Hydrology research in Christmas Brook Watershed
Update March 21, 2024
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Dal Team

Lauren Somers

- Assistant Professor
- Hydrology researcher
- Teaches in environmental and civil engineering program at Dal.

Reid Dauphinee

- MASc Candidate
- Thesis focused on Christmas Brook watershed and how water moves through it.

Julia Gillette

- Undergraduate and incoming MASc student
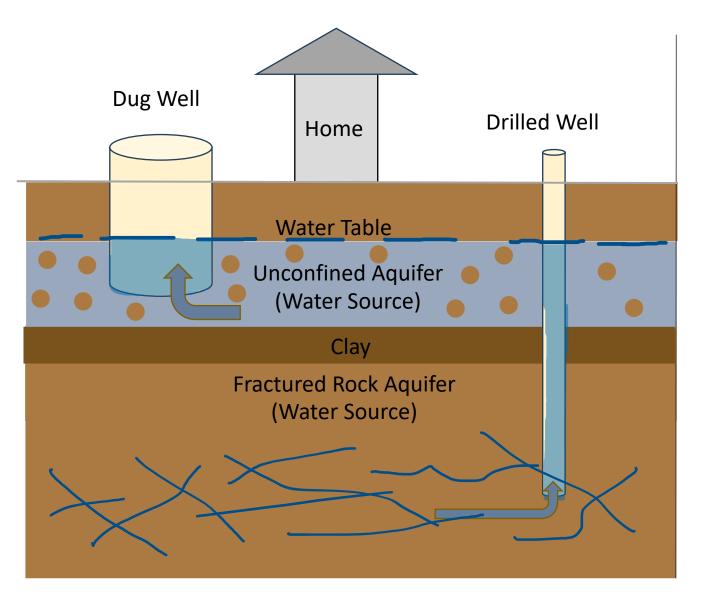- Research focused on climate change impacts on groundwater recharge in Eskasoni aquifer.
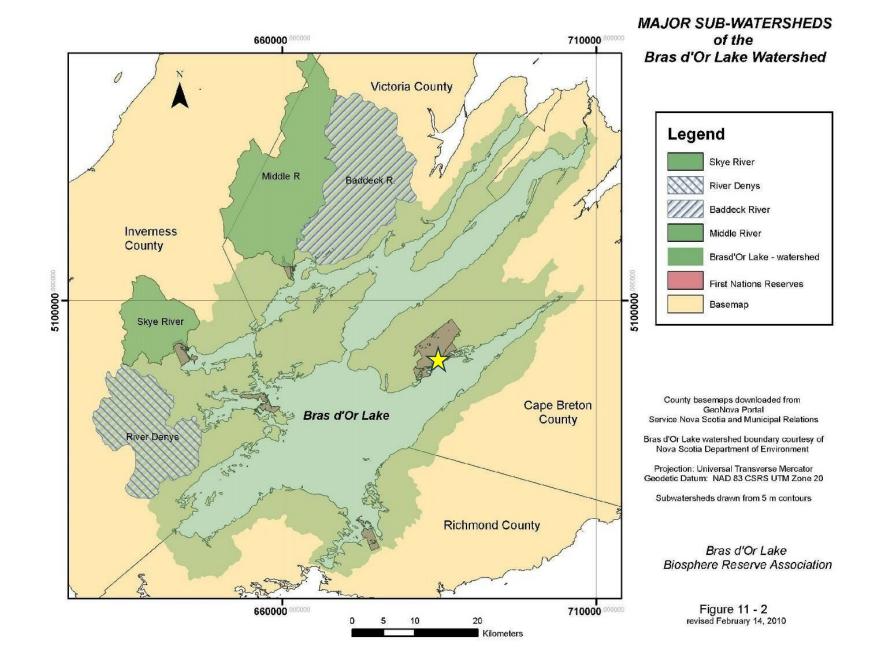
In Partnership

