released tailings), and such areas would be localized to the area directly surrounding the TMF, where no archaeological resources have been identified.

Baseline work confirmed the presence of cultural heritage resources within the PDA and to the north. The resources within the PDA will be removed to accommodate Project development. The resources to the north of the PDA are located well away from the TMF. The offsite effects of a tailings breach would be limited to flooding through topographic lows, which would not extend to identified cultural heritage resources surrounding the PDA. No cultural heritage resources were identified to the west or south of the TMF, where the most direct offsite effects from a TMF breach would be expected.

In a conservative case scenario, residual adverse effects on archaeological and cultural heritage resources are not anticipated due to their absence in the Stage 1 and 2 archaeological assessment study areas.

Land and Resource Use and Traditional Land and Resource Use

A release of tailings from the TMF has the potential to temporarily limit the use of affected areas for recreational and traditional land uses such as hunting, gathering and fishing. Both land and water-based activities may be affected.

Temporary restrictions on recreational and traditional activities could result from flooding conditions. The effects during a 'wet weather' release would be limited, as activities are unlikely to be practiced during flooding events, and such disruption would occur as a result of the natural storm event, regardless of the TMF failure. During a 'fair weather' failure, water level rises would be more noticeable, but would not affect traditional uses beyond the effects of natural weather variations.

Residual adverse effects on vegetation communities, and wildlife and wildlife habitat could occur as a result of a TMF breach, as described in the sections above. A breach would predominantly affect the PDA and could extend into the LAA under a conservative case scenario. Recreational and traditional activities will not occur in the PDA during Project construction and operation, given the ongoing disturbance from the Project, however activities may be established in areas surrounding the TMF during closure and activities in the immediate vicinity of the TMF could be temporarily disrupted by a failure.

An effect on fish habitat could result in localized reductions in fish abundance, health or condition that could limit the ability to fish in the immediate vicinity of the TMF. Consultation with recreational and traditional land uses and the application of a fisheries advisory could be considered if long-term effects on fish are experienced. There could also be temporary effects on navigation of watercourses, for example smaller watercourses could be blocked or flows could change in watercourses.

Residual adverse effects on LRU and TLRU could be of moderate magnitude, limited to the LAA, medium- to long-term and potentially irreversible.

Temporary effects on the use of MacLeod Provincial Park would result from the change in water level along the shoreline of Kenogamisis Lake. The effects from a dam breach during fair weather conditions (no precipitation) would result in an increase of 0.4 m. Such a release would be within the range of normal weather conditions related to regular precipitation events. During the 'wet weather' event, given the extreme nature of such a precipitation event, it would be expected that use of the park would already be limited due to natural weather conditions and resulting flooding, and the incremental contribution of the dam breach would not have a measurable effect on this. Potential long-term water quality effects from a deposition of tailings solids would be localized to the vicinity of the TMF, and would not be expected to extend to MacLeod Provincial Park, given the assimilative capacity of Kenogamisis Lake.

The residual effect on MacLeod Provincial Park from a dam breach would be of low magnitude; generally consistent with existing weather effects, with only an incremental increase in effect, extending into the LAA, but short term and reversible.

22.4.2 Seepage and Contact Water Collection System Failure

22.4.2.1 Seepage and Contact Water Collection Safety Measures

Water levels in collection ponds will be kept to a minimum during normal operation, with all ponds aside from pond M1 generally maintained in a dry condition, which will reduce the risk of a release in the event of a breach. A breach may occur as a result of human error, for example the inappropriate operation of heavy machinery in/around the collection system could result in the breach of a berm. The likelihood of failure of this system is considered low.

The ponds, which include emergency spillways, are designed to hold the 1:100 year 24-hr storm event without release and safely pass the regulatory storm event (Timmins Storm). The regulatory storm event is larger than a 1:500 year event (which has a 0.2% chance of occurring in a given year).

22.4.2.2 Seepage and Water Collection Emergency Response Measures

In the case of a localized breach in a collection ditch or pond, water would be pumped back to the collection system where feasible, and repairs to the containment structure would be made. If a breach were to occur near a waterbody, pumps could be deployed to send the water back to the nearest collection point.

22.4.2.3 Seepage and Contact Water Collection Failure Effects Assessment

If pond M1 were breached, untreated contact water could be released at the location of the breach. Water quality modelling results (Appendix F5; Technical Data Report: Hardrock Project – Water Balance and Water Quality Model) have confirmed that water quality in the collection ponds could exceed PWQOs for some parameters and will be dependent on the seasonality and timing of the contact water system with respect to development of Project components.

A release from pond M1 could enter the Southwest Arm Tributary, depending on the location of the breach (i.e., on the downstream perimeter of the pond near the watercourse).

A seepage and contact water collection system failure could have an effect on surface water and fish and fish habitat, as characterized below for each potentially affected VC. The effects would be localized and could be readily remediated, and would therefore have a very low consequence as described in Section 22.2.5.

Surface Water

Contact water from pond M1 could affect surface water quality if released into the Southwest Arm Tributary. Water quality modelling (appendix F05) identified that near the end of operations, under climate normal conditions, no parameters are predicted to exceed the MMER Schedule 4 criteria and only arsenic, cobalt, antimony, uranium and possibly aluminum may exceed the PWQO. The concentration of these parameters will be dependent on the volume of water and sources to pond M1 at the time and will vary seasonally and in response to operational demands. Based on the short-term nature of the upset conditions following emergency response, the limited volume of a potential release, and the expected pond M1 water quality, concentrations in Kenogamisis Lake will be attenuated within a short distance down gradient of the Southwest Arm Tributary and are expected to meet the PWQO or background levels within the LAA.

Residual adverse effects on surface water would be of low magnitude, localized to the LAA, short-term and reversible.

