

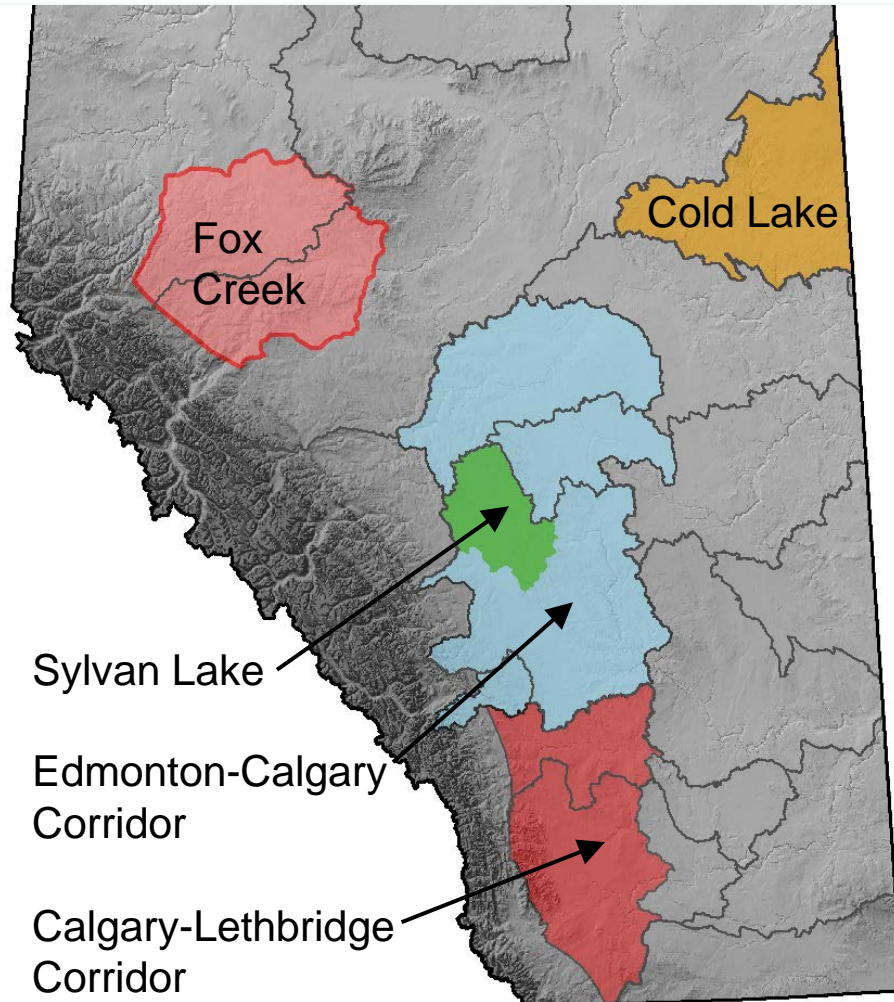
Providing geoscience to enable a better understanding of groundwater and surface water interaction in Alberta

Brian Smerdon, Lisa Atkinson, Jessica Liggett,
Dan Palombi

Alberta Geological Survey

CWRA Alberta Branch Annual Conference 2016

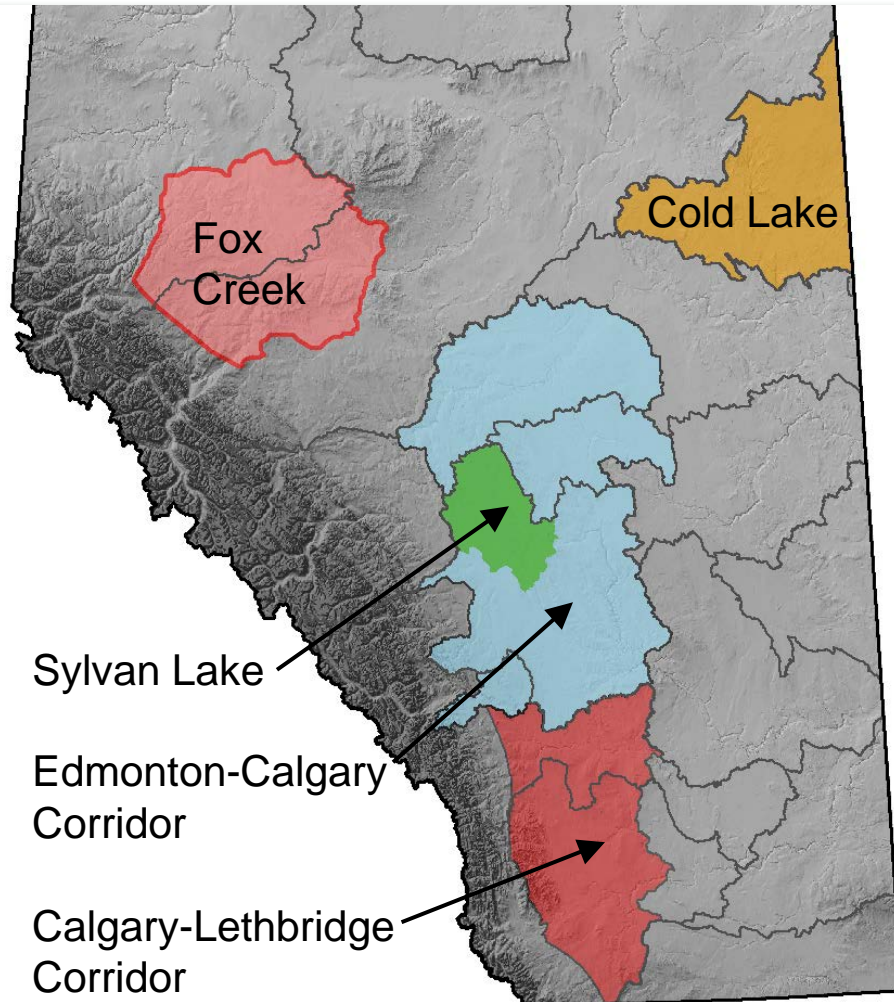
Provincial Groundwater Inventory Program



A partnership with Alberta Environment & Parks since 2008

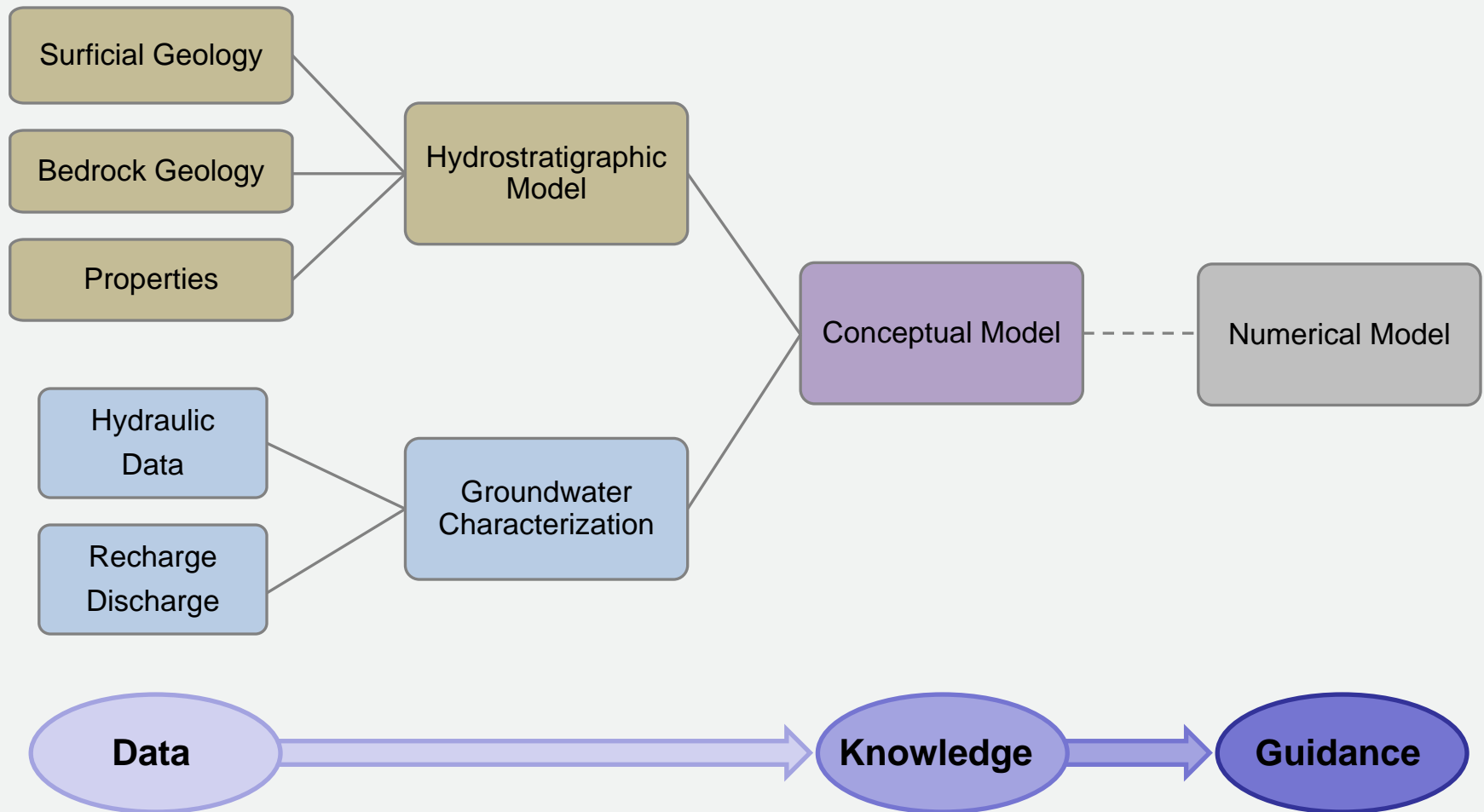
- › Map and inventory Alberta's groundwater resources
- › Establish quantity and quality at regional scale
- › Assist government in making informed decisions about groundwater
- › Assess and understand cumulative effects of development

Scale Equivalent to Management



- › Must recognize:
 - › Policy and directives evaluated at a point
 - › Transition to region assessment
- › Ensure geoscience is meaningful at the 'regional' scale:
 - › Area-based regulation
 - › Land-use planning regions

Conceptual Model Development



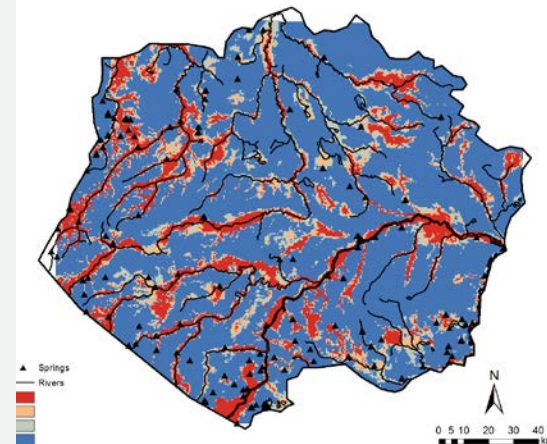
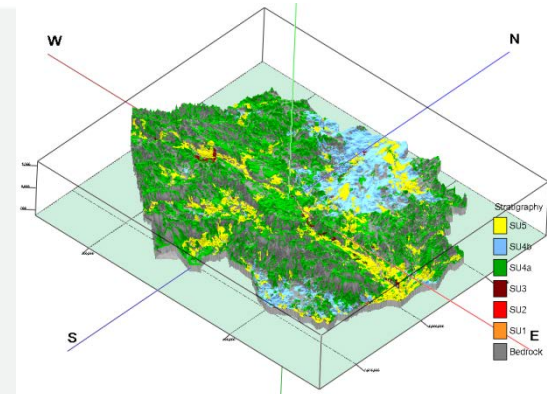
Modelling and Mapping Approach

- 》 Delineate groupings of unconsolidated sediments with common texture
 - Laterally-connected fine- or coarse-grained units
 - Can be recognized at a regional scale (> 1 km)

