



# Innovative Root Cause Analysis to Identify Chronic Surface Flooding Countermeasures

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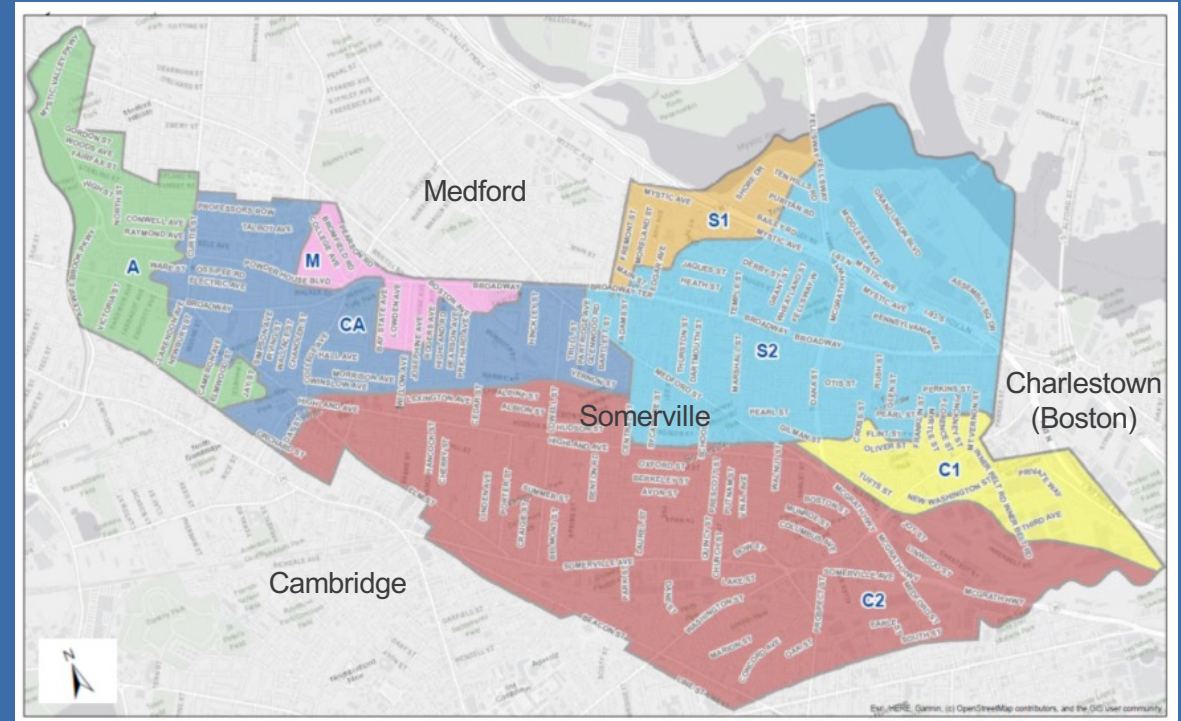
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# Agenda and Introductions

- Introductions
- Project Background
- Flood Risk Modeling and Root Cause Analysis
- Development of Flood Mitigation Alternatives
- Q/A

# Project Background

- City's combined system suffers from chronic street flooding
- Identify flooding countermeasures
  - Storage, conveyance, inlet capacity improvements, GI



# Sewershed Drainage and Water Quality Improvements Plan

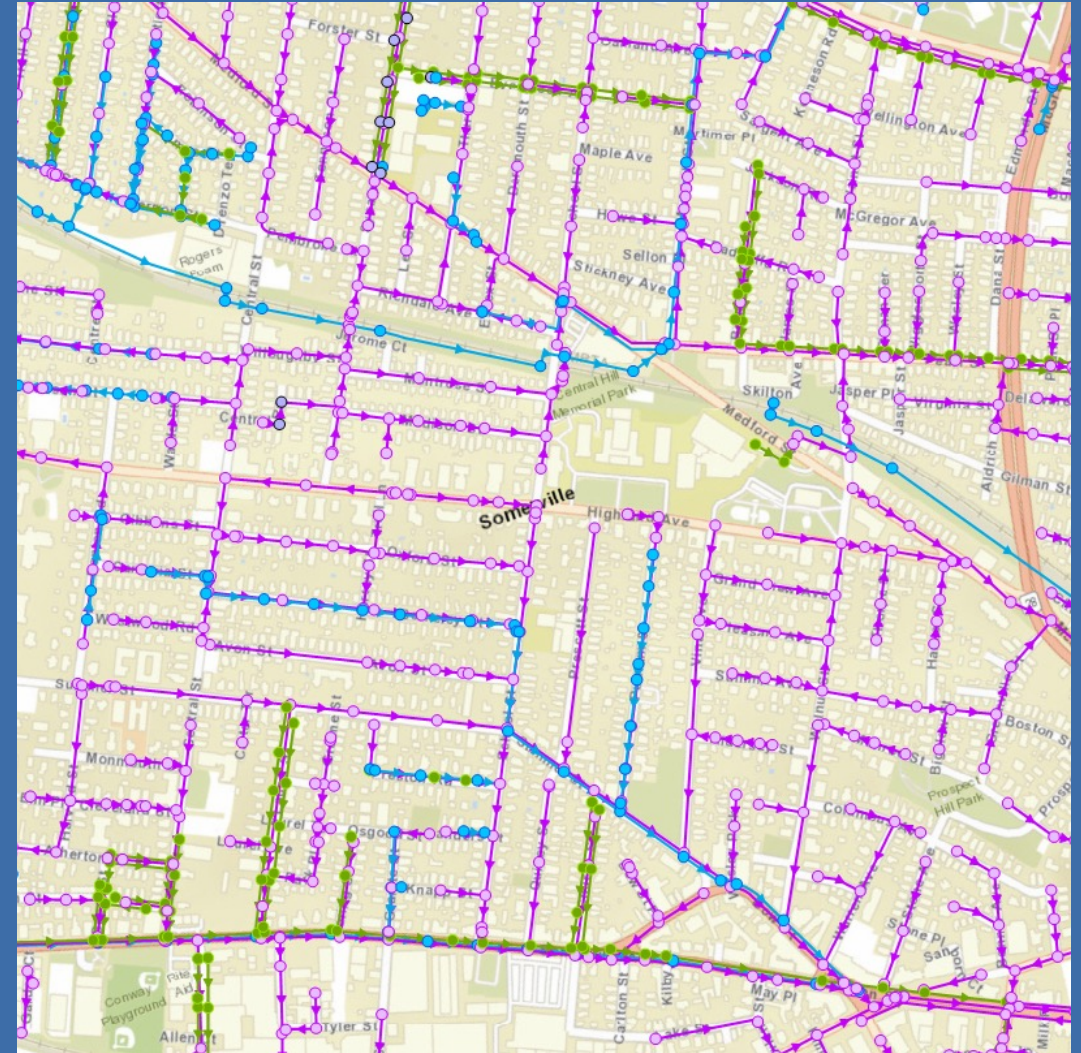
- Reduction of CSOs in combined areas
- Reduction of stormwater flooding
- Optimize use of existing system capacity with passive and/or real-time controls
- Propose water quality features and technologies to reduce Phosphorous (Green Infrastructure)

