Review of Safety, Hazards and Risks Associated with the Commissioning and Operation of the SR1 Off-stream Embankment Dam

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1. INTRODUCTION

The majority of residents in the community of Springbank, work, shop, and recreate in Calgary. We consider ourselves as Albertans, part of Rocky View County, and part of the broader Calgary community. We ***are not*** adversarial to the City of Calgary seeking protection from flooding. We desire the same outcome and believe that we all have an obligation to protecting life, livelihoods, infrastructure, and the environment both in the City of Calgary and in our community. We do, however, *have* legitimate concerns about safety and other adverse outcomes resulting from operational limitations imposed by the terrain and the placement of this dam at this location.

In the process of expressing our concerns, our community and individuals within our community have been exposed to numerous negative, unnecessary and unconstructive comments on social and other media. It is our desire to have our concerns heard, listened to, and to have our issues addressed in a constructive, meaningful, open, and impartial manner.

We are pleased that the Government of Alberta has engaged an Expert Panel to advise them on technical matters related to project management, geotechnical, hydro-technical, structural, contracting, and construction. Notwithstanding this advice, in the event of a flood equivalent to the 2013 flood, flooding will continue to occur in the section of the Elbow River below the SR1 Off-stream Embankment Reservoir and above the Glenmore Reservoir. It is noted that the project does not include any additional provisions to protect many residents and properties located at lower elevations along this section of the river. Additional discussion is provided in Section 2.

In addition to the considerations of the Expert Panel, an assurance of safety must also include and address the integration of dam operational parameters into a comprehensive Emergency Management System (EMS). In my opinion, the utilization of an off-stream dam is somewhat novel and the operations are complex. It is clear that the operations of this type of facility can have a significant impact on the hazards and risks associated with the project. In order to fully understand the safety associated with the operations of this dam, the operational plan should be fully integrated into the EMS and tested prior to commissioning. For example a fully integrated system should address the functioning of Supervisory Control and Data Acquisition (SCADA) systems, the response times of operators and communication with other agencies and external emergency response teams, etc. These materials do not form part of this application.

I recommend that these materials: the Operational Plan; the EMS (including the Emergency Preparedness Plan (EPP) and the Emergency Response Plan (ERP)) be reviewed and approved prior to the start of this project. I also recommend that the review process be transparent to the public and should allow the opportunity for public comment. A further discussion of the integration of the operational plan and EMS is provide in Section 3 of this report.

The focus of the materials provided in this report relate to the design limitations (flow rates and volumes) of this project at this location and operational considerations as they apply to the safety of people and infrastructure both in Springbank and in the City of Calgary who are situated at lower elevations along the Elbow River, below the SR1 Off-stream Reservoir and above the Glenmore Reservoir.

2. IMPLICATIONS TO RESIDENTS AND PROPERTIES LOCATED BETWEEN THE SR1 AND GLENMORE RESERVOIRS

2.1. DESIGN CRITERIA

Historically, while it understood that dams provide significant benefits, dams can also have adverse effects on ecosystems, hydrology and water quality. Dams can negatively impact the relationships between communities and political jurisdictions in both upstream and downstream directions (Brown, 2008). The placement of a large dams upstream of populated area represents a significant safety hazard that may present unacceptable risks to individuals and to society as a whole.

STANTEC materials (Stantec, 2018) indicate that flooding begins when flow rates in the Elbow River exceed excess of 160 m^3/s. Design Criteria outlined in the applicant's materials state that SR1 Reservoir will work in tandem with the Glenmore Reservoir to limit flood rates downstream of the Glenmore Reservoir (for floods equivalent to the 2013 flood) to rates less than 160 m^3/s. The report further specifies, as a positive design features, that:

- SR1 can divert up to 600 m^3/s of flow from the Elbow River into active flood storage;
- Active storage capacity is 77,771,000 m^3;
- Excess flows and storage above the design capacity will pass the diversion structure and be stored within Glenmore Reservoir;
- Glenmore Reservoir has been upgraded to handle additional active storage of 10,000,000 m^3.

Our primary safety concern (not considered as a positive design feature) relates to the Item 3; i.e., ***"Excess flows and storage above the design capacity will pass the diversion structure"***. For floods of similar in magnitude to the 2013 flood, these 'excess flows' ***will result*** *in flooding* in the section of the Elbow River below the SR1 Off-stream Reservoir and above the Glenmore Reservoir. It is noted that for a flood equivalent to the 2013 flood and with the SR1 Embankment Dam in operation, the predicted peak flow in this section of the river would exceed flood levels experienced during the 2005 and water levels would be approximately equivalent to levels achieved following a 1:50 year flood. Obviously this information is understood by the applicant, and while contained in the technical materials, this information has not been clearly communicated to the public and others in a meaningful way.

To assist the Springbank Community Land owners Group (SCLG) better understand the relationship between flows in the Elbow River, the volumes diverted into the SR1 Reservoir during flood events, and the ability of the SR1 Off-stream Project to mitigate downstream flooding, I have generated a basic EXCEL spreadsheet model (SCLG Model). This model allows users to model flow rates in the Elbow for a number of the flood hydrographs presented in the STANTEC materials, and to consider the effects of SR1 operations (diversion rates and volumes captured) on resulting flows below the SR1 Off-stream facility.

