Effectiveness of Bioretention Cells for Removal of Pollutants from Stormwater in Oklahoma

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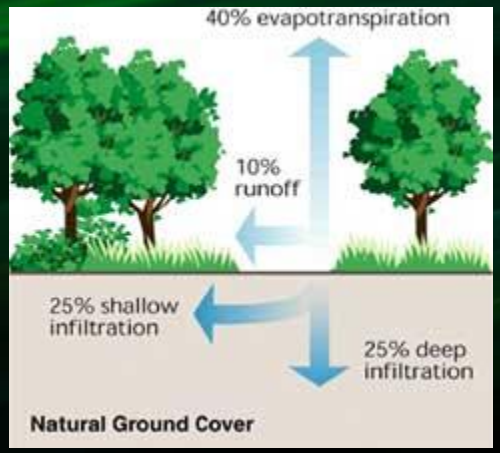
Outline

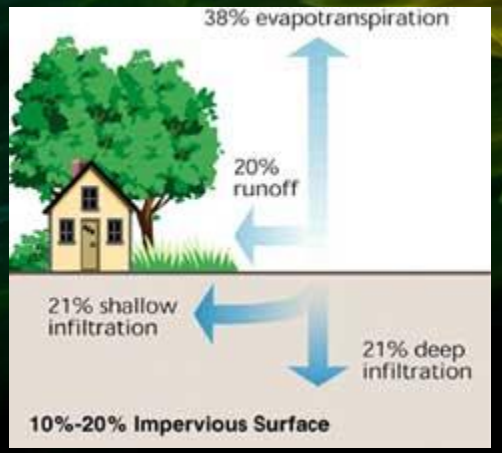
- *Brief LID background*
- *Site descriptions*
  - *Grove, OK*
  - *Oklahoma City, OK*
- *Water Quality Monitoring Setup*
- *Pollution reduction results*
- *Conclusions*

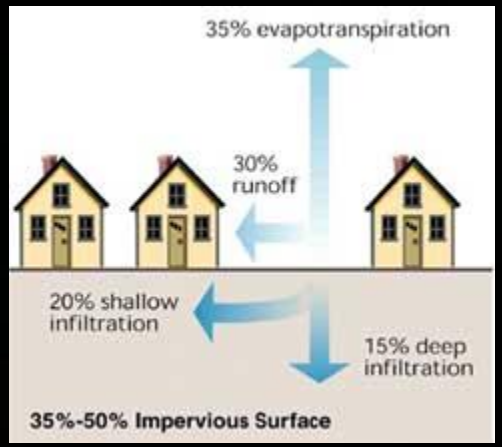
Comparison of Undeveloped and Developed Hydrology

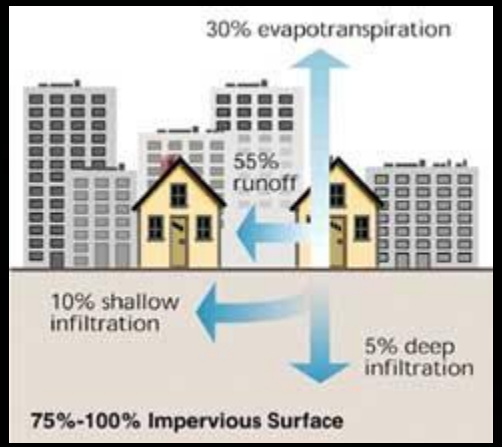
More development generally means

- *more impervious area*
- *more runoff*
- *less infiltration*
- *less evapotranspiration*









from epa.gov

What is Low Impact Development?

- *Mimics a site's predevelopment hydrology through design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.*
- *Emphasizes cost-effective strategies at the lot level*

Essentially, post-development runoff = predevelopment runoff

Excess Phosphorus

- *Eutrophication & impaired water bodies.*

Lake Erie “Toledo Crisis” 2012

Toxic algal bloom in Marion Reservoir in the headwaters of the Grand Lake Watershed (photo courtesy of Gerard A. Clyde, Jr., US Army Corps of Engineers, Tulsa District).

Objective

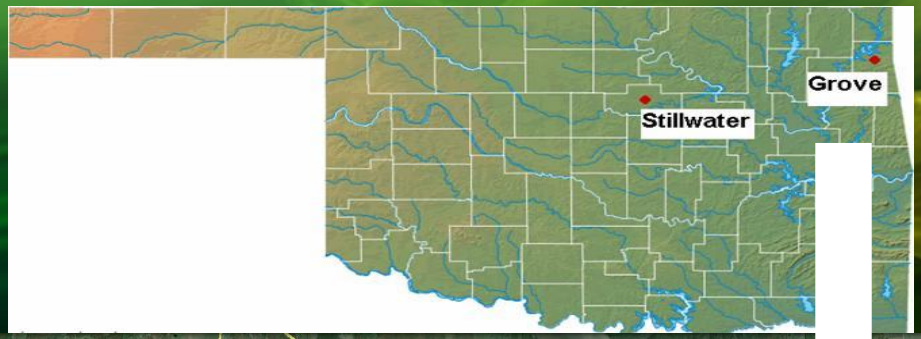
- *Examine pollutant removal efficiencies of multiple bioretention cells in Oklahoma*

