Jacobs Challenging today. Reinventing tomorrow.

SPC Water Resource Center Webinar: Blue/Green Stormwater Infrastructure

July 29, 2021

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Planning future workshop/webinar topics is currently underway! Please contact Erin Kepple-Adams, Water Resource Manager at ***ekepple@spcregion.org*** *and let her know what your needs are. She is happy to try to accommodate your requests.*

Presentation Outline

- Background
- Overview of BGSI Practices / Applications
- Reconfiguring Public Spaces For Multi Use
- Planning and Designing for Resiliency
- Adaptive Management
- Cost Implications
- Resources
- Q&A

Poll Question #1

What is your organizational affiliation?

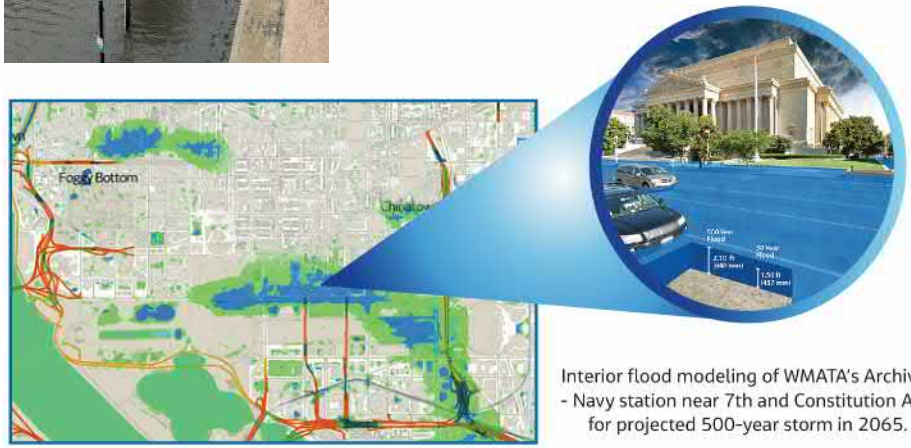
1. Government - Municipal
2. Government - Other
3. Consultant
4. Non-Profit Organization
5. Contractor
6. Other

Background

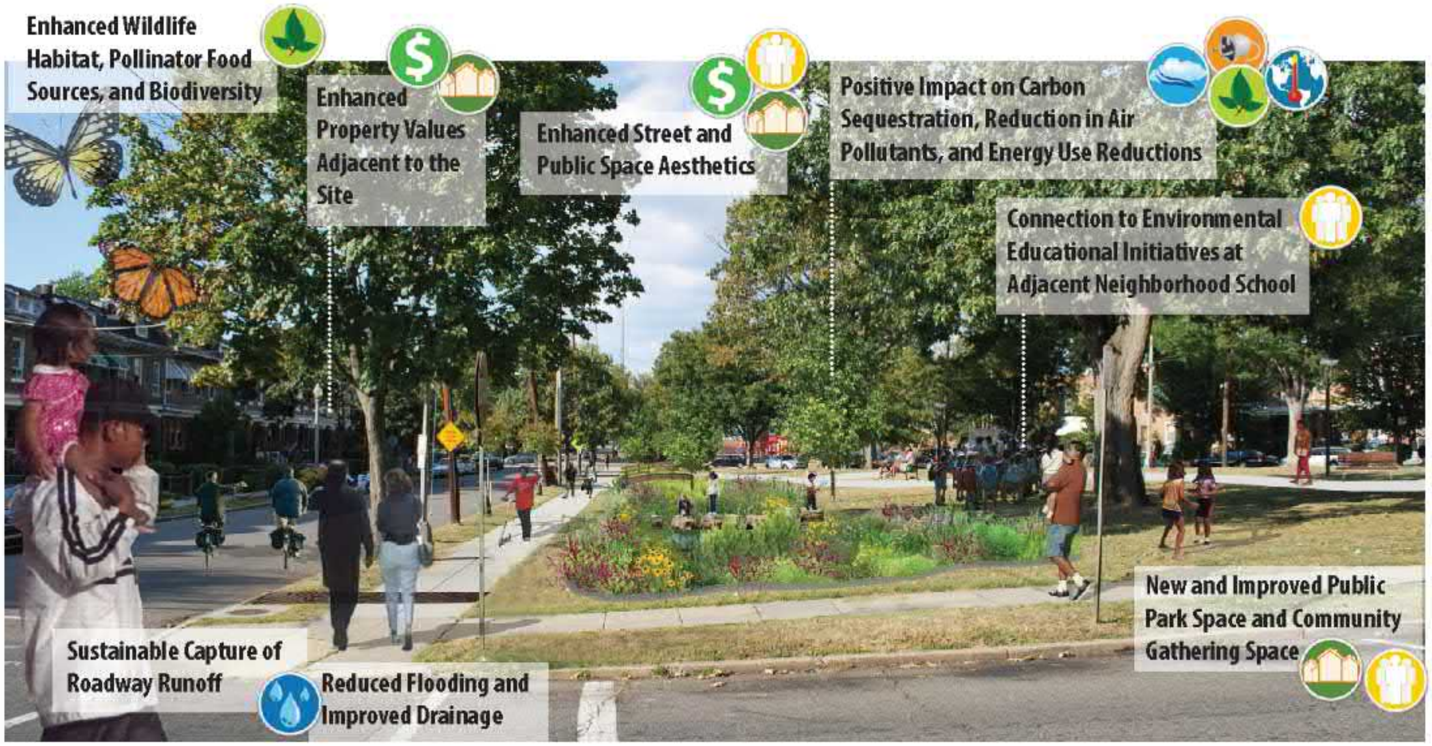
What is blue/green stormwater infrastructure and why do we need it?

Rethinking Our Current Drainage Infrastructure (and our built environments)

- Our current drainage infrastructure has not aged well
- Insufficient capacity
- Does not improve water quality
- Does not reduce volume
- Often just sends the problem downstream
- A new approach is needed to address new regulations and provide meaningful triple-bottom line (social, environmental, and financial) benefits



Interior flood modeling of WMATA's Archives - Navy station near 7th and Constitution Ave, for projected 500-year storm in 2065.




Before


After

A New and *Evolving* Approach to Stormwater Management

- Many tools are available and they are not necessarily new, but how they are designed and combined and applied is *evolving*
- The distinction b/w "green" and "blue" (or "green" and "gray") is no longer as stark
- Many communities face the following challenges:
  - Can we redevelop or retrofit our communities to **reduce flooding, improve water quality, AND create better places**?
  - Can we design stormwater practices that are both sized for **resiliency** AND **cost efficient**?
  - Can we reimagine our public spaces as both useable for **recreation** AND feasible for **flood storage**? Can we embrace the concept of "**living with water**"?

A New and *Evolving* Approach to Stormwater Management

- Can we **retrofit our existing stormwater management facilities** to be more effective for water quality and resiliency?
- Can we more effectively **engage with the community**, manage their expectations, and enhance their quality of life?

Enter Blue/Green Stormwater Infrastructure (BGSI)…
But What Does It Mean??

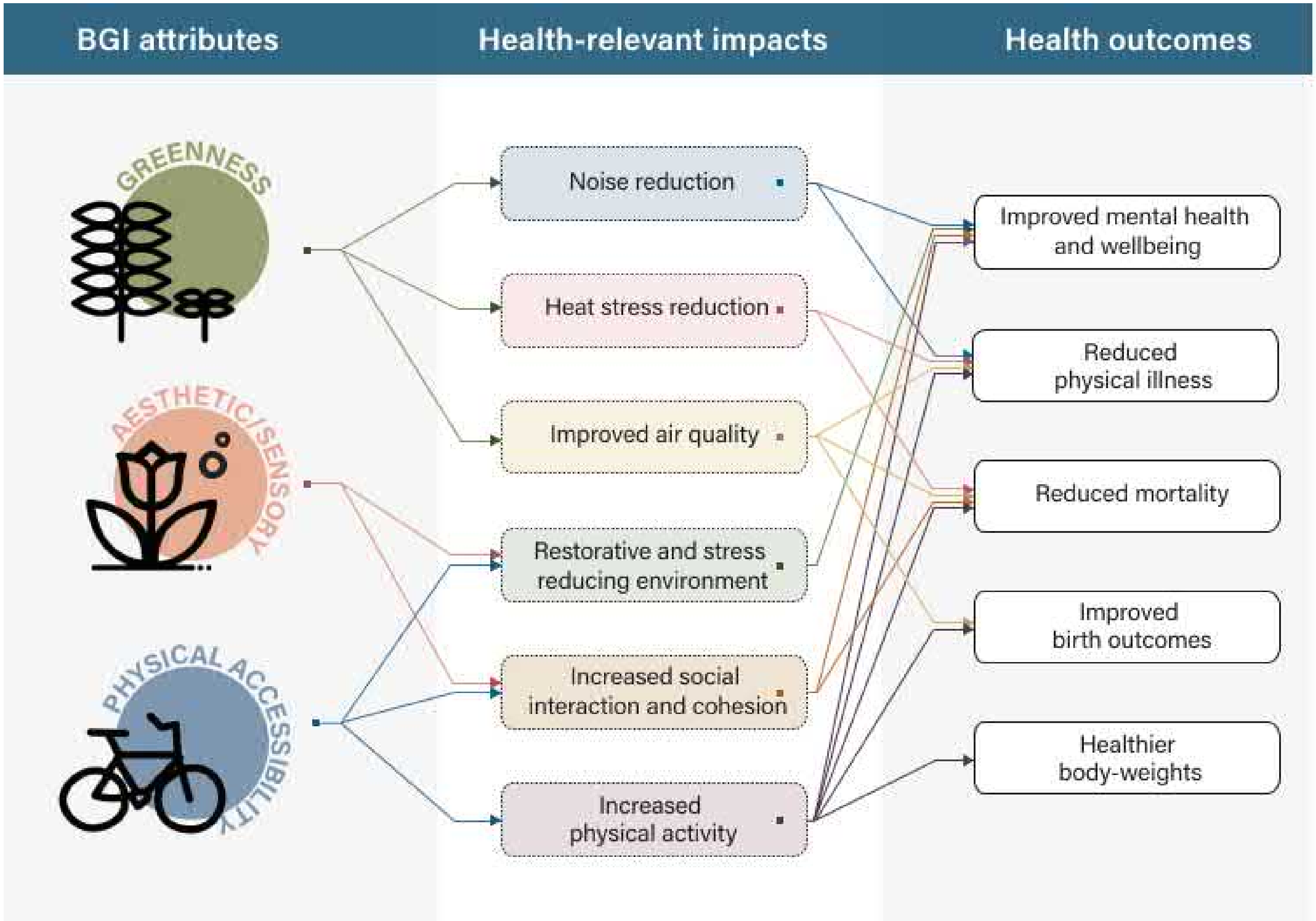
- Multiple definitions exist, but common themes include **resilient** and **attractive,** enhancing **society** and the **environment** through the provision of **multiple co-benefits**, support a **wide range of ecosystem services** (*Roadmap for the BGI Manual*)
- "BGI can be defined as a **strategic network** of **natural** and **manmade** green and blue spaces that **sustain natural processes**. BGI is designed and managed as a **multi-functional** resource, capable of delivering a **wide range of** benefits for society, the environment, and the economy." (*Blue-green infrastructure – perspectives on water quality benefits*)
- AKA, or related to: *Nature-based solutions, nature-based infrastructure, natural flood management, Low Impact Development (LID), cloudburst management measures, "sponge city", sustainable urban drainage system (SUDs), water smart city measures, water sensitive urban design, etc.*

Our Working Definition…

- **BGSI** is a strategy that combines the **water quality and community enriching benefits** of "green" stormwater infrastructure (GSI) coupled with the **flood reduction and climate resiliency benefits** of "blue" stormwater infrastructure (BSI)
- **GSI** (e.g., bioretention and permeable pavement) typically uses **vegetation, soils, and/or rainwater harvesting** to treat and reduce **smaller, more frequent** stormwater flows
- **BSI** (e.g., wet ponds and detention) temporarily **stores larger volumes** of stormwater without significant reliance on vegetation

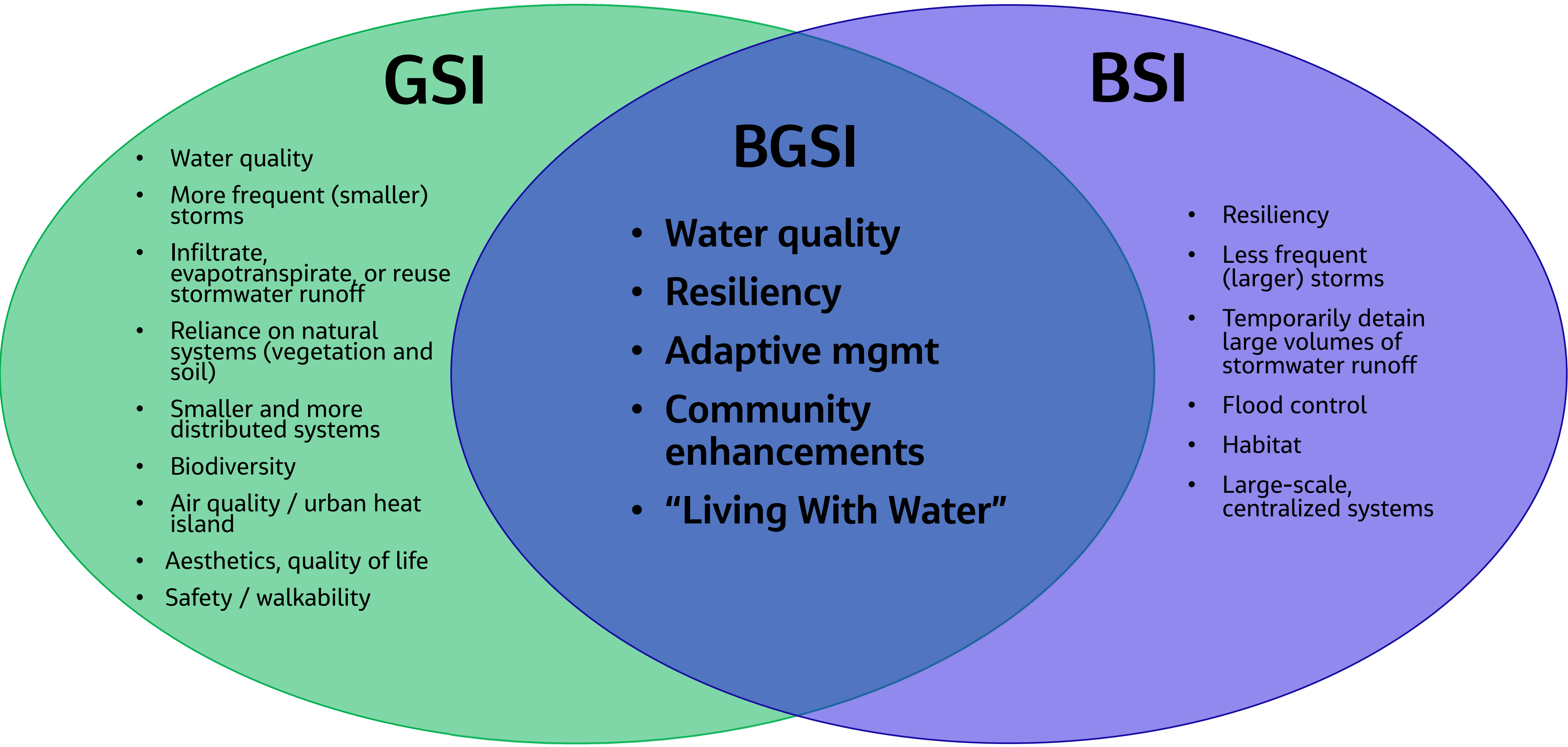
As A Combined Strategy, BGSI…

- Often includes such innovative, **“floodable” systems such as “floodable parks”, “wet plazas”, and “retention boulevards**”
- Provides **stormwater benefits** that include **water quality** improvements, **groundwater recharge**, and detention and **flood mitigation**
- Provides **community benefits** that entail **urban heat island mitigation, air quality improvement, climate resiliency, habitat** creation and improvement, and numerous other **social benefits**
  - job creation, urban aesthetics, property values, pedestrian safety, and enhanced recreational spaces