The SCLG model applies flow limits and storage parameters outlined by STANTEC (Stantec, 2018) and produces graphical outputs showing:

- The flow rates in the Elbow River upstream of the SR1 Reservoir during a flood event;
- The ability of the SR1 diversion structure to divert flows and store volumes into the SR1 Reservoir;
- The flow rates in the Elbow River between the SR1 Reservoir and the Glenmore Reservoir, and
- The flow rates in the Elbow River below the Glenmore Reservoir.

Figure 1 and Figure 2 provide a comparison between the STANTEC model (Stantec, 2018) and the SCLG model. The differences in the outputs are due to differences in the hydrograph data selected[1] and because hydrographic data applied in the SCLG model have been interpolated from graphical plots (Stantec Consulting Ltd., 2015) on 4-hour intervals[2]. As a result, there is a reduction in resolution and the hydrographs applied by SCLG are slightly lower as are the estimated volumes diverted into the reservoir.

The dark grey area on the Stantec plot represents a selected flood hydrograph in the Elbow River applied by Stantec. This area corresponds to solid blue line on the SCLG plot. It is noted that the 'Design Flood Diversion Hydrograph' shown by Stantec has a peak flow of 1,140 m^3/s. As we did not find a comparable hydrograph in their materials, we have applied Figure 8 from the Stantec PMF analysis and adjusted the flows to match the 1,140 m^3/s shown in their chart. The actual peak flow for the 2013 flood is 1,240 m^3/s.

The solid blue line on the Stantec plot rate represents the rate at which water is diverted from the river into the SR1 Reservoir. This line corresponds with light blue dotted line on the SCLG plot. In addition, the SCLG applies the diversion rate to calculate and plot the cumulative volume stored during the flood event (the orange line).

The light grey area shown on the Stantec plot represents the remaining hydrograph in the Elbow River as water diversion occurs. This light grey area corresponds with broken pink line on the SCLG plot. Both resulting river hydrographs clearly show that the peak flow of 640 m3/s bypass the SR1 Reservoir. It is the consequences relating to this peak that is of high concern for our community.

In our opinion, the results of the SCLG Model are acceptable for understanding the behaviour of this off-stream project and provide a means of considering the consequences. Estimates of the consequences have been determined using hydrographic information and open water flood inundations maps prepared for Alberta Environment and Parks by Golder Associates Inc. A discussion of consequences assessment is provided in Section 2.5 starting on page 10.

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[1] *We were unable to match the hydrograph illustrated to a specific figure in the Stantec Probable Maximum Flood Analysis report.*

[2] *There was insufficient time to readjust hydrographic information to match STANTEC calculated volumes.*

Figure 1 Copy of Figure A-3 from STANTEC Report

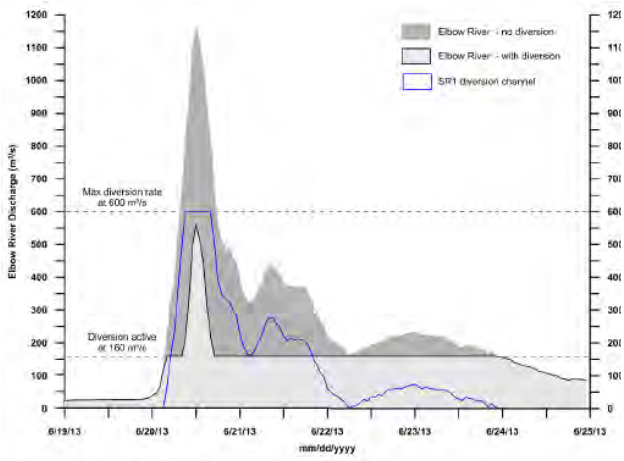
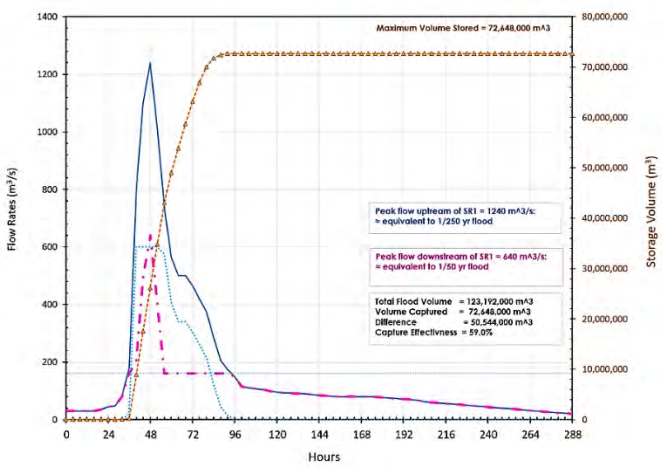


