THE OHIO STATE UNIVERSITY

Watershed-Scale Hydrologic and Water Quality Improvements due to Green Stormwater Infrastructure Implementation

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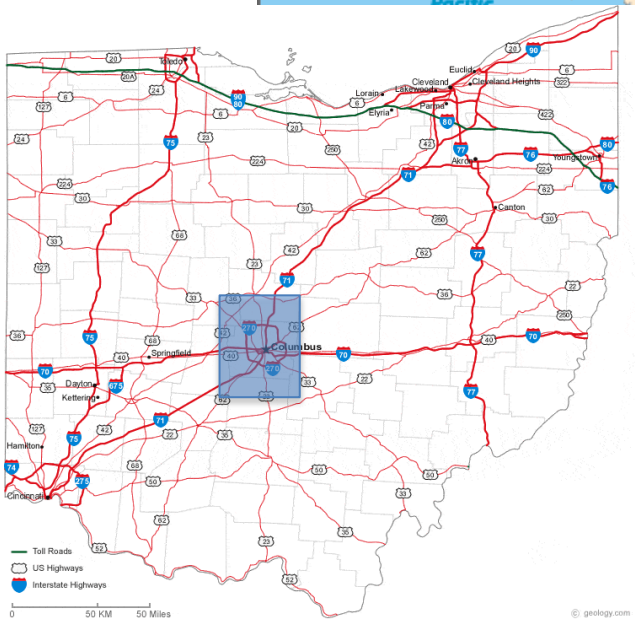
6th Symposium on Urbanization and Stream Ecology
May 31, 2023 – Brisbane, Australia

Ohio, USA

- 7th largest state in US
  - 11.7M people, 2.5M in Columbus
- Geography
  - Mountains and plains
  - Great Lakes to North
- Climate
  - Approx. 1000 mm / year precipitation



Sanitary & Combined Sewer Overflows

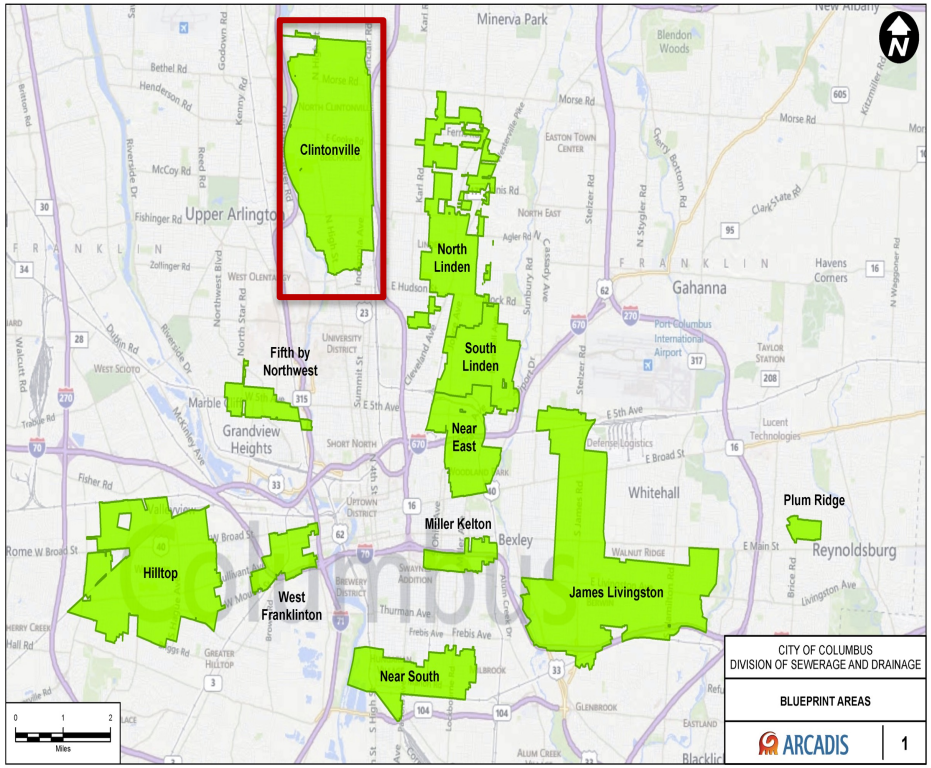
THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR
DEPARTMENT OF PUBLIC UTILITIES

~200 SSO & CSO events in Columbus in an average year

OHIO STATE

SSO Mitigation: 2 Options

- <u>Blueprint Columbus</u>
  - $1.7B USD capitol costs
  - Includes green infrastructure + other infrastructure improvements
  - Reduce infiltration and inflow by 30%

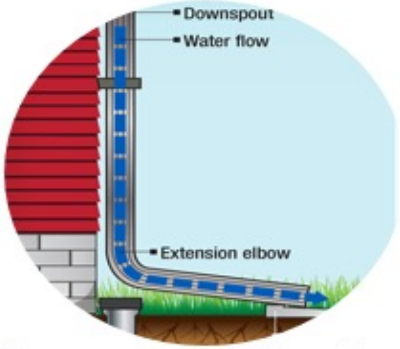


- Grey solutions = no impact on stormwater quality
- Modeling in SWMM showed greater reduction in overall SSOs for green solutions
- Ecosystem and community services