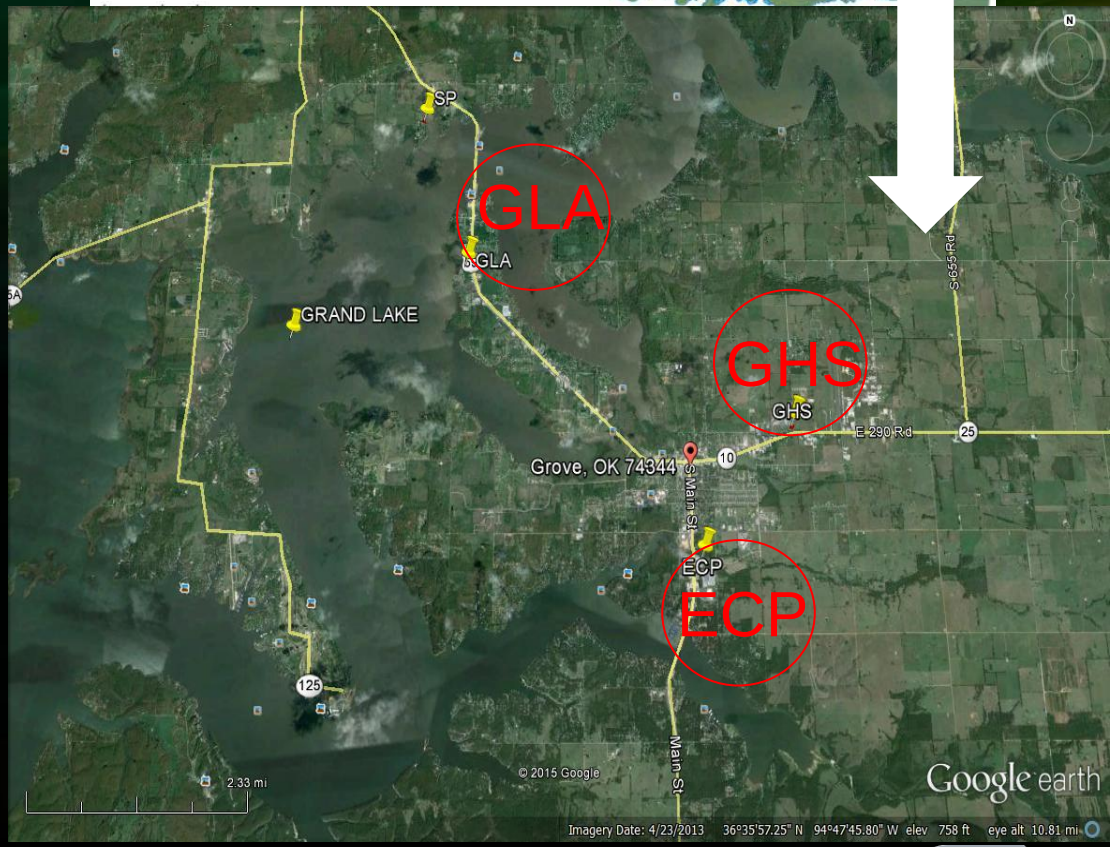
Grand Lake

- *Grand Lake, OK, like many waters in the U.S. suffers due to phosphorus (P) over-enrichment.*
- *Under EPA 319h funding through the Oklahoma Conservation Commission (2005-2008), eight BRC were built in Grove, OK in the Grand Lake basin with the specific goal of reducing P inflow to the lake.*
- *Under EPA 319h funding through the Oklahoma Department of the Environment (2012-2015) , we have gone back and sampled the cells to quantify their performance.*

Grove, OK

- *10 BRCs were constructed in 2007 to demonstrate P reduction efficiency.*
- *Filter media a blend of sand & 5% fly ash*
- *3 BRCs at Grove, OK used for this study*





Grove, OK

	Grand Lake Association	Grove High School	Elm Creek Plaza
Cell Name	GLA	GHS	ECP
Land Use	Paved/ Turf	Paved	Paved
Drainage area(Acres)	1.90	0.65	0.62
Cell area (m^2)	172	149	63
Surface/drainage area ratio	2%	6%	2%
Ponding depth (cm)	15-30	15-30	15-30
Fill media depth (m)	1	0.85	1

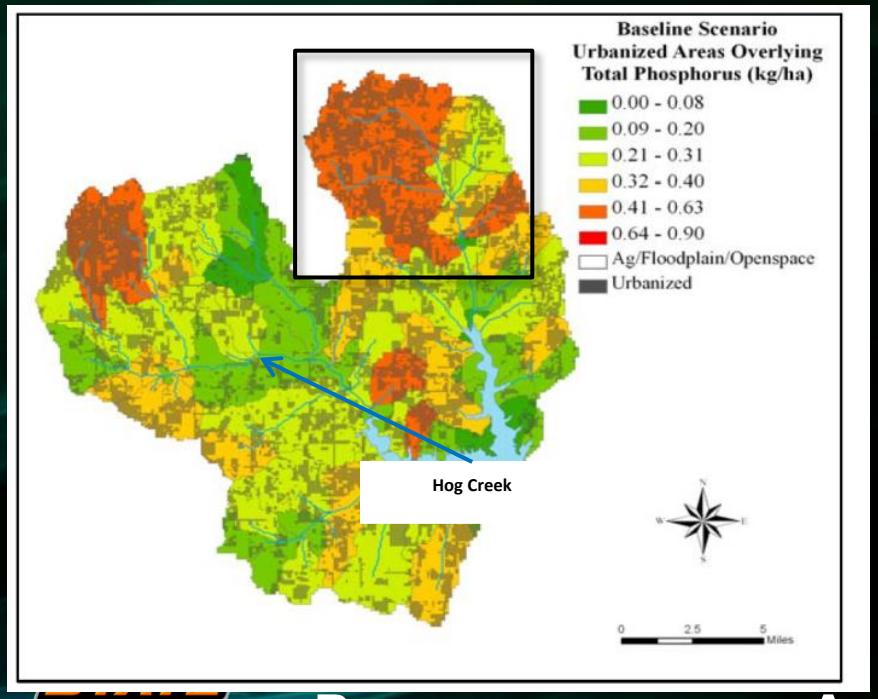

Grand Lake Association

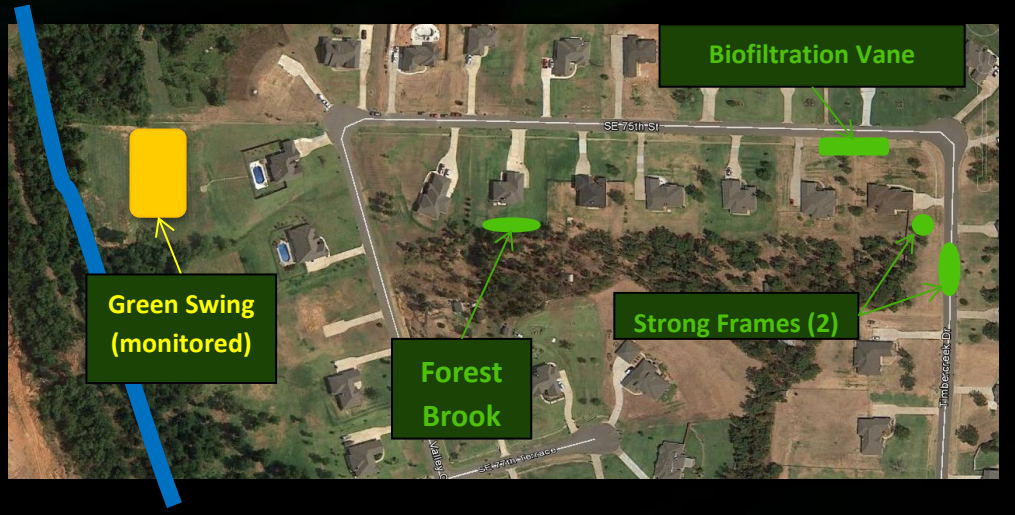

Grove High School


Elm Creek Plaza

Lake Thunderbird

- *Both Hog Creek and Lake Thunderbird are listed on the EPA 303(d) list for low dissolved oxygen and turbidity.*
- *Sediment and phosphorus in stormwater runoff are major contributors for the development of low dissolved oxygen and high turbidity conditions.*





Oklahoma City – 'Green Swing'

- *Installed Spring 2014*
- *8800 ft² cell*
- *Sample stormwater at inlet, overflow, and underdrain*
- *9-acre drainage area (houses on 1-acre lots)*
- *Monitored during spring, summer, and fall of*