Fish and Fish Habitat

Based on the water quality modeling predictions for pond M1, an uncontrolled release of water from pond M1 would not be expected to result in lethal or sub-lethal effects on fish due to rapid changes in water quality. Although some parameters may exceed PWQO, concentrations of PoPC are expected to meet effluent discharge criteria (i.e., MMER Schedule 4) and the release would be short term.

Water temperature in pond M1 is also expected to be similar to ambient conditions during most of the year, with the exception of during summer, when water temperature in Pond M1 could be cooler than local surface waters of Kenogamisis Lake (see fish and fish habitat VC [Chapter 11.0]). A rapid decrease in water temperature could result in lethal and sub-lethal effects on fish (Donaldson et al. 2008). Game and sustenance fish species (e.g., Northern Pike, White Sucker and Walleye) from Kenogamisis Lake are known to inhabit the Southwest Arm Tributary more frequently in the spring, and the diversity and abundance of fish in the Southwest Arm Tributary is reduced in the summer. Potential effects of a rapid change in water temperature are therefore not likely to occur during important spawning and migration periods for valued game and sustenance fish species.

A breach of the pond M1 berm may affect fish through physical disturbance of fish habitat. Potential effects include alteration of existing habitat due to erosion of bank material, and the suspension and deposition of eroded material. The erosion of bank material and alteration of habitat can be readily remediated through bank re-construction and bioengineering. Sedimentation from a release of contact water could affect fish including fish eggs, if present at the time of the event. Such an effect would be most pronounced in the spring, because most of the fish known to inhabit the Southwest Arm Tributary and adjacent areas of Kenogamisis Lake spawn in the spring. Sedimentation of fish eggs could lead to the partial or total loss of a fish population cohort depending on the scale of the event and presence of eggs. Sediment deposition, may also cause temporary, localized changes in benthic community composition, depending on the magnitude of the release. This, in turn has the potential to alter or limit the availability of benthic food sources for fish on a temporary basis. Suspended sediment in the water column may lead to lethal or sub-lethal effects on fish, depending on scale and duration of the event.

Given the size of pond M1 in relation to Kenogamisis Lake, such an event could have localized effects on the Southwest Arm Tributary, but potential adverse residual effects would not be anticipated on a lake-wide scale. Potential effects are considered temporary, because benthic and fish communities would be expected to recover from such an event. Potential residual adverse effects on fish and fish habitat due a pond M1 failure would be of moderate magnitude, limited to the LAA, medium-term and reversible.

22.4.3 WRSA or Overburden Storage Areas Slope Failure

22.4.3.1 WRSA or Overburden Storage Areas Slope Failure Safety Measures

Waste rock material is very coarse grained and angular in shape providing high surface locking potential and high angle of repose, which increases slope stability. Side slope angles have been designed to provide long-term geotechnical stability and benches at regular intervals will be used to shorten slope run and the potential of a slope failure. The WRSAs are located along the edge of the PDA, reaching heights up to 100 m with varying slope angles.

AMECFW considered the stability of the WRSAs during Project planning/design. The Project area is in a low seismic hazard area based on Natural Resources Canada's seismic hazard map. The 2010 National Building Code of Canada seismic hazard calculator was used to calculate interpolated seismic hazard values for the Geraldton area. Static liquefaction of foundation soils due to high rates of loading from waste rock dumping will be controlled by monitoring pore pressures and dump rates/bench heights in potentially susceptible areas. The dynamic liquefaction of the overburden soils due to seismic events is not considered to be a risk at the PDA.

Stripping of organics/peat along the perimeter of WRSAs was assumed for analysis to avoid creation of mud waves during waste rock placement as well as inherent stability and settlement issues of the WRSAs in the long term. Based on a sensitivity analyses it was determined that stripping organics along the perimeter of the WRSA footprint up to a minimum length of approximately 175 m measured from the toe of the WRSAs could be required wherever organics are thicker than 0.3 m.

The overall WRSA slopes are designed according to the shear strength of foundation material. Bench height, intermediate bench widths, inter-bench slopes and overall slope vary depending on the foundation conditions. The WRSAs have 20 m high lifts to allow for wider catch benches to facilitate rehabilitation.

An estimated 7.24 million cubic metres (Mm^3) of overburden will be generated over the LOM. The primary overburden storage area will be located on the historical MacLeod tailings. The slopes of the overburden storage area are anticipated to range from 2:1 to 4:1. In addition, smaller overburden storage areas will be developed within contingency WRSA D and adjacent to the TMF for temporary storage until required for rehabilitation of the TMF, beginning in Year 7. Other temporary overburden storage locations may be used during the construction phase, for example within the footprint of WRSA C for preparation of the mill pad. Once storage areas are completed, they will be rehabilitated as per the Conceptual Closure Plan (Appendix I).

The design of the overburden storage areas will account for the nature of the material being managed to provide long-term stability. However, the consistency of excavated material may deviate from the expected average composition. This may minimally affect the overall stability of small sections of the storage areas, but is not expected to not result in deviations large enough to result in wide scale failure.

Specific designs including toe stability berms and shear keys will be developed with ongoing Project planning and design. Ample storage space is available to allow placement in interior locations to allow for toe preparation works to be carried out.

The likelihood of a large-scale failure that would extend beyond the protection measures that are in place (benching and setbacks) is very low.

22.4.3.2 WRSA or Overburden Storage Areas Slope Failure Emergency Response Measures

Emergency preparedness measures will include maintaining access, setbacks and ongoing monitoring and inspection with thresholds to indicate exceedances of design criteria and potential failure. If a WRSA were to fail, the first response will be to stop work in the area and clear the area to maintain worker safety. A specific response plan would be developed and when safe to do so, material could be returned to the storage area, or recontoured in place depending upon the scale of the failure. Measures to reduce the extent of the released material may also be needed including silt fencing and berms to limit further movement/release of material. Areas would be restored to the extent practical.

