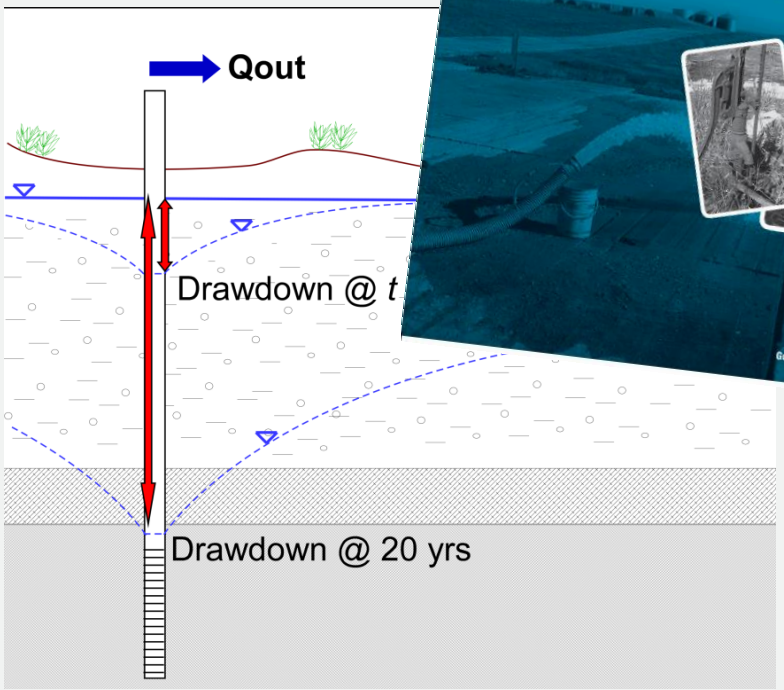
Evaluating A Nested-Scale 3D Modelling Approach To Enhance Groundwater Policy Assurance In Alberta

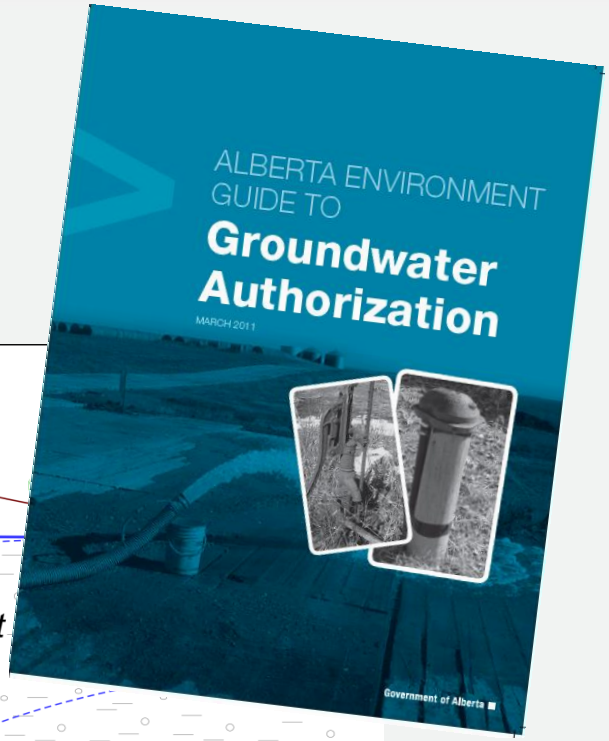
Dan Palombi, Lisa Atkinson, Amandeep Singh
Alberta Geological Survey

What Are We Trying To Enhance?

- Regulatory authorization process as part of the *Water Act* using *geological and hydrogeological models* required to:

  - Evaluate groundwater authorizations
  - Support a change from well by well (Q20) evaluations to cumulative effects based assessments
  - Identify current areas of stress to groundwater and surface water resources
  - Generate regional models to assess water-balance, drawdown and yield forecasting
  - Enable scenario modelling to evaluate future groundwater developments





Why Use A Nested-Scale Approach?