Figure A-3 Design Flood Diversion Hydrograph

Figure 2 SCLG Model – Flood Diversion Hydrograph



2.2. Operational Performance of SR1 Off-stream Embankment Project – 2013 Flood

Figure 3 shows: the 2013 flood hydrograph as reported at Sarcee Bridge (the solid blue line); the diversion rate into the SR1 Reservoir (the light blue dotted line); the cumulative volume stored in the SR1 Reservoir (the orange line); and the resulting hydrograph in the Elbow River (the broken pink line). Figure 4 provides similar information at the Glenmore Reservoir. Figure 3 and Figure 4 demonstrates the expected performance of the SR1 Off-stream Project as if operating during the 2013 flood (with a maximum peak of 1,240 m³/s). The results show that the SR1 Project will moderate flood levels in the Elbow River. However, the results also show that the project provides flood protection at two levels:

- Moderated flows, when combined with the additional capacity available at the Glenmore Reservoir, are less than flow rates that will result in flooding. Residents and properties below the Glenmore Dam are protected.
- The SR1 Project does not sufficiently moderate flows in the section of the Elbow River below the SR1 Reservoir and above the Glenmore Reservoir to reduce the peak flow below flood levels. People and infrastructure at lower elevations along this section of the river are not adequately protected and will be subject to flooding. The dam simply cannot divert sufficient water into the SR1 Reservoir fast enough.

Figure 3 Flood Diversion Hydrograph at the SR1 Off-stream Reservoir - 2013 Flood

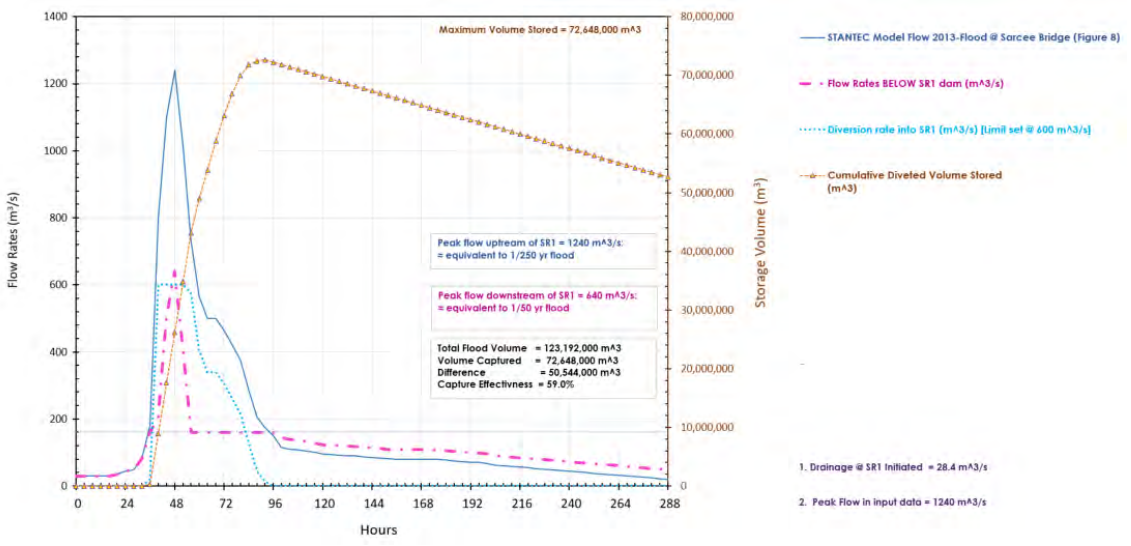
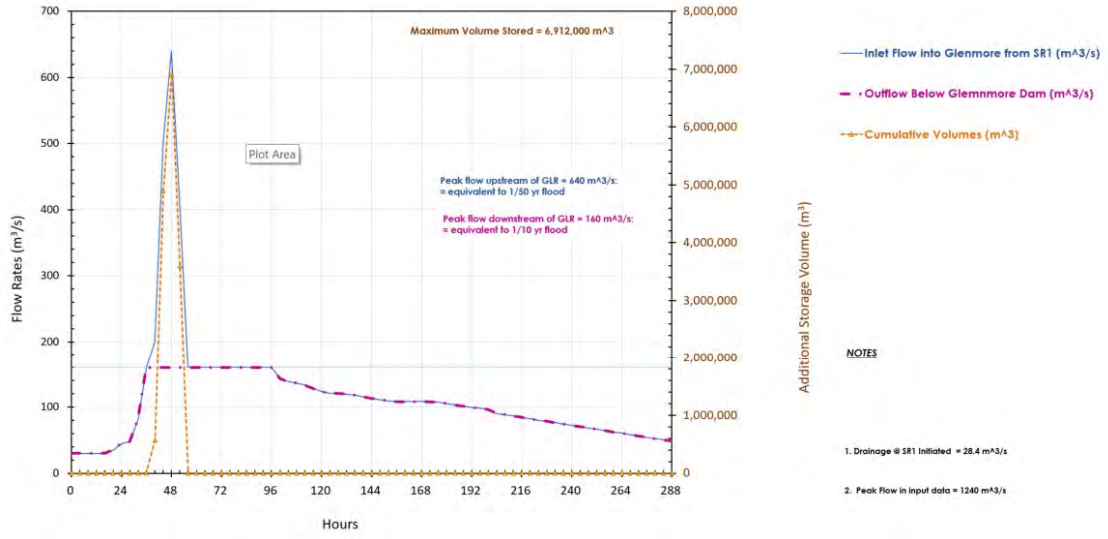


