Storming and Performing: Real-time Nitrogen and TSS Removal in an Active Control Wet Pond

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INTRODUCTION

Wet ponds have traditionally been viewed as less effective means for pollutant reduction than other BMP control measures (MS4 permit guidelines PA DEP 2016, MDE 2014).

Standards for pollutant reduction consider the wet pond a passive storage system governed by a fixed control structure designed to achieve a target quantity or water quality objective.

Advances in internet accessible controller systems have allowed continuous monitoring and adaptive control (CMAC) of BMPs, which monitors and controls stormwater infrastructure in real time to respond to forecasted weather.

Figure 1 (Left). Pictures from wet pond retrofit with Continuous Monitoring and Adaptive Control (CMAC). (From top) Solar-powered control panel, actuated valve, water quality sensor mounting.

STUDY SITE

A Wet Pond on Sligo Creek, tributary to the Anacostia River, which is impaired for nutrients and sediments (MDE/DOEE 2008). The site is located in the 64,000 square mile Chesapeake Bay Watershed (Figure 2), subject to USEPA's "pollution diet" calling for a 25% reduction in nitrogen, 24% reduction in phosphorus and 20% reduction in sediment (USEPA 2010).

HOW DOES CMAC WORK?

1) The software uses real-time National Weather Service forecast data to determine the timing and expected volume of incoming storm events.
2) In advance of the storm, the outlet valves close and only Sligo Creek baseflow passes. During and after the storm, the pond retains up to approximately 12 acre-feet of runoff volume.
3) After the retention period is over, the software sends a signal to open the valves and release the water downstream.
4) As a research extension of the project, real-time water quality sensors were installed to measure the enhanced total suspended solids (TSS) and nutrient removal performance (Table 1).

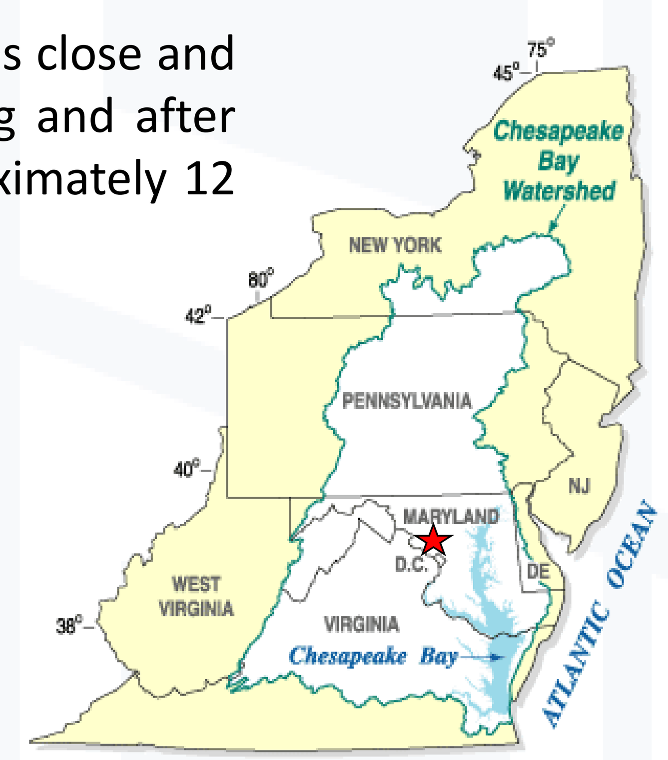

Figure 2. Chesapeake Bay Watershed Map (USGS 2014). Star indicates study site in Montgomery County, MD.

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Data Type	Sensor Installed	Measurement	Sampling
Hydraulic	OMEGA 439-005GI	Water Level	By Minute
	Texas Electronics Tipping Bucket	Precipitation	Continuous
Water Quality	Satlantic SUNA V2	Nitrate	2 hours
	Sequoia Scientific LISST 100X	Turbidity	2 hours

Table 1. Real-time sensors deployed in wet pond used for the evaluation of pollutant reduction.

METHODOLOGY

41 rainfall events (precipitation greater than 0.01") occurred during the first 9 months (Jan 2016 – Oct 2016) of the study and are being analyzed for pollutant reduction. 10-15 nitrate and TSS sensor readings per sampling period were averaged to characterize water quality in the wet pond.

Baseflow concentrations were calculated as the average of four data hours (nitrate) or six hours (TSS) prior to a runoff response in the pond.

Inflow concentration of nitrate from the runoff was calculated from the difference between the average peak mass load in the pond and the baseflow load. A cumulative sum of the load discharged throughout the storm constitutes the total outflow loading.

The difference between inflow loading (baseflow concentration included) and cumulative outflow load constitutes percent removal.

