Evaluation of a Water Budget Model for use in Wetland Design

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Introduction

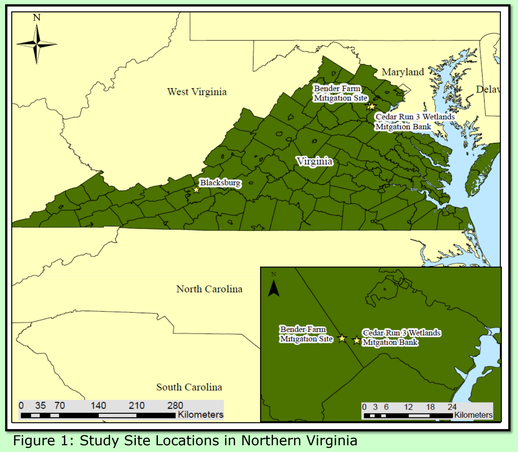


Figure 1: Study Site Locations in Northern Virginia

Many of the complex interactions that occur in a wetland are dictated by the hydrology, or water budget (Hammer and Kadlec, 1989).Traditionally wetland water budgets for mitigation design are modeled by estimating surface inflows and outflows, assuming a relatively impermeable substrate. Groundwater interactions and flow resistance due to vegetation are typically not considered in current design models. Simplifying wetland designs results in mitigated systems that do not correctly replace the ecological function that was originally impacted.

The overall goal of this research was to assess a newly developed model, Wetbud, as an uncalibrated design model for mitigation wetland water budget estimation in the Virginia Piedmont. Specific objectives include the following:

1.To compare the Pierce methodology with the MODFLOW groundwater simulation method for the design of perched and groundwater driven mitigation wetlands.

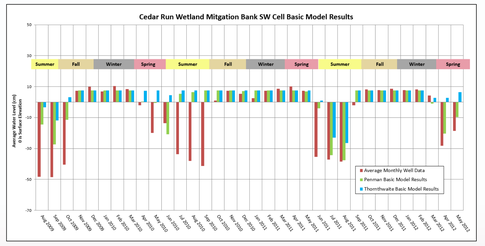
2.To compare the Thornthwaite and the FAO-56 Penman-Monteith potential evapotranspiration estimation methods for the design of perched and groundwater driven mitigation wetlands.

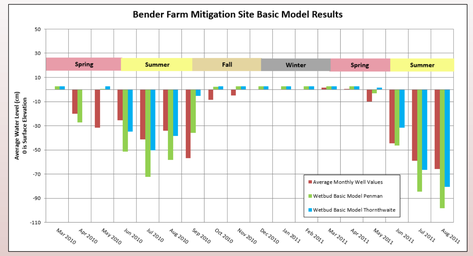
To complete the above goals and objectives, data from two existing mitigation wetlands were used to evaluate the Wetbud model.

Reference: Hammer, D. E., and R. H. Kadlec. 1989. A Model for Wetland Surface-Water Dynamics - Reply. Water Resources Research 25(5):1063-1065.

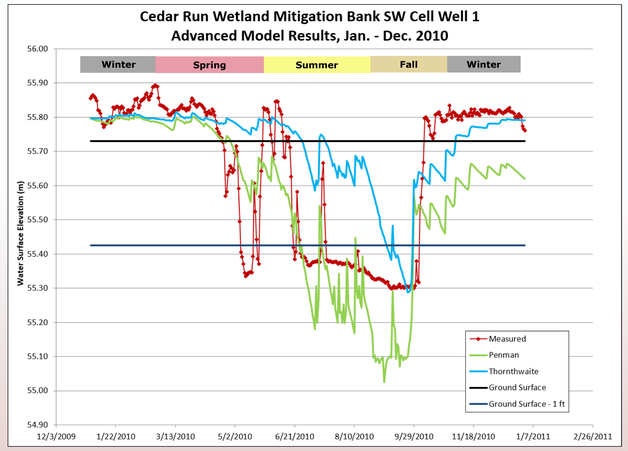
Results

Wetbud Basic Model





Wetbud Advanced Model



Model Methodology

Wetbud Basic Model

- Traditional Mass Balance Equation (1).

$$\frac{\Delta S}{t} = P + R + GW_i - ET - S_o - GW_o \qquad (1)$$

where, P = Precipitation, R = Runoff, GW_i = Groundwater In, ET = Evapotranspiration, S_o = Surface Outflows, GW_o = Groundwater Out

- Local weather and precipitation data imported from nearby weather stations thru Wetbud.
- FAO Penman-Monteith and Thornthwaite calculations for potential evapotranspiration (PET) within Wetbud.
- NRCS rainfall excess estimation technique for surface inflows, user input groundwater in and out values, and weir regulated surface outflows