# Flood Risk Modeling and Root Cause Analysis

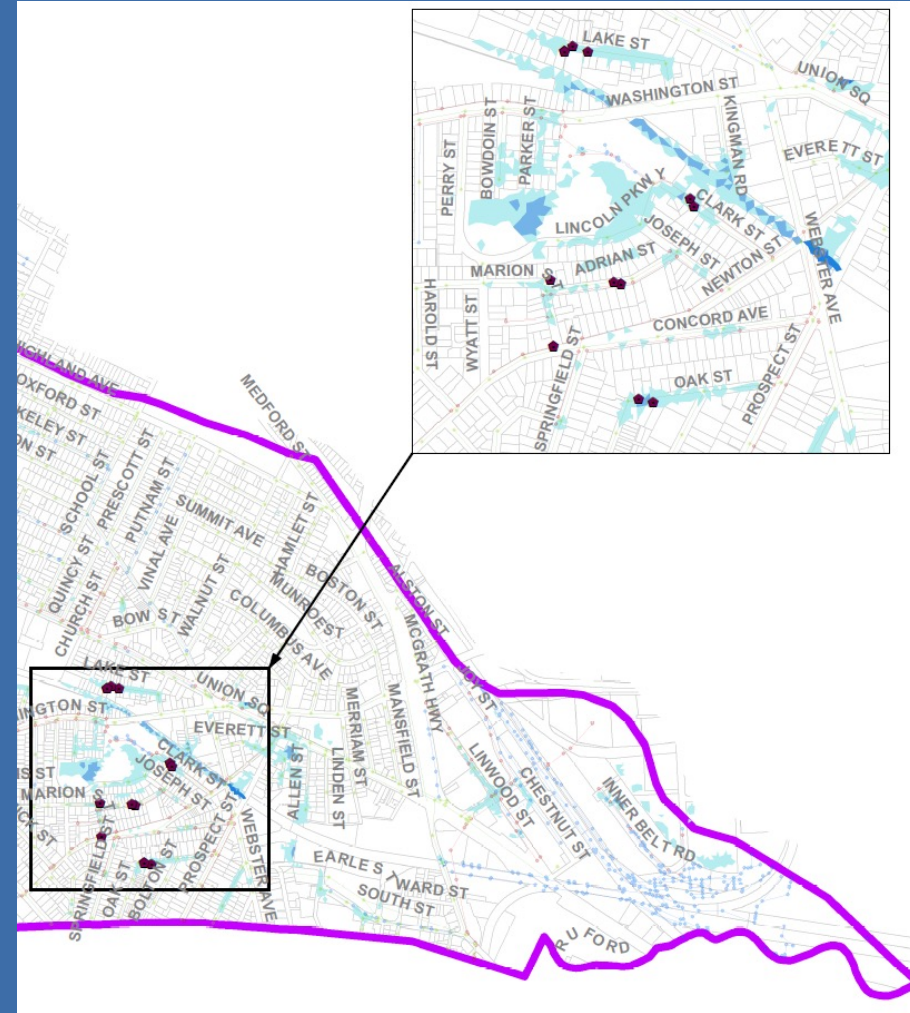
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# Modeling Considerations and Parameters

- City GIS Network and existing model as a base
- Need model to accurately reflect existing conditions – MH Inspections and CCTV Updates
- Flow metering data and flood complaints



# Model Development, Calibration, Validation



## Legend

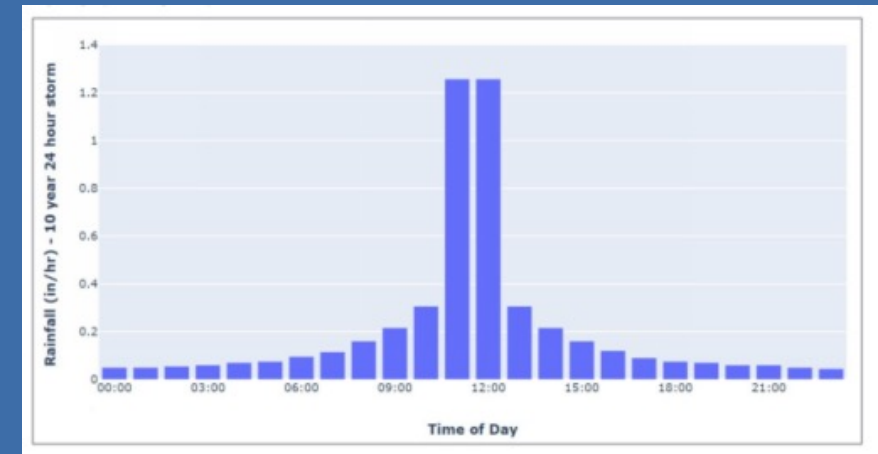
- ★ Detailed Flood Record
- ◆ Flood Complaint Location
- Combined Sewer
- Sanitary Sewer
- Storm Sewer

## Flood Depth

- 0.1 - 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- 3.0 - 10.0 ft

# Design Storms

- Goal is to keep flooding contained to the public right-of-way for 10-yr 24-hr rainfall event (Type III SCS Distribution)
- Also consider the 10-yr 30-minute short burst storm to evaluate inlet capacity restrictions

