Modeling the Groundwater Properties of an Isolated Ridgetop Wetland

Selsey A. Stribling, Department of Geological Sciences, Eastern Kentucky University
Mentor: Dr. Jonathan Malzone, Department of Geological Sciences, Eastern Kentucky University
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INTRODUCTION

Although we have many types of software which can model different wetland properties, very few modeling studies have been conducted on wetlands (Golden et al, 2014). Additionally, two different groundwater flow types, flow-through and perched precipitation, have been noted in different wetlands (Raines, 2011). Horizontal groundwater flow that passes through the wetland pool is characteristic of flow-through flow patterns, whereas water collects in the pool and infiltrates downward in perched precipitation flow patterns (2011). In the wetland site chosen for our study, both types of groundwater flow have been observed via previously monitored seasonal groundwater levels. Flow-through occurs during the spring and perched precipitation occurs during the summer and fall. This project's objective was to develop a numerical groundwater/surface water models via MODFLOW of an isolated ridgetop wetland located in the Daniel Boone National Forest (DBNF) that could account for the switching behavior of groundwater flow patterns in the wetland. Ultimately, this model could be used to predict hydraulic system changes in the wetland in the event of drought or other climatic events. This model incorporated non-traditional boundary conditions (BC) as there are no obvious BCs at the site, and the MODFLOW model will be developing a new way of modeling groundwater flow in ridgetop wetlands.

METHODS

DC2, the wetland site, has three distinct silt-clay layers in the soil profile. The profile is approximately 1 m thick and rests over an impermeable gray clay layer, which in turn overlies sandstone bedrock. Data incorporated in the MODFLOW model included: Groundwater level measurements, horizontal hydraulic conductivity data, topographic data from optical transits, evapotranspiration calculations from transducer readings, and recharge calculations from transducer readings.

Eleven days of groundwater level data gathered from March to October 2017 (Sweet and Malzone, 2018) were used to create eleven calibrated models of the wetland system. BCs used in the model included no-flow, constant head, and drains. A no flow zone was positioned along the lower edge of the wetland's watershed, where the slope steeply drops off to a cliff face. Constant heads were created from different pool sizes for previously noted seasonal changes in wetland pool size. Two hydraulic conductivity fields (0.5m/d and 1m/d) were added to incorporate previous research of different hydraulic conductivities throughout the wetland system into the model. Evapotranspiration and recharge parameters were used to calibrate the eleven steady-state models. After the first sets of models were calibrated, five drains were traced where ephemeral channels were visible in LIDAR imaging of the wetland. New models were calibrated with these added drains.

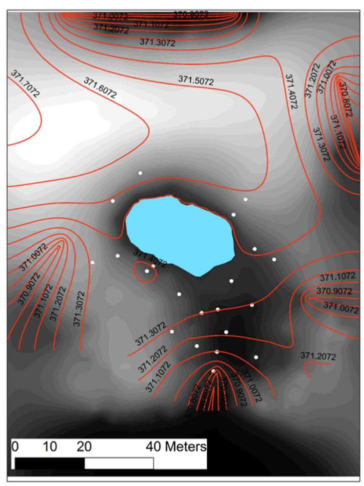

Figure 1: Groundwater contours of April 2, 2017 data over an elevation model of the wetland in ArchGIS. The contours exhibit a flow through system.

RESULTS

Groundwater mimics flow-through patterns in April 2nd, 2017 (Figure 1) by flowing from high head (top of the wetland) to low head at the bottom of the wetland. This model's RMS error is 0.06. Recharge is 0.000425m/d, and ET is 0m/d. The five drains are located on the edges of the model in the lower head regions.

In August 27, 2017, groundwater follows a perched-precipitation flow pattern with highest head located in the wetland pool and decreasing toward all five drains in the

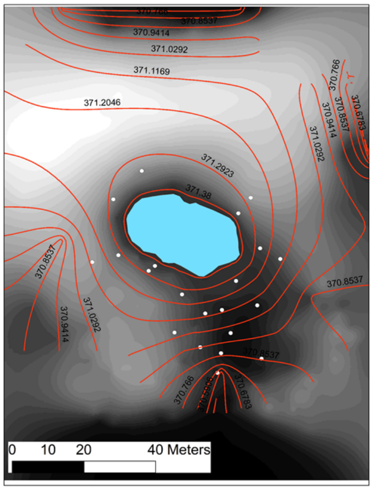

Figure 2: Groundwater contours of August 27, 2017 data over an elevation model of the wetland in ArchGIS. The contours exhibit a perched precipitation system.

wetland system. RMS is 0.13. Three wells (A24, A16, and A5) failed to calibrate to field observations. Recharge is 0.0001m/d and ET is 0.0005m/d.The wetland discharges toward all five drains located on the perimeter of the wetland model.

DISCUSSION

ET, although a significant influence, is not the primary reason for wetland drying at DC2 and, as a result, the flow switching behavior DC2 experiences.. During the spring, precipitation recharges the aquifer. ET intercepts this groundwater recharge during vegetation leaf-out in the spring and summer. This effectively prevents the aquifer from recharging during the summer. However, the groundwater models would not mimic field collected groundwater data with only ET removing groundwater. Instead, with the addition of drains, the model more closely mimics field observations and had overall lower RMS values. Most well calibrations were relatively close to field measurements with the exception of wells A24, A16 and A5. These three wells appear to be at least partially disconnected from the groundwater processes of the wetland. Future research is needed to understand this disconnection.

By finding that the drains control the water drying of the wetland during the summer, we can accurately model the groundwater flow switching behavior DC2 experiences between the spring and summer. Additionally, the ephemeral channels may suggest connectivity to lowlands, indicating that DC2 is not as isolated from lowlands as originally perceived.

Finally, this new understanding of the physical properties which influence natural wetlands may help others in the future to develop a wetland model which could assist in the restoration of many constructed wetlands in the DBNF that remain saturated year round and support predatory amphibian species (Denton and Richter, 2013).

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SELSEY STRIBLING is a junior studying Geology at Eastern Kentucky University.

JONATHAN MALZONE is a professor of Geological Sciences at EKU. He is a mentor in Eastern Kentucky University's REU program.

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