Hydrogeological Characterization in the Fox Creek Area

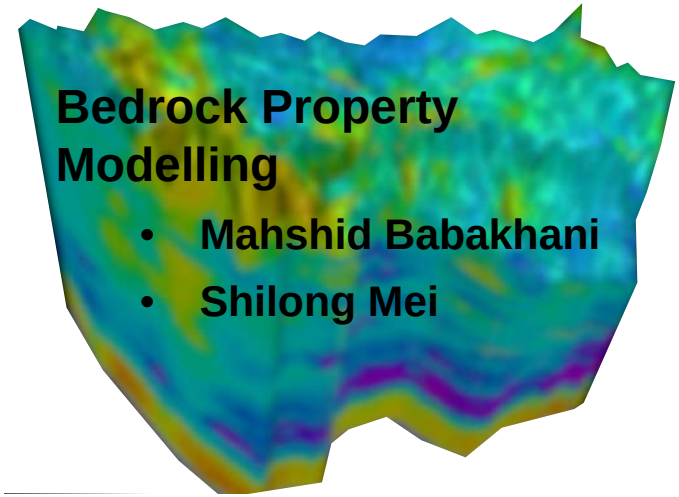
Brian Smerdon, *Alberta Geological Survey*

Mighty Peace Watershed Alliance Board Meeting
12 January 2018

AGS Project Team

Paleogene–Quaternary Stratigraphy

- Lisa Atkinson
- Greg Hartman



Bedrock Property Modelling

- Mahshid Babakhani
- Shilong Mei

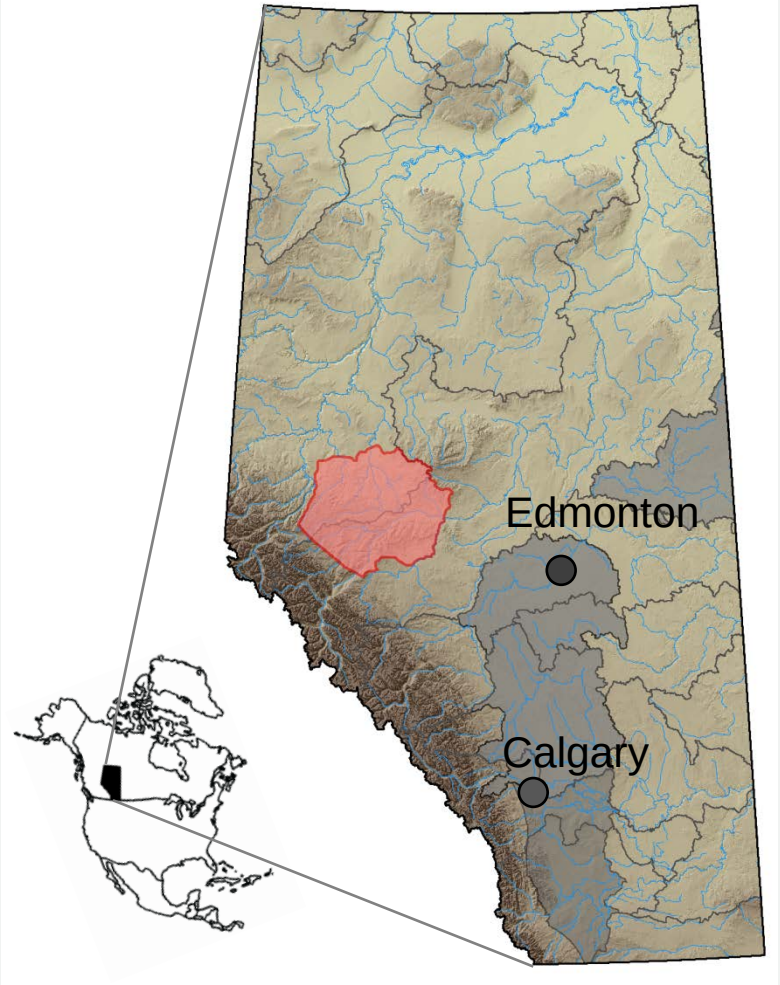
Deep Groundwater Mapping

- Nevenka Nakevska
- Jordan Brinsky
- Aman Singh

Hydrogeological Characterization

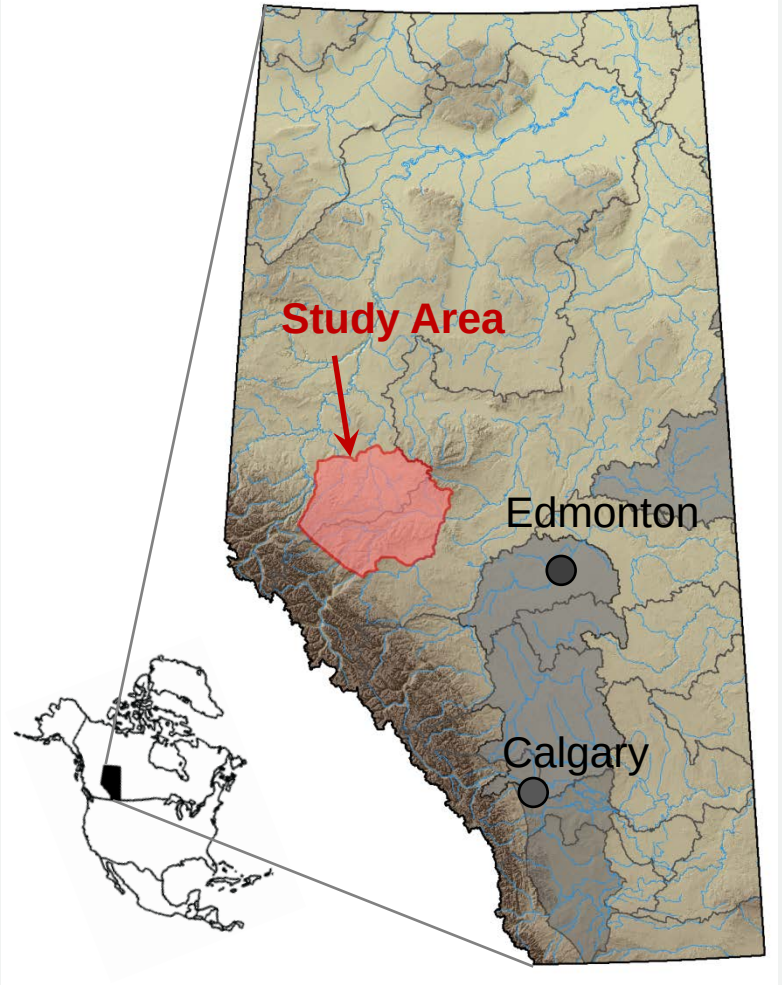
- Brian Smerdon
- Jeanette Klassen
- Alexandra Hughes

