Springbank Off-stream Reservoir Project:

climate change, hydrogeology, geochemistry & water quality

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On behalf of the Springbank Concerned Landowners Group

March 2021

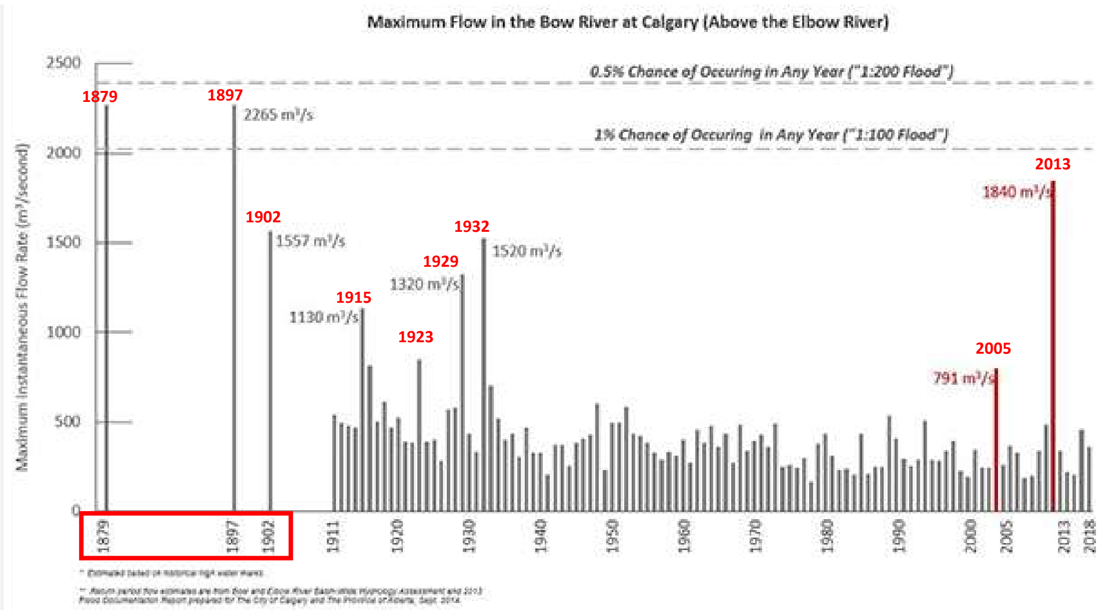
Major concerns identified re: SR1

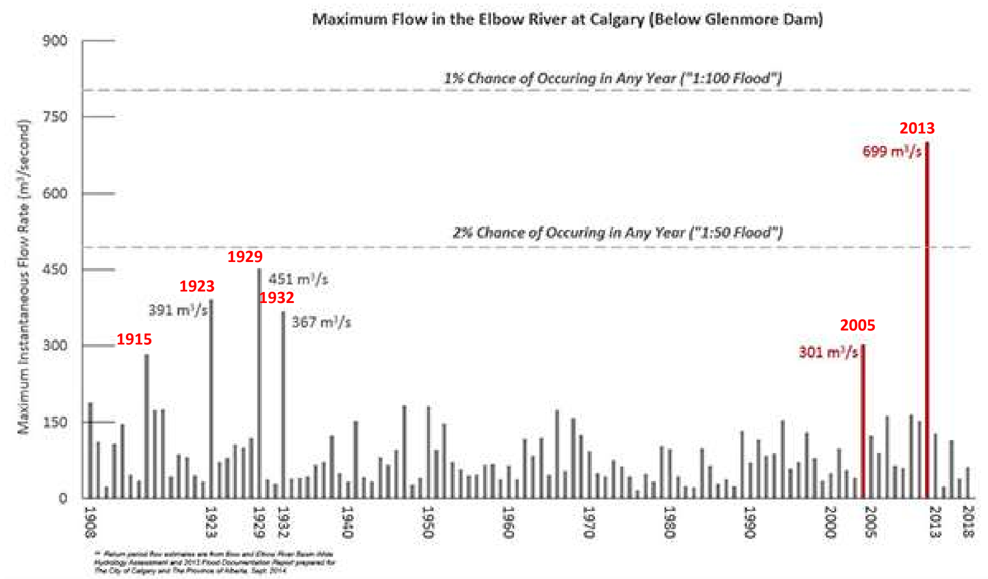
- Climate change, including the impacts from extreme flood and drought conditions and how that might affect the safe and efficient operation of SR1.
- Knowledge of the hydrogeologic regime and its influence on the success of SR1.
- Efficacy of the groundwater modelling to allow an informed decision to be made regarding whether or not to approve SR1.
- Review of the geochemical and water quality issues that could arise if SR1 is constructed and operated as planned.

Climate change

- SR1 design has not considered the likely magnitude of floods that have occurred in the past due to the protracted flow records for the Elbow River.
- SR1 design does not consider the magnitude of floods that are likely to occur in the future due to an intensifying hydroclimate.
- SR1 does not consider the risk that the structure poses from extended drought conditions.
- SR1 does not increase the water security for the City of Calgary as stated by AB Transportation.

Historical maximum flows





Source: City of Calgary https://www.calgary.ca/uep/water/flood-info/types-of-flooding-in-calgary/calgary-river-flows-historical-data.html

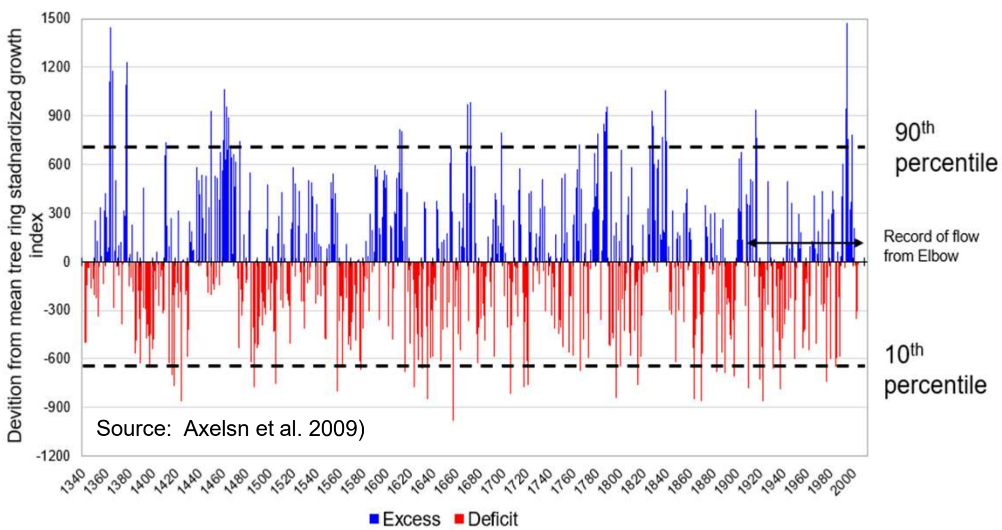
Large floods of record in the Bow Basin have not been captured in the record of the Elbow River *(does that mean they did not occur?)*

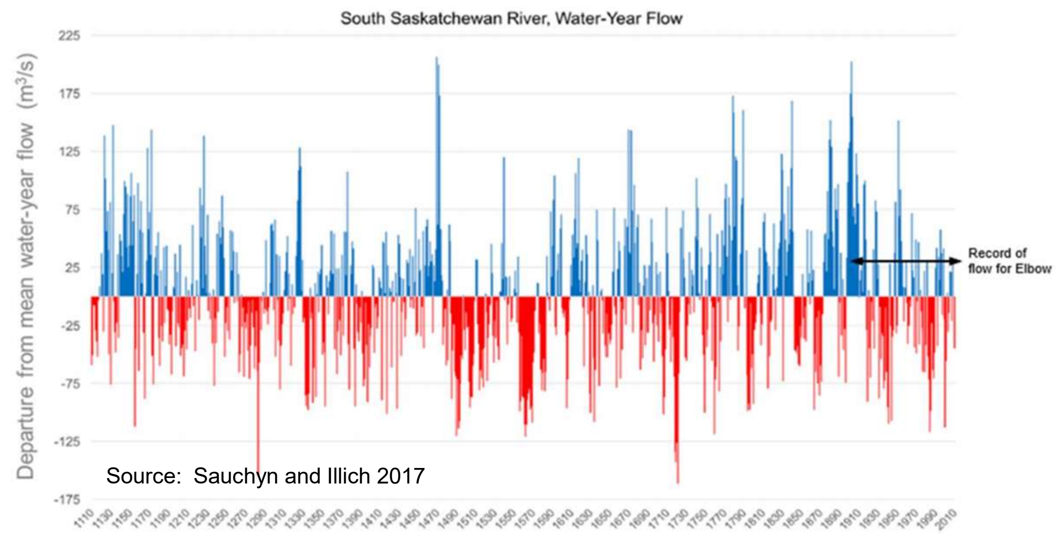
Comparison of documented floods on the Bow River indicates that flows in the Elbow River pre-dating the period of record could have been 2 or more times greater than the 2013 event.

