IOWA'S WATER
Ambient Monitoring Program

Groundwater Availability Modeling
Lower Dakota Aquifer

Will we run out of water?

This question is often asked when a proposed ethanol plant or other large water user applies for a water-use permit. The potential for new jobs and economic benefits are often counter-balanced with the concern over the potentially negative impacts this new water user may have on private and public water supplies in the area.

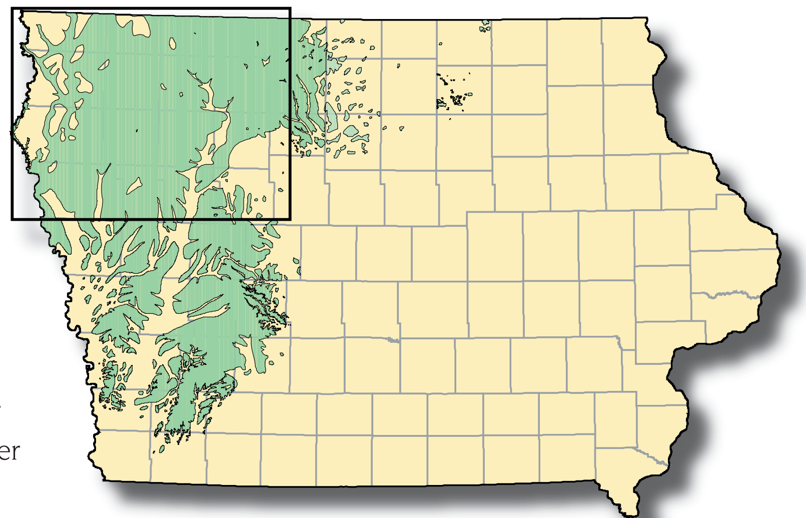

Figure 1. *Location of the Dakota Formation in northwest Iowa (green area). The outlined area indicates the lower Dakota aquifer study area.*

The average ethanol plant requires anywhere between one and two million gallons of water per day. To put this in perspective, this is equivalent to the volume of water used by a city of 10,000 to 20,000 residents. Combine this with municipal, industrial, irrigation, rural water, and livestock usage, along with quarry activities, and the potential exists for water use conflicts.

To help evaluate the potential impact of large water users and other water allocation issues, the Iowa Department of Natural Resources (IDNR) recently initiated a Water Resource Program. This program uses computer simulation models or Groundwater Availability Modeling (GAM) to evaluate current and future water use and potential impacts on aquifers. GAM will help us answer questions such as: "How much water can be pumped from an aquifer over 10, 20, or 100 years?" "Will my well go dry?" "Will the water level drop below my pump?" "What impact will increases in water use have on water quality?"

What is Groundwater Availability Modeling (GAM)?

The first and most important step in GAM is to understand the geology of a particular aquifer. Groundwater flows through rock and sediment, and the success and accuracy of GAM are dependent

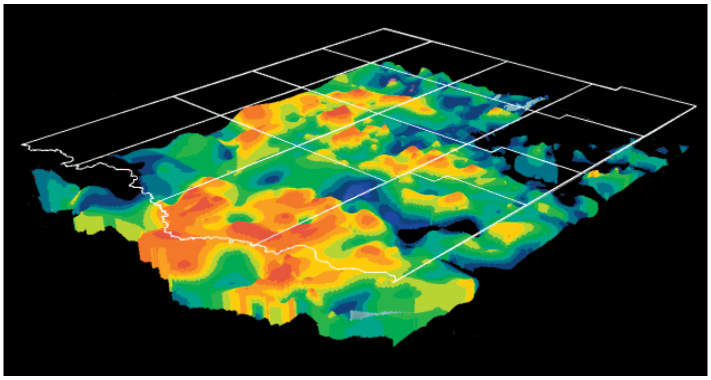

Figure 2. *Three-dimensional image of the lower Dakota sandstone aquifer in northwest Iowa.*

