APPENDIX IR14-4 HAZARD CLASSIFICATION OF THE SPRINGBANK OFF STREAM RESERVOIR PROJECT

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Memo

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Reference: Hazard Classification – Off-stream Storage Dam
Springbank Off-Stream Reservoir Project (SR1)

The purpose of this memorandum is to present Stantec's Dam Safety Hazard Classification recommendation for the Off-stream Storage Dam. The Hazard Classification is required for selection of the appropriate design standards established in the Alberta Environment and Parks *Dam and Canal Safety Guidelines* (1999) and the Canadian Dam Association (CDA) *Dam Safety Guidelines* (2007).

The Hazard Classification is selected based on the consequences associated with a hypothetical failure of the dam. To identify the dam failure consequences, a dam breach simulation is conducted, the resultant flood wave is routed downstream using hydraulic model software, and the calculated inundation area is overlain with aerial photography and mapping. The consequences are then estimated in terms of potential lives lost, and economic and environmental damages.

A preliminary breach analysis has been performed utilizing the information developed as part of the Conceptual Design Update (Stantec, 2015). The final breach analysis will be performed following substantial completion of the Preliminary Design.

DAM BREACH HYRDROGRAPH

For the purpose of this preliminary breach analysis, only one breach scenario was considered. This scenario, the Post Flood Event failure, represents a dam breach occurring with the reservoir full, but the Elbow River restored to its pre-flood levels. This scenario may be considered the equivalent of a Sunny Day failure. Using the dimensions of the Springbank Off-stream Storage Dam and Reservoir from the conceptual design, a breach hydrograph was developed for this scenario using the HEC-HMS v4.0, releasing approximately 79,500 dam^3 over approximately 2 hours and 40 minutes with a peak flow of 20,600 m^3/s. Breach parameters used in HEC-HMS such as width and development time were based on the average result of several empirical equations developed by Froehlich (1987, 1995), USBR (1988), and Von Thun and Gillette (1990).

DAM BREACH ROUTING MODEL

A breach routing model was developed using HEC-RAS v4.1.0. The City of Calgary Working Model (Golder, 2014) was used for the geometry downstream of Glenmore Dam with modifications made by Stantec for use in unsteady simulations. Stantec extended the model from Glenmore Dam upstream to Highway 22 using 1 m and 15 m LiDAR, aerial photography, and bridge/culvert

drawings. The dam breach routing model currently does not incorporate settings for potential cascade failures of Glenmore Dam. The routing model terminates at the Bow River.

PRELIMINARY RESULTS

BREACH HYDROGRAPH ROUTING

The leading edge of the breach wave reaches Glenmore Dam approximately 3 hours after the start of the breach. The breach hydrograph has attenuated upon reaching Glenmore Reservoir with a peak flow of approximately 9,100 m^3/s. Glenmore Reservoir achieves a peak water surface elevation of approximately 1082.0 m at the dam up to approximately 1082.4 m at the upstream end. Based on these preliminary results, the Glenmore Reservoir Southeast Dyke overtops by approximately 1 m with a total overtopping time of more than 2 hours. The non-overflow section of Glenmore Dam will overtop by approximately 2 meters, with flow through the arches supporting the decking along the dam crest. The breach hydrograph immediately downstream of Glenmore Dam has a maximum flow of 4,300 m^3/s. The leading edge of the breach wave reaches the confluence with the Bow River approximately 4 hours after the start of the breach. By the Bow River confluence, the breach hydrograph has attenuated further and the peak flow is approximately 3,800 m^3/s. Stability of Glenmore Reservoir Dam was not considered in this preliminary study.

The overtopping of the Southeast Dyke of Glenmore Reservoir results in a peak flow of approximately 2,200 m^3/s. A probable result of this overtopping would be a failure of the earthen dyke requiring an alternate breach routing model which is outside the scope of this preliminary breach analysis. Even without considering a failure of the dyke, the portion of the breach wave overtopping the dyke would likely impact numerous residential and commercial areas before it reaches the Bow River.

The overtopping of Glenmore Dam would likely result in greater impacts downstream if a cascade failure of the dam were simulated.

BREACH INUNDATION MAPPING

Upstream of Glenmore Reservoir, the Elbow River has a well-defined floodplain which has an average width of approximately 1,000 meters. During the simulated breach scenario, this floodplain will experience a maximum inundation depth of approximately 5 meters with velocities of 1 to 4 m/s presenting a potentially life-threatening situation to permanent populations in this area. The majority of the floodplain upstream of Glenmore Reservoir is undeveloped. However, there are two golf courses and multiple single family residential developments which would be inundated by the breach wave as shown on **Figure 1**. More than 600 residential properties are estimated to be inundated in this area.

