Hazen

Role of Green Infrastructure for North Carolina's Changing Storms

July 20, 2022

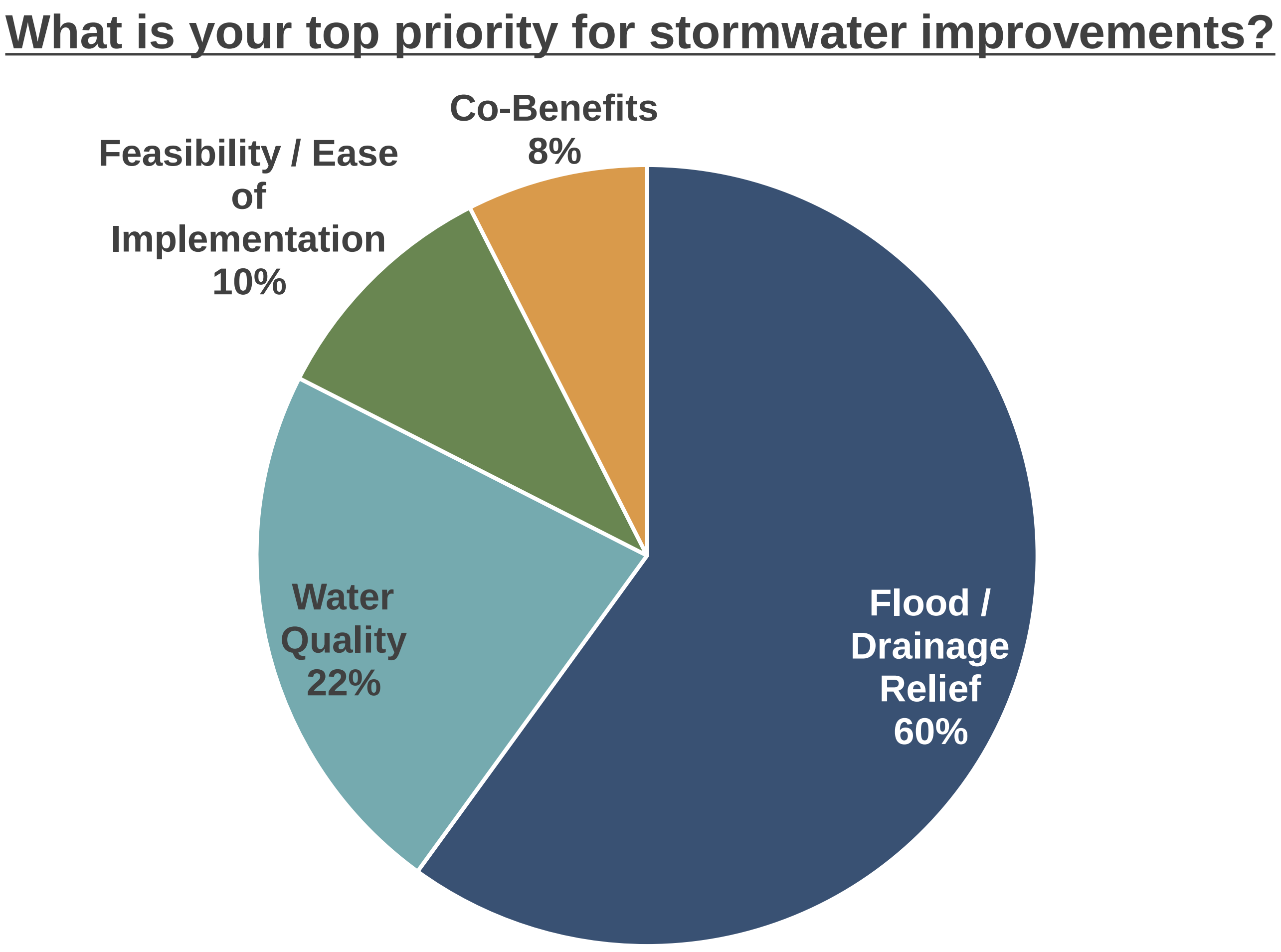
Building on Past Discussions

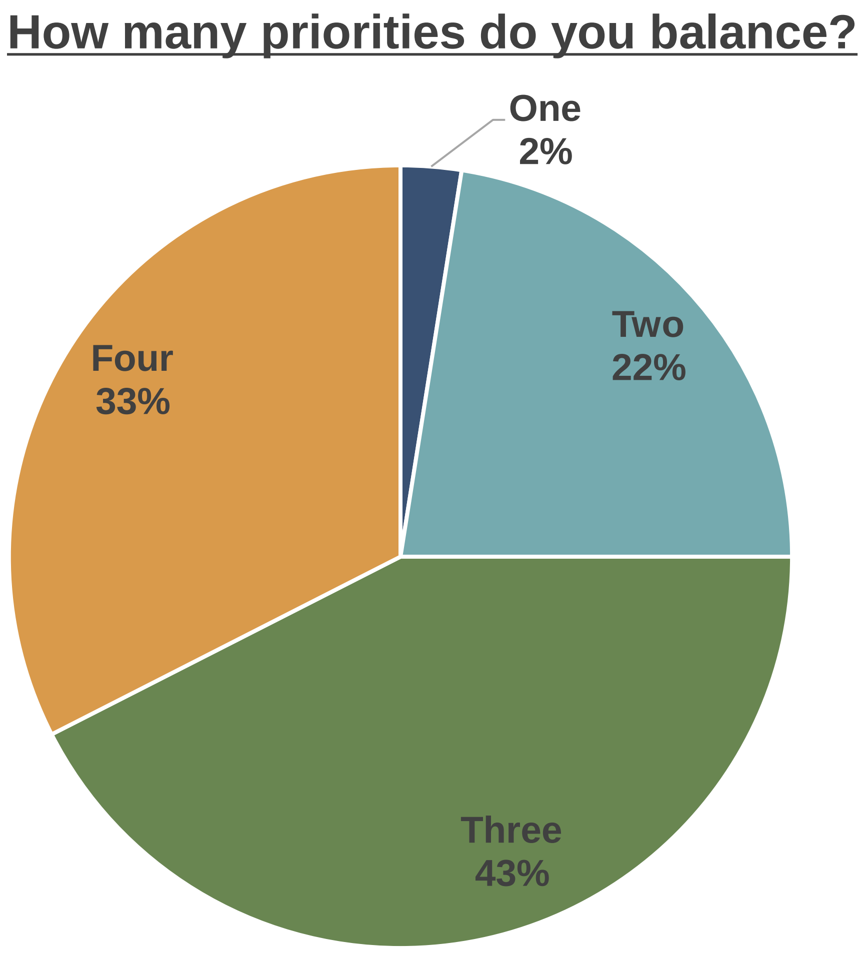
GSI Becoming More Popular and Prevalent

Storms are Changing

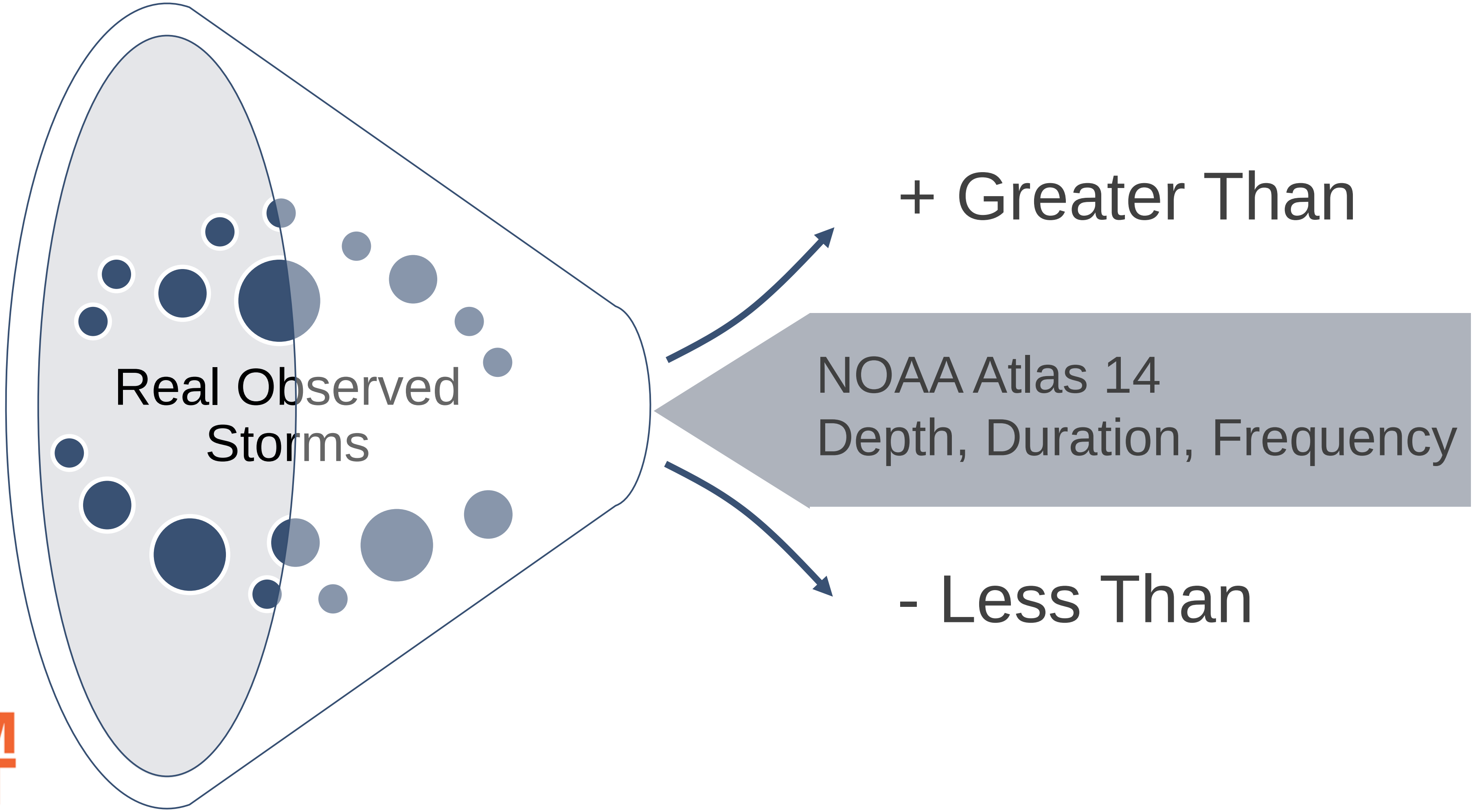
Priorities are Changing

Balancing Shifting Stormwater Priorities



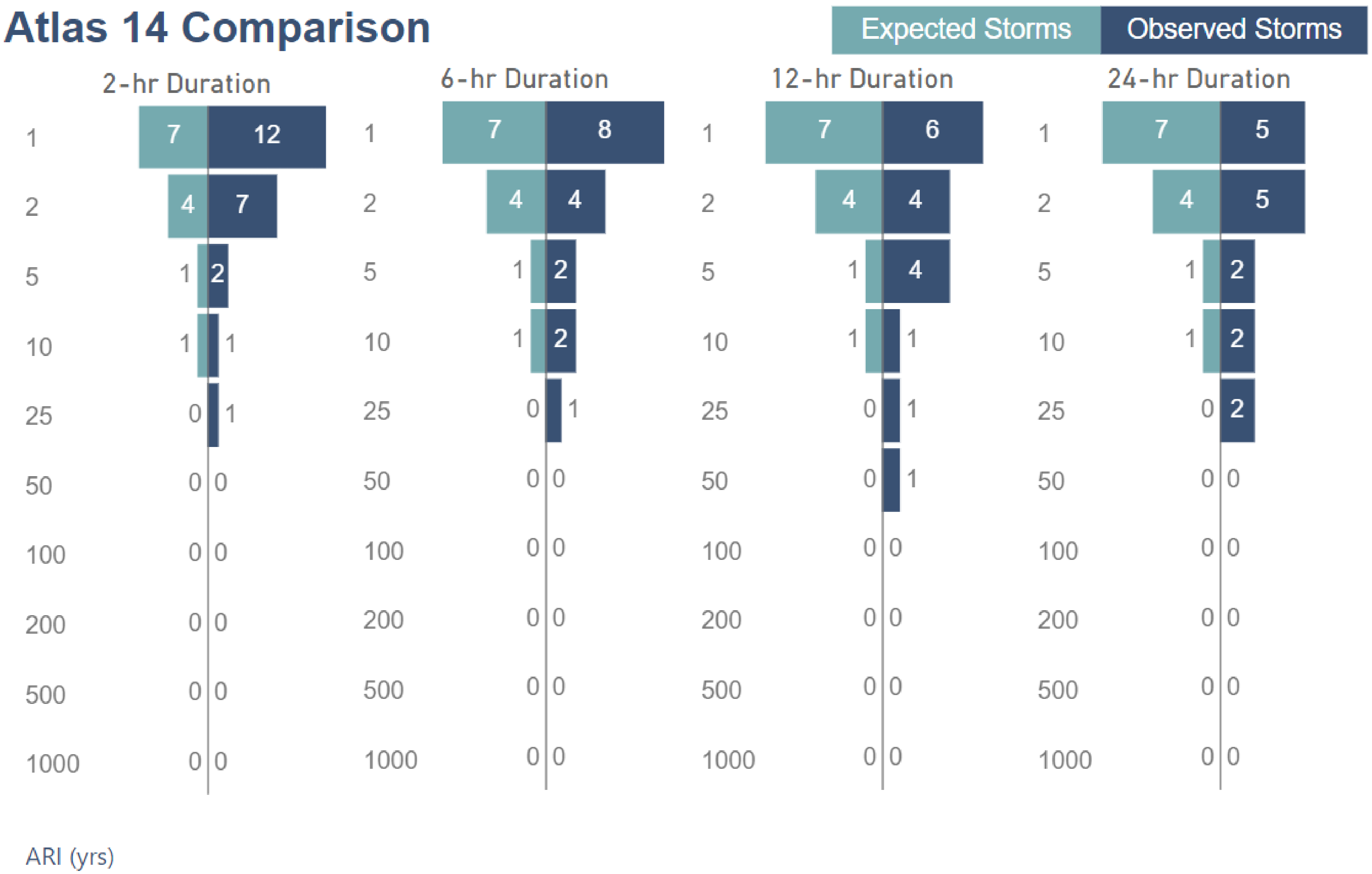


Comparing Rainfall Data to NOAA Atlas 14

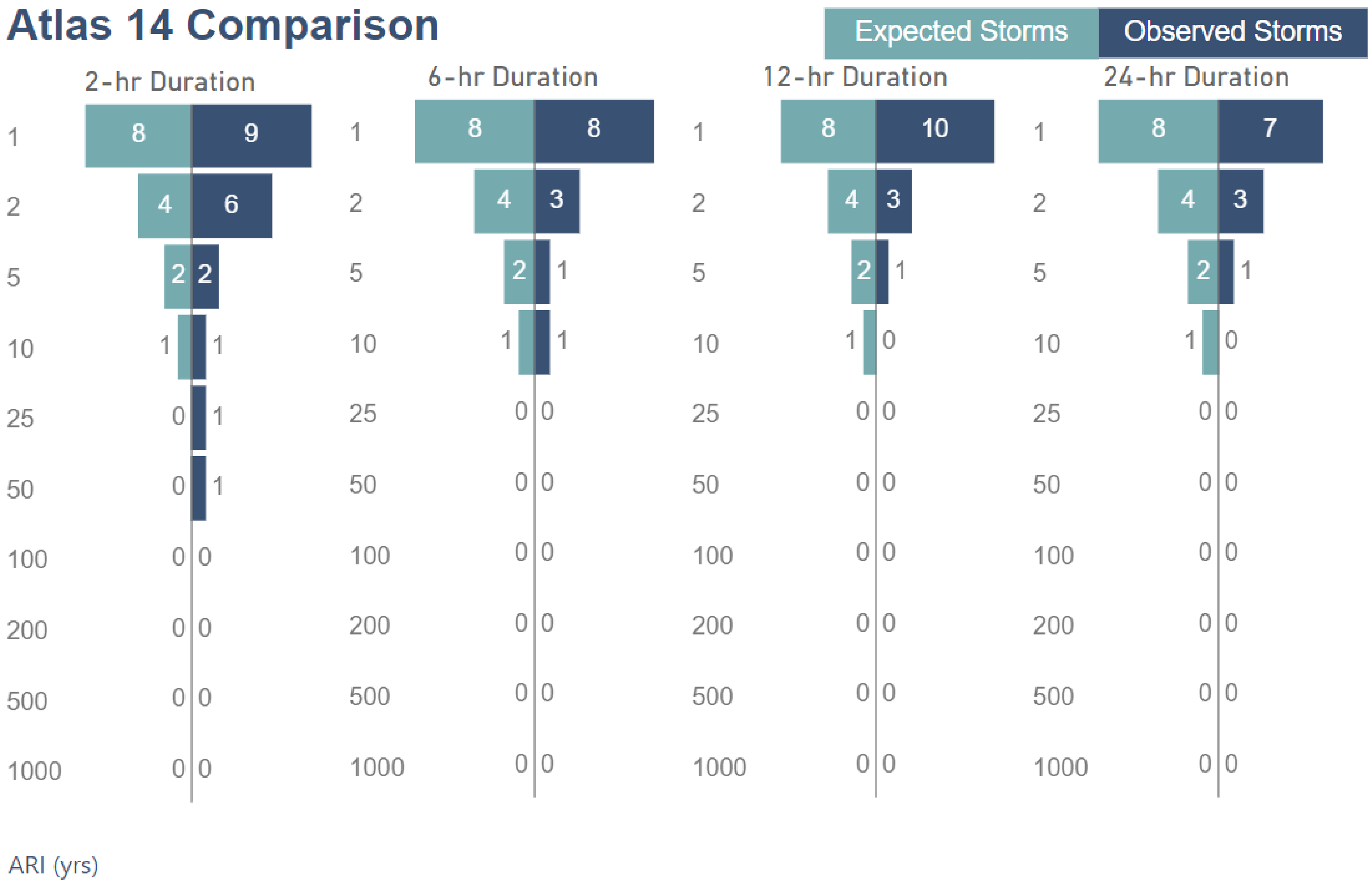


Hazen STORM SIGHT
Understanding Changing Storms

Raleigh

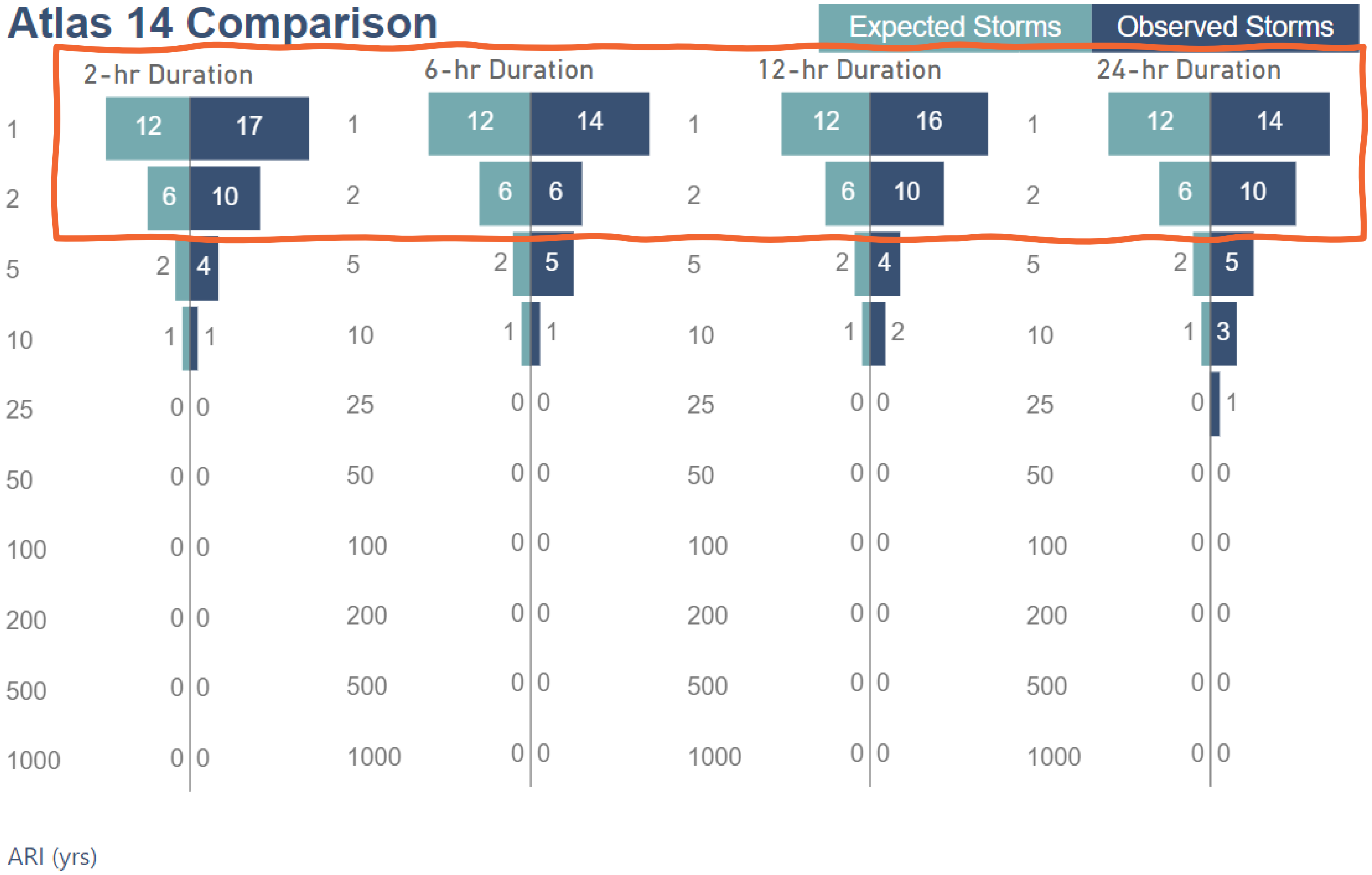

Atlas 14 Comparison
Expected Storms
Observed Storms
2-hr Duration
6-hr Duration
12-hr Duration
24-hr Duration
1
2
5
10
25
50
100
200
500
1000
ARI (yrs)
7 12
4 7
1 2
1 1
0 1
0 0
7 8
4 4
1 2
1 2
0 1
0 0
7 6
4 4
1 4
1 1
0 1
