Improving Stream Hydrology, Geomorphology, and Biology with Watershed BMPs

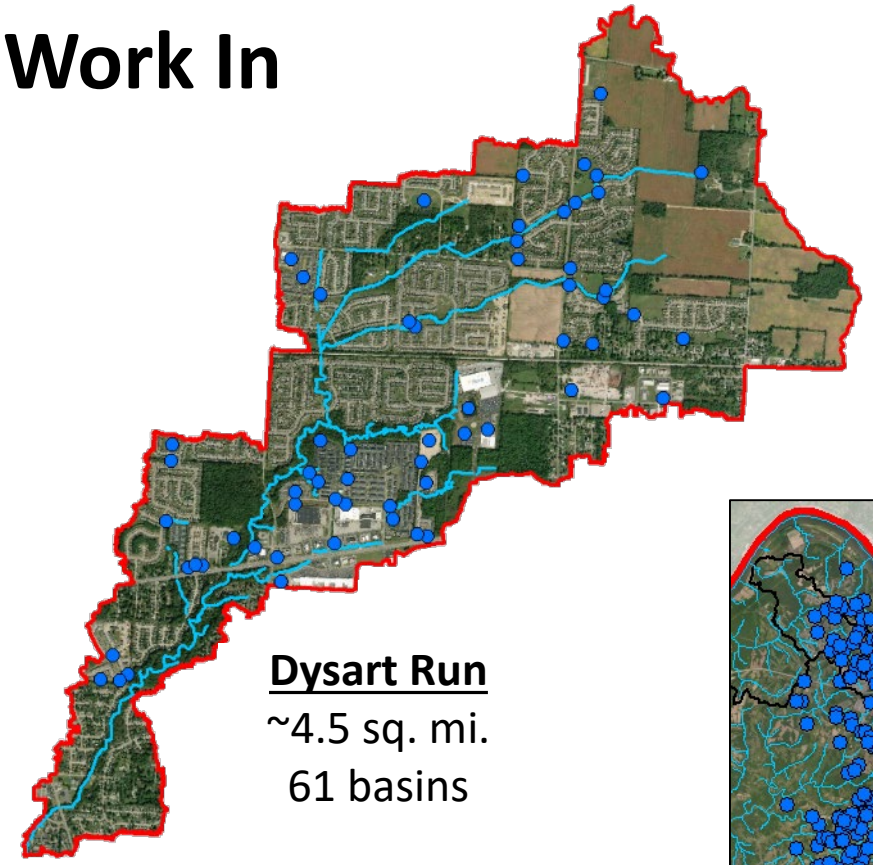
Nora Korth, P.E.

2019 Ohio Stormwater Conference

May 10, 2019

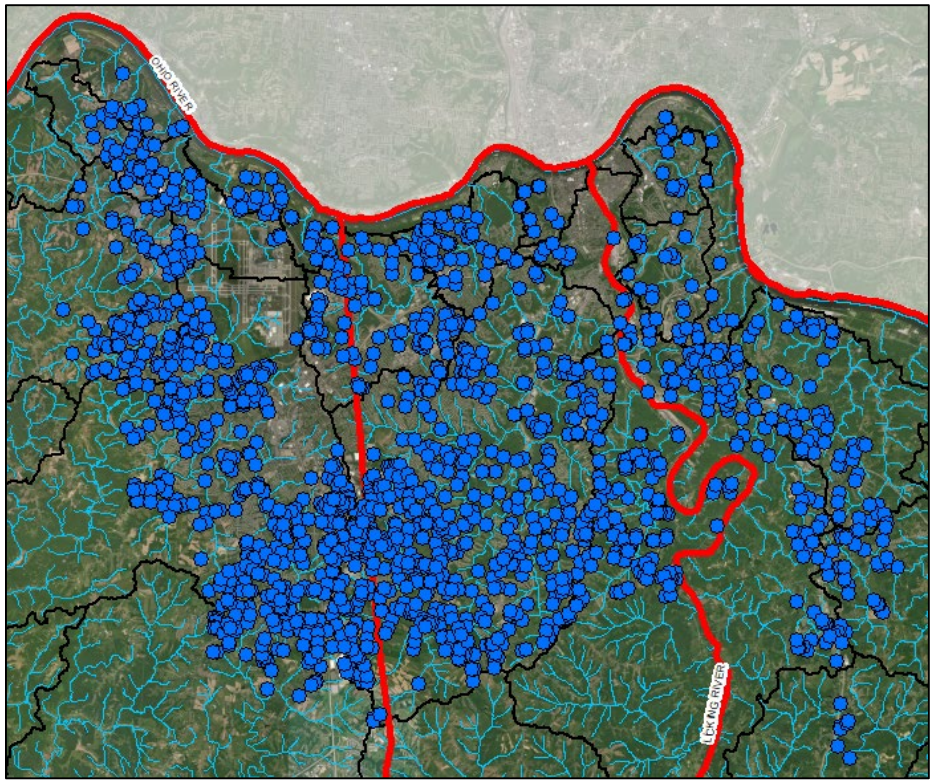
Sustainable Streams LLC
Science · Service · Solutions

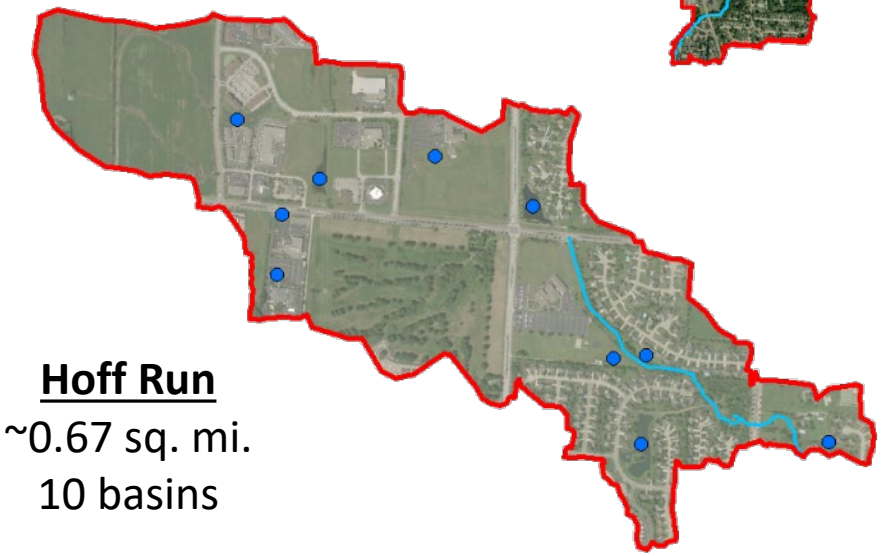
Watersheds We Work In



Dysart Run
~4.5 sq. mi.
61 basins

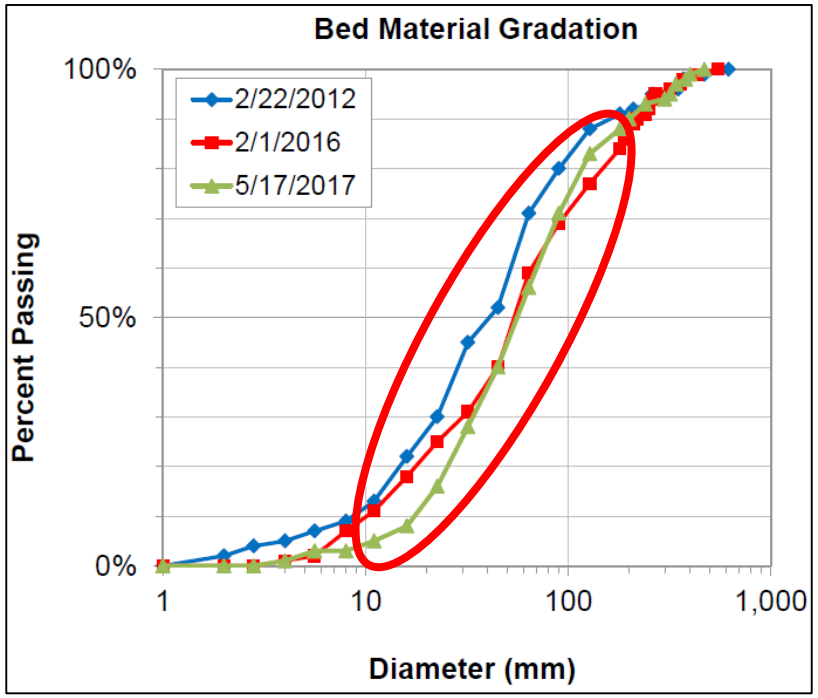
Northern Kentucky
~581 sq. mi.
1,570+ basins

