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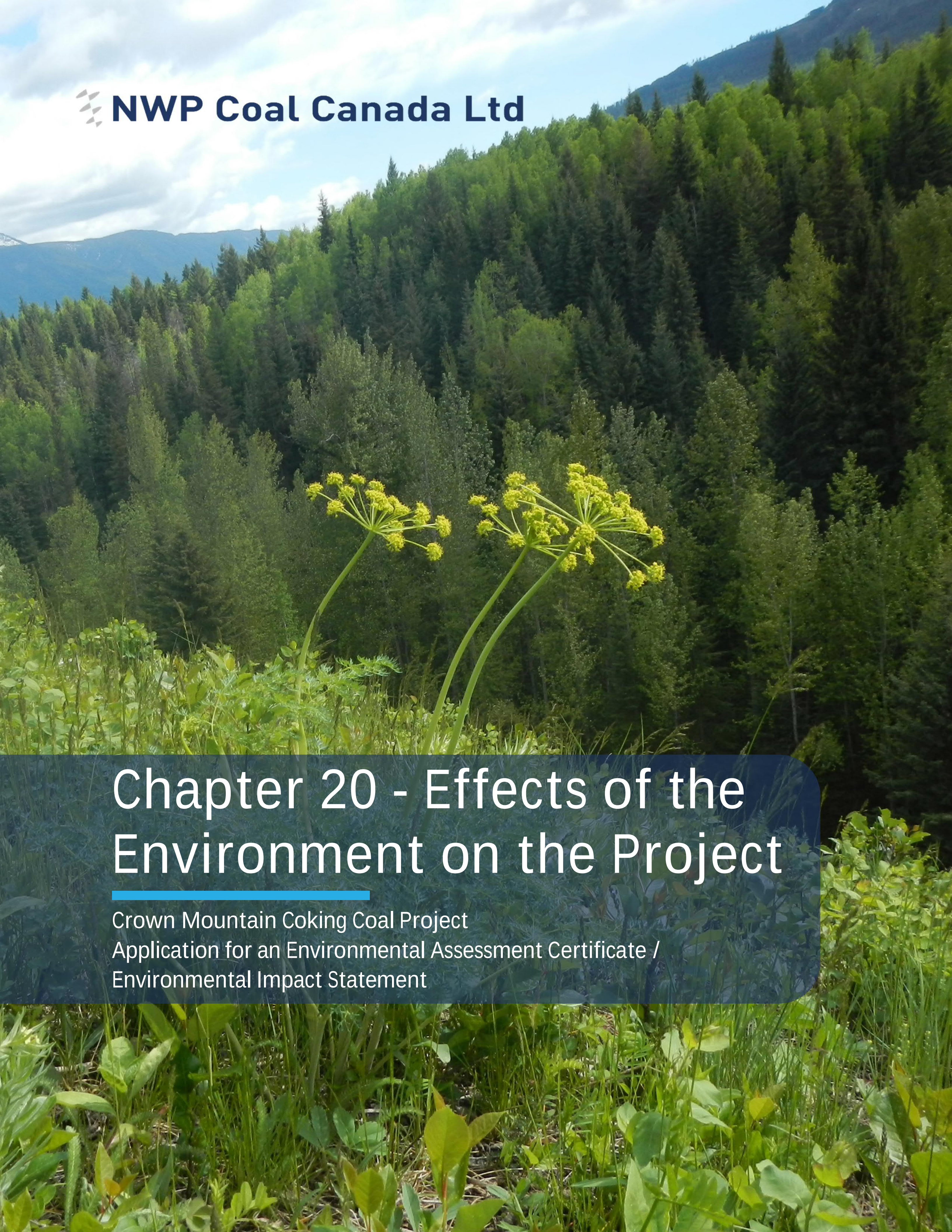

Chapter 20 - Effects of the Environment on the Project

Crown Mountain Coking Coal Project
Application for an Environmental Assessment Certificate /
Environmental Impact Statement

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20.1 Introduction

As outlined in Section 2(1)(c) of the Canadian Environmental Assessment Act, 2012, and the Application Information Requirements (AIR; Environmental Assessment Office [EAO], 2018), the environmental assessment of a project must take into consideration the potential effects of the environment on that project. This chapter includes an assessment of the potential effects that environmental conditions may have on the Crown Mountain Coking Coal Project (the Project). Environmental conditions refer to natural or anthropogenic events or forces that may affect the normal function or stability of Project-related activities or operations. The determination of the potential severity of these effects is based on the ability of the Project, as constructed, to withstand both normal and extreme environmental conditions that may be experienced at the site and within the vicinity. This can largely be accomplished through the implementation of a detailed and thorough planning process and engineering design.

20.2 Scope of the Assessment

The scope of the assessment of effects of the environment on the Project is based on the AIR (EAO, 2018) and the Guidelines for the Preparation of an Environmental Impact Statement for the Crown Mountain Coking Coal Project (EIS Guidelines; Canadian Environmental Assessment Agency [CEAA], 2015). The primary environmental factors included in the assessment to have possible consequences on the proposed Project include, but are not necessarily limited to, the following:

- Extreme weather, including:
    - Extreme precipitation events;
    - Extreme temperatures;
    - Extreme wind events; and
    - Extreme hydrological events;
- Geophysical events, including:
    - Avalanches;
    - Seismic events; and

    - Landslides;
- Forest fires; and
- Climate change.

20.2.1 Spatial Boundaries

The assessment of effects of the environment on the Project was limited to the Project footprint, which represents the area directly disturbed by Project activities, including temporary and permanent works and physical activities associated with the Project.

20.2.2 Temporal Boundaries

The potential effects of the environment were assessed for the intended Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases of the Project (including Post-Closure activities such as ongoing monitoring and reclamation).

20.2.3 Thresholds for Determining Significance

An adverse effect of the environment on the Project is considered significant if it results in one or more of the following outcomes:

- Damage to Project infrastructure resulting in a substantial increase in risks to public health and safety;
- Damage to Project infrastructure resulting in extensive repairs that would not be considered economically or technically feasible to implement;
- A substantial change in the Project construction schedule (e.g., delays extending the construction schedule by one or more seasons); and
- A substantial change in Project operation such that production targets cannot be met.

20.2.4 Indirect Effects of the Environment

Effects of the environment on the Project may lead to indirect effects on one or more valued components (VCs) that were selected for the effects assessment. For example, extreme precipitation events may increase surface runoff, which may result in the transfer of sediment and/or contaminants into nearby watercourses, affecting surface water quality and fish habitat. These VC-specific effects are similar in magnitude and frequency to those assessed in each of the VC-specific assessment chapters of the Application/EIS (including potential accidents and malfunctions arising from such effects); as such, these effects are not included in the scope of this assessment.

20.3 Assessment of Extreme Weather Events on the Project

Extreme precipitation, air temperatures, and wind events may adversely affect the Project components during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. Representative baseline weather data for the Project are summarized in the following sections to describe the conditions that are typical for the location. Baseline data were obtained from the following baseline reports that were prepared for the Project and included in the Application/EIS:

- Meteorology Baseline Report – Chapter 6, Appendix 6-B;
- Hydrology Baseline Report – Chapter 10, Appendix 10-A; and
- Terrain Stability and Geohazards Mapping Report – Chapter 8, Appendix 8-C.

20.3.1 Extreme Precipitation Events

A review of available meteorological data (i.e., climate normals for temperature and precipitation from 1981 to 2010) available from Environment and Climate Change Canada (ECCC) was conducted for three climate stations in the regional area to compare data from the Crown Mountain climate station with past meteorological averages; however, given that the Crown Mountain climate station was situated at a higher elevation on mountainous terrain, recorded climate data may not be directly comparable to long-term local and regional trends near the Project site and the local and/or regional weather stations. Thus, it is important to consider both proximity and elevation of ECCC climate stations relative to the Crown Mountain station. Existing local and regional meteorological data were compiled from three ECCC climate stations: Sparwood (ID: 1157630; 1,138 m above sea level [m asl]), Fernie (ID: 1152850; 1,001 m asl), and Fording River Cominco (ID: 1152899; 1,585 m asl), supplemented by an on-site climate station. Details on the locations and instruments installed at each of these climate stations are provided in the Meteorology Baseline Report (Chapter 6, Appendix 6-B).

The annual total and mean monthly precipitation data from the three ECCC climate stations are provided in Table 20.3-1.

Table 20.3-1: Regional Mean Monthly and Annual Precipitation (mm)

Summary Statistic	1981-2010 Climate Normals								
	SPARWOOD **Station 1157630** (1,138 m asl)			FERNIE **Station** 1152850 (1,001 m asl)			FORDING RIVER COMINCO **Station** 1152899 (1,585 m asl)		
	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total
Annual Total	411.2	264.0	613.5	902.2	325.0	1,226.9	339.8	277.3	617.1
Monthly Minimum	12.4	0.0	34.9	39.0	0.0	51.9	3.1	0.1	33.9
Monthly Average	34.3	22.0	51.1	75.2	27.1	102.2	28.3	23.1	51.4
Monthly Maximum	67.7	54.2	72.1	123.0	83.5	179.1	82.1	44.7	85.7

Source: ECCC, 2019

The mean monthly precipitation data indicate that higher amounts of precipitation occur in the late fall and early winter months (predominately as snowfall) and lower amounts of precipitation in summer and early fall months (predominately as rainfall). A notable difference exists in the amount, type, and distribution of precipitation between the Fernie climate station, which is located further south and lower in elevation, compared to the Sparwood and Fording River Cominco climate stations that are further north and at higher elevations. Similarly, mean annual rainfall, snowfall, and total precipitation appeared to be influenced by elevation and latitude, with the highest amounts recorded at the Fernie climate station, the most southerly station at the lowest elevation. Mean annual snowfall and total precipitation were the lowest at the Sparwood climate station.

