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Abbreviations

AEP	Alberta Environment and Parks
CEA Agency	Canadian Environment Assessment Agency
EDGM	Earthquake Design Ground Motion
LAA	local assessment area
PDA	project development area
RAA	regional assessment area
VC	valued component

2.0 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The Alberta Environment and Parks (AEP) Terms of Reference for the Project (Section 3.1.2 [B]) requires that the environmental impact assessment identifies stages or elements of the Project that are sensitive to changes or variability in climate parameters, including frequency and severity of extreme weather events and discusses the potential impacts over the life of the Project. The Canadian Environment Assessment Agency (CEA Agency) Guidelines for the Project, Section 6.6.2, requires an analysis of how local conditions and natural hazards, such as severe and/or extreme weather conditions and external events could adversely affect the Project and how this in turn could result in effects on the environment.

Effects of the environment on the Project are risks associated with local conditions and natural hazards that influence the Project. Mitigation tools to prevent or reduce the severity of adverse effects of the environmental on the Project include engineering design, construction methods planning and implementation, and operations preparation so that the Project can withstand normal and extreme environmental conditions.

2.1 METHODS FOR ASSESSMENT OF POTENTIAL EFFECTS

Assessment for each environmental condition follows these steps:

- the environmental conditions for consideration are identified
- the environmental conditions for consideration are assessed
  - the environmental conditions for consideration, including potential effects on the Project are identified
  - project design measures for managing or mitigating risk for each of the environmental conditions are described
  - potential residual effects that may result from effects of the environment on the Project should design measures not be fully effective are described
  - potential residual effects are characterized, including a description of likelihood and severity.

The spatial and temporal boundaries and significance determinations for the assessment of the effects of the environment on the Project are the same those stated in each valued component (VC) section (Volume 3a and 3b).

2.2 PHYSICAL ENVIRONMENTAL CONDITIONS CONSIDERED

The Project could be subject to the following environmental conditions:

- extreme and normal weather conditions
  - precipitation and flooding
  - tornadoes
  - drought
  - ice jams
  - climate change
- external events
  - wildfires
  - seismic events

In addition to the environmental conditions listed above, local environmental conditions including slope instability, erosion, and subsidence could affect the Project. These have been considered and mitigated by the design of the Project, and therefore not assessed further in this section.

2.3 ASSESSMENT OF EFFECTS OF THE ENVIRONMENT ON THE PROJECT

2.3.1 Description of Environmental Conditions

2.3.1.1 Extreme and Normal Weather Conditions

Precipitation and Flooding

The average annual rainfall measured at Springbank Airport from 1981-2010 is 469.6 mm, with 67.7 days a year observing 2 mm of rain or more (Government of Canada 2016). Historic records indicate June has the highest amount of rainfall precipitation with a monthly average of 106.7 mm (Government of Canada 2016).

The flood of June 2013 was a result of extraordinary rainfall (200 mm to 350 mm) over three days and a simultaneous rapid melt of snowpack in the Rocky Mountains (Pomeroy et al. 2015). These two events led to flooding of tributaries to the Bow River, including the Elbow River. Floods of a similar magnitude have occurred in the past, but they are not frequent: floods in the Bow River have occurred in 1879, 1884, 1897, 1902, 1909, 1923, 1929, and 1932. Floods in 1929 and 1932 were caused by rainstorms of similar magnitude to those that contributed to the 2013 flood (Pomeroy et al. 2015).

Precipitation, flooding, snow cover, and freezing conditions may affect personnel, equipment, and schedule during Project construction resulting in delays if working conditions are unsafe. The operation of the Project in the flood phase would occur when flow in the Elbow River exceeds 160 m^3/s. Debris carried by floodwaters may affect the Project during operations because debris could accumulate at the diversion structure, in the diversion channel, reservoir, or low-level outlet channel, restricting the flow of water.

Frequent precipitation events may reduce fugitive dust emissions during Project construction and post-flood operations.

Tornadoes

An average of 43 tornadoes per year occur across the Prairies; tornadoes ranging from F0-F2[1] have occurred in southern Alberta between 1980-2009 (Environment Canada 2017). Tornadoes are more likely to occur in the summer with peak tornado season occurring from June to August.

Tornadoes produce extremely high winds that could affect personnel, equipment, and schedule during Project construction. Tornadoes could also affect the Project during operations, resulting in damage to infrastructure, interruption to service, emergency shutdowns, and dam failure or breach.

Drought

Southern Alberta has experienced moderate to extreme drought conditions over the period 2002-2017 (Agriculture and Agri-Food Canada 2017) and drought conditions are likely to occur in the Project area in the future. However, drought is not anticipated to affect Project construction, dry operations, flood-operations, or post-flood operations except where drought results in higher likelihood of wildfires (see Section 2.3.1.2) occurring near the Project. Therefore, drought as an environmental condition that could affect the Project is not further assessed.

