Dewberry

Innovative Root Cause Analysis to Identify Chronic Surface Flooding Countermeasures

Miles Bateman, Michael Hanley, & Yovanni Catano

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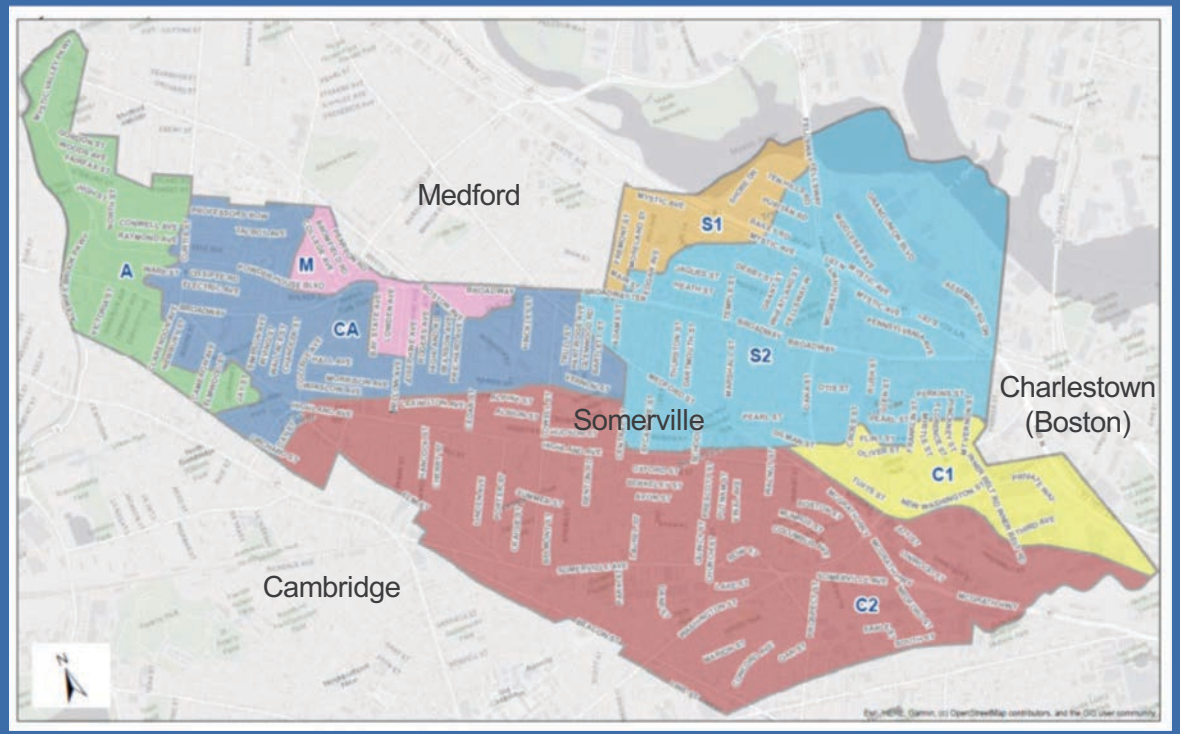
Agenda and Introductions

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

Background Information

- City of Somerville has a combined system which suffers from chronic street flooding
- City has engaged Dewberry to develop a City-Wide Drainage and Water Quality Improvements Plan
- Need to identify flooding countermeasures: storage, conveyance, and inlet capacity improvements



Sewershed Drainage and Water Quality Improvements Plan includes:

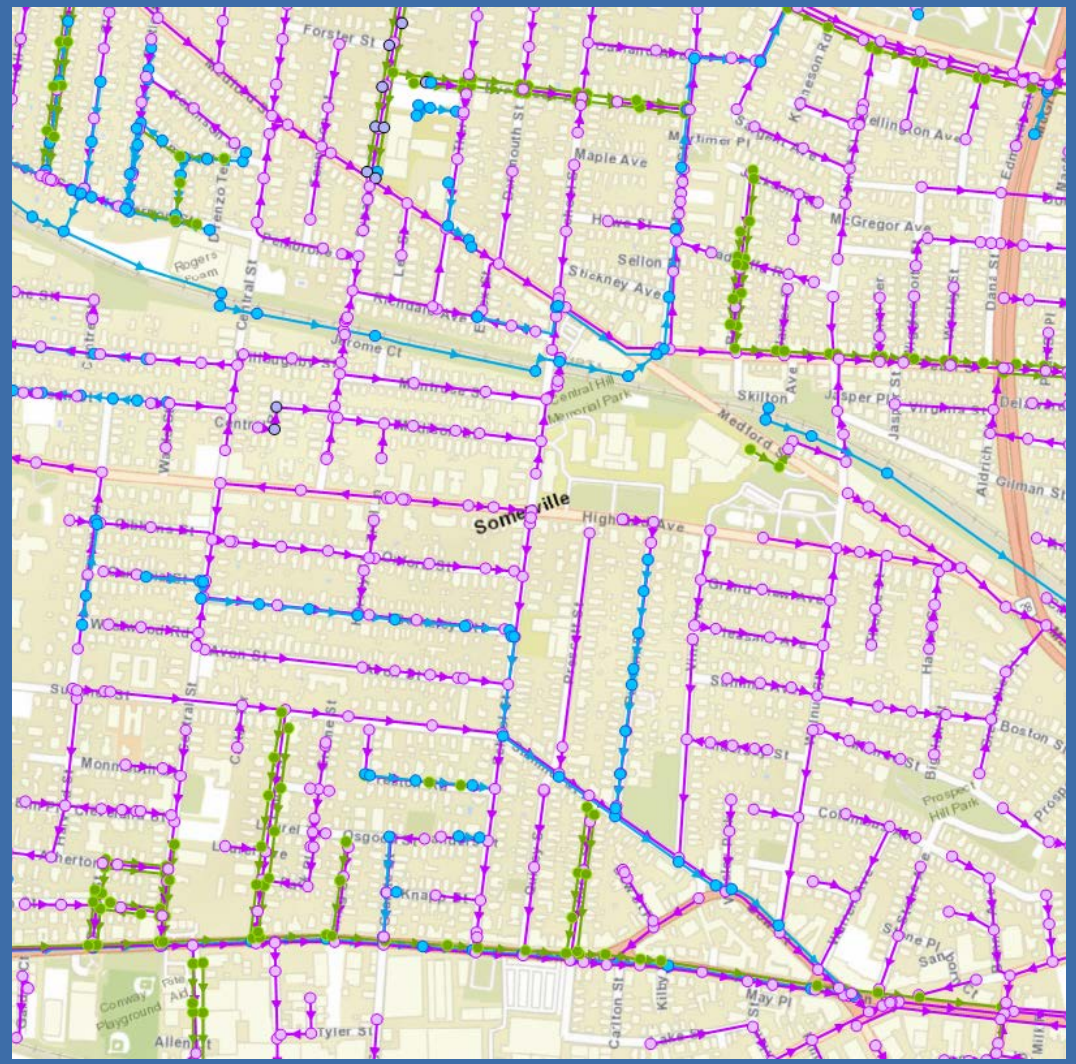
- Reduction of CSOs in combined areas
- Reduction of stormwater flooding
- Optimize use of existing system capacity with passive and/or real-time controls
- Propose water quality features and technologies to reduce Phosphorous (Green Infrastructure)

