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Pollutant Removal Efficiency of Self-Converted Dry Pond Wetlands

Baltimore County, Maryland

Metropolitan Washington Council of Governments
Innovative Approaches for Retrofitting Stormwater Ponds Workshop
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CLEAN GREEN COUNTY

Collaborative Effort

- **Funding**
  - Chesapeake Bay Trust Pioneer Grant

- **Partners**
  - Baltimore County DEPS
  - KCI Technologies Inc.
  - Towson University UEBL
  - Chesapeake Environmental Management

Project Background

- Self-Converted Stormwater Management Pond
  - Definition: SWM ponds that over time, due to maintenance, aggraded sediment, clogged pilot channel or outlet, groundwater intrusion, and other factors have developed wetland conditions
- Better understand removal efficiencies
  - Shallow marsh and forested wetland systems
- Hypothesis
  - Self-converted dry detention ponds provide greater removal efficiencies than unconverted dry detention ponds.

Goals

- To determine removal efficiencies (TN, TP, TSS) of self-converted dry ponds relative to control unconverted dry ponds
- To provide evidence for crediting re-evaluation for these BMPs in the Chesapeake Bay restoration and MS4 compliance frameworks
- To more effectively prioritize restoration activities for pollutant load reductions across the County.

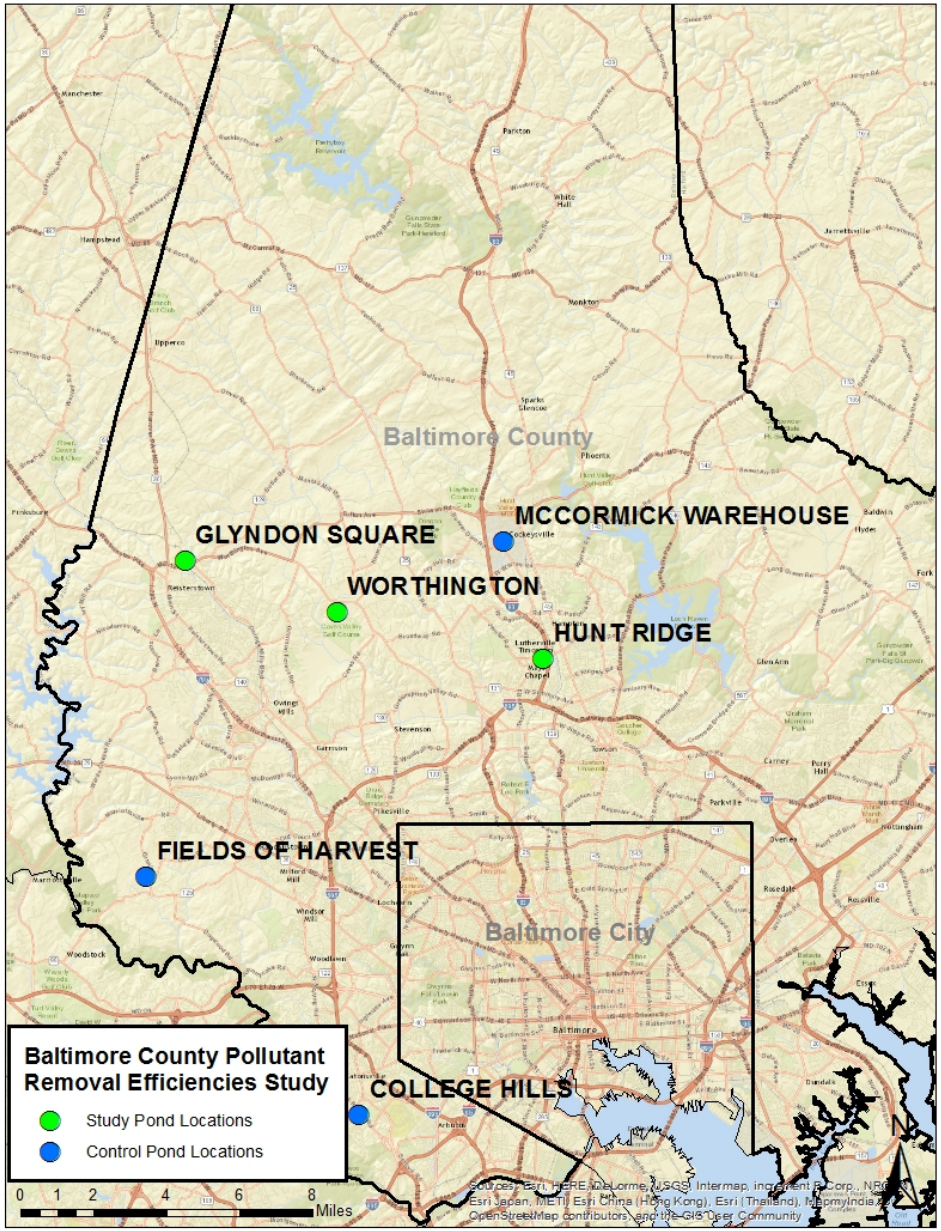
Site Selection

- **General Inclusion Criteria:**
  - Facility must be a dry detention pond
  - Facility must not be a dry extended detention pond
  - Attempt will be made to select sites representing a range of characteristics
    - land use
    - impervious cover
    - drainage area
    - % wetland
- **Sampleability Criteria:**
  - Inlets and outlets should be accessible for gauging instruments
  - Pipe slopes should be low enough to allow for accurate flow gauging
  - Pipes should not be backwatered at regular intervals
  - Attempts to limit the number of inlets