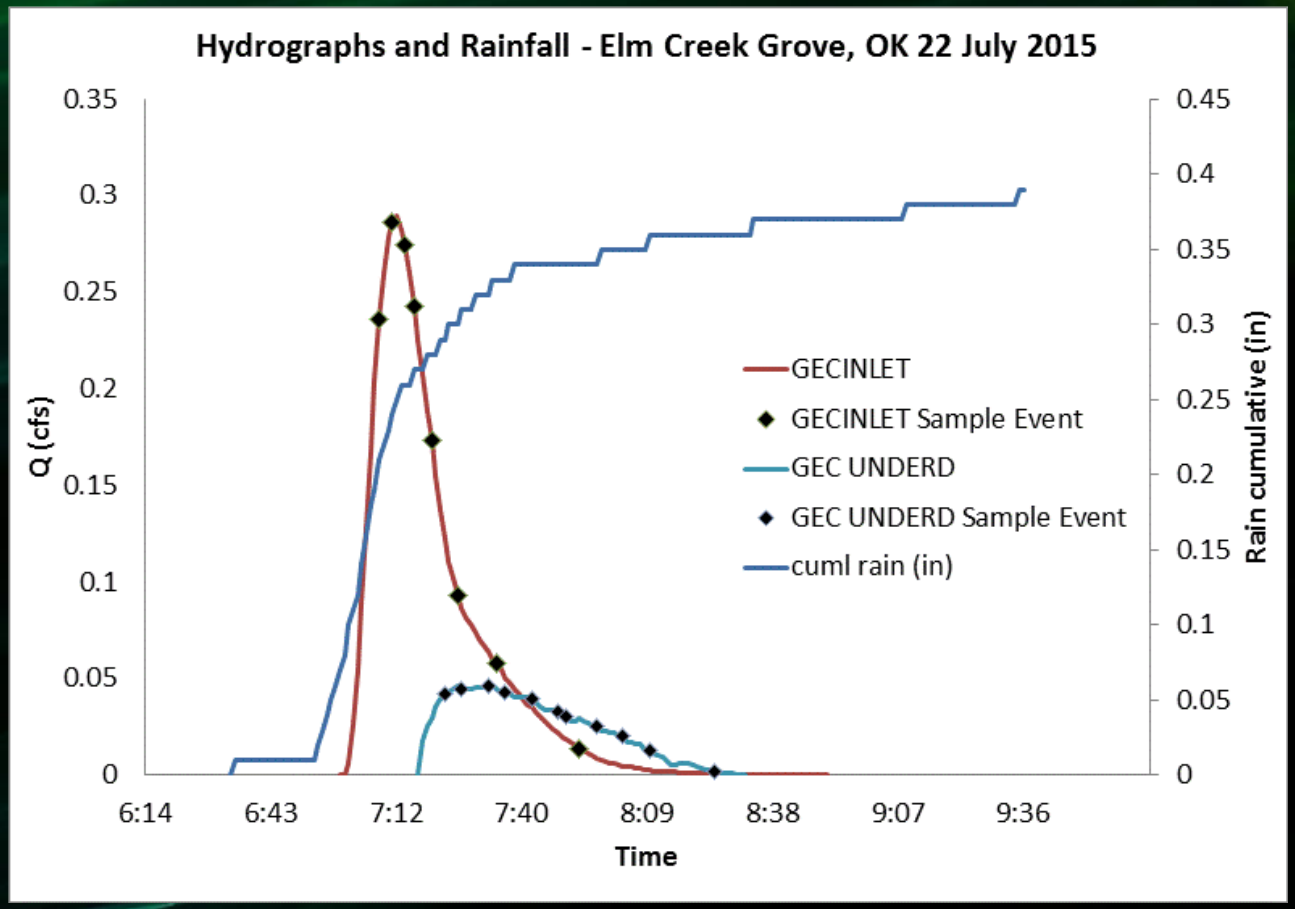
Monitoring – equipment

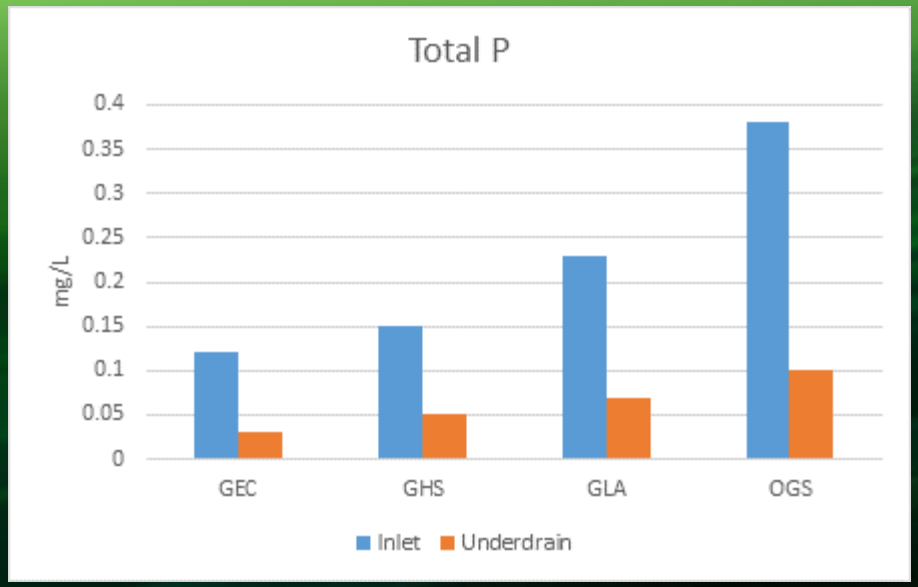
- *Flow measurement*
  - *H-flumes, sharp edged wiers, Palmer-Bowlus Flumes*
  - *Pressure level sensors*
- *ISCO refrigerated samplers*
- *Rain Gauge*
- *Measure*
  - *Phosphorus – total and dissolved*
  - *Nitrogen – total and dissolved*
  - *Metals*
  - *Total suspended solids*
  - *Turbidity*
  - *Bacteria*
  - *pH, EC*

