Detention Basin Retrofits Are Not Just For Hydrology Anymore

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Jim Goodrich, Rajib Sinha, John Hall, and Bob Hawley

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Presentation Overview

1) Retrofit Device Background
   - Recent hydrologic assessment

2) Water Quality Treatment Media Evaluations
   - Pilot Scale Set-up
   - Media
   - Contaminants

3) Data Results
   - Performance/Breakthrough

Retrofit Device Hydrologic Update

Site Selection

- Large Industrial Property
  - ~31 acres, 52% impervious
- Conventional Detention Design
  - Peak Matching for 2, 10, 50, 100-year design storms

Site Installation

Restricted Release for Most Storms

- 75% Restriction of 24” Outlet
- Reduced stream erosion
- Enhanced water quality treatment

Bypass for Large Events

- Maintain Flood Control Performance
- 18” Bypass at 3’ above inlet of 24” inlet

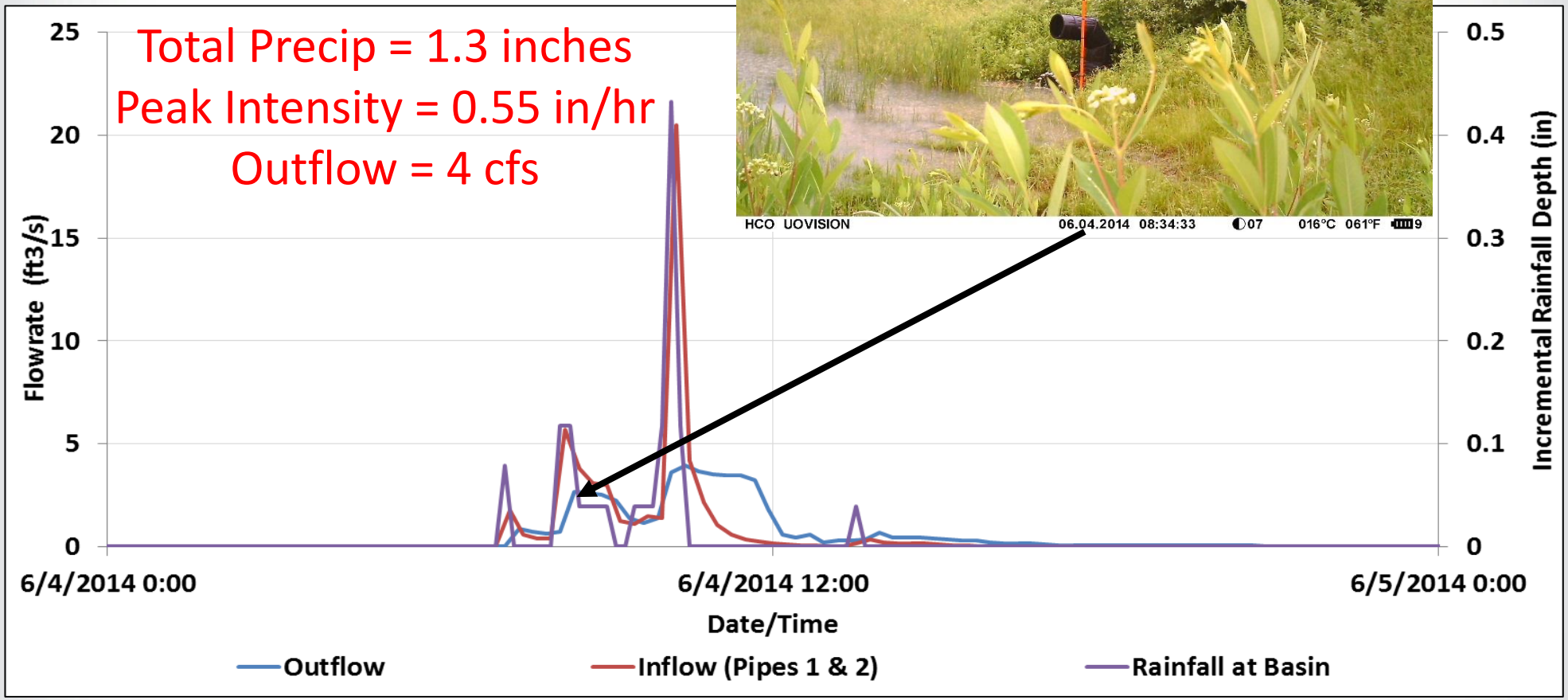
Inexpensive

- No Heavy Equipment or Re-grading Required

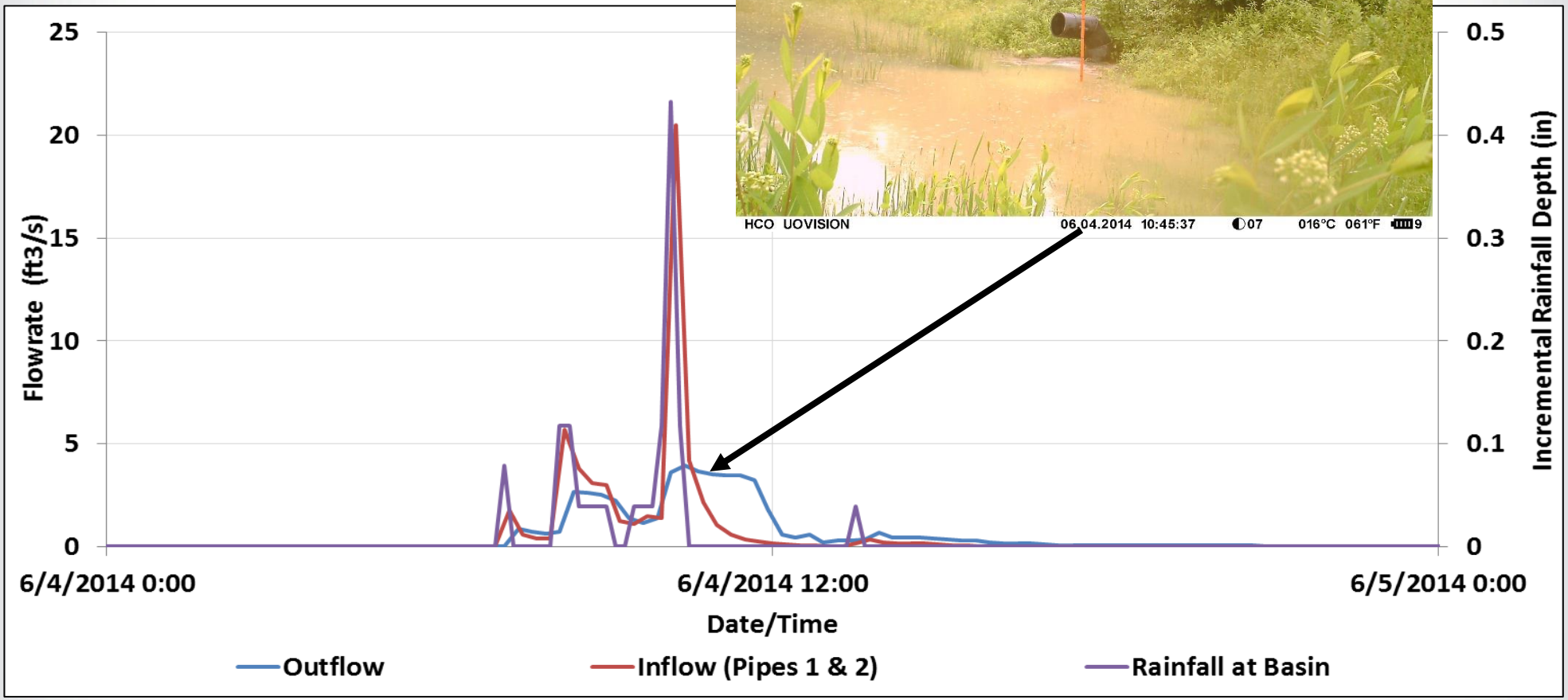
Extended Detention

Example Storm Event

Total Precip = 1.3 inches
Peak Intensity = 0.55 in/hr
Outflow = 4 cfs



Post-retrofit



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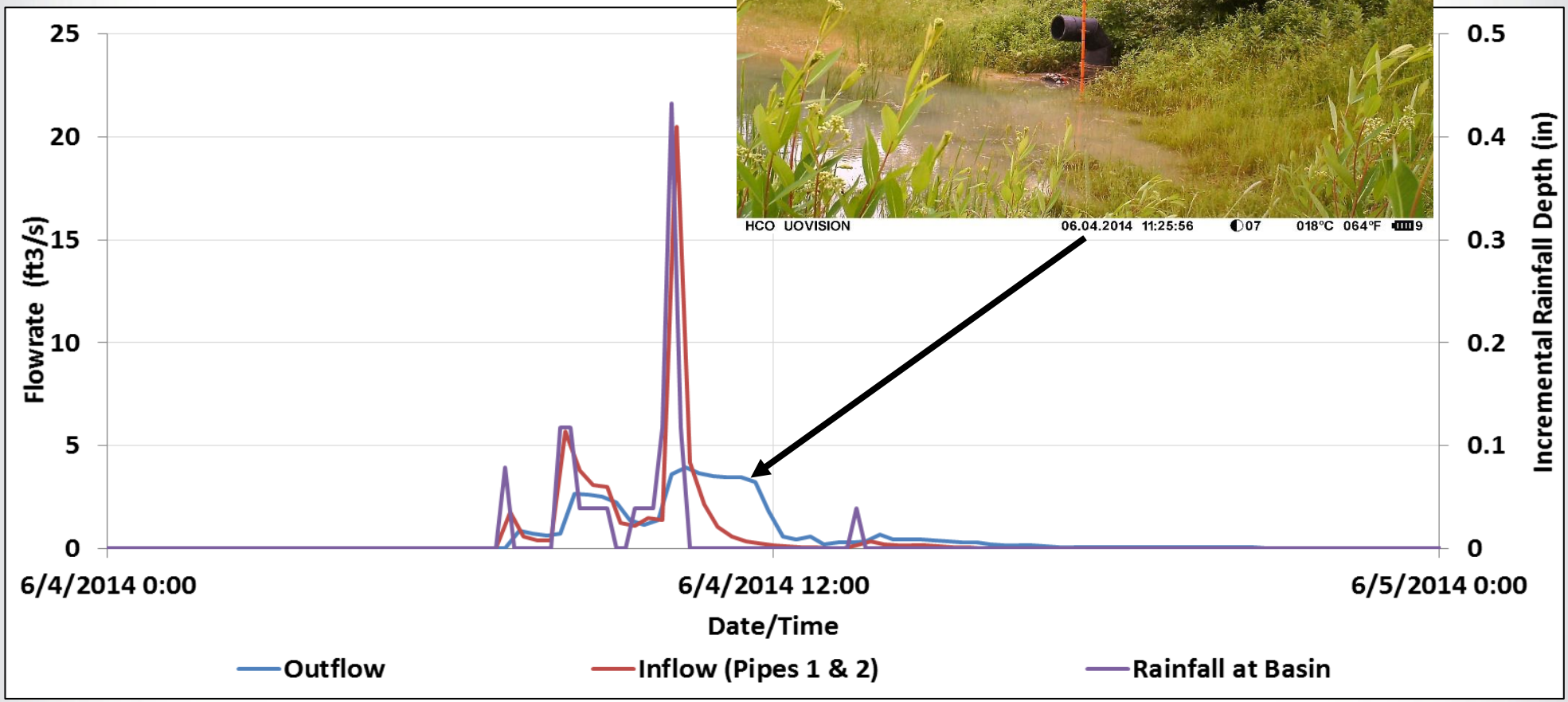

