GROUNDWATER AND STRATIGRAPHY IN TWO VALLEY BOTTOM WETLANDS CENTRAL PIEDMONT, VIRGINIA, USA

Kerby Dobbs and G. Richard Whittecar

Department of Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, Virginia

ABSTRACT

In landscapes surrounding urban zones, exploration continues for large sites that can be converted to mitigation wetlands. Piedmont terrains normally support wetlands only in valley bottoms, so sites most appropriate for efficient conversion lie on low terraces and floodplains. In order to evaluate the hydrogeologic settings typical to valley bottom wetlands in the central Virginia Piedmont, sites near Powhatan and Chester were chosen for their apparently non-distinctive geology, topography and hydrology. Both analyses illustrate the role of stratigraphy, geomorphic processes, and land-use history in controlling the role of groundwater and overbank flow in valley-bottom wetlands. The expected stratigraphic package in Piedmont valley bottoms is a fining-upwards (gravel-sand-mud) point-bar/flood basin sequence deposited by a stream channel migrating laterally. Floodplains underlain by this sedimentary sequence often contain numerous riparian wetlands fed by rain, groundwater and overbank flow. This stratigraphic scenario seems to be less common than expected because of valley damming during the 18th and 19th centuries. Extensive and unexpectedly thick mud beds deposited in historic, abandoned millponds carpet both of valley bottoms analyzed and produce markedly altered subsurface hydrologic conditions. Surface flow often changes, too, because many streams have incised steep-sided channels 1-3 m deep into those deposits. The more deeply-incised streams are hydraulically disconnected from their old floodplains.

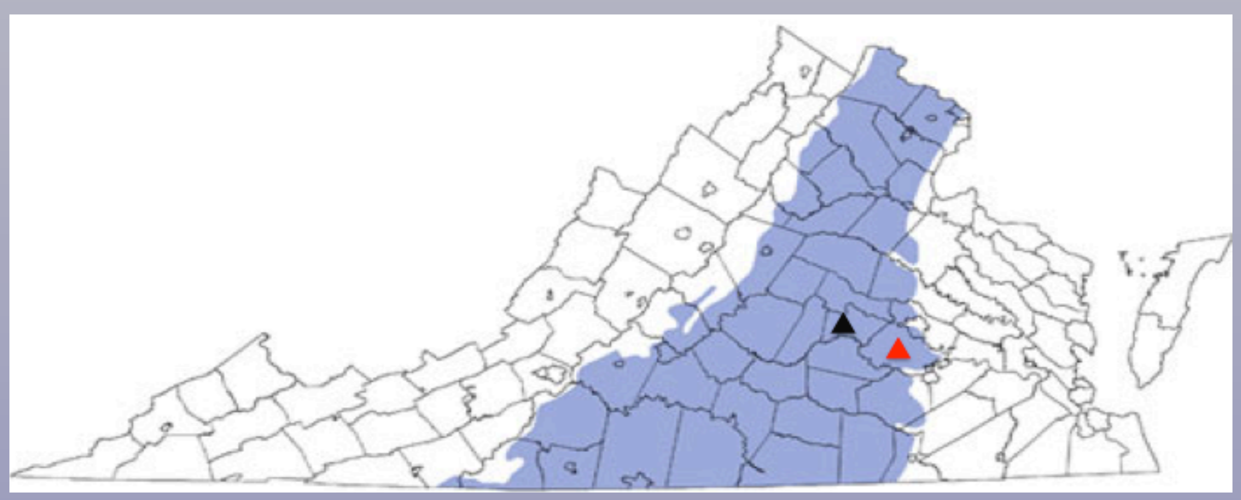
At both sites studied, groundwater discharge contributes significantly to wetland water budgets at toe-slopes along floodplain edges. In the middle of the valley bottom at the Powhatan site, though, wetland water on floodplain surfaces near incised streams drains downward into soil pipes and other megapores developed in the silty millpond sediments. This complex history of deposition, incision and piping created terrace surfaces with water levels too low to support wetlands that are not in the proximity of toe-slope seeps. In such settings, successful hydrologic designs for mitigation wetlands might rely upon the groundwater that emerges at toe-slope seeps and can be spread across regraded sloping surfaces carved from the historic milldam sediments.