Flood Risk Modeling and Root Cause Analysis

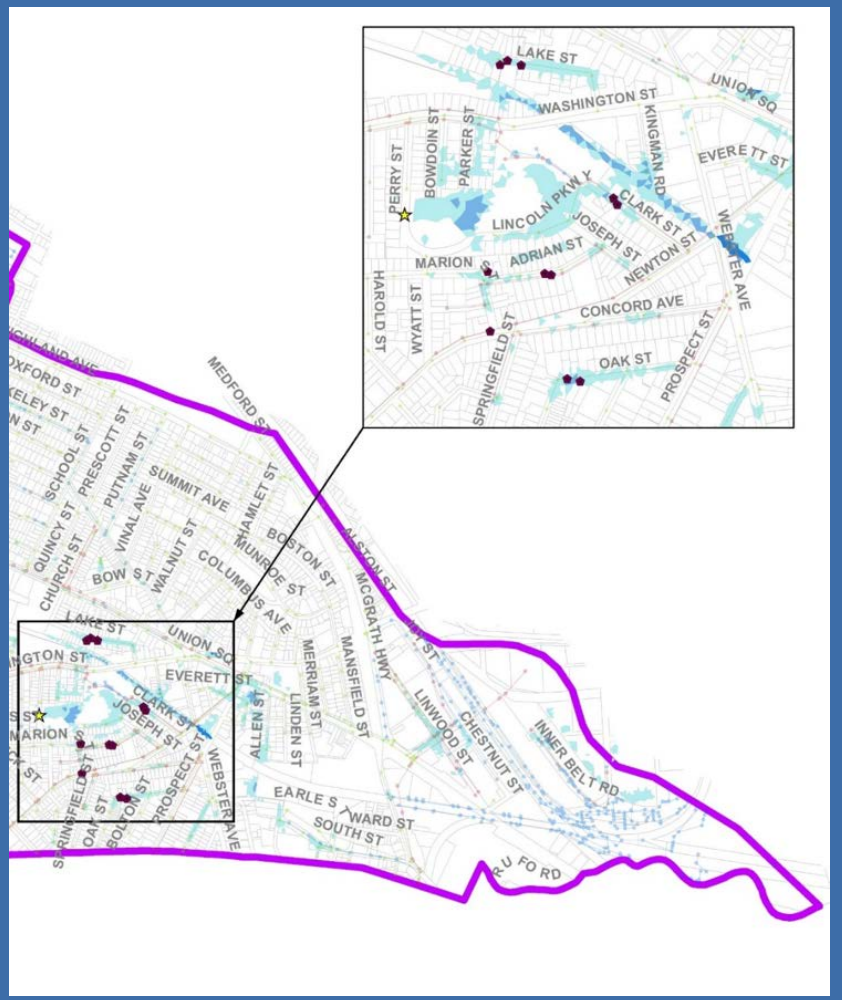
Michael Hanley

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



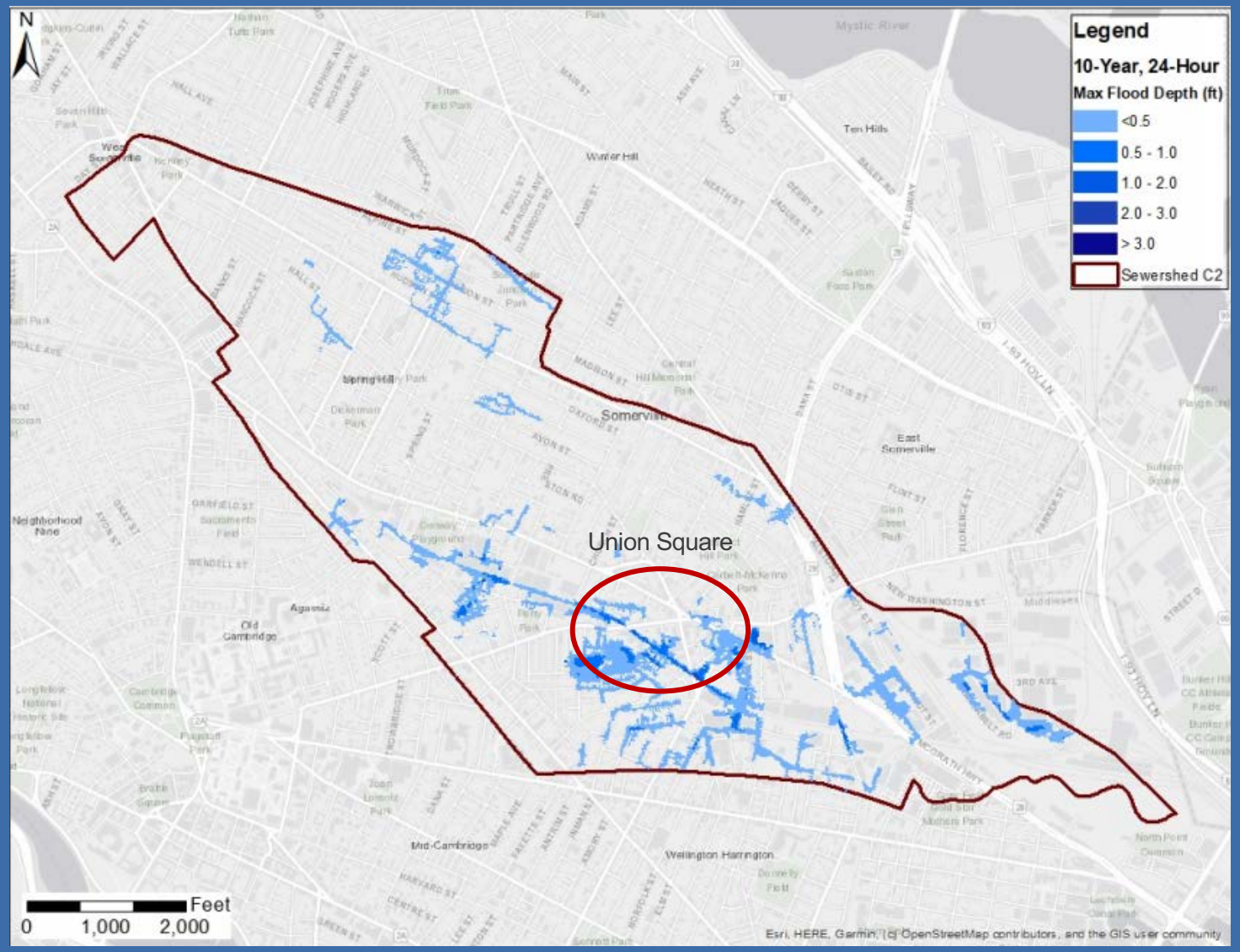
Legend

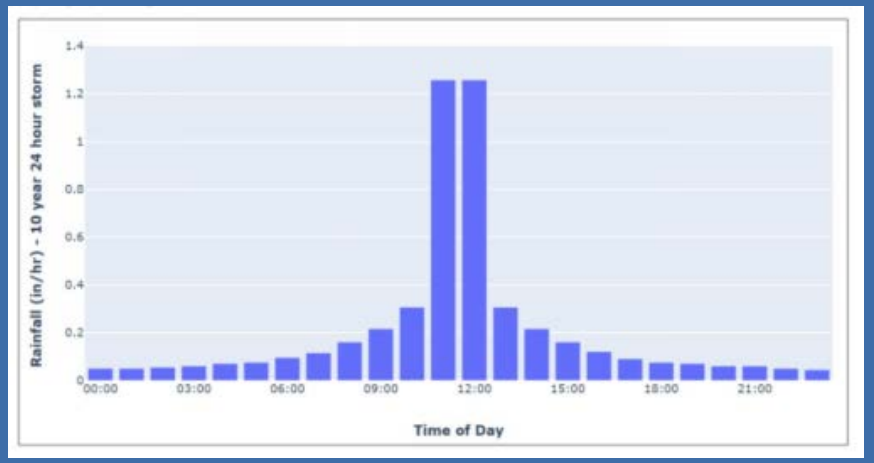
- Detailed Flood Record
- Flood Complaint Location
- Combined Sewer
- Sanitary Sewer