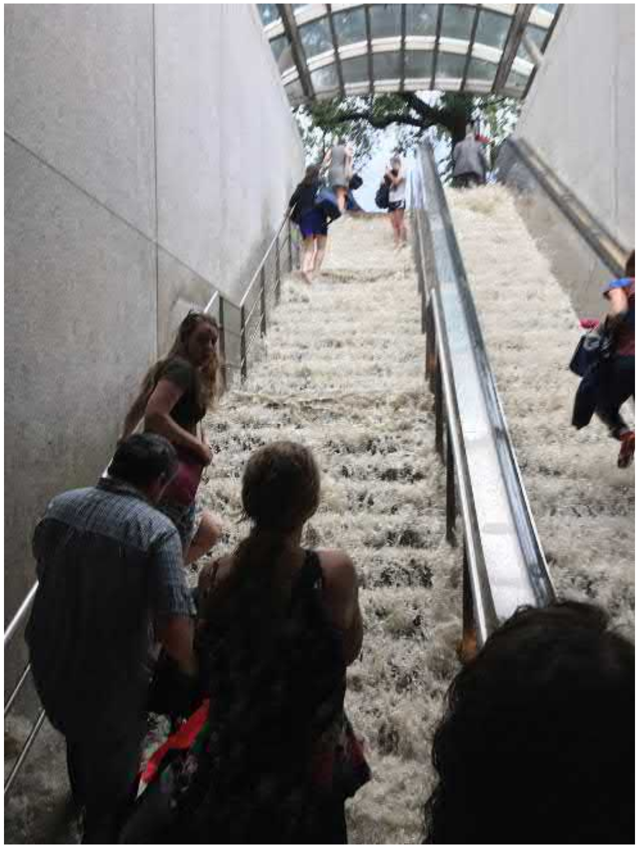


Schematic pathways showing different attributes of BGI, and their relationship to health-relevant impacts and health outcomes. Kenyon, A. & Choe, E. Y.

Source: Designing Blue Green Infrastructure (BGI) for Water Management, Human Health, and Wellbeing: summary of evidence and principles for design; Choe, Kenyon, and Sharp, University of Sheffield, Sept. 2020


GSI
Water quality
More frequent (smaller) storms
Infiltrate, evapotranspirate, or reuse stormwater runoff
Reliance on natural systems (vegetation and soil)
Smaller and more distributed systems
Biodiversity
Air quality / urban heat island
Aesthetics, quality of life
Safety / walkability
BGSI
Water quality
Resiliency
Adaptive mgmt
Community enhancements
"Living With Water"
BSI
Resiliency
Less frequent (larger) storms
Temporarily detain large volumes of stormwater runoff
Flood control
Habitat
Large-scale, centralized systems

When we say "Living With Water"…



or?

"Living With Water"

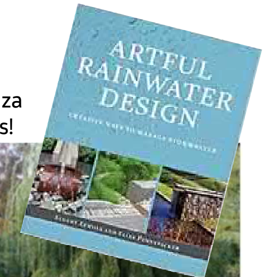
- Combine the best of both BSI and GSI
- Floodable parks, plazas, and streets that increase climate resiliency, minimize current/future property impacts, and provide solutions with many co-benefits
- Accepting that some areas may be temporarily inaccessible or have reduced usability after storms
- Drawing more attention to stormwater, using it to enhance spaces (Artful Rainwater Design, or ARD)

Tåsinge Plads - Copenhagen's first climate change-adapted urban space; storage allows sewers to handle larger cloudburst storms (Source: DHI Group)

PENNSTATE artful rainwater design

Rainwater is a resource, not a waste product. Innovative ideas for your artful rainwater design project.

Check out the ARD book by Eliza Pennypacker and Stuart Echols!



https://artfulrainwaterdesign.psu.edu/

Example BGSI Practices (the "tools")

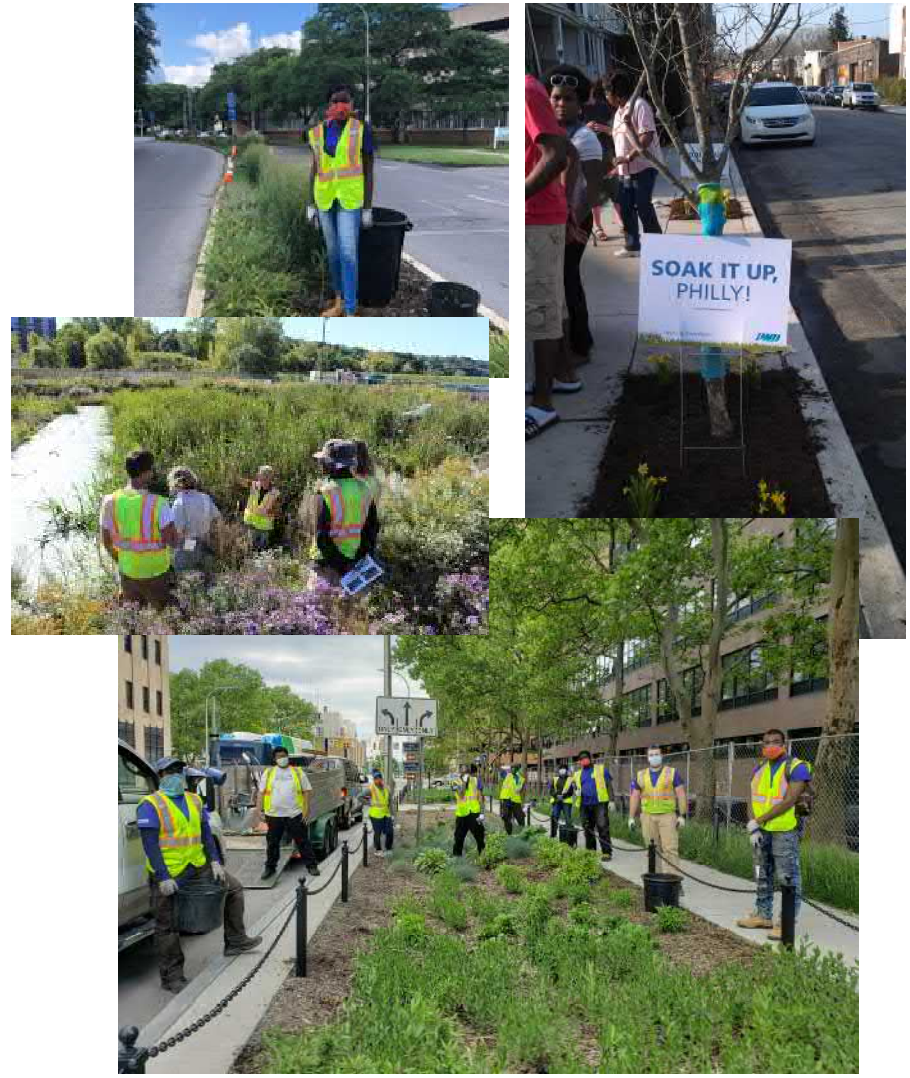
- Above-Ground Detention Tanks
- Basins/Ponds (Infiltration, Detention, Retention)
- Bioretention/Bioswales
- Blue & Green Roofs
- Canal Enhancements / Stream Restoration
- Canopy Trees
- Constructed Wetlands
- Drainage/Gravity Wells
- Enhanced Tree Pits/Trenches
- Floating Wetland Islands
- High Flow Media Filters
- Injection Wells
- Living Walls
- Permeable Pavement
- Pumping to/for BGSI Systems
- Rainwater Harvesting
- Stormwater Planters
- Subsurface Flow Wetland
- Subsurface Infiltration/Detention Systems
- Water Plazas/Parking Lots

Reconfiguring Public Spaces For Multi Use

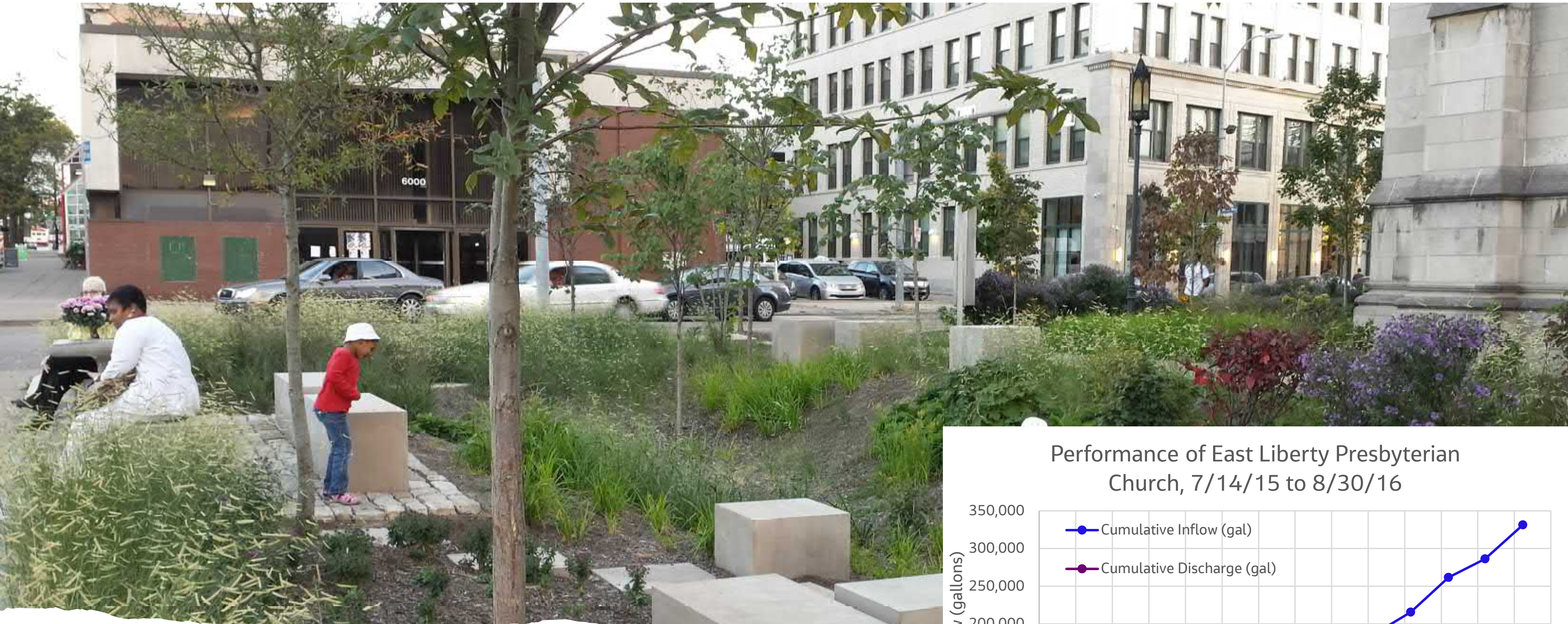
How can we re-imagine our public plazas, parks, golf courses, and streets to achieve multiple benefits and create “living with water” opportunities?