Tree-ring reconstruction from Wildcat Hills

(approx. 30 km to NW of SR1)

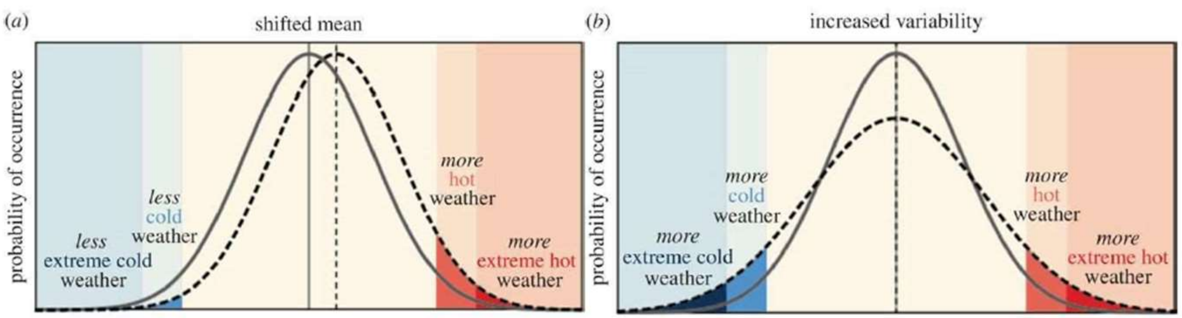
Figure 10 of Exhibit 261, pdf pg. 18





Paleo-records indicate numerous periods consistent with flood (above 90th percentile) and drought (below 10th percentile). Although this does not speak to individual events, its does speak to probability of occurrence *(i.e. floods and drought happen more during extended wet and dry periods, respectively)*.

Anticipated changes due to climate change



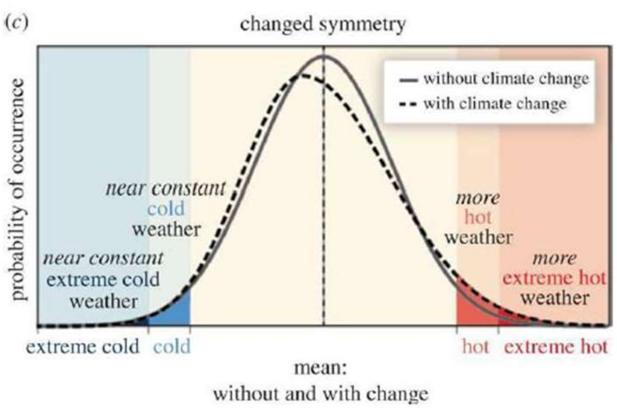
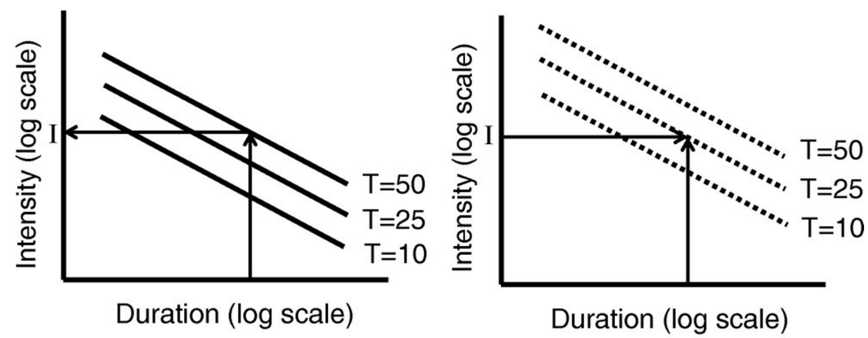


Figure 15 of Exhibit 261, pdf pg. 22



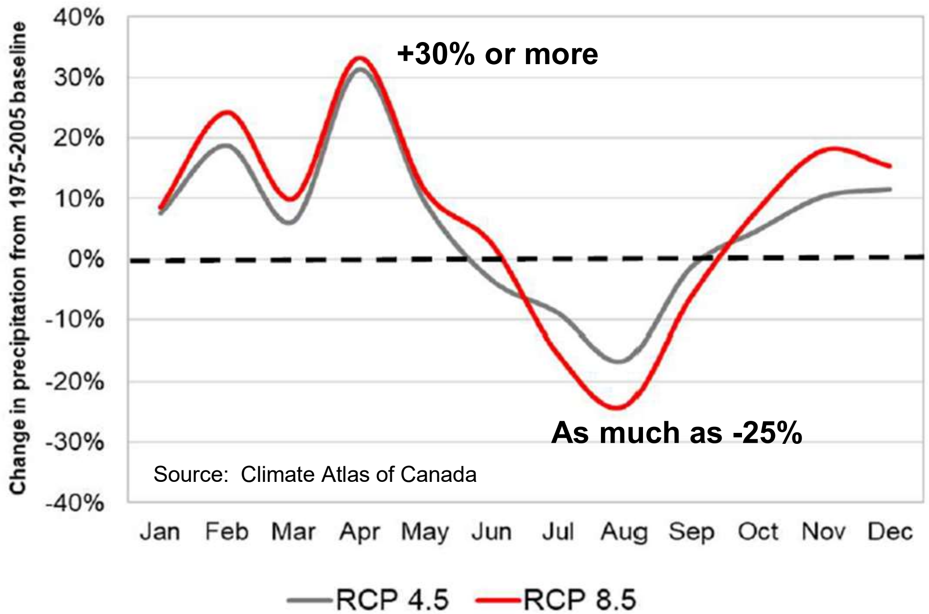
"Future IDF curves show a wide range of increased intensities especially for storms of short durations (≤1-h). Conversely, future ***IDF curves are expected to shift upward*** *because of increased air temperature and precipitable water which are projected to be about 2.9 °C and 29 % in average by 2071–2100, respectively." (Kuo et al. 2015)*

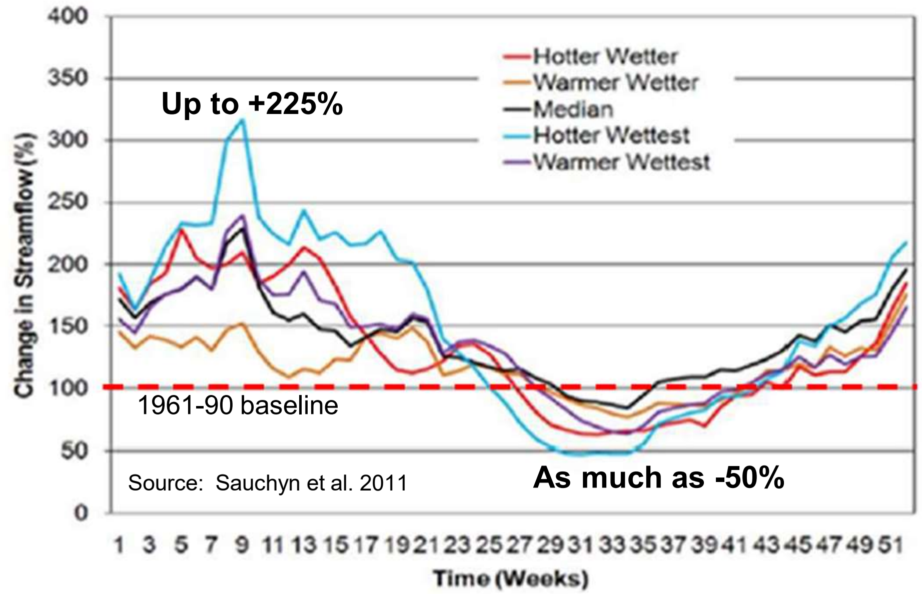
Shift from mean results in increase in extreme conditions (>90th percentile)