Precipitation data were collected at the Crown Mountain climate station between January 2014 and May 2016; however, due to a malfunction of the precipitation gauge caused by high winds, some of the data were deemed to be inaccurate. As such, precipitation conditions for the Project footprint were characterized using a regression analysis of data collected at nearby climate stations. The Sparwood (11557630) and Natal Harmer Ridge (1155402) climate stations were selected for the analysis given their proximity to the Crown Mountain climate station, elevation, and available period of record. For the purpose of the analysis, only the data for the common period of record (1980 to 1990) for the two stations were utilized for the regression analysis of the climate station data.

The results of the regression analysis indicate that the mean summer precipitation at the Crown Mountain climate station (1,920 m asl) is 14.9 millimetres (mm) higher than at the Sparwood climate station (1,138 m asl), and the mean winter precipitation is 23.9 mm lower. The seasonal relationships for mean summer and winter precipitation were applied to derive the monthly precipitation for the Project footprint. The monthly mean precipitation varied throughout the assessment period, with the lowest values generally corresponding to the summer months (a lowest mean of 35.4 mm in August) and higher precipitation in the early winter months (a highest mean of 89.6 mm in November). The maximum monthly precipitation was 268.6 mm in December and the minimum monthly precipitation was 2.9 mm in February. The total annual precipitation from January 2014 to May 2016 was approximately 760 mm in 2014 and 700 mm in 2015 (Chapter 6, Appendix 6-B).

20.3.1.1 Potential Effects on the Project

Potential effects of extreme precipitation events (i.e., high amounts of precipitation in a short timespan) include the potential for severe runoff resulting in flooding of pits or other mine infrastructure and potential washout of roads. Slopes may become eroded and undercut, which may, in turn, compromise slope stability and discharge sediment into local watercourses. Runoff could also result in the transfer of contaminants (e.g., hydrocarbons) into local watercourses.

As discussed, the majority of precipitation within the Project footprint occurs in the late fall and early winter months, predominately as snowfall. High volumes of snowfall could hinder equipment and vehicle travel along access roads and work areas, due to reduced traction or visibility. Further, snow accumulation can increase loads on Project buildings and infrastructure, which may result in structural damage. High snowfall events can also rapidly increase the snowpack in the area, which in turn can increase the potential for avalanches (see Section 20.4.1).

20.3.1.2 Mitigation Measures

The following mitigation measures will be implemented to address the potential effects of extreme precipitation on the Project:

- Design mine infrastructure with a sufficient safety factor to manage for weather extremes that can be expected during Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. Though the Project life is relatively short (34 years) in comparison to the timeframes for expected climate change to occur, design will also consider future conditions that may be associated with climate change;
- Design the site such that the runoff expected during extreme precipitation events can be handled by a sufficiently sized drainage and treatment network;

- Develop and implement a weather monitoring program that will anticipate upcoming weather events, and allow for appropriate planning in response to extreme conditions;
- Schedule Project activities to coincide with appropriate seasonal and weather conditions (i.e., instream work, if required, will be conducted during the drier summer months);
- Implement regular inspection and site maintenance programs, so areas compromised by extreme precipitation events are promptly identified and repaired;
- Develop and implement an Erosion and Sediment Control Plan (Chapter 33, Section 33.4.1.4) to manage effects related to erosion and sediment transfer in susceptible areas of the Project;
- Design ponds for flood redundancy such that extra capacity is incorporated to manage the most extreme rainfall events anticipated;
- Effectively communicate weather response protocols to all mine employees; and
- Construct all buildings and infrastructure to be compliant with the National Building Code of Canada (National Research Council Canada, 2015).

20.3.1.3 Characterization of Residual Effects of Extreme Precipitation Events

Based on the long-term climate data collected in the Project region, extreme precipitation events are not a common occurrence. The potential effects of extreme precipitation events on the Project during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases will be taken into consideration and incorporated into the planning and detailed engineering design of the Project. By constructing the Project components to current and relevant building codes and standards, including use of appropriate building materials, design specifications, and procedures, the potential effects of extreme precipitation (e.g., increased load from snow accumulation) can be largely addressed.

During construction, an appropriate drainage network and stormwater management system will be developed, to allow unimpeded flow of surface runoff away from Project infrastructure (e.g., buildings, storage areas, machinery, and access roads). These will remain in place and maintained throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases.

Through proactive planning, incorporating flood redundancy and contingencies into Project design to account for substantial storm events, and monitoring site conditions regularly to identify and promptly address deficiencies, the likelihood of extreme precipitation events to affect the Project is considered low. In the event that extreme precipitation events are substantial or prolonged to a point where effects to the Project may occur, implementation of appropriate weather monitoring programs, management plans (e.g., Erosion and Sediment Control Plan) and prompt rehabilitation of affected areas will reduce the severity of these effects. Therefore, the residual effects of extreme precipitation on the Project are not expected to be significant.

20.3.2 Extreme Temperatures

Long-term meteorological data available from ECCC (2019) for the Sparwood (ID: 1157630), Fernie (ID: 1152850), and Fording River Cominco (ID: 1152899) stations were collected to describe temperature normals for the region and compare data from the Crown Mountain climate station with past meteorological averages. Similar to precipitation, recorded climate data may not be directly comparable to long-term local and regional trends near the Project site and the local and/or regional weather stations, given that the Crown Mountain climate station was situated at a higher elevation on mountainous terrain (Chapter 6, Appendix 6-B).

Air temperatures in the region are variable and influenced by various factors including elevation, latitude, and local topography. Air temperatures were lowest at Fording River Cominco (1,585 m asl) and highest at Fernie (1,001 m asl), respectively. The Crown Mountain climate station air temperature data are most closely aligned with the corresponding data for Fording River Cominco, which is the station that is nearest in elevation. Mean monthly air temperature ranges at each regional station between 1981 and 2010 included the following:

- At Sparwood, mean monthly air temperatures ranged from -7.3°C in December to 15.8°C in July, with an annual average of 4.4°C;
- At Fernie, mean monthly air temperatures ranged from -6.1°C in December to 16.8°C in July, with an annual average of 5.3°C; and
- At Fording River Cominco, mean monthly air temperatures ranged from -11.3°C in December to 12.6°C in July, with an annual average of 0.9°C.

Air temperature data were collected at the Crown Mountain climate station between January 2014 and May 2016. During this monitoring period, the mean monthly air temperatures ranged from -8.1°C in December to 14.9°C in July, with an annual average of 1.2°C. The extreme minimum temperature at the Crown Mountain climate station was -32.3°C on March 1, 2014 and the extreme maximum temperature was 35.2°C on June 7, 2015 (Chapter 6, Appendix 6-B).

Extreme warm temperatures events are often described using a 20 year return period, or an annual probability of 5% occurrence. However, what are currently 1-in-20-year extreme warm temperature events are predicted to occur much more frequently in the coming decades, and extreme cold events will likely become less frequent. Therefore, characterizing different probability patterns for extreme temperatures events was not further considered in this assessment as return periods for extreme events are anticipated to change during the Project life. An assessment of climate change on the Project is provided in Section 20.6.

20.3.2.1 Potential Effects on the Project

Based on the baseline data provided in Chapter 6, Appendix 6-B, extremely cold temperatures predominately occur as sudden cold snaps in the Project footprint; however, prolonged periods of cold temperatures can also occur. These conditions can affect the operation and integrity of machinery and infrastructure, and pose a health and safety risk to site personnel (i.e., risk of hypothermia or frostbite). Increased lubricant viscosity and increased heating requirements may result in a higher frequency of equipment malfunction, damage, and potential for spills. Also, additional heating requirements for buildings, vehicles, and machinery will increase the power demand for the Project.

Extreme high temperatures may also affect the Project. Workers may be at higher risk to dehydration, heat exhaustion, and heat stroke while working in high temperatures over a prolonged duration. Periods of high temperature and low precipitation could result in surficial cracking of the ground, which has the potential to affect water infiltration, health of vegetation communities, and terrain integrity.

20.3.2.2 Mitigation Measures

The following mitigation measures will be implemented to address the potential effects of extreme temperatures on the Project:

- Design mine infrastructure with a sufficient safety factor to manage for weather extremes that can be expected during Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. Design will also consider future conditions associated with climate change, despite the relatively short Project life in comparison to timeframes when climate change effects may be persistently realized;
- Develop and implement a weather monitoring program that will anticipate upcoming weather events and allow for appropriate planning in response to extreme conditions;
- Conduct ongoing inspection and maintenance of all site components, particularly during and after extreme weather events, to identify areas in need of immediate mitigation and repair;
- Effectively communicate weather response protocols to all mine employees;
- Workers will wear appropriate clothing suitable for the weather conditions, and will be trained in assessing risks related to extreme temperatures; and
- Construct all buildings and infrastructure to be compliant with the National Building Code of Canada (National Research Council Canada, 2015).

20.3.2.3 Characterization of Residual Effects of Extreme Temperatures

Current building codes and construction design criteria for buildings, roads, and other Project infrastructure are likely sufficient to tolerate the extremes in air temperature that have been documented in the Project region. The Project will be designed to meet any criteria (including criteria related to extreme temperature exposure) identified in the National Building Code of Canada (National Research Council Canada, 2015).

During the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases of the Project, weather monitoring will be implemented as part of the Health and Safety Management Plan (Chapter 33, Section 33.4.2.3), and appropriate measures will be followed to reduce the potential effects of extreme temperatures on the health and safety of Project personnel, including provision of personal protective equipment and adjusting work schedules to avoid periods of extreme temperatures.