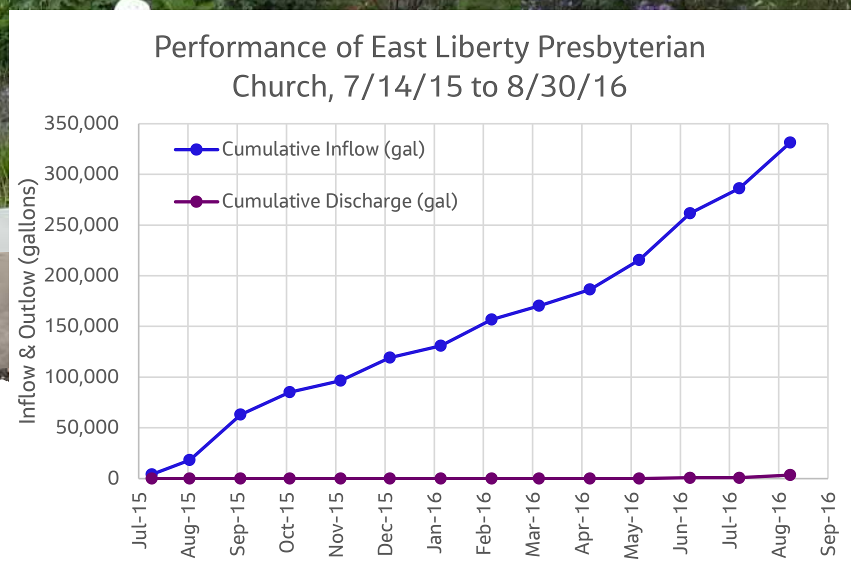
First Consider the Where and the Who (Social Equity)

- Planning / prioritizing BGSI projects must consider the where and the who
- Weigh water quality and flood reduction benefits vs. community improvement needs (often aligned, but not always)
- Social benefits of BGSI are many:
  - Job creation
  - Increased pride in the community
  - Increased safety
  - Urban revitalization / redevelopment



Source: Onondaga Earth Corps https://onondagaearthcorps.org/





Re-Imagining Public Spaces – Urban Plazas

Re-Imagining Public Spaces – Urban Plazas

- "Water squares" gaining popularity in Europe (especially in cities like Copenhagen and Rotterdam)
- Benthemsquare in Rotterdam:
  - Combines temporary water storage with the improvement of the quality of urban public space
  - "Dynamic place for young people, lots of space for play and lingering, but also nice, green intimate places"
  - "Water… had to be excitingly visible while running over the square: detours obligatory!"
- *Are American cities ready to embrace floodable plazas?*

The water square became official policy on an urban scale in the "Rotterdam Waterplan 2" in 2007. (Source: De Urbanisten http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein)

Source: Gallery Community Forms | Black Cube;
partially **funded by FEMA Arts in Mitigation Fund**

Re-Imagining Public Spaces – Urban Plazas / Parks

Re-Imagining Public Spaces – Parks

- Sidmouth Amphitheatre, UK
- Driver: flooding in beautiful coastal town
  - Insufficient space to deliver a flood protection in the town center, due to low elevation, narrow streets, and buildings on shallow foundations
- Goals: capture exceedance flows, enhance / minimize negative impacts on parkland, create dual use flood storage facility / public performance space, biodiversity
- Design Components: diversion of road runoff, swale w/ energy dissipation and check dams, spiral filter drain over drainage blanket and modular storage, and central control chamber that manages infiltration in relation to groundwater levels
- Community Engagement: tours to local interest groups, signage, film being developed

See the video at:

Day 2 Session 3 Paul Hargreaves - YouTube

PA4

Re-Imagining Public Spaces – Parks

- Sunset Park (Renton, WA) part of public investments and partnerships to catalyze **revitalization of an underserved community**
- Concept developed through a series of facilitated **community design charettes**
- BGSI (bioretention cells and infiltration gallery) **integrated** with park and pedestrian improvements
- Funding through state stormwater **grant** and the integration of stormwater and community revitalization led to additional funding

Rendering Source: HBB Architecture

Re-Imagining Public Spaces – Golf Courses

Retrofit: Maintain Use

Repurpose: Convert Part

Re-Imagine: Convert All

Re-Imagining Public Spaces – Golf Courses

- Former golf course, now a large groundwater recharge and wetlands system in a 60-acre park in Ocala, FL
- Planting plan maximizes native plant diversity and suppresses invasives
- Wetlands range from deep open water to shallow marshes, islands, and rookeries as habitat for birds
- Over 2.5 miles of trails and boardwalks

Re-Imagining Public Spaces – Streets

- Notoriously dangerous intersection
- Lancaster partnered w/ brewery to install bioretention and permeable pavers (parking and patio)
- Reduce accidents
- Improve pedestrian safety
- Capture runoff
- Best Urban BMP in the Bay Award
- Governor's Award for Environmental Excellence

700-Gallon Cistern Serves as Public Art and Irrigates Planters

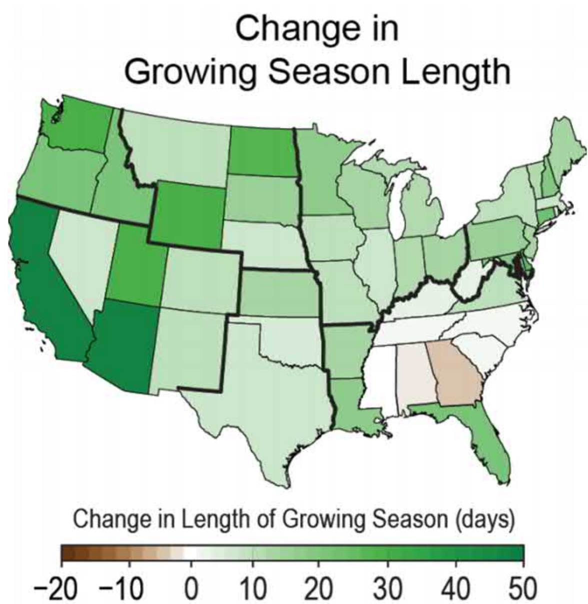
5 MPH reduction in average traffic speed

Planning and Designing for Resiliency

Where and how are BGSI projects designed to achieve resiliency goals?

Planning and Designing for Resiliency

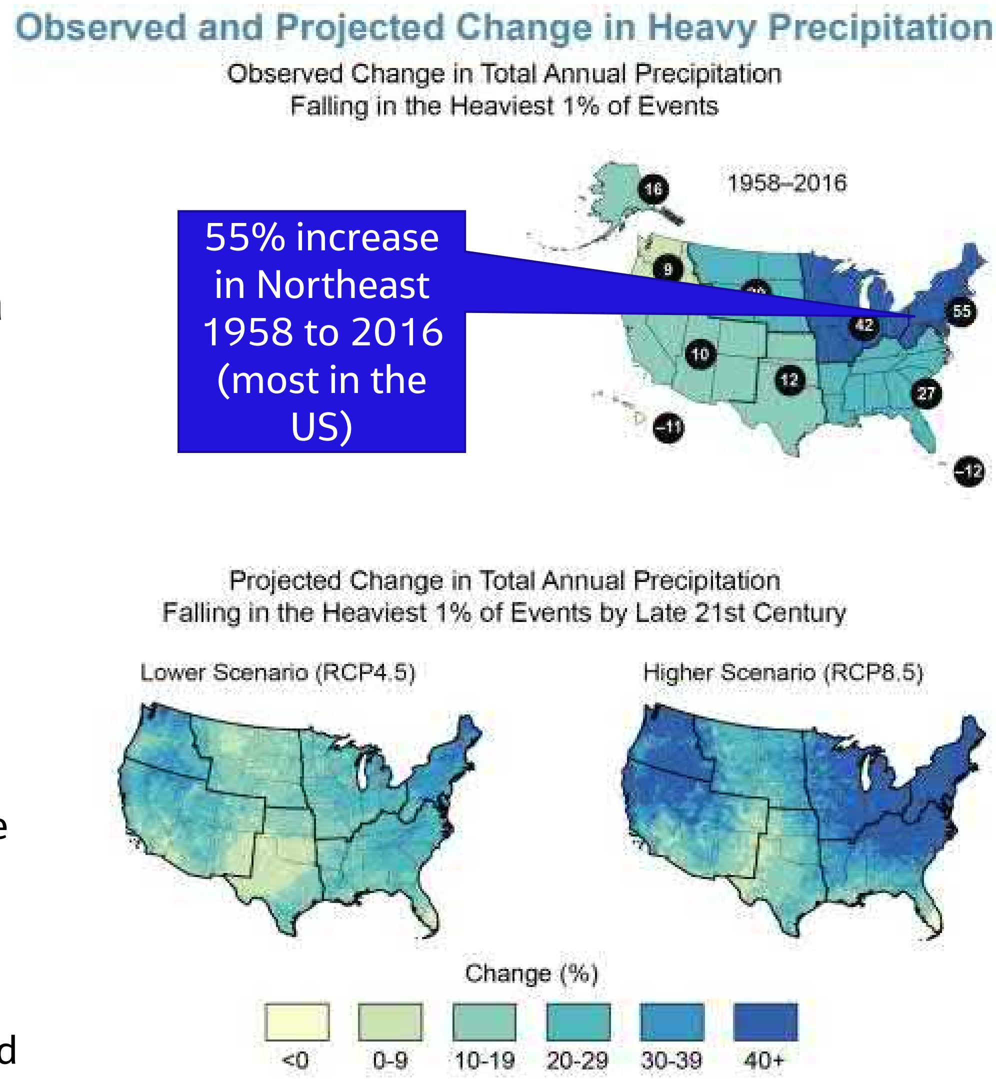
- Consider the design life of the BGSI when determining design criteria
- What external factors should be considered?
  - Flooding
  - Rainfall intensity and duration increases
  - Groundwater elevation changes
  - Extended drought
  - Changing temperature and precipitation patterns
- What BGSI parameters do these factors impact?
  - Location (site selection)
  - Size (footprint & volume)
  - Inlet/outlet configurations
  - Invert
  - Plant selection
  - Maintenance
  - Cost



Fourth National Climate Assessment, 2018

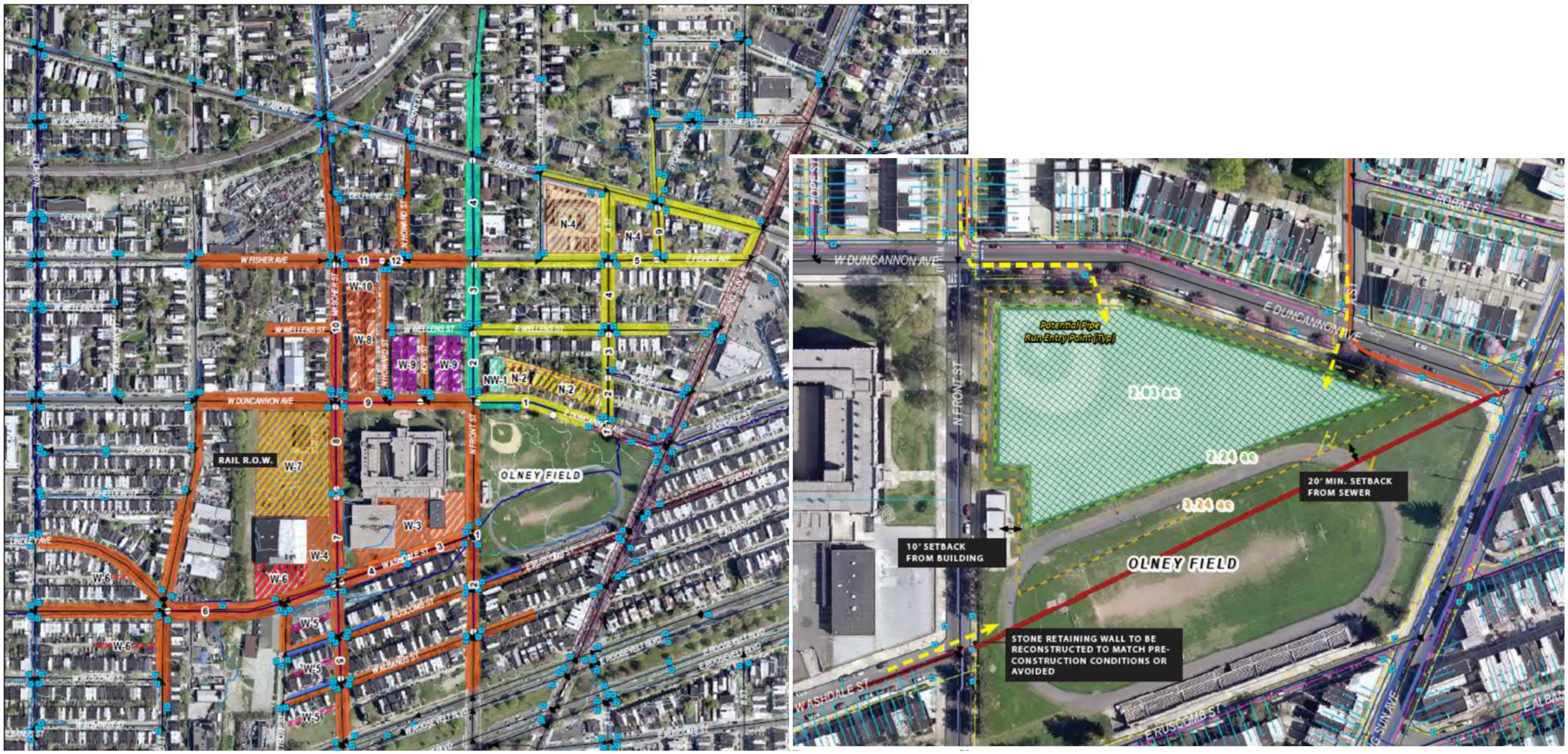
Climate Change: Past & Future

- Precipitation patterns have changed already (NOAA Atlas 14 is based on data through 2000)
  - Much more rainfall in heavier storms
  - Less rainfall outside those events (drought implications)
- Prediction is for further changes in our region
  - Climate change is an increasingly important consideration in municipal decision making
  - Ensuring that existing and proposed infrastructure can **withstand or adapt** to the precipitation that will occur **throughout its lifespan**
  - Knowledge of current precipitation and future predictions allows for informed decisions about municipal policies, project prioritization, codes and standards, etc.