Groundwater Resources

- ~50% of Nova Scotia relies on groundwater for water supply. Groundwater systems can be complex and difficult to observe, especially in rugged topographic settings, complex geology and cold regions.
- Our research seeks to develop hydrological understanding of groundwater systems and support source water protection.
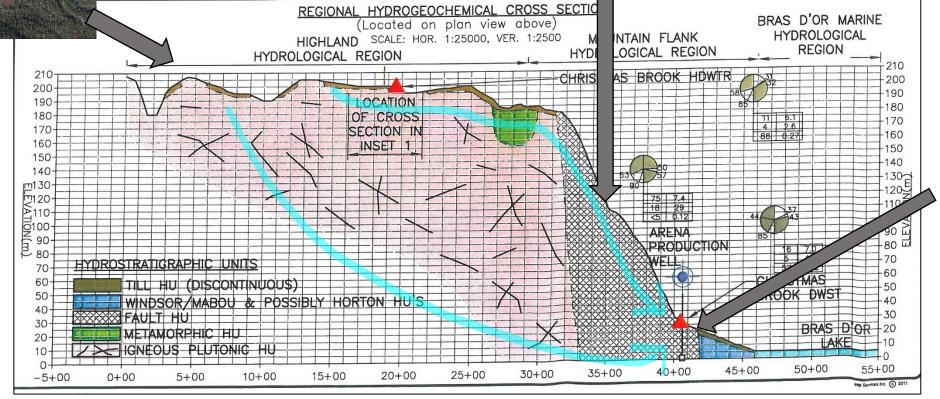
Study Area

MAJOR SUB-WATERSHEDS
of the
Bras d'Or Lake Watershed

660000

710000

Victoria County

Middle R

Baddeck R.

Inverness County

5100000

Skye River

Bras d'Or Lake

River Denys

Cape Breton County

Richmond County

5100000

Legend

- Skye River
- River Denys
- Baddeck River
- Middle River
- Brasd'Or Lake - watershed
- First Nations Reserves
- Basemap

County basemaps downloaded from
GeoNova Portal
Service Nova Scotia and Municipal Relations

Bras d'Or Lake watershed boundary courtesy of
Nova Scotia Department of Environment

Projection: Universal Transverse Mercator
Geodetic Datum: NAD 83 CSRS UTM Zone 20