Figure 4 Flood Diversion Hydrograph at the Glenmore Reservoir - 2013 Flood



2.3. Selection of Hydrographical Information

It appears that Stantec has selected a single flood event as the basis for evaluating the performance of the proposed SR1 Off-stream Embankment Project: i.e., the 'Design Flood' and this represents the 2013 flood hydrograph at the Sarcee Bridge. As noted in the PMF Report each profile is dependent upon many factors such; as diurnal cycle, snow pack, temperature gradient, rain fall, etc. Each flood will be an individual, discrete realization with a unique hydrological profile and total flood volume. The performance and ability of the SR1 Project to mitigate downstream flows will vary based on the nature of each individual even, the limitations of the design (maximum diversion rate and volume), the information available and lead times, and the decisions of the operator. As noted in several places in the Design Report, the operator will have considerable latitude in decision-making.

It would be useful to have the opportunity to review the Operations Manual and evaluate various flood scenarios over a range of peak flows and volumes to consider how flood scenarios, operator decisions and dam limitations influence the outlet hydrograph. It would also be useful understand at what peak rate and storage volume the system can no longer meet the required objective of protecting the City of Calgary.

On the basis of our simple model, an increase of 18% (i.e., approximately 1,463 m³/s) in the peak flood rate upstream of the proposed SR1 Project is a sufficient flow rate that causes the first occurrence where flow rates below the Glenmore Dam begin to exceed 160 m³/s. Given all of the variables noted, and considering that the effects of climate change are not factored in, and higher flows are associated with longer flood return periods, is the design adequate to protects us into the future?

Figure 5 and Figure 6, below provide examples of the effects of an 18% increase in the peak flow.

Figure 5 Example Hydrograph at SR1 (18% increase)

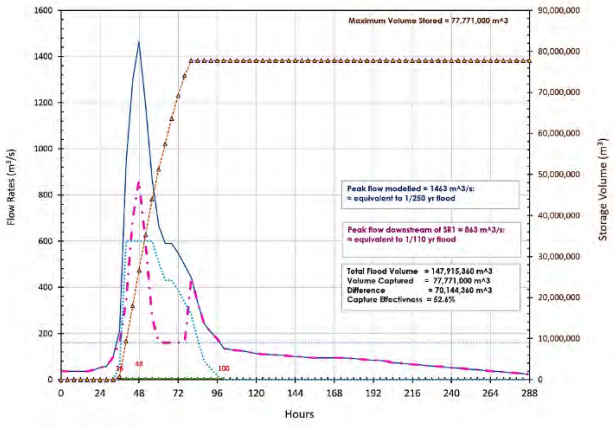
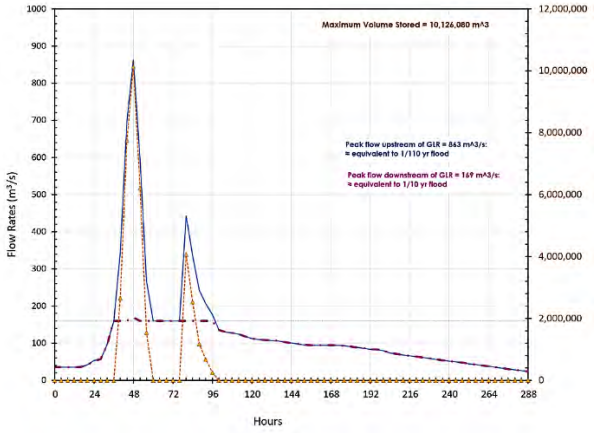


Figure 6 Example Hydrograph at Glenmore (18% increase)



As food for thought, we have clearly heard that 'While this dam is designed to meet the needs of 1:200 year return period (It should be built as soon as possible!) because this return period doesn't mean that it will be 200 years between floods. It simply represents an average and another flood could happen this spring. This may be true, but such logic also applies to a 1:500 year flood with a median peak flow rate of 1,660 m³/s. A flood of this size would result in peak flow below the SR1 Reservoir of 1,050 m³/s a flood levels in the section of the Elbow River equivalent to a 1:170 flood

2.4. Consequences Associated with 2013 Flood with SR1 Embankment Project Operating

In order to evaluate the consequences associated with a 1:50 year flood we have used the Hydrographic Information and Open Water Flood Inundations Maps (Golder Associates Ltd., 2020) to relate peak flow rates in the river and flood return periods. The flood return periods were then used to select the appropriate flood inundations maps which have been superimposed onto Google Earth to evaluate those homes and properties that may be adversely affected by either below-ground or overland flooding. A summary of these consequences is provided in Table 1, below and this table references the figures from which these results we determined.