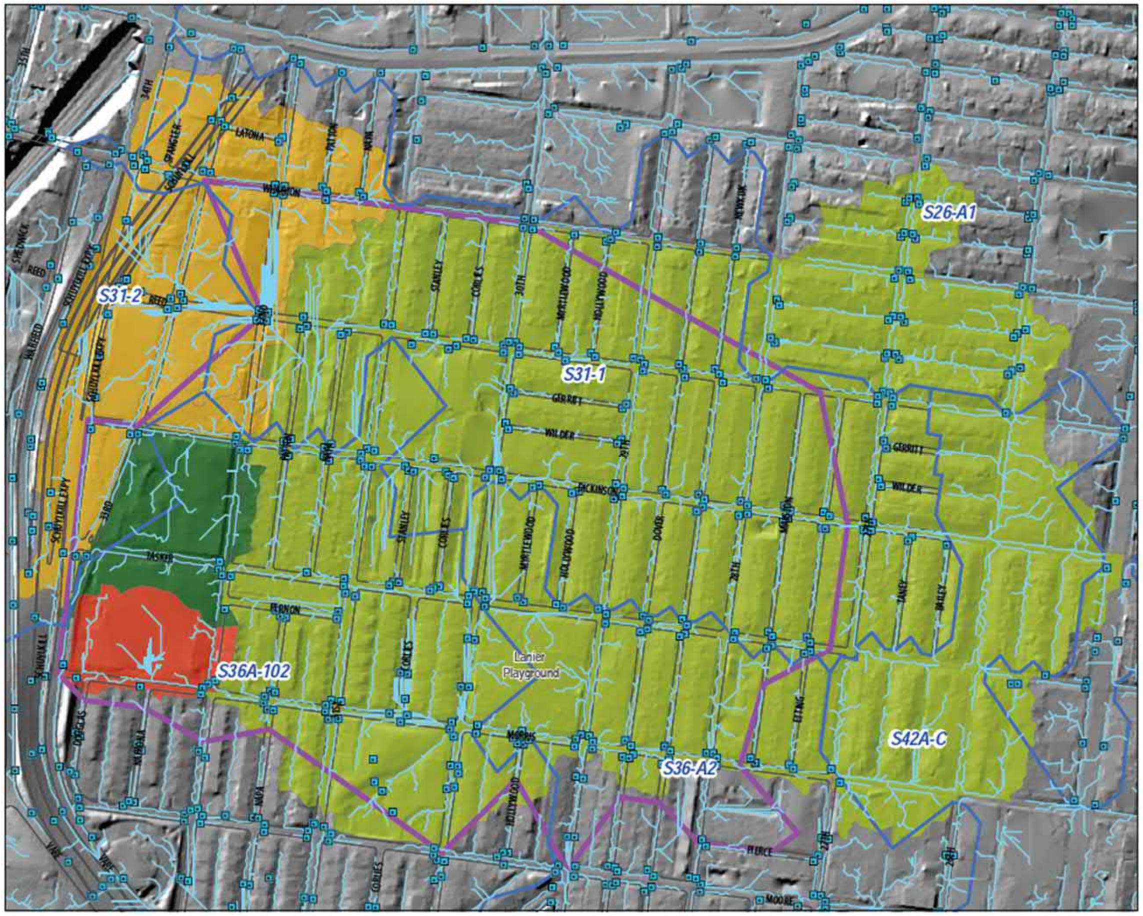


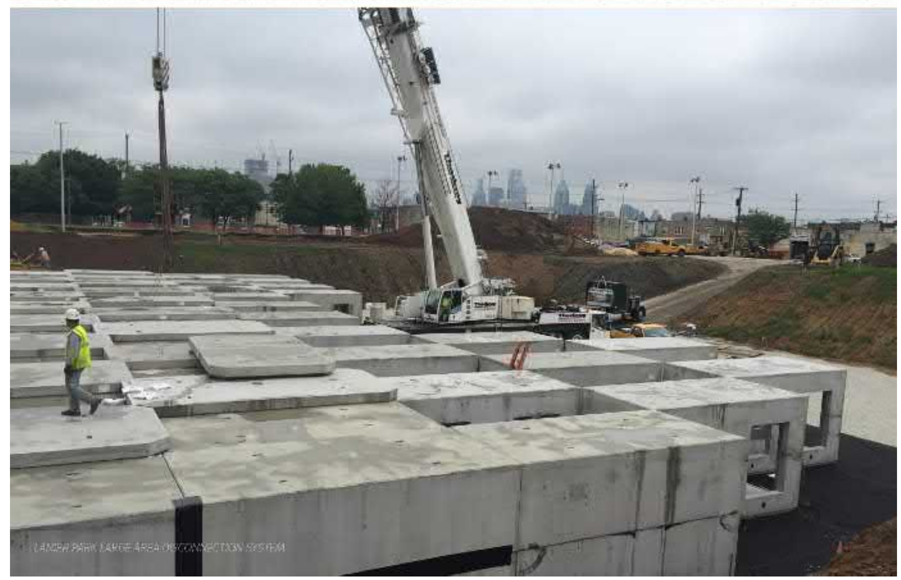
Fourth National Climate Assessment, 2018

BGSI managing runoff on a neighborhood scale with large stormwater management practices



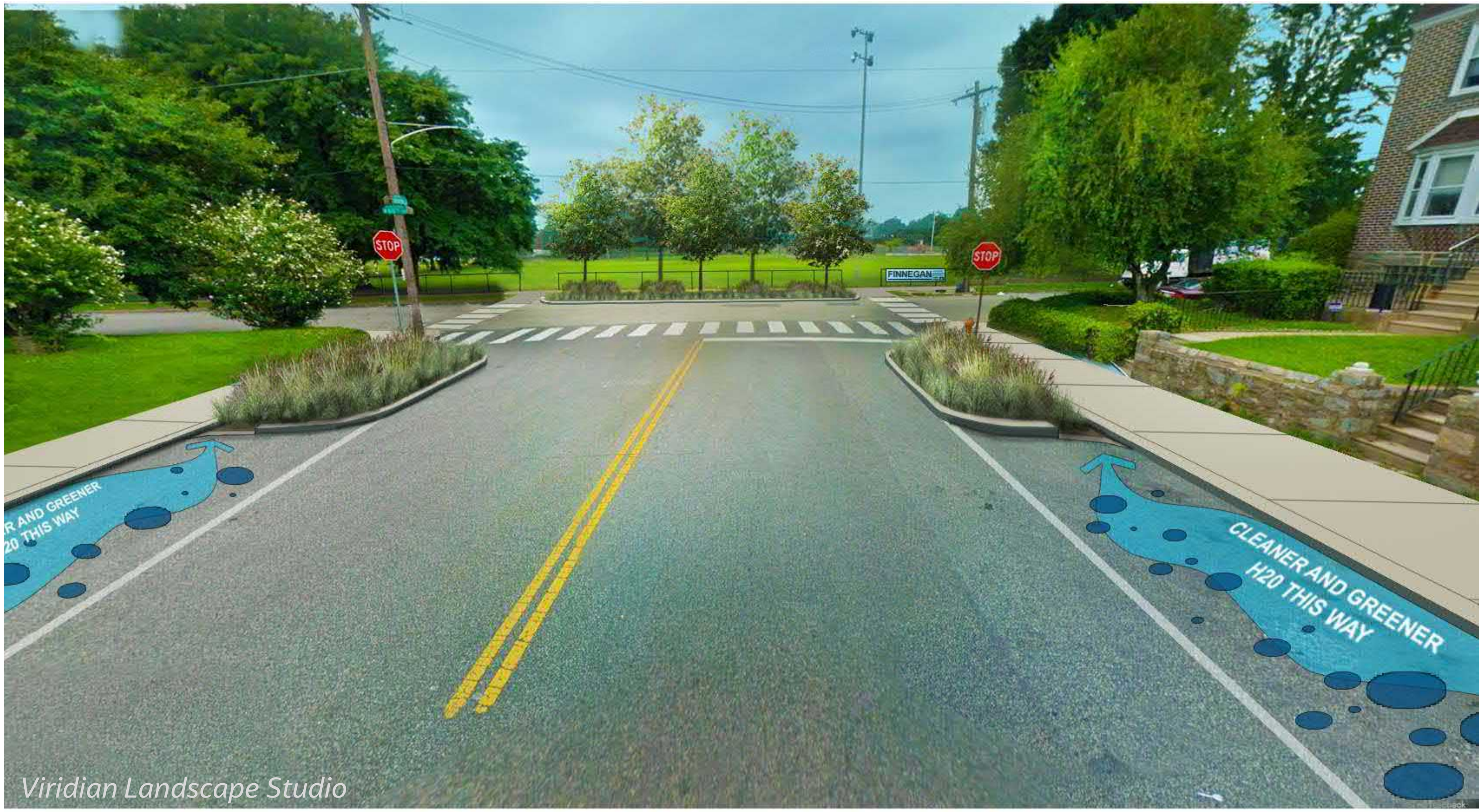
Lanier Park





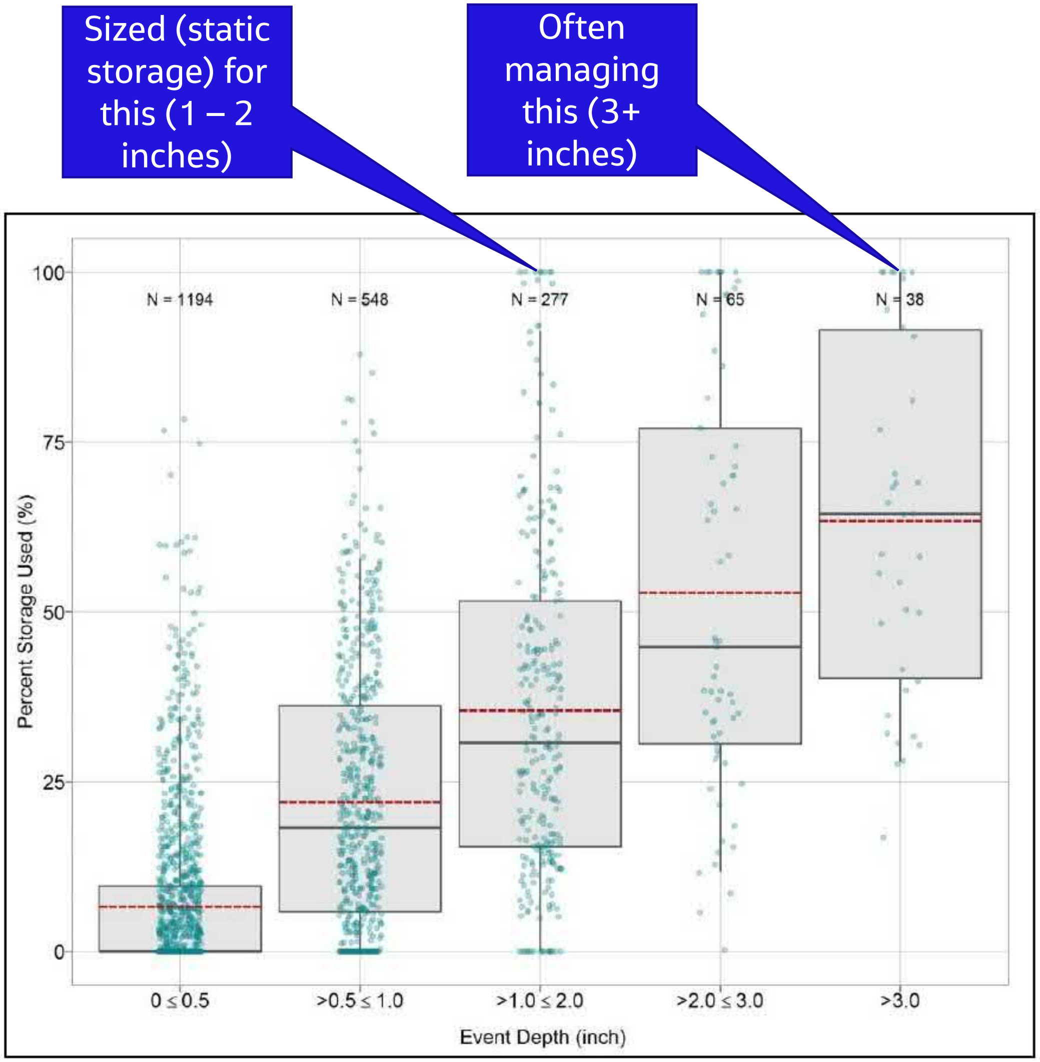
Images: Jacobs (above), Philadelphia Water Department (right)

Integrating Vegetated Systems and Gateways



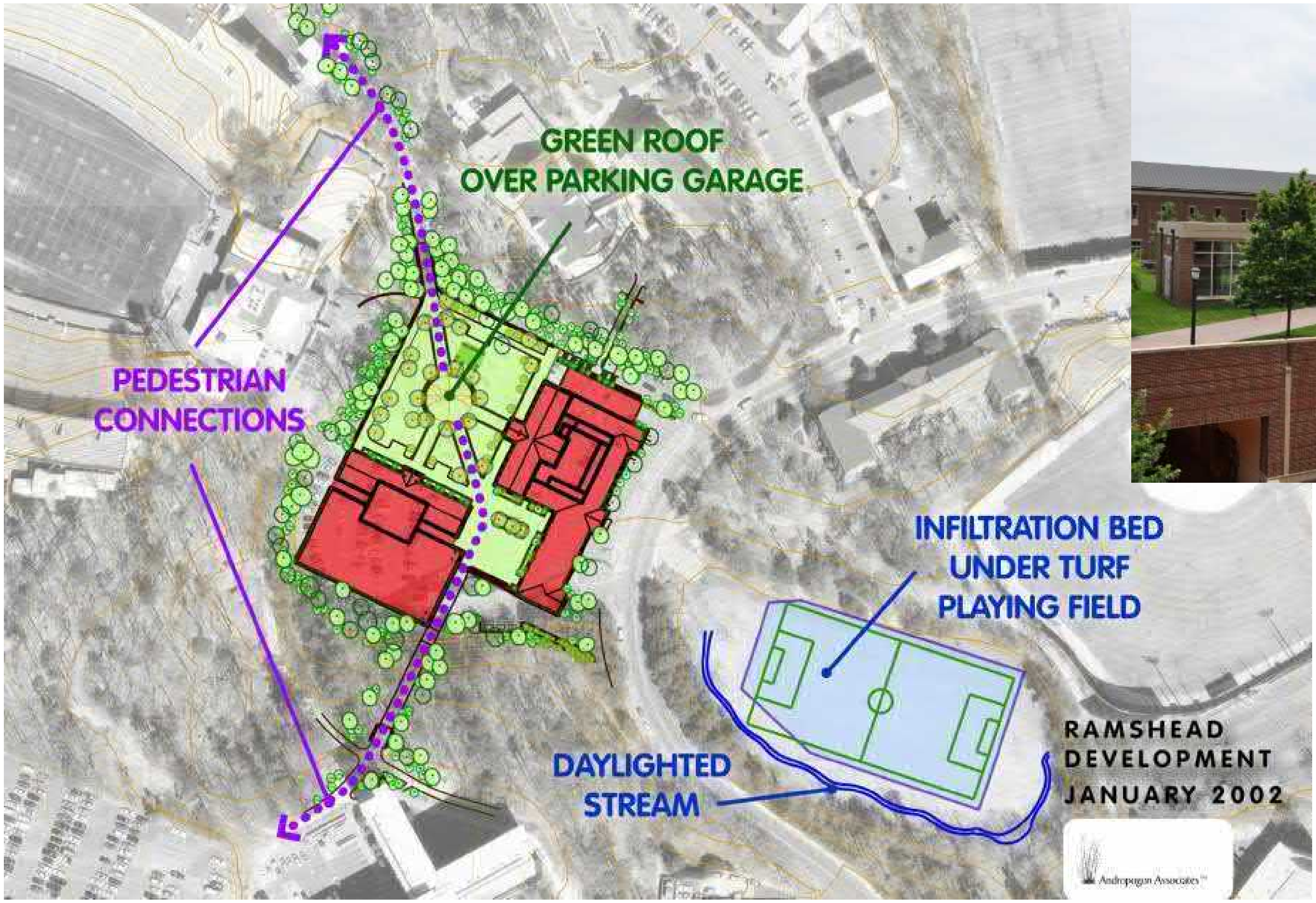
Sizing for Resiliency

- GSI: typically sized for 0.5-1.5 inches of runoff
- BSI: can be sized for flood control (up to 100-year, 24-hour storm)
- Greater resiliency can often be cost effectively achieved by sizing GSI for 1.5-3.0 inches of runoff
  - High voids media
  - Maintain reasonable loading ratios
  - Infiltrate where feasible
  - Consider static vs. dynamic sizing



Green City, Clean Waters 5-year Summary, Philadelphia Water Dept, 2016

University of North Carolina Rams Head Center - $75M Student Center



1-acre Green Roof Plaza on Top of a Several Story Parking Garage

- With a 56,000-gallon cistern under the brick sidewalks
- Overflows to a vegetated swale, a re-created stream channel, and a large infiltration bed under an artificial turf field.