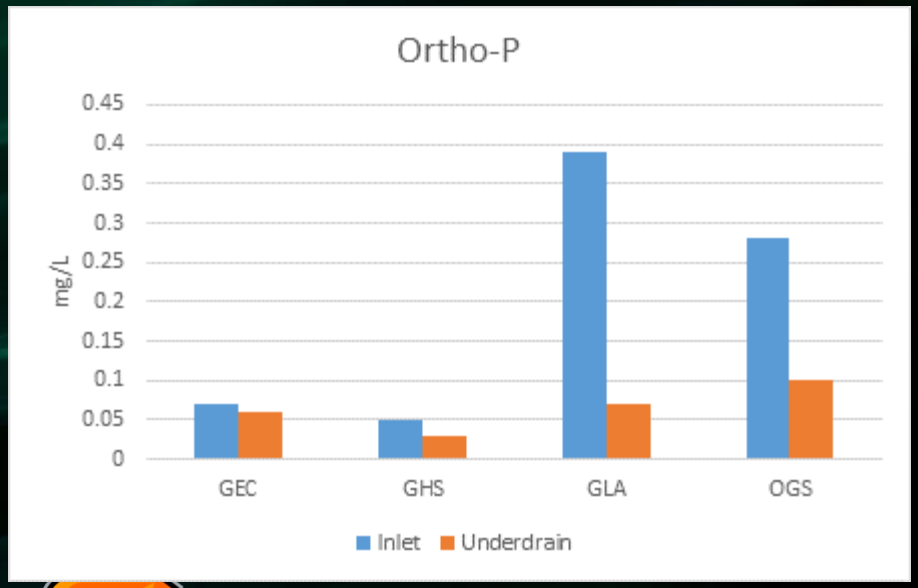
Elm Creek Plaza, Grove, OK

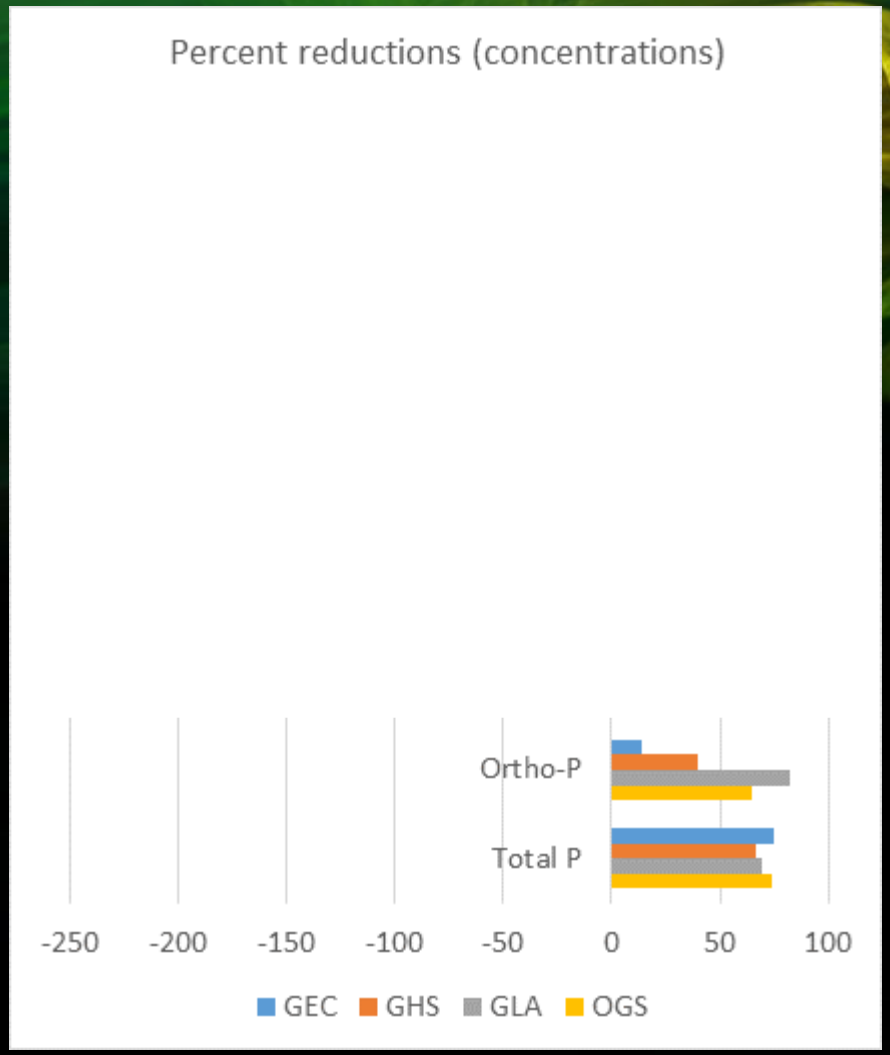
Elm Creek Plaza – Grove, OK

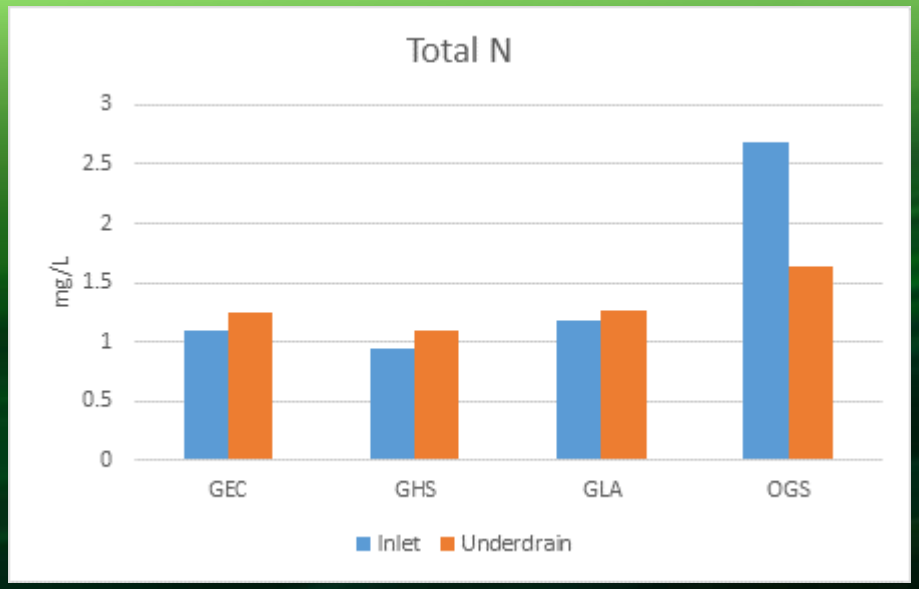
- *Peak delay: 21 mins*
- *Number of samples: Inlet=8 Underdrain=11*