Site Selection

- **Study Ponds (3)**
  - Facility must contain wetland soils
  - Facility must have evidence of wetland hydrology
  - Facility must support wetland vegetation
  - Facility must be well-vegetated and not actively mowed
  - A range of wetland percentages were selected

- **Control Ponds (3)**
  - Facility must not contain wetland
  - Facility must have regularly maintained vegetation


Baltimore County
GLYNDON SQUARE
MCCORMICK WAREHOUSE
WORTHINGTON
HUNT RIDGE
FIELDS OF HARVEST
Baltimore City
COLLEGE HILLS
Baltimore County Pollutant Removal Efficiencies Study
Study Pond Locations
Control Pond Locations
0 1 2 4 6 8
Miles
N


Glyndon Square


College Hills

Site Characteristics

Facility and Code	County Pond #	Predominant Land Use	Drainage Area (ac)	Impervious Area (ac)	Impervious Percent	Runoff Curve Number
Study (Self-Converted) Ponds						
Glyndon Square (GS)	18	Commercial	5.7	3.43	60.0	82.7
Hunt Ridge (HR)	111	Residential (Medium Density)	20.6	4.82	23.4	78.9
Worthington (WO)	64	Residential (Low Density)	63.4	6.81	10.7	68.8
Control Ponds						
McCormick (MC)	1385	Commercial	8.6	6.07	70.9	93.7
College Hills (CH)	415	Residential (Medium Density)	8.0	1.97	24.6	75.9
Fields of Harvest (FH)	495	Residential (Low Density)	7.2	0.91	12.6	67.9

Facility and Code	County Pond #	Number of Inlets	Pond Year Built	Pond Age (years as of 2015)	Pond Footprint Area (ac)	Pond Bottom Area (ac)	Wetland Area (ac)	Wetland Percent
Study (Self-Converted) Ponds								
Glyndon Square (GS)	18	1	1979	36	0.92	0.37	0.23	62%
Hunt Ridge (HR)	111	2	1981	34	1.19	0.50	0.02	4%
Worthington (WO)	64	1	1979	36	0.98	0.48	0.39	82%
Control Ponds								
McCormick (MC)	1385	2	1977	38	0.32	0.11	0.00	0%
College Hills (CH)	415	1	1988	27	0.25	0.08	0.00	0%
Fields of Harvest (FH)	495	1	1985	30	1.04	0.37	0.00	0%

Sampling Methods

- **Methods**
  - Followed recommendations in USEPAs *Urban Stormwater BMP Performance Monitoring Manual.* Prepared by Geosyntec Consultants and Wright Water Engineers Inc.
  - Developed a Quality Assurance Project Plan
  - Standard Operating Procedures
    - Lab analysis, downloading and maintenance, sampling, chain of custody

- **Storm Flow Sampling**
  - Eight storm events at each pond
  - Three samples at each inlet/outlet, representing rise, peak and fall
  - Baseflow sample collected if present
  - 24 hours of antecedent dry time
  - Stage measurements every 5-10 minutes (or even more frequent)

Sampling Methods

- **Continuous Discharge**
  - In-Situ Rugged TROLLs logging depth at 5-minute intervals
  - Flow restriction devices: Thel-Mar volumetric Weirs, 90° and 120° v-notch weirs, and compound weirs

- **Precipitation**
  - Onset RG3 rain gauges
  - Tru-Chek® rain gages
  - Rainfall water quality samples to account for direct wet pollutant deposition into ponds

Analysis – Data Preparation

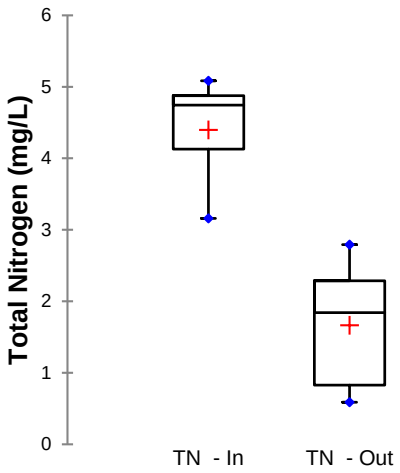
- **Outlier Screening**
  - XLSTAT version 2010.3.07
- **Volume**
  - Flow volume determined by level logger data, stage-discharge relationships
- **Event Mean Concentrations (EMC)**
  - Discharge data plotted to produce hydrographs allowing partition of rise, peak and fall
  - $EMC = \frac{\sum_{i=1}^{n} V_i C_i}{\sum_{i=1}^{n} V_i}$
- **Influent and Effluent Annual Load Calculation**
  - Load Estimation
    - Uses mean daily discharges, storm event EMCs, and baseflow concentrations to calculate annual loads
  - Precipitation Load Calculation
    - Pond side slopes runoff curve number in addition to pond bottom area and rainfall to determine wet deposition loads