- Advantages
  - Provides regional context for management-scale model
  - Reduces influence of boundary conditions on management-scale model
  - Accounts for groundwater flux between sub-domains
  - Allows for use of Local Grid Refinement Package (LGR) in MODFLOW
- Disadvantages
  - Cumbersome data management
  - Demanding computational requirements
  - Lengthy project durations
  - Multiple approaches to select

Sub-domain models embedded in coarser regional model

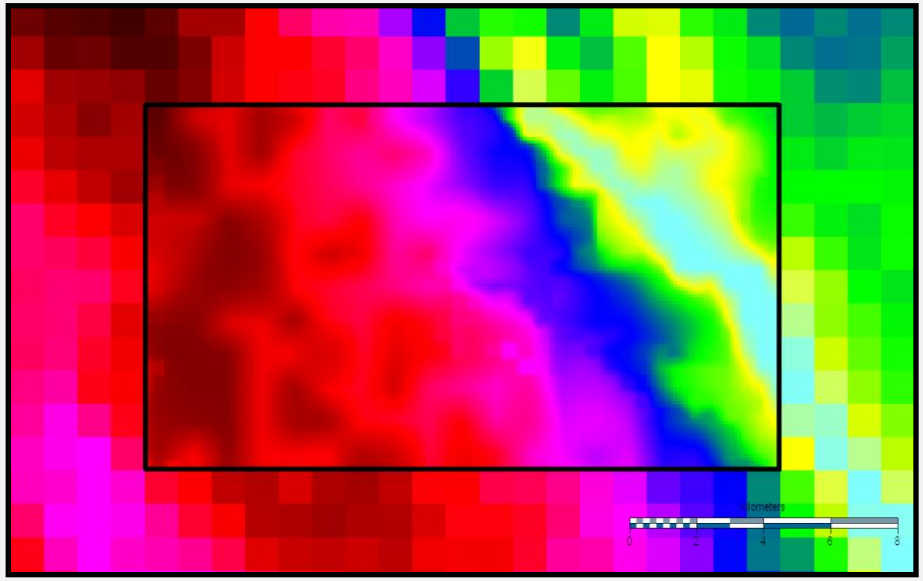
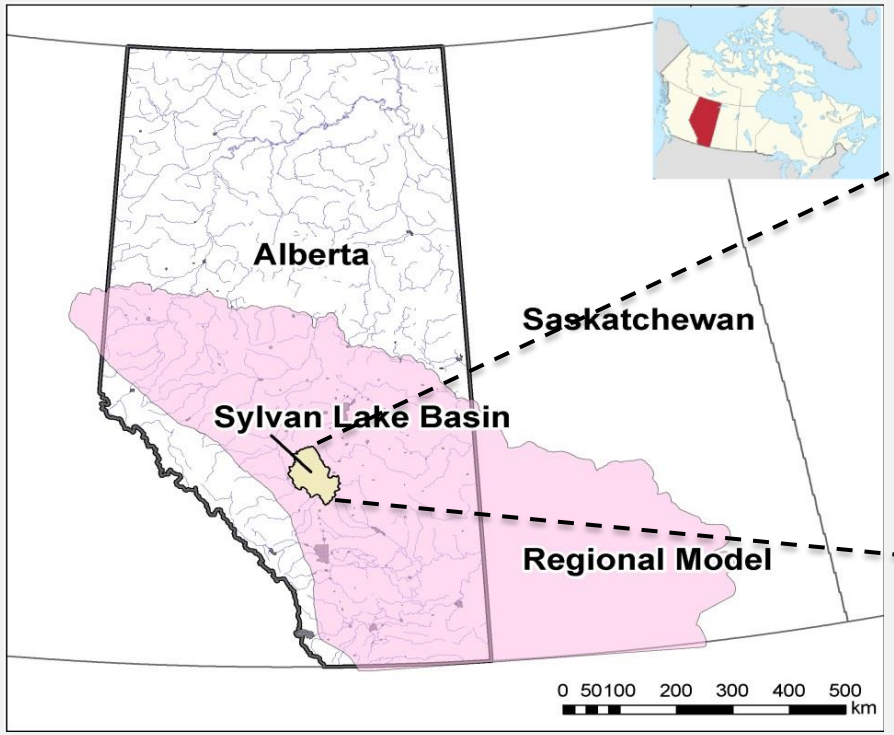