Subsurface Floodplain Restoration at Radnor Middle School, Wayne, PA

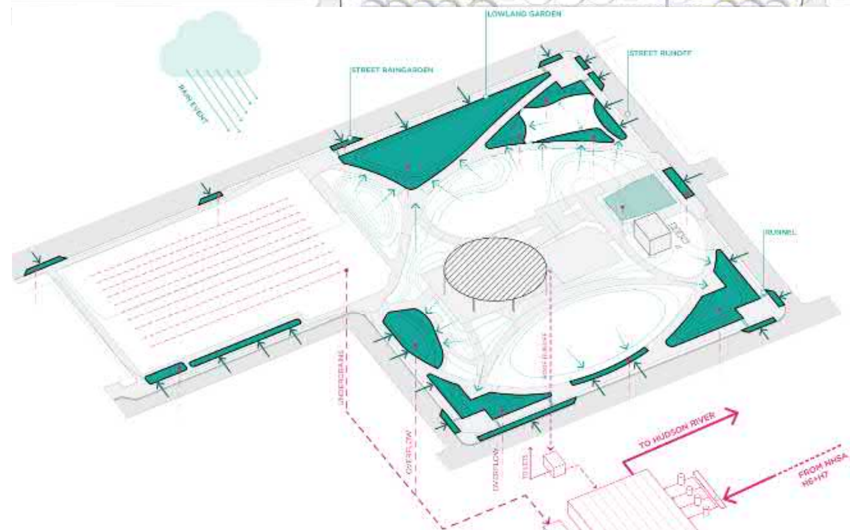
- ▪Floodplain filled in and stream channel put into pipe
- ▪Historic flooding on school playfield and adjacent streets
- ▪Underground storage / infiltration system w/ modular tanks
- ▪Other GSI: rain gardens, permeable pavement, green roof, infiltration trenches
- ▪LEED – Gold certification

Incorporating Resiliency into our Designs/Modeling

- A few things to consider:
  - Past rainfall is not an indication of **future rainfall** – we know rainfall patterns are changing and designers should consider ways to address this in their analysis
    - E.g., **"stress test"** the system by simulating higher intensity-short duration events or simulate extended periods of drought and impacts on water level and vegetation
  - Climate change impacts on flooding can also be incorporated by including model scenarios that address **higher downstream water levels** and evaluating the impact on the BGSI being designed
  - **Seasonal variation in infiltration rates** can be incorporated into models if it is a critical part of the asset and the asset is a critical part of the flood control design
  - Many BGSI systems have some component of infiltration; groundwater modules can be incorporated to better **evaluate deep infiltration and interflow** to nearby surface waters, as well as infiltration recovery rates
  - **Weather-forecast integration** into models can support adaptive management of stormwater assets (more to come…)

Resiliency Park in Hoboken, NJ

- Project Goals:
  - Reduce CSOs for regulatory compliance
  - Improve long-term resilience
  - Reduce/eliminate street flooding
  - Integrate with Hoboken Green Infrastructure Plan and Rebuild by Design after Superstorm Sandy
  - Consider climate change (storm surge, etc.)
- Project Components:
  - Rain gardens integrated into new park
  - High level storm sewers
  - Raising / leveling streets
  - Stormwater storage under new park
  - Pump station and force main to drain stormwater storage even with elevated river levels



Consultants: Jacobs, Mott MacDonald, E&LP, OLIN, nARCHITECTS, Atlantic Traffic+Design, Studio Ludo, TEND

PA5

Flood Mitigation – Deer Creek, Brentwood, MO

Address ongoing flooding issues

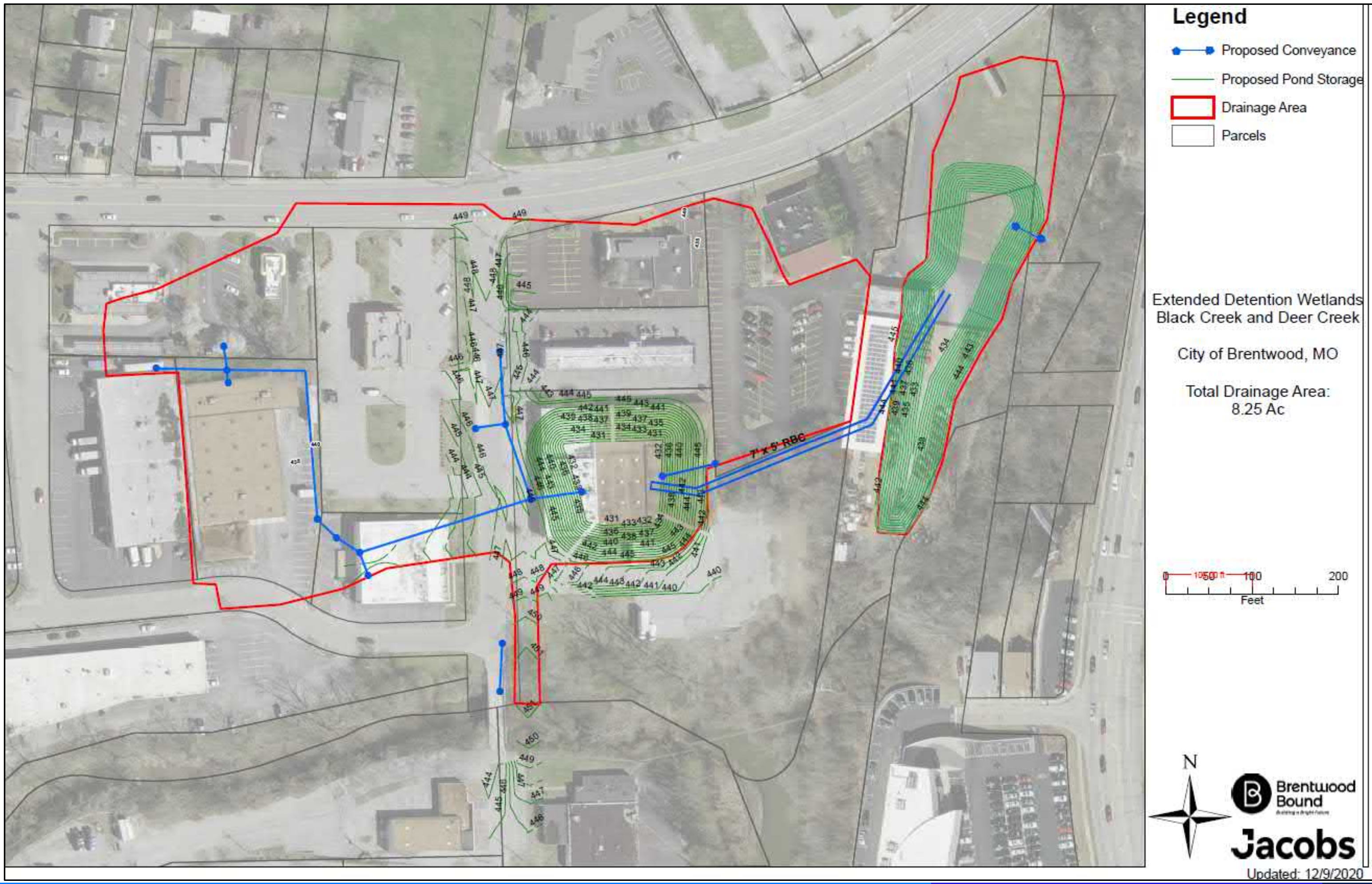
- Opportunity for sustainable urban creek area and redevelopment unique in St. Louis
- Solve 100-year recurring public health & safety problem
- Area has flooded over 30 times since 1957
- Remove Manchester Road from the 100-year floodplain
- Reduce 100-year floodplain from 60 acres to 29 acres (reclaim approximately 31 acres)
- 29 acres remaining in floodplain will adequately handle anticipated stormwater volume

Brentwood Bound – Project Area Current Floodplain

Brentwood Bound – Project Area Future Floodplain

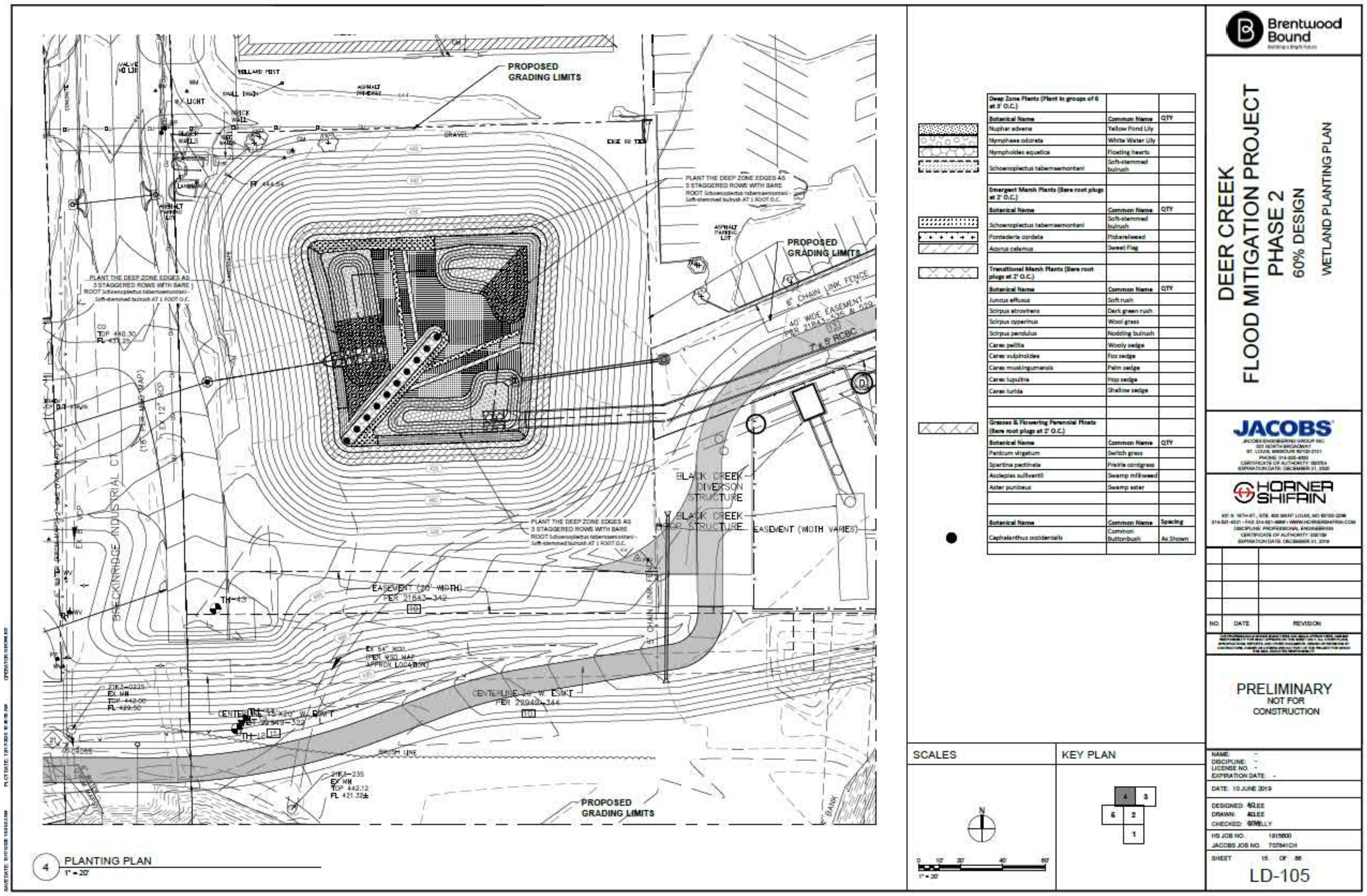
Early Concept of Flood Control Ponds (Blue Only)

- Two pond system
- River backs up into West Pond
- West Pond is connected to East Pond
- Creates extra storage for 50+ year event



Final Design of Flood Control Ponds (BGSI)

- Deer Creek is impaired for E. coli
- Helped City obtain a s.319 grant
- East Pond was converted to dual purpose – Flood Control + Water Quality – as an extended detention wetland
- Pathogens (coliform, E. coli) - Up to 75% reduction with stormwater wetlands