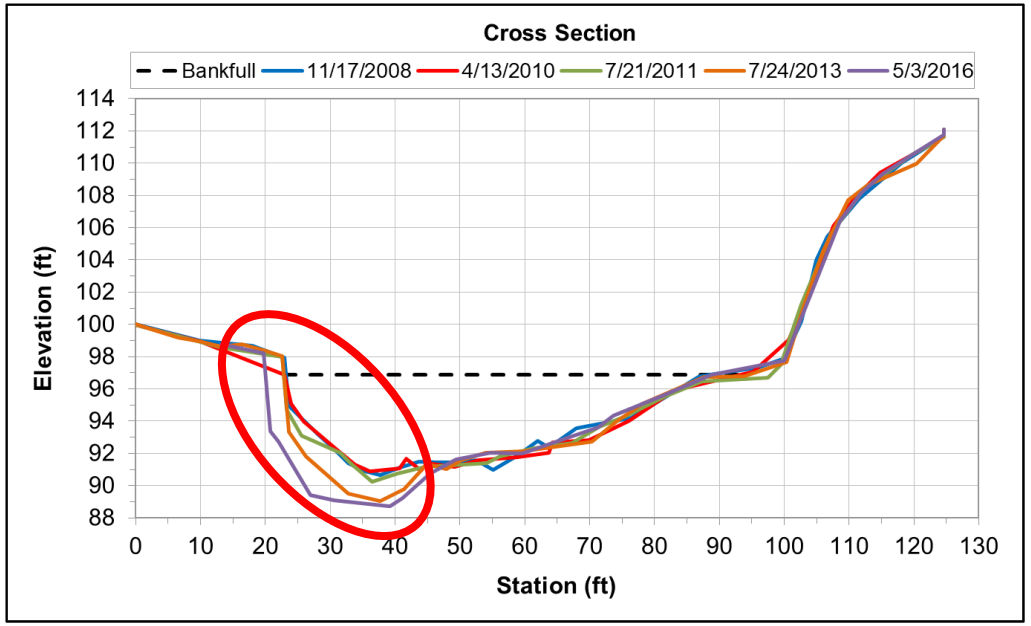


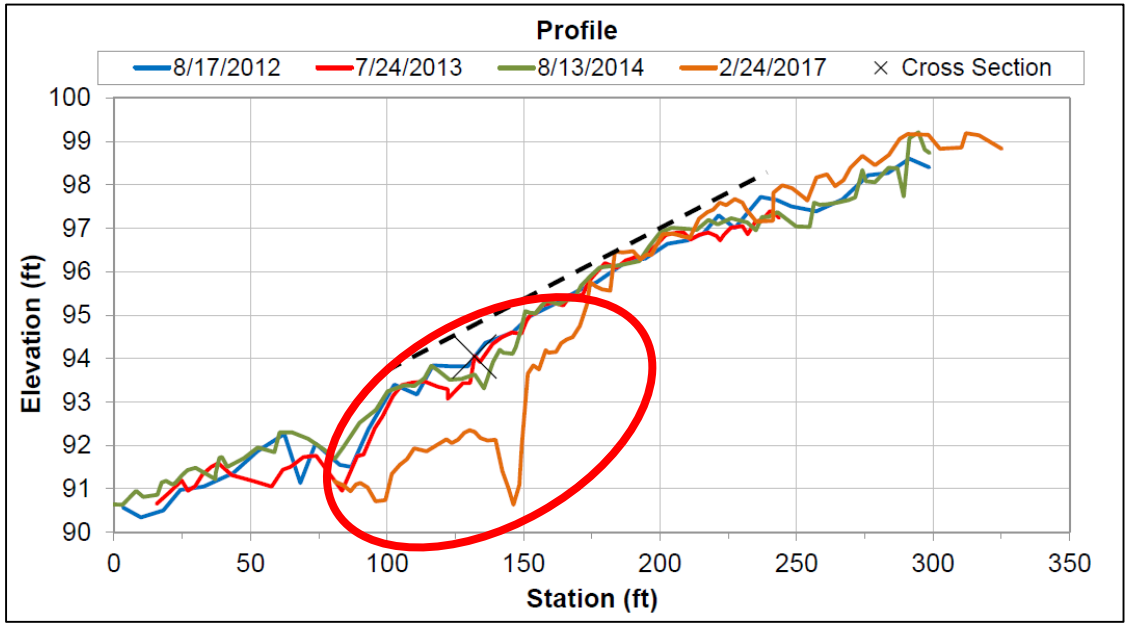


Hoff Run
~0.67 sq. mi.
10 basins

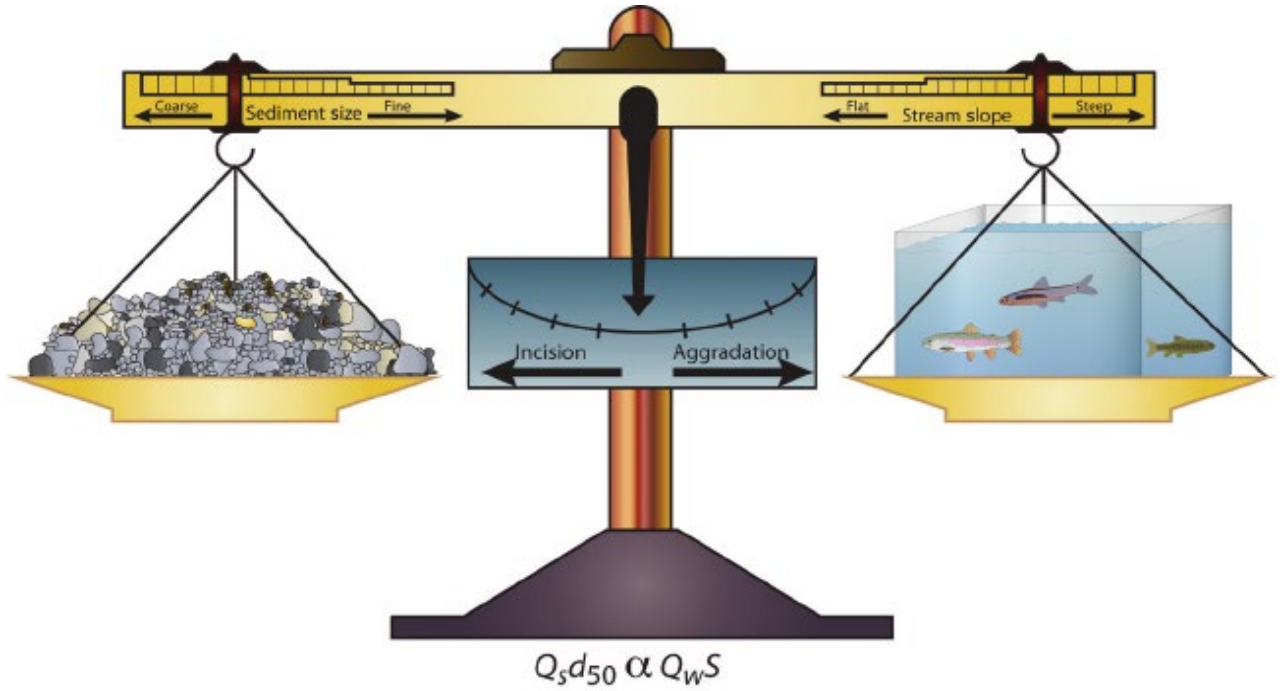
Watersheds We Work In



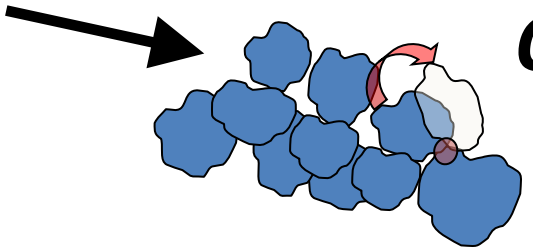




The Urban Flow Regime Increases Bed Material Mobility and Channel Instability



Adapted from Lane (1955). Figure from www.researchgate.net



$Q_{critical}$

- Biological
- Physicochemical
- Geomorphology
- Hydraulics
- Hydrologic

Adapted from Harman et al. 2012

Watershed BMPs to Restore Stream Hydrology

<u>Toyota North American Parts Center of Kentucky</u> – ***Hebron, KY***

- Simple detention basin retrofit

<u>Gateway Community & Technical College</u> – ***Florence, KY***

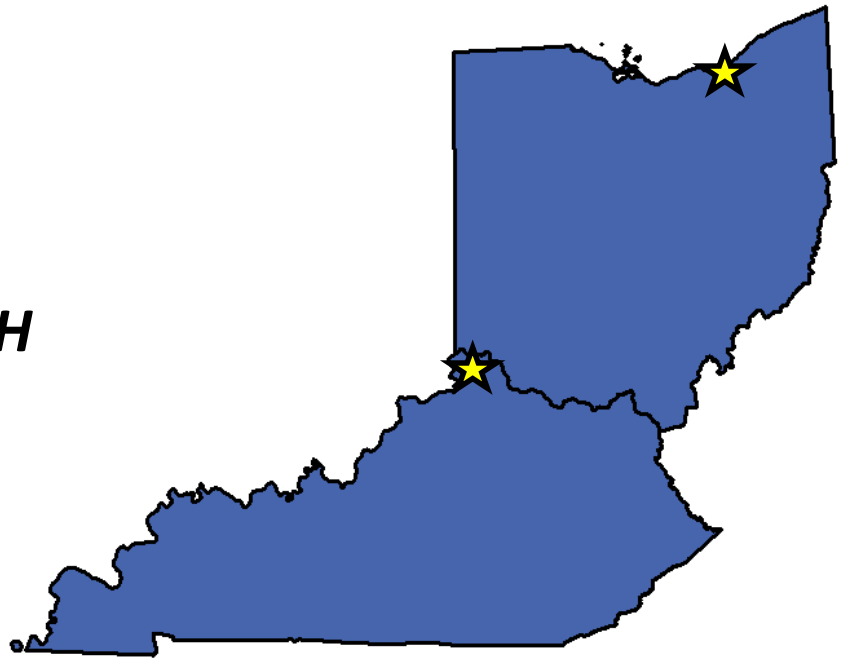
- Complex detention basin retrofit

<u>SPUI Intersection Improvements</u> – ***Burlington, KY***

- Bioretention basin design

<u>Acacia Reservation Improvements</u> – ***Lyndhurst, OH***

- Complex detention basin retrofit
- Stream daylighting



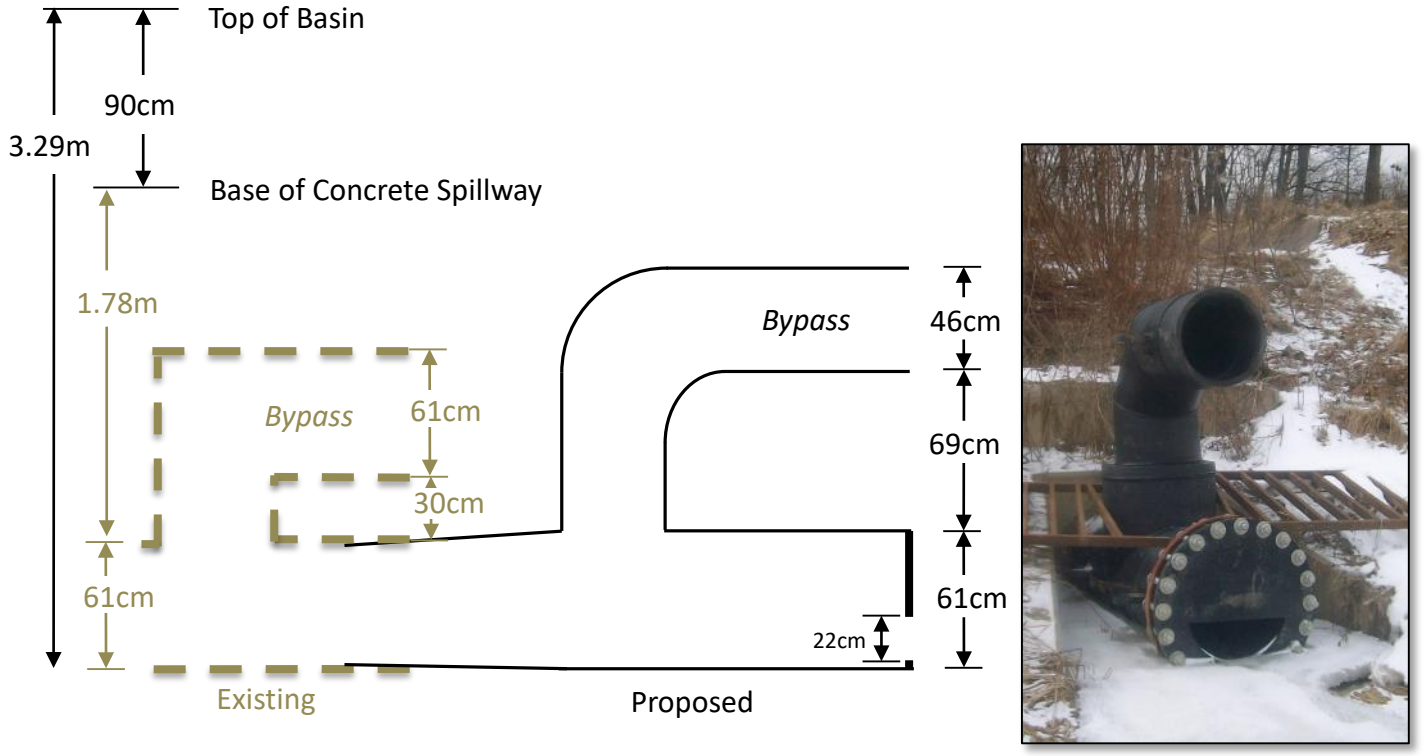
Simple Detention Basin Retrofit

Toyota North American Parts Center of Kentucky

Headwater stream with large impervious area

Simple Detention Basin Retrofit

Toyota North American Parts Center of Kentucky

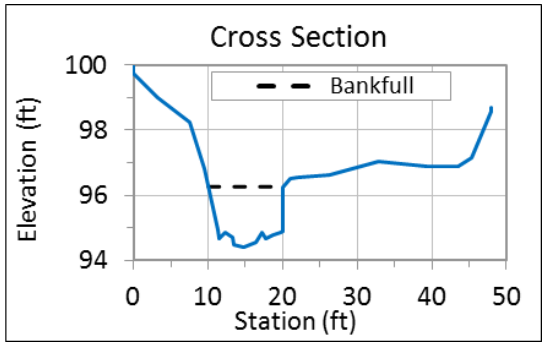


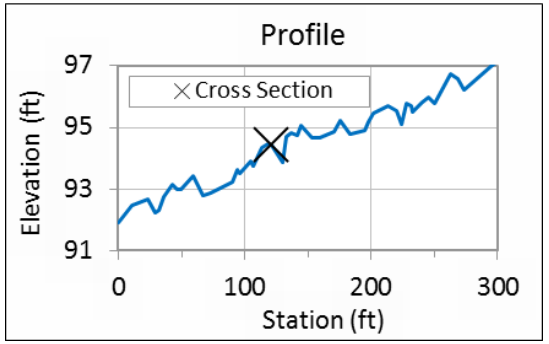
Adapted from Hawley et al. (2017)

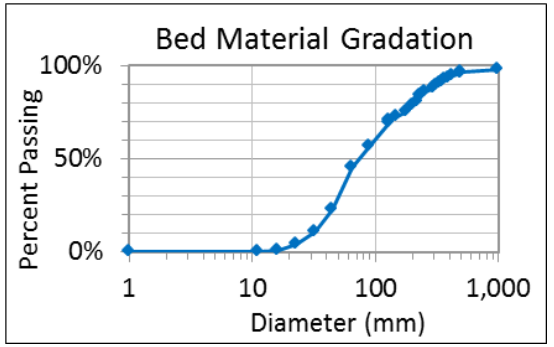
Sustainable Streams LLC
Science · Service · Solutions

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Retrofit Optimized to Reduce Downstream Erosion Based on Hydrogeomorphic Data







Retrofit Modeled for $Q_{critical}$ Benefits

- Maintain Flood Control
- Reduce frequency of discharges > $Q_{critical}$

TABLE 1. Modeled Peak Discharges (m^3/s) for the Respective 24-h Design Storms Predict that the Retrofit Device Reduces the Three-Month, Six-Month, and One-Year Storms Such That They no Longer Exceed the $Q_{critical}$ Design Target[1].

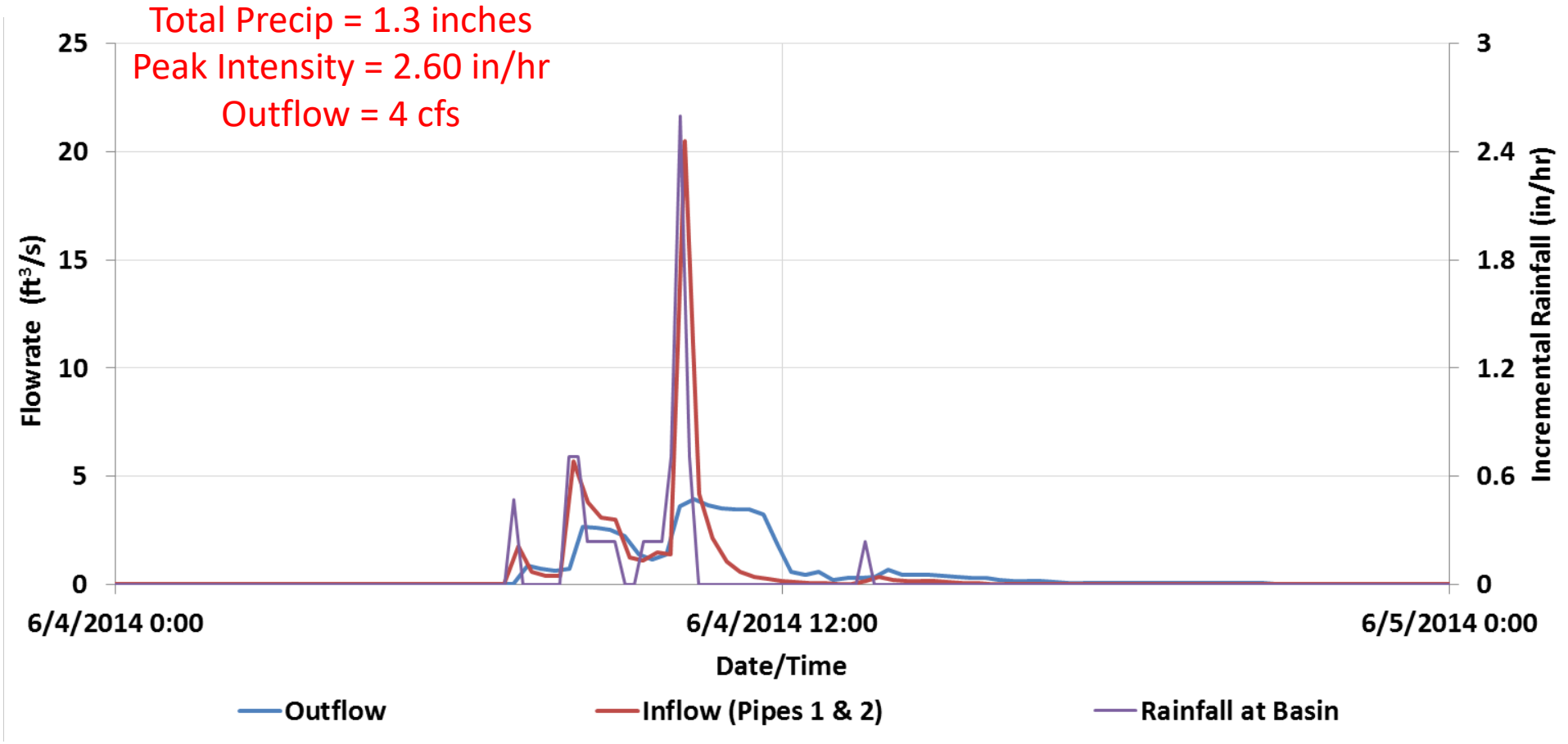
Return Period	Predeveloped Conditions	Postdeveloped Conditions		
		Detention Basin Inflow	Preretrofit Outflow	Postretrofit Outflow
3-Month	0.14	0.88	**0.43**	**0.19**
6-Month	0.34	1.26	**0.51**	**0.22**
1-year	0.63	1.69	**0.60**	**0.25**
2-year	0.95	2.12	0.67	0.47
10-year	1.93	3.28	1.00	0.91
25-year	2.58	3.97	1.22	1.11
50-year	3.10	4.52	1.37	1.25
100-year	3.67	5.10	1.50	1.40

[1] $Q_{critical}$ estimated as 0.38 m^3/s (40% of the predeveloped two-year flow).

Adapted from Hawley et al. (2017)