- Storm Sewer

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

Existing and Proposed Alternatives Modeling



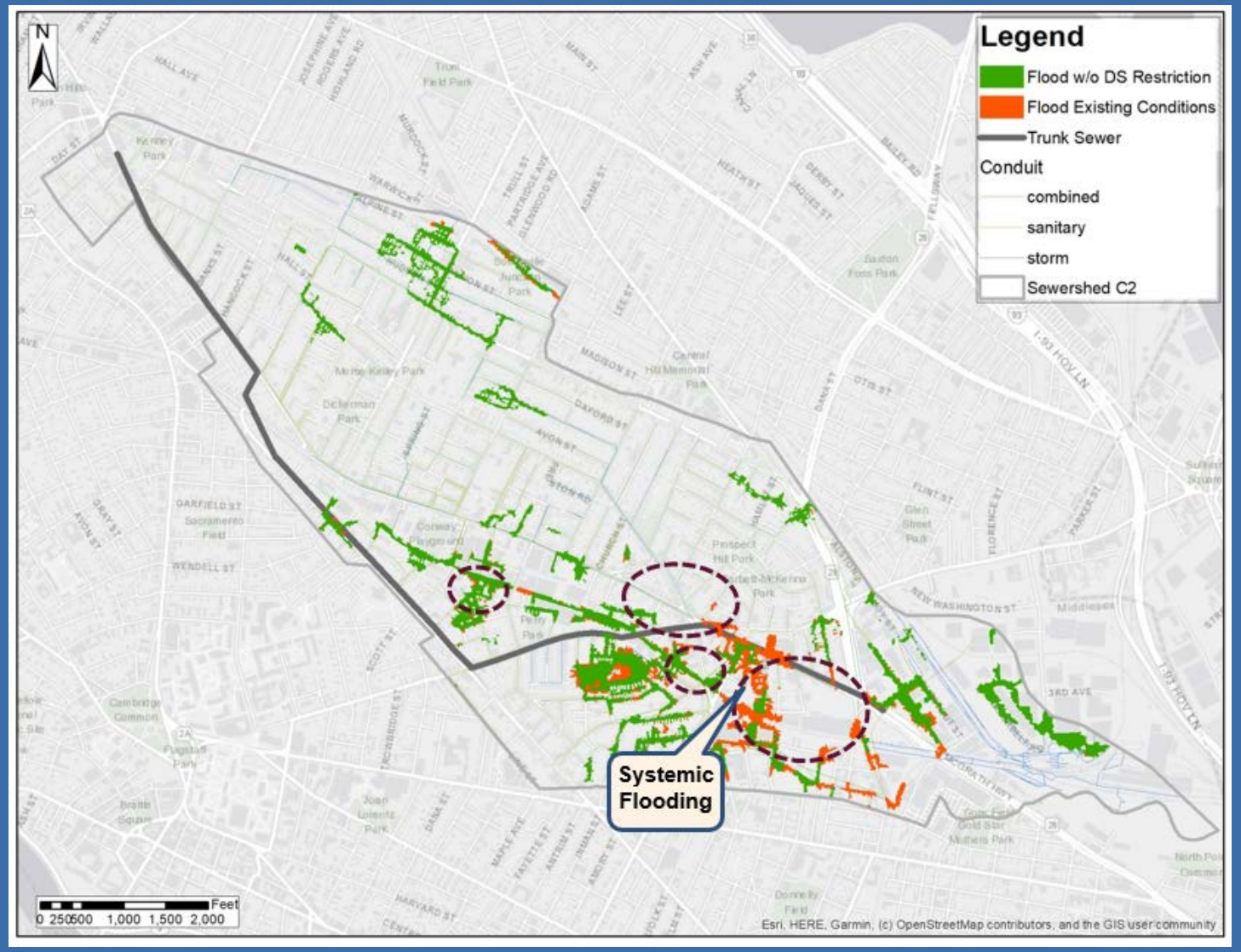


PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

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 (2.01-4.98)
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)