Table 1 Consequences of Flooding along the Elbow River (SR1 to Glenmore Reservoirs)

Description of Area	Residences & Buildings		Notes	Reference Figures
	Estimated Overland Flooding	*Estimated Below-ground Flooding*		
Springbank Properties	16		*Houses located below SR1 Embankment*	Figure 7
Springbank Elbow River Estates Area	1			Figure 8
The Glenco Golf & Country Club	1		*Service building*	Figure 8
The Glenco Golf & Country Club Fairways & Greens			*Flooded*	Figure 8
City of Calgary - Elbow Valley Residential Homes	13	4		Figure 9
City of Calgary - Elbow Springs Golf Club	1		*Club House*	Figure 9
Discovery Ridge	25	46	*Houses*	Figure 10
Discovery Ridge - 20 Discovery Ridge Close)	390		*3 Multi Unit Housing Complexes*	Figure 10
Total units involved	**447**	**50**		

Figure 7 shows a number of Springbank residences and properties located directly below and South of the proposed SR1 Embankment Reservoir. These residents experienced below-ground flooding during the 2005 flood and overland flooding during the 2013 flood. Residences at risk of overland flooding are shown in yellow, below-ground flooding shown in orange.

Figure 7 Residences and Properties below the SR1 Embankment Dam (1:50 yr)

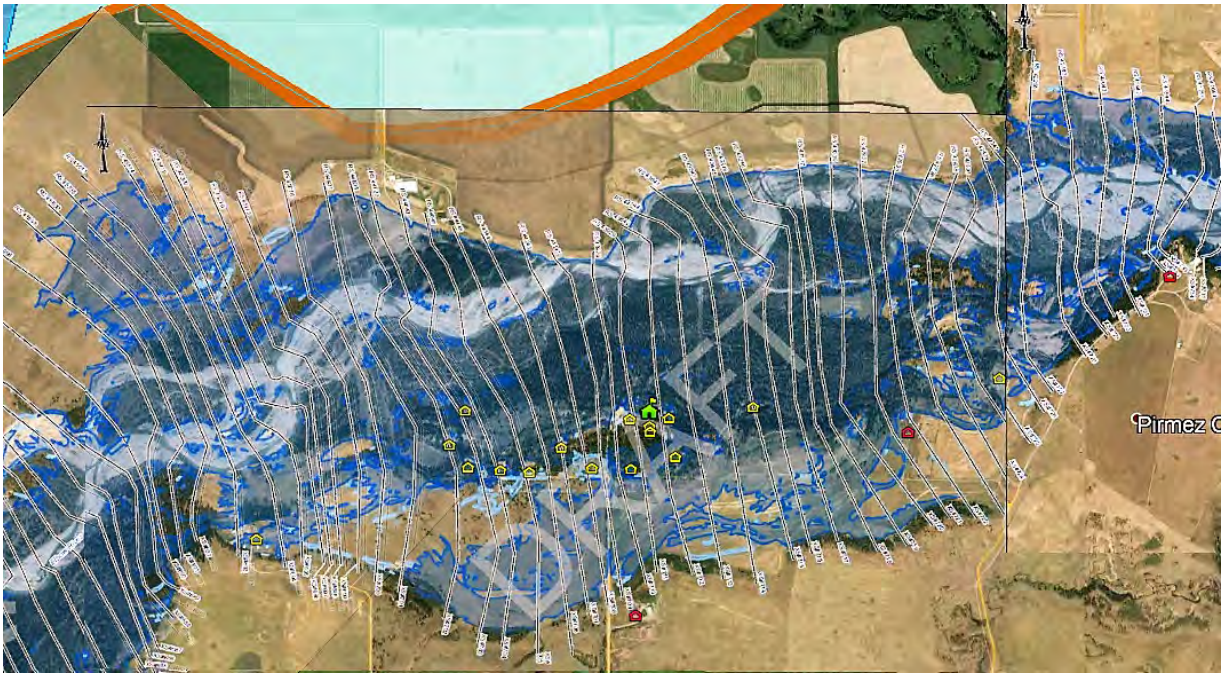


Figure 8 Residence and GLENCO Golf Course Fairways at Risk of Flooding (1:50 yr.)

