22. ACCIDENTS AND MALFUNCTIONS

22.1 INTRODUCTION

This section of the Application/EIS evaluates the potential effects of any Project-related accident (unexpected occurrence or unintended action) or malfunction (failure of a piece of equipment, a device, or a system to function normally), which may be associated with adverse effect to a Project valued component (VC).

Accidents and malfunctions may occur during any phase of the Murray River Coal Project (the Project). The primary environmental concern resulting from accidents and malfunctions is the possibility for spills or release of chemicals, reagents, petroleum products or process materials onto the land or water. Fires, including forest fires and structure fires, present another risk to the Project, staff and environment. The objective of HD Mining is to minimize the likelihood of incidents and the associated consequences that might affect people and the environment.

The prevention of accidents and malfunctions associated with industrial activities is a focus of the current regulatory regime for the mining sector in British Columbia (BC) and Canada. The Project will be developed and operated in accordance with the BC *Mines Act* (1996) and associated Heath, Safety and Reclamation Code for Mines in British Columbia (BC MEMPR 2008). The *Mines Act* (1996) provides guidance and approvals for all stages of mine development, from exploration through to construction, production, closure, and reclamation. The *Mines Act* (1996) also requires that the stability of stream, river, wetland, and seepage area crossings (Sections 9.4 and 9.10) and the stability of man-made structures (e.g., impoundments, dumps, slopes), are planned in advance, inspected, monitored, and maintained throughout the operations and at the time of project closure (Sections 10.6 and 10.7).

The main objective of this Chapter is to assess potential effects that may result from identified Project-related accidents and malfunctions. This Chapter also identified operational procedures and management measures to be implemented, including:

- procedures that will reduce or eliminate the potential for accidents and malfunctions to occur;
- initial response measures following an accident or malfunction; and
- processes to remediate and restore the environment to a pre-incident state, including follow-up and monitoring programs.

22.2 SCOPE

The Project's approved Application Information Requirements (AIR; BC EAO 2013) states that:

The Application will identify the probability and potential magnitude of accidents and/or malfunctions associated with all Project facilities and activities by Project phase. The assessment will:

- *describe the method (e.g., Failure Modes Effects Assessment) for assessing the potential for, or likelihood of, failure of structures, equipment or processes;*

- *describe the circumstances under which these events could occur;*
- *describe the consequences and/or effects of such failures;*
- *identify mitigation/controls that are incorporated into the proposed Project design to reduce the risk; and*
- *identify contingency plans and response options to address residual risks.*

Potential effects that will be assessed include, but are not limited to:

- *Contamination due to construction equipment fuel or hydrocarbon spills (e.g., during refueling operations);*
- *Spills of hazardous substances stored on site (reagents, fuels, contained liquid waste);*
- *Unintended leakage from containment ponds;*
- *Failure of the coarse coal rejects pile;*
- *Pipeline leakage or failure;*
- *Accidental discharge of off-specification effluent from treatment plants;*
- *Power outages;*
- *Fires or explosions that could potentially be caused during construction or operation;*
- *Motor vehicle accidents involving construction, maintenance, or transport crews and any resulting contaminant spills; and*
- *Sediment releases into watercourses.*

The health and safety of mine employees will be addressed throughout the Application with appropriate reference to the HSRC and other legislation/regulations.

The final Environmental Impact Statement guidelines (EIS Guidelines; CEA Agency 2013) for the Project state that:

The proponent will identify the probability of potential accidents and malfunctions related to the project, including an explanation of how those events were identified, potential consequences (including the environmental effects), the plausible worst case scenarios and the effects of these scenarios.

The geographical and temporal boundaries for the assessment of accidents and malfunctions may be different than those in the scope of factors for each VC. This will include an identification of the magnitude of an accident and/or malfunction, including the quantity, mechanism, rate, form and characteristics of the contaminants and other materials likely to be released into the environment during the accident and malfunction events.

The EIS will also describe the safeguards that have been established to protect against such occurrences and the contingency/emergency response procedures in place if accidents and/or malfunctions do occur. Detailed contingency and response plans will be presented.

22.3 METHODOLOGY

The following three step process was followed to assess potential Project-related accidents and malfunctions:

1. Potential accidents, malfunctions, and unplanned events that might occur during the life of the Project were identified using historical performance data for other similar projects and professional judgment. The analysis is focused on events that may result in risks to personnel, the environment, infrastructure, and human health (Section 22.3.1).
2. The potential interactions between each event scenario and relevant VC receptors are considered. The VC receptors are the same as considered in the environment assessment, and the interaction analysis serves as a screening tool to identify potential residual effects of the unplanned event (Section 22.3.2). The interactions between each event and the VCs are analyzed to establish the potential significance and severity of the effects. Mitigation and management measures are considered within this interaction analysis.
3. A risk assessment is conducted using the likelihood and severity of the unplanned event in each scenario (Section 22.3.3). The analysis of residual effects is used to establish the severity of the hazard associated with the event scenario and likelihood is derived from experience with past, similar projects, literature sources, and professional judgment.

The scenarios used for the purpose of this environmental assessment are described more fully in Table 22.3-1 and Section 22.3.1.

22.3.1 Scenarios Identified for Assessment

The assessment of the risks of accidents and malfunctions considers the following scenarios (in alphabetical order, Table 22.3-1):

1. accidental discharge of off-specification effluent;
4. failure of the coarse coal reject (CCR) pile;
5. failure of the underground mine stability;
6. failure of water diversion channels;
7. fires or explosions on the surface;
8. fires or explosions underground;
9. fuel spills;
10. hazardous material spills;
11. unintended leakages from containment ponds;
12. motor vehicle accidents;
13. power outages;
14. sediment releases in watercourses; and
15. natural gas pipeline failure.

The scenarios are developed from an analysis of historical events associated with mines, the proposed Project design, and professional judgment. Emphasis was placed on unplanned events with the potential for significant interactions with the environment, for significant potential for risks to personnel or infrastructure, and for regulatory and permitting concerns. Each scenario is designed with a conservative set of assumptions to focus the analysis and describe a reasonable "worst-case" scenario for an objective assessment of hazard and risk.

22.3.2 Interactions between Assessed Scenarios and Receptor VCs

The interactions between each unplanned event scenario and the relevant biophysical and social VCs are assessed using a similar ranking system as the effects assessments (Chapter 5, Assessment Methodology). The potential for interactions between the VCs and the scenario are ranked according to the following criteria:

- Hollow – No anticipated interaction;
- Green – Negligible to minor effects; implementation of best practices, standard mitigation and management measures; and
- Yellow – Moderate effects or greater, including potentially significant effects; requires active mitigation, management, and monitoring.

The potential interactions are ranked using past experience, guidance documents, and professional judgement for each of the VCs (Table 22.3-2). If the potential interaction between the scenario and VCs is considered to be absent, negligible, or then the interaction will not be discussed. If the interaction is considered minor, then a brief discussion will be included. If the potential interaction between the scenario and the VCs is considered **Moderate** or greater, then the effects to the VCs will be characterized with respect to the magnitude, extent, reversibility, and context of the effects. This characterization is used as the description of the hazard for the risk assessment for each scenario.

22.3.3 Risk Assessment

The risk for each of the hazards associated with accidents, malfunctions, or unplanned events are assessed using the effects of the Project-based scenarios on VCs relating to each of these potential accidents or malfunctions (Sections 22.4 to 22.17). The risk assessment consists of a three-step process:

1. Evaluate frequency (probability of occurrence) – the degree of risk posed by each hazard;
2. Evaluate consequences (severity of occurrence) – select the category which best describes the effects of a credible mishap on personnel, environment, and facilities, assuming that emergency planning and management controls are in place, using the assessment developed for each scenario-VC interaction; and,
3. Evaluate risk – for each hazard, select the risk category based on probability and consequences.

Table 22.3-1. Description of Possible Accident and Malfunction Scenarios

Scenario	Description	Mitigation: Design Measures	Mitigation: Management Plans	Emergency Response	Clean-up and Restoration	Monitoring and Follow-up
1. Effluent from treatment plants	Discharge of off-specification effluent from water and sewage treatment systems into the Murray River.	Treatment systems designed with sufficient capacity for influence volumes and quality; All sedimentation ponds and retaining structures built to contain maximum effluent volumes; Routine inspection and monitoring of effluent quality and infrastructure; and Redundancy and back-up power supplies.	Environmental Management Plan; Waste Management Plan Metal Leaching and Acid Rock Drainage Management Plan	Notify supervisors and management, engage emergency response team if necessary; halt discharges; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies where required.	–	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, if necessary.
2. Failure of CCR pile	Failure of stability or seepage control measures of the CCR piles. Failure results in release of CCR and fine coal rejects (FCR) into creeks M19, M19A, M17B and M17 Creek and the Murray River	Designed for a "design earthquake"; designed for a minimal acceptable factor of safety under static conditions of 1.3 for short-term operating conditions and 1.5 after reclamation and abandonment; progressive reclamation where possible	Environmental Management Plan Waste Management Plan	Notify supervisors and management, engage emergency response team if necessary; halt failure; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies where required.	Clean up of debris from failure and return to CCR pile; re-contour pile in area of failure; restore damaged water management infrastructure around the CCR pile; review geotechnical stability of pile and design adjustments as appropriate.	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, if necessary.
3. Failure of underground mine stability	Failure or collapse of a mine face or along a mainline tunnel.	-	-	-	-	-
4. Failure of water diversion channels	Failure of water management infrastructure used to divert non-contact water into existing drainage networks. Failure may result in unanticipated increases in site contact water volumes or unplanned flow of runoff overland into Murray River.	Water management infrastructure designed to accommodate high runoff periods; installation of soil erosion and sediment control measures; and routine inspection and maintenance of infrastructure.	Soil Erosion and Sediment Control Plan	Notify supervisors and management, engage emergency response team if necessary; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies where required.	Restoration of water management infrastructure with on-site equipment and personnel; Installation of further water management and erosion control measures, as appropriate; and Re-vegetation and restoration of any affected terrestrial or riparian habitat, if necessary.	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, if necessary.
5. Fires or explosions – surface	Fire or explosion on-site, with the potential for regional-scale forest fire.	Non-vegetated buffer; policies restricting possible ignition sources and accelerants; and fire monitoring systems.	Emergency Response Plan Explosives and Nitrogen Management Plan	Notify supervisors and management, engage emergency response team if necessary; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies.	Clean-up and disposal of damaged materials and infrastructure; and Restoration of infrastructure, vegetation.	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, if necessary.
6. Fires or explosions - underground	Fire or explosion contained to the underground environment	Fire prevention and suppression measures; policies restricting possible ignition sources and accelerants; and fire monitoring system	Emergency Response Plan Explosives and Nitrogen Management Plan	Notify supervisors and management, engage emergency response team if necessary; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies.	Clean up and repair damaged areas underground; review geotechnical safety	None related to VCs

(continued)

Table 22.3-1. Description of Possible Accident and Malfunction Scenarios (continued)

Scenario	Description	Mitigation: Design Measures	Mitigation: Management Plans	Emergency Response	Clean-up and Restoration	Monitoring and Follow-up
7a. Fuel spill (into water)	Spill of a truck-load of fuel into Murray River.	Design, construct and maintain Project site and access roads for safe use; prevent roads from becoming wildlife attractants; ensure users adhere to standards, including speed limits; regular inspection and maintenance of roads and vehicles; and training for safe driving and emergency response	Site Access Management Plan Emergency Response Plan	Notify supervisors and management, engage emergency response team if necessary; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies where required.	Contain and recover spilled material, using berms, sumps, diversions, vacuum trucks, absorbents, or booms when necessary and feasible; Divert water around spill; Recover and dispose of any contaminated media (e.g., soil, fill, or vegetation); and Restoration of any disturbed ground cover, including implementation of erosion control and terrain stability measures.	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, as necessary, to determine the extent of residual effects.
7b. Fuel spill (onto land)	Spill of truck-load of fuel along transport route.					
8. Hazardous material spill (into water)	Spill of truck-load of aluminum chloride into Flatbed Creek.					
8b. Hazardous material spill (onto land)	Spill of truck-load of aluminum chloride along transport route.					
9. Unintended Leakage from containment ponds	Failure of the containment structure for a settling pond, which would lead to the sudden release of the entire pond contents to the nearby Murray River	Design, construct and maintain Project containment ponds to contain high precipitation scenarios	Water Management Plan Metal Leach and Acid Rock Drainage Management Plan Flocculent Management Plan Waste Management Plan.	Notify supervisors and management, engage emergency response team if necessary; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies where required..	Halt the discharge of effluent to the receiving environment, as soon as feasible; immediate assessment of the potential effects to the environment, health, and safety, to ensure the safety of employees, site personnel, and the public; and notify the appropriate stakeholders. These include government agencies and any nearby communities or landowners. The prompt notification of government agencies is essential	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, as necessary, to determine the extent of residual effects.
10. Motor vehicle accidents	Vehicle accident resulting in serious injury or fatality.	Design, construct and maintain Project site and access roads for safe use; prevent roads from becoming wildlife attractants; ensure users adhere to standards, including speed limits; regular inspection and maintenance of roads and vehicles; and training for safe driving and emergency response	Site Access Management Plan Emergency Response Plan	Notify supervisors and management, engage emergency response team if necessary; and immediate assessment of potential effects to environment, health, and safety.	Clean-up of any spilled fuel or hazardous materials.	Assessment of safety measures, including signage and speed limits.
11. Power outage	-	-	-	-	-	-
12. Sediment releases into watercourses	Severe rain or snowmelt leading to significant erosion and mass wasting event.	Planning Project infrastructure to minimize soil and vegetation disturbance, as well as maintain terrain stability; application erosion and sedimentation management measures; and monitoring and maintenance or sediment and erosion control measures, including blocked culverts and slope failures.	Soil Erosion and Sediment Control Plan Emergency Response Plan	Notify supervisors and management, engage emergency response team if necessary; immediate assessment of potential effects to environment, health, and safety; and notification of regulatory agencies where required.	Stabilization of disturbed slope; Removal of material encroaching watercourses; Installation of sediment and erosion control measures, including re-vegetation where applicable.	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, as necessary, to determine the extent of residual effects.

(continued)

Table 22.3-1. Description of Possible Accident and Malfunction Scenarios (completed)

Scenario	Description	Mitigation		Emergency Response	Clean-up and Restoration	Monitoring and Follow-up
		Design Measures	Management Plans			
13a. Natural gas pipeline failure - explosion	Failure of underground natural gas pipeline leading to an explosion	The natural gas pipeline route is included in the underground mining exclusion zones; no digging or excavation work would occur near the pipeline route; regular inspection and maintenance of natural gas pipeline and storage tanks; and ensure training of mine personnel and contractors for emergency response and spill contingency procedures.	Emergency Response Plan	Notify supervisors and management, engage emergency response team if necessary; and immediate assessment of potential effects to environment, health, and safety.	Clean-up and disposal of damaged materials and infrastructure; repair and assessment of damaged pipeline; and restoration of infrastructure, vegetation.	Monitoring of water quality, sediment quality, aquatic resources, and fish in receiving environment, if necessary.
13b. Natural gas pipeline failure – no explosion	Failure of underground natural gas pipeline leading to a release of natural gas into the environment	The natural gas pipeline route is included in the underground mining exclusion zones; no digging or excavation work would occur near the pipeline route; regular inspection and maintenance of natural gas pipeline and storage tanks; and ensure training of mine personnel and contractors for emergency response and spill contingency procedures.	Emergency Response Plan	Notify supervisors and management, engage emergency response team if necessary; and immediate assessment of potential effects to environment, health, and safety.	Clean-up and disposal of damaged materials and infrastructure; and repair and assessment of damaged pipeline	None related to VCs

Table 22.3-2. VC-Scenario Interaction Table for Accidents and Malfunctions

Accident or Malfunction	Project Phase* C	O	D&R	PC	Atmospherics	Hydrogeology	Surface Water and Aquatic Resources	Fish and Fish Habitat	Terrain	Terrestrial Ecology	Wetlands	Wildlife and Wildlife Habitat	Economics	Social	Heritage	Human Health
1. Effluent from treatment plants	×	×	×		○	○	🟢	🟢	○	○	○	🟢	○	🟢	○	🟢
2. Failure of CCR pile		×	×	×	○	○	🟡	🟡	○	○	○	🟢	○	🟢	○	🟢
3. Failure of underground mine stability	×	×	×		○	○	○	○	○	○	○	○	○	○	○	○
4. Failure of water diversion channels	×	×	×		○	○	🟡	🟢	🟡	🟢	○	○	○	🟢	○	○
5. Fires or explosions – surface	×	×	×	×	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡
6. Fires or explosions -underground	×	×	×		🟢	○	○	○	○	○	○	○	○	○	○	○
7a. Fuel spill (into water)	×	×	×		○	🟢	🟡	🟡	○	🟢	○	🟢	○	🟢	○	🟢
7b. Fuel spill (onto land)	×	×	×		○	🟡	○	○	○	🟢	🟡	🟢	○	○	○	🟢
8a. Hazardous material spill (into water)	×	×	×		○	○	🟡	🟡	○	🟢	○	🟢	○	🟢	○	🟢
8b. Hazardous material spill (onto land)	×	×	×		○	🟡	○	○	○	🟢	🟡	🟢	○	○	○	🟢
9. Leakage from containment ponds	×	×	×		○	🟢	🟡	🟡	○	○	○	🟢	○	○	○	🟢
10. Motor vehicle accidents	×	×	×	×	○	○	○	○	○	○	○	🟢	○	○	○	🟡
11. Power outage	×	×	×	×	○	○	○	○	○	○	○	○	○	○	○	○
12.Sediment releases into watercourses	×	×	×		○	○	🟡	🟡	🟡	🟢	○	○	○	🟢	○	○
13a. Natural gas pipeline failure - explosion	x	x	x		🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡
13a. Natural gas pipeline failure – no explosion	x	x	x		🟢	○	○	○	○	○	○	○	○	○	○	○

**C = Construction; O = Operations; D&R = Decommissioning and Reclamation; PC = Post-Closure*
○= *No anticipated interaction*
🟢= *Negligible to minor effects; implementation of best practices, standard mitigation and management measures*
🟡= *Moderate effects or greater, including potentially significant effects; requires active mitigation, management, and monitoring*

Risk is derived from the product of probability and consequences. Probability is based on an assessment of the likelihood and frequency of events based on past experience and professional judgment (Table 22.3-3). The severity of the consequences is based on the description of hazards to VCs developed from the analysis of interactions, mitigation and management measures, and the characteristics of the VCs (Table 22.3-4). For scenarios with effects to multiple VCs, the most severe effect is used to establish the severity of the consequences. Probability and consequences are combined in a risk matrix to establish risk categories ranging from **Very Low** to **Extreme** (Table 22.3-5). Risks in the highest category are considered non-routine and would receive additional planning, employee training, and management scrutiny, as appropriate.

