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Memo

PGL File #: 3705-06.01

DATE: April 16, 2018

TO: Janes Freedman Kyle Law Corp.

FROM: L. Beckmann and M. Hammond, PGL

RE: BRAGG CREEK FLOOD MITIGATION PROJECT: POTENTIAL PATHWAYS OF EFFECT ON DOWNSTREAM LANDS AND WATERS

This memo has been prepared to support Statements of Concern made by Janes Freedman Kyle Law Corp. on behalf of several of their clients living in the vicinity of the proposed Bragg Creek Flood Mitigation Project (the Project). Following a review of the Application Material (Bragg Creek Flood Mitigation Design Report and supporting Appendices A through I), we noted a number of potential errors and deficiencies in the application that undermine its credibility: the information is not sufficient to support a finding of minimal adverse effect downstream of the proposed infrastructure.

This memo is structured to provide some basic technical background for the informed layperson, followed by an overview of a number of potential adverse effects to downstream river processes and landforms that have not been sufficiently assessed. These effects are organized by four flow conditions that range from typical “least flow” conditions to an hypothetical “catastrophic” flood that exceeds the design parameters of the Project.

1.1 Project Summary

- The Project is composed of a discontinuous set of hard structures, most adjacent to or inland of the south bank of the Elbow River, designed to contain the floodwaters as they rise to 100-year design flood maximum.
- The upstream limit of the Project is at the confluence of Bragg Creek and the Elbow River; the downstream limit of the proposed infrastructure is immediately west of the IR#145. Works are also proposed for Bragg Creek itself.

1.2 Basics of River Behaviour and Shape

- Bragg Creek is located in the narrowest portion of Elbow River, at the transition point between a steep, defined channel and a flat, braided floodplain. This point can be thought of as the narrowest portion of a funnel, where mountain meltwater has carved (incised) a deep channel through the mountains. As large pulses of water enter the flood plain spread out, the energy of the water moves the bed of the river (bedload) and any entrained material. Because the flows are rapid and seasonal, the river channel changes frequently, resulting in a typical “braided” appearance. This process is the reason why the Elbow River channel changed shape following the 2013 flood.
- Hard flood-control structures are widely understood to increase river depth and speed through the “trained” section of rivers.
- The Application Materials (Figure 6.4, Appendix B – Hydrology Model) identify a downstream channel incision during a 1:100-year flood that is consistent with the effects of increased flow and speed through an upstream training structure.

1.3 Basics of Flood Prediction

- Flood prediction is based on a statistical exercise in which historical flood records are used to predict the frequency of floods of different magnitudes.
- Floods are discussed in terms of “return periods” that reflect the likelihood of a flood of a certain size. A 1:100-flood is one that is only likely to occur once every hundred years.
- Methods for the statistical calculation of flood return periods are being revised in response to the understanding that temperature and precipitation trends continue to change as a result of climate change, and that the past is no longer a reliable predictor of the future.
- The addition of a statistical safety factor ranging from 5% to 20% on top of current flood volumes is often recommended to account for how climate change is leading to more frequent or intense floods.

1.4 Flood Conditions Considered In This Memo

- <u>Low-flow conditions:</u> these occur from the period following the end of snowmelt to the start of the following snowmelt. For the Bragg Creek area, these are the conditions prevailing from late summer, through winter, to early spring. For reference, this is the flow associated with the 1-in-2-year flood, or 57m^3/s (Elbow River near Glenmore Reservoir; Application Material, Table 2.2., p.6).
- <u>“Normal” freshet (spring runoff) conditions:</u> for the purpose of this memo, “normal” conditions are those in which flows do not exceed the 1-in-20-year flood, or 440m^3/s (Application Material, Table 2.2., p.6).
- <u>Design flood conditions:</u> this is the 1-in-100-year flood volume and represents the maximum flow that the Project is designed to control. For reference, this flow is 930 m^3/s.
- <u>Catastrophic floods</u>: this is any flow volume over the 100-year flow. For reference, the measured flow during the 2013 flood was 1,170 m^3/s (Application Material, p.1, Footnote 5). This is greater than the design volume for the Bragg Creek project. The volume associated with the 2013 flow is closer to that (1,197m^3/s) associated with an unadjusted-for-climate-variability 1:200-year flood.