Shift in precipitation IDF increases risk of higher floods of record

Anticipated changes in precipitation and streamflow conditions

Figure 13 of Exhibit 261, pdf pg. 21

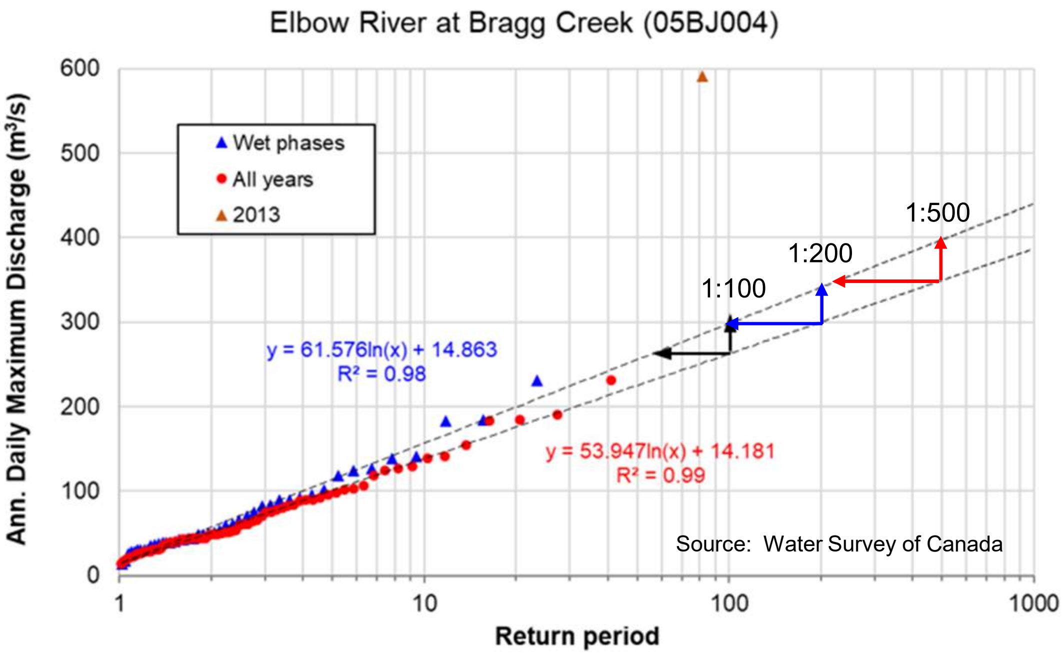




Projected shift in timing and magnitude of spring precipitation, as well as the anticipated change in river flow conditions, leads to an increase floods larger than 2013.

Anticipated changes to flood frequency, magnitude, and probability

Figure 16 of Exhibit 261, pdf pg. 23



% chance of occurrence

Year	Return period			
	1:1000	**1:500**	**1:200**	**1:100**
5	0.5	1	2.5	4.9
10	1	2	4.9	9.6
25	2.5	4.9	11.8	22.2
50	4.9	9.5	22.2	39.5
100	9.5	18.1	39.4	63.4

Flood statistics for wet climatic periods are very different from flood statistics generated from the entire period of record. Shortening of return periods results in increased risk of higher magnitude floods.

Risks posed by prolonged drought

Wind blown dust & respiratory risk

Increased dust inhalation risk (fine particles with associated contaminants).

Algal blooms & insects = additional heath risks

Accumulated water with nutrients + seasonal warming = algal blooms (e.g. cyanobacteria) & insect breeding.

Ground cracking and increased seepage risk

Decrease in water table promoting drying of clay/tills, increased fracturing, and creation and/or enhancement of seepage pathways.

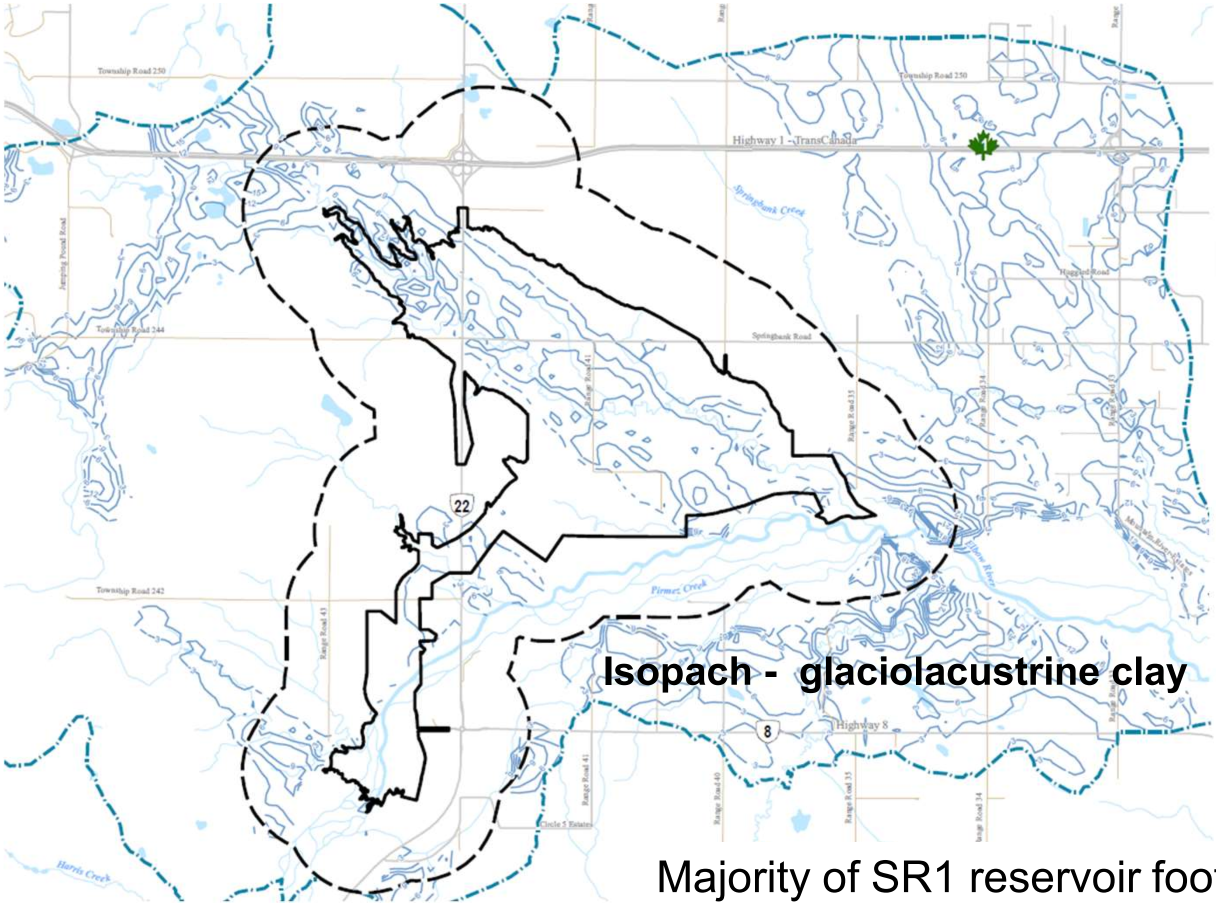
Increased forest fire hazard leading to higher watershed yields & associated river flows, plus degraded water quality

Hydrogeology, geochemistry & water quality

- Model setup does not honour the geology of the SR1 site; lack of K value measurements in the underlying clay/tills leads to concerns regarding the appropriateness of the results.
    - *Systemic bias appears to be present in the model output leading to concerns regarding efficacy in certain parts of the model domain.*
    - *Seepage estimates from SR1 reservoir are considered low due to model layering issues.*
- Geotechnical concerns related to pore pressures and shear-slip risk.
- Water quality assessment is lacking with respect to any geochemical risk *evaluation (i.e. mobilization of contaminants to local receptors)*.

Geological setting: surficial deposits

Exhibit 110, pdf pg. 47



Isopach - glaciolacustrine clay

Side view of surficial deposits

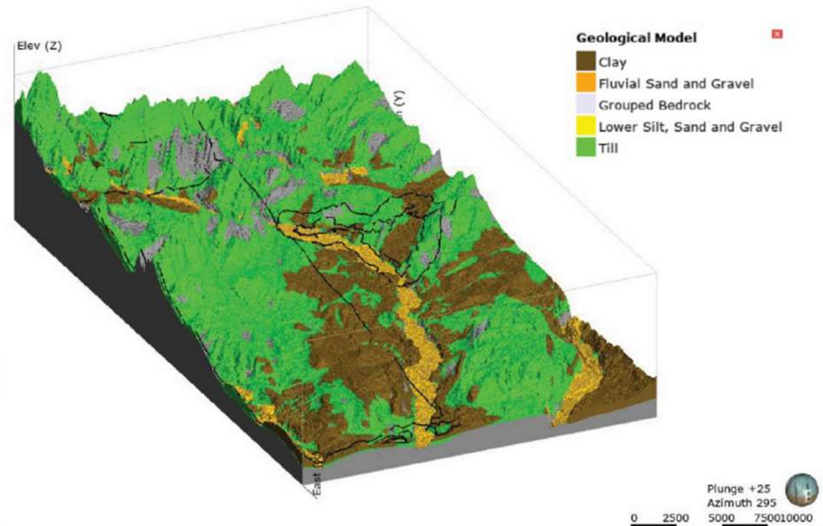


Exhibit 110, pdf pg. 50

Majority of SR1 reservoir footprint underlain by lacustrine clay

Discrepancy with geological configuration

Exhibit 327, pdf pg. 44

Dr. Fennell asserts that the presence of the surficial fluvial gravel (unit Gg) and fluvial channel sands (unit Cs) should have necessitated the collection of more information regarding the hydraulic conductivity of the surficial unconsolidated sediments, given that the presence of these coarse textured sediments would lead to higher variability in those measured values. However, since these coarser textured units are not present in the SR1 PDA, a smaller range of variability is reasonably expected given the consistently clay and silt dominated lithologies of the lacustrine and till units that have been described in the Hydrogeology Technical