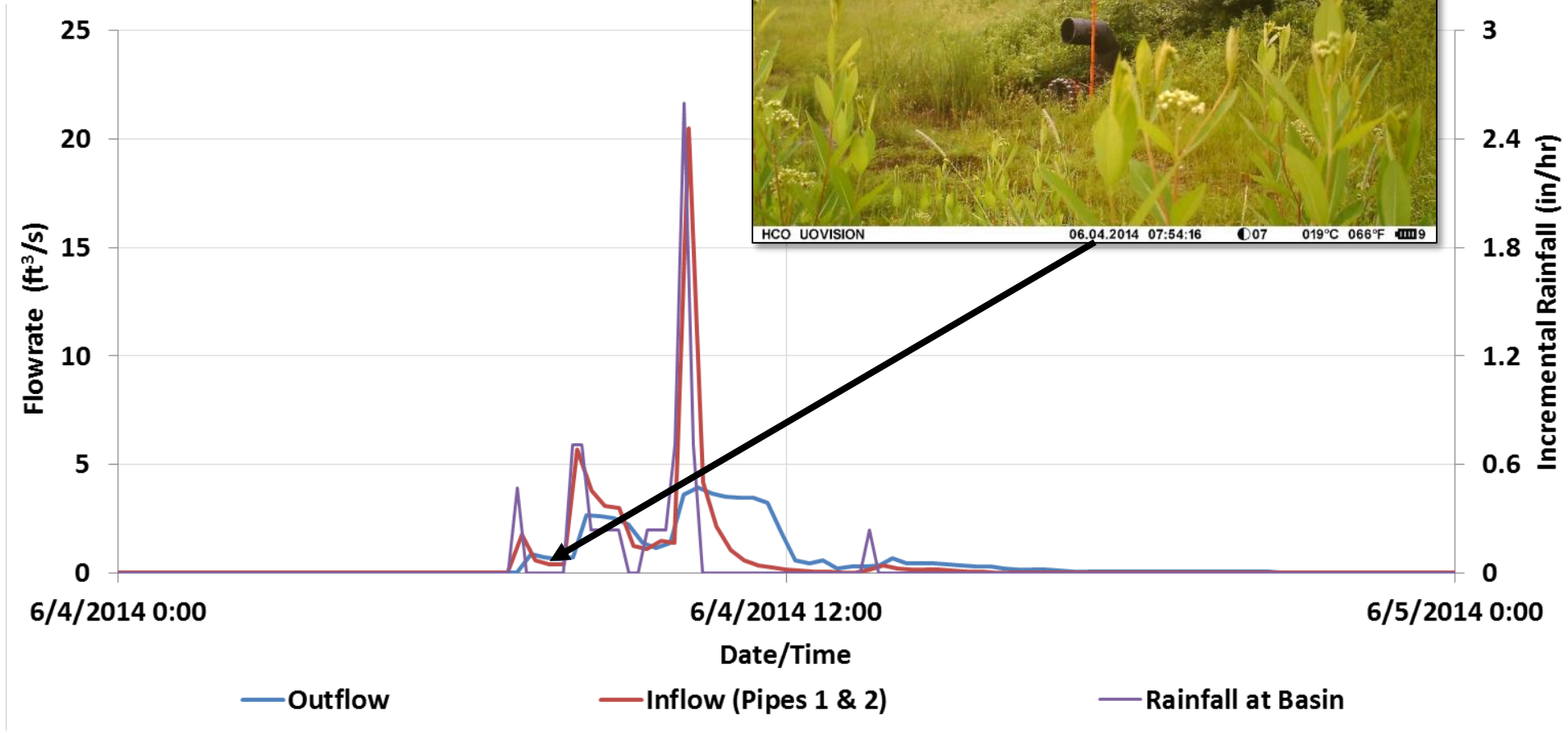
Detention Basin Retrofit

Post-retrofit Monitoring



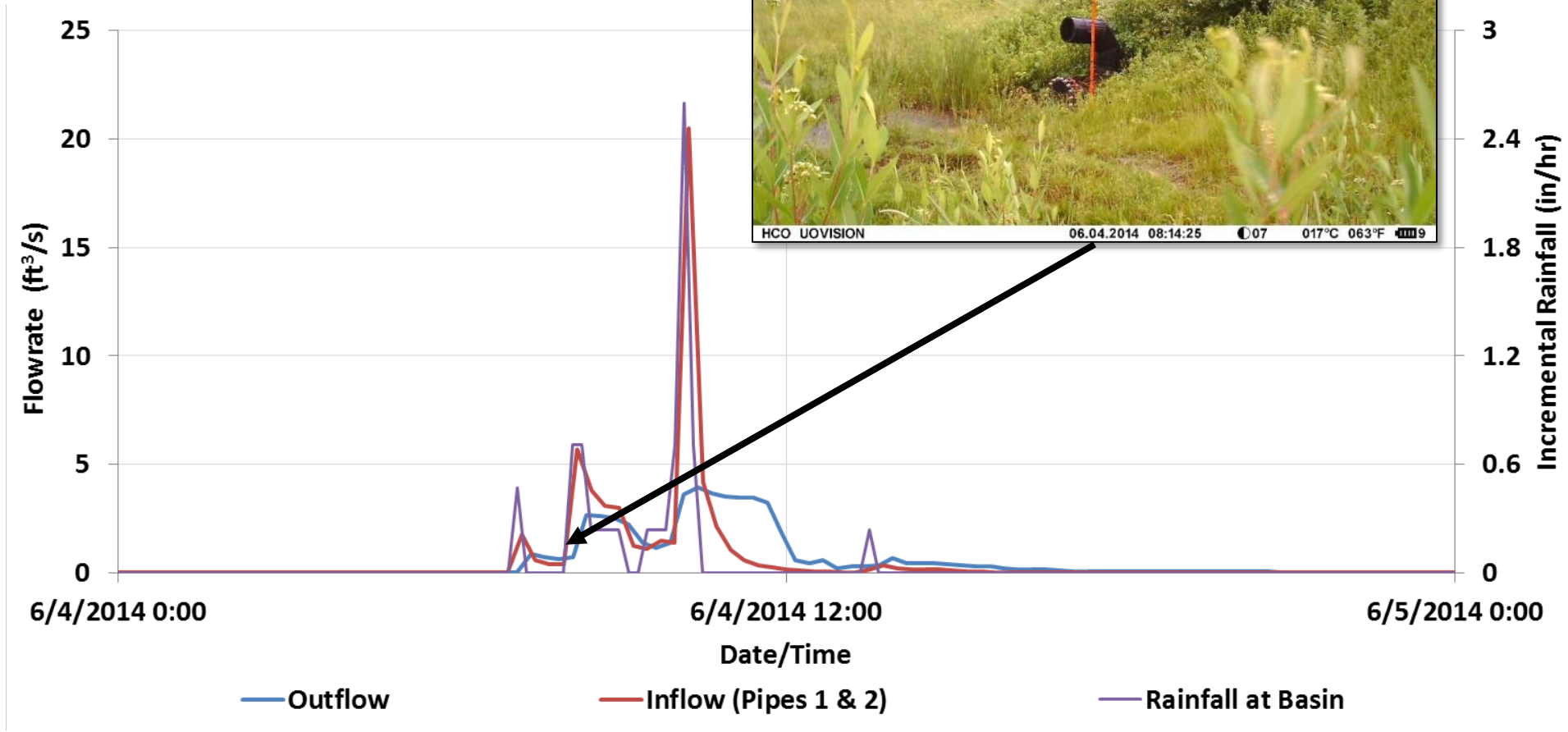
Adapted from Hawley et al. (2017)

Post-retrofit



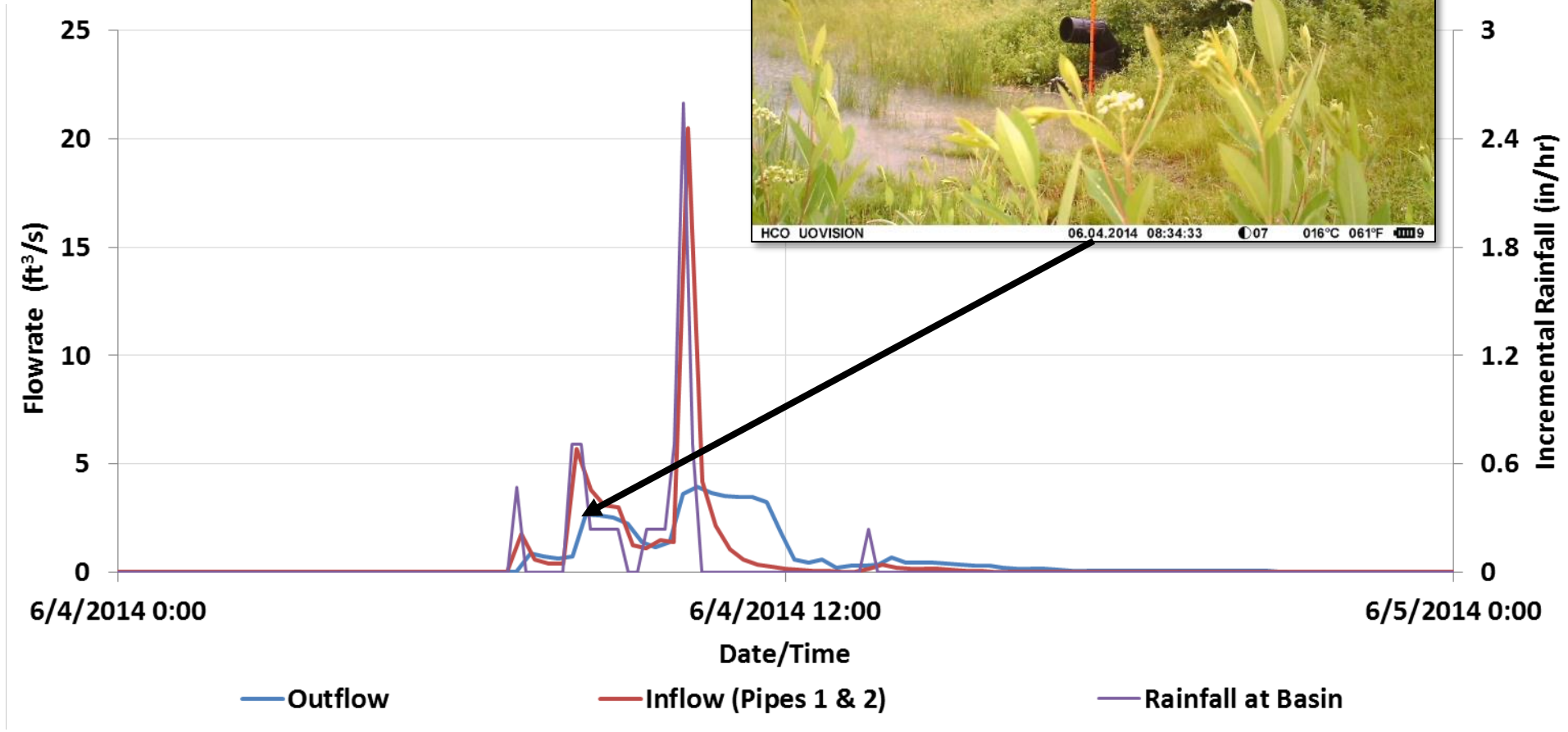
Adapted from Hawley et al. (2017)

Post-retrofit



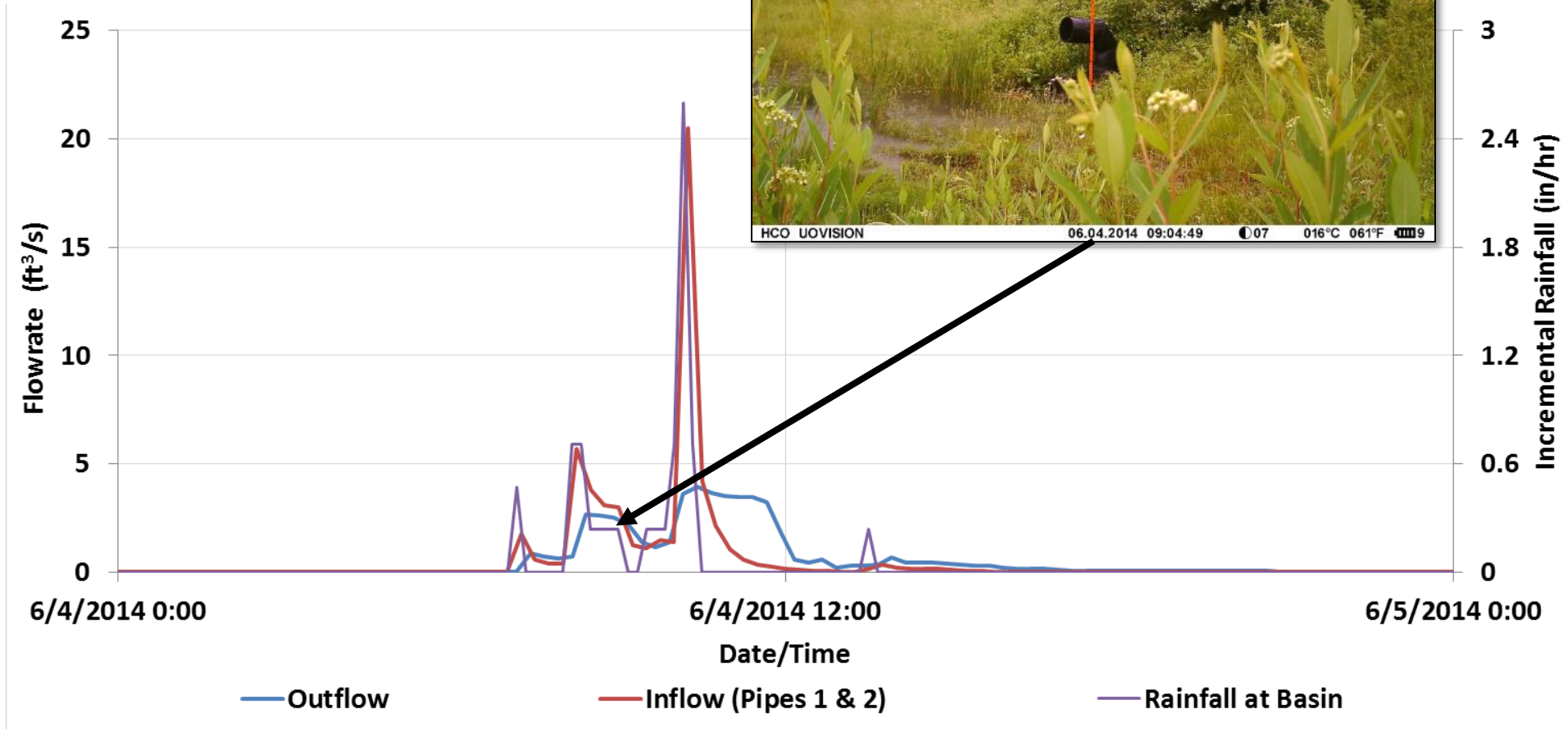
Adapted from Hawley et al. (2017)

Post-retrofit



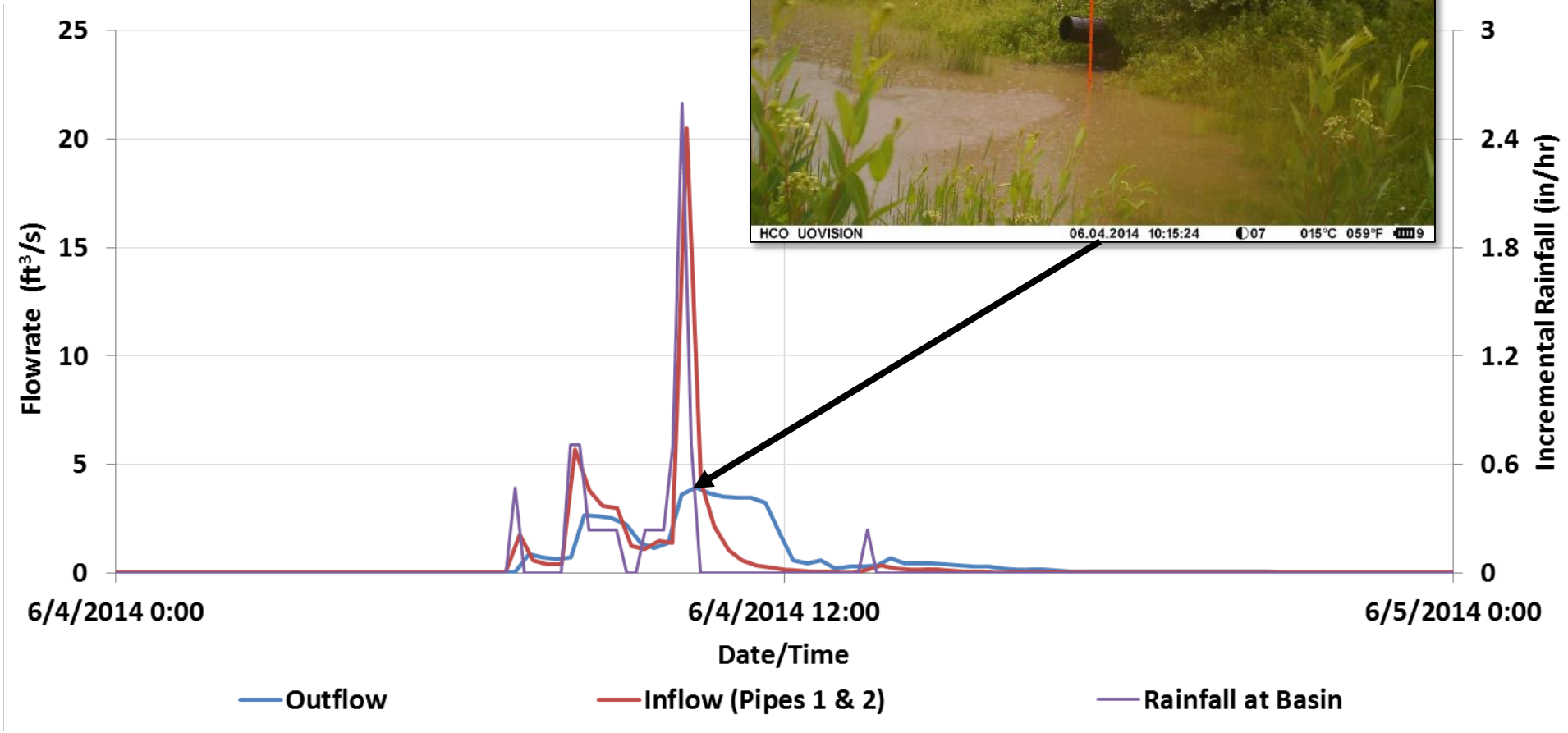
Adapted from Hawley et al. (2017)