Four Pillars of Blueprint

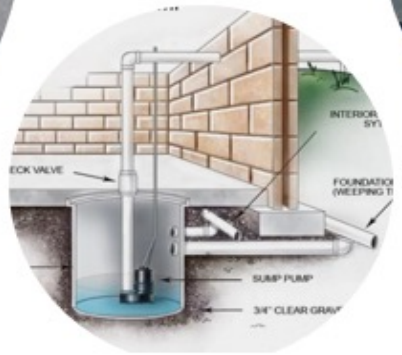
City Property Retrofits

Private Property Retrofits



Downspout Redirection

Sewer Lateral Lining



Sump Pump Installation

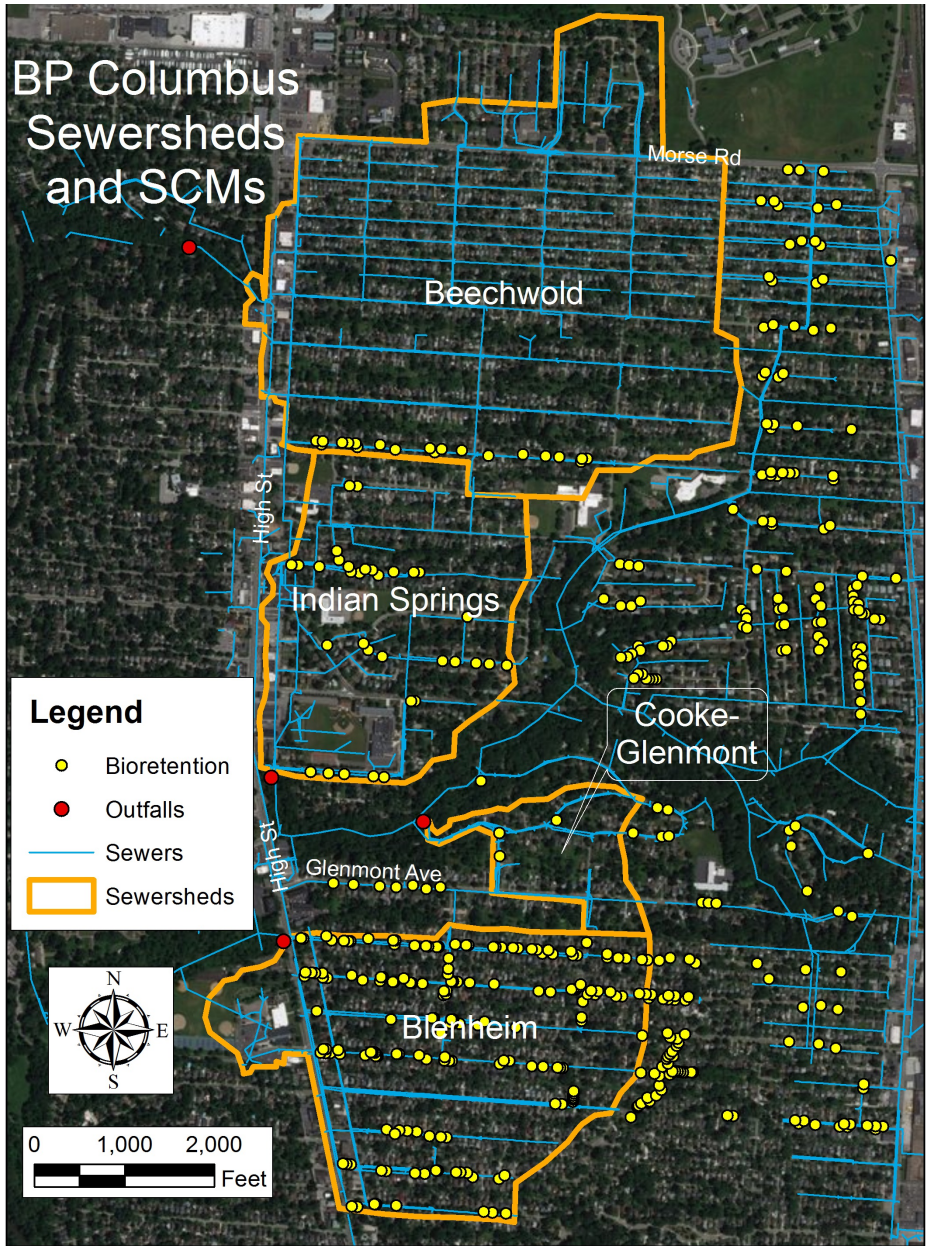
Blueprint Objectives & Research 2016-23:

1. Control Stormwater Flows
   - Analyze storm flows
2. Improve water quality
   - Analyze water quality
3. Provide habitat
   - Analyze species in bioretention
4. Improve property values
   - Track home prices
5. Stabilize neighborhoods
   - Survey residents

BLUE PRINT COLUMBUS
Clean streams.
Strong neighborhoods.

Study Design

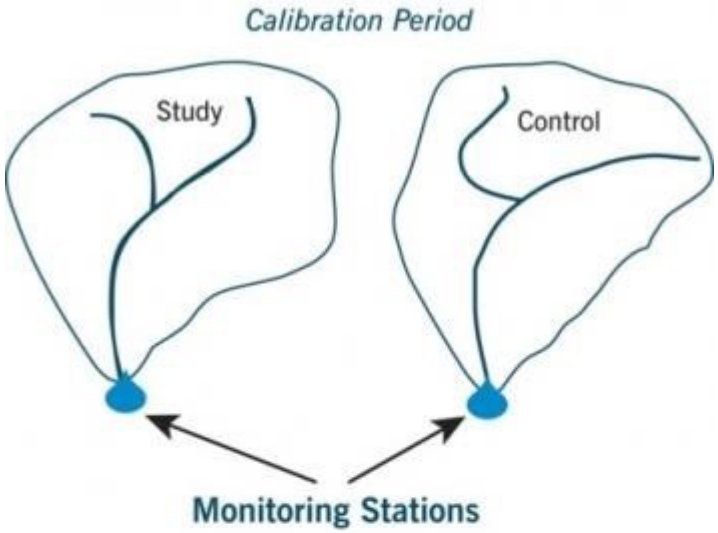
- Beechwold (111 ha)
  - no green infrastructure, control for experiment
- Indian Springs (48 ha)
  - Permeable pavement
  - Moderate density GI
- Cooke-Glenmont (11.5 ha)
  - Low density GI
  - Larger bioretention cells
- Blenheim-Glencoe (61 ha)
  - High density GI
  - Bioretention only