- 》 Evaluate distribution of bedrock properties
 - Identify permeable zones

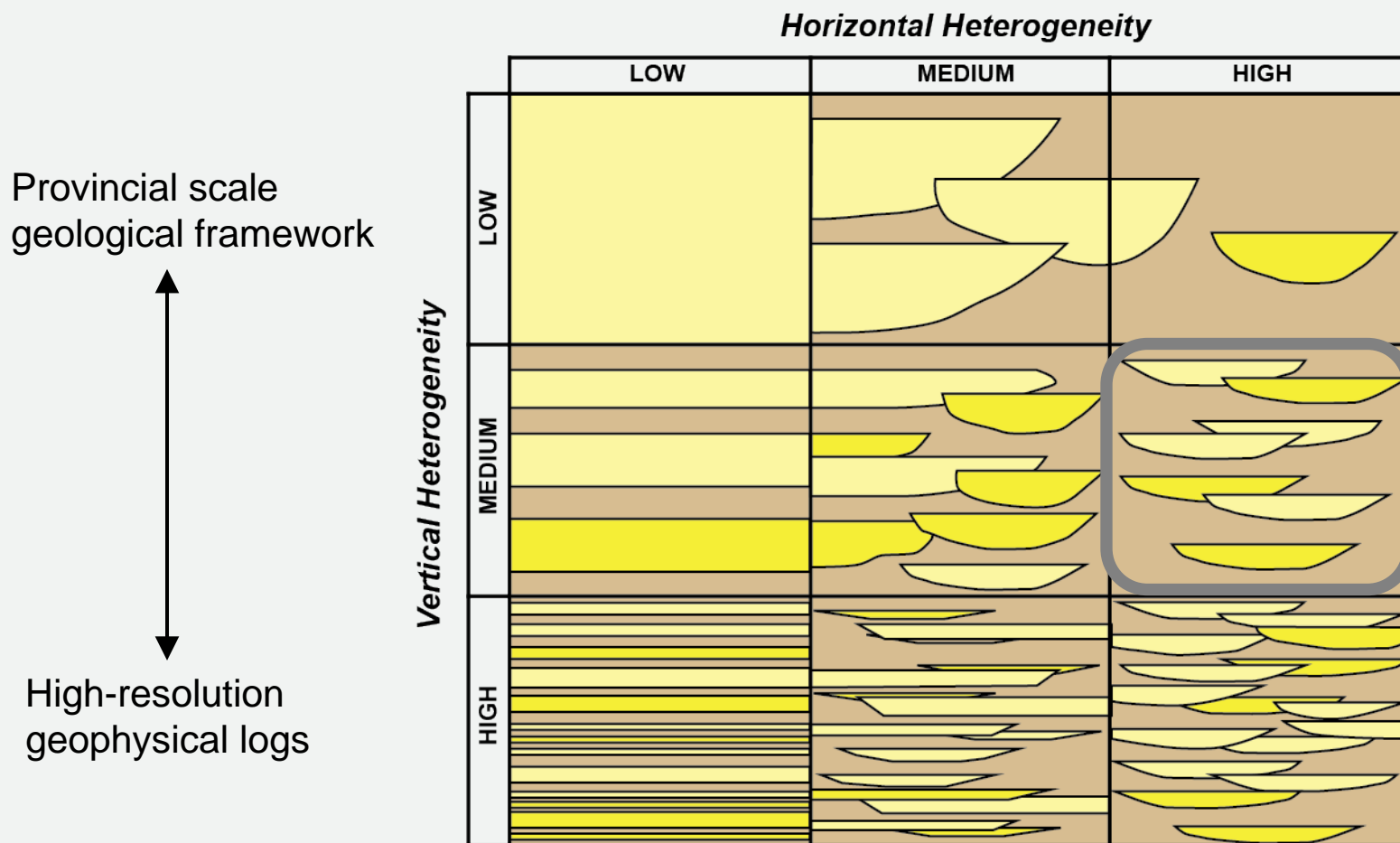
- 》 Map hydrogeological data within new framework
 - Hydraulic heads, water chemistry
 - Regional recharge and discharge areas

AGS



Scale and Detail:

Finding the Sweet Spot



Tyler and Finley 1991; SPE-22670-MS

Calgary-Lethbridge Corridor

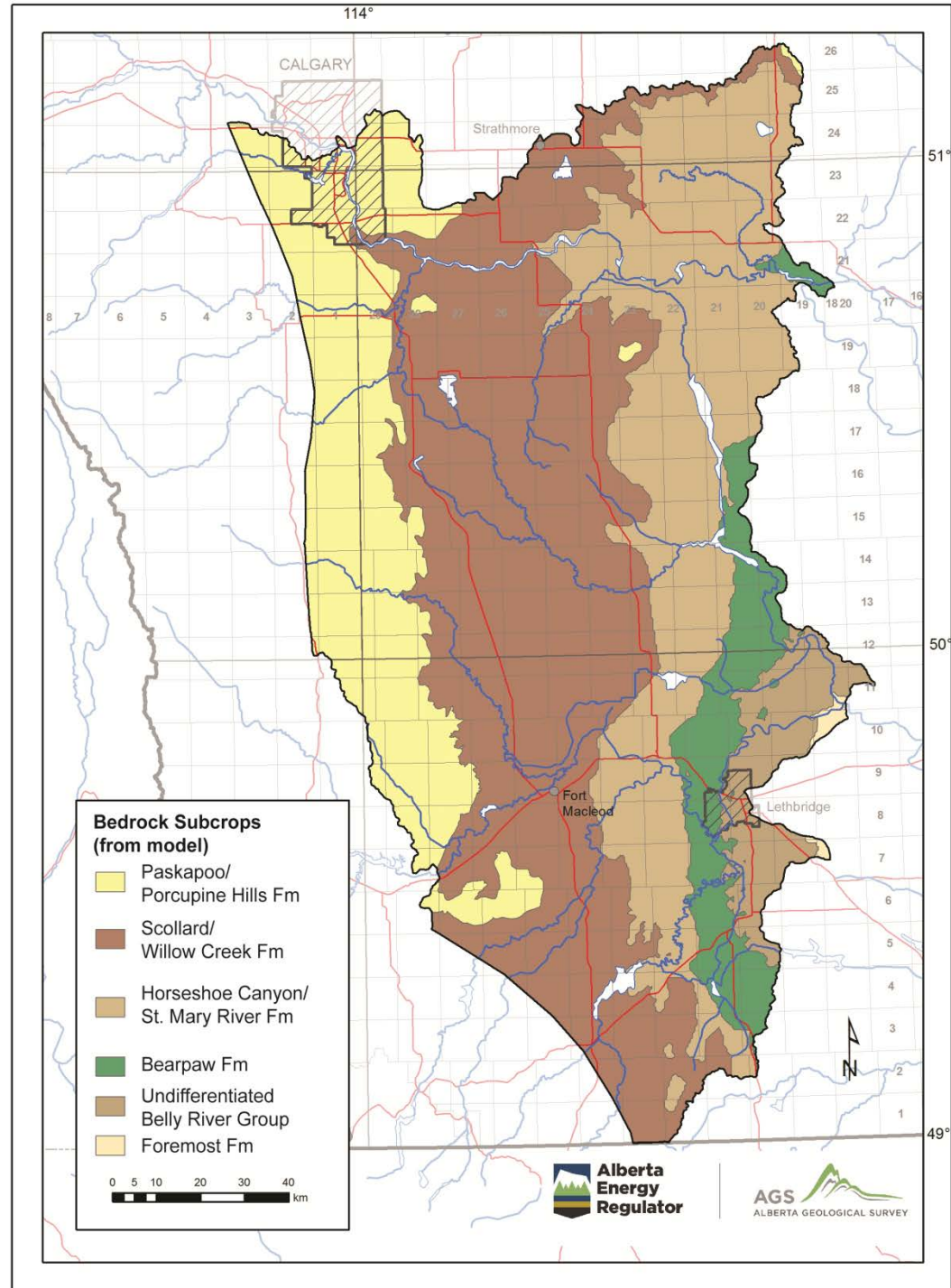


St. Mary River

CLC Study

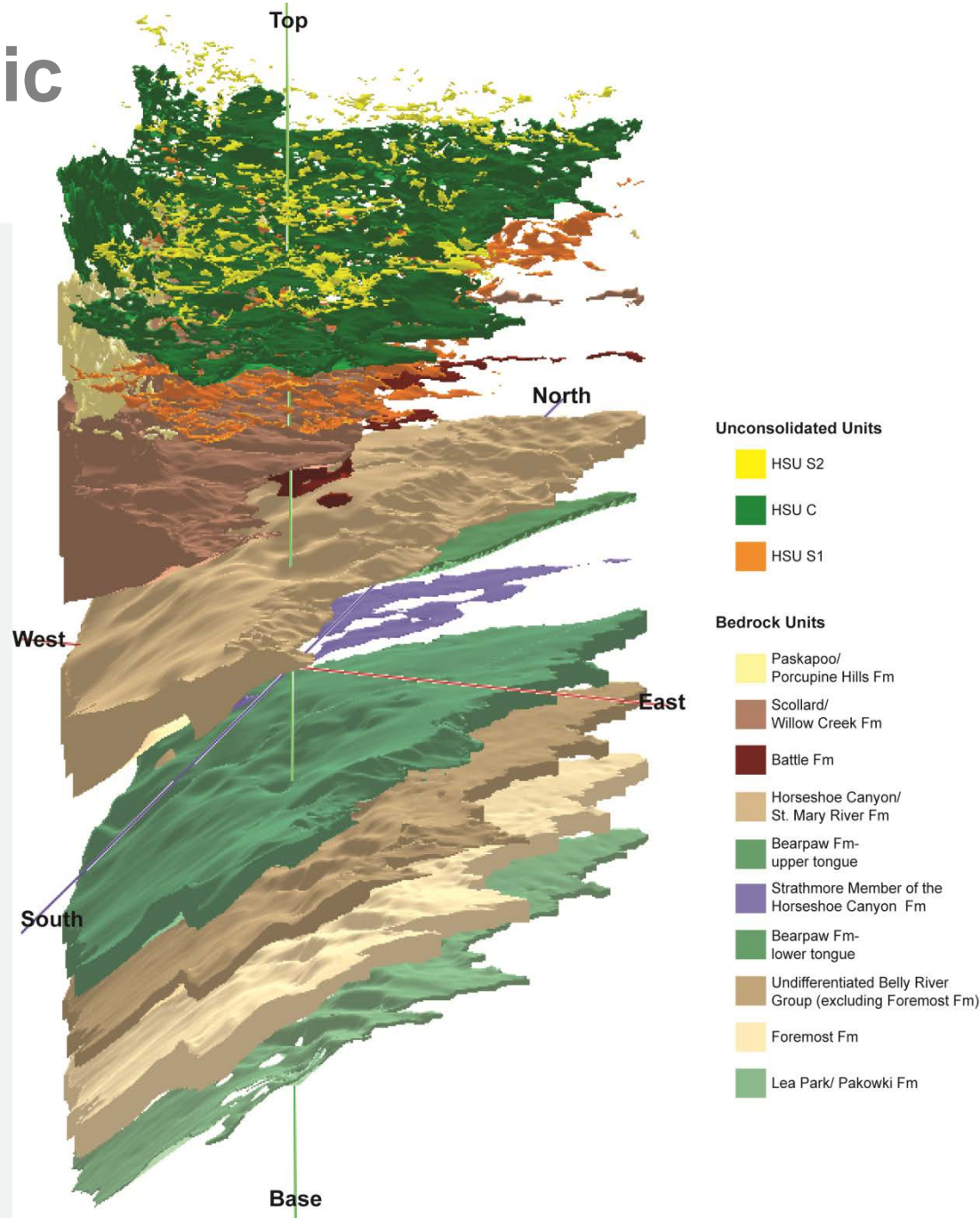
- › Develop a digital hydrostratigraphic framework
- › Regional characterization for South Saskatchewan Regional Plan
- › Defined by 8 sub-basins and deformation belt to the west
- › 21,159 km²

AGS



Hydrostratigraphic Model

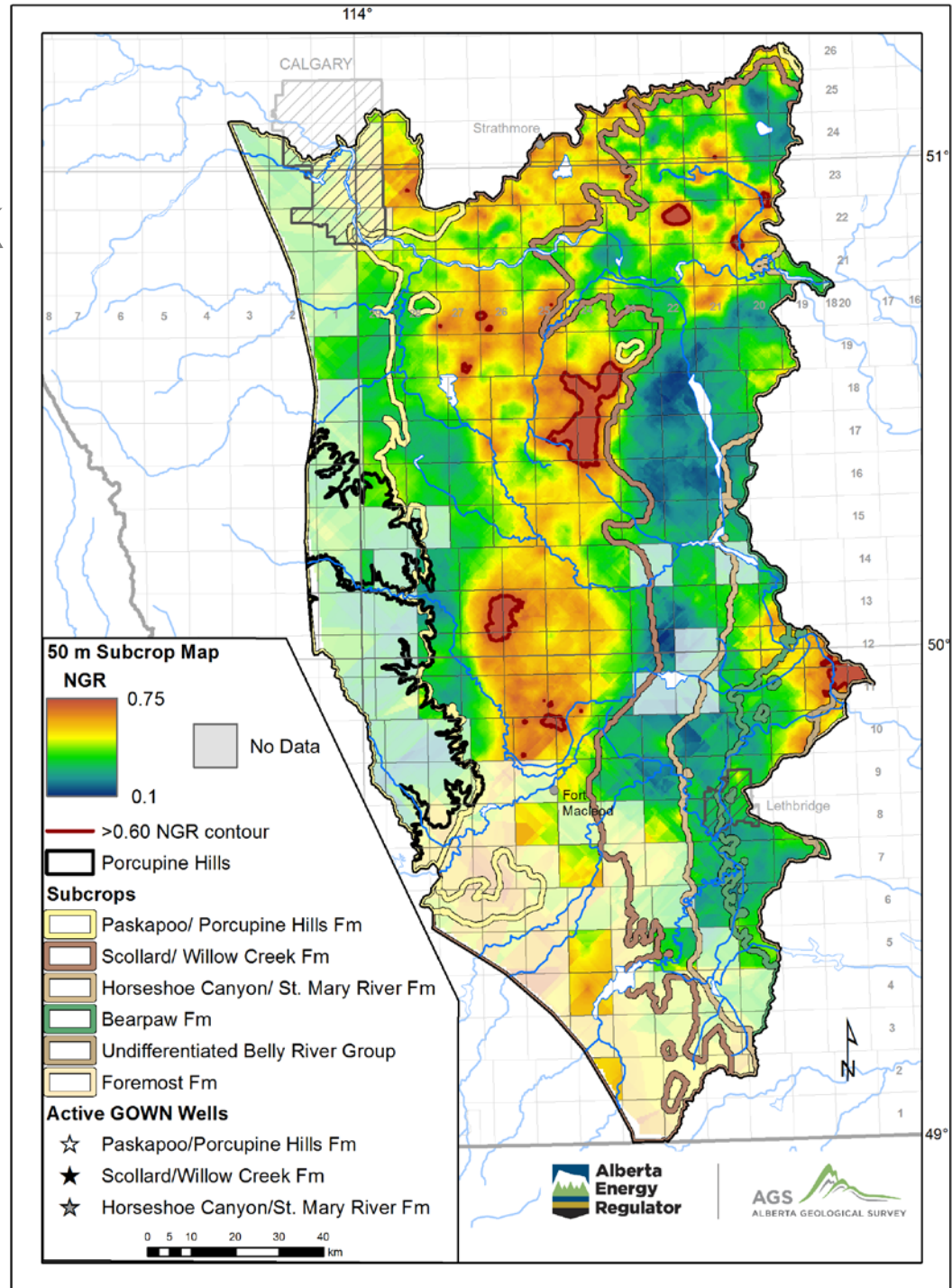
- 3 HSU's developed for unconsolidated sediments
- Each bedrock formation defined as an HSU
- Updated bedrock topography and paleovalleys