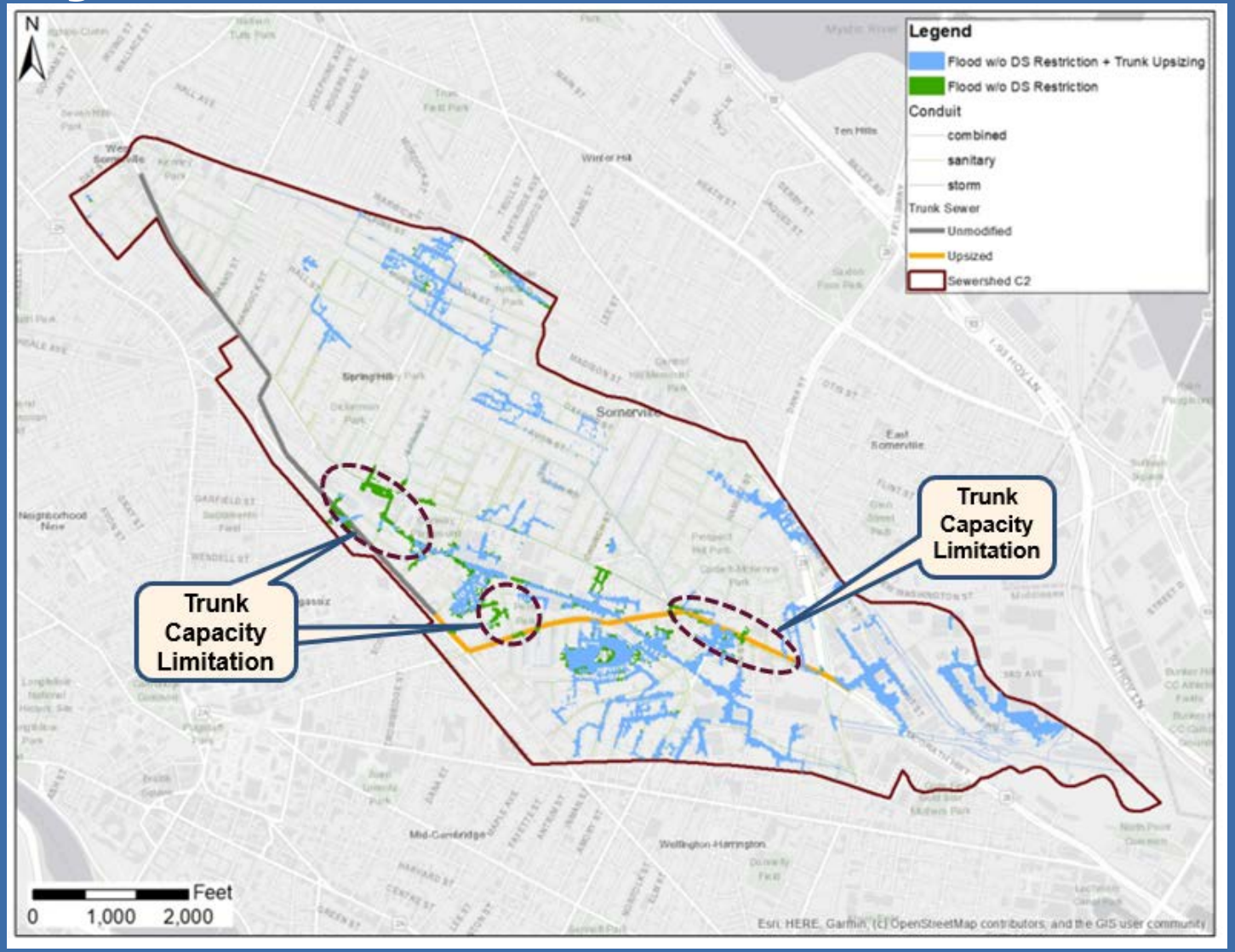
System-Wide Regional Limitations

- Boundary condition limitations specific to each sewershed (e.g. Interceptor system capacity, end-of line pump capacity, or river and ocean levels)