Through proactive planning, compliance with relevant building and design standards, implementation of mitigation measures, and establishing effective health and safety policies, the likelihood and severity of the potential effects of extreme temperatures on the Project are considered to be low. Therefore, the residual effects of extreme temperatures on the Project are not expected to be significant.

20.3.3 Extreme Winds

Of the three climate stations in the region from which long-term meteorological data were reviewed (ECCC, 2019) only the Sparwood (ID: 1157630) climate station collected data for wind speed and direction in the 1981 to 2010 climate normal data. During this period, the maximum recorded hourly wind speed was 83 kilometre/hour (km/h) on February 23, 1994. The most frequent wind direction was traveling westerly (i.e., from the east).

Wind speeds between 2 and 6 km/h were most frequently recorded during the monitoring period from January 2014 to May 2016. Wind speeds below 3.6 km/h or 1 metres/second (m/s) (i.e., calm winds) occurred 33.6% of the time, and wind speeds over 21.6 km/h or 6 m/s (i.e., strong winds) occurred 1.4% of the time. The maximum instantaneous wind speed was 58.4 km/h on February 6, 2016. The most frequent wind direction was traveling west-northwesterly (i.e., from the south-east), at approximately 22.9% of the recorded entries (Chapter 6, Appendix 6-B).

For the purpose of the Project, a threshold of 125 km/h wind gusts was determined based on a combination of wind speed ranges described in the Enhanced-Fujita Scale for estimating wind speeds based on damage (ECCC, 2013). Another supporting resource that informed this choice was the preliminary analysis conducted by the National Research Council (Schriever, 1977) on the wind sensitivity of single- and double-wide mobile homes and associated anchor requirements to prevent overturning.

A second threshold of 95 km/h 10-min wind was extracted from CAN/CSA-C22.3 No.60826-10 Design Criteria of Overhead Transmission Lines (Canadian Standards Association [CSA], 2010). This threshold is representative of an estimated 50-year return period for the area, and is used as the design threshold load for electrical transmission lines of standard reliability. Table 20.3-2 presents historic probabilities for the wind events described above.

Table 20.3-2: Historic Annual Frequency of Extreme Wind Events

Climate Parameter	Wind Gusts (≥ 125 km/h)	Wind Design Value (95 km/h; 10 min wind)
Unit/Threshold	Annual Frequency	Annual Frequency
Historic	0.02	0.02

Notes:
Data obtained from internal analysis.

The probability patterns for the historic annual probabilities for >125 km/h and 95 km/h; 10 min winds are presented in Table 20.3-3. According to the frequency analysis conducted for each phase of the Project and for the entire Project life, there is a 49.7%% probability that these extreme wind events will occur over the 34 year Project life.

Table 20.3-3: Return Period Probabilities for Extreme Wind Events During Each Project Phase and Throughout the Project Life

Probability for Any Given Year	Probabilities for Project Phases				
	Construction and Pre-Production (Year 1 to 2)	Operations (Year 3 to 17)	Reclamation and Closure (Year 18 to 19	Post-Closure (Year 20 to 34)	Project Life (Year 1 to 34)
2.0%	4.0%	26.1%	4.0%	26.1%	49.7%

Note:
The probabilities of wind events to occur during each Project phase were calculated using the frequency analysis formula: Probability = $1-(1-P)^n$, where P is the probability for an event to occur in any single year, and n is the Project phase length.

20.3.3.1 Potential Effects on the Project

Overall, winds in the Project footprint are of low velocity, and are not likely to have significant effects on the Project; however, occasional high wind speeds have been known to occur. High winds during low air temperatures can result in an increased wind chill and blowing snow. Blowing snow can reduce visibility, limiting access to and from the Project site. High wind speeds can also:

- Accelerate the spread of forest fires;
- Erode sensitive soils; and
- Knock down trees or infrastructure, which may present a health and safety risk, or cause electrical failures.

20.3.3.2 Mitigation Measures

The following mitigation measures will be implemented to address the potential effects of extreme winds on the Project:

- Design mine infrastructure with a sufficient safety factor to manage for weather extremes that can be expected during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. Design will also consider future conditions associated with climate change;
- Develop and implement a weather monitoring program that will anticipate upcoming weather events and allow for appropriate planning in response to extreme conditions;
- Conduct ongoing inspection and maintenance of all site components, particularly during and after extreme weather events, to identify areas in need or immediate mitigation and repair;
- Effectively communicate weather response protocols to all mine employees;
- Construct all buildings and infrastructure to be compliant with the National Building Code of Canada (National Research Council Canada, 2015); and
- Implement a vegetation management program to cut back or remove vegetation that may present a hazard to workers or Project infrastructure (e.g., powerlines).

20.3.3.3 Characterization of Residual Effects of Extreme Winds

As described above, winds in the Project footprint are generally low in velocity and are unlikely to have significant effects on the Project; however, periodic or occasional high wind speeds could result in damages to Project infrastructure, power outages from fallen trees, poor visibility from blowing snow, increased spread of forest fires, or risk of hypothermia or frostbite for on-site Project personnel.

Current building codes and construction design criteria for buildings, roads, and other Project infrastructure are likely sufficient to tolerate periods of high wind speeds in the Project region. The Project will be designed to meet any criteria (including criteria related to extreme winds) identified in the National Building Code of Canada (National Research Council Canada, 2015). Vegetation management will be used to remove trees that may come into contact with power transmission lines, and to create a firebreak around the Project footprint to manage forest fires. Monitoring weather conditions will allow Project personnel to plan appropriately in the event that extreme wind conditions occur.

Through compliance with relevant building and design standards, implementation of management plans, and establishing effective health and safety policies, the likelihood and severity of the potential effects of extreme winds on the Project are considered to be low. Therefore, the residual effects of extreme winds on the Project are not expected to be significant.

20.3.4 Extreme Hydrological Events

A baseline hydrology monitoring program was completed for the Project, in which five hydrometric monitoring stations were established in three watercourses in the Aquatic Local Study Area (LSA): Alexander Creek, West Alexander Creek, and Grave Creek (Appendix 10-A). Based on the results of the monitoring program from 2014 to 2016, most of the runoff occurred between April and July at all of the hydrometric monitoring stations in the Aquatic LSA, with a significant portion of the runoff generated in the months of June and July during the freshet. The mean annual and monthly runoff was generally highest at Station A3B within Alexander Creek, with the greatest annual value in 2014 (1,367.3 mm). The lowest proportion of runoff typically occurred in the late summer, winter, and early spring months at all of the hydrometric monitoring stations.

Different probability patterns for flood events are presented in Table 20.3-4. According to the frequency analysis conducted for each phase of the Project and for the entire Project life, there is a 97.2% probability that a 1-in-10-year flood event will occur during the Project life, a 28.9% probability that a 1-in-100-year event will occur, and a 15.7% chance that a 1-in-200-year event will occur over the 34 year Project life.

Table 20.3-4: Return Period Probabilities for Flood Events During Each Project Phase and Throughout the Project Life

Flood Event	Probability for Any Given Year	Probabilities for Project Phases				
		Construction and Pre-Production (Year 1 to 2)	Operations (Year 3 to 17)	Reclamation and Closure (Year 18 to 19	Post-Closure (Year 20 to 34)	Project Life (Year 1 to 34)
1-in-10-year	10.0%	19.0%	79.4%	19.0%	79.4%	97.2%
1-in-20-year	5.0%	9.8%	53.7%	9.8%	53.7%	82.5%
1-in-50-year	2.0%	4.0%	26.1%	4.0%	26.1%	49.7%
1-in-100-year	1.0%	2.0%	14.0%	2.0%	14.0%	28.9%
1-in-200-year	0.5%	1.0%	7.2%	1.0%	7.2%	15.7%
1-in-500-year	0.2%	0.4%	3.0%	0.4%	3.0%	6.6%

Note:
The probabilities of flood events to occur during each Project phase were calculated using the frequency analysis formula: Probability = $1-(1-P)^n$, where P is the probability for an event to occur in any single year, and n is the Project phase length.

20.3.4.1 Potential Effects on the Project

Extreme flood events have the potential to affect the Project by damaging or inundating infrastructure, including roads, bridges, and culverts, which may, in turn, result in temporary road closures, affecting Project construction or operation. Floods can cause erosion and deposit sediment, debris, and contaminants into watercourses, affecting water quality. Floods can cause retention ponds to overflow or breach if they are not suitably designed or maintained.

Conversely, periods of extreme low water flow (i.e., droughts) can affect Project activities or operations by limiting the ability to withdraw water from watercourses, affecting mine processing operations.

20.3.4.2 Mitigation Measures

The following mitigation measures will be implemented to address the potential effects of extreme hydrological events on the Project:

- Design mine infrastructure with a sufficient safety factor to manage for hydrological extremes that can be expected during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. Design will also consider future conditions associated with climate change;
- Design the site such that the runoff expected during extreme precipitation or hydrological events can be handled by a sufficiently sized drainage and treatment network;
- Develop and implement a weather monitoring program that will anticipate upcoming weather events and allow for appropriate planning in response to extreme conditions (e.g., flood events);
- Develop and implement an Erosion and Sediment Control Plan, with necessary materials and equipment available to quickly respond to flood events;
- Conduct ongoing inspection and maintenance of all site components, particularly during and after extreme hydrological events, to identify areas in need of immediate mitigation and repair;
- Effectively communicate weather response protocols to all mine employees;
- Construct all buildings and infrastructure to be compliant with the National Building Code of Canada (National Research Council Canada, 2015); and
- Design sediment ponds according to B.C. Ministry of Environment Technical Guidance 7 Environmental Management Act requirements (B.C. MOE, 2015). Sediment ponds will be sized to settle particles having a diameter of 5 to 10 microns or greater during conveyance of runoff resulting from the 10-year, 24-hour storm event. They also include riprap spillway structures and containment berms to contain and convey the 200-year, 24-hour storm and maintain adequate freeboard.