Distribution of Permeable Bedrock

- › Identify major sandstone trends → *aquifer potential*

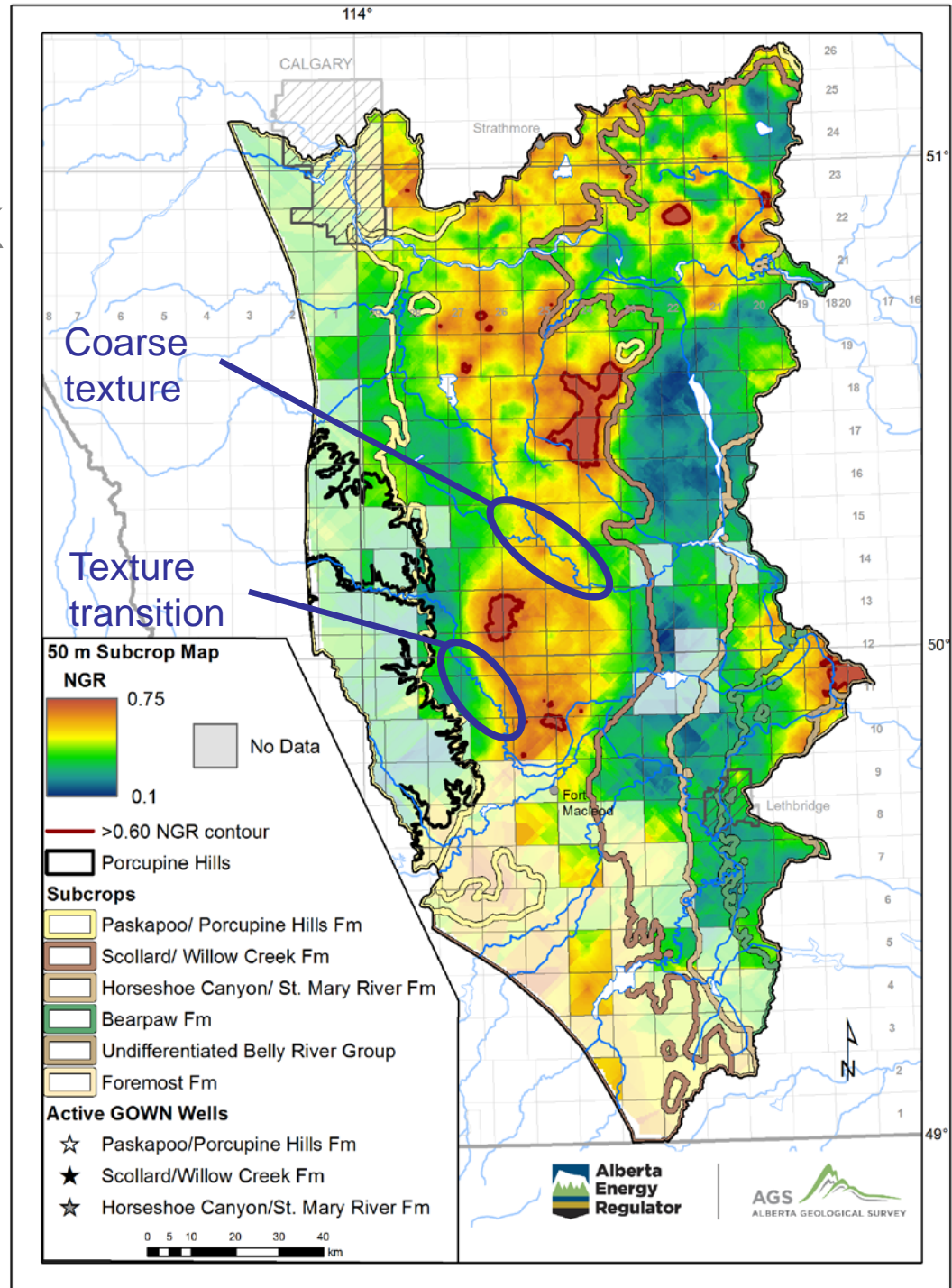
AGS



Distribution of Permeable Bedrock

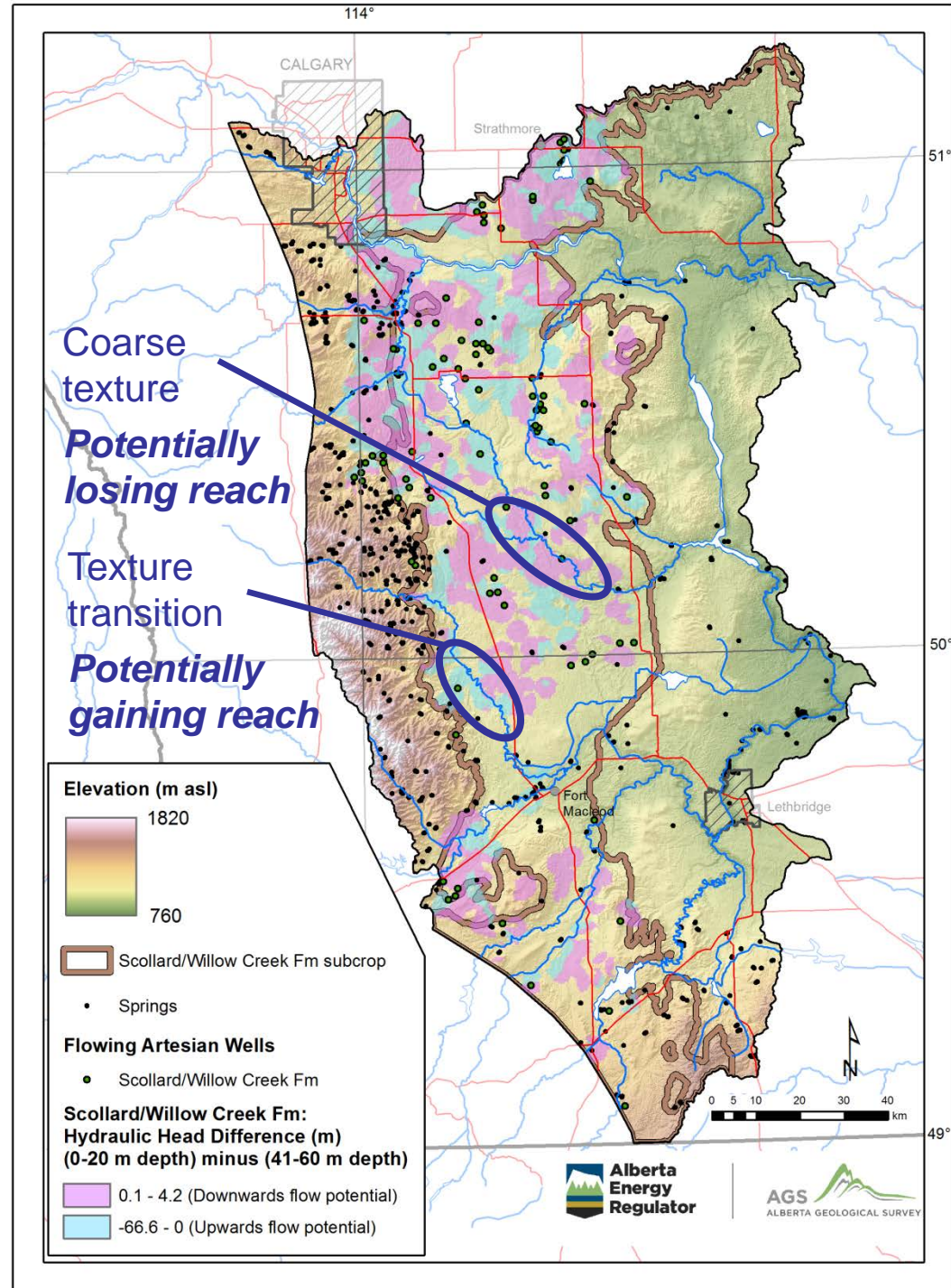
- Identify major sandstone trends → *aquifer potential*
- Locate where permeable bedrock could intersect rivers
- Framework for mapping gaining/losing reaches at regional scale

AGS

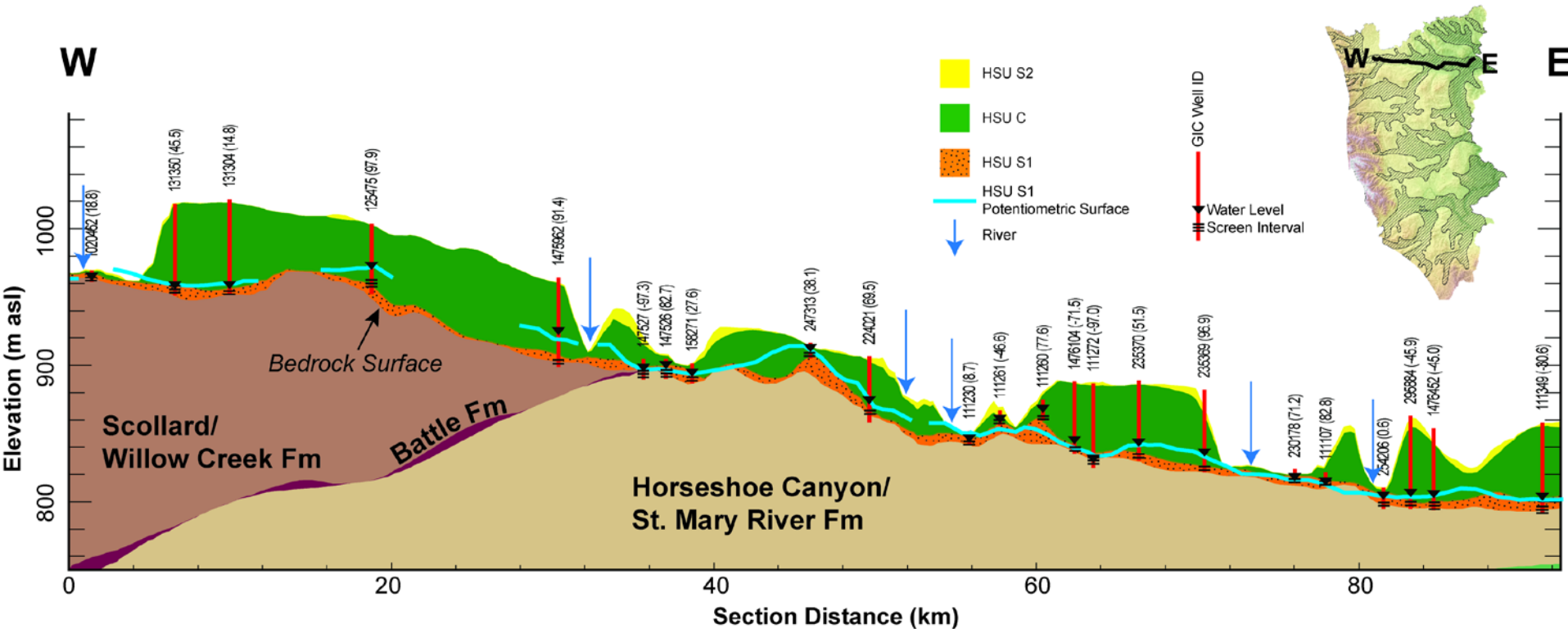


Potential Recharge Discharge Areas

- Potentiometric surfaces developed from water well database
- Analysis of hydraulic head difference
- First-order mapping of groundwater and surface water interaction



