Planning for Extremes – When, Where and How Much?

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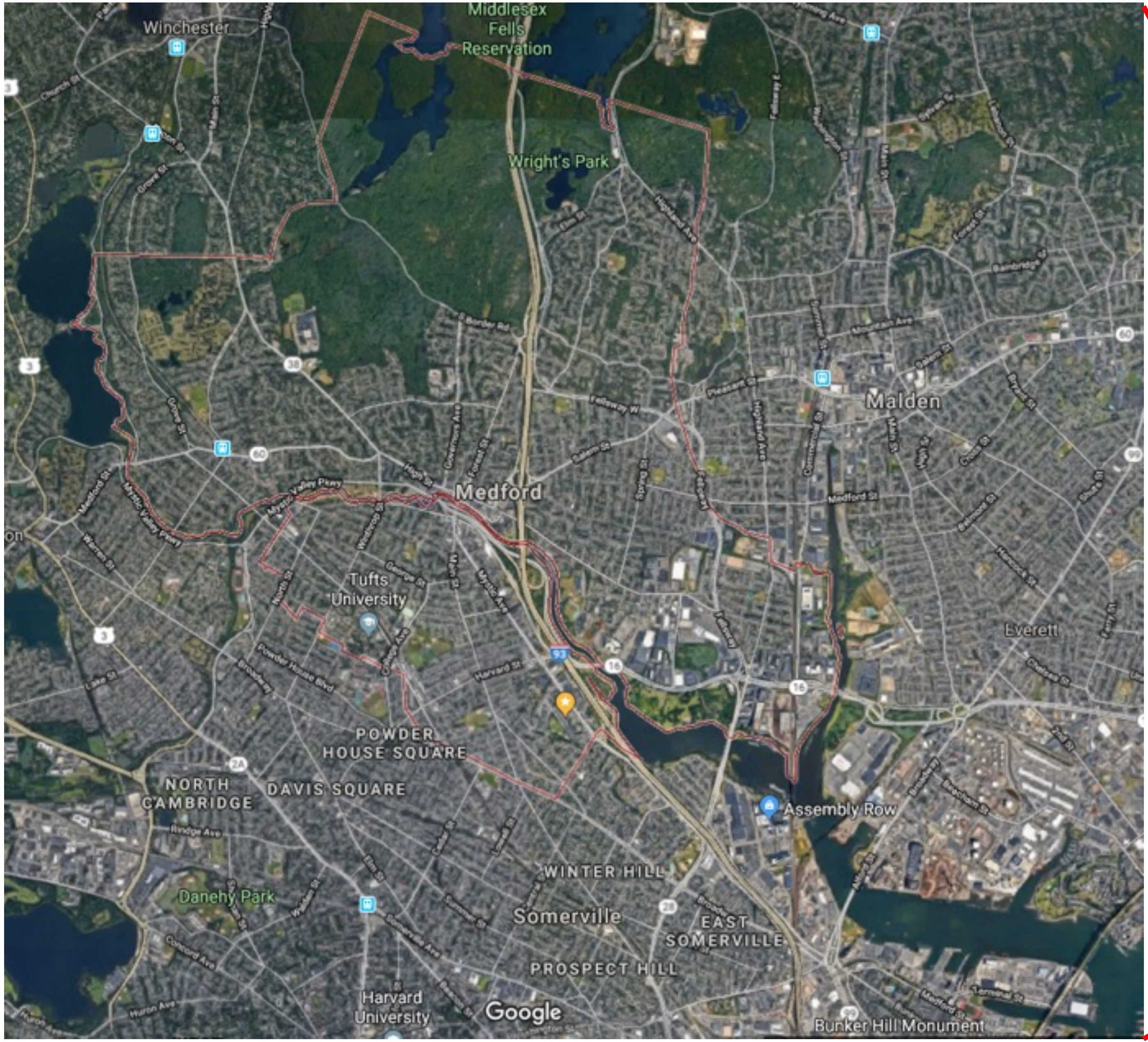
NEWEA CSO Wet Weather Issues Conference

Portland, Maine
October 30, 2018

Overview

- Background
- Climate Change Impacts to Medford
- Vulnerability Assessment
- Development of Citywide Inundation Model
- Simulating Extreme Precipitation Scenarios
- Developing Resiliency Strategies
- Next Steps

