City of Medford: 2D Inundation Model and Flood Mitigation Strategies

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Overview

- City of Medford / MVP Background
- Climate Change Impacts to Medford
- Vulnerability Assessment
- Development of Citywide Inundation Model
- South Medford Flood Mitigation
- Preliminary Results and Next Steps

City of Medford, MA

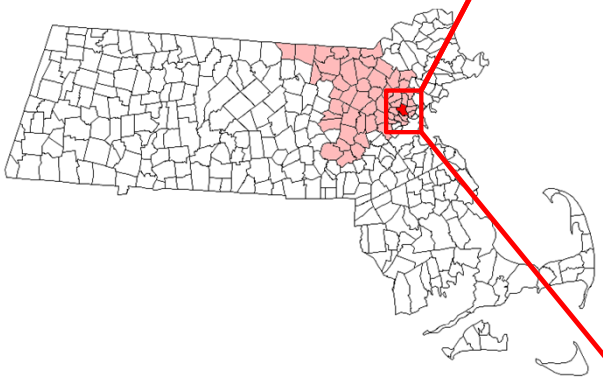
8.1 sq. miles

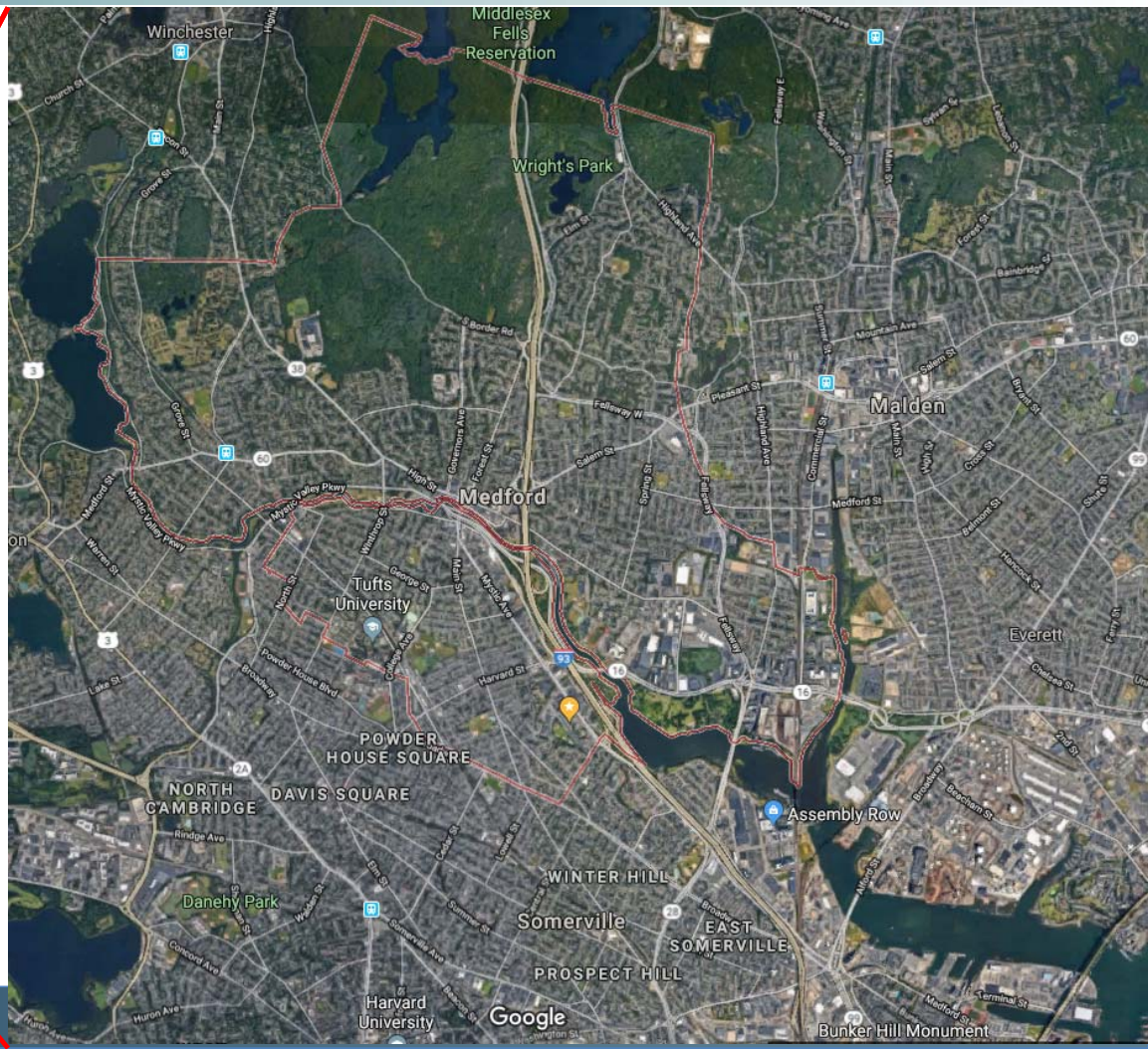
57,797 residents

5 miles outside of Boston

Fourth English settlement

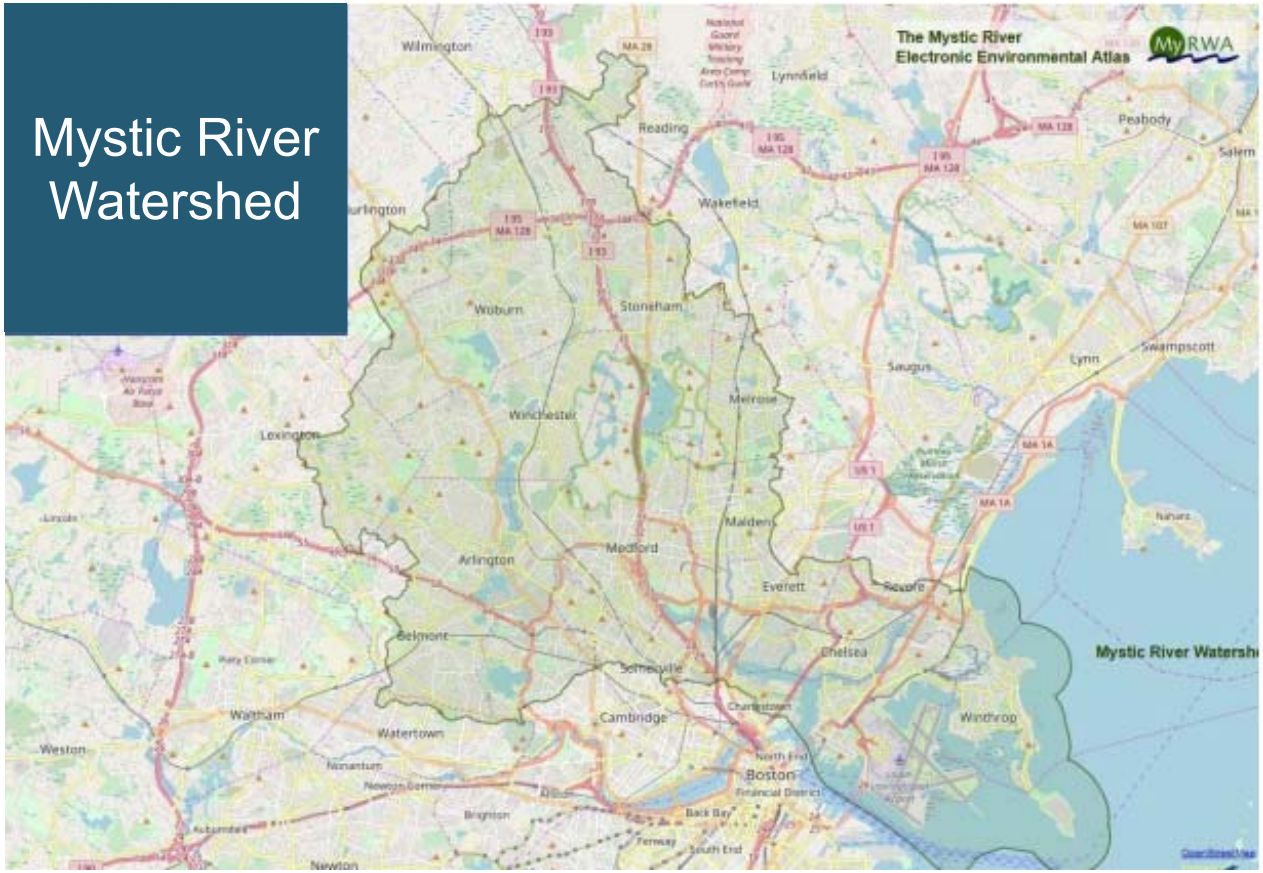
1 watershed





- **Boston Metro Mayors Climate Preparedness Commitment**
  - Develop climate vulnerability assessments
  - Pledge to be Carbon Neutral by 2050
  - Climate Preparedness Taskforce – 14 municipalities
- **Mystic River watershed coalition**
- **UN Compact of Mayors**
  - Climate Vulnerability Assessment
  - Climate Adaptation Plan
  - Community-Wide Greenhouse Gas Inventory

Mystic River Watershed



Vulnerability Assessments in the Region

Cities	State	Other Groups
• Boston • Cambridge • Somerville • MVP program	• Mass DOT • Mass DOH • Mass Office of Energy and Environment	• USACE • MWRA • MAPC • The Boston Harbor Association • EPA

MVP Action Grant

- Kleinfelder assisted the City of Medford to understand and apply for the grant

- To implement priority climate adaptation actions identified by MVP Communities
- Projects to build resilience, incorporating new climate change data
- FY18 grants ranged from $15K-$100K;
- Preference for nature-based solutions

MVP Action Grant

Projects to **build resilience**, are **proactive** and clearly demonstrate efforts to redesign, re-evaluate, or reconsider and **incorporate new climate change** data.

Projects are encouraged to utilize **nature-based strategies** to address climate change impacts.

Many of these projects might also be funded through existing grant programs

- e.g., EEA's Dams and seawalls, CZM's coastal resiliency, DER's culvert replacements

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Purpose of a Vulnerability Assessment

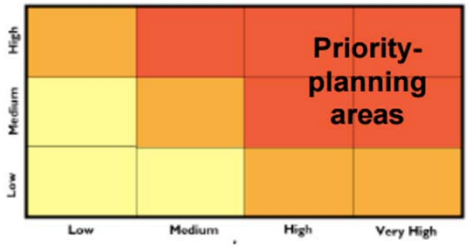
- Develop a shared understanding of climate change impacts
- Identify key physical and social vulnerabilities
- Understanding local impacts

Components of a Vulnerability Assessment

Step 1
- Climate Projections
- Systems at Risk

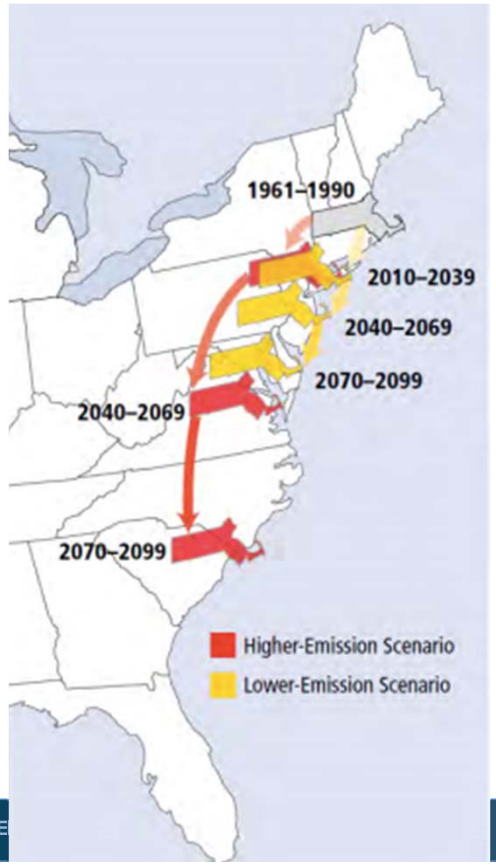
Step 2
- Vulnerability & Risk Assessment