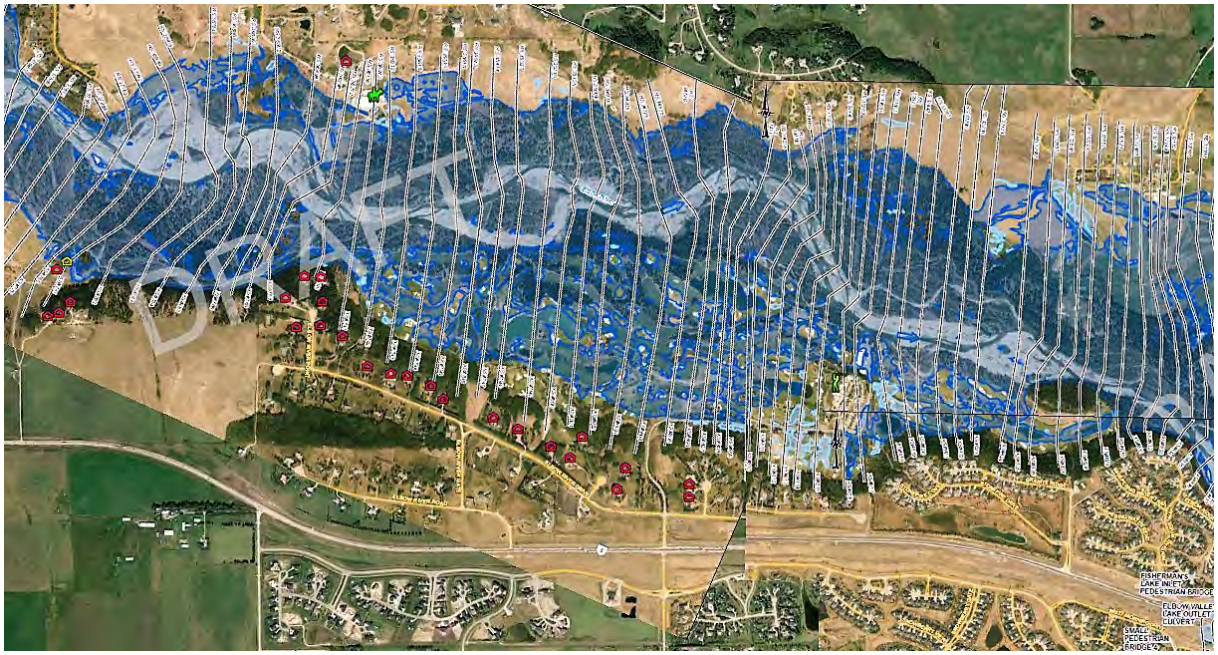


Figure 9 Residences in Elbow Valley at Potential Risk of Flooding (1:50 yr.)

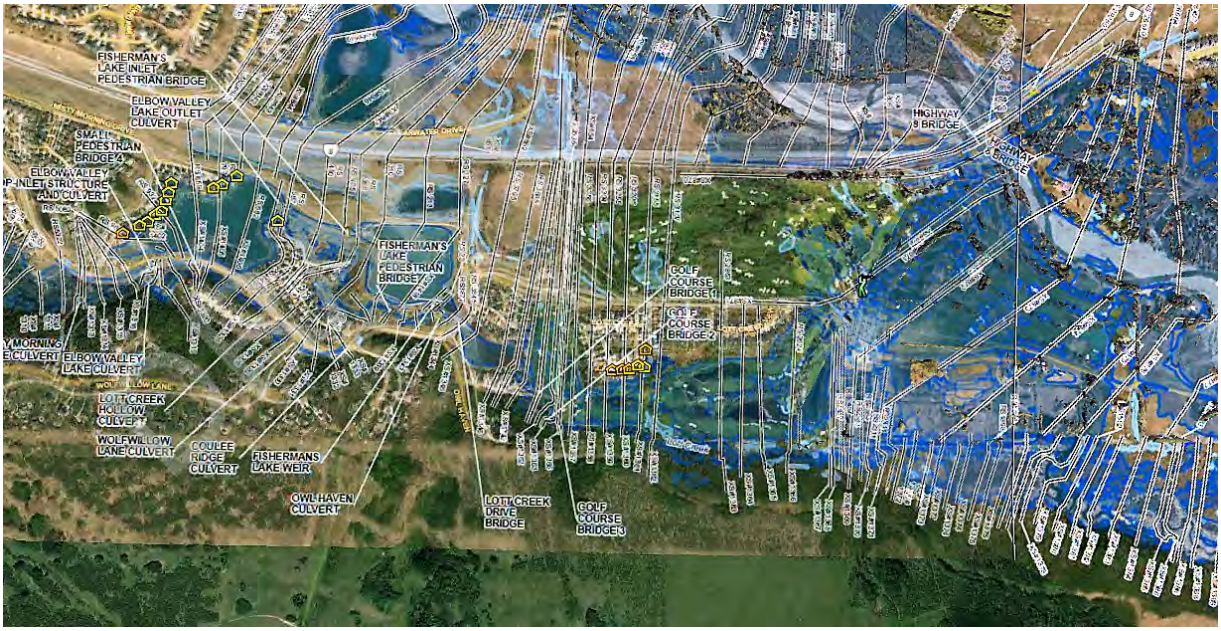
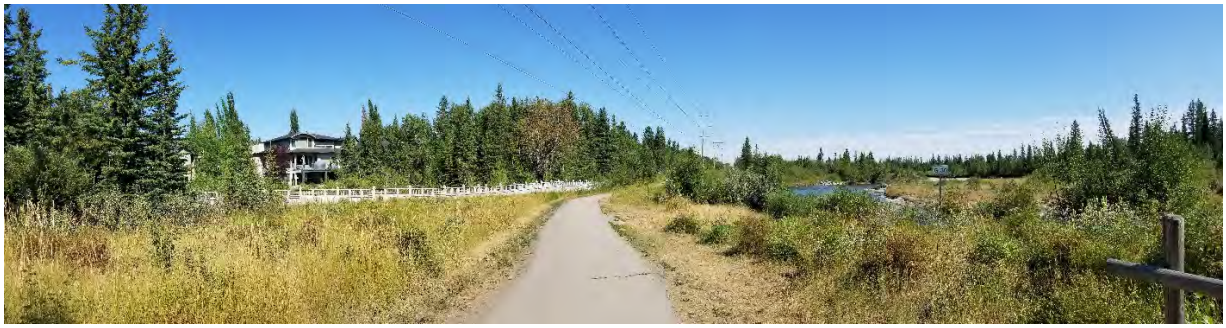


Figure 10 Discovery Ridge at Potential Risk of Above & Below-ground Flooding (1:50 yr.)