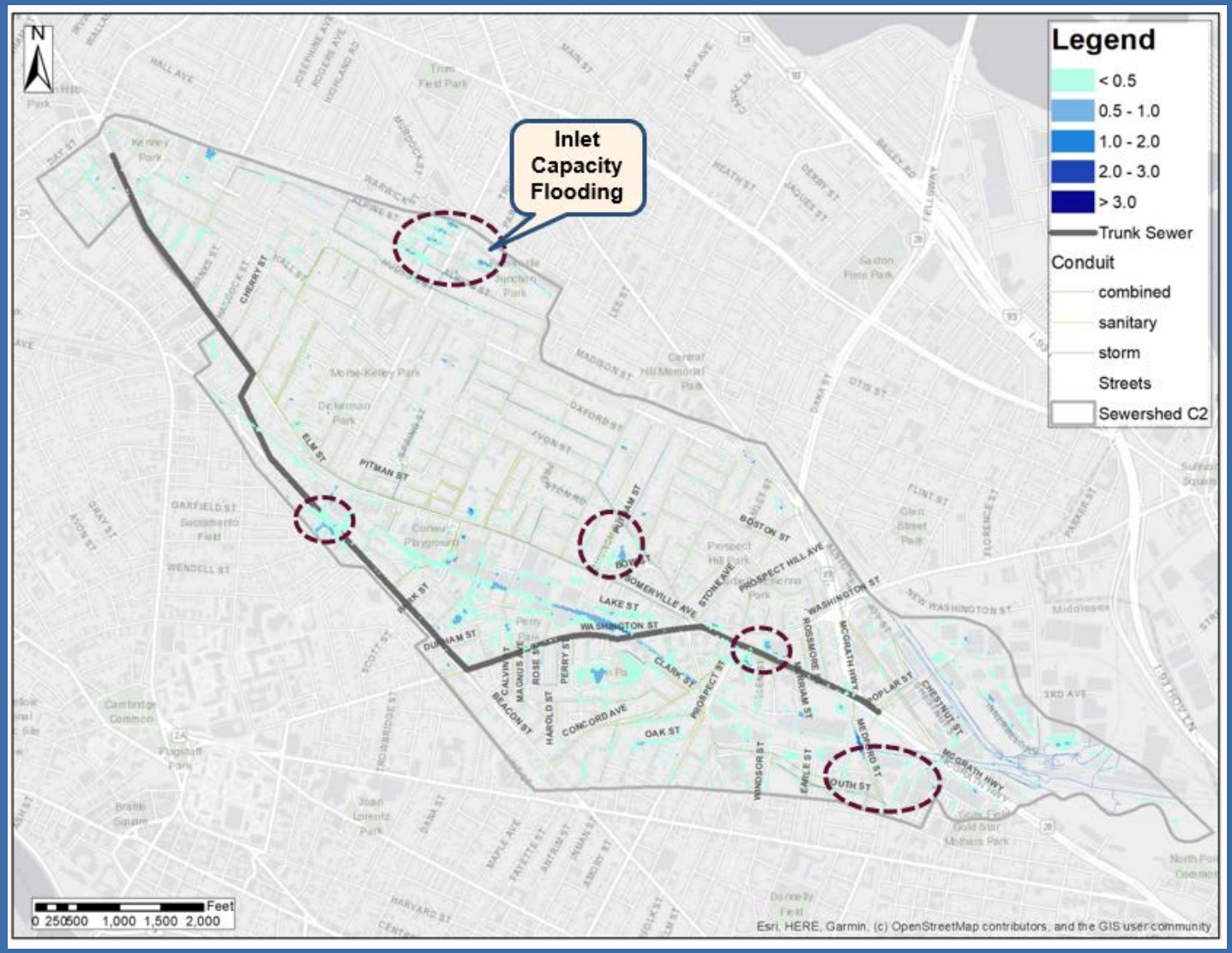
Trunk Conveyance System Limitations

- Identify trunk conveyance system bottlenecks (i.e. downstream combined sewer trunk lines)



Localized System Limitations

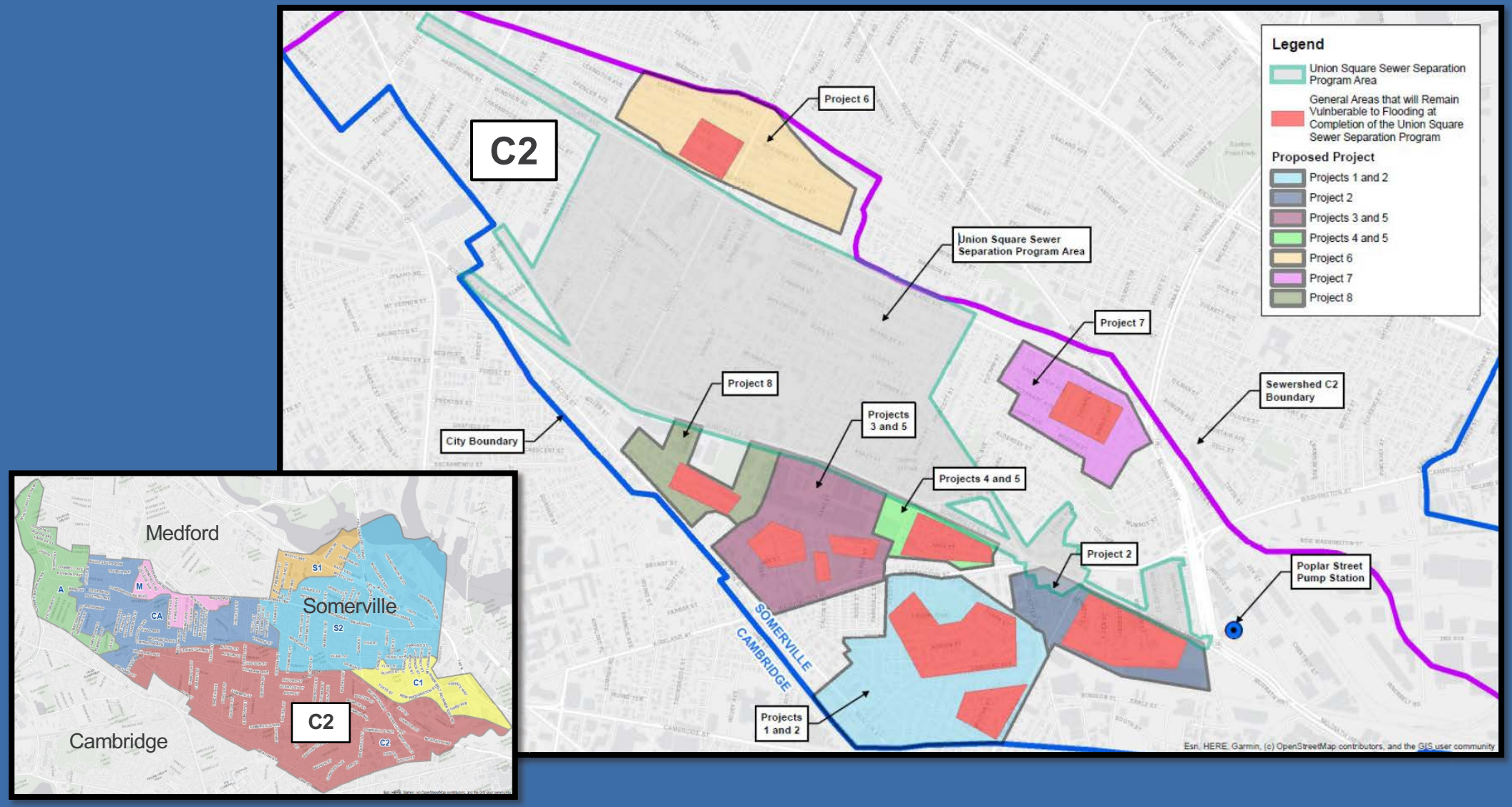
- Identify flood issues that remain once the systemic and trunk conveyance limitations are removed.
  - Undersized local conduits, lack of inlet capacity, localized low-lying areas, etc.
- Create Scenario for CBs and Rain on Mesh Model (ROMM)