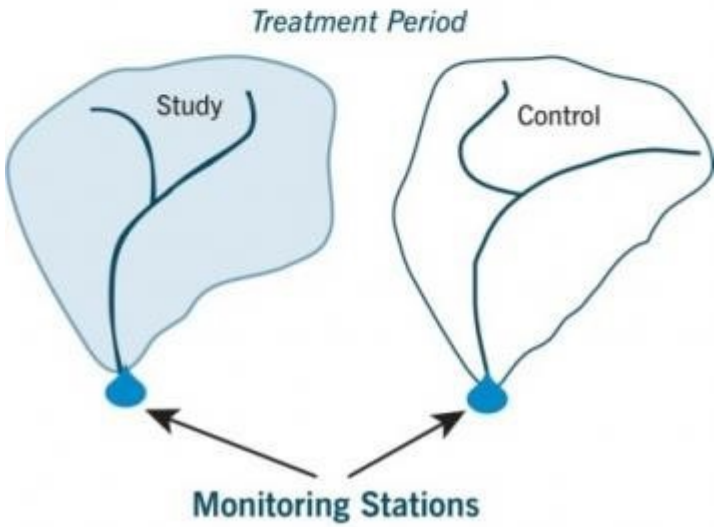



BUMP

Paired Watershed Design

- Two Watersheds
  - Control
  - Treatment
- Two Monitoring Periods
  - Calibration
  - Treatment
- Accounts for year-to-year and seasonal climate changes
- Changes can be attributed to a treatment

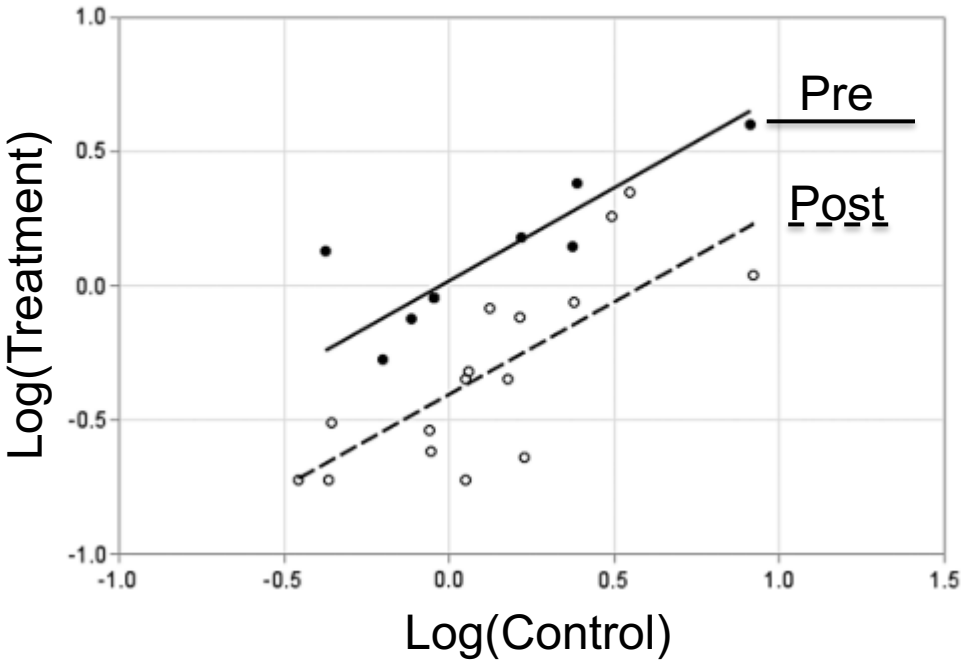




agriculture.vermont.gov

Statistical Methods

- Before / After – Control / Impact
- Analysis of Covariance (ANCOVA)



- % Difference: least squares mean/arithmetic

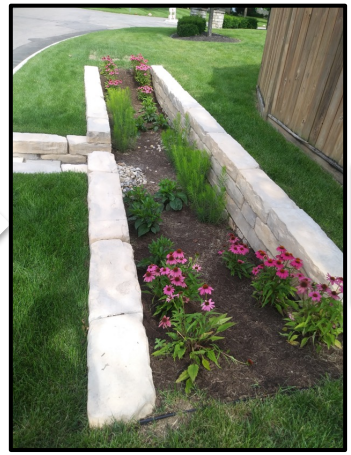
adapted from Page et al. (2015)

Stormwater Monitoring

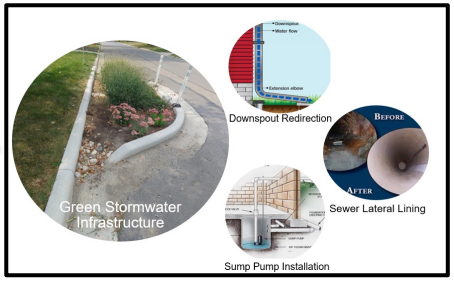
- Continuous rainfall and flow monitoring (baseflow and stormflow) at stormwater outfalls
- ISCO samplers used to obtain flow proportional, composite samples
- Analyzed for nutrients, sediment, metals, bacteria

Project Timelines and Data Sets

Construction Phase 1: GI



Construction Phase 2



Pre- GI
Began July 2016

Post- GI

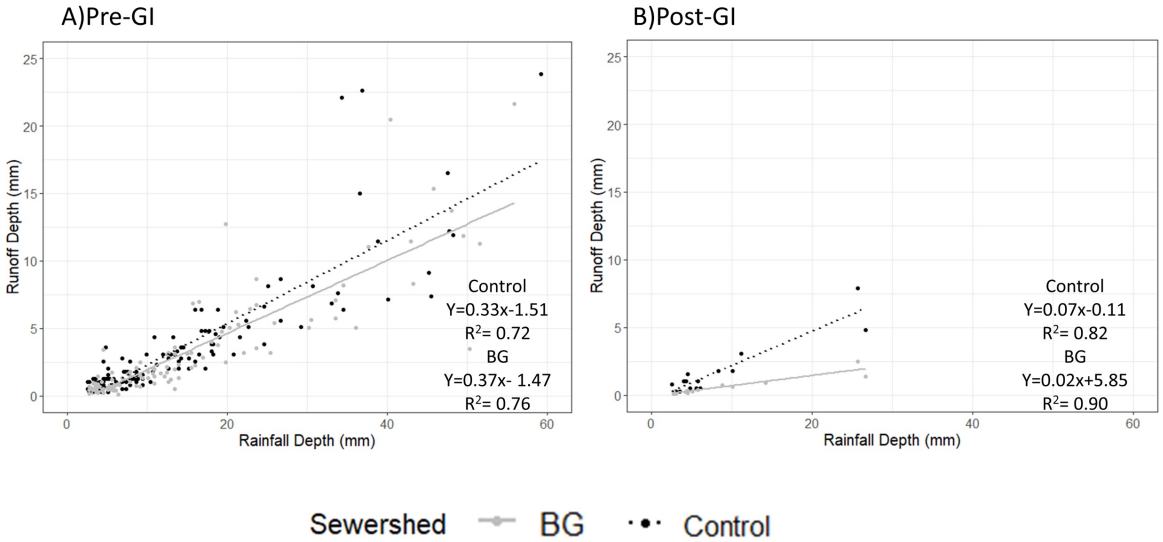
Post-AI[2]
All 4 Blueprint Pillars Completed