Provincial Groundwater Inventory Program



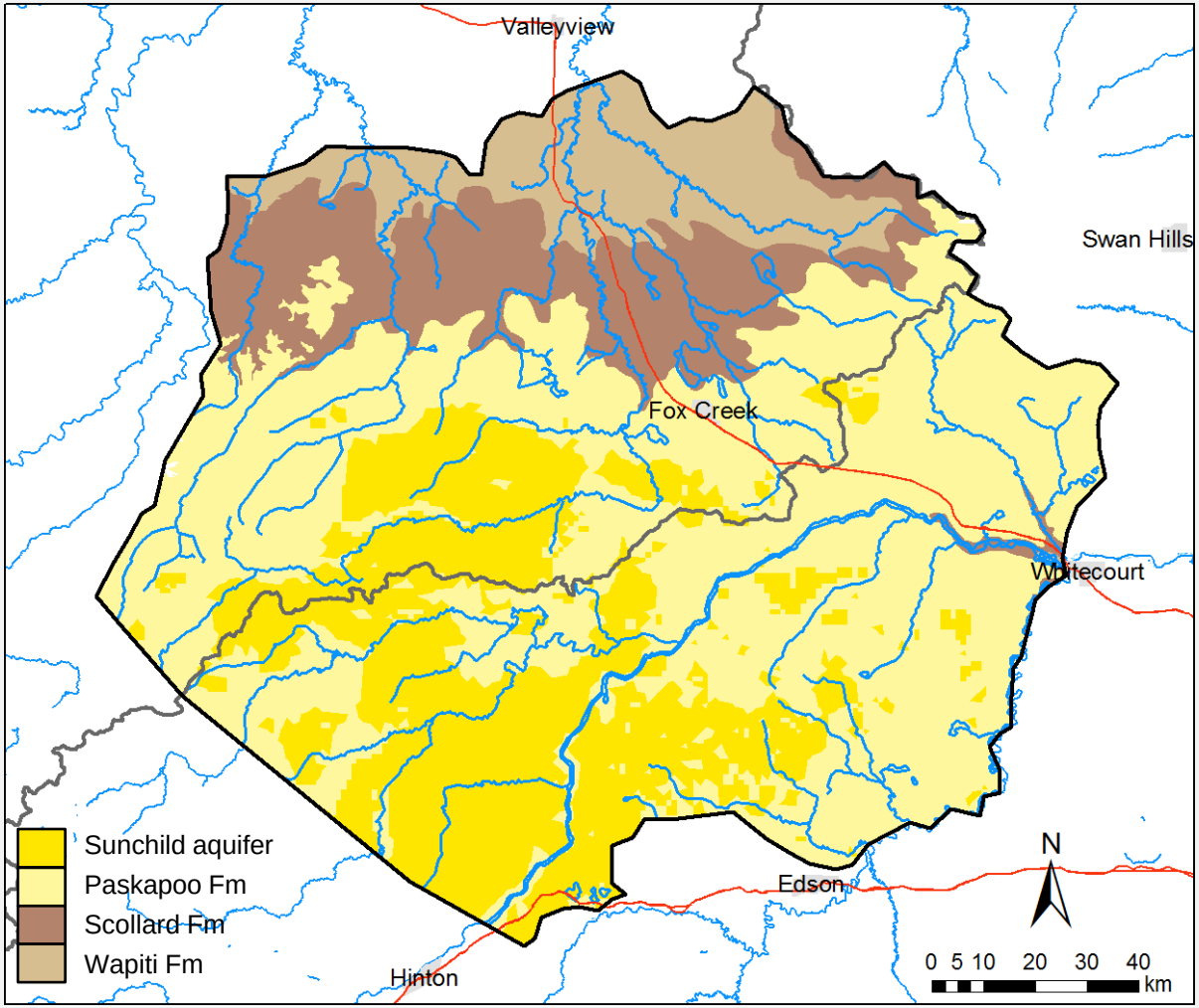
- Characterize Alberta's groundwater resources
  - Regional-scale mapping and inventory
  - Basis for assessing cumulative effects of development
- Ensure geoscience is meaningful at the 'regional' scale
  - Area-based regulation
  - Land-use planning regions
  - ~20,000 km^2

West-Central Alberta Project



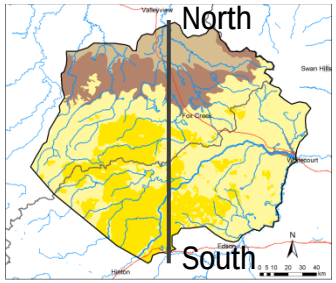
- Forested, relatively unpopulated region
- Unconventional hydrocarbon development
  - 30,000 to 50,000 m^3 water per well for hydraulic fracturing
  - Typically sourced from surface water and shallow groundwater
- Project approach
  - Hydrostratigraphic unit (HSU) mapping
  - Bedrock property modelling
  - Hydrogeology (flow patterns, TDS, groundwater residence time)
- **Develop conceptualization of groundwater circulation**