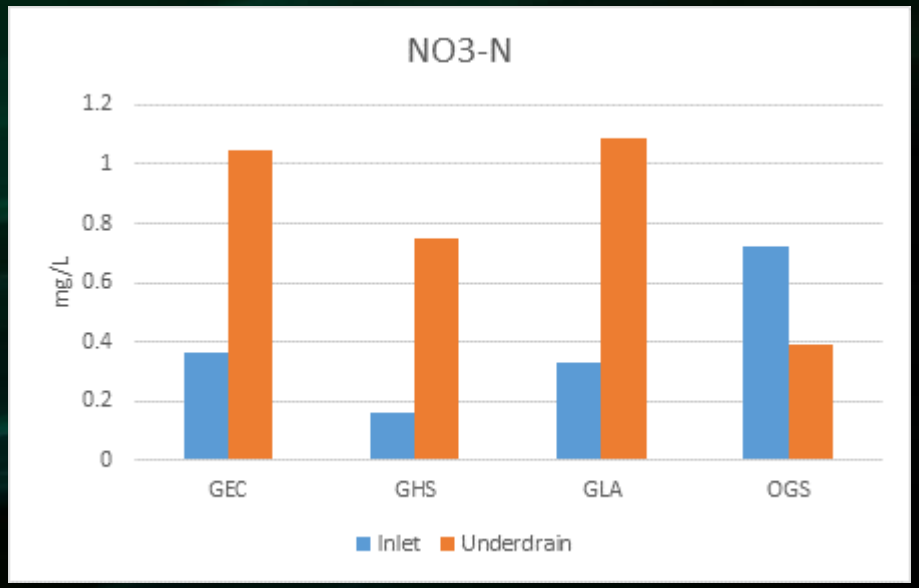


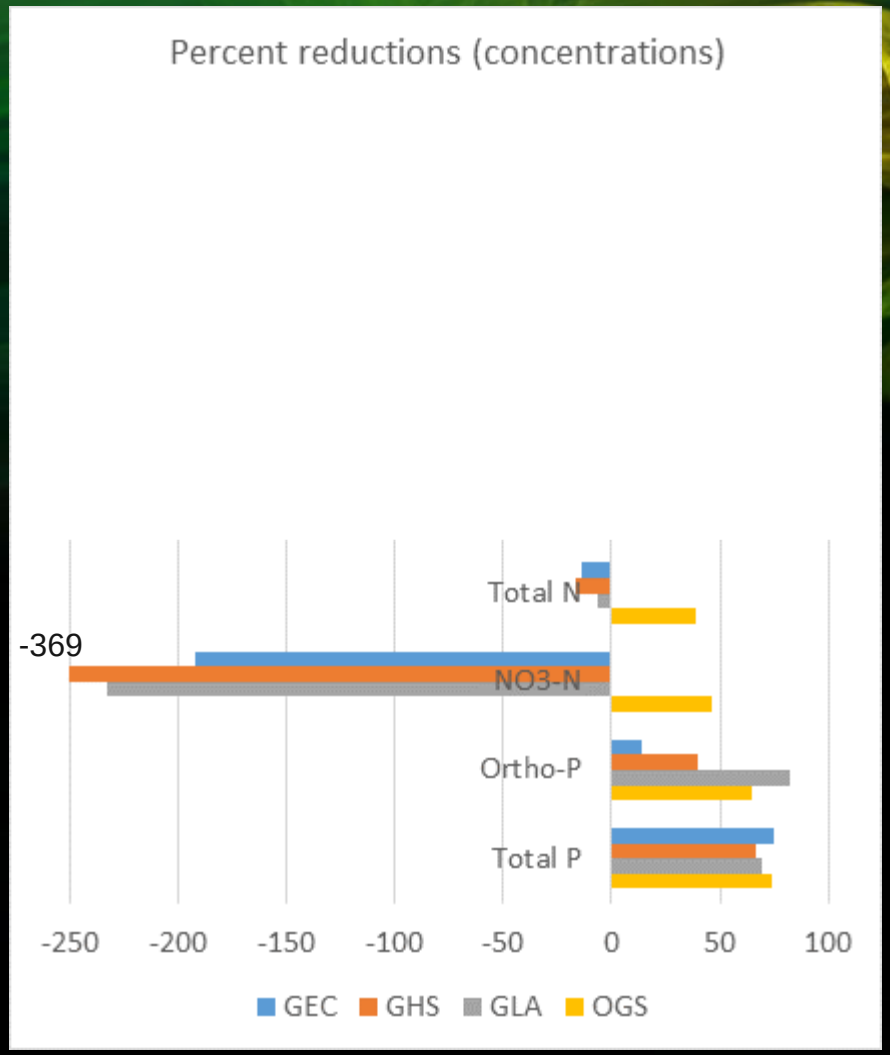

Total P
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
GEC
GHS
GLA
OGS
Inlet
Underdrain


Ortho-P
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
GEC
GHS
GLA
OGS
Inlet
Underdrain

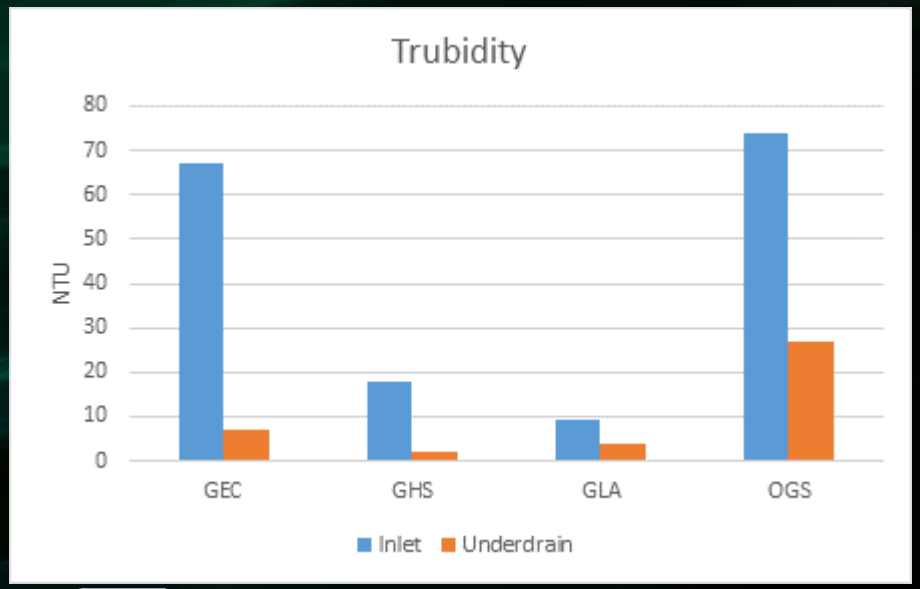

Percent reductions (concentrations)
Ortho-P
Total P
-250
-200
-150
-100
-50
0
50
100
GEC
GHS
GLA
OGS

