Simulation of Groundwater Flow and Groundwater/Surface-water Interactions in the Bad River Watershed, Wisconsin

Andy Leaf, Mike Fienen, Randy Hunt (USGS)
AWRA – Wisconsin Section 37th Annual Meeting
March 8, 2013, Brookfield, WI
Overview

Background/Motivation

Analytic Element

Screening Model

Evaluating new data worth

3-D MODFLOW model
Motivation

- Importance to watershed ecosystems
  - Kakagon slough
  - Fish habit
- Primary drinking water source
- No previous quantitative framework
- Potential future mining

http://johnsonplanteologyresearch.files.wordpress.com/
Geologic Setting

from Cannon et al 2008
Geologic Setting

- Copper Falls Fm.
- Puritan Batholith and Archean Volcanics
- 1675 ft. asl
- Mellen Complex and Keweenawan Volcanics
- Oronto Group (steeply dipping sandstone and conglomerate)
- Miller Creek Fm.
- Bayfield Group (sub-horizontal sandstone)
- 602 ft. asl

USGS
20x vertical exaggeration
Screening model overview

GFLOW

2-D (Dupuit Forchheimer)

Steady-State
Screening model overview
Screening model overview
Calibration Data
Calibration Data by weight
Pareto optimization
Final screening model calibration results
Final screening model calibration results

Simulated vs. Observed Streamflows (ft^3/d)
Evaluating new data worth - uncertainty propagation

Observations
(heads, stream baseflows)

Groundwater Flow Model
(Parameters, such as hydraulic conductivity, recharge, etc.)

Prediction
(heads, stream baseflows)
Evaluating new data worth

Relative worth of potential well locations

Bad River Flow at Highway 13
Geologic Setting

- **S**
  - Copper Falls Fm.
  - 1675 ft. asl
  - Puritan Batholith and Archean Volcanics
  - Mellen Complex and Keweenawan Volcanics

- **N**
  - Miller Creek Fm.
  - 602 ft. asl
  - Oronto Group (steeply dipping sandstone and conglomerate)
  - Bayfield Group (sub-horizontal sandstone)

2 Miles
20x vertical exaggeration
3D MODFLOW model – Layer 1 hydraulic conductivity
3D MODFLOW model – Layer 2 hydraulic conductivity
3D MODFLOW model – streamflow routing
Streamflow Routing
Fractures!

Figure 11. Schematic block diagram illustrating the geometry of fault sets in the central Gogebic iron range. Simplified from Hotchkiss (1919). Black units are diabase dikes.

From Cannon et al. 2008
Upcoming work

Finish and calibrate MODFLOW model

Additional field data collection
- baseflow measurements
- water levels
- additional wells?
- DTS??
References

# Data sources

<table>
<thead>
<tr>
<th>Data type</th>
<th>Source:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model input</strong></td>
<td></td>
</tr>
<tr>
<td>Surficial Geology</td>
<td>GIS data from the USGS (Open File Report 99-546)</td>
</tr>
<tr>
<td></td>
<td>GIS data from WGNHS (digitized from Quaternary Geologic Maps of the U.S.)</td>
</tr>
<tr>
<td></td>
<td>Lake Superior bathymetry from NOAA (<a href="http://www.ngdc.noaa.gov/mgg/greatlakes/superior.html">http://www.ngdc.noaa.gov/mgg/greatlakes/superior.html</a>)</td>
</tr>
<tr>
<td>Subsurface Geology</td>
<td>WGNHS Well Construction Reports</td>
</tr>
<tr>
<td></td>
<td>GIS data from USGS (Misc. Field Studies Map 1174)</td>
</tr>
<tr>
<td>Elevation</td>
<td>National Elevation Dataset 30m DEM</td>
</tr>
<tr>
<td>Soil/Land surface</td>
<td>USDA and USGS GIS datasets</td>
</tr>
<tr>
<td>hydrology</td>
<td></td>
</tr>
<tr>
<td>Climate</td>
<td>NWS Temperature and Precip records from Mellen Airport</td>
</tr>
<tr>
<td>Streams and Lakes</td>
<td>GIS data and tables from National Hydrologic Dataset (NHDPlus v2)</td>
</tr>
<tr>
<td><strong>Calibration</strong></td>
<td></td>
</tr>
<tr>
<td>Water Levels</td>
<td>National Water Information System (NWIS) database</td>
</tr>
<tr>
<td></td>
<td>Reservation Wells</td>
</tr>
<tr>
<td></td>
<td>WGNHS Well Construction Reports</td>
</tr>
<tr>
<td></td>
<td>Field Observations</td>
</tr>
<tr>
<td>Streamflow</td>
<td>NWIS</td>
</tr>
<tr>
<td></td>
<td>Seepage Runs</td>
</tr>
</tbody>
</table>
Early screening model calibration results
### Streamflow Routing – NHDPlus data utilized

<table>
<thead>
<tr>
<th>NHDPlusAttributes</th>
<th>NHDFlowlineVAA (Value Added Attributes)</th>
<th>GIS line features representing streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevslope</td>
<td>Min/Max elevations for each segment</td>
<td></td>
</tr>
<tr>
<td>PlusFlow</td>
<td>Value Added Attributes, including segment length, arbolate sum, stream order, hydrosequence numbering, and codes describing the feature type</td>
<td></td>
</tr>
<tr>
<td>PlusFlow</td>
<td>Routing Information</td>
<td></td>
</tr>
</tbody>
</table>