22.4.3.3 WRSA or Overburden Storage Areas Slope Failure Effects Assessment

Small scale slumping or sloughing at the toe of the WRSAs will be repaired without deposition beyond the PDA. A larger scale failure of a WRSA could result in slumping and release of waste rock into either the open pit, Kenogamisis Lake or the Southwest Arm Tributary. A failure to the north could also affect the realigned Highway 11 as well as a residential property located in proximity to WRSA A. Failures in other areas of the overburden storage areas and WRSAs would be limited by the location of Project components such as site roads.

Geochemical baseline studies (Appendix E6) have confirmed that overburden is not potentially acid generating (NPAG); however, leachate quality from the overburden may potentially exceed PWQO for arsenic, cobalt, and copper due to background soil and rock properties. Waste rock was sampled from a variety of lithologies with the majority of waste rock screened as NPAG (less than 4% is potentially acid generating). Concentrations of arsenic and cobalt may potentially exceed PWQO, and antimony, aluminum and uranium may potentially exceed the interim PWQO.

Storage area slopes will be designed to maintain stability, so even a conservative case scenario failure should have a limited potential for release beyond the PDA; however, there is potential for material to enter the LAA. A large scale storage area slope failure would have a localized effect on surface water and fish and fish habitat. Effects on these VCs could also impede the use and access of land and water resources for recreational and traditional uses in localized areas. Community services and infrastructure, such as the realigned Highway, may also be affected by a slope failure.

The effect on VCs would be localized and predictably remediated, and would therefore have a low consequence as described in Section 22.2.5.

Surface Water

Waste rock or overburden material has the potential to affect surface water quality if released into water bodies adjacent to the PDA. Based on the short-term nature of the upset conditions following emergency response, the limited volume of a potential release, and the expected water quality, concentrations in Kenogamisis Lake will be attenuated within a short distance down gradient of the release and are expected to meet the PWQO or background levels within the LAA.

A release of overburden into surface water would also lead to localized increases in turbidity and suspended sediment, while suspended sediment from waste rock would be limited due to the coarse nature of the material. Long term leaching would be a greater concern for waste rock, but this material can also be more readily recovered in the event of a failure.

Following closure, the open pit will form a pit lake that will be stratified, with fresh water in the upper layer and denser water with elevated concentrations of various elements in the lower layer. A failure of overburden or waste rock into the open pit following closure could disturb this stratification, resulting in a mixing of the upper and lower layers of the pit lake. This could result in increased concentrations of select elements, potentially above applicable water quality objectives, being discharged to Kenogamisis Lake and requiring treatment.

Residual adverse effects on surface water would be of moderate magnitude, localized to the LAA, short-term and reversible.

Fish and Fish Habitat

Water quality modelling results demonstrate that while elevated concentrations of arsenic are expected from WRSA runoff, the concentrations are below thresholds that could lead to fish mortality.

A sudden increase in suspended solids in the water column has the potential to cause acute mortality in fish, with resulting sediment deposition potentially affecting spawning habitats, however, death of fish would be a one-time event and not persist over time. Although the loss of individual fish would be permanent, it is anticipated that fish communities would recover over time. Effects of sediment deposition would be short-term in duration.

Deposition of waste rock or overburden into surface water features (or material that is mobilized due to WRSA slope failure) could affect fish habitat. Remedial actions would be considered, but material may be left in place, as removal could result in further disturbance. The effect of material deposition on fish habitat would be a one-time event and, if left in place, could be restored to ecologically functional habitat naturally or through remedial measures.

Residual adverse effects on fish and fish habitat would be of low magnitude, limited to the LAA, short-term and potentially reversible.

Community Services and Infrastructure

A failure of one of the storage areas to the north of the open pit has the potential to affect the realigned Highway 11. Depending on the size of the failure, a portion of the highway could be damaged. Effects on the highway would be addressed through cleanup and repairs as necessary, and would result in temporary traffic disruptions.

Residual adverse effects on community services and infrastructure would be of moderate to high magnitude, limited to the LAA, short-term and reversible.

Land and Resource Use and Traditional Land and Resource Use

A failure of a WRSA slope could affect fishing for recreational and traditional purposes in a localized area, if the affected area were used for such activities. Access may be limited for a short duration if remedial activities are proposed, and fish populations may be temporarily disrupted. If materials are left in place, fish habitat will be restored naturally or through remedial measures, which would limit the localized effect on fishing over the long term. Concentrations of PoPC and release rates from leaching are not expected to be high enough to lead to fish mortality. Sedimentation of fish eggs would be localized to the failure site.

Residual adverse effects on LRU and traditional uses would be of moderate magnitude, limited to the LAA, short-term and reversible.

22.4.4 Loss of Stability of Historical MacLeod Tailings

22.4.4.1 Loss of Stability of Historical MacLeod Tailings Safety Measures

An estimated 22% of the historical MacLeod tailings will be removed from the open pit footprint and for the construction of the buttressing along the south edge of the tailings in the area of the open pit to address stability design requirements.

Overburden and topsoil will be stored north of the open pit within the overburden storage area, the majority of which will be located over top of the remaining historical MacLeod tailings. The placement of material over the remaining historical tailings in this area will include a drainage layer of coarse rock to act as a capillary break for drainage control. Overburden will then be placed in a controlled manner to provide an enhanced cover system to reduce infiltration through the historical tailings and decrease metal loadings to Kenogamisis Lake.

