Jacobs Challenging today. Reinventing tomorrow.

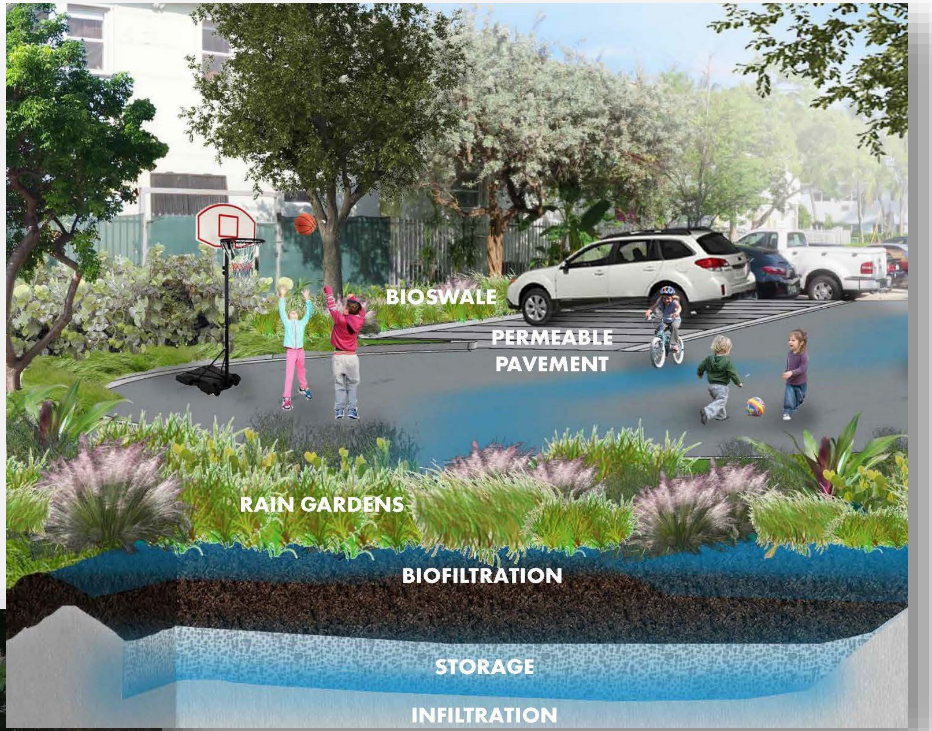
Nature-Based Stormwater Solutions and Blue Green Stormwater Infrastructure

March 19, 2024

Andy Potts, PE, LEED AP

Presentation Outline

- Background on Blue Green Stormwater Infrastructure (BGSI)
- Reconfiguring Public Spaces
- Planning and Designing BGSI for Resiliency
- Cost Implications
- Q&A



Background

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

Urban Flooding: Many Causes, Many Challenges

Precipitation - Driven

Stormwater/ Drainage

Localized flooding

Riverine

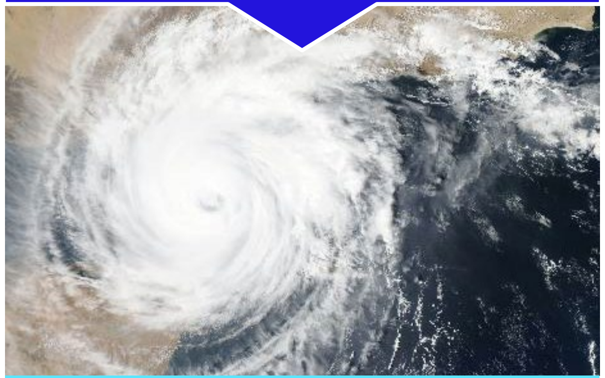
Regional flooding

Coastal

Tidal/Groundwater

Recurrent flooding from increasing tide levels

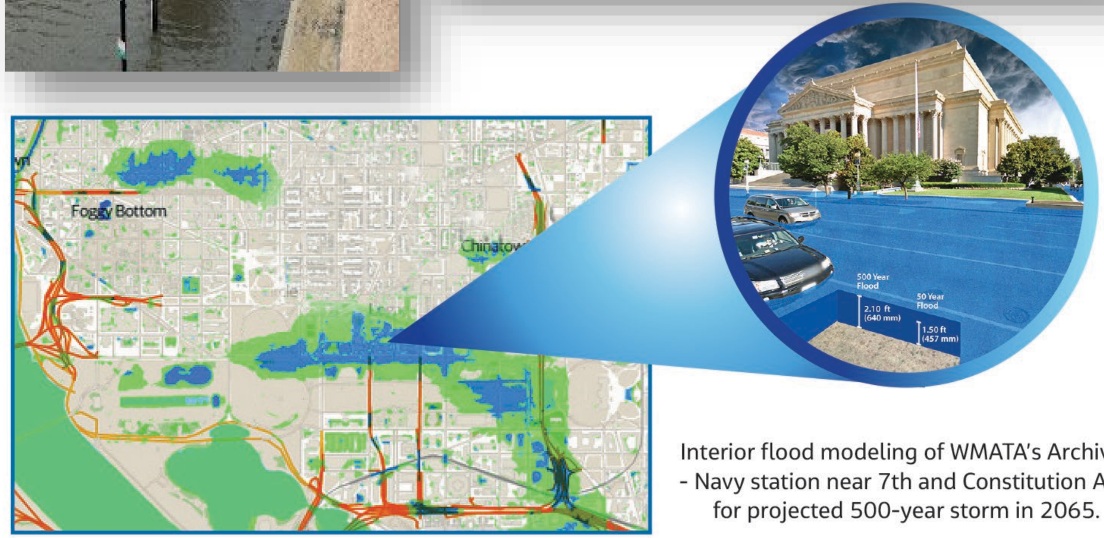
Storm Surge



Coastal flooding

Rethinking Our Drainage Infrastructure (and our built environments)