RESEARCH GOALS

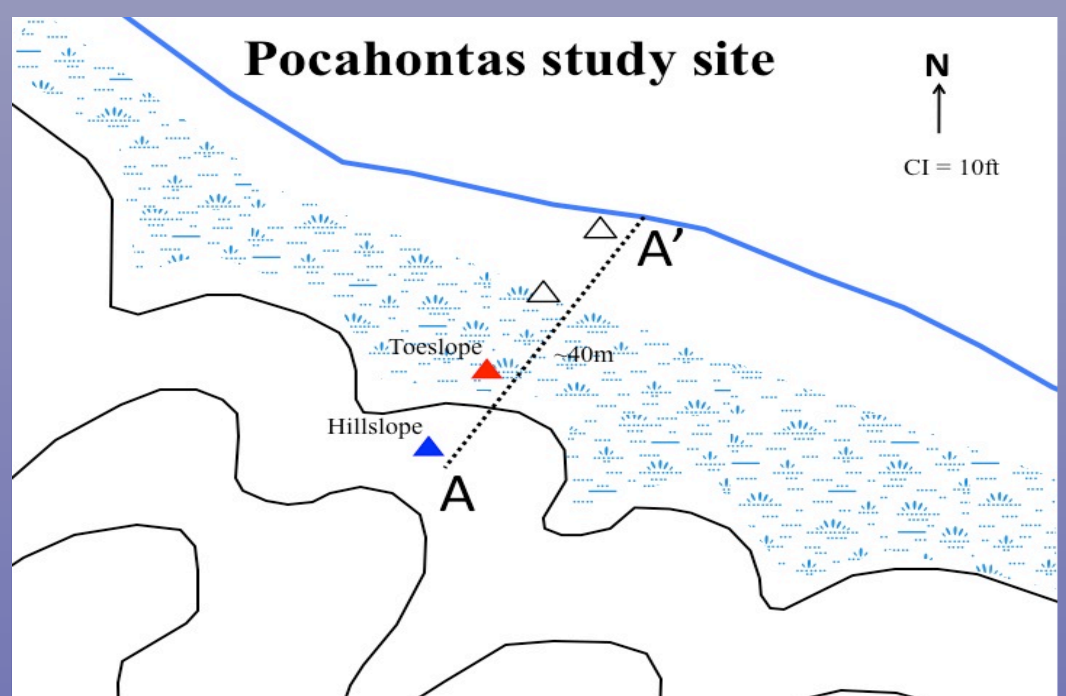
The purpose of this research is to characterize the depositional history, distribution of surficial materials, and the hydrogeologic properties that are common in Piedmont valley bottoms. In addition, it is to assess groundwater available for wetlands constructed in Piedmont toe-slopes/valley bottoms by answering critical questions regarding the hydrologic regime of these types of settings (i.e. How constant are the water levels in toe-slopes?). The results of this study should provide guidance about many aspects of wetland construction and wetland water budgeting.