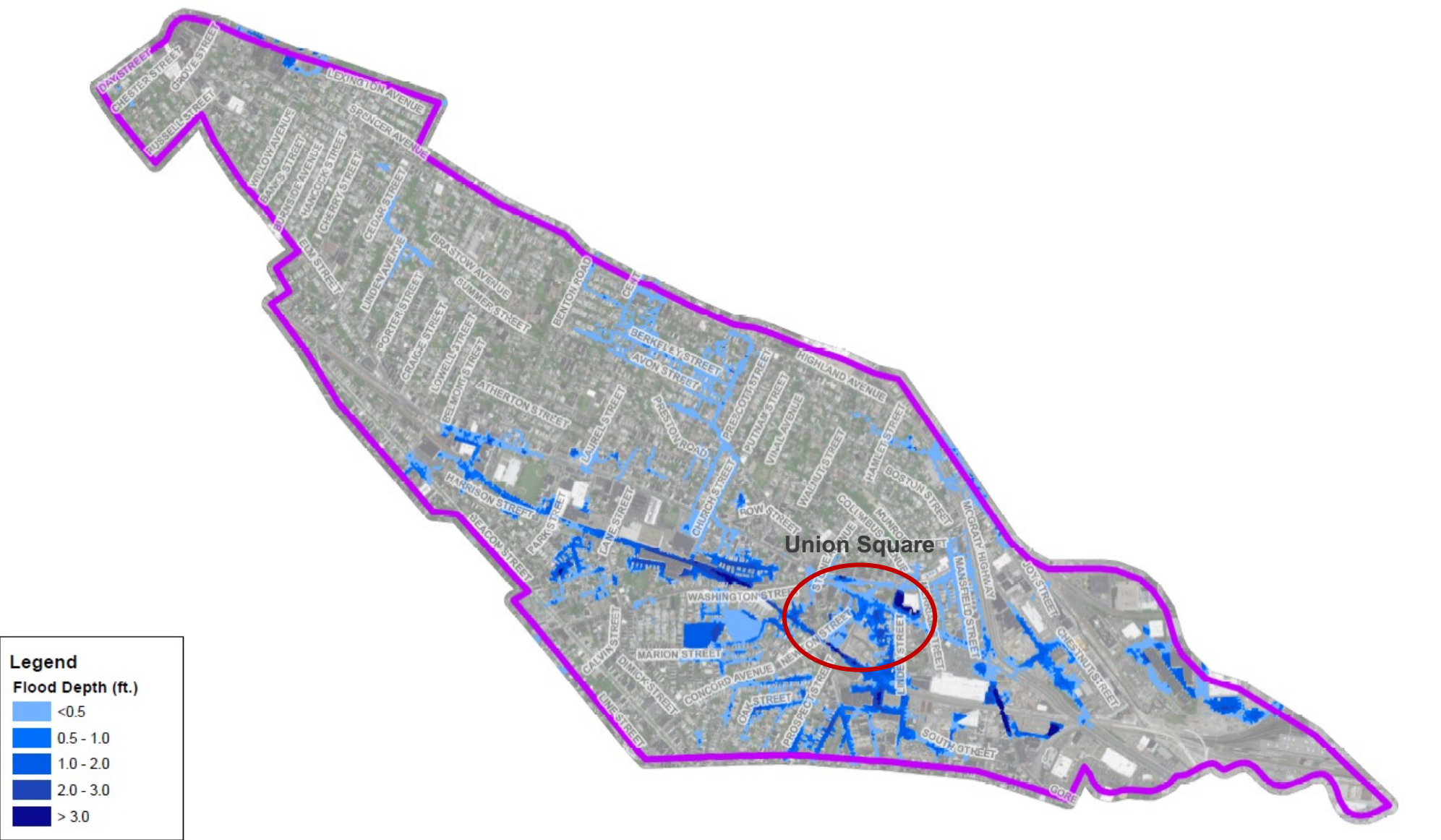


**PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup>**

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.302 (0.240-0.376)	0.371 (0.295-0.462)	0.484 (0.383-0.606)	0.577 (0.454-0.728)	0.706 (0.537-0.944)	0.801 (0.597-1.10)	0.904 (0.655-1.31)	1.03 (0.695-1.51)	1.22 (0.790-1.87)	1.38 (0.873-2.17)
10-min	0.428 (0.340-0.533)	0.525 (0.417-0.655)	0.685 (0.542-0.857)	0.817 (0.642-1.03)	1.00 (0.761-1.34)	1.14 (0.846-1.56)	1.28 (0.929-1.85)	1.46 (0.985-2.14)	1.72 (1.12-2.65)	1.95 (1.24-3.07)
15-min	0.503 (0.400-0.627)	0.618 (0.491-0.771)	0.806 (0.638-1.01)	0.962 (0.756-1.21)	1.18 (0.895-1.57)	1.34 (0.995-1.84)	1.51 (1.09-2.18)	1.71 (1.16-2.52)	2.03 (1.32-3.11)	2.30 (1.46-3.61)
30-min	0.687 (0.546-0.856)	0.845 (0.672-1.05)	1.10 (0.873-1.38)	1.32 (1.04-1.66)	1.62 (1.23-2.16)	1.83 (1.37-2.52)	2.07 (1.50-3.00)	2.36 (1.60-3.47)	2.80 (1.82-4.29)	3.17 (2.01-4.96)
60-min	0.871 (0.693-1.09)	1.07 (0.852-1.34)	1.40 (1.11-1.76)	1.68 (1.32-2.12)	2.06 (1.56-2.75)	2.33 (1.74-3.21)	2.64 (1.91-3.81)	3.00 (2.03-4.42)	3.57 (2.31-5.47)	4.05 (2.56-6.36)
2-hr	1.12 (0.900-1.39)	1.39 (1.12-1.73)	1.84 (1.46-2.29)	2.20 (1.75-2.76)	2.71 (2.08-3.61)	3.08 (2.32-4.22)	3.49 (2.56-5.03)	4.00 (2.72-5.84)	4.80 (3.13-7.30)	5.51 (3.49-8.55)
3-hr	1.31 (1.05-1.61)	1.62 (1.31-2.00)	2.14 (1.71-2.65)	2.57 (2.04-3.21)	3.16 (2.44-4.19)	3.60 (2.72-4.91)	4.07 (3.00-5.85)	4.68 (3.18-6.78)	5.63 (3.67-8.50)	6.46 (4.11-9.97)
6-hr	1.70 (1.38-2.08)	2.10 (1.70-2.58)	2.76 (2.22-3.39)	3.31 (2.65-4.09)	4.06 (3.14-5.33)	4.61 (3.50-6.23)	5.22 (3.85-7.41)	5.98 (4.08-8.58)	7.17 (4.69-10.7)	8.21 (5.23-12.5)
12-hr	2.18 (1.78-2.65)	2.68 (2.19-3.26)	3.50 (2.84-4.28)	4.18 (3.37-5.14)	5.11 (3.98-6.65)	5.80 (4.42-7.75)	6.55 (4.85-9.17)	7.47 (5.13-10.6)	8.89 (5.84-13.1)	10.1 (6.47-15.2)
24-hr	2.64 (2.17-3.18)	3.27 (2.68-3.95)	4.30 (3.52-5.22)	5.16 (4.19-6.30)	6.34 (4.97-8.19)	7.21 (5.53-9.56)	8.16 (6.08-11.3)	9.34 (6.44-13.1)	11.2 (7.36-16.3)	12.8 (8.19-19.0)



