Model Management
Moving Forward in Ontario

Workshop on Groundwater Data Framework and Hydrogeology Model, Southern Ontario
November 24th 2015 | Grand River Conservation Authority
YPDT-CAMC Oak Ridges Moraine Groundwater Program
Well-maintained data appreciate in value like a vintage car.

As our models increase in sophistication we should be investing in more comprehensive monitoring to shed light on how well the models reflect reality (Silberstein, 2006).

As reliable data supplies dry up, scientists are resorting to sophisticated data assimilation models (e.g. Rodell et al., 2004; Fekete et al., 2004)—models that produce numbers consistent with what we think the data would show if we actually had data.

At the rate we are going, by the 2020s we will use model output as model inputs to drive all of our models and we will verify our models with output from other models, eliminating the requirement for data at all.

Each and every hydrologist needs to imagine what their information needs might be in 20 years time, and from that perspective consider what monitoring decisions need to be made today in order to supply those information needs.
Groundwater Models

Numerical Groundwater Model Extents
Surface Water Models

Hydrological Model Extents
Model Management - Reviews

Action Required
The errors described above are generally due to linking errors indicating that care was not taken to ensure that the model files were easily transferable to LSRCA. We could attempt to correct these issues in order to complete Task 3; however, this won’t guarantee that the Pefferlaw ORMCP model will be the same as completed and reported upon by Earthfx. It is therefore recommended that a cleaned-up version of the model files be obtained from Earthfx.

2.8 Holland and Black Creeks ORMCP

Details
- Earthfx Inc., 2010
- Local MODFLOW steady-state groundwater model, using ZONEBUDGET
- Based on the Core Model, a 1056 row by 840 column by 8 layer finite difference grid
- Current run time: unknown
- VL-MODFLOW is a proprietary MODFLOW executable available from Earthfx Inc.

Status
The transferred directory (~Holland_black ORMCP) does not contain any model files, only the results required to run ZoneBUDGET. To run ZONEBUDGET, an Earthfx-proprietary executable named budpren.exe is required; this executable was not included in the transfer to LSRCA; however, it is in CAMC’s possession. ZONEBUDGET computes volumes based on the outputs from the Core Model; thus no model was built specifically for this project.

An attempt was to run budpren.exe, but to no avail as some files were missing and two other Earthfx-proprietary executables were unavailable: drain_sum.exe and river_sum.exe.

Preliminary groundwater and surface water model review (Task 1) 9 of 19
September, 2014

Action Required
It is recommended that a cleaned-up version of the model and ZoneBudget files be obtained from Earthfx and the executables drain_sum.exe and river_sum.exe.

2.9 Barrie Tier-3 Water Budget

Details
- Matrix Solutions Inc., 2013
4 Midland and Penetanguishene Tier-3 Water Budget

4.1 Model Details

- Regional MIKE SHE surface water model and FEFLOW groundwater model (Figure 1)
- MIKE SHE specifications:
  - 284 rows by 234 columns, 100 metre resolution grid
  - 33,490 finite-difference cells plus 1,102 boundary condition cells
  - Linear reservoir used to represent groundwater system (model not run in an integrated model); no wells
  - Hourly climate input run using a half-hourly time step
  - >19 hour runtime for a 15-year simulation
- FEFLOW specifications:
  - 8 layers, 0.6M nodes, 1.1M elements at 128-38,000 m² varying resolution
  - Saturated flow only
  - Low-order streams not represented; stream boundary conditions: hydraulic-head constrained max flow of 0 m³/d
  - 50 wells
  - Current run time: ~10 minutes, running in steady-state

4.2 Project Summary

The Midland and Penetanguishene Tier-3 Water Budget study was initiated as it was determined that the Midland Area subwatershed was moderately stressed under the Tier-2 water budget and stress assessment performed by Golder and Aqua Resource in 2010. The MIKE SHE and FELOW models extend well beyond the Midland subwatershed and encompass the entire Midland and Penetanguishene peninsulas (Figure 1). The models were based on the Tier-2 and Tiny Township North Simcoe model. The model files delivered include:
- A MIKE Zero project (includes MIKE SHE and MIKE 11)

4.3 Comments

The MIKE SHE model built for the Midland and Penetanguishene Tier-3 Water Budget study built solely to estimate recharge for the FELOW model. The MIKE SHE model was greatly simplified and remains purpose-built for regional water budget simulation. The model had its integrated groundwater simulation disabled and stream channels highly simplified: All stream channels were given the geometry of triangular channels without floodplain access. The triangular channel geometry built into this model reflects a bare-minimum consideration for these features, and only serve as a boundary to the finite-difference overland flow system. With all the capabilities of MIKE SHE, the Midland and Penetanguishene Tier-3 MIKE SHE model has been reduced to a standard surface water model; albeit, the model provides all that is required for a Tier-3 analysis.