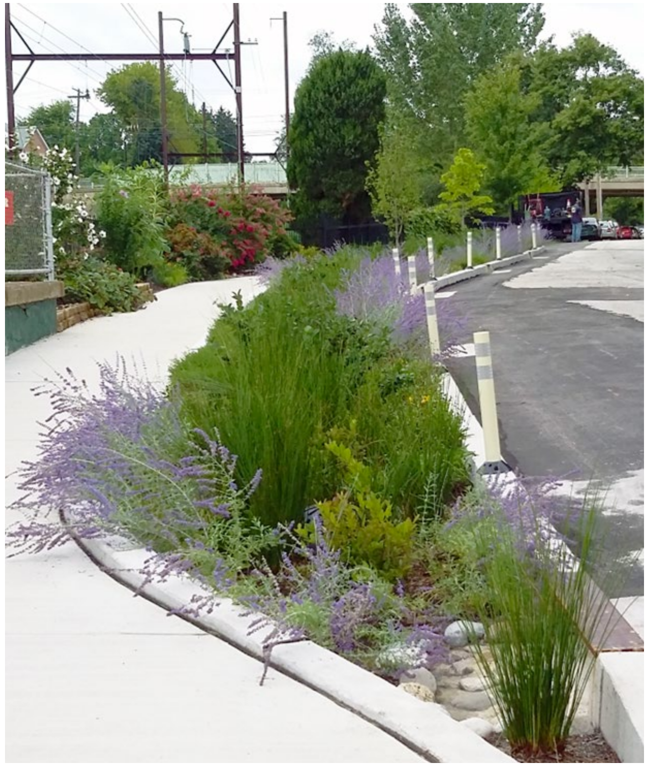
- Our current/historic drainage infrastructure has not aged well, it often:
  - Has Insufficient capacity
  - Does not improve water quality
  - Does not reduce volume
  - Just sends the problem downstream
  - Is single-purpose



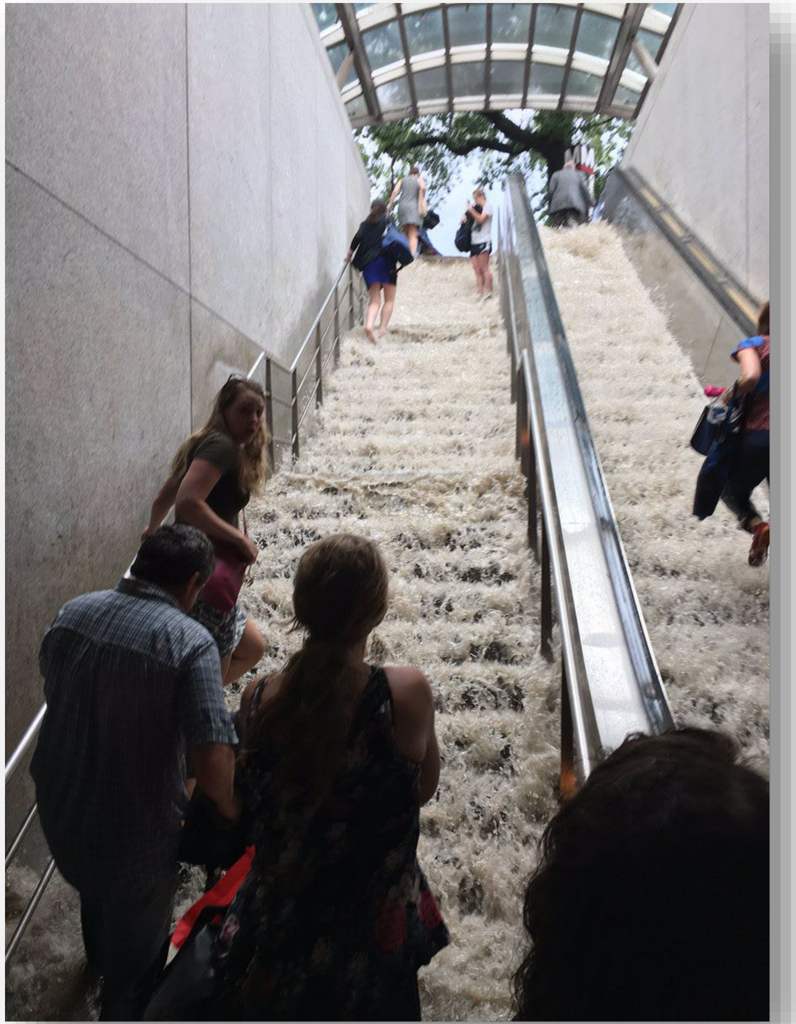
Interior flood modeling of WMATA's Archives - Navy station near 7th and Constitution Ave, for projected 500-year storm in 2065.

Enter… Blue Green Stormwater Infrastructure

- **Green Stormwater Infrastructure (GSI)**
  - Vegetation, soils
  - Typically designed for smaller more frequent storms
- **Blue Stormwater Infrastructure (BSI)**
  - Temporary storage of large stormwater volumes
- **Blue Green Stormwater Infrastructure (BGSI)**
  - Combines Blue and Green
  - Water quality and community enhancement
  - Flood reduction and climate resiliency
  - Social, environmental, and financial benefits
  - “Living with water”



When we say
"Living With Water"…



or?

Reconfiguring Public Spaces

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

Sidmouth Amphitheatre, UK

- Historic town center impacted by flooding
- Captures upgradient flows that exceed the infrastructure capacity and minimize negative impacts to the park
- Created a multi-function facility
  - Flood storage and resiliency
  - Public space
- Surface storage and 150,000 gallons of underground storage