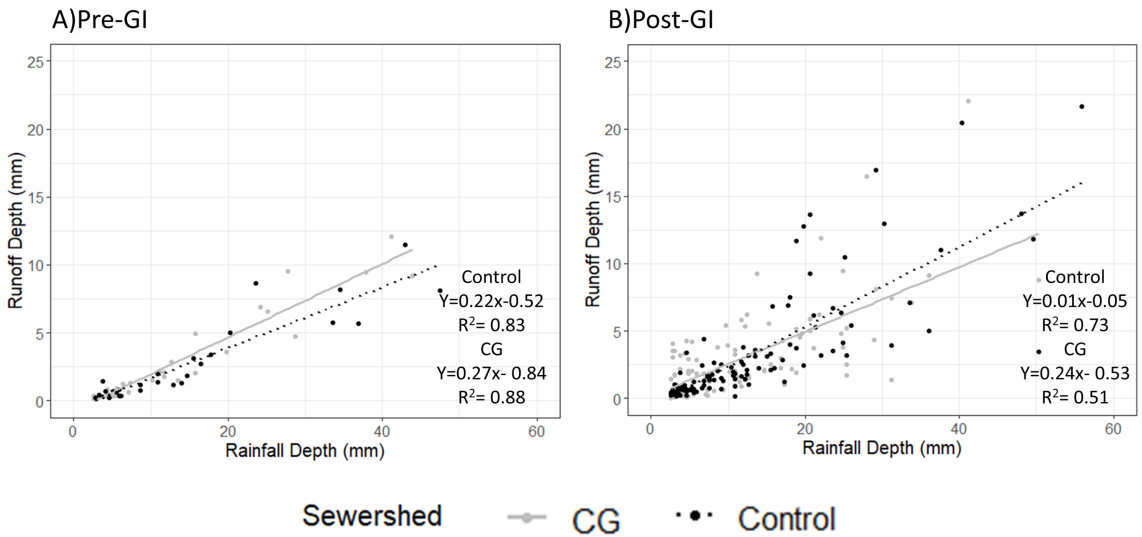
<u>Monitored Events:</u>
Cooke-Glenmont: 22
Indian Springs: 56
Blenheim-Glencoe: 106

<u>Monitored Events:</u>
Cooke-Glenmont: 99
Indian Springs: 35
Blenheim-Glencoe: 16

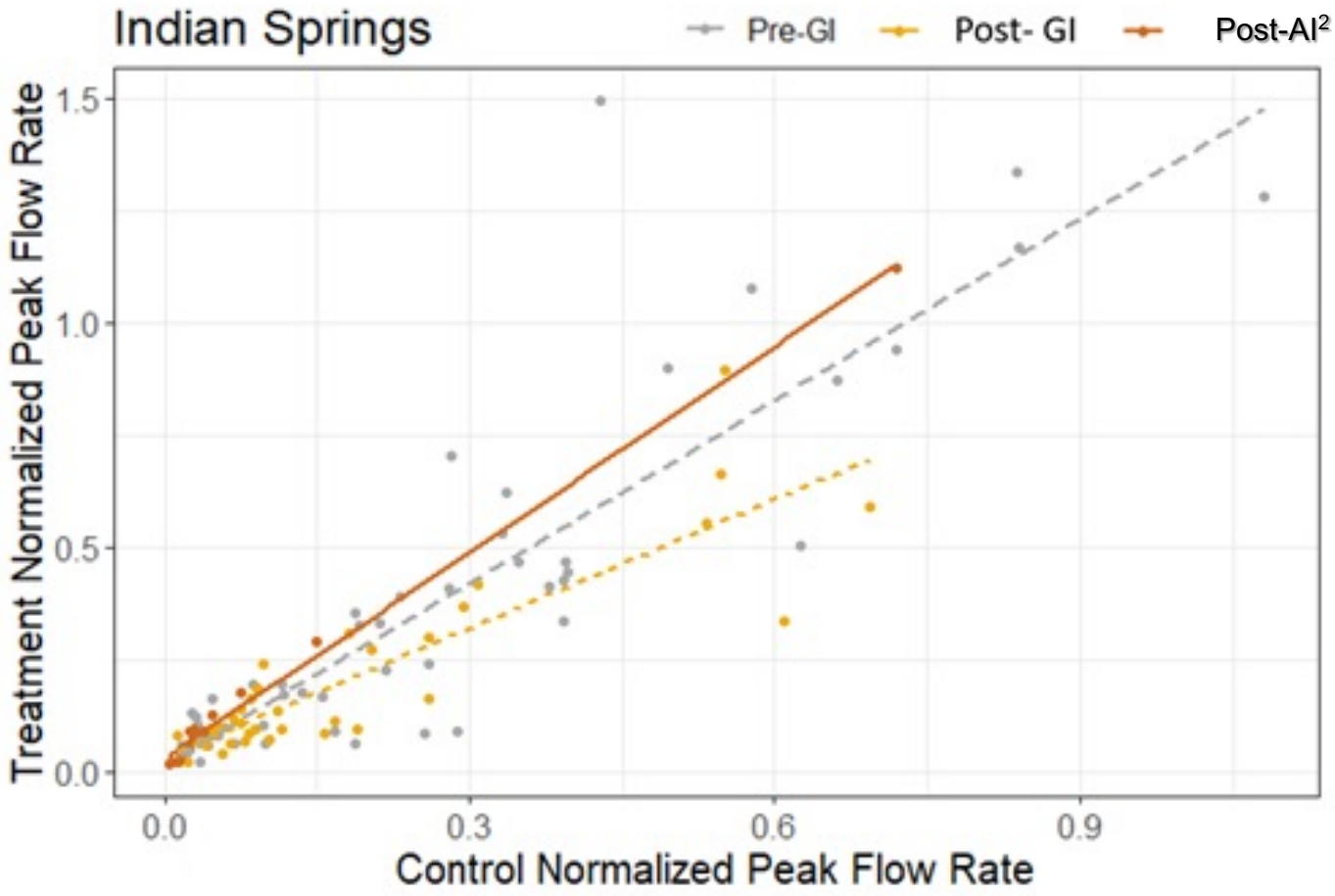
<u>Monitored Events:</u>
Cooke-Glenmont:13
Indian Springs: 94
Blenheim-Glencoe: 6