Exhibit 159, pdf pg. 195

10.3.6.2 Seepage Control within the Unnamed Creek

The geotechnical investigation indicated that the Unnamed Creek is an undersized river valley infilled with fluvial materials (sands and gravels) overlain by glacial till. The fluvial materials are consistently present in borings and test pits performed in the Unnamed Creek. The hydraulic conductivity of the fluvial materials is relatively high. It is likely that hydraulic conductivity may exist between the fluvial materials and the reservoir, which could result in unacceptable factors of safety against piping. To mitigate against this, seepage control measures were evaluated. Data from the geotechnical investigation near the creek show that the fluvial materials located in this area are typically overlain by a low permeability glacial till layer. However, it is plausible that the

Exhibit 178, pdf pg. 16

- Alluvial sand and gravel soils were encountered in the low-lying area of the unnamed creek near Station 23+200 of the Storage Dam. The alluvial sand was described as dense, brown, clayey sand with gravel and silty sand with gravel. The alluvial gravel was described as very dense, clayey and silty gravel with sand. The thickness of the alluvial soils ranges from 1 to 7 meters in the area of the unnamed creek.

Reported model layer parameter values

Exhibit 110, pdf pg. 473

Table E.1-2 Modelled Parameter Values

Hydrostratigraphic Unit	Steady State Calibration				Changes in Sensitivity Run 1		Changes in Sensitivity Run 2	
	XY Hydraulic Conductivity (m/s)	Z Hydraulic Conductivity (m/s)	Specific Storage (1/m)	Specific Yield (volume/ volume)	XY Hydraulic Conductivity (m/s)	Z Hydraulic Conductivity (m/s)	Specific Storage (1/m)	Specific Yield (volume/ volume)
Clay	5.1E-06	5.1E-07	3.5E-03	0.07	5.1E-06	5.1E-07	1.0E-02	0.14
Fluvial sand and gravel	2.8E-03	2.8E-04	2.3E-05	0.25	2.8E-03	2.8E-04	1.0E-03	0.35
Grouped Bedrock layer 6	1.4E-06	1.4E-07	1.1E-05	0.17	1.4E-03	1.4E-04	1.0E-04	0.30
Grouped Bedrock layer 7	2.7E-07	2.7E-09	1.1E-05	0.17	2.7E-04	2.7E-05	1.0E-04	0.25
Lower silt, sand and gravel	8.3E-05	8.3E-06	2.3E-05	0.2	8.3E-05	8.3E-06	1.0E-03	0.35
Till North	7.2E-08	7.2E-08	4.0E-03	0.04	7.2E-05	7.2E-05	1.0E-02	0.10
Till South	7.2E-07	7.2E-07	4.0E-03	0.04	7.2E-04	7.2E-04	1.0E-02	0.10
Till-high conductivity North	8.3E-05	8.3E-05	3.8E-03	0.04	8.3E-05	8.3E-05	1.0E-02	0.10
Till-high conductivity East	1.0E-04	1.0E-04	3.8E-03	0.04	1.0E-04	1.0E-04	1.0E-02	0.10

Only 3 hydraulic conductivity (K) field tests actually completed for clay/tills intervals: 1 for clay and 2 for tills (see Table 2-1 of Exhibit 110, pdf pg. 19-20) - not enough to properly constrain K field variability)

Some interesting configurations regarding K values assigned (e.g. Till-high K North)

Model layer configuration: surficial deposits

Exhibit 110, pdf pg. 113-116

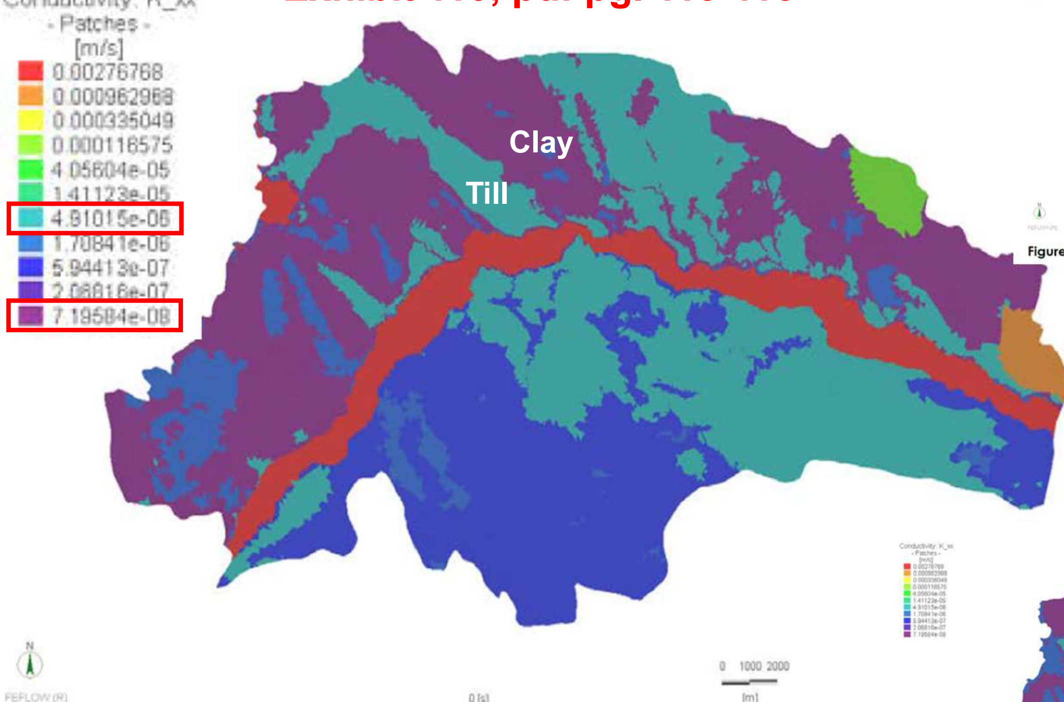


Figure 4-5 Hydraulic Conductivity Distribution in Layer 1

No sand & gravel added for the unnamed creek, leading to a concern regarding groundwater pathway constraints.