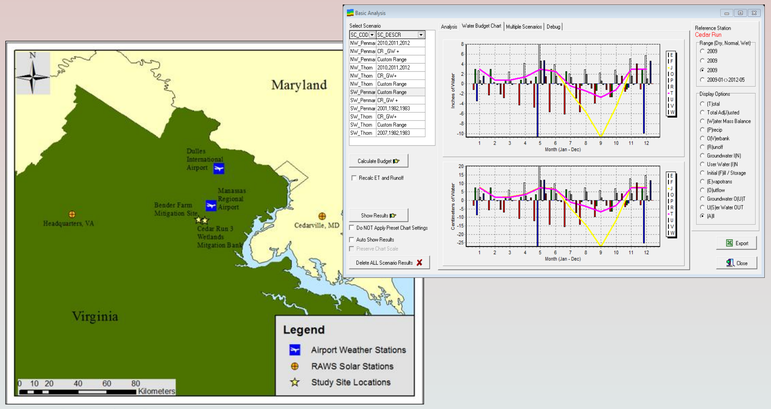
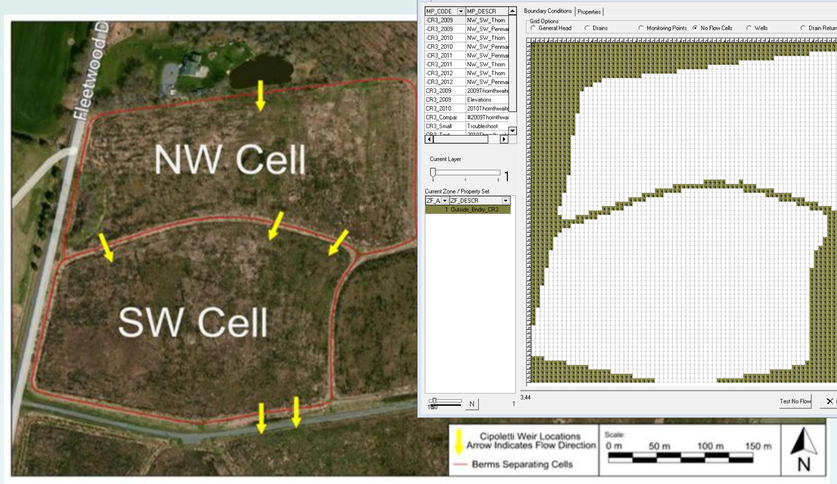


Figure 2: Weather Station Locations

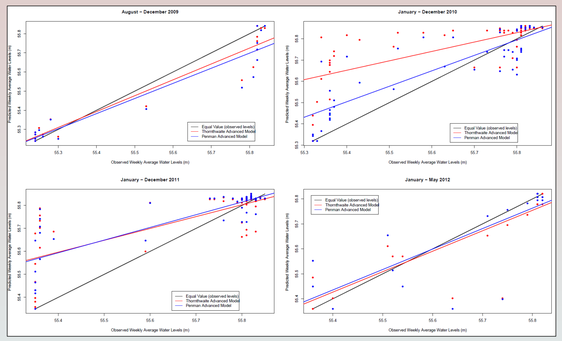


Wetbud Advanced (MODFLOW-NWT) Model

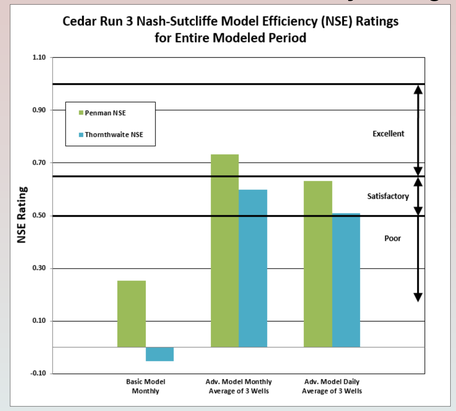
- Generated User Interface (GUI) for MODFLOW-NWT modular finite difference model.
- Imported topography to incorporate site slope.
- Three layer model to represent vegetation resistance and geologic site strata.
- Surface inflows, PET, and precipitation imported from basic model.
- Multiple modular packages loaded into Wetbud to accurately model inflows and outflows.

Model Statistical Evaluation

Cedar Run Wetland Mitigation Bank SW Cell Advanced Model Linear Regression



Nash-Sutcliffe Model Efficiency Ratings



Conclusions

- Based on the NSE model rating, the Wetbud Advanced (MODFLOW-NWT) Model performed better than the Wetbud Basic model utilizing the Pierce Methodology in all cases.
- In the basic and advanced models for groundwater and perched wetland systems, the FAO Penman-Monteith PET estimation provided better water budget estimations than the Thornthwaite PET estimation technique.
- Model performance was the poorest during the summer drawdown period for both the basic and advanced model. This error is possibly due to an overestimation of surface inflows by the SCS/NRCS excess rainfall estimation technique.

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Wetland Studies and Solutions, Inc.

Peterson Family Foundation