H2O

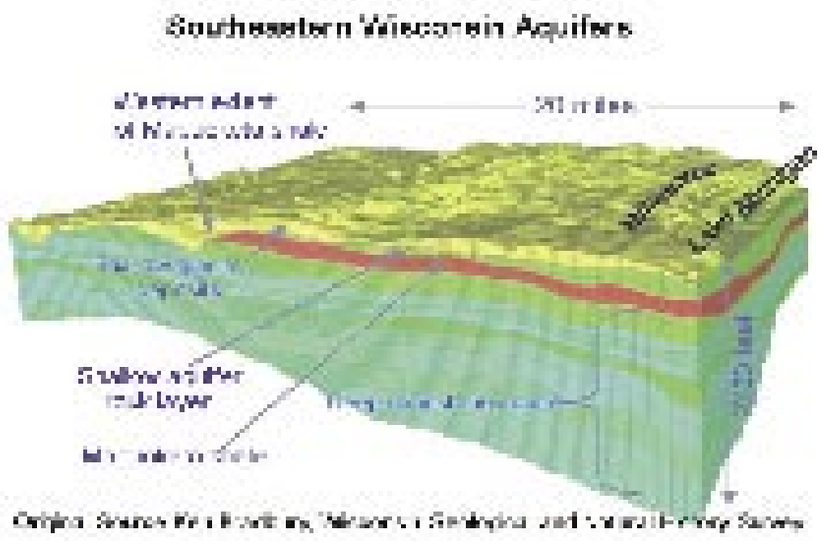
Budgeting our groundwater

Computer model predicts flow

By Casey Twanow

Groundwater—water found beneath the surface—is a hidden resource, often difficult to quantify and protect.

Regional groundwater issues have drawn public attention recently, as growing populations and continued development, for example, in parts of Waukesha County, strain water supplies. Most southeastern Wisconsin communities, with the exception of those along Lake Michigan, rely on groundwater wells for their water needs.



To study hidden groundwater resources in southeastern Wisconsin, scientists have developed a computer model that simulates and predicts groundwater flow through regional aquifers—underground areas of porous rock or sediment through which groundwater flows.

With this sophisticated model, scientists can learn where in our region groundwater use is sustainable, and where over-pumping has depleted aquifer water levels or reduced base flow—groundwater flow that keeps streams, lakes, and wetlands healthy during dry periods.

The computer model is also a valuable tool for developing future water management plans. Currently, its simulations are a major component of an ongoing regional water supply study by SEWRPC, the Southeastern Wisconsin Regional Planning Commission.

At the University of Wisconsin-Milwaukee, hydrogeologist Doug Cherkauer is using the model to look closely at groundwater sustainability in southeastern Wisconsin. He likens a sustainable groundwater supply to a well-managed bank account.

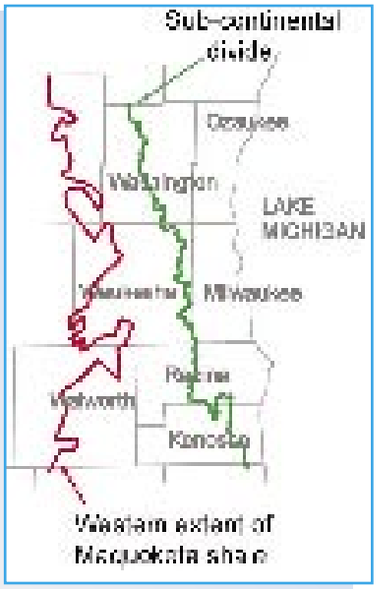
"We all know if we withdraw more than we deposit, our bank account goes to zero because we have a deficit budget," he said. By the same token, pumping more groundwater than what is deposited in the aquifer by natural replenishment leads to a deficit.

Natural groundwater replenishment comes from recharge—rainfall and snowmelt that infiltrates the ground—as well as underground flow.

In southeastern Wisconsin, groundwater flows through two aquifers—the shallow aquifer of dolomite rock and glacial sand and gravel, and the deep aquifer of layered sandstone. (In the eastern part of our region the aquifers are separated by a confining layer of shale that limits natural replenishment to the deep aquifer.)

In Cherkauer's analysis of the deep aquifer, from which most municipal and industrial wells pump water, he found many areas in a groundwater budget deficit. This was especially true in Waukesha County, which pumped 5.5 times its natural replenishment in 2000. The city of Waukesha pumped up over six times its natural replenishment.

When pumping in the deep aquifer exceeds natural replenishment, groundwater levels drop. In eastern Waukesha County, deep groundwater levels are hundreds of feet below predevelopment levels. Surrounding groundwater is drawn toward this depression, expanding the area where a sustainable water supply could be a problem.



While declining water levels are a significant long-term management challenge, naturally occurring radium in the deep aquifer (a health risk at high levels) is a more pressing concern. Dozens of Wisconsin communities, including many in Waukesha County that rely on deep groundwater, are under DNR consent orders to reduce radium levels to meet national water quality standards.

In the shallow aquifer, which receives more recharge than most of the deep aquifer, Cherkauer found that natural replenishment exceeded pumping in all counties. Some individual communities, however, like the villages of Grafton and Saukville, were in a water budget deficit.

The shallow aquifer is in direct contact with surface waters and it provides base flow to streams, lakes, and wetlands. Municipal and domestic shallow wells, however, pump base flow before it reaches surface waters. Sustainable pumping can minimize the impacts on surface waters, but as an area nears a water budget deficit, pumping reduces base flow. This can lower water levels and harm aquatic ecosystems. In Ozaukee County, for example, base flow is an average 13 percent lower than pre-development levels. Cherkauer says this lost base flow is most apparent during dry periods. In extreme cases, a water body can run dry (as the Little Plover River in Stevens Point has twice in recent summers).

Luckily, Cherkauer's work will go beyond identifying areas where pumping is not sustainable. In his next step, he'll use the model to evaluate alternatives for individual communities to sustainably meet their long-term needs. Some of this information will be available to communities in SEWRPC reports and Cherkauer hopes to make his analyses available online.

How the Model Works

The model was developed by the U.S. Geological Survey (USGS) and the Wisconsin Geological and Natural History Survey, with support from UWM and SEWRPC.

It is founded on known aquifer characteristics and historic data, including six decades of water levels from observation wells, 150 years of water use records and well construction reports from large wells in and around the region, and USGS streamflow measurements. The data are integrated into a 3-D grid that represents regional aquifers. Its layers are based on aquifer geology, and each layer is broken down into thousands of half-mile square "cells."

For each cell, the model calculates how its flow and water balance affect adjacent cells. It repeats these calculations for intervals between 1864 and the present. Collectively, these billions of calculations simulate flow through regional aquifers. The model is calibrated to observed groundwater levels over time and to actual streamflow measurements to ensure that it accurately reproduces aquifer conditions. Scientists can tweak variables—for example, increase the groundwater pumped by wells in one part of the aquifer—and the model will simulate the effects over time on surrounding areas.

Cherkauer says that on his computer, the model completes an aquifer simulation in about 30 minutes.

Next month in this column, learn more about diverse water management options that can help our region plan for the future.

The Great Lakes WATER (Wisconsin Aquatic Technology and Environmental Research) Institute is the largest freshwater academic research institute in the Great Lakes region. More information: glwi.uwm.edu.

Doug Cherkauer is a UWM Department of Geosciences professor and specializes in water resources, groundwater, environmental issues and regulations. His water budget research is supported by SEWRPC and the Brico Fund.