Step 3
- Adaptation Planning and Design



Climate Change Impacts in Medford

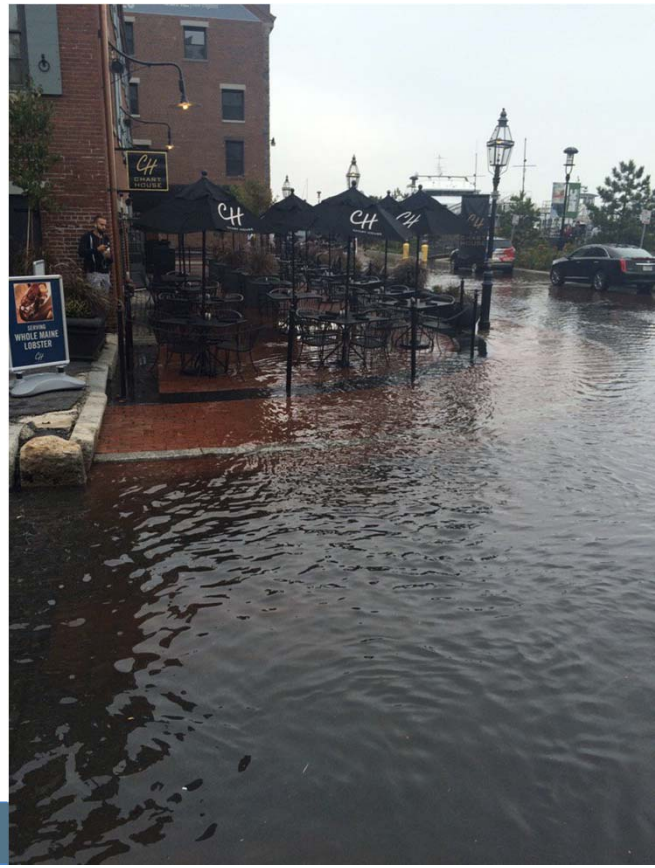
Temperature



Precipitation

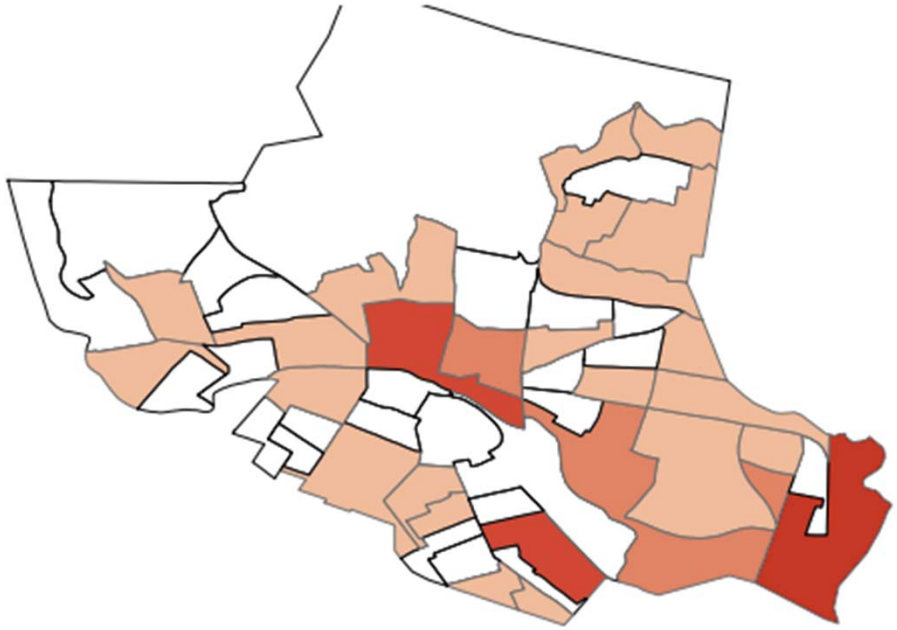
Extreme Events

Sea Level Rise/Storm Surge



Social Vulnerability Index

Population
Under 5
65 or over
Income in the past 12 months below poverty level
12th grade, no diploma
Households
Households with population over 65
Household with population over 65 living alone
Limited English speaking household



Climate Change – Temperature

By 2030, the number of days above 90 F could triple

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

1971 - 2000
(Baseline)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

2015 - 2044
(2030)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

2055 - 2084
(2070)

Above 90°F - Low Scenario
Above 90°F - High Scenario
Above 100°F - Low Scenario
High 100°F - High Scenario

*Summer is considered to be the 91 days of June through August

Source: Kleinfelder for City of Cambridge based on Atmos Research, 2015

Climate Change- Flooding

Today

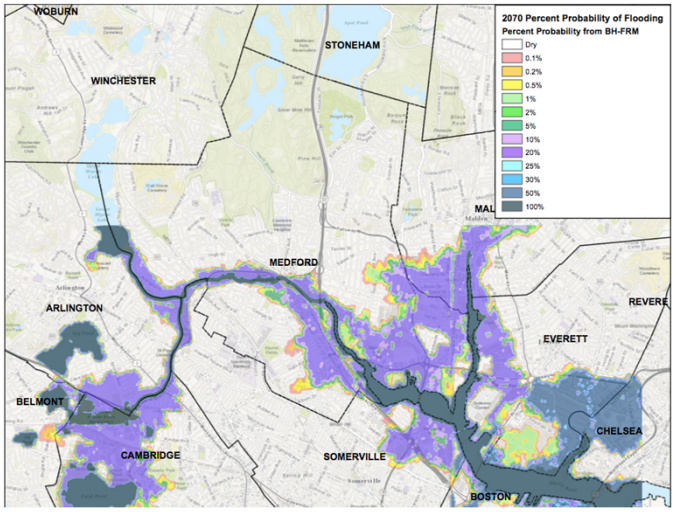
More Intense Precipitation

2030

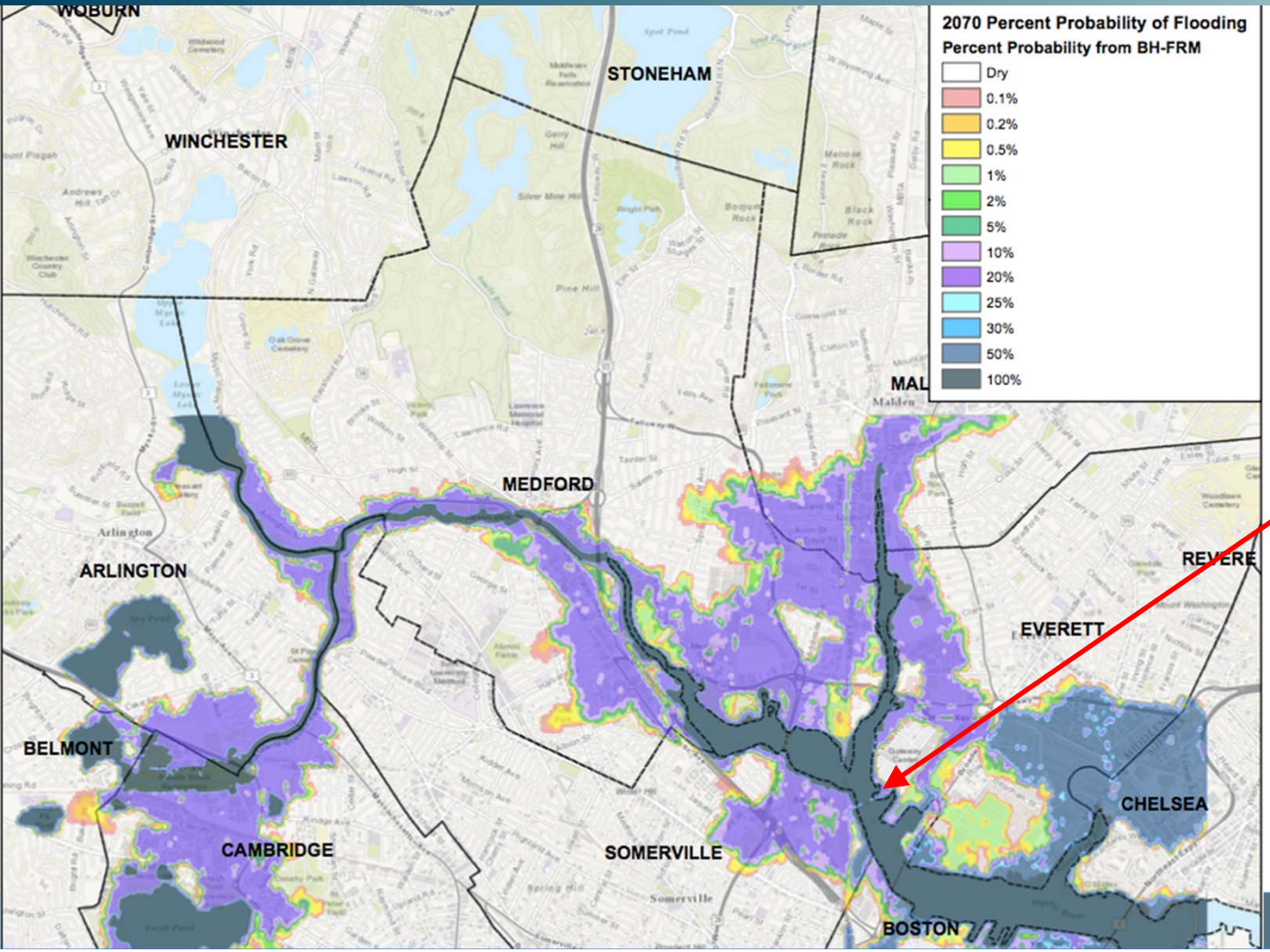
Increased Potential for Inland River and Piped infrastructure Flooding