Construction & Post-Construction

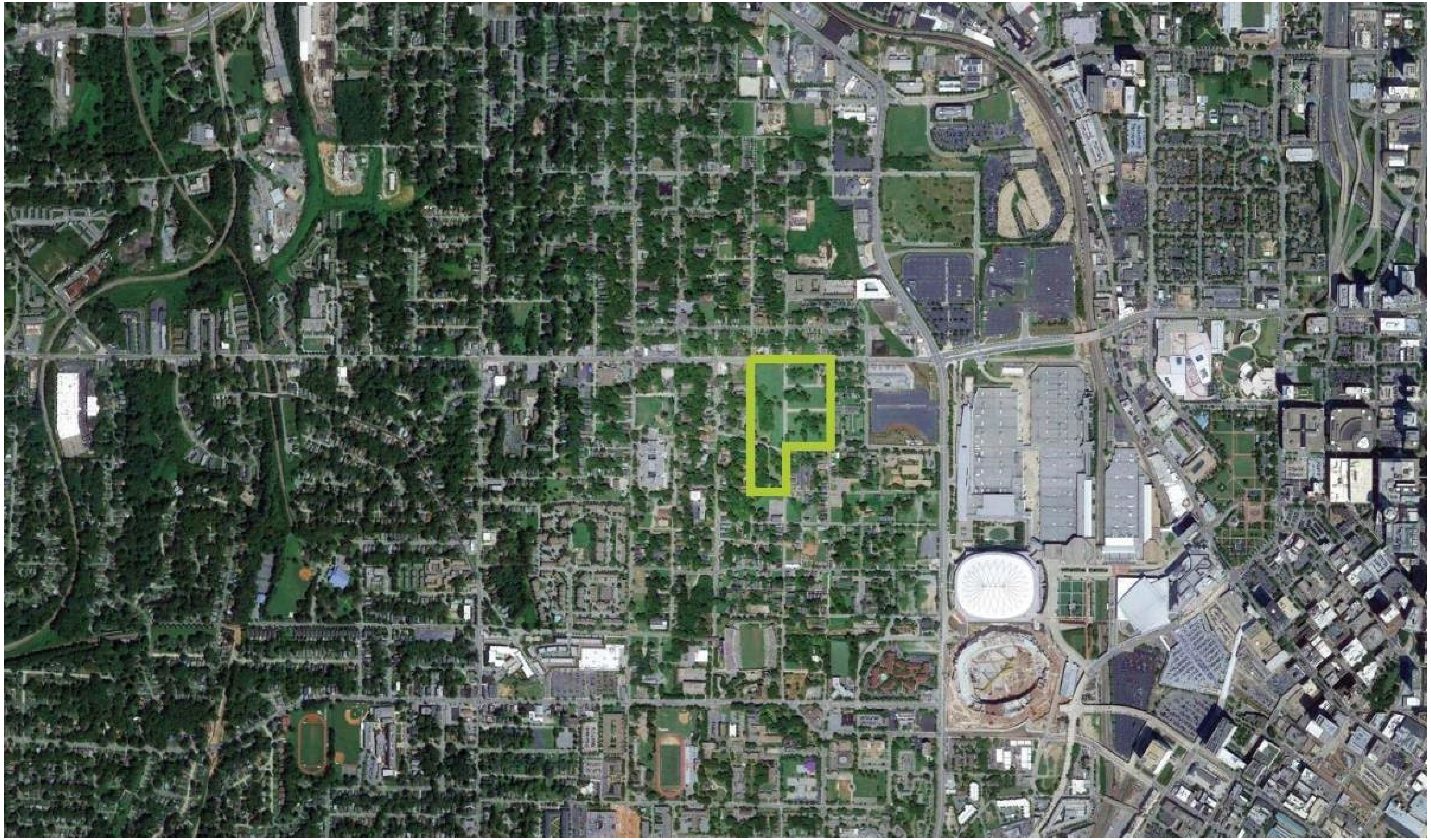
“ No one imagined that a scheme that obviously requires a significant volume of water to be intercepted and stored before it gets to the town could in effect be hidden in plain sight, giving the community a real asset that will be a draw for people.”

— Sidmouth County Councilor
Stuart Hughes, 2021

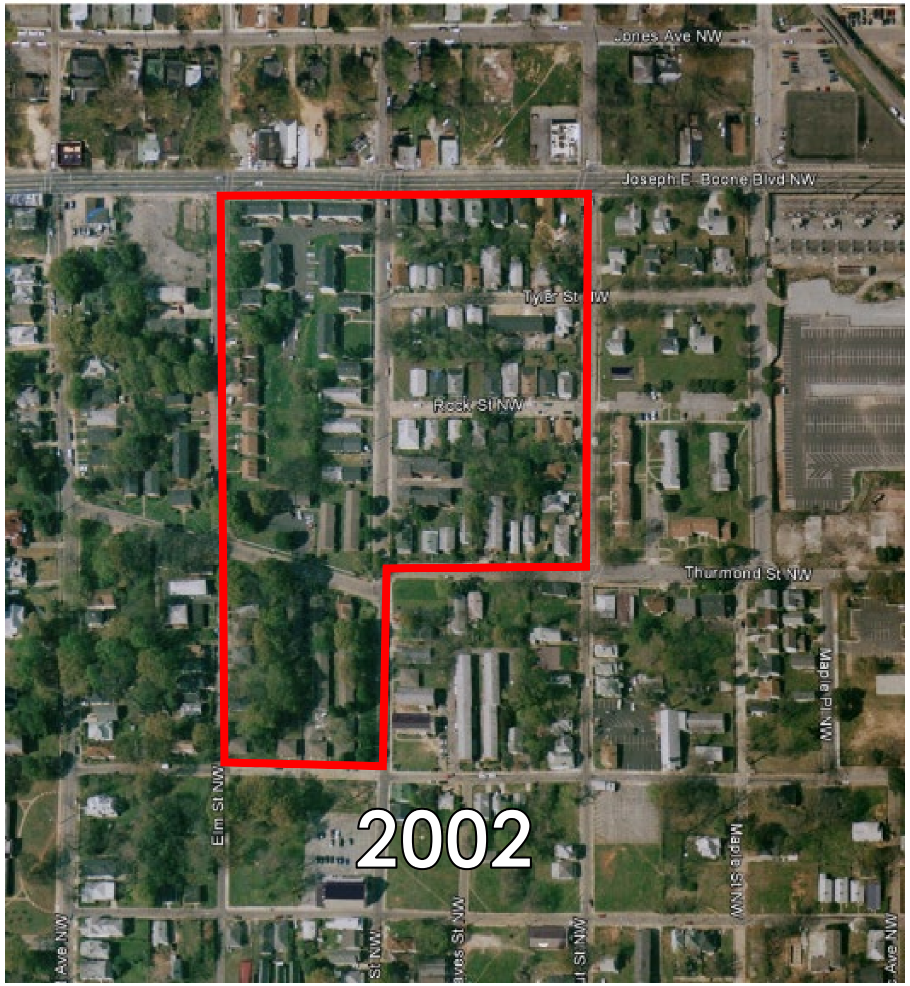
Storage crates installation (2021)