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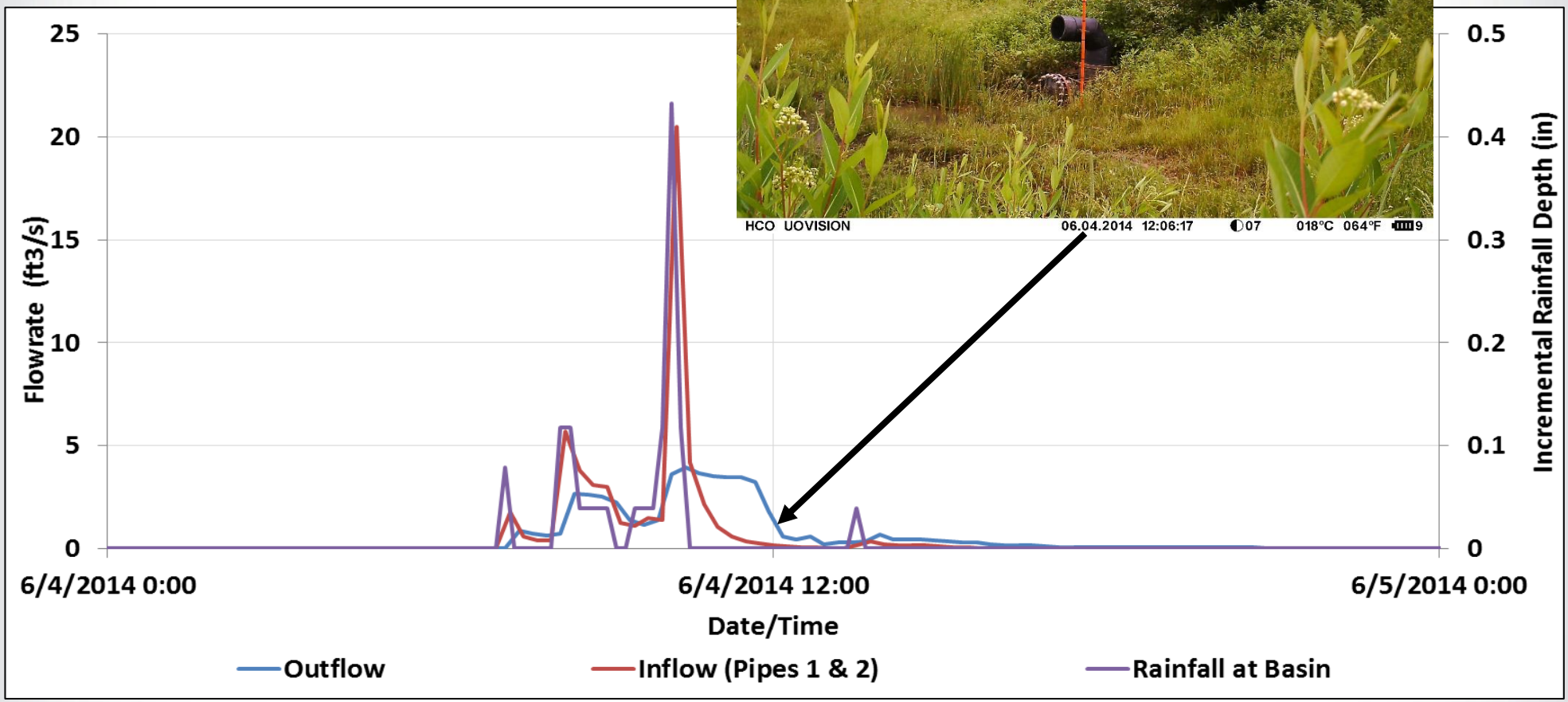
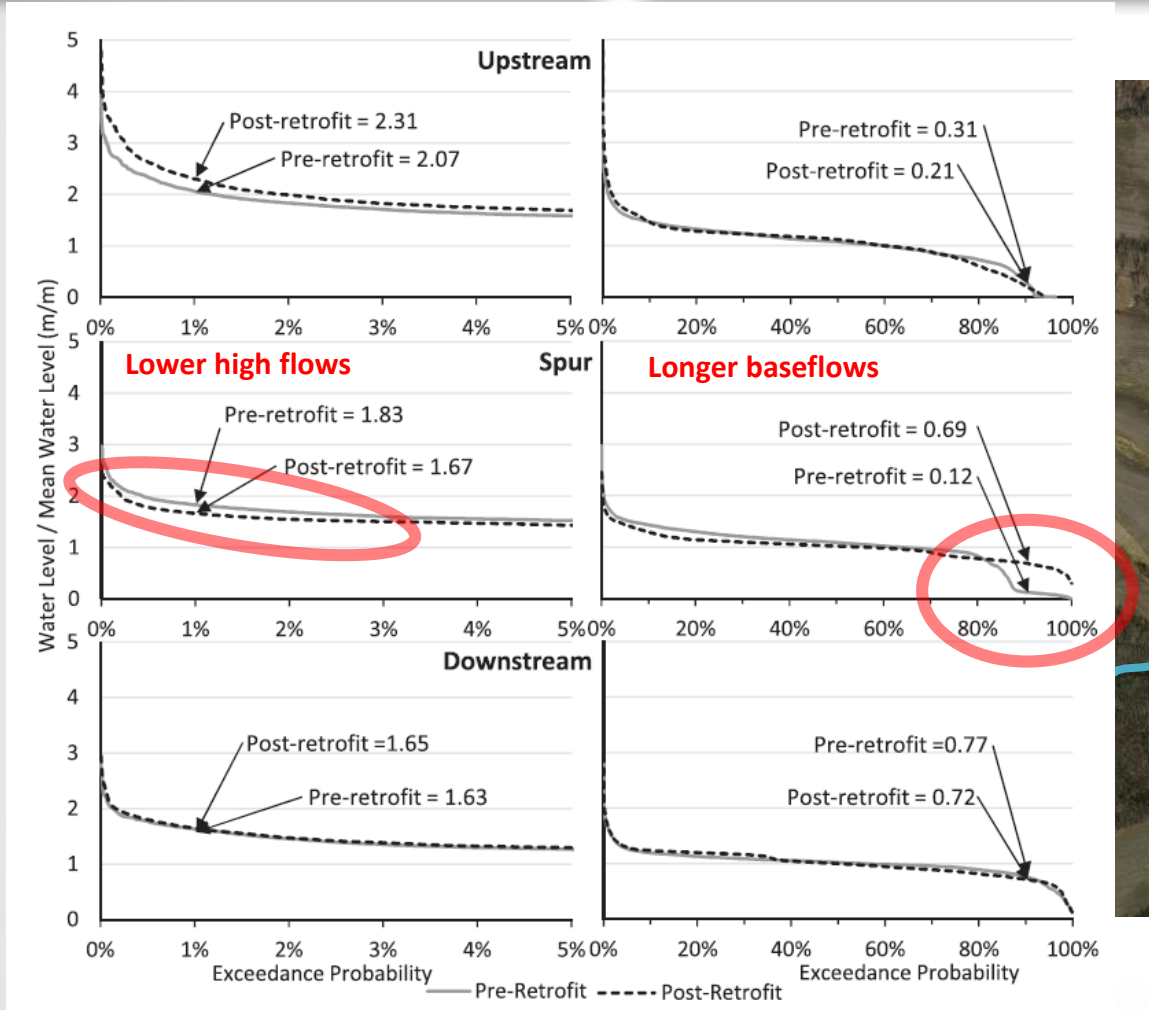
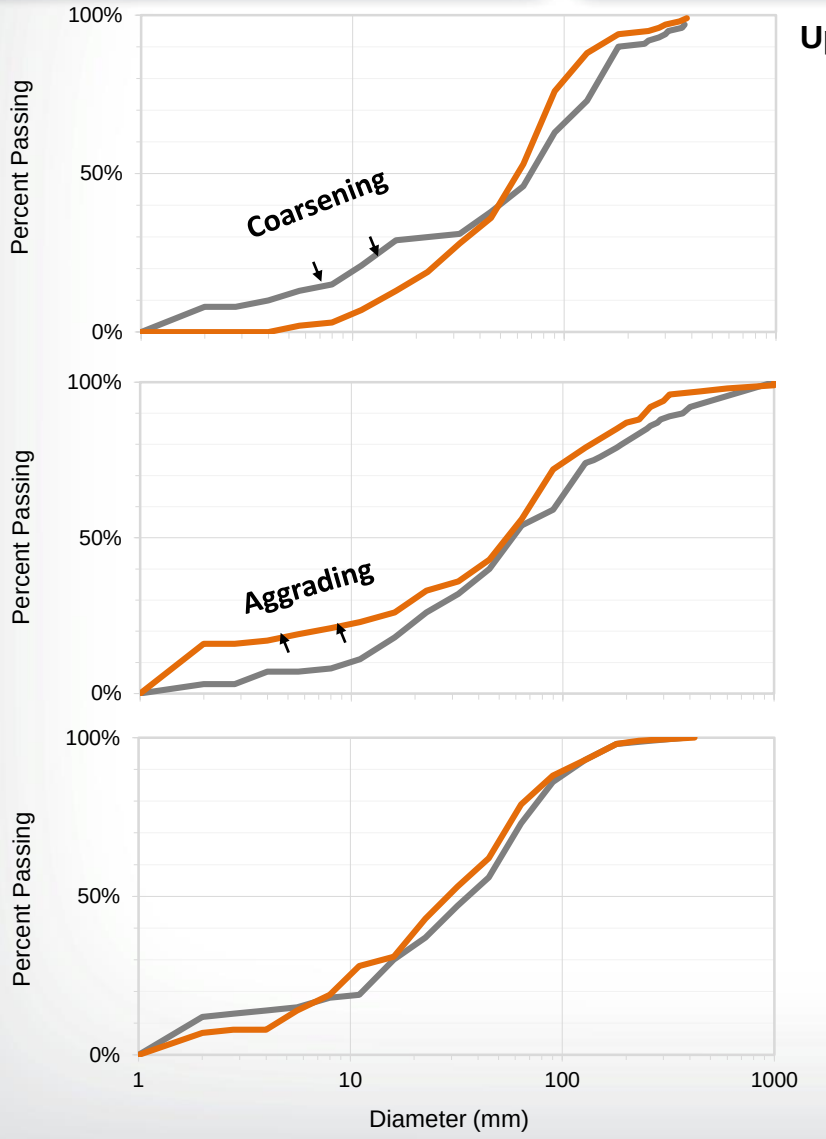


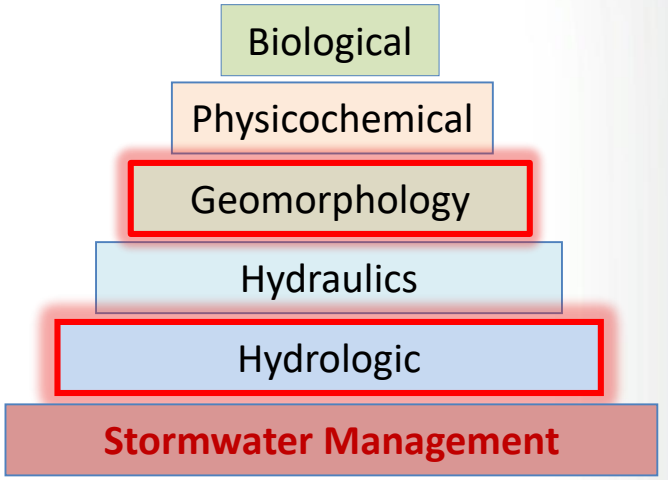
Restoration of High and Low Flows



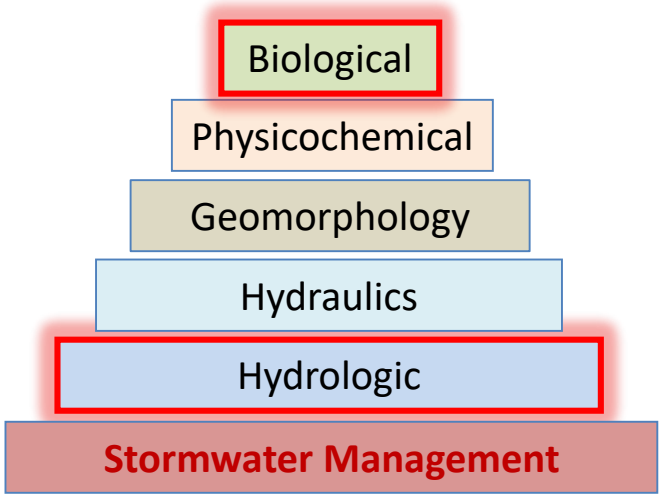
Adapted from Hawley et al. (2017)

Restricted High Flows Reduces Streambed Erosion





Restored Baseflows Supports Ecological "Lift"



~Dozen native minnows in 1st pool immediately downstream of the outfall (2 circled). Flow was evident coming out of the basin despite the relatively dry/hot week