1.5 Bragg Creek Project – Potential Downstream Effects

The following sections identify effects that may be expected to result from the Project. The application does not provide sufficient information to conclude that the effects, particularly those in Sections 1.5.2 and 1.5.3, are not significant.

1.5.1 Potential Project Effects Under Low-Flow Conditions

Under these conditions:

- The Elbow River will not overtop Project infrastructure;
- Water depth and speed will increase in the Elbow River in the reach of river bounded by Project infrastructure. The increase over base-conditions is predicted in the Application to be 0.31m and 0.47m/s close to the boundary between Bragg Creek and IR145;
- Water depth and speed will attenuate beyond the downstream infrastructure. According to the Application, depth and volume will be indistinguishable from pre-project conditions (0.01m and 0.01m/s) at the downstream end of the community of Redwood Meadows;
- Changes to river morphology (shape) may occur, but are expected to be minimal; and
- Increased water speed and volume may increase water turbidity (concentrations of suspended sediment), with corresponding potential effects on fish health and reproductive success.

1.5.2 Potential Project Effects Under “Normal” Freshet Conditions (To A 1:20-year Flood)

Under these conditions:

- The Elbow River will not overtop Project infrastructure;
- As above, water depth and speed will increase in the Elbow River in the reach of river bounded by the Project infrastructure;
- Additional water energy has the potential to move more or larger material downstream towards the community of Redwood Meadows; and
- Gradual deepening of the Elbow River downstream of the project structure is likely. The speed at which this will occur depends on the frequency of high volume flooding.

1.5.3 Potential Project Effects Under Design Flood Conditions Conditions

Under these conditions, the Elbow River is predicted to rise to within 0.3m of the top of the Project infrastructure, but not to overtop it.

The Application notes that downstream effects are unlikely, because “the channel downstream of the Hamlet boundary is wide and braided...[and] As such…is expected to have limited impacts on the current channel morphology of this reach.”

This statement is inaccurate. As indicated in Application Appendix C, Figure 6.4 (reproduced at left), the 1924 bank line (in blue) shows a braided river downstream of the Township/Reserve boundary; the 2012 (green) and 2013 (red) bank lines show a substantially narrower bank that, if unprotected, could reasonably be expected to be the site of a bank breach and subsequent flood onto Tsuut’ina land.

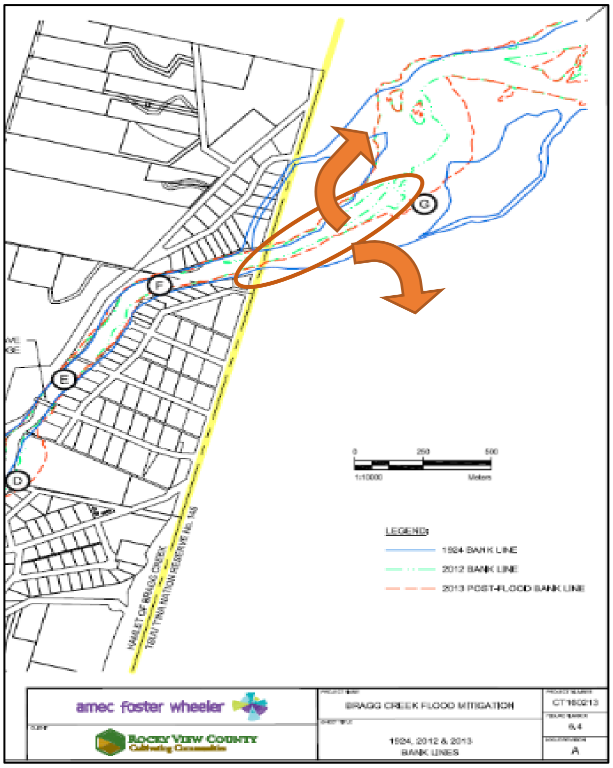

Figure 1: After Application Appendix C, Figure 6.4. Shapes in orange added to identify potential overtopping area (orange oval) and direction of flooding (orange arrows).