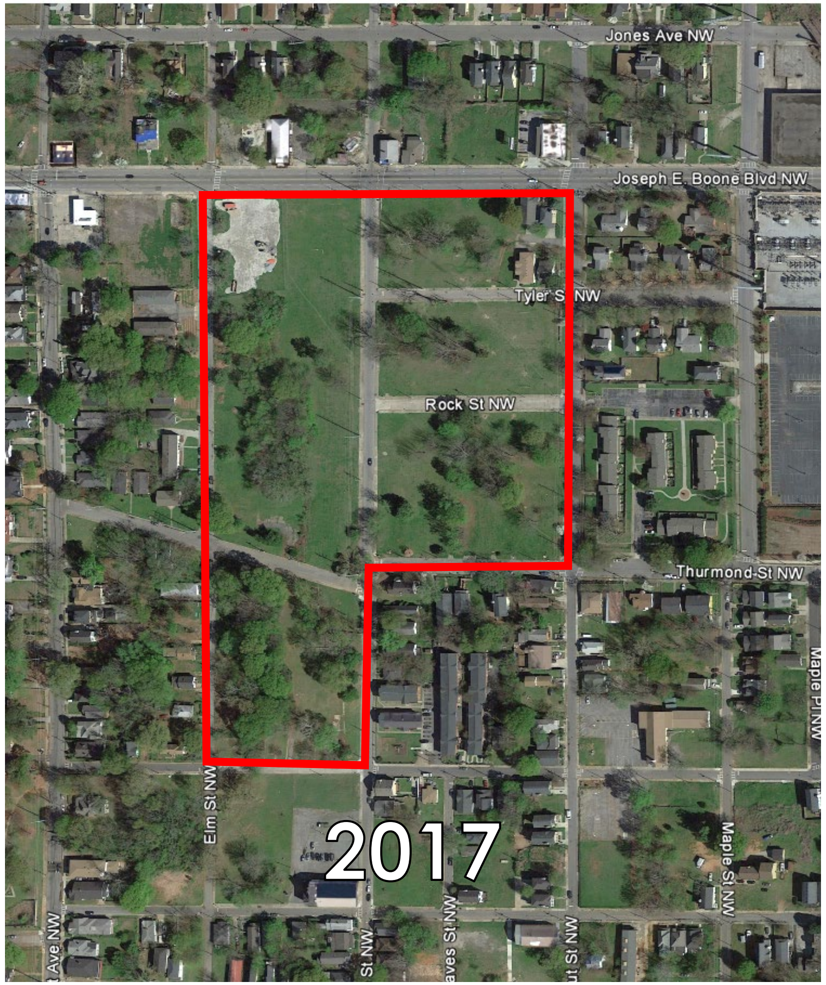
Amphitheatre nearly complete

Re-Imagining Public Spaces – Parks
Rodney Cook, Sr. Park in Atlanta, Georgia

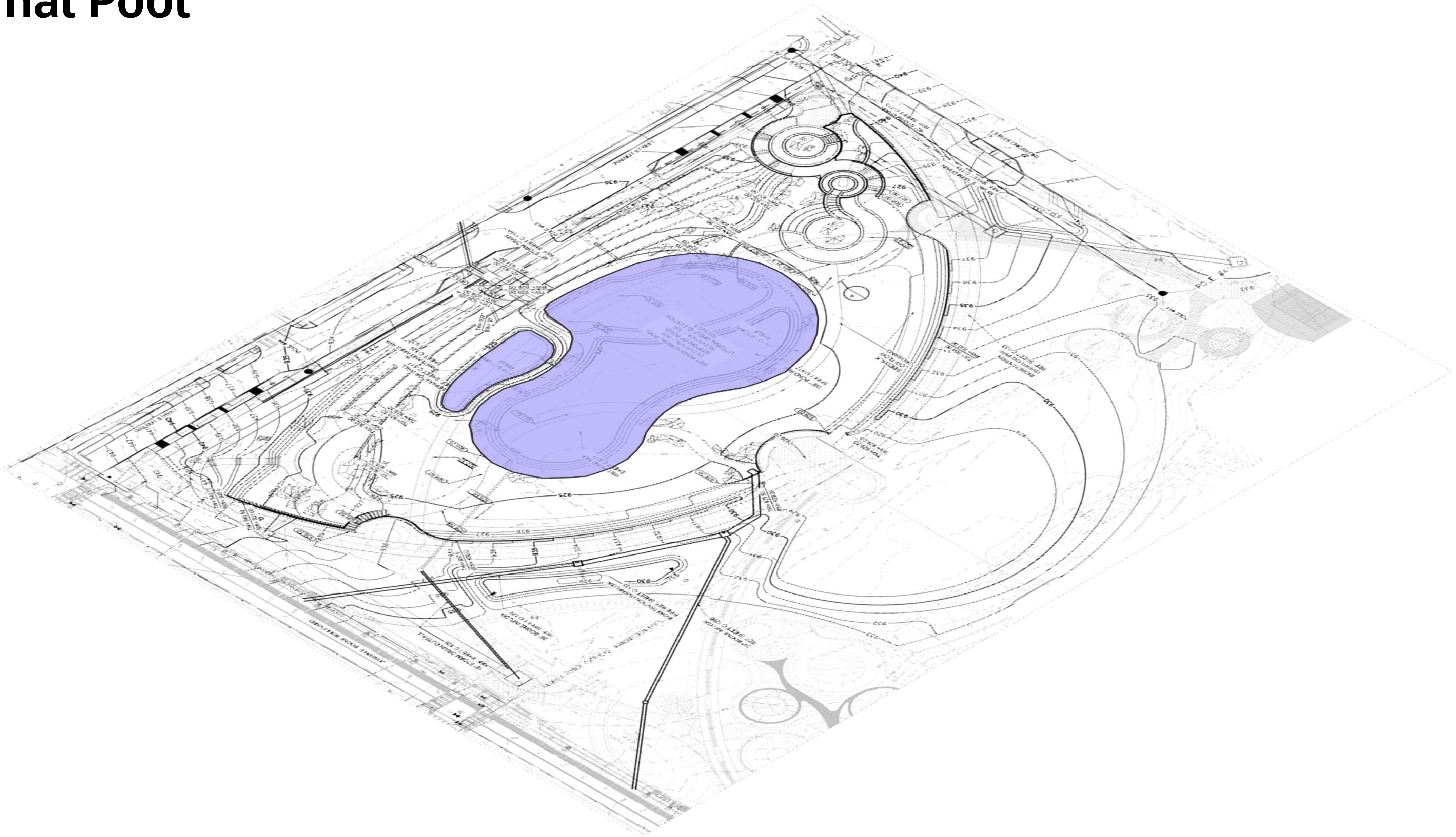


Before and After Major Flooding

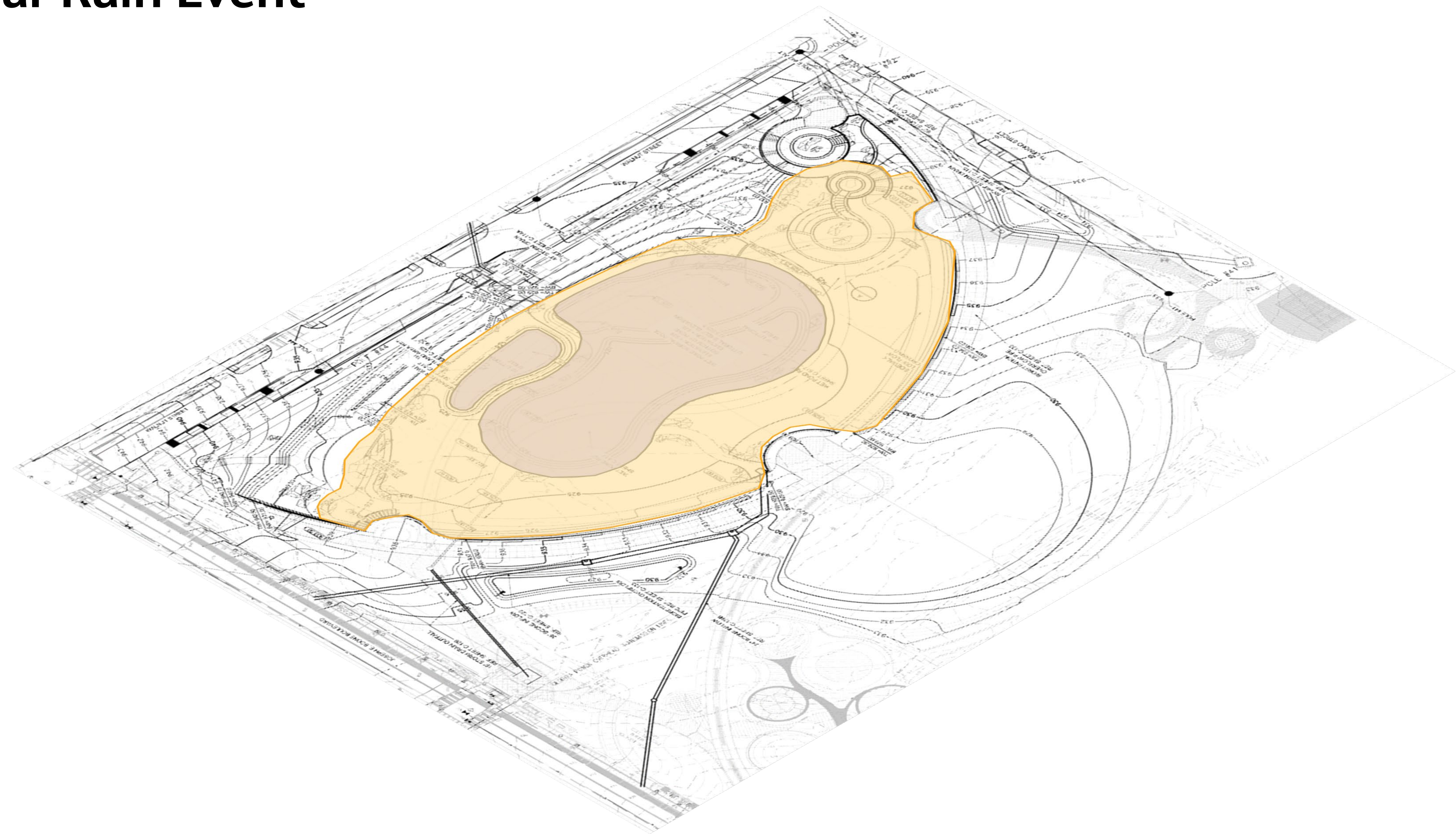