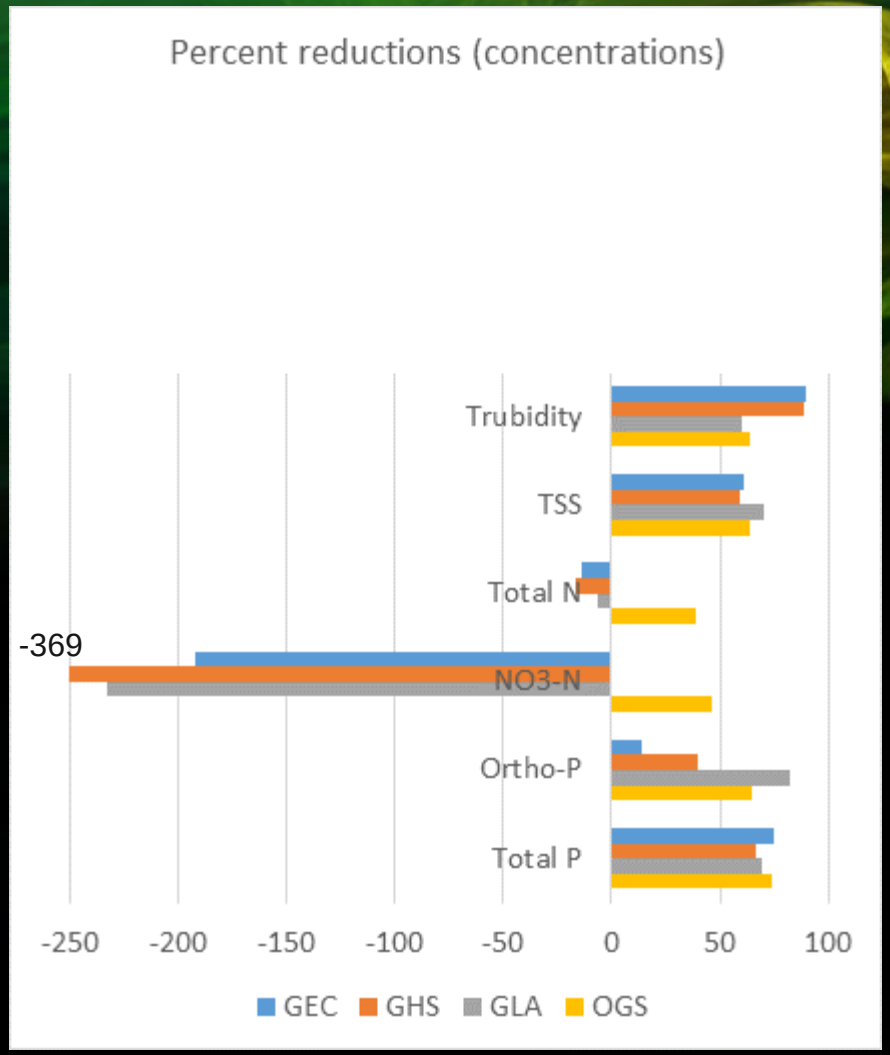

Total N
3
2.5
2
1.5
1
0.5
0
mg/L
GEC
GHS
GLA
OGS
Inlet
Underdrain

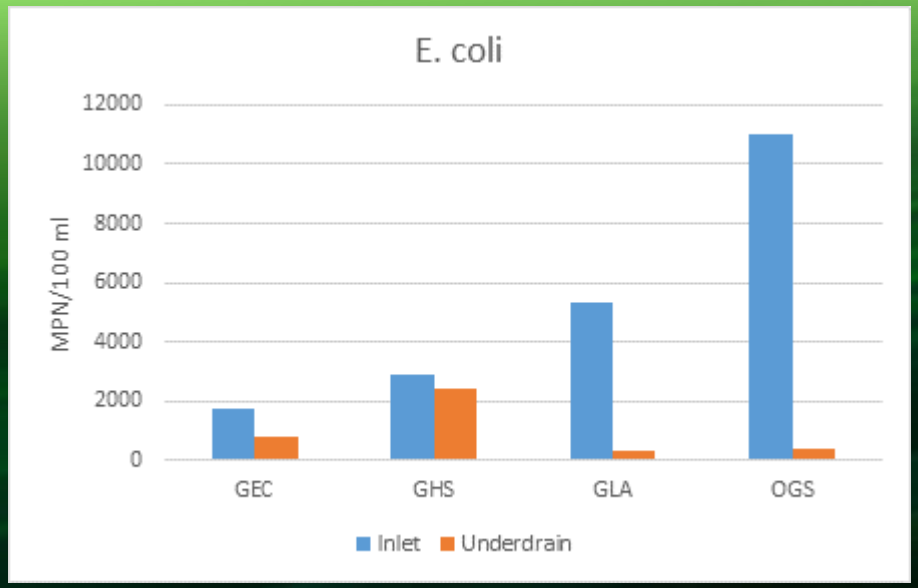

NO3-N
1.2
1
0.8
0.6
0.4
0.2
0
mg/L
GEC
GHS
GLA
OGS
Inlet
Underdrain

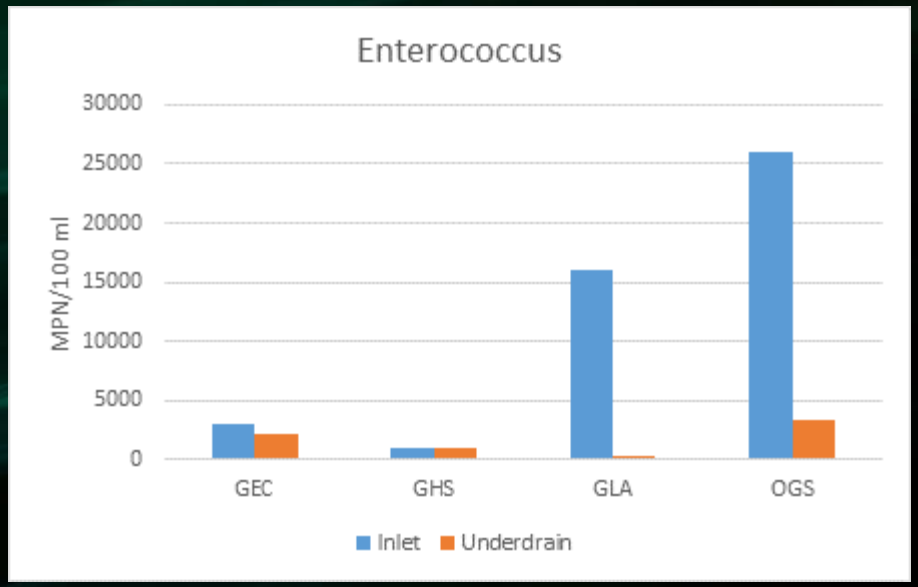

Percent reductions (concentrations)
-369
Total N
NO3-N
Ortho-P
Total P
-250
-200
-150
-100
-50
0
50
100
GEC
GHS
GLA
OGS