Application to Watershed Integration and Emergency Response

- Incorporate ***water quality treatment*** into stormwater hydrologic control

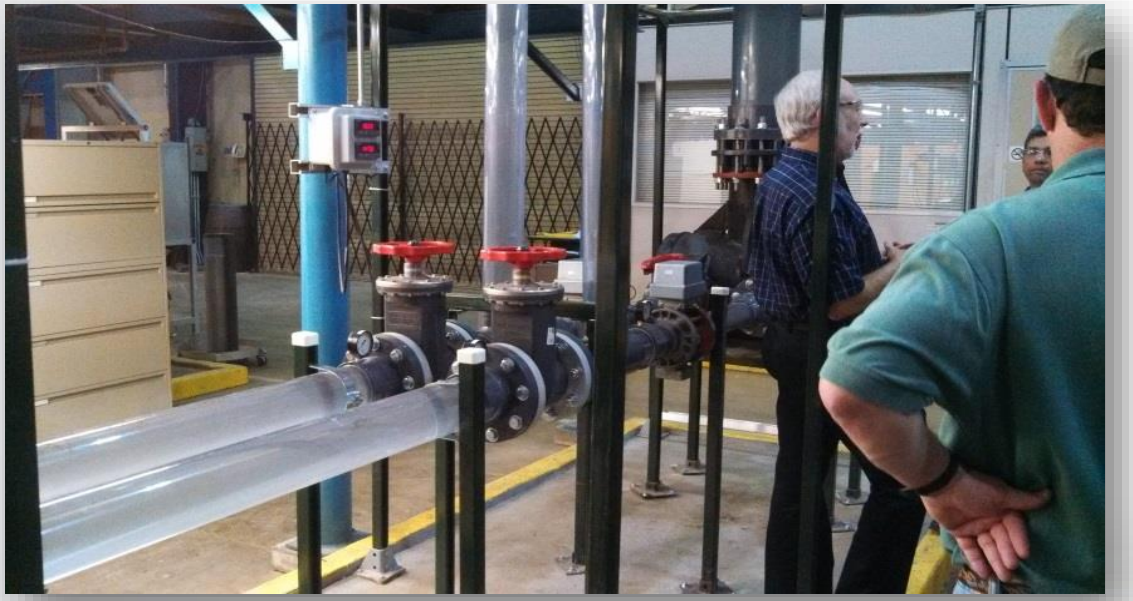
- Provide ***multiple co-benefits*** for routine storm events and decontamination responses to natural and man-made incidents

Test & Evaluation Facility
- Media Evaluations -

Pilot-Scale Detention Basin

Media Evaluations

- Natural and man-made media
  - Various coatings
- Flow Rates by Falling Head
  - Model breakthrough
- Water Quality Contaminants
  - Radioactive Surrogate
  - Microbial Surrogate
  - Fertilizer
  - Petroleum



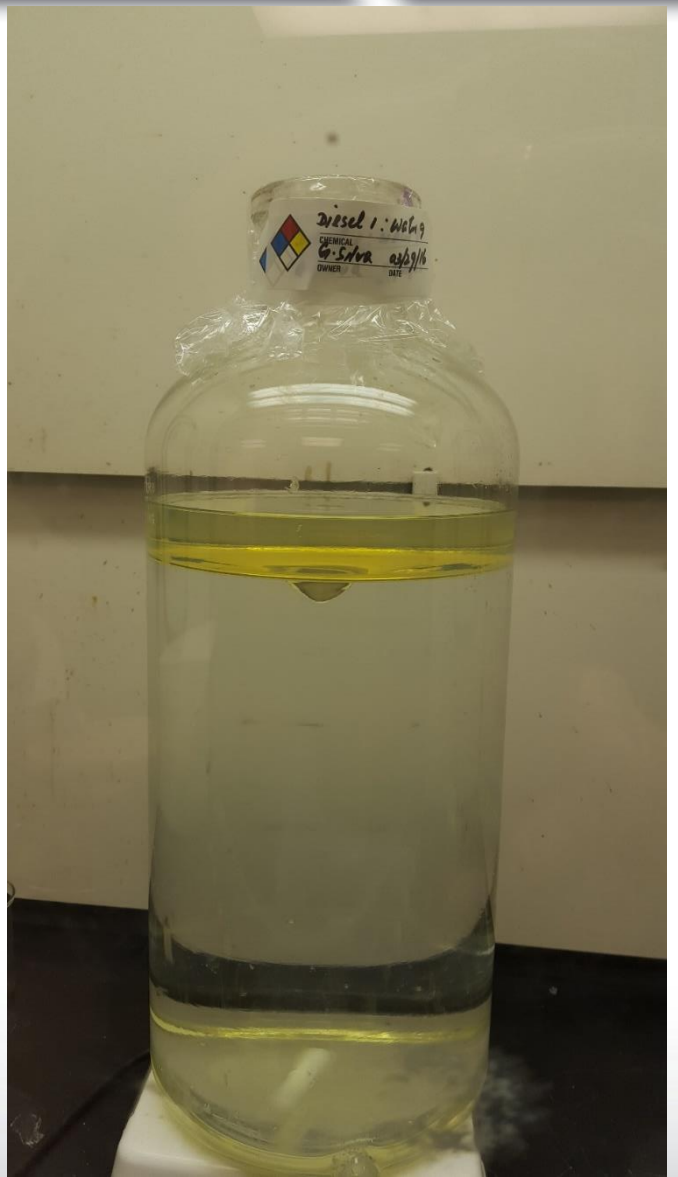
Example Media

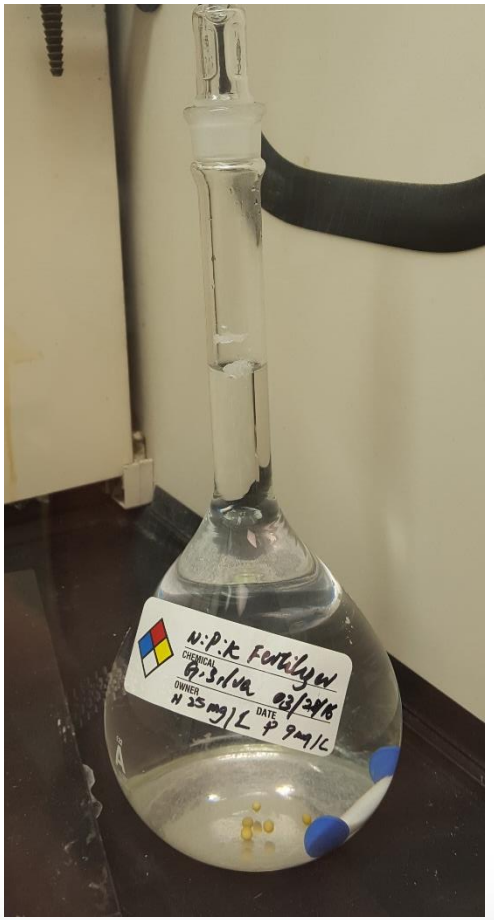
Switchgrass

Coated Gravel

Collecting Outlet Water Sample

Contaminant Injections





Media Experiments

Media Tested	Description	Target Contaminants
Coated Gravel	#4 stone coated with an adsorbent media.	Nutrients (N&P)
Switchgrass	Chopped into ~6 inch strips and placed in a mesh sock.	Nutrients (N&P) Radioactive compounds Bacteria
Granular Activated Carbon	Activated carbon in a sock.	Nutrients (N&P) Organic compounds Radioactive compounds
Iron Oxide Media	Granular and coarse activated ferric oxide.	Metals (e.g., arsenic) Bacteria
Clinoptiolite	Natural zeolite - microporous arrangement of silica and alumina tetrahedral.	Metals
Sintered Metal	Adsorptive sintered metal coated onto a substrate and placed in a sock.	Metals Radioactive compounds

Time To Filter Breakthrough

Permeability by Falling Head

$K = (a / A*t) \ln (h_1 / h_2)$

Where:

K = coefficient of permeability.