Post-retrofit



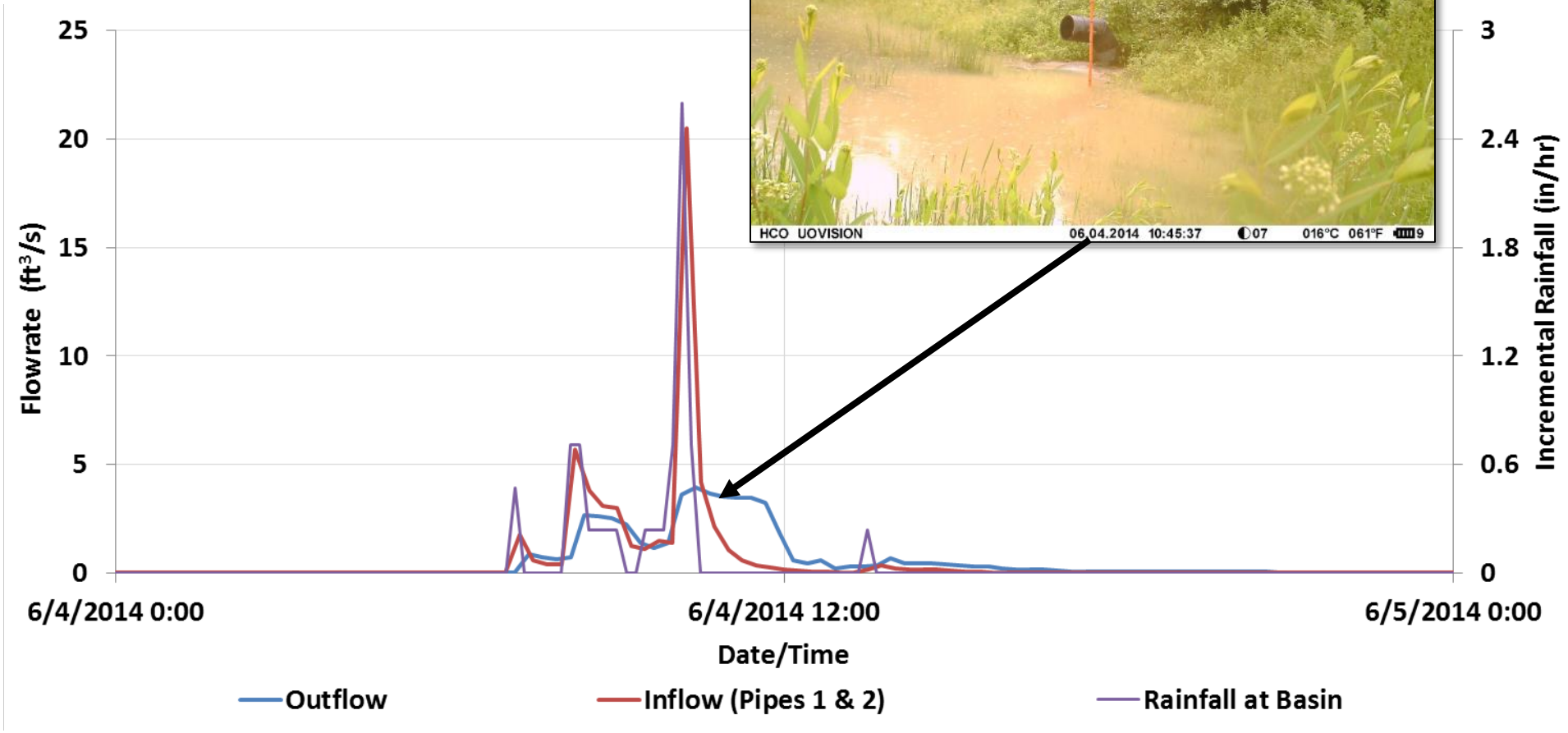
Adapted from Hawley et al. (2017)

Post-retrofit



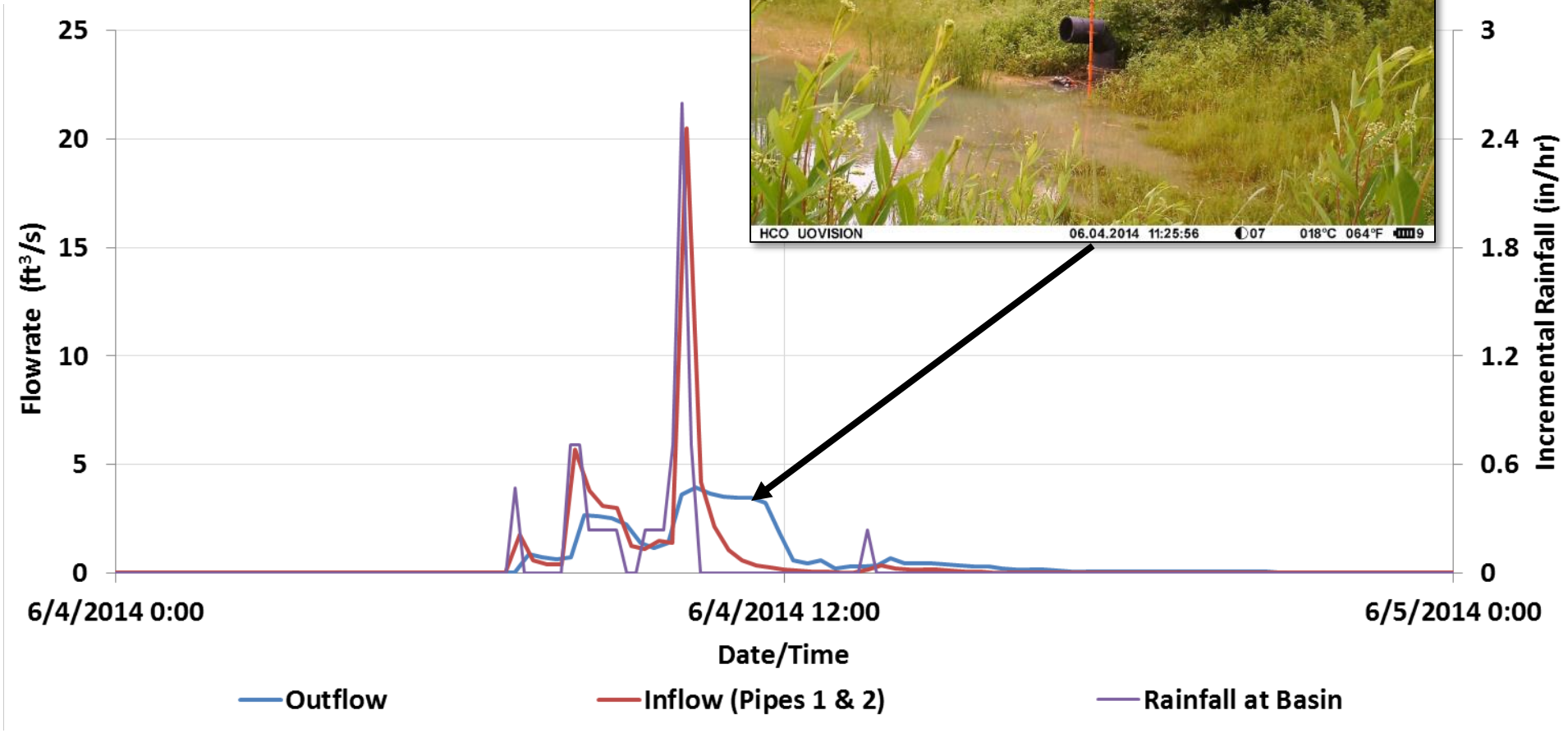
Adapted from Hawley et al. (2017)

Post-retrofit



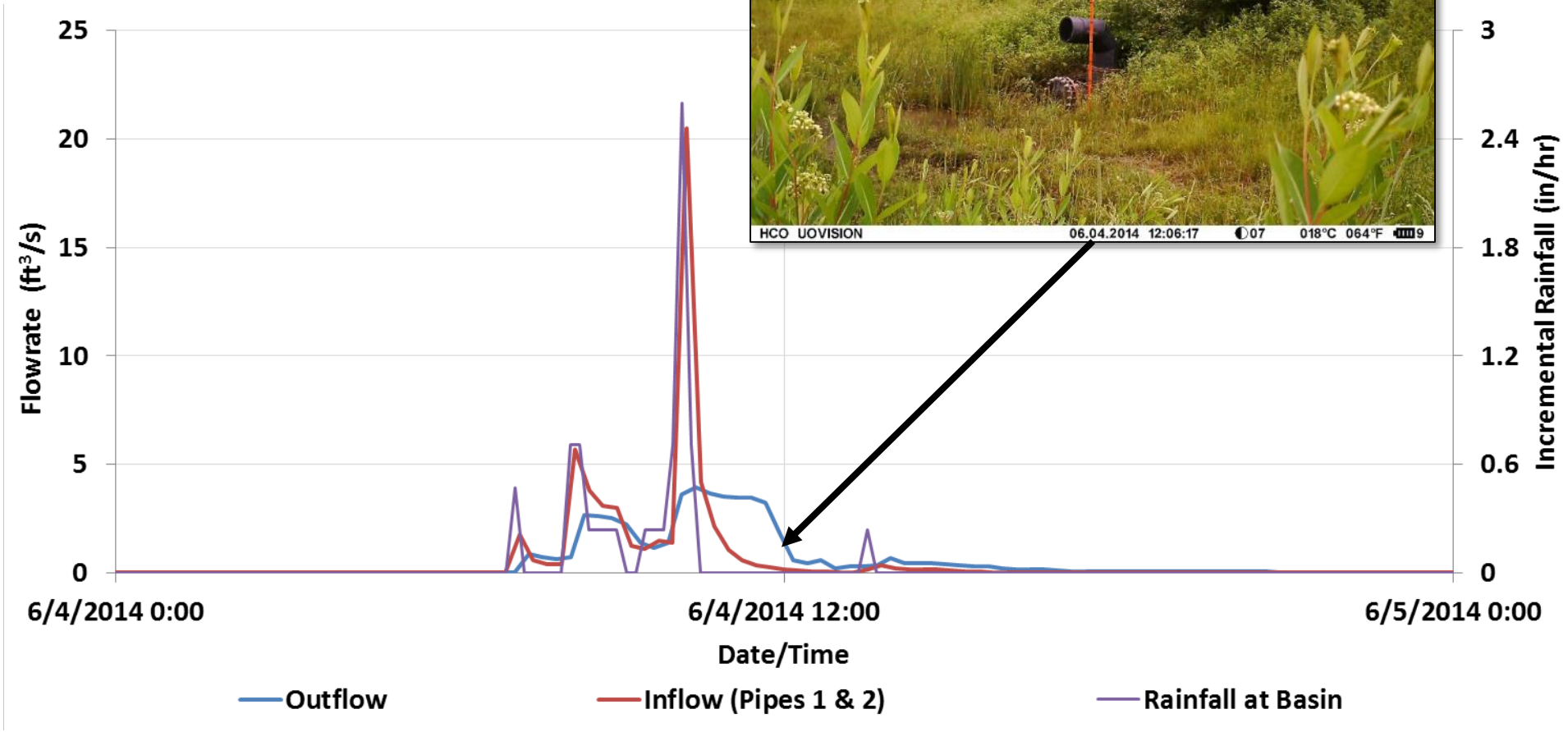
Adapted from Hawley et al. (2017)

Post-retrofit



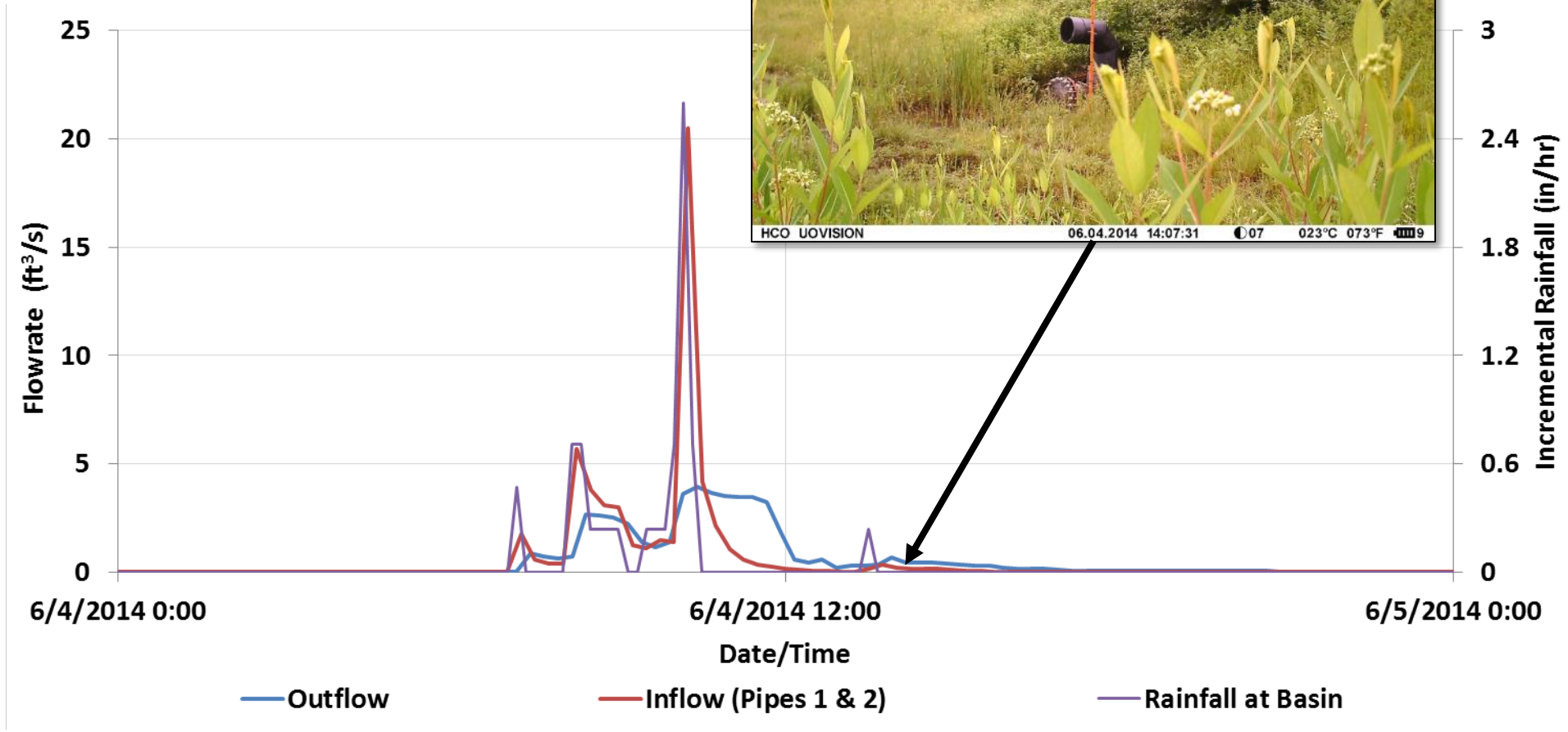
Adapted from Hawley et al. (2017)

Post-retrofit



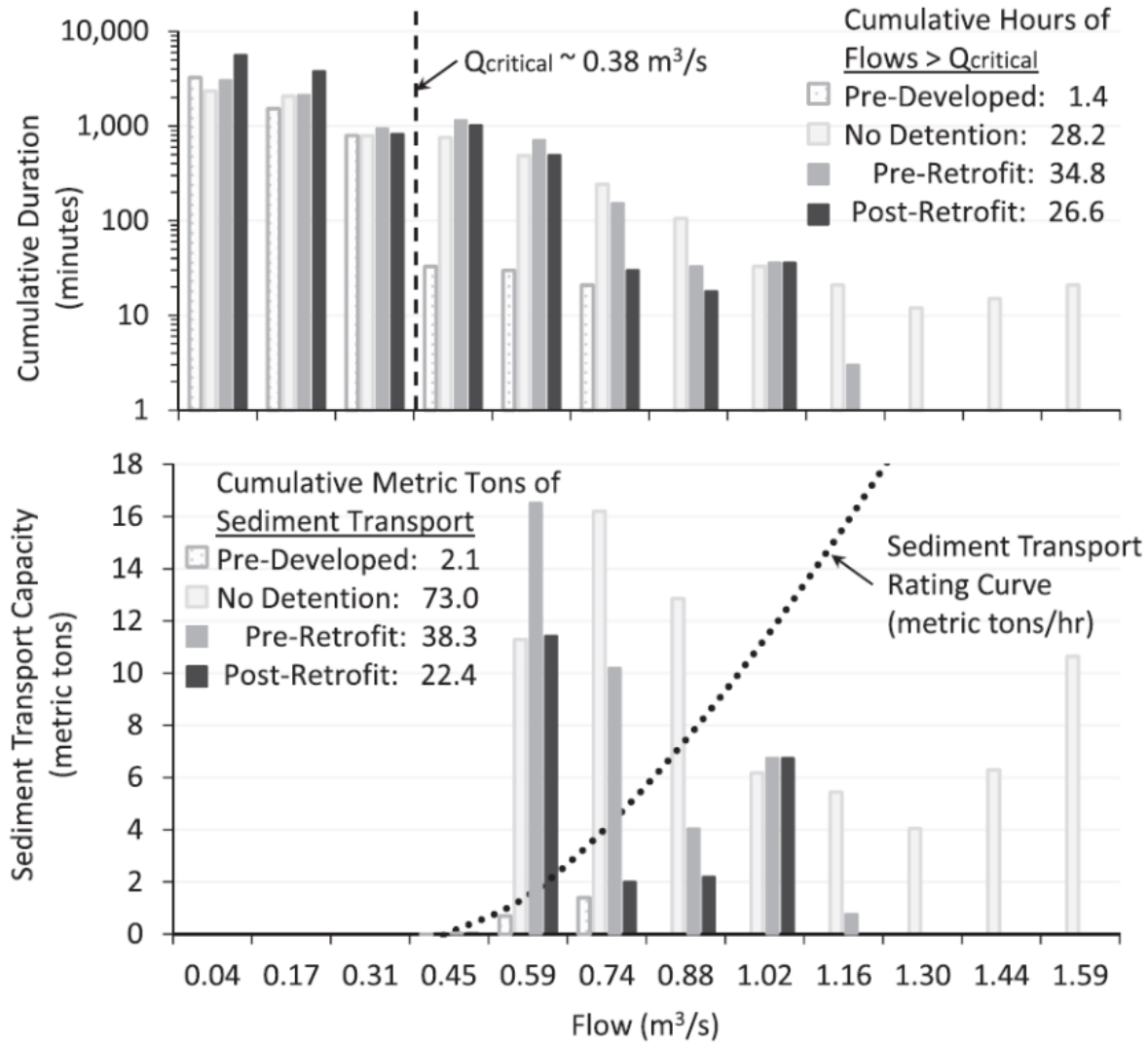
Adapted from Hawley et al. (2017)

