The need for a new regional groundwater flow model for Dane County

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Human health and welfare, environmental quality, economic and industrial development, and agriculture all depend on abundant and clean water supplies. In Dane County, Wisconsin, groundwater supplies 100% of drinking water needs and the majority of commercial and industrial water uses. Understanding and properly managing the groundwater system is thus essential. Currently, a computerized groundwater flow model exists for the county. This model was constructed during the early 1990s with funding from local water utilities, DCRPC, MMSD, Dane County, UW-Extension, USGS, and DNR.

The model, publicly available and housed at the Wisconsin Geological and Natural History Survey, UW-Extension (UWEX), has become an important tool for groundwater planning and management. Over the last decade many agencies and commercial firms have utilized the model to aid in decision making for water-resource planning in the county. Construction of the model also fostered important research investigations by UW, WGNHS, and USGS scientists and students; these investigations have added to our understanding of Dane County's groundwater and surface water resources. As a result, the tool developed over 10 years ago no longer reflects the current state of our understanding, which can limit its utility for current and future use.

Current need and proposal:
Dane County should support development of an updated regional groundwater flow model for the County. Such a project would be conducted cooperatively by the WGNHS and USGS.

Background:

- Existing groundwater flow model was constructed in 1994 (12 years ago); basic architecture of model not changed since 1994
- Steady state only, fixed lake and stream levels
- Since then, pumping rates of municipal wells have been updated and some recalibration has occurred
- Report (Bulletin 98) published in 2000
- Model is in regular use today, but is not adequate for many questions

What has changed since 1994:

- Better computers, improved modeling and calibration codes, better graphics, GIS, internet
- New bedrock and glacial geologic maps of Dane County are available
- Vastly improved understanding of bedrock hydrogeology (Eau Claire aquitard, Tunnel City Group)
- Greatly increased understanding of subregions of the regional model from inset groundwater and surface water modeling
- Many new wells constructed; more subsurface data available
- Many more surface water measurements available

- Additional hydraulic data available (pumping tests, piezometer nests)
- Increasing development pressures; increasing water use
- Better understanding of water use statistics
- Greater public awareness of water supply issues; developers and planners more aware and responsive to groundwater issues

Expected capabilities and advantages of the new model:

- More accurate representation and analyses of the upper bedrock units. In particular, the model will simulate high-conductivity zones in the Tunnel City Formation. Research over the last decade has shown that these features often control flow to springs and shallow bedrock wells and can be routes of rapid contaminant transport. Including these features will refine the depiction of contributing areas for wells completed in the shallow aquifer.
- More accurate representation of the Eau Claire aquitard and the connection between the shallow and deep aquifer systems. Over the last decade we have collected a great deal of data on the Eau Claire that is not incorporated in the current regional model.
- Ability to conduct transient, or time-dependant, analyses of various management scenarios (the current model is limited to steady-state simulations). Examples include the impacts of short climatic events like seasonal droughts or floods, infiltration events, lake level changes, and pumping schedules.
- Explicit simulation of the interactions of lakes and groundwater. For example, how will raising or lowering the levels of Lakes Mendota or Monona impact nearby groundwater levels?
- Ability to include major springs in the county, and to simulate the impacts of pumping and land-use changes on springs.
- Explicit simulation of the transient interactions between surface water (streams, wetlands) and groundwater.
- Improved detail of flow paths near water supply wells.
- Overall better model calibration and error analysis based on state-of-the-are model calibration techniques not previously available.

Proposed work:

1. Re-evaluate county hydrogeology and hydraulic properties based on both old and recently-acquired data

2. Re-compile and evaluate water use and pumping rates in the county, with more emphasis on transient use and non-municipal wells

3. Re-evaluate recharge rates using recently published soil water balance techniques

4. Conduct laboratory and field evaluations of effective porosity

5. Construct improved groundwater flow model

- add new wells; update pumping rates to latest estimates
- refine grid spacing and add more model layers to allow more spatial detail
- better simulation of rivers and lakes to address lake level and streamflow issues
- more detailed depiction of recharge
- use MODFLOW 2005 (faster, more powerful computer code)
- recalibrate using PEST inversion tools and associated utilities (sophisticated parameter estimation codes)
- add transient capabilities (allows seasonal predictions of water levels and streamflow)

6. Conduct simulations for interested communities (currently Verona, Fitchburg, Madison have immediate needs).

7. Prepare reports and conduct public education and outreach

Possible Cooperators/Partners:

Wisconsin Geological and Natural History Survey, UWEX
Dane County Coop Extension, UWEX
USGS
Dane County
City of Madison
DNR
Madison Water Utility, other water utilities(?)
MMSD

Costs, Time Frame:

At this time we are envisioning a 2-year project, with a total cost of approximately $350,000, or about $175,000 per year. Costs are negotiable based on final scope and length of the project.