Expanded City/SAJB Groundwater Flow Model

September 2012

GSI Water Solutions, Inc.

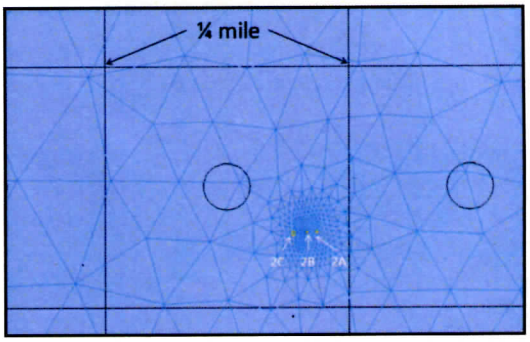
Facts About the Model

In 2012, the City of Spokane and the Spokane Aquifer Joint Board (SAJB) contracted with GSI to create a high-resolution groundwater flow model encompassing the entire footprint of the Spokane Valley – Rathdrum Prairie (SVRP) aquifer. GSI created a new multi-layer model using finite-element modeling methods, which makes use of a flexible mesh to efficiently simulate groundwater flow and groundwater/surface water interactions at both regional and local scales – all in one model simulation. The model uses the MicroFEM® software, which is a Dutch program for modeling multi-layered aquifers using both steady-state and transient (time-varying) methods.

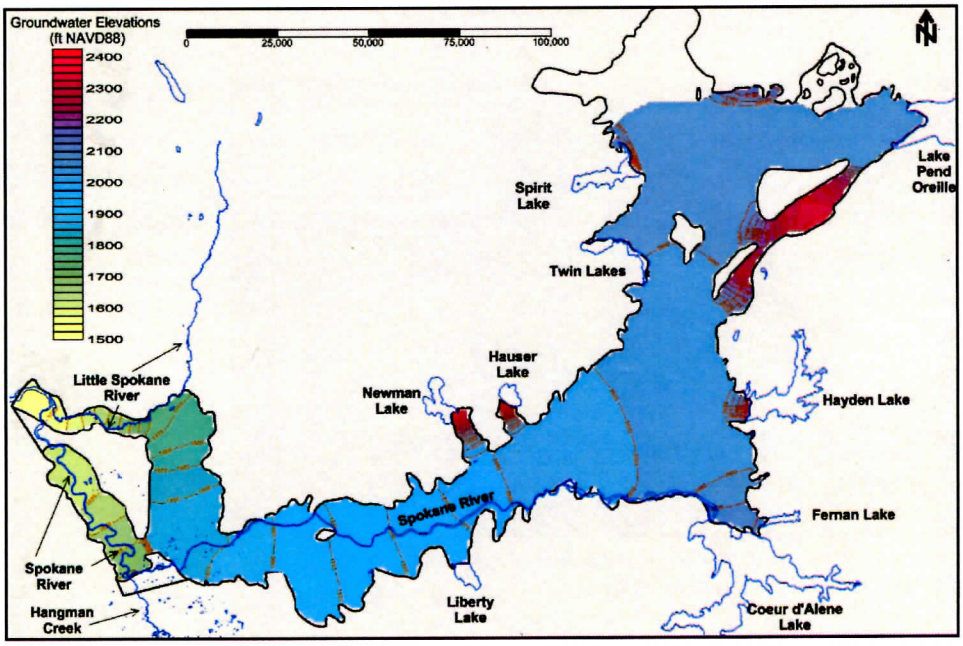
A significant distinguishing characteristic of the new City/SAJB model is the high spatial resolution of the finite-element mesh. Within the area modeled by a single cell in the earlier Bi-State finite-difference model, the new City/SAJB model contains tens – and in some locations, hundreds – of individual nodes at which groundwater elevations and groundwater budget terms are calculated by the MicroFEM® software. In fact, where the Bi-State finite-difference model computed groundwater conditions at 5,200 grid cells spanning the areal extent of the SVRP aquifer, the new City/SAJB model conducts these calculations at nearly 45,000 grid points across this same area.

Other significant characteristics that are unique to the new City/SAJB model include:

- It uses multiple layers to simulate groundwater flow variations with depth.
- It contains up-to-date information (as of 2012) on well locations and pumping rates.
- It incorporates the findings from recent studies of groundwater recharge from precipitation, stormwater infiltration, septic systems, and outdoor irrigation (both in urban areas and from irrigated agriculture).
- It contains seasonal and long-term average profiles of the stage of the Spokane River. Unlike the earlier Bi-State finite-difference model, the pumping terms are distinct from the terms that describe the portion of pumping returning as recharge to the aquifer, which makes this model far more amenable to conducting rapid analyses of changes in recharge or pumping.
- The data used to derive model input files are stored within the model itself (a characteristic that is unique to MicroFEM®). This provides three distinct advantages for future use of the model:
  1. The raw data and the model simulation results can be directly displayed together through the contouring capabilities of MicroFEM®.
  2. The model registers that store data are designed to facilitate mathematical analyses of the data, including for quality control and verification purposes.
  3. If future changes are made to the flexible mesh, the values of the stored data are retained and are extrapolated to any new nodes that are added to the mesh, which greatly facilitates the process of rebuilding the input terms for subsequent model simulations.