Subwatersheds drawn from 5 m contours

Bras d'Or Lake
Biosphere Reserve Association

Figure 11 - 2
revised February 14, 2010

660000

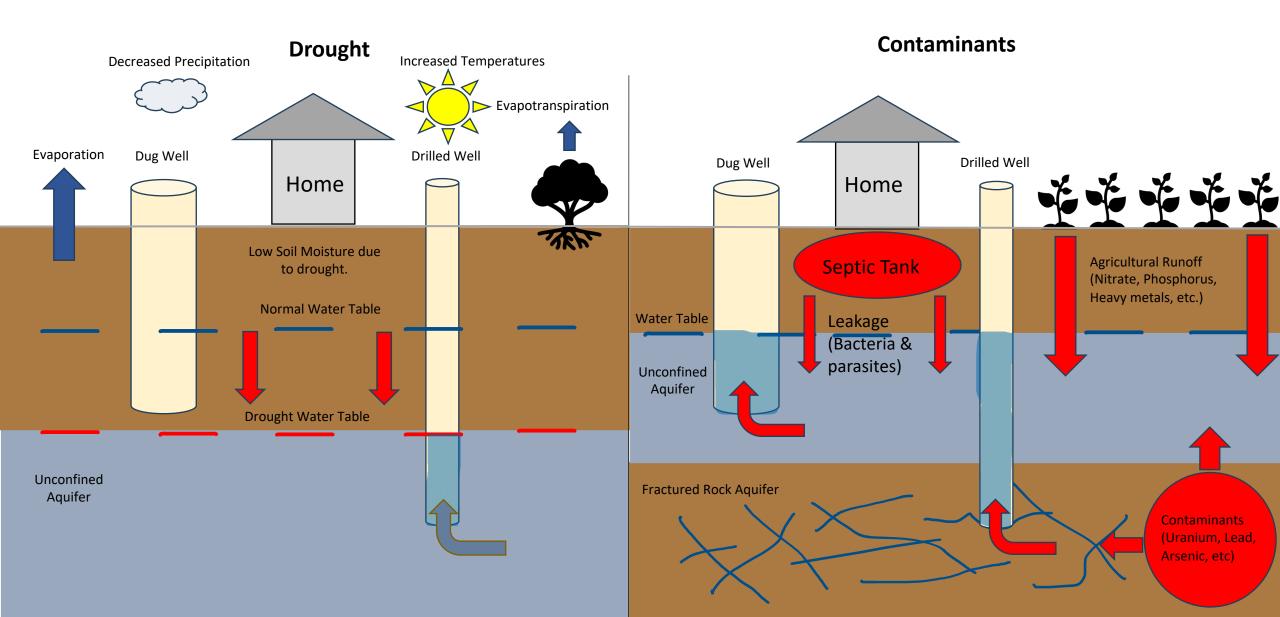710000

0   5   10   20
Kilometers

Christmas Brook

Baechler, 2012

Vulnerability of Groundwater

Research overview:

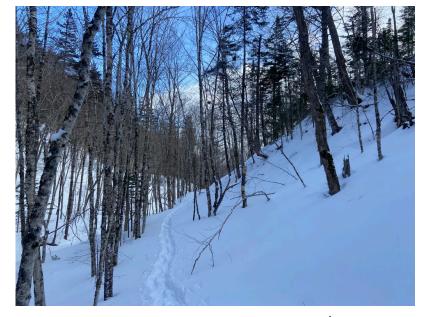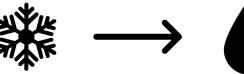**2022-2024: Develop hydrological understanding**

1. Monitoring streamflow, groundwater levels, water chemistry in Christmas Brook watershed.

2. Using those observations to determine how water moves through the watershed.

2024-2026: Understand climate change impacts

1. Determine if snowmelt or rain is a larger component of aquifer recharge and how a shift towards more winter rain (and less snow) may impact groundwater recharge.

2. Characterize the spatial extent and groundwater age of the fault aquifer

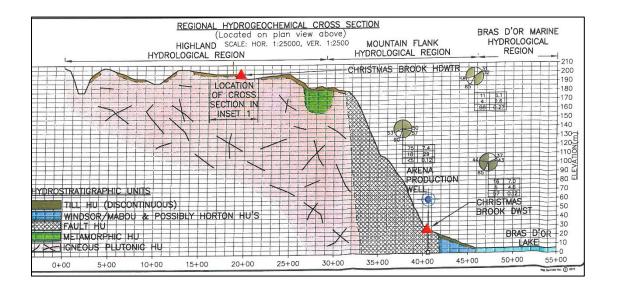3. Project climate change impacts on the hydrological system

Christmas Brook Watershed

Research questions

1. What are the main sources of Christmas Brook Streamflow? Lakes, wetlands, deeper groundwater, recent precipitation?
2. What are the main sources of groundwater recharge that feed the Arena Road production wells?

3. How can we use improved hydrologic understanding to support watershed protection/management?
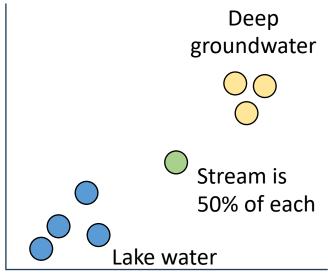
Methods

Hydrochemical mixing analysis

- Water from different sources has different chemistry
- Collect water samples and analyze the chemistry (ions, metals, isotopes)
- Use the chemical signatures to figure out major sources of streamflow and groundwater.