0 1
7 5
4 5
1 2
1 2
0 2
0 0

Charlotte


Atlas 14 Comparison
Expected Storms
Observed Storms
2-hr Duration
6-hr Duration
12-hr Duration
24-hr Duration
ARI (yrs)

ARI (yrs)	2-hr Expected	2-hr Observed	6-hr Expected	6-hr Observed	12-hr Expected	12-hr Observed	24-hr Expected	24-hr Observed
1	8	9	8	8	8	10	8	7
2	4	6	4	3	4	3	4	3
5	2	2	2	1	2	1	2	1
10	1	1	1	1	1	0	1	0
25	0	1	0	0	0	0	0	0
50	0	1	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0

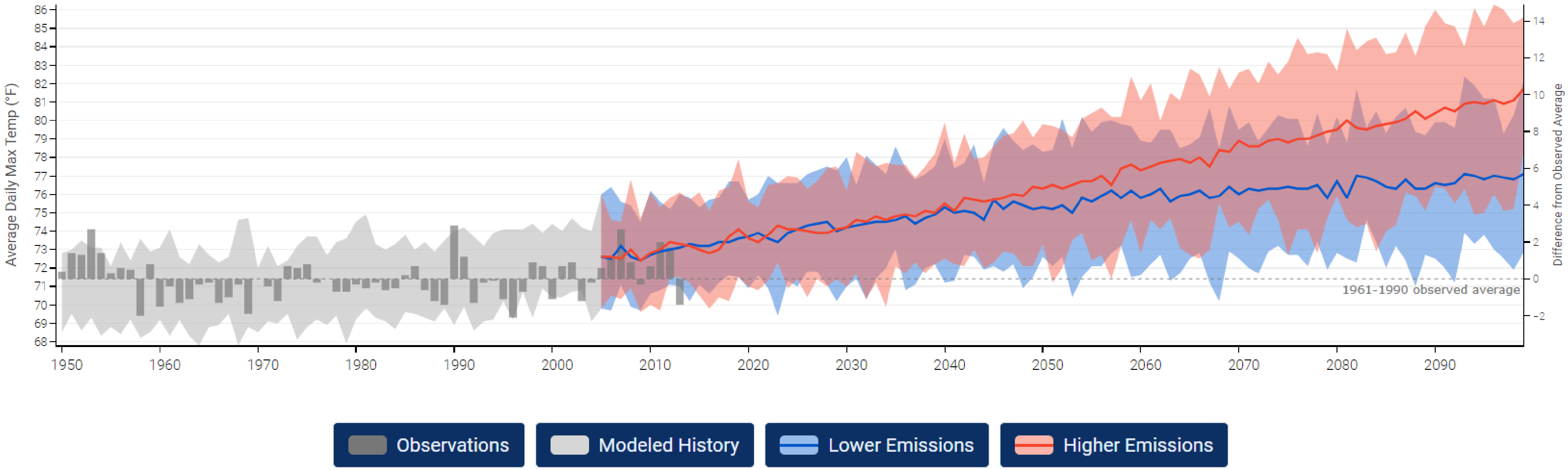
Wilmington



Atlas 14 Comparison
Expected Storms
Observed Storms
2-hr Duration
6-hr Duration
12-hr Duration
24-hr Duration
1
12
17
2
6
10
5
2
4
10
1
1
25
0
0
50
0
0
100
0
0
200
0
0
500
0
0
1000
0
0
12
14
6
6
2
5
1
1
12
16
6
10
2
4
1
2
12
14
6
10
2
5
1
3
0
1
ARI (yrs)

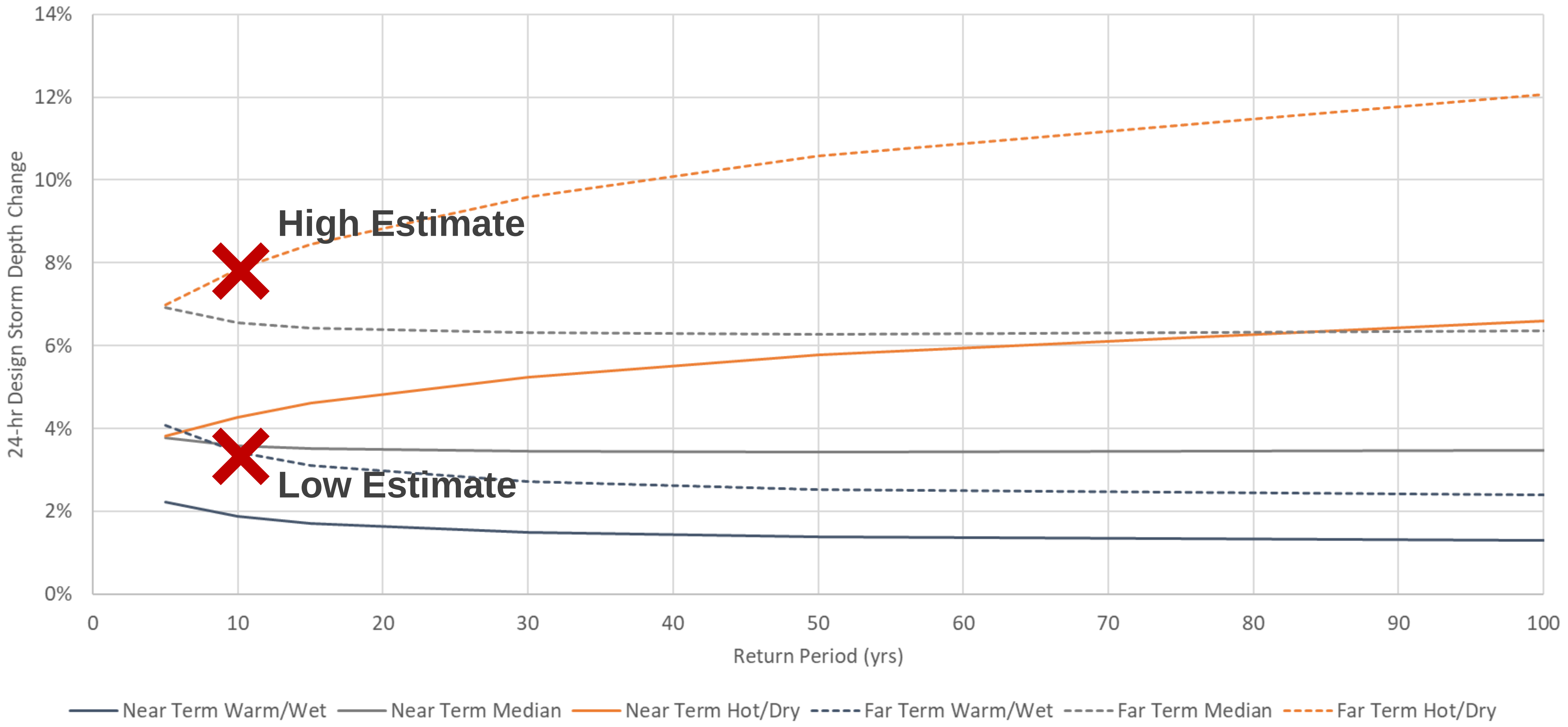
What about the future?