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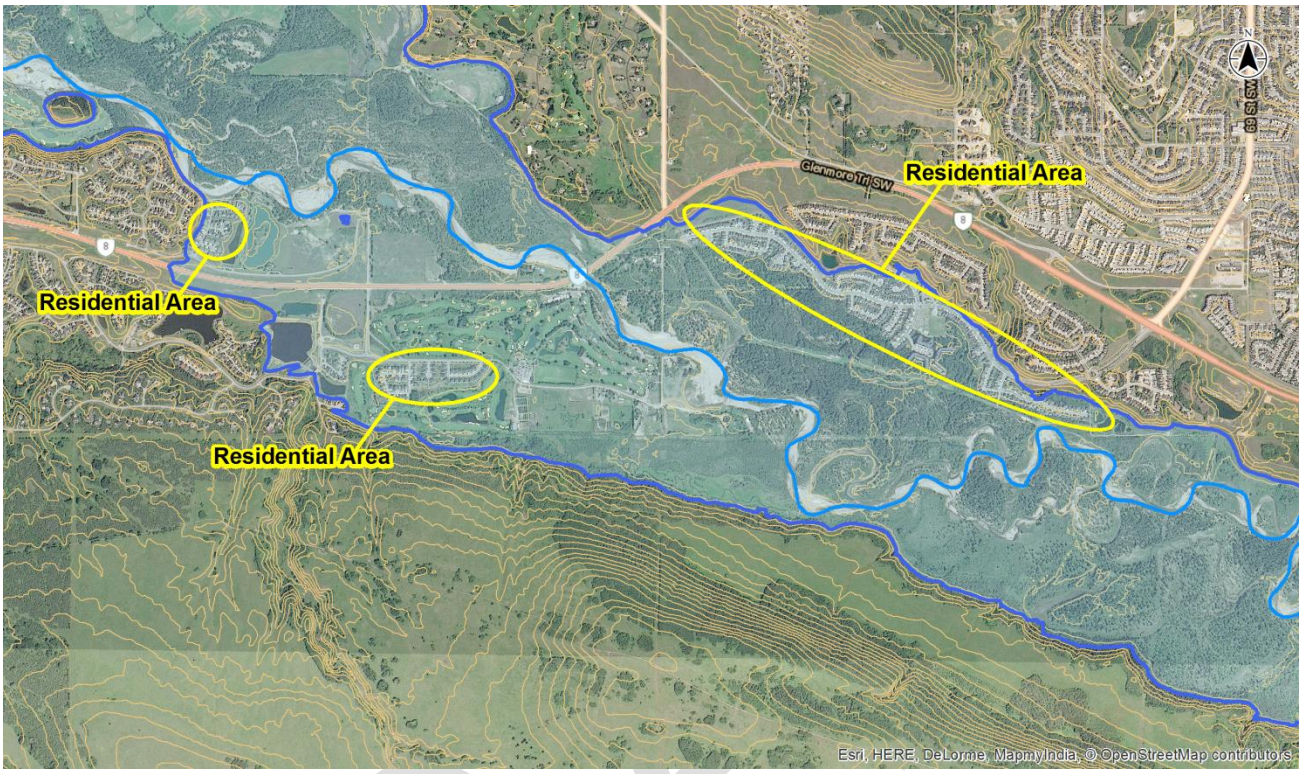

Figure 1. Breach Inundation: Upstream of Glenmore

For the reach downstream of Glenmore Dam and upstream of Mission Road, the Elbow River still has a well-defined floodplain which has a width of 300-600 meters. During the simulated breach scenario, this floodplain will experience a maximum inundation depth of approximately 5 meters with velocities of 1 to 2 m/s presenting a potentially life-threatening situation to permanent populations in this area. The floodplain between Glenmore Dam and Mission Road contains significant single family residential development which would be inundated by the breach wave as shown on **Figure 2**. More than 1100 residential properties are estimated to be inundated in this area.