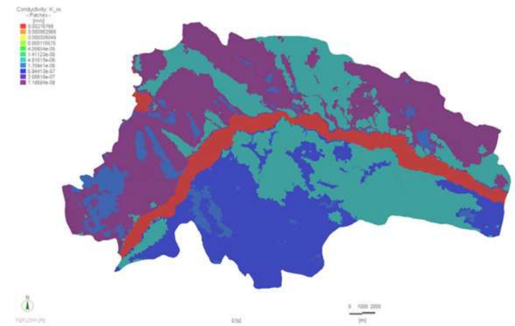


Figure 4-6 Hydraulic Conductivity Distribution in Layer 2

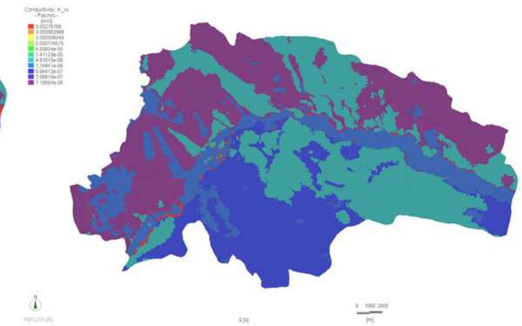


Figure 4-7 Hydraulic Conductivity Distribution in Layer 3

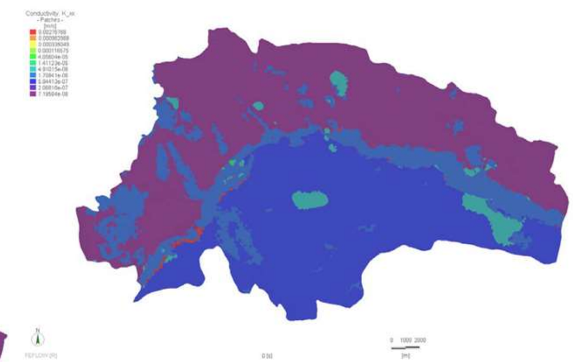


Figure 4-8 Hydraulic Conductivity Distribution in Layer 4

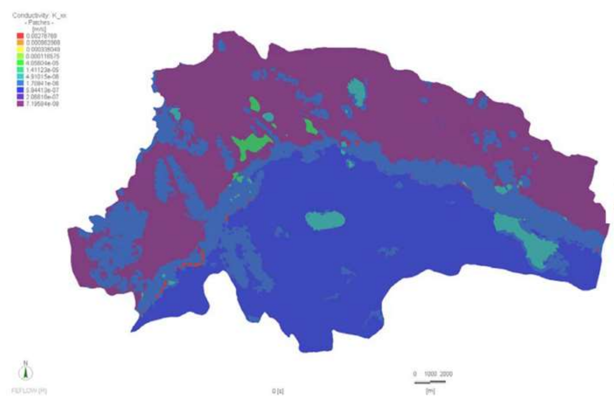
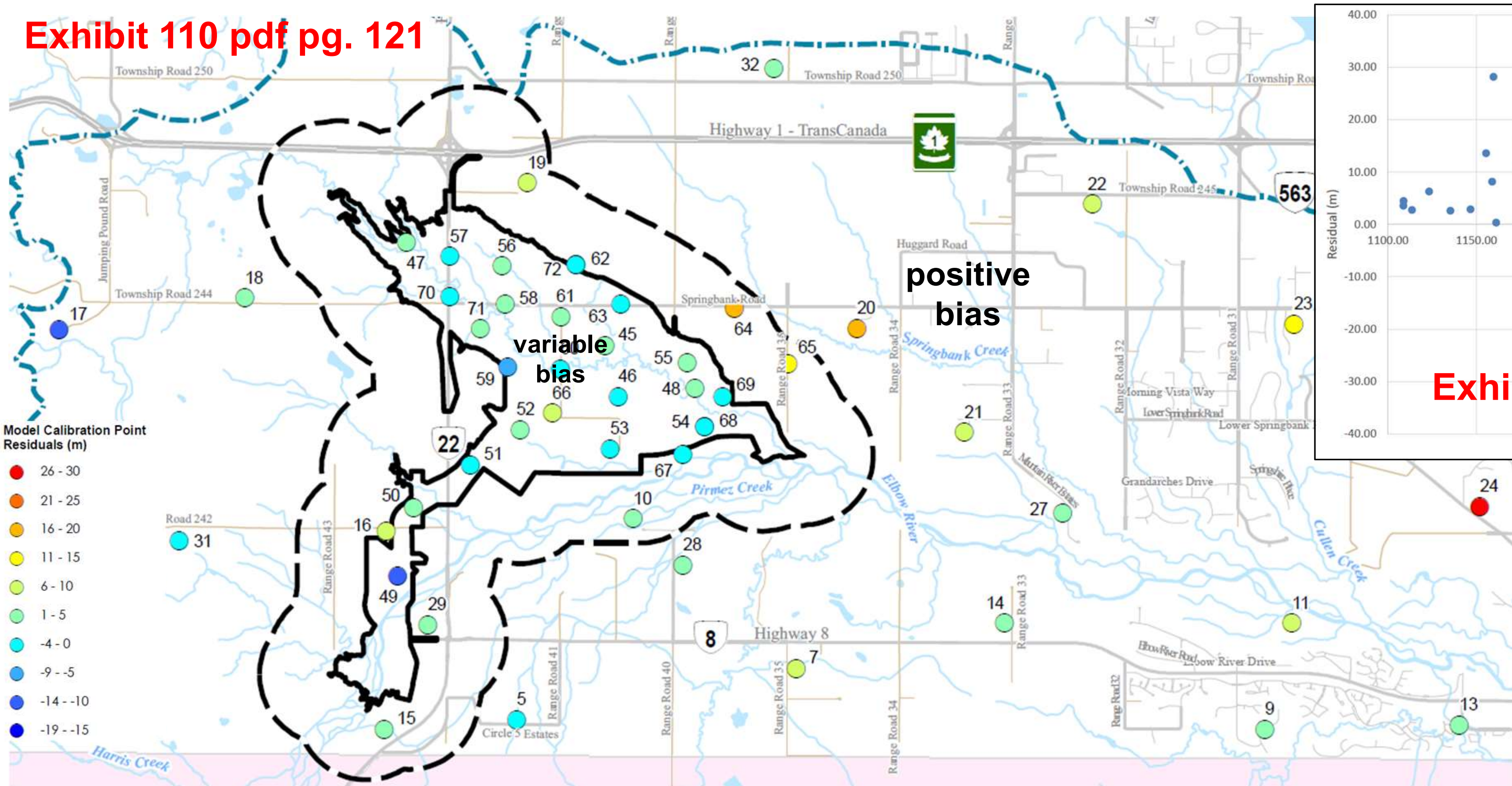
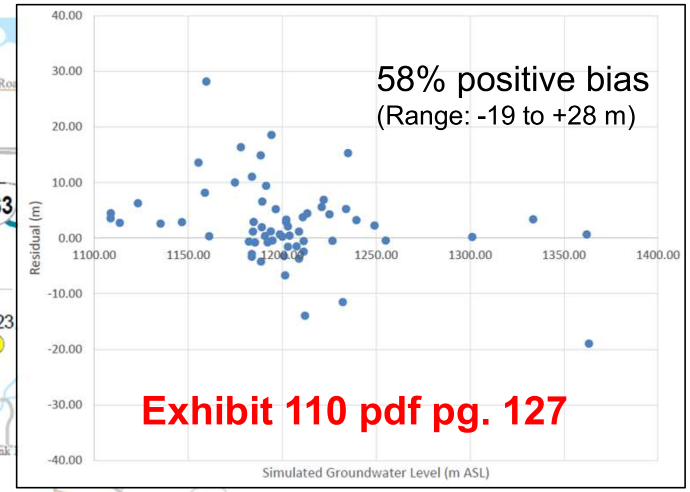


