The Ontario Geological Survey’s Groundwater Initiative

A. Bajc, F. Brunton, A. Burt, S. Hamilton, A. Marich, R. Mulligan & E. Priebe
Ontario Geological Survey’s Groundwater Initiative

- Geoscience activities applied to groundwater resource assessment and protection have been ongoing at the OGS for well over half a century.
- The level of activity has fluctuated over this time period primarily in response to changing government priorities.
- The OGS groundwater initiative is part of an expanded geoscience mandate that went into effect in 2007.

The initiative consists of 4 main geoscience activities:

- 3-D Sediment Mapping (Bajc, Burt, Mulligan and Priebe)
- 3-D Paleozoic Bedrock Mapping (Brunton and Priebe)
- Ambient Groundwater Geochemistry Project (Hamilton)
- Thematic studies (Marich, Brunton and CA staff)
**Logic Model: OGS Groundwater Geoscience Initiative**

### Issues/ Government Priorities

**Improving Quality of Life for Ontario families:**
- Economy: water is essential to growth
- Improving Quality of Life: abundant clean water is a pre-requisite for healthy families + communities
- Understanding groundwater systems (Clean Water Act; Greenbelt) will enable protection of natural beauty + resources
- Identification of groundwater quality issues & geo-hazards mitigates public health & safety issues

### Outcomes

#### Outputs

**3-5 years**
**Final Geoscience Products**
- 3D Block Model synthesis of major stratigraphic units, Groundwater Resources Study synthesis that includes discussion of geometry and character of each unit, an evaluation of aquifer vulnerability and recharge potential as well as visualization tools; continued outreach
- Final 3D fence diagrams of study area, update regional stratigraphic (formational-scale) relationships and place within a chemostratigraphic and sequence stratigraphic framework in order to produce syntheses delineating extent of hydro-geological units including physical and chemical properties, Groundwater Resources Study synthesis report including detailed methods, analysis and interpretation; continued outreach

**1-3 years**
**Preliminary Geoscience Products**
- Maps, reports, data releases, borehole logs, geophysical data, talks and presentations to client groups, peer groups and stakeholders, field trips, press releases, workshops
- Maps, reports, data releases, borehole logs, geophysical data, talks and presentations to client groups, peer groups and stakeholders, field trips, press releases, workshops
- Annual reports, homeowner reports, talks and presentations to client groups, peer groups and stakeholders, field trips, press releases, workshops

### Activities

#### 3D Sediment Mapping
- Development of 3D models of the glacial deposits that overlie bedrock
- Characterization of the geometry and properties of aquifers and aquitards

#### 3D Bedrock Mapping
- Development of a testable sequence stratigraphic framework
- Delineation, characterization and mapping of regional scale groundwater flow systems

#### Ambient Groundwater Geochemistry
- Characterization and mapping of the chemistry of natural groundwater of southern Ontario
- Evaluation of the relationship between rock and groundwater chemistry

### Uptake by Municipalities, Conservation Authorities, consultants, and other Stakeholder Groups
- Maps, reports, data releases, borehole logs, geophysical data, talks and presentations to client groups, peer groups and stakeholders, field trips, press releases, workshops

### Key Performance Indicators:
- Influence on decision by municipalities (cost savings, health)
- Discovery of new groundwater resources.

### Risk Identification and Mitigation:
- Apply technologies that may or may not work – learn from mistakes
- Receptor awareness and understanding – communication strategy
• fully attributed
• seamless
• standardized legends
3-D Sediment Mapping

- Ground Gravity
- TDEM
- GSC Seismic
- Section Logging
- Continuous Coring
- 3-D Model
- GSC Borehole Geophysics

© Queen’s Printer for Ontario, 2016
3-D Sediment Mapping

- Waterloo Moraine
- Barrie-Oro Moraine
- Brantford-Woodstock
- Orangeville Moraine - Fergus
- South Simcoe County
- Niagara Peninsula
- Central Simcoe County