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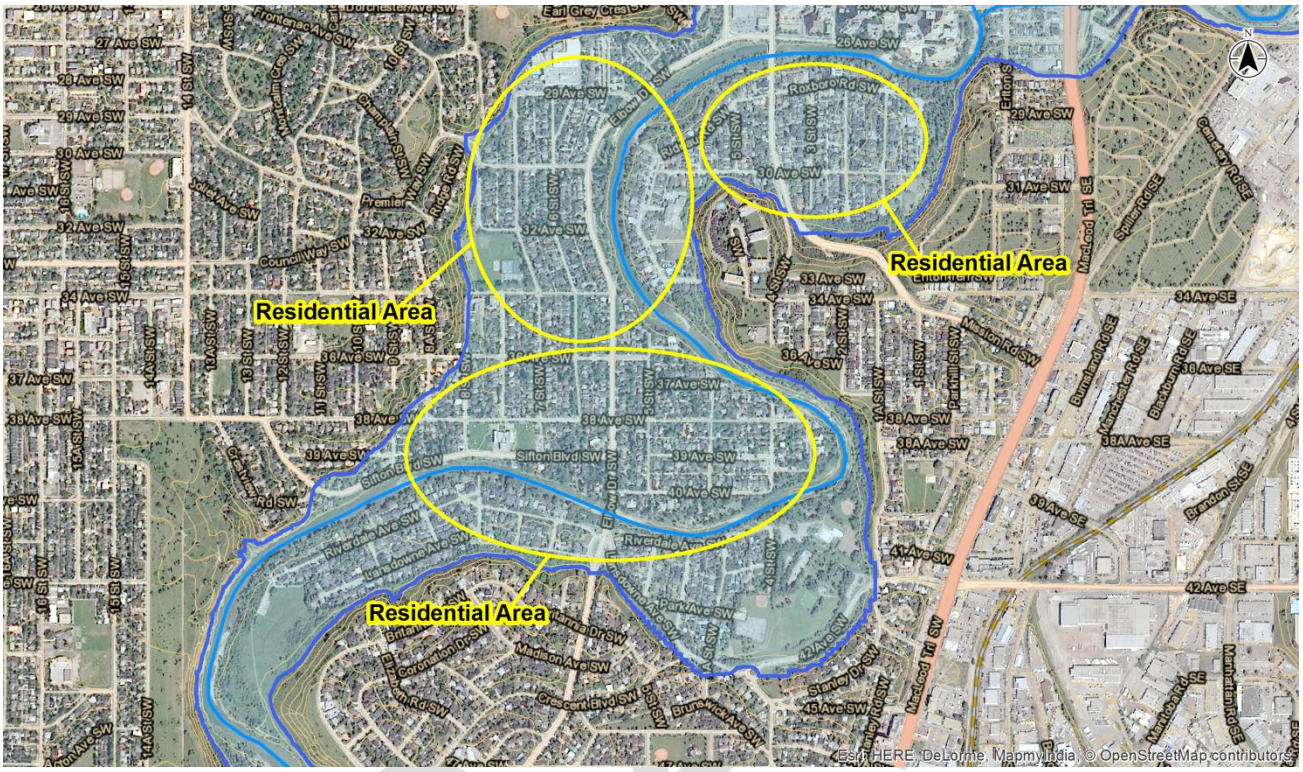

Figure 2. Breach Inundation: Glenmore Dam to Mission Road

Downstream of Mission Road, the Elbow River has a well-defined right floodplain; however the left floodplain is not confined by topographic features due to the confluence with the Bow River. During the simulated breach scenario, this floodplain will experience a maximum inundation depth of approximately 5 meters with velocities of 1-2 m/s presenting a potentially life-threatening situation to permanent populations in this area. The floodplain is fully developed with mixtures of single and multi-family residential, commercial, and industrial which would be inundated by the breach wave as shown on **Figure 3**. At least 200 residential properties are estimated to be inundated in this area along with numerous commercial and industrial properties.