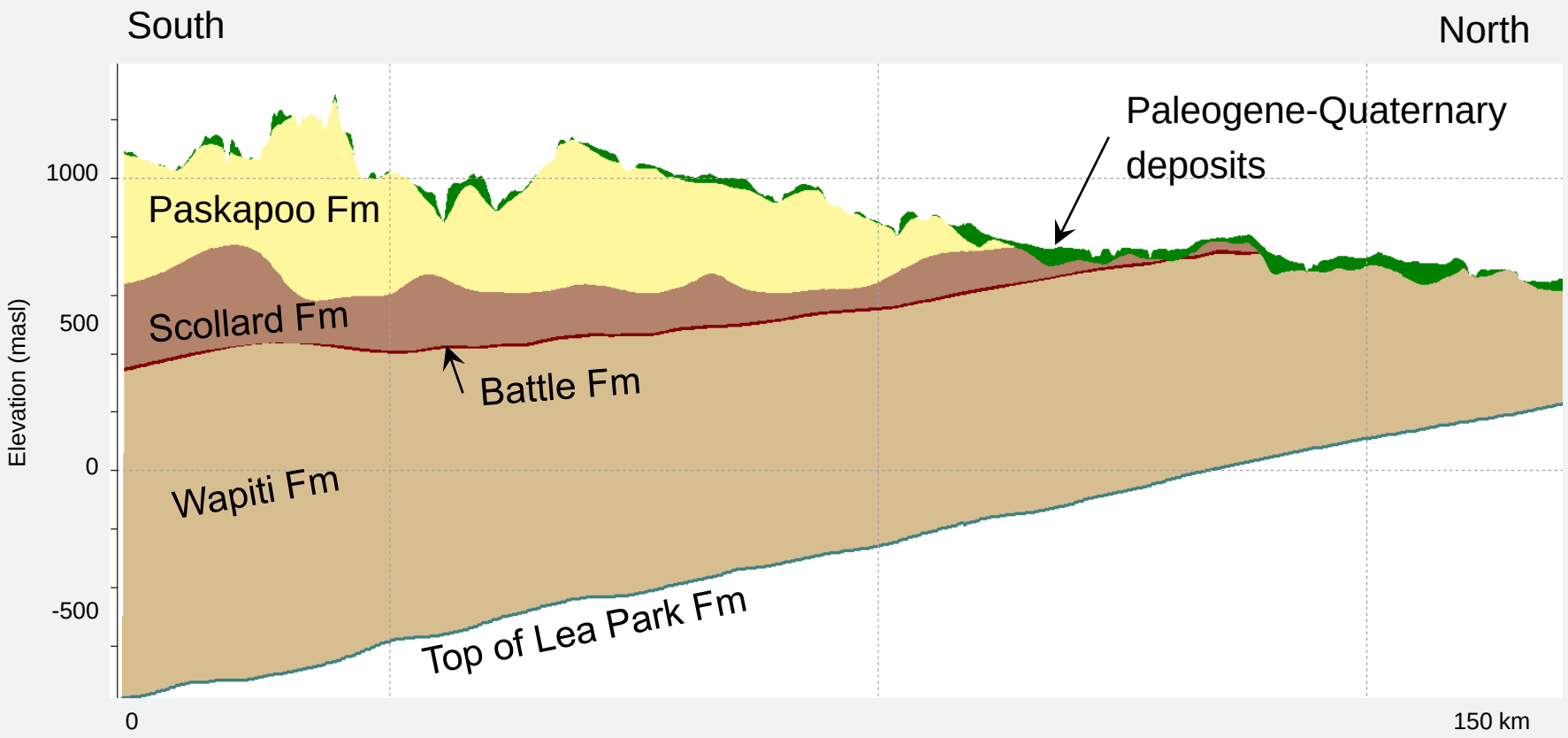
Study Area Extent



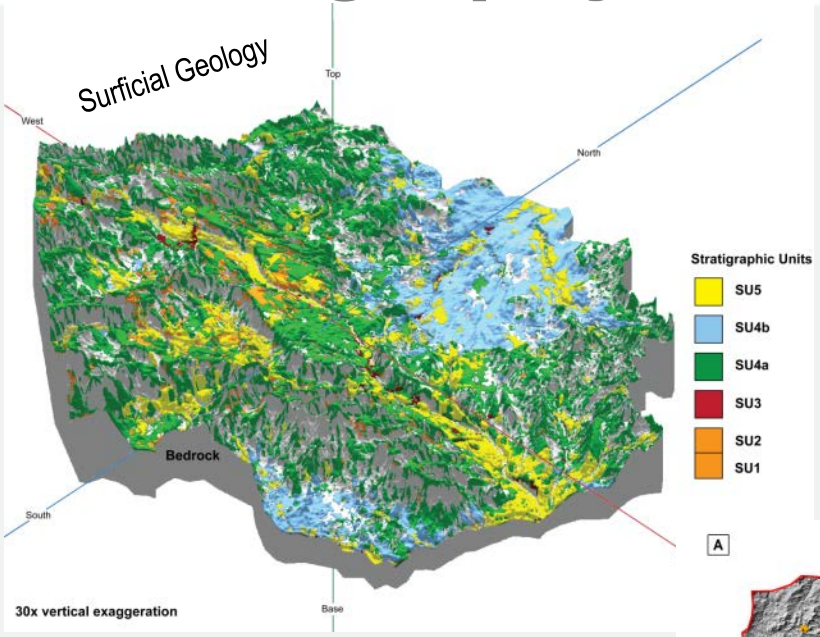
- Relatively shallow bedrock
- Uppermost bedrock forms a major aquifer system in Alberta
- Headwater rivers incised into bedrock
- 22,000 km^2

Study Area Depth Interval





Paleogene–Quaternary Stratigraphy