2070

New Additional Storm Surge Flooding Risk when Dam Overtops



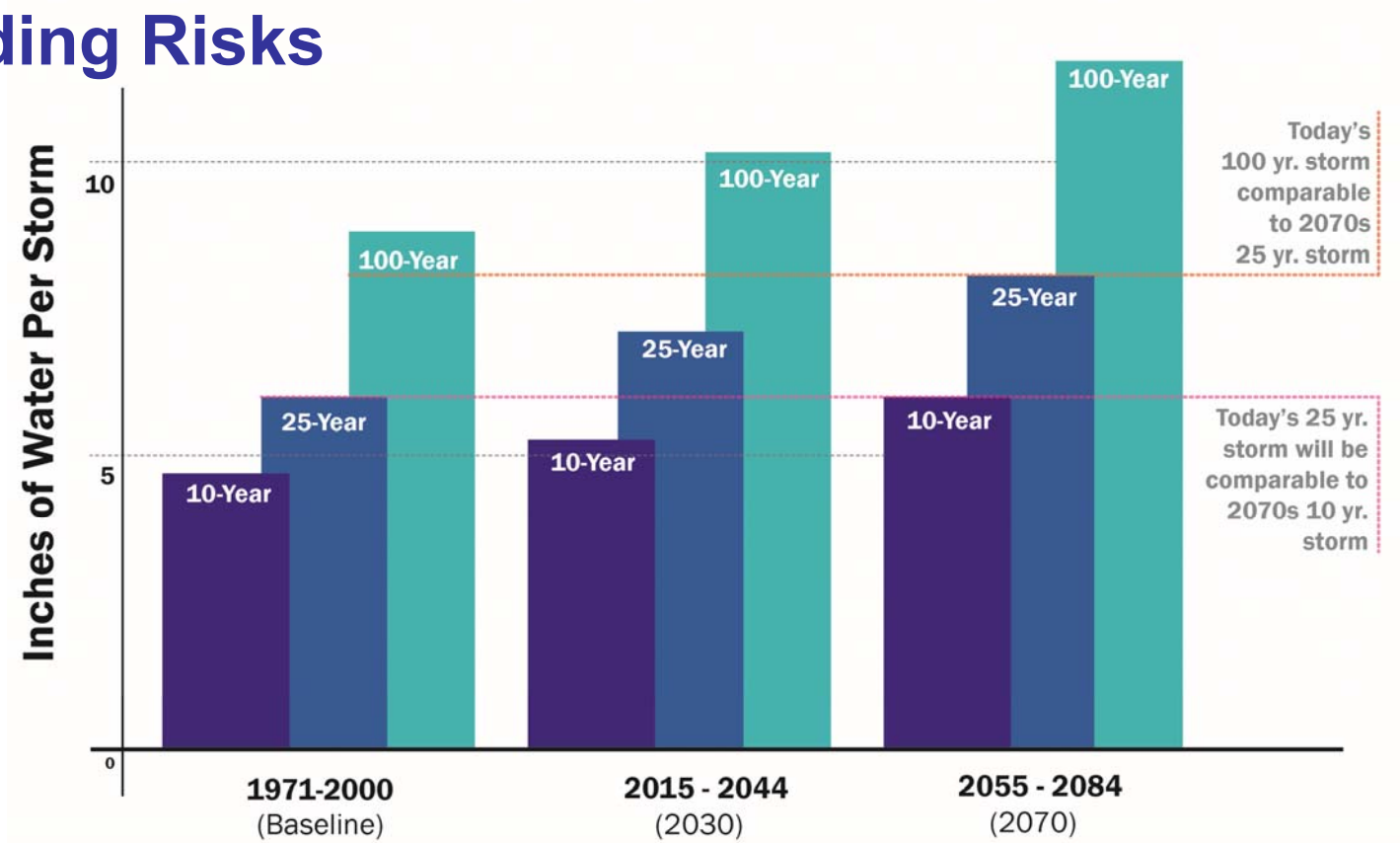
Storm Surges from Boston Harbor



Amelia Earhart Dam

Source: Kleinfelder & Woods Hole Group for the City of Medford, February 2017

How to Translate Extreme Precipitation Projections to Flooding Risks

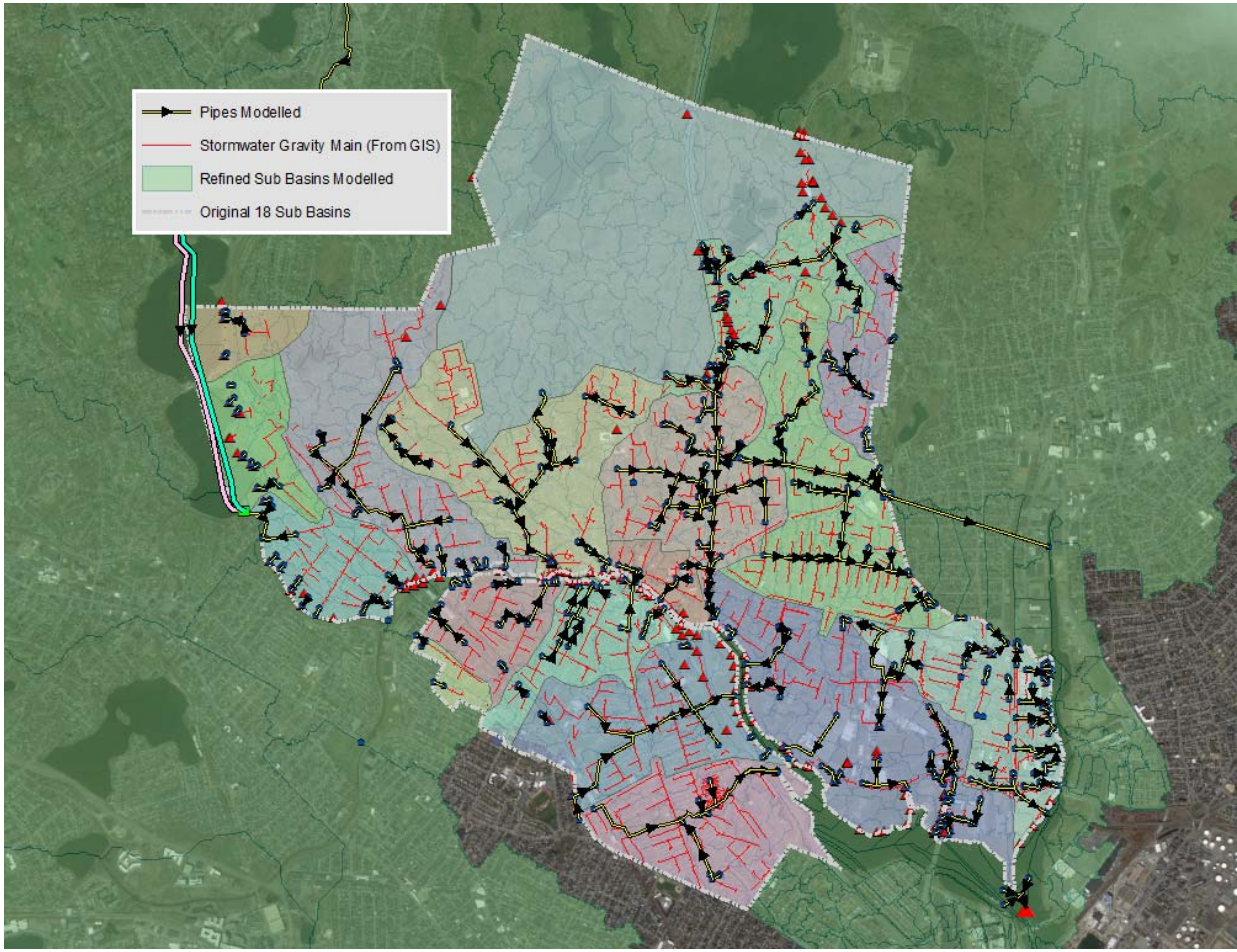


Precipitation projections, CCVA Part 1, City of Cambridge *(Source: Kleinfelder based on ATMOS projections, Nov.2015)*

Impacts – Critical Infrastructure

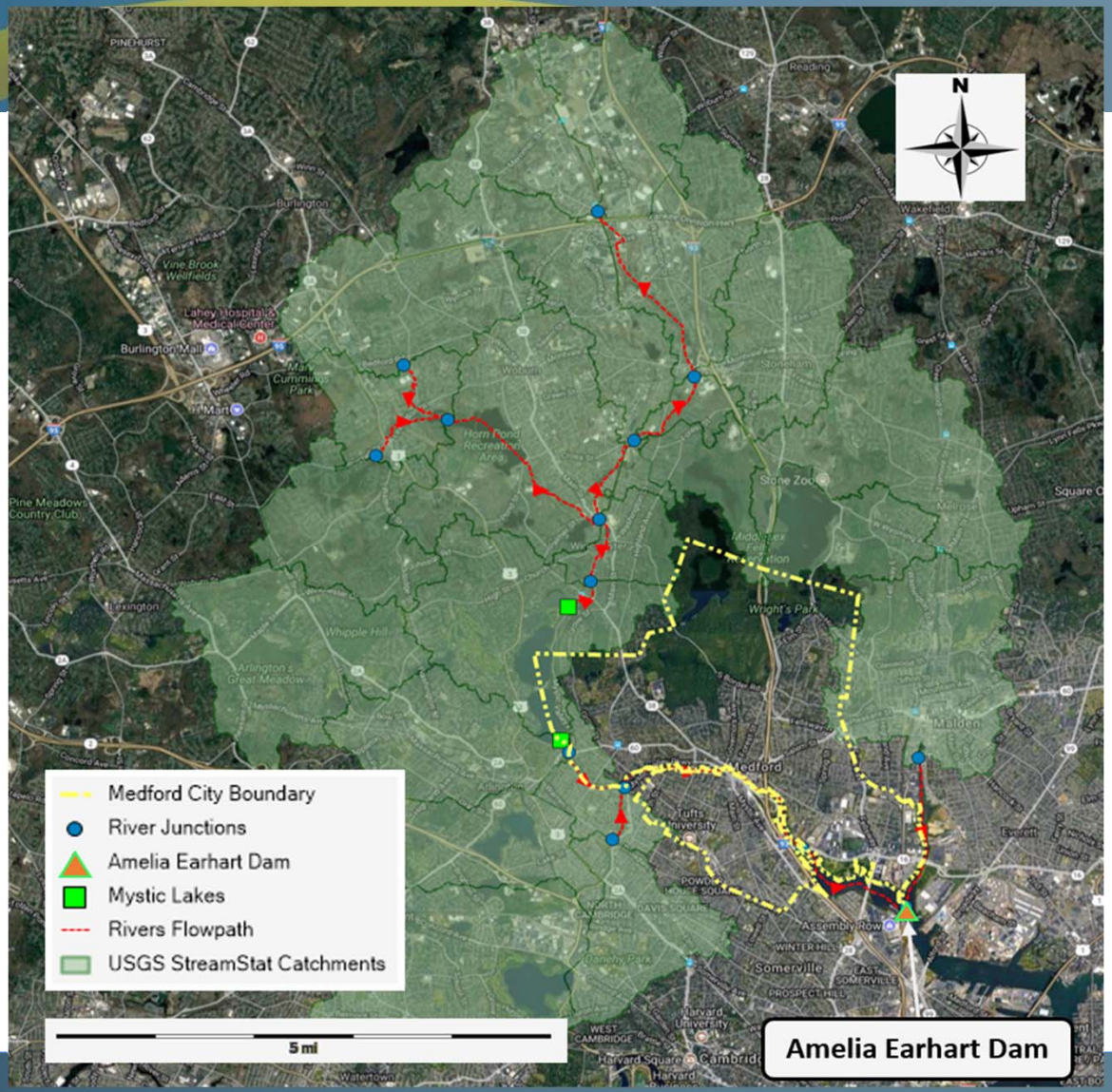
City Model Overview

- City's GIS data and MassGIS data
- PCSWMM
- 2D surface model was created to simulate the dynamic spreading of floodwaters on the ground surface
- The 1D-2D integrated inundation model was validated with historical flood reports.