The realigned Highway 11 will traverse approximately 1.2 km of the historical MacLeod tailings. Highway construction materials and techniques along the historical MacLeod tailings will be applied to maintain stability and limit the infiltration of precipitation. The design of the highway will consider standard design and performance criteria for the highway as well as design criteria for the historical MacLeod tailings. Where traversing the historical MacLeod tailings, the road profile has been set to provide a minimum 2 m separation between profile grade and original ground surface. An approximately 70 to 80 m wide by 5 m high rockfill buttress will be constructed over the historical MacLeod tailings and along the toe of the overburden storage area. In the central portion where the highway is to be constructed over the historical MacLeod tailings, the buttress along the toe of the overburden storage area is increased to about 7 m height and about 40 to 50 m width. The Highway 11 Realignment PDR (Appendix H2) provides further design recommendations related to stability, including preloading and buttressing, that will be adhered to during highway construction.

Based on the geotechnical design considerations being applied for construction on top of historical tailings, the likelihood of a failure is considered very low.

22.4.4.2 Loss of Stability of Historical MacLeod Tailings Emergency Response Measures

As per the Conceptual ERP (Appendix M3), the first response would be to stop work in the area and clear and secure the area to maintain worker and public safety. Notification of authorities, emergency responders, local residents and Aboriginal communities would occur if required. The historical MacLeod tailings would be contained to the extent possible using temporary dams of earth or snow and silt fences, and through other available equipment or means. Remediation and monitoring of tailing-impacted areas would be implemented, and the basic causes of the failure would be investigated to inform the development and implementation of measures to reduce the possibility of recurrence.

If a storage area were to fail as a result of the historical MacLeod tailings failure, material would either be excavated if safe to do so and returned to an appropriate overburden storage area with remediation if required, or be recontoured in place.

22.4.4.3 Loss of Stability of Historical MacLeod Tailings Effects Assessment

The failure of the historical MacLeod tailings could lead to localized slumping and the exposure of historical tailings to increased erosion or infiltration resulting in the release of PoPC. Failure could also result in damage to the realigned Highway 11. The historical MacLeod tailings are separated from the shoreline of Barton Bay and the Central Basin of Kenogamisis Lake by the historical MacLeod low tailings. In a highly unlikely scenario, a failure of a steeper section of the historical MacLeod high or low tailings could result in material sliding toward the shoreline, or result in a cascading failure of the previously stable low tailings, which could result in deposition to surface water.

The major parameter of concern in the historical MacLeod tailings is arsenic, although there are elevated levels of a number of metals in groundwater that exceed PWQO.

In a conservative case scenario, a failure of the historical MacLeod tailings could have a localized effect on surface water, fish and fish habitat, groundwater, and community services and infrastructure. Effects on surface water and fish and fish habitat could also impede the use and access of land and water resources for recreational and traditional uses. Due to the uncertainty in attempting the complete removal of historical tailings deposition from the lake, and that fact that tailings already existing within the lake from historical mining practices, remediation would be uncertain, and would therefore have a high consequence as described in Section 22.2.5.

Surface Water

Surface water quality baseline data demonstrated the 75th percentile arsenic concentration exceeds the Interim PWQO and the 75th percentile total iron and total phosphorus concentrations exceed the PWQO in Barton Bay.

A release of historical tailings into Kenogamisis Lake would affect surface water quality, particularly related to already elevated levels of arsenic and some metals in the receiving waters. The potential for contamination could be limited by cleanup activities, but it may be difficult to entirely remove deposited tailings material due to the presence of historical tailing already within the lake from past mining activity.

Residual adverse effects on surface water would be of moderate magnitude, localized to the LAA, long-term and potentially irreversible.

Fish and Fish Habitat

The release of arsenic and metals at a high enough concentration could result in fish mortality. Arsenic concentrations may come close to the approximate limit for fish mortality of 550 µg/L; however, potential fish mortality would be expected to be localized near the release point and not affect an entire fish population within an ecological unit (i.e., stream or lake). It is anticipated that deposition to the lake would be localized, so that potential effects on fish and fish habitat would be limited, although localized increases of PoPC could be experienced at the release point over the long term.

A sudden increase in suspended solids in the water column has the potential to cause acute mortality in fish, with resulting sediment deposition potentially affecting spawning habitats, however, mortality of fish would be a one-time event and not persist over time. Although the loss of individual fish would be permanent, it is anticipated that fish communities would recover over time. Effects of sediment deposition would be short-term in duration.

Residual adverse effects on fish and fish habitat would be of moderate magnitude, limited to the LAA, long-term and irreversible.

Groundwater

A failure of the historical tailings has the potential to affect groundwater quality, if the tailings material shifts and results in increased infiltration to local groundwater. Groundwater is already affected by seepage from historical tailings; however, an upset of existing stable conditions may result in the increased potential for releases beyond baseline conditions of arsenic and other metals.

The effect on groundwater would be confined to the LAA, and would be considered low magnitude, long-term and potentially irreversible.

Community Services and Infrastructure

A failure of the historical MacLeod tailings under or near Highway 11 could result in slumping that affects the highway, causing damage to the highway, requiring immediate stabilization and repair.

Residual adverse effects on community services and infrastructure would be of moderate magnitude, limited to the PDA, short-term and reversible.

Land and Resource Use and Traditional Land and Resource Use

Historical tailings deposition to the Kenogamisis Lake could affect fishing for recreational and traditional purposes in a localized area, if the affected area were used for such activities. Access may be limited for a short duration if remedial activities are proposed, and fish populations may be temporarily disrupted. Concentrations of PoPC and release rates from leaching are not expected to be high enough to lead to fish mortality. Sedimentation effects on fish or fish eggs would be localized to the failure site. A localized deposition of historical tailings should not affect overall fishing activities in Kenogamisis Lake.