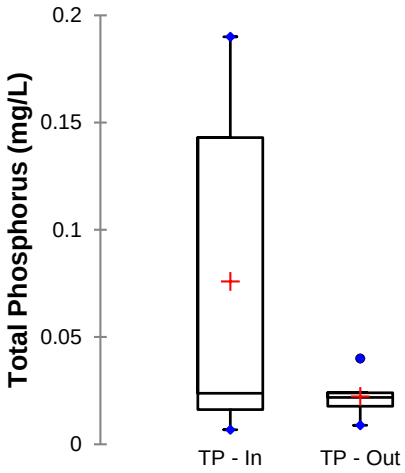
Volume Reduction Estimation

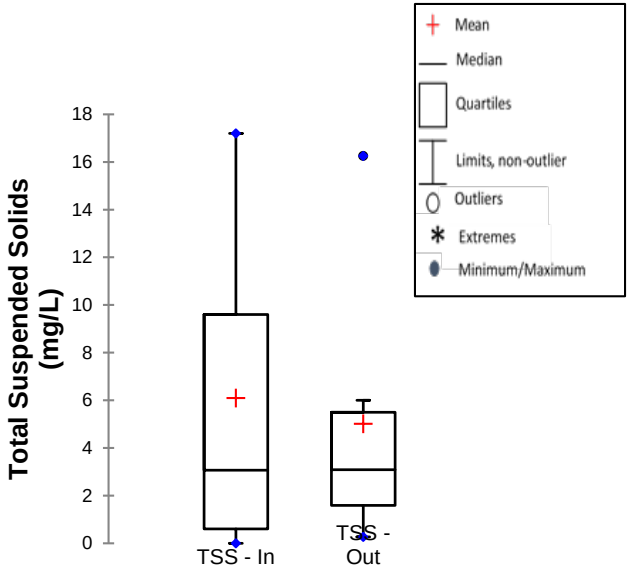
Site	Rainfall (in)	Rainfall (cf)	Inlet A (cf)	Inlet B (cf)	Volume In (cf)	Volume Out (cf)	Flow Reduction (cf)	Flow Reduction (%)
Self Converted Study Ponds								
Glyndon Square	38.33	106,580	472,556	321,984	901,120	737,533	163,586	18%
Hunt Ridge	43.63	157,870	413,275	353,261	924,406	671,201	253,204	27%
Worthington	33.25	101,386	984,378	-	1,085,764	896,004	189,760	17%
Control Ponds								
McCormick	47.16	45,434	100,642	667,763	813,839	727,789	86,050	11%
College Hills	55.2	41,237	288,197	-	288,197	261,997	26,200	9%
Fields of Harvest	34.91	109,717	395,268	-	504,985	381,227	123,758	25%