Post-retrofit

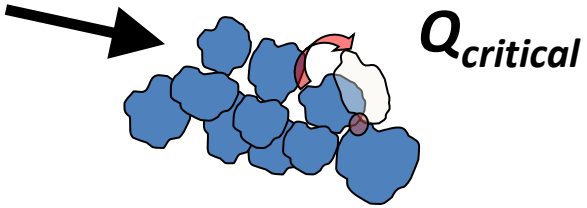


Adapted from Hawley et al. (2017)

Reduced Erosive Power



Adapted from Hawley et al. (2017)



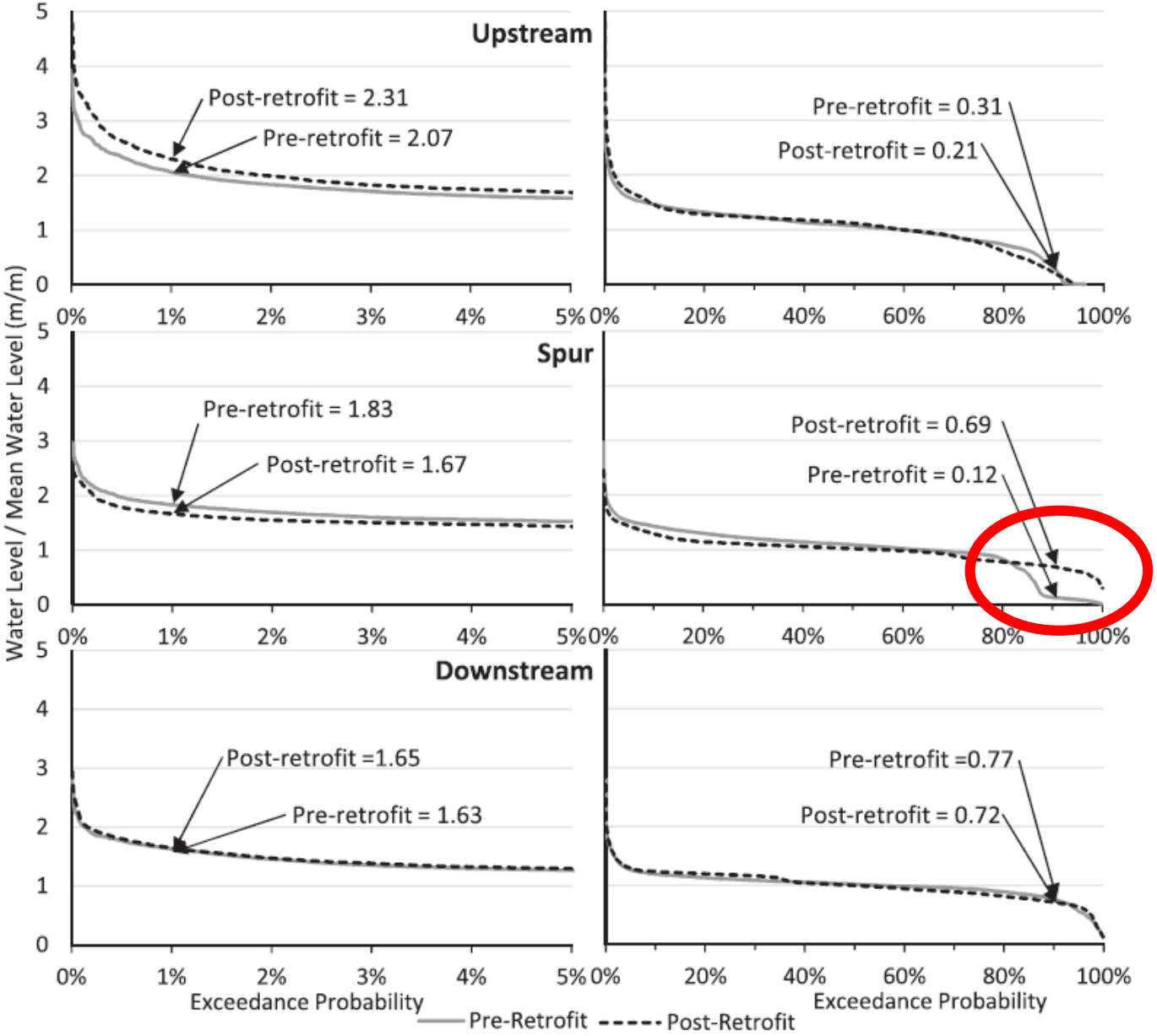
Reduces the sediment transport capacity by >40%

Monitoring Documents Improvements in the Stream

- Toyota Pond Pipe Flow
  - Inflow 1
  - Inflow 2
  - Outflow
- Precipitation
  - Site Rain Gage
  - NWS Gage (Northern Kentucky/Cincinnati Airport)
- Off-site Stream Flow & Hydrogeomorphic Surveys
  - Spur
  - Upstream
  - Downstream

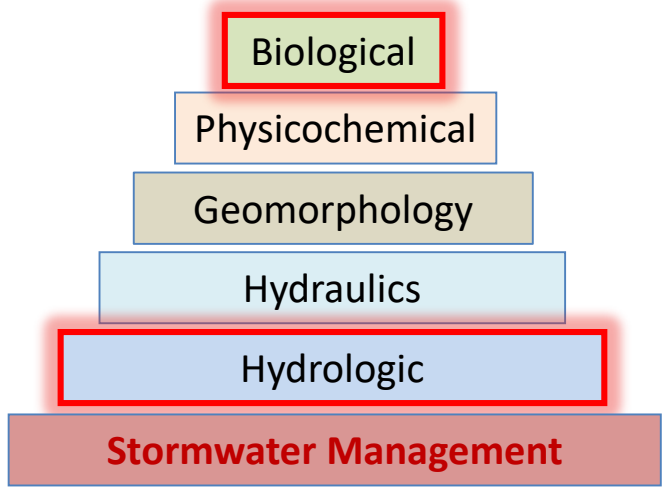
Adapted from Hawley et al. (2017)

Restoration of both High and Low Flows



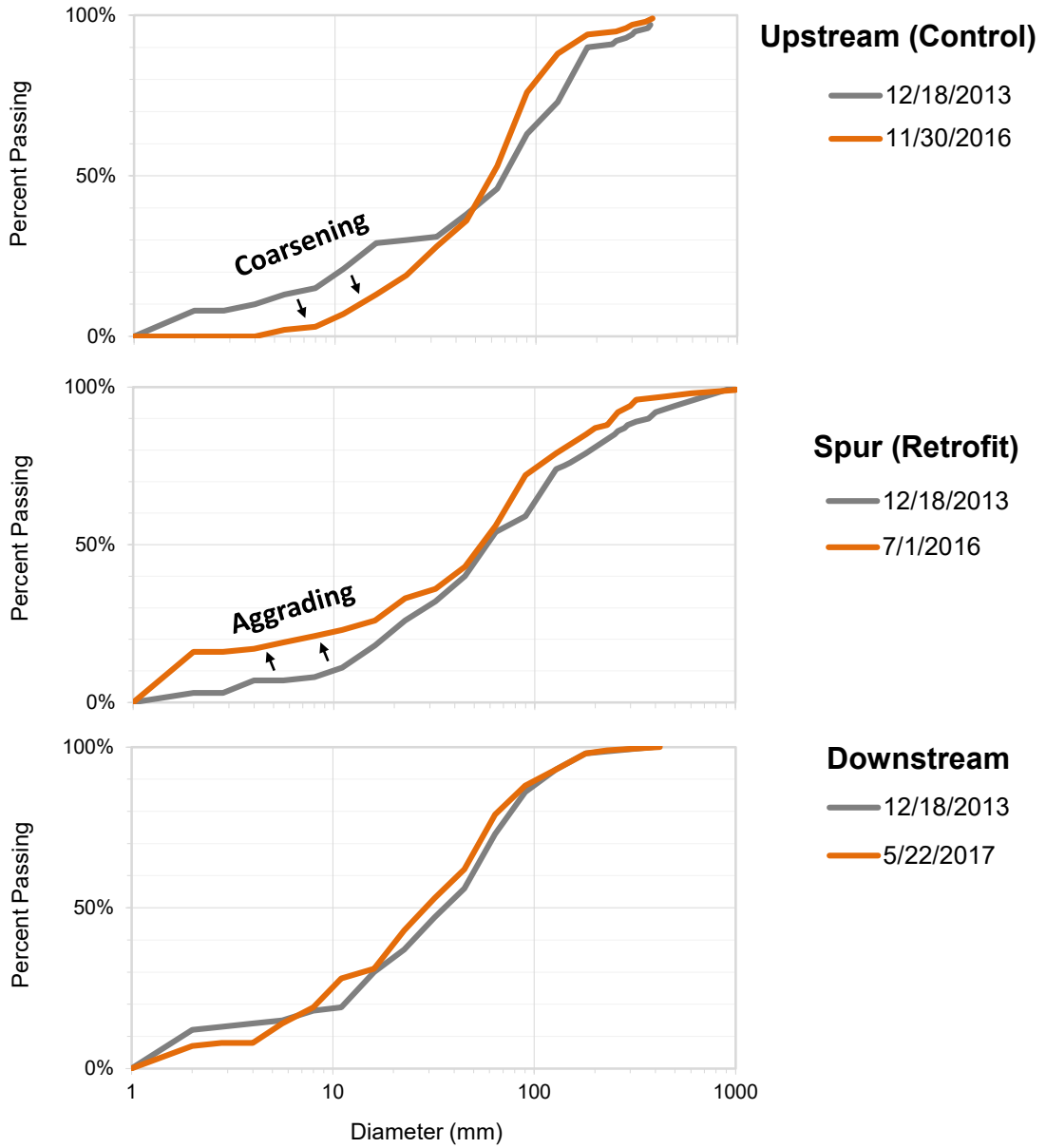
Adapted from Hawley et al. (2017)

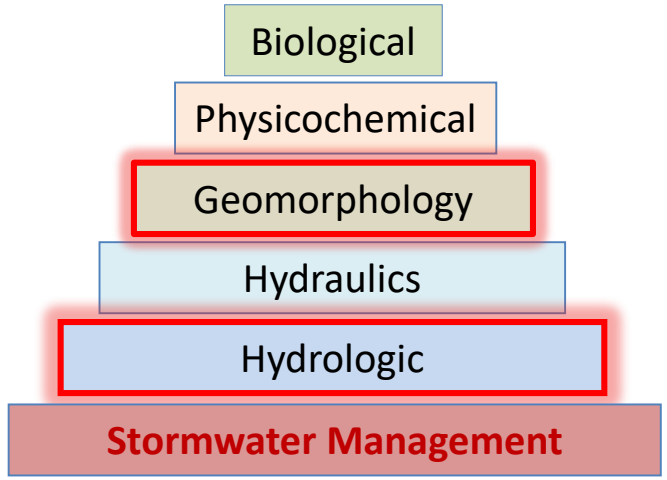
Restoration of Baseflows Supports Ecological “Lift”



~Dozen native minnows in 1st pool immediately downstream of the outfall on 9/16/16 (2 circled). Flow was evident coming out of the basin despite the dry/hot week

Restricted High Flows Reduces Streambed Erosion





Complex Detention Basin Retrofit

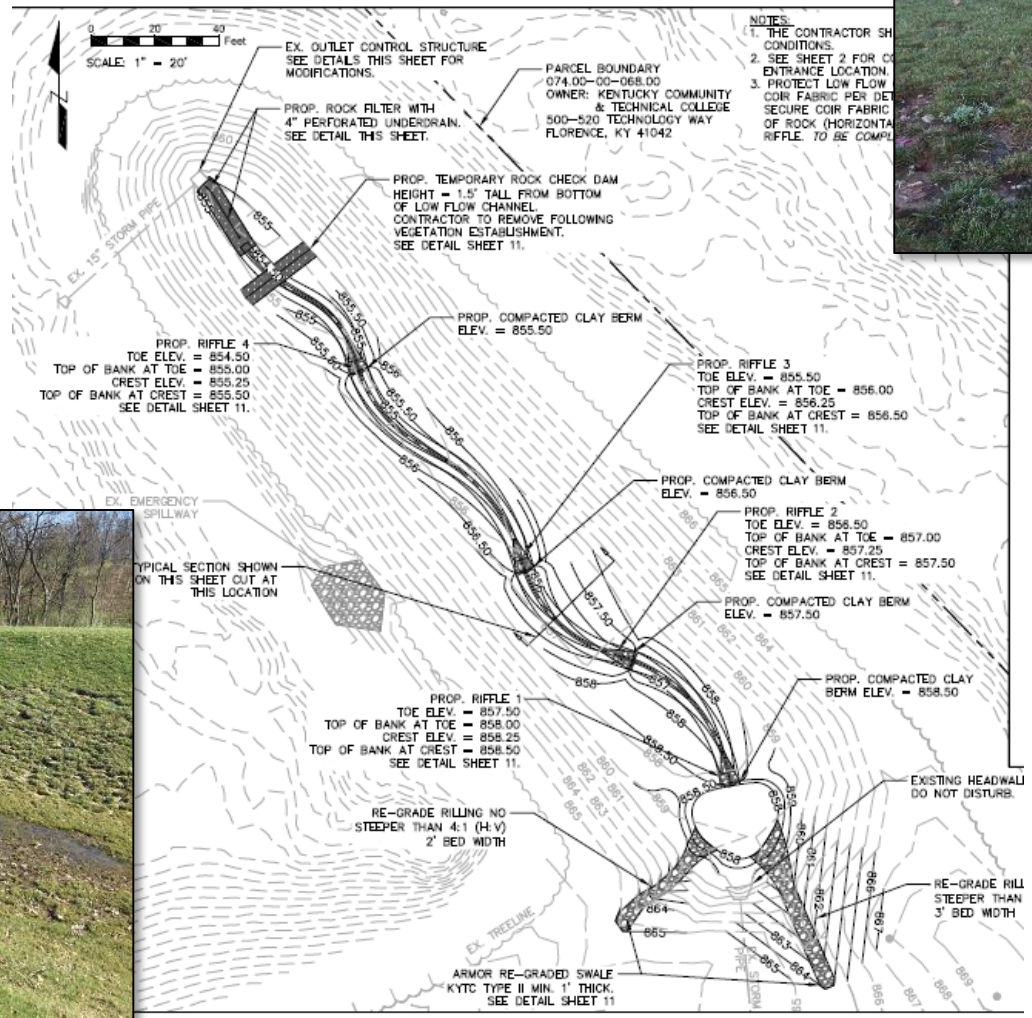
Gateway Community & Technical College

2016 303(d) List

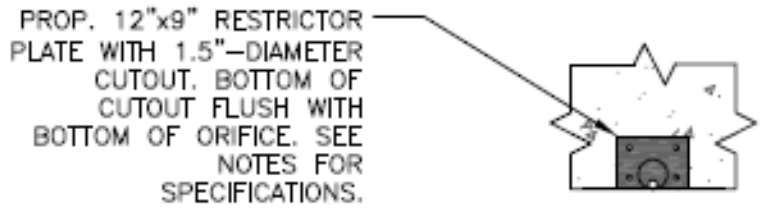
- **Sedimentation/siltation**
- **Turbidity**
- Organic enrichment (sewage) biological indicators
- Nutrient/eutrophication biological indicators
- *E.coli*