Figure 4-9 Hydraulic Conductivity Distribution in Layer 5

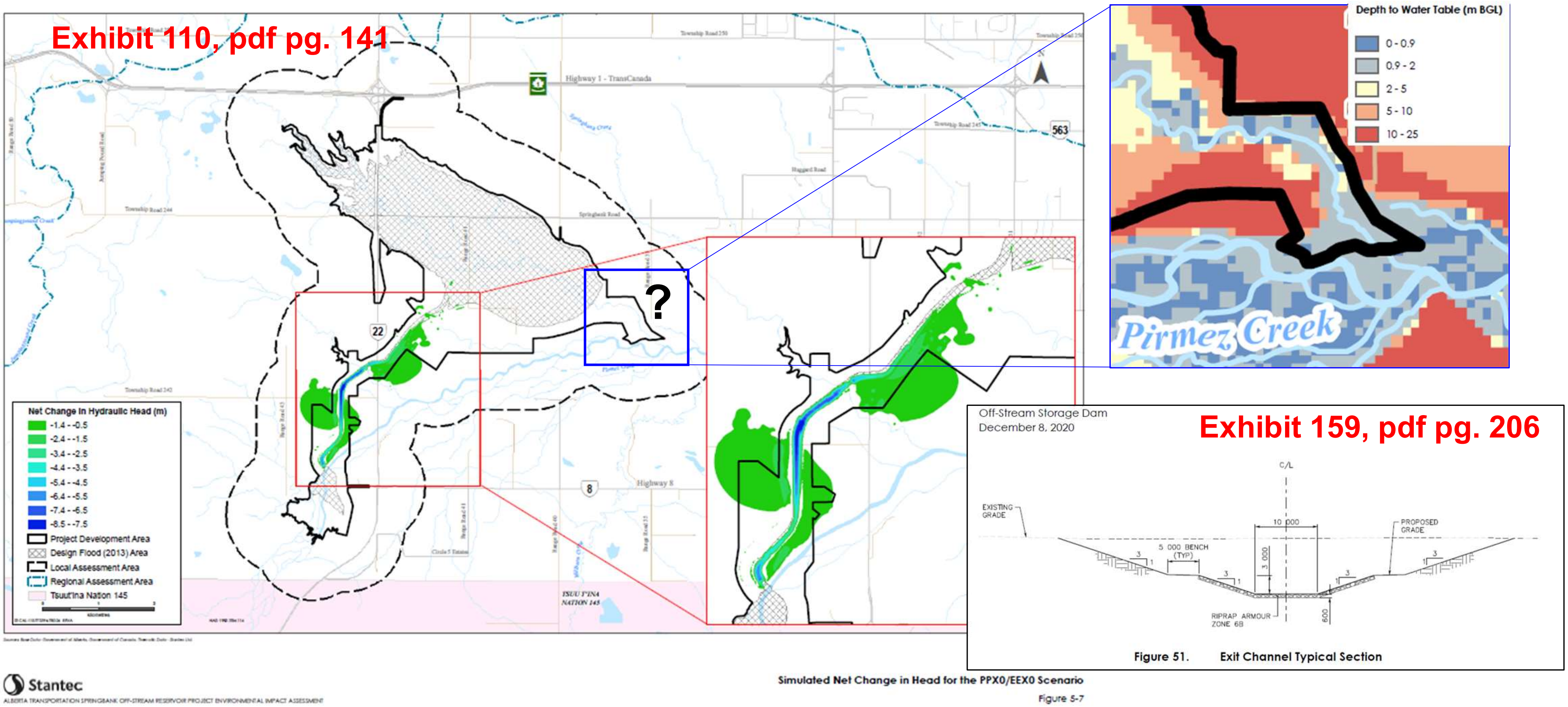
Model bias is apparent





Despite contention that model results are acceptable, evidence of "positive bias" exists for calculated residuals, plus some spatial bias to higher residuals east of the SR1 indicating issues within model domain (reduced confidence).

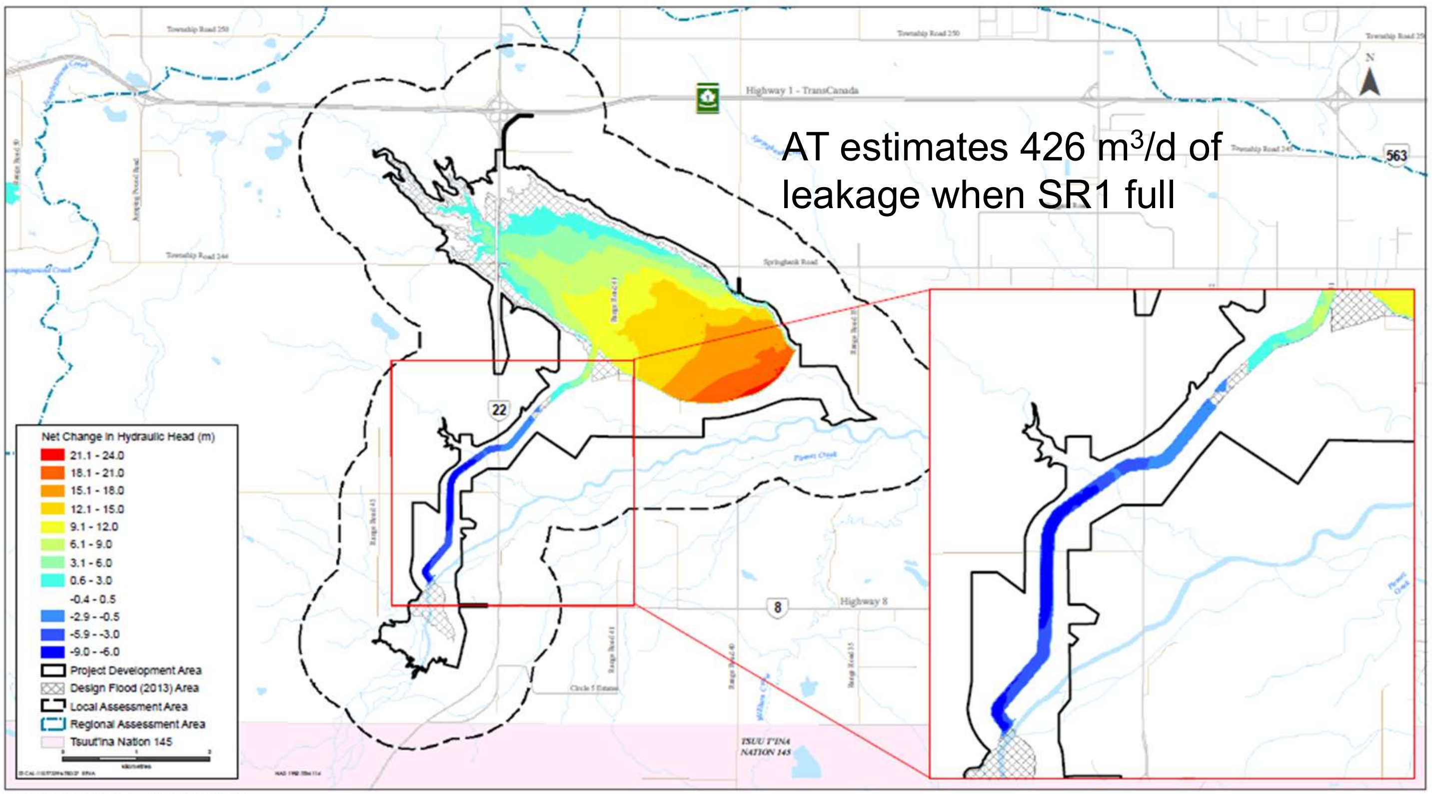
Drawdown impact discrepancy



No drawdown impact identified around the SR1 outlet, even when an excavation 7 m or more below the water table is in place *(likely due to low K values selected)*.

Modelled head increase & leakage estimates

Exhibit 110, pdf pg. 149



Stantec
ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Simulated Net Change in Head for the PPX1/EEX1 Scenarios at Timestep 650
Figure 5-13

Increase in head of up to 24 m over areas + high depth to groundwater = greater leakage potential from SR1 when full or partially filled.

- Higher leakage estimates obtained when more appropriate K values used *(analytical calculations suggest over 100,000 m³/d; even more if "Till-high conductivity North" values in Table E.1-2 used)*

- Greater flushing of contaminants from or through clay/tills to bedrock and connected systems *(e.g. outlet channel to Elbow River)*

Mapped vertical flow gradients

Exhibit 110, pdf pg. 74

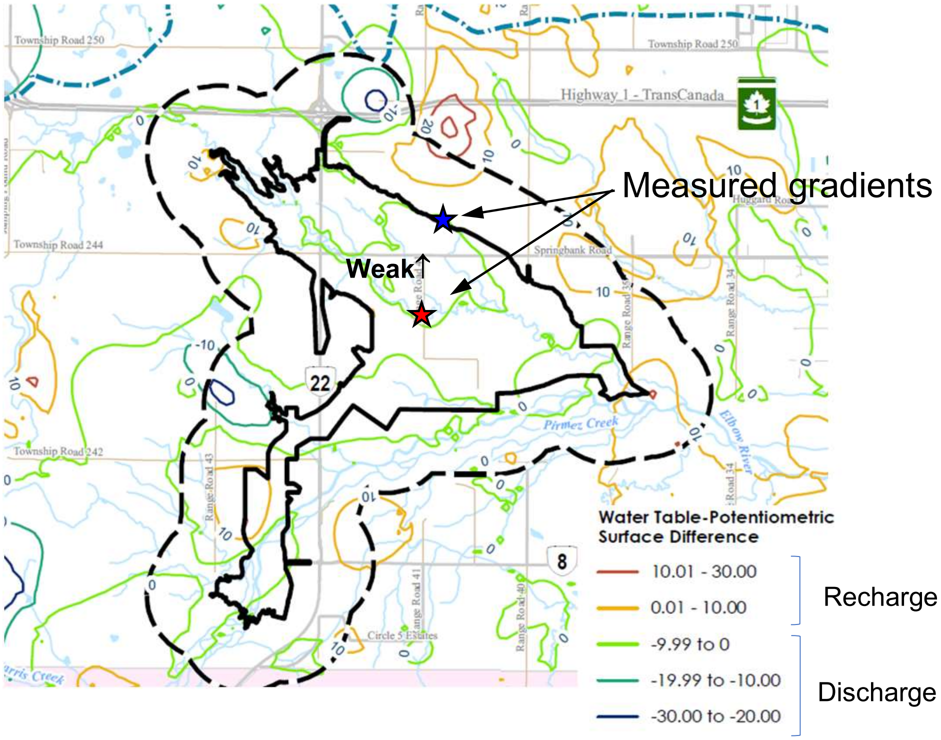
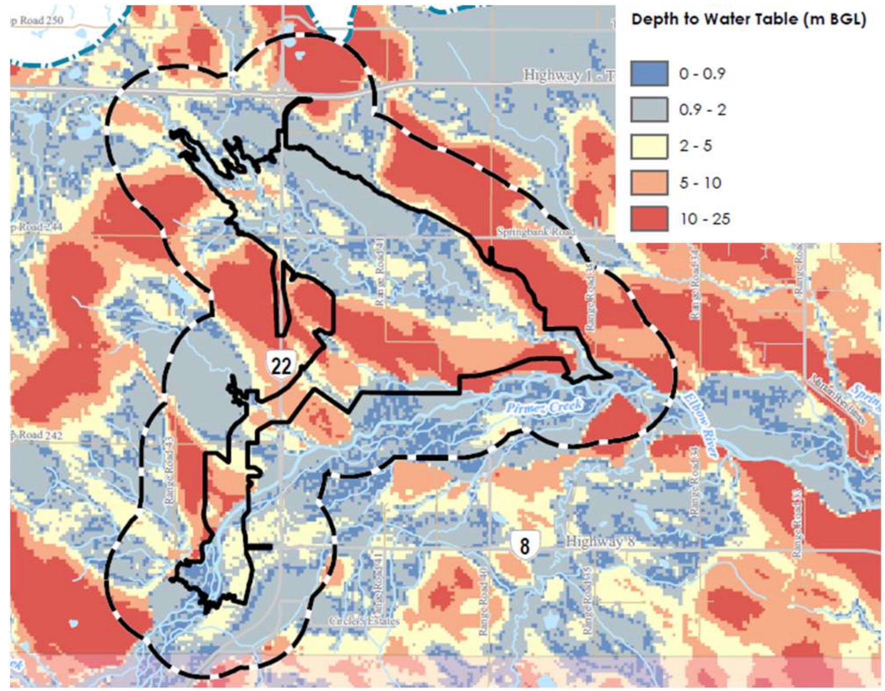