Residual adverse effects on LRU and traditional uses would be of low magnitude, limited to the LAA, long-term and irreversible.

22.4.5 Goldfield Creek Diversion Failure

22.4.5.1 Goldfield Creek Diversion Safety Measures

The principles of natural channel design will be used to guide the development of the new diversion channel. Natural channel design is based on using a functioning stream system near the Project site as a reference for the design of the new channel. The design is developed through an understanding of the geomorphic processes (e.g., flow regime, sediment regime, valley type) shaping the reference stream. Goldfield Creek will be used as the reference stream for the new diversion channel. The potential effects of climate change, such as substantial precipitation events, will be addressed through the design of the channel and its associated floodplain. Risks associated with extreme events can be mitigated by designing a channel with the appropriate pattern, dimension and profile and by providing effective floodplain access.

The Goldfield Creek diversion channel will be sized to convey the 100 year 24-hour rainfall event (which would have the greatest peak flow), and to safely release the peak flow from the regulatory storm event and the Inflow Design Flood corresponding to the PMF without overtopping the diversion dam located north of the TMF to direct flows to the new diversion channel. This design accounts for upstream flows and contributing flows from the TMF emergency spillway (i.e., flows from the TMF in excess of the EDF). To account for extreme flood conditions, the diversion channel floodplain has been sized adequately to accommodate the flows from the TMF spillway and Goldfield Creek in events greater than the 100-year storm, and has the capacity to pass flows up to and including the PMF event.

There is limited risk of failure during construction because the new channel will be constructed with no connection to watercourse or fish habitat. Erosion and sediment control measures (e.g., silt fence, sediment traps, sediment basins) as per the Conceptual Erosion and Sediment Control Plan will be included and monitored to prevent sediment from leaving the construction area.

The potential for failure during commissioning will be limited by implementing the natural channel design principles noted above, as well as by having the design engineer available as required during construction. This will help confirm that the instream and bank protection unique to natural channel design are constructed properly. Once the new channel is constructed, flow will be released into the new channel incrementally, in a controlled manner. The potential for failure will be reduced as vegetation is established and stabilizes the streambank and streambed.

A substantial failure would only be expected as part of an unanticipated extreme precipitation event beyond the conservative case considered in Project design, so the likelihood of a failure is very low.

22.4.5.2 Goldfield Creek Diversion Emergency Response Measures

The diversion channel will be monitored on a regular basis and adaptive management will support long-term stabilization. If a breach occurs repairs will occur when it is safe to do so. In the event that a structural failure occurred and habitat was permanently damaged, additional offsetting measures may be required in accordance with relevant legislation.

22.4.5.3 Goldfield Creek Diversion Failure Effects Assessment

Minor areas of erosion are common during the first few years as the new channel makes some minor adjustments to its pattern, dimension and profile. But these areas of erosion are generally small and produce only minor increases in turbidity. In most cases, these areas of erosion heal themselves and are considered part of the natural geomorphic process.

In a conservative case scenario, a failure would extend several hundred metres, resulting in sedimentation to the Southwest Arm Tributary and potentially the Southwest Arm of Kenogamisis Lake. A failure of the Goldfield Creek diversion would have a localized effect on surface water and fish and fish habitat. Since a failure would be linked to a severe precipitation event, the extent of effects on these VCs would be short term and not likely to impede the use and access of land and water resources for recreational and traditional uses beyond the disruption from natural flooding and erosion. The effect would be predictably remediated, and would therefore have a low consequence as described in Section 22.2.5.

Surface Water

A failure of the Goldfield Creek diversion could result in a change in surface water quality in the Southwest Arm Tributary and Southwest Arm of Kenogamisis Lake. The highest potential for effects would be in the Southwest Arm Tributary, directly downstream of the diversion. This watercourse would experience the highest flow and sedimentation, potentially leading to further erosion beyond the extent of the constructed diversion. The volume of water and assimilative capacity of Kenogamisis Lake would reduce the effect of increased flow and sedimentation. High flows and sediment releases would be caused by a precipitation event, and would be expected to cease shortly following the storm. Following the sediment release, water quality of affected watercourse would return to normal conditions, as sediment is washed downstream and deposited in waterbodies.

Residual adverse effects on surface water would be of low magnitude, localized to the LAA, short-term and reversible.

Fish and Fish Habitat

A variety of habitats exist for fish within the Southwest Arm Tributary and Kenogamisis Lake. Sedimentation, particularly if it is composed of fine sized particles, could negatively affect fish including fish eggs, if present. Effects on adult fish would likely be short-term in duration. Adverse changes to the quality of fish habitat would be expected to reverse following the sedimentation event. Additional remedial measures may be required to restore the quality of fish habitat in the constructed channel.

Residual adverse effects on fish and fish habitat would be of moderate magnitude, limited to the LAA, short-term and reversible.

Land and Resource Use and Traditional Land and Resource Use

A failure of the diversion would result in increased sedimentation and flow downstream through the Southwest Arm and into Kenogamisis Lake, however the effects from a failure would not increase substantially beyond the natural effects of a severe precipitation event. This would result in a temporary disturbance to fishing and navigation, that would be cleared naturally following the weather event. Access to the Southwest Arm Tributary is not anticipated during Project construction and operation, so effects on the use of the watercourse are expected to be limited to the closure phase, when the channel has been stabilized. If a failure occurred that required restoration, use would be restricted until restoration was completed.

Residual adverse effects on LRU and traditional uses would be of moderate magnitude, limited to the LAA, short-term and reversible.