For additional details on water management structures, refer to Chapter 3, Section 3.7.5, and Chapter 33, Section 33.4.1.8.

20.3.4.3 Characterization of Residual Effects of Extreme Hydrological Events

The potential occurrence and resulting effects of extreme hydrological events will be considered during the Project design. Prior to construction, a Site Water Management Plan (Chapter 33, Section 33.4.1.8) will be established, which will incorporate measures to mitigate potential effects from extreme hydrological events. The Site Water Management Plan will remain in place throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases, and the plan will be continually revised and improved upon through adaptive management practices. Also, Project infrastructure will be designed to convey, constraint, or control runoff during freshet and following extreme precipitation events.

Through proactive and considerate planning and Project design, implementation of a Site Water Management Plan throughout Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure, and regular inspection and maintenance of Project infrastructure, the likelihood and severity of the potential effects on the Project from extreme hydrological events are considered low.

Therefore, residual effects of extreme hydrological events on the Project are not anticipated to be significant.

20.3.5 Characterization of Residual Effects of Extreme Weather on the Project

By implementing the above mitigation measures, following standard industry best management practices (BMPs), and continually improving upon procedures through adaptive management, the residual effects of extreme weather on the Project are not expected to be significant.

20.4 Assessment of Geophysical Events on the Project

20.4.1 Avalanches

The frequency and magnitude of avalanches are dependent on the available snow load and terrain of a landscape. A desktop avalanche hazard assessment was completed on the mine access road for the Project by Dynamic Avalanche Consulting Ltd. (Dynamic Avalanche Consulting, 2020). The assessment identified eight avalanche paths in the Grave Creek valley that have potential to affect the access road. The frequency and magnitude of the avalanche paths were estimated based on a series of factors, including the path size, incline, aspect (for evaluation of wind effects), path configuration, existing damage to vegetation in the avalanche path runout zone, and estimated snow supply based on snow climate data. The frequency and magnitude estimates also considered the uncertainty of avalanches as natural phenomena, in that unstable snow conditions may result in the occurrence of avalanches over terrain where they would otherwise not be considered likely to occur (Dynamic Avalanche Consulting, 2020).

Of the eight avalanche paths assessed by Dynamic Avalanche Consulting (2020), five were determined to have a low frequency of occurrence (i.e., 1 event per 30 years), two were considered to have a very low frequency of occurrence (i.e., 1 event per 100 years), while one avalanche path has a documented history of avalanches reaching the access road, and represents the highest risk to occur. This avalanche path was estimated to have a higher frequency of occurrence (i.e., 1 event in 10 years) of an avalanche that could bury a car, destroy a small building, or break a few trees. These criteria are based on the established Avalanche Frequency table and the Canadian Avalanche Size Classification table (McClung and Schaerer, 2006).

20.4.1.1 Potential Effects on the Project

Due the limited use of the mine access road, there are few documented avalanche observations in the vicinity of the road corridor. Avalanches have the potential to damage Project infrastructure and present risks to workers' health and safety, as well as that of wildlife. Overhead power transmission lines may be damaged by avalanches, potentially causing power outages until repairs can be completed. Further, avalanches may encounter roads, resulting in road closures, traffic delays, or injuries to drivers and/or passengers.

20.4.1.2 Mitigation Measures

The following mitigation measures will be implemented throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases to address the potential effects of avalanches on the Project:

- Establish an Avalanche Safety Program to monitor the snow pack, evaluate the avalanche potential based on local conditions, and, if required, implement controls to manage the risk of affecting the Project (e.g., helicopter control programs, Remote Avalanche Control Systems [RACS] and snow defence structures);
- Provide on-site workers with avalanche training and provide safety equipment to personnel working in areas where avalanche risks exist; and
- Develop and implement appropriate check-in policies for workers in areas where avalanche risks exist.

20.4.1.3 Characterization of Residual Effects of Avalanches

Avalanche management is a critical component of industrial operations in alpine regions, and management programs are well-established and in place throughout B.C. NWP developed an Avalanche Safety Plan for the Project during the planning phase, which was used by personnel when travelling to the Project and completing fieldwork during avalanche season. An appropriate Avalanche Safety Plan will be developed and implemented throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases of the Project. It is anticipated that the Avalanche Safety Plan will sufficiently mitigate the specific risks related to avalanches.

Prior to construction, a new Avalanche Safety Program will be developed, which will be specific to the planned activities within the Project footprint. Through effective avalanche forecasting, implementing appropriate avalanche controls, training programs for personnel, and developing safety check-in procedures, the likelihood of an avalanche affecting the Project infrastructure, schedule, production targets, or the health and safety of workers or the public is considered low. In the event that the Project is affected by an avalanche, the severity of the predicted effect is also considered low. Therefore, the potential residual effects on the Project as a result of avalanches are not expected to be significant.

20.4.2 Seismic Events

Seismic events (i.e., earthquakes) are caused by the slow deformation of the earth's tectonic plates due to heating and cooling processes (Natural Resources Canada, 2018). The Project site is located within an area that has been rated as having a moderate potential for seismic activity by Natural Resources Canada, which corresponds to a 5 to 15 percent chance that a damaging seismic event will occur every 50 years (Natural Resources Canada, 2015). The National Earthquake Database (Natural Resources Canada, 2020) was reviewed for all records of earthquake occurrences within 20 km of the Project footprint. The largest and most recent earthquake occurred on October 21, 2016 and was recorded approximately 13 km southeast of the Project footprint. This earthquake registered a magnitude of 3.2 on the Richter scale, which is very unlikely to cause any damage (Natural Resources Canada, 2018).

An analysis of seismic hazards was performed using the 2015 National Building Code of Canada Seismic Hazard Calculator (Natural Resources Canada, 2021). Peak Ground Acceleration (PGA) is a measure of how hard the earth shakes during an earthquake, and is measured in units of acceleration due to gravity (g).

The PGA was calculated for the Project area for four probabilities of exceedance in 50 years, assuming firm ground (Table 20.4-1). The United States Geological Survey (USGS) has developed a table of intensity descriptions for PGA (Worden et al., 2020). Based on this scale, the maximum PGA predicted for the Project of 0.126 g would be perceived as “strong perceived shaking”, with a “light” potential for structural damage.

Table 20.4-1: Exceedance Probabilities and Peak Ground Acceleration for Seismic Events During Each Project Phase and Throughout the Project Life

Probability of Exceedance in 50 Years	Probability of Exceedance for Any Given Year	PGA (g)	Probabilities for Project Phases				
			Construction and Pre-Production (Year 1 to 2)	Operations (Year 3 to 17)	Reclamation and Closure (Year 18 to 19)	Post-Closure (Year 20 to 34)	Project Life (Year 1 to 34)
2%/50 year	0.04%	0.126	0.08%	0.60%	0.08%	0.60%	1.36%
5%/50 year	0.10%	0.073	0.20%	1.49%	0.20%	1.49%	3.34%
10%/50 year	0.21%	0.045	0.42%	3.10%	0.42%	3.10%	6.90%
40%/50 year	1.00%	0.014	1.99%	13.99%	1.99%	13.99%	28.94%

Note:
The probabilities of seismic events to occur during each Project phase were calculated using the frequency analysis formula: Probability = $1-(1-P)^n$, where P is the probability for an event to occur in any single year, and n is the Project phase length.

20.4.2.1 Potential Effects on the Project

Earthquakes could affect the mine site, haul road or associated infrastructure should they occur, particularly in steeper terrain areas. Earthquakes are also a safety concern for workers. These impacts could include slope failure, spills, and pipe failure. These impacts to the mine’s infrastructure could affect the environment in a number of ways including:

- Discharge of sediment and debris into local creeks;
- Blocking of creeks with material such that fish access is impeded;
- Flooding resulting from debris jams; and
- Spills of hydrocarbons or other deleterious substances into local watercourses.

20.4.2.2 Mitigation Measures

There are a number of measures which can be applied to mitigate the potential impacts associated with earthquakes. Buildings at the site will be constructed such that they are compliant with the National Building Code of Canada (National Research Council Canada, 2015). The applicable measures outlined in the Canadian Standards Association documents will also be applied. If applied as indicated, the likelihood of an earthquake exceeding the design standard for this area is expected to be very low.

Other mitigation that will be applied includes a geotechnical characterization of the Project footprint to ensure that engineering designs are sufficiently able to address the anticipated seismic activity in the area. In addition, regular inspection and maintenance of the mine’s infrastructure will be implemented to reduce the potential of a catastrophic failure to the extent possible.

20.4.2.3 Characterization of Residual Effects of Seismic Events

Based on the available historical records of earthquakes in the region, a seismic event capable of damaging Project infrastructure or posing a risk to workers or the public has never been recorded in the region. Moreover, a geotechnical characterization of the Project area will be completed to further inform NWP of the potential risk of seismic events to the Project. The findings of the geotechnical characterization will also be used to inform the detailed engineering design of the Project, and all buildings on-site will be constructed in compliance with the National Building Code of Canada (National Research Council Canada, 2015). Therefore, any potential residual effects on the Project as a result of seismic events are not expected to be significant.