Ice Jams

Ice jams are the accumulation of ice that restrict and obstruct the flow of water in a waterbody and may result in flooding. Ice jams are common on rivers during freeze-up and breakup periods (Environment Canada 2013). However, the likelihood of ice jams occurring on the Elbow River is extremely low due to minimal winter water flow. Data derived from ice surveys at the location of the diversion structure indicates that ice is not likely to form a jam (see Volume 3a and Volume 3B, Section 6). Therefore, ice jams as an environmental condition that could affect the Project are not further assessed.

[1] The Fujita Scale (F scale) rates tornado intensity based on the damage they inflict. F0 = light damage, F1 = moderate damage, F2 = Significant damage.

Climate Change

Climate change is anticipated to influence weather events including temperature averages, precipitation, seasonality, seasonal flooding, and long-term drought in Western Canada (Sauchyn and Kulshreshtha 2008; NRCAN 2015). Climate change is also anticipated to increase the frequency, duration, and magnitude of extreme weather events, including extreme precipitation events (IPCC WGI 2007). Climate projections models for Canada suggest that precipitation rates for 1:20 year extremes will rise by 50 mm/day by the 2050s, by more than 70 mm/day by the end of the century and that heavy precipitation events may double in frequency. For instance, when averaged over all of Canada, today's 1:40-year extremes could become 1:10 year events by the 2090s (Kharin and Zwiers 2000).

Due to the short duration of construction, effects of long-term climate change on Project construction are not likely. Extreme weather events in the future may affect maintenance during dry operations and cleanup during post-flood operations. Climate change may affect the frequency of flood operations and volume of floodwaters diverted by the Project because of the predicted increase in precipitation rates and risk of seasonal flooding.

2.3.1.2 External Conditions

Wildfires

The Project is in an area primarily composed of agricultural lands and native grassland with some conifers and broadleaf stands. Fires that may affect the Project could result from uncontrolled grassfires or fires on agricultural lands, project component or equipment malfunctions, or anthropogenic events (see Volume 3D, Section 1). On average, 1,547 wildfires occur across Alberta each year, of which 64% are caused by anthropogenic activities and 36% are caused by lightning (Government of Alberta 2017).

Fires could affect all phases of the Project. Fires could affect personnel, equipment, and schedule during Project construction, maintenance during dry operations, and cleanup during post-flooding operations. Fires could also damage Project components during operations, resulting in interruption to service and emergency shutdowns.

Seismic Events

The Project is in an area of low to moderate seismic activity (Earthquakes Canada 2015). Induced seismic events are common in the foothills region of Alberta (Schultz et al. 2014, 2015a, 2015b; Wetmiller 1986) Induced seismicity could increase seismic hazard at the PDA.

Seismic events could affect all phases of the Project. Seismic events could affect personnel, equipment, and schedule during Project construction, maintenance during dry operations, and cleanup during post-flooding operations. Seismic events during operations could also affect the functionality of the Project if the events were substantial enough to affect the structural engineering of Project components.

2.3.2 Project Design Measures to Reduce Risk

2.3.2.1 Extreme and Normal Weather Conditions

Precipitation and Flooding

In the event of adverse weather during construction, dry operations, and post-flood operations, contractors would implement contingency and emergency response measures and stop work if conditions are unsafe. Site-specific drainage control measures and erosion and sediment control measures would be employed during construction to mitigate effects of precipitation and flooding within the PDA. Site-specific drainage control measures during operations include surface drainage flumes on the dam face that discharge into drainage ditches at the inner and outer bases of the dam. The drainage ditches slope toward the low-level outlet. The dam structure incorporates an internal drainage system to control seepage when the dam is in use and provisions for monitoring pore water pressure within the dam.

The purpose of the Project is to mitigate extreme precipitation and flooding events. The Project is designed for 77,800 dam^3 of water retention in the off-stream reservoir. The Project would commence flood operations (i.e., divert water from the Elbow River to the off-stream reservoir) when flow in the Elbow River exceeds the capacity of the Glenmore Reservoir outlet (160 m^3/s). Flood diversion would continue until the off-stream reservoir is full or the flow in the Elbow River falls below 160 m^3/s.

The Project is designed to improve the transport capacity of bed-material sediment and large woody debris through the service spillway and diversion inlet to prevent buildup of debris and flooding of areas upstream of the Project. An emergency spillway is included in the design in case the diversion channel becomes obstructed with debris. A debris management program would also be implemented during all phases of Project operation. This program would include measures such as debris removal in the Elbow River at the diversion structure, upstream of the diversion structure, and within the off-stream reservoir.