Runoff Volume Response



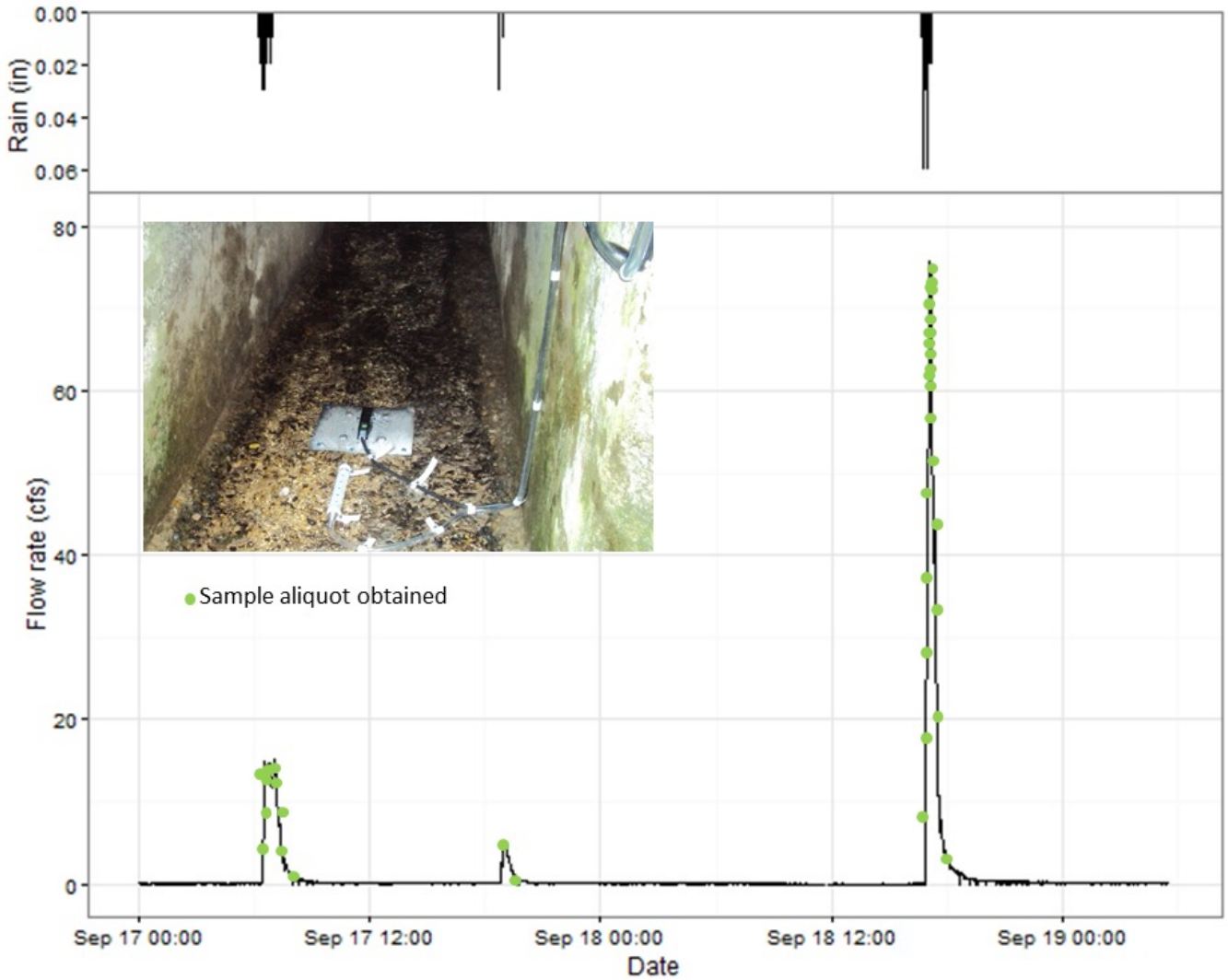


- Significant runoff volume reductions (20-40%) at watershed scale following Green Infrastructure retrofits
- Return to pre-GI conditions in AI^2 period