Upstream Basin

- Mystic River Watershed - 76 square miles
- Upstream basin delineation for the upper reaches was acquired using the USGS StreamStats delineation tool.
- A recent storm event was selected to calibrate the model, such that model results would closely match the observed data after the calibrations were completed



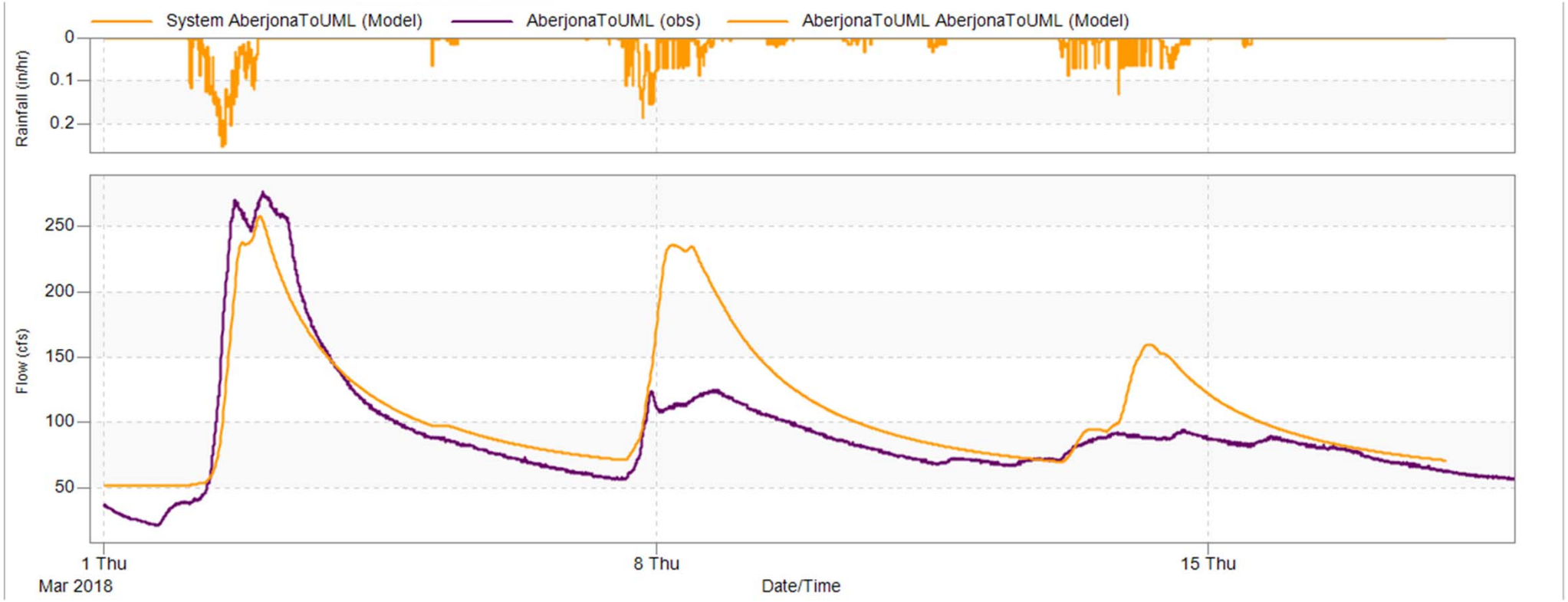
2D Model

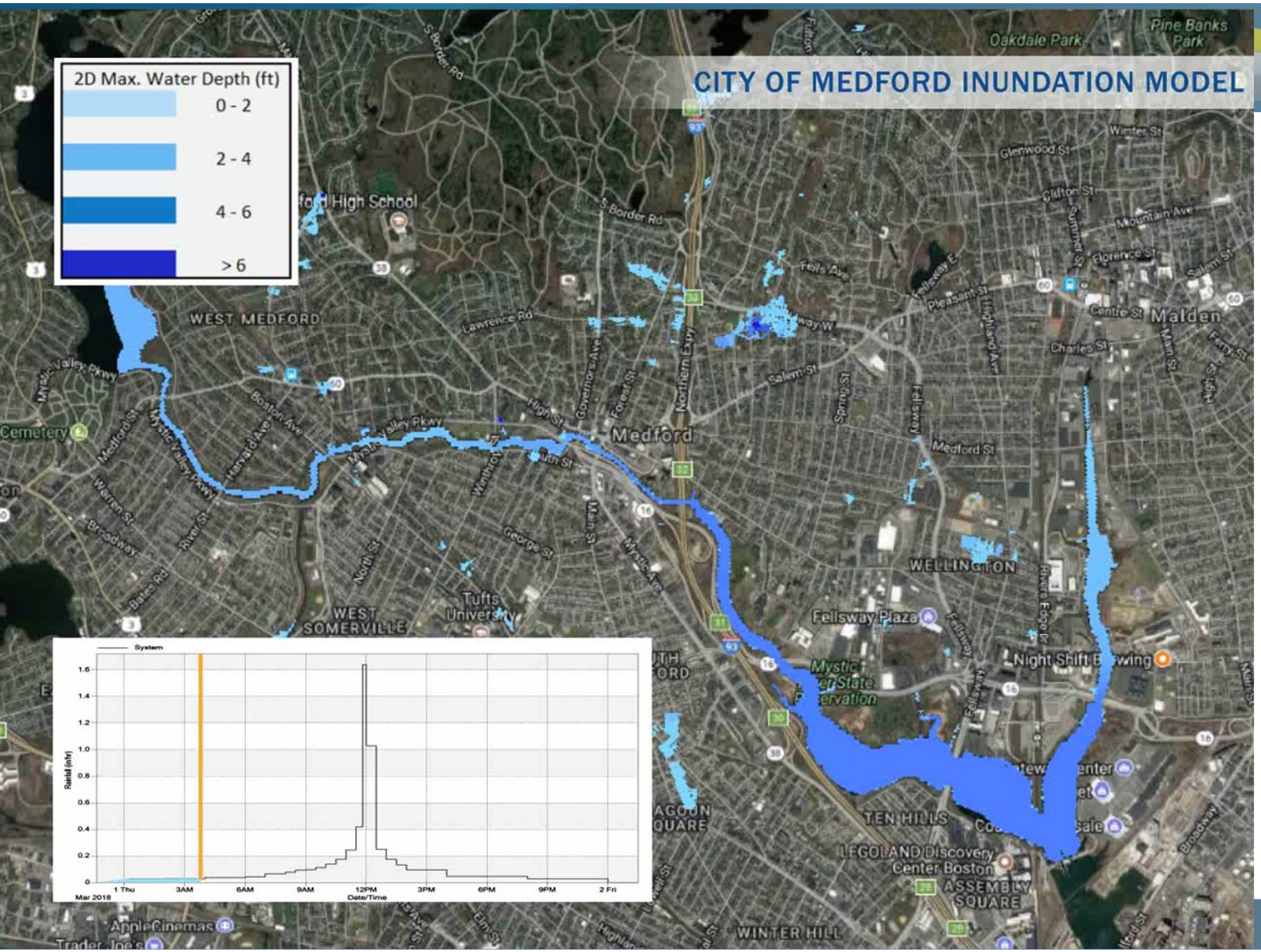
- Coastal National Elevation Database (**CoNED**) Applications Project
  - Digital terrain model (DTM)
  - River bathymetry
  - Building Footprints

- Bathymetry data used to develop river cross sections and help to improve flow interactions along the Mystic and Malden Rivers.

- Buildings footprints are acknowledged in the 2D surface mesh to ensure that the flood flow paths recognize the buildings as obstruction.

Upstream Basin Model





Citywide Model Visualization

https://earth.google.com/web

Primary Objectives of the Citywide Drainage Model

- Evaluate if main storm drainage pipes in the City have sufficient conveyance capacity under future storm scenarios
- Identify additional areas/infrastructure at risk of flooding from extreme rainfall events alone and in combination with sea level rise and storm surge.
- Evaluate flooding at critical infrastructure locations, such as electrical substations, roadways, train stations, emergency shelters, schools, housing for vulnerable population groups, hospitals and emergency services in terms of
  - Peak flood depth
  - Peak flood elevation, and
  - Flood duration.

Medford System Overview

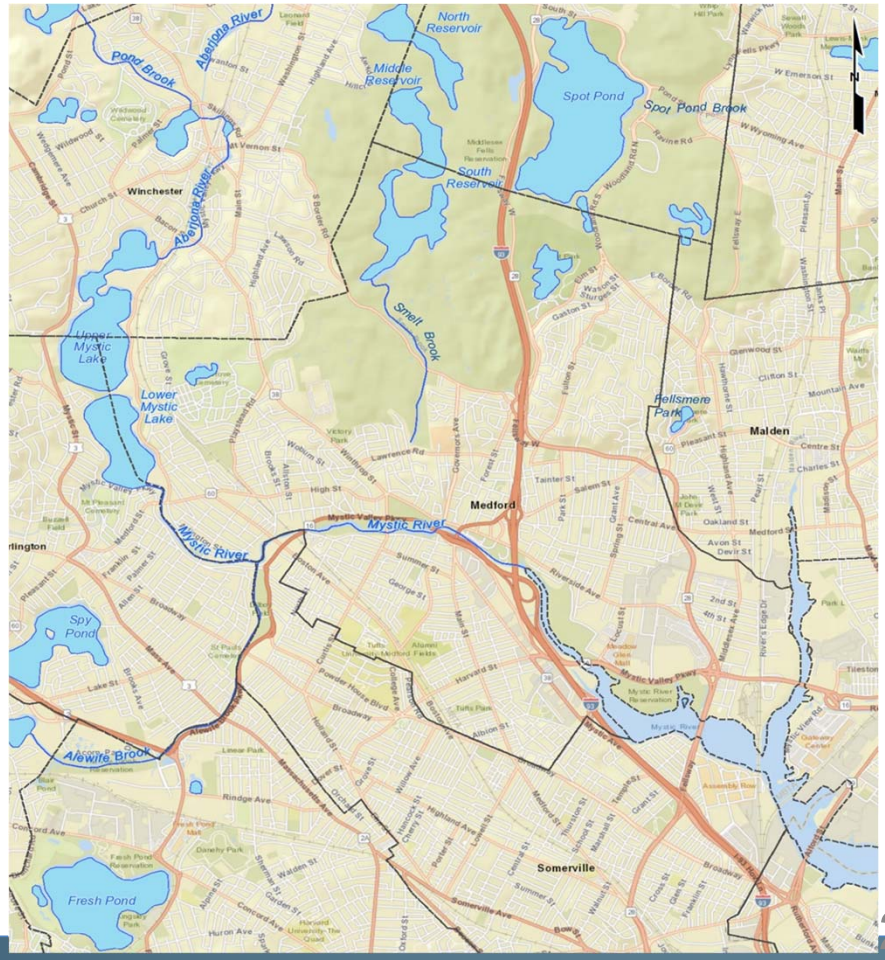
- Medford's stormwater system consists of
  - 115 miles of storm drain pipes,
  - 7,000 acres of tributary area
  - 18 drainage sub-basins
  - 70 stormwater outfalls

- Smelt Brook connects the Winchester Reservoirs to upstream pipes near the Lawrence Memorial Hospital.

- Flows contributing to the Mystic River mainly come from the Aberjona River and Alewife Brook.

- Malden River tributary area significantly smaller than that of the Mystic River. Confluence is just upstream of the Amelia Earhart Dam.

- Dam operation regulates basin elevation between -1.93 ft-NAVD (104.5 ft MDC datum) and 0.07 ft-NAVD (106.5 ft MDC datum).