20.4.3 Landslides

A terrain stability and geohazards mapping program was completed on the Project (Chapter 8, Appendix 8-C). The findings of the program determined that a large portion of the Project footprint is situated on glaciolacustrine sediments, which are more susceptible to landslides and surface erosion than other materials. Landslide geohazards were identified throughout the study area and include:

- Slow moving landslides, including slumps in bedrock and surficial material, tension cracks and deep-seated gravitational slope deformation; and
- Rapid moving landslides, including rockfall, debris flows, debris slides, and rockslides.

20.4.3.1 Potential Effects on the Project

Similar to avalanches, landslides have the potential to damage Project infrastructure and present risks to workers' health and safety. Overhead power transmission lines may be damaged by landslides, potentially causing power outages until repairs can be completed. Further, landslides may encounter roads outside of the mine site, resulting in road closures, traffic delays, or injuries to drivers and/or passengers.

20.4.3.2 Mitigation Measures

The following mitigation measures will be implemented to address the potential effects of landslides on the Project:

- The implementation of an ongoing geotechnical monitoring program to determine if the landslide risk is changing;
- Incorporate design elements into the mine's infrastructure intended to minimize the potential for landslide effects. These include appropriate site grading, dewatering areas of potential instability, buttressing, and grouting as appropriate;
- Improve site drainage to minimize the potential for slope undercutting and the buildup of pore pressure; and
- Monitor slope conditions and pore pressure regularly within the Project footprint and surrounding areas to identify areas susceptible to landslides and implement appropriate corrective actions.

20.4.3.3 Characterization of Residual Effects of Landslides

The potential occurrence and resulting effects of landslides has been considered throughout the Project design. Potentially unstable areas of the Project footprint have been identified through a geohazard mapping program, and ongoing geotechnical programs will be used to further characterize these areas. The results of these programs will be used to inform the Project design, to ensure that infrastructure will be constructed on stable land, and that appropriate controls will be installed in accordance with industry standards.

Throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases of the Project, the Project footprint and surrounding areas will be regularly monitored through ground surveys by qualified personnel to identify unstable areas susceptible to landslides and implement preventative measures prior to their occurrence.

By completing a thorough characterization of geohazards within the Project footprint, implementing the mitigation measures described above, and monitoring slope conditions throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases, the likelihood that a landslide could affect Project infrastructure, schedule, production targets, or pose a risk to workers or the public is considered low. Further, the severity of effects on the Project by landslides is predicted to be low. Therefore, the residual effects of landslides on the Project are not expected to be significant.

20.4.4 Characterization of Residual Effects of Geophysical Events on the Project

By implementing the above mitigation measures, following standard industry BMPs, and continually improving upon procedures through adaptive management, the potential effects of geophysical events on the Project can be addressed, and the residual effects of geophysical events on the Project are not expected to be significant.

20.5 Assessment of Forest Fires on the Project

Forest fires are a common disturbance to forest and grassland ecosystems throughout B.C. Approximately 2,000 forest fires occur each year in B.C.; approximately 40% of which are caused by humans, while the remaining 60% are caused by lightning (B.C. Wildfire Service, 2020a). Forest fires in B.C. are tracked and managed by the B.C. Wildfire Service, an agency that operates under the Ministry of Forests, Lands, Natural Resource Operations and Rural Development. The B.C. Wildfire Service has developed a spatial database of historical fires, including the location, year, and areal extent of the fire (B.C. Wildfire Service, 2020b).

20.5.1.1 Potential Effects on the Project

There is potential for forest fires to disrupt Project activities during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. The severity of the effects associated with a fire depends greatly on the location and size of the event. The primary potential effects of forest fires on the Project pertain to potential damage to Project infrastructure and the potential risk to human health and safety as well as that of wildlife. Smoke from forest fires may also obscure visibility, thereby presenting a hazard to vehicle traffic.

20.5.1.2 Mitigation Measures

The following mitigation measures will be implemented to address the potential effects of forest fires on the Project:

- Implementation of the Mine Emergency Response Plan (Chapter 33, Section 33.4.2.2) which includes protocols for the detection, notification, and evacuation in the event of an emergency;
- Consider forest fire potential during the detailed engineering and design of the Project components, including buildings and hazardous materials storage areas (e.g., fuels);
- Coordination of fire control efforts with local emergency response personnel;
- Create fire breaks around mine infrastructure as appropriate;
- Maintenance of fire prevention and response equipment on-site at all times, including having fire extinguishers available throughout the site;
- Regular maintenance and replacement of fire protection systems and fire extinguishers, as required;
- Train all employees in prevention, detection, and response to forest fires;
- Prohibition of smoking except in designated areas that are set well back from Project infrastructure as well as potential sources of combustible materials (e.g., conveyors and coal stockpiles);
- Restrict the use of outdoor fires or open flames except as required for warmth or for signalling;
- Implementation of fire bans during times of elevated fire risk;
- Adjusting work procedures to limit risk during times of elevated fire risk;
- Park off-road vehicles on gravel areas kept free of fire fuel;
- Establish designated refuelling areas where open flame is prohibited;
- Maintenance of all equipment in good condition; and
- Constructing buildings and infrastructure on-site to comply with B.C. and federal fire codes.

20.5.2 Characterization of Residual Effects of Forest Fires on the Project

The B.C. Wildfire Service has a well-developed provincial forest fire management program in place to quickly respond to fires and reduce the magnitude and extent of their effects in the province, including the Project region. Throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases, management plans and procedures will be established to prevent fires from occurring on the Project, and respond appropriately to fires that occur outside of the Project footprint (i.e., forest fires). During onboarding, workers on-site will undergo training to become familiar with these management plans and procedures.

The potential effects of forest fires on the Project will be considered during the detailed engineering and design of the Project components, including buildings and hazardous materials storage areas (e.g., fuels), so that in the event that a forest fire occurs in proximity to the Project footprint, the potential for the fire to result in substantial damage to infrastructure will be reduced.

By implementing the above mitigation measures, following standard industry BMPs, and continually improving upon procedures through adaptive management, the likelihood of a forest fire occurring in close proximity to or encroaching on the Project is considered to be low; however, in the event of a forest fire occurrence, appropriate emergency response procedures will be in place to quickly control and extinguish the fire before coming into contact with Project components or posing a risk to human health and safety. Therefore, the residual effects of forest fires on the Project are not expected to be significant.

20.6 Assessment of Climate Change on the Project

A Climate Change Impact Assessment was completed for the Project (Dillon Consulting Limited [Dillon], 2020, see Appendix 20-A), in which the potential effects related to climate change were assessed following the principles of International Organization for Standardization (ISO) 31000 Risk Management Standards (ISO, 2019) . This section includes a summary of the information provided in the Climate Change Impact Assessment report. For further details beyond this summary, the reader is referred to Appendix 20-A.

Though the Project life is relatively short in comparison to the timeframes for expected climate change to occur, the assessment of climate change impacts on the Project considers future conditions that may be associated with climate change. Longer-term effects of climate change are considered up to and including the projected Post-Closure phase of the Project, which is anticipated to occur prior to the end of the mid-term time period for climate change projections used in the assessment (e.g., by 2055), as discussed in Section 20.6.3.

20.6.1 Regulatory Context

An Adaptation Strategy was developed by the B.C. Government to address impacts related to climate changes (B.C. Ministry of Environment, 2010). The B.C. Government is also developing a climate preparedness and adaptation strategy, which will be implemented to build on existing climate adaptation strategies in the Province.

The Government of Canada formed the Pan-Canadian Framework on Clean Growth and Climate Change, a plan for the federal, provincial, and territorial governments to collaborate with the objective of growing the economy, reducing emissions, and adapting to climate change across Canada (Government of Canada, 2016).

Currently, there is no specific federal or provincial legislation in place that requires the Project to implement adaptive measures to address climate change.

20.6.2 Past Regional Climate Change

Climate data from the Climate Atlas of Canada (2019) were collected for the Fording River meteorological station, which Dillon confirmed to be the most representative station for the Crown Mountain Project site following a correlation analysis on the site meteorological station, which compared the Crown Mountain station to other nearby stations. Observed historical climate data were compiled for the period 1981 to 2010. The historical data are summarized alongside the projection data in Sections 20.6.3.1 to 20.6.3.10.

20.6.3 Regional Climate Change Projections

Climate change projections were compiled for the time periods between 2030 and 2040 (short-term), and between 2045 and 2055 (mid-term) using an ensemble of Global Climate Models (GCM) with an emission scenario of Representative Concentration Pathway (RCP) 8.5 (van Vuuren et al., 2011), demonstrating “business as usual”.

Climate data projections for the more complex climate parameters (i.e., snow events, drought conditions, wind events, avalanche threats, forest fire risks, and lightning) were informed by literature sources, internal analysis, and qualitative discussions. Table 20.6-1 lists the climate parameters considered and the corresponding climate data source. The following subsections summarize the specific climate change parameters used for the impact assessment (Dillon, 2020).

Table 20.6-1: Climate Data Sources

Climate Parameter	Open Source Data	Quantitative Analysis
High Temperatures	✓	
Low Temperatures	✓	
Heavy Precipitation	✓	
Freeze-Thaw Cycles	✓	✓
Snow Events – Extreme and Regular		✓
Drought Conditions		✓
Wind Events – Extreme and Regular		✓
Avalanche Threats		✓
Forest Fire Risk		✓
Lightning		✓

20.6.3.1 High Temperatures

Very Hot Days are defined as the average number of days in a year when the temperature is above +30 °C or +32 °C, while Extremely Hot Days is defined as the average number of days in a year when the temperature is above +35 °C; these parameters are recorded as occurrences per year. As shown in Table 20.6-2, the climate parameters related to hot temperatures are expected to increase over the projected time period.

