The Harney Basin Groundwater Model (HBGM)

OREGON WATER RESOURCES DEPARTMENT

Modeling Objective

Studies show that the Harney Basin has experienced more groundwater withdrawal than what is naturally replenished, resulting in a significant decrease in groundwater levels and storage. The Harney Basin Groundwater Model (HBGM) developed by the United States Geological Survey (USGS) in coordination with the Oregon Water Resources Department (OWRD) provides a better understanding of groundwater movement in the basin which will aid in sustainable management of the resource.

Model Design

The HBGM is a three-dimensional numerical model that covers the entire Harney Basin and surrounding areas and runs from 1930 through 2018 utilizing 89 years of data. The model divides the area into a grid of 78,064 square cells each covering approximately 2,000 by 2,000 feet. Each cell represents a small part of the landscape, such as terrain, rock units, streams, springs and more. The average value for aquifer properties, such as groundwater flow rates through a given material, are assigned to each cell to describe the groundwater framework. The model consists of 10 vertical layers of varying thickness based on the type of aquifer materials and their hydraulic properties.

Model Inputs

Hydraulic Properties

Individual model cells were assigned water movement properties based on the aquifer characteristics of the layer they represent. The thickness of each layer was estimated using previous studies and information from drilling records. These water movement properties describe how efficiently different layers can transmit and store or release water. There's a lot of variation in these properties across the groundwater flow system. In parts of the model with less data, like deeper layers in upland areas, the representation of these properties is more generalized and varies less with depth.

Recharge

Recharge represents the water that flows into the groundwater system. The primary source of recharge to the Harney Basin in the uplands is infiltration of rainwater and snowmelt. Additionally, recharge from surface-water infiltration where streams enter the lowlands and lose water to the subsurface was also considered and integrated into the model.

Discharge

Discharge represents the water that flows out of the groundwater system. Groundwater discharge consists of two parts: natural and artificial. Natural discharge happens through evapotranspiration (ET, a process by which the water moves from land to atmosphere via soil surface and vegetation) and flow into streams and springs. Artificial groundwater discharge comes from pumping water from wells. The rates of groundwater pumping for irrigation were estimated using satellite-based ET data and groundwater rights information. Pumping rates for other uses were calculated using reported or publicly available data.

Model Calibration

Model inputs were adjusted through multiple iterations to match both measured and estimated hydrological conditions. This included modifying factors like aquifer properties, ET parameters, and recharge. The model's accuracy was assessed by comparing its predictions to measurements for stream baseflow and groundwater levels. Overall, the model's estimates for basin-wide baseflow were within 5 percent of the most reliable available data. It also showed a good match across the basin's range of groundwater levels, which vary by up to 1,300 ft.

Model Outputs

Model results show that many of the lowland areas began experiencing substantial declines in groundwater levels after 1990, the period when pumpage began to increase across the basin. The simulated decline by the year 2018 in the Weaver Spring area is greater than 90 ft, in the Northern lowlands is greater than 100 ft, and in the Crane, area is greater than 40 ft. The total volume of pumped groundwater during the model period was supplied relatively equally by decreased lowland ET (35%), decreased spring and stream discharge (32%), and the deficit in lowland groundwater storage represented by groundwater declines (32%).

The model outputs can be used to forecast how groundwater levels, discharge, and storage might change depending on hypothetical future groundwater management scenarios. The HBGM can also show how groundwater flow changes over time due to variations in recharge and groundwater pumping.

Model Limitations

Numerical models simplify complex natural systems. Every model has some limitations and uncertainties. The model divides the area into cells, averaging conditions within each cell, which can overlook changes at smaller scales. Additionally, the monthly time intervals used for model inputs may not accurately capture shorter-term hydrological changes. The model gives us an idea of how groundwater is changing across a region, but it might not accurately predict how each individual well behaves. The model overpredicts in some areas and underpredicts in others. The model's accuracy is better in places where the data, such as water levels, well records, and pumping rates, are abundant.

While the HBGM isn't perfect for predicting precise groundwater levels at a specific well, it offers insights into the basin's hydrogeologic system and can help compare different water-management strategies at the landscape scale. Despite some limitations, the model is the most realistic, accurate and reliable tool, at present, for understanding the basin's groundwater dynamics.
For more information about the HBGM please refer to the report, published on March 22, 2024, Groundwater Model of the Harney Basin, Southeastern Oregon.