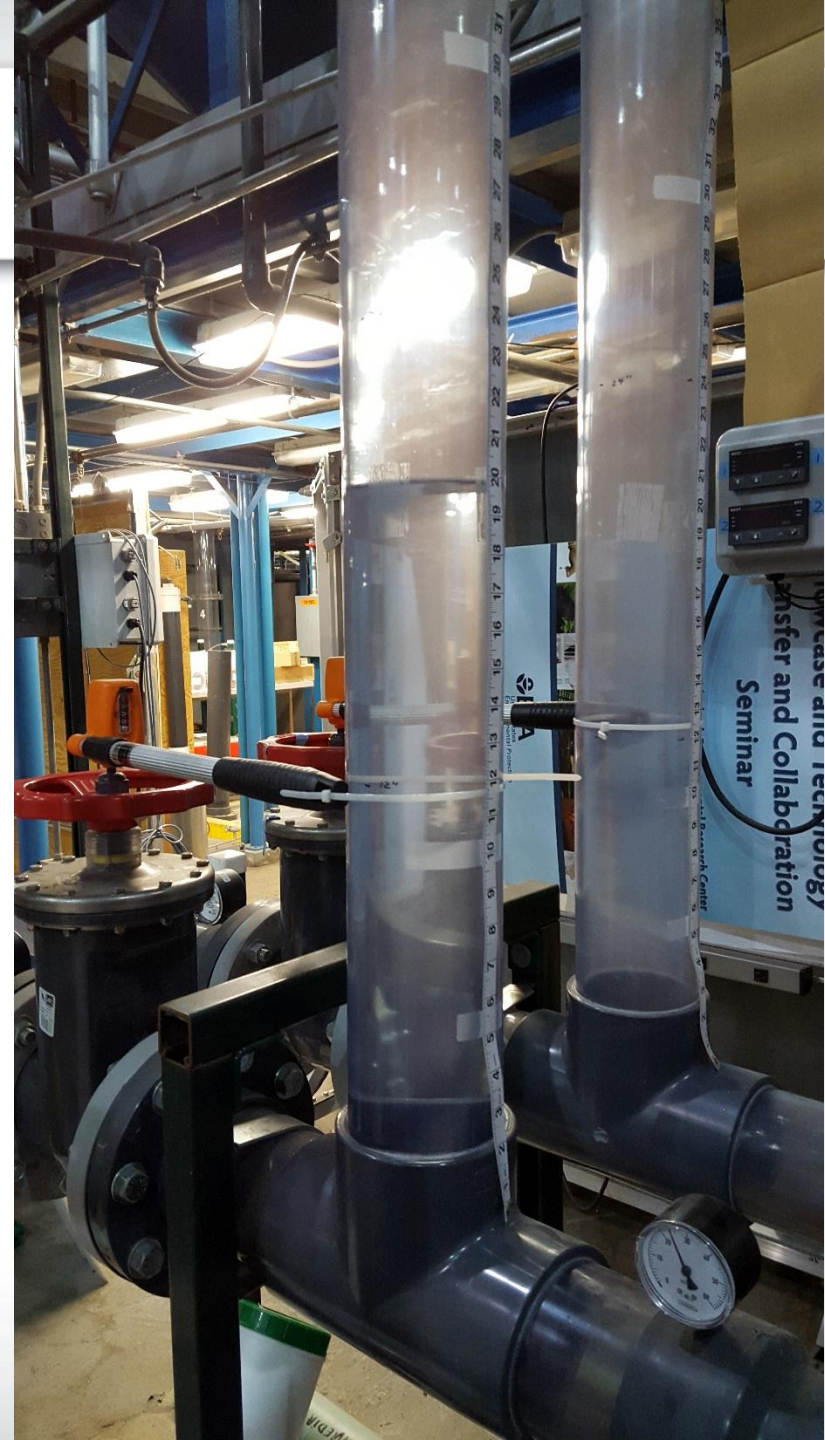
a = cross-sectional area of the standpipe.

A = cross-sectional area of the sample.

t = elapsed time increment.

h_1 = height of water at the beginning of time increment in inches.

h_2 = height of water at the end of time increment in inches.



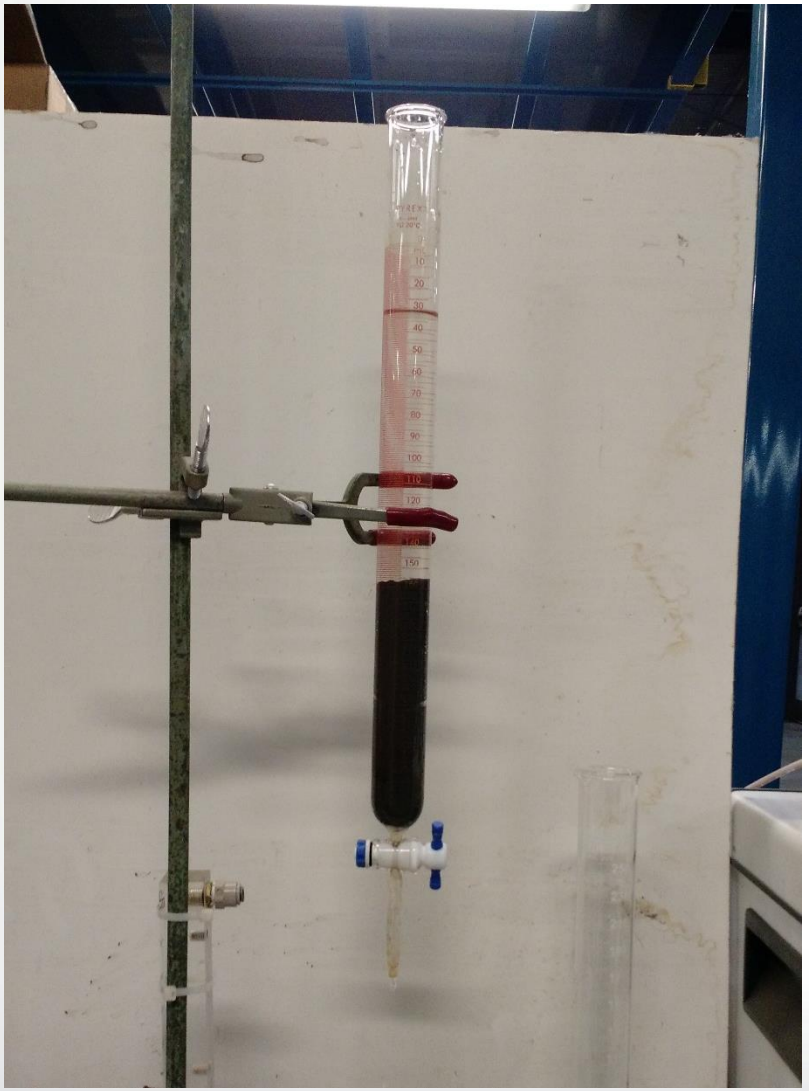
Coefficient of Permeability

1.5” Rock:
14.7 cm/sec (28.9 ft/min)

Coated Gravel:
5.87 cm/sec (11.55 ft/min)

Switchgrass:
2.45 cm/sec (4.82 ft/min)

Burette Tests



Granular Iron Oxide:
0.45 cm/sec (0.89 ft/min)

Coefficient of Permeability

Generic Reference	k		Time to Drain (vs. Reference)	Apparatus
Reference - 1.5" Rock	28.90	ft/min	1	Pilot Test
Coated Gravel	11.55	ft/min	3	Pilot Test
Switchgrass	4.82	ft/min	6	Pilot Test
Granular Iron Oxide	0.89	ft/min	32	Burette
Activated Carbon	0.68	ft/min	43	Pilot Test
Natural Zeolite	0.63	ft/min	46	Pilot Test
Iron composite metal	0.44	ft/min	66	Burette
Sintered Metal with Cu	0.39	ft/min	74	Burette
Powdered Iron Oxide	0.15	ft/min	193	Pilot Test
Powdered Reagent Mix	Very small		Very Long	Pilot Test

In-Tank Falling Head Tests

- Media with coated gravel removed from the field after 2 years of operation.

- Placed inside a 5,000 gal tank.