Wake County Average Daily Max Temperature



U.S. Climate Resilience Toolkit Climate Explorer

Storm Projections from SWMM-CAT



Projected 10-yr, 24-hr Design Storm Changes

2045-2074 Timeframe

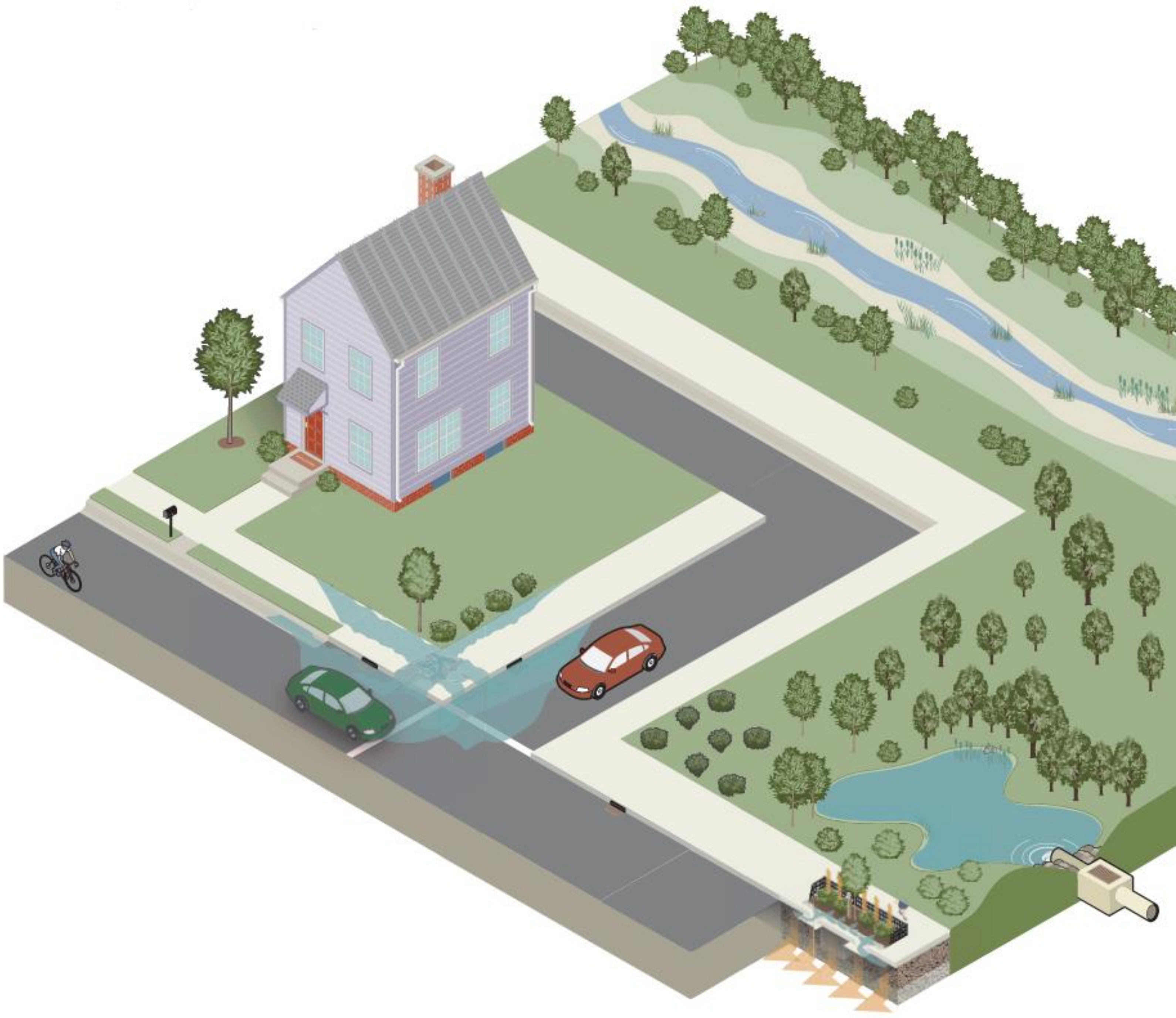
City	Current	Low Adjustment	High Adjustment	Low Adjustment	High Adjustment
Wilmington	7.22''	-0.3%	5.5%	-0.02''	0.39''
Greenville	5.81''	0.9%	5.8%	0.05''	0.33''
Raleigh	4.94''	0.5%	6.2%	0.02''	0.30''
Fayetteville	5.52''	0.1%	6.1%	0.01''	0.34''
Greensboro	4.77''	0.7%	6.1%	0.03''	0.29''
Charlotte	4.86''	-0.4%	5.6%	-0.02''	0.27''
Asheville	4.94''	2.6%	6.5%	0.13''	0.32''

How are storms changing?

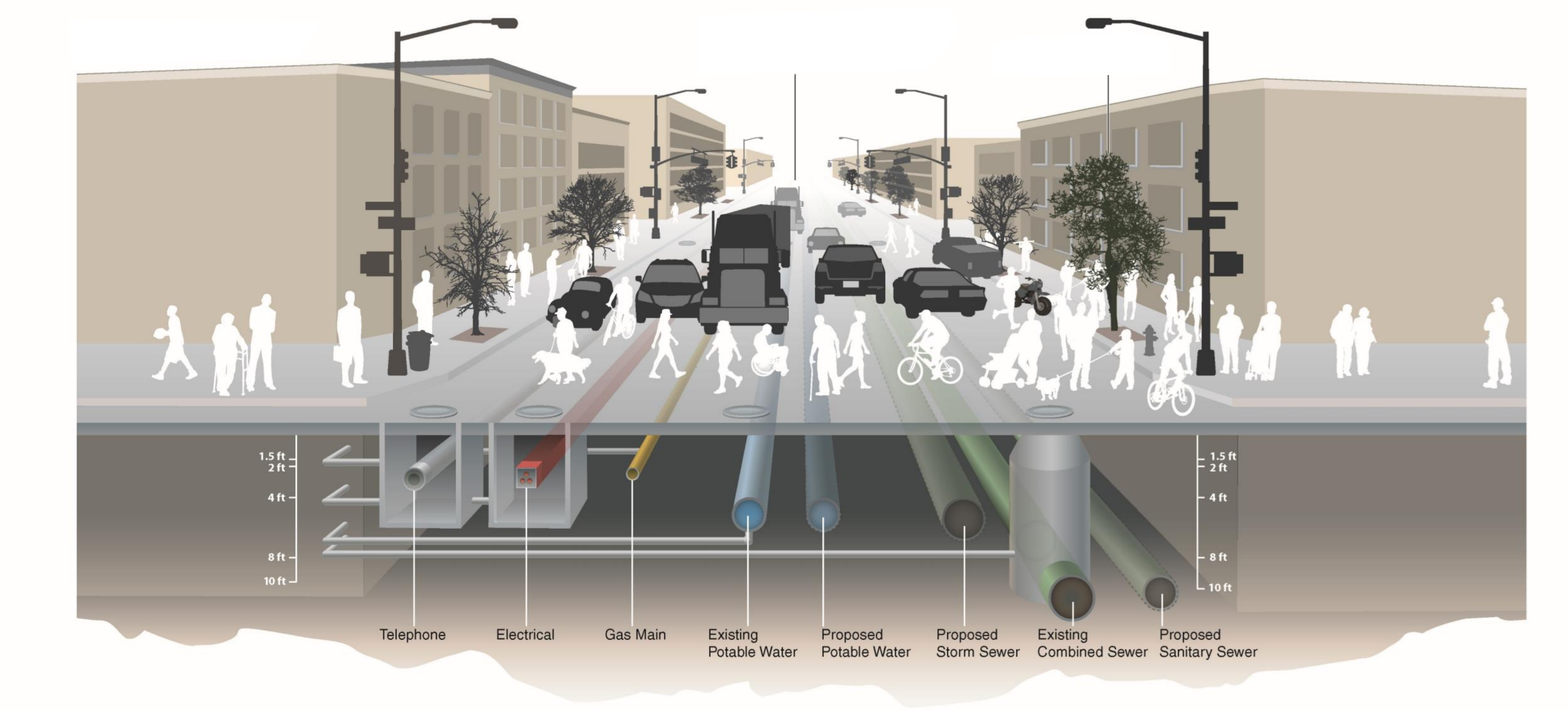
- Increased frequency of smaller storms contributing to nuisance flooding
- Incremental increases in 10-yr storm depths
  - 10-yr depth increases for many locations are less than 0.5 inches

What is the role of GSI?

- Can GSI mitigate incremental increases in storm depth associated with climate change?
- Can GSI play a larger role in managing localized urban flooding?



Limitations of Conventional Pipe Upsizing



Construction Disruption and Impacts

Pipe Replacement

Green Stormwater Infrastructure

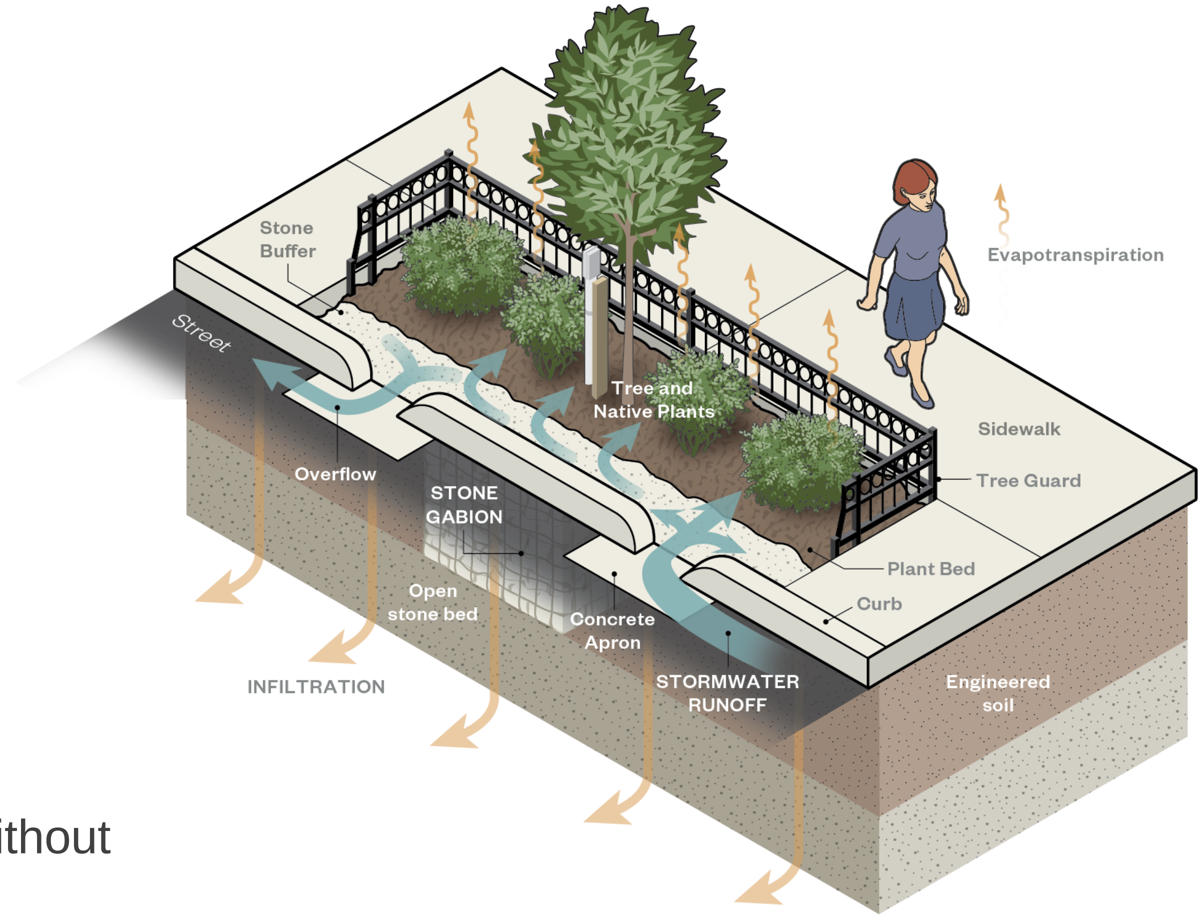
Green Stormwater Infrastructure and Runoff Detention