Table 20.6-2: High Temperatures

Climate Parameter	Very Hot Days (+30 °C)	Very Hot Days (+32 °C)
Unit/Frequency	Annual - # Days	Annual - # Days
Historic[1]	0.17	0.01
Predicted 2030s	1.18	0.00
Predicted 2050s	3.27	0.55

Notes:
Data obtained from the Climate Atlas of Canada.
[1] Historic average from 1981-2010 from the Climate Atlas of Canada.

20.6.3.2 Low Temperatures

Very Cold Days are defined as the average number of days in a year when the temperature is below -15°C, while Extremely Cold Days are defined as the average number of days in a year when the temperature is below -25°C and -30°C; these parameters are recorded in average number of days per year (for any year within the specified time period). As shown in Table 20.6-3, by the 2050s, it is expected that the climate parameters related to cold temperatures are expected to decrease over the Project time period.

Table 20.6-3: Cold Temperatures

Climate Parameter	Very Cold Days (-15 °C)	Extremely Cold Days (-25 °C)	Extremely Cold Days (-30 °C)
Unit/Frequency	Annual - # Days	Annual - # Days	Annual - # Days
Historic	45.64[1]	7.98[2]	4.22[1]
Predicted 2030s	38	3.64	3.09
Predicted 2050s	32.27	2.32	1.55

Notes:
Data obtained from Climate Atlas of Canada and Climate Data Canada
[1] Historic average from 1981-2010 from the Climate Atlas of Canada Climate.
[2] Modeled historical data from Climate Data predictions.

20.6.3.3 Heavy Precipitation

Heavy Precipitation occurrences are predicted to increase throughout the lifespan of this Project. An increase in heavy rainfall events may lead to more frequent washouts of the access road and localized flooding in pits, causing delays in work, lost productivity, and increased maintenance and repairs.

Precipitation includes rain, drizzle, snow, and sleet. The Annual Precipitation parameters were recorded in mm, while Heavy Precipitation days were recorded in occurrences per year. As shown in Table 20.6-4, the Annual Precipitation is increasing, and Heavy Precipitation days (both measured as number of days with at least 10 mm and 20 mm of rain) are expected to increase by the 2050s.

Table 20.6-4: Heavy Precipitation

Climate Parameter	Annual Precipitation	Wet Days	Heavy Precipitation Days (10mm)	Heavy Precipitation Days (20mm)
Unit/Frequency	Annual (mm)	Annual - # Days	Annual - # Days	Annual - # Days
Historic[1]	675.15	142	13.50	2.24
Predicted 2030s	745.55	141	17.73	3.27
Predicted 2050s	749.30	143	18.27	3.18

Notes:
Data obtained from the Climate Atlas of Canada.
[1] Historic average from 1981-2010 from the Climate Atlas of Canada.

20.6.3.4 Freeze-thaw Cycles

Freeze-thaw cycles occur when the air temperature fluctuates between freezing and non-freezing temperatures. During these cycles, infrastructure may be substantially impacted and significant damage to concrete and other structures due to water freezing, melting, and re-freezing may occur. As shown in Table 20.6-5, freeze-thaw cycles are expected to slightly decrease by the 2050s, after increasing in the 2030s.

Table 20.6-5: Freeze Thaw Cycles

Climate Parameter	Freeze-thaw Cycles
Unit/Frequency	Annual - # Days
Historic[1]	105.91
Predicted 2030s	110.23
Predicted 2050s	100.91

Notes:
Data obtained from the Climate Atlas of Canada.
[1] Historic average from 1981-2010 from the Climate Atlas of Canada.

20.6.3.5 Snow Events – Extreme and Regular

Snow events were qualitatively examined for the Project due to its complex interactions with other climate hazards in question, and inherent difficulties in qualifying projections. Regular events are characterized by snowfall events between 10 cm and 30 cm, which is a common occurrence and threshold that operators have been managing currently. Extreme snow events are characterized by snowfall events of at least 60 cm, in which the probability was deemed almost certain to occur at least once over a 20 year period.

20.6.3.6 Drought Conditions

Drought conditions were considered throughout the Project, and discussed qualitatively based on its interactions with other climate hazards in question, such as forest fire risk. As such, it is a climate parameter that is difficult to quantify. The one parameter chosen to help inform the possibility of drought conditions is the longest spell of +30°C days. As shown in Table 20.6-6, the longest spell of +30°C days is expected to increase.

Table 20.6-6: Longest Spell of+30°C Days

Climate Parameter	Longest Spell of +30°C Days
Unit/Frequency	Annual - # Days
Historic[1]	0.05
Predicted 2030s	0.00
Predicted 2050s	1.09

Notes:
Data obtained from the Climate Atlas of Canada.
[1] Historic average from 1981-2010 from the Climate Atlas of Canada.

Hot and dry conditions already exist in the Elk Valley region during the summer months. With a changing climate, warmer and drier conditions during the summer months in conjunction with other climate hazards can present increasing compounding impacts. An interaction of concern for the Project includes drought conditions and thunderstorms; drought conditions may lead to an increase in likelihood and occurrence of lightning-caused forest fires.

20.6.3.7 Wind Events – Extreme and Regular

For the purpose of the Project, a threshold of 125 km/h wind gusts was determined based on a combination of wind speed ranges described in the Enhanced-Fujita Scale for estimating wind speeds based on damage (ECCC, 2013). Another supporting resource that informed this choice was the preliminary analysis conducted by the National Research Council (Schriever, 1977) on the wind sensitivity of single- and double-wide mobile homes and associated anchor requirements to prevent overturning.

A second threshold of 95 km/h 10-min wind was extracted from CAN/CSA-C22.3 No.60826-10 Design Criteria of Overhead Transmission Lines (Canadian Standards Association [CSA], 2010). This threshold is representative of an estimated 50-year return period for the area, and is used as the design threshold load for electrical transmission lines of standard reliability. Table 20.6-7 presents data for the wind events described above.

Table 20.6-7: Wind Events

Climate Parameter	Wind Gusts (≥ 125 km/h)	Wind Design Value (95 km/h; 10 min wind)
Unit/Threshold	Annual Frequency	Annual Frequency
Historic	0.02	0.02
Predicted 2050s	0.03[1]	0.025[2]

Notes:
Data obtained from internal analysis.
[1] ~40% probability of occurrence over a 20 year period.
[2] >35% probability of occurrence over a 20 year period.

20.6.3.8 Avalanche Threat

For this Project, risk analysis of the avalanche threat was supported by a preliminary study on the Project's access roads completed by Dynamic Avalanche Consulting (2020). The risk scoring for this parameter capitalizes on the findings related to the size and return periods of avalanche risks on the Grave Creek Road. The study found that the area was susceptible to a maximum of a size 3 avalanche, and calculated a return period of 10 years. The classification of a size 3 avalanche is described in Table 20.6-8. A return period of 10 years is classified as moderate frequency and active in some heavy snow winters (McClung and Schaerer, 2006).

Table 20.6-8: Canadian Avalanche Size 3 Classification

Size	Description (Destructive Potential)	Typical Mass (t)	Typical Path length (m)	Typical Impact Pressure (kPa)
3	Could bury a car, destroy a small building, or break a few trees.	10^3	1,000	100

Source: McClung and Schaerer, 2006.

20.6.3.9 Forest Fire Risk

Forest fire risk was evaluated on both a qualitative and quantitative basis for the Project due to its complex nature. A brief forensic study into past wildfire events between the years 2017 and 2020 in the region was conducted.

Climate change will bring longer fire seasons, increased lightning strikes, and deteriorating forest health conditions, each of which can increase the risk of longer active wildfire seasons. One notable interaction is fires caused by lightning strikes, which account for roughly 50% of forest fires. Lightning-caused fires are reasonably expected to increase for the region due to the increase in hot and dry conditions, as well as increased occurrence and severity of thunderstorm events.

Additionally, wildfires can also exacerbate the severity of avalanches by reducing forest cover, which provides slope stability and soil cohesion in mountainous areas. After a wildfire, the soil characteristics change, potentially impacting vegetation growth and leading to erosion and slope failure.

For the purpose of the Project, the annual frequency for this forest fire event was calculated based on the annual likelihood of forest fires for the region and updated climate change forest fire projections provided by Yan Boulanger (Y. Boulanger personal communications, September, 2020.), forest ecology researcher at Natural Resources Canada. This can be viewed in Table 20.6-9.

Table 20.6-9: Forest Fire Risk

Climate Parameter	Wildfire[1]
Unit/Threshold	Annual Frequency[2]
Historic	3.83×10^{-4} per year
Predicted 2050s	1.42×10^{-3} per year[3]

Notes:

[1] ~2% - 3% probability of occurrence over a 20 year period.

[2] Fire return period for "Southern Cordillera" Forest Zone, as defined by Canadian Forestry Service (Boulanger et al, 2019).

[3] Although these values are extremely low, we note that forest fire projections suggest an increase of ~3.7 times by mid-century under the RCP 8.5 warming scenario (ref.).

20.6.3.10 Lightning

The historical trends observed in the Elk Valley region reflect that thunderstorms occur during the summer months, between June and September. With climate change, thunderstorms are expected to become more severe.

It is well documented that lightning strikes affect mining equipment, especially blasts and blasting equipment. Lightning strikes are known to detonate explosives prematurely and have taken the lives of mining personnel. For the purpose of this Project, lightning data used were based on local lightning climatology using the Canadian Lightning Detection Network, based on a summary of 10 years of data, shown in Table 20.6-10.

Table 20.6-10: Lightning

Climate Parameter	Lightning
Unit/Frequency	Annual Frequency
Historic	0.05 per year (mine site); 0.008 per year (rail loading area)
Predicted 2050s	0.06 per year (mine site)[1] ; 0.01 per year (rail loading area) [2]

Notes:

[1] ~70% probability of occurrence over a 20 year period for mine site buildings.