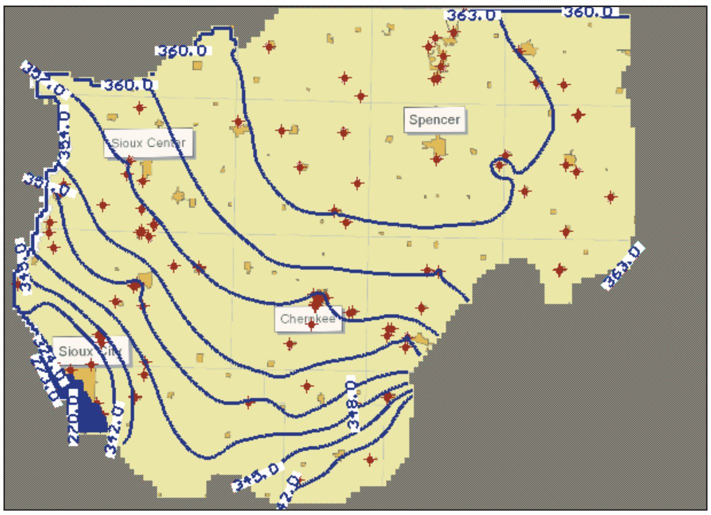

Figure 3. *Visual* MODFLOW *results showing the regional groundwater contours (potentiometric surface). Red symbols = production wells and contours are in meters.*

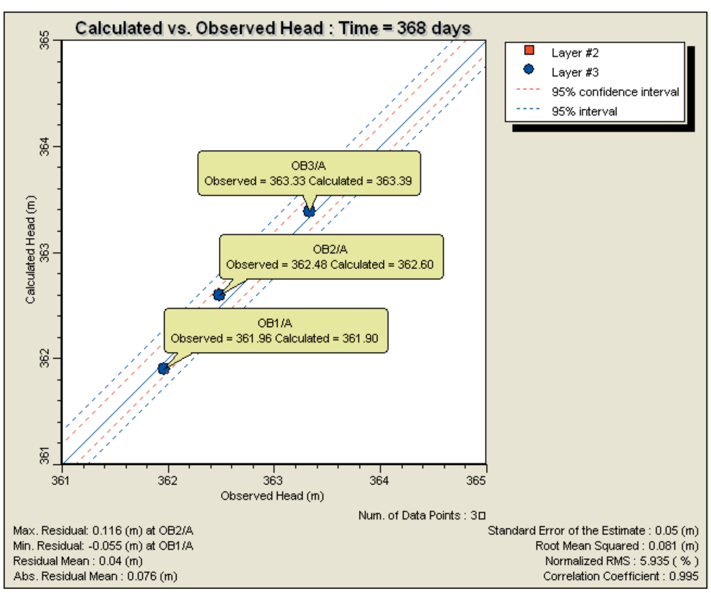

Figure 4. *Calibration results using observation well data.*

on conceptualizing and entering these geologic data into the model. Figure 1 shows the location of the Dakota aquifer in northwest Iowa. The Dakota aquifer is the first regional aquifer in Iowa to be studied using GAM. The Dakota aquifer is a sandstone unit that varies in horizontal and vertical extent. Figure 2 represents the complex geology that had to be studied, characterized, and electronically entered into the model. The geologic information used in the Dakota GAM is the accumulation of over 100 years of data collected and stored at the Iowa Geological Survey in Iowa City.

The next step in GAM is to represent the hydrologic or water-flow properties of the various geologic units. This is usually obtained from tests performed on large capacity wells, water levels collected in wells, or known and estimated boundary conditions. These hydrologic properties must be entered for each layer in the model.

The third step is to place a grid on each active layer in the model. A complex set of groundwater flow equations is simplified and solved within each individual cell of the grid. The grid solutions are then summed and groundwater flow and elevation data are produced as shown in Figure 3.