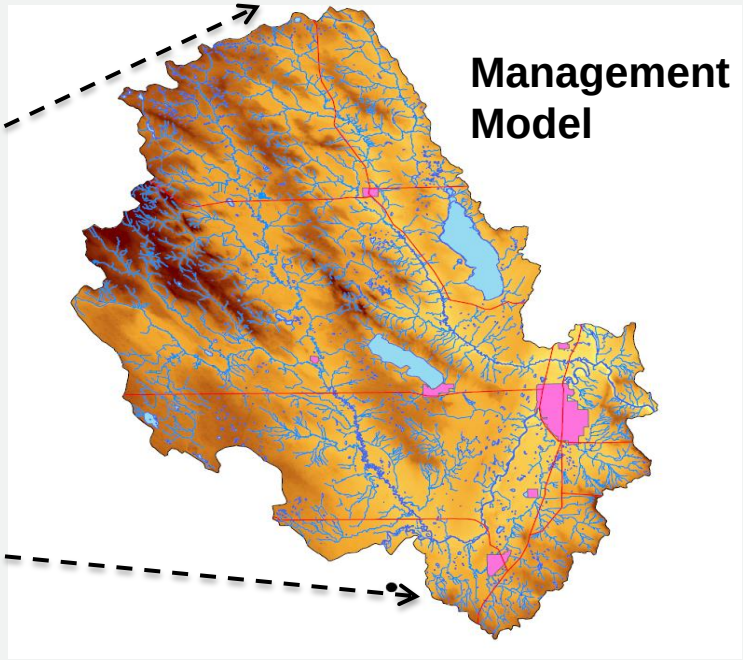
Figure courtesy of Bennie Minnema, Deltares

- Both models are based on the same input data set, only difference is the assigned grid extent and resolution

Nested-Scale Approach

- Local-scale groundwater management model “nested” within a regional groundwater model
- “Nested” predominantly refers to numerical boundary conditions (heads and fluxes)





Alberta Energy Regulator

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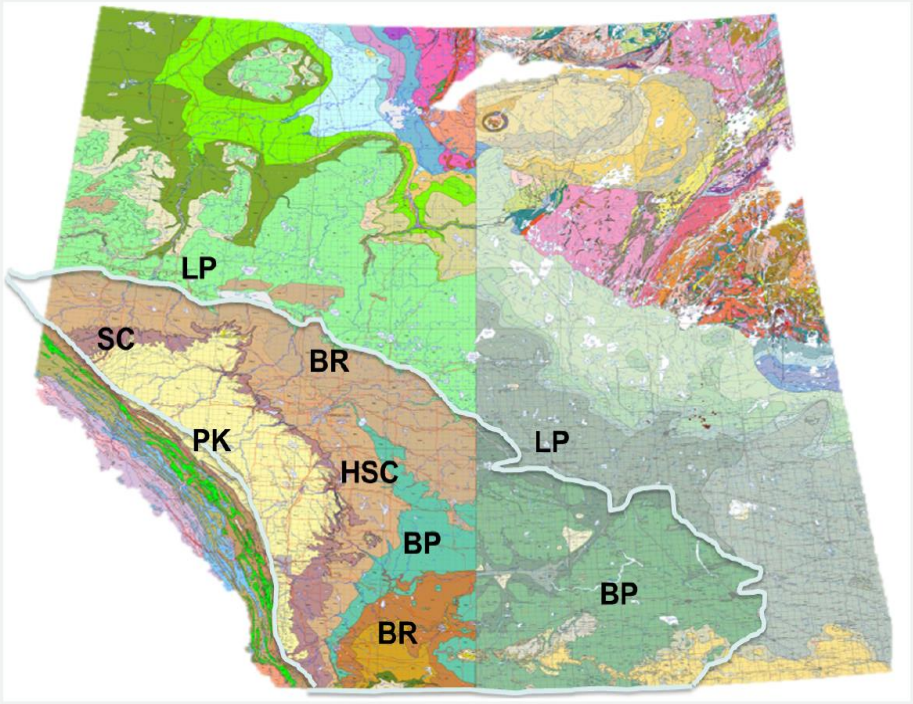
Southern Alberta Regional Groundwater Simulation: SARGS Regional Model

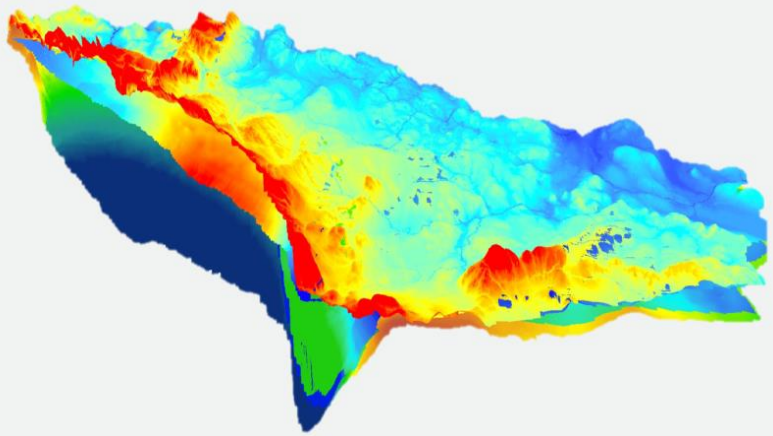


PK: Paskapoo, SC: Scollard, HSC: Horseshoe Canyon, BP: Bearpaw, BR: Belly River, LP: Lea Park.