Adaptive Management

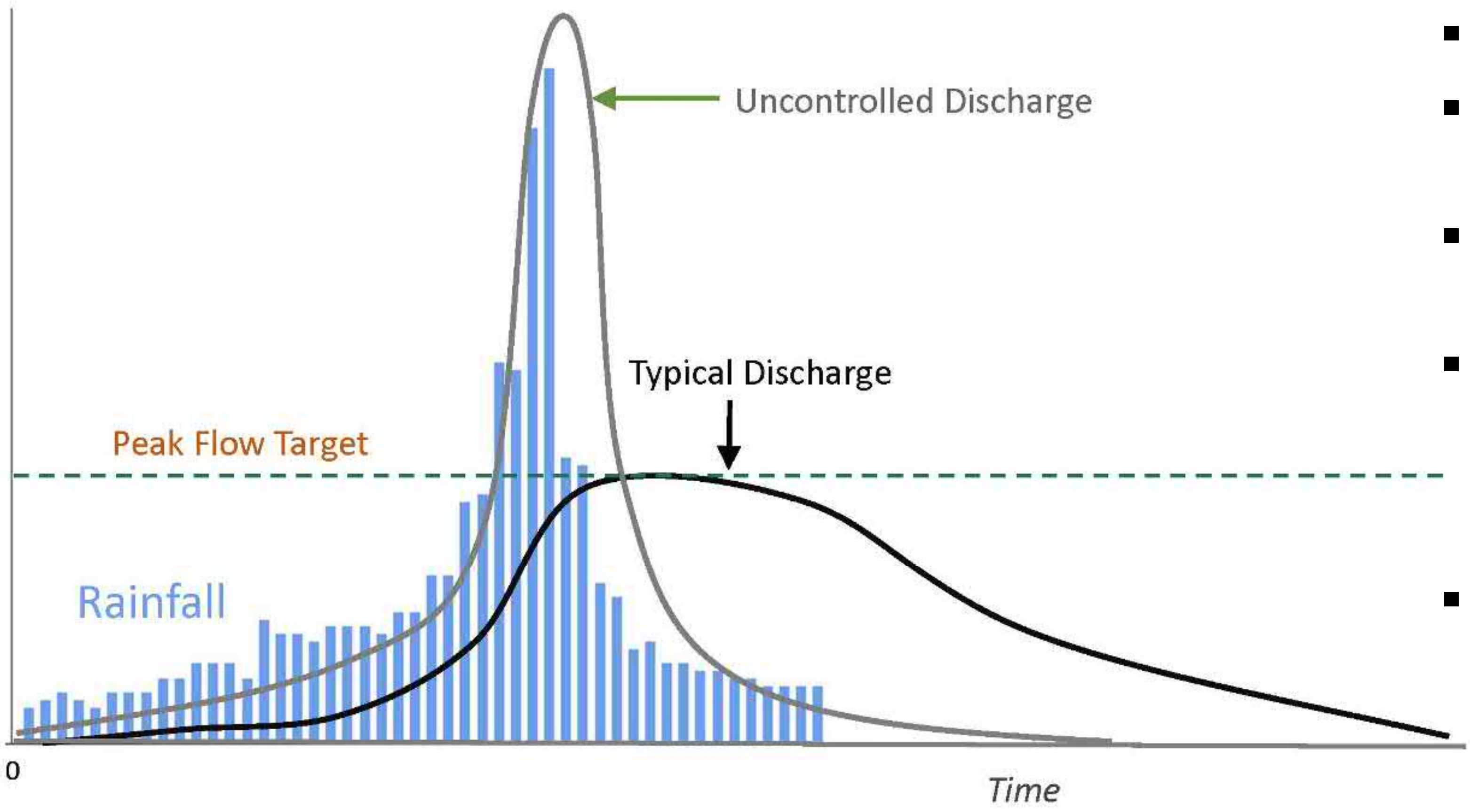
How can we make our BGSI systems adapt to changing weather and site conditions?

How can we make our stormwater systems adapt to changing conditions?

- We know…
  - green infrastructure can significantly improve water quality of small events…
  - blue infrastructure is great for large event flood detention…
  - climate change is affecting the quantity and intensity of precipitation around the world…
- How can we make our stormwater infrastructure "work harder"?

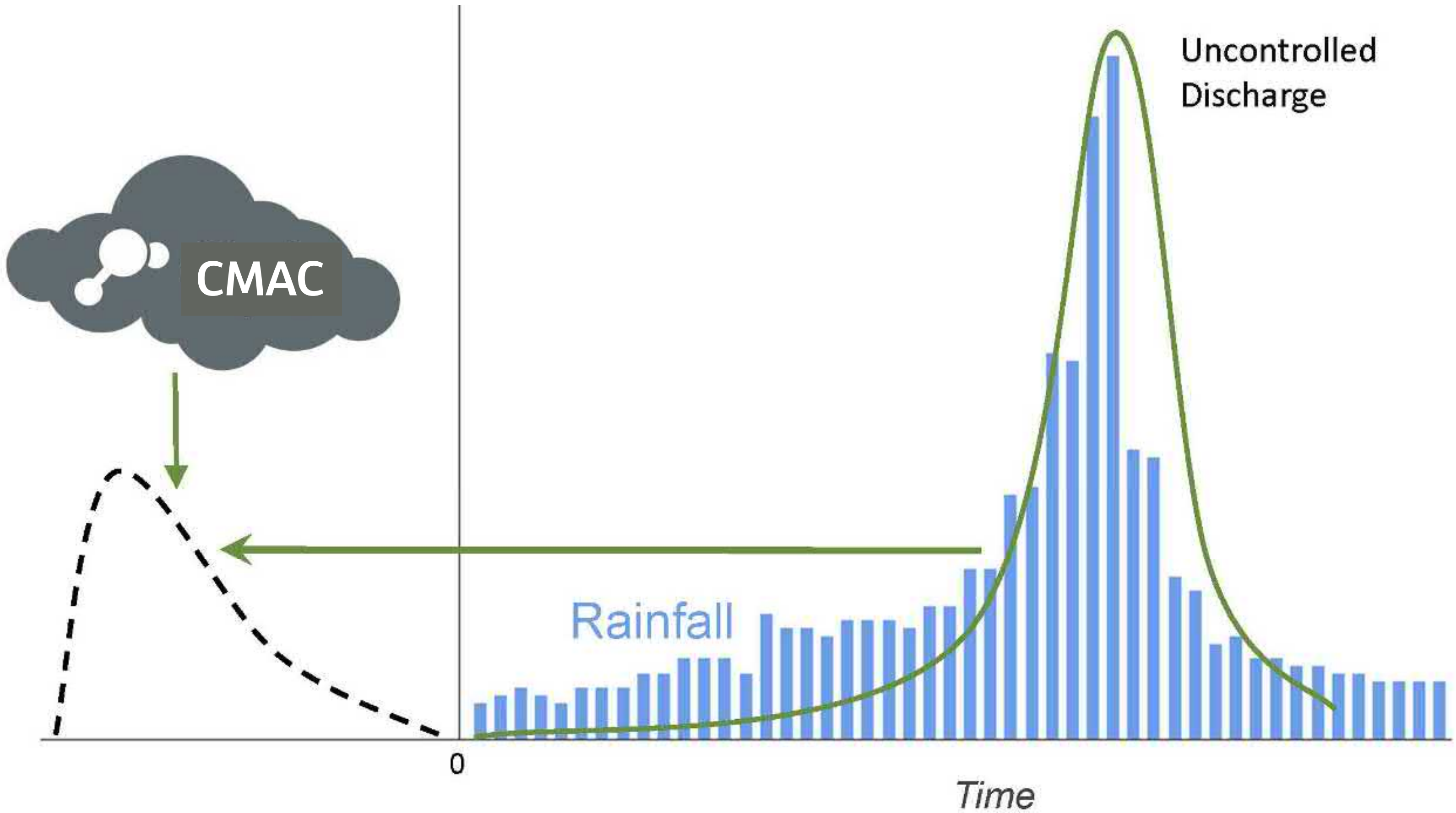
❖ One way is through intelligent control of existing assets!

Passive Stormwater Control



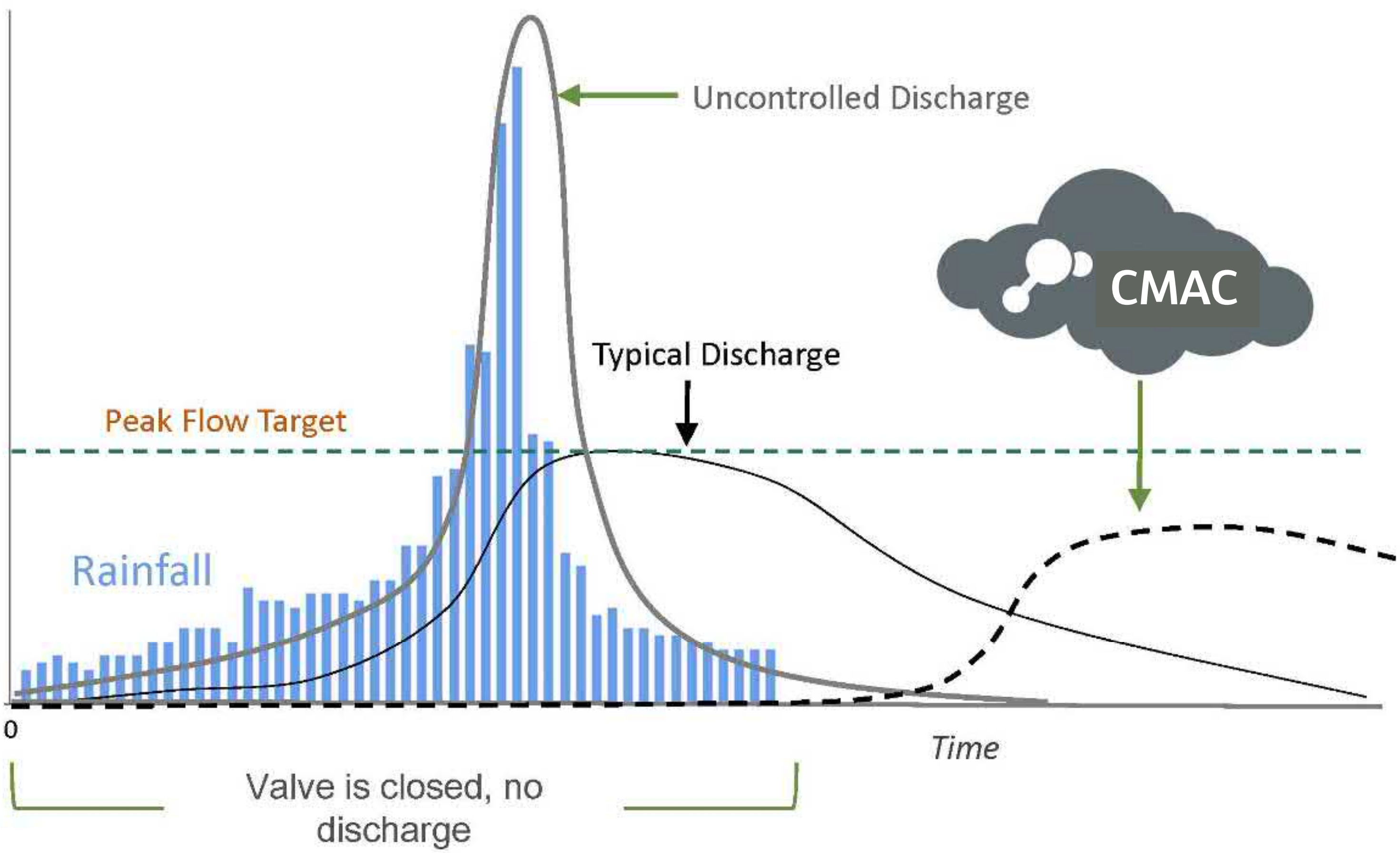
- Storm arrives
- Peak flow is mitigated
- Little or no volume reduction
- In traditional designs, little/no water quality benefit
- Extended release at a lower rate; longer time to recover volume

Intelligent Control – Pre-event Preparation



- Storm is coming
- Weather forecast triggers dry-weather release
- Storage volume is recovered to make room for forecasted rainfall event

Intelligent Control – Event Management and Post-event Discharge



- Storm arrives
- No discharge during event
- Provides enhanced flow management and enhanced WQ benefit (increased retention time)
- Post-event discharge, if desired (e.g., to maintain BMP vegetation)