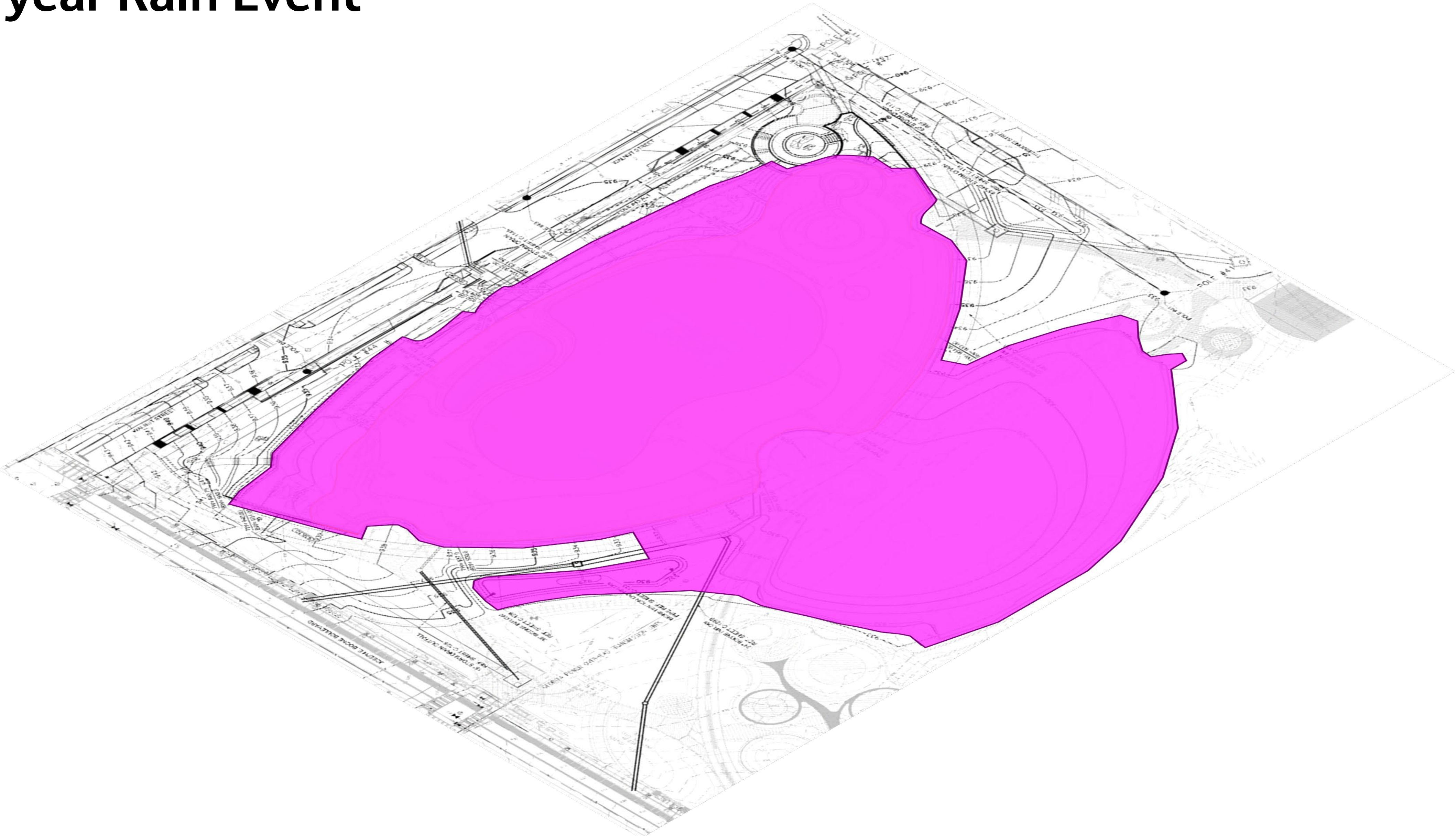
Normal Pool

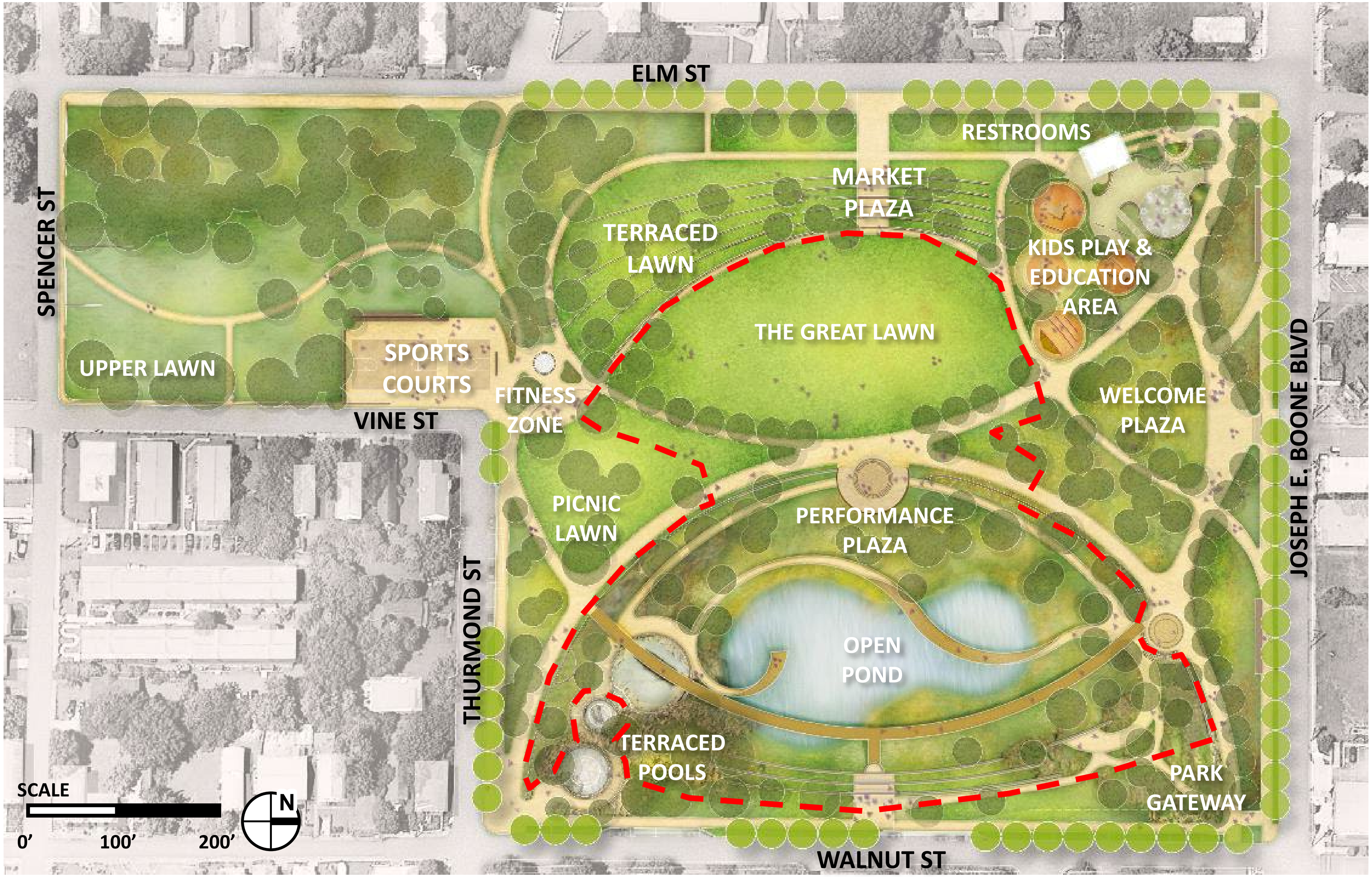


2-year Rain Event



100-year Rain Event





Rodney Cook, Sr. Park
CONCEPT PLAN

HDR andropogon THE TRUST FOR PUBLIC LAND

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

Rams Head Center at Univ. of North Carolina – Chapel Hill

- 1-acre blue-green roof plaza on top of multi-story parking garage
- 56,000-gallon cistern under the brick sidewalks on the roof
- 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 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