SITE DESCRIPTIONS

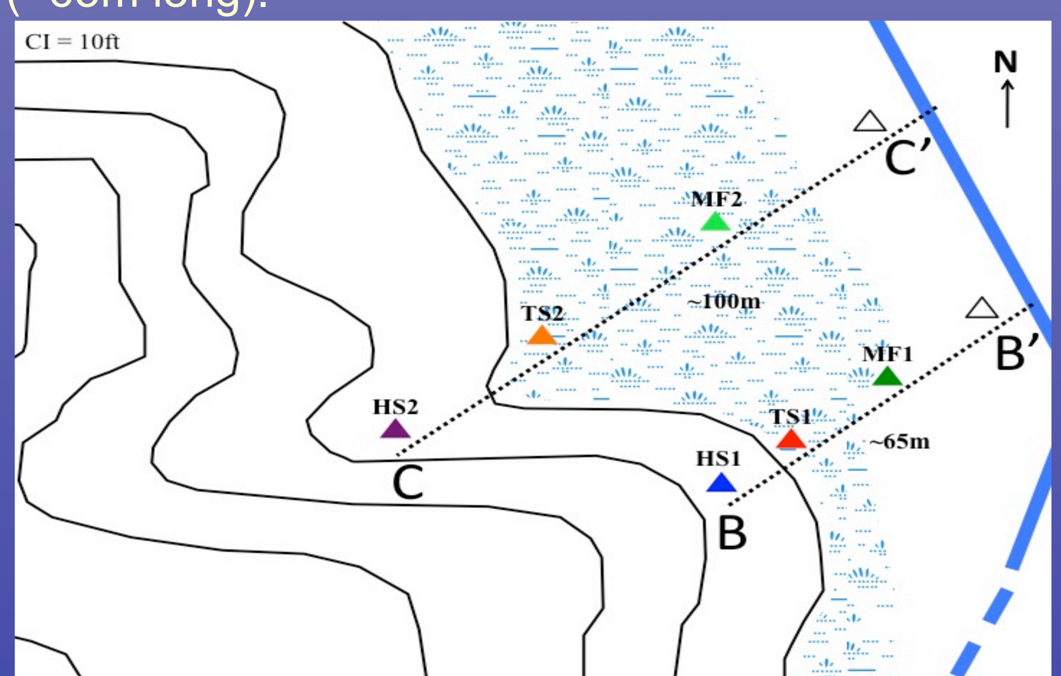
Two study sites in the Piedmont, Pocahontas State Forest and Powhatan Wildlife Management Area, have been selected for further investigation because each site overlies a bedrock type (e.g. granite; granite gneiss, biotite gneiss) common in the Virginia Piedmont and exhibits a variety of toe-slope shapes with seeps that include hillside scarps and sediment aprons.



Pocahontas State Park (red triangle above), located in Chesterfield, VA. First Branch (below right), a moderately incised stream, drains this site. Dashed line (A-A') indicates cross-section transect (~40m long). Triangles below indicate positions of monitoring wells and piezometers.



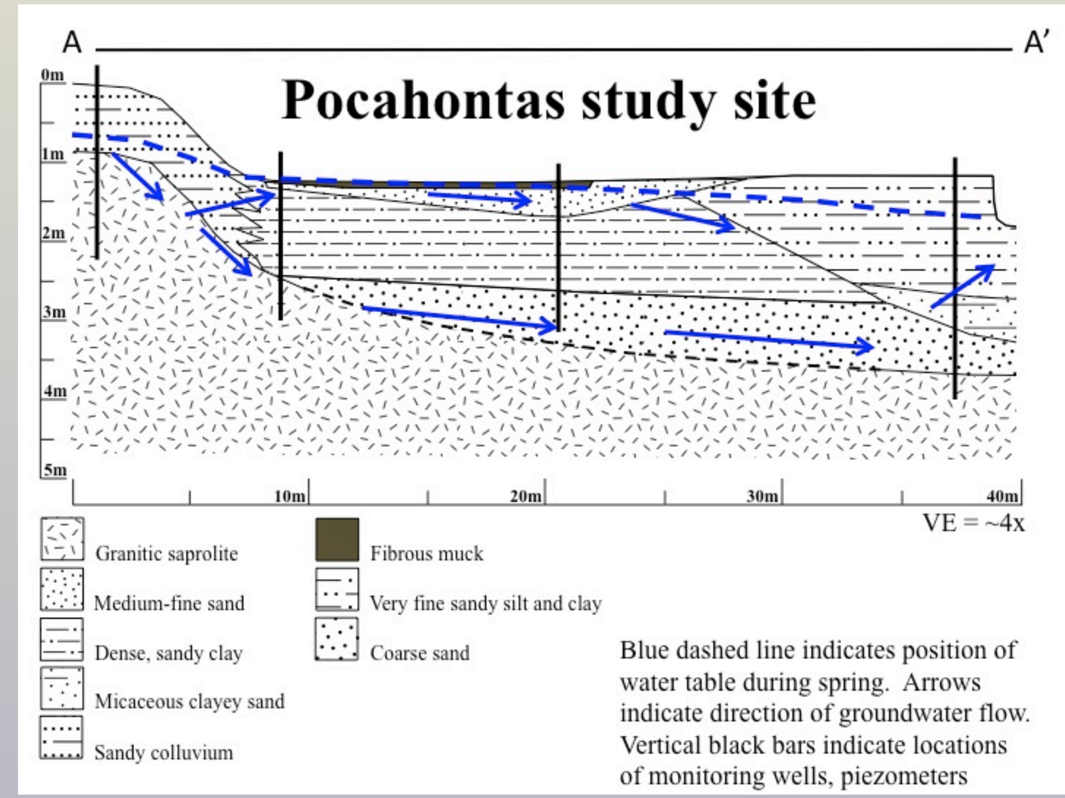
Powhatan Wildlife Management Area (black triangle above), located in Powhatan, VA. Sallee Creek (below right) drains this site. It is deeply incised and hydraulically disconnected from its floodplain, which sits approximately 3m above base flow in the stream. Dashed line (B-B') indicates cross-section transect (~65m long).