The confidence in the risk assessment is ranked into three categories:

- **Low** – The cause-effect relationship(s) between the unplanned event and the VCs is poorly understood and/or subject to a high degree of uncertainty; mitigation, management, and restoration measures are poorly development and confidence in their effectiveness is low;
- **Medium** – The cause-effect relationship(s) between the unplanned event and the VCs is not fully understood and/or subject to some uncertainty; mitigation, management, and restoration measures are established and confidence in their effectiveness is moderate; and
- **High** – The cause-effect relationship(s) between the unplanned event and the VCs are well-understood and are supported by guidelines, best practices, and scientific literature; mitigation, management, and restoration measures are established and routine, and their effectiveness is high.

Table 22.3-3. Categories of Consequence Likelihood

Likelihood	Likelihood of Occurrence for Environmental Consequences (events/years)
Not Likely (NL)	<0.1% chance of occurrence; 1:1000 years
Low (L)	0.1 – 1% chance of occurrence; 1:1000 – 1:100 years
Moderate (M)	1 – 10% chance of occurrence; 1:100 – 1:10 years
High (H)	10 – 50% chance of occurrence; 1:2 – 1:10 years
Expected (E)	>50% chance of occurrence; >1:2 years

Table 22.3-4. Categories of Consequence Severity

Consequence Severity	Definition
Extreme	Catastrophic, irreversible impact on Valued Component
High	Significant, irreversible impact on Valued Component
Moderate	Significant, reversible impact on Valued Component
Low	Minor, reversible impact on Valued Component
Negligible	No measurable impact

Table 22.3-5. Risk Matrix

Consequence Severity	Consequence Likelihood				
	Not Likely	Low	Moderate	High	Expected
Extreme	Moderate	Moderately High	High	Very High	Critical
High	Moderately Low	Moderate	Moderately High	High	Very High
Moderate	Low	Moderately Low	Moderate	Moderately High	High
Low	Very Low	Low	Moderately Low	Moderate	Moderately High
Negligible	Negligible	Very Low	Low	Moderately Low	Moderate

22.4 SCENARIO 1: ACCIDENTAL DISCHARGE OF OFF-SPECIFICATION EFFLUENT FROM TREATMENT PLANTS

22.4.1 Description of Possible Scenario

The Project will operate management infrastructures to meet or exceed the applicable permit standards (Sections 3.6.3.8 and 3.6.3.9, Chapter 3 of the Application/EIS). Discharge of excess water from the Project will be to Murray River. The unplanned event scenario is the discharge of off-specification effluent into Murray River from the Coal Processing Site. In this scenario, the discharged effluent is off-specification, and has higher concentrations of suspended solids, metals, and nutrients than permitted. The worst case scenario would be discharge during the winter, when dilution capacity in the river is the lowest. This scenario is applicable during Construction, Operation, and Decommissioning and Reclamation. No discharges are currently planned for the Project during the Post-Closure phase.

22.4.2 Mitigation and Management Measures for Off-specification Effluent

22.4.2.1 Project Design Measures to Minimize Risk from Off-specification Effluent

The potential for the discharge of off-specification effluent will be minimized by the application, when appropriate and feasible, of the following measures:

- adherence to the Environmental Management Plan (Chapter 24), the Waste Management Plan (Chapter 24.13), and the Metal Leaching and Acid Rock Drainage Management Plan (Chapter 24.7), including updating the relevant contingency plans when necessary;
- design water and sewage treatment systems for sufficient capacity for expected influent volumes and quality during all phases of the Project;
- conduct routine inspection and maintenance of water management infrastructure and equipment, including geotechnical stability of sedimentation pond retaining structures;
- provide access to back-up power supplies for continued operation of water and sewage effluent equipment in the advent of power failure;
- design redundancy into water and sewage treatment systems to ensure treatment objectives are met during routine maintenance or unplanned equipment failures; and

- routine monitoring and surveillance of discharge water quality to assess the performance of the treatment systems and to meet permitted discharge criteria.

These measures are designed to ensure that the discharge meets or exceeds the permitted discharge criteria during routine operations. However, if these preventative measures do not prevent the unplanned release of off-specification effluent to the receiving environment, the emergency response and clean-up processes will be implemented (Section 22.4.2.2).

22.4.2.2 Emergency Response Approach for Off-specification Effluent

In the event of discharge of off-specific effluent, notifications will be given immediately to appropriate supervisors, the Environmental Manager and the Mine Manager. As appropriate, these notifications will be extended to regulatory agencies where required. The emergency response approach for the off-specification effluent discharge will:

- halt the discharge of effluent to the receiving environment, as soon as feasible;
- immediate assessment of the potential effects to the environment, health, and safety, to ensure the safety of employees, site personnel, and the public; and
- identify and repair the treatment processes failures that have resulted in the off-specific effluent.

If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent's overall Emergency Response Plan. If fish and fish habitat may be affected by the event, it would also be reported to Fisheries and Oceans Canada.

Monitoring and assessment programs will be initiated to identify any residual effects in the receiving environment of the Murray River.

22.4.2.3 Clean-up and Restoration Methods

If the failure of the water management infrastructure results in substantial changes to natural channels, streams and river banks, or natural ground cover, then the following clean-up and restoration measures may be implemented:

- stabilization of the disturbed areas, including removing or diverting sources of excess water, removing excess unstable material, creating slope breaks, covering the slope to prevent additional surface erosion; and re-vegetating the slope;
- removal of material encroaching into watercourse, unless removal would cause additional damage to aquatic habitat or fish; and
- installation of sediment and erosion control measures to prevent additional material from entering the watercourse (e.g., silt fencing, ditch breaks, settling ponds).

The aim of any clean-up and restoration measures will be to rebuild the water management infrastructure, restore natural flow paths as much as feasible, and ensure no significant loss of aquatic or terrestrial habitat occur. Monitoring programs would be used to inform the design and implementation of any restoration activities.

22.4.3 Potential Environmental Effects of Off-specification Effluent

The interactions between the un-intentional release of off-specification effluent and the receiving environment, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: surface water quality, aquatics resources, fish and fish habitat, wildlife and wildlife habitat, social, and human health. Negligible interactions were predicted between the failure of a water diversion channel and the atmospheric, hydrogeology, terrain stability, terrestrial ecology, wetlands, economic, and heritage VCs. For each respective VC, the worst case scenario considers the release of off-specific effluent into the Murray River.

22.4.3.1 Surface Water and Aquatics Resources

The discharge of off-specific effluent into the Murray River in this scenario would have the potential effects of increasing the concentrations of suspended material, metals, and nutrients above the guidelines for the protection of aquatic life. The decrease in water quality, as a result, would continue until the discharge is halted and the issue is corrected. Effluent quality and the performance of the treatment systems will be monitored, along with the water quality of the receiving environment. Routine maintenance and inspection of the treatment systems and these monitoring programs are expected to detect the release of off-specification effluent. Once detected, the discharge of off-specification effluent will be halted as soon as feasible. Depending on the circumstance of the events leading to the unintended discharge, the detection and cessation of release could occur days to weeks after the start of the off-specification effluent discharge. Equipment failures or unanticipated increases in influent volumes, for example, may present challenges to the immediate cessation of discharge. However, in any event, the emergency response approach will be to halt discharge as soon as possible. The short duration of the effects would be coupled with dispersion and removal processes in the receiving environment. Suspended sediments would be distributed by the flowing water, whereas many metals will be sequestered in sediments from natural sorption and mineralization processes. Nutrients contained in the effluent, such as phosphorus, nitrate, or ammonia, would be available to primary producers, but the effects would be attenuated by dilution and uptake downstream of the effluent outfall.

The effects from the discharge of off-specification effluent are assessed to be **Minor**. The primary effect would be a short-term increase in the concentrations of suspended material, metals, and nutrients that may exceed water quality guidelines for the receiving environment. Surface water quality and aquatic organisms would be resilient to the one-time, short-term increase in concentrations because of the expected short duration of the off-specification effluent release and the natural processes of dispersion and dilution. Negligible effects to sediment quality and aquatic resources are expected because of the short duration of the discharge.

22.4.3.2 Fish and Fish Habitat

The discharge of off-specific effluent would have the potential for effects to fish and fish habitat. The elevated suspended sediment, metal, and nutrient concentrations would have the potential to cause lethal effects to fish, and potentially affect fish behaviour, metabolism, growth, and reproduction. However, as was discussed for water quality and aquatic resources, the effects would be restricted to the immediate environment of the effluent outfall, and would be short-term because of the emergency response of halting discharge as soon as feasible. Therefore, any lethal or sublethal effects would be local and short-term, and the fish community would be expected to fully recover. The effects from the discharge of off-specification effluent are, therefore, assessed to be **Minor**.

22.4.3.3 Wildlife and Wildlife Habitat

The discharge of off-specification effluent in the Murray River would have potential effects to wildlife through direct contact with effluent constituents, alteration of habitat and the availability of prey, and sensory disturbance from the spill constituents. The effects from direct contact with effluent constituents would likely be minor; many of the significant wildlife species are mobile and would immediately avoid the effluent. Aquatic and amphibious organisms, like amphibians and waterfowl, would have higher likelihoods of exposure, but the natural processes of dispersion and degradation will decrease the concentrations of effluent constituents and thus decrease the wildlife exposure. The direct effects would be expected to be local and short-term because of the cessation of discharge as soon as possible once the event is identified. The effects would be reversible due to the natural processes of dispersion and degradation. Likewise, sensory disturbance from effluent constituents would have local and short-term effects; odours will dissipate and the clean-up activities will be short-term.

Monitoring and follow-up programs for water quality, sediment quality, aquatic resources, fish, and fish habitat will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to surface water and aquatic resources (Section 22.4.3.1) and fish (Section 22.4.3.2). Decreases in ecosystem productivity and prey abundance could reduce the available food for some wildlife species. However, as those receptor VCs recover, the availability of food and the effects to the wildlife would be predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible and short-term (e.g., less than five years). The effects of off-specification effluent discharge on wildlife are assessed to be **minor**, based on the local geographic restriction and the predicted recovery of the freshwater ecosystem.

22.4.3.4 Social

Effects from off-specification effluent discharge to traditional and non-tradition land uses are not expected, because the effects will be restricted to the vicinity of the effluent discharge outfall. The discharge of off-specification effluent into the Murray River is not expected to have significant economic effects (Section 22.4.3.9). Tourism activities along the downstream reaches of the Murray River may be affected immediately following the unintended release of off-specification effluent, but the immediate cessation of discharge combined with natural dispersion and degradation would make the effects short-term. Sport-fishing may be also affected because of effects to aquatic resources and fish, but any effects would be restricted to the affected reaches of the Murray River only, would be reversible as the ecosystem recovers, and would be negligible on a regional scale because of the availability of many other sport-fishing locations. The effects from off-specification effluent discharge into the Murray River on social VCs are assessed to be **minor**.

22.4.3.5 Human Health

The potential for human health effects could include exposure effects from heavy metals in the effluent and exposure to heavy metals from the consumption of fish and wildlife. Direct exposure to effluent constituents is not likely as a result of the discharge Natural dispersion and degradation processes will reduce the concentrations of potentially harmful constituents over time.

Monitoring programs and follow-up programs for water quality, sediment quality, aquatic resources, and fish will identify any remaining effluent constituents in the environment and in the tissue of fish harvested for human consumption (Section 22.4.3.4). These monitoring programs will mitigate the effects to human health; therefore the effects to human health from off-specification effluent discharge into the Murray River are assessed to be **minor**.

22.4.4 Risk Assessment for Off-specification Effluent

The analysis of potential environmental effects from the unintended release of off-specification effluent in the Murray River identifies no moderate residual effects. Minor residual effects were assessed for the following VCs:

- effects to water quality, sediment quality, and aquatic resources;
- effects to fish and fish habitat;
- effects to wildlife and wildlife habitat;
- effects to social VCs; and
- effects to human health.

All residual effects to these VCs are assessed to be short-lived and restricted to the immediate vicinity of the effluent discharge outfalls because of the application of mitigation, management, and monitoring activities.

The severity of the hazard from the discharge of off-specification effluent into the Murray River is assessed to be **Low**. All identified effects are assessed to be minor in magnitude, restricted to the vicinity of the spill and the downstream environment, and fully reversible. The likelihood of the scenario is assessed to be **High**. Therefore, the risk associated with the discharge of off-specification effluent is assessed as **Moderate**. The confidence in the risk assessment is **High** because of the frequent monitoring of effluent quality and treatment performance.

22.5 SCENARIO 2: FAILURE OF THE COARSE COAL REJECT PILES

22.5.1 Description of Possible Scenario

The Project will construct, operate, and close two coarse coal reject piles, which will have sufficient capacity to store approximately 17.4 Mm^3 of waste material (i.e., co-mingled coarse and fine coal reject materials; Ausenco 2014; Appendix 3-C). The northern CCR pile material may be Potential Acid Generating (PAG) due to the lack of neutralizing materials.

Failures involving the CCR piles may affect M19, M19A, M17B and M17 Creeks, which all drain to the Murray River. Failure of the CCR piles may occur through design flaws, unexpected physical properties of the fine coal rejects (FCR) and the CCR, construction issues, seismicity, and failures of the liner and seepage management system. This scenario assumes a stability failure of either one or both of the CCR piles, resulting in a deposition of CCR and FCR into the local creeks (M19, M19A, M17B, and M17) and ultimately to the Murray River.

22.5.2 Mitigation and Management Measures for Failure of the CCR Piles

22.5.2.1 Project Design Measures to Minimize Risk

A stability analysis of the CCR piles has been performed for the Project (Ausenco 2014; Appendix 3-C of the Application/EIS). A brief summary of this report is provided here; refer to Appendix 3-C of the Application/EIS for the full analysis.

The CCR piles have been designed for a "design earthquake", which is the earthquake with a 10% probability of occurrence in 50 years with a corresponding return period of 475 years (BC Mine Waste Rock Pile Research Committee 1991). The probability of exceedance for this event is only 5% for a 25-year operating period (including a pre-production year). For a return period of 475 years, the corresponding mean average peak acceleration is 0.060g. Limited deformation of the CCR piles is acceptable under seismic loading from the design earthquake, provided their overall stability and integrity is maintained (Ausenco 2014; Appendix 3-C of the Application/EIS).

Stability analyses were conducted on the CCR piles to determine the factors of safety for the given slope geometry of the respective coal reject stockpiles. These results are compared against the Dump Stability Rating scheme from the Investigation and Design Manual Interim Guidelines (BC Mine Waste Rock Pile Research Committee 1991). The dump rating guidelines were used to classify the Project's CCR piles. The piles are classified as Class II, Low Hazard.

In general, the dump stability classification indicates that a basic stability analysis is required. In accordance with provincial guidelines (BC Mine Waste Rock Pile Research Committee 1991) and standard industry practice, the minimum acceptable factor of safety for waste dumps under static conditions is 1.3 for short-term operating conditions and 1.5 after reclamation and abandonment. A factor of safety under seismic conditions of less than 1.0 may be acceptable provided that calculated deformations resulting from seismic loading are not significant. The lowest factors of safety for the northern pile are 1.87 (static) and 1.52 (pseudo-static) and for the southern pile are 1.53 (static) and 1.15 (pseudo-static). These factors are acceptable under the conditions laid out in the DSR scheme.

The final factors of safety at closure exceeds the minimum factor of safety of 1.5 for structures after reclamation and abandonment and is thus acceptable, all factors of safety are in excess of the minimum factor of safety of 1.3 for short-term operating conditions.

Reducing the opportunity for failure may be possible through progressive reclamation, such as the placement of a final capping system over the waste piles. Progressive reclamation would consist of capping completed portions of the waste pile with the intent of limiting the exposed surface area of waste coal as much as possible during life of mine. The capping system would consist of placing a low permeability layer of fine coal reject, and topsoil, growing medium, over a graded and compacted coal waste surface. Hydroseeding would be employed to create a root mat to limit erosion of the topsoil layer.

Physical (e.g., grain size, compaction, etc.) and geochemical properties of the coarse and fine fraction materials will be measured and tracked as the CCR piles are built to ensure the pile remains within design parameters. Regular inspections of the pile(s) will be completed to identify, document, and remediate areas of potential instability.

22.5.2.2 Emergency Response Approach

A communications strategy will be established on the Project site to report on the effectiveness of the plan(s) to the Environmental Manager. In the event of failure of a CCR pile, notifications will be given immediately to appropriate supervisors, the Environmental Manger and the Mine Manager. As appropriate, these notifications will be extended to regulatory agencies where required. The emergency response approach for the failure of the CCR pile will include:

- containment: halt the failure and deposition of CCR/FCR to the receiving environment, as soon as feasible;
- immediate assessment of the potential effects to the environment, health, and safety, to ensure the safety of employees, site personnel, and the public; and
- identify and repair the cause that have resulted in the failure of the CCR pile.

If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent's overall Emergency Response Plan. If fish and fish habitat may be affected by the event, it would also be reported to Fisheries and Oceans Canada.

Monitoring and assessment programs will be initiated to identify any residual effects in the receiving environment of the Murray River.

22.5.2.3 Clean-up and Restoration Methods

If the failure of the CCR piles results in substantial changes to natural channels, streams and river banks, or natural ground cover, then the following clean-up and restoration measures may be implemented:

- stabilization of the disturbed areas, including removing or diverting sources of excess water, removing excess unstable material, creating slope breaks, covering the slope to prevent additional surface erosion; and re-vegetating the slope;

- removal of material encroaching into watercourse, unless removal would cause additional damage to aquatic habitat or fish; and
- installation of sediment and erosion control measures to prevent additional material from entering the watercourse (e.g., silt fencing, ditch breaks, settling ponds).

The aim of any clean-up and restoration measures will be to rebuild the water management infrastructure, restore natural flow paths as much as feasible, and ensure no significant loss of aquatic or terrestrial habitat occur. Monitoring programs would be used to inform the design and implementation of any restoration activities.

22.5.3 Potential Environmental Effects

The interactions between the failure of a CCR pile, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: surface water quality, aquatics resources, fish and fish habitat, wildlife and wildlife habitat, social, and human health. Negligible interactions were predicted between the failure of a water diversion channel and the atmospheric, hydrogeology, wetlands, economic, and heritage, VCs. For each respective VC, the worst case scenario considers the failure of a CCR pile into the tributary creeks and mainstem of the Murray River.

22.5.3.1 Surface Water and Aquatic Resources

The material in the CCR piles would have potential effects on water quality, sediment quality, and aquatic resources if released into the freshwater environment in the Murray River and its tributaries. Some of the CCR material has the potential to generate acid from the oxidation of sulphide minerals, as well as increasing the concentrations of cations, metals such as selenium, and suspended sediments. The release of CCR material in the freshwater environment would result in a decrease in water quality. Clean-up and restoration activities would remove as much of the CCR material as possible from the watercourses, and natural dispersion and dilution processes would further reduce the concentrations of metals and cations in the freshwater environment. With active mitigation and clean-up, the effects to the water quality would be reversible in the short-term (e.g., less than five years) and restricted to local environment.