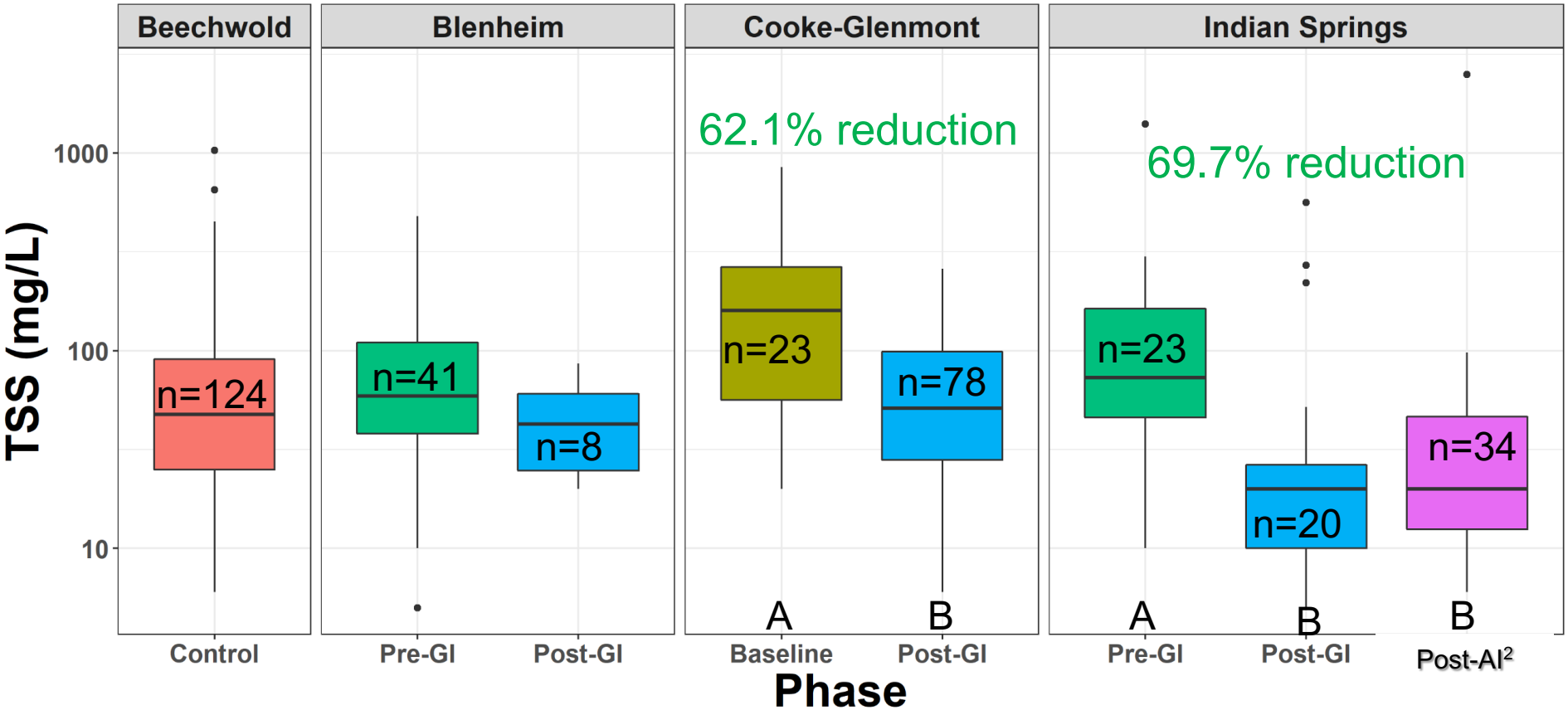


- Peak Flow Rates were significantly reduced (52-72%) Post-GI.
- Post AI^2 (four pillars complete) peak flow rates returned to those of Pre-GI