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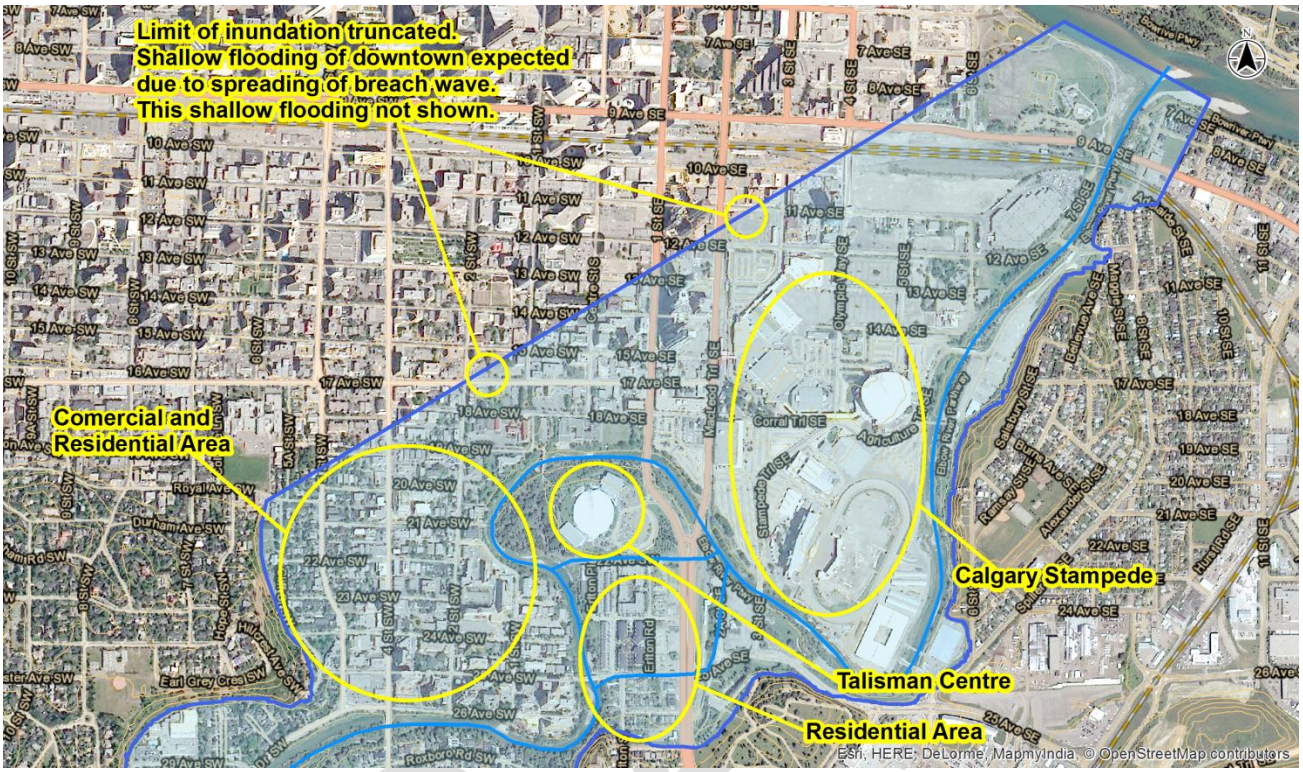

Figure 3. Breach Inundation: Mission Road to Bow River

DAM CLASSIFICATION

According to Alberta Environment and Parks *Dam and Canal Safety Guidelines* (1999), using the traditional standards based approach; a dam should be assigned a classification of "very high" if there would be a large number of fatalities or extreme damages as shown in **Figure 4**. The Post Flood scenario simulated in this preliminary breach analysis would impact thousands of residential and commercial properties by deep and fast moving waters. Cascade failures, if simulated, may result in even greater potential for damage and loss of life. The size of the population at risk and preliminary dam breach analysis indicates that a large number of fatalities probable in the event of a failure of the Springbank Off-stream Storage Dam. A dam class of "very high" is justified according to the table in Figure 4.

TABLE 1
CLASSIFICATION OF DAMS IN TERMS OF CONSEQUENCES OF FAILURE

CONSEQUENCE CATEGORY	POTENTIAL INCREMENTAL CONSEQUENCES OF FAILURE [a]	
	LIFE SAFETY[b]	SOCIO-ECONOMIC FINANCIAL ENVIRONMENTAL[b] [c]
VERY HIGH	Large number of fatalities	Extreme damages
HIGH	Some fatalities	Large damages
LOW	No fatalities anticipated	Moderate damages
VERY LOW	No fatalities	Minor damages beyond owner's property

Figure 4. Table Excerpt from AE Dam and Canal Safety Guidelines, 1999

The CDA guidelines provide an alternative dam classification standard. According to CDA, the dam would receive a consequence category "Extreme" if there is a permanent population at risk, with an incremental loss of life of more than 100 due to failure as shown in **Figure 5**.

Table 2-1: Dam Classification

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

Figure 5. Table Excerpt from CDA Dam Safety Guidelines, 2007

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RECOMMENDATION

Stantec recommends that the Springbank Off-stream Storage Dam be designed in accordance with a hazard classification of "very high" per the Alberta Environment and Parks *Dam and Canal Safety Guidelines* (1999) and "extreme" per the Canadian Dam Association *Dam Safety Guidelines* (2007).

REFERENCES

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