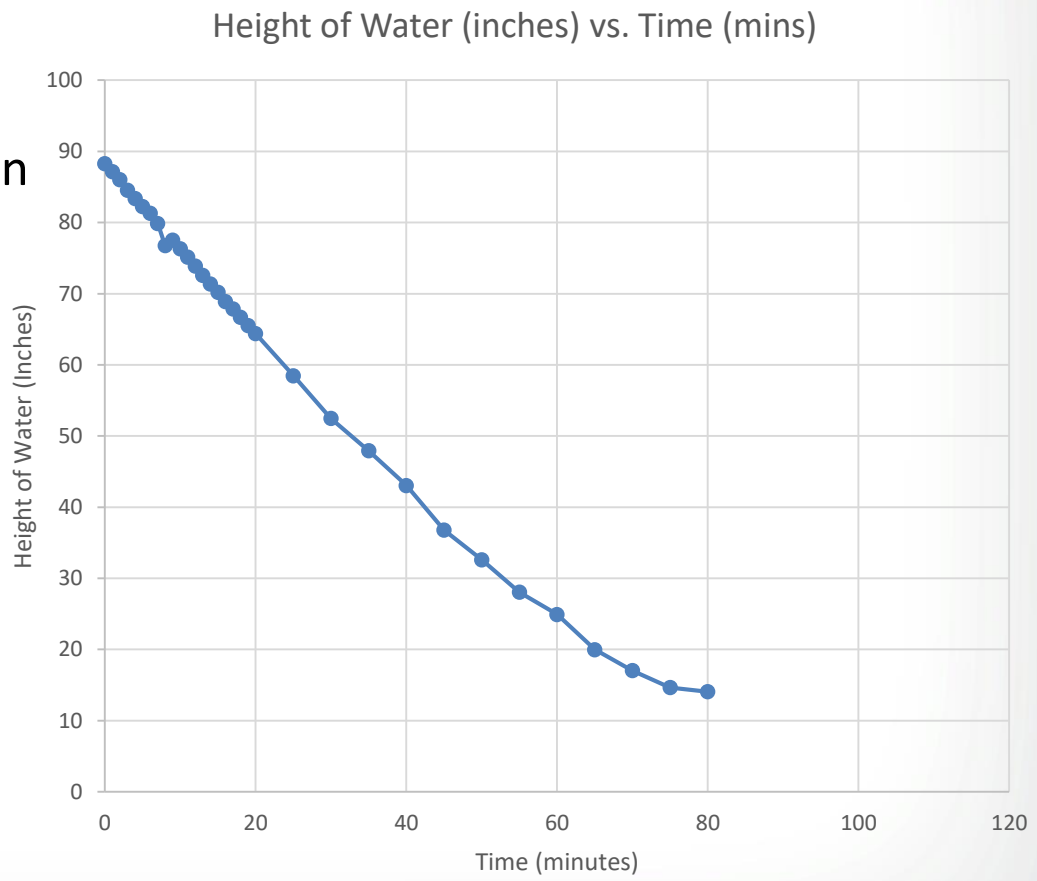
- Used to measure permeability using falling head tests.

In-Tank Falling Head Tests

Coefficient of permeability = 5.49 ft /min

Pilot Test K calculated = 11.55 ft/min

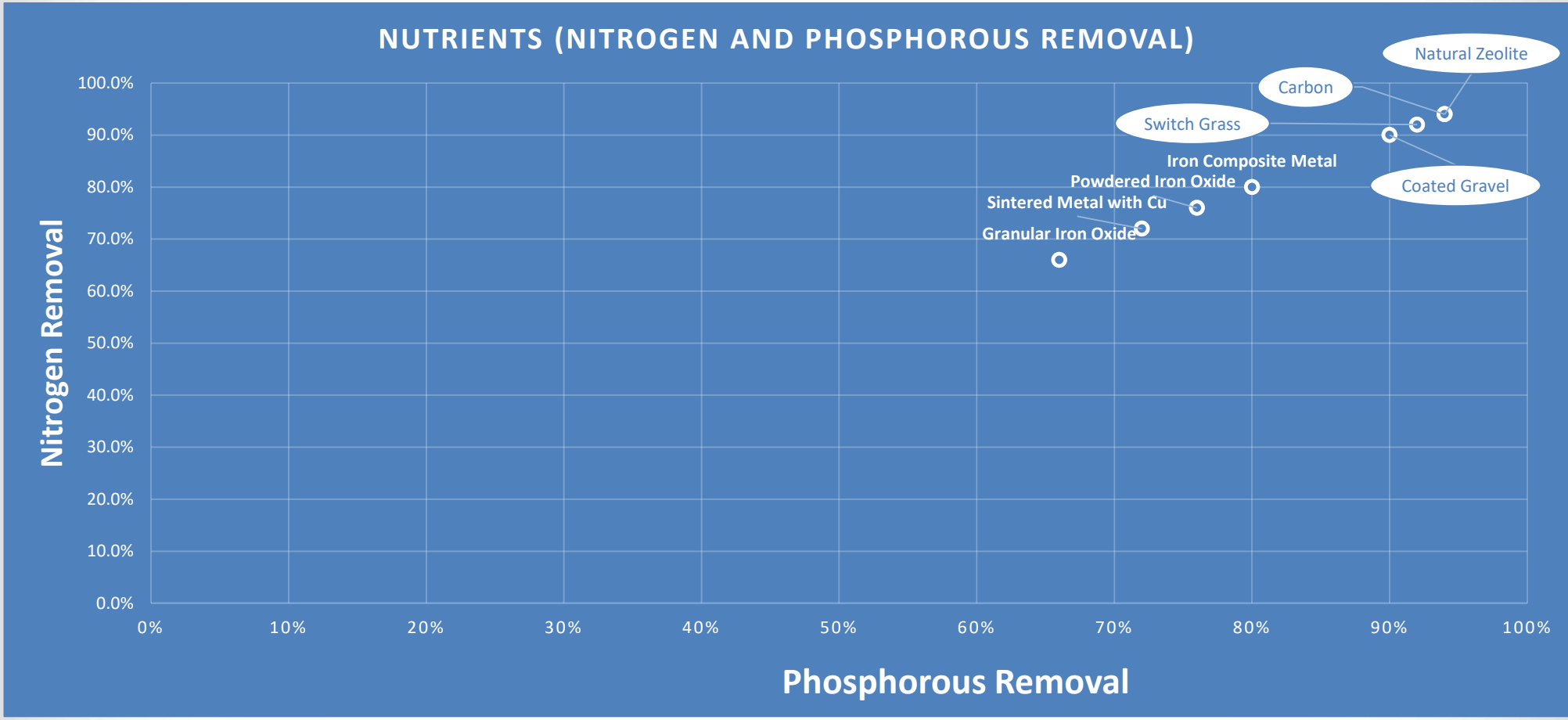
About a two-fold reduction of permeability observed.