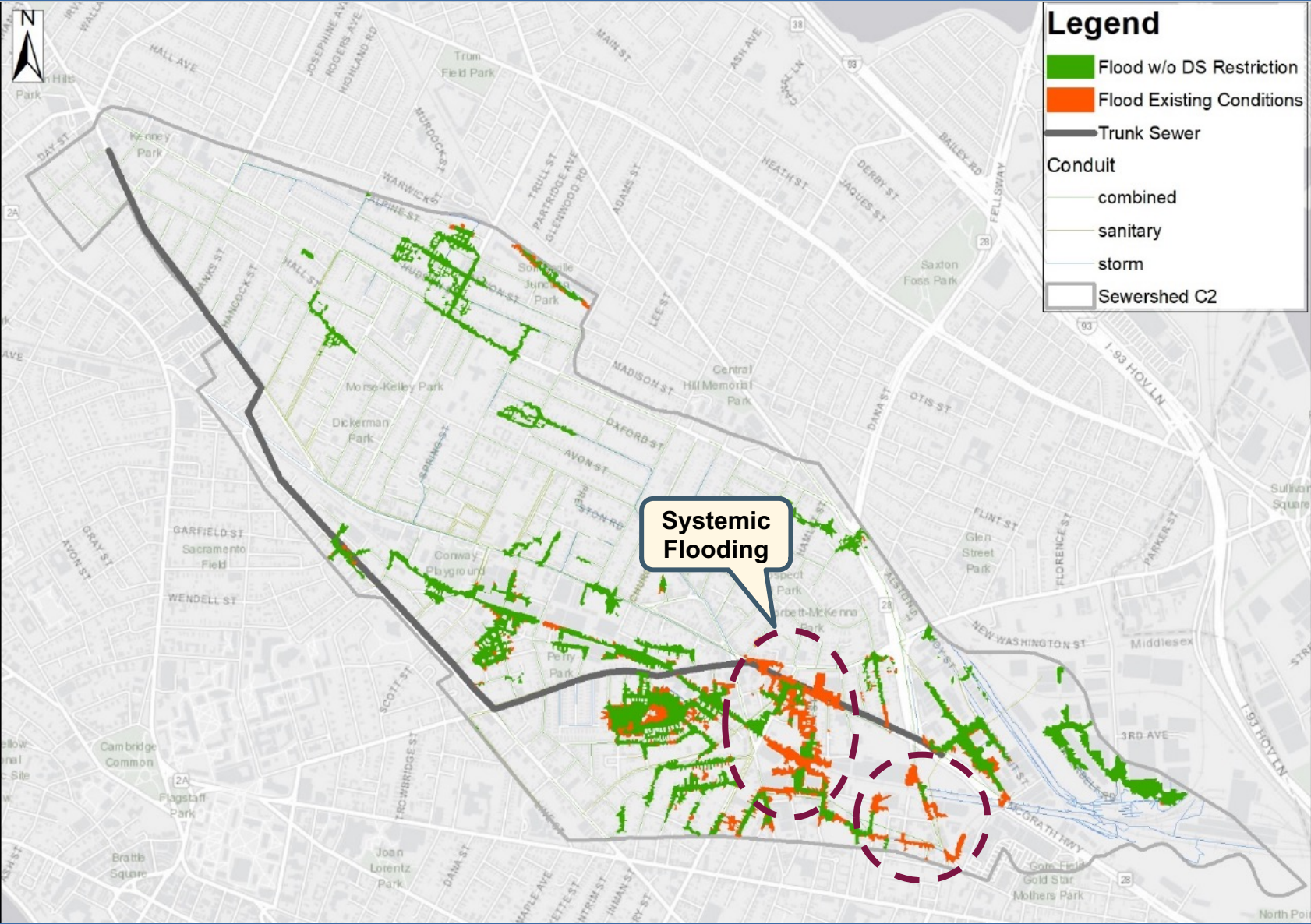
# Sewershed C2 – 10yr 24hr Storm Flooding