Bedrock Map

Hydrostatigraphic Layers	Hydraulic Property	Source
Recent	Variable	AER\AGS
Paskapoo	Aquifer	
Scollard	Aquifer	AER\AGS
Battle	Confining	AER\AGS
Horseshoe Canyon	Aquifer	
Bearpaw	Confining	Hamblin(GSC) picks\AGS\Saskatchewan \Outcrops
Belly River	Aquifer	AER\AGS\SWA
Lea Park (Top of Colorado Group)	Confining	AER\AGS\SWA

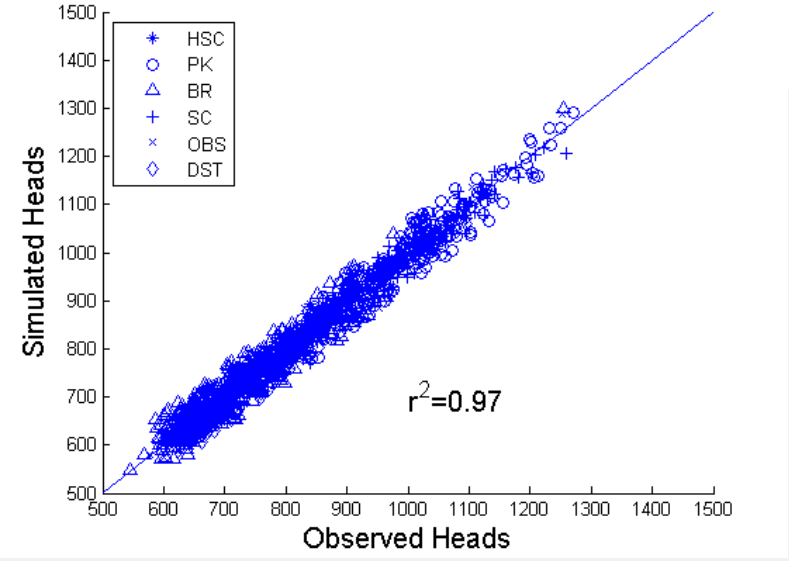
SARGS (9 Layers)