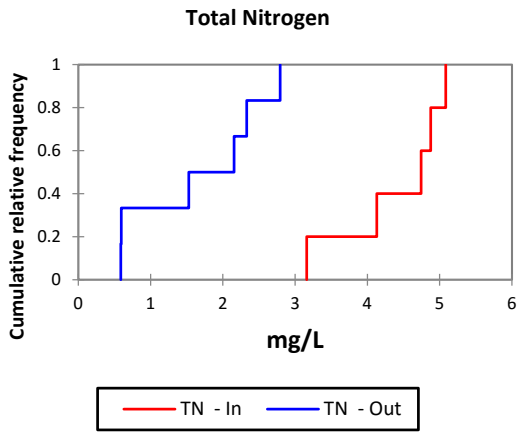
EMC Evaluation - baseflow

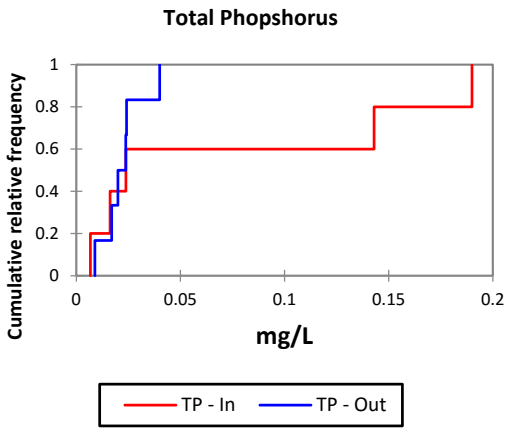
- **Worthington**

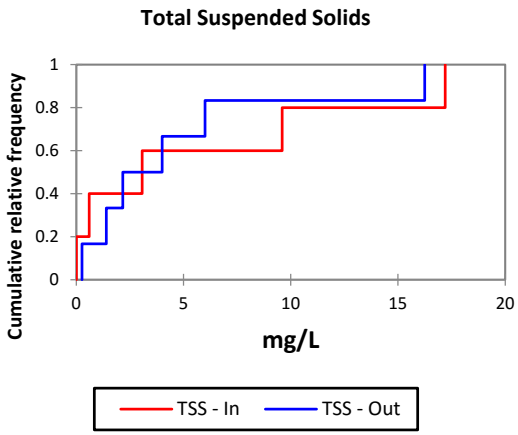