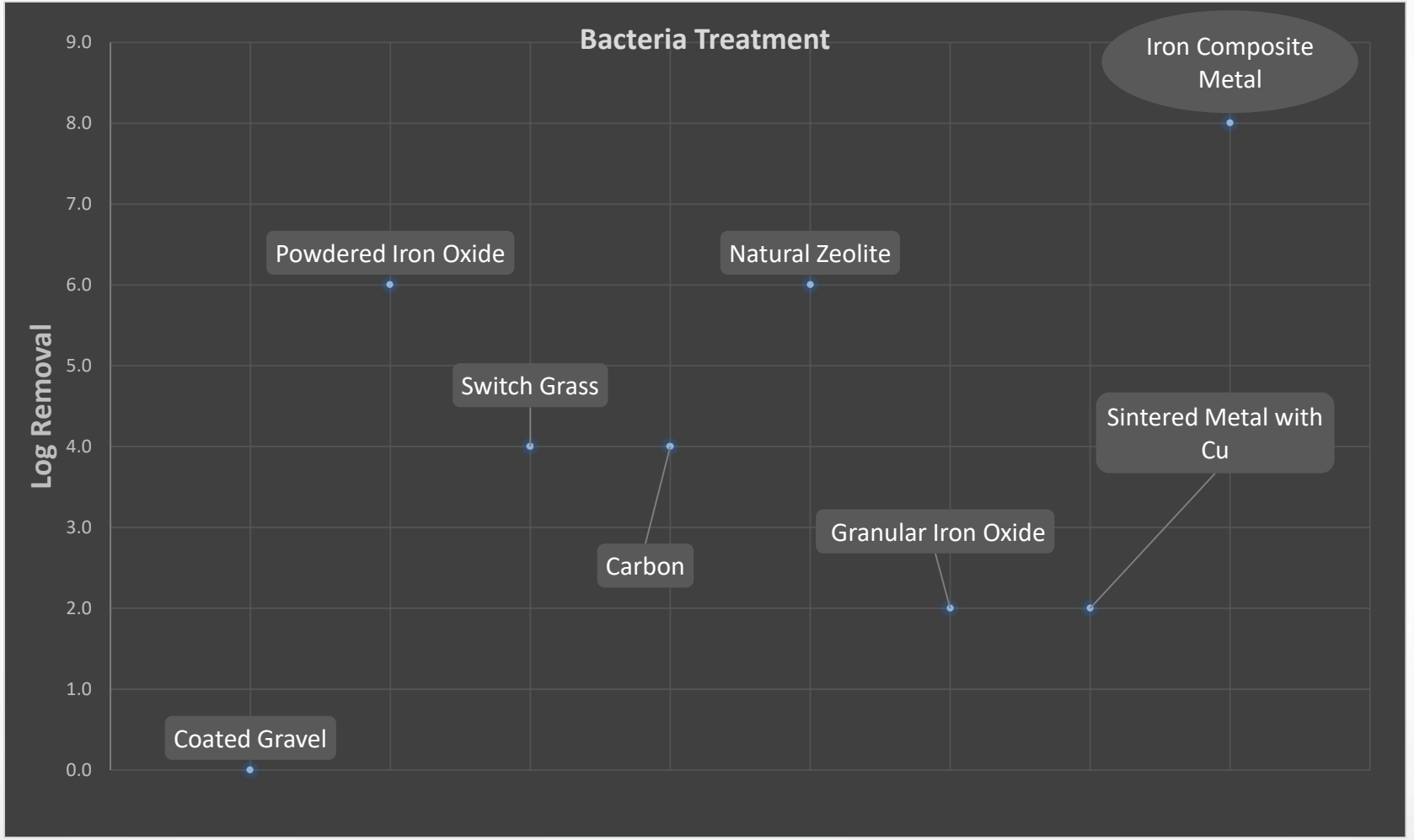
Contaminant Removal Tests

	Nutrients				Radioactive	Bacteria
Parameter	Total N	NH3-N	Total P	PO4-P	Cesium	E. coli
Description	% Removal	% Removal	% Removal	% Removal	% Removal	Log Removal
Coated Gravel	90.0	78.0	100.0	86.0	92.0	0.0
Powdered Iron Oxide	76.0	78.0	100.0	98.0	94.0	6.0
Switchgrass	92.0	76.0	64.0	90.0	94.0	4.0
Activated Carbon	94.0	76.0	90.0	84.0	80.0	4.0
Natural Zeolite	94.0	80.0	88.0	86.0	96.0	6.0
Granular Iron Oxide	66.0	74.0	100.0	100.0	NT	2.0
Sintered Metal with Cu	72.0	78.0	56.0	54.0	NT	2.0
Iron Composite Metal	80.0	80.0	100.0	100.0	NT	8.0

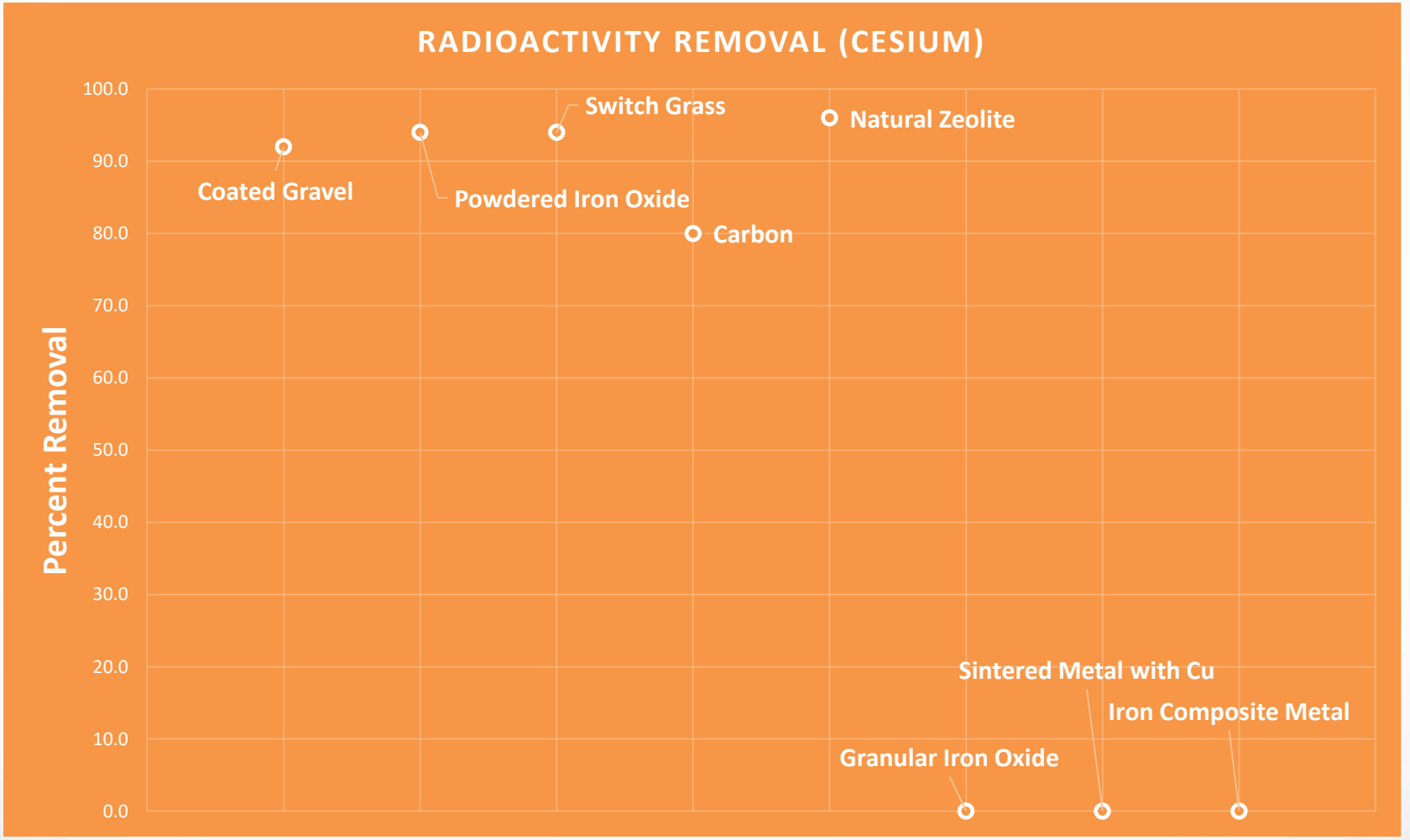
Nutrients Removal



E. Coli Removal

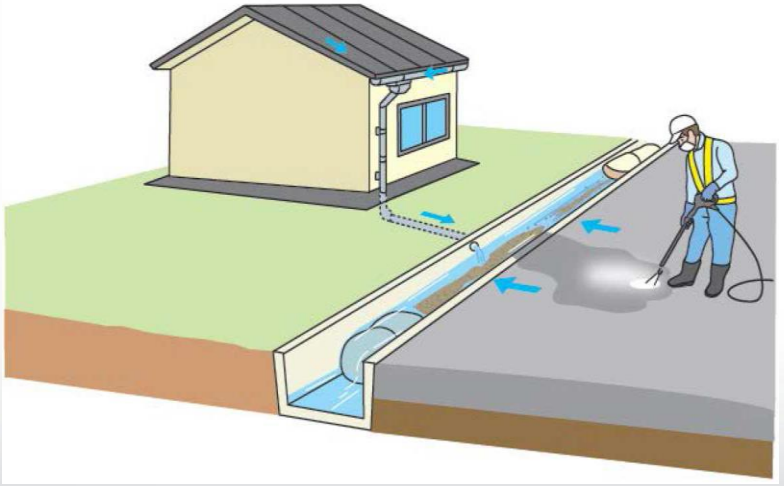


Radioactive Compound Removal



Generation of Contaminated Stormwater

- Intentional (e.g. terrorist attacks) and unintentional (e.g. natural disasters, industrial spills, land use, etc.)
  - Washdown activities involving CBR agents from indoor-outdoor areas
  - May include water from decontamination activities such as extinguishing industrial fires
  - Runoff during precipitation events prior to or during decontamination activities