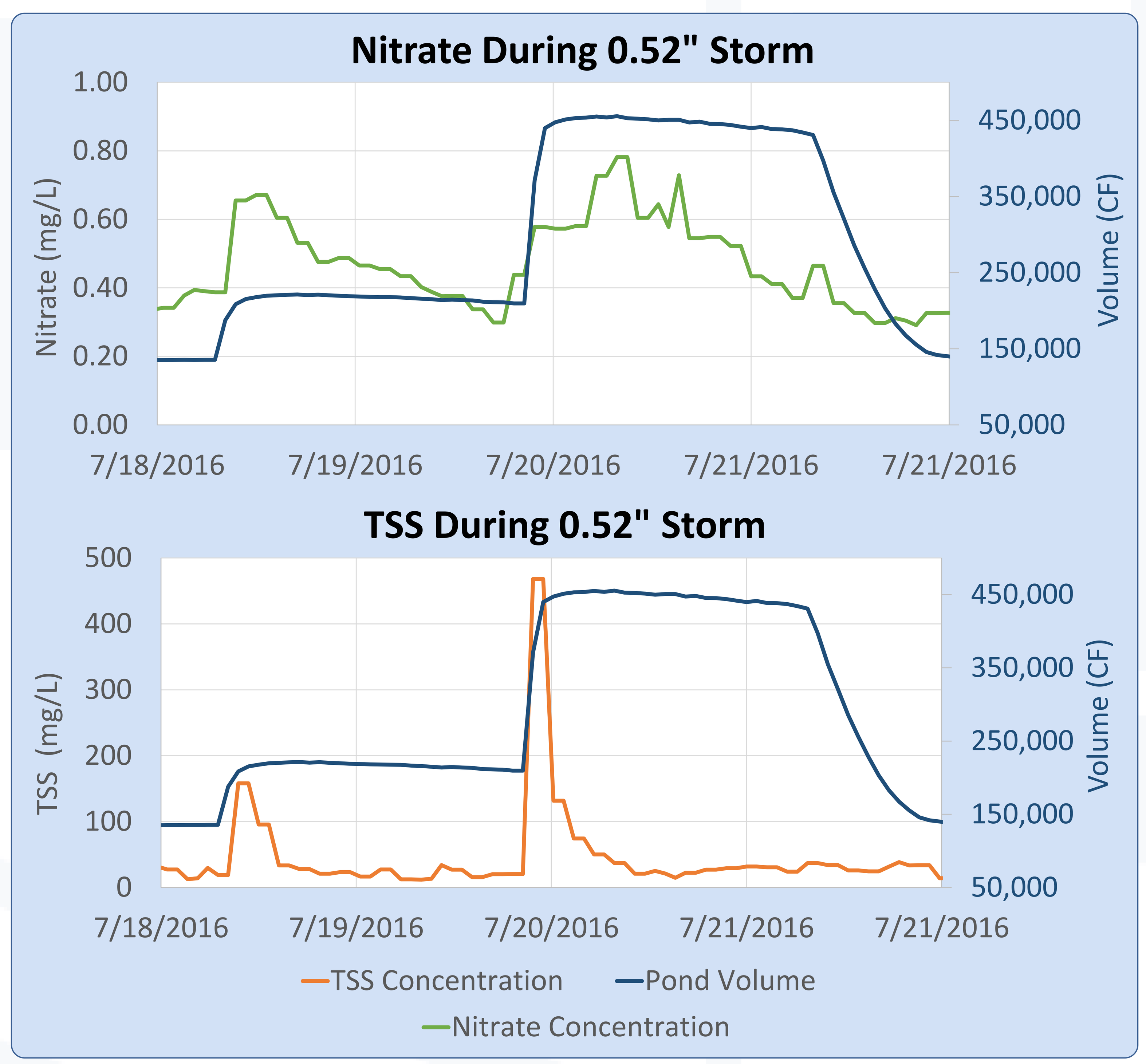

Figure 3. Continuous monitoring offers a data set that cannot be replicated by field sampling. Example storm shown above with nitrate and TSS concentrations throughout the storm.

FINDINGS

- Nitrate percent removal ranged from 28% to 68%; TSS percent removal ranged from 53% to 86%
- Removal percentages surpass the State of Maryland's stormwater credit removal efficiency for ponds (MDE 2014)
- Retention times for these storms were longer than the design requirement of 24 hours, and longer than the target 48 hours, averaging 96 hours