<u>**Example Characteristics**</u>

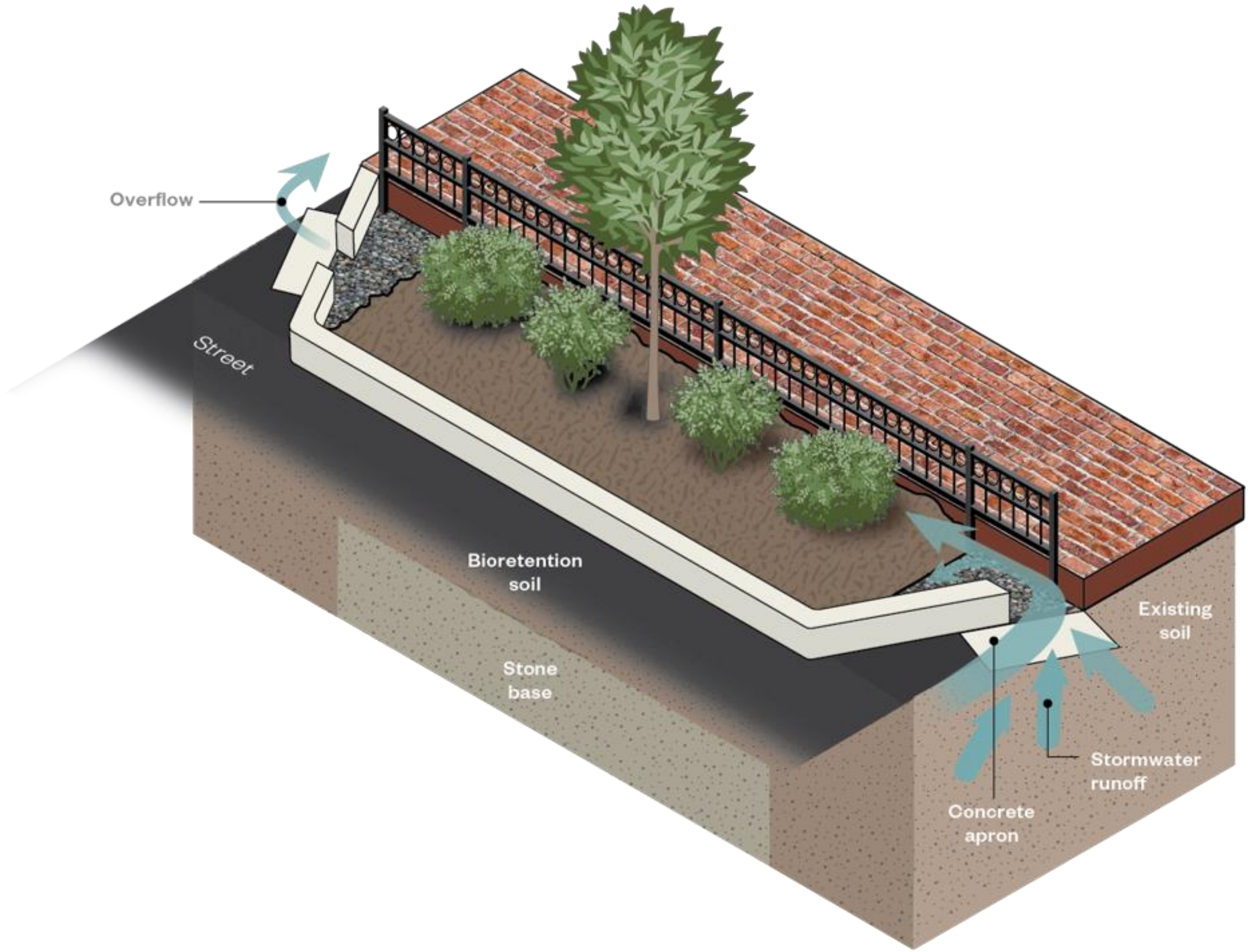
- Curbside bioretention
- Sized to store runoff from 1” storm
- Assumed soil infiltration rate of 0.5 in/hr

<u>**Hydrologic Simulations**</u>

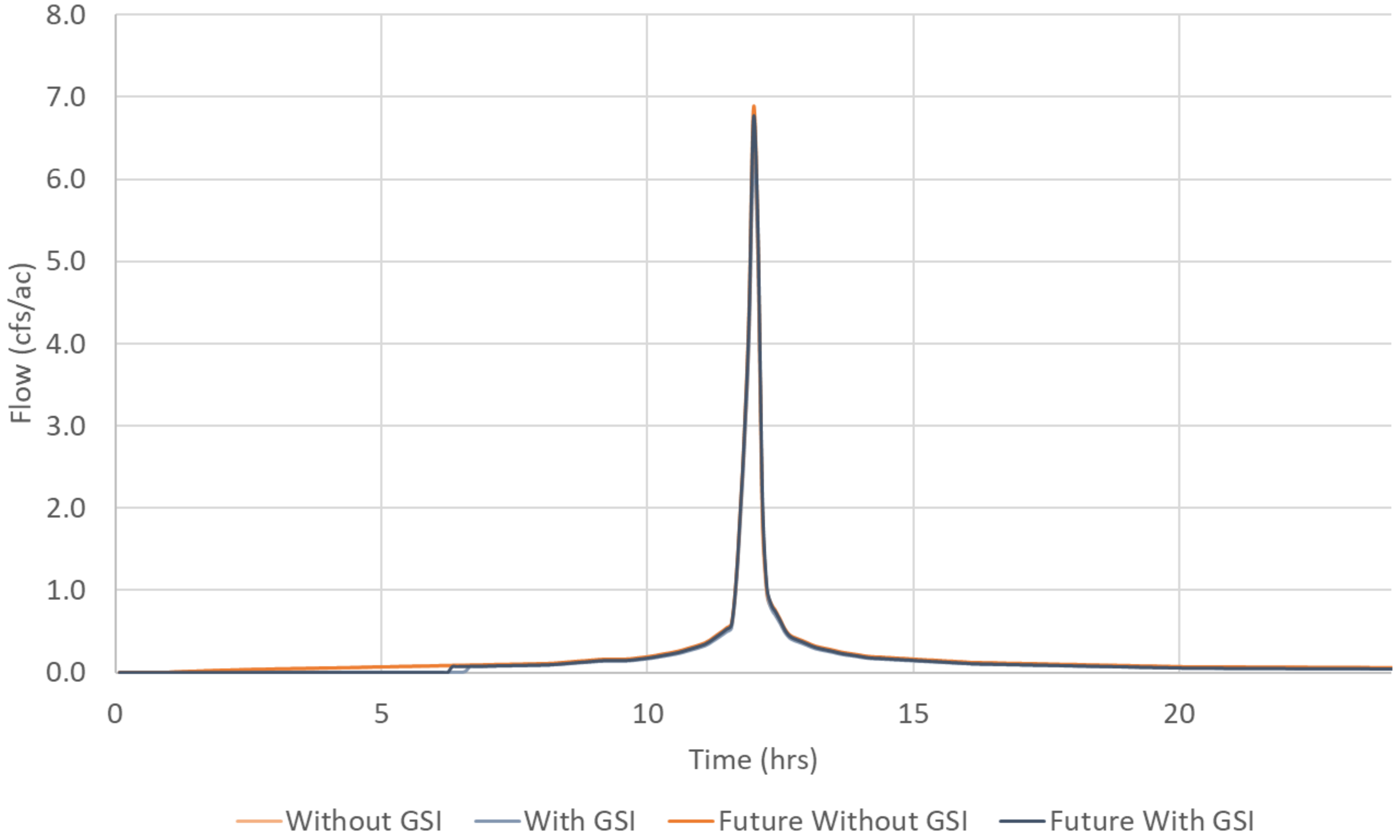
- 10-yr, 24-hr NRCS hydrograph
  - **6% increase to a 4.9” 10-yr storm**
- Routed through bioretention, accounting for bypass/overflow
- Existing and future conditions with and without GSI
- If peak flow for future condition with GSI < existing without GSI, then storm changes are mitigated



Basic Bioretention Scenario



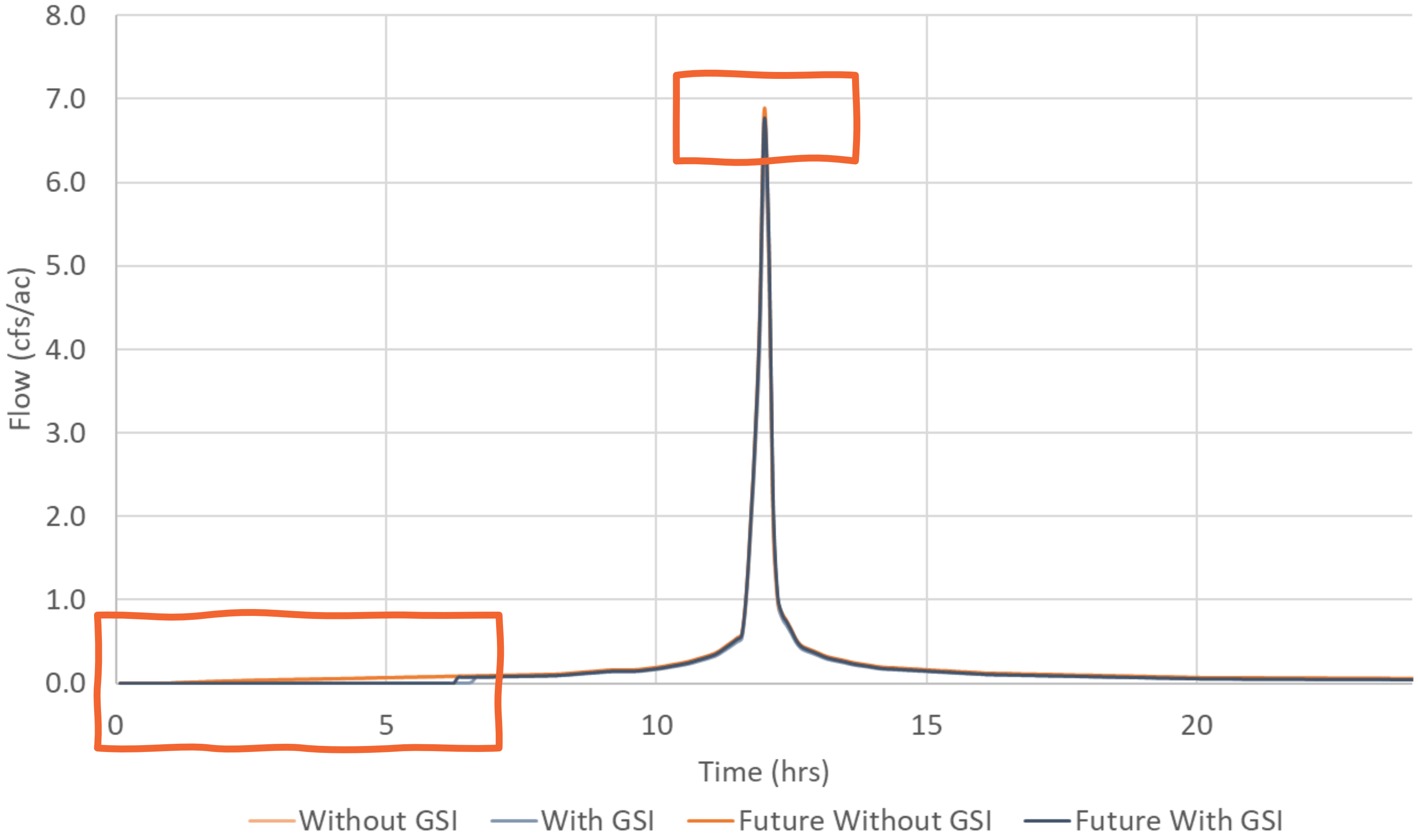
GSI Sizing Target	Internal Overflow	Controlled Underdrain	Simulated Storm
1.0” Storm	No	No	10-yr, 24-hr

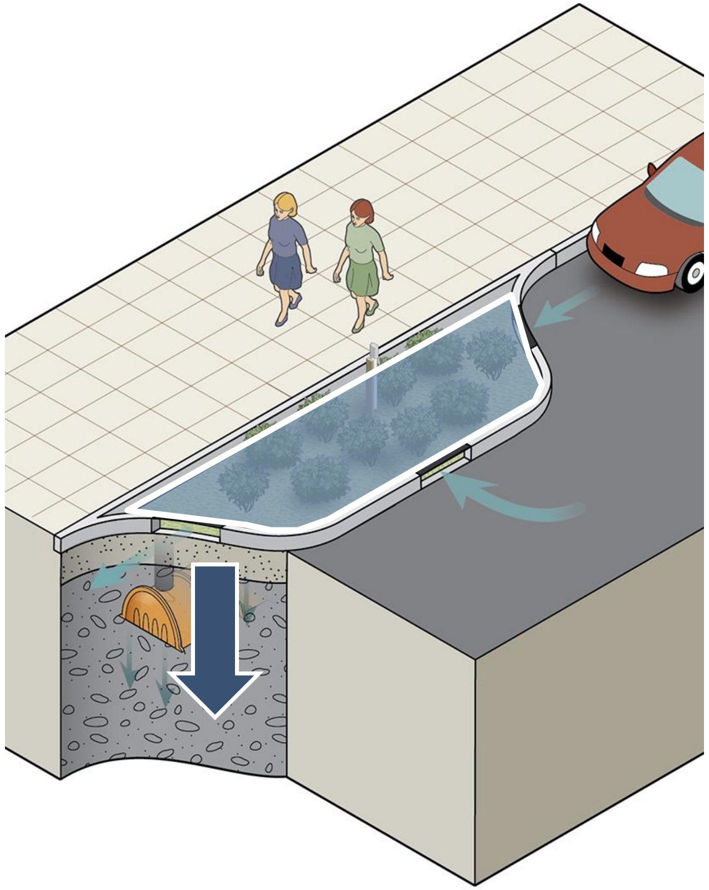


	No GSI	With GSI
Current	**6.46 cfs/ac**	6.31 cfs/ac
Future	6.87 cfs/ac	**6.76 cfs/ac**

5% Increase from Existing

GSI Sizing Target	Internal Overflow	Controlled Underdrain	Simulated Storm
1.0” Storm	No	No	10-yr, 24-hr





Basic Bioretention

No Underdrain

No Internal Overflow

Scenario Summary

Current Conditions

- GSI capacity exceeded before storm peak
- Marginal peak reduction attributed to infiltration

Future Conditions

- GSI capacity exceeded before storm peak
- Marginal peak reduction attributed to infiltration

Mitigated Impacts of Changing Storms?