The increases in metal and cation concentrations and the potential decrease in pH may have lethal and sublethal effects on aquatic organisms. Metals, such as selenium, and cations have toxic effects to primary and secondary producers if concentrations are sufficient elevated. Furthermore, direct smothering of aquatic organisms by the CCR material may also have substantial effects. To be conservative, it is expected that the effects of the CCR pile failure would result in immediate substantial effects to aquatic resources. However, with the clean-up of the CCR material and natural dispersion and dilution, the effects would be short-term. Natural re-colonization and recovery processes would be expected to occur once the CCR material is removed from the environment and the concentrations of metals and suspended material begin to decrease. Based on the expected resiliency of the surface water and aquatic resources, the effects from a failure of a CCR pile are assessed to be **Moderate**.

A monitoring program, in conjunction with the Aquatic Effects Monitoring Program, will be implemented that will assess water quality, sediment quality, and aquatic resources for any residual effects from the CCR material.

22.5.3.2 Fish and Fish Habitat

The failure of a CCR pile would have effects to fish and fish habitat. The elevated suspended sediment and metal concentrations and changes in pH would have the potential to cause lethal effects to fish, and potentially affect fish behaviour, metabolism, growth, and reproduction. Immediate mortality would likely be negligible, but the subsequent avoidance of affected reaches by fish and the substantial effects to fish habitat from the deposition of CCR material would be substantial. However, as was discussed for water quality and aquatic resources, the effects would be restricted to the immediate environment of the deposited CCR material, and would be short-term (e.g., less than five years) because of the clean-up of CCR material from watercourses and natural dispersion and dilution processes. Fish populations would be expected to recover with the restoration of natural flow pathways, re-colonization from nearby unaffected fish populations, and the recovery of primary and secondary producers. The effects to fish and fish habitat from the CCR pile failure are assessed to be **Moderate**, due to the proposed clean-up measures and the expected resiliency of the freshwater ecosystem.

Fish population, fish habitat, and fish tissues will be monitored after the failure of the CCR pile to assess any residual effects. Some of the metals present in CCR materials, such as selenium, have the potential to bioaccumulate. Monitoring fish tissue metals for the bioaccumulation of metals would be implemented to ensure no indirect effects to wildlife (Section 22.5.3.3) and human health (Section 22.5.3.5) occur as a result of the CCR pile failure.

22.5.3.3 Wildlife and Wildlife Habitat

A failure of a CCR pile would have potential effects to wildlife through direct contact with CCR material, alteration of habitat and the availability of prey, and sensory disturbance from the pile failure and clean-up activities. The effects from direct contact with CCR material would be negligible; many of the significant wildlife species are mobile and would immediately avoid the effluent. Aquatic and amphibious organisms, like amphibians and waterfowl, would have higher likelihoods of exposure, but the natural processes of dispersion coupled with recovery of CCR material from watercourses will decrease the concentrations of CCR material and thus decrease the wildlife exposure. The direct effects would be expected to be local and short-term, because of the clean-up activities. The effects would be reversible because of re-colonizing and recovery processes that would occur after the clean-up of CCR material and the recovery of the freshwater ecosystem. Sensory disturbance from the pile failure and subsequent clean-up and restoration activities would be restricted to the immediate vicinity of the pile and predicted to be negligible.

Monitoring and follow-up programs for water quality, sediment quality, aquatic resources, fish, and fish habitat will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. Fish tissue monitoring for the bioaccumulation of metals will assess the potential for wildlife exposure (Section 22.5.3.2). These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to surface water and aquatic resources (Section 22.5.3.1) and fish (Section 22.5.3.2). Decreases in ecosystem productivity and prey abundance could reduce the available food for some wildlife species. However, as those receptor VCs recover, the availability of food and the effects to the wildlife would be predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible and short-term (e.g., less than five years). The effects of CCR pile failure on wildlife are assessed to be **minor**, based on the local geographic restriction and the predicted recovery of the freshwater ecosystem.

22.5.3.4 Social

Effects from the failure of the CCR piles to traditional and non-tradition land uses are not expected, because the effects will be restricted to the vicinity of piles. The discharge of CCR and FCR into the Murray River is not expected to have significant economic effects. Tourism activities along the downstream reaches of the Murray River may be affected immediately following failure of the piles, but immediate cessation and cleanup activities, combined with natural dispersion and degradation would make the effects short-term. Sport-fishing may be also affected because of effects to aquatic resources and fish, but any effects would be restricted to the affected reaches of the Murray River only, would be reversible as the ecosystem recovers, and would be negligible on a regional scale because of the availability of many other sport-fishing locations. The effects from the failure of the CCR piles on social VCs are assessed to be **Minor**.

22.5.3.5 Human Health

The potential for human health effects could include exposure effects from metals in the CCR material and exposure to metals from the consumption of fish and wildlife. Direct exposure to CCR material is not likely as a result of the pile failure. Natural dispersion processes and active recovery of CCR material in the environment will reduce the concentrations of potentially harmful constituents over time.

Monitoring programs and follow-up programs for water quality, sediment quality, aquatic resources, and fish will identify any remaining CCR constituents in the environment and in the tissue of fish harvested for human consumption (Section 22.4.3.2). These monitoring programs will mitigate the effects to human health; therefore the effects to human health from CCR pile failure are assessed to be **Minor**.

22.5.4 Risk Assessment for Failure of CCR Pile

The analysis of potential environmental effects from a CCR pile failure into the Murray River identifies two moderate residual effects:

- effects to surface water and aquatic resources; and
- effects to fish and fish habitat.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC.

The severity of the hazard from the release of CCR and FCR into the Murray River is assessed to be **Moderate**. All identified effects are assessed to be **Moderate** in magnitude, restricted to the vicinity of the Project and the downstream environment, and fully reversible. The likelihood of the scenario is conservatively assessed to be **Low,** as the piles are in close proximity to four creeks draining to the Murray River. Therefore, the risk associated with the discharge of off-specification effluent is assessed as **Moderately-low**. The confidence in the risk assessment is **High** because of the frequent monitoring of CCR pile stability, which would minimize the duration of potential effects.

22.6 SCENARIO 3: FAILURE OF UNDERGROUND MINE STABILITY

22.6.1 Description of Possible Scenario

The creation of any underground opening influences the stress state of the surrounding ground with related deformation and displacements of the material. As the size of the underground opening increases, the rock will eventually collapse causing further stress redistribution in the overlying rocks; eventually the deformations and displacements propagate up to the surface causing subsidence. Such mining subsidence movement has both vertical and lateral components and can be continuous (smooth) or discontinuous (stepped or cracked) depending on specific mining and geological conditions.

If the underground works are not sufficiently supported then failure of underground mine stability can lead to a portion of the mine face potentially collapsing However, failure of the entire underground facility caused by an accident or malfunction is extremely unlikely; any such failure would be caused by a major natural event such as an earthquake. A discussion of the effects of seismicity on the Project is considered in the assessment of Effects of the Environment on the Project (Chapter 23 of the Application/EIS) and is not discussed further here.

The collapse behind an active longwall faces is an integral part of the Project design and no unintended consequences are predicted. Unplanned events, such as the collapse of portion the mine face, will have potential effects to worker health and safety, which is strictly legislated under the provincial Health, Safety, and Reclamation Code (BC MEMPR 2008). HD Mining will operate the mine in compliance with the Code, and will maintain an Occupational Health and Safety Plan that specifically addresses underground mining risks, policies and procedures.

However, there will be no effects to Project VCs as a result of the unplanned failure of underground mine stability, and this scenario is not discussed further here.

22.7 SCENARIO 4: FAILURE OF WATER DIVERSION CHANNELS

Water diversion channels are proposed to conduct non-contact water around Project infrastructure to maintain natural drainage patterns (Section 3.6.3.8, Chapter 3). The water management infrastructure will be constructed during the construction phase, and will be maintained throughout the operations phase until decommissioning during the closure of the Project. Failure of the water management infrastructure may result in unanticipated increases in site contact water or in the flow of runoff through an unplanned path into the Murray River. The increase in site contact water may result from a failure in the water management infrastructure because non-contact water, which was intended to be diverted away from Project infrastructure, instead flows into the site and is incorporated in the site contact water. This unanticipated increase in site contact water would have the potential to exceed the design parameters of the water treatment system and the site water containment ponds, which could result in the discharge of off-specification effluent or failure of the containment ponds. Those failure scenarios are discussed in Section 22.4 (off-specification effluent) and Section 22.9 (containment ponds).

The other potential result of a failure in the water diversion channels would be the runoff of water through an unplanned channel into the Murray River. This scenario is described and assessed below.

22.7.1 Description of Possible Scenario

Failure of water diversion channels may occur due to a very large, unanticipated rainfall event, a geotechnical failure, or an accident. For this scenario, a water diversion channel has failed and surface flow is entering the Murray River overland through an unplanned path. In this scenario, the failure of the water diversion channel has caused runoff to overflow the defined natural drainage networks and the Project water management infrastructure, and create a new flowpath to the river. Although unlikely, this creation of a new flowpath would represent a reasonably foreseeable worst-case scenario because of the potential consequences to the environment.

22.7.2 Mitigation and Management Measures for a Failure of Water Diversion Channels

22.7.2.1 Project Design Measures to Minimize Risk

Water management infrastructure will be design to accommodate likely high runoff periods, based on an analysis of the return period of precipitation events and high flows. Furthermore, water diversion channels and other water management infrastructure will be designed by qualified professionals and support by geotechnical data to ensure the stability and performance of the infrastructure. Actions to minimize erosion and sediment releases into watercourses are outlined in the Erosion and Sediment Control Plan (Chapter 24.5 of the Application/EIS) and include:

- minimizing soil and vegetation disturbance;
- re-vegetating disturbed areas with an appropriate seed mix as soon as possible;
- soil surface stabilization as necessary with materials such as weed-free mulch, geo-textiles, or soil binder;
- controlling slope erosion by terracing and/or installing fibre logs, geotextiles, erosion control mats, straw, or gravel bags;
- controlling and directing runoff from disturbed areas by grading slopes and ditching;
- minimizing runoff energy by limiting the length and steepness of bare, exposed slopes and by applying appropriate surface drainage techniques (e.g., ditch blocks, ditch surface lining, rip-rap); and

- stabilizing water diversion channels and ditches and protecting channel banks with willow, rocks, gabions, or fibre mats.

Water management infrastructure and sediment erosion control measures will be inspected and maintained on a regular basis by Environmental Technicians and Coordinators and all personnel will be encouraged to report channel instability or issues such as blocked culverts, slope failures, gullying, and siltation.

22.7.2.2 Emergency Response Approach

A communications strategy will be established on the Project site to report on the effectiveness of the plan(s) to the Environmental Manager. In the event of the failure of a water diversion channel, notifications will be given immediately to appropriate supervisors, the Environmental Manager and the Mine Manager. As appropriate, these notifications will be extended to regulatory agencies where required, such as for incidents in which fish and aquatic habitat could be adversely affected, or if potential geohazards result from the infrastructure failure.

In the event of channel failure as described in this scenario, the Emergency Response Plan (Chapter 24.20) and the Soil Erosion and Sediment Control Plan (Section 24.5) will be triggered.

If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent's overall Emergency Response Plan. If fish and fish habitat may be affected by the event, it would also be reported to Fisheries and Oceans Canada.

A site-wide communication system (including access roads) will ensure rapid notification of any water management infrastructure failures. Heavy equipment crews on site will be capable of responding to mass wasting events and conducting the rehabilitation of disturbed areas. Environmental technicians and coordinators will be trained to install and maintain sediment and erosion control measures to minimize the likelihood of mass wasting events due to failure of water management infrastructure. Environmental crews will also be responsible for monitoring re-vegetation efforts on disturbed areas.

If the water diversion failure event cannot be fully mitigated in clean-up and restoration, a program will be implemented to monitor any residual effects in the freshwater environment, including water quality, sediment quality, aquatic resources, fish, and fish habitat.

22.7.2.3 Clean-up and Restoration Methods

If the failure of the water management infrastructure results in substantial changes to natural channels, streams and river banks, or natural ground cover, then the following clean-up and restoration measures may be implemented:

- stabilization of the disturbed areas, including removing or diverting sources of excess water, removing excess unstable material, creating slope breaks, covering the slope to prevent additional surface erosion; and re-vegetating the slope;

- removal of material encroaching into watercourse, unless removal would cause additional damage to aquatic habitat or fish; and
- installation of sediment and erosion control measures to prevent additional material from entering the watercourse (e.g., silt fencing, ditch breaks, settling ponds).

The aim of any clean-up and restoration measures will be to rebuilt the water management infrastructure, restore natural flow paths as much as feasible, and ensure no significant loss of aquatic or terrestrial habitat occur. Monitoring programs would be used to inform the design and implementation of any restoration activities.

22.7.3 Potential Environmental Effects

The interactions between the failure of a water diversion channel, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: surface water quality, aquatics resources, fish and fish habitat, terrain stability, terrestrial ecology, and social. Negligible interactions were predicted between the failure of a water diversion channel and the atmospheric, hydrogeology, wetlands, wildlife, economic, heritage, and human health VCs. For each respective VC, the worst case scenario considers the failure of a water diversion channel and the direct runoff of flow from the channel into the Murray River. The assessment for an unanticipated release of sediment into the Murray River, discussed in section 22.16, shares substantial overlap with this water diversion failure scenario.

22.7.3.1 Surface Water and Aquatic Resources

Potential effects on surface water quality and aquatic resources include increases in the concentration of suspended material, alteration of sediment quality from the deposition of material, and effects to aquatic resources from smothering by sediment. Deposition of sediment into a watercourse will may the quantity of suspended material and decrease water quality. It is likely that concentrations of suspended material will exceed the guideline values for the protection of aquatic life during the period of direct runoff. The material carried in the runoff from the failure of the water diversion channel will be dispersed and carried downstream in the Murray River, with detectable effects for hundreds of meters downstream. However, the runoff of material would only last until clean-up and restoration activities repair the infrastructure. To be conservative, the unanticipated flow in Murray River would continue for at most ten days. Additional restoration activities would continue, with re-vegetation, debris removal, and erosion control measures implemented as necessary.

The short-term duration (e.g., less than two weeks) of the direct effects from the water channel diversion failure is expected to result in fully reversible effects to surface water and aquatic resources. The natural processes of dispersion will re-distribute sediments downstream and reduce the immediate effects to water quality, sediment quality, and aquatic resources. Any affected habitat would be re-colonized by primary and secondary producers. The follow-up monitoring program would examine the recovery of the aquatic ecosystem and identify any necessary addition restoration or mitigation activities. The effects from a failure of a water diversion structure are assessed, therefore, as **Moderate** because of the short-term increase in the concentration of suspended material above guidelines, but the effect is expected to be fully reversible because of the natural dispersion and recovery processes combined with restoration and monitoring.

22.7.3.2 Fish and Fish Habitat

The failure of a water diversion structure may result in the runoff of sediment into the freshwater environment, which may have effects on fish and fish habitat. Direct effects may occur to fish behaviour, metabolism, feeding, and reproduction because of the additional suspended material, as well as effects to the quality of fish habitat and the availability of prey (Section 22.7.3.3). Direct mortality is not expected, however, in the event of the failure of a water diversion structure, because of the limit duration of the expected effects to water quality (Section 22.7.3.3). The short-term increase in suspended sediment concentrations may cause changes in the distribution of fish in Murray River, and potentially effect spawning and feeding, but these effects are expected to be short-term and tied to the recovery of the habitat and aquatic resources. The effect from the failure of a water diversion structure on fish and fish habitat is assessed, therefore, as **Minor**.

22.7.3.3 Terrain Stability

The failure of a water diversion structure could result in slope failure and erosion because of the unanticipated overland flow of runoff. The likelihood of such a failure occurring is low due the relatively subdued nature of the topography. In the event of a water diversion failure, re-establishing terrain stability is one of the first requirements to protect human safety, water supplies, water quality, fish habitat, and reestablish landscape aesthetics, vegetation and recreational use of the area.

The *Mines Act* (1996) is very explicit in the mitigation measures to be followed in the event of a mass wasting event. These mitigation measures may be effective in the event of water diversion structure failures. The measures include:

- restorative activities will be designed and implemented by a qualified person to minimize further mass wasting events such as landslides, channelized debris or mud flow, and gully bank destabilization; and
- mitigation measures that will be implemented after a water diversion structure failure has occurred to address terrain stability include:
  - stabilizing any disturbed areas; and
  - ensuring a geotechnical engineer prepares a terrain remediation plan in a timely manner (e.g., within 30 days).

If a mass wasting event does occur due to compromised terrain stability, which in this scenario may result from failure of a water diversion structure, a residual effect is anticipated. With preventative mitigation, the likelihood of a mass wasting event is minimal. However, with unforeseen storm events, a change in terrain stability can occur within hours to days. If mass wasting does occur, there will be changes from baseline conditions. The change is non reversible, sporadic in frequency and is site specific. The magnitude is considered low if the area of terrain stability is not increased and stabilization efforts are effective.

The changes to terrain stability are permanent, but a new equilibrium for terrain stability can be established and allow for the previous land use to occur. Monitoring and follow-up efforts will be implemented, which may include:

1. determine whether the preventative and mitigation measures employed have achieved terrain stability;
2. check for renewed erosion or instability (frequency of monitoring program will depend on effectiveness of mitigation); and
3. inspect re-vegetation progress (effectiveness will be visible within one growing season, if not deemed successful, additional inspections may be required).

The effect from a water diversion structure failure on terrain stability is assessed as **Moderate**, due to the potential for mass wasting events.

22.7.3.4 Terrestrial Ecology

The failure of a water diversion channel, in this scenario, results in the unanticipated overland flow of runoff and subsequent erosion and suspended material transport. Vegetation and terrestrial ecosystems can be affected by this failure of a water diversion channel by direct erosion and damage to vegetation. Sediment may smother vegetation, particularly if there is flooding or debris flows associated with the sediment transport. Mitigation measures to limit the extent of the impact to terrestrial ecosystems include re-vegetation of disturbed areas, and monitoring of the success of planted vegetation.

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

22.7.3.5 Social

The failure of a water diversion channel may affect water quality, aquatic resources, and fish downstream of the flow into the Murray River (Sections 22.7.3.3 and 22.7.3.4). These effects would be reversible as the ecosystem recovers, and would be negligible on a regional scale. Clean-up and restoration activities combined with natural dispersion of sediment would make the effects short-term. The effects from a water diversion channel failure on social VCs are assessed to be **Minor**.

22.7.4 Risk Assessment for Failure of Water Diversion Channels

The analysis of potential environmental effects from the failure of a water diversion channel identifies the following moderate residual effects:

- effects to water quality, sediment quality, and aquatic resources; and
- effects to terrain stability.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC. The severity of the hazard is assessed to be **Moderate**. All identified effects (i.e., surface water and terrain stability) are assessed to be **Moderate** in magnitude, restricted to the vicinity of the spill and the downstream environment, and fully reversible. The likelihood of the scenario is assessed to be **Not Likely**. Therefore, the risk associated with a sediment release into water is assessed as **Low**. The confidence in the risk assessment is **Medium** because of the uncertainties associated with predicting the location of the water management structure failure.