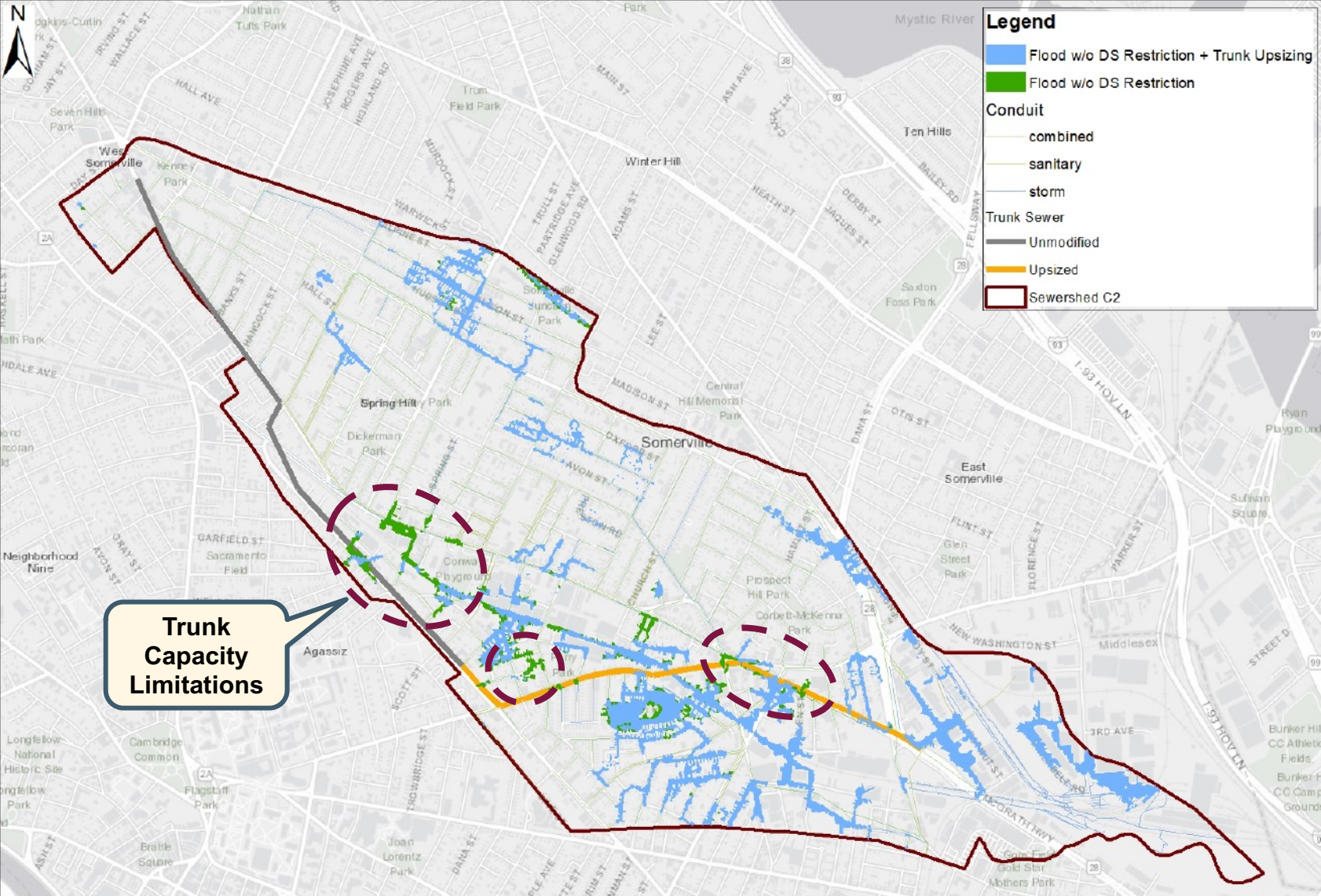
# Root Cause Analysis Approach

- System-wide Regional Limitations
  - Boundary condition limitations specific to each sewershed (e.g. Interceptor system capacity, end-of line pump capacity, or river and ocean levels)
- Trunk Conveyance System Limitations
  - Identify trunk conveyance system bottlenecks (i.e. downstream combined sewer trunk lines)
- Localized System Limitations
  - Undersized local conduits, lack of inlet capacity, localized low-lying areas, etc.