Exhibit 110, pdf pg. 75

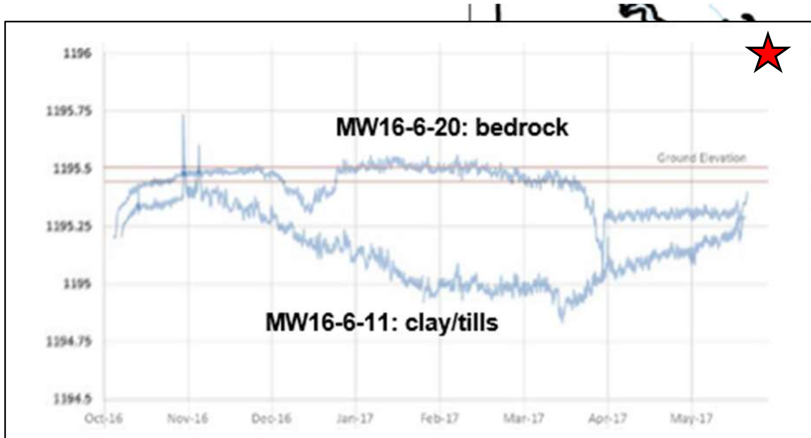


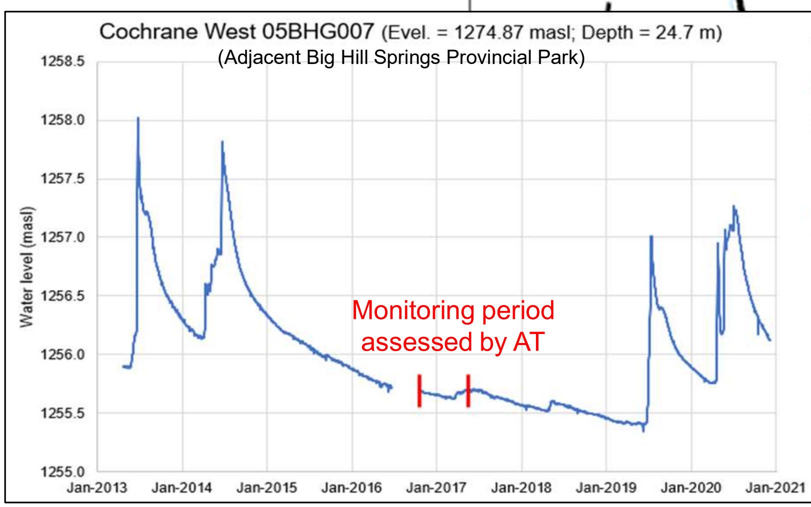
Mapping of vertical flow potential *(i.e. water table elevation minus potentiometric surface for bedrock)* indicates weak upward gradient beneath SR1, and variable conditions around perimeter.

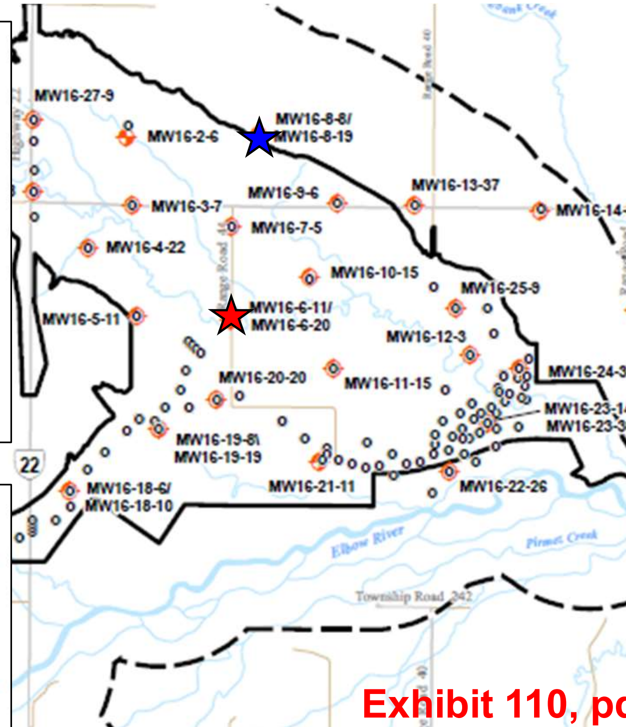
Depth to water table generally greater than 1 m, and up to 10 m or more in some locations.

Variable measured vertical flow gradients

Exhibit 110, pdf pg. 78-80







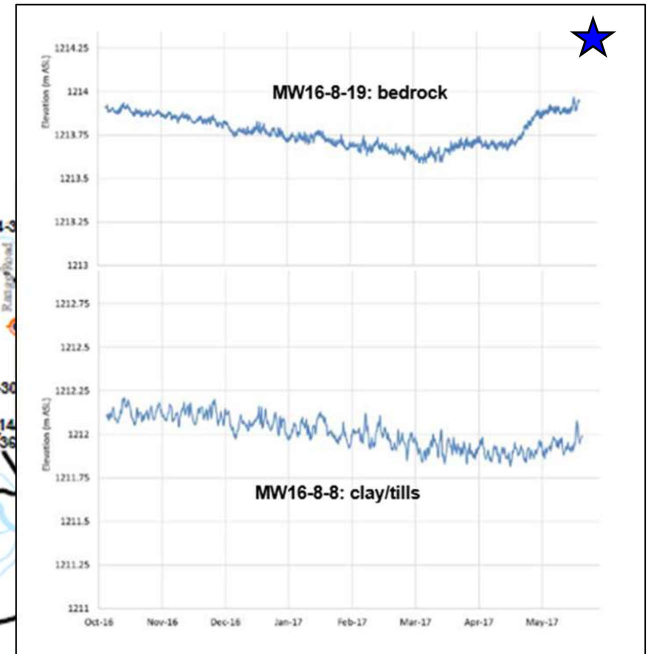


Exhibit 110, pdf pg. 18

Assumption that flow gradients are consistently upward from the bedrock to clay/tills *(as stated in Exhibit 327 pdf pg. 46)* is challenged by lack of monitoring record. Possibility of long-term sustained gradient reversal exists.