ORM: Oak Ridges Moraine

Drift Thickness (m)

Value:
- High: 262
- Low: 0

Legend:
- Completed 3-D Mapping Studies
- 3-D Mapping Studies (in progress)
3-D Sediment Mapping

1: Waterloo Moraine
2: Barrie-Oro Moraine
3: Brantford-Woodstock
4: Orangeville Moraine - Fergus
5: South Simcoe County
6: Niagara Peninsula
7: Central Simcoe County
ORM: Oak Ridges Moraine

Drift Thickness (m)
Value
High : 262
Low : 0

Ontario
3-D Mapping: Orangeville-Fergus
3-D Mapping: Orangeville-Fergus

Groundwater Resources Study 15

Ontario Geological Survey

Three-Dimensional Mapping of Surficial Deposits in the Orangeville-Fergus Area, Southern Ontario

2016

Interactive Graphic Borehole Logs and Stratigraphic Correlations, Orangeville–Fergus Three-Dimensional Map Area

A.K. Burt
J. E. Chartrand

Orange borders indicate interactive elements. Click on the circles to navigate through the contents of the pdf.
3-D Mapping: South Simcoe
3-D Mapping: Niagara Peninsula

Lake Ontario

Lake Erie

Borehole Locations
Seismic Lines
Ground gravity lines

Elevation (m asl)
Value
High: 340
Low: 72

9.5, 4.75, 0, 9.5 Kilometers
3-D Mapping: Niagara Peninsula

Composite Log

<table>
<thead>
<tr>
<th>Summary Lithology</th>
<th>Stratigraphic Unit</th>
<th>Depositional Environment and Primary Sediments</th>
<th>Example Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glacial Lake Iroquois</td>
<td>Glaciolacustrine (nearshore)</td>
<td>Sandy, sand, and gravel</td>
<td>![Example Photo]</td>
</tr>
<tr>
<td></td>
<td>Glaciolacustrine (deep water)</td>
<td>Laminated, rhythmically bedded and/or interbedded clay, silty clay and clayey silt</td>
<td></td>
</tr>
<tr>
<td>Upper Glaciolacustrine Unit</td>
<td>Glaciolacustrine (deep water)</td>
<td>Laminated, rhythmically bedded and/or interbedded clay, silty clay and clayey silt</td>
<td></td>
</tr>
<tr>
<td>Halton Unit</td>
<td>Ice-contact delta, glaciolacustrine (nearshore)</td>
<td>Sandy, sand and gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glaciolacustrine (deep water)</td>
<td>Massive, laminated and rhythmically bedded clay and silty clay</td>
<td></td>
</tr>
<tr>
<td>Lower Glaciolacustrine Unit</td>
<td>Glaciolacustrine (deep water)</td>
<td>Laminated, rhythmically bedded and/or interbedded clay, silty clay and clayey silt, rare sand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glaciolacustrine (?)</td>
<td>Sandy, sand and gravel, gravel</td>
<td></td>
</tr>
<tr>
<td>Lower Drift</td>
<td>Glacial hard to overconsolidated stony silt</td>
<td>Sand and gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Esker (?)</td>
<td>Interbedded silt - sand with dirty sand and gravel and/or gravel</td>
<td></td>
</tr>
<tr>
<td>Bedrock</td>
<td>Gravel to boulders</td>
<td>Bedrock: Gravina Formation cherty limestone and Dardew Formation limestone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bedrock: Esquesing Formation bluish-gray dolomite, Gravel Formation very fine sand, gravels and cobbles, and Bride Formation dolomite</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bedrock: Queenston Formation highly weathered to competent shale</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Silt to clay diamictic
- Silt to sand diamictic
- Clay
- Silt and clay
- Silt
- Silt to very fine sand
- Sand
- Laminated, rhythmically bedded
- Devonian bedrock
- Silurian bedrock
- Ordovician bedrock
- Interbedded
- Sand
- Sand and gravel
- Gravel to boulders
- Dirty sand and gravel
- No Recovery