Complex Detention Basin Retrofit

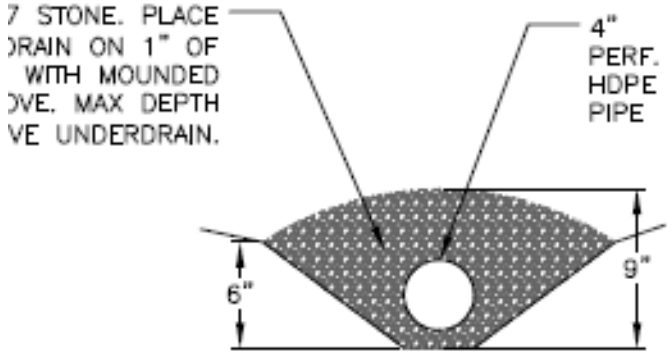
Gateway Community & Technical College



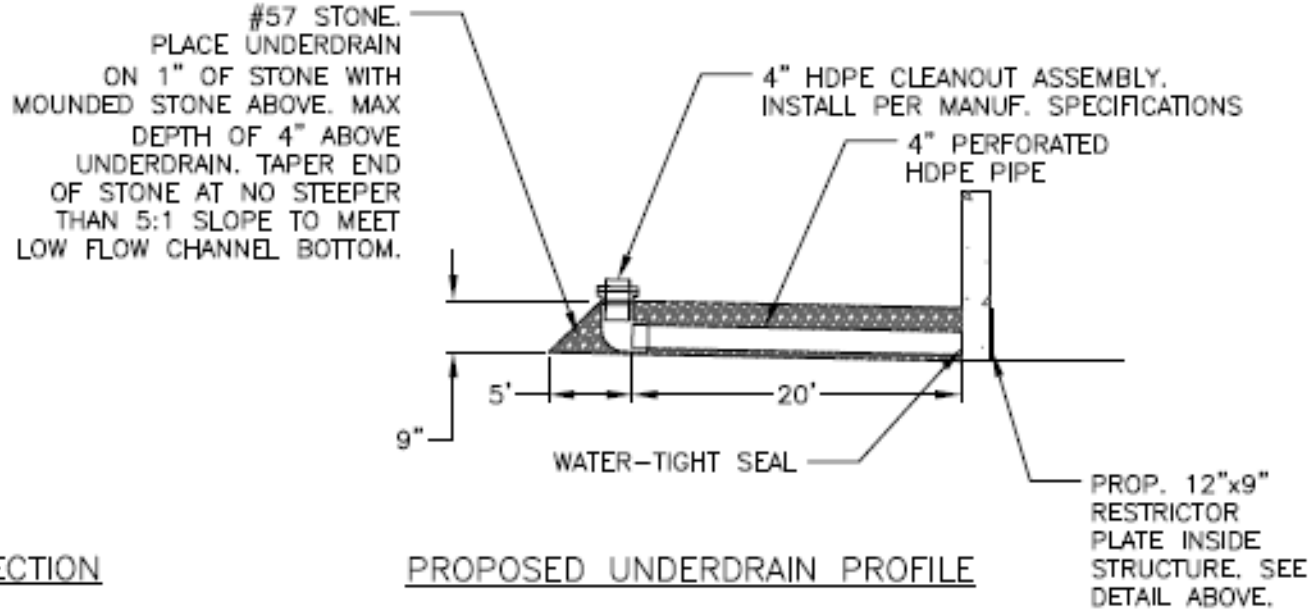
Removable Retrofits Allow for Post-construction Modifications



PROPOSED INTERIOR OF OUTLET STRUCTURE FROM LOW FLOW PIPE

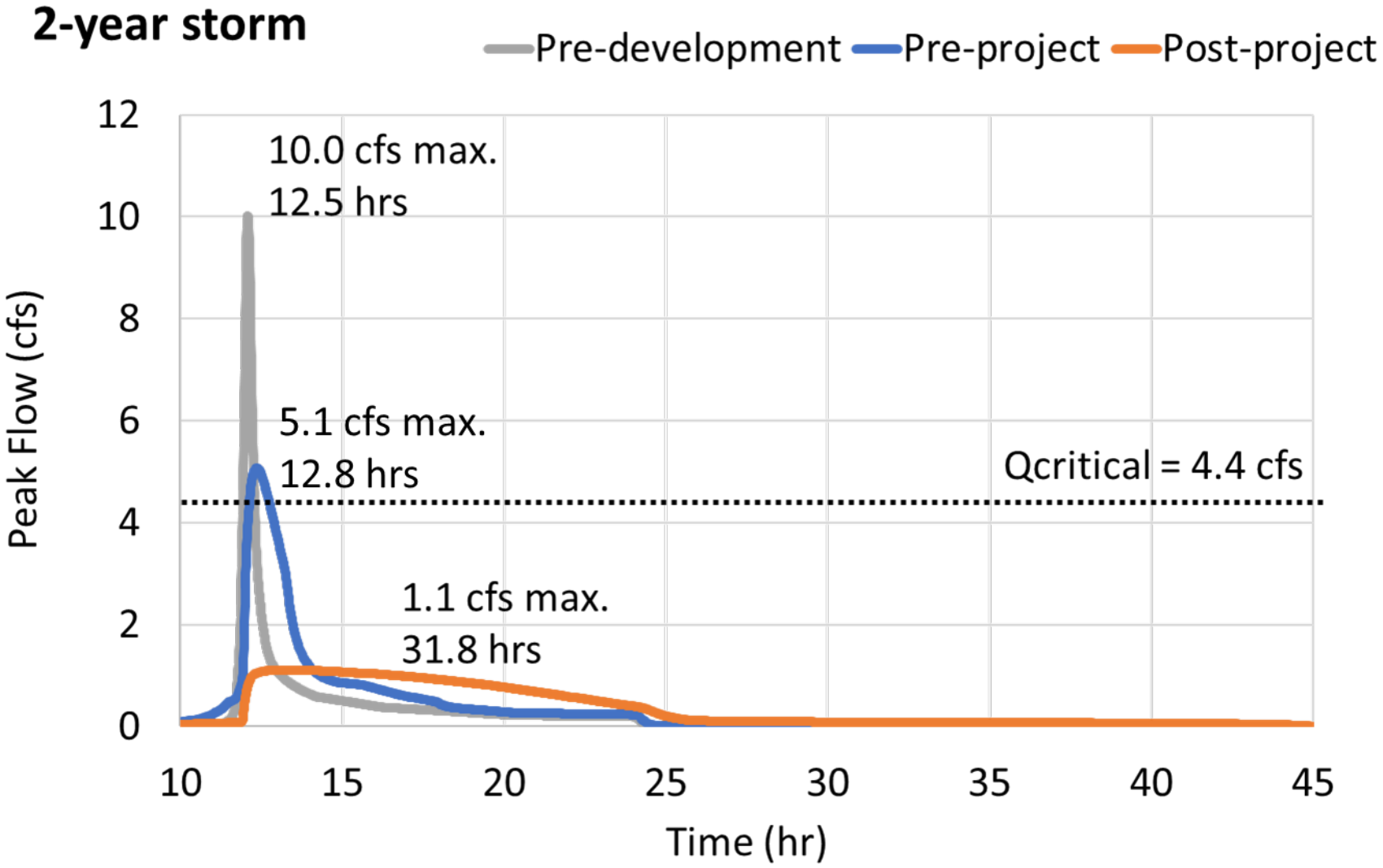


PROPOSED UNDERDRAIN CROSS SECTION



PROPOSED UNDERDRAIN PROFILE

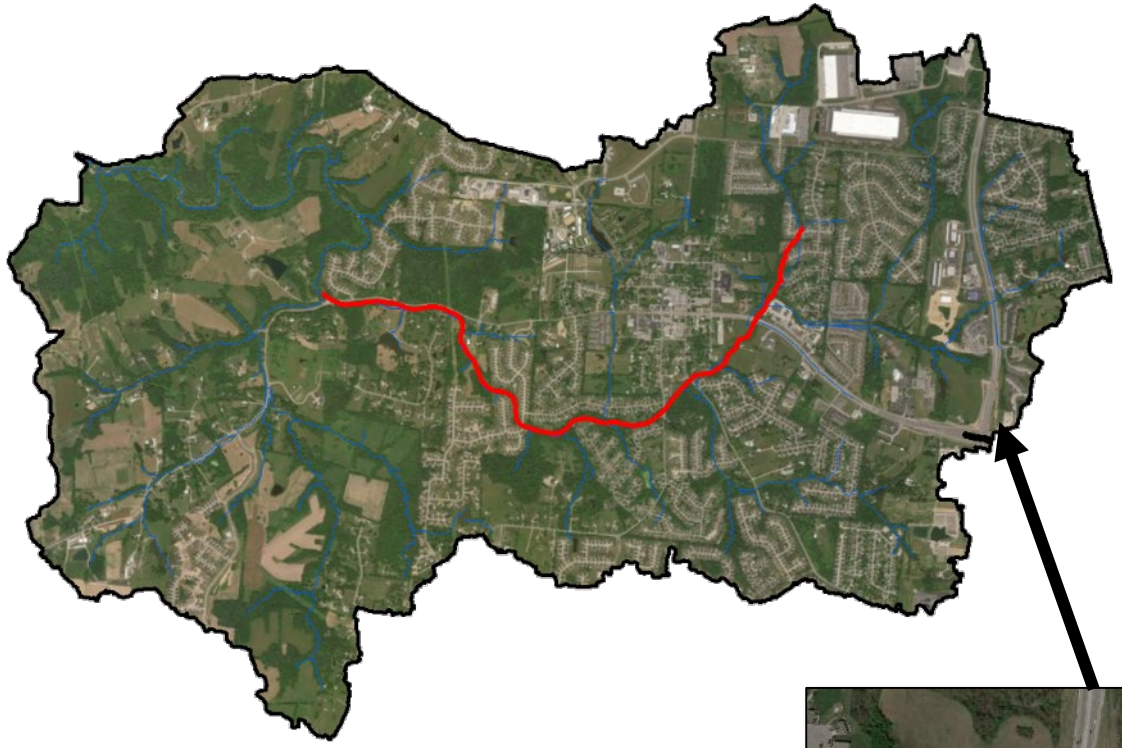
Modeling Shows Extended Flow Duration and Reduced Flashiness