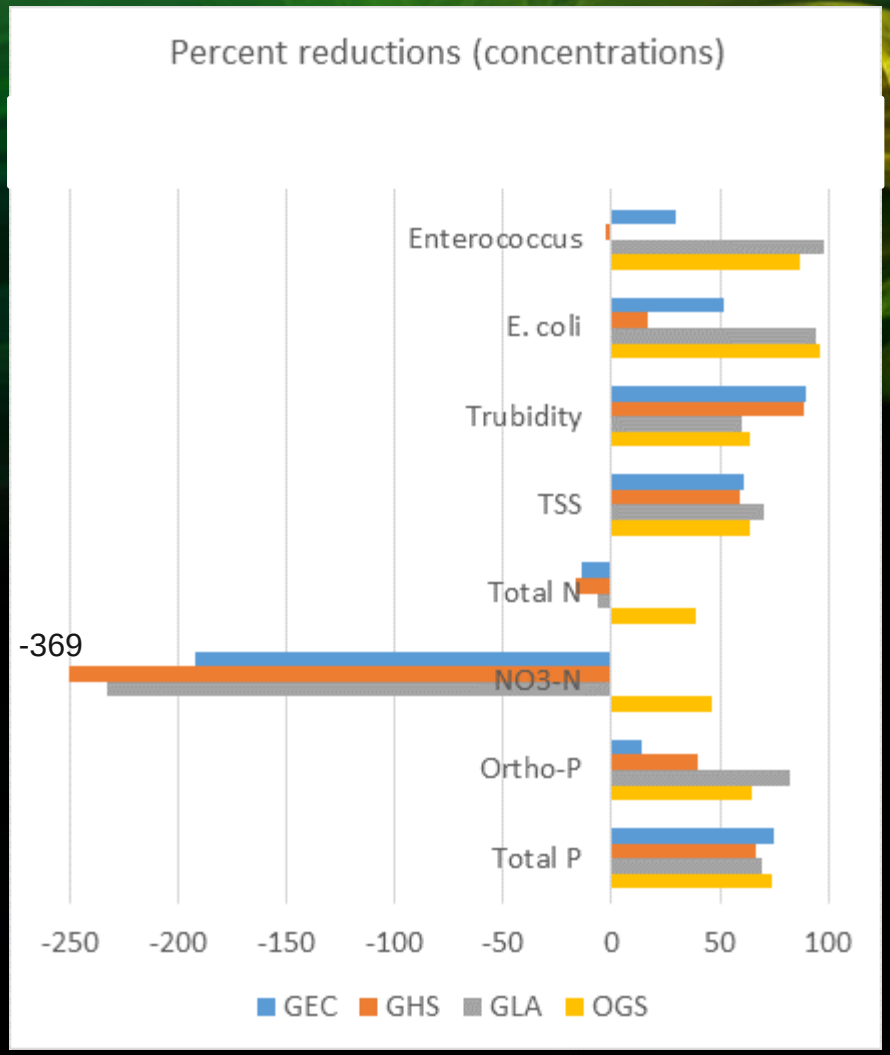

TSS
250
200
150
100
50
0
mg/L
GEC
GHS
GLA
OGS
Inlet
Underdrain

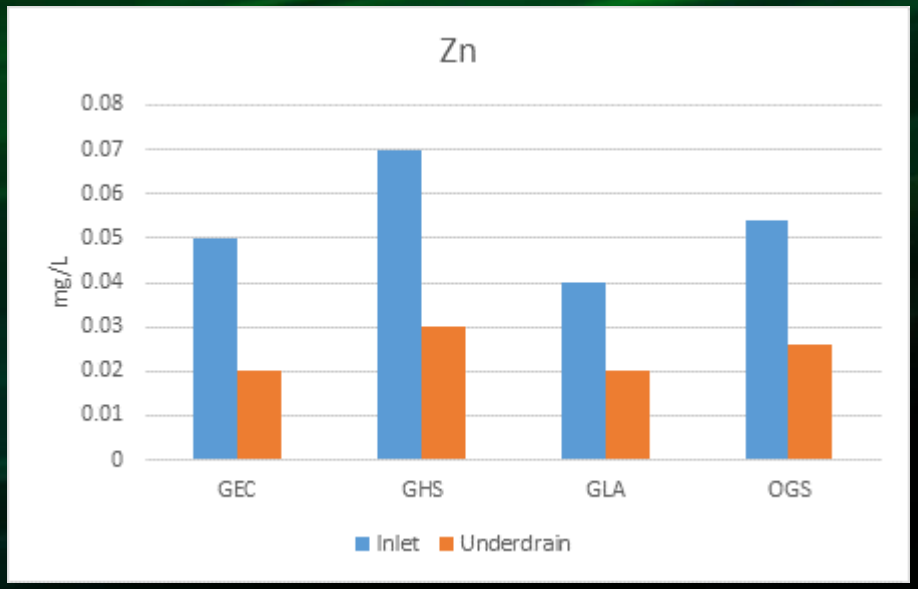

Trubidity
80
70
60
50
40
30
20
10
0
NTU
GEC
GHS
GLA
OGS
Inlet
Underdrain

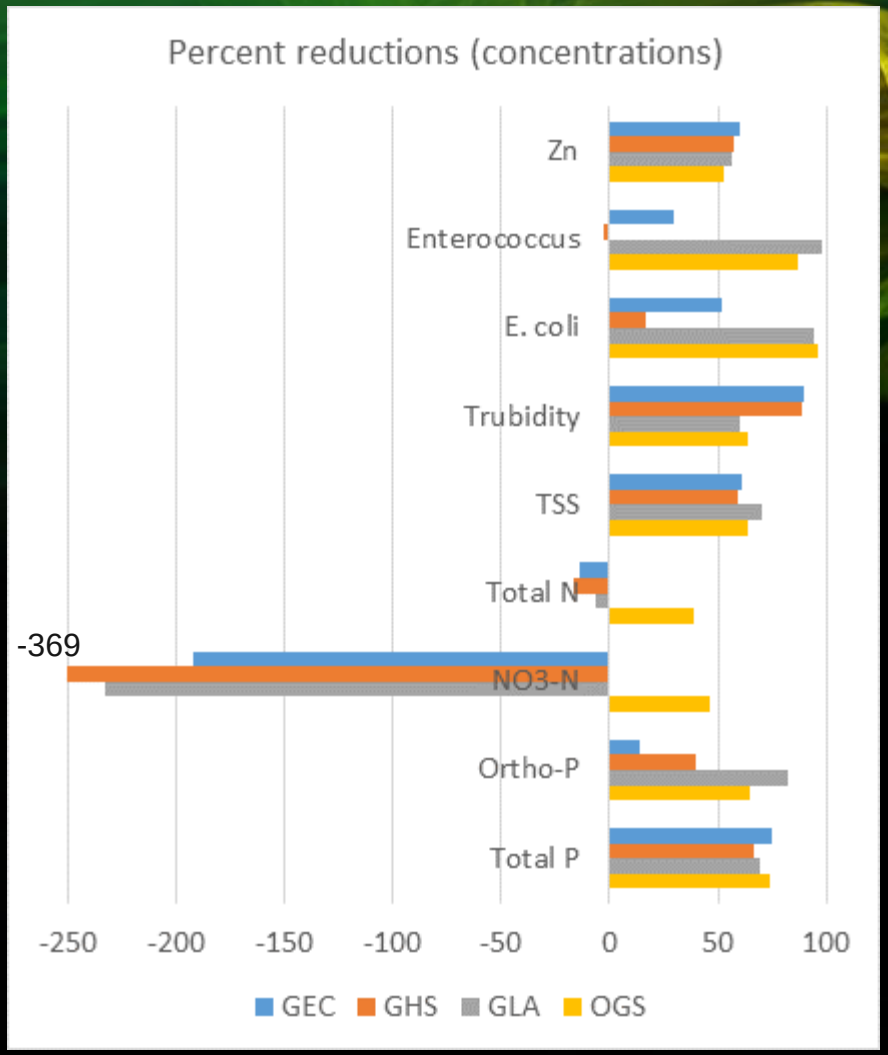

Percent reductions (concentrations)
Trubidity
TSS
Total N
-369
NO3-N
Ortho-P
Total P
-250
-200
-150
-100
-50
0
50
100
GEC
GHS
GLA
OGS