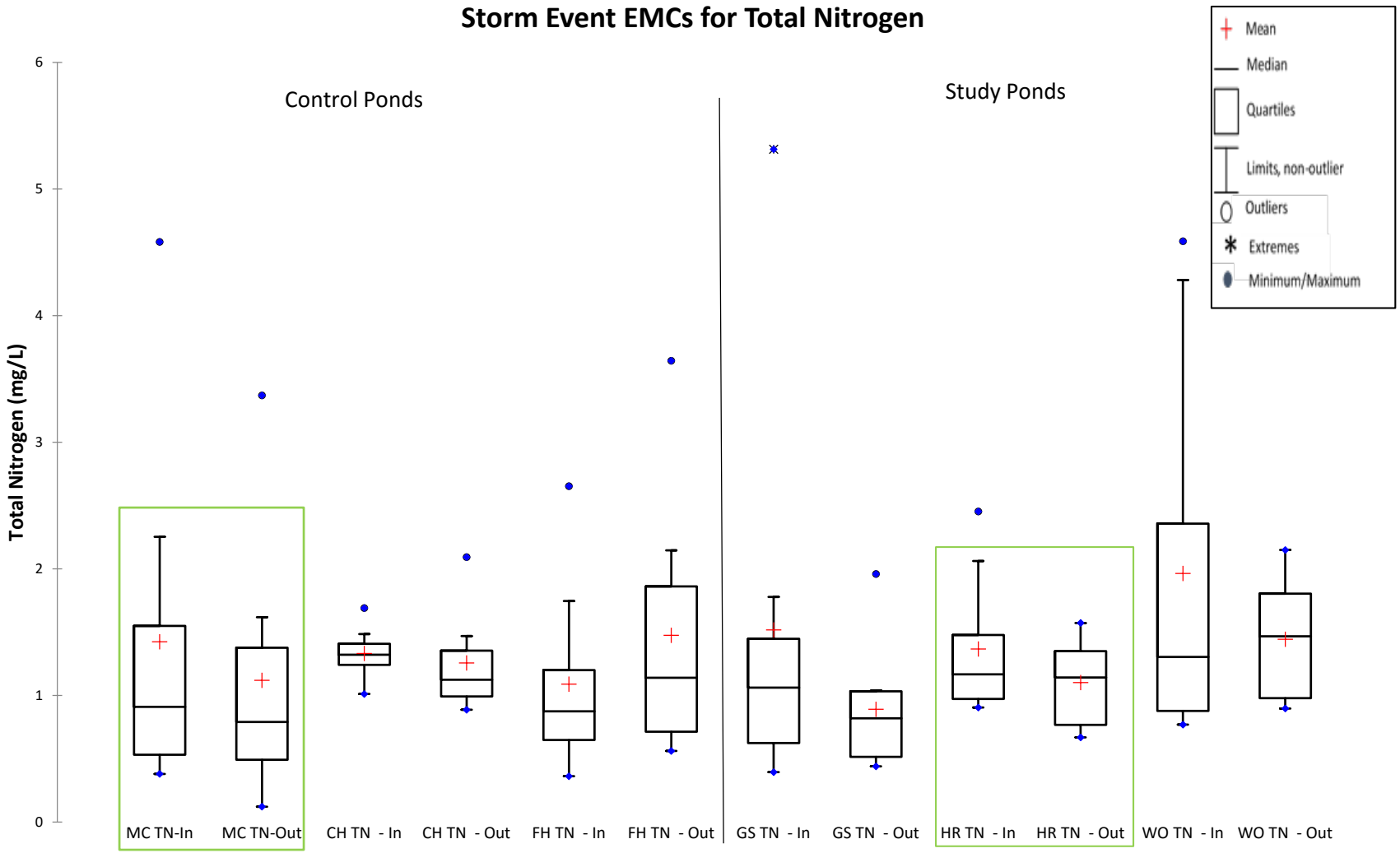








EMC Evaluation - Nitrogen



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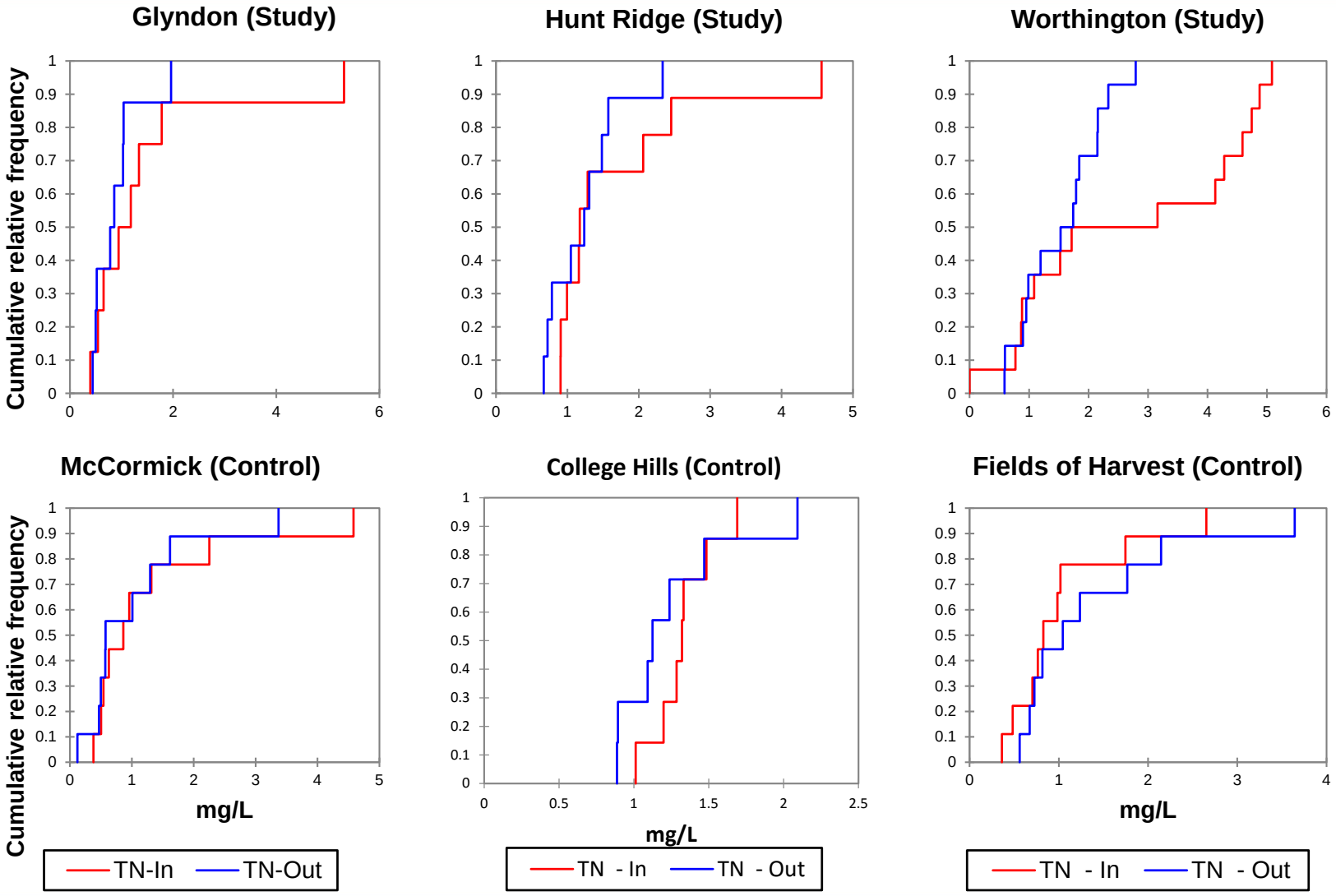
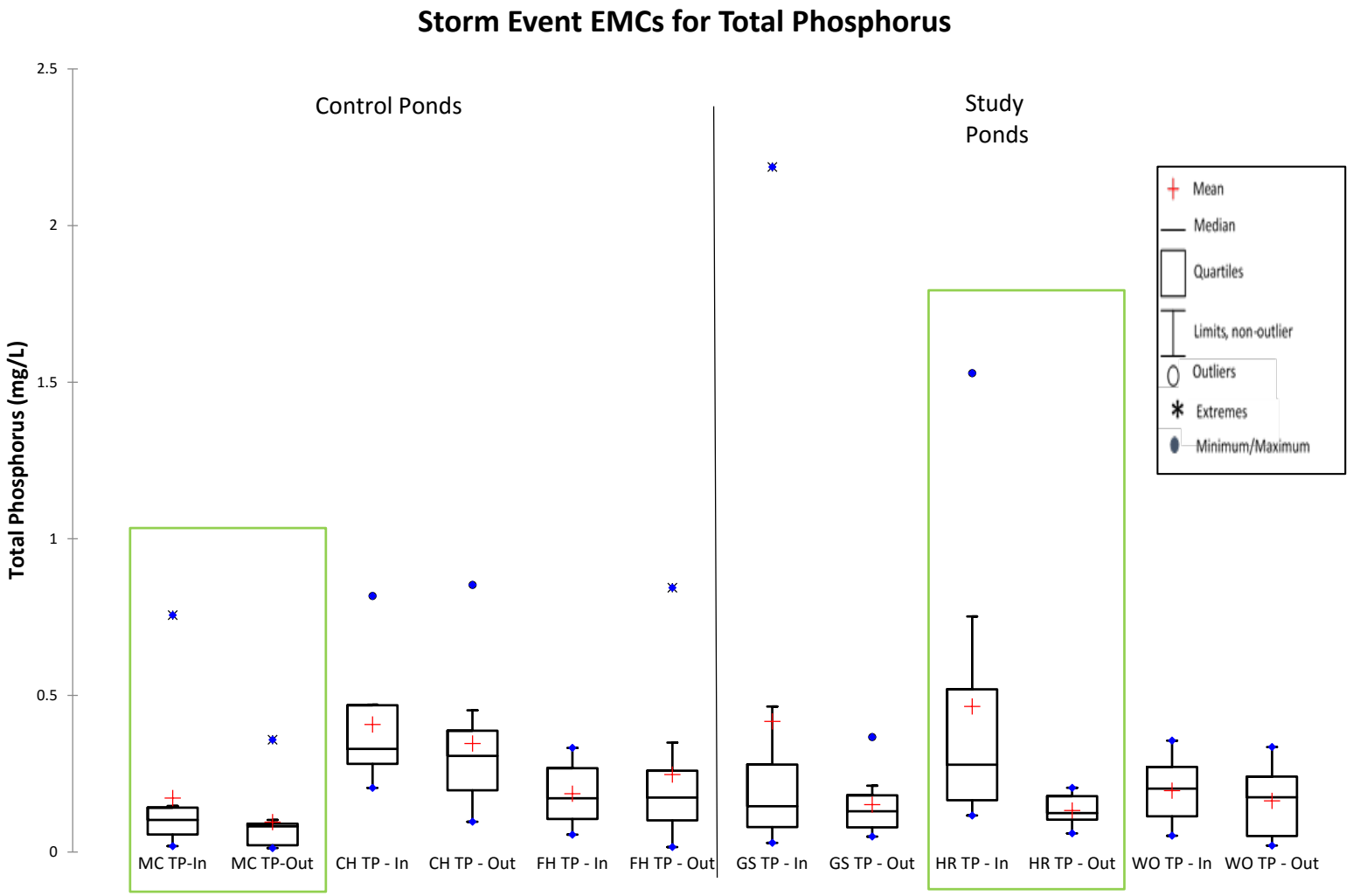