- No

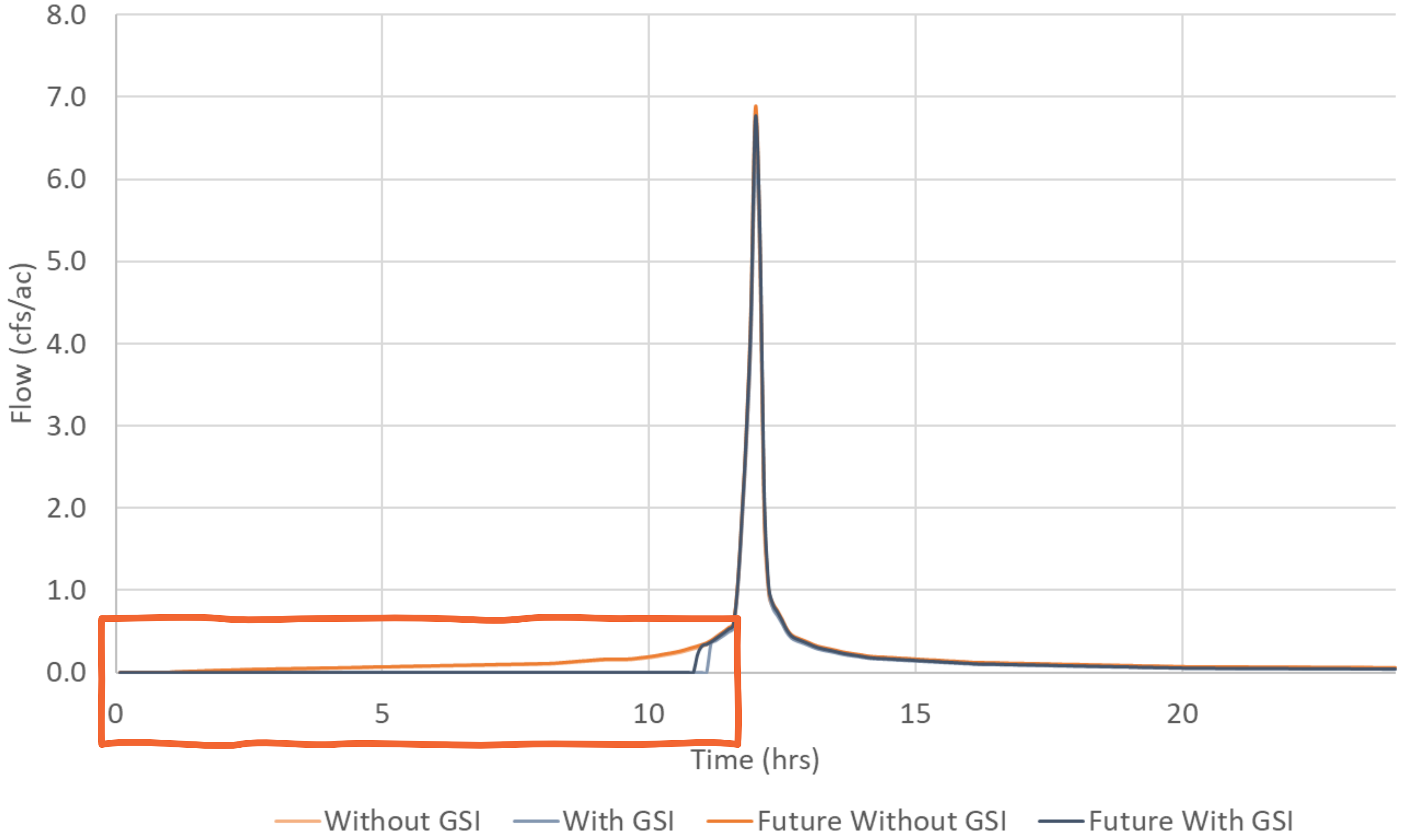
Internal Overflow

<u>Internal Overflow Options</u>

- Stone Gabion
- Perforated Riser
- Inlet Connected to Perforated Distribution Pipe

Exchanging WQ treatment for storage capacity

GSI Sizing Target	Internal Overflow	Controlled Underdrain	Simulated Storm
1.0” Storm	Yes	No	10-yr, 24-hr



	No GSI	With GSI
Current	**6.46 cfs/ac**	6.31 cfs/ac
Future	6.87 cfs/ac	**6.76 cfs/ac**

5% Increase from Existing

Bioretention

No Underdrain

Internal Overflow

Scenario Summary

Current Conditions

- Better capture
- GSI capacity exceeded before storm peak
- Marginal peak reduction attributed to infiltration

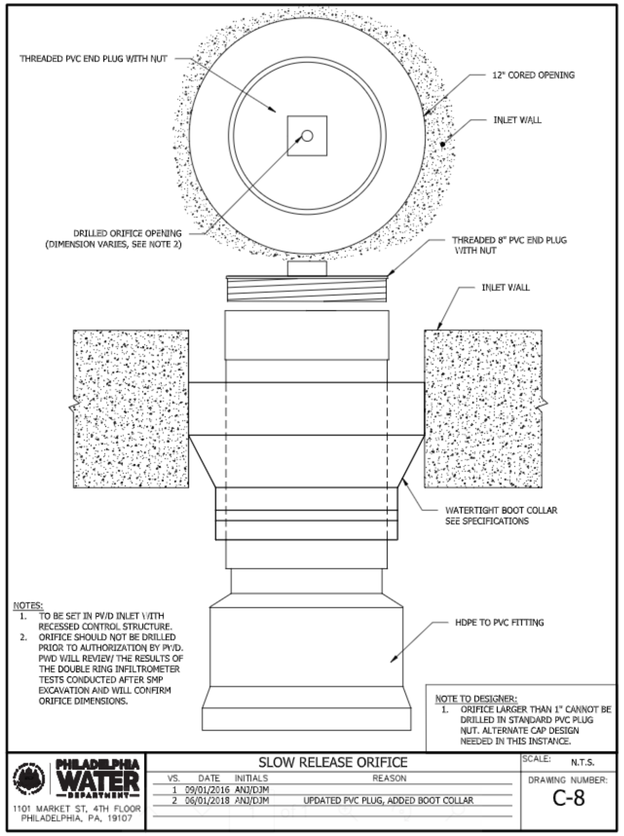
Future Conditions

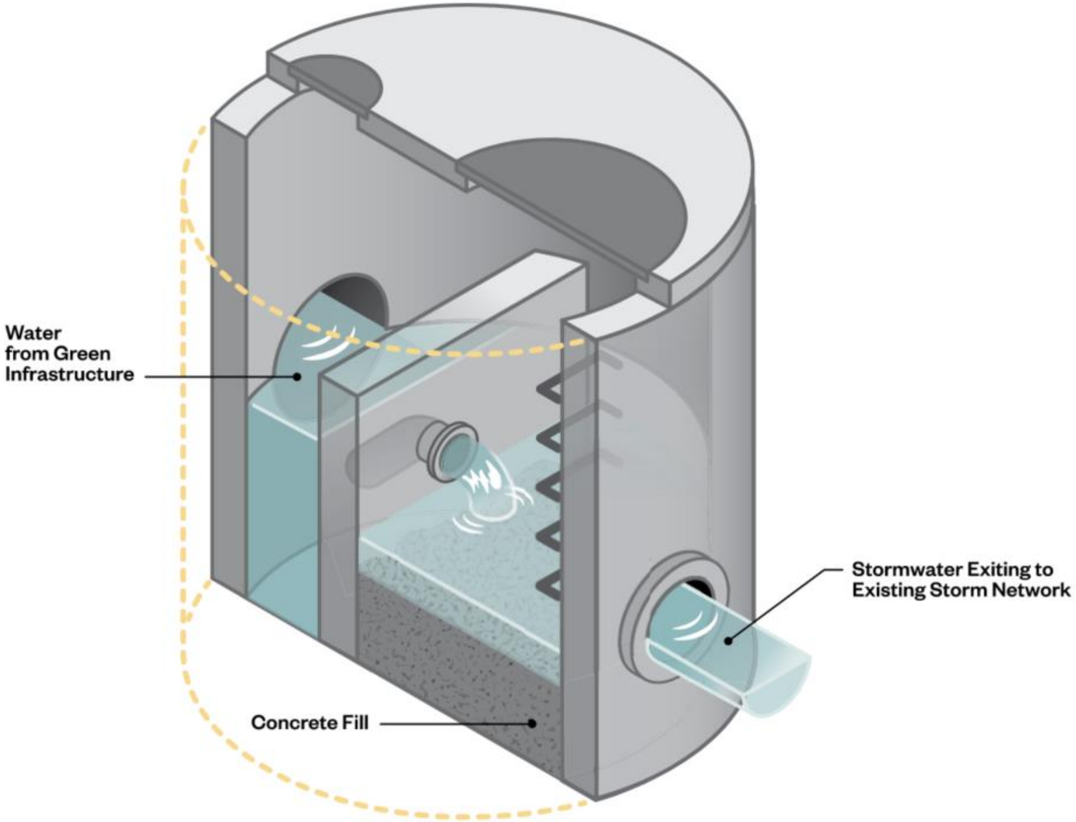
- Better capture
- GSI capacity exceeded before storm peak
- Marginal peak reduction attributed to infiltration

Mitigated Impacts of Changing Storms?

- No

Controlled Underdrain



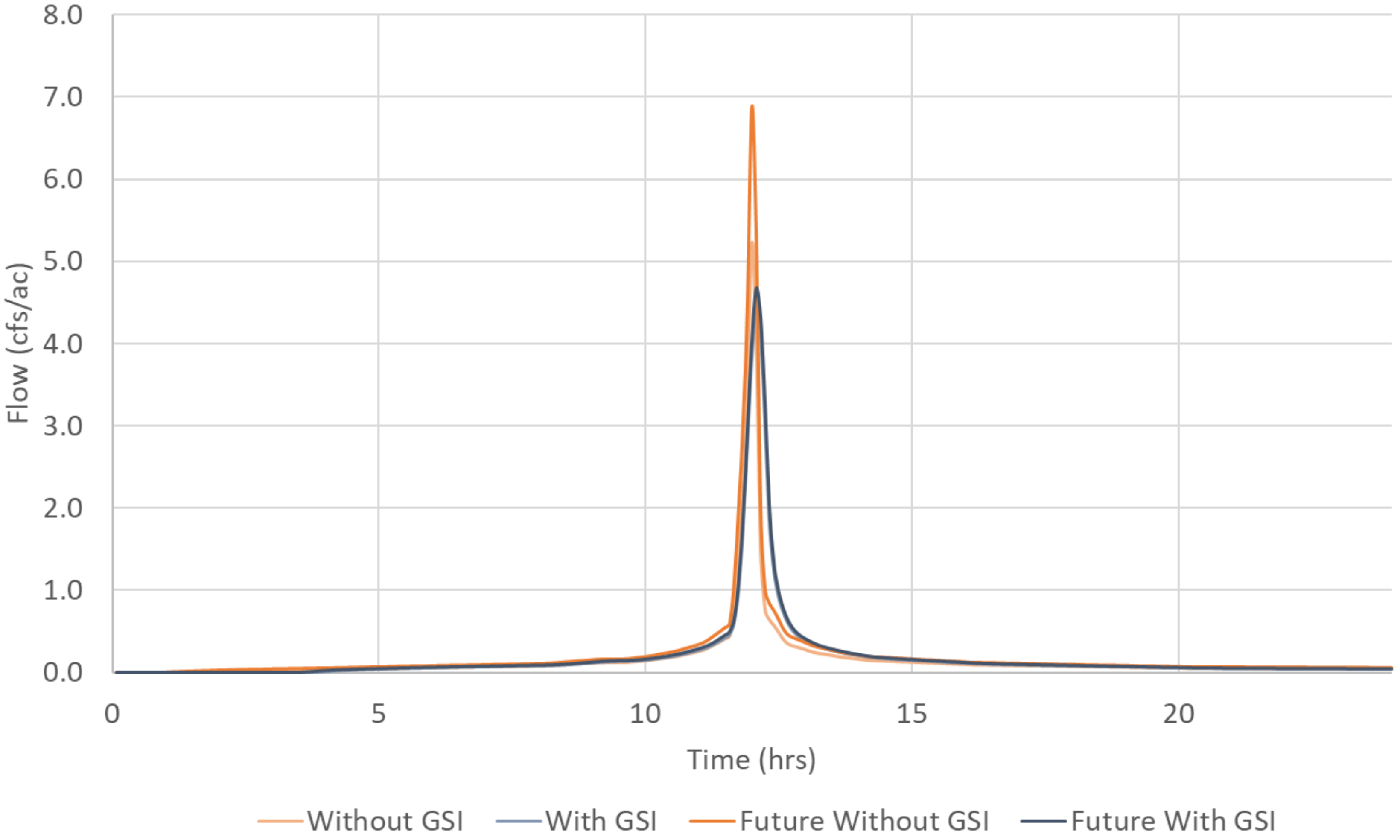


Underdrain flow restriction tailored to maximize storage for 10-yr event

Controlled Underdrain Options

- Cap w/ drilled orifice
- Weir wall
- Valve
- Automated valve

GSI Sizing Target	Internal Overflow	Controlled Underdrain	Simulated Storm
1.0” Storm	Yes	Yes	10-yr, 24-hr



	No GSI	With GSI
Current	**5.22 cfs/ac**	4.46 cfs/ac
Future	6.87 cfs/ac	**4.68 cfs/ac**