Hydrological modelling

- A computer model that represents how water moves through the catchment
- Monitor water inputs, outputs and storage in the watershed (Precipitation, streamflow, groundwater levels)
- Test different hypotheses about where water moves
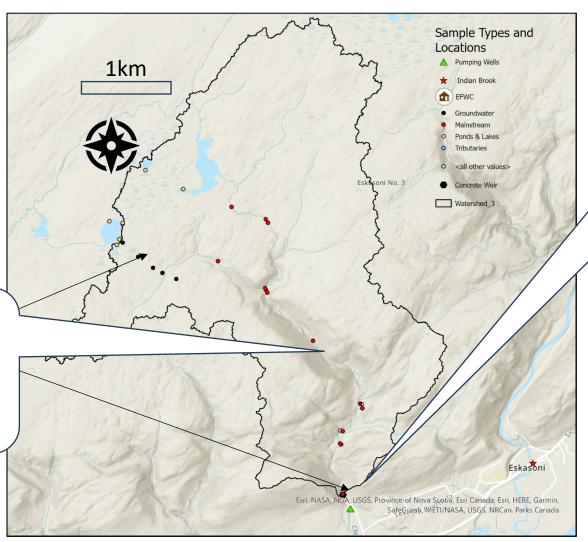
Magnesium concentration

Deep groundwater

Stream is 50% of each

Lake water

Calcium concentration

Water sampling

Water samples are collected from streams, ponds and wells in the watershed
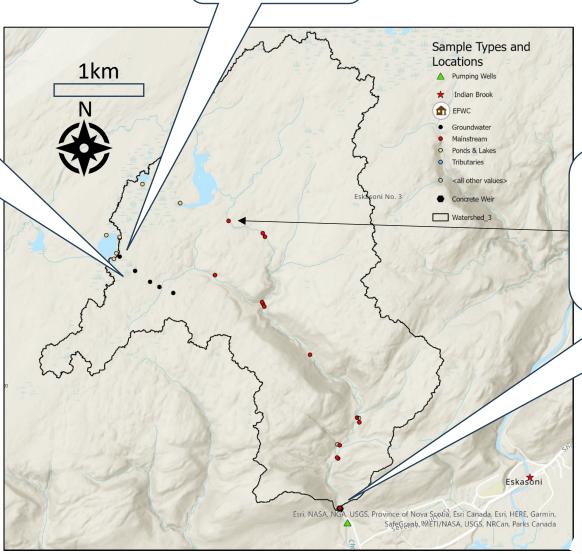
Precipitation is sampled monthly