Additional Improvements on Campus Increase Benefits and Education

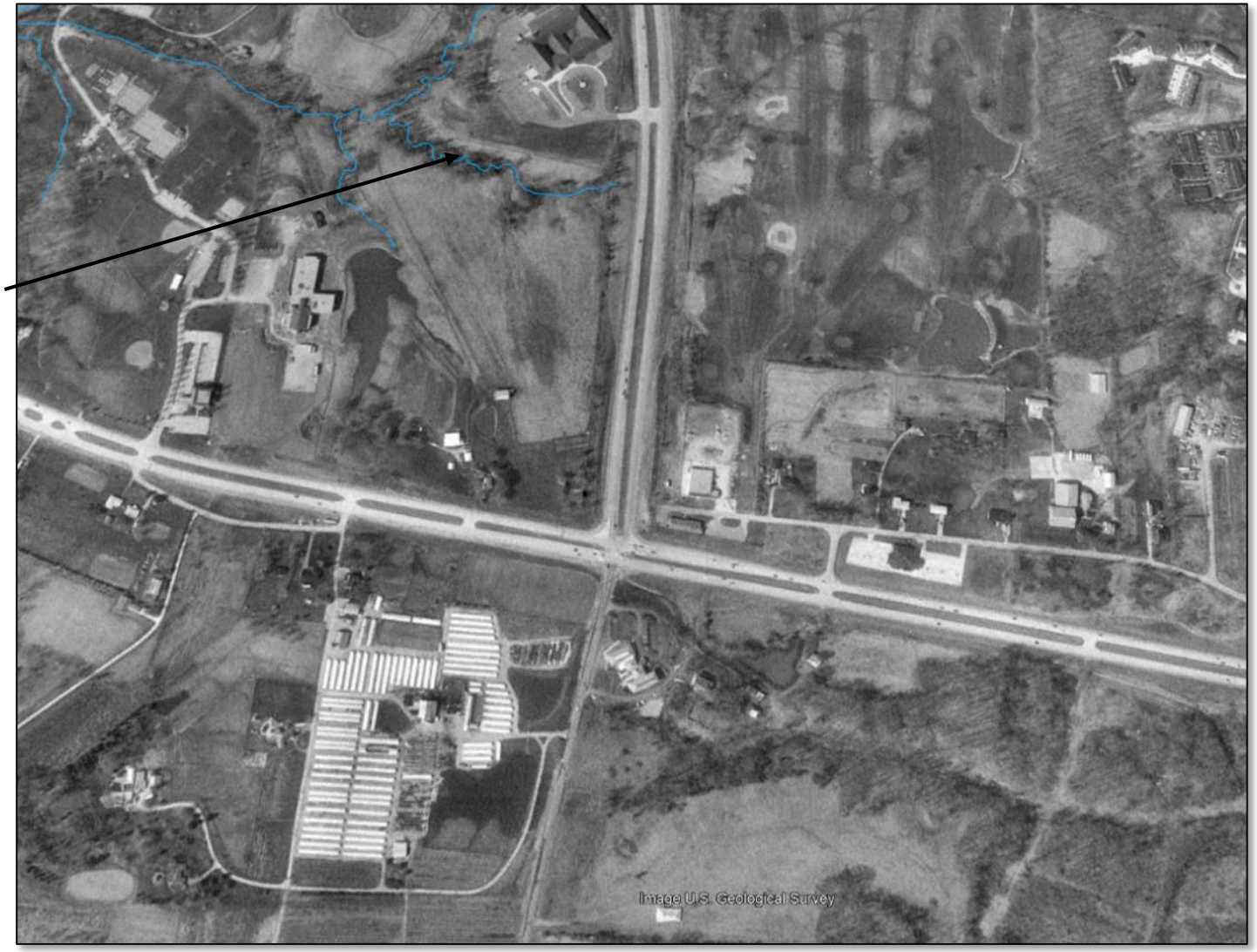
Bioretention Stream/Wetland Complex

SPUI Intersection Improvements



Bioretention Stream/Wetland Complex

SPUI Intersection Improvements



1993

Bioretention Stream/Wetland Complex

SPUI Intersection Improvements

2000

Bioretention Stream/Wetland Complex

SPUI Intersection Improvements

2010

Bioretention Stream/Wetland Complex

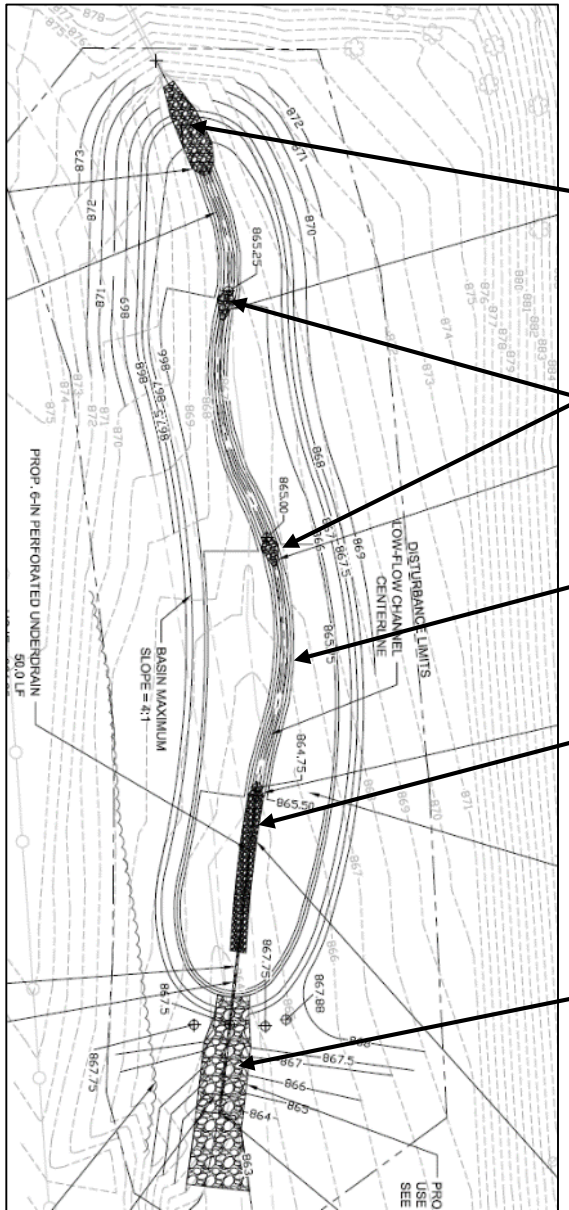
SPUI Intersection Improvements

Tributary to
Allen Fork

2017

Bioretention Stream/Wetland Complex

SPUI Intersection Improvements



Rock Inlet Protection

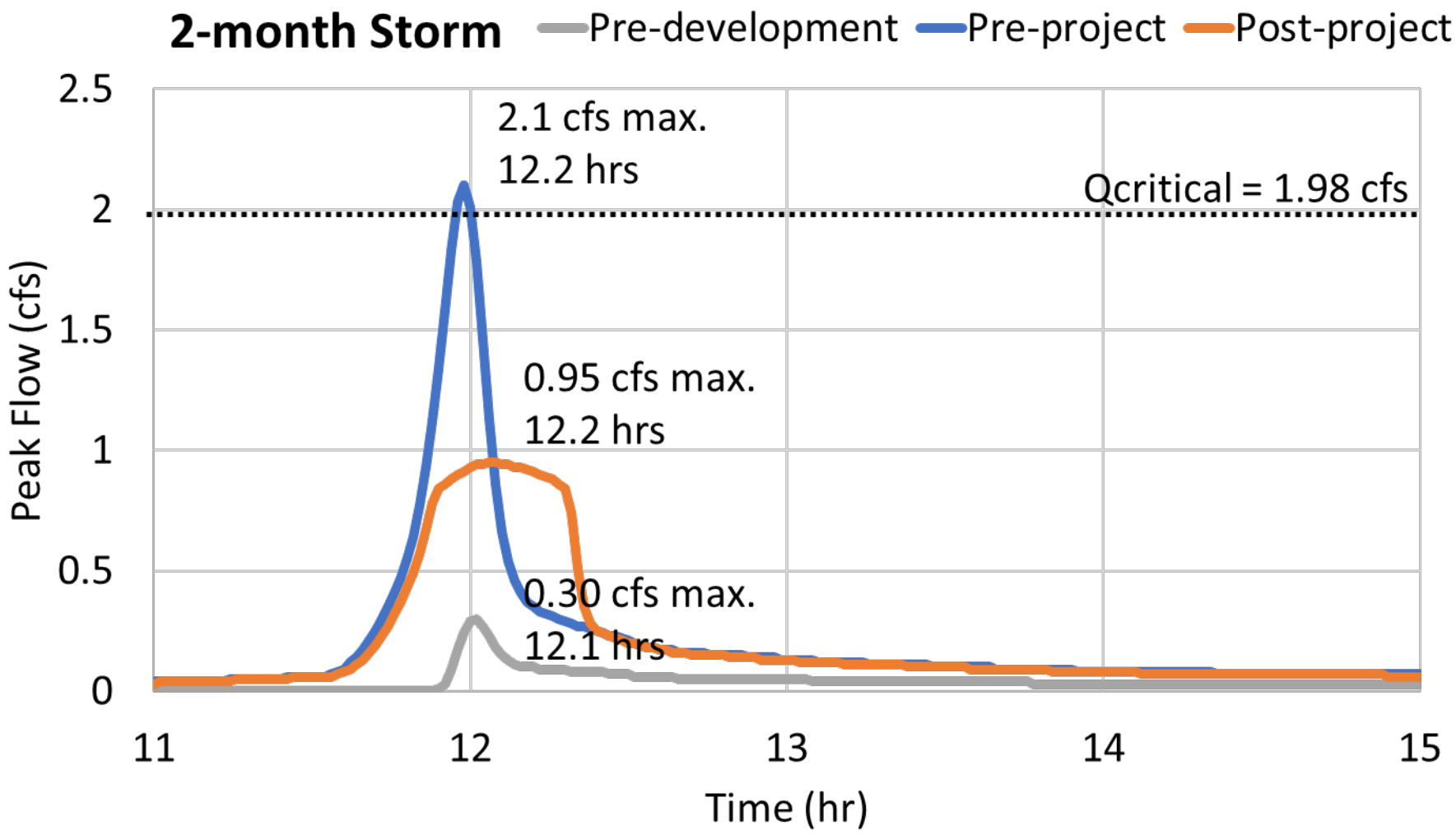
Rock Filtration Riffles

Low Flow Channel

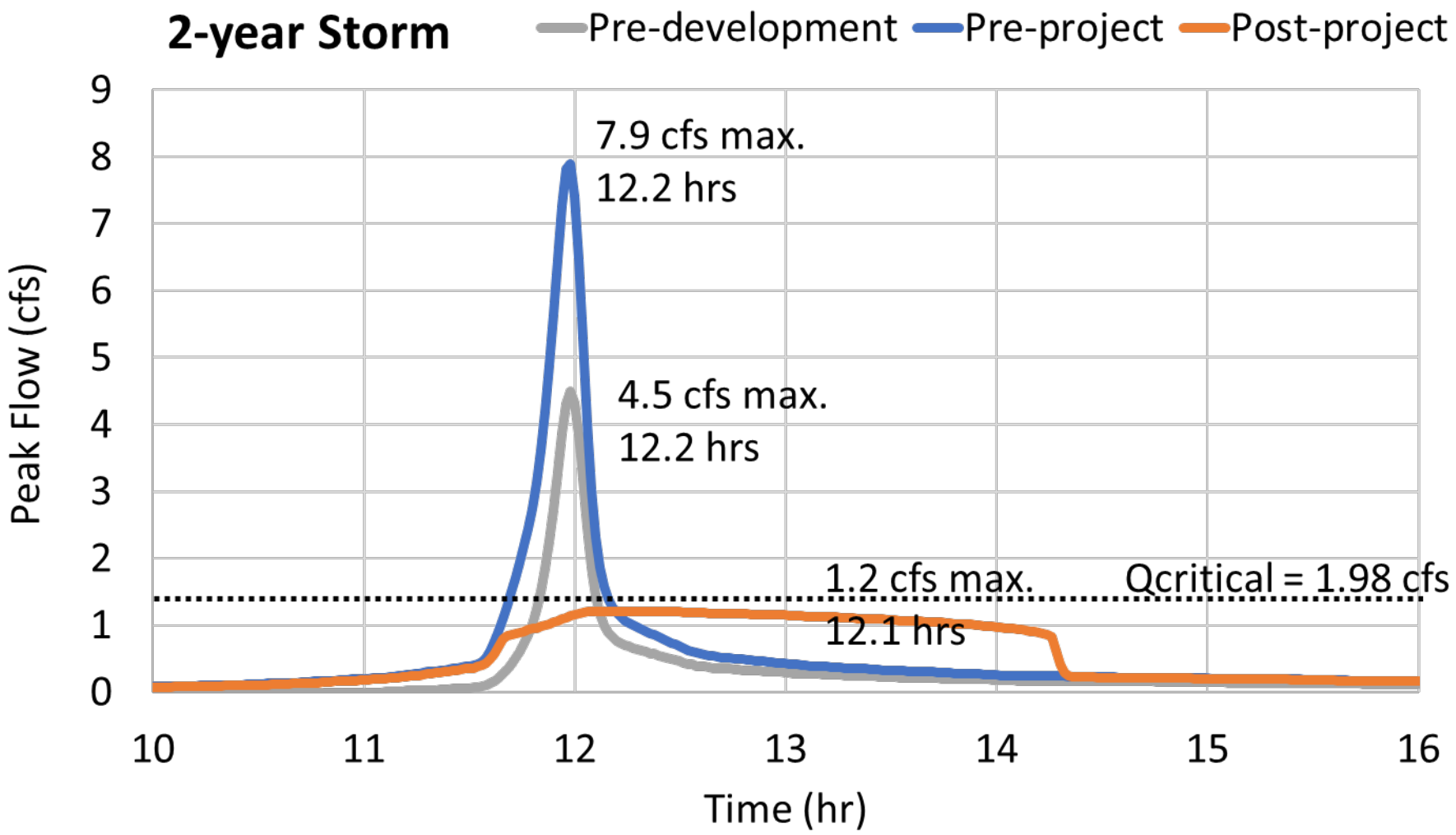
Underdrain Filter Rock

Spillway

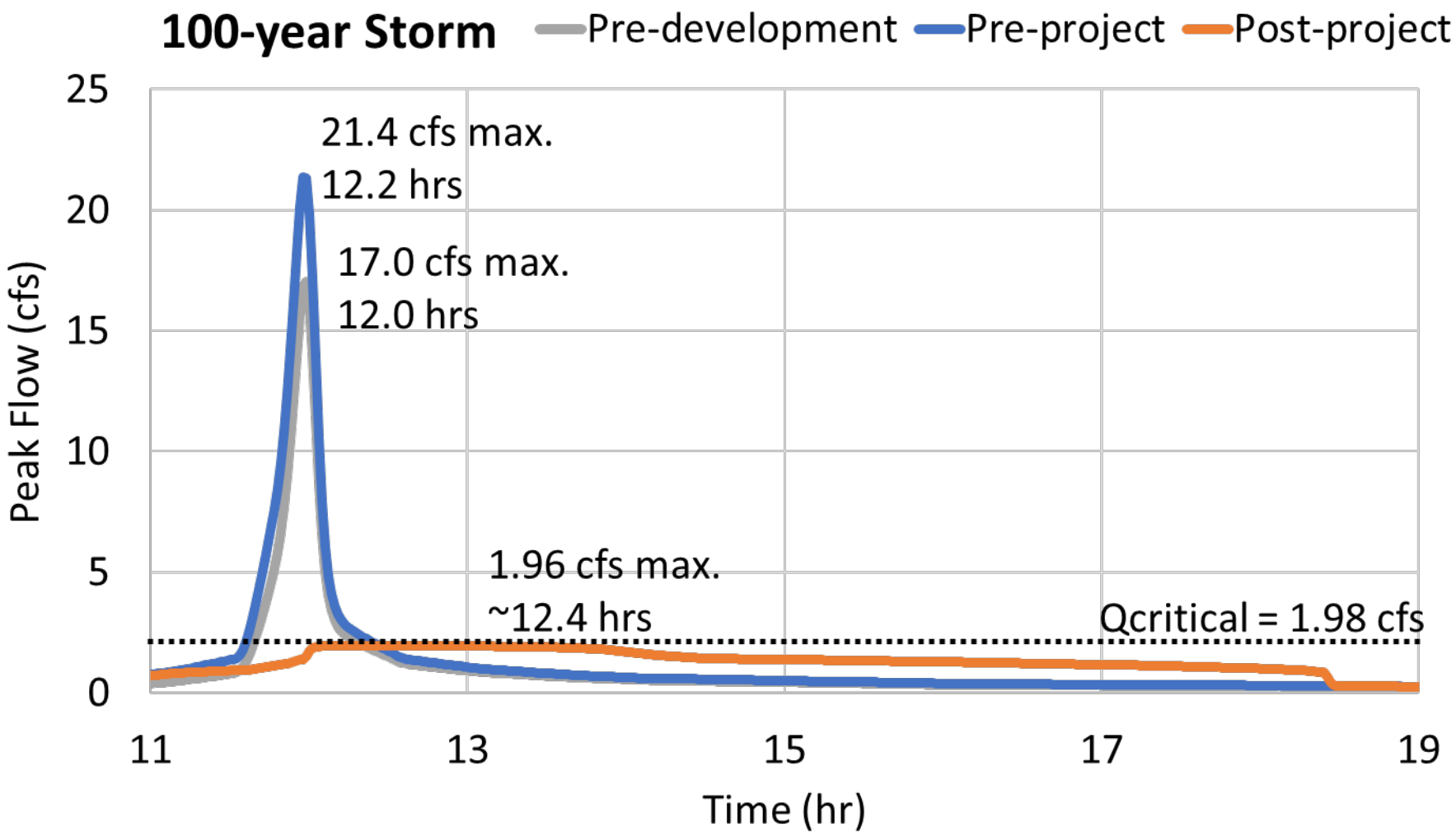
Reduced Flashiness in Most Frequent Storms



Reduced Flashiness in Most Frequent Storms



“Offloading” the 100-year Event from the System



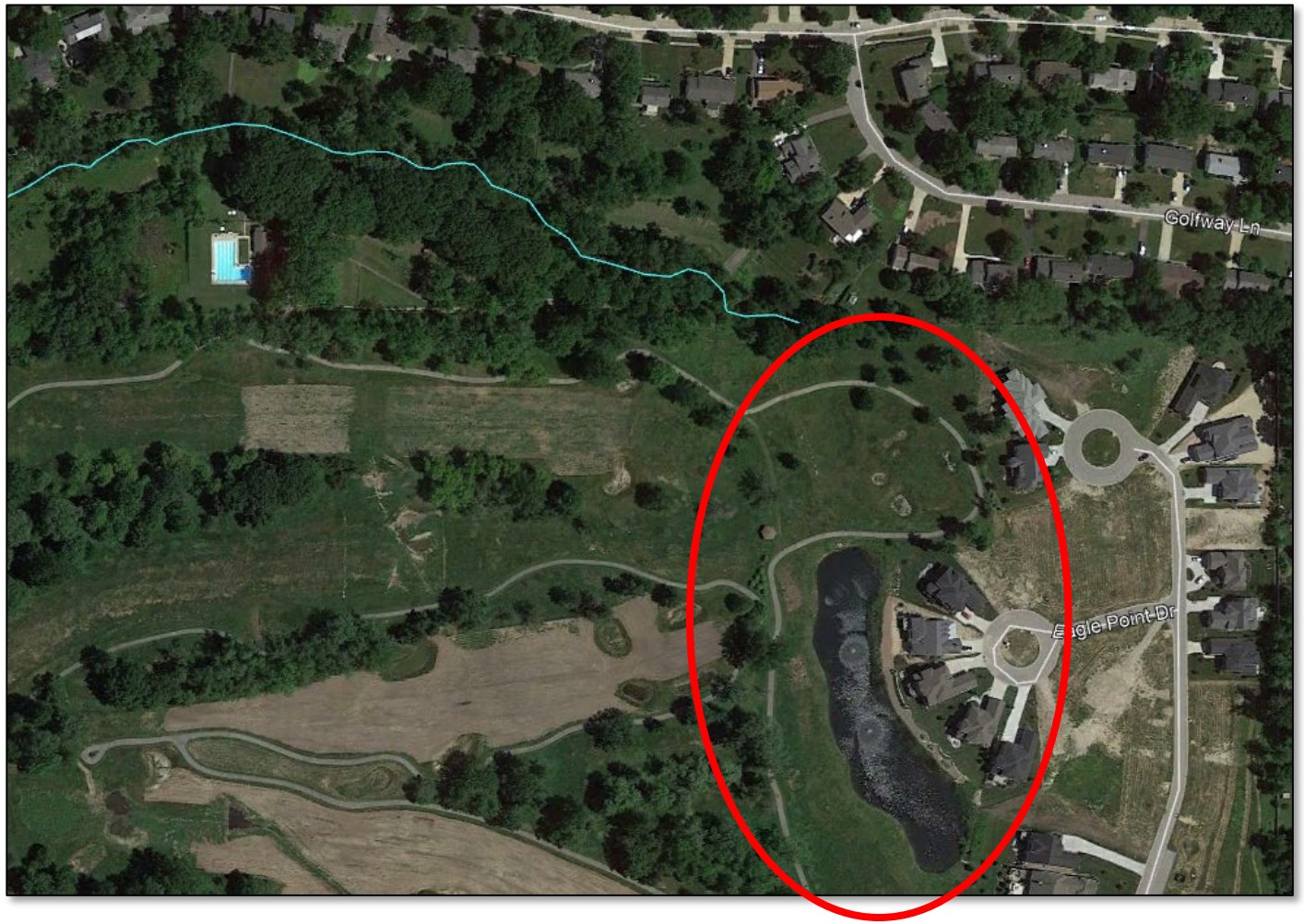
Complex Detention Retrofit & Stream Daylighting