10% Reduction from Existing

Bioretention

Controlled Underdrain

Internal Overflow

Scenario Summary

Current Conditions

- Flow regulated throughout storm
- Substantial peak reduction

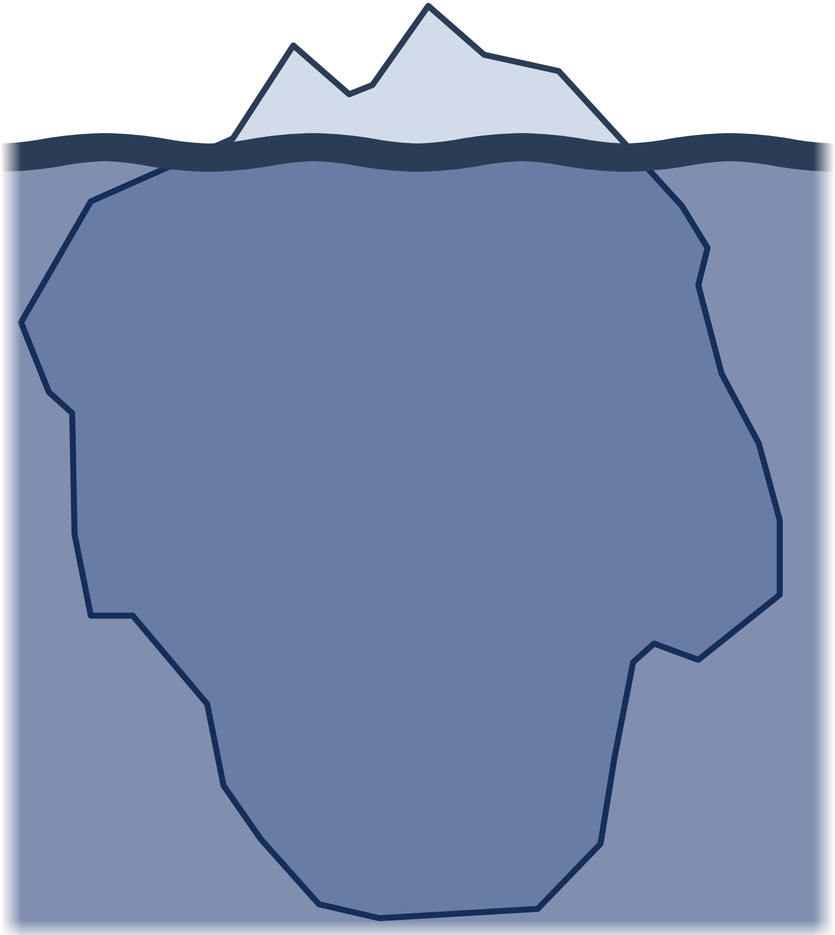
Future Conditions

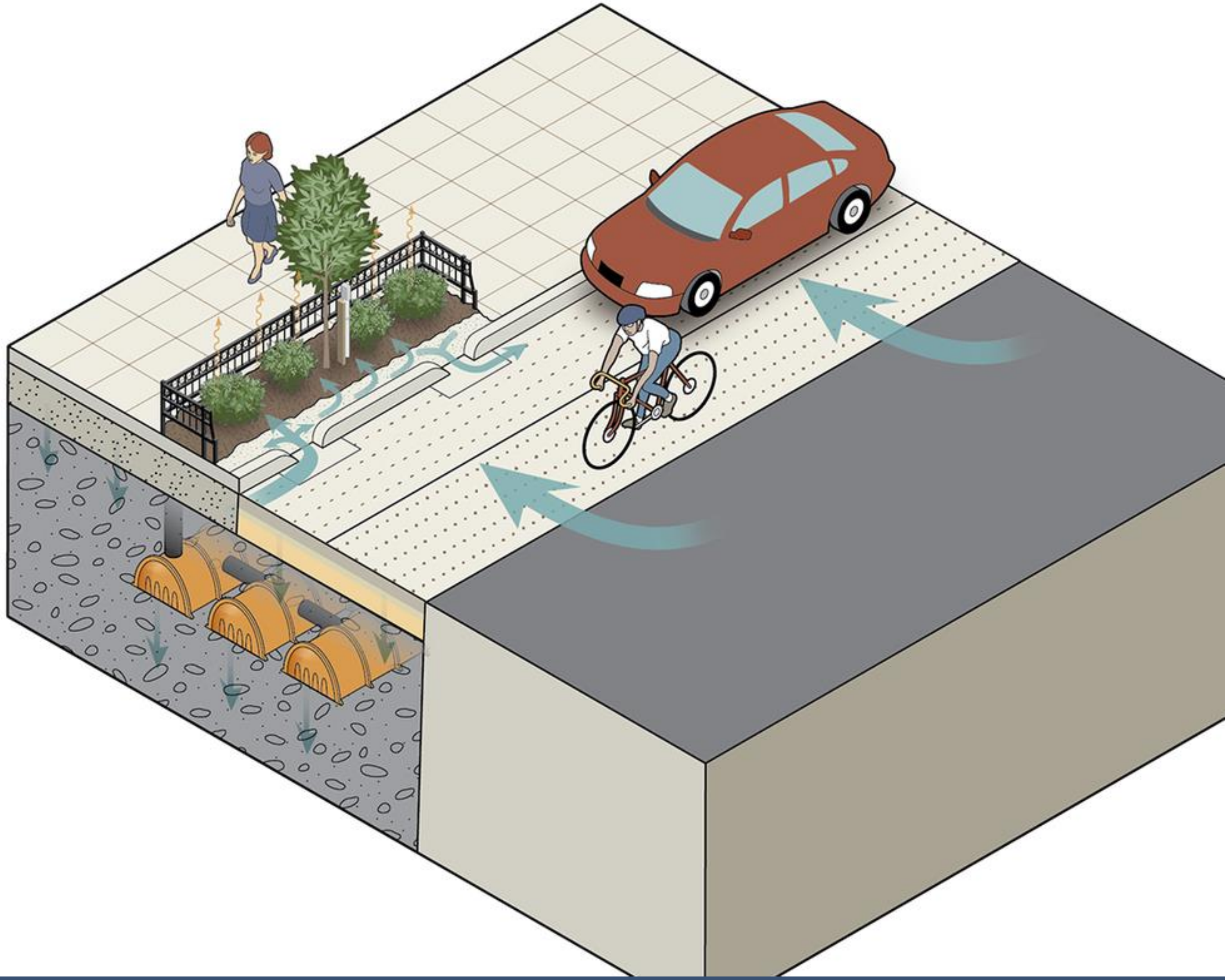
- Flow regulated throughout storm
- Substantial peak reduction

Mitigated Impacts of Changing Storms?

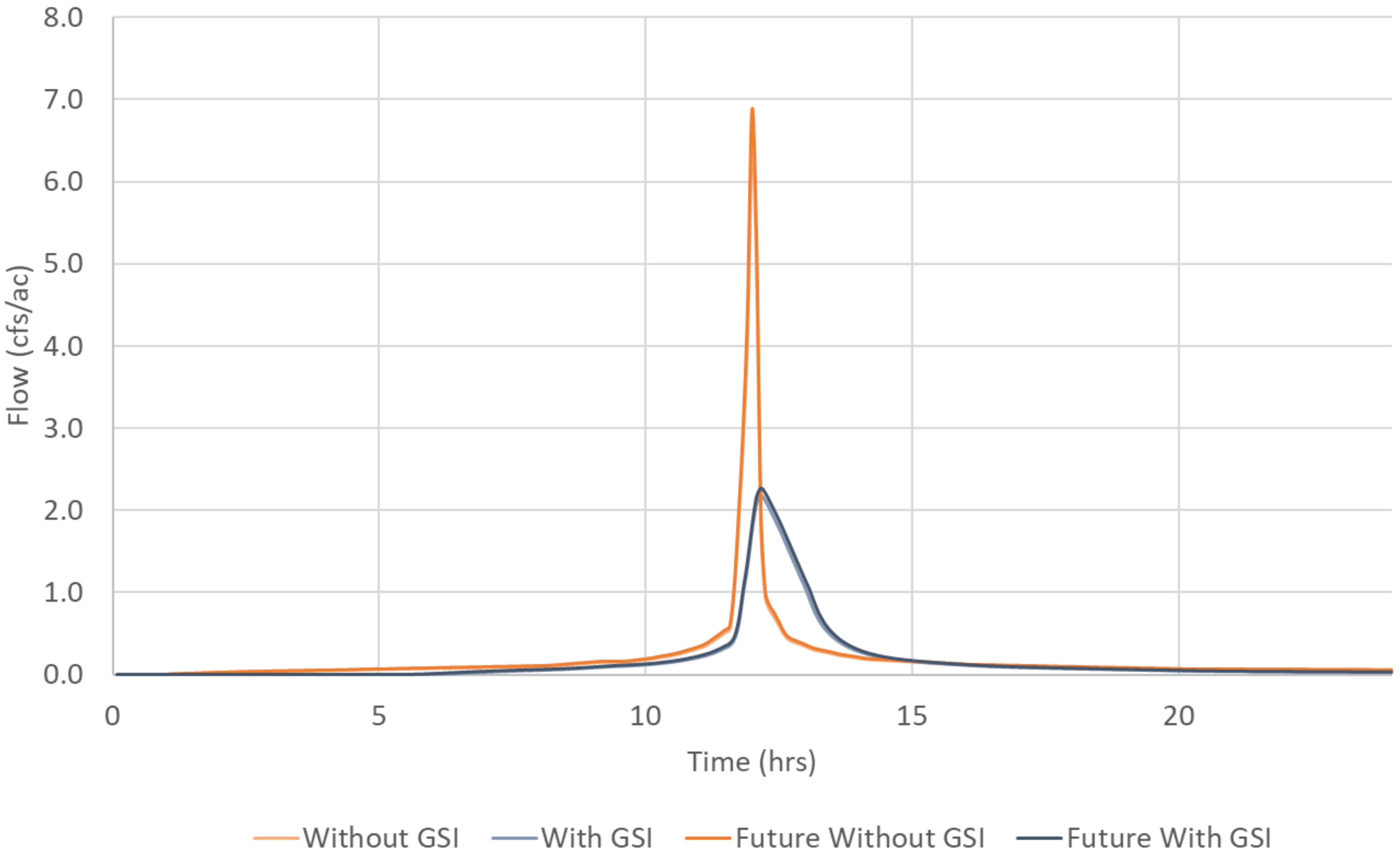
- Yes

Iceberg Green Stormwater Infrastructure





GSI Sizing Target	Internal Overflow	Controlled Underdrain	Simulated Storm
2.0” Storm	Yes	Yes	10-yr, 24-hr



	No GSI	With GSI
Current	**6.46 cfs/ac**	2.18 cfs/ac
Future	6.87 cfs/ac	**2.27 cfs/ac**

65% Reduction from Existing

Expanded Bioretention

Controlled Underdrain

Internal Overflow

Scenario Summary

Current Conditions

- Flow regulated throughout storm
- Substantial peak reduction

Future Conditions

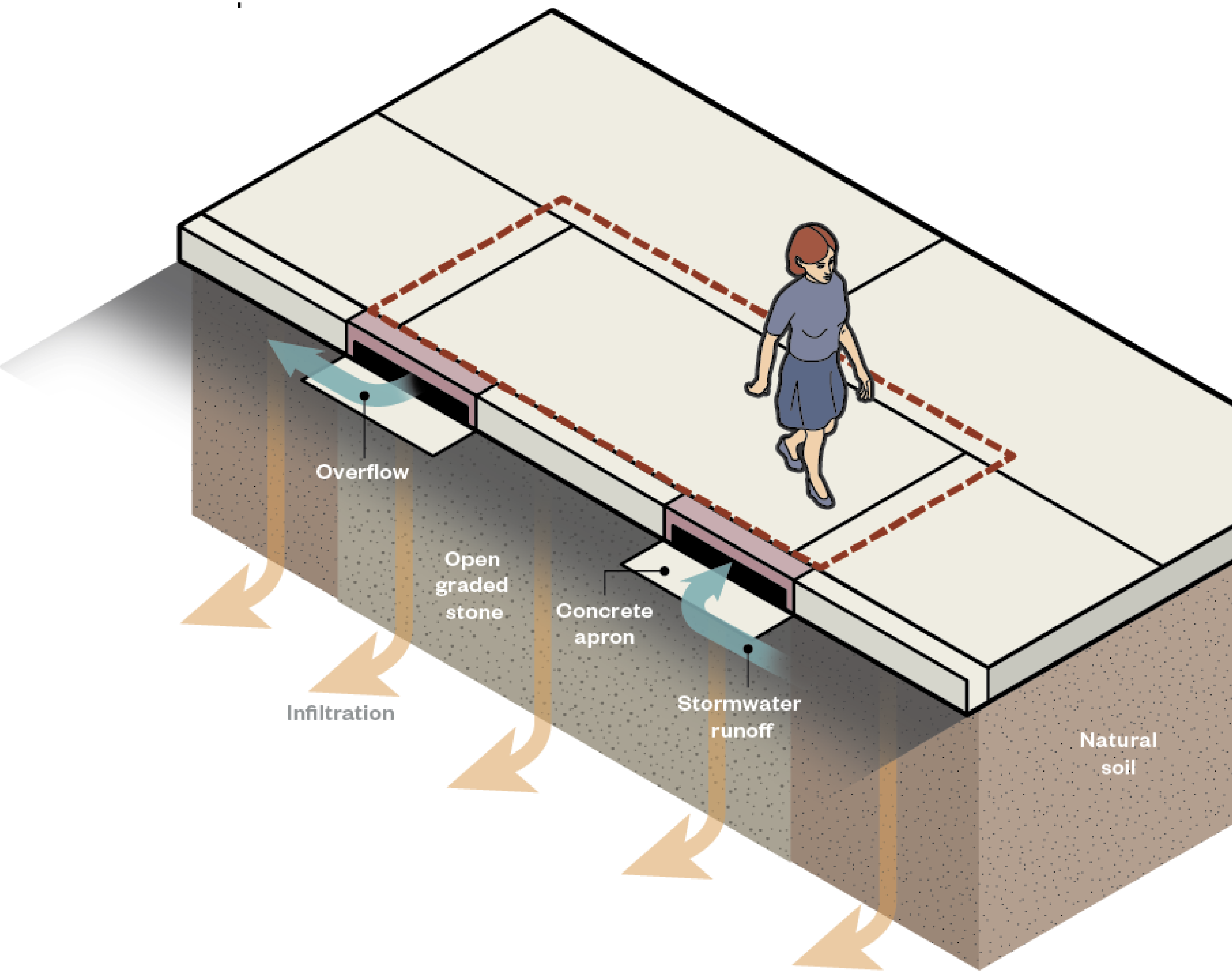
- Flow regulated throughout storm
- Substantial peak reduction

Mitigated Impacts of Changing Storms?