22.8 Scenario 5: Fires or Explosions – Surface

22.8.1 Description of Possible Scenario

An fire or explosion at the surface may be caused by a number of failure modes, including explosion or malfunction of equipment, improper use or storage of explosives, combustion of temporary coal stockpiles, or smoking, Two scenarios are considered in this assessment: one where a fire or explosion at the surface is contained to the Project site, and another where a fire or explosion at the surface causes a wildfire.

22.8.2 Mitigation and Management Measures for Fires or Explosions - Surface

22.8.2.1 Project Design Measures to Minimize Risk

A non-vegetated buffer will be established around all Project equipment. Equipment will be maintained to minimize electrical failures. A strict non-smoking policy will be established, with the exception of designated smoking areas. Use of prohibited items will be strictly prohibited.

Spontaneous combustion (SC), a process whereby certain materials can ignite through internal reactions, is also an observed phenomenon in exposed coal reject piles. However, based on the mining method, limited coal concentrations in waste, co-mingling of both coarse and fine rejects, and the experience of neighbouring properties, there should be no risk of SC of the CCR pile. Emergency Response Approach

Firefighting equipment will be provided and maintained at locations throughout the site where fire may endanger life or property. Firefighting personnel will be part of the mine rescue team. Water systems for fire suppression are incorporated into the Project design. Fire hazard areas, such as fuelling stations, may be designated as areas where no means of producing heat or flame will be permitted. Such areas will be clearly marked with warning signs.

The Emergency Response Procedures, as outlined in the Emergency Response Plan (ERP) will address three levels of response in an emergency operation: Containment, Notification, and Mobilization.

Containment is the initial step in the effort to control an emergency, and exists from the moment a problem is discovered until emergency response personnel are notified. The steps in the Containment Level include: discovery and reporting of the problem, monitoring the situation, and early and immediate action. The goal at this level will be for on-site personnel to follow concise Emergency Response Procedures immediately.

Upon discovering a fire, all employees will be expected to be aware of, and capable of, carrying out initial containment measures. These measures will include an attempt to control the fire with the nearest extinguisher, raising the alarm, and seeking assistance. A fire within the any building will trigger a building evacuation.

The *Notification* level will start when management decides outside help is needed to handle a situation or additional notification is necessary. Action will be taken immediately to minimize hazards to all persons and to get assistance as efficiently as possible. If an emergency occurs, managers will notify their own workers of the hazards and, if required, get them to safety and notify key personnel in order to activate the Emergency Response Procedures. The procedures to be followed will be clear and concise to avoid confusion or delays.

All supervisors and persons named in a notification process will be trained in how to initiate the Notification Level. Normal operating procedures cease to apply during the Notification Level. The Notification Level procedures will be kept simple, and the Notification plan will contain only those names absolutely required.

The *Mobilization* level will take effect when the emergency operations centre (EOC) has been established and senior management has assumed direction of emergency operations. All key persons will report to the Incident Command Post upon arrival at the mine site. The Mine Manager or a designate will assume the role of Incident Commander on arrival. Extreme fire conditions may cause the access roads into the Project to be closed to traffic. This could result in the cessation of operation until such time as the roads are once again passable. Water for firefighting, if required, will be drawn from the fresh water diversions or other sources of non-contact water.

22.8.2.2 Clean-up and Restoration Methods

Clean-up and restoration measures will be implemented to remove and dispose of any damaged material or infrastructure. Materials will be disposed in accordance to the relevant regulations and guidelines. Restoration of vegetation and ground-cover will be conducted, where appropriate.

Any residual effects on atmospherics, hydrogeology, surface water and aquatics resources, fish and fish habitat, terrain, terrestrial ecology, wetlands, wildlife and wildlife habitat, economics, social, heritage, and human health will be monitored. The monitoring program will assess the recovery of these VCs and help identify any additional mitigation and management measures.

22.8.3 Potential Environmental Effects

22.8.3.1 Atmospherics

A surface fire or explosion may affect the atmospheric environment through the volatilization of particulate matter, carbon monoxide, and volatile organic compounds (BC Air Quality n.d.). However, with mitigation and emergency response measures in place, any surface fires or explosions will occur over the short-term and be immediate to the Project site with **negligible** effects on air quality associated with fires or explosions on the Project site.

However, if a surface fire or explosion from the Project were to result in a forest fire, the potential impact may be of a longer duration and regional in extent. Forest fires are the second-largest source of $PM_{2.5}$ from wood smoke in the province (second to open-burning sources). They can have significant impacts on local air quality, visibility and human health. Emissions from forest fires can travel large distances, affecting air quality and human health far from the originating fires. In this case, a **Moderate or greater** effect may be associated with these fires or explosions for air quality.

22.8.3.2 Hydrogeology

The potential effects to hydrogeology from a surface fire or explosion on the Project site are expected to be **negligible**. Water used to extinguish the fire may infiltrate the soil and has the potential to transport metals or other soluble compounds (including fire retardants; e.g., Pappa, Tzamtzis, and Koufopoulou 2006) but the extent of the infiltration will be the immediate vicinity of the fire and will be restricted to the duration of the fire-fighting operations.

A forest fire caused by a surface fire on the Project site may have substantially greater effects; the potential extent of the fire is regional in scale and may have a significantly longer duration. A large-scale wildfire has substantial effects on the landscape, and can alter terrain and surface water flows, with the potential for effects to groundwater resources. Therefore, the effect to hydrogeology from a forest fire is assessed to be **Moderate** because of this potential for landscape-scale effects.

22.8.3.3 Surface Water and Aquatics Resources

A surface fire or explosion contained to the Project site may have minor effects to surface water and aquatic resources as any chemicals used to control these fires may reach the aquatic environment. However, this chemical release would be of short-duration and would disperse quickly and become diluted by the receiving environment. Thus, **Negligible** effects from fires or explosions local to the Project site are expected for surface water and aquatic resources.

However, if a surface fire or explosion from the Project were to result in a forest fire, the resultant effects to surface water and aquatics resources may be of higher magnitude, longer duration and regional in extent. Forest fires have immediately impacts to surface water quality, including increasing water temperature, altered water chemistry from absorption of smoke and deposition of ash, and reduction in dissolved oxygen (Hall and Lombardozzi 2008). Aquatic resources, such as aquatic invertebrates, may experience direct mortality as well as indirect effects from changes to surface water quality and flows (Minshall 2003). As a result, a residual effect may be associated with surface fires and explosions for surface water and aquatic resources. However, forest fires are a natural component of the environment, and stream ecosystems tend to recover from fire-related disturbances in the short-term, although the recovery is dependent on complex interactions between hydrology, the deposition of coarse woody debris into the freshwater environment, and biological re-colonization from unaffected areas (Minshall 2003; Mellon, Wipfli, and Li 2008; Arkle, Pilloid, and Strickler 2010). Active restoration measures are known to enhance the recovery of the aquatic ecosystems (Minshall 2003). Therefore, the effect from a forest fire on surface water quality and aquatic resources is assessed to be **Moderate** because of the application of restoration activities and the expected resiliency of the aquatic ecosystem.

22.8.3.4 Fish and Fish Habitat

A surface fire or explosion contained to the Project site may have minor effects to fish and fish habitat as any chemicals used to control these fires may reach the aquatic environment. However, this chemical release would be of short-duration and would disperse quickly and become diluted by the receiving environment, and has been shown to have little effects on water quality (Crouch et al. 2006). Thus, **Negligible** effects from fires or explosions local to the Project site are expected for fish and fish habitat.

However, if a surface fire or explosion from the Project were to result a forest fire, the resultant effects to fish and fish habitat may be of higher magnitude, longer duration and regional in extent. Fire may cause direct mortality in affected reaches, as well as longer term effects due to habitat loss, disruption of foodwebs, and then disruption of flow and movement. As discussed for aquatic resources (Section 22.8.3.3), fire is a natural component of the environment in the Project area. The resiliency of fish and fish habitat to the effects of forest fires is dynamic and dependent on a complex web of biotic and abiotic factors (Rieman and Dunham 2000; Dunham et al. 2003). The recovery of fish populations after a fire can extend into the medium term (e.g., between 5 and 25 years) if there are barriers to migration and re-colonization (Dunham et al. 2003).

The effects of a forest fire, therefore, are assessed to be **Moderate** because of the uncertainty in the duration of the recovery of fish populations and the restoration of fish habitat.

22.8.3.5 Terrain

A surface fire or explosion contained to the Project site may have **Minor** effects on terrain stability and may lead to increased erosion and sedimentation.

If a surface fire or explosion from the Project were to result in a forest fire, the resultant effects to terrain stability may be of higher magnitude, longer duration and regional in extent. Wildfire effects on terrain stability are dependent on fire severity, intensity, and size as well as slopes, and soil characteristics. The consumption of tree and understory vegetation cover and humus can expose soils to precipitation and elevated rates of soil erosion. Fire also causes chemical changes in the soil that increase soil hydrophobicity which reduces infiltration rates and can result in increased overland flow and associated soil erosion, especially in association with fine textured soils. The loss of rooting in the soil profile can also result in increased probability of slope failure, especially in Class IV or V terrain or on soils susceptible to slumping or rotational failure. Increases in peak runoff rates and alterations in the timing of flows due to increased snow pack and changes in solar insolation and albedo are often recorded after severe wildfires have reduced forest cover. These changes can increase soil erosion or mass wasting. The effects on terrain from a forest fire are assessed to be **Moderate or greater** because of this potential for significant mass wasting events.

22.8.3.6 Terrestrial Ecology

A surface fire or explosion contained to the Project site should have no effects on terrestrial ecology because vegetation at the Project site would have been cleared during Project construction.

If a surface fire or explosion from the Project were to result in a forest fire, the resultant effects to terrestrial ecology may be of higher magnitude, longer duration and regional in extent. These fires result in large-scale changes to forest vegetation composition and soils that can endure over the long-term. As a result, **Moderate or greater** effects are expected to occur for terrestrial ecology.

22.8.3.7 Wetlands

A surface fire or explosion contained to the Project site should have **Negligible** effects on wetlands because no wetlands occur at the Project site.

If a surface fire or explosion from the Project were to result in a forest fire, the resultant effects to wetlands may be of higher magnitude, longer duration and regional in extent. These fires result in large-scale changes to vegetation composition and water quality (see Section 22.8.3.6) that can endure over the long-term. As a result, the effects to wetlands are assessed to be **Moderate or greater**.

22.8.3.8 Wildlife and Wildlife Habitat

A surface fire or explosion contained to the Project site may have minor effects to wildlife and wildlife habitat as any chemicals used to control these fires may reach the aquatic environment. This chemical release would and potentially cause direct effects to aquatic wildlife such as aquatic birds and amphibians. The amount of habitat available to these species may also be reduced through the release of chemicals. However, this chemical release would be of short-duration and would disperse quickly, become diluted by the receiving environment, and has been shown to have limited effects on water quality (Crouch et al. 2006). Thus, **Negligible** effects associated with fires or explosions local to the Project site are expected for wildlife and wildlife habitat.

If a surface fire or explosion from the Project were to result a forest fire, the resultant effects to wildlife and wildlife habitat may be of higher magnitude, longer duration and regional in extent. Wildlife habitat would be lost through the direct effects of fire. Wildlife may also experience direct mortality from the fire. Wildlife habitat may also be degraded through fragmentation and ash deposition into areas not directly affected by the fire. As a result, a **Moderate or greater** effect may be associated with surface fires and explosions for wildlife and wildlife habitat.

22.8.3.9 Economics

It is likely that Project operations would be temporarily suspended during the event of a wildfire with consequent effects to employment and procurement generated by the Project, with **Moderate or greater** effects to the economics VCs.

22.8.3.10 Social

A surface fire or explosion contained to the Project site should have no additional effects to social VCs as the Project area would be already be disturbed.

A surface fire or explosion that resulted in a forest fire may interact with social VCs through a potential loss of traditional and non-traditional land use. As a result, a **Moderate or greater** effect may be associated with surface fires and explosions for social VCs.

22.8.3.11 Heritage

A surface fire or explosion contained to the Project site should have **Negligible** effects to heritage VCs because the Project area would be disturbed. Any Project related effects will have been already mitigated and managed, and no further effects from the fire would be expected.

A forest fire resulting from a fire or explosion at the Project would have the potential for affecting heritage and archeological sites in the region. Depending on the scale of the fire, the effects to heritage VCs could be **Moderate or greater**.

22.8.3.12 Human Health

With respect to human health, effects of a surface fire or explosion contained to the Project site may affect workers. Worker health and safety is strictly regulated under the BC Health, Safety and Reclamation Code (BC MEMPR 2008), is considered for the Project in HD Mining's Occupational Health and Safety Management Plan, and is not discussed further here.

A surface fire or explosion that resulted in a forest fire may interact with human health by direct effects through injury or fatalities as well as wider effects by the reduction of air quality in the regional area. The smoke from forest fires can adversely affect the health of people outside the immediate area of the wildfire, and may lead to respiratory issues for those people. Fire-fighting personnel may be injure or killed during fire-fighting operations, and the spread of forest fires to residential areas increases to the probabilities of civilian injuries. Therefore, the effects of a Project-related forest fire on human health are assessed to be **Moderate or greater**.

22.8.4 Risk Assessment for Surface Fires or Explosions

The analysis of potential environmental effects from a surface fire or explosion on the surface identified the following potential residual effects:

- atmospherics;
- hydrogeology;
- surface water and aquatic resources;
- fish and fish habitat;
- terrain;
- terrestrial ecology;

- wetlands;
- wildlife and wildlife habitat;
- economics;
- social;
- heritage; and
- human health.

For all potential residual effects, the likelihood of occurrence is assessed as **Not Likely**. However, the changes to the VCs are expected to be **Moderate or greater**. Thus, the most conservative risk to the VCs (if changes to VCs are **Extreme**) is assessed to be **Moderate**. The confidence in this risk assessment is low because of the challenges associated with seasonality and climate conditions contributing the severity and intensity of forest fires.

22.9 SCENARIO 6: FIRES OR EXPLOSIONS – UNDERGROUND

22.9.1 Description of Possible Scenario

Potential effects of underground fires or explosions are related primarily to worker health and safety, which is legislated under the provincial Health, Safety, and Reclamation Code (BC MEMPR 2008). HD Mining will operate the mine in compliance with the Code, and will maintain an Occupational Health and Safety Plan that specifically addresses underground mining risks, policies and procedures.

An underground fire or explosion may be caused by a number of failure modes, including fire involving rubber-tired vehicles, coal bed gas explosion, explosion of coal dust, spontaneous combustion of coal, or an electrical equipment fires. Any underground fires/explosions will result in a short-term, reversible degradation to air quality as smoke from the fire is vented to the surface.

22.9.2 Mitigation and Management Measures for Fires and Explosions - Underground

22.9.2.1 Project Design Measures to Minimize Risk

Multiple measures will be in place to minimize the risk of underground fires and explosions. The specific approach to managing coal bed gas (CBG) will be adaptive and site specific, as it will depend on actual conditions observed underground. However, in general, CBG management will employ an inter-connected drainage system to collect CBG and vent it to the surface via the ventilation shaft. Particularly in Seam J, where CBG density is higher, the roof CBG drainage method will be employed as a supplement to the coal seam pressure and CBG drainage method. Boreholes will be drilled in the roof or roof strata within Seam J, paralleling the return airway.

As a primary fire and explosive preventative measure, nitrogen gas will be injected into underground mined gobs and areas with higher fire potential. With nitrogen application, the oxygen density within a gob will be less than 7% for fire protection, while less than 3% for combustion suppression. Mobile nitrogen gas generators will be provided in intake airways in working coal faces. Retarders such as calcium chloride ($CaCl_2 \cdot 5H_2O$) and magnesium chloride ($MgCl_2 \cdot 6H_2O$), will also be used for suppressing coal spontaneous combustion.

To monitor the CBG content in the underground air, air quality monitors will be mounted on key pieces of underground equipment and will be connected with the mine production safety monitoring system. The CBG content in the ventilation airflow will be monitored and reported in real-time at the surface control center.

Fire hazard areas, such as fuelling stations, may be designated as areas where no means of producing heat or flame will be permitted. Such areas will be clearly marked with warning signs.

22.9.2.2 Emergency Response Approach

The underground mine is designed with an air reversing ventilation system in case of a mine fire. It includes the ability to reverse the whole underground mine air flow, as well as reversing at working faces.

The underground mine will be equipped with a fire safety system. Fire water pipe networks and hydrants will be installed in related tunnels and chambers. Panel mining areas will be sealed after mining. Fire-proof doors will be installed in areas underground, including the water pump station and the power substation. A firefighting equipment and materials warehouse will be constructed in the Underground Operation Hub and equipped with firefighting tools and materials, such as high-expansion foam fire extinguisher, fire extinguishing grenades, and foam and dry chemical fire extinguishers.

Firefighting equipment will be provided and maintained at locations throughout the site where fire may endanger life or property. Firefighting personnel will be part of the mine rescue team. Water systems for fire suppression are incorporated into the Project design.

Upon discovering a fire, all employees will be expected to be aware of, and capable of, carrying out initial containment measures. These measures will include an attempt to control the fire with the nearest extinguisher, raising the alarm, and seeking assistance. A fire within the any building will trigger a building evacuation. Similarly, a fire in any of the underground workings will trigger evacuation of the underground areas.

22.9.2.3 Clean-up and Restoration Methods

Following an underground fire or explosion, areas will be inspected, and work will be completed to ensure safe operation can resume. Further clean up and repair of damaged equipment/infrastructures will then be completed. No further response is expected to be required specific to the VCs considered in this assessment.

22.9.3 Potential Environmental Effects

22.9.3.1 Atmospherics

Risks to the atmospheric environment from an underground fire would involve and effects to surface air quality as the smoke is vented to the surface. These effects will be short-term and immediately local to the Project site, and with mitigation measures should have **Minor** effects on the environment.

22.9.4 Risk Assessment for Failure for Fires or Explosions – Underground

As no moderate effects are predicted for this scenario, no risk assessment is necessary or has been performed.

22.10 SCENARIO 7A: FUEL SPILL INTO WATER

The Project will be using and storing a variety of hydrocarbon fuels, lubricants, and process chemicals throughout the construction, operations, and closure phases. Diesel and natural gas will be the primary fuels, with diesel transport to site by truck and natural gas being delivered by pipeline (Chapter 3). The potential spill of natural gas is considered separately in Section 22.18. Kerosene and octanol will be used in the CPP for coal processing. The transport, storage, and use of hydrocarbons have associated risks for the unintended release of these compounds in the environment. Failure modes include vehicle accidents, failures of tanks and containment systems, spills during maintenance or fueling operations, or releases associated with other failures such as fires. For this assessment, the most significant potential scenario is the direct spill of a hydrocarbon load.