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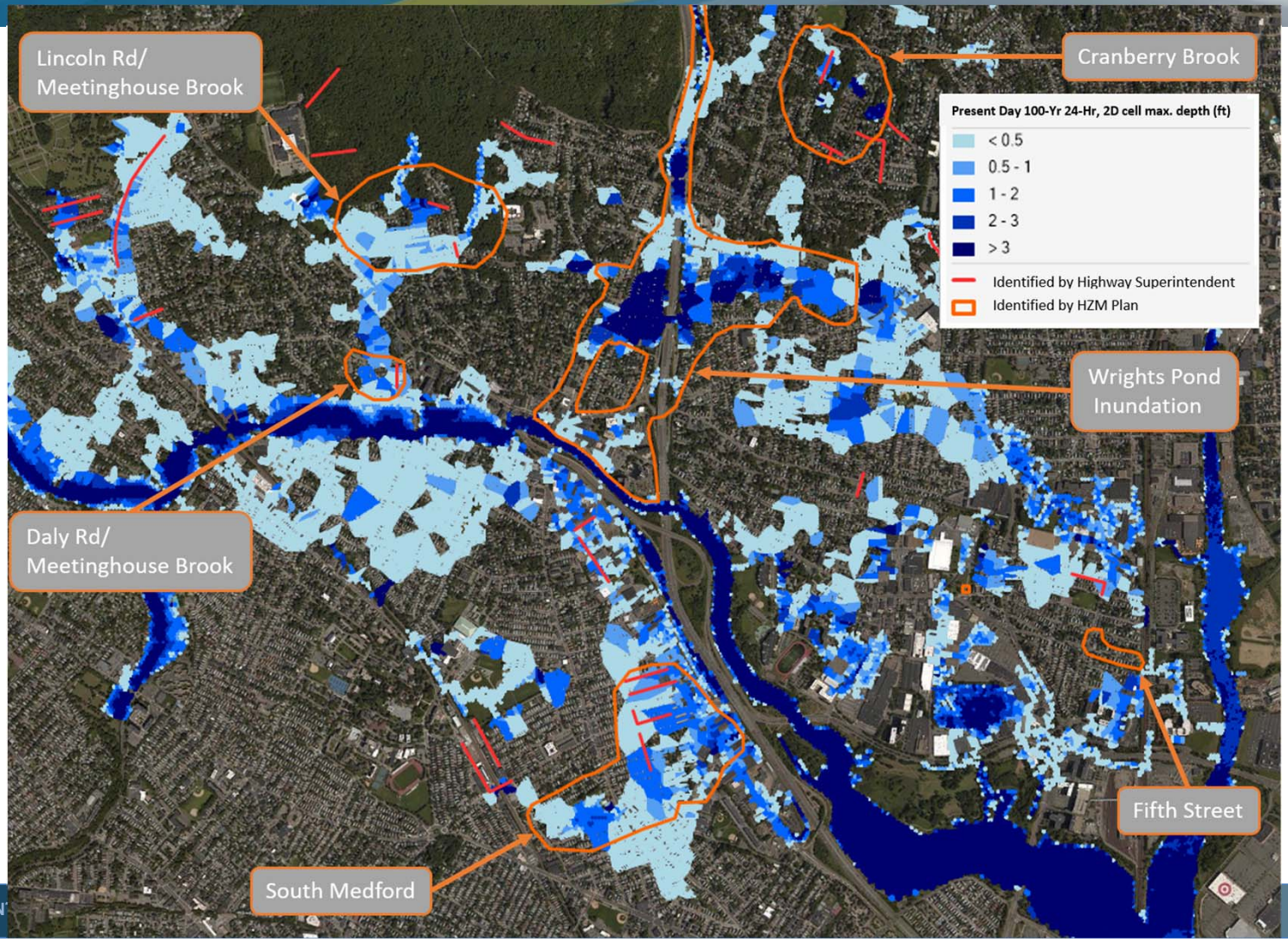
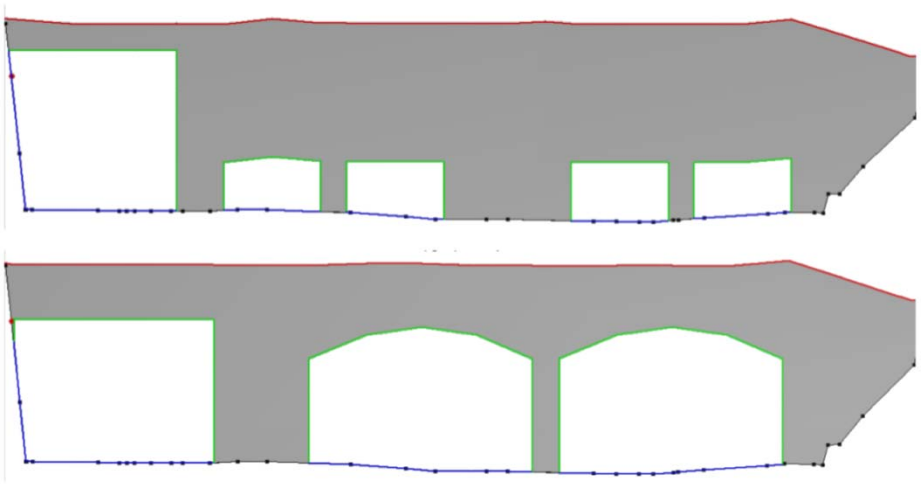
2D Model Validation/Verification



Model Revisions

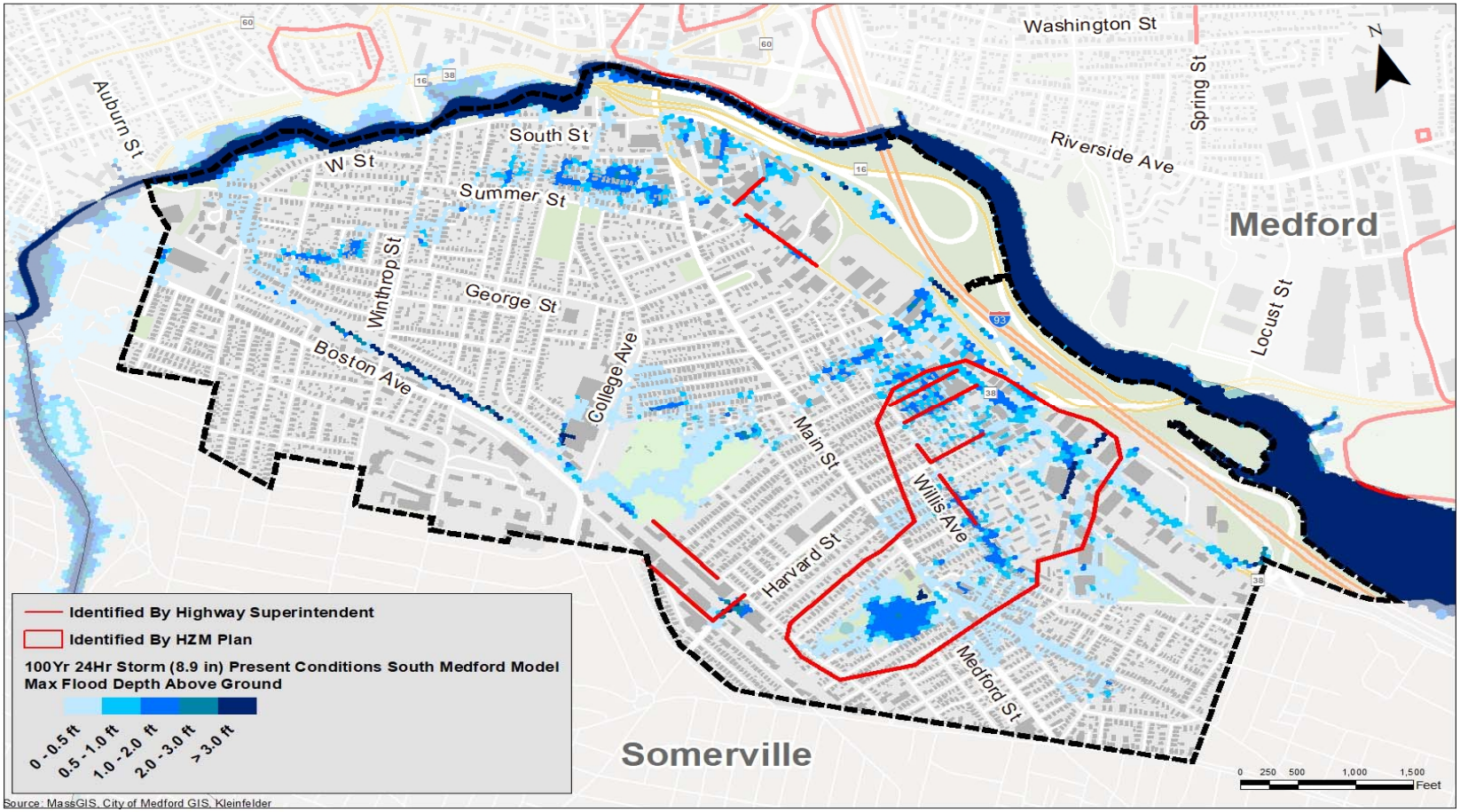
Figure 7: Pre- (above) and post-reconstruction (below) cross sections of the Cradock Bridge in Medford, MA

Table 2: Main differences between the HEC-RAS model used in the CCVA and the Infoworks ICM integrated model



- Bridge crossings were added for all 12 major bridges, including the reconstructed Craddock Bridge
- 2D Mesh was revised to include:
  - South Medford area only
  - Finer resolution for 2D cells