Calgary Valley Paleochannel



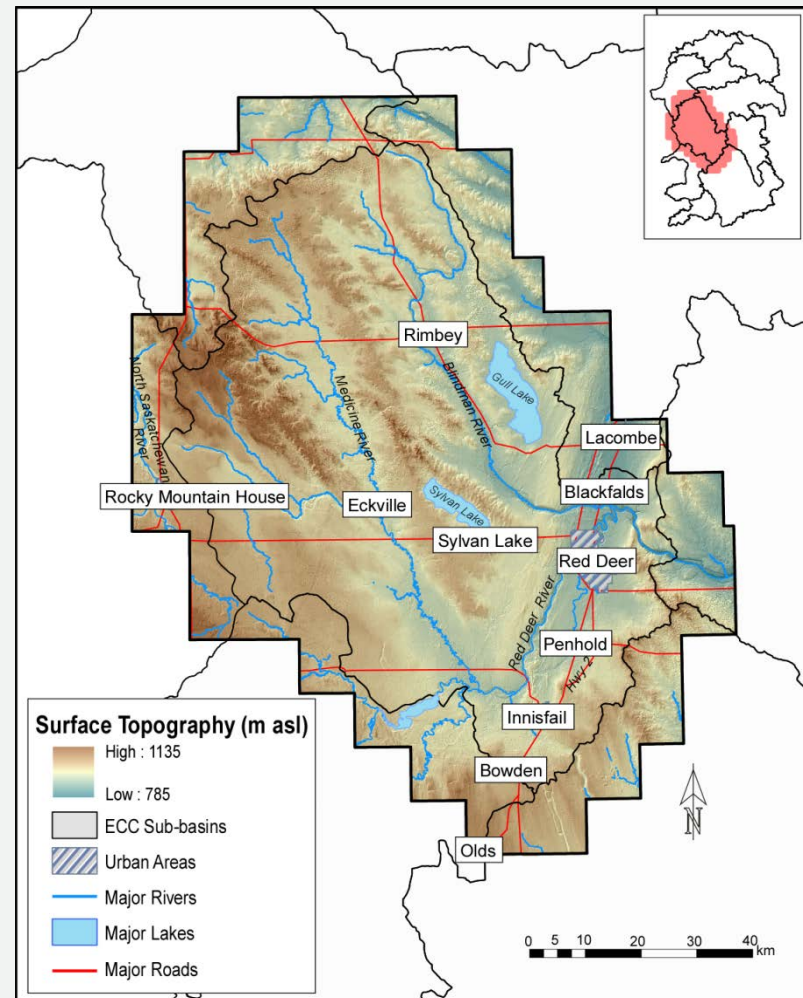
- Some intersection with modern Bow River valley
- Spatially variable connection of paleochannel and river
- HSU's provide a framework for mapping gaining/losing reaches

Sylvan Lake Region



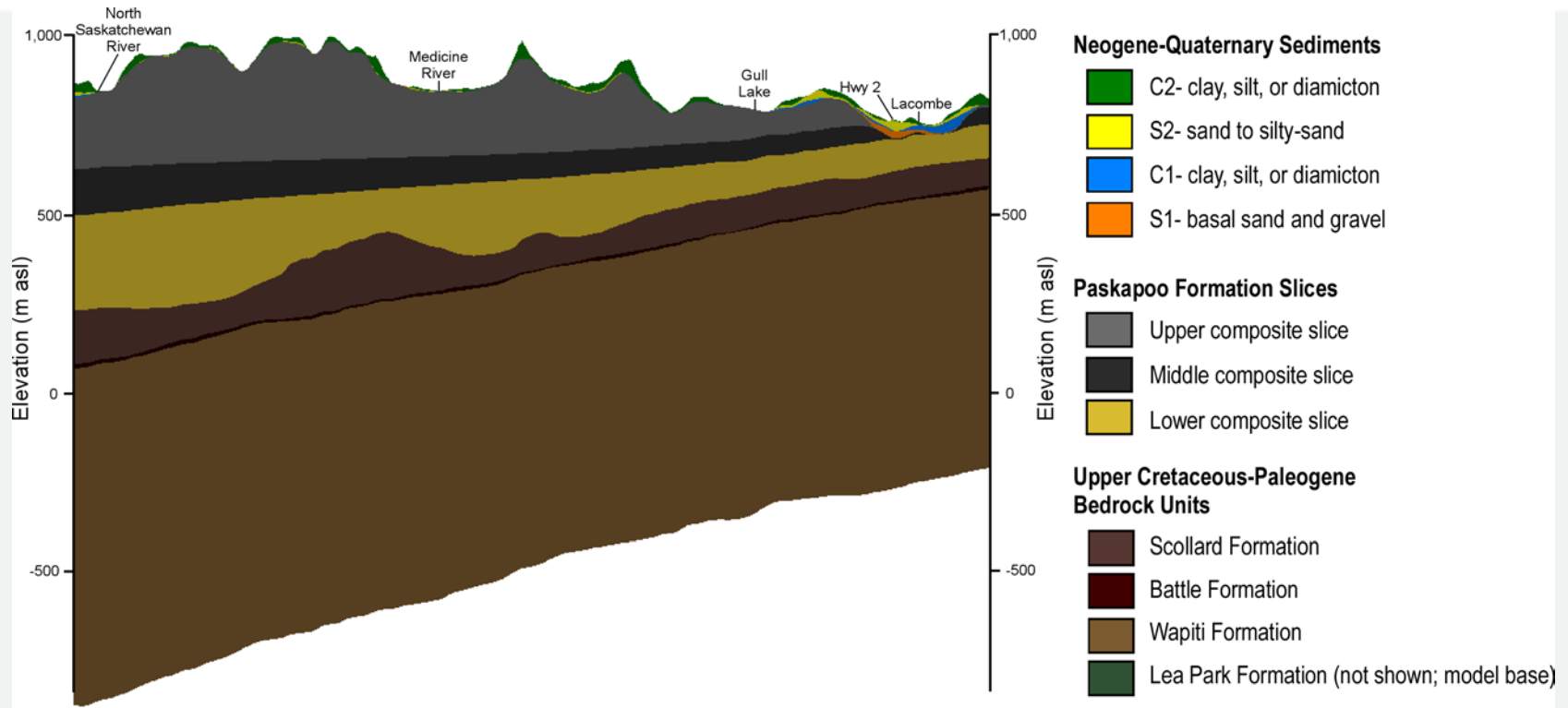
Sylvan Lake Region

- Medicine-Blindman sub-watershed (5,933 km²)
- Growing population dependent on water resources
 - Agriculture
 - Recreation
 - Municipal, domestic
- Groundwater resources within unconsolidated sediments and shallow bedrock
 - Unconsolidated sediments vary from 0 to 130 m thick



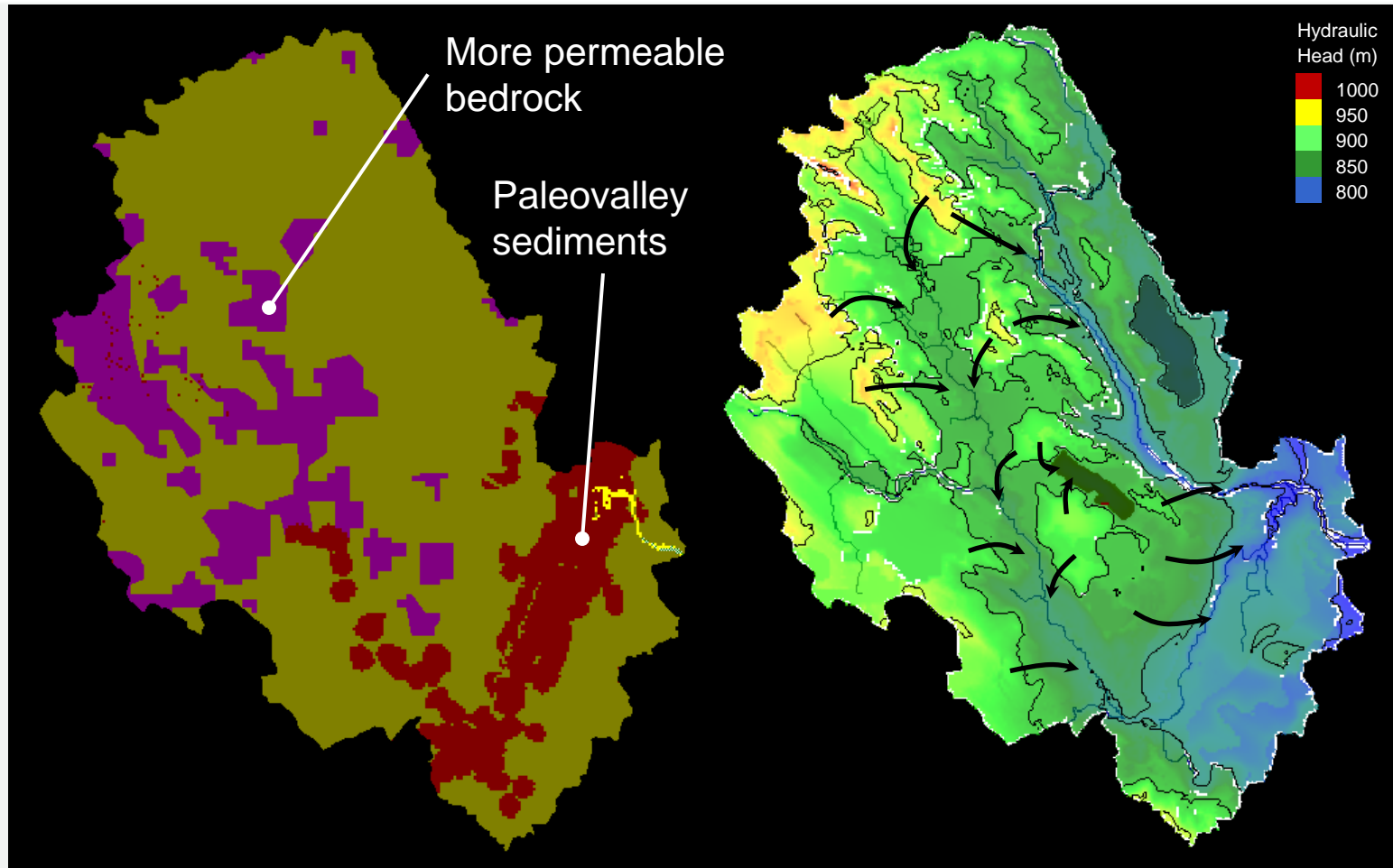
Atkinson and Glombick, 2015; AGS OFR 2014-10

Hydrostratigraphic Model



- 4 HSU's developed for unconsolidated sediments
- Each bedrock formation defined as HSU, with some differentiation in the Paskapoo Formation
- Hydrostratigraphic model used directly in groundwater model