The final step is to compare the simulated results to observed water level data collected in observation wells. The closer the correlation between simulated and observed data, the more accurate and useful the model is at evaluating the long-term availability of water in a particular aquifer.

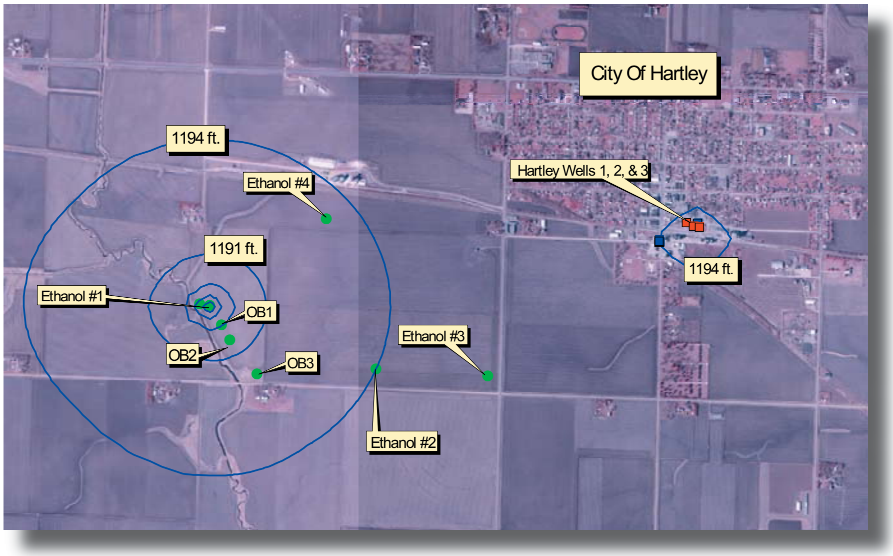

Figure 5. *Groundwater flow map (potentiometric surface) after 3-day pump test for Hartley, Iowa. A potentiometric surface is an imaginary surface defined by the level to which water will rise in a well. With the 3-day pump test, depression in the potentiometric surface is restricted to the area immediately adjacent to the Ethanol #1 well.*

OB = *observation well*

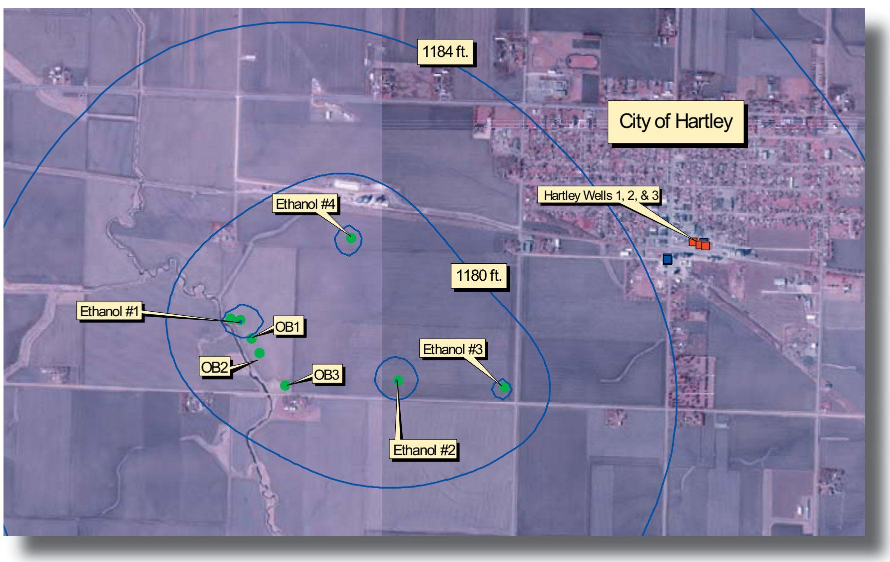

Figure 6. *Groundwater flow map (potentiometric surface) after 10 years of pumping the proposed ethanol wells. With 10 years of pumping, depression in the potentiometric surface extends beyond the City of Hartley to the northeast.*