2D Model Validation/Verification



Source: MassGIS, City of Medford GIS, Kleinfelder

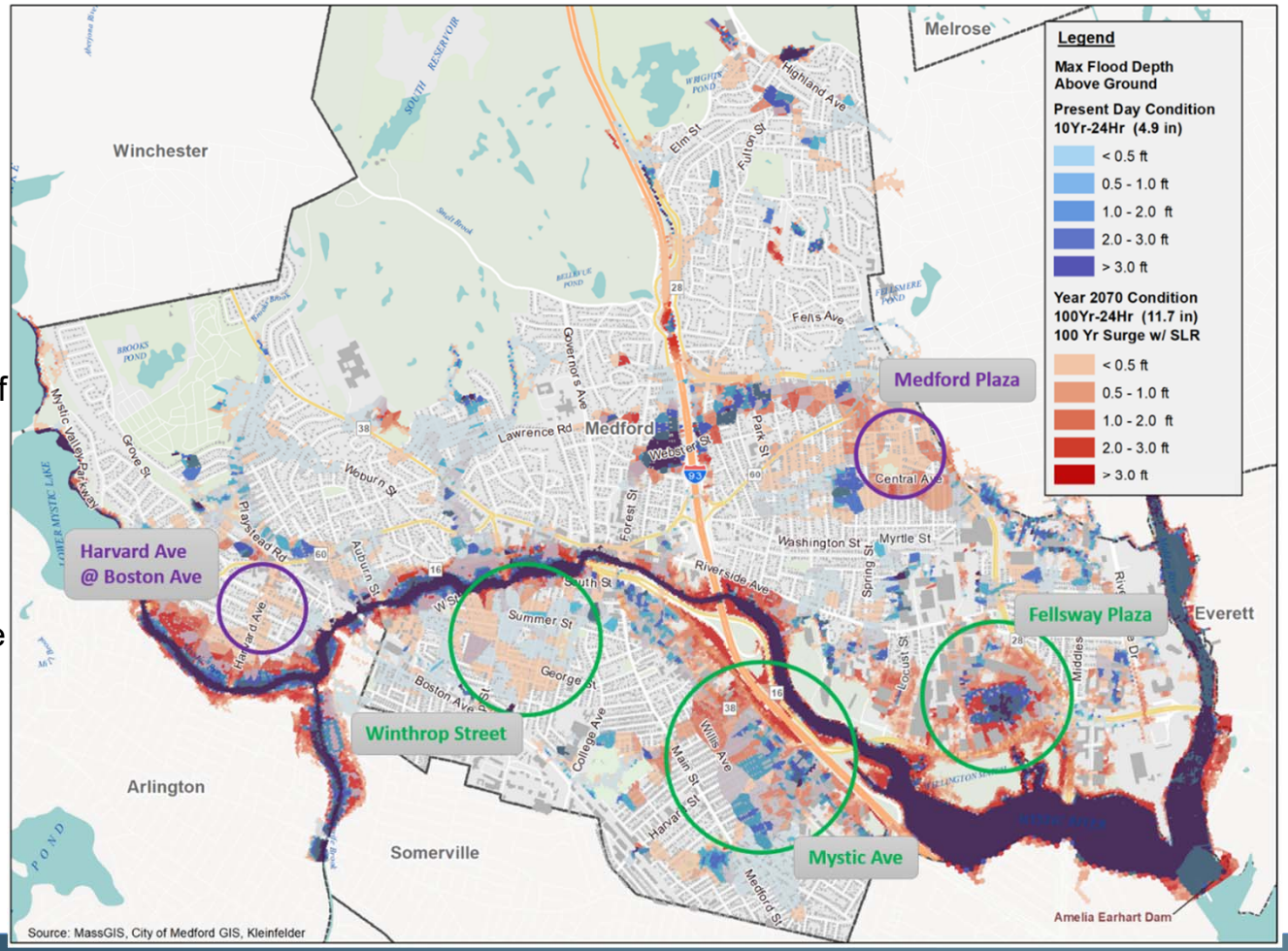
Future Scenario Simulations

	Scenario	Total Precipitation (in.)	Peak Intensity (in. / hr)	Amelia Earhart Dam Operation
1)	Present 10-Year 24-Hour Storm	4.91	1.23	Normal ; Basin water level maintained between -2 ft-NAVD88 to 0 ft-NAVD88
2)	2030 10-Year 24-Hour Storm	5.63	1.41	
3)	2070 10-Year 24-Hour Storm	6.38	1.6	
4)	Present 100-Year 24-Hour Storm	8.88	2.22	
5)	2030 100-Year 24-Hour Storm	10.19	2.55	
6)	2070 100-Year 24-Hour Storm	11.7	2.93	
7)	2070 10-Year 24-Hour Storm with 100-Year Storm Surge and Sea Level Rise	4.91	1.23	Dam is flanked and overtopped. Peak tide elevation = 13.26 ft-NAVD88 Dam flanking elevation = 10.52 ft-NAVD88 Overtopping elevation = 11.66 ft-NAVD88 Pump operating at max capacity (4,200 cfs)
8)	2070 100-Year 24-Hour Storm with 100-Year Storm Surge and Sea Level Rise	11.7	2.93	

Impacts – New Areas at Risk of Flooding

- For the 10-year 24-hour design storm, area of the City projected to flood increases from 13% in the present to
  - 15% by 2030,
  - 17% by 2070
  - 22% by 2070 when combined with a 100-year storm surge with sea level rise

- For the 100-year 24-hour design storm, area of the City projected to flood increases from 21% in the present to
  - 22% by 2030,
  - 23% by 2070,
  - 27% by 2070 when combined with a 100-year storm surge with sea level rise



Flood Mitigation Strategies

Gray Infrastructure Flood Mitigation Options:

- Increase conveyance capacity
- Tanks, pump stations to drain floodwaters quicker

Neighborhood-Wide Flow Reduction and Flood Attenuation Alternatives

- Reduction of impervious areas
- Collective implementation of stormwater management techniques

Green Infrastructure Options

- Nature-based solutions at different project sites, such as bioretention basin, sub-surface infiltration chambers, green roofs, porous asphalt
- Quantify flood reduction benefits and water quality improvements

Bioretention basin

Porous asphalt

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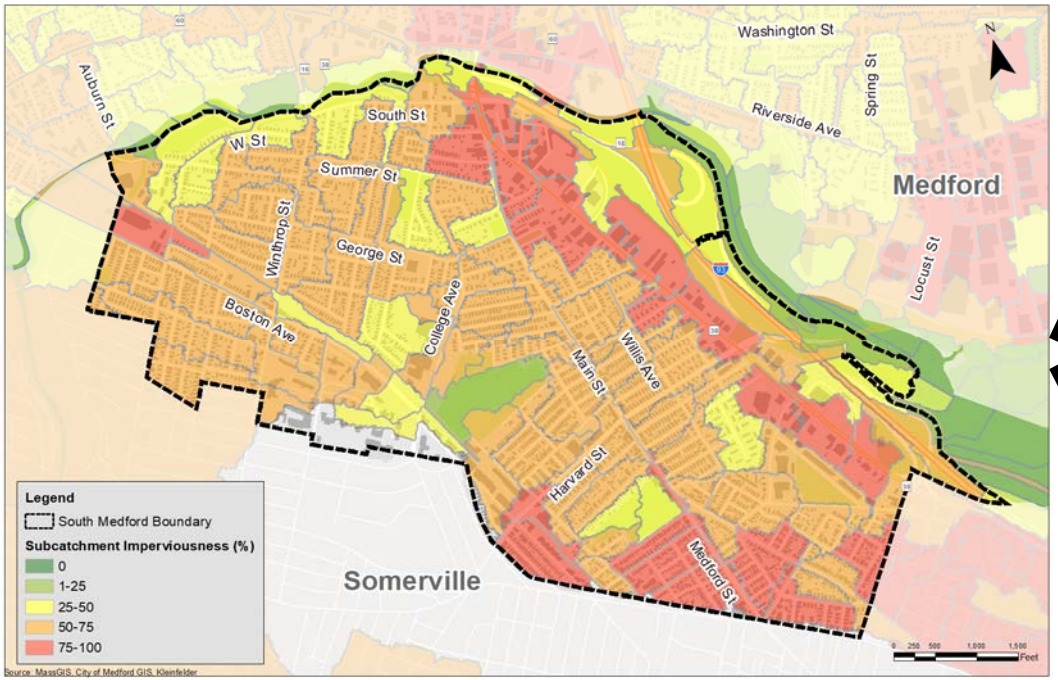
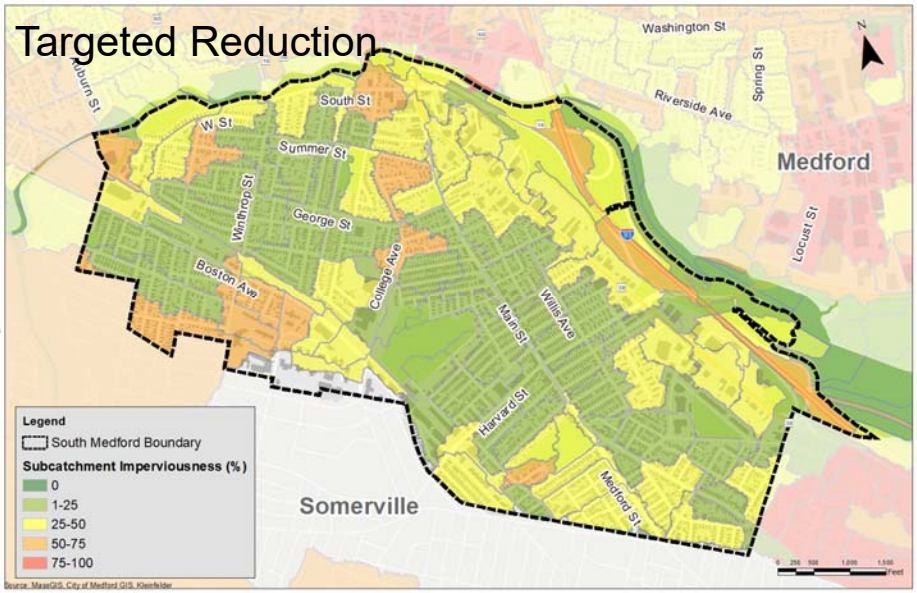
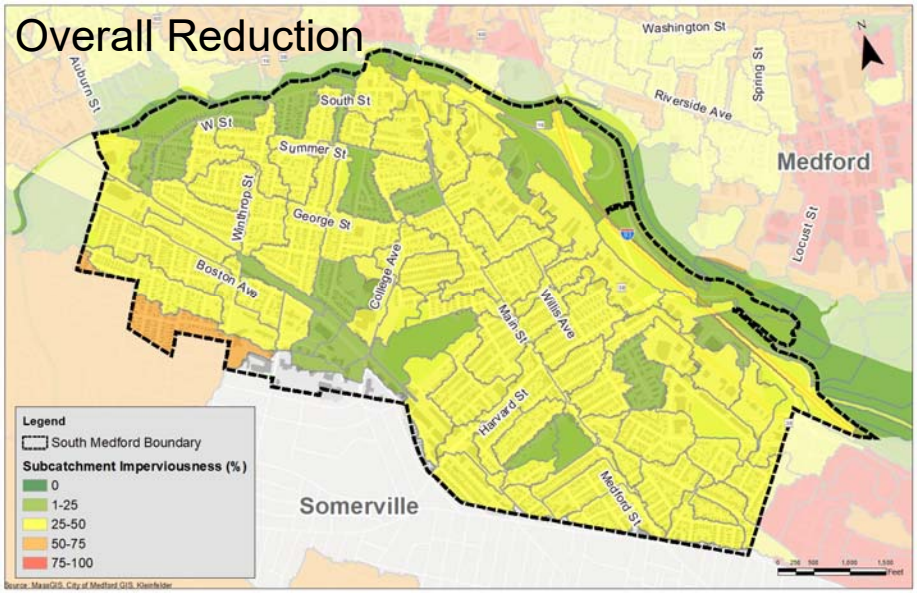
Impervious Area Reduction