Geotechnical concerns

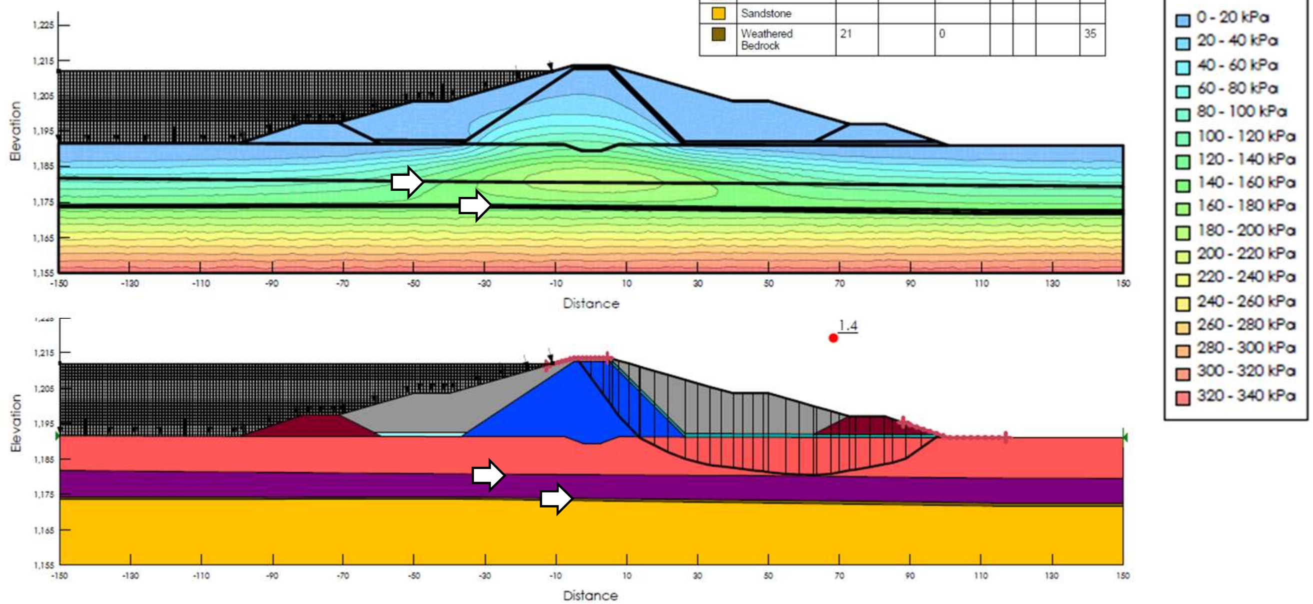
From Exhibit 178, pdf pg. 408 & 409

Stantec

Alberta Transportation SR1 Storage Dam

Section 22+500
Load Case: End Construction, Year 3, Flood
Total Stress Parameters
Incipient Motion in the Downstream Direction

Color	Name	Unit Weight (kN/m³)	Cohesion Spatial Fn	Cohesion' (kPa)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (kPa)	Phi' (°)
	Drain	21		0				33
	Embankment Core (Undrained)	20		0	28	19	427	
	Embankment Shell (Undrained)	20		0	24	15	141	
	Glacial Till (Undrained)	18		0	27	19	363.2	
	Glacio-Lacustrine (Undrained)	18	Undrained GL					0
	Granular Zone	21		0				33
	Rock Toe	20		0				33
	Sandstone							
	Weathered Bedrock	21		0				35



Increase in subsurface porewater pressures due to external loading *(dam materials + water)* is a concern with respect to possible shear-slip at interface between soil/rock or in weak soil intervals *(i.e. montmorillonite-rich layers)*.

Exhibit 327 pdf pg. 45

on groundwater if hydraulic conductivity values were increased by a factor of 1,000 above the best estimates previously noted. In addition, effects on pore pressures were in fact examined under the most conservative scenario, where the complete external loading due the 'weight of the water' impounded in the reservoir was applied directly to the underlying bedrock, assuming that none of this external load would be borne by the overlying clays/tills. Further conservatism was added by conducting these simulations under steady state conditions, representing the scenario where water in the reservoir is held indefinitely.

Connectivity of clay/tills and bedrock *(chemical evidence)*

From App IR42-1
Exhibit 110
Pdf pg.92

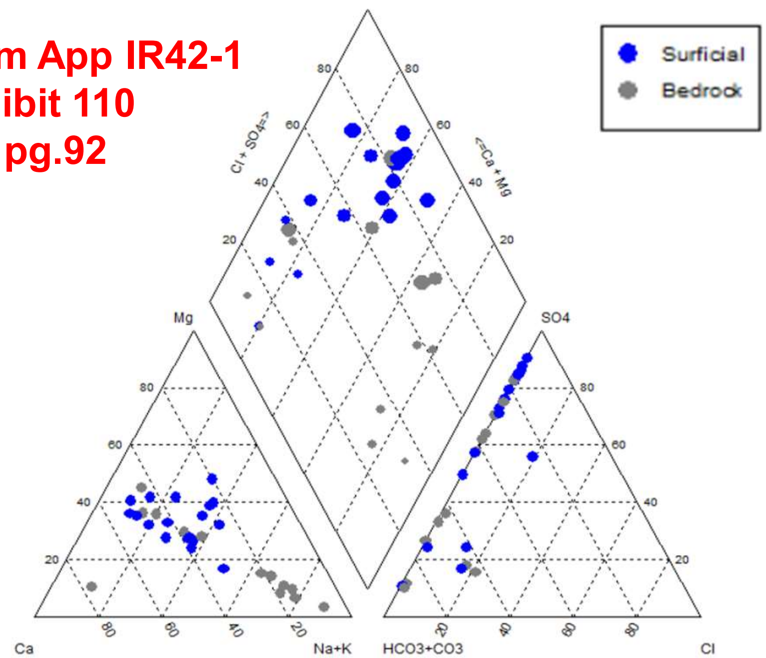


Figure 3-30 Diagram of Monitoring Well Chemistry

Statistical comparison of TDS

▼Nonparametric: Sign Test

Sign Test Results
Counts of Differences (row variable greater than column)

Two-Sided Probabilities for each Pair of Variables

	TILL_CLAY	BEDROCK
TILL_CLAY	1.000	
BEDROCK	0.424	1.000

▼Nonparametric: Wilcoxon Signed-Rank Test

Wilcoxon Signed-Rank Test Results
Counts of Differences (row variable greater than column)
Two-Sided Probabilities using Normal Approximation

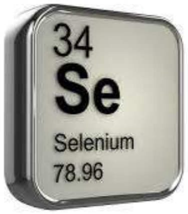
	TILL_CLAY	BEDROCK
TILL_CLAY	1.000	
BEDROCK	0.074	1.000

Similarity in major ion composition for groundwater in clay/tills and bedrock intervals provides evidence of hydraulic connectivity.

Statement that no difference exists in TDS values *(Exhibit 327 pdf pg. 46 para.1)* for clay/till and bedrock waters is unsubstantiated based on statistical testing.

Water quality and risk to connected systems

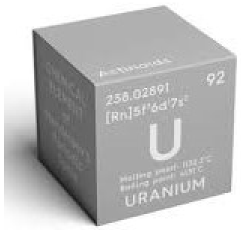
- Baseline assessment indicates the presence of selenium and uranium above safe levels for human consumption and protection of aquatic life; elevated nutrients *(i.e. organic & inorganic nitrogen)* and coliforms also documented.



- Impact from contaminant flushing from clay/tills intervals to bedrock and connected systems *(outlet channel drainage)* increases risk of impact when SR1 full or partially filled.

- Mobilization of additional contaminants possible from introduction of oxygenated waters *(enhanced reactions)*.

- Absolutely no assessment of:
  - *potential impact to groundwater quality*
  - *actual redox state of the groundwater (oxidizing v. reducing)*
  - *possible geochemical changes or transport & fate characteristics*



The assumption that water quality will not be an issue prevails, but remains unassessed and unresolved.

Final considerations

- SR1 design does not address floods greater than the 2013 event (a 1:200) which can be expected.
  - *MC1 is a superior option given its ability to manage higher magnitude floods (up to the PMF), protect all downstream communities, and store water for future drought mitigation (i.e. more in the public interest).*

- SR1 will increase the risk to human and ecological health due to:
  - *flushing/leakage of existing or accumulated contaminants to the underlying groundwater and connected systems*
  - *dust inhalation from a large open area of accumulated sediments (with associated contaminants)*

- SR1 only provides additional water security for the City of Calgary in flood years because:
  - *during prolonged drought conditions water levels in Glenmore reservoir will not likely be lowered as much in order to retained water for use*
  - *flood risk will be low due to lack of precipitation (including snowpack), so SR1 will not be needed to support operations at Glenmore reservoir*

Final considerations

- AB Transportation (AT) has not provided a sufficient level of assessment relating to the physical and chemical hazards and related risks posed by SR1.
- AT should have assessed these hazards more fully to ensure that all stakeholders have the information necessary to fully understand the risks poses to the surrounding community and receiving environment.
- AT has relied on models to frame the hydrogeological risk of SR1, but nothing has been done to address geochemical risk.
    - *It is also important to remember that models are only as good as the information used, understanding of the site, and skill of the modeller. They are non-unique and inherently inaccurate (but sometimes useful).*
- AT is relying on monitoring to address the information gaps noted. Monitoring is not mitigation, and often times when an issue is detected it is too late. That is why worst-case assessment is important.

Final considerations

- Many, if not all, of the issues related to SR1 would disappear if the MC1 option had been advanced.
- At the very least the proponent should be compelled to undertake more assessment work to provide the information necessary to facilitate a good decision in the public interest.

Thank you.