22.4.6 Spill from Vehicle Collision or Mechanical Failure

22.4.6.1 Vehicle Collision or Mechanical Failure Safety Measures

A number of traffic safety measures will be in place to reduce the potential for vehicle collisions or mechanical failures to occur as a result of the Project. These include, but are not limited to, the following:

- road, safety, and traffic control improvements that are required to accommodate the realignment of Highway 11 will be implemented based on a study that was conducted to review current traffic conditions and analyze traffic forecasts during the Project (Appendix F9; Technical Data Report: Hardrock Project – Traffic Impact Assessment)

- the realignment of Highway 11 will be designed and constructed to applicable standards and adhere to the highest standard practices for highway construction
- dedicated turning lanes will be implemented if and as required for safety
- drivers will be required to adhere to posted speed limits
- Project vehicles will be manually inspected on a regular basis to confirm there are no problems
- transported amounts of hazardous materials (e.g., fuel, cyanide, LNG, ammonia) will be limited to the amounts required by the Project, and transported by licensed contractors.

To reduce the likelihood of such an event, emphasis will be placed on safety and accident prevention.

Fuel will be transported to the Project along the regional road network by tanker trucks. The tanker trucks will consist of single units that typically have a capacity of 7.5 kilolitres. Tanker trucks are generally compartmentalized, such that if there were to be an accident, only a portion of the load will be lost except in a catastrophic incident.

The "Technical Data Report: Hardrock Project – Traffic Impact Assessment" (Appendix F9) indicates that traffic along Highway 11 is very low (less than 2,000 vehicles per day), and well within the capacity of the highway. A two lane highway that exhibits near capacity conditions would have daily traffic volumes near 15,000 vehicles per day. As a result, the vehicles generated by Project activities can be easily accommodated, resulting in a very low likelihood of a collision along existing routes.

22.4.6.2 Vehicle Collision or Mechanical Failure Emergency Response Measures

A detailed ERP will be developed and submitted to appropriate regulatory agencies for review prior to the initiation of Project activities. It will contain specific measures related to offsite emergencies, including:

- medical response
- notification of regulatory authorities
- spill containment
- removal/cleanup of contaminated soils and water
- monitoring of environment
- ongoing staff training to learn from any accidents.

In addition, a SPRP will also be developed to address onsite spill scenarios, including related to prevention, contingency planning and reporting practices for the timely and effective response to vehicle collisions involving mine equipment or transport trucks may result in the release of hazardous materials such as mill reagents and fuel, or other non-hazardous materials such as construction material. A Conceptual SPRP is provided in Appendix M8.

22.4.6.3 Vehicle Collision or Mechanical Failure Effects Assessment

In the event of a vehicle collision or mechanical failure, a spill could result in the release of a PoPC, depending on the contents of the vehicles or the nature of the failure. Mill reagents will be delivered in bulk, such as lime, sodium hydroxide, elemental sulphur, and hydrochloric acid, while other reagents will be delivered in smaller quantities, depending on the application. Diesel and, potentially, LNG will also be delivered in tanker trucks. Failures may result in fuel leakage or hydraulic fluid release. Non-hazardous material transported to the Project will include sand/aggregates in approximately 50 t (metric tonne) trucks.

The potential for effects would depend on the location of the collision or failure and the nature of the materials being released. Volumes of hazardous material will be limited based on the needs of the Project and delivered on a regular ongoing basis.

A vehicle collision or mechanical failure could have a localized effect on surface water and fish and fish habitat if it occurs close to a surface water feature. Effects on these VCs may also impede the use and access of land and water resources for recreational and traditional uses. The effect would be readily remediated, and would therefore have a low consequence as described in Section 22.2.5.

Surface Water

A vehicle collision or mechanical failure resulting in the release of fuel or hazardous material could have localized effects on surface water. If a vehicle collision were to occur outside the PDA, the response time to implement emergency measures may be longer, resulting in potentially increased effects. Depending on the location of the collision, this could include the release of fuel or hazardous materials into watercourses, which could carry PoPC downstream before cleanup activities are started. Emergency response times should be adequate to contain and remediate downstream effects, since hazardous materials would only be transported in limited quantities. A sand or aggregate spill into a watercourse may result in temporary sedimentation and flow impediment until cleanup can occur.

Residual adverse effects on surface water would be of low to moderate magnitude, short-term and reversible, but may extend downstream from the collision site.

Fish and Fish Habitat

If a vehicle collision or mechanical failure resulted in a spill of fuel or hazardous material near fish habitat, this may lead to localized fish mortality. Based on the relative abundance and distribution of fish populations, it is anticipated that depending on the size of the spill and toxic materials spilled, fish mortality could range from a few fish (not affecting the sustainability and productivity of a fishery), to larger scale levels of fish mortality (which could have a temporary effect on localized fish populations). It is anticipated fish populations would reestablish themselves within one or two generations in larger events. A sand or aggregate spill may have a localized effect on fish through disruption to habitat or temporary sedimentation until cleanup can occur.

Residual adverse effects on fish and fish habitat would be of low to moderate magnitude, short-term and reversible, and may extend downstream from the collision site.

Land and Resource Use and Traditional Land and Resource Use

A release from a vehicle collision or mechanical failure could temporarily limit or affect the use of the area surrounding the accident site for recreational and traditional land uses such as fishing, if the affected area were used for such activities. However, fish populations affected by mortality from contaminated material would reestablish themselves within one or two generations. Effects would be temporary and localized, with limited effect on overall fishing within the LAA.

Residual adverse effects on LRU and traditional uses would be of moderate magnitude, limited to the LAA, short-term and reversible.

22.5 RISK ANALYSIS

The assessment of the potential risk of environmental effects resulting from accidents or malfunctions involves the use of a risk matrix (Figure 22-1), where the residual risk is determined based on the likelihood and consequence of that particular accident or malfunction, as defined in Section 22.2.5. Risk levels are colour coded to provide a visual means of expressing risk, the definitions of which are provided in Figure 22-2. Where a range of risk ratings could occur for a particular accident or malfunction, a conservative approach was taken whereby the highest rating was considered. The results of the risk assessment are provided in Table 22-3.