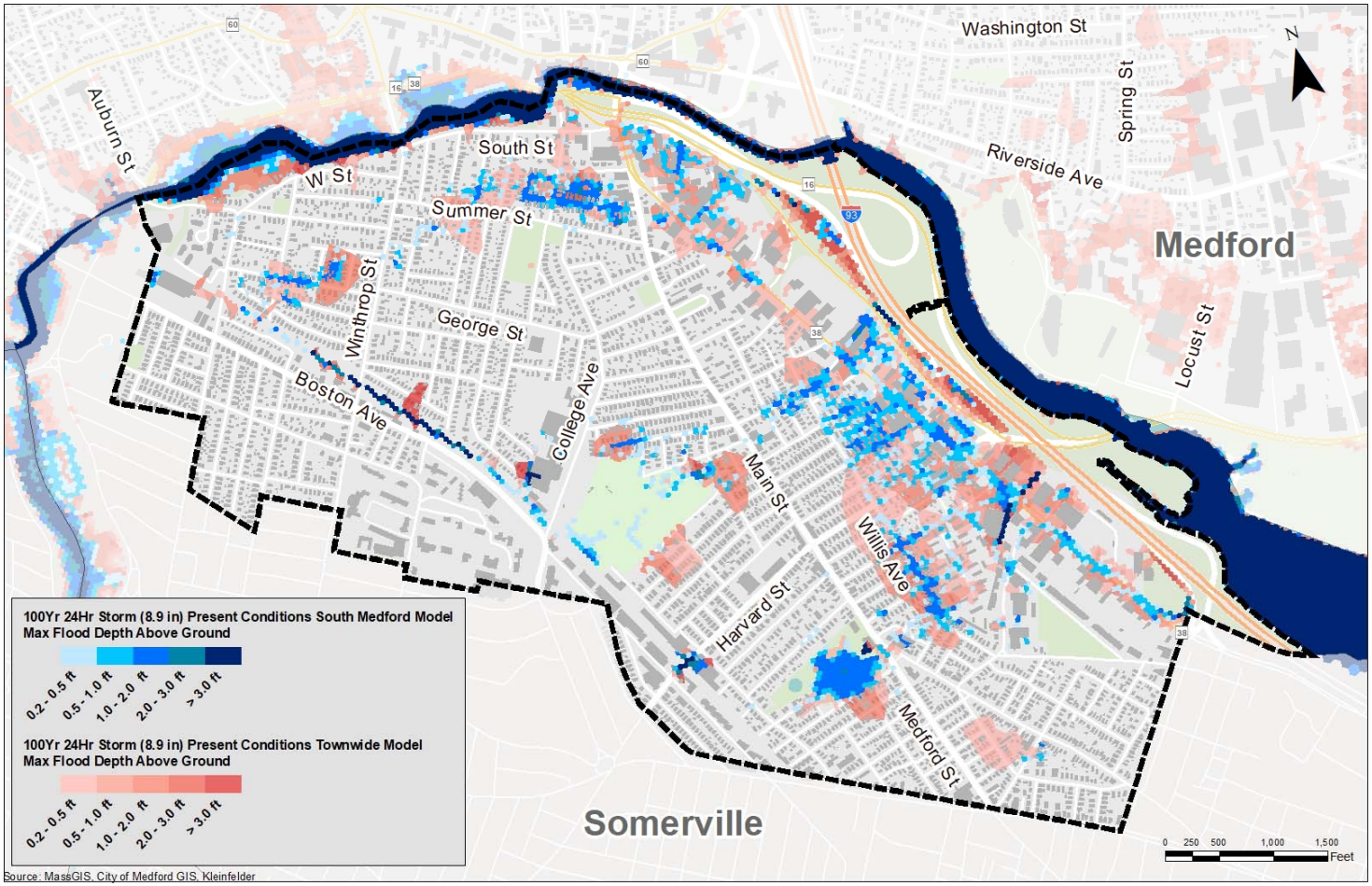






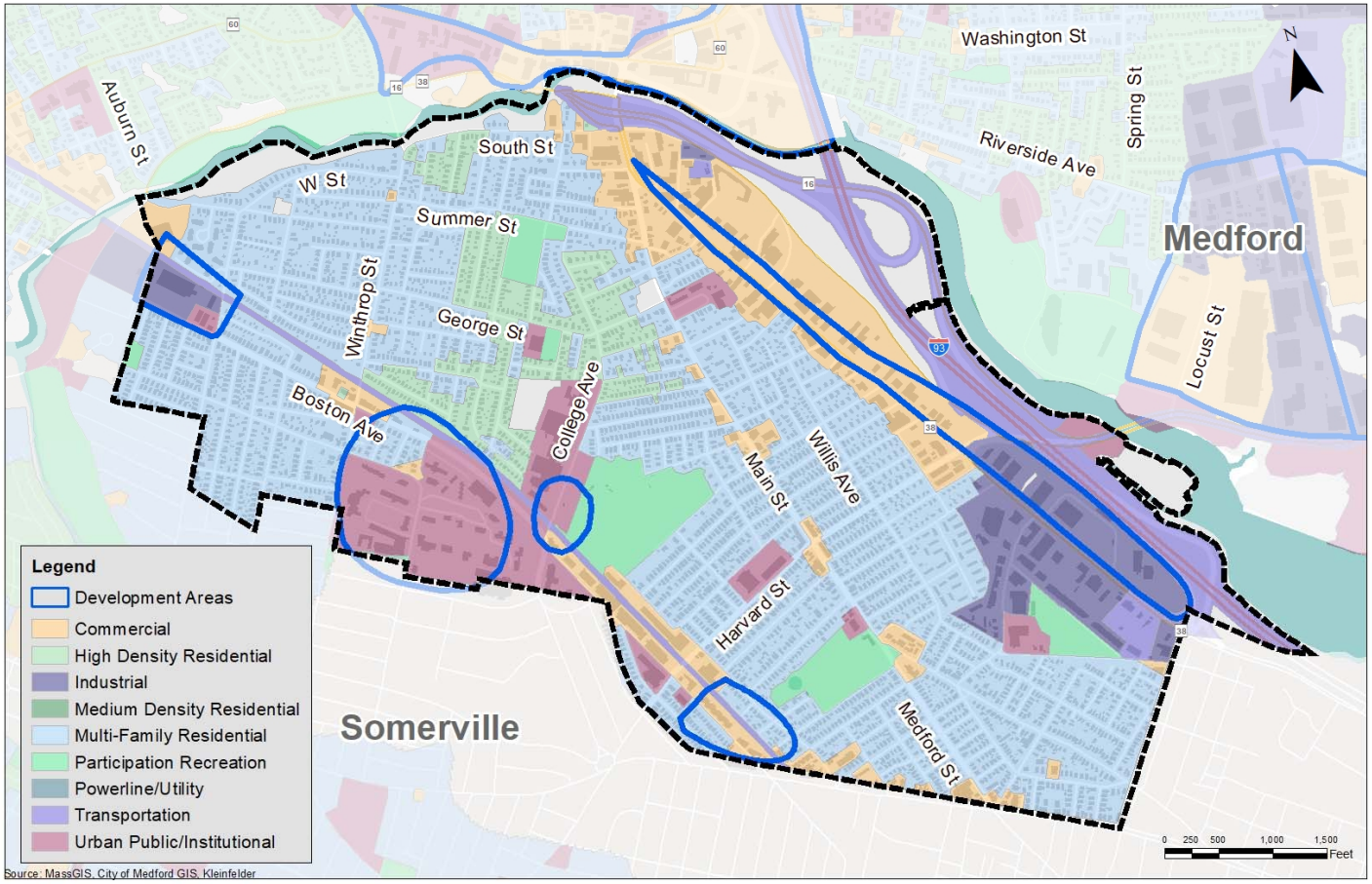
South Medford Model H&H refinement

100-Year, 24-Hour, Year 2070 Conditions

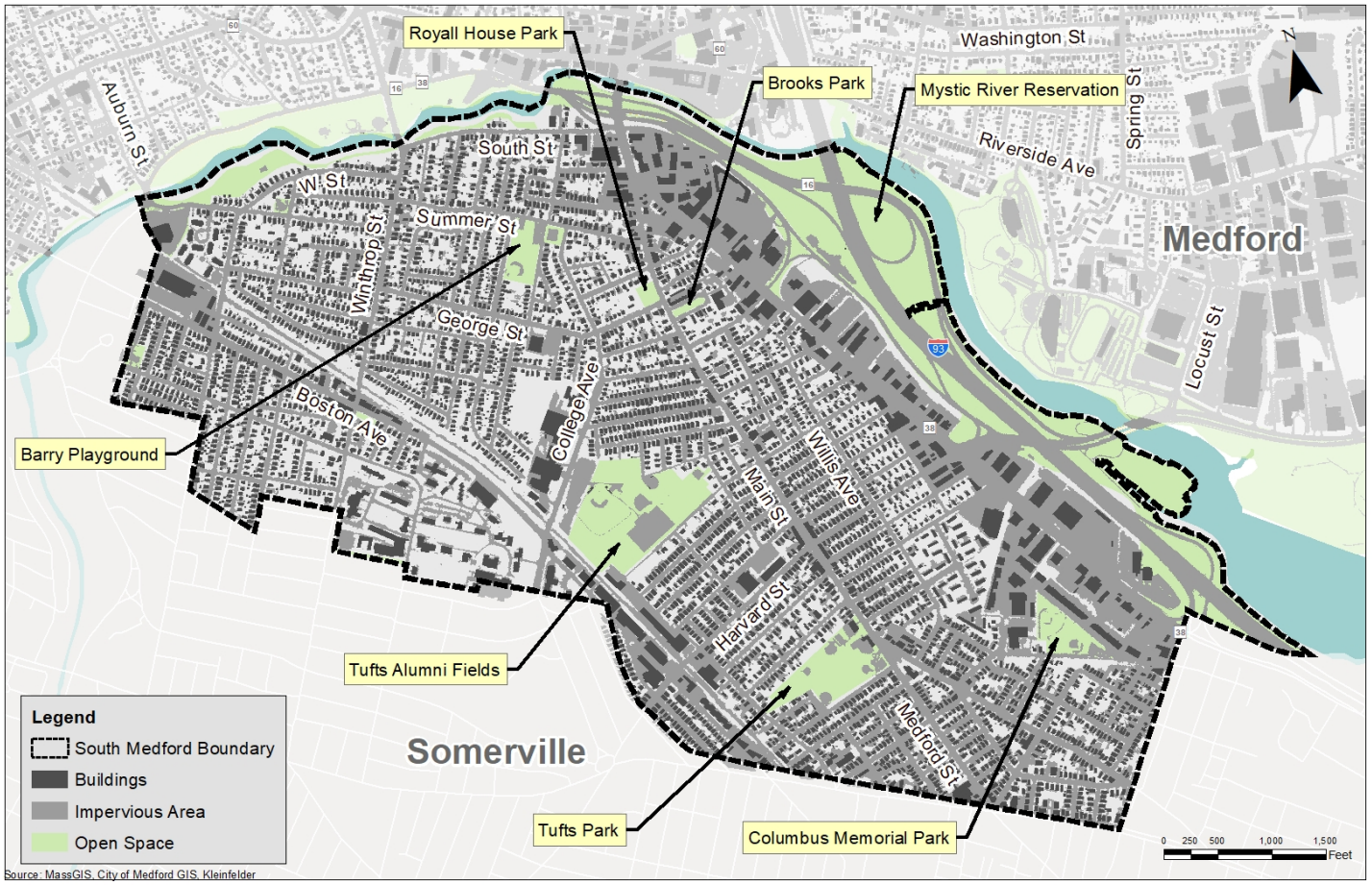


Source: MassGIS, City of Medford GIS, Kleinfelder

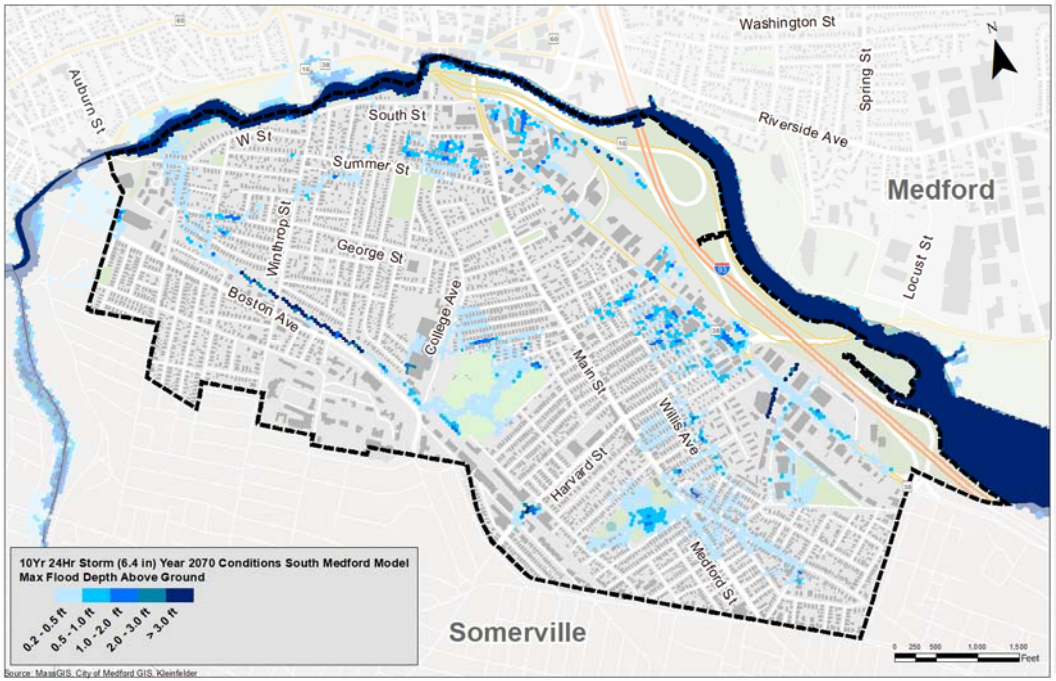
Development Areas and Land Use

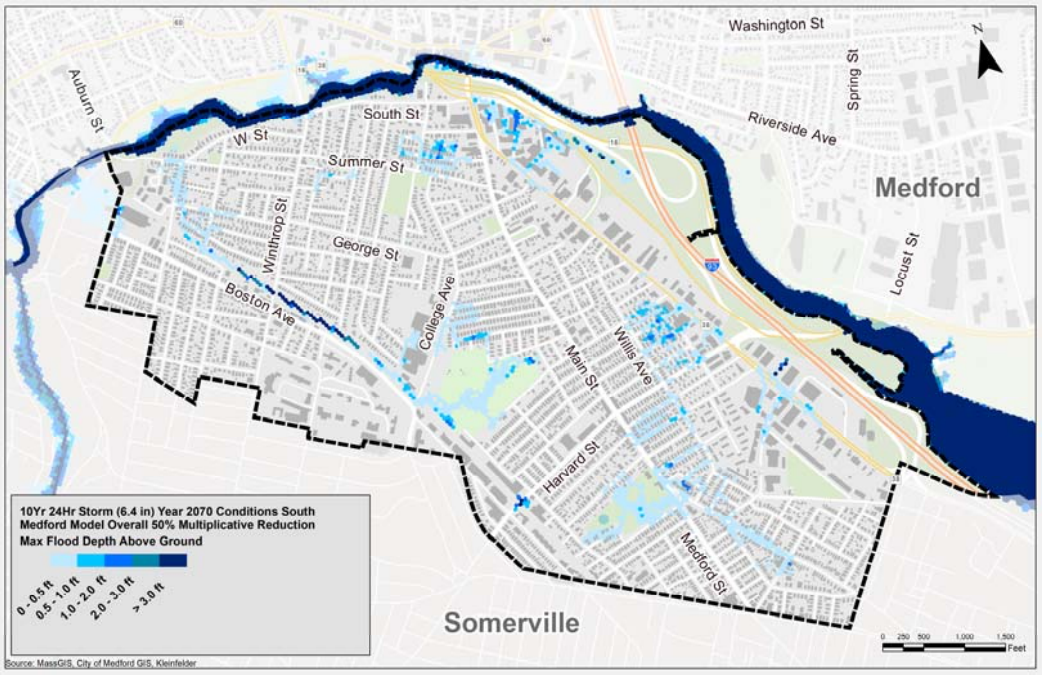


Impervious Area Reduction & Open Spaces



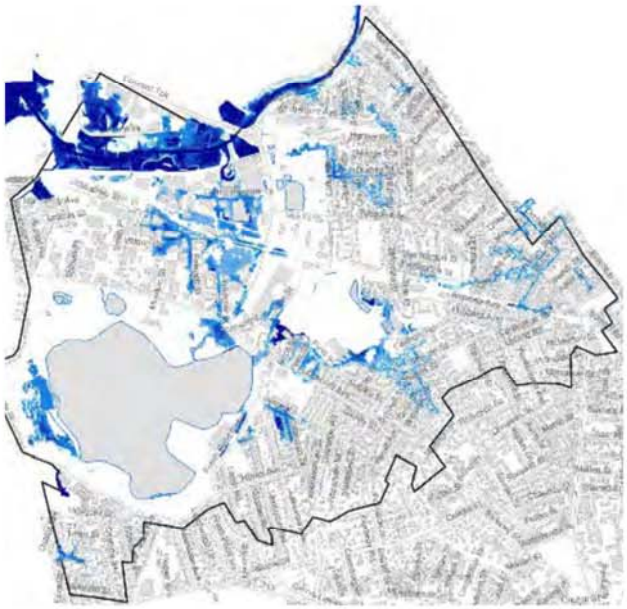
Impervious Area Reduction



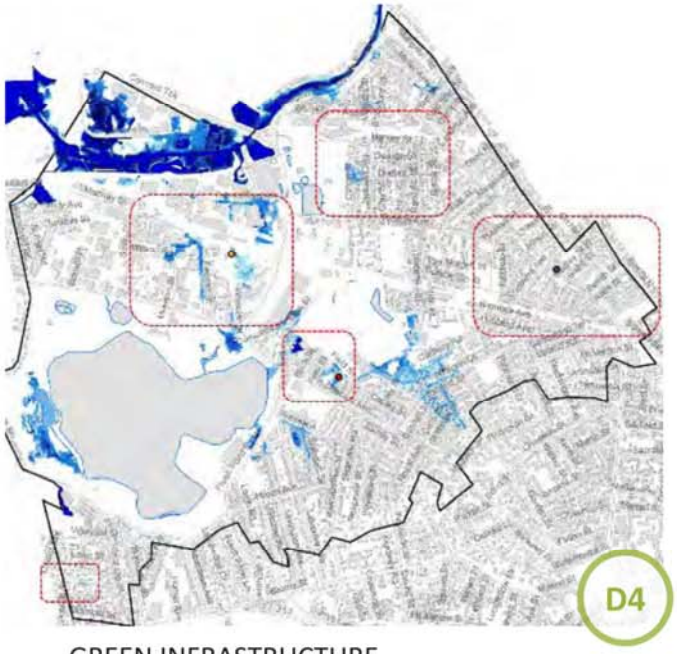


Flood Reduction From Collective Implementation

10-YEAR FLOODING IN 2070



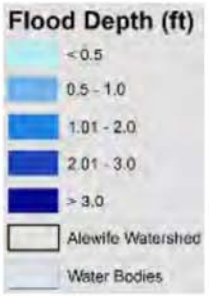
AS-IS INFRASTRUCTURE



GREEN INFRASTRUCTURE

GREEN INFRASTRUCTURE TO MITIGATE FLOODING

Flood volume for the 10-year 24-hour storm in the Alewife area is projected to increase from approximately 13 MG in the present to 33 MG by 2070. Implementation of the green infrastructure solutions at the Maximum Extent Practicable (MEP) scale in the Alewife area can reduce flooding extent by 37% to approximately 21 MG of flood volume.



[SOURCE: CCPR, 2017]

Source: CCPR, City of Cambridge, 2017

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Impacts – Critical Infrastructure

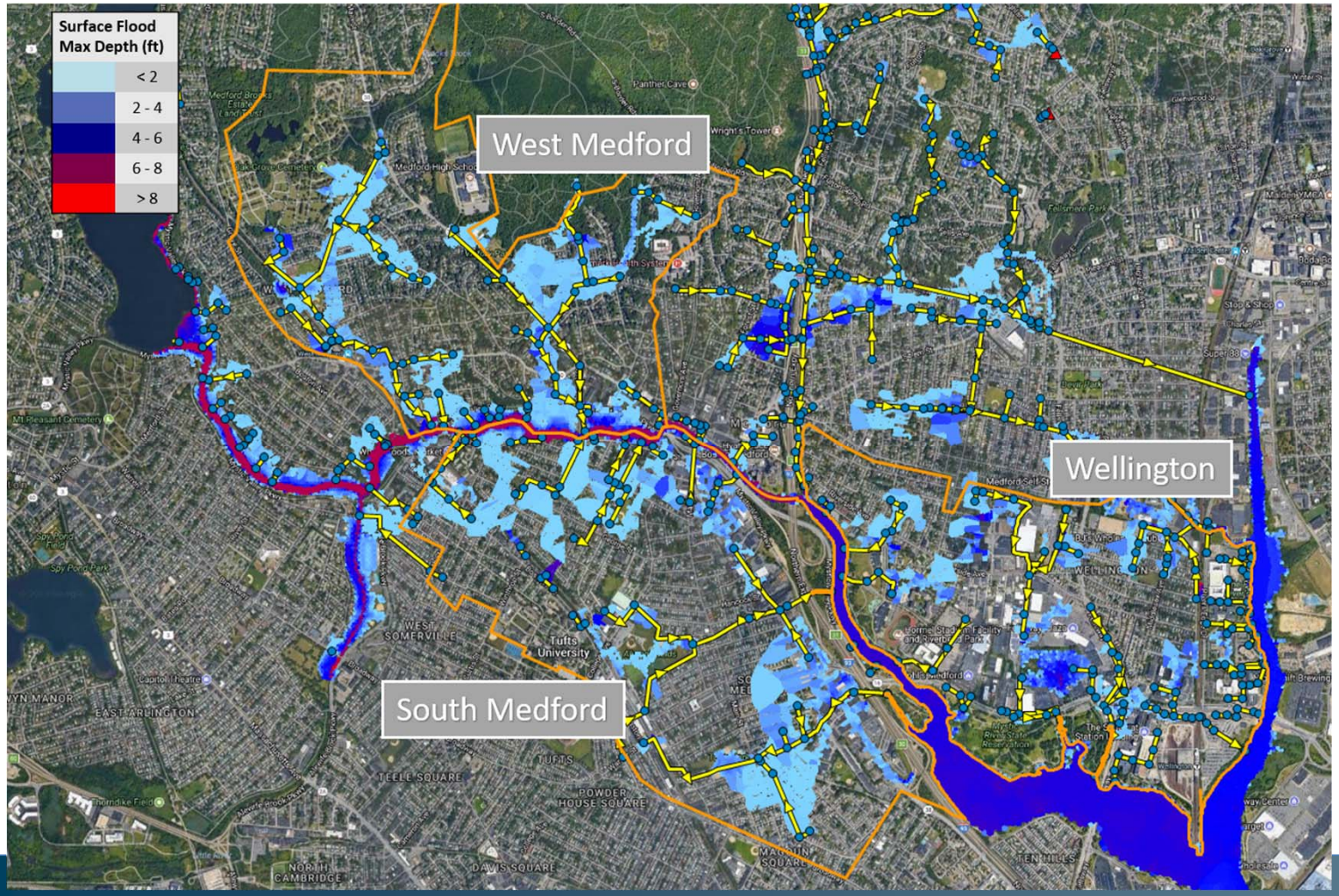
Storm Scenario	2)	6)	7)		2)	6)	7)		2)	6)	7)
	2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked		2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked		2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked
Locations	Peak Flood Depth				Peak Flood Elevation				Flood Duration (Hour)		
Six Acres Day Care	1.59	3.37	2.46		39.23	41.01	40.1		5	7	7
