

Lake Owen Groundwater Model Summary—2021

Rationale of study

In 2020-21 a groundwater model was developed for Lake Owen, Bayfield County, Wisconsin. A groundwater model is a mathematical model that utilizes many data to determine the boundaries of the water table that flows into a particular area, in this case, Lake Owen. The model also estimates the volume of groundwater flow into Lake Owen and can be used to evaluate human activities that can affect the groundwater flow. These include large withdrawal of groundwater through high-capacity wells and pollution sources that could affect the groundwater quality. Since Lake Owen is primarily fed by groundwater, understanding the groundwater flow into the lake is essential for future management. It is especially significant if development and commercial activities increase in ways that can adversely affect groundwater.

Methods to create the model

The building of the groundwater model was simplified by the fact that the USGS had completed a groundwater model for the region including Lake Owen and there were other available data with extensive publications. After reviewing the existing data and model, a local refinement of the current calibrated model delineated the contributing groundwater area into Lake Owen. The model used is known as GFLOW. Within GFLOW, adjustments were made to focus on the area surrounding Lake Owen as well as streamflow paths and outflow from Lake Owen.

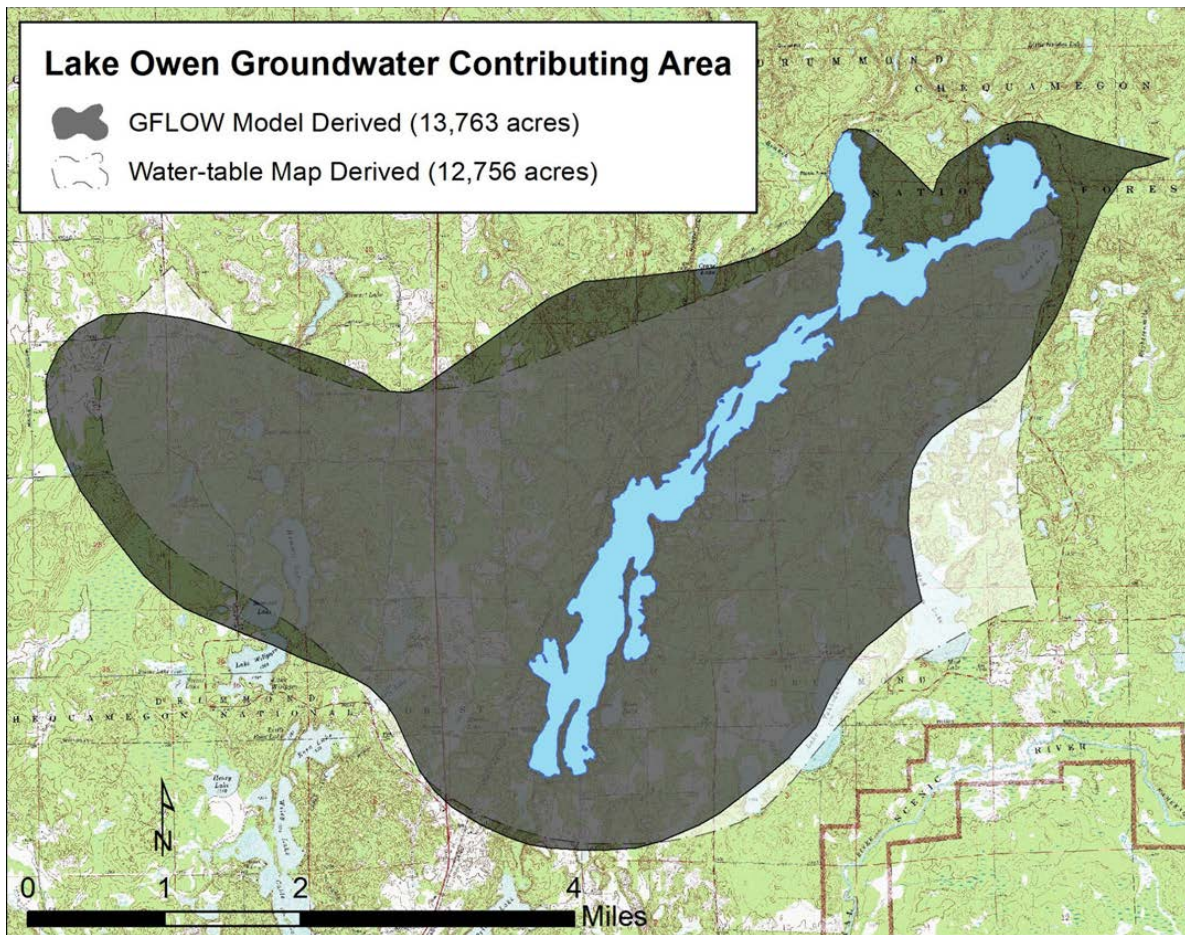
Model results

The model results produced a higher resolution of the groundwater flow path around Lake Owen. The water table elevations in the updated model were in better agreement with the well construction reports. It also resulted in a good agreement with the outflow volume monitored in Lake Owen from 2019 to 2021. (The measured value of 23.3 ft³/s, and the modeled value of 30 ft³/s.)

Within the model, particle tracking was used to delineate the contributing area of groundwater for Lake Owen. Digital particles are placed within the model, and flow paths are marked. The model then delineates the area of flow of groundwater into the lake with high confidence. This led to a change in the groundwater contributing boundary from previous predictions made using only water table data. The map below demonstrates how the model predicts particle flow, allowing for boundary delineation.



The resulting output of the model creates a Lake Owen groundwater contributing area map.



As the map shows, the area of groundwater contributions is predicted to be larger by the model, and the boundaries have changed. This delineation better represents the groundwater area than the previous map and provides a more precise map for potential groundwater issues in the future. This updated map provides essential information for groundwater management.