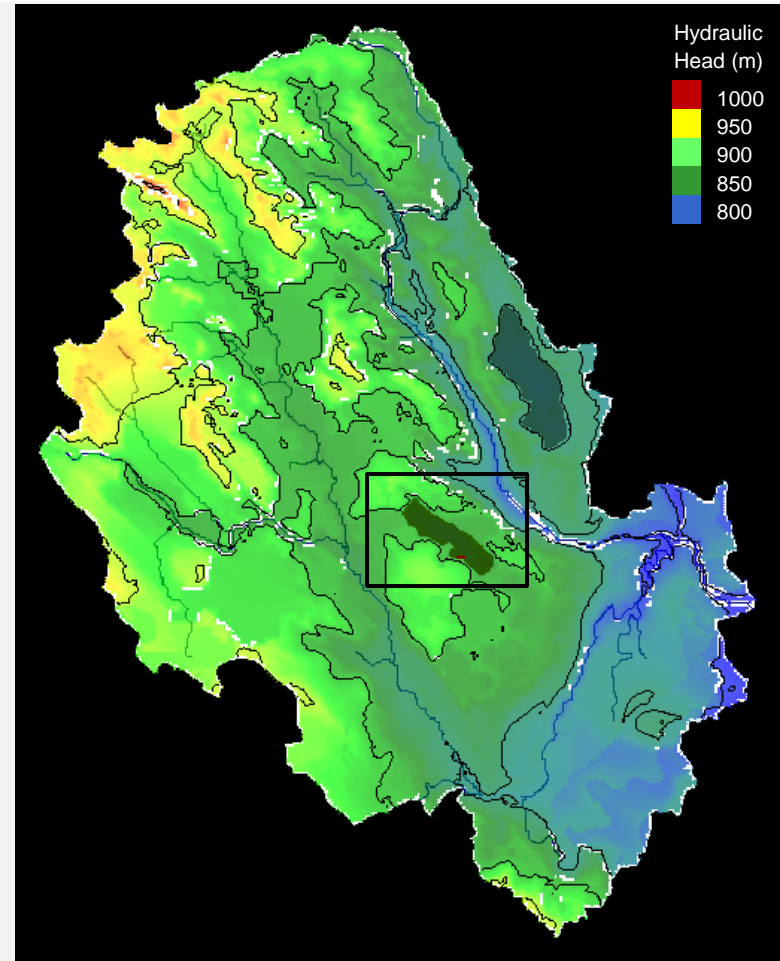
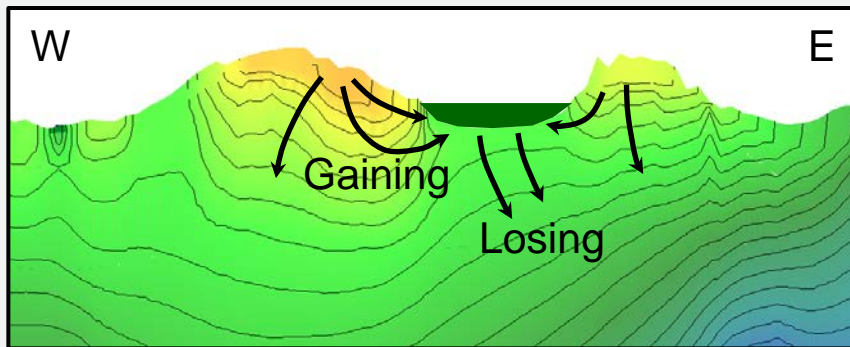
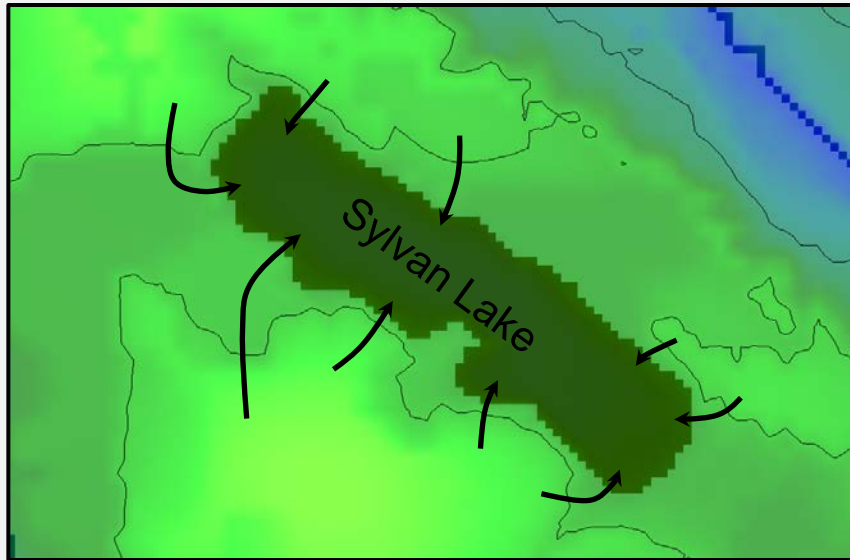
Groundwater Model



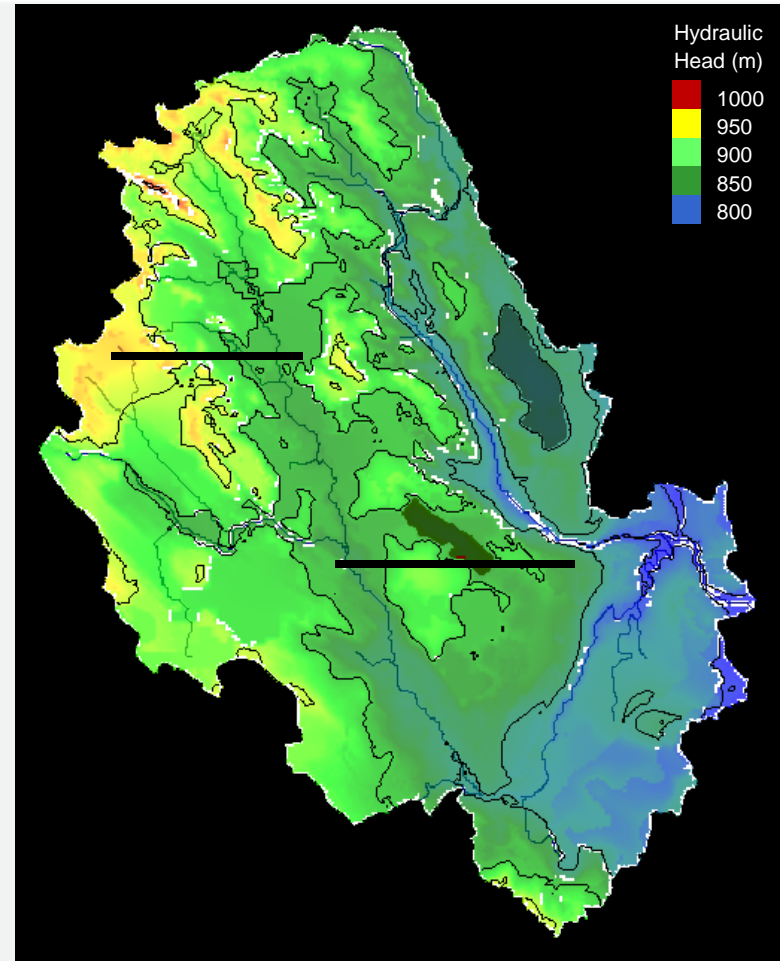
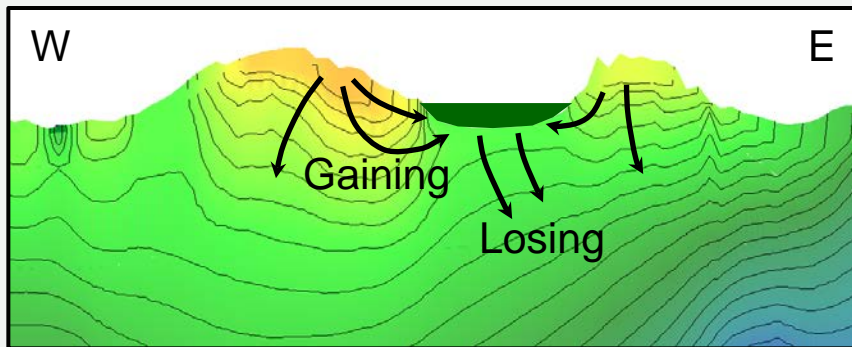
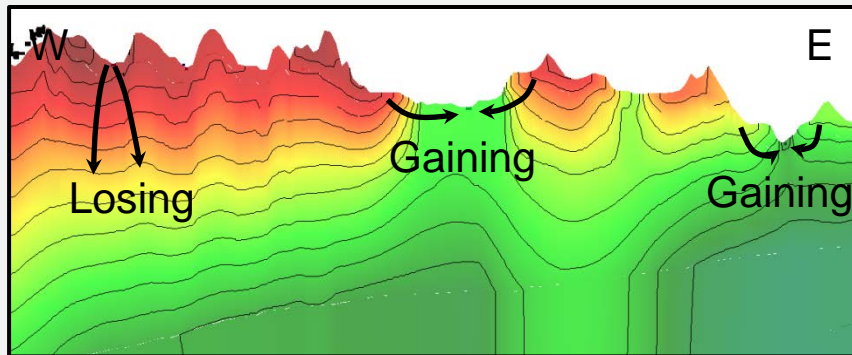
HSU's → property zones