Field monitoring

Weather station

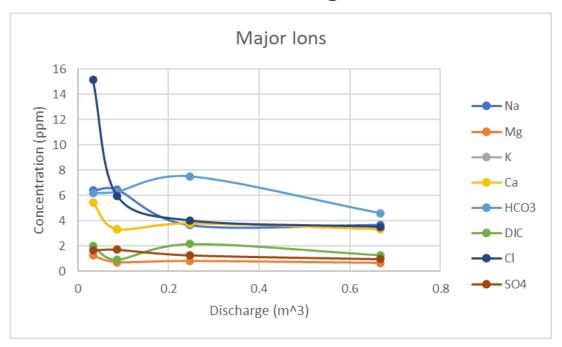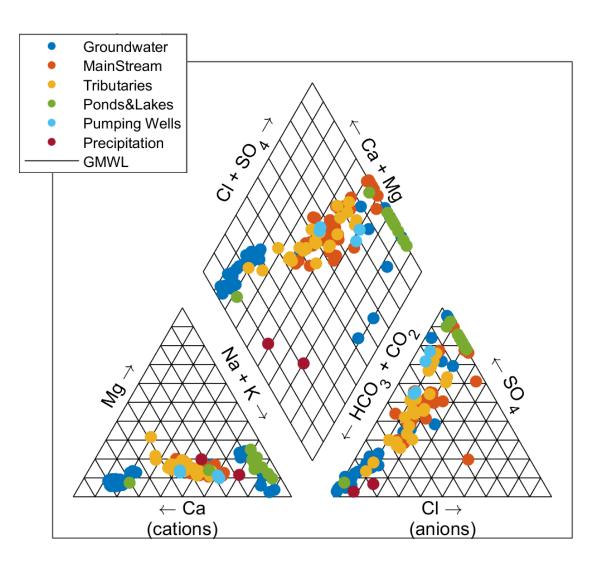Observation wells in the wetlands and bedrock record groundwater levels
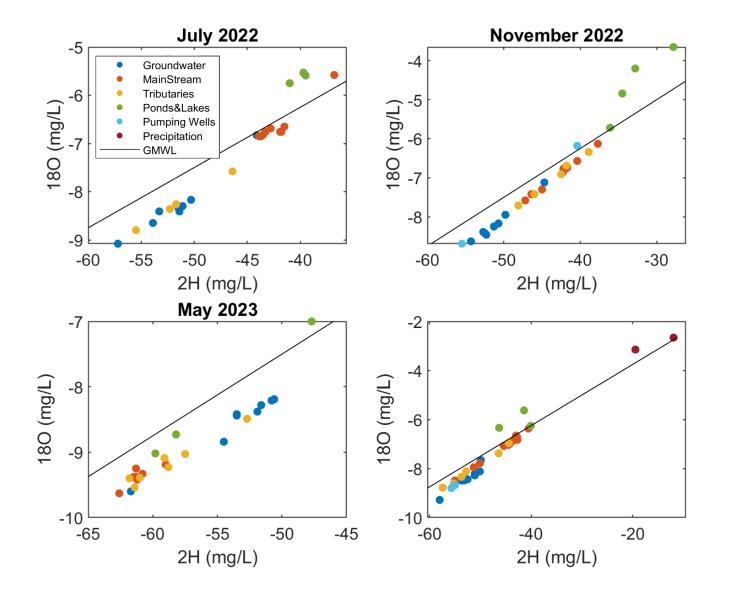
Stream gauges record streamflow at two locations

Sample Types and Locations

△ Pumping Wells
★ Indian Brook
⌂ EFWC
● Groundwater
● Mainstream
○ Ponds & Lakes
○ Tributaries
○ <all other values>
● Concrete Weir
▢ Watershed_3

1km

N

Eskasoni No. 3

Eskasoni

Esri, NASA, NGA, USGS, Province of Nova Scotia, Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, NRCan, Parks Canada