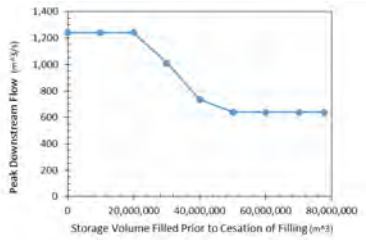
Figure 11 View from Griffith Woods Park showing the proximity of Houses to Elbow River



2.5. Commissioning of the SR1 Off-stream Embankment Dam

The Stantec Project Description Report indicates that ***"In lieu of testing, the off-stream dam contains sensors that will be monitored during operation. Should the monitoring reveal a problem with the dam, the diversion can be stopped and the problem addressed."***

While the majority of issues relating to the commissioning of this project are outlined in the Austin Engineering report that forms part of the SCLG materials, we have several additional concerns regarding the ability to reduce or remove a flood hazard during commissioning under flood conditions. If water diversion is curtailed the peak downstream flows will be dependent on the volume of storage achieved prior to cessation of filling. Just common sense, but more water stored means lower the peak downstream flows and less flooding. The figure on the right shows the relationship between stored volumes and peak downstream flows.



The dilemma faced is that if problems are detected early during the diversion of water into storage, flood flows will be unmitigated and higher levels of flooding will occur. If problems are detected late in the filling process, flood flows will be reduced. However, should monitored problems lead to a dam failure, the outcome could be catastrophic. In either case, risks to the public will be elevated during the commissioning activities under flood conditions. Certainly the statement that in the event of an alarm *'filling will cease and the problem will be addressed',* is not sufficient to properly public safety address safety. .

3. EMERGENCY MANAGEMENT SYSTEM

We have taken a look at the Guideline for Emergency Preparedness for Flood Emergencies (Alberta Environment, 2003) and given the size of this project and its proximity to members of the Springbank Community and to the City of Calgary we find it a little light. This is a big dam. Figure 12, below graphically shows the components that represent best practice in a number of international jurisdictions and to some extent demonstrate the weight that individuals place on these components. As the safety includes the physical system, corporate culture and a strong Emergency Management System, it is our intention, as part of our cross examination of the applicant, to ask the applicant a number of questions that address many of areas noted below.

It would be our intention to focus our questions on areas of corporate roles and responsibilities, accountability, and hazard identification.

Figure 12 Emergency Management Systems – Best Practices Applied in a Number of Jurisdictions