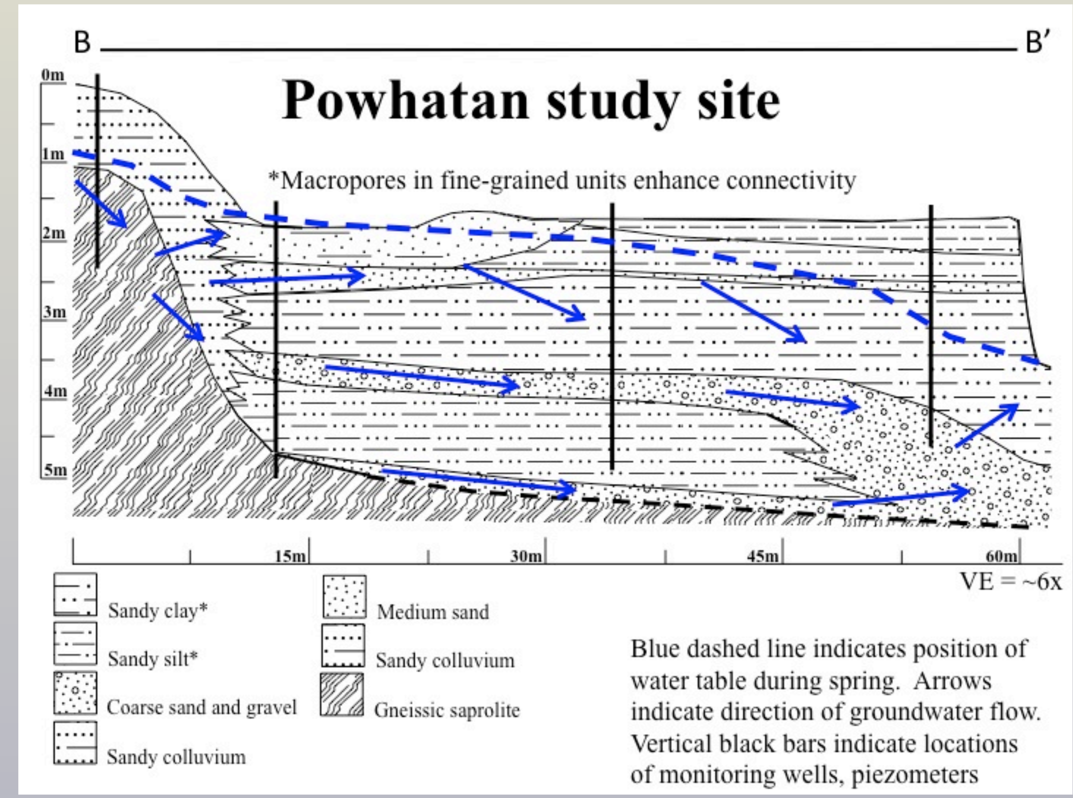
STRATIGRAPHIC CROSS-SECTIONS

Stratigraphic analysis indicates that the majority of deposition at each site was in a low-energy/slack-water environment, resulting in thick deposits of poorly conductive fine-grained silt and clay that overlie coarse sands of the former valley bottom. However, macropores at the Powhatan site enhance hydrologic connectivity of these units. In addition, the degree of incision at Powhatan prevents overbank flow from reaching the wetland.

