Pollutant Removal Efficiencies of Self-Converted Dry Detention Ponds in Baltimore County, MD

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INTRODUCTION

- The EPA developed the Chesapeake Bay TMDL (Total Maximum Daily Load) for priority pollutants: Nitrogen, Phosphorus and Sediment in 2010 [1].
- Maryland Department of the Environment (MDE) currently gives no reduction of pollutant load to dry detention or dry extended detention ponds for the EPA's TMDL pollutants [2].
- Dry detention pond BMP's were originally designed and installed to provide quantity control with little to no water quality treatment of stormwater.
- Previous studies have indicated that dry detention ponds can provide increased removal efficiencies than are currently being credited by MDE [3].
- This study compares the pollutant removal efficiencies of standard dry detention ponds and dry detention ponds that have self-converted to ponds with wetland characteristics (soils and vegetation).

OVERVIEW

Goals

- Better understand the pollutant load removal efficiencies of dry detention ponds that have self-converted to wetlands.
- Acquire data to potentially revise dry detention pond removal efficiency assumptions.

Methods

- Three (3) self-converted (study) ponds and three (3) control ponds were selected following the guidance of the *Urban Stormwater BMP Performance Monitoring Manual* [4].
- Water Quality sampling was performed during eight (8) storm events spread over the course of 12 months at each monitoring location.
- During storm events, samples were taken from each inlet/outlet location representing the rising limb, peak and falling limb of the storm hydrograph. Discharge levels were recorded during sample collections and at 5-10 minute intervals during storm flow. Samples were preserved on ice and taken to laboratory for analysis.
- Water samples were analyzed for Total Suspended Solids (TSS), Total Nitrogen (TN) Total Kjehdahl Nitrogen (TKN), Nitrate/Nitrite Nitrogen, Total Phosphorus (TP), Orthophosphorus and Total Dissolved Solids (TDS). Continuous discharge was monitored at each site using In-Situ Rugged TROLL® 100/200 data loggers paired with flow restriction devices (i.e., weirs, orifices).
- Continuous rain data was also collected using automated Onset RG3 rain gauges.

Table 1: Site specific parameters

Facility	Code	BMP Type	Inlets	Drainage Area (acres)	Land Use	Pond Bottom (acres)	Pond Footprint (acres)	Wetland (acres)	Percent Wetland	Impervious surface (acres)	Percent Impervious
Study Ponds											
Glyndon Square	GS	Dry Pond	1	5.72	Comm	0.37	0.92	0.2	62%	3.43	59%
Hunt Ridge	HR	Dry Pond	2	20.60	Res	0.50	1.19	0.02	4%	5.75	28%
Worthington	WO	Dry Pond	1	63.39	Res	0.48	0.98	0.4	81%	8.28	13%
Control Ponds											
McCormick	MC	Dry Pond	2	8.56	Ind	0.11	0.32	0	0.00%	6.07	71%
College Hills	CH	Dry Pond	1	8.00	Res	0.08	0.25	0	0.00%	2.64	33%
Fields of Harvest	FH	Dry Pond	1	7.20	Res	0.37	1.04	0	0.00%	0.91	13%

Fig. 1: Thelmar weir used at MC Inlets, HR Inlets and Outlets.

Fig. 2: Stainless Steel Compound Weir used at MC Outlet.

Evaluation

- Flow records were compared to rainfall data to ensure accurate volumes.
- Event Mean Concentrations (EMC) were calculated for each storm in mg/L.
- We used continuous flow records and EMCs to calculate pollutant loads (lbs/yr) at each site using FLUX32 software [5].
- Nonparametric testing (Wilcoxon-sign rank and Kolmogorov-Smirnov) were used to evaluate statistical significance between influent and effluent EMCs at each facility.

RESULTS – EVENT MEAN CONCENTRATIONS (mg/L)

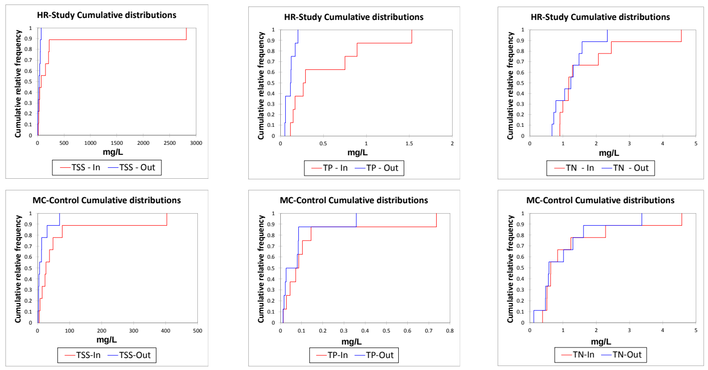


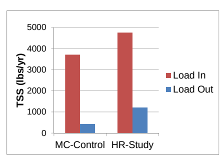
Fig. 3: Cumulative distribution plots of TSS, TP and TN at HR-Study and MC-Control facilities.