- Develop an understanding of the surficial geology
  - What does the subsurface container look like?
  - Describe the geology in 3D
  - Refine bedrock topography

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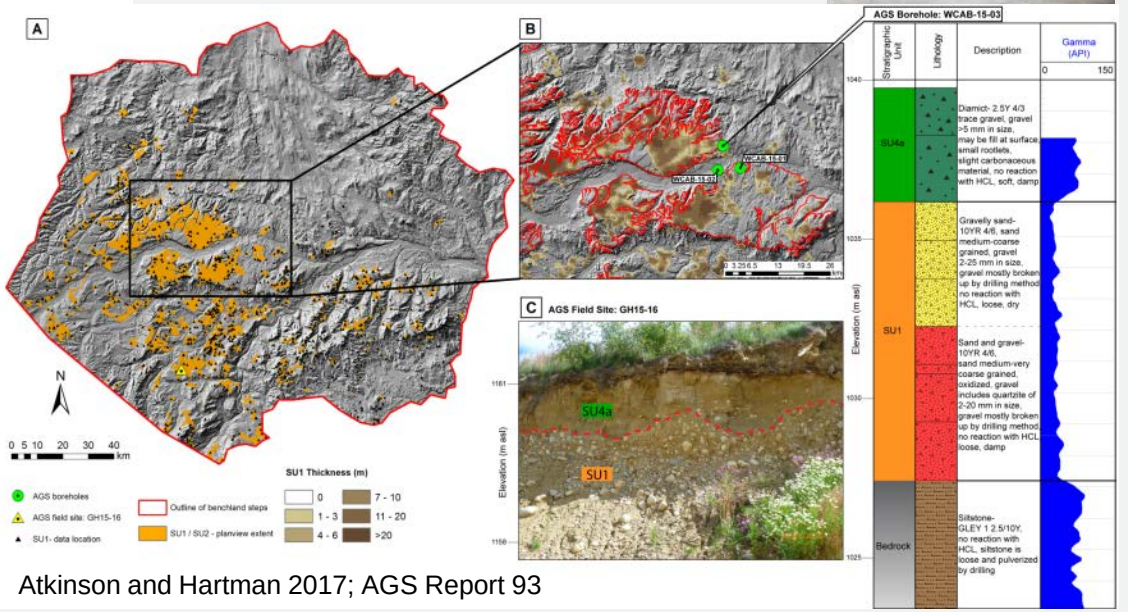
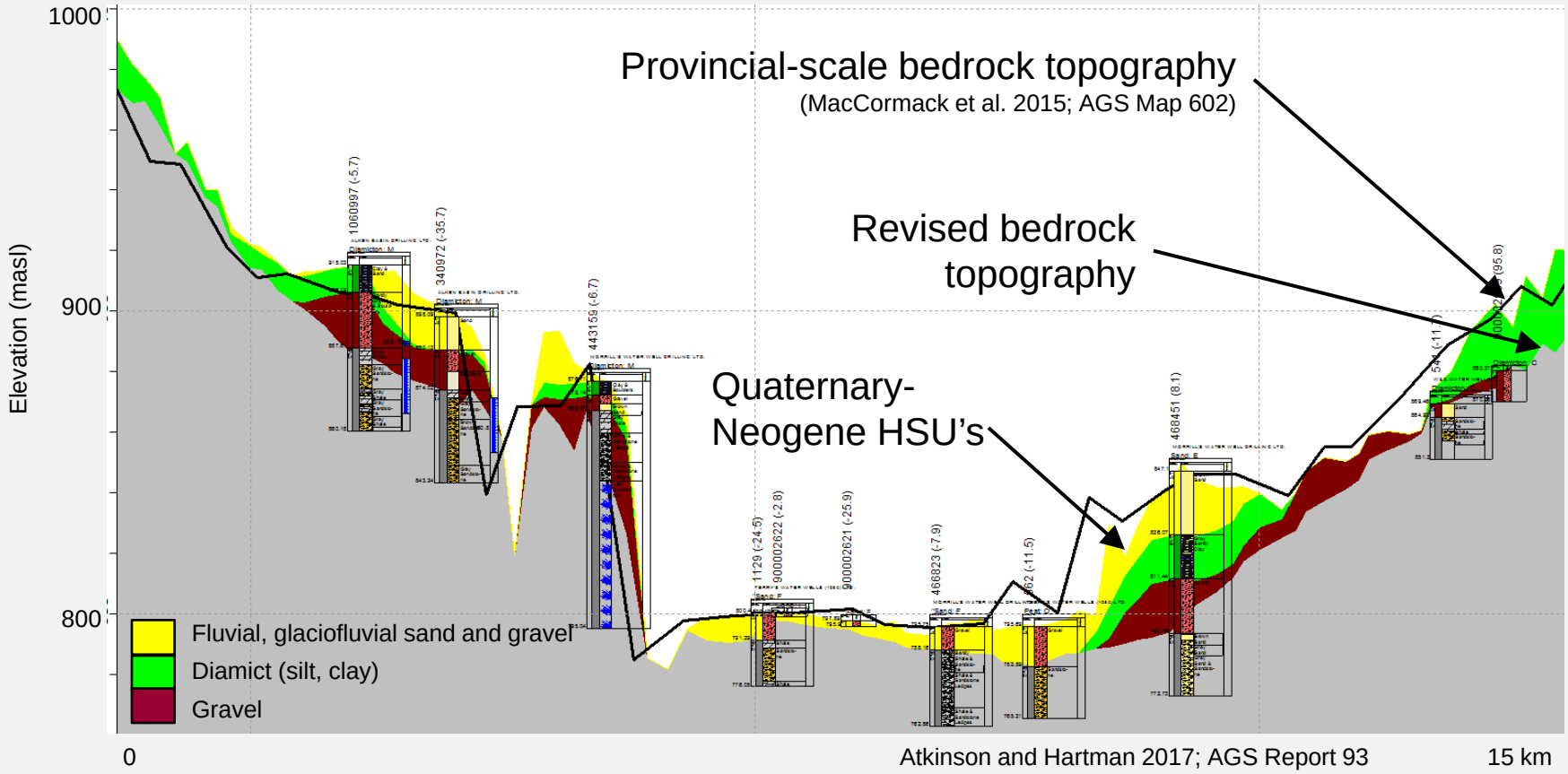
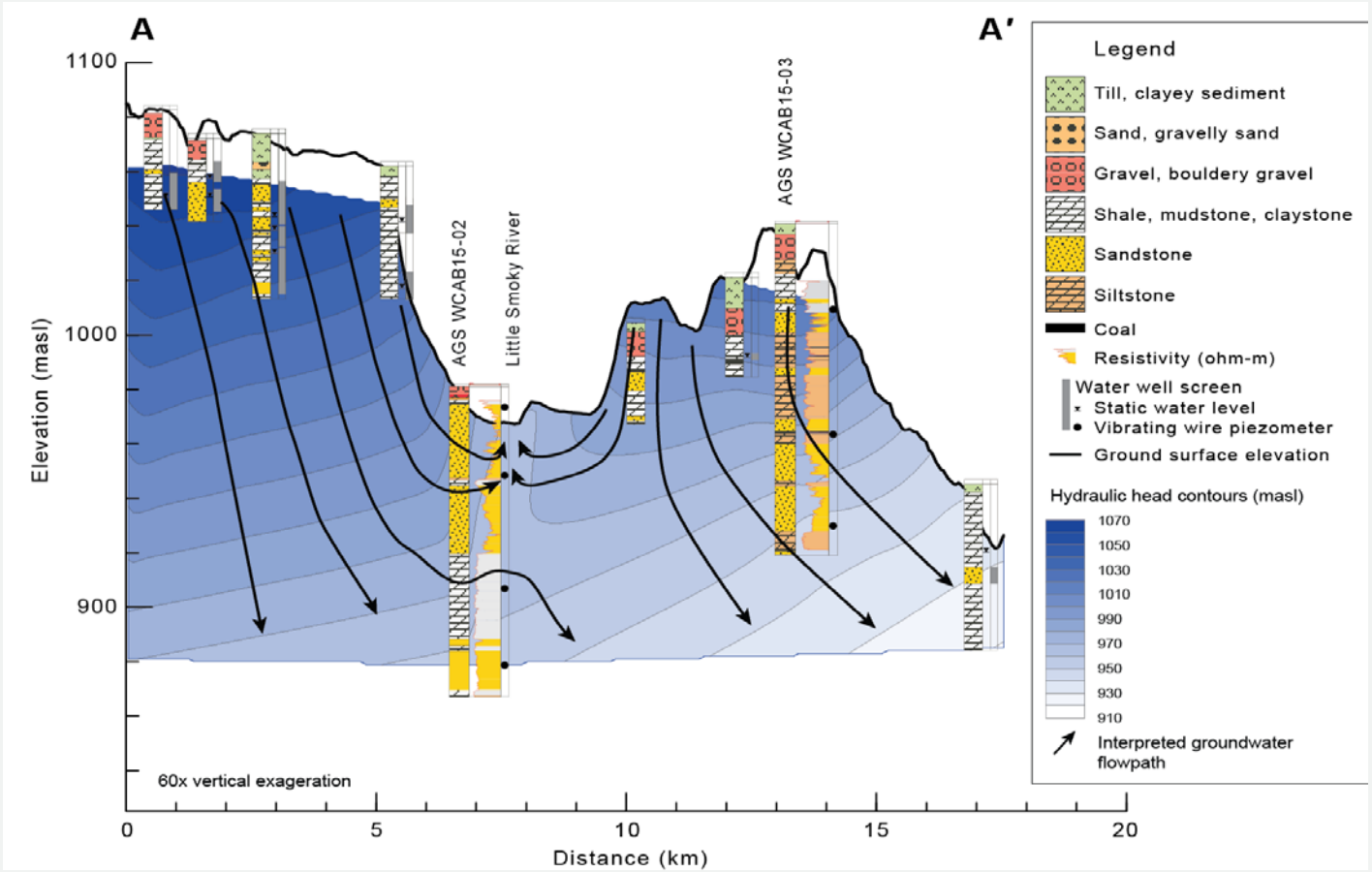