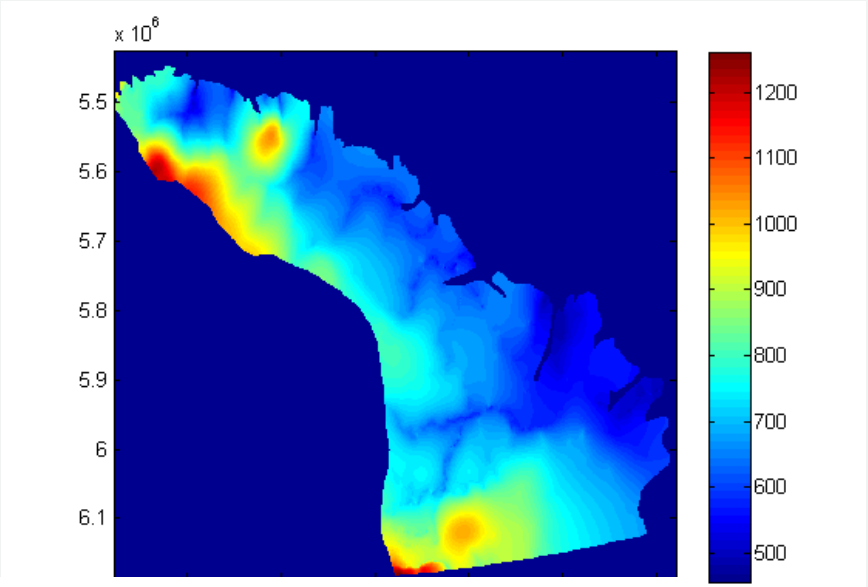


Model Domain

Southern Alberta Regional Groundwater Simulation

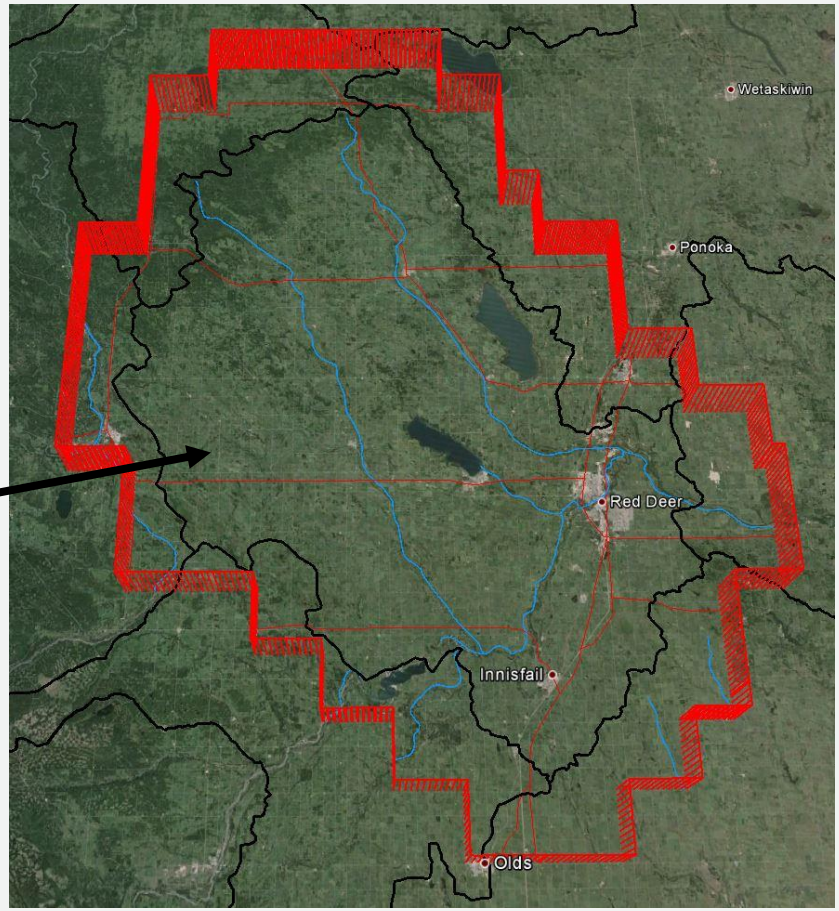
- 1st order regional flow model
- Successfully calibrated, steady state MODFLOW model
- Indicates regional flow patterns
- Serves as foundational model for higher resolution nested-models
- Enables rapid regional water budget calculations
- Provides lateral and vertical boundary conditions for management-scale models