Chippawa Channel - East Salina Basin Area

<table>
<thead>
<tr>
<th>Elevation (m a.s.l.)</th>
<th>BH14</th>
<th>BH15</th>
<th>BH21</th>
<th>BH11</th>
<th>BH31</th>
<th>BH03</th>
<th>BH22</th>
<th>BH26</th>
<th>BH12</th>
<th>BH24</th>
<th>BH23</th>
<th>BH25</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>155</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>135</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- All terraces - Shale
- Moraine
- Escarpment
- Ice-contact till

© Queen's Printer for Ontario, 2016
OGS Bedrock Aquifer Mapping Program

Objectives

- Delineate and map regional-scale groundwater flow systems to differentiate key aquifers & aquitards.
- Develop testable sequence stratigraphic frameworks for predictive mapping/exploration of new groundwater resources.
- Develop field- & lab-based protocols to integrate rock and water geochemistry to facilitate groundwater investigations and answer questions related to human health.

Approach

- Collect, log, photograph PQ-HQ core down to regional aquitard: >80 cores; >300 wells; >15000 logs within outcrop-subcrop belt.
- Downhole – camera, optical-acoustic televiewer, geophysics, packer testing, flow profiling, pumping tests, dye tracer tests, FLUTE® K-profiling, heat pulse profiling.
- Sampling - lithogeochemistry, hydrochemistry, chemostratigraphy, biostratigraphy, SEM and petrography.
Integration of Hydrogeology and 3-D Bedrock Mapping: Guelph Case Study

Objectives

- Characterize the groundwater flow zones hydrogeologically
- Evaluate how rock character influences groundwater flow

Approach

- Integration of stratigraphic logs with Kh values estimated from discrete hydraulic tests

Outcomes

- Improved understanding of the range and spatial distribution of Kh at the member scale to support GW flow model development.
- Supporting the selection of future water supply exploration targets
Dissolved Methane (CH$_4$) in Bedrock

Methane Percent Saturation
Bedrock Wells

Methane Study
Collaborative Agreement:
Ontario Geological Survey
Geological Survey of Canada
University of Arizona
Thematic: Dundas Buried Bedrock Valley
Thematic: Dundas Buried Bedrock Valley

• Data compilation
• Regional ground-based gravity survey
• Preliminary assessment of valley fills
• Continuous coring to bedrock at 11 sites
• Development of conceptual geologic models
• Hydraulic testing of aquifers and geochemical characterization of groundwaters
• Reporting of results in GRS
Thematic: Norfolk Tier 3 Study

An Assessment of Subsurface Sediments in the Central Norfolk Sand Plain, Norfolk and Oxford Counties, Southern Ontario

2014
CA Thematic Studies

- **GRS 001**: Central Lake Ontario Groundwater Resources Study
- **GRS 002**: Essex Region Groundwater Resources Study
- **GRS 004**: Long Point Groundwater Resources Study
- **GRS 006**: Groundwater Resources of the Credit River Watershed
- **GRS 007**: Karst Delineation and Sinkhole Investigation in the Ausable Bayfield Conservation Authority Watershed and Surrounding Area
- **GRS 008**: An Investigation of the Buried Bedrock Valley Aquifer System in the Schomberg Area of Southern Ontario
- **GRS 009**: An Investigation of the Buried Bedrock Valley Aquifer System in the Caledon East Area, Southern Ontario
- Vars Winchester esker study, aquifer screening tool, etc.
3D Mapping of Surficial Aquifers

3D Mapping of Surficial Aquifers contains information regarding the three dimensional distribution and character of surficial materials that may form groundwater aquifers and aquitards. Data includes: borehole information, isopachs, structural contours and both bedrock and surficial geology image overlays.

http://www.geologyontario.mndm.gov.on.ca/