Simulated hydraulic heads

Groundwater - Surface Water Interaction



Groundwater - Surface Water Interaction

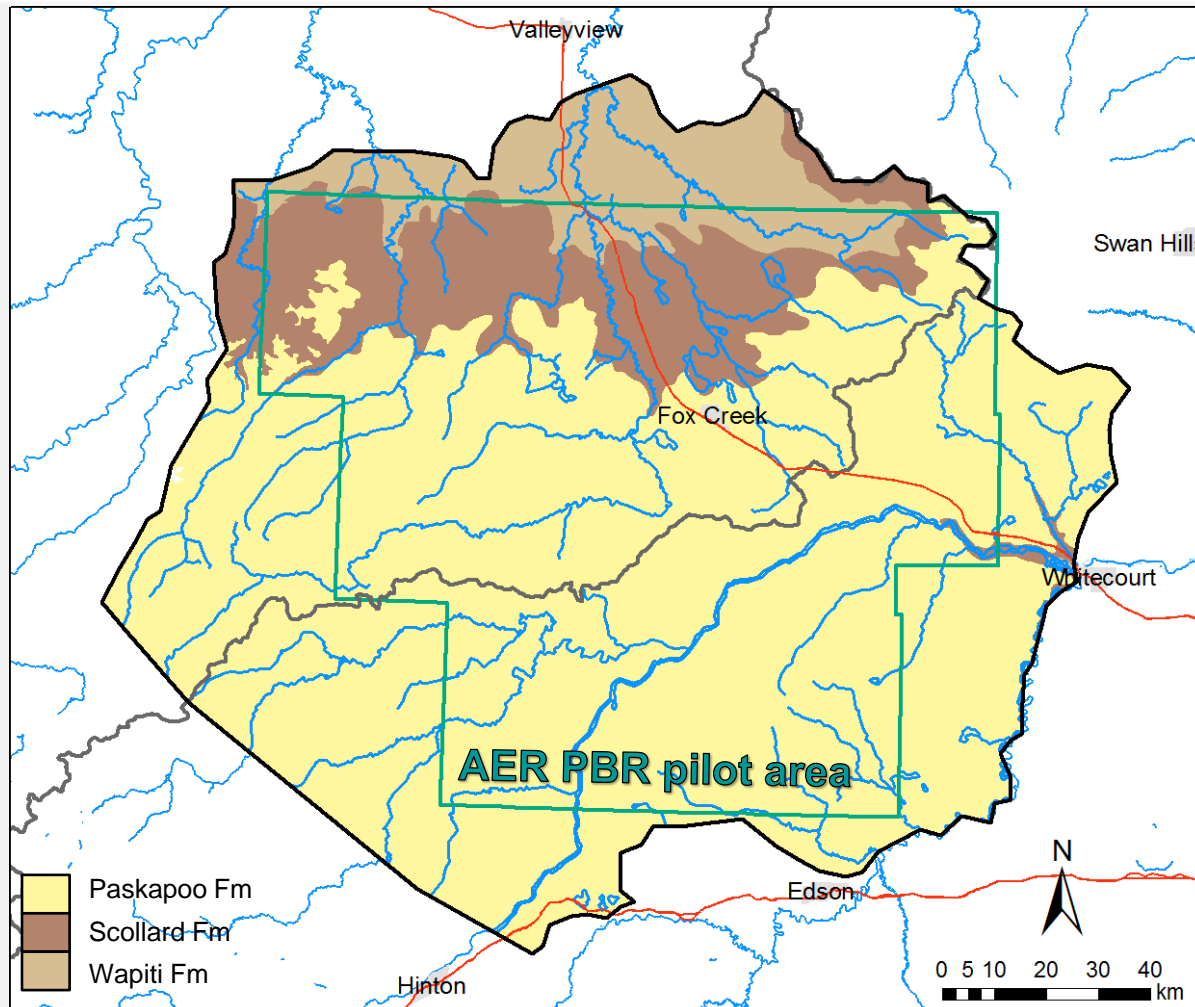


Fox Creek Area



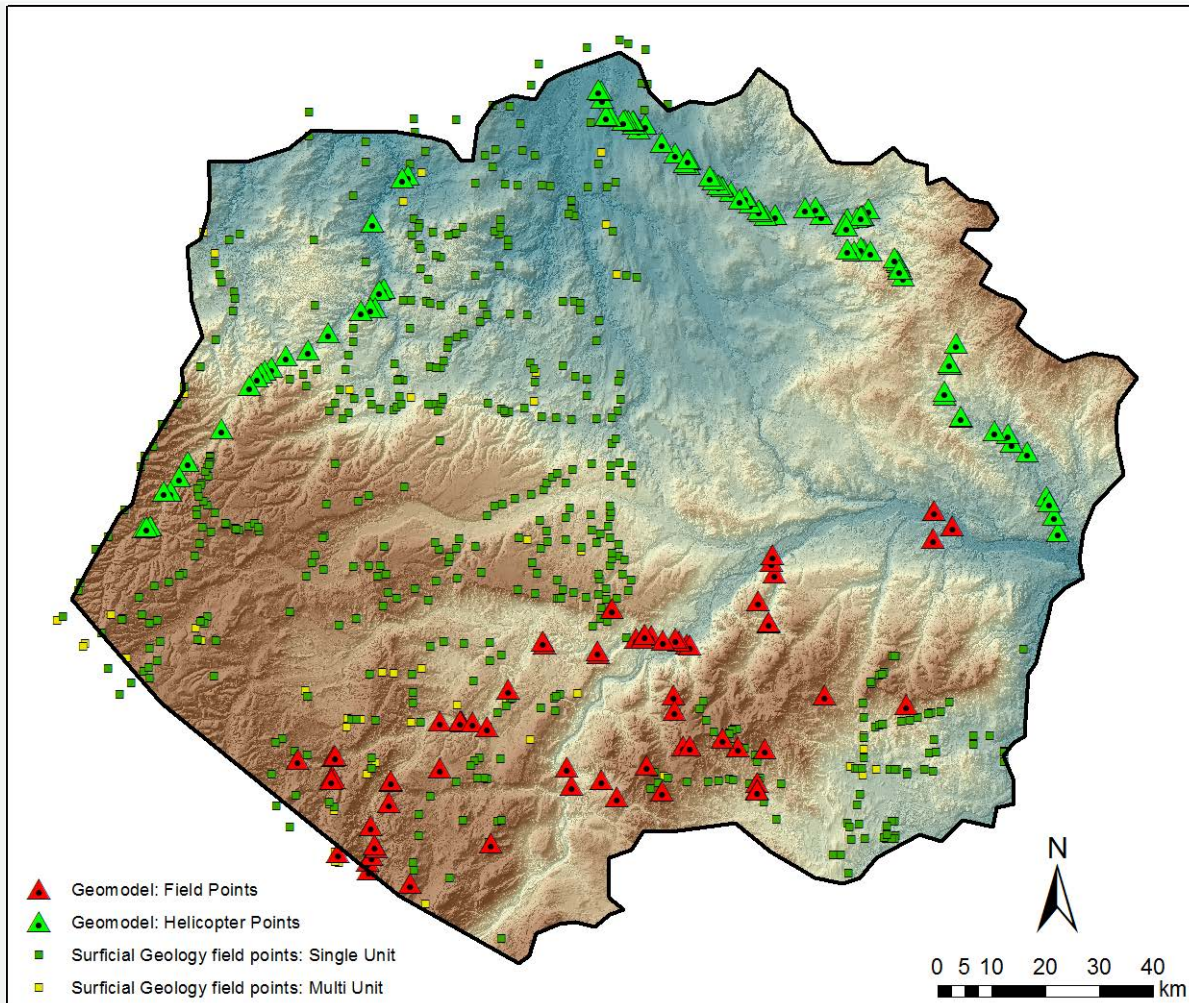
Little Smoky River

Fox Creek Area



- › Spans Peace and Athabasca basins
- › Defined by sub-basin drainage
- › Encompasses AER PBR pilot area
- › 22,000 km²

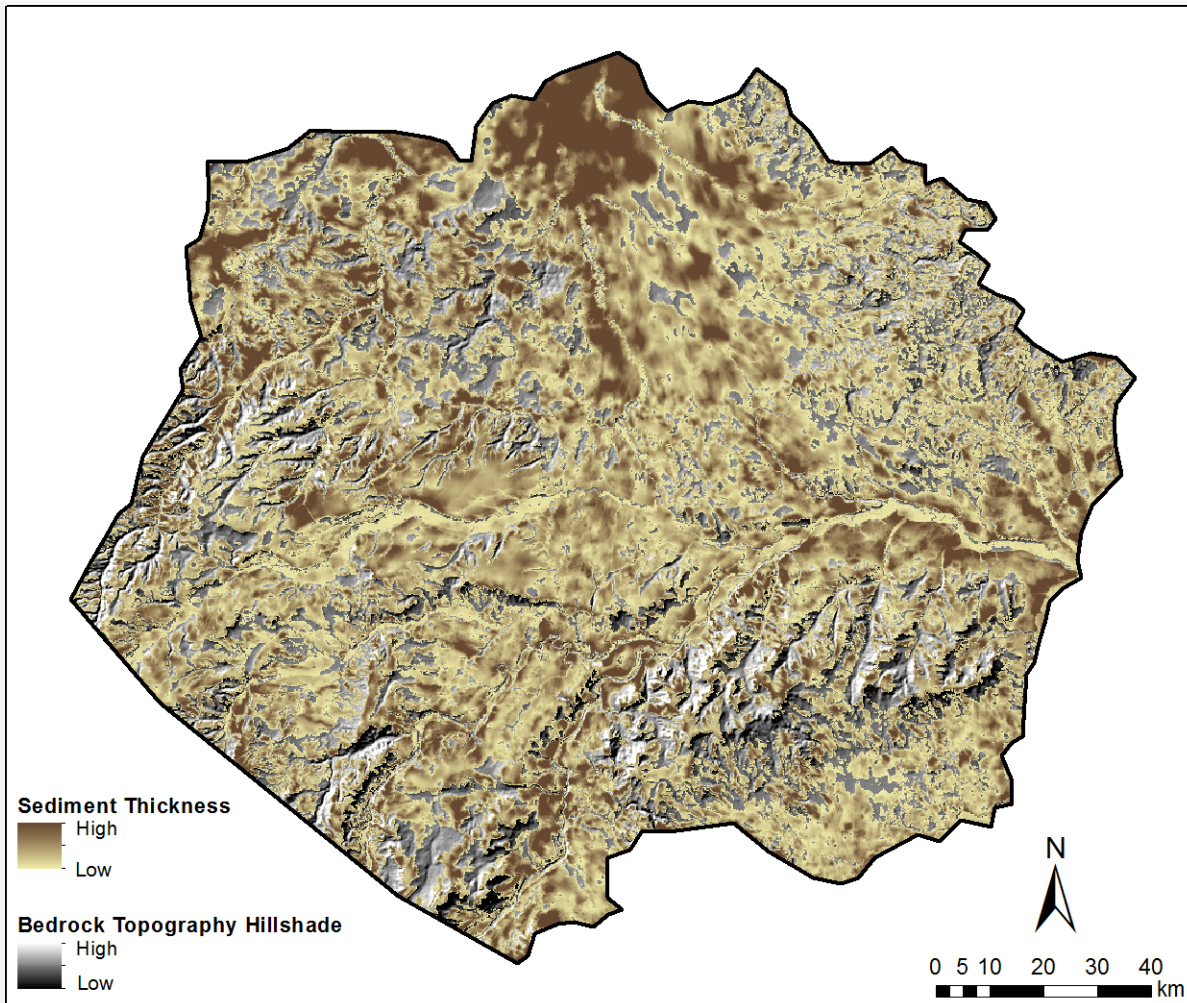
Hydrostratigraphic Modelling



Data Sources:

- › 2015 field mapping
- › Surficial geology field mapping
- › Gamma logs to ground surface
- › Legacy boreholes (e.g. ARC coal)
- › Water wells (used to infill as needed)

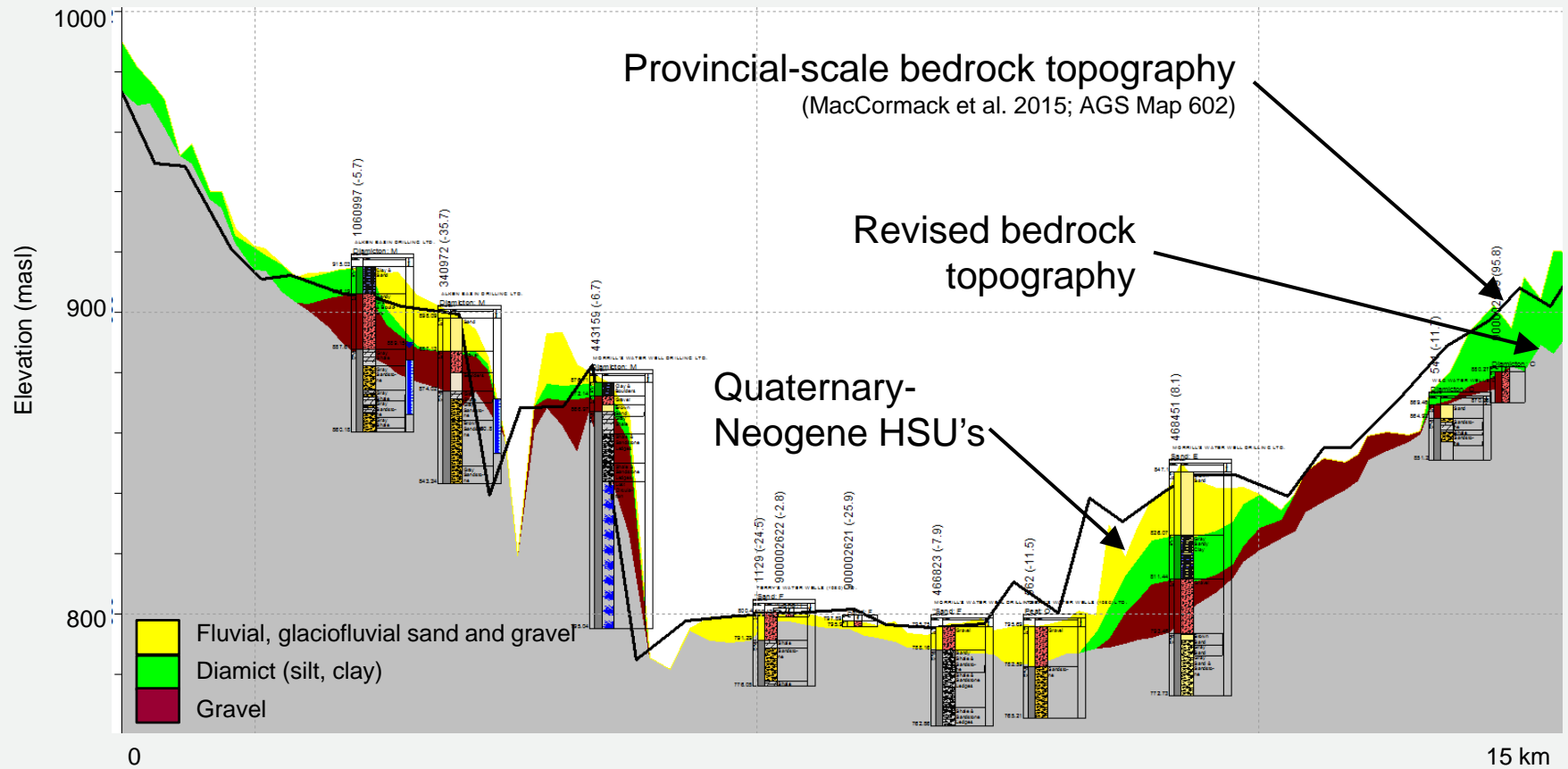
Hydrostratigraphic Modelling



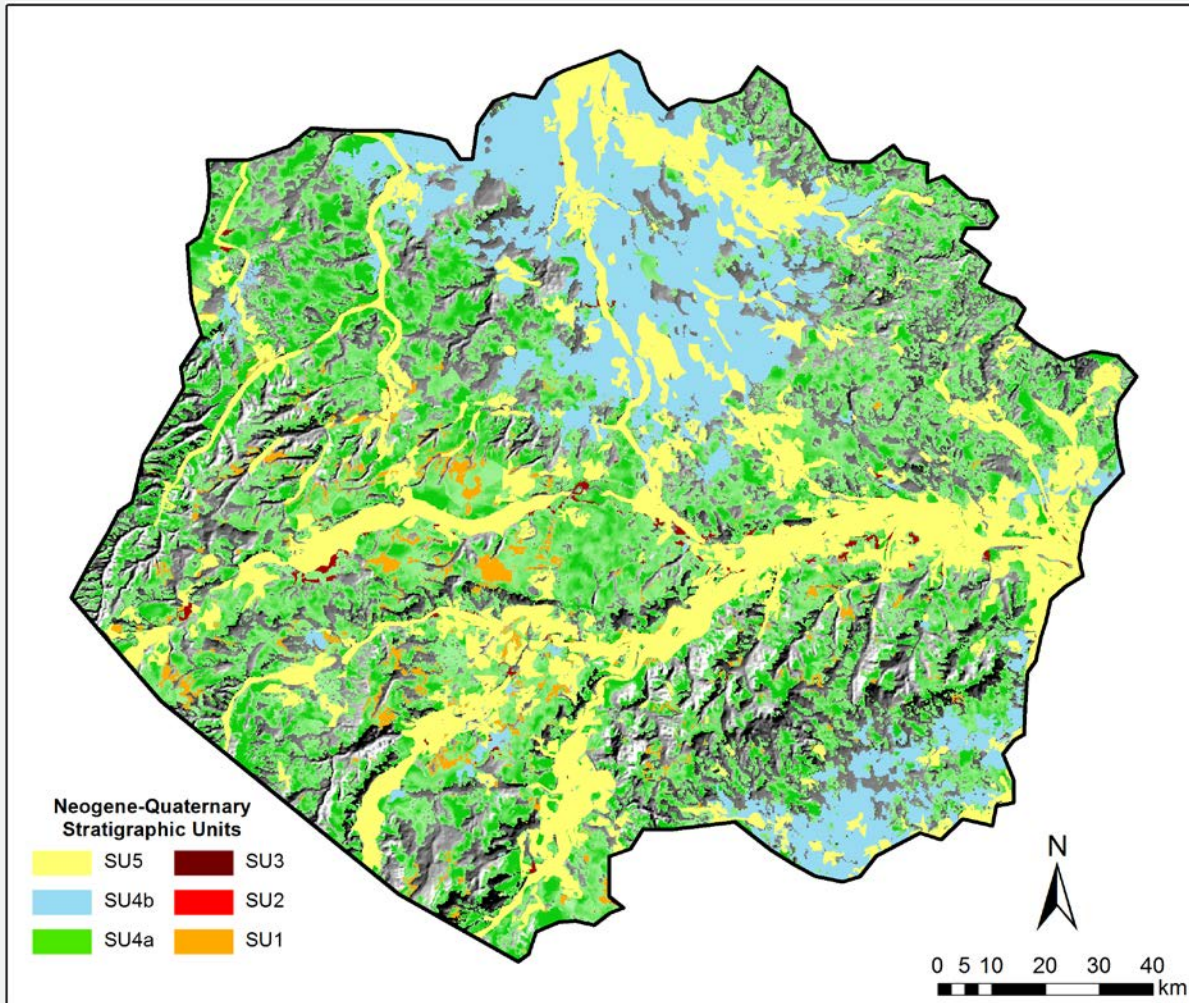
Process:

- › Revise bedrock topography to fit new data
- › Define Quaternary-Neogene hydrostratigraphic units (HSU's)
- › Sand slice mapping (Lea Park Fm to bedrock top)
- › Generate 3D block model

Updated Bedrock Topography

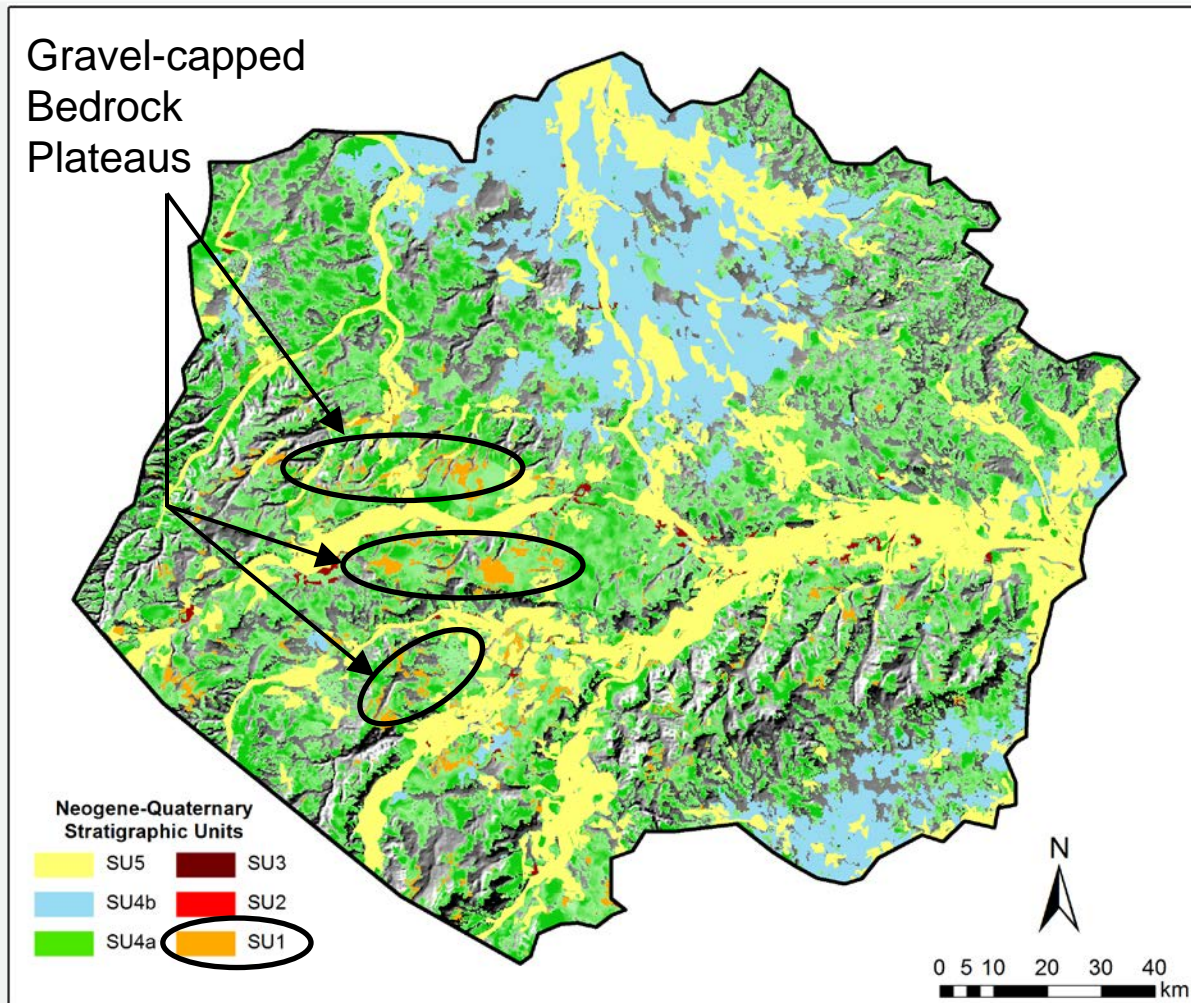


Quaternary-Neogene HSU's



- Broadly similar to surficial geology
(Fenton et al. 2013; AGS Map 601)
- 3D representation of units important for water cycling

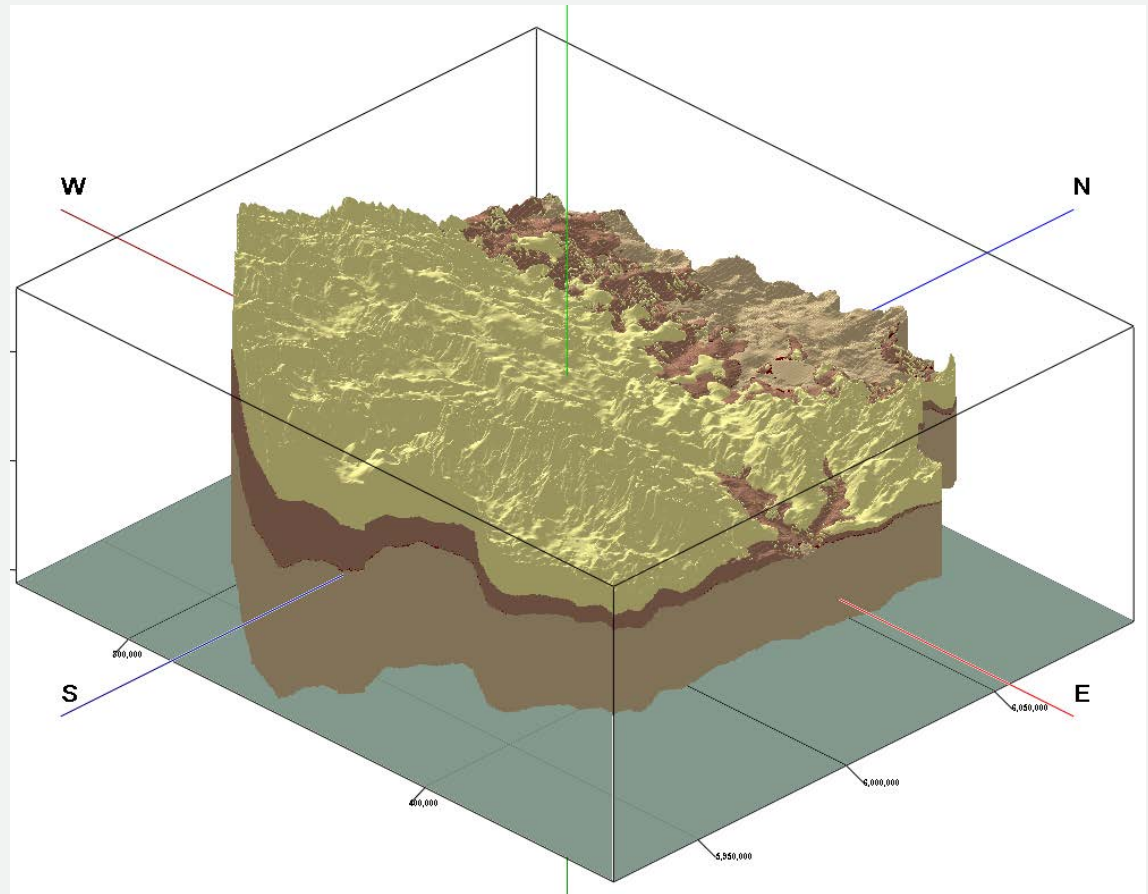
Quaternary-Neogene HSU's



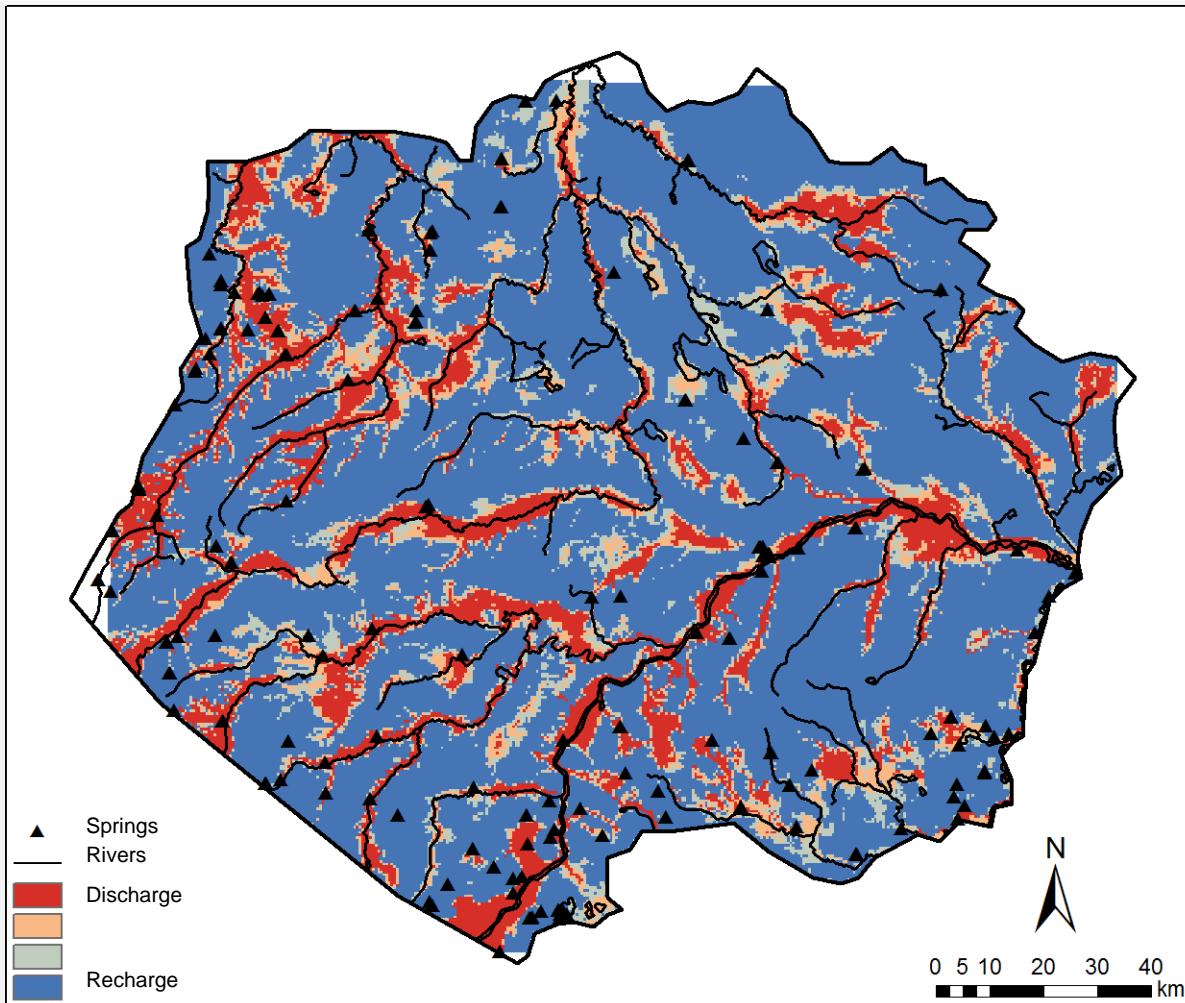
- › Broadly similar to surficial geology
(Fenton et al. 2013; AGS Map 601)
- › 3D representation of units important for water cycling
- › Identify key features related to groundwater recharge

Hydrostratigraphy: Next Steps

- › Slice analysis
 - › Lea Park Fm to bedrock top
 - › Net-to-gross sandstone ratio from gamma ray and water well logs
- › Generate 3D block model
 - › Hydraulic properties
 - › Evaluate trends in permeability