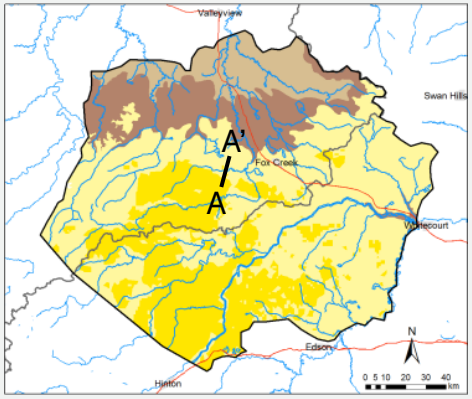
Atkinson and Hartman 2017; AGS Report 93

Paleogene–Quaternary Stratigraphy



Bedrock Hydrogeology

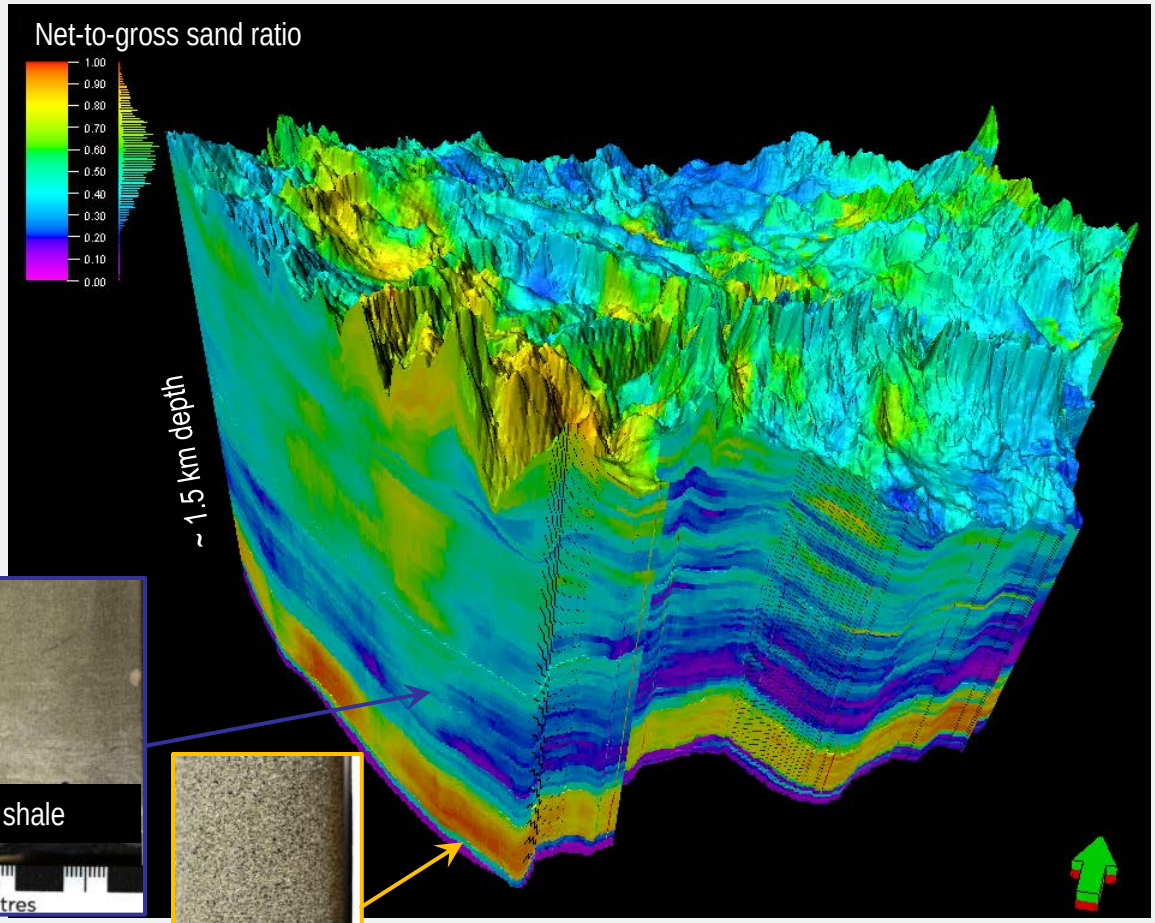




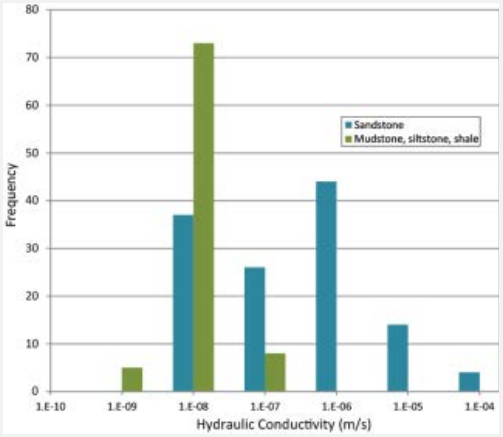
Smerdon et al., 2016; AGS OFR 2016-02

Bedrock Hydraulic Properties

- Define the ‘sandiness’ of the bedrock
  - Developed from oil & gas geophysical logs
  - Thousands of wells to help define formation architecture
- Quantify hydraulic properties
  - Permeability and porosity