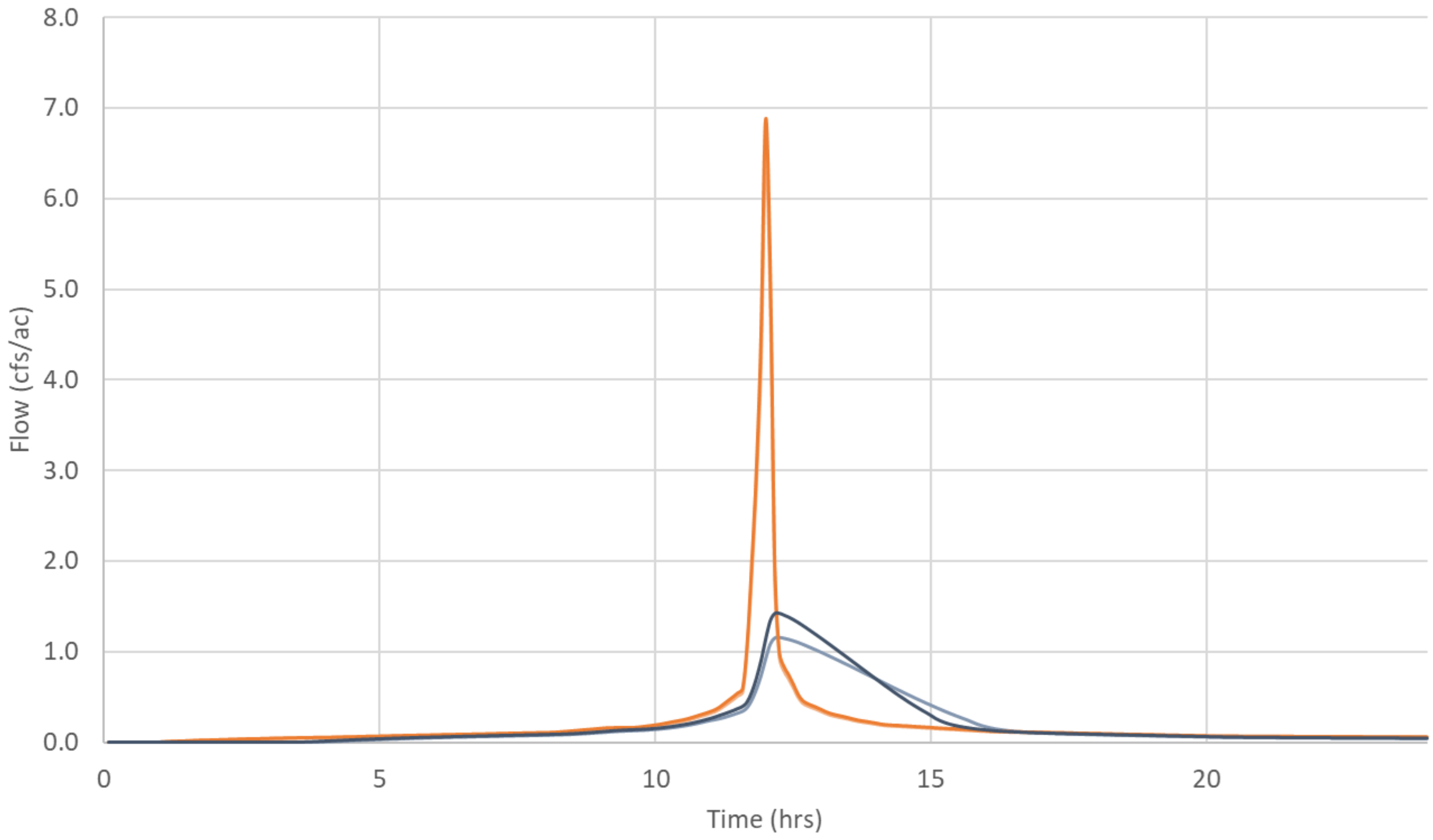
- Yes

Gutted Bioretention

- Responsive repurposing of bioretention to maximize storage and support drainage relief
- Remove treatment elements
- Maximize storage within footprint
- Include controlled underdrain
- Could be retrofitted near end of functional life



GSI Sizing Target	Internal Overflow	Controlled Underdrain	Simulated Storm
Retrofit to Max Porosity	Yes	Yes	10-yr, 24-hr



	No GSI	With GSI
Current	**6.46 cfs/ac**	1.15 cfs/ac
Future	6.87 cfs/ac	**1.42 cfs/ac**

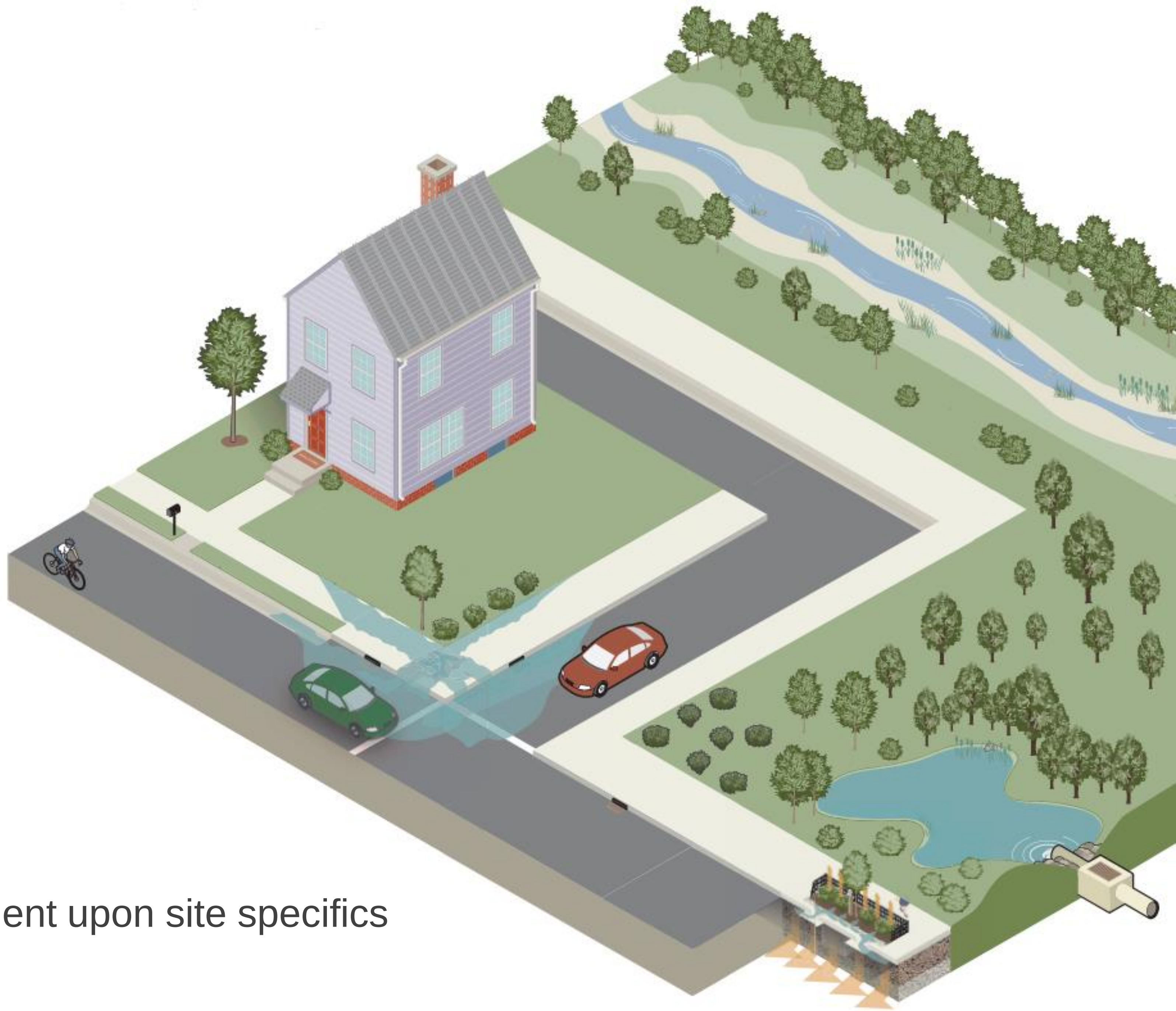
78% Reduction from Existing

Bioretention Modifications

	Basic Bioretention	**Internal Overflow**	**Controlled Underdrain**	**2” Target GSI**	**Gutted Bioretention**
Internal Overflow	No	Yes	Yes	Yes	Yes
Controlled Underdrain	No	No	Yes	Yes	Yes
2” Target GSI	No	No	No	Yes	No
<u>Future Climate w/ GSI vs. Current Climate w/ No GSI</u>					
Peak Flow Change	+5%	+5%	-10%	-65%	-78%
Climate Impacts Mitigated?	☒	☒	☑	☑	☑

What is the role of GSI?

- Can GSI mitigate incremental increases in storm depth associated with climate change?
- Can GSI play a larger role in managing localized urban flooding?