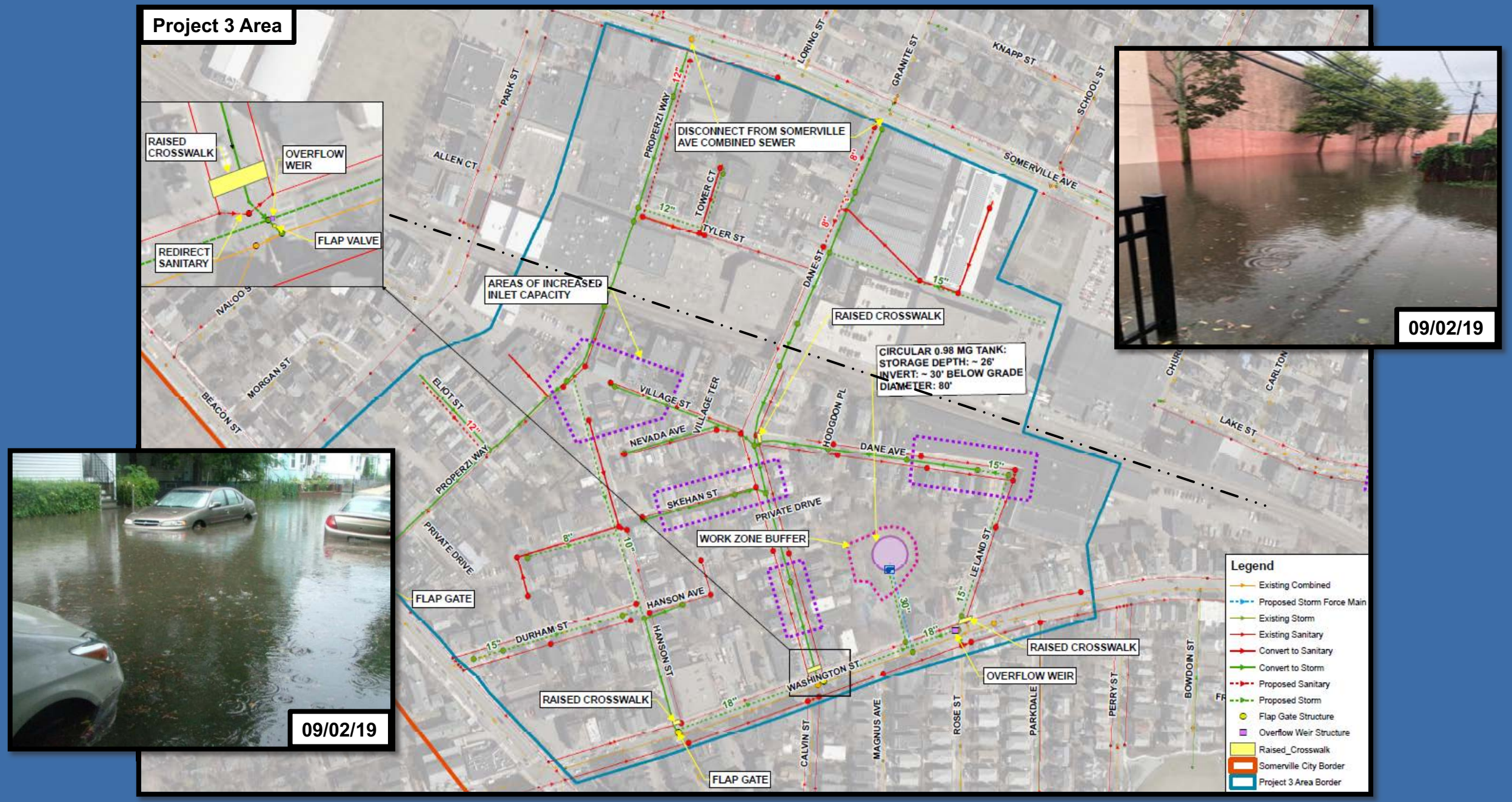


Development of Potential Mitigation Alternatives

Miles Bateman

Project Areas

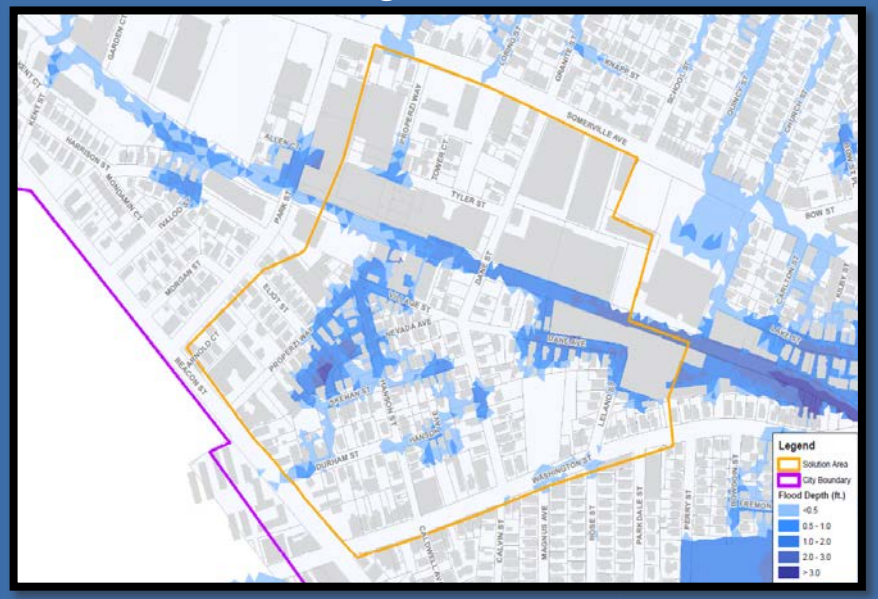



Project 3 Area
RAISED CROSSWALK
OVERFLOW WEIR
FLAP VALVE
REDIRECT SANITARY
DISCONNECT FROM SOMERVILLE AVE COMBINED SEWER
AREAS OF INCREASED INLET CAPACITY
RAISED CROSSWALK
CIRCULAR 0.98 MG TANK:
STORAGE DEPTH: ~ 26'
INVERT: ~ 30' BELOW GRADE
DIAMETER: 80'
WORK ZONE BUFFER
FLAP GATE
RAISED CROSSWALK
OVERFLOW WEIR
RAISED CROSSWALK
FLAP GATE
09/02/19
09/02/19
PARK ST
ALLEN CT
PROPERZI WAY
LORING ST
GRANITE ST
KNAPP ST
SCHOOL ST
SOMERVILLE AVE
TOWER CT
TYLER ST
DANE ST
IVALOO ST
MORGAN ST
BEACON ST
ELIOT ST
VILLAGE ST
VILLAGE TER
NEVADA AVE
HODGDON PL
DANE AVE
SKEHAN ST
PRIVATE DRIVE
HANSON AVE
DURHAM ST
HANSON ST
WASHINGTON ST
LELAND ST
CALVIN ST
MAGNUS AVE
ROSE ST
PARKDALE
PERRY ST
BOWDOIN ST
LAKE ST
CARLTON
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