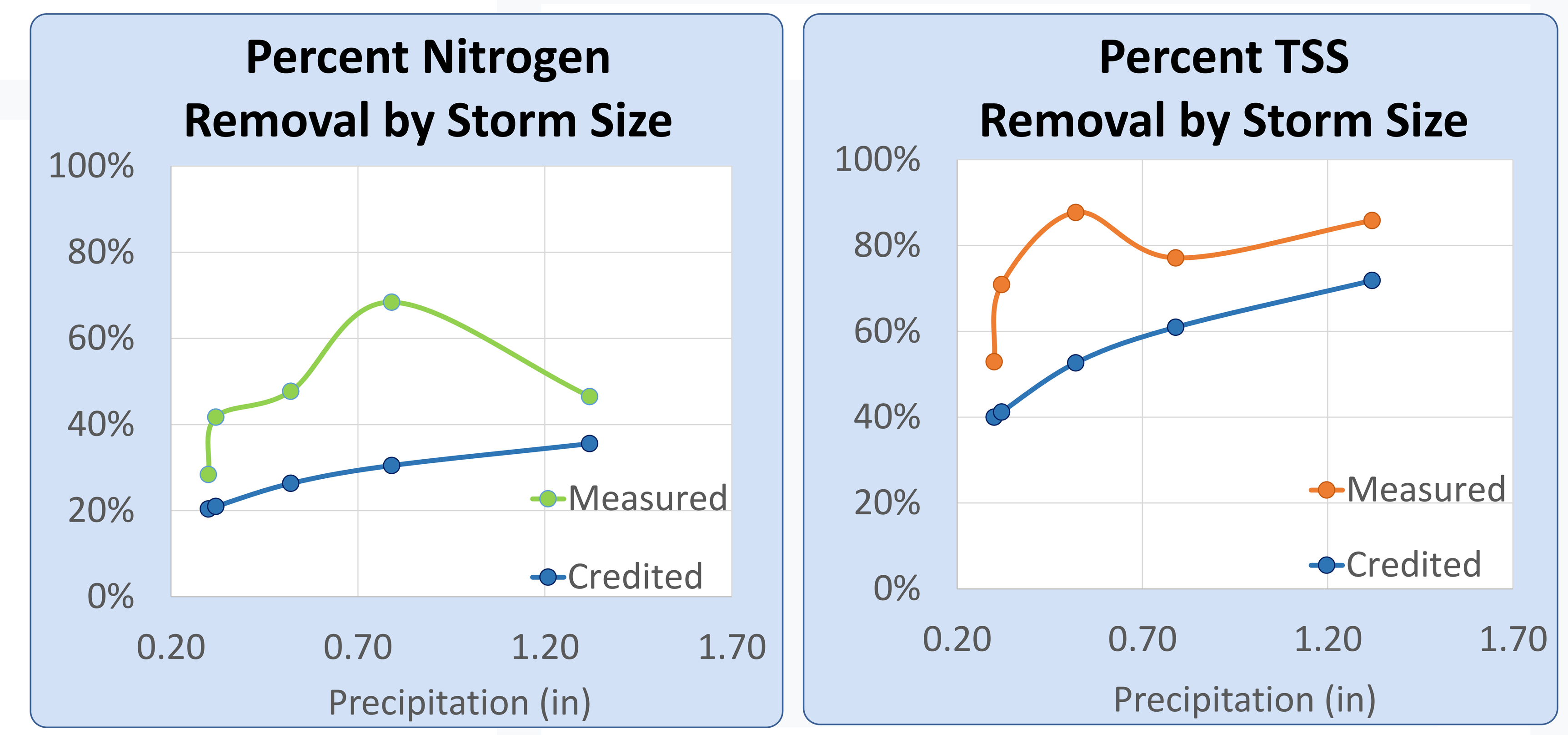

Figure 4 (above) and Table 2 (below). Comparison of nutrient removal from CMAC retrofit pond and Maryland crediting values.

Storm Size (in)	Nitrate Percent Removal		TSS Percent Removal	
	CMAC	Wet Pond (MDE 2014)	CMAC	Wet Pond (MDE 2014)
0.30	28%	20%	53%	40%
0.32	42%	21%	71%	41%
0.52	48%	26%	88%	53%
0.79	68%	30%	77%	61%
1.32	47%	36%	86%	72%

CONCLUSION

Retention and detention ponds have been used throughout the country to control runoff for flood protection and, more recently, for water quality improvement. Communities often choose to retrofit these older ponds to meet today's regulatory standards. CMAC provides a lower cost, less disruptive retrofit option. This study quantifies the enhanced pollutant removal performance of CMAC ponds, enabling communities to confidently use this new technology as part of their strategy to meet regulations and permit requirements.

REFERENCES

1) Maryland Department of the Environment (MDE) (2014). Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Guidance for the National Pollutant Discharge Elimination System Stormwater Permits.

2) Maryland Department of the Environment (MDE) and District of Columbia Department of Energy and Environment (DOEE) (2008). Total Maximum Daily Loads of Nutrients/Biochemical Oxygen Demand for the Anacostia River Basin.

3) Pennsylvania Department of Environmental Protection (DEP) (2016). BMP Effectiveness Values. 3000-PM-BCW0100m.

4) US Environmental Protection Agency (USEPA) Region 3 (2010) Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus, and Sediment.