Iowa Example of GAM Application – City of Hartley

GAM for the lower Dakota aquifer was used to evaluate the 10-year water-use permit for a proposed ethanol plant west of Hartley, Iowa (O'Brien County). The City of Hartley has three active public wells screened in the Dakota aquifer. A proposed ethanol plant has four production wells that will be pumped on a rotational basis. The water-use permit called for a continual water withdrawal of 1,100 gallons per minute or 1.6 million gallons per day (gpd). This compares to an average daily usage of 300,000 gpd for the City of Hartley.

GAM was first calibrated using the steady-state regional model and then by entering water level data from a three-day pump test conducted using the ethanol plant wells. Figure 4 shows how close the model simulated the water levels in the on-site observation wells located approximately 300, 600, and 1,500 feet from the ethanol production well. Figure 5 shows the impact on the local groundwater flow during the 3-day test. The model reproduced the observed water levels with a mean residual error of only 1.7 inches.

Based on the close calibration of the simulated results and the observed pump test results, the model was run for 1-year and 10-year time periods. The additional drawdown on the City of Hartley wells was simulated at 13.5 feet after 1 year, and 17.1 feet after 10 years (Figure 6). The pumping water level in the city wells is 60 feet above the pumps. Based on the model results, there is a margin of safety of 42.9 feet for the City of Hartley wells during the 10-year ethanol plant water use permit.

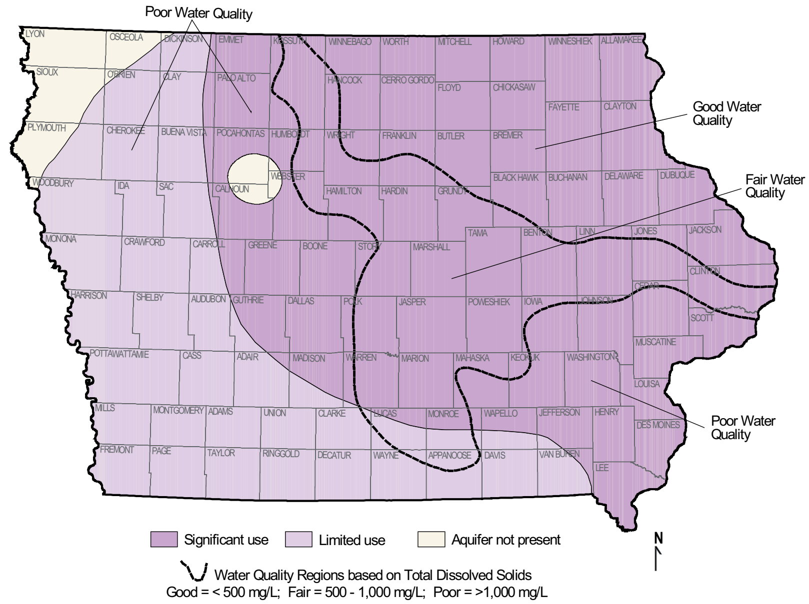

Figure 7. *Location of the Cambrian-Ordovician aquifer in Iowa (purple areas), extent of its use, and water quality regions based on total dissolved solids.*

Future Efforts

Additional calibration of the lower Dakota aquifer GAM is necessary following the final input of all the Dakota production well data. Following this final calibration, the available water will be calculated using mass balance methods. The completion of the lower Dakota aquifer GAM is scheduled for June 30, 2008, and the model and the various input files will be available through the IDNR web site on that date. In July 2008, development of the Cambrian-Ordovician (Jordan Sandstone) GAM will begin. The extent of this aquifer is shown on Figure 7.

Acknowledgements

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The Iowa groundwater quality database can be found on the IDNR's GIS Library – www.igsb.uiowa.edu/nrgislibx/

Iowa Watershed Monitoring and Assessment Program Web Site – wqm.igsb.uiowa.edu

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