What is CMAC – Continuous Monitoring and Adaptive Control

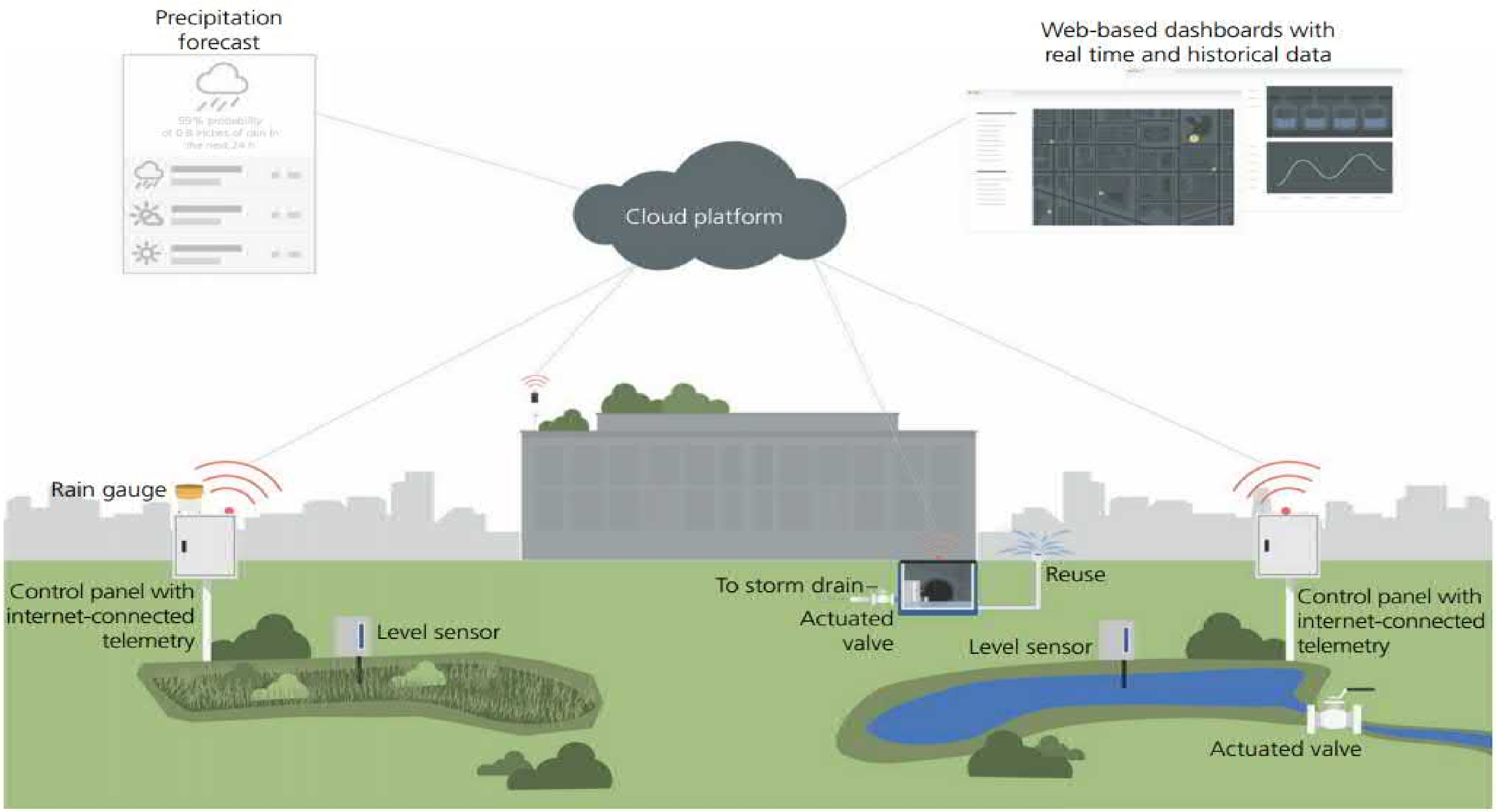
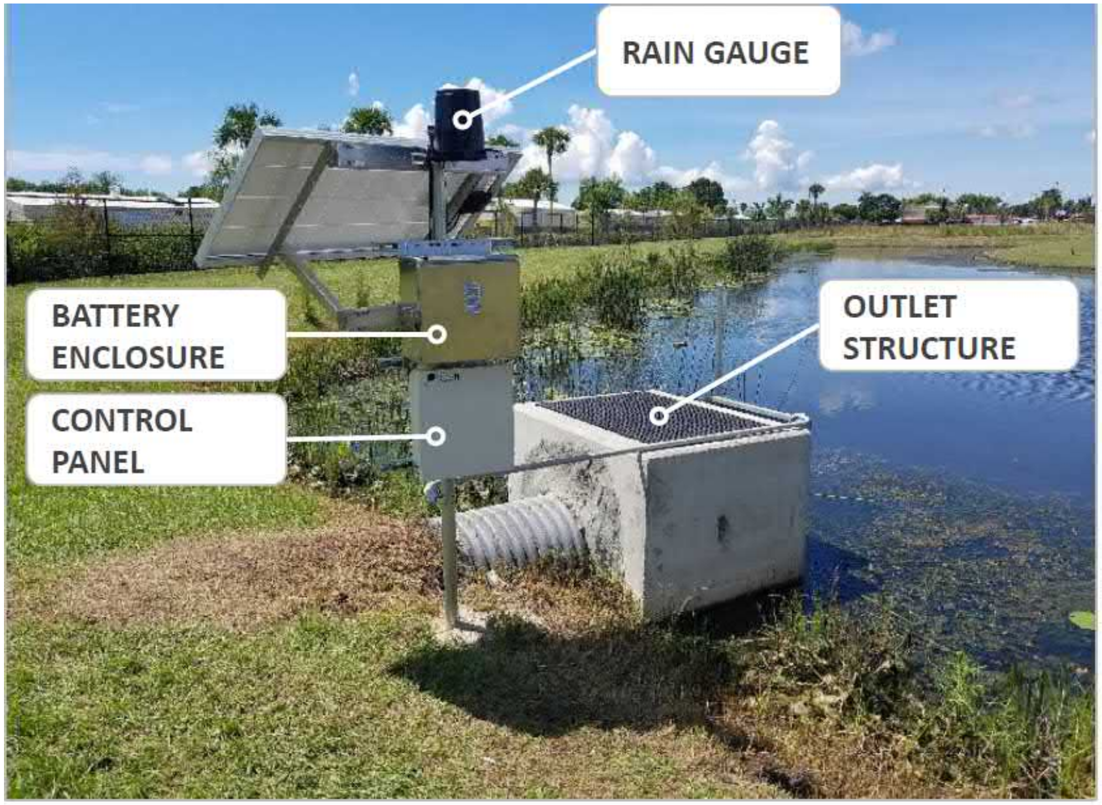


Image Credit: OptiRTC, Inc.

CMAC System Needs

- Water Level Sensor
- Automated Valve or Pump
- Control Panel
  - Panel is equipped with a cellular gateway and integrated cellular antenna for communication with the Software Platform
- Power (solar or line power)



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CMAC System Needs

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Image Credit: OptiRTC, Inc.

Neighborhood Park Pond Retrofit - Harrisburg

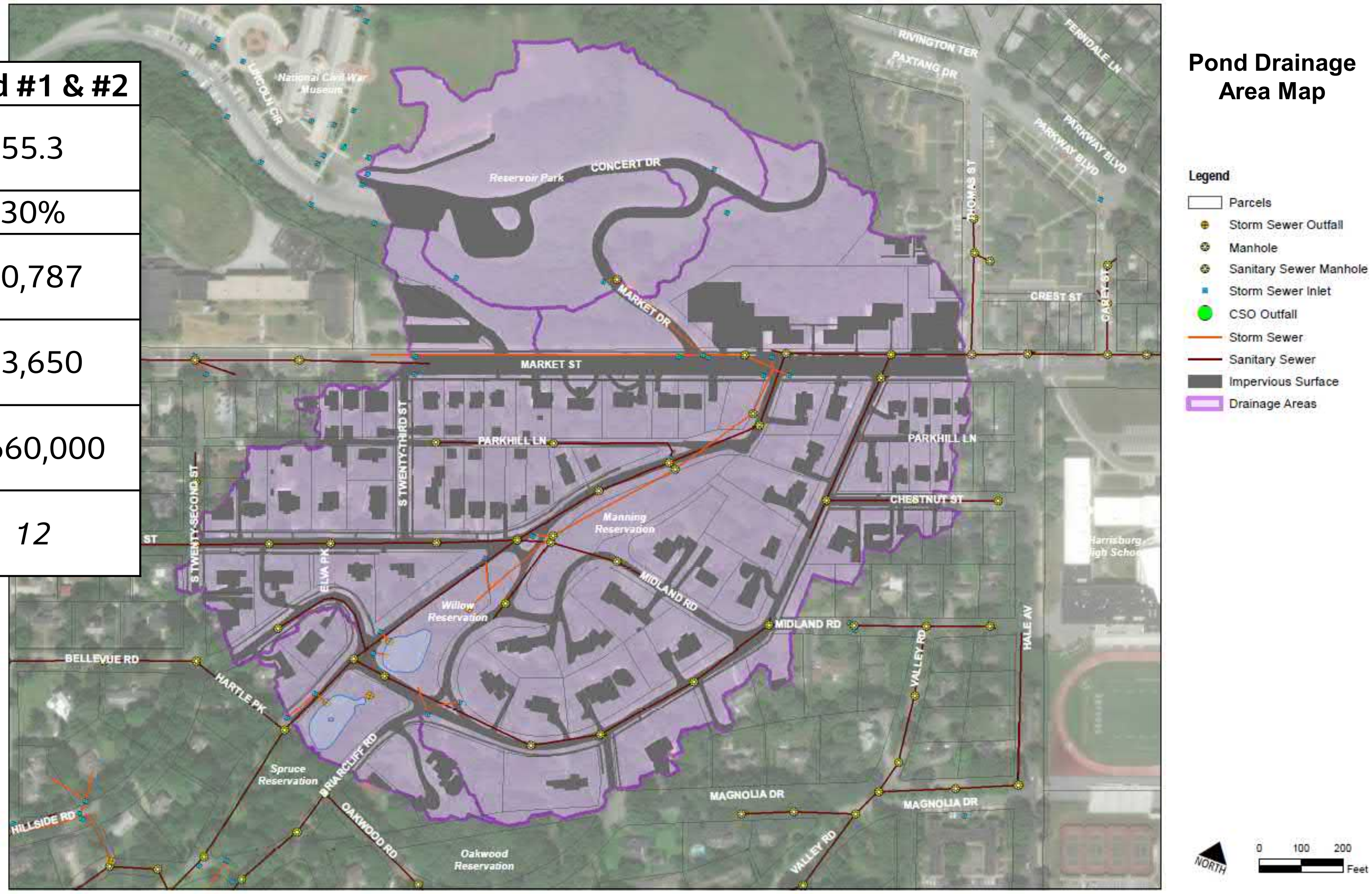
- Recent historic pond retrofit project with multiple stakeholders and goals
- Client goals:
  - ✓ Improve pond water quality
  - ✓ Optimize the ponds for stormwater management
  - ✓ Provide aesthetic and ecological benefits
  - ✓ Balance aesthetics & function
- Community goals (in addition to the above):
  - ✓ Maintain and enhance the historical character of the two pools as a neighborhood centerpiece
  - ✓ Retain and enhance recreation opportunities

Additional Design Elements

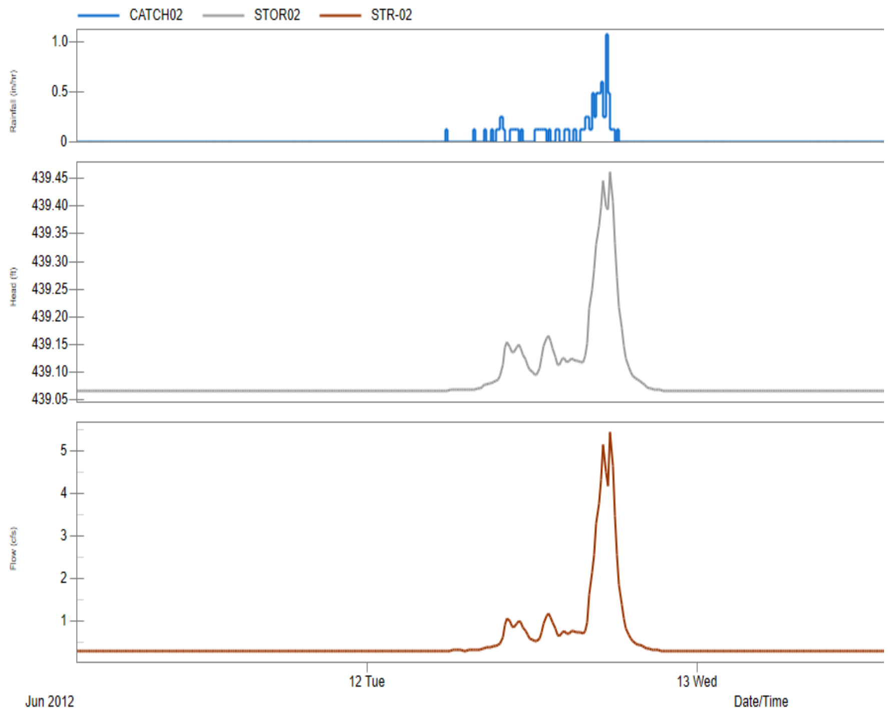
- Maximize pond storage through enhanced pond dredging and slope grading
- Design overflow spillway for peak rate attenuation, stable transition to stream, and safe passage of the 100-year event
- Edge grading and landscaping for habitat and aesthetics
  - Too “wild” or “natural” may be perceived negatively by community
  - Accommodate Maintenance

Ponds Drainage Area

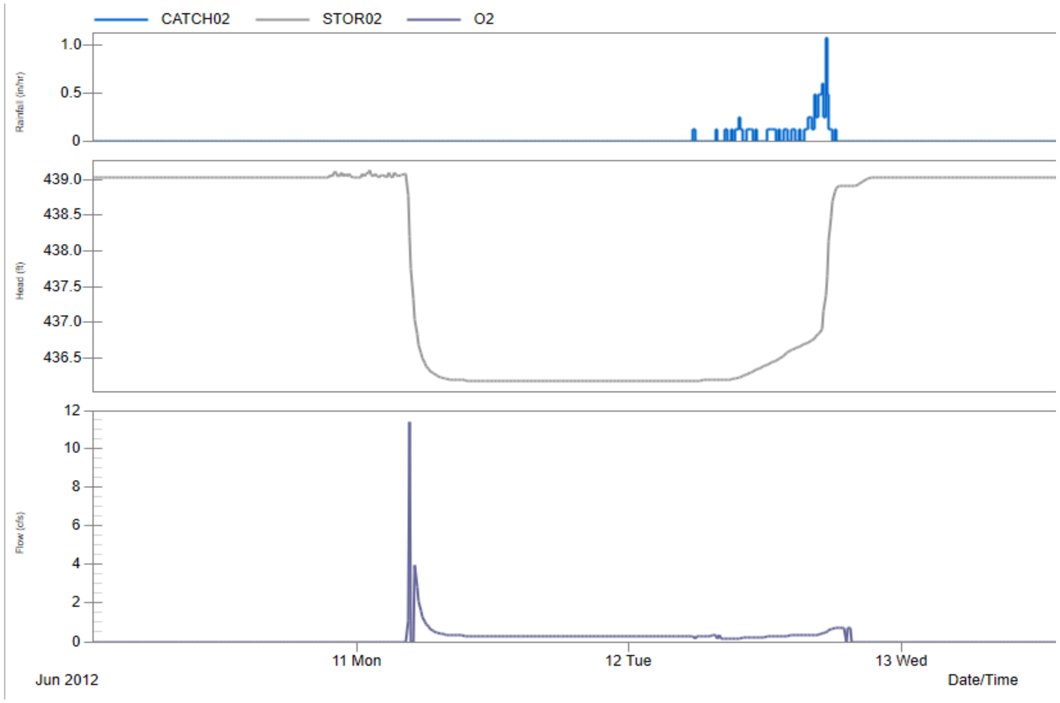
	Pond #1 & #2
Total Drainage Area (ac)	55.3
Impervious (%)	30%
Minimum Capture Goal (0.85") (CF)	50,787
Optimum Capture (1.4") (CF)	83,650
Typical Year Runoff Volume Inflow (CF)	1,660,000
Typical Year Runoff Volume Inflow (MG)	*12*