The FELOW model appears appropriate for general regional groundwater management in the area and well optimization. Both transient and baseflow calibration results are adequate. This model will be maintained and it is suggested that any future groundwater modelling work performed in this region be accomplished using this model. The only drawback of the FELOW model is that the unsaturated flow process option was disabled, and this may have had an impact on the transient simulations seeing how from the steady state simulation (scenario C) the depth to water table in many places exceed 50 m. Without unsaturated processes being modelled, infiltration occurring at the model surface would be transmitted instantaneously to the groundwater table, no matter the depth to water table.

4.4 Future Applications

The MIKE SHE model is built is applicable to regional water budget analysis only. This model can be used to estimate distributed evapotranspiration, runoff and recharge, provided that groundwater feedback mechanisms (i.e., groundwater seepage that occurs when the water table is close to surface) can be neglected. It is also suitable to investigate impacts to groundwater recharge due to changes in land use. As mentioned earlier, any application beyond basic region water balances should be avoided unless improvements are made to groundwater system and stream channel representation.
Model Management – Why?

• No “re-inventing the wheel” over and over again
• Build on existing data/knowledge/insights (infrastructure)
• Reproducibility of results
• Improved decision making
Model Management - Issues

- Technical thinking – cyclical nature
- Ownership
- Custodianship
- Delivery
- Authoritative
- Accessibility and Sharing
- Managing changes/updates
- Capacity – Technical & Financial
Cyclical nature of modelling

- Manage in similar fashion to OPs
- Current decisions based on current model
- OP/Model amendment can be requested if required
Numerical Model Stream

Database → Interpretation → Numerical Models

Numerical Model Building Blocks

- Water levels
- Streamflow
- Climate data
- Pumping
- Geologic Picks
  - polylines
  - Krige algorithms
- K, n, S, T
- 3D streams
  - + attributes
- Geologic Layers
- Hydrogeologic Layers
- K distribution
- Recharge
- Water Table
- Potentiometric Surfaces

Models
- Archive
- Refinement (versions)
- New
Ownership

• Premise: Owner has ability to decide:
  – Future model uses
  – Who can use model

• For new models – specify ownership in RFP/Contract

• For existing models
  – Province owns (Action – letter to use)
  – Province doesn’t own (Action – clarify)
  – Indeterminate (Action – clarify)
Custodianship

• Ensure proper transfer of files
  – complete/not corrupt/match reporting
• Establish storage location/organize files
• Ensure and deliver files in future (accessibility)
• Establish procedures and implement for model updates/tracking changes into the future
• Inform all interested/partnered agencies of status
Model Delivery – Standardized Folders

- ReadMe File
- Start-up
- Original Data
- Communications
- Related Project
- Model Delivery
  - As delivered by consultant
- Model Output
- Model Executables
  - Model Code
- Scripts/Code Modifications
- Model Report
- Derived Results/Data
- Miscellaneous
- Operational Folder
  - active model version for internal agency

- Consultant
- Client
- Both
Accessibility and Sharing

• Establish at outset – joint decision or each agency?
• Liability/disclaimers
• Alternatives:
  – No sharing
  – Full model
  – “Cutout”
  – “Building blocks”
• Transfer updates/changes back to owner?
• Update Model or just building blocks?
• Nomenclature
Managing Changes/Updates

• Ties in to cyclical nature of modelling
• Who decides?
  – New Jersey – no changes accepted back
  – UK – depends on the changes
• Are updates:
  – Continuous?
  – Stepped – on regular basis (5/10 yrs)?
  – Stepped – demand driven (new wells, etc.)
• Versions
“Authoritative” Model

• Is there a need for this?
• Different models – different interpretations – how to reproduce results
• Science vs opinion
• Who decides?
Capacity

• Technical Capacity
  – Limited within Province (consultants have most/Province has least)

• Financial Capacity
  – Limited within Province (Province has most?)
  – Option – set small user fee to build water management “centres of excellence”
Summary

• Province not well prepared for post SWP era
• Recognition that significant “infrastructure like” investments being made – but no thought/actions as to how to capitalize on investment;
• Need some concrete directions to ensure models are not “shelved”
Modelling = Knowledge Management