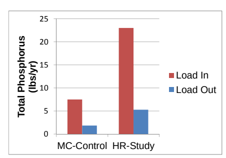
Table 2: **Event EMC comparison.** Data are non-normally distributed, thus nonparametric Wilcoxon-sign rank and Kolmogrov-Smirnov tests were performed. Wilcoxon-sign rank shows influent and effluent concentrations are significantly different for priority pollutants at HR-Study, while at MC-Control, only TSS was found to be significantly different. Kolmogorov-Smirnov test results indicate a statistical significance between sample distributions only at HR-Study for TP.

Wilcoxon-sign rank						
	HR-Study			MC-Control		
	TSS	TP	TN	TSS	TP	TN
V	42	35	39	45	30	35
p-value	0.020	0.016	0.055	0.004	0.109	0.164
alpha	0.1	0.1	0.1	0.1	0.1	0.1

Kolmogorov-Smirnov						
	HR-Study			MC-Control		
	TSS	TP	TN	TSS	TP	TN
D	0.444	0.625	0.333	0.556	0.375	0.222
p-value	0.352	0.087	0.730	0.126	0.660	0.989
alpha	0.1	0.1	0.1	0.1	0.1	0.1

RESULTS – LOAD REDUCTIONS (lbs/yr)





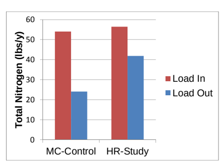


Fig. 4: Flux model results. Influent and effluent loads (lbs/yr) of pollutants at MC and HR for TSS, TP and TN.

Table. 3: Flux model reductions. Reduction percentages of influent vs. effluent at MC and HR for TSS, TP and TN

	TSS	TP	TN
MC-Control	88%	75%	55%
HR-Study	74%	77%	26%

- The FLUX32 uses a Ratio Estimate methods to calculate loads based on EMCs and annual discharge.
- Rainfall loads were added to pond influent at each site. Rainfall volume was calculated by using rain gauge data along with pond footprint area. Eight (8) rain collections were analyzed throughout the year for pollutants TSS,TP and TN.
- MC-Control had episodic baseflow influent through one inlet which was stored by the facility. This baseflow storage could attribute to the higher than expected reductions from this control site.

HYDROGRAPH ANALYSIS

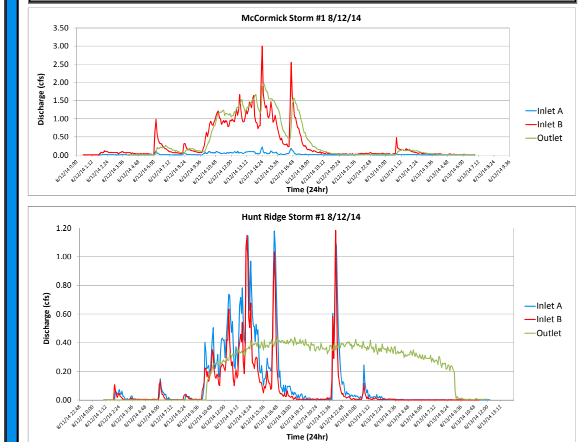


Fig. 4: Storm hydrographs were created to accurately determine rising limb, peak and falling limb times and volumes. Discharge amounts are highly dependent on preceding conditions: precipitation amount and intensity, drainage area and percent impervious.

CONCLUSIONS

- A comparison of influent and effluent loads shows load reductions for all priority pollutants at both the control site and study site. Although load reductions were observed, effluent concentrations were not significantly reduced across all sites and for all parameters.
- Hunt Ridge pond bottom is only 4% converted wetland which may explain why there are only small differences in nutrient mitigation when compared to McCormick. We would expect higher nutrient removal rates at Glyndon Square and Worthington because they have a greater wetland area.
- McCormick (control) and Hunt Ridge (study) are just two of the six ponds that are being evaluated. At this time we cannot make any definitive conclusions until the other four ponds have been analyzed.
- It is apparent however, that there are quantifiable reductions taking place in dry and self-converted dry detention ponds contrary to MDE Waste Load Allocations [1].

For Consideration:

- Continuing this study for another year would increase sampling size which will help reduce error or outlier storm data.

REFERENCES and ACKNOWLEDGEMENTS

[1] USEPA, 2010
[2] MDE, 2014
[3] Koch et al., 2014
[4] USEPA, 2009
[5] USACE

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