22.10.1 Description of Possible Scenario

Liquid fuels will be transported to the mine site by truck and a fuel spill into the freshwater environment is possible as a result of a vehicle accident that releases some or all of a load of fuel into a waterbody. Fuel trucks will travel from Tumbler Ridge along highways 29 and 52 to the Murray River FSR road, and then to the fuel storage facilities at the decline site and the coal processing facility. Generally, the route is more than 100 m from any waterbodies, but Highway 52 crosses the Flatbed Creek approximately 5.5 km from Tumbler Ridge and 8 km from the Murray River FSR road. The proposed truck route to the decline also crossed the Murray River on the Murray River FSR road bridge.

This scenario assumes the entire load of a standard fuel truck (50,000 l of fuel) will be deposited into the freshwater environment of the Murray River at the Murray River FSR crossing. To be conservative, it is assumed that all of the fuel enters the freshwater environment. This scenario is applicable during Construction, Operation, and Decommissioning and Reclamation; no significant fuel transport is expected in the Post Closure.

22.10.2 Mitigation and Management Measures for Fuel Spill into Water

22.10.2.1 Project Design Measures to Minimize Risk of Fuel Spills

Project design measures to minimize the risk of hydrocarbon and fuel spills largely surround the safe operation of vehicles (Site Access Management Plan). These measures include the following:

- design, construct, and maintain Project site roads so that they are safe for designated uses including, where appropriate, the use of guard rails and berms to prevent overturning and/or capture load loss;
- prevent site and access roads from becoming wildlife attractants to avoid wildlife vehicle collisions;
- control excessive speed;
- regular inspection, maintenance, and equipping of mine and contractor vehicles;
- ensure training of mine personnel and contractors for safe driving, emergency response and spill contingency procedures

As well, all fuel handling and storage infrastructure and equipment will be regularly inspected and maintained.

22.10.2.2 Emergency Response Approach to Fuel Spill in Water

In the event of a spill, the Spill Response Plan (Chapter 22.22) will be triggered. If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent's overall Emergency Response Plan. Statutory reporting of spills of more than 100 L of fuel to provincial authorities is also necessary, and any spills will be documented in a Spill Report that would be submitted within 24 hours to the BC Provincial Emergency Program. If fish and fish habitat may be affected by the spill, the spill would also be reported to Fisheries and Oceans Canada.

A site-wide communication system (including access roads) will ensure rapid notification of any observed spills. The site will have a trained Emergency Response Team with resources to contain and recover spills, to reduce the size of any spill and thus reduce any potential adverse environmental or health effects. On-site equipment will include absorbent pads and booms, skimmers, and dike materials as part of comprehensive spill recovery kits that will be contained on a trailer or truck for rapid deployment to any spill scene. Comprehensive spill recovery kits will be located throughout the Project to ensure availability in the event of an emergency spill.

If the release of fuel cannot be fully mitigated in clean-up and restoration, a program will be implemented to monitor any residual effects in the freshwater environment, including water quality, sediment quality, aquatic resources, fish, and fish habitat.

22.10.2.3 Clean-up and Restoration Methods for Fuel Spill in Water

The response to a fuel spill in water will be to recover as much fuel as possible from the environment to minimize potential effects. However, fuel spilled into flowing waterbodies can be rapidly dispersed, which can make recovery challenging. The deployment of containment systems are not always feasible in rivers or streams, although in some cases water can be diverted around the spill using berms or other engineered structures. If practical for the circumstances of the spill, the deployment of containment and recovery equipment will occur as soon as feasible. Cleanup techniques for spills to be considered include the following:

- construct berms around the spill with gravel, earth, or overburden using heavy equipment (e.g., loader, dozer, or excavator);
- excavate a sump using a backhoe, line it with appropriate impervious lining material (e.g., tarp or poly), and divert spill into the sump;
- block culverts with plywood, poly, and/or sandbags;
- divert spill into settling pond or tailing facility where it can be isolated;
- divert spill into site drainage sump and block inlet and/or outlet;
- use vacuum truck to collect spilled material;
- use absorbents (e.g., oil booms or pads) for hydrocarbon spills; and
- use granular absorbents where appropriate.

Disposal of contaminated soil and special wastes (e.g., material with >3% oil by mass) will comply with the appropriate environmental waste management procedures such as the *Environmental Management Act* (2003) and associated Regulations. All clean-up and restoration activities will be conducted in consultation with the appropriate regulatory agencies, including the BC MOE and Fisheries and Oceans Canada.

22.10.3 Potential Environmental Effects

The interactions between a spill into water, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: hydrogeology, surface water quality, aquatics resources, fish and fish habitat, terrestrial ecology, wildlife and wildlife habitat, social, and human health. Negligible interactions were predicted between a fuel spill in water and the atmospheric, terrain stability, wetlands, economic, and heritage VCs. For each respective VC, the worst case scenario considers the spill of the full volume of material into the Murray River at the Murray River FSR bridge.

22.10.3.1 Hydrogeology

In this fuel spill scenario, the spilled fuel is entering the freshwater environment of the Murray River. The Murray River is likely a groundwater discharge zone, so minimal interaction between fuel constituents and groundwater will likely occur. **Negligible** effects to groundwater are expected for a fuel spill into the freshwater environment in Murray River.

22.10.3.2 Surface Water and Aquatics Resources

A fuel spill in the Murray River, as described in this scenario, may have substantial effects on water quality, sediment quality, and aquatic resources. The flowing waters in the River will disperse and mix the fuel, which would lead to decreases in water quality for some distance downstream (several kilometers). Some fuel constituents, like polycyclic aromatic hydrocarbons (PAHs) are hydrophobic and would likely move from the water phase to the sediment environment. Natural processes of dispersion and volatilization will immediately decrease the concentrations of fuel constituents in the water and clean-up efforts will remove any remaining accessible fuel. Natural degradation processes, mediated by microbes and other organisms, use hydrocarbons as substrates for growth and metabolism (Singer et al. 2004). As a result, the effects to water quality are expected to be short-term and reversible in the short-term (e.g., less than 5 years).

The distribution of fuel constituents to the sediments will depend on the conditions within the receiving environment. Depositional environments, such as eddies, will preferentially accumulate sediments and hydrophobic fuel constituents, whereas the flow rate within the river will determine the dilution and distance of travel. It is likely that sediment quality will be degraded at some locations downstream of the spill. Natural processes of volatilization and degradation will act on the fuel constituents in the sediments and will naturally reduce the concentrations of constituents over time. However, the process is depended on temperature and oxygen supply, and may take significantly longer than the processes that act in the underlying river water. To be conservative, the effects of the spill on sediment quality are assessed to be reversible in the medium-term (e.g., 6 to 25 years).

The dispersion of the spilled fuel in the freshwater environment would expose aquatic organisms to potentially toxic constituents. Primary producers, which are aquatic plants and algae, and secondary producers, which are aquatic invertebrates and zooplankton, are potentially susceptible to acute toxic effects from fuel constituents (Lewis and Pryor 2013; Shales et al. 1989). A spill of 50,000 L would likely cause acute toxicity in primary producers and aquatic invertebrates in the immediate vicinity of the spill. Benzene, toluene, ethylbenzene, and xylenes (BTEX) are significant components of fuels and are potentially toxic to aquatic organisms. Provincial and federal water quality guidelines have been established for BTEX compounds for the protection of aquatic life based on the known toxicity of BTEX (BC MOE 2014; CCME 2014).

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

Secondary producers would similarly be affected by the fuel spill. Lethal and sublethal effects to aquatic invertebrates would immediately occur associated with the plume of fuel constituents (Lytle and Peckarsky 2001; Smith et al. 2009). Significant aquatic invertebrate mortality occurs immediately after the fuel spill, and lethal effects have been observed at least 5 km downstream from diesel spills (Lytle and Peckarsky 2001). Sublethal effects include changes in the composition of the secondary producer community; for example, more hydrocarbon-tolerant beetles were observed downstream of a diesel spill in the United Kingdom (Smith et al. 2009). The natural dispersion, degradation, and volatilization of fuel constituents reduce the lethal and sublethal effects on the scale of months-to-years. It would be expected for the abundance and diversity of the secondary producer community to return to pre-spill levels within five years.

Follow-up water quality, sediment, and aquatic organism monitoring would be conducted to assess short- and long-term effects and to identify any additional mitigations required. Surveillance of sediment PAH concentrations would measure the accumulation and persistence of those potentially harmful compounds, and potentially identify depositional areas that could be dredged and de-contaminated. The effect of the spill to surface water and aquatic resources is assessed as **Moderate** because of the expected immediate lethal and sublethal effects to water quality, primary producers, and secondary producers, but mitigated by the expected reversible and short-term effects.

22.10.3.3 Fish and Fish Habitat

A fuel spill into the Murray River is expected to have effects on fish and fish habitat because of the potential lethal and sublethal effects of fuel constituents on fish and the indirect effects on fish prey and habitat. As discussed for primary and secondary producers, fuel constituents such as BTEX and PAHs have known effects on the behaviour, metabolism, growth, and reproduction of fish (Shales et al. 1989; CCME 2014). Some fish mortality is expected in the immediate vicinity of the spill, where fuel constituent concentrations are high enough to be toxic. Fish will also avoid habitats with elevated concentrations of fuel constituents, which would lead to local decreases in fish community abundance and diversity. The decreases in primary and secondary production, due to fuel effects on those lower-food-web organisms, would have indirect effects on fish by reducing the availability of food and habitat (Section 22.10.3.2). The geographic extent of the effects would likely be similar to the effects to secondary producers, and may extent more than 5 km downstream of the spill site.

The active efforts to recover spilled fuel along with the natural processes of dispersion, volatilization, and degradation are expected to reduce the concentrations of fuel constituents substantially in the freshwater environment (Section 22.10.3.2). As a result, the effects to fish are expected to be short-term (e.g., less than five years). The fish community is expected to recover; fish would recolonize affected habitats as water and sediment quality improves and the communities of prey (e.g., primary and secondary producers) recover back to their natural state.

The follow-up monitoring programs will be important to measure the recovery of the ecosystem and identify any further opportunities for restoration. Fish community and fish habitat studies will be conducted to measure the rate and extent of recovery. The effect of the fuel spill into Murray River on fish and fish habitat is assessed to be **Moderate**, due to the potential for significant fish mortality and the immediate loss of fish habitat and prey. However, effects to the fish community and habitat are expected to be short-term and fully reversible because of the combination of active fuel recovery measures, natural degradation and dispersion processes, and the monitoring and adaptive management of residual effects.

22.10.3.4 Terrestrial Ecology

Vegetation and terrestrial ecosystems can be affected by fuel spills by direct damage from the hydrocarbon constituents and by longer-term effects from potentially toxic hydrocarbon constituents. In the water fuel spill scenario, the fuel is entering the freshwater environment of the Murray River and will have little immediate contact with the terrestrial environment. Riparian vegetation downstream of the spill would be potentially vulnerable to the spill constituents. However, the potential effects would be attenuated by dispersion and dilution in the following water of the Murray River, by evaporation of volatile fuel constituents, and the microbially mediated breakdown of hydrocarbons. Furthermore, riparian areas with significant accumulation of fuels will be targeted for clean-up and remediation efforts.

Therefore, the effects from a fuel spill into water would be predicted to be local to the spill, and short-term because of the natural processes of dispersion and the directed efforts of fuel recovery and clean-up. The effects to the terrestrial environment are expected to be reversible after restoration and with the natural processes of dispersion and degradation. The effects on terrestrial ecology of the spill into the water are assessed to be **minor**.

22.10.3.5 Wildlife and Wildlife Habitat

A fuel spill into the Murray River would interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. The effects from direct contact with fuel constituents would likely be **minor**; many of the significant wildlife species are mobile and would immediately avoid the vicinity of the spill. Aquatic and amphibious organisms, like amphibians and waterfowl, would have higher likelihoods of exposure, but the natural processes of dispersion, evaporation, and degradation will decrease the concentrations of fuel constituents and thus decrease the wildlife exposure. The direct effects would be expected to the local and short-term, and would be reversible due to the natural processes of dispersion and degradation combined with recovery of any accessible spilled fuel. Likewise, sensory disturbance from volatile fuel constituents and restoration activities would have local and short-term effects; odours will dissipate and the clean-up activities will be short-term.

Monitoring and follow-up programs for water quality, sediment quality, aquatic resources, fish, and fish habitat will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to surface water and aquatic resources (Section 22.10.3.2) and fish (Section 22.10.3.3). Decreases in ecosystem productivity and prey abundance could reduce the available food for some wildlife species. However, as those receptor VCs recover, the availability of food and the effects to the wildlife would be predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible but the recovery may occur over the medium-term (>4 years) because of the potential for slower recovery for benthic invertebrates (Section 22.10.3.2). The effects of an in-water fuel spill on wildlife are assessed to be **minor**, based on the local geographic restriction and the predicted recovery of the freshwater ecosystem.

22.10.3.6 Social

The fuel spill into the Murray River is not expected to have significant economic effects. Effects to traditional and non-tradition land uses are not expected, because the effects will be restricted to the vicinity of the spill. Tourism activities along the downstream reaches of the Murray River may be affected immediately following the spill, but the clean-up and restoration activities combined with natural dispersion and degradation would make the effects short-term. Sport-fishing may be also affected because of effects to aquatic resources and fish, but any effects would be restricted to the affected reaches of the Murray River only, would be reversible as the ecosystem recovers, and would be negligible on a regional scale because of the availability of many other sport-fishing locations. The effects from a fuel spill in the Murray River on social VCs are assessed to be **Minor**.

22.10.3.7 Human Health

The potential for human health effects could include acute exposure effects from the fuel constituents and exposure to fuel constituents from the consumption of fish and wildlife. Direct exposure to fuel constituents is not likely as a result of the spill. The emergency notification procedures will include notices to avoid consumption of the water downstream of the spill until the water is shown to be safe. Natural dispersion and degradation processes combined with active fuel recovery where possible will reduce the concentrations of potentially harmful fuel constituents over time.

Monitoring programs and follow-up programs for water quality, sediment quality, aquatic resources, and fish will identify any remaining fuel constituents in the environment. These monitoring programs will mitigate the effects to human health; therefore the effects to human health from a fuel spill into the Murray River are assessed to be **Minor**.

22.10.4 Risk Assessment for Fuel Spill into Water

The analysis of potential environmental effects from a fuel spill in the Murray River identifies two moderate residual effects:

- effects to water quality, sediment quality, and aquatic resources; and
- effects to fish and fish habitat.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC. The severity of the hazard from a fuel spill into the Murray River is assessed to be **Moderate**. Both identified effects (i.e., surface water and fish) are assessed to be **Moderate** in magnitude, restricted to the vicinity of the spill and the downstream environment, and fully reversible. The likelihood of the scenario is assessed to be **Not Likely**. The transport route for fuels has only two major river crossings, which decreases the likelihood of an event resulting in the deposition of fuel into a waterbody. Furthermore, adherence to transport regulations and the identified design measures (Section 22.10.2.1) will reduce the likelihood of a spill. Therefore, the risk associated with a fuel spill into water is assessed as **Low**. The confidence in the risk assessment is **Medium** because of the challenges in recovering spilled fuel from flowing waterbodies and the potential for rapid dispersal of the spilled fuel, which reduce the effectiveness of immediate restoration measures and introduce uncertainty in the eventual distribution of fuel constituents.

22.11 Scenario 7B: Fuel Spill onto Land

22.11.1 Description of Possible Scenario

Liquid fuels will be transported to the mine site by truck and a fuel spill into the terrestrial environment is possible as a result of an accident that releases some or all of a load of fuel. Fuel trucks will travel from Tumbler Ridge along highways 29 and 52 to the Murray River FSR road, and then to the fuel storage facilities at the Decline Site and the Coal Processing Site. This scenario assumes the entire load of a standard fuel truck (50,000 L of fuel) will be deposited into the terrestrial environment along the transport route. This scenario is applicable during the construction, operations, and closure phases of the Project; no significant fuel transport is expected in the post-closure phase.

22.11.2 Mitigation and Management Measures for Fuel Spill onto Land

22.11.2.1 Project Design Measures to Minimize Risk of Fuel Spills

Project design measures to minimize the risk of hydrocarbon and fuel spills largely surround the safe operation of vehicles (Site Access Management Plan). These measures include the following:

- design, construct, and maintain Project site and access roads so that they are safe for designated uses including, where appropriate, the use of guard rails and berms to prevent overturning and/or capture load loss;
- prevent site and access roads from becoming wildlife attractants to avoid wildlife vehicle collisions;
- control excessive speed on access roads;
- regular inspection, maintenance, and equipping of mine and contractor vehicles;
- ensure training of mine personnel and contractors for safe driving and emergency response and spill contingency procedures

As well, all fuel handling and storage infrastructure and equipment will be regularly inspected and maintained as described in the Spill Response Plan (Chapter 22.22).

22.11.2.2 Emergency Response Approach to Fuel Spills

In the event of a spill, the Spill Response Plan (Chapter 22.22) will be triggered. If an emergency response is triggered, control of the situation will be transferred to the emergency response team.

The team will be guided by the Proponent's overall Emergency Response Plan. Statutory reporting of spills of more than 100 L of fuel to provincial authorities is also necessary, and any spills will be documented in a Spill Report that would be submitted within 24 hours to the BC Provincial Emergency Program. If fish and fish habitat may be affected by the spill, the spill would also be reported to Fisheries and Oceans Canada.

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

If the release of fuel cannot be fully mitigated in clean-up and restoration, a program will be implemented to monitor any residual effects in the terrestrial environment, including hydrogeology, terrestrial ecology, and wildlife and wildlife habitat. .

22.11.2.3 Clean-up and Restoration Methods for Fuel Spill onto Land

The response to a fuel spill onto land will be to recover as much fuel as possible from the environment to minimize potential effects. If practical for the circumstances of the spill, the deployment of containment and recovery equipment will occur as soon as feasible. Cleanup techniques for spills to be considered include the following:

- construct berms around the spill with gravel, earth, or overburden using heavy equipment (e.g., loader, dozer, or excavator);
- excavate a sump using a backhoe, line it with appropriate impervious lining material (e.g., tarp or poly), and divert spill into the sump;
- block culverts with plywood, poly, and/or sandbags;
- divert spill into settling pond or tailing facility where it can be isolated;
- divert spill into site drainage sump and block inlet and/or outlet;
- use vacuum truck to collect spilled material;
- use absorbents (e.g., oil booms or pads) for hydrocarbon spills; and
- use granular absorbents where appropriate.

Disposal of contaminated soil and special wastes (e.g., material with >3% oil by mass) will comply with the appropriate environmental waste management procedures such as the *Environmental Management Act* (2003) and associated Regulations. All clean-up and restoration activities will be conducted in consultation with the appropriate regulatory agencies, including the BC MOE and Fisheries and Oceans Canada.

22.11.3 Potential Environmental Effects

The interactions between a spill into water, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: hydrogeology, terrestrial ecology, wetlands, wildlife and wildlife habitat, and human health. Negligible interactions are predicted between a fuel spill onto land and the atmospheric, surface water, aquatic resources, fish and fish habitat, terrain stability, economic, social, and heritage VCs. For each respective VC, the worst case scenario considers the spill of the full volume of material into the terrestrial environment along the right-of-way of the transport route.