EMC Evaluation - Phosphorus



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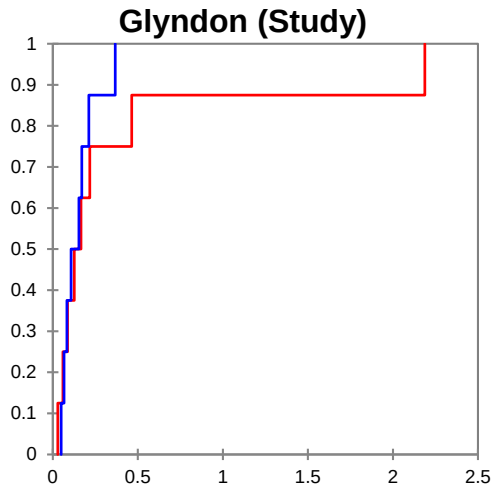
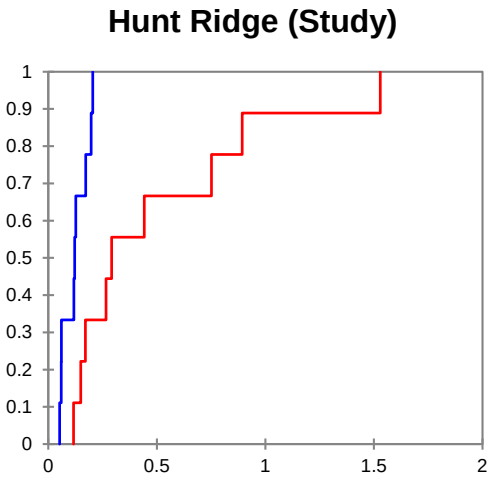
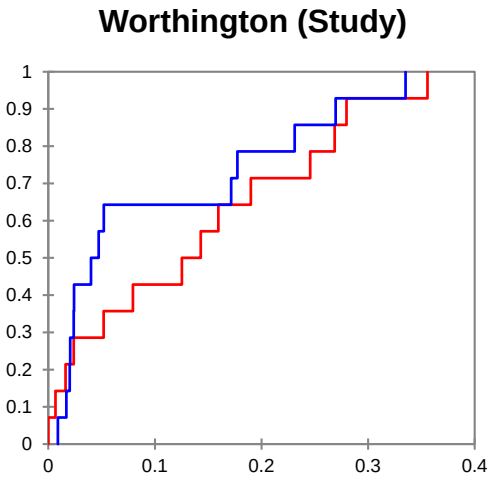
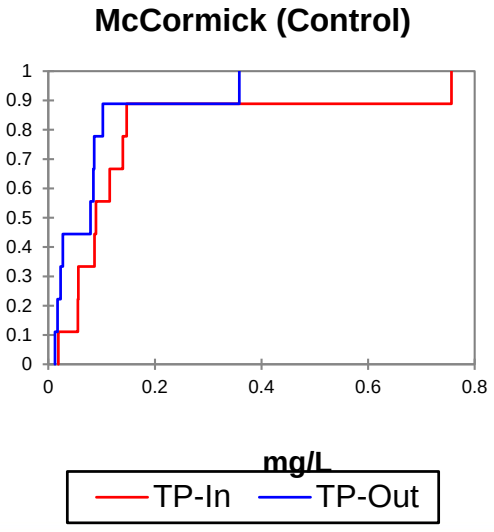
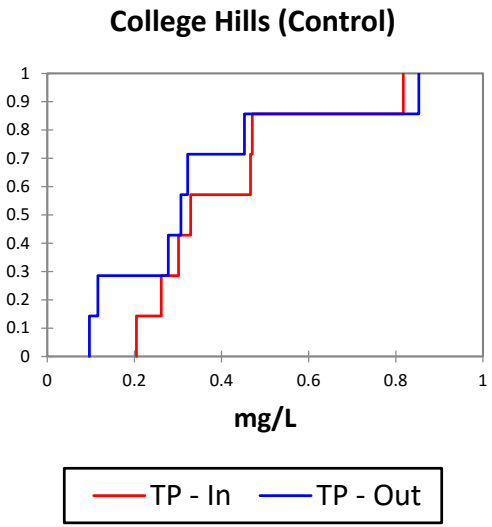
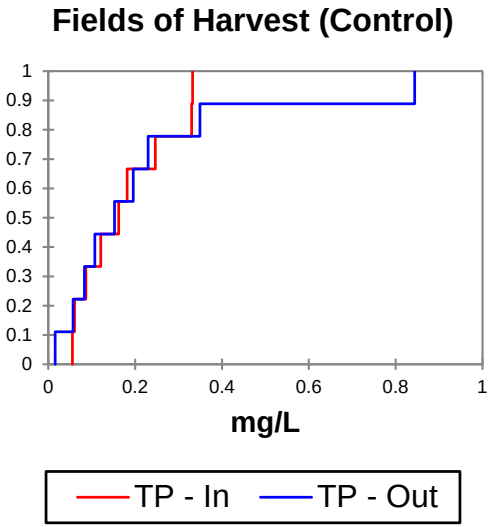