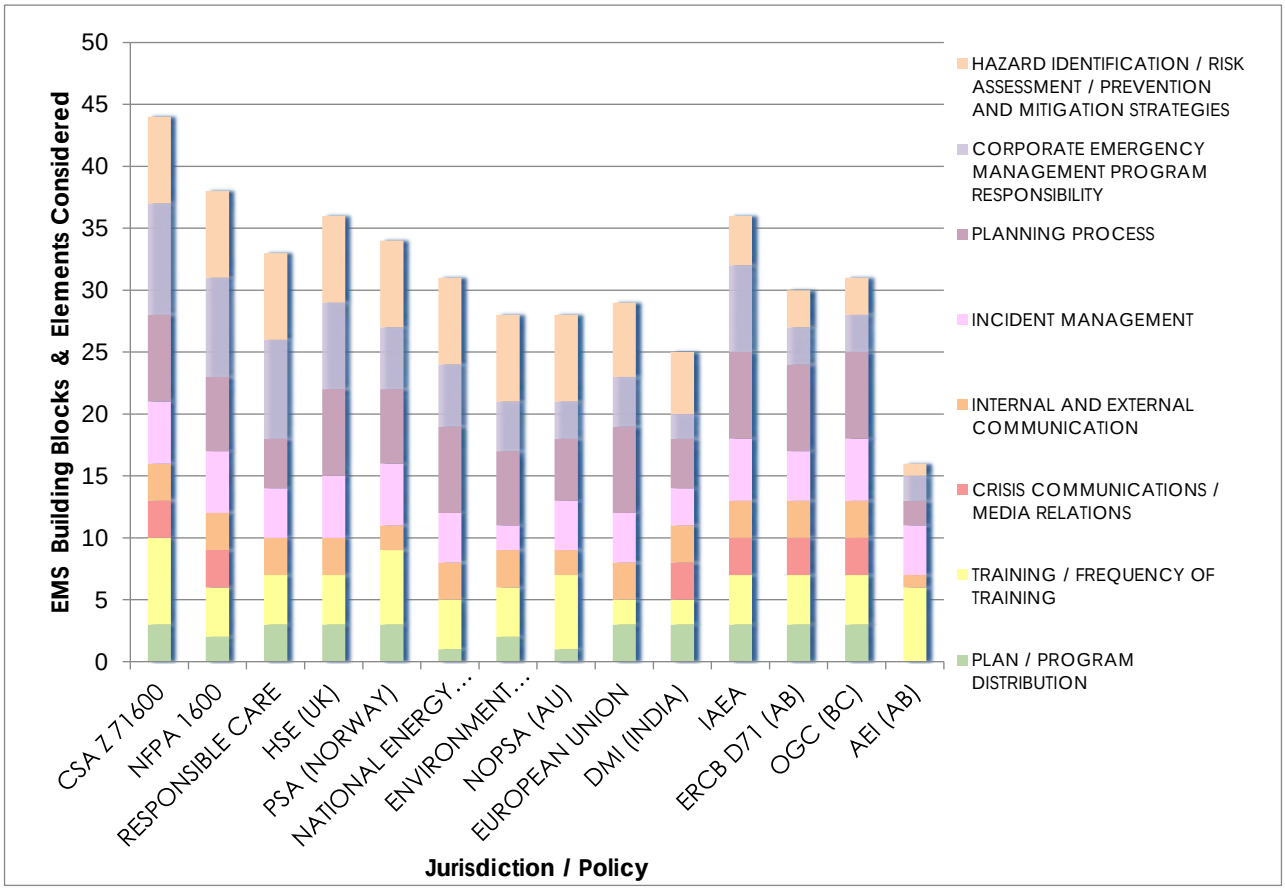


Table 2 Emergency Management System – The Building Blocks and Components of Practice

EMS Building Blocks	Components Considered
OVERALL THEMES	Prescriptive (rule-based) approaches
	Objective (goal-based) approaches
	Approval process
	Updating cycle
	Plan, Do, Check, Act cycle
	As Low As is Reasonably Practicable
	Prevention policy / national standard
	Safety report / case vs. ERP focus
CORPORATE EMERGENCY MANAGEMENT PROGRAM RESPONSIBILITY	Executive / senior management accountability
	Executive approved policy (HSE) statement
	Program coordinator designated
	Program advisory committee
	Program budget / financial support
	Program records management process
	Program review / change management
	Program goals and objectives description
	Program elements determination: prevention, mitigation, preparedness, response, recovery
HAZARD IDENTIFICATION / RISK ASSESSMENT / PREVENTION AND MITIGATION STRATEGIES	Hazard identification
	Risk assessment
	Prevention strategies based on hazard identifications and risk assessments (high risk should be eliminated)
	Hazard monitoring system establishment (non-eliminated hazards - non high/high hazards)
	Interim and long term actions to eliminate hazards
	Mitigation strategies to limit or control consequences or severity of non-high/high risk hazards
	Mitigation plan for interim and long term actions to reduce impact of hazards that cannot be eliminated (ALARP)
PLANNING PROCESS	Public awareness program for public impacted by hazard
	Stakeholder participation in planning process
	Identification of internal and external agencies, organizations, departments and positions
	Resource capability assessment
	Identification of logistics support and resource requirements
	Mutual aid assistance
	Inventory of internal and external resources
INCIDENT MANAGEMENT	Incident management system (complete with role assignment and coordination)
	Priorities of strategies (people, property, and environment)
	Immediate actions / first on the scene / plan activation
	Operational procedures for responding to specific hazards (on-site and off-site)
	Primary and alternate EOCs
INTERNAL AND EXTERNAL COMMUNICATION	Internal communication protocol developed
	External communication protocol developed (external agencies)
	External communication protocol developed (public - sheltering / evacuation / other)
CRISIS COMMUNICATIONS / MEDIA RELATIONS	On-site
	Corporate
	External agency liaison
TRAINING / FREQUENCY OF TRAINING	Personnel orientation
	Communication system drill (plant muster alarm)
	Limited drills
	Table top exercise
	Simulation exercise
	Full scale exercise
	Post incident review
PLAN / PROGRAM DISTRIBUTION	Internal - field
	Internal - corporate
	External

4. Final Comments

The proposed Off-stream Embankment Project does not provide equal protection from flooding for all people located at lower elevations along the Elbow River. While the SR1 Off-stream Embankment Project will aid in reducing peak flows and will help mitigate flood levels along the Elbow River, the project will not prevent flooding from occurring in the Elbow between the SR1 Reservoir and the Glenmore Reservoir. This limitation is due to the inability of the diversion system to move sufficient flood water into storage. Also, once the storage capacity of the SR1 Reservoir has been reached flood waters will bypass the diversion structure and continue downstream. People located below the Glenmore Reservoir are safe from flooding only because the Glenmore Reservoir additional and sufficient storage capacity. The limitations of the SR1 Project appear to be imposed by the terrain in which the dam is to be situated. A better option might be to consider an across-stream dam that simply blocks flood water rather than diverting it, and/or find terrain where there is sufficient capacity to store the volumes required.

When considering the approval of a project of this magnitude and cost, all Albertans potential affected by the project deserve to be provided with an equal level of flood protection, regardless of where they reside along the river. Springbank residents, and residents within the City of Calgary itself are at risk of flooding. Many have not been directly informed about the project nor provided with appropriate and meaningful information describing the project, its operation, and its potential for flooding. Their opinions, comments, and input are noticeably missing from materials submitted as part of the consideration of this project. When speaking with residents located directly below the proposed SR1 Off-stream Embankment Project, several residents indicated that their first contact with the proponent occurred in the week just prior to the NRCB pre-hearing meeting to consider the scope of their consideration. These residents should be heard.

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