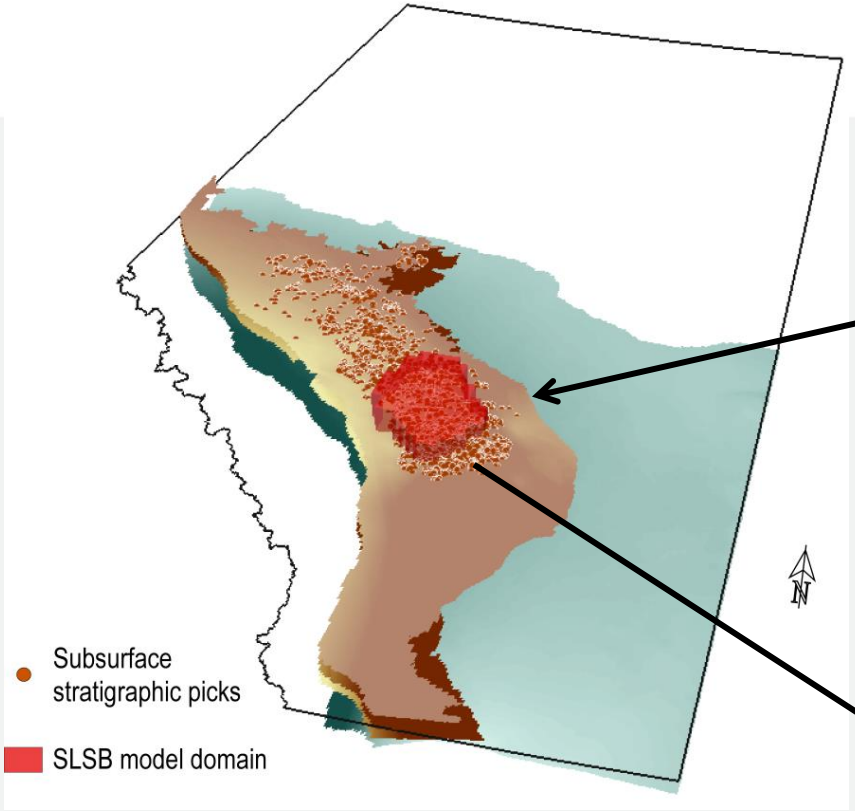


Modelled Belly River unit heads

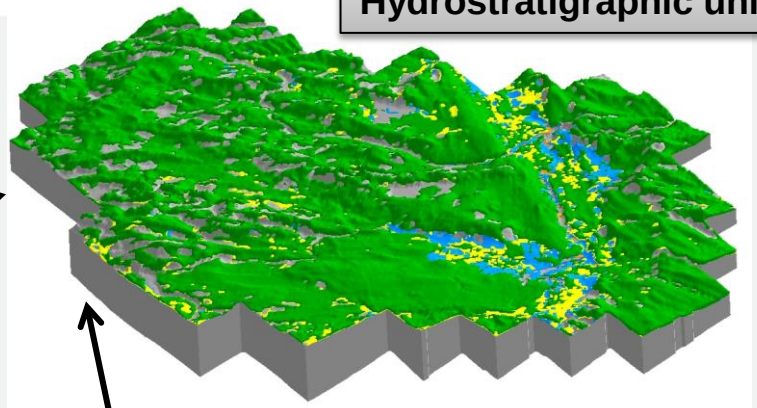
Sylvan Lake Study Area: Management-Scale Modelling