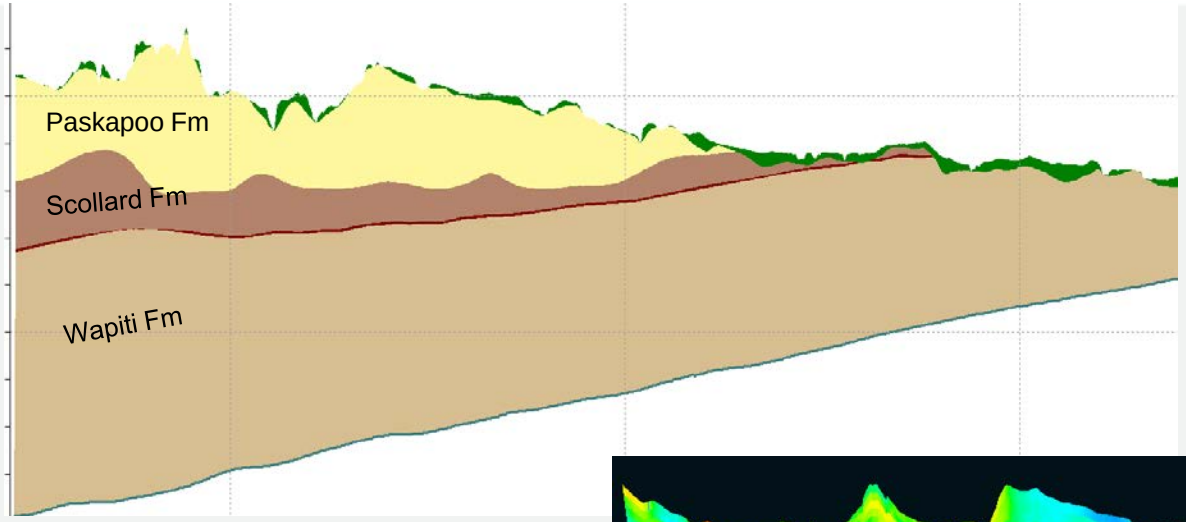


Babakhani and Mei; AGS OFR in-prep

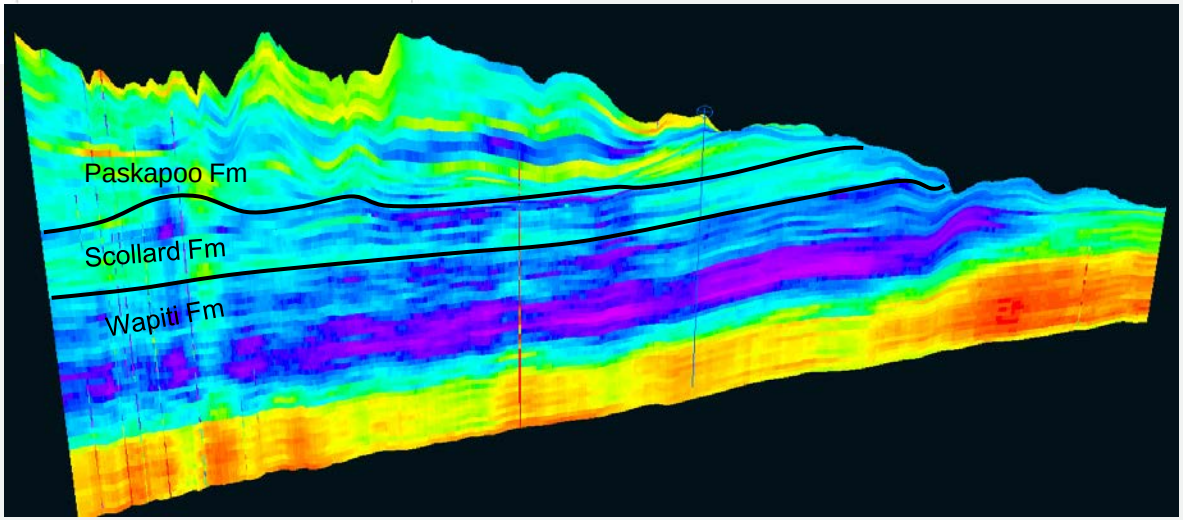


Hughes et al., 2017; AGS OFR 2016-03

Bedrock Property Modelling



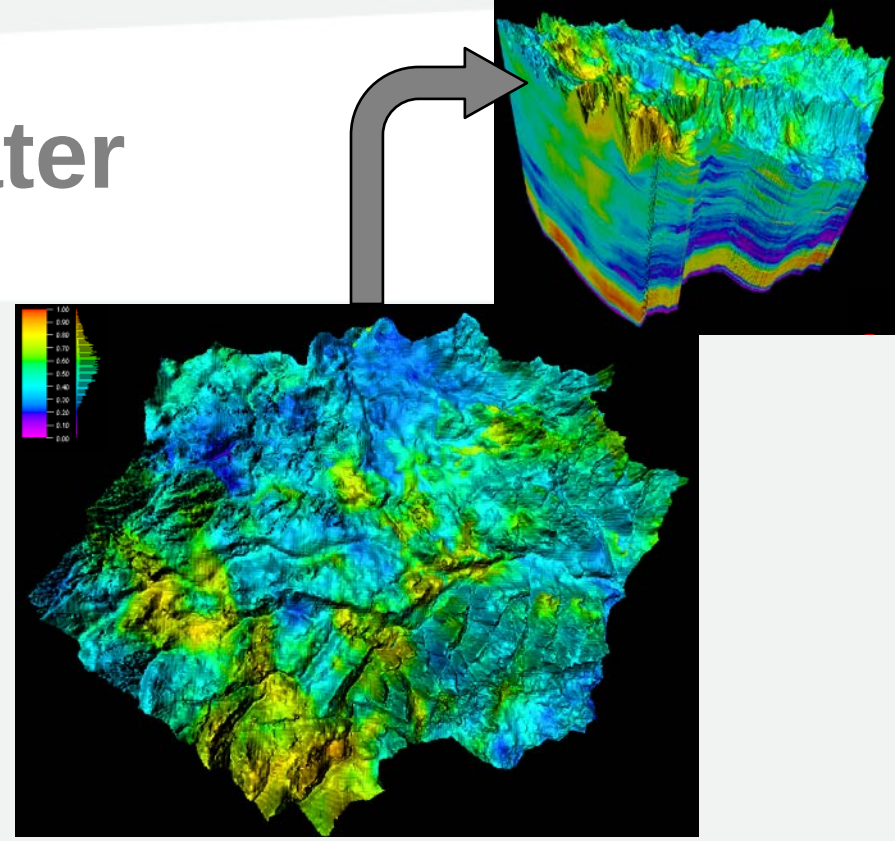
- An enriched view of the subsurface
- Helpful for understanding groundwater circulation

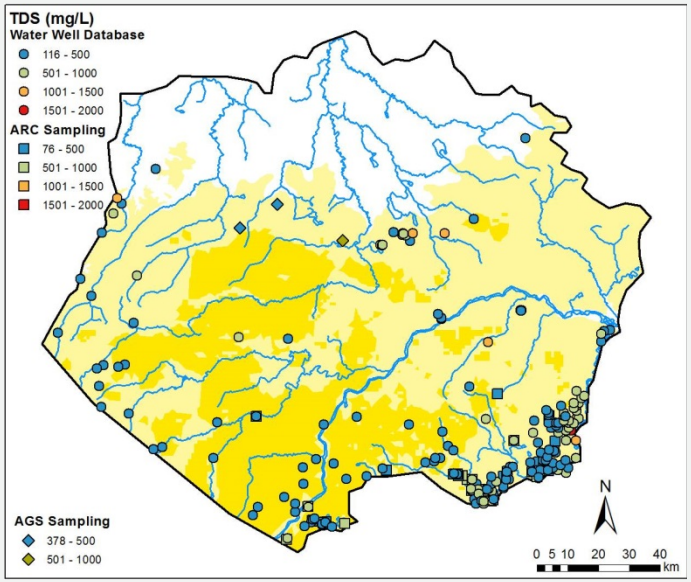


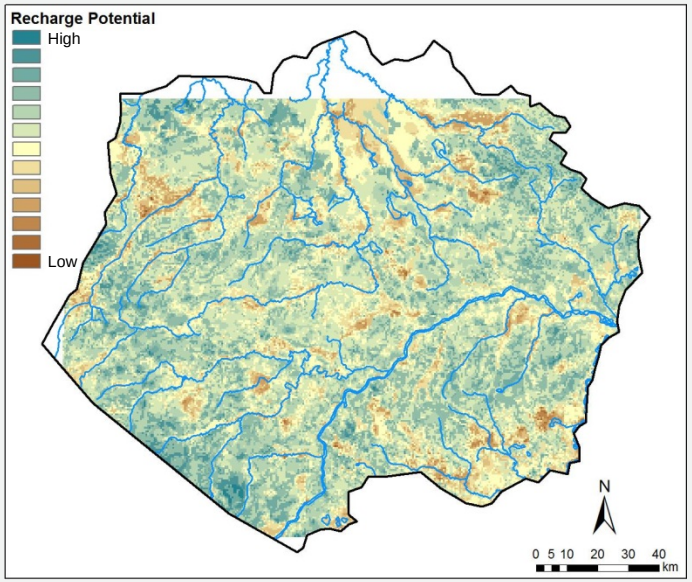
Shallow Groundwater

Paskapoo Formation

- Isolated sandstone channels within mudstone (highly heterogeneous)
- Hydrogeological mapping
  - TDS typically < 800 mg/L
  - Recharge potential developed from HSU mapping, bedrock properties, water well data



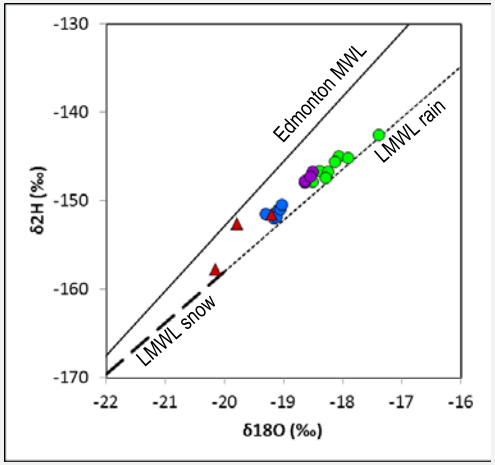


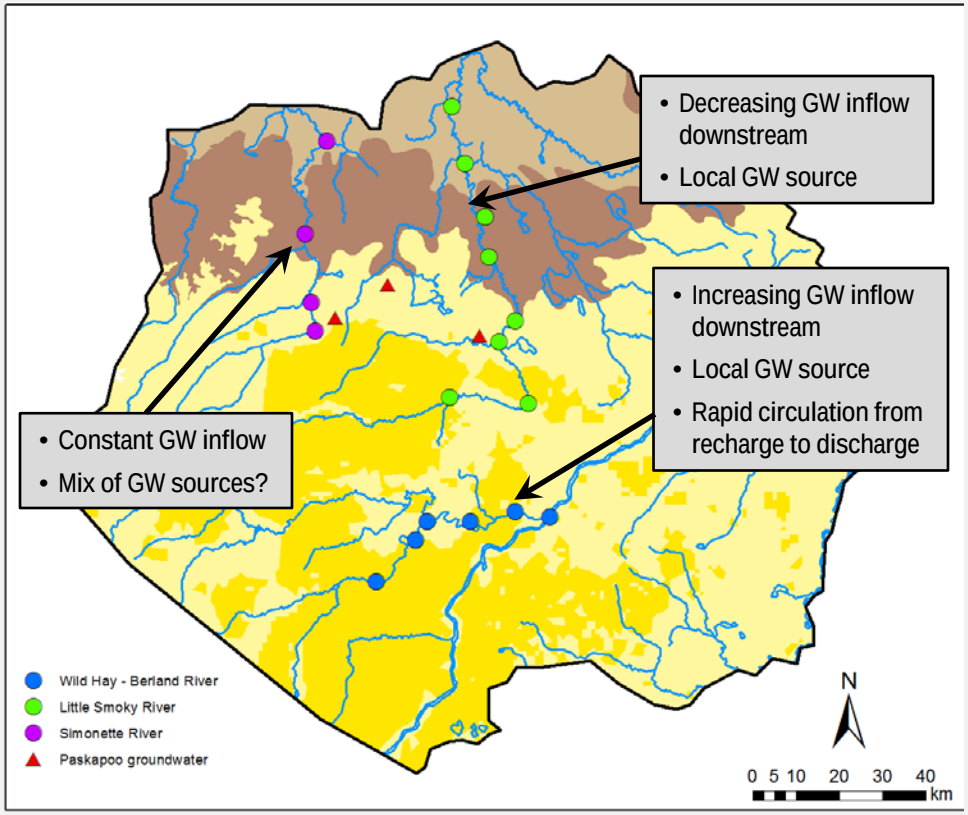


Shallow Groundwater Residence Time

- Environmental Tracers
  - ^{2}H, ^{18}O, ^{222}Rn, ^{3}H, SF_6, ^{4}He
  - 1st order GW inflow rates to rivers