Future uses of the groundwater model

In the immediate future, the model output will be used to update the water budget for Lake Owen. The groundwater model suggests that the amount of groundwater entering Lake Owen (as a percentage) may be somewhat higher.

The model can also be used in the future to predict the results of various human activities that could affect the groundwater table. Since Lake Owen has most of the water inputs coming from groundwater, anything that affects groundwater could potentially affect Lake Owen's volume and water quality.

Examples of activities that could affect groundwater that the model may be used to evaluate include:

High-capacity well placement—High-capacity wells remove large volumes of water in a small amount of time and can affect the groundwater table level. If such wells are placed within the model’s established area map, the model can predict the results of specific rates of withdrawals and the effect on Lake Owen.

Migration paths of groundwater contaminants—If an industry is installed that can potentially contaminate the groundwater, the model can determine the flow paths and the result of such contamination. This could be used to assess drinking water wells that would be susceptible and the potential impact on Lake Owen.

Land cover changes/Climate change—The model can be used to gain or lose groundwater under different land use or climate conditions. Sustained droughts, significant storm events, or land cover conversion that reduces water infiltration (such as increases in impervious surfaces) could affect groundwater and, therefore, Lake Owen.

More complex modeling—The GFLOW model can be coupled with another more complex model, MODFLOW (3-D vs. 2-D). This would allow the evaluation of specific sites and their impact on the groundwater.

Acknowledgment: A thank you goes out to the residents that participated in shallow well water testing during this study. Their participation was helpful and appreciated.

Reference Links to data and documents utilized

TR004-04 GFLOW Model Files and Documentation:

- https://water.usgs.gov/GIS/metadata/usgswrd/XML/leaf2019_WGNHS_Washburn.xml
- <https://wgnhs.wisc.edu/catalog/publication/000961>

Hydrogeologic Atlas of Bayfield County:

- <https://wgnhs.wisc.edu/catalog/publication/000967>

Bayfield County Water-table Map and Well Water Database:

- <https://wgnhs.wisc.edu/catalog/publication/000948>

GFLOW Model Documentation and Software:

- <https://www.haitjema.com/ModelingofGroundwaterFlow6312.pdf>
- <https://www.epa.gov/ceam/gflow-groundwater-flow-analytic-element-model>