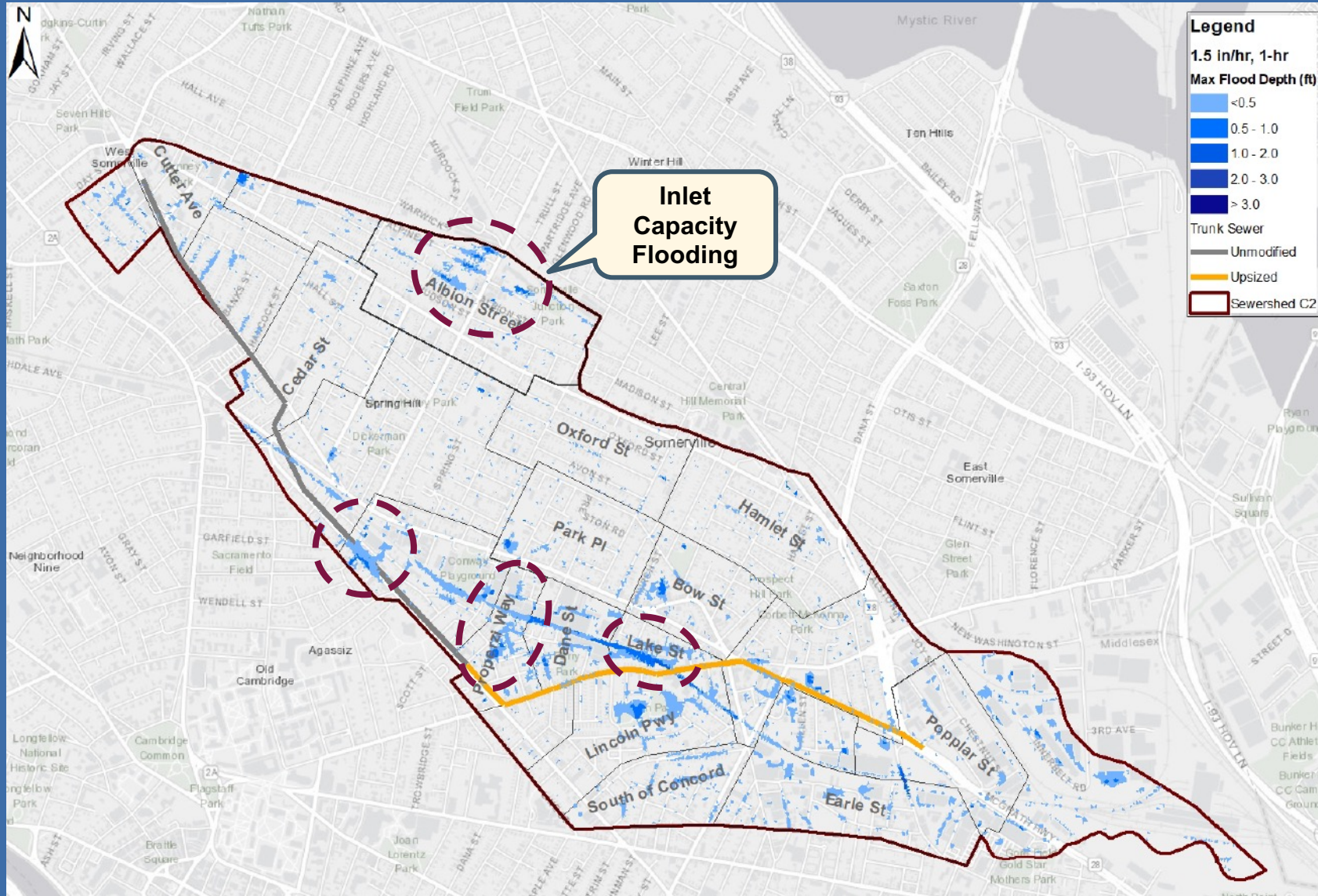
# System-Wide Regional Limitations



# Trunk Conveyance System Limitations



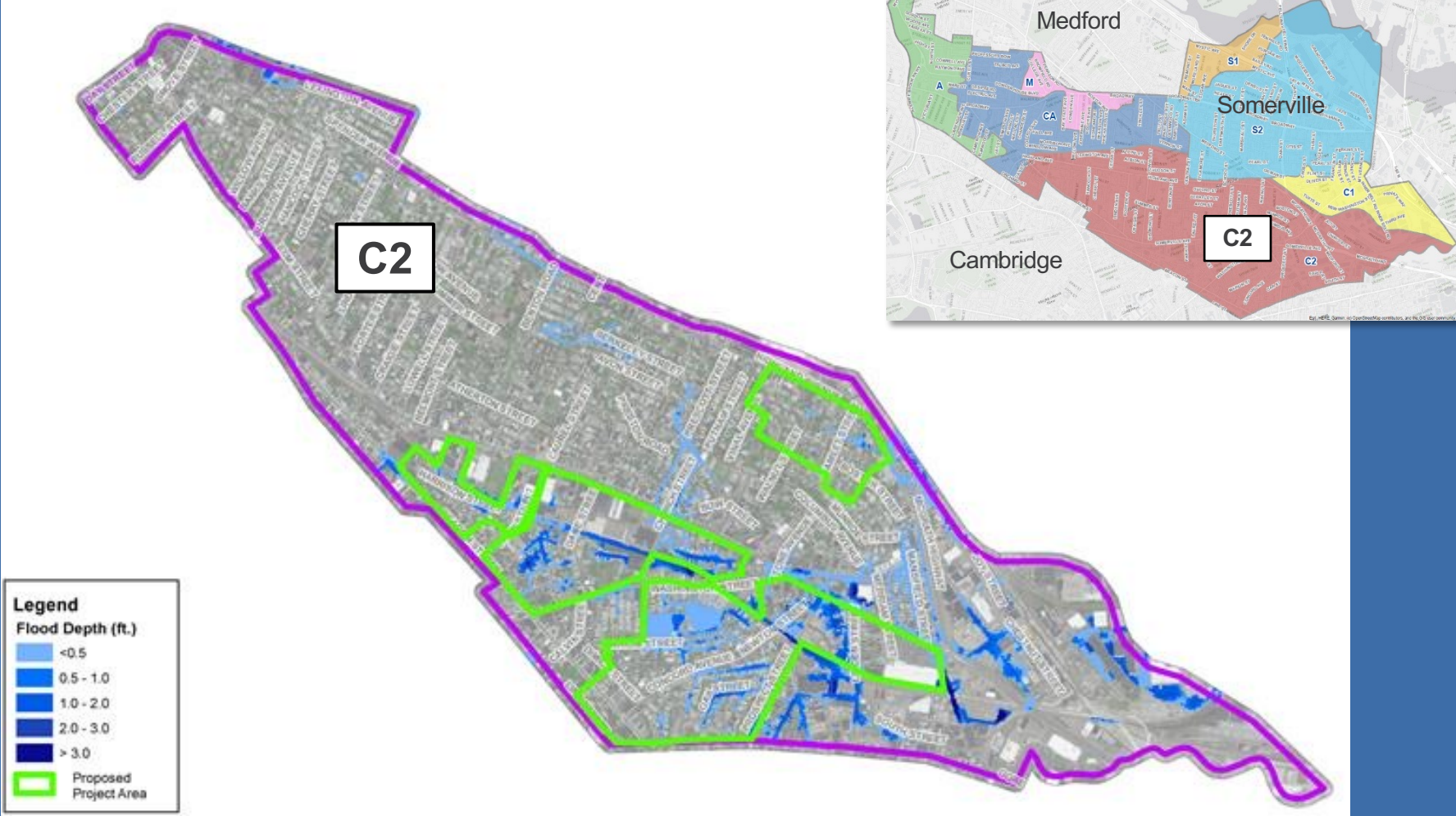
# Localized System Limitations



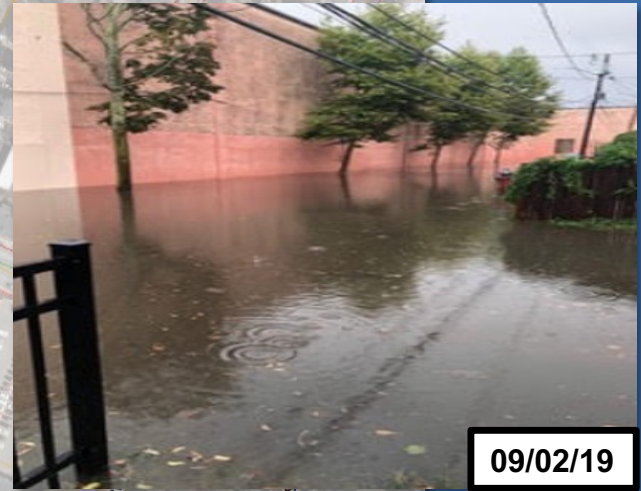
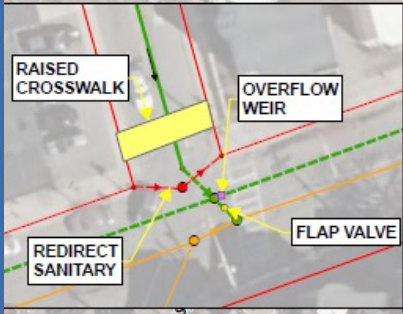
# Development of Potential Mitigation Alternatives

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# Project Areas



# Project 3 Area



**Legend**

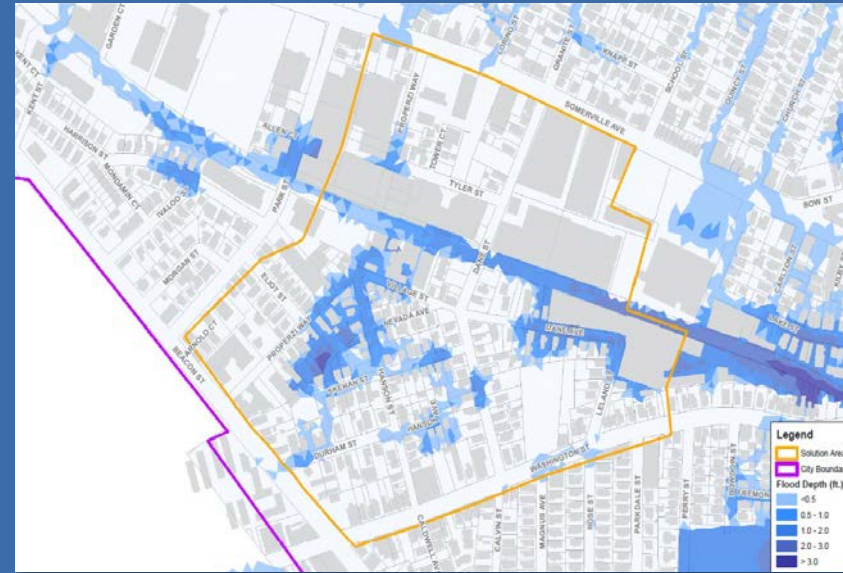
- Existing Combined
- Proposed Storm Force Main
- Existing Storm
- Existing Sanitary
- Convert to Sanitary
- Convert to Storm
- Proposed Sanitary
- Proposed Storm
- Flap Gate Structure
- Overflow Weir Structure
- Raised\_Crosswalk
- Somerville City Border
- Project 3 Area Border