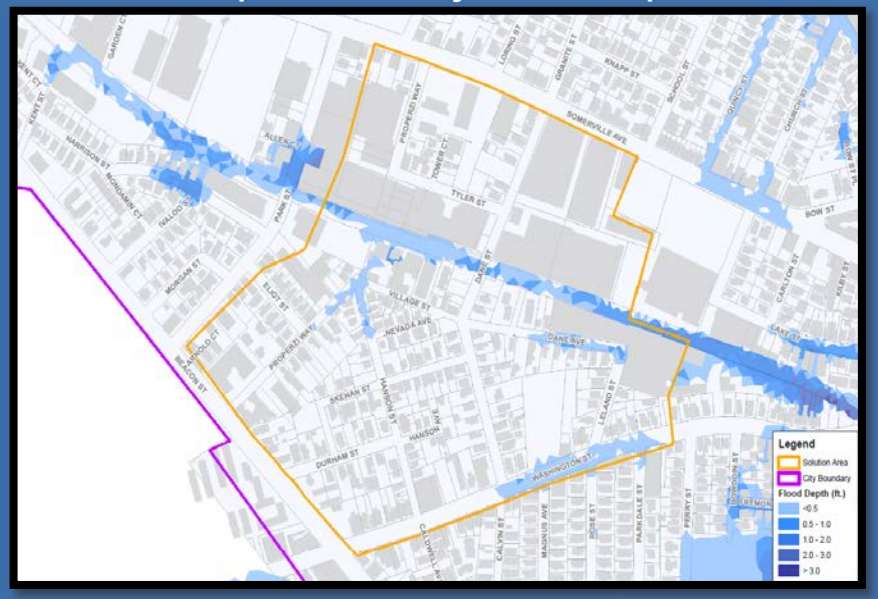
Project 3
Flood & I/I Reductions

Project 3 – Flood & I/I Volume Reductions	
Flooding during 10-Year 24-Hour Design Event (MG)	
Existing Conditions	1.49
At Project completion	0.21
Flooding during 10-Year 30-Minute Design Event (MG)	
Existing Conditions	0.57
At Project completion	0.11
I/I Volume Reduction (MG)	
Estimated I/I Reduction with Project as Proposed	N/A*
Project Cost Estimate*	$19.8M