Pocahontas State Park

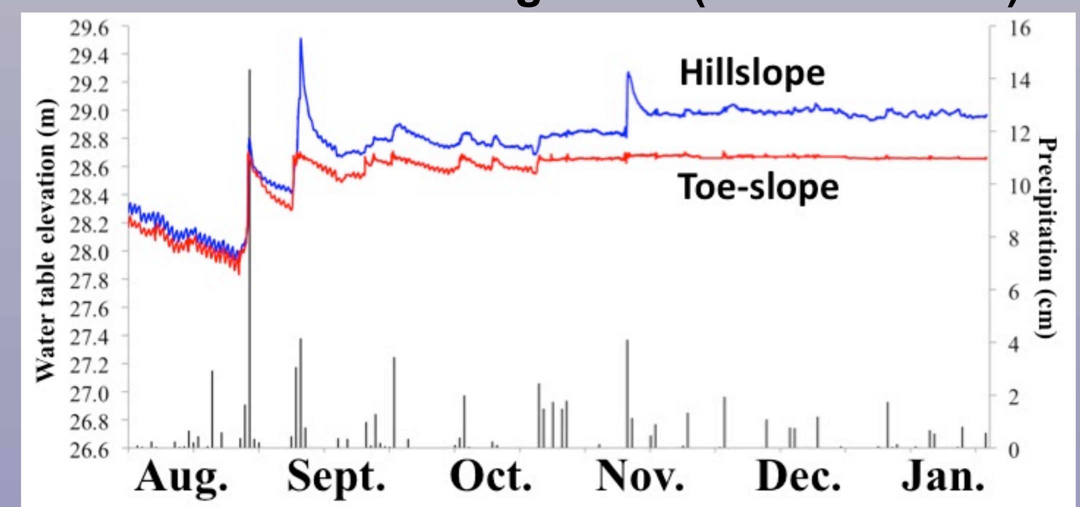


Powhatan Wildlife Management Area

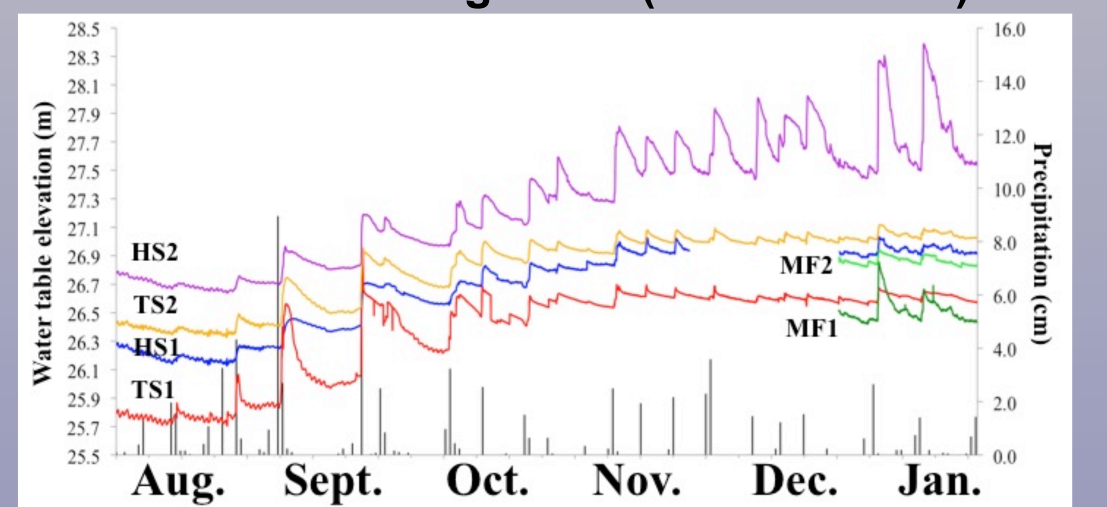


GROUNDWATER HYDROGRAPHS

Pocahontas Monitoring Wells (8/2/11-1/31/12)



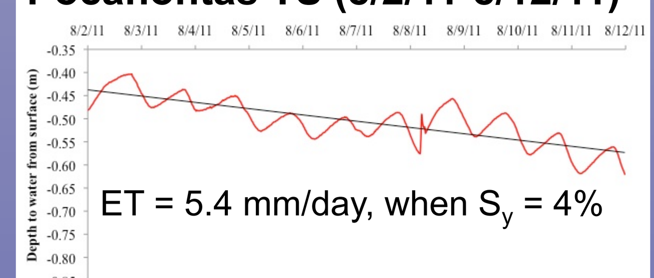
Powhatan Monitoring Wells (8/2/11-1/31/12)