- Paskapoo groundwater
  - ^{3}H = 0.1 to 4.5 TU
  - SF_6 = 0.01 to 0.07 pg/kg
  - 30 to 50 year residence time
  - $\delta^{18}O$ and $\delta^{2}H$ indicate snowmelt recharge





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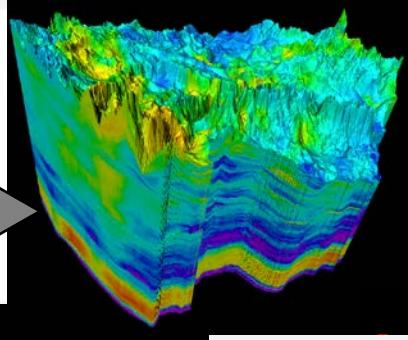
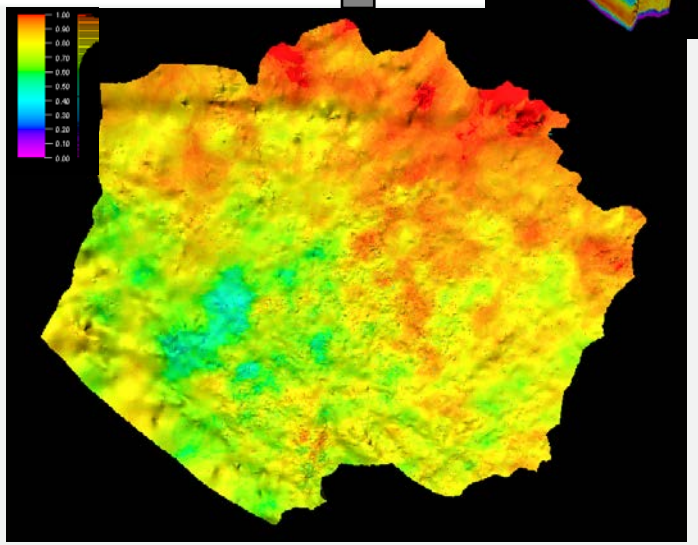
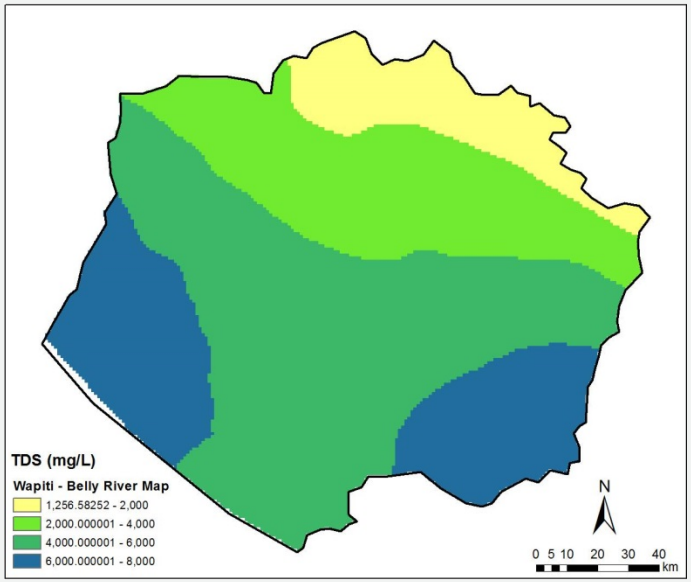
Deeper Groundwater

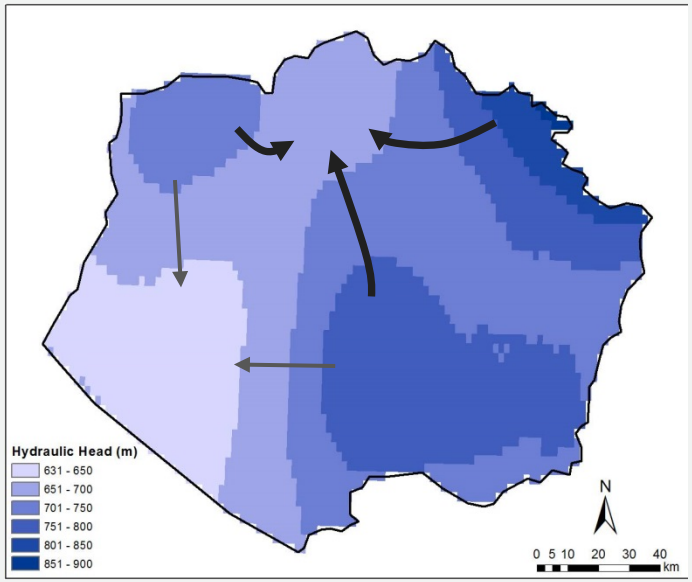
Wapiti Formation



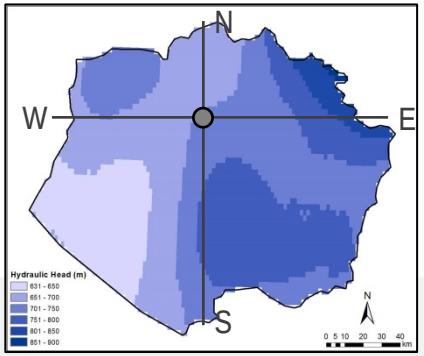
- Upper mudstone, lower sandstone
- Formation scale mapping
  - TDS varies from 600 to 8000 mg/L
  - Complex groundwater flow pattern (topographic effect and under-pressuring)