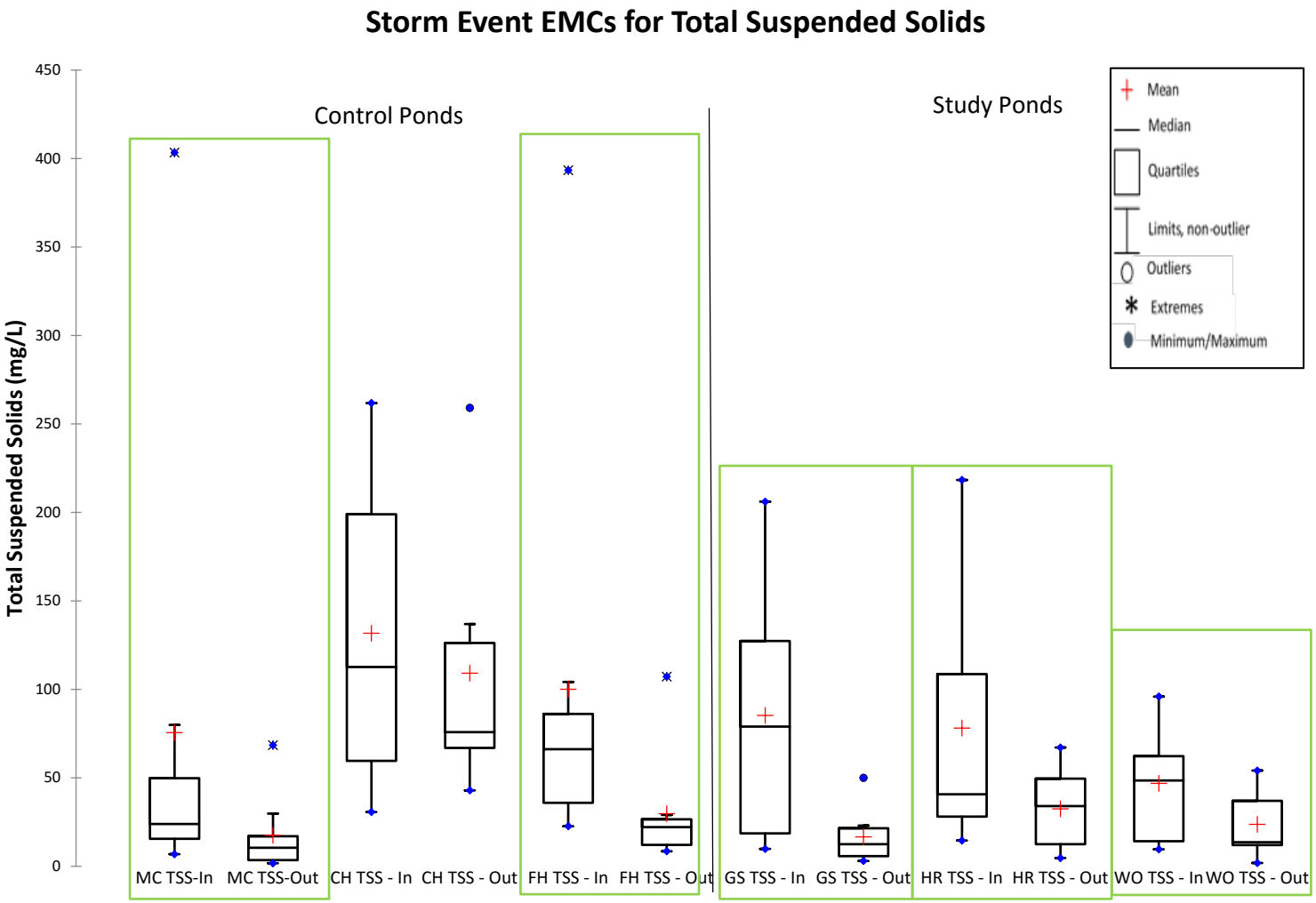








EMC Evaluation – Total Suspended Solids



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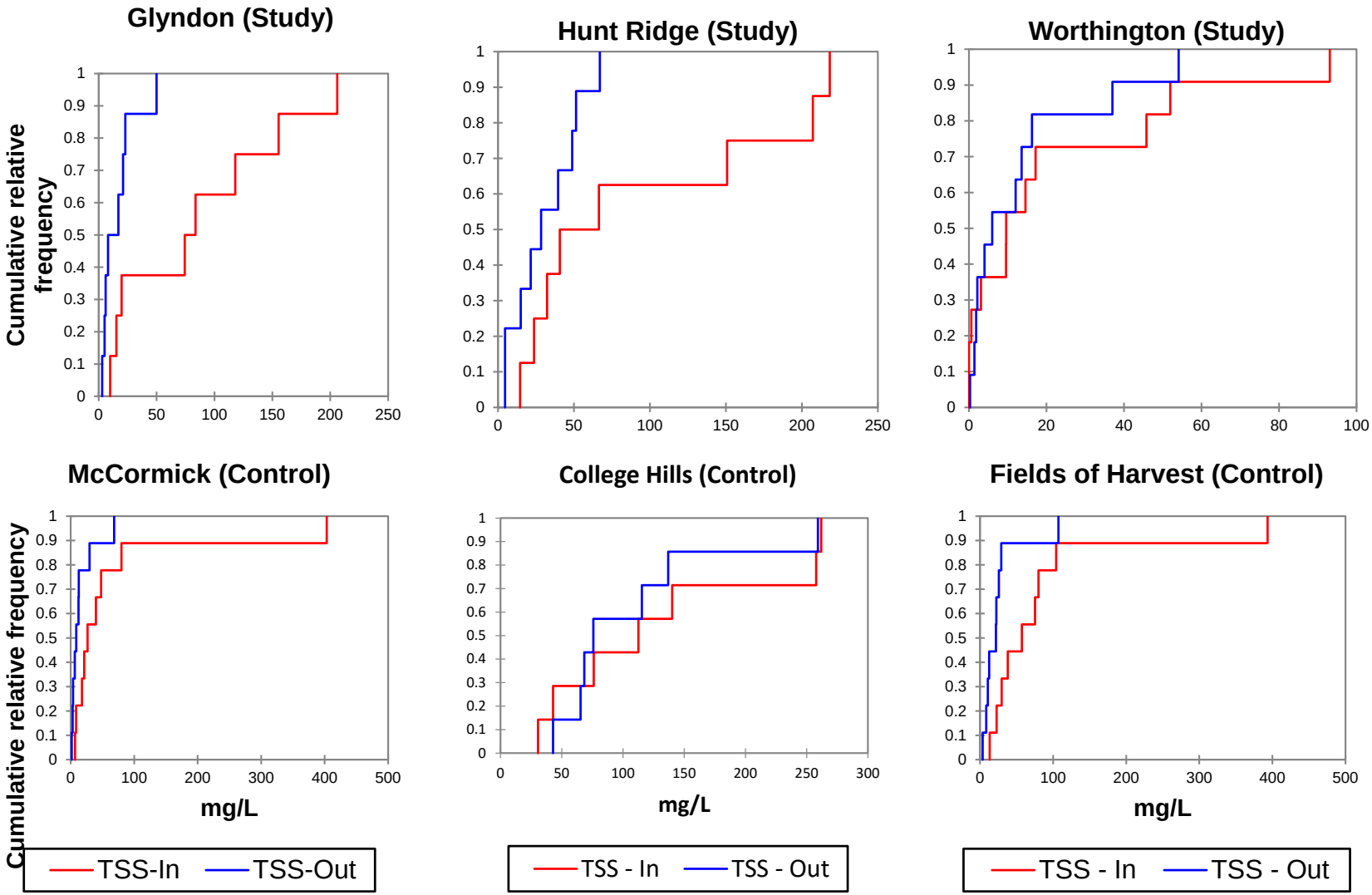