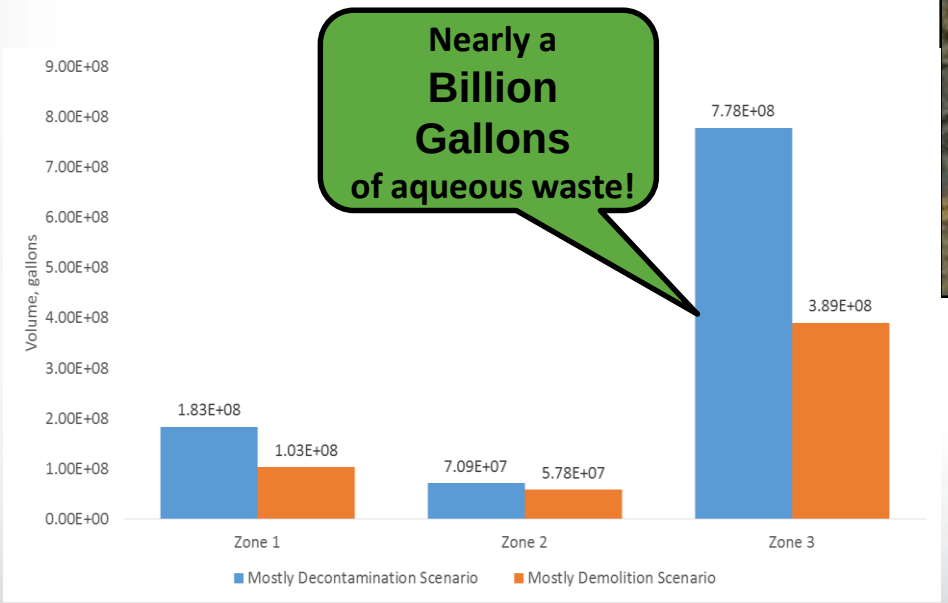


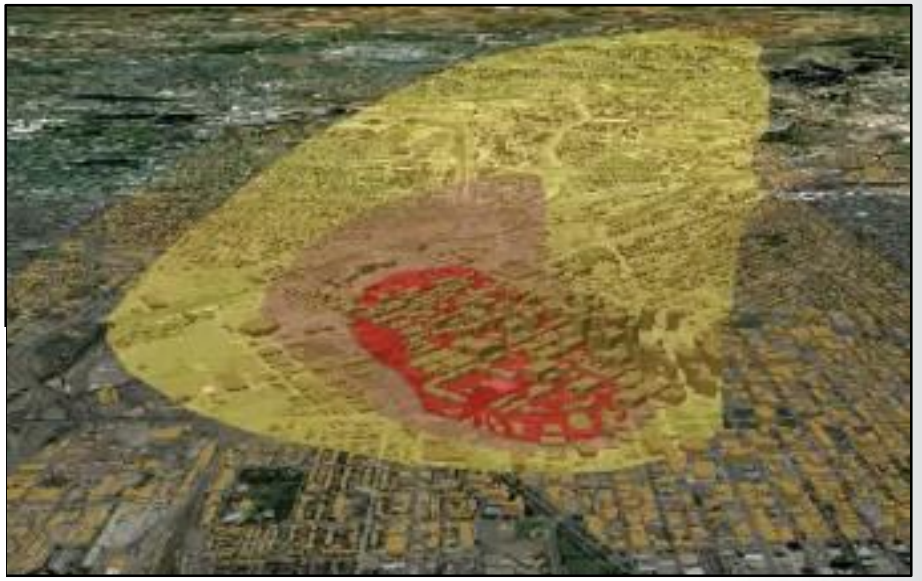
Decontamination Incidents

How much contaminated water is generated?

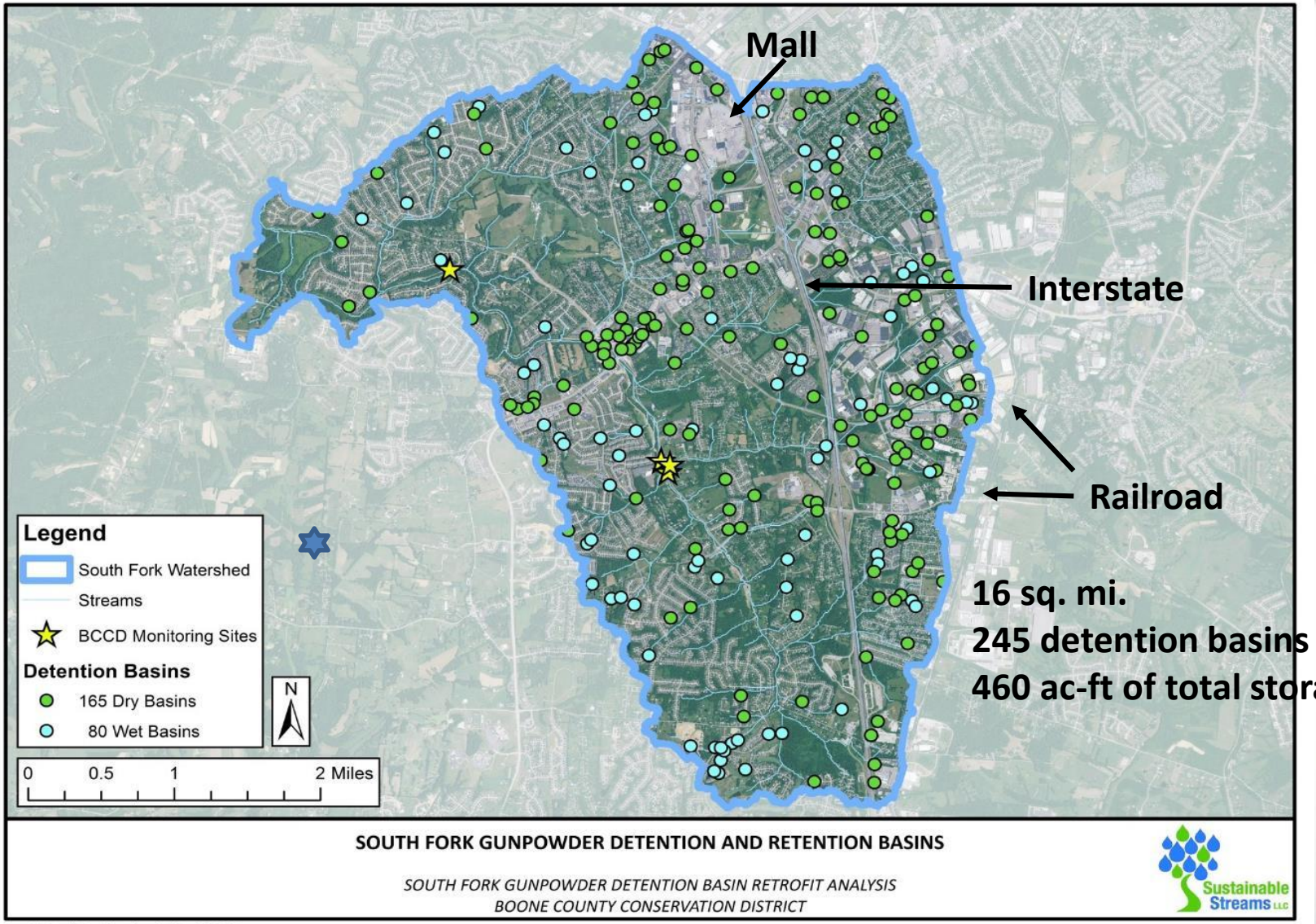
Aqueous waste estimation:

- Both scenarios (decontamination and demolition) generate significant volumes of contaminated wash water that may require special treatment or disposal.





Example Watershed Integration



Next Step – Long Term Field Applications

Retrofit Benefits Summary

- Base Flow Restored – 'ecologic lift'

- Water Quality Improvement
  - Many media options available to fit contaminant in question
  - Minimal O&M

- Strategic stormwater infrastructure protection approach can provide benefits to daily operation and emergency response

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