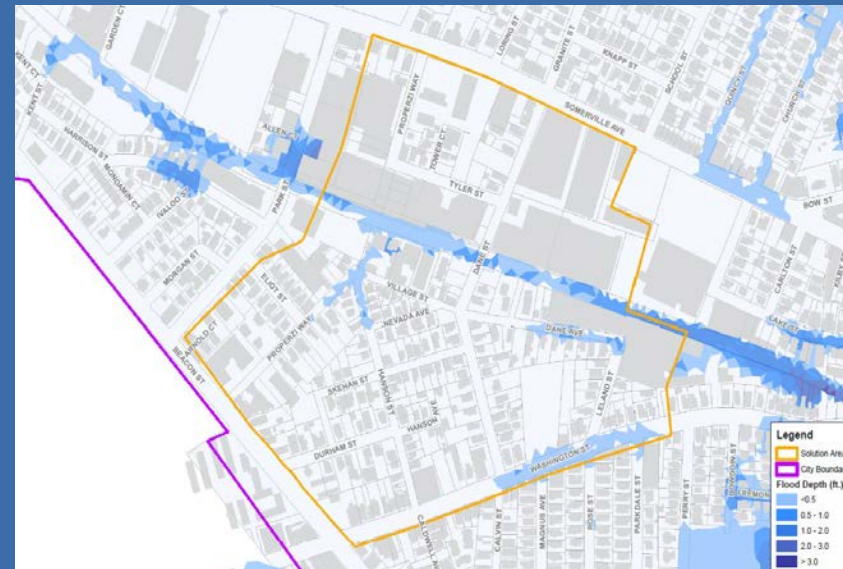
# Project 3 Flood & I/I Reductions

Project 3 – Flood & I/I Volume Reductions	
<b>Flooding during 10-Year 24-Hour Design Event (MG)</b>	
Existing Conditions	1.49
At Project completion	0.21
<b>Flooding during 10-Year 30-Minute Design Event (MG)</b>	
Existing Conditions	0.57
At Project completion	0.11
<b>I/I Volume Reduction (MG)</b>	
Estimated I/I Reduction with Project as Proposed	N/A*

Existing Conditions



At Proposed Project Completion



Note: Maps depict 10-yr 24-hr Rainfall Event

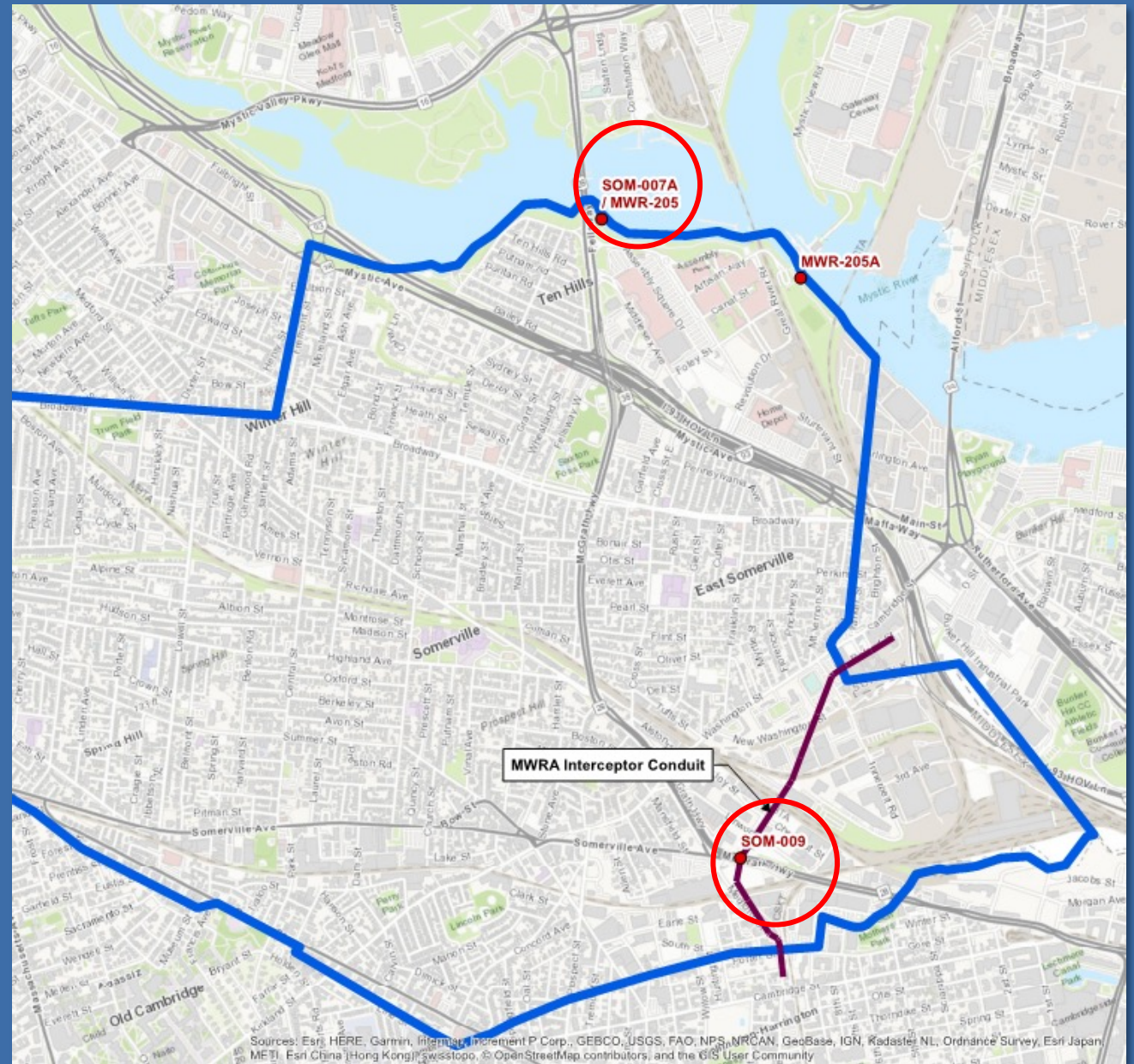
# CSO Considerations

Design Criteria:  
Do Not Worsen Conditions at CSOs

Sewershed Tributary to the following CSOs

- SOM-009
- SOM-007A

SCENARIO	10-YR, 24-HR	
	SOM-009	SOM-007A
Existing Conditions	42.54	24.62
Completion of Ongoing Projects	36.73	24.45
Project 3	36.00	24.34