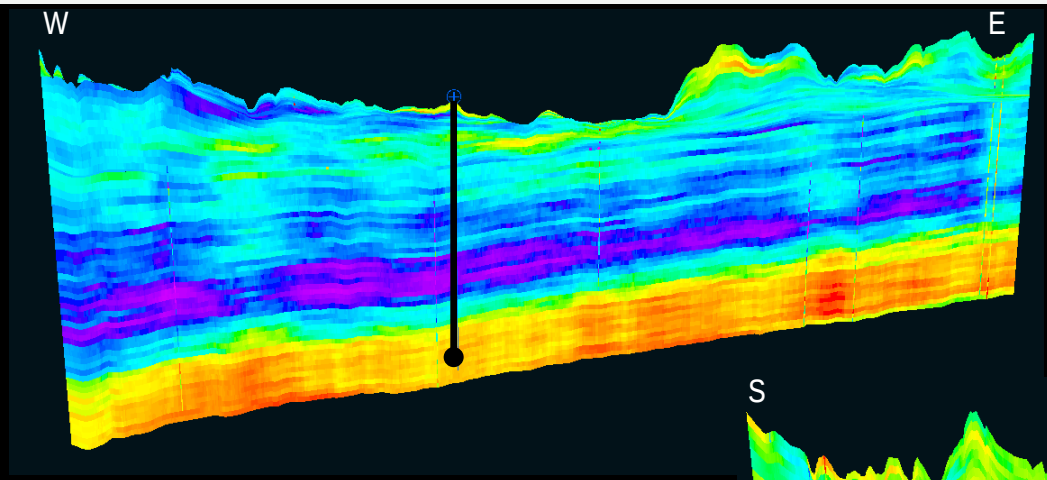


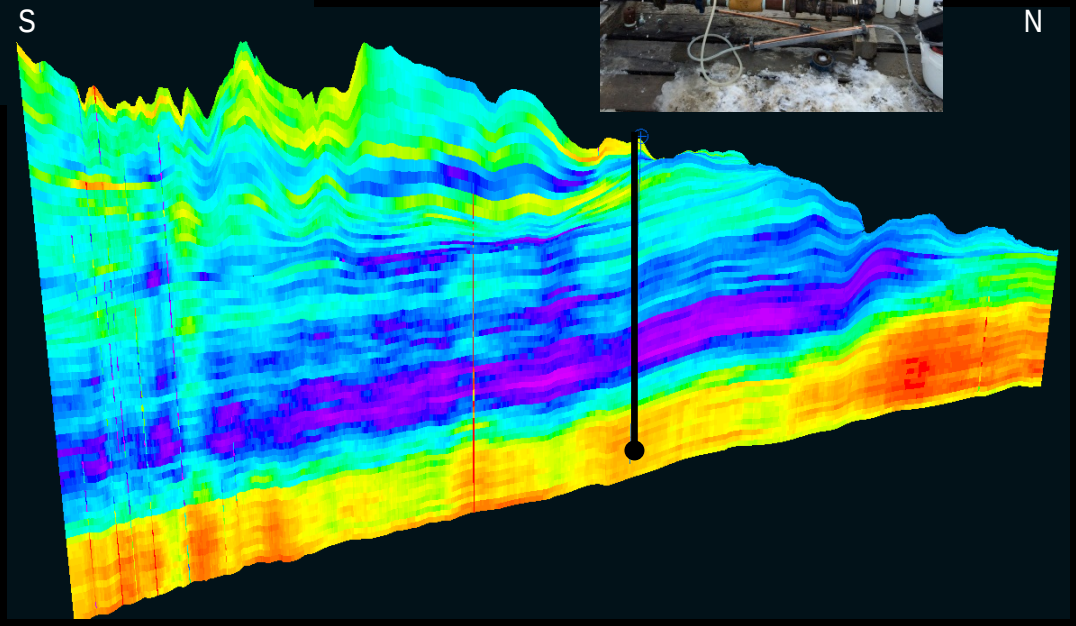




Deeper Groundwater Residence Time

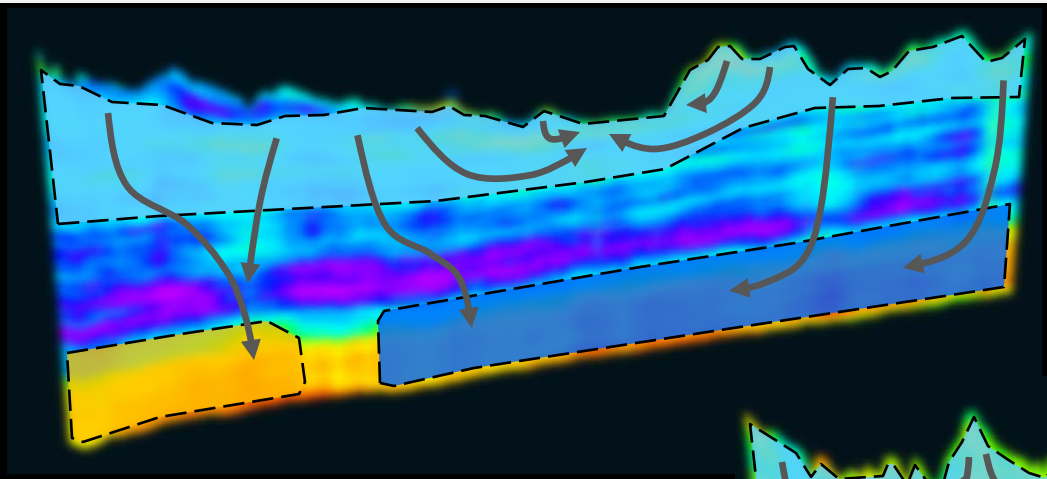




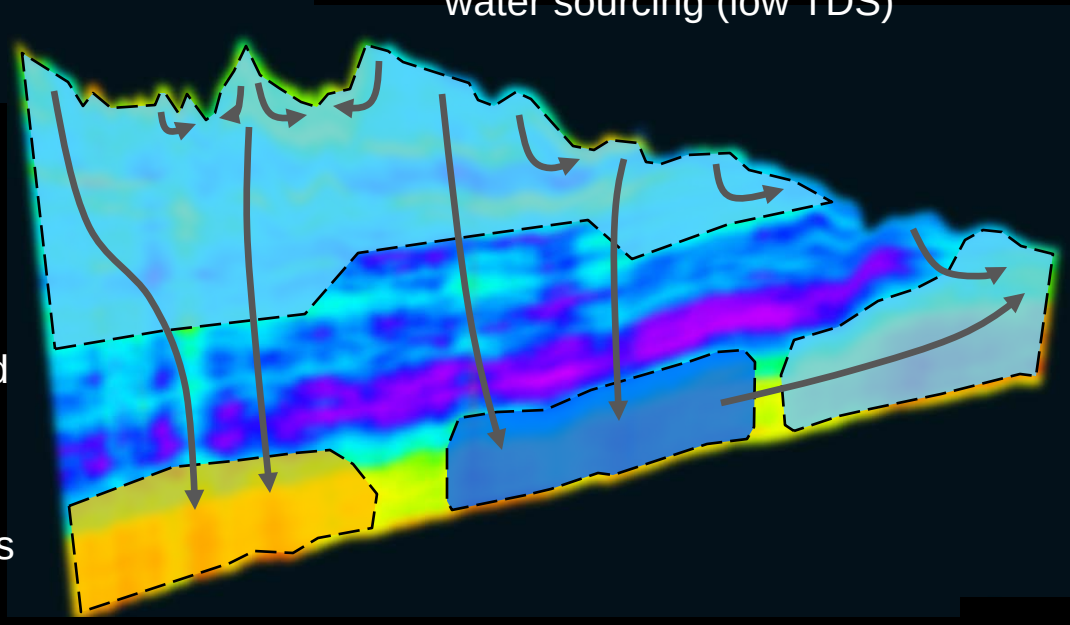


- Environmental Tracers
  - ^{3}H = 0.05 TU
  - ^{14}C = 0.9 pMC
  - ^{4}He = 1.8e-6 ccSTP/g
- Residence Time?
  - ~135,000 years

Conceptual Model



- Shallow groundwater circulation
  - <10 years near rivers
  - 50+ years elsewhere
  - Rivers capture local groundwater
  - Isolated permeable zones for water sourcing (low TDS)



- Deeper groundwater circulation
  - >100,000 years
  - Low TDS where actively recharged
  - High TDS where deeper and more stagnant
  - More widespread permeable zones

Conclusions

- 3D geological modelling helps identify permeable pathways and reservoirs
  - Critical for mapping recharge and groundwater susceptibility
- Evidence of nested groundwater flow
  - Hydraulic and isotopic data suggest rivers capture local groundwater
  - Dominance of recharge across most of study area
  - Groundwater circulation to ~1km depth
- Future work
  - Continue releasing reports and data
  - Shift toward northwest and focus on Upper Peace Region

Thank you