Appendix B, Figure 6.4 (reproduced in part, at right) demonstrates that this does, in fact, occur under a 1:100-year flood scenario. While the model predicts that the Project should reduce the level of flooding over the no-project scenario in certain locations, flooding will still occur in other locations. Given the increased water velocities predicted to result downstream as a result of the Project it is reasonable to expect that more and/or larger debris may be carried through the project reach to be deposited downstream of the project on Tsuut’ina or other lands. The distance this material may be carried has not been modelled.

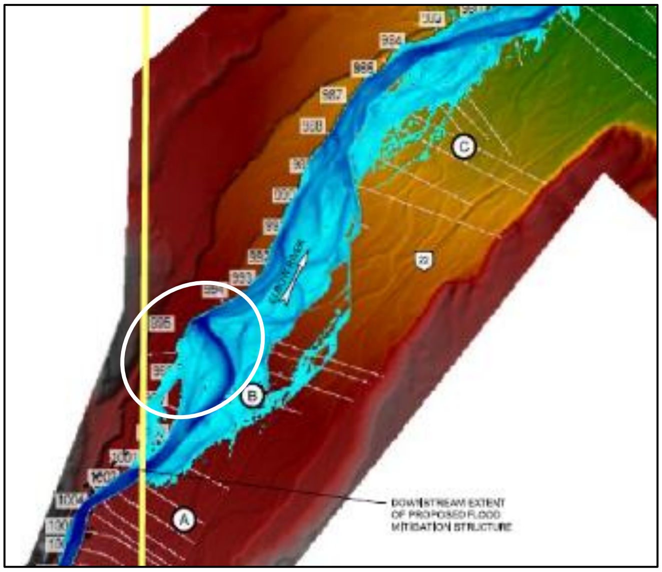

Figure 2: After Application Appendix B, Figure 6.4 showing predicted 1:100-year flood water levels with training structure upstream. White oval indicates a narrow reach before the Elbow River widens to the braided floodplain where flooding is likely.

1.5.4 Potential Project effects Under Catastrophic Floods Conditions

Under this condition, the Elbow River overtops flood structures. For the reasons noted in Section 1.3, above associated with increased climate variability, this is a plausible scenario and may be expected to occur more than once every hundred years.

In the event of a catastrophic flood:

- Spillout leads to widespread flooding;
- The location of flooding is unknown because a “Breach Analysis” has not been completed; and
- Given the increased volume and velocity through the trained section of the river, the river will have greater power and carrying capacity, so will have the ability to move larger debris. In this situation, therefore, debris may reasonably be expected to move downstream and overtop banks as the floodwaters do.

1.6 Longer Term Effects

While the emphasis of this memo is on flood conditions and on effects of changes to the river shape and flow, there is also the potential for a deeper ecosystem change resulting from year-on-year reductions in alluvial aquifer recharge.

1.6.1 Aquifer Drawdown

The Elbow River Basin Water Management Plan (ERBWMP), produced in 2008, was a decision-support tool produced collaboratively by a number of provincial government agencies, municipal governments, and the Tsuut’ina Nation. Important for this discussion, the report notes that the Elbow River alluvial aquifer:

“was formed by alluvial (river) deposition and is very permeable and highly hydraulically connected to the Elbow River. The upper surface of the unconfined aquifer is the water table and the other surfaces are bound by less permeable sandstones and shales (Manwell and Ryan 2006). ***Groundwater from the alluvial aquifer flows into the river during periods of low river flow and river water flows into the aquifer during times of high river flow*** (emphasis added, ERBWMP, Elbow River Watershed Partnership, May 2008, emphasis added).

The aquifer is identified in pink in Figure 3, to the right.