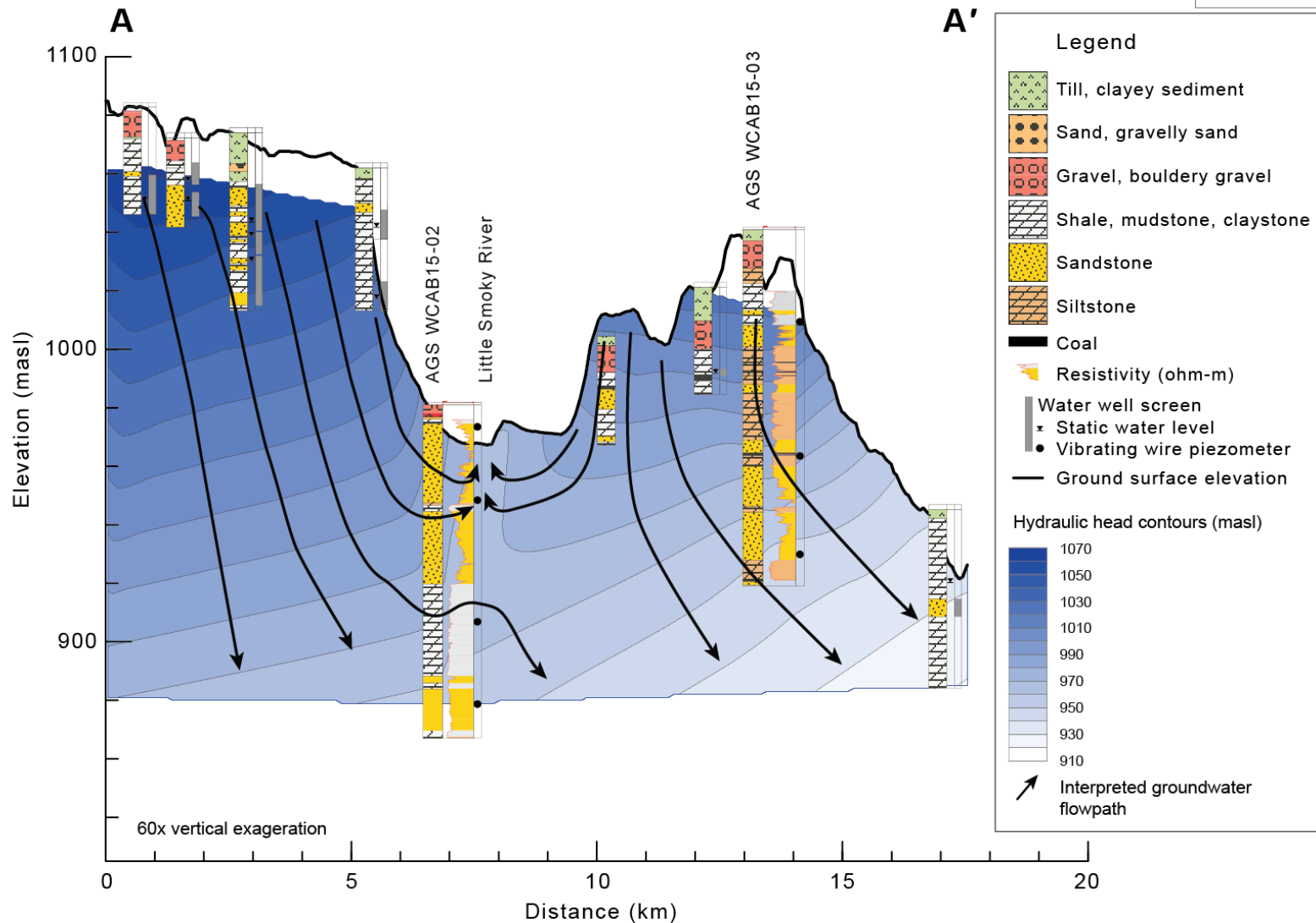
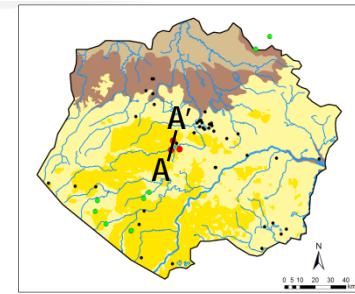


Paskapoo Hydrogeology

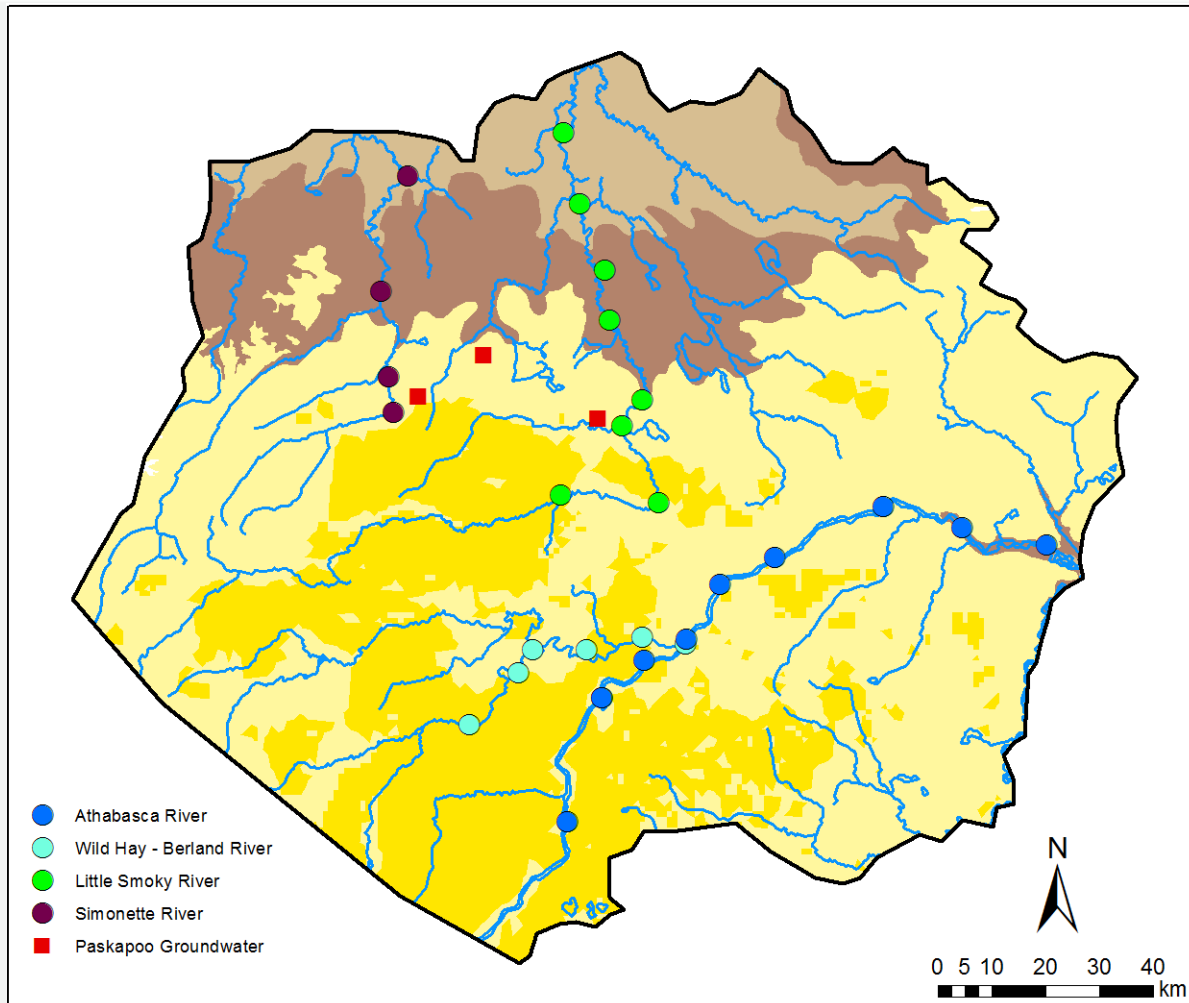


- › Potentiometric surface of uppermost bedrock relative to ground surface
- › Estimate of recharge-discharge potential
- › Dominance of groundwater recharge
- › Localized flow systems provide base flow to rivers

Paskapoo Hydrogeology



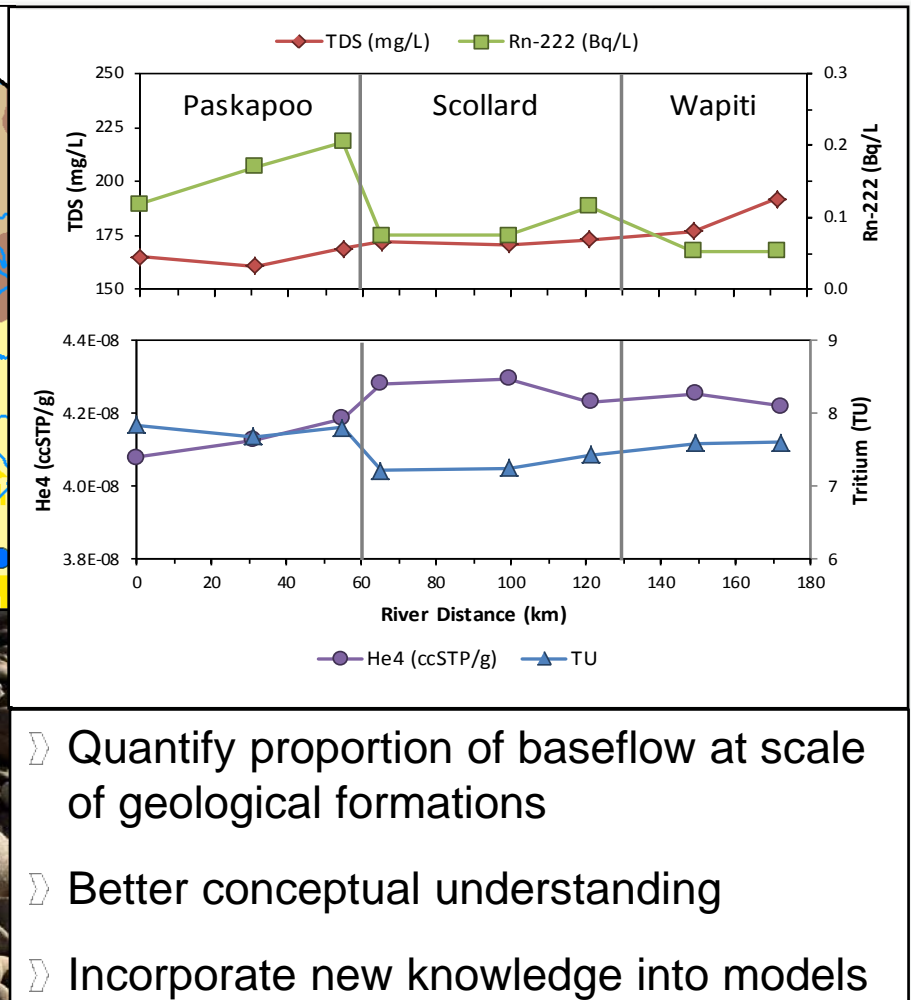
Environmental Tracer Sampling



Process:

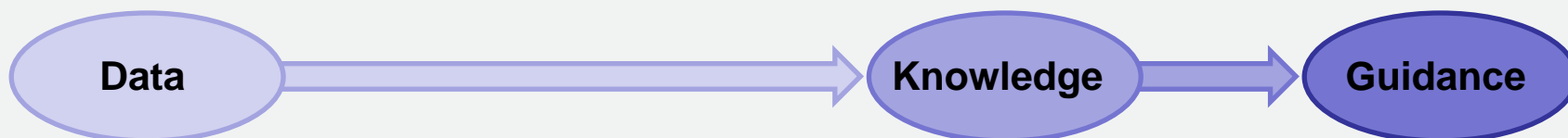
- › Rivers as an integrator of the groundwater circulation
- › Sample river water at low flow (September 2015)
- › Analyze for naturally occurring tracers (noble gases, ^3H , SF_6 , ^{222}Rn , stable isotopes)

Environmental Tracer Sampling



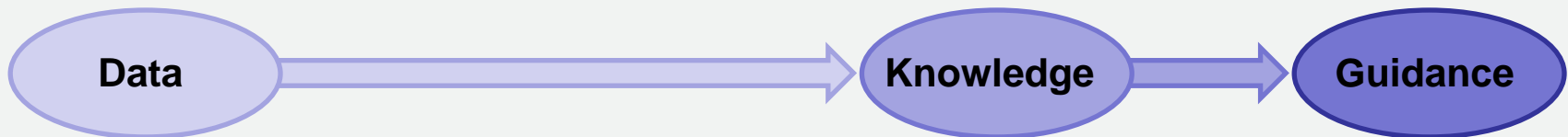
Geoscience for GW-SW Interaction

- 》 Mapping and modelling to develop the ‘big picture’
- 3D hydrostratigraphy
 - Conceptualization of hydrogeology
 - Framework for mapping gaining/losing reaches at regional scale
 - Providing guidance using numerical models for regulators and water policy managers



Geoscience for GW-SW Interaction

- 》 Mapping and modelling to develop the ‘big picture’
- 3D hydrostratigraphy
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- 》 First-order mapping of groundwater interaction
- Provides a basis and justification for more detailed investigation
 - Supports cumulative effects management initiatives



Questions



A landscape photograph showing a wide, rocky riverbank in the foreground. The river flows towards the background, bordered by a dense green forest. The sky is blue with scattered white clouds. A large, light gray chevron graphic points to the right, partially overlapping the text.

Thank you