Planning and Designing for Resiliency

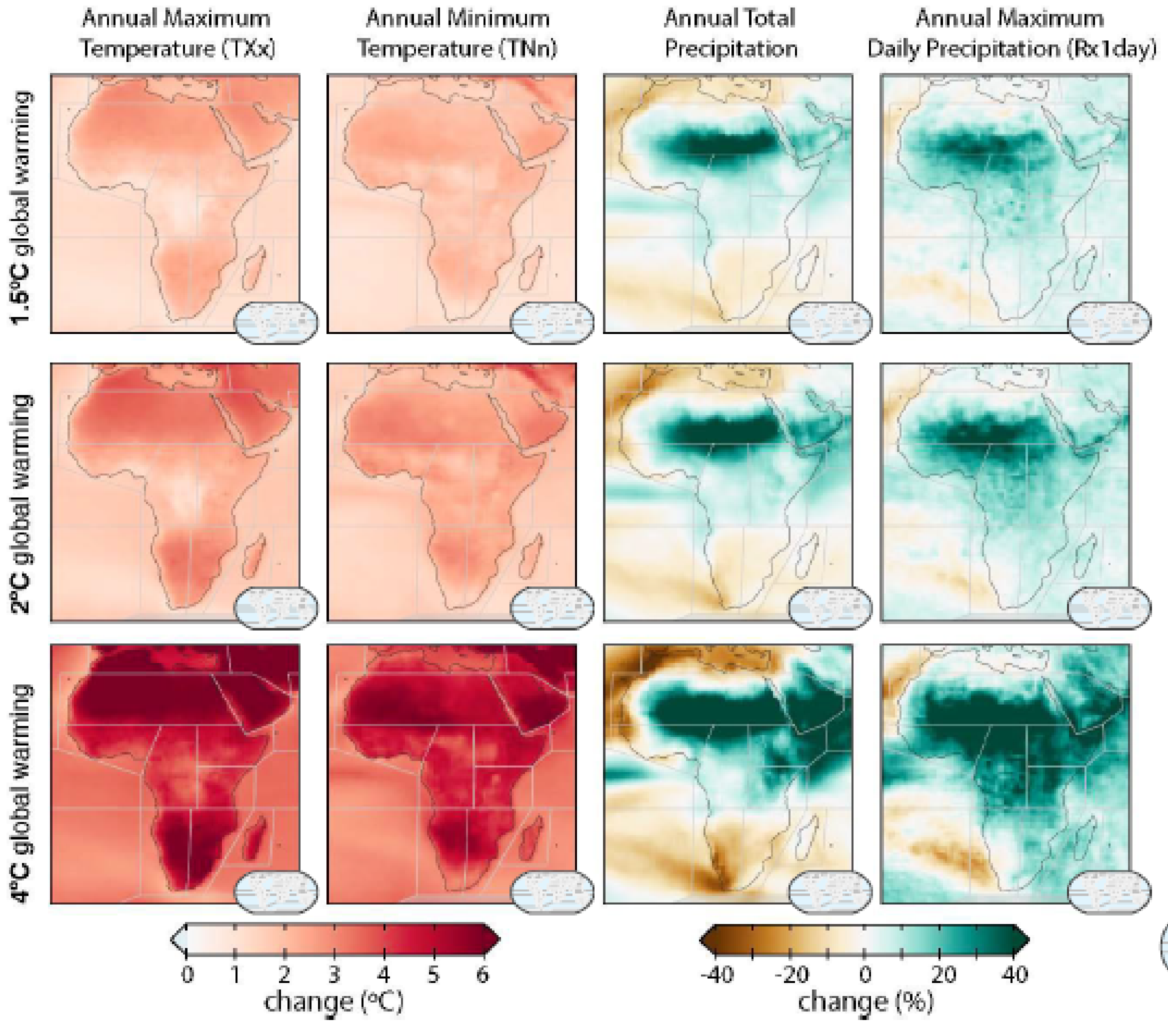
Where and how are BGSI projects designed to achieve resiliency goals?

Climate Change Projections

- Climate change should influence municipal decision making
- Ensuring infrastructure can **withstand or adapt** to the climate changes that will occur **throughout its design life** is important

IPCC 6th Assessment Report Regional fact sheet - Africa

The frequency and intensity of heavy precipitation events are projected to increase almost everywhere in Africa with additional global warming (*high confidence*).



With additional increases in global warming, changes in hot and cold temperature extremes, mean and maximum one-day precipitation get larger.

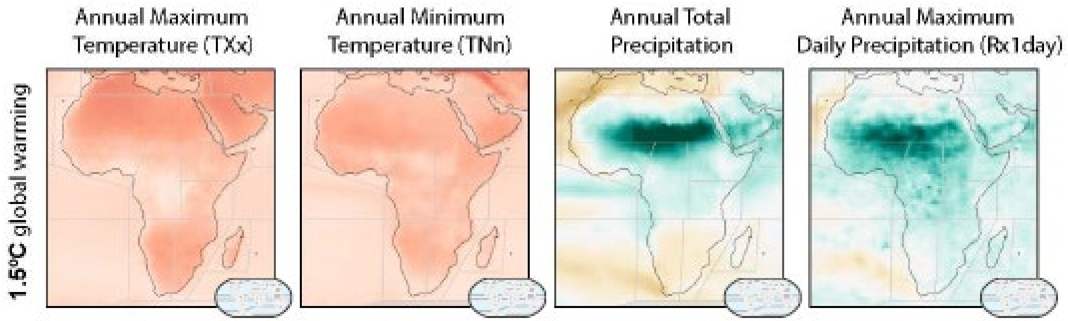
Projected changes in annual maximum temperature (TXx), annual minimum temperature (TNn), annual mean precipitation and annual maximum daily precipitation (RX1day) at 1.5°C, 2°C, and 4°C of global warming (in rows) compared to 1851–1900. Results are based on simulations from the CMIP6 multi-model ensemble mean.

Results expanded in the Interactive Atlas (active links)

interactive-atlas.ipcc.ch

Planning and Designing for Resiliency

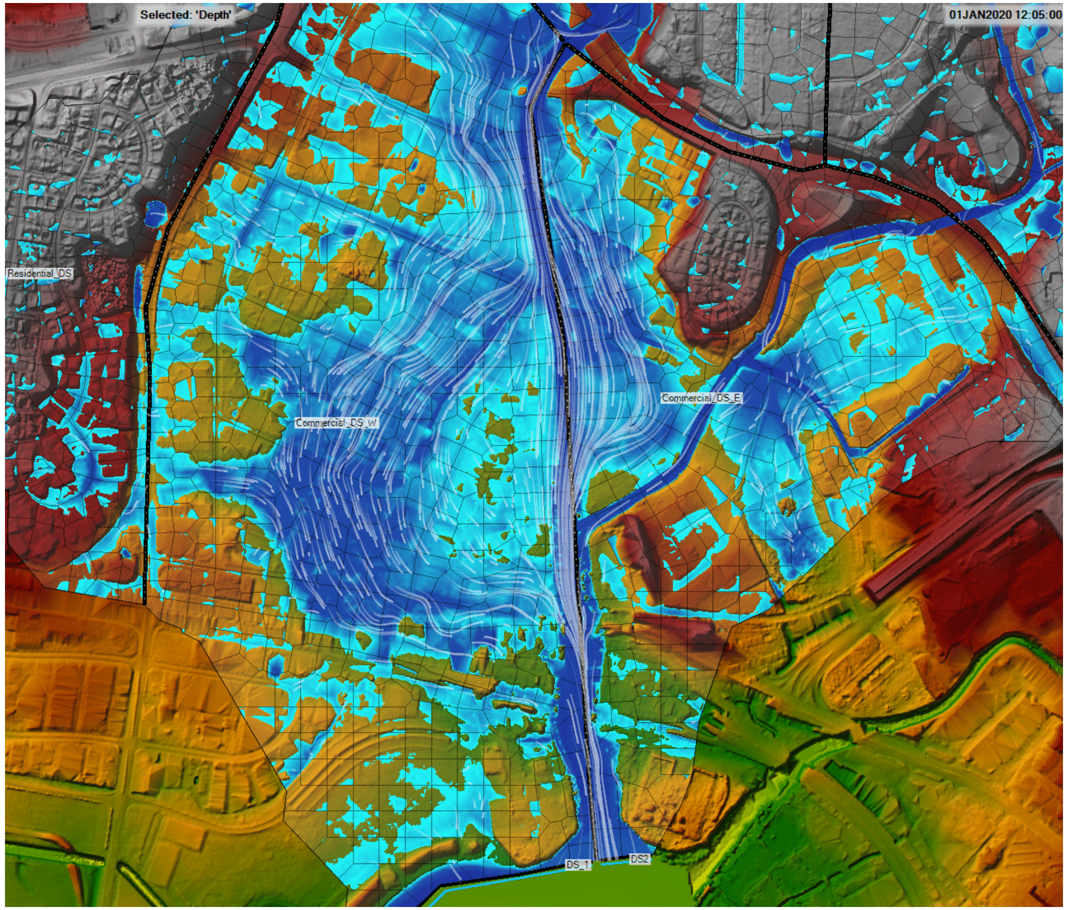
- Consider the design life of the BGSI when determining design criteria
- What external factors should be considered?
  - Flooding
  - Rainfall intensity and duration increases
  - Groundwater elevation changes
  - Extended drought
  - Changing temperature and precipitation patterns
- What BGSI parameters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