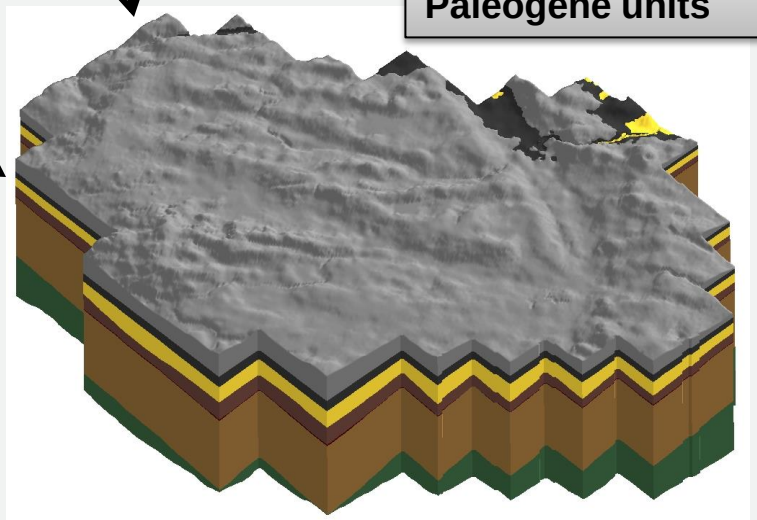
Multi-Scalar Geological Modelling



Neogene-Quaternary Hydrostratigraphic units

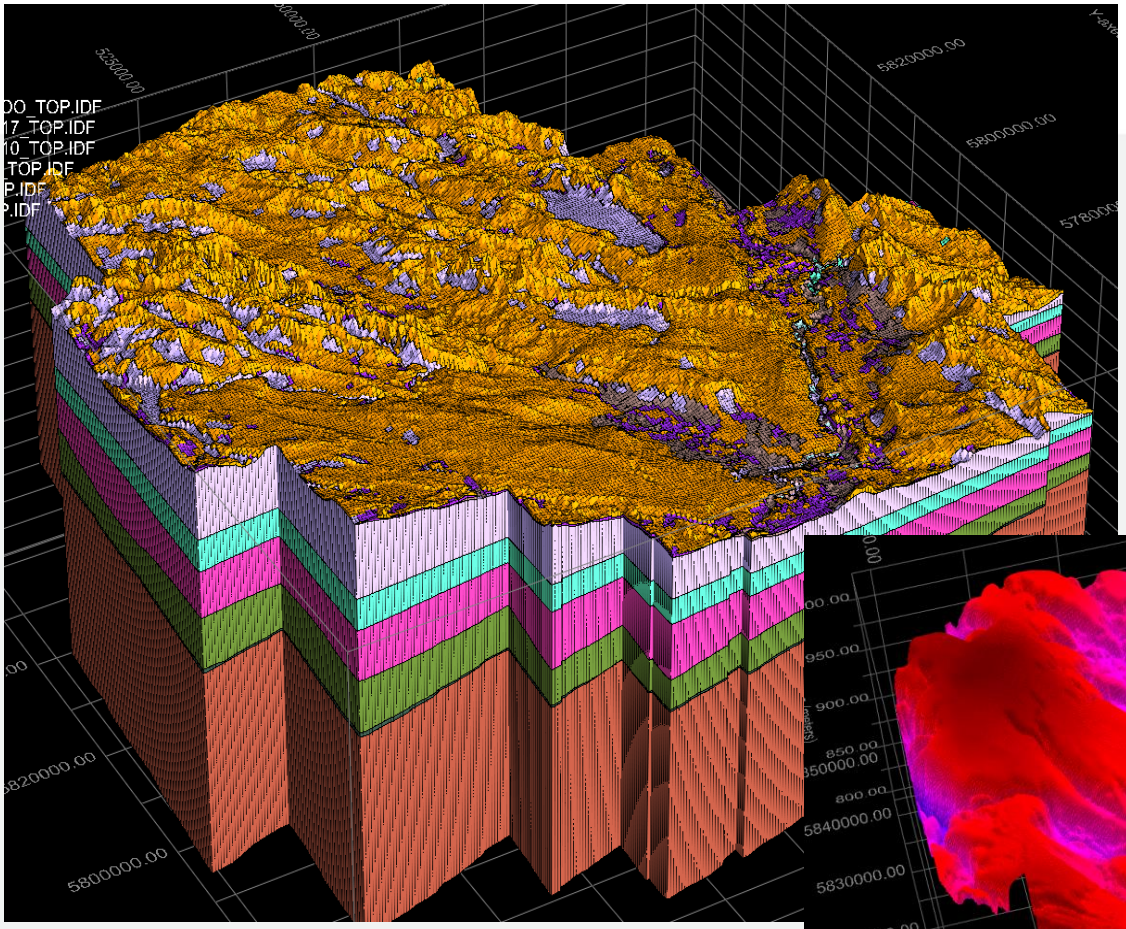


Upper Cretaceous-Paleogene units



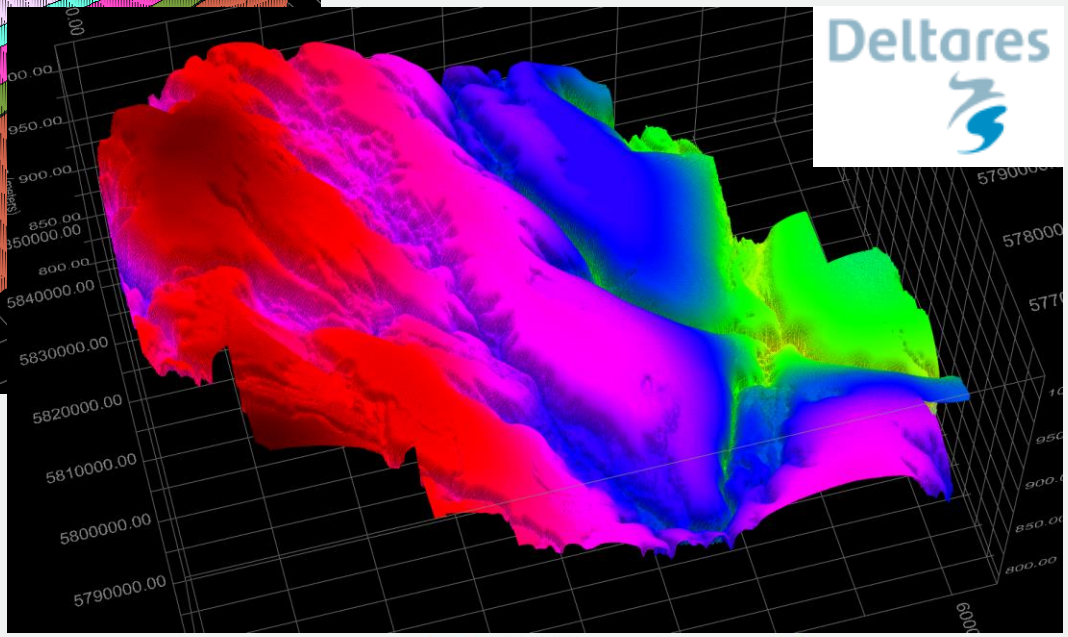
- **Utilization of modelling from the provincial-scale 3D geological framework of Alberta**

Sylvan Lake Groundwater Model Built On Geomodel



• 3D geological model of bedrock and Neogene-Quaternary units (above)

• 3D representation of hydraulic heads (below)