Preliminary Model Results



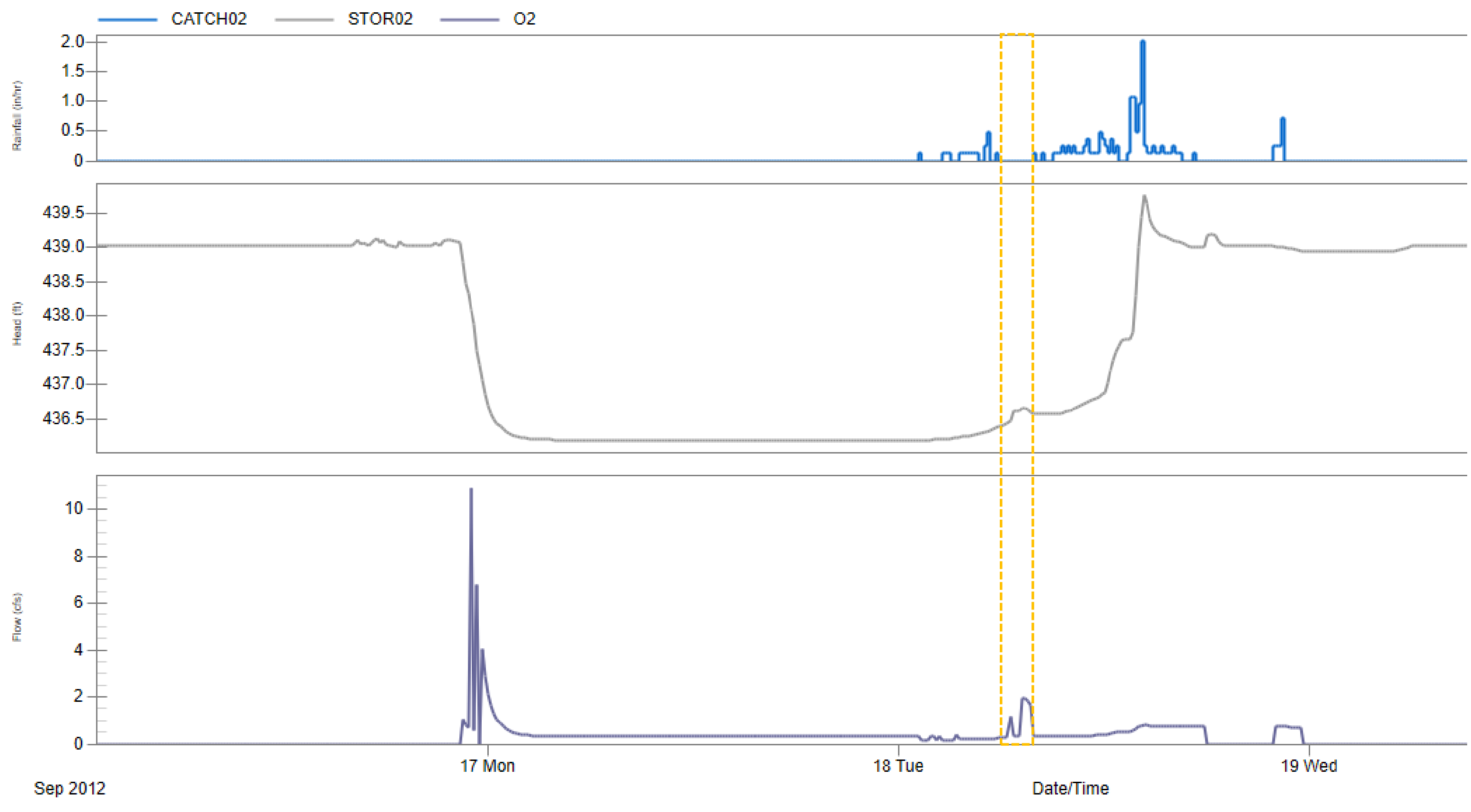
Modeled flows with passive outlet control



Modeled flows with CMAC system control

CMAC resulted in a **100% reduction** in wet weather flow above the max. release rate (1 inch captured off imp. watershed area)

Preliminary Model Results



CMAC Benefits

- **Adaptive control:** system responds automatically to environmental changes (i.e., changes in predicted forecast, water level changes).
- **Flexible operation criteria**: system logic can be adjusted over time as conditions change.
  - E.g., if additional drainage area is added or if compliance criteria change, the logic can be updated to adjust how the system functions as a response to input data.
- **Alerting capabilities:** system uses alerts to trigger inspection of system components.
  - E.g., maintenance personnel can be alerted if the system goes offline
  - System can alert user if it does not respond as expected, e.g., if the water level does not drop when valves are open, which could indicate a blockage.

Cost Implications

Sounds great, but is it affordable?

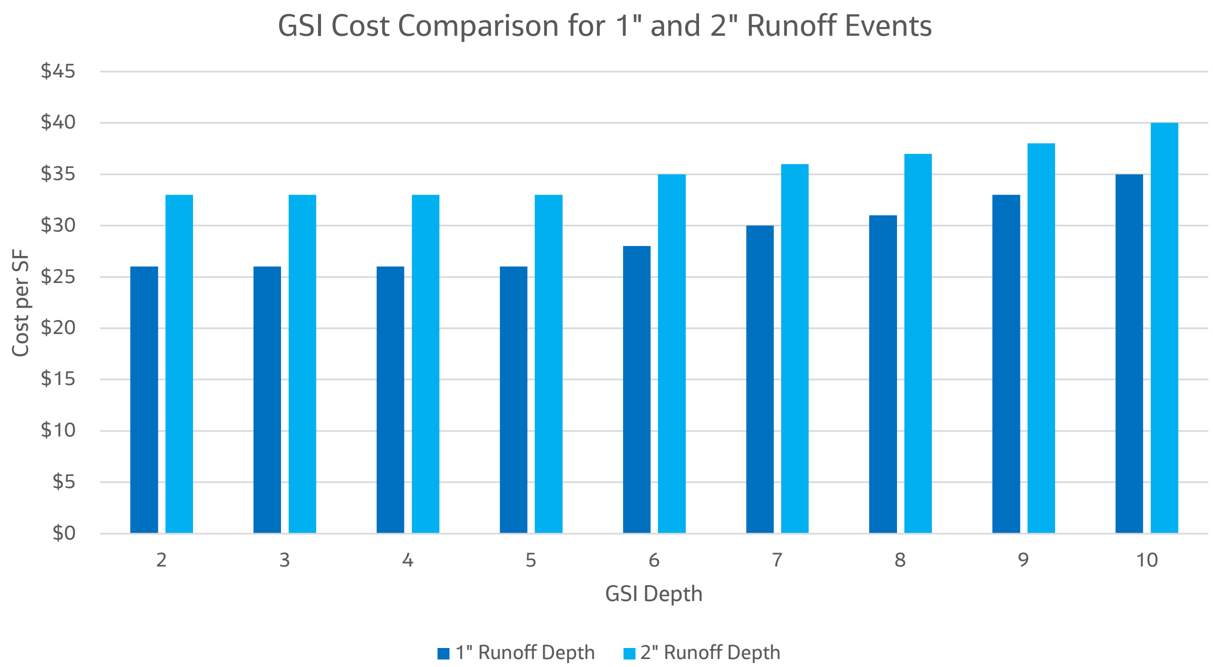
Factors Impacting BGSI Implementation and Costs

- Presence, density, and alignments of existing utilities
- Level of integration with other capital project needs
- Space limitations/proximity to basements/structures
- Anticipated vehicular and pedestrian traffic
- Local market conditions
- Land value (if acquisition is required)
- Geotechnical considerations

Table 1-2. Planning-Level Estimates of Cost Impacts Associated with Various Relative Constraints to GSI Implementation (cost increases that might be expected compared to a location without that constraint)

Relative Constraints	Potential Cost Implications	Constraint Subcategory	Approximate Cost Increase
Utility Pipe Corridors	Cost of liner and/or protecting/working around utilities	-	18% - 25%
Slopes	Extra excavation/fill, baffles, sheeting and shoring	5 to 9.99%	5% - 7%
		10 to 14.99%	15% - 21%
		15 to 24.99%	25% - 35%
Hydrologic Soil Group (HSG)	Increased excavation costs for urban soils, need for underdrains, soil amendments	B/D	8% - 11%
		C	3% - 4%
		C/D	8% - 11%
		D	10% - 14%
		Urban Fill	5% - 7%
Depth to Bedrock	Shallow bedrock could increase excavation costs and/or liner costs	1.1 to 2.6 feet	15% - 21%
		2.6 to 5.0 feet	5% - 7%
		5.0 to 5.7 feet	3% - 4%
Depth to Water Table (annual minimum)	Shallow water table could increase excavation costs and/or liner costs	Less than 0.49 feet	25% - 35%
		0.5 to 1.35 feet	20% - 28%
		1.36 to 1.9 feet	15% - 21%
		1.91 to 2.26 feet	13% - 18%
		2.27 to 2.59 feet	10% - 14%
FEMA 100-year Floodplains	Cost impact more on the O&M/restoration side	-	15% - 21%
Forest Land Cover	Tree removal/replacement and/or protection	-	13% - 18%
Brownfield Parcels, Parcels with Abandoned Mines, Cemeteries	Cost of liner and/or soil disposal	-	15% - 21%
Streets/Roadway	Increased demo and/or pavement/curb restoration costs	-	8% - 11%

Cost Effectively Increasing GSI Storage



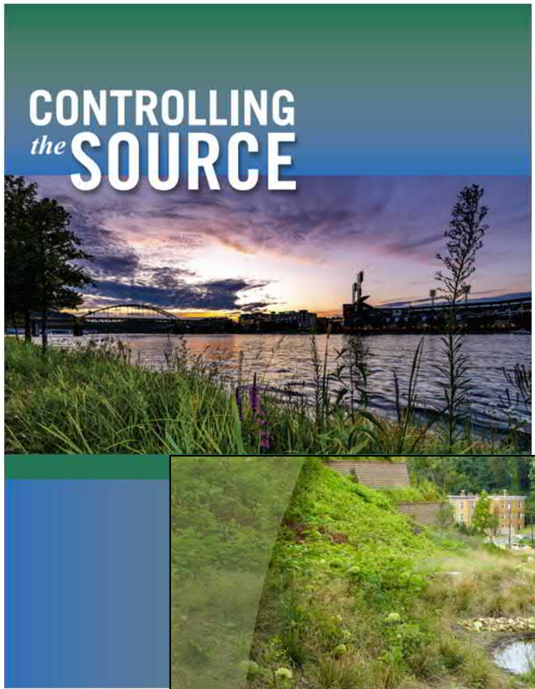
Estimated costs per square foot for these infiltration trenches with vegetated cover show that **doubling the storage capacity only increases the construction cost by 14 to 27%** as much of the cost is sunk in mobilization, pipes, structures, traffic control, surface restoration, etc. that do change significantly between 1 and 2 inches of storage.

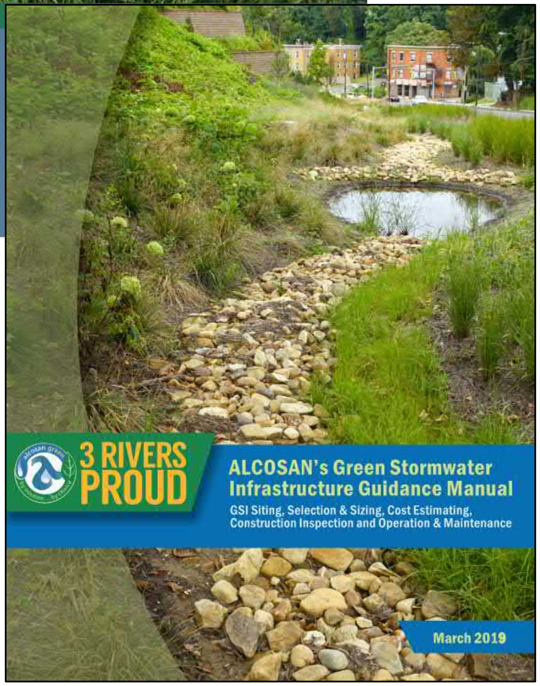
BGSI Resources

Are there BGSI planning and design resources available to the design community?

Guidance Resources

Reference Name	Publishing Agency	Date Published/ Updated	Link
ALCOSAN's Green Stormwater Infrastructure Guidance Manual	ALCOSAN	2019	https://www.alcosan.org/docs/default-source/grow/alcosan_guidancedocs_march2019.pdf?sfvrsn=7c5d69ae_4
Addressing Green Infrastructure Design Challenges in the Pittsburgh Region Fact Sheet Series	EPA, Environmental Protection Agency	January 2014	Addressing Green Infrastructure Design Challenges in the Pittsburgh Region
Resource Guide for Planning, Designing and Implementing Green Infrastructure in Parks	National Recreation and Park Association	2017	Resource Guide for Planning, Designing and Implementing Green Infrastructure in Parks
Green Solutions Fact Sheets	3 Rivers Wet Weather	2016	Green Solutions Bioswales Disconnected Downspout Green Roof Planter Box Permeable Pavement Rain Barrel Rain Garden Vegetated Filter Strip Vegetated Swale
Procedures Manual for Developers Chapter 9: Green Stormwater Infrastructure	Pittsburgh Water and Sewer Authority	January 2018	Procedures Manual for Developers
Pennsylvania Stormwater BMP Manual	Pennsylvania Department of Environmental Protection, Bureau of Watershed Management	December 2006	Pennsylvania Stormwater BMP Manual
Green Stormwater Infrastructure Planning & Design Manual	Philadelphia Water	April 2018	Green Stormwater Infrastructure Planning & Design Manual
Green Streets Design Manual	Philadelphia Water, Philadelphia Streets	2014	City of Philadelphia Green Streets Design Manual
Best Management Practice (BMP) Toolkit	Westmoreland Conservation District.	2015 - 2016	Westmoreland Conservation District BMP Toolkit





Selected BGSI Resources

- ACTION PLAN FOR NATURE-BASED STORMWATER STRATEGIES: Promoting Natural Designs that Reduce Flooding and Improve Water Quality In North Carolina
- An overview of the Social Innovations for Blue-Green Infrastructure in the ten BEGIN-cities
- Blue-green infrastructure – perspectives on water quality benefits (ciria)
- Blue-green infrastructure – perspectives on planning, evaluation and collaboration (ciria)
- Blue-Green Infrastructure (BGI) in Dense Urban Watersheds. The Case of the Medrano Stream Basin (MSB) in Buenos Aires
- Designing Blue Green Infrastructure (BGI) for water management, human health, and wellbeing: summary of evidence and principles for design
- Envisioning Blue Cities: Urban Water Governance and Water Footprinting
- Factsheet – Benefits and beneficiaries of green – blue measures
- Hybrid Blue-Green Infrastructure: Feasibility Study for the State of Maharashtra; India
- The implementation of Blue-Green Infrastructure in a Sustainable Urban Stormwater Management
- International Perceptions of Urban Blue-Green Infrastructure: A Comparison across Four Cities
- Living with Water: Lessons from Singapore and Rotterdam
- Miami Beach Blue/Green Infrastructure Concept Plan
- Roadmap for the BGI Manual
- Storm Smart Cities – Integrated Green Infrastructure into Local Hazard Mitigation Plans (US EPA)
- Tasinge Plads

Poll Question #2

What are the greatest challenges or concerns you have regarding BGSI implementation?

1. Site and Space Constraints
2. Cost/Funding
3. Public Acceptance
4. Lack of Qualified Designers
5. Lack of Qualified Contractors
6. Maintenance/Monitoring
7. All of the Above

Thank You! Questions?

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