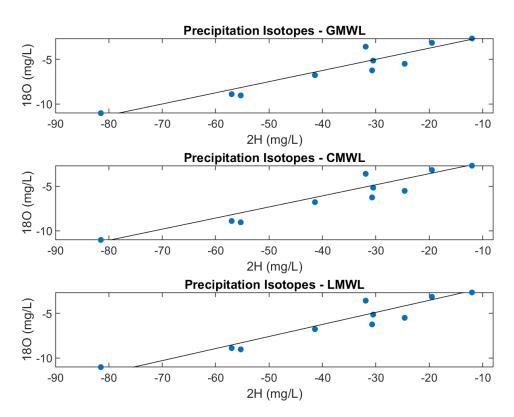DALHOUSIE

Results – Water ion chemistry

- Water sample chemistry clusters in groups according to their source.
- Low metals/ions concentrations overall. In some bedrock wells, elevated sodium, aluminum, calcium, manganese, iron.
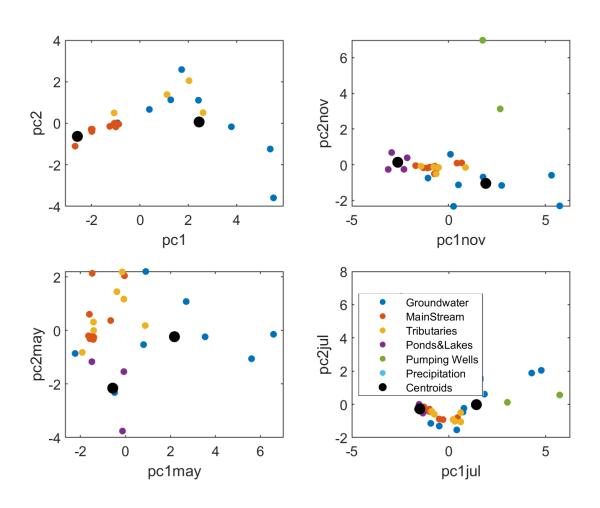
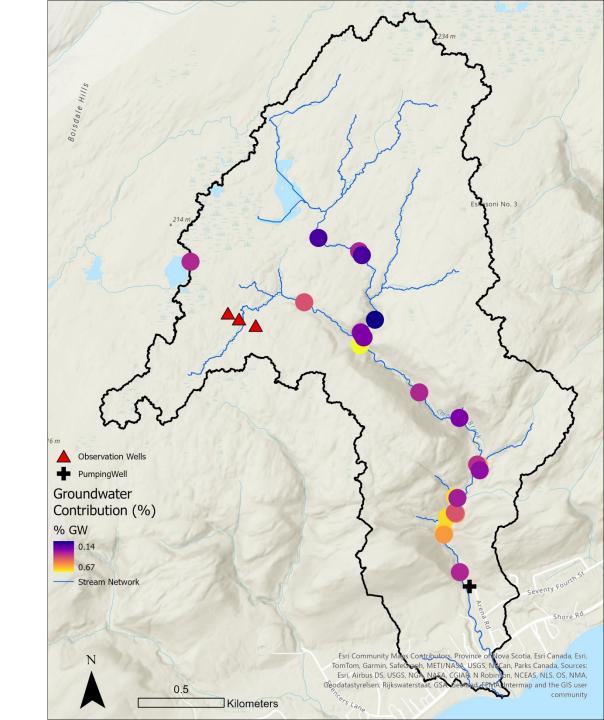# Results - Isotopes

Preliminary results - Mixing analysis

- Average stream composition is 40% groundwater, 60% ponds and lakes in the headwaters
- Pumping wells are chemically distinct
- Mixing model doesn't work with May dataset

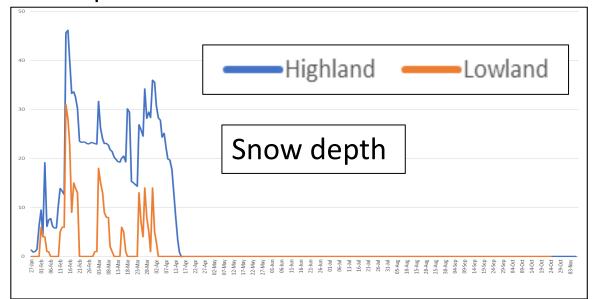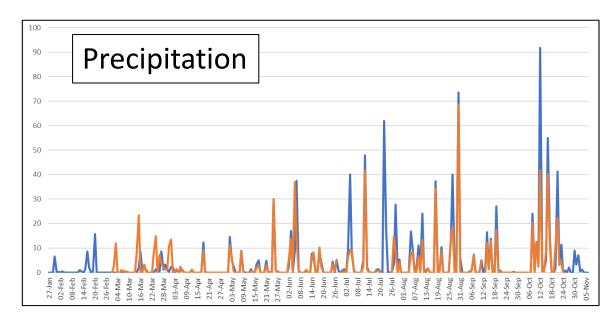| Campaign Date	Groundwater (%)	Ponds & Lakes (%)
July 2022	25	75
November 2022	43	57
May 2023	Invalid	Invalid
July 2023	33	67