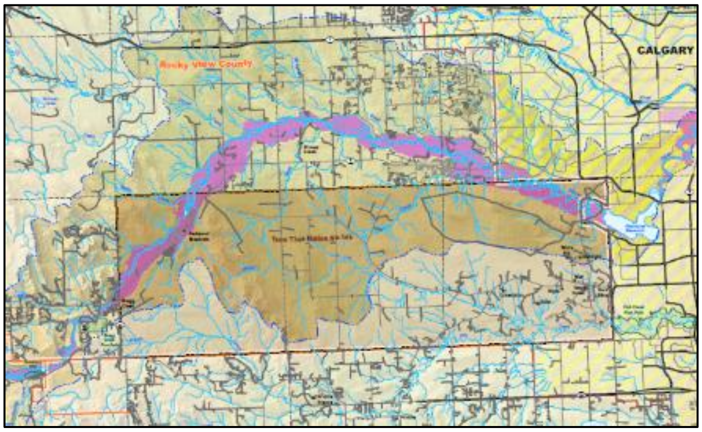

Figure 3: From "Government of Alberta, 2009. Prepared by the ASRD, South Rockies, Resources Information Unit-Calgary). Elbow River Alluvial Aquifer shown in pink.

Over time, the faster flowing water through the project infrastructure may promote downstream changes. Specifically, the Project may foster a narrower, faster river downstream of the infrastructure, with consequent effects on the aquifer.

Reduced aquifer recharge could in turn:

- Reduce well-water production rates;
- Affect water temperature, potentially increasing it during low flow periods when groundwater otherwise flowing into the river would cool temperatures;
- Affect fish species dependent on groundwater recharge; and
- Reduce soil moisture and agricultural capability.

These effects may be felt as far downstream as the downstream limit of the aquifer (to the Glenmore Reservoir); that development has been encroaching on the natural flood plain for the past century suggests that these effects may already have begun and that this Project will exacerbate long-term effects to downstream water users.

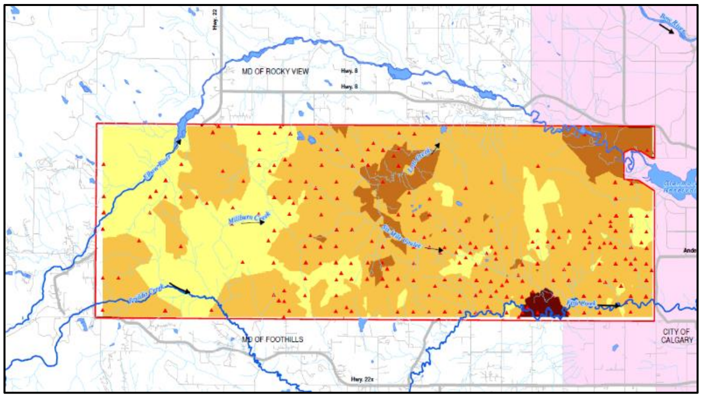

Figure 4: From: Tsuut'ina Nation Water Needs Assessment, Dillon Consulting for Tsuut'ina First Nation, 2009, excerpt from Figure 5.7. Colour represents well yield in gallons/minute; lighter colour are lower producing wells. Effects of the Project on these wells has not been assessed.

1.7 Other Considerations

Fluvial (river) processes are governed by complex physics and represent systems that are not static, but in dynamic equilibrium (it is constantly changing internally but has achieved a generally steady state). While the Bragg Creek Design Report notes that water level and velocity changes are "relatively minor" they are not zero. Under 1:100-year flood conditions (Application Figure 6.4), there appears to be a meaningful difference between pre-project and project inundation patterns that extend well past Redwood Meadows.

As presently written, however, the Design Report does not consider how components of other projects, notably the backwatering required at the proposed diversion structure associated with the Springbank Off-stream Reservoir (SR1) project, may interact with the changes resulting from the Bragg Creek project. The absence of a cumulative effects assessment limits confidence in the conclusion made in the Bragg Creek Design Report that downstream effects are indeed "relatively minor."

1.8 Summary

As noted above, the Application documents do not contain sufficient information to adequately assess several potential downstream effects, particularly those associated with high and extreme flows. To adequately support the application's conclusions that there will be no significant downstream effects, additional information is required. This should include:

- Modelling to predict and assess effects on river shape and aquifer recharge over multiple flood events, with and without the SR1 Project;
- Modelling to determine the extent of increased debris movement associated with increased river volume and velocity through the project works;
- The rationale behind the seemingly small safety factor used to compensate for climatic variability and increased storm frequency; and
- A breach analysis to predict effects in the event of infrastructure failure or a flood larger than that for which the project has been designed.

In the absence of these additional data, it is difficult to concur with the proponent's conclusion that the project will have no significant downstream effects.