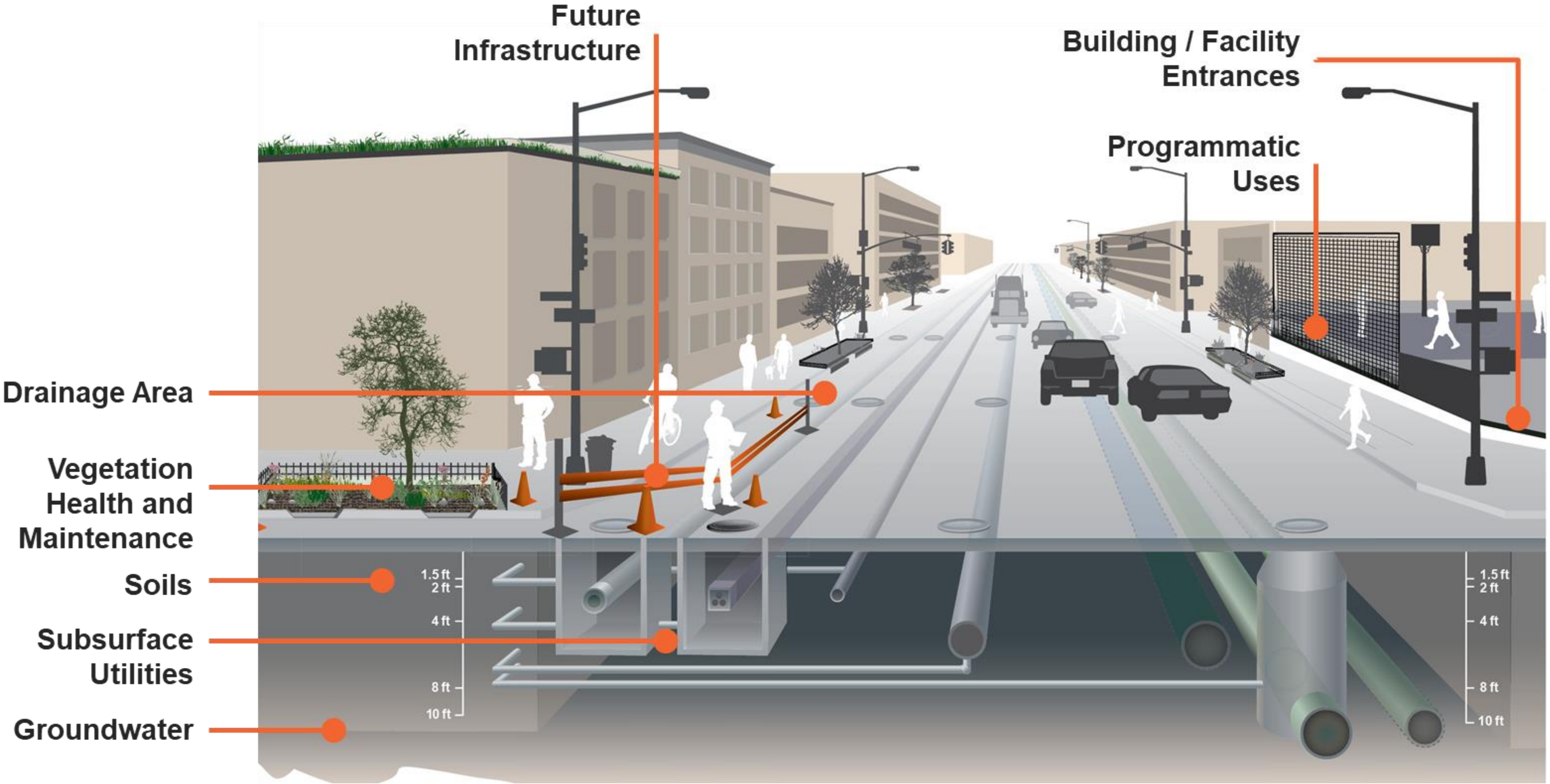
A: Yes

Part of the toolbox but dependent upon site specifics

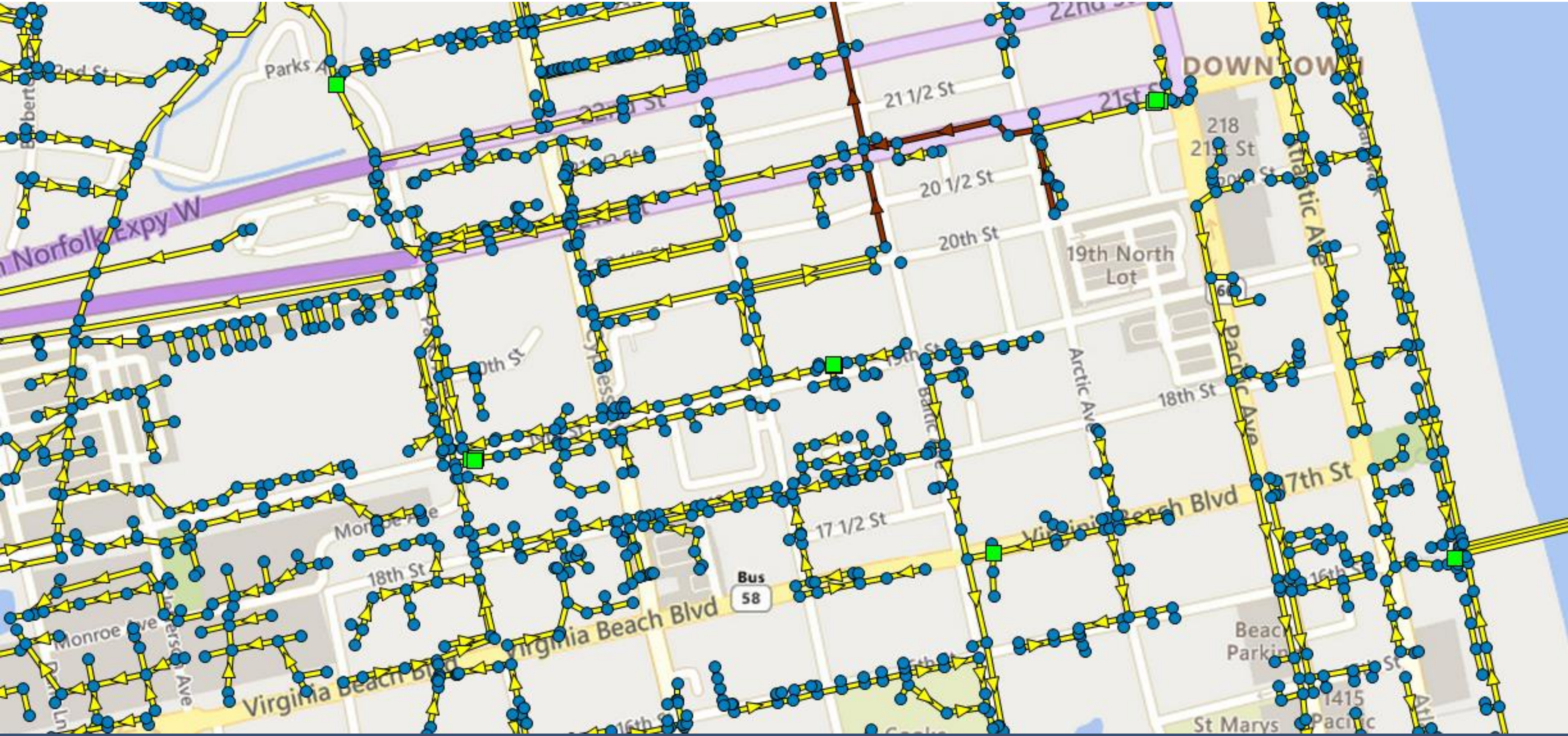
Why Grey Infrastructure is Not Going Away

GSI Not Addressing Entirety of Storms

Siting Constraints Limit Full Implementation



Localized Hydraulics Vary



Stormwater Controls Can’t Do Just One Thing

Water Quality

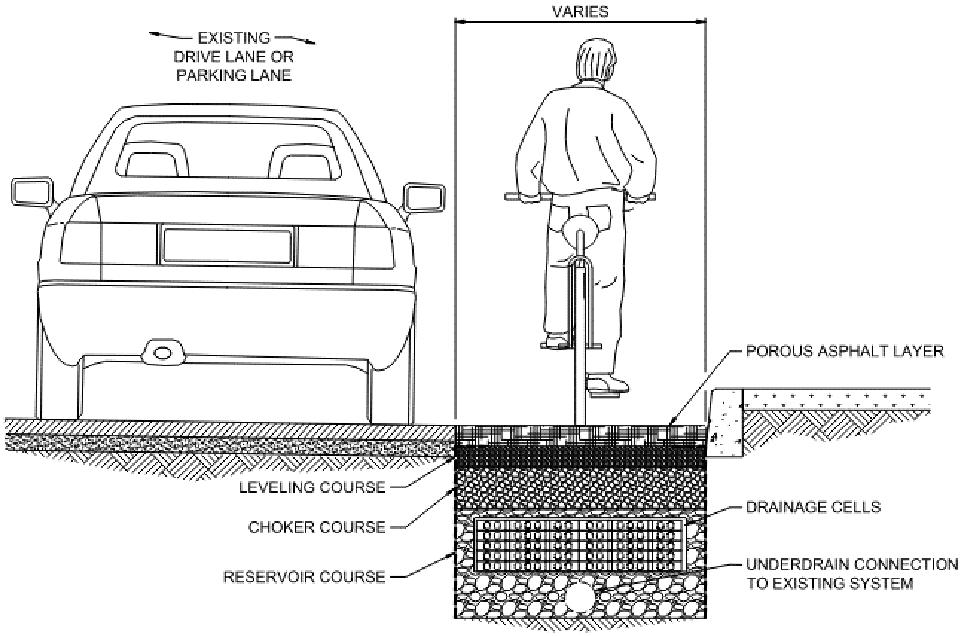
Drainage Issues

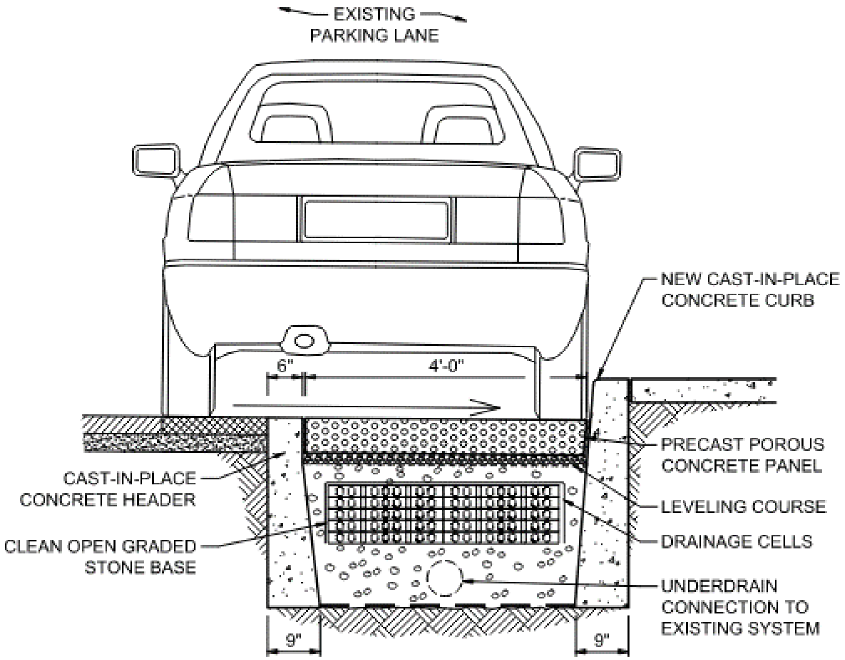
Flood Control

Ecosystem Services

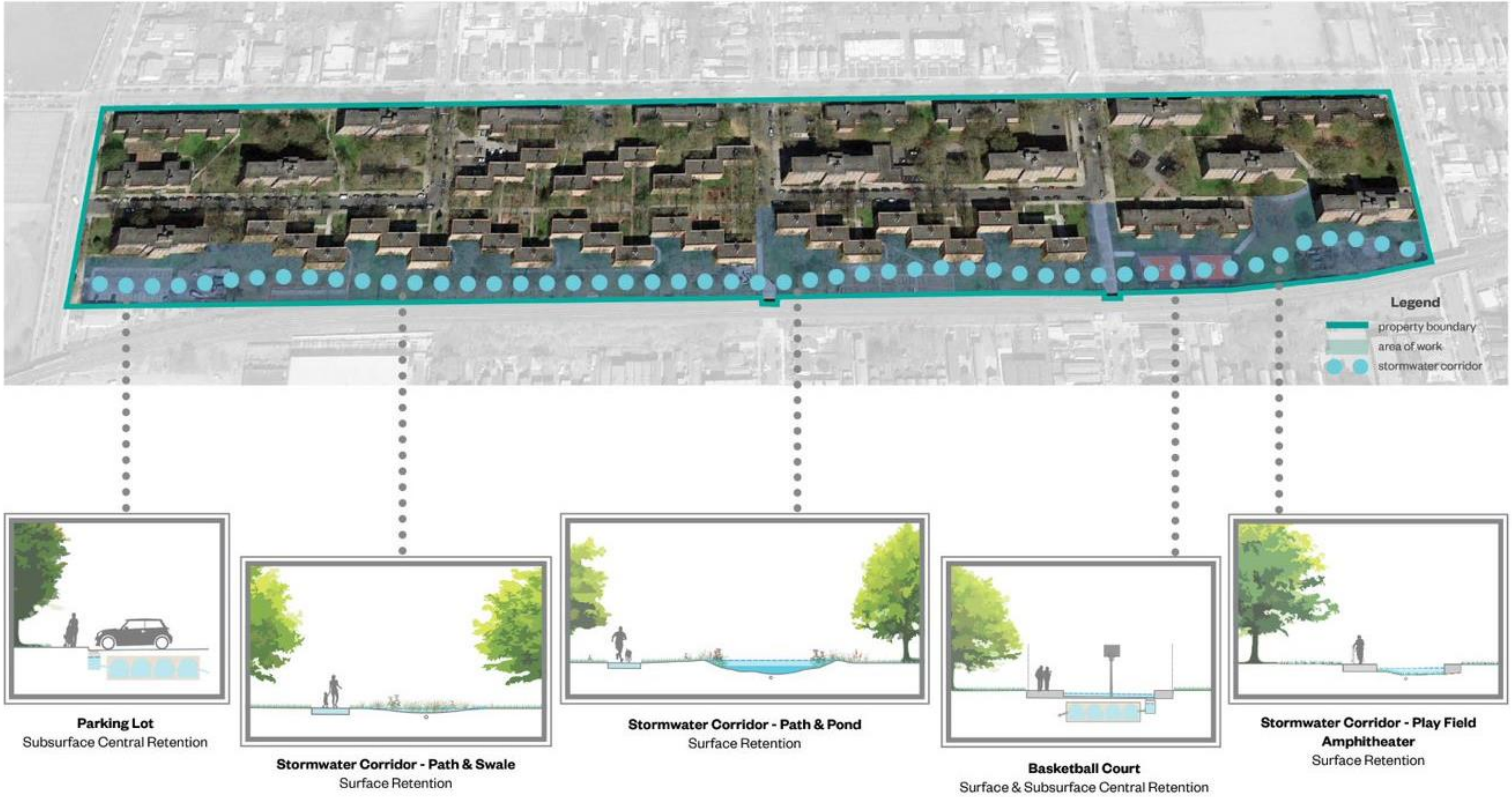
Community Amenities

Multi-Function Stormwater Management Areas



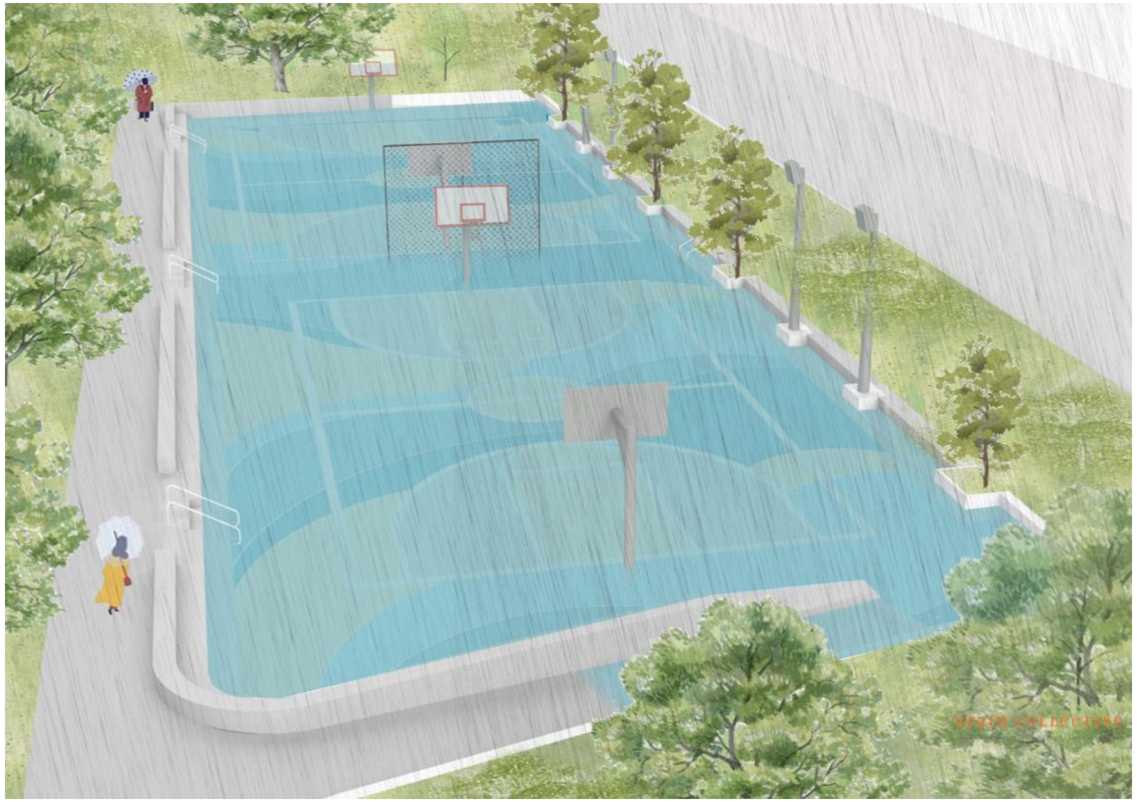


Multi-Function Stormwater Management Areas



Multi-Function Stormwater Management Areas

Dry Weather



Cloudburst Event

Building a Bigger Toolbox

Building Adaptability for the Future

Questions

Matthew Jones, PhD, PE
mjones@hazenandsawyer.com

Hazen