22.11.3.1 Hydrogeology

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

In the event of a spill, the clean-up and restoration measures will start as soon as feasible. The close proximity of the spill to the transport route, in this scenario, will facilitate the rapid response and deployment of containment and recovery equipment. It is expected that a significant portion of the spilled fuel will be removed from the terrestrial environment with the rapid implementation of clean-up efforts (Section 22.11.2.3). The potential effects from the spill to groundwater will therefore be minimized, and the quantity of fuel constituents infiltrating into groundwater will be minimized. A monitoring and follow-up program will be implemented to determine the extent and concentration of residual fuel constituents, and to track any further infiltration and movement away from the immediate vicinity of the spill site. Further mitigation measures, including the removal of additional source materials, would be implemented as necessary based on the information collected in the monitoring program.

Residual fuel constituents would possibly remain in the groundwater environment after the restoration and clean-up efforts. The clean-up efforts are expected to recover and remove the majority of the spilled fuel, but the remaining material may remain for years to decades as it naturally degraded and dispersed. To be conservative, the duration of the effects from a spill along the transport route on hydrogeology is assessed to be medium-term (e.g., 6 to 25 years) but reversible because of the implementation of clean-up measures, follow-up monitoring and management, and natural degradation. Therefore, the effect of the spill on groundwater resources is assessed to be **Moderate**.

22.11.3.2 Terrestrial Ecology

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

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

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

22.11.3.3 Wetlands

Wetlands are located along the transportation route. A fuel spill onto one of these wetland areas would have effects on the wetland plants and animals from mortality associated with direct contact with fuel constituents. The relatively high soil moisture levels and standing water in wetlands can increase the mobility, and ultimately the potential effects, of fuel constituents. Furthermore, the low oxygen concentrations often found in wetlands can inhibit the natural degradation of hydrocarbons.

Fuel recovery and wetland restoration activities would be implemented as soon as feasible after a spill (Section 22.11.2). The construction of berms and sumps will restrict the mobilization and enhance the recovery of spilled fuel, which will reduce the exposure of wetland organisms and the residual effects. As discussed for the effects on terrestrial ecology (Section 22.11.3.6), the re-vegetation and restoration of the affected wetland would be implemented and will aid in returning the wetland to a natural state. The extent of the effects from the spill is expected to be localized because of the fuel recovery and restoration activities; fuel constituents are not expected to be mobilized beyond the immediate vicinity of the spill. Monitoring and follow-up programs would be implemented to assess the performance of the mitigation and restoration measures, as well as identify and remove any significant remaining fuel constituents. The effects from a spill into a wetland are expected to be medium-term, because of the slow degradation of hydrocarbons, but reversible. The effects of a spill along the transport route on the wetland VC are assessed to be **Moderate**, due to the significance of wetlands in the ecology and biogeochemistry of the landscape and the potential for longer-term residual effects.

22.11.3.4 Wildlife and Wildlife Habitat

A fuel spill along the transport route would interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. The effects from direct contact with fuel constituents would likely be minor; many of the significant wildlife species are mobile and would immediately avoid the vicinity of the spill. The direct effects would be expected to be local and short-term, and would be reversible due to the natural processes of dispersion and degradation combined with recovery of any accessible spilled fuel. Likewise, sensory disturbance from volatile fuel constituents and restoration activities would have local and short-term effects; odours will dissipate and the clean-up activities will be short-term.

Monitoring and follow-up programs for soil quality will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. Wildlife tissue monitoring for the bioaccumulation of hydrocarbons will assess the potential for wildlife exposure. These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to terrestrial ecology (Section 22.11.3.6) and wetlands (Section 22.11.3.7). Decreases in ecosystem productivity could reduce the available food for some wildlife species. However, the availability of food and habitat would increase with the re-vegetation and restoration of the habitat and the effects to the wildlife would be predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible but, to be conservative, the recovery may occur over the medium-term (>4 years). Furthermore, the road right-of-way is not likely a significant habitat for wildlife species because of the traffic and existing effects from human activities. The effects of an in-water fuel spill on wildlife are assessed to be **Minor**, based on the local geographic restriction and the predicted recovery of the terrestrial ecosystem.

22.11.3.5 Human Health

The potential for human health effects could include acute exposure effects from the fuel constituents and exposure to fuel constituents from the consumption of fish and wildlife. Direct exposure to fuel constituents is not likely as a result of the spill. Access to the site will be restricted. Natural dispersion and degradation processes combined with active fuel recovery where possible will reduce the concentrations of potentially harmful fuel constituents over time.

Effects to human health from a fuel spill along the transport route are assessed to be **Minor**.

22.11.4 Risk Assessment for Fuel Spill onto Land

The analysis of potential environmental effects from a fuel spill along the transport route identifies two moderate residual effects:

- effects to groundwater; and
- effects to wetlands.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC. The severity of the hazard from a fuel spill on to land is assessed to be **Moderate**. Both identified effects (i.e., groundwater and wetlands) are assessed to be **Moderate** in magnitude, restricted to the vicinity of the spill, and fully reversible over the medium-term (i.e., less than

25 years). The likelihood of the scenario is assessed to be **low**. Furthermore, adherence to transport regulations and the identified design measures (Section 22.10.2.1) will reduce the likelihood of a spill. Therefore, the risk associated with a fuel spill onto land is assessed as **Moderately-low**. The confidence in the risk assessment is **High** because of the well-established clean-up and restoration measures for fuel spills onto land and the implement of appropriate monitoring programs.

22.12 Scenario 8A: Spills of Non-hydrocarbon Hazardous Substances into Water

Hazardous waste materials, such as spoiled processing reagents and used batteries, laboratory waste, oil and lubricants will be generated throughout the life of the Project, from construction to decommissioning. The primary hazardous substances identified in Project planning are the following:

- polyacrylamide, used in the processing of coal;
- aluminum chloride, used in the processing of coal;
- used batteries; and
- laboratory waste.

Polyacrylamide and aluminum chloride are expected to be on-site in the largest quantities (11 and 30 tonnes, respectively). The identified non-hydrocarbon hazardous materials associated with the Operations phase of the Project. All potentially hazardous substance will be transported to and from site by truck.

The effects of a hydrocarbon or other fuel spill are considered in Sections 22.10 and 22.11. Environmental Management Plans for several non-hydrocarbon hazardous materials are presented in Section 24. These management plans include the:

- Flocculent Management Plan (Chapter 24.8);
- Explosives and Nitrogen Management Plan (Chapter 24.9); and
- Waste Management Plan (Chapter 24.13).

The implicit understanding of hazardous includes negative environmental consequences if an accident or malfunction were to occur on either land or in water. The failure modes identified for these accidents and malfunctions are vehicle accidents during transport and unplanned releases during storage and use. The worst-case scenario would be a complete release of the most environmentally toxic of these substances into either land or in water (See Section 22.13).

22.12.1 Description of Possible Scenario

Aluminum chloride will be transported to the mine site by truck and a spill into the freshwater environment is possible as a result of an accident that releases some or all of a load of aluminum chloride into a waterbody. Trucks will travel from Tumbler Ridge along highways 29 and 52 to the Murray River FSR road, and then to the storage facilities at the coal processing facility. Generally, the route is more than 100 m from any waterbodies, but Highway 52 crosses Flatbed Creek approximately 5.5 km from Tumbler Ridge and 8 km from the Murray River FSR road.

This scenario assumes the entire load of aluminum chloride (15 t) will be deposited into the freshwater environment of the Flatbed Creek at the Highway 52 crossing. To be conservative, it is assumed that all of the aluminum chloride enters the freshwater environment. This scenario is applicable during the operations phase of the Project; aluminum chloride will only be required during operations of the coal processing plant.

22.12.2 Mitigation and Management Measures for Hazardous Substances into Water

22.12.2.1 Design Measures to Minimize Risk

All hazardous materials will be anticipated in advance; segregated, inventoried, and tracked in accordance with applicable legislation and regulations such as the federal *Transportation of Dangerous Goods Act* (1992). A separate secure storage area will be established with appropriate controls to manage spillages. Hazardous waste will be labeled and stored in appropriate containers for shipment to approved off-site disposal facilities.

All employees, contractors, and sub-contractors who are handling hazardous waste for the Project will be provided with Workplace Hazardous Materials Information System (WHMIS) training or required under contract to have that training, so they can identify hazardous waste and know how to handle it appropriately.

Transportation of Dangerous Goods (TDG) training will be provided, or required of employees, contractors, and sub-contractors who are receiving, off-loading, and storing potentially hazardous materials, or involved in the storage and shipment off-site of hazardous waste.

Reputable certified transportation contractors will be used for the transport of goods and materials to and from the site. Project personnel will periodically inspect the transporters' performance and compliance with British Columbia and federal transport regulations, contract requirements, and overall performance.

Hazardous waste will be transferred to an approved hazardous waste facility that will issue a certificate of destruction. Periodic audits of this facility to ensure proper handling and destruction of hazardous waste will be considered.

22.12.2.2 Emergency Response Approach

The spill response procedures for a non-hydrocarbon hazardous waste spill are the same as those for a fuel or hydrocarbon spill and are discussed in Section 22.10.2.

22.12.2.3 Clean-up and Restoration Methods

The clean-up and restoration procedures for a non-hydrocarbon hazardous waste spill are the same as those for a fuel or hydrocarbon spill and are discussed in Section 22.10.2.

22.12.3 Potential Environmental Effects

The interactions between a spill into water, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: surface water quality, aquatics resources, fish and fish habitat, terrestrial ecology, wildlife and wildlife habitat, social, and human health. Negligible interactions are predicted between the spill of aluminum chloride and the atmospheric, hydrogeology, terrain stability, wetlands, economics, and heritage VCs. For each respective VC, the worst case scenario considers the spill of the full volume of material into Flatbed Creek at the Highway 52 bridge.

22.12.3.1 Surface Water and Aquatics Resources

Both components of aluminum chloride may have effects on water quality, sediment quality, and aquatic resources. Both aluminum and chloride are readily soluble in water and can have toxic effects to aquatic organisms, if in sufficient high concentrations. Guidelines have been established for the protection of aquatic life for both aluminum and chloride (BC MOE 2014). Concentrations of aluminum and chloride are expected to be greater than the applicable water quality guidelines immediately following the spill into Flatbed Creek. However, the concentrations are expected to decrease because of the recovery efforts and the dilution and dispersion of the spilled aluminum chloride. The effects to water and sediment quality are expected to be short-term (e.g., less than five years) and reversible because of the solubility of aluminum and chloride and the natural dispersion processes.

Aquatic organisms are expected to be effected by the significant increases in aluminum and chloride in the vicinity of the spill. Lethal and sublethal effects to primary producers and secondary producers are expected, with substantial decreases in the abundance, diversity, and productivity in the immediate vicinity of the spill. The effects are expected to be attenuated with distance from the spill because of dilution and dispersion. The acute effects of the spilled aluminum chloride would decrease over time and aquatic organisms would re-colonize the affected areas of the Flatbed Creek. As discussed in the context of a fuel spill into water (Section 22.10.3.2), primary and secondary producers will re-colonized affected habitats on a scale of months-to-years. The effects on aquatic resources are, therefore, expected to be short-term (e.g., less than five years) and reversible.

The effects of the aluminum chloride spill in Flatbed Creek on surface water and aquatic resources are assessed to be **Moderate** because of the immediate effects to water quality and aquatic resources, but the effects are expected to be attenuated by recovery of any accessible aluminum chloride and natural dispersion and dilution. A monitoring program will assess the long term effects and will help identify any further mitigation and management measures.

22.12.3.2 Fish and Fish Habitat

As discussed for surface water and aquatic resources (Section 22.12.3.1), the spilled aluminum chloride is expected to have immediate effects on fish and fish habitat. The effects will be greatest in the immediate vicinity of the spills, and will be mitigated by active recovery and natural dispersion. As a result, the effects to fish are expected to be short-term (e.g., less than five years). The fish community is expected to recover; fish would recolonize affected habitats as water and sediment quality improves and the communities of prey (e.g., primary and secondary producers) recover back to their natural state.

The follow-up monitoring programs will be important to measure the recovery of the ecosystem and identify any further opportunities for restoration. Fish community and fish habitat studies will be conducted to measure the rate and extent of recovery. Aluminum and chloride are not expected to accumulate in the tissue of fish. The effect of the aluminum chloride spill into Flatbed Creek on fish and fish habitat is assessed to be **Moderate**, due to the potential for significant fish mortality and the immediate loss of fish habitat and prey. However, effects to the fish community and habitat are expected to be short-term and fully reversible because of the combination of active fuel recovery measures, natural degradation and dispersion processes, and the monitoring and adaptive management of residual effects.

22.12.3.3 Terrestrial Ecology

Vegetation and terrestrial ecosystems can be affected by aluminum chloride by lethal and sublethal effects from both aluminum and chloride. In this scenario, the spill is entering the freshwater environment of Flatbed Creek and will have little immediate contact with the terrestrial environment. Riparian vegetation downstream of the spill would be potentially vulnerable to the spilled aluminum chloride. However, the potential effects would be attenuated by dispersion and dilution in the following water of the Flatbed Creek. Furthermore, riparian areas with significant accumulation of material will be targeted for clean-up and remediation efforts.

Therefore, the effects from a spill of aluminum chloride into water would be predicted to be local to the spill, and short-term because of the natural processes of dispersion and the directed efforts of fuel recovery and clean-up. The effects to the terrestrial environment are expected to be reversible after restoration and with the natural processes of dispersion and degradation. The effects on terrestrial ecology of the spill into the water are assessed to be **Minor**.

22.12.3.4 Wildlife and Wildlife Habitat

A spill of aluminum chloride into Flatbed Creek would interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. The effects from direct contact with spill aluminum chloride would likely be minor; many of the significant wildlife species are mobile and would immediately avoid the vicinity of the spill. Aquatic and amphibious organisms, like amphibians and waterfowl, would have higher likelihoods of exposure, but the natural process of dispersion will decrease the concentrations of aluminum chloride and thus decrease the wildlife exposure. The direct effects would be expected to the local and short-term, and would be reversible due to the natural processes of dispersion combined with recovery of any accessible spilled aluminum chloride. Likewise, sensory disturbance from restoration activities would have local and short-term effects; odours will dissipate and the clean-up activities will be short-term.

Monitoring and follow-up programs for water quality, sediment quality, aquatic resources, fish, and fish habitat will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to surface water and aquatic resources (Section 22.12.3.1) and fish (Section 22.12.3.2). Decreases in ecosystem productivity and prey abundance could reduce the available food for some wildlife species. However, as those receptor VCs recover, the effects to the wildlife would be predicted to decrease. The effects of an in-water aluminum chloride spill on wildlife are assessed to be **minor**, based on the local geographic restriction and the predicted recovery of the freshwater ecosystem.

22.12.3.5 Social

The aluminum chloride spill into Flatbed Creek is not expected to have significant economic effects. Effects to traditional and non-tradition land uses are not expected, because the effects will be restricted to the vicinity of the spill. Tourism activities along the downstream reaches of Flatbed Creek may be affected immediately following the spill, but the clean-up and restoration activities combined with natural dispersion would make the effects short-term. Sport-fishing may be also affected because of effects to aquatic resources and fish, but any effects would be restricted to the affected reaches only, would be reversible as the ecosystem recovers, and would be negligible on a regional scale because of the availability of many other sport-fishing locations. The effects from an aluminum chloride spill in Flatbed Creek on social VCs are assessed to be **Minor**.

22.12.3.6 Human Health

The potential for human health effects could include acute exposure effects from the spilled aluminum chloride. Direct exposure is not likely as a result of the spill. The emergency notification procedures will include notices to avoid consumption of the water downstream of the spill until the water is shown to be safe. Natural dispersion processes combined with active recovery where possible will reduce the concentrations of potentially harmful spill constituents over time.

Monitoring programs and follow-up programs for water quality, sediment quality, aquatic resources, and fish will identify any significant remaining aluminum chloride in the environment. These monitoring programs will mitigate the effects to human health; therefore the effects to human health from an aluminum chloride spill into Flatbed Creek are assessed to be **Minor**.

22.12.4 Risk Assessment for Spills of Hazardous Substances into Water

The analysis of potential environmental effects from an aluminum chloride spill into Flatbed Creek identifies two moderate residual effects:

- effects to water quality, sediment quality, and aquatic resources; and
- effects to fish and fish habitat.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC. The severity of the hazard from the aluminum chloride spill is assessed to be **Moderate**. Both identified effects (i.e., surface water and fish) are assessed to be **Moderate** in magnitude, restricted to the vicinity of the spill and the downstream environment, and fully reversible. The likelihood of the scenario is assessed to be **Not Likely**. The transport route for aluminum chloride has one major water crossing, which decreases the likelihood of an event resulting in the spill into a waterbody. Furthermore, adherence to transport regulations and the identified design measures (Section 22.10.2.1) will reduce the likelihood of a spill. Therefore, the risk associated with an aluminum chloride spill into water is assessed as **Low**. The confidence in the risk assessment is **Medium** because of the challenges in recovering spilled aluminum chloride from flowing waterbodies and the potential for rapid dispersal of the spill, which reduce the effectiveness of immediate restoration measures and introduce uncertainty in the eventual distribution of spill constituents.

22.13 SCENARIO 8B: SPILLS OF NON-HYDROCARBON HAZARDOUS SUBSTANCES ONTO LAND

22.13.1 Description of Possible Scenario

Aluminum chloride will be transported to the mine site by truck and a spill into the terrestrial environment is possible as a result of an accident that releases some or all of a load of aluminum chloride. Trucks will travel from Tumbler Ridge along highways 29 and 52 to the Murray River FSR road, and then to the storage facilities at the coal processing facility. This scenario assumes the entire load of aluminum chloride (15 t) will be deposited into the terrestrial environment along the Highway 52 alignment. To be conservative, it is assumed that all of the aluminum chloride enters the terrestrial environment. This scenario is applicable during the operations phase of the Project; aluminum chloride will only be required during operations of the coal processing plant.

22.13.2 Mitigation and Management Measures for Hazardous Substance Spill onto Land

22.13.2.1 Project Design Measures to Minimize Risk

The designs measures for a hazardous material spill onto land are the same as for a spill into water (Section 22.12.2.1).

22.13.2.2 Emergency Response Approach

The spill response procedures for a non-hydrocarbon hazardous waste spill are the same as those for a fuel or hydrocarbon spill and are discussed in Section 22.11.2.

22.13.2.3 Clean-up and Restoration Methods

The clean-up and restoration procedures for a non-hydrocarbon hazardous waste spill are the same as those for a fuel or hydrocarbon spill and are discussed in Section 22.11.2.

22.13.3 Potential Environmental Effects

The interactions between a spill onto land, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: hydrogeology, terrestrial ecology, wetlands, wildlife and wildlife habitat, and human health. Negligible interactions are predicted between an aluminum chloride spill onto land and the atmospherics, surface water, aquatic resources, terrain stability, economic, social, and heritage VCs. For each respective VC, the worst case scenario considers the spill of the full volume of material into the terrestrial environment along the right-of-way of the transport route.