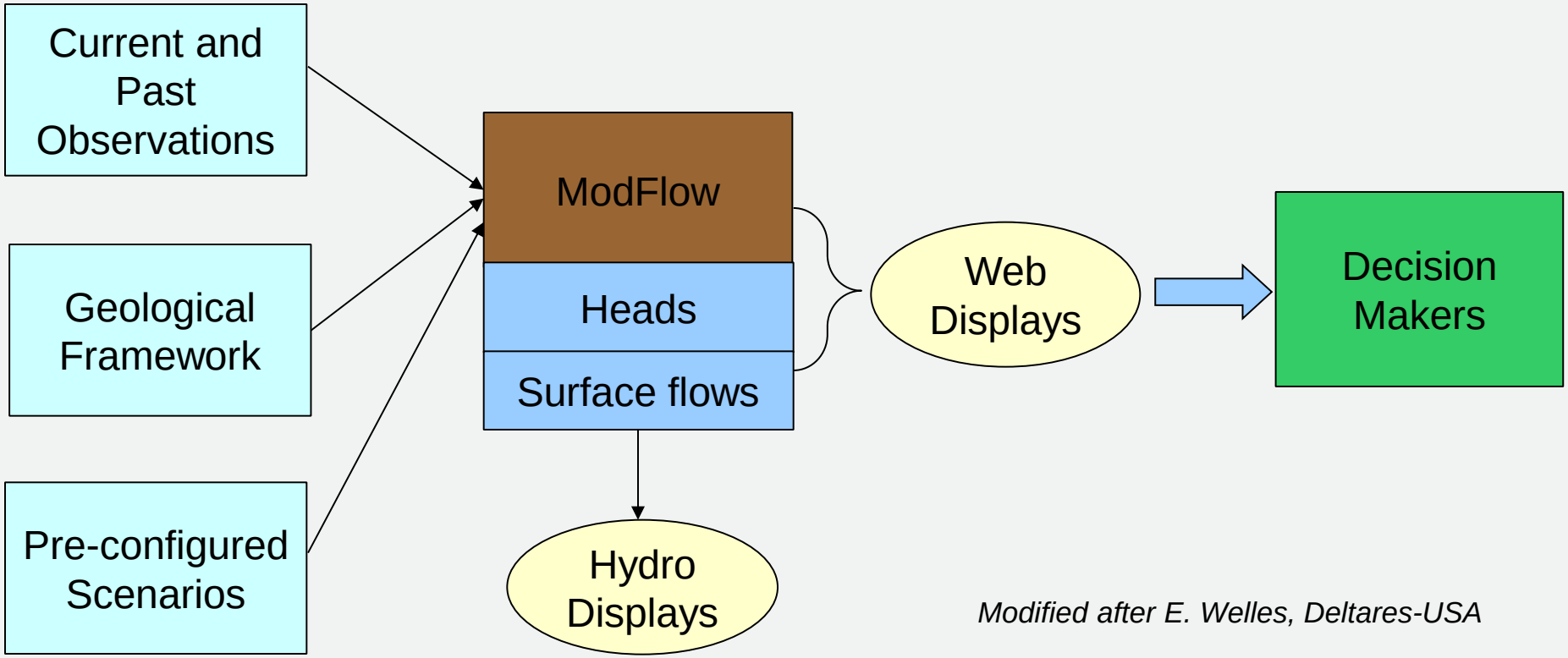


Deltares

What Is Important To Extend Models To Decision-Makers?

- Create scientific linkage between regulators, model developers, managers, and the public
- Enable model users to run & view results outside of the modelling environment
- Compare model results from different scenarios
- Rely upon pre-defined metrics, graphs & thresholds
- ***Focus is on distributing science and knowledge***

Workflow Design of Regulatory Tool for Groundwater Policy Assurance



Modified after E. Welles, Deltares-USA

Summary

- The groundwater regulatory authorization process in Alberta requires an enhancement to evaluate the cumulative effects of development.
- Alberta is a large, geologically complex, province with various demands of water use across sectors calling for a long-term sustainable approach to understanding and predicting effects of groundwater and surface water authorizations.
- Nested-scale geological and hydrogeological models build confidence in modelling results and promote a greater understanding of the regional- and local-scale groundwater systems.
- This approach facilitates model users/decision-makers to utilize scientific results in an operational setting across a large area.

Acknowledgments

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✓ Go To: Paper No. 205-5; *Liggett et al.*, Integration of Regional Geological and Hydrogeological Mapping for Land-use Planning in Southern Alberta