Water Quality Sampling



TSS Concentrations

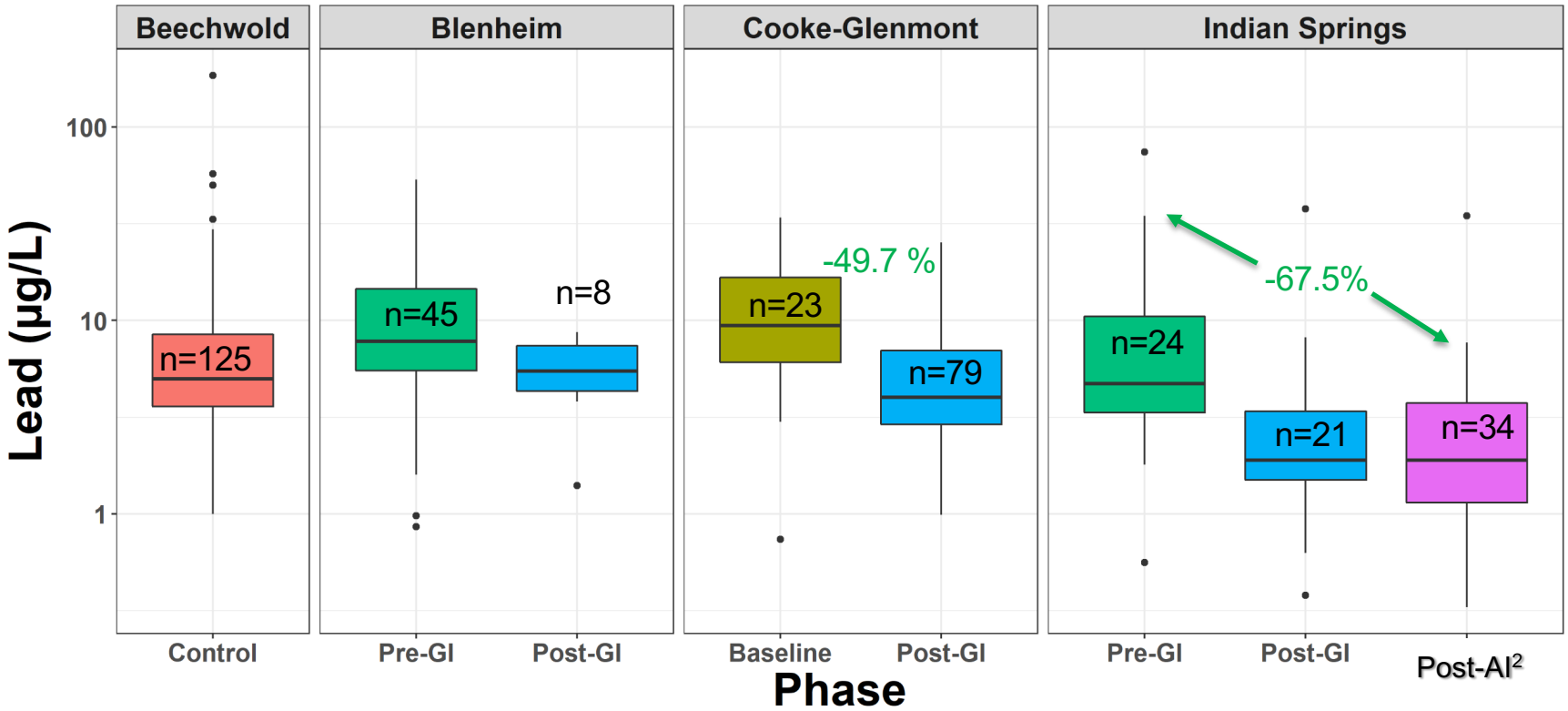


Relationship between TSS Concentrations & Imperviousness

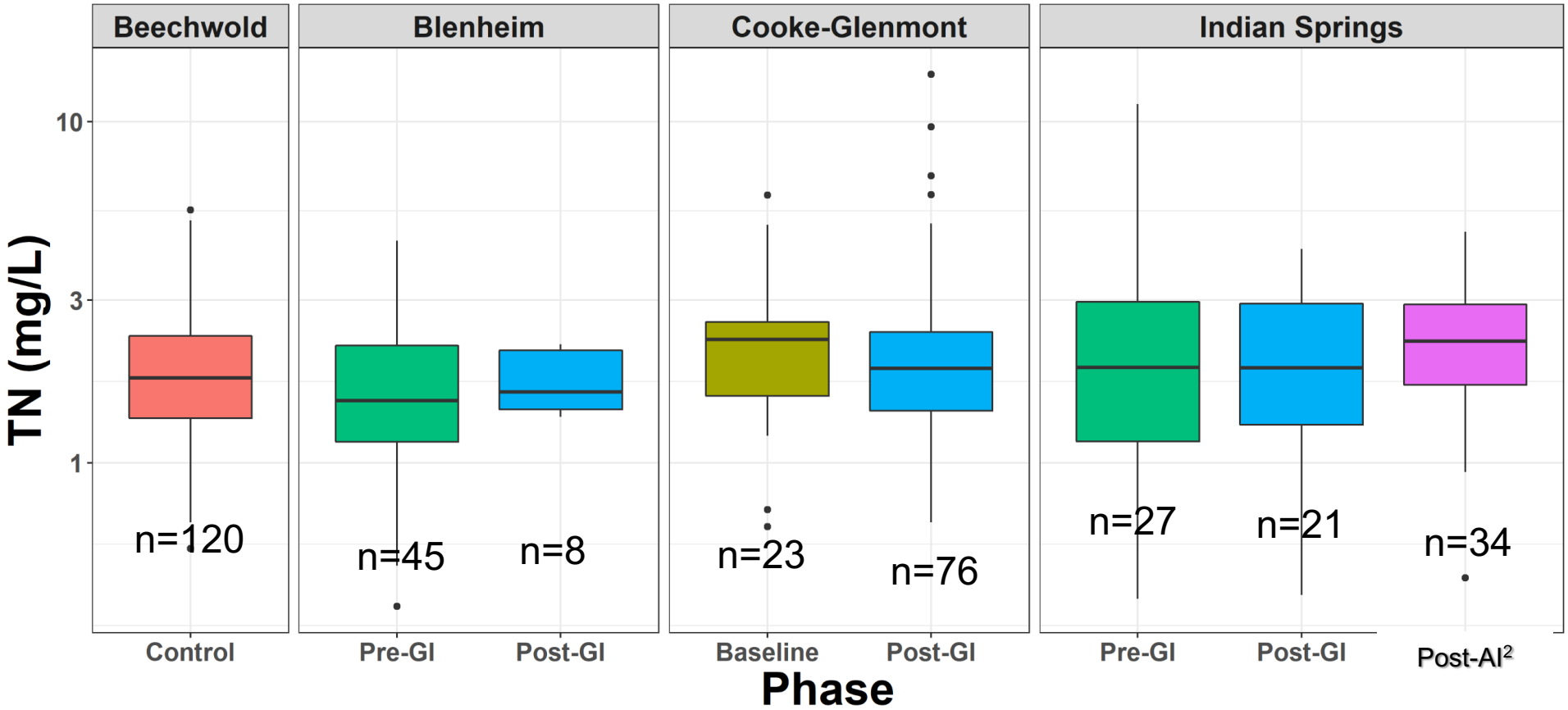
% sewershed imperviousness treated by GI ≈ % TSS concentration reductions (<5% margin)

- Cooke-Glenmont
  - 66.5% of the sewershed imperviousness treated by GI
  - 62.1% reduction in TSS concentration (sig.)
- Indian Springs
  - 69.7% of the sewershed imperviousness treated by GI
  - 67.7% reduction in concentration at Indian Springs (sig.)