Existing Conditions



At Proposed Project Completion



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

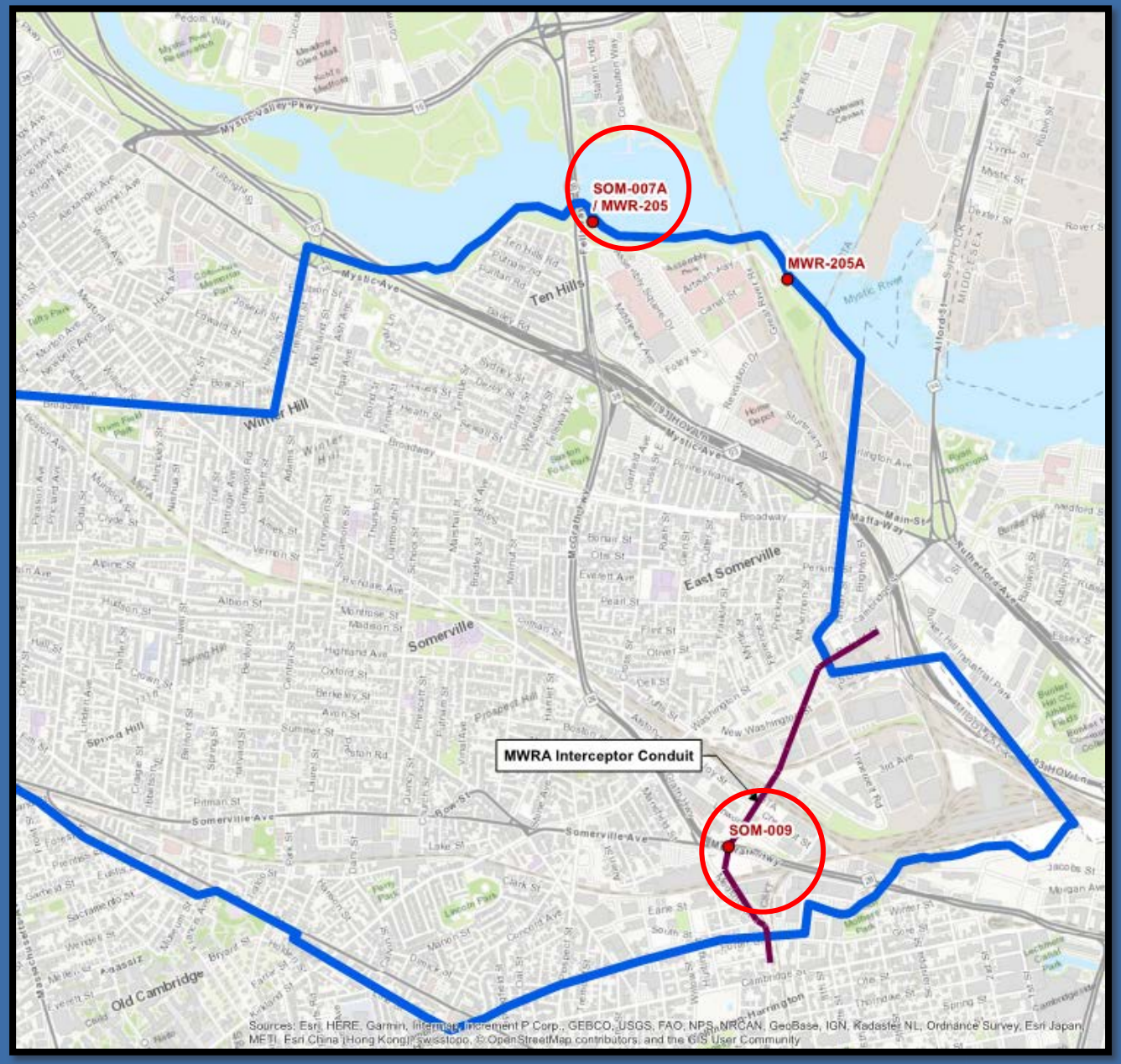
CSO Considerations

Design Criteria:
Do Not Worsen Conditions at CSOs

Sewershed Tributary to the following CSOs

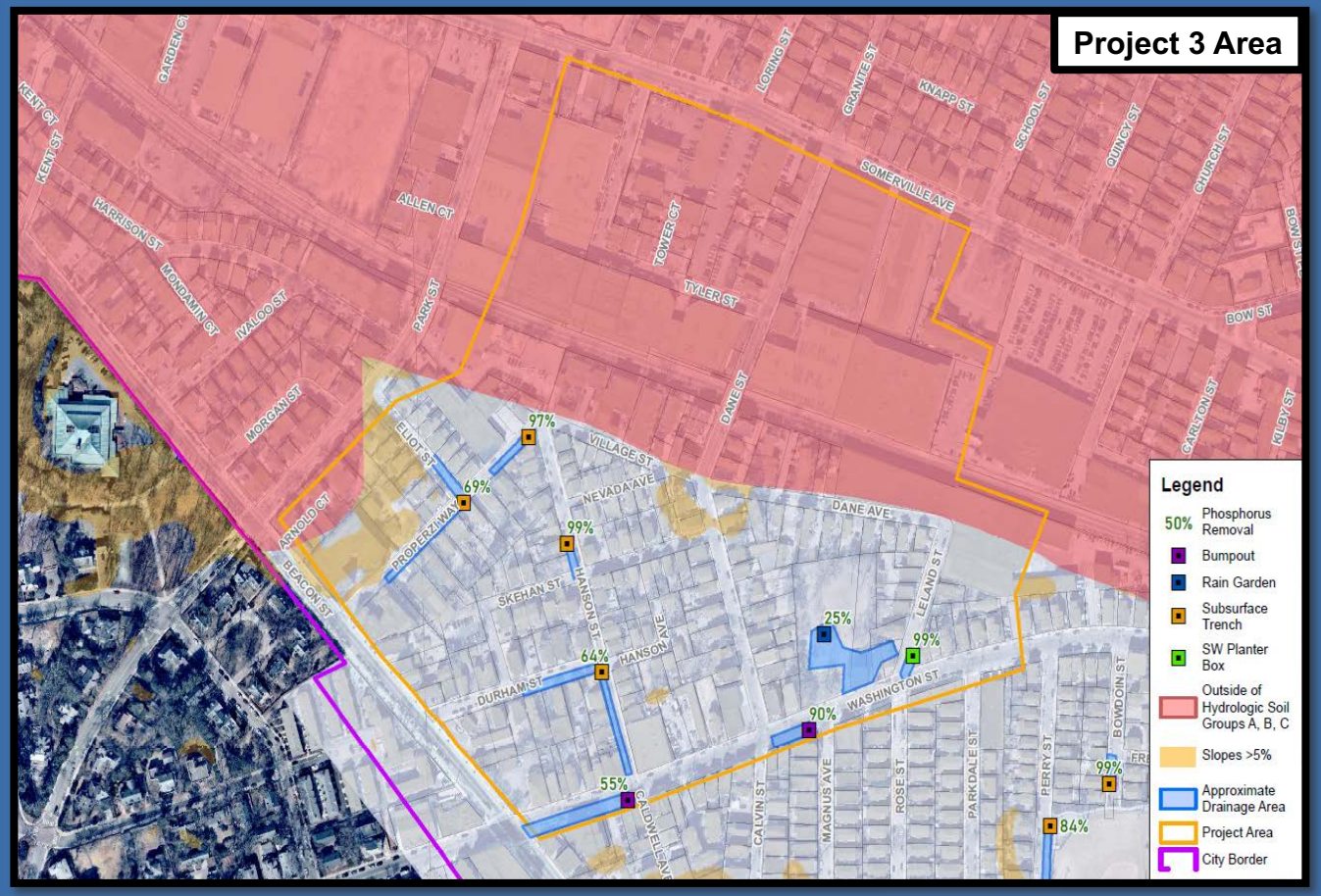
- SOM-009
- SOM-007A

	10-YR, 24-HR	
SCENARIO	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 Structural BMPs

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

Green-Infrastructure 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 Basins & Sewer Services
  - CIP Rehabilitation & Manhole Lining
  - CCTV & Dye Testing; 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

	Dane Street Area (Project 3)	
	Normal Scenario	**Conservative Scenario**
Estimated Construction Sub-total	**$12.3M**	**$17.5M**
Contingency		
Estimated Construction Total		
Engineering Design		
Resident Engineering		
Estimated Project Total	**$19.8M**	**$28.2M**

Conclusions

Sewershed Drainage and Water Quality Improvements Plan

Root Cause Analysis for Flooding Inundation
- System-wide or systemic limitations
- Trunk conveyance system limitations
- Local system limitations

Stormwater Model
- InfoWorks ICM – 2D Overland Flow Model
- Very detailed & well calibrated using field investigations & flow metering

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
  - Reduce Phosphorous concentrations in storm discharge

Green Infrastructure Analysis
- Structural & non-structural BMPs

Cost Analysis

Let's connect!

Mike Hanley, EIT:
mhanley@dewberry.com

Miles Bateman, EIT:
mbateman@dewberry.com

Yovanni Catano, PhD, PE, D.WRE:
ycatano@dewberry.com

Questionnaire

True or False:

1. Trunk conveyance is one of the system limitations considered by the flood inundation root cause analysis.

2. Proposed alternatives were designed for a level of service storm equal to a 100-yr, 15-min rain event.