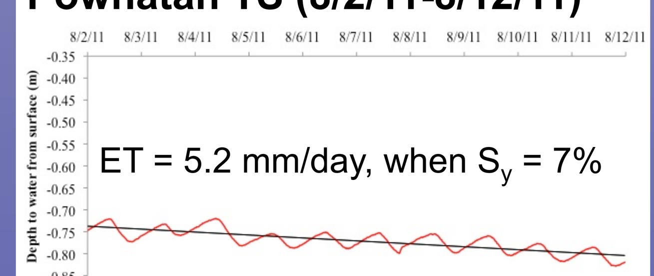
Differences in lithology and landscape position are reflected in the monitoring wells at each site. While the overall fluctuation of water levels in toe-slopes is similar at each site, the Pocahontas site exhibits persistent surface wetness throughout the year, which may be a result of impermeable clays and the ability of this wetland to receive overbank flow.

Determining Specific Yield (S_y) using $ET = S_y (\Delta s_1/\Delta t_1 + \Delta s_2/\Delta t_2)$ (modified from White, 1932)

Pocahontas TS (8/2/11-8/12/11)

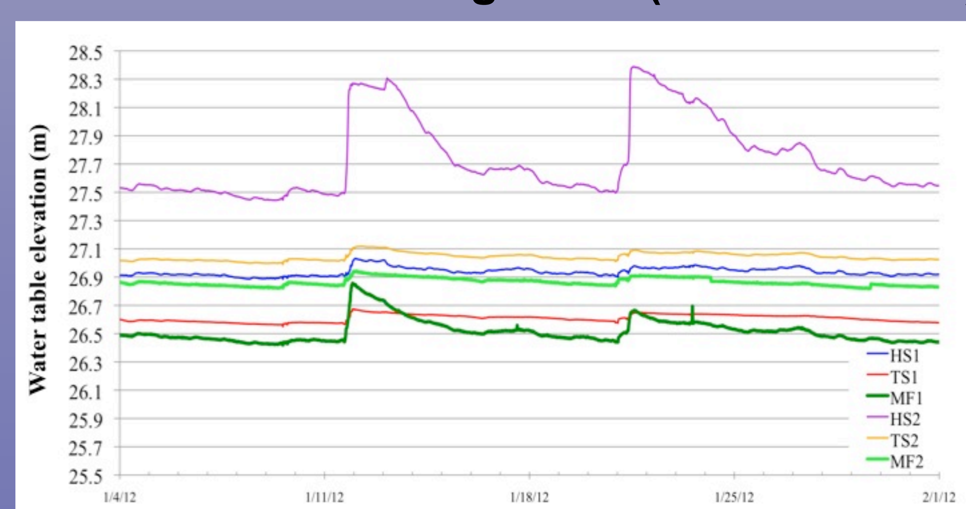


Powhatan TS (8/2/11-8/12/11)



Assuming ET is the same at both sites based on similar vegetation and meteorological influences, we can extrapolate values for specific yield. These specific yield values reflect sediments at toe-slopes where the majority of groundwater is discharged.

Powhatan Monitoring Wells (1/4/12-1/31/12)



Bold green lines represent wells screened in fine-grained sediment. Their synchronicity with other wells suggests macropores in these sediments enhance vertical connectivity between coarse and fine units.

FUTURE WORK

Monitoring well data and data regarding the hydrologic properties of surface materials in these settings will be used to calibrate the Wetland Water Budget model, which will calculate water budgets for a planned wetland site on Piedmont floodplains or terraces using many possible water sources. Historical maps and land-use records will be obtained to constrain the time frame and depositional environment for each site.

ACKNOWLEDGEMENTS

We acknowledge the assistance and cooperation of J. Mcleod, W. Boll, Z. Howerton, W. Myers, M. Richardson (ODU), Virginia Department of Game and Inland Fisheries, Virginia Department of Conservation and Recreation, and Wetland Studies and Solutions, Inc. Funding is provided by a grant from the Peterson Family Foundation.