Annual Load Reduction

- **Results**

Site	Type	TN Pounds Removed (lbs/yr)	TN Percent Reduction	TP Pounds Removed (lbs/yr)	TP Percent Reduction	TSS Pounds Removed (lbs/yr)	TSS Percent Reduction
CH	Control	0.4	2%	0.8	15%	293.6	19%
FH	Control	6.6	24%	2.4	42%	965.7	68%
MC	Control	9.5	29%	1.1	29%	1277.8	73%
Control mean (% removal)			**18.5%**		**28.8%**		**53.2%**
GS	Study	16.4	36%	2.3	24%	2632.4	82%
HR	Study	14.0	25%	16.1	75%	3545.0	74%
WO	Study	10.6	9%	8.7	45%	609.0	24%
Study mean (% removal)			**23.3%**		**47.9%**		**60.0%**

Reduction Efficiency

- **Differences between population means not statistically significant**
- **Crediting Comparison**
  - **Generally higher values observed than credited**

BMP Type	Reduction Efficiency			Runoff Reduction
	TN	TP	TSS	
Chesapeake Bay Program Rates (Schueler and Lane, 2012)				
Dry Detention Pond	5%	10%	10%	
Dry Extended Detention	20%	20%	60%	
Wet Ponds/Wetlands	20%	45%	60%	
Study Results				
Dry Detention Ponds (Avg)	18.5%	28.8%	53.2%	15.0%
Self-Converted Ponds (Avg)	23.3%	47.9%	60.0%	20.6%

Conclusions

- **Load Reductions**
  - All ponds provided volume reduction
  - Evidence of load reductions for TN, TP, TSS at both control and study sites.
  - Although load reductions were observed, effluent concentrations were not significantly reduced at all sites for all parameters
  - No statistical difference between study and control site population means for any parameter
  - Removal rates for study and control ponds are higher than CBP crediting

- **Confounding Factors**
  - Small sample size - six ponds evaluated
  - Each pond functions differently depending on site specific factors and maintenance

Pond Specific Features

Site	Pond Characteristics							
	Direct Flow Path	Diffuse Flow	Base flow Input	Base flow Retained	Mowed Vegetation	Herbaceous Vegetation	Woody Vegetation	Detritus Present
GS		↑	—	↑		↑	↑	↑
HR		↑				↑	↑	↑
WO	↓		—			↑	↑	↑
MC	↓		—	↑	↓	↑		
CH	↓				↓			
FH		↑			↓	↑		

↑ indicates an expected increase in pollutant removal performance

↓ indicates an expected decrease in pollutant removal performance

— indicates unknown effect on pollutant removal performance

Recommendation

- **New BMP Sub-class**
  - ‘Self-Converted Dry Detention Pond’ sub-class within the ‘Dry Detention Pond’ class
  - Credit qualifying ponds with Wet Pond/Wetlands removals
    - TN – 20%
    - TP – 45%
    - TSS – 60%

- **Notes**
  - Not currently seeking re-evaluation of unconverted Dry Detention Ponds crediting
  - Would hypothesize that self-converted Dry Extended Detention Ponds would have similar results, however this has not been tested.

Facility Qualifying Criteria

- **Pond Characteristics**
  - The wetlands within the facility must be delineated using the 3 parameter USACE methods.
  - Herbaceous or woody vegetation should be predominate, covering > 50% of the pond bottom
  - The wetland area must cover >10% of the facility bottom.
  - Facility must have diffuse flow or a meandering flow path without a concrete pilot channel or a riprap/gabion channel.
  - No woody vegetation on the embankment or within 25 feet of a pond structure
  - Wetland condition should not be the result of a structural failure

Facility Qualifying Criteria

- **Qualifying Data**
  - Need to provide photo-documentation of the site conditions
  - Need to provide delineation data meeting qualifying criteria
  - Must have an original as-built and passed triennial inspections

- **Inspection and Verification**
  - Visual verification and photo documentation of wetland conditions for subsequent triennial inspection.
  - Credit duration would be the same as for other SWM facilities, with a re-delineation of wetlands for extending the credit duration.
  - All other reporting requirements for new, redevelopment, or retrofit facilities would apply.

Future Work

- **Next Steps**
  - Data submission to the International BMP Database
  - Publication

- **Additional Analyses**
  - Compare land use loading rates to model values
  - Analyses of other parameters tested
    - Sodium, chloride, other nutrient species

Bonus Hydrograph Slide!!