22.13.3.1 Hydrogeology

Spilled aluminum chloride has the potential for infiltration into groundwater because of its solubility in water, with subsequent decreases in the quality and utility of groundwater resources. The rate and extent of infiltration depend on the soil and environment conditions, including soil moisture and temperature.

In the event of a spill, the clean-up and restoration measures will start as soon as feasible. The close proximity of the spill to the transport route, in this scenario, will facilitate the rapid response and deployment of containment and recovery equipment. It is expected that a significant portion of the spilled aluminum chloride will be removed from the terrestrial environment with the rapid implementation of clean-up efforts (Section 22.11.2.3). The potential effects from the spill to groundwater will therefore be minimized, and the quantity of aluminum chloride infiltrating into groundwater will be minimized. A monitoring and follow-up program will be implemented to determine the extent and concentration of spilled-related aluminum and chloride, and to track any further infiltration and movement away from the immediate vicinity of the spill site. Further mitigation measures, including the removal of additional source materials, would be implemented as necessary based on the information collected in the monitoring program.

To be conservative, the duration of the effects from a spill along the transport route on hydrogeology is assessed to be medium-term (e.g., 6 to 25 years) but reversible because of the implementation of clean-up measures, follow-up monitoring and management, and natural dispersion. Therefore, the effect of the spill on groundwater resources is assessed to be **Moderate**.

22.13.3.2 Terrestrial Ecology

Vegetation and the terrestrial ecology would be affected by an aluminum chloride spill along the transport route. Effects to growth, metabolism, and reproduction may occur from exposure to aluminum chloride. However, the clean-up and restoration activities would be implemented rapidly, and are expected to mitigate the effects of aluminum chloride on vegetation to an acceptable level. Contaminated soil would be removed for appropriate treatment and disposal. The restoration activities in the affected area may include:

- replacing fill or topsoil where required, including measures to minimize erosion prior to the establishment of ground cover;
- re-vegetation with appropriate vegetation types; and

- weed control measures, if required, to ensure the re-growth of a suitable plant community.

A monitoring and follow-up program would be implemented to ensure the restoration and re-vegetation efforts are successful. Addition mitigation measures, such as the application of soil amendments to foster vegetation growth, would be applied as necessary. As a result of the clean-up and restoration activities, the effects of a spill on vegetation and the terrestrial ecosystem are expected to the restricted to the spill site, short-term in duration and reversible. With the implementation of the monitoring program, the effects from a spill on terrestrial ecology are assessed to be **Minor**.

22.13.3.3 Wetlands

Wetlands are located along the transportation route. A spill onto one of these wetland areas would have effects on the wetland plants and animals from mortality associated with contact with aluminum chloride. The relatively high soil moisture levels and standing water in wetlands can increase the mobility, and ultimately the potential effects, of spilled aluminum chloride.

Recovery and wetland restoration activities would be implemented as soon as feasible after a spill (Section 22.11.2). The construction of berms and sumps will restrict the mobilization and enhance the recovery of spilled aluminum chloride, which will reduce the exposure of wetland organisms and the residual effects. As discussed for the effects on terrestrial ecology (Section 22.13.3.6), the re-vegetation and restoration of the affected wetland would be implemented and will aid in returning the wetland to a natural state. The extent of the effects from the spill is expected to be localized because of the fuel recovery and restoration activities. Monitoring and follow-up programs would be implemented to assess the performance of the mitigation and restoration measures. The effects from a spill into a wetland are expected to be medium-term but reversible. The effects of a spill along the transport route on the wetland VC are assessed to be **Moderate**, due to the significance of wetlands in the ecology and biogeochemistry of the landscape and the potential for longer-term residual effects.

22.13.3.4 Wildlife and Wildlife Habitat

An aluminum chloride spill along the transport route would interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. The effects from direct contact with the spill would likely be minor; many of the significant wildlife species are mobile and would immediately avoid the vicinity of the spill. The direct effects would be expected to be local and short-term, and would be reversible due to the natural processes of dispersion combined with recovery of any accessible spilled aluminum chloride. Likewise, sensory disturbance from restoration activities would have local and short-term effects; odours will dissipate and the clean-up activities will be short-term.

Monitoring and follow-up programs for soil quality will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to terrestrial ecology (Section 22.13.3.6) and wetlands (Section 22.13.3.7). Decreases in ecosystem productivity could reduce the available food for some wildlife species. However, the availability of food and habitat would increase with the re-vegetation and restoration of the habitat and the effects to the wildlife would be predicted to decrease. As a result, the indirect effects to wildlife are predicted to be reversible but, to be conservative, the recovery may occur over the medium-term (>4 years). Furthermore, the road right-of-way is not likely a significant habitat for wildlife species because of the traffic and existing effects from human activities. The effects of an in-water fuel spill on wildlife are assessed to be **Minor**, based on the local geographic restriction and the predicted recovery of the terrestrial ecosystem.

22.13.3.5 Human Health

The potential for human health effects could include acute exposure effects from aluminum chloride. Direct exposure is not likely as a result of the spill. Access to the site will be restricted. Natural dispersion processes combined with active recovery where possible will reduce the concentrations of potentially harmful fuel constituents over time.

Monitoring programs and follow-up programs for groundwater (Section 22.13.3.1) will identify any remaining aluminum chloride in the environment. These monitoring programs will mitigate the effects to human health; therefore the effects to human health from a spill along the transport route are assessed to be **Minor**.

22.13.4 Risk Assessment for Fuel Spill onto Land

The analysis of potential environmental effects from an aluminum chloride spill along the transport route identifies two moderate residual effects:

- effects to hydrogeology and groundwater; and
- effects to wetlands.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC. The severity of the hazard from an aluminum chloride spill along the transport route is assessed to be **Moderate**. Both identified effects (i.e., groundwater and wetlands) are assessed to be **Moderate** in magnitude, restricted to the vicinity of the spill, and fully reversible over the medium-term (i.e., less than 25 years). The likelihood of the scenario is assessed to be **low**. Furthermore, adherence to transport regulations and the identified design measures (Section 22.10.2.1) will reduce the likelihood of a spill. Therefore, the risk associated with an aluminum chloride spill onto land is assessed as **Moderately-low**. The confidence in the risk assessment is **High** because of the well-established clean-up and restoration measures for fuel spills onto land and the implement of appropriate monitoring programs.

22.14 SCENARIO 9: UNINTENDED LEAKAGE FROM CONTAINMENT PONDS

Multiple containment ponds will be constructed, operated, and closed during the life of the Project. During construction and operation, these include the sediment pond, sewage treatment plant ponds, and underground seepage pond. During the Project's closure phase, these may include sediment ponds.

Failure of any of these containment ponds may result in the release of off-specification effluent or sediment into watercourses or onto land. Management of containment ponds is covered under the following management plans:

- Water Management Plan (Chapter 24.6);
- Metal Leach and Acid Rock Drainage Management Plan (Chapter 24.7);
- Flocculent Management Plan (Chapter 24.8); and
- Waste Management Plan (Chapter 24.14).

Failure of these ponds could lead to a large release of contaminate water onto land or into water. Failure could arise from poorly designed or constructed ponds, failure of the pond liner, or operational mistake leading to unintentional release of untreated water.

22.14.1 Description of Possible Scenario

The scenario considered for this assessment is the failure of the containment structure for a settling pond, which would lead to the sudden release of the entire pond contents to the nearby Murray River. The scenario assumes that the water in the containment pond has elevated concentrations of suspended material, metals, and nutrients. Detailed engineering plans for the containment/sedimentation ponds are not available, but it is assumed that the pond will have the capacity for 3× the maximum daily flow (20,000 m^3; based on 6,600 m^3/d, Project Description, Chapter 3 of the Application/EIS). Therefore, the scenario describes the release of 20,000 m^3 from the pond to Murray River. The containment structures will be constructed and put into operation during the construction phase, and are expected to be used throughout the operations phase until decommissioning during the closure phase.

22.14.2 Mitigation and Management Measures

22.14.2.1 Project Design Measures to Minimize Risk

The water management infrastructure is designed to diverted non-contact water around Project infrastructure and activities. Potentially poor-quality water will be captured and treated, if necessary, prior to contact with the environment. Underground seepage water will be collected in the mine water sump and sedimentation pond at Underground Operation Hub and then be pumped into the surface seepage sedimentation pond and treatment plant at CPP site. The CCR piles will be lined with geosynthetic liners. After supplying for the coal processing circuit, any excess water will be discharged out to the environment and will meet the relevant permitting and regulatory requirements. Further project design measures for the management of site and mine contact water are described in Section 22.4.2.

All containment ponds have been placed at a distance from any waterbodies, and have been designed by Professional Engineers. Geotechnical information will be used, when appropriate, to ensure the stability and performance of the engineered water management infrastructure. Routine monitoring and maintenance will be performance on the water treatment systems and water management infrastructure. Routine samples of effluent quality will be collected, along with flow measurements, which will be used to monitor treatment performance and identify any unanticipated issues.

22.14.2.2 Emergency Response Approach

In the event of discharge of the failure of a containment pond, notifications will be given immediately to Mine Manager and Environmental Manager. Where required, these notifications will also be extended to regulatory agencies. The emergency response process for the failure of a containment pond will:

- halt the discharge of effluent to the receiving environment, as soon as feasible; and
- immediate assessment of the potential effects to the environment, health, and safety, to ensure the safety of employees, site personnel, and the public.

If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent's overall Emergency Response Plan. If fish and fish habitat may be affected by the event, it would also be reported to Fisheries and Oceans Canada.

Monitoring and assessment programs will be initiated to identify any residual effects in the receiving environment of the Murray River.

22.14.2.3 Clean-up and Restoration Methods

The response to a containment pond failure will be to repair the containment structures to minimize the quantity of water reaching Murray River and to prevent the continued release of contact water. Clean-up and restoration efforts to be considered include the following:

- construct berms around the failure location with gravel, earth, or overburden using heavy equipment (e.g., loader, dozer, or excavator);
- excavate a sump using a backhoe, line it with appropriate impervious lining material (e.g., tarp or poly), and divert remaining water into the sump;
- divert water into other settling ponds;
- divert water into site drainage sump and block inlet and/or outlet; and
- use vacuum truck to collect spilled material.

Disposal of contaminated soil and special wastes (e.g., material with >3% oil by mass) will comply with the appropriate environmental waste management procedures such as the *Environmental Management Act* (2003) and associated Regulations. All clean-up and restoration activities will be conducted in consultation with the appropriate regulatory agencies, including the BC MOE and Fisheries and Oceans Canada.

22.14.3 Potential Environmental Effects

The interactions between the failure of a containment pond and the receiving environment, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: hydrogeology, surface water quality, aquatics resources, fish and fish habitat, wildlife and wildlife habitat, and human health. Negligible interactions are predicted between a failure of a containment pond and the atmospheric, terrain stability, terrestrial ecology, wetlands, economics, social, and heritage VCs. For each respective VC, the worst case scenario considers the release of the contents of a containment pond into the Murray River.

22.14.3.1 Hydrogeology

The majority of the water released during the failure of the containment pond is expected to enter the freshwater environment of the Murray River. The Murray River is likely a groundwater discharge zone, so minimal interaction between effluent constituents and groundwater will likely occur. However, in the immediate vicinity of the point of failure in the containment structure, released water from the pond may have the potential to infiltrate the ground. The duration of infiltration would be limited, because the majority of the water would flow into the Murray River, the emergency response procedures would halt the continued flow of effluent in the containment pond, and the implementation of the clean-up and isolation measures. This short-term infiltration may increase in the concentrations of metals in groundwater, but it is expected the increase to be minor and short-term. The effects to hydrogeology and groundwater resources are, therefore, assessed to be **Minor**.

22.14.3.2 Surface Water and Aquatic Resources

The water released into the freshwater environment by the failure of a containment pond would have the potential to increase the concentrations of metals, suspended material, and nutrients in Murray River. The relatively large volume of released water would likely increase the concentrations of these parameters beyond the applicable water quality guidelines (BC MOE 2014; CCME 2014) and therefore would reduce surface water quality. The implementation of the emergency response and clean-up measures, combined with natural dilution and dispersion processes, are expected to decrease concentrations towards baseline values within the short-term (e.g., less than five years). The failure of the containment pond would represent a single, sporadic input of poor-quality water, and the effects would be reversible.

Mortality and sublethal effects to the behaviour, growth, and reproduction of aquatic organisms could be expected to occur in the immediate receiving environment of the water from the failed containment pond. The expected high concentrations of metals and suspended material could have acute, local effects of primary and secondary producers due to toxicity of metals and smothering by suspended material, and the effects may extend for hundreds of meters downstream. However, the communities of aquatic organisms would be expected to recover, as discussed in the effects of hydrocarbon spills in the freshwater environment (Section 22.10.3.2). The effects of the one-time input of poor-quality water would decrease relatively quickly (days to months) with the natural processes of dispersion and dilution, and any affected organisms would be expected to be replaced by migration and reproduction. The decreases in organism abundance and diversity would be expected to be reversible in the short-term (e.g., less than five years).

The effects of the failure of the containment pond on surface water and aquatic resources are assessed to be **Moderate** because of the immediate effects large volume of poor-quality but tempered by the expected recovery. Recovery will be supported by the monitoring program, which will assess the restoration of water quality and aquatic resources and identify any further requirement mitigation or restoration measures.

22.14.3.3 Fish and Fish Habitat

The effects of the failure of a containment pond on fish and fish habitat would be expected to be similar to the effects to surface water and aquatic resources (Section 22.14.3.2). The elevated suspended sediment, metal, and nutrient concentrations would have the potential to cause lethal effects to fish, and potentially affect fish behaviour, metabolism, growth, and reproduction. However, as was discussed for water quality and aquatic resources, the effects would be restricted to the immediate environment of the released water. Therefore, any lethal or sublethal effects would be local and short-term, and the fish community would be expected to recover. The implementation of a monitoring program will help identify any long-term effects to fish habitat and populations. The effects from the discharge of off-specification effluent are, therefore, assessed to be **Moderate**.

22.14.3.4 Wildlife and Wildlife Habitat

The failure of a containment pond would interact with wildlife through direct contact, alteration of habitat and the availability of prey, and sensory disturbance due to the spill constituents and the subsequent clean-up and restoration efforts. The effects from direct contact with released water would likely be minor; many of the significant wildlife species will be deterred from the vicinity of the Project where the containment pond is located. Aquatic and amphibious organisms, like amphibians and waterfowl, would have higher likelihoods of exposure, but the natural process of dispersion will decrease the concentrations of metals and suspended material and thus decrease the wildlife exposure. The direct effects would be expected to be local and short-term, and would be reversible due to the natural processes of dispersion and dilution. Likewise, sensory disturbance from volatile fuel constituents and restoration activities would have local and short-term effects; odours will dissipate and the clean-up activities will be short-term.

Monitoring and follow-up programs for water quality, sediment quality, aquatic resources, fish, and fish habitat will assess the longer term effects and recovery of these indicators, and will be used to assess the significance of indirect effects to wildlife. These monitoring measures will be used to identify and plan further mitigation and management measures.

Indirect effects to wildlife may occur because of effects to surface water and aquatic resources (Section 22.12.3.2) and fish (Section 22.12.3.3). Decreases in ecosystem productivity and prey abundance could reduce the available food for some wildlife species. However, as those receptor VCs recover, the effects to the wildlife would be predicted to decrease. The effects of the release of water from the containment pond on wildlife are assessed to be **Minor**, based on the local geographic restriction and the predicted recovery of the freshwater ecosystem.

22.14.3.5 Human Health

The potential for human health effects could include acute exposure effects from the poor-quality water. Direct exposure is not likely as a result of the spill. The emergency notification procedures will include notices to avoid consumption of the water downstream of the containment pond release until the water is shown to be safe. Natural dispersion processes will reduce the concentrations of potentially harmful constituents over time.

Monitoring programs and follow-up programs for water quality, sediment quality, aquatic resources, and fish will identify any significant remaining metals or nutrients in the environment. These monitoring programs will mitigate the effects to human health; therefore the effects to human health from a failure of the containment pond are assessed to be **Minor**.

22.14.4 Risk Assessment for Containment Pond Failure

The analysis of potential environmental effects from a containment pond failure into the Murray River identifies the following moderate residual effects:

- effects on surface water and aquatic resources; and
- effects on fish and fish habitat.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC.

The severity of the hazard is therefore assessed to be **Moderate** because of the anticipated magnitude of effects to water quality, aquatic organisms, and fish. The effects are expected to be restricted to the local environment in Murray River and reversible in the short-term. The likelihood of the scenario is assessed to be **Not Likely** because of the experience and knowledge that will be used for the design and construction of the containment ponds. Therefore, the risk associated with un-intentional failure of a containment pond is assessed as **low**. The confidence in the risk assessment is **High**; the water management infrastructure will be designed to a high standard by qualified personnel and routine monitoring and maintenance is expected to ensure the long-term performance of the infrastructure.

22.15 Scenario 10: Motor Vehicle Accidents

22.15.1 Description of Possible Scenario

During Project Construction, Operations, and closure Phases material and personnel will be transported to and from the site by motor vehicle. Personnel and material will travel from Tumbler

Ridge along Highways 29 and 52 to the Murray River FSR road, and then to the Project facilities at the Decline Site and the Coal Processing Site. Generally, the route is more than 100 m from any waterbodies, but Highway 52 crosses Flatbed Creek approximately 5.5 km from Tumbler Ridge and 8 km from the Murray River FSR road. The proposed truck route to the Decline Site also crossed the Murray River on the Murray River FSR road bridge.

A motor vehicle accident may occur under a range of conditions including road conditions, driver fatigue, collisions with wildlife, vehicle malfunctions, and radio malfunctions. These accidents could occur during all Project phases, but are most likely to occur during Construction and Operations when Project traffic would be the highest. Several scenarios are considered here: a single vehicle accident with a large wildlife species (e.g., a moose), a multi-vehicle accident between a Project vehicle and another passenger vehicle. It is also possible that a vehicle accident would cause a fuel spill into water or on land. These scenarios are considered in Sections 22.10 and 22.11. It is also possible that a vehicle accident would occur underground due to a variety of causes such as driver fatigue or a communications system failure. It is unlikely that such an event would have an effect beyond worker health and safety. As worker health and safety is managed under the Health, Safety and Reclamation Code (BC MEMPR 2008) and HD will maintain an Occupational Health and Safety Plan that will address this issue. Thus, this scenario is not considered further.

22.15.2 Mitigation and Management Measures

22.15.2.1 Project Design Measures to Minimize Risk

Vehicle access to the Project site will be controlled under the Site Access Management Plan (Chapter 24.17). This plan has the following objectives relative to reducing vehicle accidents:

- to design, construct, and maintain Project access roads so that they are safe for designated uses;
- to minimize wildlife mortality due to vehicle collisions along access roads and public highways;
- to prevent access roads from becoming wildlife attractants;
- to ensure that all authorized users of roads behave in accordance with company policies; and
- to protect workers and the public and minimize potential adverse effects of increased human presence on the environment by controlling access along Project access roads (working towards zero unauthorized users).

