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

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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

Data → Knowledge → Guidance

- Surficial Geology
- Bedrock Geology
- Properties
- Hydraulic Data
- Recharge Discharge
- Hydrostratigraphic Model
- Groundwater Characterization
- Conceptual Model
- Numerical Model

Data Knowledge Guidance
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
Scale and Detail: Finding the Sweet Spot

Provincial scale geological framework

High-resolution geophysical logs

Horizontal Heterogeneity

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
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*
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
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
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
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

More permeable bedrock

Paleovalley sediments

HSU's → property zones

Simulated hydraulic heads

Hydraulic Head (m)

- 1000
- 950
- 900
- 850
- 800
Groundwater - Surface Water Interaction

Hydraulic Head (m)

- Sylvan Lake

W

Gaining

Losing

E
Groundwater - Surface Water Interaction

Losing - Gaining

Hydraulic Head (m)

1000
950
900
850
800
Fox Creek Area
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

Provincial-scale bedrock topography
(MacCormack et al. 2015; AGS Map 602)

Revised bedrock topography

Quaternary-Neogene HSU’s

- Fluvial, glaciofluvial sand and gravel
- Diamict (silt, clay)
- Gravel
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
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, $^3$H, SF$_6$, $^{222}$Rn, stable isotopes)
Environmental Tracer Sampling

- Quantify proportion of baseflow at scale of geological formations
- Better conceptual understanding
- Incorporate new knowledge into models
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

Data ➔ Knowledge ➔ Guidance
Geoscience for GW-SW Interaction

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First-order mapping of groundwater interaction
- Provides a basis and justification for more detailed investigation
- Supports cumulative effects management initiatives
Thank you