West Medford Train Station	0.53	1.51	0.6		18.32	19.3	18.39		3	5	3
Wellington Station	0.16	0.24	0.54		8.76	8.84	9.14		2	3	4
Key Span	2.11	3.01	3.13		8.87	9.77	9.89		12	24+	24+
Mass Electric Sub Station	0.41	1.03	0.49		7.29	7.91	7.37		8	10	10
Walkling Court	-	0.01	0.38		-	9.73	10.1		-	6	5
Route 16 / Route 28 Intersection	0.32	0.36	0.77		9.62	9.66	10.07		5	12	12
DPW / Police HQ / Fire HQ	2.3	2.64	2.69		9.53	9.87	9.92		12	24+	24+
City Hall	0.02	0.05	0.57		9.57	9.6	10.12		8	8	24+
Curtis Tufts School	0.08	0.75	0.3		13.13	13.8	13.35		1	4	2

Conclusions/Next Steps

Results of the model were instructive with respect to several major areas of interest:

- Areas of chronic flooding under a present day 10-year storm will see exacerbated flooding of greater inundation extents and depth in the cited worst case future scenario. Examples are Winthrop Street in South Medford, Mystic Avenue at Harvard Street and Fellsway Plaza.
- New areas that have not been subject to flooding in the past are likely to be inundated under future extreme storm scenarios. Examples are Harvard Avenue near Boston Avenue and Medford Plaza near Fellsway.
- South Medford, being a low-lying area by nature, is highly vulnerable to storm surge flooding at critical assets, such as the DPW building, the Police and the Fire Headquarters. The area near Harvard Street and Mystic Avenue is likely to experience 12 to 24 hours of flooding in many of the scenarios.

Next Steps



- Refine model
- Better understanding of flood risks
- Evaluate flood mitigation strategies

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