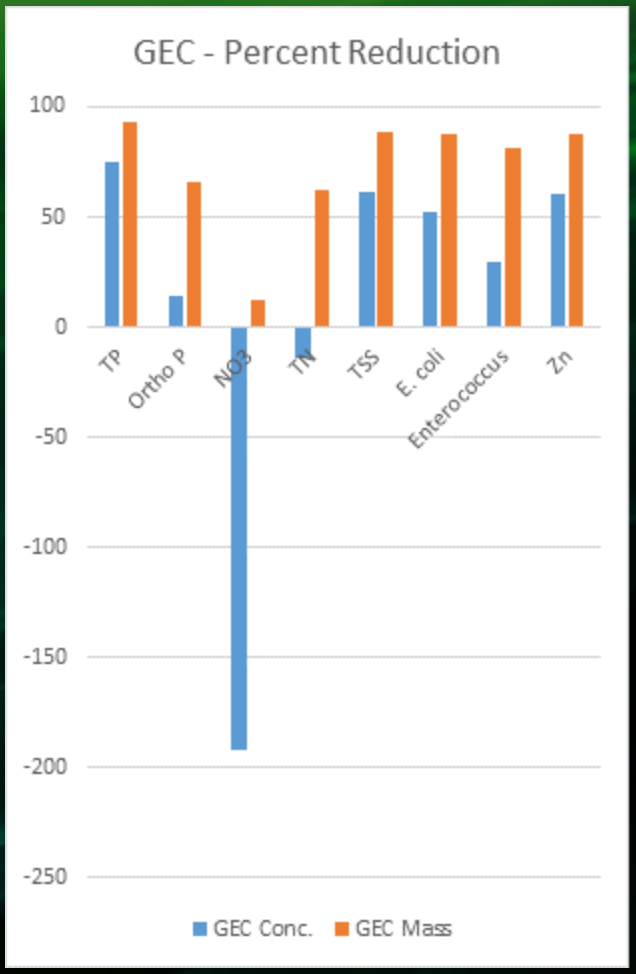

E. coli
12000
10000
8000
6000
4000
2000
0
MPN/100 ml
GEC
GHS
GLA
OGS
Inlet
Underdrain

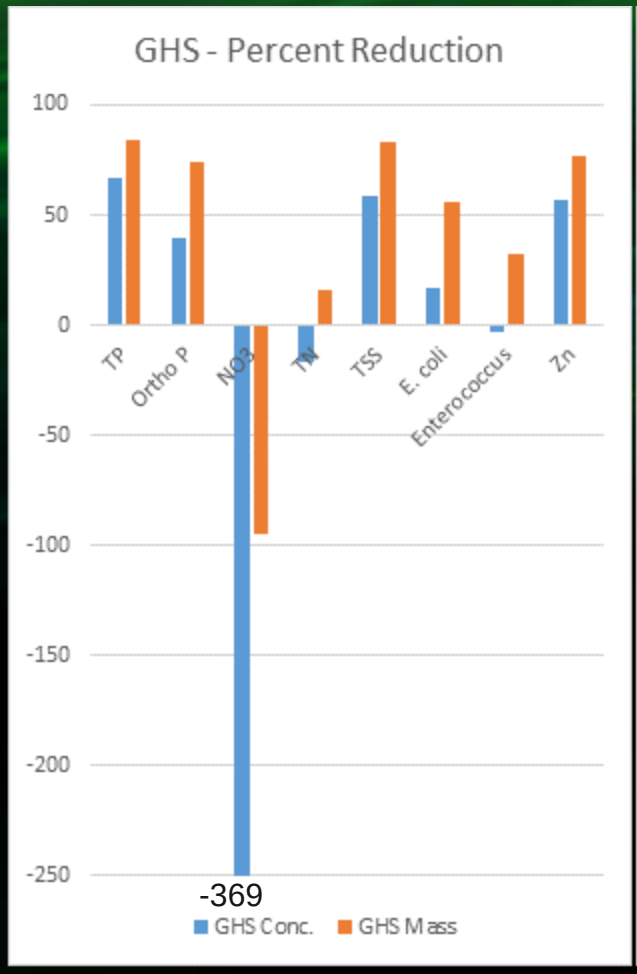

Enterococcus
30000
25000
20000
15000
10000
5000
0
MPN/100 ml
GEC
GHS
GLA
OGS
Inlet
Underdrain

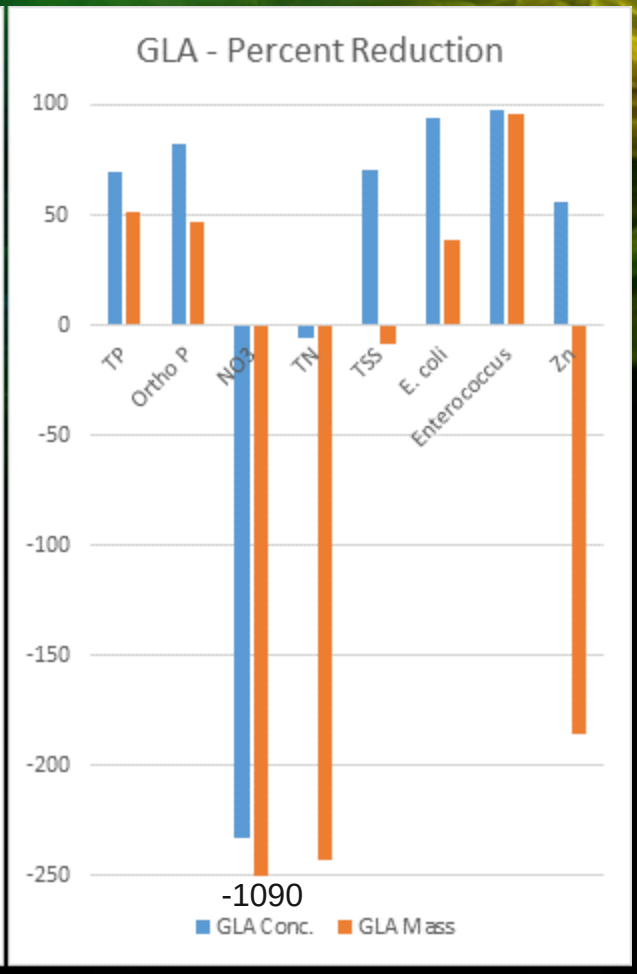

Percent reductions (concentrations)
Enterococcus
E. coli
Trubidity
TSS
Total N
-369
NO3-N
Ortho-P
Total P
-250
-200
-150
-100
-50
0
50
100
GEC
GHS
GLA
OGS


Zn
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
mg/L
GEC
GHS
GLA
OGS
Inlet
Underdrain


Percent reductions (concentrations)
Zn
Enterococcus
E. coli
Trubidity
TSS
Total N
-369
NO3-N
Ortho-P
Total P
-250
-200
-150
-100
-50
0
50
100
GEC
GHS
GLA
OGS


GEC - Percent Reduction
100
50
0
-50
-100
-150
-200
-250
TP
Ortho P
NO3
TN
TSS
E. coli
Enterococcus
Zn
GEC Conc.
GEC Mass


GHS - Percent Reduction
100
50
0
-50
-100
-150
-200
-250
TP
Ortho P
NO3
TN
TSS
E. coli
Enterococcus
Zn
-369
GHS Conc.
GHS Mass


GLA - Percent Reduction
100
50
0
-50
-100
-150
-200
-250
TP
Ortho P
NO3
TN
TSS
E. coli
Enterococcus
Zn
-1090
GLA Conc.
GLA Mass

Conclusions

- *Pollutant concentrations flowing in vary across our sites*
- *Overall, bioretention cells reduce concentration of pollutants from stormwater*
  - *Nitrogen was not reduced by Grove cells*
- *Percent reduction vary among pollutants and among sites*
- *These cells do reduce Phosphorus (Total and Dissolved) and sediments (TSS and Turbidity)*
- *Mass removal is dependent on:*
  1. *Filtering efficiency (concentration reduction)*

Thanks!

For more information,

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