Likelihood Post-Mitigation	**Very High**	Low	Moderate	High	Very High	Very High
	High	Low	Moderate	Moderate	High	Very High
	Moderate	Very Low	Low	Moderate	Moderate	High
	Low	Very Low	Low	Low	Moderate	Moderate
	Very Low	Very Low	Very Low	Very Low	Low	Low
		Very Low	**Low**	**Moderate**	**High**	**Very High**
		Potential Consequence Post-Mitigation				

Figure 22-1: Risk Matrix

Legend		**Description**
	Very Low	Risk is negligible; no additional risk mitigation required
	Low	Risk is acceptable; continue to monitor risk; no additional risk mitigation required
	Moderate	Risk may be acceptable; more detailed review required; if warranted, additional mitigation may be required
	High	Risk is unacceptable; appropriate risk mitigation needs to be applied
	Very High	Risk is imminent; mitigation needs to be applied; long term risk reduction plan needs to be developed and implemented

Figure 22-2: Risk Level Legend

Table 22-3: Summary of Accidents or Malfunctions Risk Analysis

Accident/ Malfunction	Parameters of Potential Concern Released (If Event Occurs)	In-design Safety Measures	Emergency Response Measures	Description of Residual Adverse Effects	Likelihood of Event	Severity (Consequence) of Residual Event	Residual Risk
Tailings Management Facility Failure	Tailings Heavy metals Suspended solids	Construct TMF (with emergency spillways) using safe and proven design specifications. Construct dam to withstand PMF and maximum credible earthquake. Design dam to hold the EDF. Diversion dam north of the TMF, between the TMF and Goldfield Creek Diversion to direct water away from the TMF and toward the new diversion channel. Emergency spillway for excess flows. Deposition plan displaces the pond into the central portion of the TMF so that solid beaches will form against the perimeter of the TMF for added safety. Limits the size of the ponds to reduce risks. Conduct a Failure Mode and Effect Analysis and a Mechanisms and Dam Break and Inundation Study during detailed design. Meet Canadian Dam Association and International Commission on Large Dams standards. Fund an ITRB to review and advise on the design, construction, operation, performance, and closure planning for the TMF. Monitoring and routine surveillance. Annual dam safety inspections	Shutdown pumping of tailings to the TMF in the event of failure. Notify emergency responders and stakeholders. Initiate evacuation procedures if required. Implement emergency repairs, if safe to do so. Pump the TMF to the open pit for containment if possible to reduce the amount of released effluent. Contain the spill through temporary dams, silt fences and other means. Effects on surface water may be mitigated by using turbidity curtaining, isolating affected areas through the use of cofferdams, and removing and redepositing contaminated material in the TMF. Stabilize spilled tailings and haul back to TMF if feasible. Restore areas to the extent practical. Develop surface and groundwater monitoring plan.	In the event of a TMF dam failure tailings would be released to the environment affecting the waterways within the PDA and ultimately reach the Southwest Arm of Kenogamisis Lake. Solids could also be deposited along the failure pathway, extending from the breach location, potentially causing localized infilling of vegetated areas, watercourses or the shoreline of Kenogamisis Lake. A failure would result in effects that extend to surface water, fish and fish habitat, groundwater, vegetation communities, and wildlife habitat, and would have the potential to disrupt archaeological and heritage resources. Effects on these VCs would also impede the use of and access to land and water resources for recreational and traditional uses. Locations outside of the PDA (and within the LAA) along the shoreline of Kenogamisis Lake, including MacLeod Provincial Park would experience effects from water level increases. Remediating a TMF failure could have uncertain results due to the potentially widespread extent of the release.	Very Low	High	Low
Seepage and Contact Water Collection System failure	Process water/ effluent Suspended solids Ammonia	Designs for collection ditching and collection ponds will take into account safe distances from nearby infrastructure and water features. High water berms may be constructed to protect Project infrastructure against potential flooding. Design system to control runoff up to the 1:100 year return, with emergency overflow to 1:500. Water levels in collection ponds will be kept to a minimum during regular operation, which will limit the potential for increased levels of PoPC, and reduce the risk of a release in the event of a breach.	Structural repairs and debris cleanout as required. Water would be pumped back to the collection system where feasible, and repairs to the containment structure would be made. If a breach were to occur near a waterbody, absorbent materials and booms may be applied to limit releases to surface water.	If the seepage and contact water collection system were breached, untreated contact water could be released at the location of the breach, which could exceed PWQOs for some parameters. A seepage and contact water collection system failure could have a localized effect on surface water, fish and fish habitat, and vegetation communities. The effects would be localized and could be readily remediated.	Low	Very Low	Very Low