Observed heavy metal % conc. reductions similar to TSS

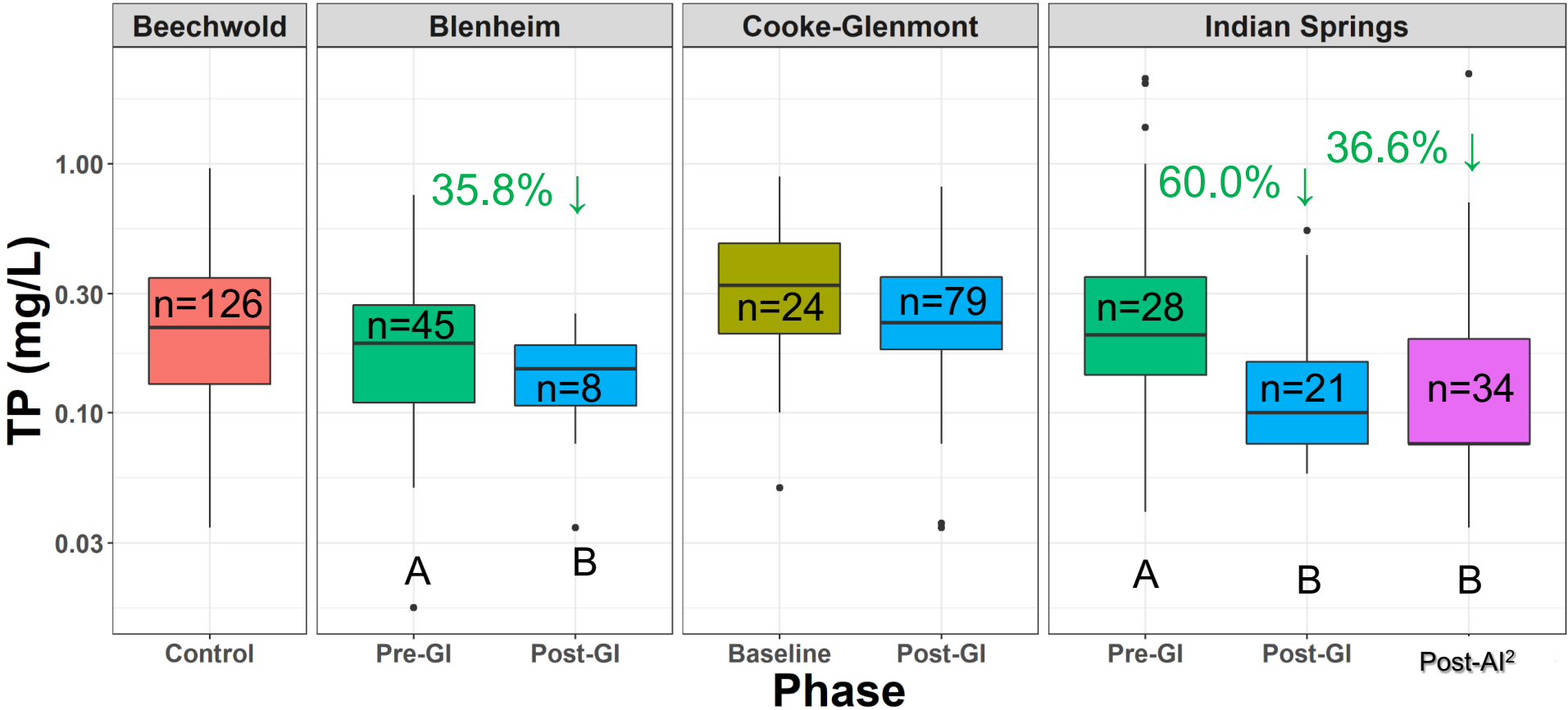


Total Nitrogen



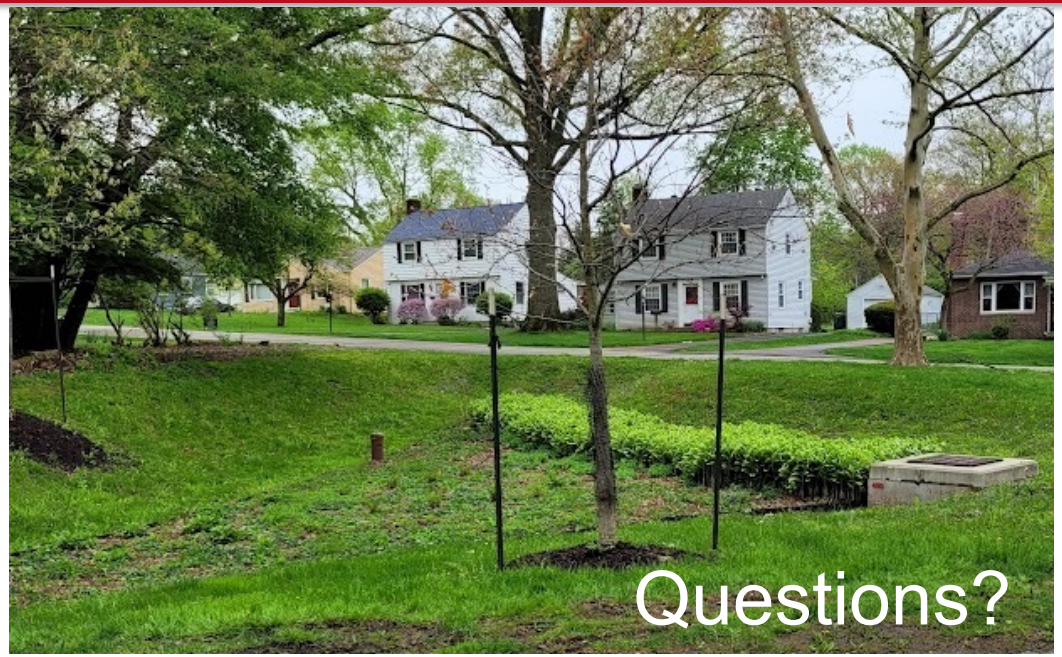
Total Phosphorus

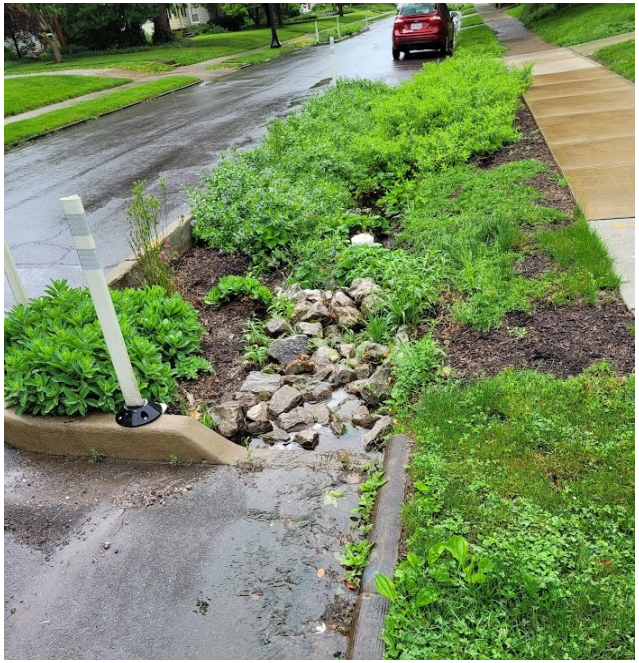
- Significant conc. reductions
- Particulate P removal



Summary

- Using a paired watershed approach, we observed effects of green infrastructure installation:
  - Runoff reduction at watershed scale (20-40%) following green infrastructure implementation
    - Subsequent return to baseline conditions following other infrastructure improvements
  - TSS, TP, metals reductions above expectations (50-60%)
  - No change in TN concentration
- Questions for the future: Impacts to stream geomorphology / habitat / erosion?


Questions?

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