Mixing analysis

- Percent groundwater averaged by sample location
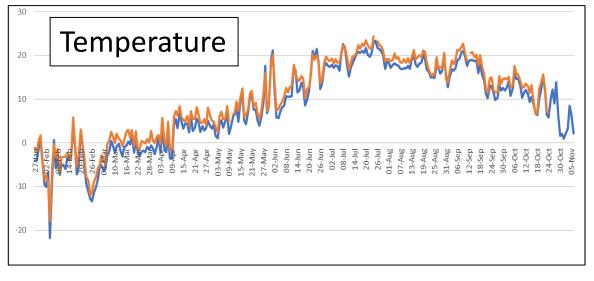
- Groundwater contribution ranges from 14-67%

Preliminary results - Weather Station Comparison

- Comparison between January 2023 to November 2023
- Highland weather station average temperature was 1.5º C less
- Highland station recorded an additional 273mm of precipitation over 11 months.
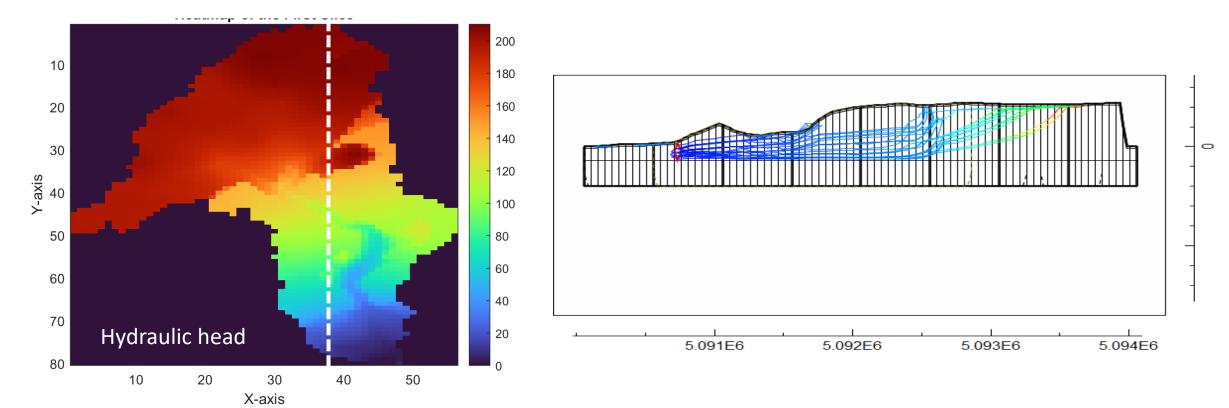- Highland station recorded 1260 cm more snowpack v time

Precipitation

Snow depth

Highland   Lowland

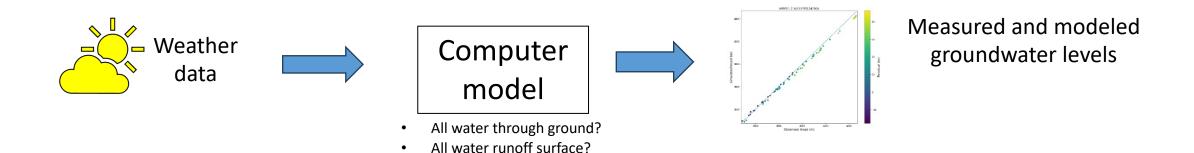Temperature

Hydrogeologic model

- MODFLOW: Groundwater flow model – simulating environmental conditions (physically based) to evaluate natural water movement
- MODPATH: particle tracking – postprocessing, computes specific flow paths using model output

Next steps

- **Hydro-chemical uncertainty analysis**: uncertainty estimate of end-member mixing using generalized likelihood uncertainty estimate (GLUE).

- **Hydrological Modeling:**
  - Model calibration using parameter estimation (PEST)
  - Transient model development

Weather data → Computer model
- All water through ground?
- All water runoff surface?

→ Measured and modeled groundwater levels

Thank You

✉ Lauren.Somers@dal.ca

🐦 @LaurenDSomers

Acknowledgements:

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