Incorporating Resiliency into our Designs/Modeling

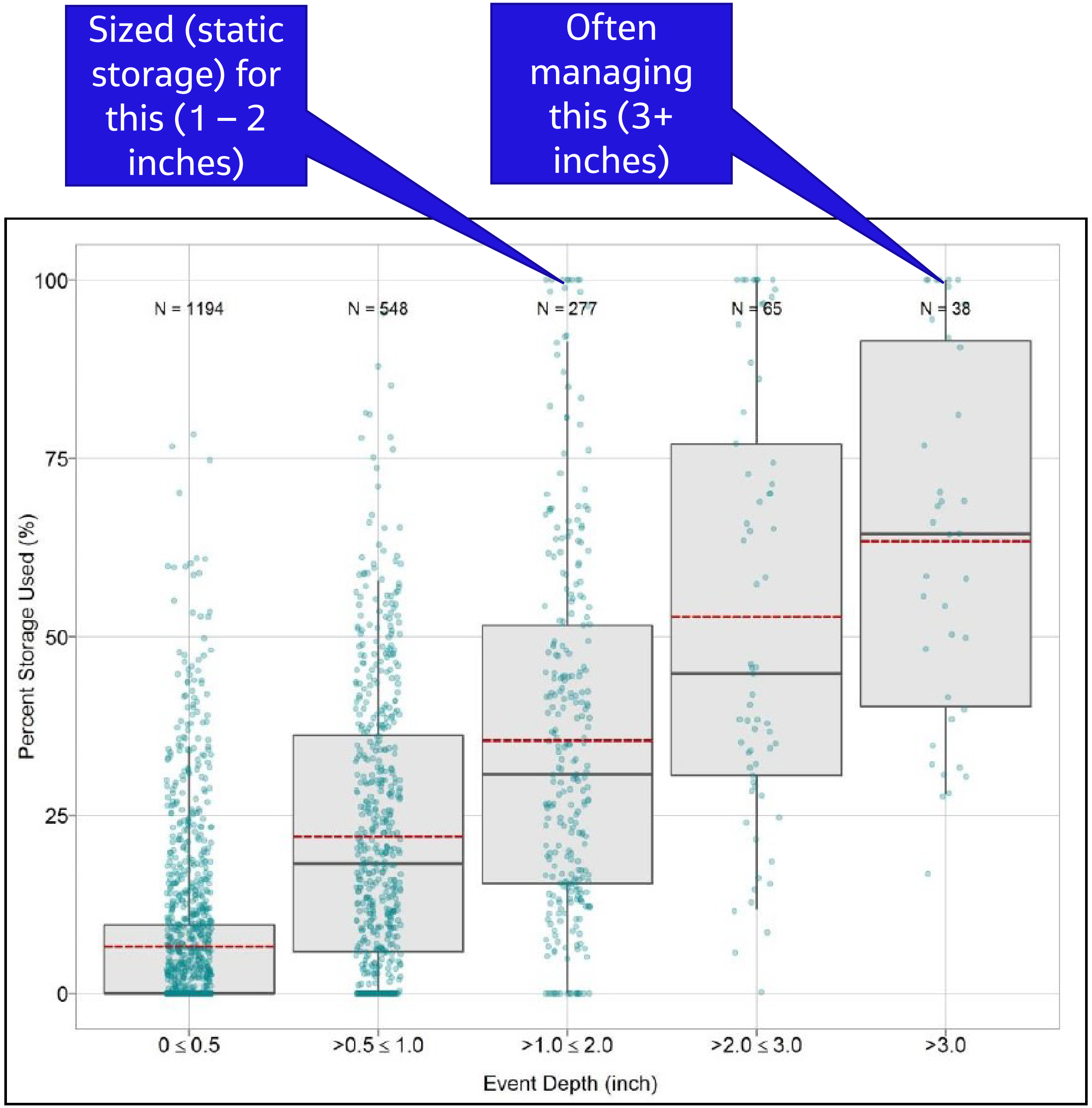
A few things to consider:

- Changing rainfall patterns
  - Simulating higher intensity-short duration events or simulate extended periods of drought and impacts on water level and vegetation
- Flooding in the surrounding area
  - Model scenarios that address higher downstream tailwater levels and evaluating the impact on the BGSI being designed
- Seasonal variation in infiltration rates
- Groundwater models
  - Consider deep infiltration and interflow to nearby surface waters, as well as infiltration recovery rates



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

Cost Implications

Sounds great, but is it affordable?

Many Factors Impact BGSI Implementation and Costs

- **Doubling the storage capacity** of GSI typical often only **increases construction cost by 15 to 30%**
- Presence, density, and alignments of existing utilities
- Level of integration with other capital projects
- Space limitations/proximity to basements/structures
- Anticipated vehicular and pedestrian traffic
- Local Market and Land value (if acquisition is required)
- Geotechnical considerations

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%

Planning-Level Cost Impact Table From Allegheny County Sanitary Authority (ALCOSAN) Green Stormwater Infrastructure Guidance Manual, 2019

Thank You! Questions?

Andy Potts

Andrew.Potts@Jacobs.com