Acacia Reservation Improvements

Great Lakes RESTORATION

Cleveland Metroparks®

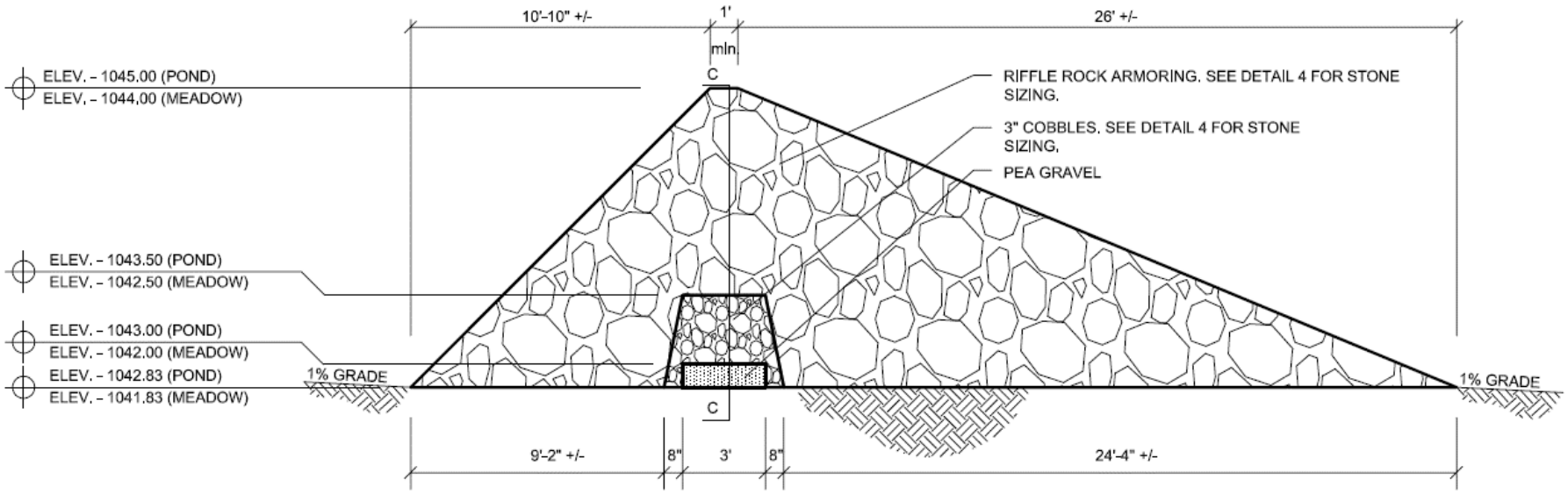
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



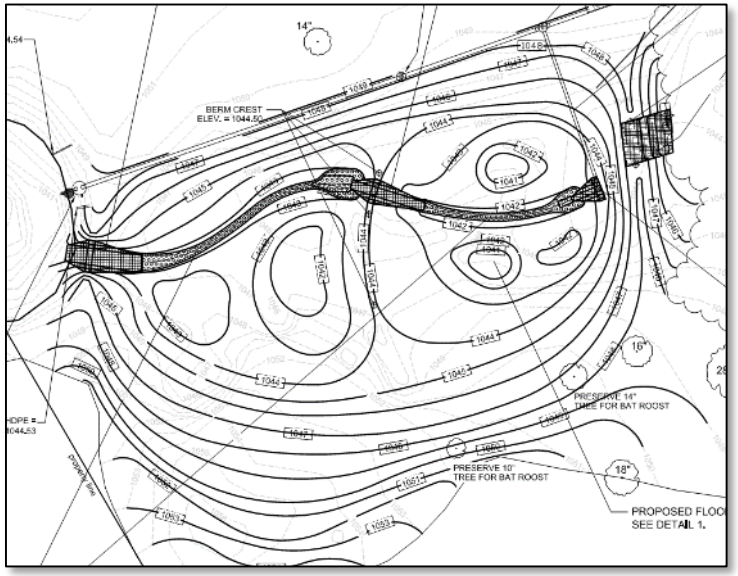
Complex Detention Retrofit & Stream Daylighting

Acacia Reservation Improvements

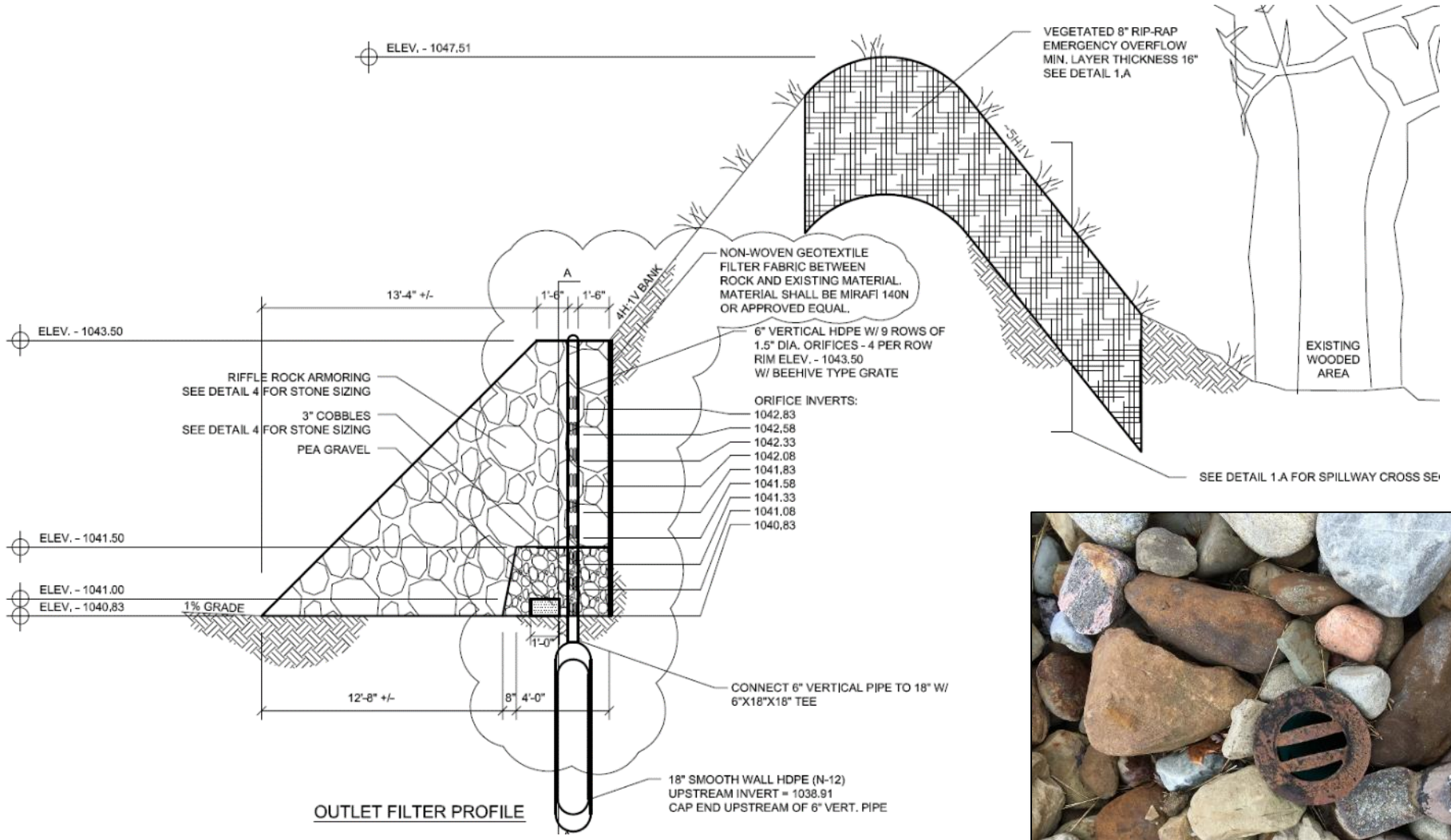
Detention Basin Retrofit



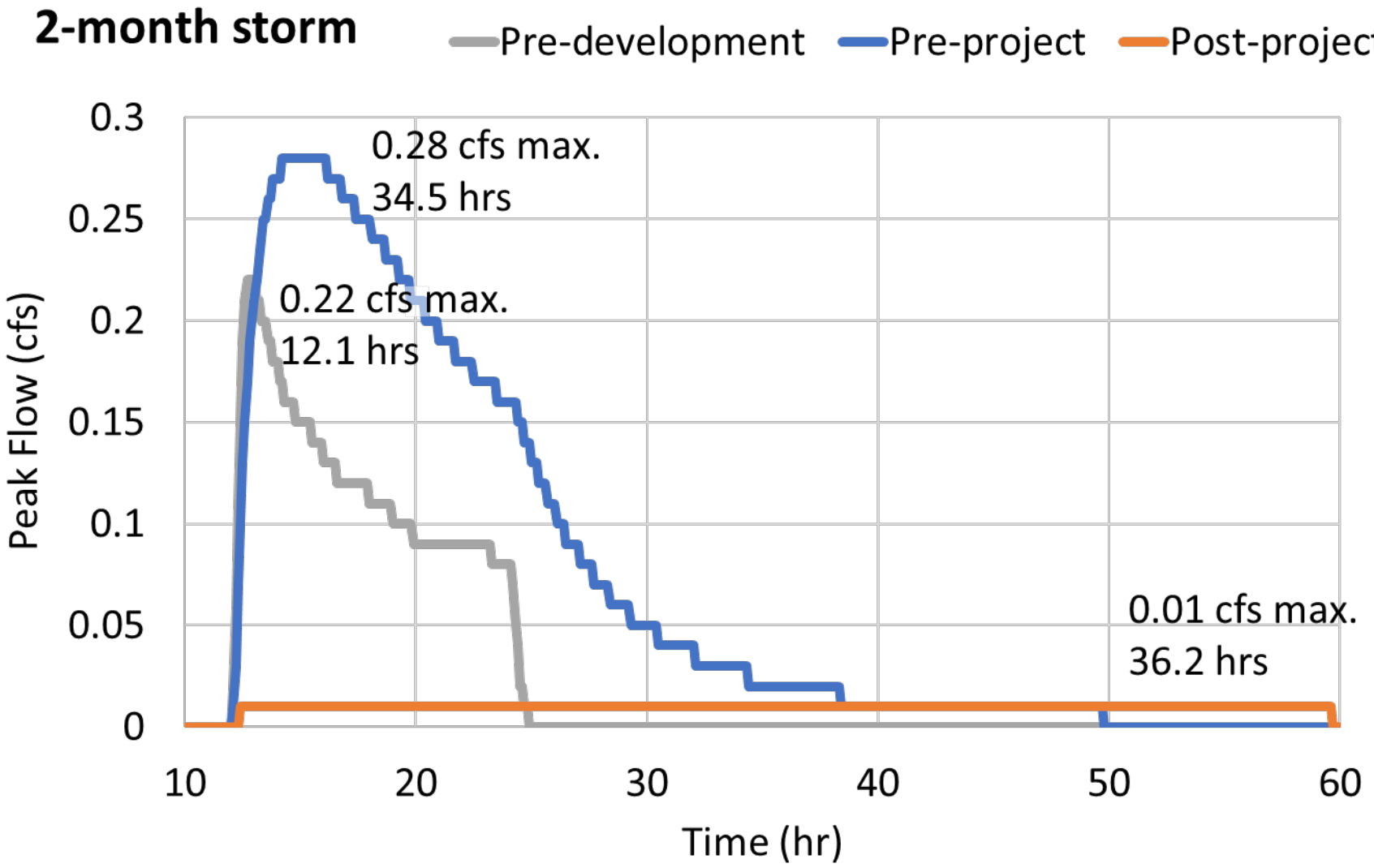
Stream Daylighting



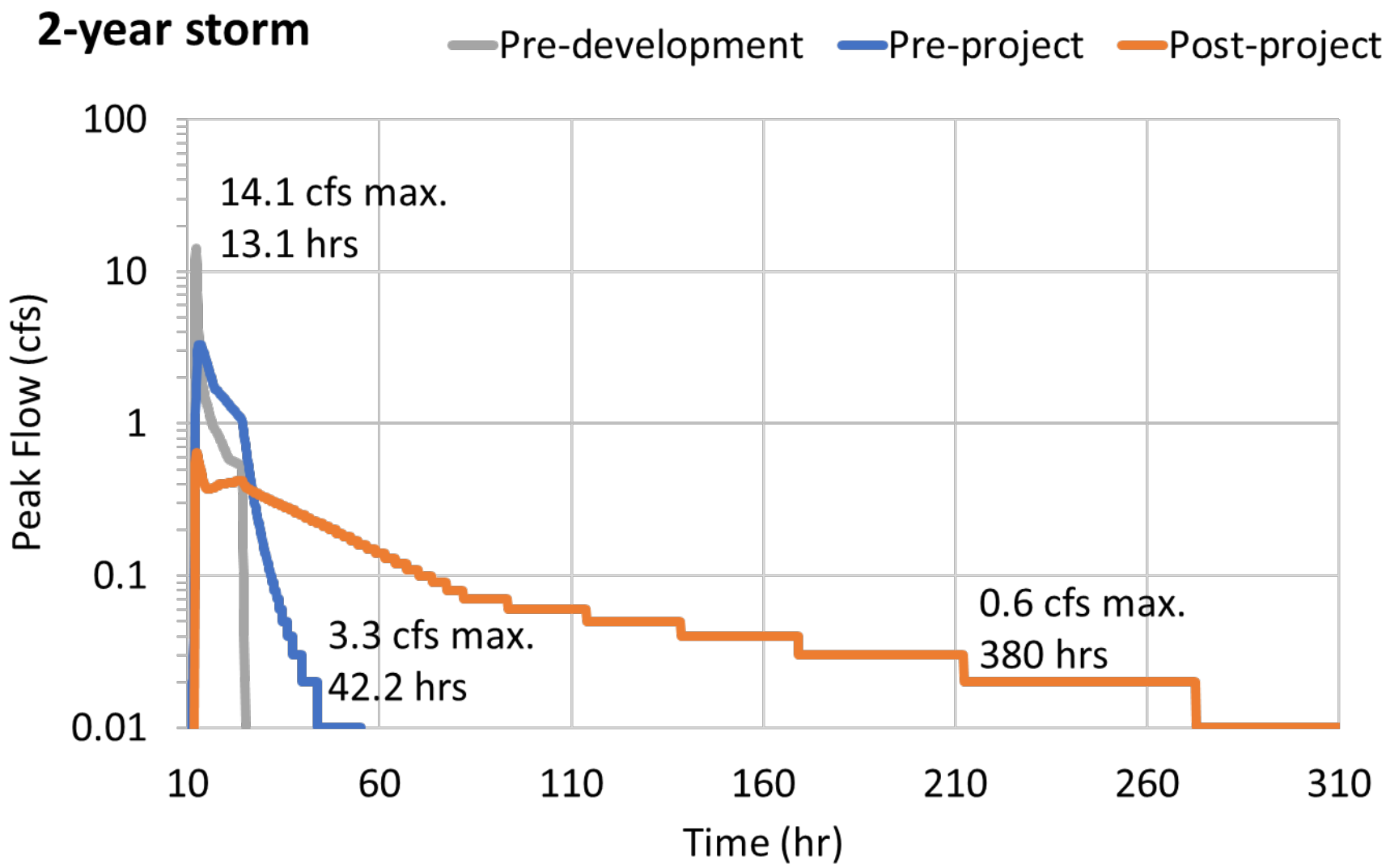
Stream Daylighting



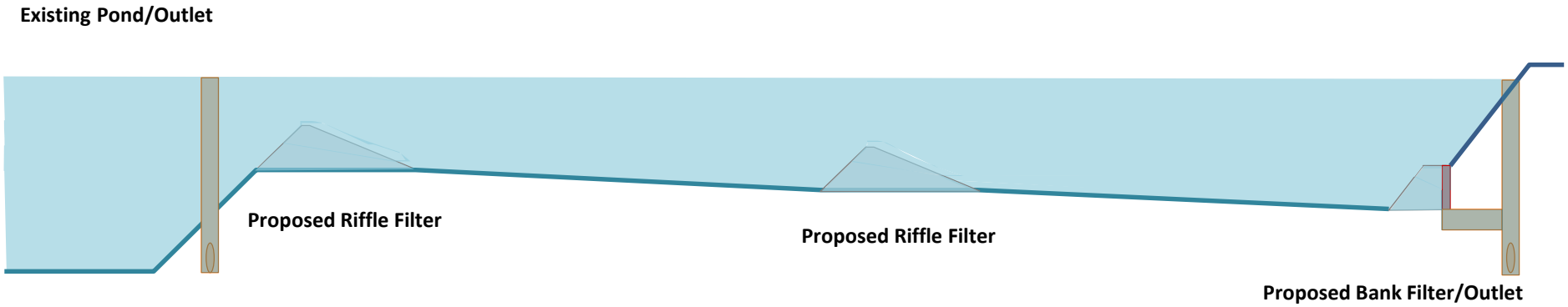
Increased Storage and Reconfigured Outlet Reduces Flows



Increased Storage and Reconfigured Outlet Reduces Flows



Conceptual Animation Illustrates Filtration and Storage



10-100 Year Rainfall Event


Thank you!