The Bi-State finite-difference model uses ¼ mile square grid cells (in black) whereas the new City/SAJB model uses a flexible mesh (in blue) that provides a higher-resolution model output. The points labeled 2A, 2B, and 2C are pumping wells.



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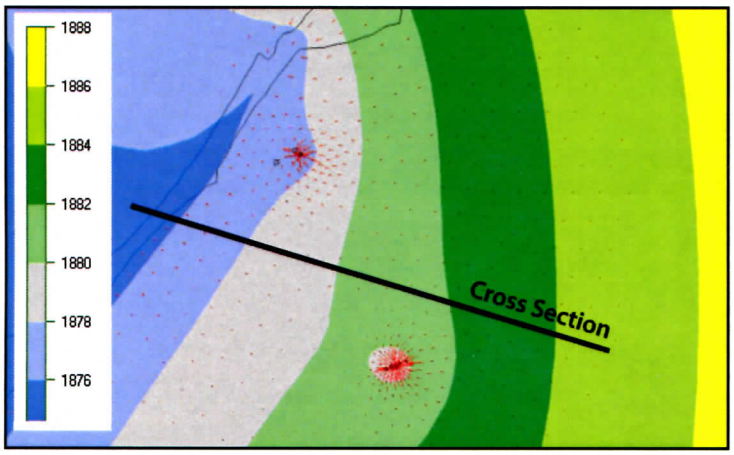
Example Applications of the Expanded City/SAJB Groundwater Flow Model

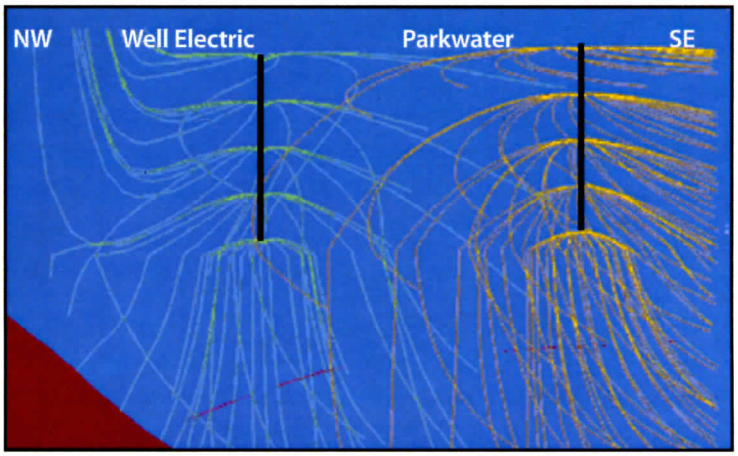
The level of simulation detail in the model is useful for many types of analyses, such as delineating the portion of the aquifer that contributes groundwater to a pumping well. By placing imaginary particles on a flexible mesh that contains closely spaced nodes, one can begin to understand the areas and depths from which a well obtains its water, and use that information to assist with wellfield operations, groundwater supply management, and groundwater quality protection. Two examples are shown here.

Example 1 (below)

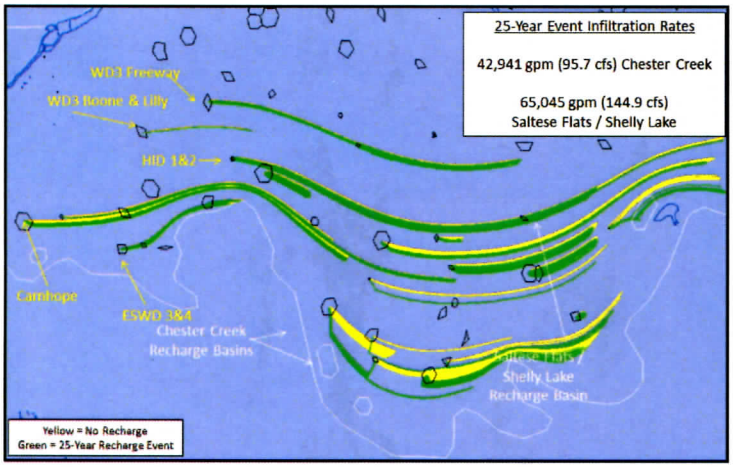
The City of Spokane's Parkwater and Well Electric pumping stations have the largest pumping capacities of any other wells or pumping stations in the SVRP aquifer (63,000 gallons per minute [gpm] at Parkwater, and 39,000 gpm at Well Electric). Pumping is simulated at selected points within a grid that has spacing ranging from 15 feet at each well to 550 feet in outlying areas. The model shows groundwater elevations, velocities, and flowpaths in both plan and section view.



Map of model-simulated groundwater elevations (color flood plot) and groundwater velocities (red arrows)



Cross-sectional view of model-traced groundwater flowlines converging towards the Well Electric and Parkwater well screens from various depths in the SVRP aquifer. The vertical black lines represent the open interval of each well, as represented in the model.



Comparison of Capture Zones for Pumping Wells, with and without Infiltration of the 25-Year Rainfall/Stormwater Runoff Event.

Example 2 (left)

In the City of Spokane Valley, the model illustrates how the areas contributing groundwater to several wells can be affected by routing stormwater from a 25-year precipitation event into the Chester Creek and Saltese Flats/Shelly Lake recharge basins.