Table 22-4: Summary of Accidents or Malfunctions Risk Analysis

Accident/ Malfunction	Parameter of Potential Concern Released (If Event Occurs)	In-design Safety Measures	Emergency Response Measures	Description of Residual Adverse Effects	Likelihood of Event	Severity (Consequence) of Residual Event	Residual Risk
WRSA or Overburden Storage Area Slope Failure	Suspended solids Heavy metals	Waste rock stability assessment undertaken and foundations treatments, such as toe slope berms and shear keys identified. Side slope angles designed for long-term stability. Benches at regular intervals to shorten slope run and the potential of a slope failure. Instrumentation installed to monitor performance.	Maintaining access to determine if the height of the toe stability berm can be increased if monitoring data indicates incipient failure. First response will be to stop work in the area to maintain worker safety. Material will be excavated and returned to the storage area, or recontoured in place depending upon the scale of the failure. Silt fencing and monitoring may also be required depending upon the scale of the failure as well as repair of damaged infrastructure. Areas would be restored to the extent practical. A monitoring program will be designed to monitor the success of rehabilitation measures.	A failure of the waste rock or overburden slopes may result in the release of this material into surface water and fish and fish habitat, increasing levels of PoPC and sedimentation. These effects may also have a localized effect on resource use and traditional uses related to fishing, if practiced in the affected area. A failure toward the realigned Highway 11 could result in damage to the highway. The effect on VCs would be localized and predictably remediated.	Very Low	Low	Very Low
Loss of Stability of Historical MacLeod Tailings	Tailings Heavy Metals	Removal of portions of historical MacLeod tailings within the PDA (only overburden storage and highway realignment will take place on top of existing historical tailings). Stability assessment undertaken. Buttressing and berms will be constructed to provide stability for Highway 11 and overburden storage. Highway embankments will be constructed based on geotechnical recommendations to maintain stability.	First response will be to stop work in the area to maintain worker safety. Notification of authorities and stakeholders. The historical MacLeod tailings will be contained to the extent possible using temporary dams of earth or snow and silt fences, and through other available equipment or means. A remedial action plan will be developed in consultation with appropriate government agencies. A surface water and groundwater monitoring program will be designed to monitor the movement of parameters that may infiltrate from historical tailings and the success of rehabilitation measures. Material will be excavated if safe to do so and returned to an appropriate storage area location with appropriate remediation if required. Storage areas may also be recontoured in place depending upon the scale of the failure.	A failure of the historical MacLeod tailings may result in the release of this material into surface water and fish and fish habitat, increasing levels of PoPC and sedimentation. These effects may also have a localized effect on resource use and traditional uses related to fishing, if practiced in the affected area. It may not be possible to contain all material released, which could have long-term effects on water quality. Loss of stability could disrupt existing hydrogeological characteristics, resulting in increased infiltration of PoPC into groundwater. Effects which would be localized with uncertain remediation.	Very Low	High	Low

Table 22-4: Summary of Accidents or Malfunctions Risk Analysis

Accident/ Malfunction	Parameter of Potential Concern Released (If Event Occurs)	In-design Safety Measures	Emergency Response Measures	Description of Residual Adverse Effects	Likelihood of Event	Severity (Consequence) of Residual Event	Residual Risk
Goldfield Creek Diversion or Watercourse Crossing Failure	Suspended solids	Channel will be sized to convey the peak flow from the EDF and to safely release the peak flow from the regulatory storm event and the Inflow Design Flood without overtopping the diversion dam located north of the TMF. Design accounts for upstream flows and contributing flows from the TMF emergency spillway in a flood event. The principles of natural channel design will be used to guide the development of the new diversion channel. Potential effects of climate change, such as substantial precipitation events, will be addressed through the design of the channel and its associated floodplain. Construct channel offline to avoid risk of failure during construction. Implement and regularly inspect erosion and sediment control measures (e.g., silt fence, sediment traps, sediment basins). Construct channel with design engineer present.	The diversion channel will be monitored on a regular basis and adaptive management will support long-term stabilization. If a breach occurs repairs will occur when it is safe to do so. If a structural failure permanently damaged habitat, additional offsetting measures may be required in accordance with relevant legislation.	Changes to surface water quality resulting from an erosion or sedimentation event would be short in duration and reversible. As the flow in watercourses would clean away sediment deposited during an erosion or sedimentation control failure, changes to fish habitat would also be expected to be short-term in duration. These effects may also affect resource use and traditional uses related to fishing, if practiced in the affected area. Effects will be localized and predictably remediated.	Very Low	Low	Very Low
Spill from Vehicle Collision or Mechanical Failure	Fuel Oil Hazardous material	Adhere to applicable standards and practices for highway construction. Implement dedicated turning lanes as required. Require drivers to adhere to posted speed limits. Regular vehicle inspections. Regular equipment maintenance. Limit the amounts of hazards materials being transported.	Development of a Spill Prevention and Response Plan will also be developed to address onsite spill scenarios. Notification of regulatory authorities. Spill containment. Removal/cleanup of contaminated soils and water. Monitoring of environment. Ongoing staff training to learn from accidents.	A vehicle collision may result in the release of fuel or hazardous materials in areas with no surface water controls, thereby allowing materials to enter waterbodies with fish habitat. These effects may also affect resource use and traditional uses related to fishing, if practiced in the affected area. Emergency responses procedure can be implemented to clean up spills and limit the extent of potential effects. Effects will be localized and readily remediated.	Low	Very Low	Very Low

22.6 SUMMARY

Residual adverse effects from accidents and malfunctions to VCs are characterized in Section 22.4 with the risk of each scenario that was considered summarized in Section 22.5. The Project is planned and designed to prevent accidents and malfunctions primarily through adherence to accepted design codes and standards. Most accidental/unintended events that are expected to occur are expected to be responded to and addressed by Project personnel with little or no environmental consequences. Emergency response plans will be advanced and implemented to effectively respond to accidents and malfunctions to reduce the magnitude and duration of residual adverse effects. These plans include internal and external communications, roles and responsibilities, training requirements, and mitigation/response measures in the event of an unplanned event or emergency.

In the unlikely event of a major industrial accident at the Project involving a large scale environmental release, there is a potential for significant residual adverse effects, however, the risk to VCs from Project-related accidents and malfunctions, considering mitigation and the advanced level of design information in the EA, provide for a very low probability of an event occurring. As a result of project design and emergency response measures, the results of the risk analysis indicate that the residual risk (severity and likelihood) of accidents and malfunctions is either low or very low.

22.7 REFERENCES

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