[2] ~15% probability of occurrence over a 20 year period for rail loading area.

Statistics have been provided for three values:

1) Average cloud-to-ground lightning occurrence for the location in strikes per square kilometer:
2) Adjusted probability taking into account mine site buildings; and
3) Adjusted probability taking into account rail spur building footprint.

Calculations are based on total footprint of buildings at the mine site and at rail spur/loading areas, including 20 meter buffer around each building. The 20 meter buffer is based on estimate lethal range for cloud-to-ground strikes (i.e., fatalities have occurred at this distance from the location of the lightning strike; U.S. Army Training and Doctrine Command, 2002).

20.6.4 Potential Effects on the Project

The assessment process was comprised of three steps:

1. Risk Identification: This step involved cross-referencing the climate hazards/parameters to the individual infrastructure component by means of an interaction matrix to determine the potential for impacts on assets/ operations;
2. Risk Analysis: This step involved assigning likelihood and severity scores for the identified interactions to determine the consequence of the impacts; and
3. Risk Evaluation: This step involved calculating risk scores and identifying unacceptable risks where adaptation options may be required.

20.6.4.1 Risk Identification

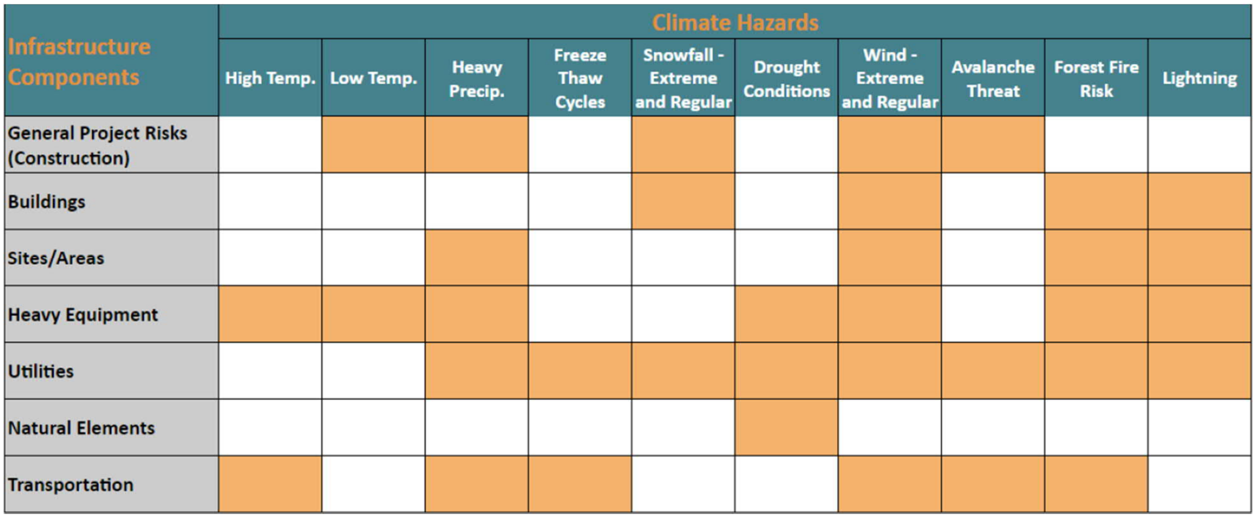
An interaction matrix was compiled to identify the potential interactions between specific climate change parameters and Project infrastructure components. A multidisciplinary team at Dillon populated the interaction matrix by first determining if an interaction between the climate parameter and the infrastructure component was deemed feasible and that it could cause potentially negative impacts. The feasible interactions that may result in negative impacts are depicted by the shaded cells in Figure 20.6-1.

20.6.4.2 Risk Analysis

Upon identification of the initial interactions and risk statements, an internal Dillon workshop was held to identify likelihood and severity scores for each risk statement. For additional details on the identification of likelihood and severity scores, refer to Appendix 20-A. The likelihood scores were developed based on how likely the risk event is to occur over the life of the Project. Table 20.6-11 displays the scale used to rank the likelihood of the risk event occurring.

The consequence of the impacts were discussed and assigned a severity score to the risk event. The workshop participants assigned severity scores to each risk and discussed the potential consequences of the event, which in turn helped provide rationale for the scores selected. The severity was assessed using three guiding categories: public safety or social risk, financial consequence or economic risk, and environmental consequence.

Table 20.6-12 displays the scale used to rank the severity of interactions. Professional assessment and judgement were primary elements used in assigning severity scores, and developing expected consequences.



Infrastructure Components	Climate Hazards									
	High Temp.	Low Temp.	Heavy Precip.	Freeze Thaw Cycles	Snowfall - Extreme and Regular	Drought Conditions	Wind - Extreme and Regular	Avalanche Threat	Forest Fire Risk	Lightning
General Project Risks (Construction)		🟧	🟧		🟧		🟧	🟧		
Buildings					🟧		🟧		🟧	🟧
Sites/Areas			🟧				🟧		🟧	🟧
Heavy Equipment	🟧	🟧	🟧			🟧	🟧		🟧	🟧
Utilities			🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧
Natural Elements						🟧				
Transportation	🟧		🟧	🟧			🟧	🟧	🟧	

Figure 20.6-1: Risk Identification Interaction Matrix

Table 20.6-11: Likelihood of Risk Occurring

Score	Descriptor	Likelihood of Single Event	Likelihood of Ongoing Event	Likelihood of Climate Parameter Occurring
1	Remote	Not likely to occur in Time Period	Not likely to become critical in Time Period	1 in 100 to 1 in 1000; ≤ 1% to 5%
2	Unlikely	Likely to occur once in 10 to 20 years	May become critical in 10 to 20 years	1 in 10; 5% to 15%
3	Possible	Likely to occur once between 5 and 10 years	May become critical in 5 to 10 years	1 in 5; 15% to 35%
4	Likely	Likely to occur once in 5 years (1/5)	May become critical within 5 years	1 in 2; 35% to 90%
5	Almost Certain to Occur	Likely to occur once or more Annually	Will become critical within 1 year	1 in 1.01; 90% to >99%

Table 20.6-12: Consequence of Risk Occurring

Score	Descriptor	Likelihood of Single Event	Likelihood of Ongoing Event	Likelihood of Climate Parameter Occurring
1	Low or Negligible	No injuries - Near miss	Infrastructure Damage or Delays leading to ≤ $ 50K	Short term no impact offsite

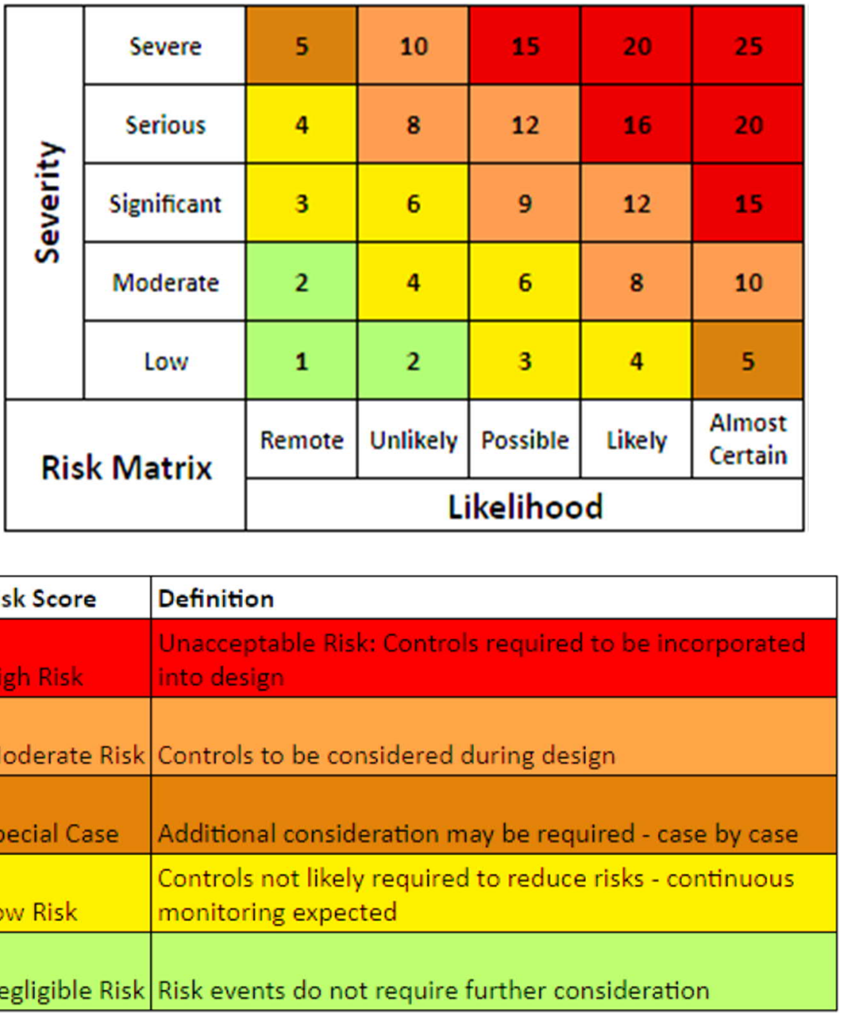
Score	Descriptor	Likelihood of Single Event	Likelihood of Ongoing Event	Likelihood of Climate Parameter Occurring
2	Moderate	Minor injuries to small number of public	Infrastructure Damage or Delays leading to > $ 50K - ≤ $ 100K	May impact offsite and ecosystem – Small scale < 1 month
3	Significant	Medical treatment/Reportable Injury	Infrastructure Damage or Delays leading to > $100K - ≤ $ 300K	Offsite and ecosystem impacted – Duration up to 1 year – Repairable
4	Serious	Partial disability, hospital treatment (i.e., surgery)	Infrastructure Damage or Delays leading to > $ 300K - ≤ $ 750K	Extended range – Long-term impact – May regenerate in ten years
5	Severe	Death or permanent total disability	Infrastructure Damage or Delays leading to > $ 750K	Long-term severe irreparable environmental impact - Over extended range beyond site

The final risk score was calculated based on standard risk assessment principles whereby Risk = Likelihood x Severity. Likelihood is defined as the probability of an event or an incident occurring, whether defined, measured or determined objectively or subjectively. Severity is defined as the consequence of the event or incident in question occurring, in consideration of public safety, economic impacts, and environmental impacts. Figure 20.6-2 shows the risk tolerance threshold used in evaluating the risk score for the Project.