With the implementation of mitigation measures, residual effects of precipitation and flooding on the Project are not anticipated and are not assessed further.

Tornadoes

In the event of a tornado, contractors would implement contingency and emergency response measures and stop work if conditions are unsafe. Damage to infrastructure caused by tornadoes would be repaired.

Climate Change

The environmental impact assessment, hydrologic engineering analysis, planning, design and operation of hydraulic structures accounts for possible future effects of climatic variability and change. The Project is designed to mitigate effects of climate change on flood operations, including extreme precipitation events and increased risk of seasonal flooding. The emergency spillway is designed to operate if the capacity of the off-stream reservoir is exhausted and the diversion inlet structure is still open. After the diversion inlet structure is closed, flood waters would continue downstream.

2.3.2.2 External Conditions

Wildfires

Contractors would develop fire protection procedure to address fire prevention and emergency response on site during construction, dry operations maintenance activities, and post-flood operations cleanup activities. Onsite personnel would be trained in fire prevention, including proper disposal of hot or burning material and designated smoking areas, and response.

Equipment and project components would be maintained to applicable standards in order to reduce the likelihood of malfunction resulting in fire and explosion. Flammable material would be stored following Alberta Labour guidance.

Access roads constructed to the PDA and in the PDA (e.g., along the top of the dam) would be permanent for the life of the Project and allow for access to the PDA by firefighters during all phases of the Project.

Damage to Project infrastructure caused by wildfires during dry operations and post-flood operations would be repaired.

Seismic Events

The Project is classified as an extreme consequence dam with the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2007). For an extreme consequence dam, these guidelines stipulate that the dam and associated structures must be designed to resist an earthquake design ground motion (EDGM) with a mean estimate of hazard. A risk assessment was

completed for the Project to determine the EDGM with a mean estimate of hazard based on the history of seismic events in the area. the Project is designed to withstand the EDGM determined for the Project based on the history of seismicity in the area.

Natural and induced seismic events could increase the seismic hazard at the site. Measures to mitigate the risks of seismic events would be implemented for the Project, including:

- establish an exclusion zone around the Project for commercial operations that may result in induced seismic events. Exclusion zones would be determined in consultation with appropriate regulators
- implement a real-time monitoring system to monitor seismic activity within 25 km of the Project
- develop and implement a response plan if earthquake frequencies exceed those incorporated into the design of the Project.

In the event of a seismic event during Project construction, dry operations, and post-flood operations, contractors would implement contingency and emergency response measures and stop work if conditions are unsafe.

Damage to Project infrastructure caused by seismic events during dry operations and post-flood operations would be repaired.

2.3.3 Potential Residual Effects

With the implementation of Project design and mitigation measures, potential residual effects of the environment on the Project are limited to the following environmental conditions:

- climate change
- tornadoes
- wildfires
- seismic events

Climate change could result in potential residual effects on the Project if the magnitude of flooding events exceeds the magnitude of the design flood. In this situation, the Project would divert floodwaters until the off-stream reservoir is full (77,800 dam^3). Residual floodwaters would flow out the emergency spillway or continue downstream of the Project if the diversion inlet is disengaged.

Damage to infrastructure caused by wildfires, seismic events, or tornadoes during flood operations could result in dam failure or breach.

2.3.4 Characterization of Potential Residual Effects

Climate change is likely to increase the frequency, duration, and magnitude of extreme weather events, including extreme precipitation and flooding. If the magnitude of flooding events exceeds the magnitude of the design flood, potential residual effects on the Project because of climate change would extend into the regional assessment area (RAA). The magnitude of these residual effects would be attenuated because the Project would divert 77,800 dam^3 of floodwaters. Therefore, the significance of these potential residual effects is rated not significant.

The likelihood of tornadoes, wildfires or seismic events damaging Project infrastructure at the same time as a flood event is low. If damage to Project infrastructure does occur at the same time as a flood event, the potential residual effects of a dam failure or breach would extend into the RAA and could be significant, depending on the magnitude of the flood.

2.4 CONCLUSIONS

Eight environmental conditions that could affect the Project were assessed: precipitation and flooding, climate change, slope instability, erosion, subsidence, wildfires, seismic events, and tornadoes. These environmental conditions could affect personnel, equipment, and schedule during Project construction and functionality of the dam during operations. Design measures are incorporated into the Project to mitigate risks of environmental conditions affecting the Project. Contingency plans and emergency response measures would be implemented in the event of adverse and extreme weather or seismic events. With project design and the implementation of response measures, potential residual effects of the environment on the Project are limited to climate change and damage to infrastructure because of wildfires, seismic events, and tornadoes. Potential residual effects would extend into the RAA and are rated not significant, except for dam failure or breach, which would be significant in the unlikely event of damage to Project infrastructure during a high magnitude flooding event.

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