Development of a Numerical Model to Support Regional Cumulative Effects Groundwater Management within the NAOS Area

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Overview

- Context
- Methodology
- Modelling Tool Development
  - Conceptualization
  - Numerical Model
- Continued Work
Alberta Government has committed to manage and protect water resources through the Water for Life Strategy

**Goals**
- Safe secure drinking water
- Healthy aquatic ecosystems
- Reliable quality supplies for a sustainable economy

**Key Directions**
- Knowledge and Research
- Partnerships
- Conservation
Concern within AOS

Potential cumulative impacts of historic, current, and future development on:

- Quantity
- Quality
- Interactions

Surface Water

Groundwater
Develop & Integrate Tools

- Modelling
- Management
- Monitoring
Monitoring
Management
Modelling

NAOS
Developing Regional GW Flow Model (ongoing)

SAOS
Developed Regional GW Flow Model (2010)

NAOS & SAOS:
Draft Groundwater Management Frameworks (in review)

NAOS:
Implemented RGWMN (2009)
Expand RGWMN (2010)

SAOS:
Designing RGWMN (2012)
Methodology

1. Develop Study Objectives
2. Define Study Area
3. Collect Data
4. Develop Conceptual Model
5. Develop Numerical Model
6. Apply Model to Study Objectives

Industry Consultation
External Experts

Review & Refine
Cumulative Impact Assessment

- Develop numerical modelling tools
  - Quantify potential cumulative impacts from regional oil sands development
  - Support Groundwater Management Framework
  - Expand the NAOS RGWMN
Industry Participants

- Athabasca Oil Sands Corp.
- Cenovus Energy
- Esso
- Imperial Oil
- Suncor Energy
- Synchro crude
- HS Energy
- Total
- Canadian Natural
External Experts

Alfonso Rivera
- Director of Geoscience for the Geological Survey of Canada
- Member of expert panel that reviewed the NAOS Groundwater Management Framework

René Therrien
- Chair, Department of Geology and Geological Engineering at Université Laval
- Member of the Royal Society of Canada Expert Panel
Study Area

- NOAS Model Domain
- Groundwater Model Study Area
- Land Use Planning Regions
- Sub-Basins
- Hydrology

**Oil Sand Leases**

**Status**
- No Activity
- Producing
- Proposed
Study Area

- Mineable
- In Situ
Data Compilation

- Geology & Hydrogeology
- Hydrology & Meteorology
- Land Use
- Oil & Gas Production

MAP DATA

Non-digital Maps
- Scan *.tif
- Digitize features *.dxf
- Import into ArcGIS
- Transform into map coordinates

Digital Maps

DIGITAL DISCREET DATA

Ascii Text File
- Excel Spreadsheet
- Access Database
- Import into database

Note: Imported ascii, excel and other database info may require conversion of coordinates.
Physiography boundaries delineated from Andriashek & Atkinson (2007).

Boreal Forest Subregions approximated from Natural Regions Committee (2006).
Hydrology

Annual Low Flows

- Athabasca River Below Eymundson
- Athabasca River Below McMurray
- Clearwater River At Draper
- Clearwater River Above Christina River
- Firebag River Near The Mouth
Modified from Andriashek & Atkinson 2007

<table>
<thead>
<tr>
<th>Interval</th>
<th>Groundwater flow velocity (m/y)</th>
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<tbody>
<tr>
<td>Till</td>
<td>&lt;1</td>
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<tr>
<td>Surficial sands and buried channels</td>
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<td>&lt;1 to 7</td>
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<tr>
<td>McMurray oilsands</td>
<td>&lt;1 to 2</td>
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<tr>
<td>Basal McMurray</td>
<td>&lt;1 to 35</td>
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<tr>
<td>Waterways</td>
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<td>Prairie Evaporite</td>
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<td>Methy</td>
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## Hydrostratigraphy

<table>
<thead>
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<th>Period</th>
<th>Group</th>
<th>Formation</th>
<th>Hydrostratigraphy</th>
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<tr>
<td>Quaternary</td>
<td>Surficial</td>
<td>Undifferentiated</td>
<td>Sand Aquifer 1</td>
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<td>Overburden</td>
<td>Till Aquitard 1</td>
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<tr>
<td></td>
<td>Sands</td>
<td></td>
<td>Sand Aquifer 2</td>
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<tr>
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<td>Tills</td>
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<td>Till Aquitard 2</td>
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<td>Sands</td>
<td>Coarse Fluvial</td>
<td>Bedrock Channel Aquifer</td>
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<td>Tills</td>
<td>Sediments</td>
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<td></td>
<td>Coarse</td>
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<tr>
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<tr>
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<td>Tills</td>
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<td>Colorado</td>
<td>La Biche</td>
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<td>Joli Fou</td>
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<td>Upper</td>
<td>Grand Rapids</td>
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<tr>
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### Hydrostratigraphy (continued)

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<td>Mannville</td>
<td>Clearwater</td>
<td>Clearwater Aquitard</td>
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<td>Upper</td>
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<td></td>
<td></td>
<td>Middle (Top Water)</td>
<td>Middle McMurray Top Water Aquifer</td>
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<td></td>
<td></td>
<td>Middle (Bitumen)</td>
<td>McMurray Aquitard</td>
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<tr>
<td></td>
<td></td>
<td>Lower (Bitumen)</td>
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<tr>
<td></td>
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<td>Lower (Basal Sand)</td>
<td>McMurray Basal Sand Aquifer</td>
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<td>Sub-Cretaceous Unconformity</td>
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<td>Devonian</td>
<td>Beaverhill Lake</td>
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<td>Beaverhill Lake-Cooking Lake Aquifer/Aquitard</td>
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<td>Watt Mountain</td>
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<td>Muskeg</td>
<td>Prairie Aquitard/Aquiclude</td>
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<td>Contact Rapids Aquitard</td>
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<td>Basal Red Beds/La Loche</td>
<td>Basal Aquifer</td>
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</table>
Surface & Isopach Development

- Data compiled in relational databases
- Developed database tools to QA/QC data
- Linked databases to visualization software

Devonian Surface
Operator Tops (50,433)
Grid Data (10,485)
Control Points (5)
Conceptualization
Conceptualization
Conceptualization
Conceptualization
Calibration Data

- 1,019 Unique Wells
- 853,266 Water levels
- Date range: 1974 to 2011
- Includes NAOS RGWMN Data
21 layer FEFLOW model (3.0 million elements)

Calibration Methodology
1. Manual steady state calibration
2. Automated (PEST) to optimize parameters and assess confidence bounds
3. Initial transient calibration for McMurray Basal Sand Aquifer
4. Full transient calibration (future)
Continued Work

- Complete transient model calibration (Phase 2)
- Define a scenario(s) for analysis (Phase 2)
- Apply scenario results to identify locations for the expansion of the NAOS RGWMN (Phase 2)
- Develop tools to facilitate communication of results with the public (Phase 3)
- Develop a model update schedule (Phase 2)
Questions?

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