A negligible score (i.e., green square) signifies a negligible risk event that does not require further consideration or mitigation. A low score (i.e., yellow square) signifies a low risk where controls or mitigation measures are likely not required to reduce the risk, but continuous monitoring should be a consideration. A moderate score (i.e., orange square) signifies a moderate risk where some controls or mitigation measures may be required to control or lower risks. These are typically the areas of “known” risks, where the risk is simply identified for consideration during the design of the Project. A high score (i.e., red square) signifies a high or unacceptable risk where high priority or immediate controls and mitigation are required.

A risk score of five (i.e., brown square) signifies that the risk is a special case and additional consideration may be required on a case-by-case basis. As per the matrix, a risk score of five can only be achieved when a severity or a likelihood score is at the extreme (i.e., score of five). Acute conditions with high severity scores signify that the event is not likely to occur, but if it does, the consequences are severe or catastrophic. Likewise, acute conditions with high likelihood scores signify that the event may occur several times over the lifespan of the infrastructure, but the consequence is minimal, leading to an ongoing or cumulative effect that can be generally managed by good practices and mitigation. Both situations warrant additional consideration to help lessen potential impacts on the infrastructure.

As per Figure 20.6-2, adaptation measures were developed for moderate and high risks only, and special case risks were discussed on a case-by-case basis. The full list of risks can be found in Appendix B of the Climate Change Impact Assessment (Dillon, 2020; see Appendix 20-A) and includes the risk statements, the likelihood and severity scores, as well as the calculated risk score and corresponding rating. From the climate hazards used for the assessment, wind events, avalanches, and lightning were found to produce the most infrastructure interactions.



Severity						
	Severe	5	10	15	20	25
	Serious	4	8	12	16	20
	Significant	3	6	9	12	15
	Moderate	2	4	6	8	10
	Low	1	2	3	4	5
Risk Matrix		Remote	Unlikely	Possible	Likely	Almost Certain
		Likelihood				

Risk Score	Definition
High Risk	Unacceptable Risk: Controls required to be incorporated into design
Moderate Risk	Controls to be considered during design
Special Case	Additional consideration may be required - case by case
Low Risk	Controls not likely required to reduce risks - continuous monitoring expected
Negligible Risk	Risk events do not require further consideration

Figure 20.6-2: Risk Evaluation Matrix

20.6.5 Adaptation Measures

The purpose of the Climate Change Impact Assessment was to identify potential climate change related impacts and risks related to the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases of the Project. A final adaptation workshop was held with the Dillon internal team and the main Project contact at NWP to review moderate and high risks and discuss current risk mitigation measures, and potential additional risk mitigation/ adaptation measures to be considered. The workshop included consideration of special case risks as well, and included of the development of policy-based and physical-based adaptation measures for recommendation.

Policy-based measures include updates and recommendations related to Standard Operating Procedures (SOP) as well as operations, maintenance, and management plans. Physical-based measures typically included alterations or design changes to the physical components of assets or sites. The measures and strategies intended to minimize the potential environmental effects of the environment on the Project as it relates to climate change are detailed in Sections 20.6.5.1 to 20.6.5.7. The measures are presented in detail in Appendix C of the Climate Change Impact Assessment (see Appendix 20-A), but are summarized below by climate parameter.

20.6.5.1 Heavy Precipitation

Heavy precipitation events can impact access roads by way of localized flooding and or washouts. It is assumed that access and haul roads are to be constructed with proper drainage and storm water management systems in consideration of precipitation trends for the region. Proper notification protocols are also expected to be in place to trigger prompt road work following a washout event.

20.6.5.2 Snow Events – Extreme and Regular

The main interactions and risks associated with snow events were related to buildings on-site, particularly the sprung and modular structures. Snow accumulated on roof systems can impact the structural integrity of buildings. Extreme snow events are characterized by at least 60 cm of snow in a day, while regular snow events are characterized by 10 cm to 30 cm of snow in a day. The recommended adaptation measures are to obtain area-specific roof loading requirements from ECCC and build structure to those recommendations. Additionally, buildings shall include snow-shedding capabilities to help periodically remove snow to avoid excessive build-up of ice and snow.

20.6.5.3 Drought Conditions

During drought conditions when it is hot and dry, the overland conveyors may be impacted by higher risks of fire, which can result in large infrastructure and environmental damage. It is expected that fire prevention, detection, and suppression systems would be in place to manage this risk, but a review of current recommended best practices would help inform future decision-making in this regard. For site reclamation and closure, a wide variety of plant species will be established in the revegetation during Reclamation and Closure to provide enhanced resilience to disturbance and climate change induced stress (e.g., herbivory, disease, insects).

A risk interaction related to the sediment ponds requires further assessment to determine if projected drought conditions may impact pond water levels, which may result in concentration of mine-affected water. Environmental compliance monitoring will take place continuously throughout the Project, and mitigation and adaptive management measures will be implemented as necessary.

20.6.5.4 Wind Events – Extreme and Regular

A total of seven risk interactions were identified for wind events – both for extreme and regular events.

Extreme wind events with speeds of greater than 125 km/h are anticipated to impact modular buildings, power lines, and heavy machinery and equipment. The adaptation measures recommended as part of the Project include additional anchoring of equipment where required, and appropriate reviews of Operations and Maintenance plans and SOPs to include frequent conditions assessments of infrastructure components.

Regular wind events are expected to transport dust to surrounding areas and nearby streams. This can lead to environmental compliance concerns, which can impact operations if these impacts are not mitigated; however, it is assumed that the dust control measures outlined in the Air Quality and Greenhouse Gas Management Plan (Chapter 33, Section 33.4.1.1) for the Project will sufficiently mitigate these specific risks.

20.6.5.5 Avalanche Threat

Avalanches can impact access roads and above-ground power lines. The risk analysis of the avalanche threat completed by Dynamic Avalanche Consulting recommended several mitigation measures for further evaluation, including avalanche forecasting systems, worker safety programs, a helicopter control program, Remote Avalanche Control Systems (RACS), and snow defence structures. These procedures and policies will be further evaluated and incorporated into an appropriate Avalanche Safety Plan, which will be implemented throughout the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases of the Project. It is anticipated that the Avalanche Safety Plan will sufficiently mitigate the specific risks related to avalanches.

20.6.5.6 Forest Fire Risk

The forest fire risk interactions identified were considered acute conditions (special cases) with high severity scores and low probability of occurrence. These events are not likely to occur, but if they do, the consequences can be severe or catastrophic. The assets of concern for the Project include the explosives facility, the coal stockpile at the rail loadout, the main overland conveyor, the above-ground power lines, and the rail loop. Sufficient buffer zones will be established around all Project assets from the tree line to help mitigate this risk; however, it is recommended to consider the use of fire retardant equipment and materials for construction, and that there is a nearby water supply and firefighting equipment in case of a fire.

20.6.5.7 Lightning

Lightning is anticipated to have possible impacts on the explosives facility, the coal stockpiles at the rail loadout, heavy machinery and equipment, and the overland conveyors. The adaptation measures recommended encompassed grounding sites and facilities, and establishing systems that would reliably predict and warn Project personnel about incoming thunderstorm events. Revisions of the SOP for operations during thunderstorm events are also recommended to have the appropriate and effective protocols in order to manage the risks of catastrophic impacts.

20.6.6 Characterization of Residual Effects of Climate Change on the Project

As described in the above sections the potential effects of climate change on the Project range widely, including hazards related directly to climate conditions (e.g., heavy precipitation and drought conditions), as well as increased occurrence of geophysical events (e.g., avalanches) and forest fires. The potential effects of climate change will be considered during Project planning and decision making wherever possible, throughout all phases of the Project.

The adaptation measures described above will be implemented to address the potential effects of climate change on the Project. Adaptation measures (in addition to the management plans and policies implemented for the Project) will be revised or improved upon continually throughout the life of the Project, following an adaptive management approach. An adaptive management approach will allow for flexibility to address the uncertainty of the magnitude and timing of the potential effects of climate change on the Project.

20.7 Summary and Conclusions

Extreme weather, geophysical events, forest fires, and climate change all have the potential to affect the Project and associated infrastructure. This, in turn, could result in impacts to aquatic and terrestrial habitat through sedimentation, spill of hydrocarbons, the discharge of debris, loss of habitat, or wildlife mortality. The implementation of appropriate and site-specific mitigation or adaptation measures, including appropriate design, monitoring, maintenance of facilities, and response to incidents, can significantly reduce the potential for the environment to impact the site and the associated impact to habitat. With effective design and construction, mitigation, adaptive measures, and good housekeeping and management practices, the residual effects of the environment on the Project (including the residual effects of extreme weather, geophysical hazards, forest fires, and climate change) are rated not significant, with a high level of confidence.

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