Coordination will occur with the BC Ministry of Environment (or the appropriate governing agency) to identify areas with higher risk of wildlife collisions so that appropriate warning signs may be posted. Locations identified as having a higher likelihood for vehicle collisions with wildlife will be managed adaptively. Other traffic-related mitigation measures related to general safety procedures include:

- all heavy vehicles travelling to and from the Project area will follow dedicated heavy vehicle routes;

- vehicle load rates will be optimized to minimize the number of trips;
- contractors and workers will be required to adhere to a zero-tolerance policy on alcohol and drugs on the Project site and while transporting goods and materials to and from the site;
- information on weather and highway conditions will be made available to all drivers before departure. Drivers will be required to check road conditions prior to departure and adjust driving styles to conditions; and
- drivers and personnel will receive appropriate training (e.g., safe driving practices such as maintaining appropriate distances between vehicles, adjusting driving styles to suit road conditions).

22.15.2.2 Emergency Response Approach to Vehicle Accidents

In the event of an accident, the Emergency Response Plan will be triggered.

If an emergency response is triggered, control of the situation will be transferred to the emergency response team. Specific responses regarding spills of fuels or hazardous materials are discussed in Sections 22.10 through 22.13.

A site-wide communication system (including access roads) will ensure rapid notification of any accidents. The site will have a trained Emergency Response Team with resources to respond to vehicle accidents. Clean-up and restoration measures will be employed if necessary, as described in Sections 22.10 through 22.13.

22.15.3 Potential Environmental Effects

The potential effects to each VC are considered for a motor vehicle accident on the Project site or access roads (Section 22.15.1).

22.15.3.1 Wildlife and Wildlife Habitat

Wildlife may experience mortality through a direct collision with a vehicle. Collisions would likely affect a single individual, and therefore the effects from the collision would be minor on the scale of the local population for that wildlife species. Natural migration and population growth would be expected to replace the lost individual, so the effect would be expected to be reversible. The effect of a collision on wildlife and wildlife habitat is therefore assessed as **Minor**.

22.15.3.2 Human Health

A vehicle collision between a Project vehicle and another passenger vehicle may result in one or more fatalities or serious injuries. Therefore, the effect is assessed as **Major**.

22.15.4 Risk Assessment for Motor Vehicle Accidents

The potential for serious injuries or fatalities due to vehicle accident is significant. Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC.

The severity of the hazard from a vehicle accident is assessed to be **Extreme**. The likelihood of the scenario (e.g., an accident causing a human fatality) is assessed to be **Not Likely** because of the extensive mitigation and management measures, including the active monitoring and management of safety performance. Therefore, the risk associated with a vehicle accident is assessed as **Moderate**. The confidence in the risk assessment is **High** because of the well-established safety measures associated with vehicle traffic.

22.16 Scenario 11: Power Outages

A potential power outage may be caused a events such as a windstorm, snowstorm, forest fire, or bird strike to the transmission lines that service the Project. Under the worst-case scenario, where immediate repair of the transmission line is not possible, a long-term power outage may occur at the Project site. However, in the event that electricity is interrupted, the Project will have several standby diesel generators located on site. These standby generators will have sufficient power to operate critical equipment such as pumps and ventilation fans. A plan will be in place for the orderly shutdown of all non-essential machinery to reduce risks of injury or damage to equipment when the power is re-established.

Even under the worst-case scenario, this scenario will have **negligible** interaction with Project VCs.

22.17 Scenario 12: Sediment Releases into Watercourses

22.17.1 Description of Possible Scenario

Clearing of vegetation, construction activities on steep slopes, soil disturbance, blockage of drainage culverts, concentration of run-off on steep slopes, and natural terrain instabilities contribute to the potential for erosion and sedimentation. These actions may alter soil integrity and result in increased instability, particularly on steep slopes. In a worst-case scenario, severe rain or snowmelt events may exacerbate instabilities in the soil, leading to large sediment transport events such as mass wasting (e.g., landslides and mud slides) into local watercourses. A slide into a watercourse may block flow, causing water to back up and increasing the potential for debris flows and scouring. Debris flows may be triggered by slides of less than 100 m^3, but may ultimately entrain up to 10,000 m^3 of debris (Swanston 1991). Such debris flows may scour streambeds, causing long-term alteration of in-stream habitat.

This scenario assumes a small to moderate landslide originating from a disturbed site within the Project area into a local watercourse, blocking flow.

22.17.2 Mitigation and Management Measures

22.17.2.1 Project Design Measures to Minimize Risk of Sediment Release into Water

Actions to minimize erosion and sediment releases into watercourses are outlined in the Erosion and Sediment Control Plan (Chapter 24.5) and include:

- minimizing soil and vegetation disturbance;
- re-vegetating disturbed areas with an appropriate seed mix as soon as possible;

- soil surface stabilization as necessary with materials such as weed-free mulch, geo-textiles, or soil binder;
- controlling slope erosion by terracing and/or installing fibre logs, geotextiles, erosion control mats, straw, or gravel bags;
- controlling and directing runoff from disturbed areas by grading slopes and ditching;
- minimizing runoff energy by limiting the length and steepness of bare, exposed slopes and by applying appropriate surface drainage techniques (e.g., ditch blocks, ditch surface lining, rip-rap); and
- stabilizing water diversion channels and ditches and protecting channel banks with willow, rocks, gabions, or fibre mats.

In addition, sediment and erosion control measures will be inspected and maintained on a regular basis by Environmental Technicians and Coordinators and all personnel will be encouraged to report incidences of sediment transport or soil instability such as blocked culverts, slope failures, gullying, and siltation.

22.17.2.2 Emergency Response Approach to Sediment Release into Water

A communications strategy is included in the Emergency Response Plan. In the event of a sediment and erosion control failure, notifications will be given immediately to the Mine Manger and Environmental Manager and where required regulatory agencies, such as for incidents in which fish and aquatic habitat could be adversely affected, or if potential geohazards result from the sediment transport event.

In the event of a large sedimentation event, the Emergency Response Plan (Chapter 24.19) and the Erosion and Sediment Control Plan (Chapter 24.5) will be triggered. If an emergency response is triggered, control of the situation will be transferred to the emergency response team. The team will be guided by the Proponent’s overall Emergency Response Plan. If fish and fish habitat may be affected by the event, it would also be reported to Fisheries and Oceans Canada.

A site-wide communication system (including access roads) will ensure rapid notification of any observed erosion and sediment transport events. Heavy equipment crews on site will be capable of responding to mass wasting events and rehabilitation disturbed slopes. Environmental technicians and coordinators will be trained to install and maintain sediment and erosion control measures to minimize the likelihood of mass wasting events. Environmental crews will also be responsible for monitoring re-vegetation efforts on disturbed slopes.

If the mass wasting event cannot be fully mitigated in clean-up and restoration, a program will be implemented to monitor any residual effects in the freshwater environment, including water quality, sediment quality, aquatic resources, fish, and fish habitat.

22.17.2.3 Clean-up and Restoration Methods

The response to a mass wasting event into a watercourse includes:

- Stabilization of the disturbed slope, including removing or diverting sources of excess water, removing excess unstable material, creating slope breaks, covering the slope to prevent additional surface erosion; and re-vegetating the slope;

- Removal of material encroaching into watercourse, unless removal would cause additional damage to aquatic habitat or fish; and
- Installation of sediment and erosion control measures to prevent additional material from entering the watercourse (e.g., silt fencing, ditch breaks, settling ponds).

22.17.3 Potential Environmental Effects

An unintended release of sediments into a water courses may have substantial effects on the freshwater environment. The interactions between a release of sediments from a mass wasting environment and the receiving environment, after the mitigation and clean-up efforts, are considered for each of the most relevant VCs: surface water quality, aquatics resources, fish and fish habitat, terrain stability, terrestrial ecology, and social. Negligible interactions are predicted between a sediment release and the atmospheric, hydrogeology, wetlands, wildlife and wildlife habitat, heritage, and human health VCs. For each respective VC, the worst case scenario considers the release of the sediment in the freshwater environment in the Murray River.

22.17.3.1 Surface Water and Aquatic Resources

Potential effects on surface water quality and aquatic resources include increases the concentration of suspended material, alteration of sediment quality, and mortality of aquatic biota due to smothering by sediment. Deposition of sediment into a watercourse will increase concentrations of suspended material and decrease water quality. These effects may alter surface water quality and aquatic resources for hundreds of metres downstream. Once the source of the sediment is removed, aquatic resources are generally resilient to the effects of increased suspended material. Mitigation and clean up measures to protect water quality and aquatic resources would begin with containing the sediment, both at the source and at accessible downstream locations. Immediate removal of sediment from the watercourse may be required to prevent further damage from avulsions or debris flows.

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

The residual effects of a large sediment transport event into a watercourse could include the temporary alteration of water quality, both during the event and after clean-up as storm events remobilize deposited sediment, increasing turbidity. The geographic extent and magnitude of the environmental effects of a major sediment release to a watercourse could be significant. However, the temporal effects can be reduced and managed with the application of a well-defined emergency response plan, complemented by additional mitigation and compensation measures as identified in a follow-up and monitoring plan. It is anticipated the effects would be short-term (e.g., less than five years) and reversible. The significance of the effects on surface water and aquatic resources is therefore assessed as **Moderate**.

22.17.3.2 Fish and Fish Habitat

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

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

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

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

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

22.17.3.3 Terrain Stability

A major sediment transport event into a watercourse could have effects on local terrain stability, including increasing the potential for additional slope failures and erosion. The likelihood of such a failure occurring is low due the relatively subdued nature of the topography coupled with preventative measures including:

- regular road maintenance;
- appropriate sizing of culverts (design stage);
- monitoring of debris traps and culvert condition;
- assessing culvert condition during and after storm events; and
- regular maintenance.

However, terrain stability may become compromised when preventative measures are unable to prevent ponded water above the road as a result of a culvert blockage or damage. The ponded water can cause increased pore pressure in the sediment resulting in a change in natural terrain stability upslope from the road. Areas where culverts are required often are associated with incised landscape features including gullies, seepage areas and natural drainages including creeks and rivers. In this scenario the area is near the Murray River. These areas inherently have slope conditions and geomorphic processes that may make them predisposed or at risk of mass wasting.

The most effective way to mitigate the effects of mass wasting is in proper road design. Detailed terrain assessments prior to road construction allow for the identification of material type, stratigraphy, depth to bedrock, slopes, topography and locations of hazardous terrain. This information allows for the proper design of roads including appropriate culvert size, and if possible, the avoidance of hazardous terrain. Once the road is constructed preventative measures as outlined above further reduce the probability and scale of a mass wasting event.

In the event of a road culvert failure, re-establishing terrain stability is one of the first requirements to protect human safety, water supplies, water quality, fish habitat, and reestablish landscape aesthetics, vegetation, and recreational use of the area. For this reason, the timely response in the event of a road culvert failure is to act on stabilizing the terrain.

The *Mines Act* is explicit in the mitigation measures to be followed in the event of a mass wasting event. These mitigation measures also are effective in the event of road culvert failures. The measures include restorative activities will be designed and implemented by a qualified person to minimize further mass wasting events such as landslides, channelized debris or mud flow, and gully bank destabilization.

Mitigation measures that will be implemented after a road culvert failure has occurred to address terrain stability include:

- stabilizing any disturbed areas; and
- ensuring a geotechnical engineer prepares a terrain remediation plan in a timely manner (e.g., within 30 days).

If a mass wasting event does occur due to compromised terrain stability, which in this scenario may result from failure of a road culvert resulting in bank erosion, a residual effect is anticipated. With preventative mitigation, the likelihood of a mass wasting event is minimal. However, with unforeseen storm events, a change in terrain stability can occur within hours to days. If mass wasting does occur, there will be changes from baseline conditions. The change is non reversible, sporadic in frequency and is site specific. The magnitude is considered low if the area of terrain stability is not increased and stabilization efforts are effective.

The changes to terrain stability are permanent, but a new equilibrium for terrain stability can be established and allow for the previous land use to occur. Modifications to road design may be required, but overall rating of the effect is not significant as prior land uses can be re-established quickly.

In the event that an event such as a road culvert failure occurs follow-up and monitoring would be appropriate to:

- determine whether the preventative and mitigation measures employed have achieved terrain stability;
- check for renewed erosion or instability (frequency of monitoring program will depend on effectiveness of mitigation); and
- inspect re-vegetation progress (effectiveness will be visible within one growing season, if not deemed successful, additional inspections may be required).

The significance of the residual effect on terrain stability is classified as **Moderate**.

22.17.3.4 Terrestrial Ecology

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

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

22.17.3.5 Social

A major sediment release to a waterbody may affect the distribution of fish downstream. These effects would be reversible as the ecosystem recovers, and would be negligible on a regional scale because of the availability of many other sport-fishing locations. Clean-up and restoration activities combined with natural dispersion of sediment would make the effects short-term. The effects from a sediment release into a watercourse on social VCs are assessed to be **Minor**.

22.17.4 Risk Assessment for Sediment Release into a Watercourse

The analysis of potential environmental effects from a sediment release into a watercourse identifies the following moderate residual effects:

- effects to water quality, sediment quality, and aquatic resources;
- effects to fish and fish habitat; and
- effects to terrain stability.

Effects to other VCs are assessed to be minor or negligible based on the application of mitigation, management, and restoration activities and on the lack of interaction between the scenario and the VC.

The severity of the hazard from a sediment release into a watercourse is assessed to be **Moderate**. All identified effects (i.e., surface water, fish, and terrain stability) are assessed to be **Moderate** in magnitude, restricted to the vicinity of the spill and the downstream environment, and fully reversible. The likelihood of the scenario is assessed to be **Not Likely**. Therefore, the risk associated with a sediment release into water is assessed as **Low**. The confidence in the risk assessment is **Medium** because of the potential for a major sediment release to trigger a larger debris flow, which would increase the severity of impacts on the environment and make rehabilitation more difficult.

22.18 SCENARIO 13: NATURAL GAS PIPELINE LEAKAGE OR FAILURE

HD Mining has engaged Pacific Northern Gas to supply natural gas from their existing network (Appendix 3-F). A short pipeline (approximately 800 m) will be installed to supply the Coal Preparation Plant for coal drying and boilers. This pipeline will be installed underground. Natural gas will also be required to run the boilers at the Decline Site. A natural gas tank will be located in the Decline Site with the capacity to supply 15 days of consumption during Operation. The tank will be refilled through regular truck delivery. The total annual natural gas requirement is estimated to be about 18.4 Mm^3/yr.

This scenario assumes a pipeline failure that results in an uncontrolled release of natural gas into the environment for a short amount of time. As the natural gas would be released into a confined space (i.e., underground), it may combust and cause an explosion, although the chance of this occurring is highly unlikely (NEB 2011). A failure of the underground natural gas pipeline may be caused by excavation damage, corrosion, a fire or explosion causing a pipeline incident, or even a vehicle striking an aboveground meter or regulator (American Gas Association 2014). Mitigation measures specific to the natural gas pipeline are listed below, but otherwise, all other mitigation, management and emergency response and clean-up measures, environmental effects, and risk assessment would be the same as for a surface fire or explosion. These measures and analysis are discussed in Section 22.8.

In the case of a leak or spill from a natural gas pipeline that does not ignite, mitigation, management and emergency response and clean up measures will be the same as outlined for fuel spills discussed in Sections 22.10 and 22.11. Any effects from such a spill would be minimal and very short-term as natural gas evaporates and would naturally disperse in the atmosphere. A short-term decrease in air quality may occur as methane concentrations in any created vapour cloud may be high. However, this vapour cloud would most likely disperse quickly and no medium-term or long-term changes to the Project's atmospherics VC would be expected. Thus, no moderate effects would be predicted and no risk analysis is performed.

In addition to the standard mitigation and management actions described in Section 22.8.2, actions to minimize natural gas pipeline failure include:

- signage indicating the pipe location to provide warning and reduce risk of unplanned/unauthorized digging or excavation work near the pipeline route;
- regular inspection and maintenance of natural gas pipeline and storage tanks; and
- training of mine personnel and contractors for emergency response and spill contingency procedures.

22.19 SUMMARY OF ASSESSMENT FOR ACCIDENTS AND MALFUNCTIONS

Table 22.19-1 presents the summary of risks for accidents and malfunctions.

Table 22.19-1. Summary of Risks for Accidents and Malfunctions, Murray River Mine Project

Scenario	Effects	Severity	Likelihood	Risk	Confidence
1. Effluent from treatment plants	Minor, reversible effects to surface water and aquatic resources, fish and fish habitat, wildlife and wildlife habitat, social, and human health VCs	**Low**	**High**	**Moderate**	**High**
2. Failure of CCR pile	Moderate, reversible effects to surface water, aquatic resources, and fish after clean-up efforts	**Moderate**	**Moderate**	**Moderate**	**High**
3. Failure of underground mine stability	No moderate effects to Project VCs	**-**	**-**	**-**	**-**
4. Failure of water diversion channels	Moderate, reversible effects to surface water and aquatic resources and terrain VCs	**Moderate**	**Not Likely**	**Low**	**Medium**
5. Fires or explosions – surface	Moderate or greater, significant effects to atmospherics, fish and fish habitat, terrain, terrestrial ecology, wetlands, wildlife, economics, social, heritage, and human health VCs from forest fires	**Extreme**	**Not Likely**	**Moderate**	**Low**
6. Fires or explosions – underground	No moderate effects to Project VCs	**-**	**-**	**-**	**-**
7a. Fuel spill (into water)	Moderate, reversible effects to surface water and fish	**Moderate**	**Not Likely**	**Low**	**Medium**
7b. Fuel spill (onto land)	Moderate, reversible effects to wetlands and groundwater	**Moderate**	**Low**	**Moderately-Low**	**High**
8a. Hazardous material spill (into water)	Moderate, reversible effects to surface water and fish	**Moderate**	**Not Likely**	**Low**	**Medium**
8b. Hazardous material spill (onto land)	Moderate, reversible effects to wetlands and groundwater	**Moderate**	**Low**	**Moderately-Low**	**High**
9. Leakage from containment ponds	Moderate, reversible effects surface water and fish	**Moderate**	**Not Likely**	**Low**	**High**
10. Motor vehicle accidents	Moderate, significant effect due to serious injury or fatality	**Extreme**	**Not Likely**	**Moderate**	**High**
11. Power outage	No moderate effects to Project VCs	-	-	-	-

(continued)

Table 22.19-1. Summary of Risks for Accidents and Malfunctions, Murray River Mine Project (completed)

Scenario	Effects	Severity	Likelihood	Risk	Confidence
12. Sediment release	Moderate, effects to surface water, fish, and terrain stability	**Moderate**	**Not Likely**	**Low**	**Medium**
13a. Pipeline failure - explosion	Moderate or greater, significant effects to atmospherics, fish and fish habitat, terrain, terrestrial ecology, wetlands, wildlife, economics, social, heritage, and human health VCs from forest fires	**Extreme**	**Not Likely**	**Moderate**	**Low**
13b. Pipeline failure – no explosion	No moderate effects to Project VCs	-	-	-	-

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

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