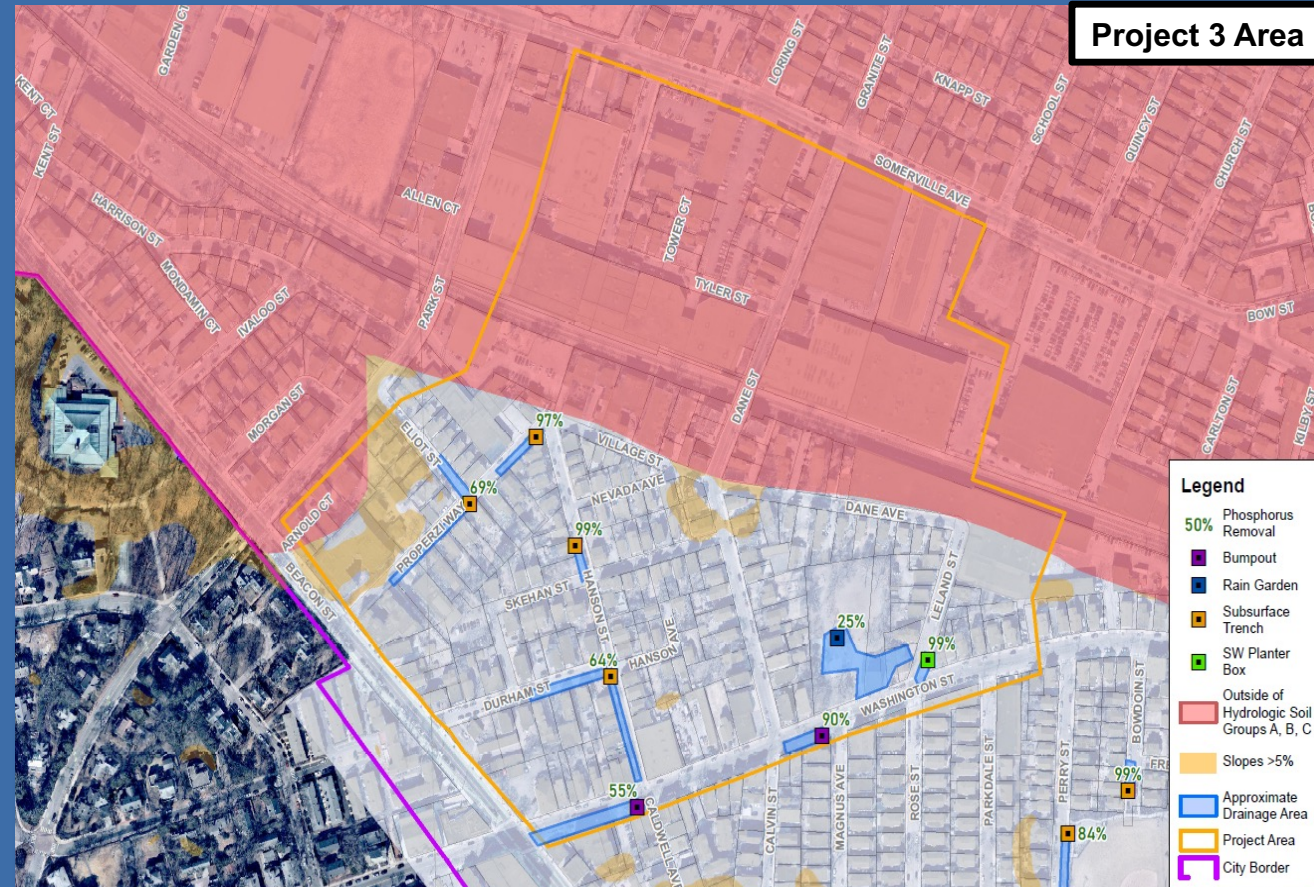


# Green-Infrastructure Analysis

Surface Area	Percent Impervious	Project Area PLER (lbs/acre/year)	Project Area Loading (lbs/year)	GSI Phosphorous Reduction (lbs/year)	GSI Phosphorous Reduction (Percent)
45.1	81.0%	1.5	69.4	1.3	1.9%

## Siting Considerations:

- Within City Right-of-way
- Terrain / Slope
- Soil Type
- Groundwater Depth
- Sidewalk Width (for Planter Boxes)
- Adequate Clearance from Following Elements:
  - Underground Utilities
  - Buildings
  - Trees
  - Parking Meters
  - Railroad
  - Driveway / Curb Cut
  - Crosswalks / Sidewalk Ramps



# BMP Analysis

## Non-Structural BMPs



- Street Sweeping
  - Equipment Types:
    - Mechanical
    - Vacuum Assisted
    - High Efficiency Regenerative Air-Vacuum
- Catch Basin Cleaning
- Organic Waste & Leaf Litter Collection Program

Project Area Loading (lbs/year)	Street Sweeping Reduction* (lbs/year)	Catch Basin Cleaning Reduction (lbs/year)	Leaf Litter Collection Reduction (lbs/year)	Total Reduction (lbs/year)	Total Reduction (Percent)
69.4	0.38 – 0.97	0.73	1.50	2.62 – 3.20	3.8% – 4.6%

# Cost Analysis

- Normal vs Conservative Scenarios
- Costing Considerations:
  - Open-Trench Pipe Installation
  - New Manhole & Catch Basin Installations
  - Redirection of Catch Basin Laterals & Sewer Services
  - CIP Pipe Rehabilitation & Manhole Lining
  - CCTV & Dye Testing, including Pipe Cleaning
  - Linear Surface Restoration
  - Removal & Disposal of Contaminated Wastes
  - Stormwater Tanks & Regulator Structures
  - Lump Sum Items:
    - Trench Dewatering
    - Bypass Pumping
    - Traffic Control / Police Details
    - Mobilization

# Conclusions

## Sewershed Drainage and Water Quality Improvements Plan

### Stormwater Model

InfoWorks ICM – 2D Overland Flow Model

Very detailed & well calibrated using field investigations & flow metering

### Root Cause Analysis for Flooding Inundation

System-wide or systemic limitations

Trunk conveyance system limitations

Local system limitations

### Development of Flood Mitigation Alternatives

Designed to level of service storm: 10-year, 24-hour

- Main Goals:
- Eliminate flooding or reduce flooding to within public right-of-way
  - Do not worsen conditions at CSOs
  - Limit Phosphorous loading in storm discharge

### Phosphorous Control BMPs

Green infrastructure & non-structural BMPs

### Cost Analysis

# Let's connect!



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