Where is Medford



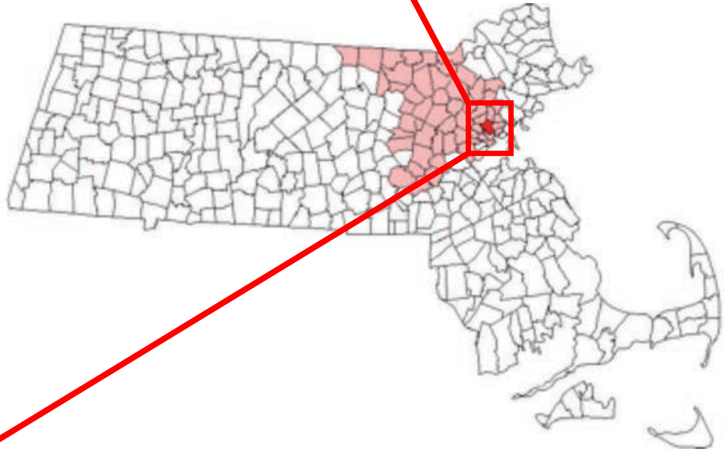
8.1 sq. miles

57,797 residents

5 miles outside of Boston

Fourth English settlement

1 watershed



Climate Change Commitments

- Metropolitan 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

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

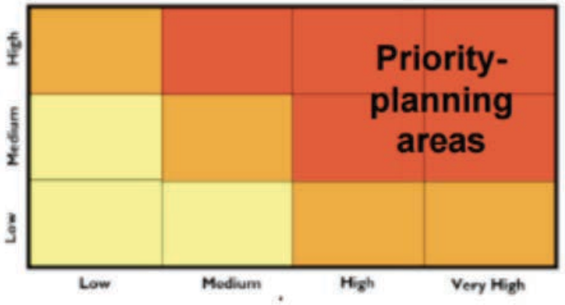
Step 1
- Climate Projections
- Systems at Risk

→

Step 2
- Vulnerability & Risk Assessment

→

Step 3
- Adaptation Planning and Design



Vulnerability Assessments in the Region

Cities

- Boston
- Cambridge
- Somerville
- MVP program

State

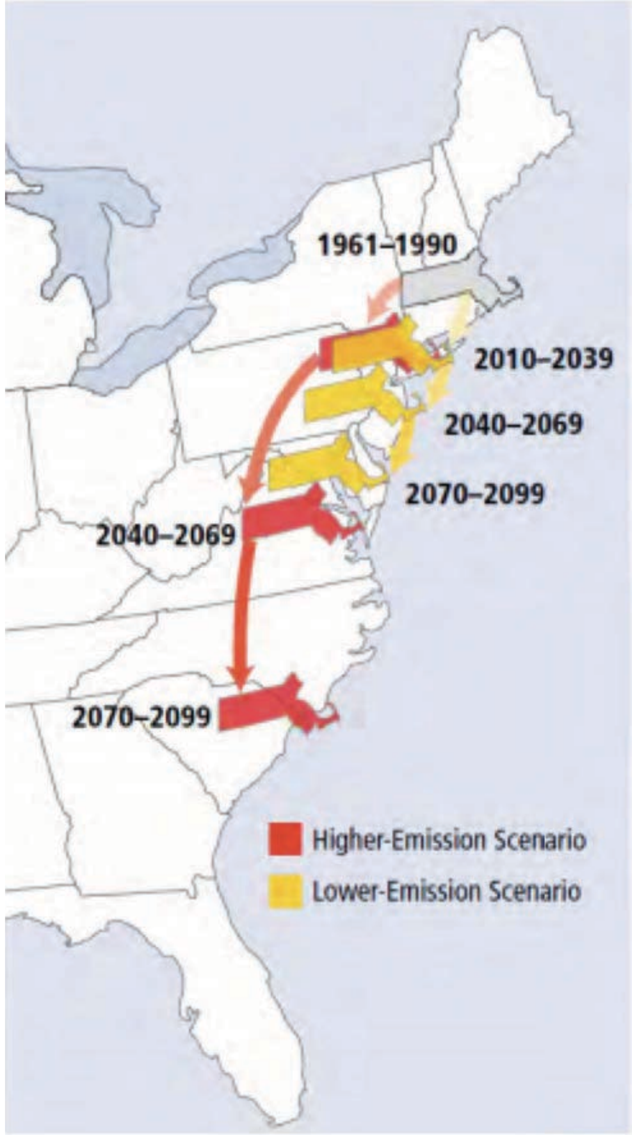
- Mass DOT
- Mass DOH
- Mass Office of Energy and Environment

Other Groups

- USACE
- MWRA
- MAPC
- The Boston Harbor Association
- EPA

Climate Change Impacts in Medford

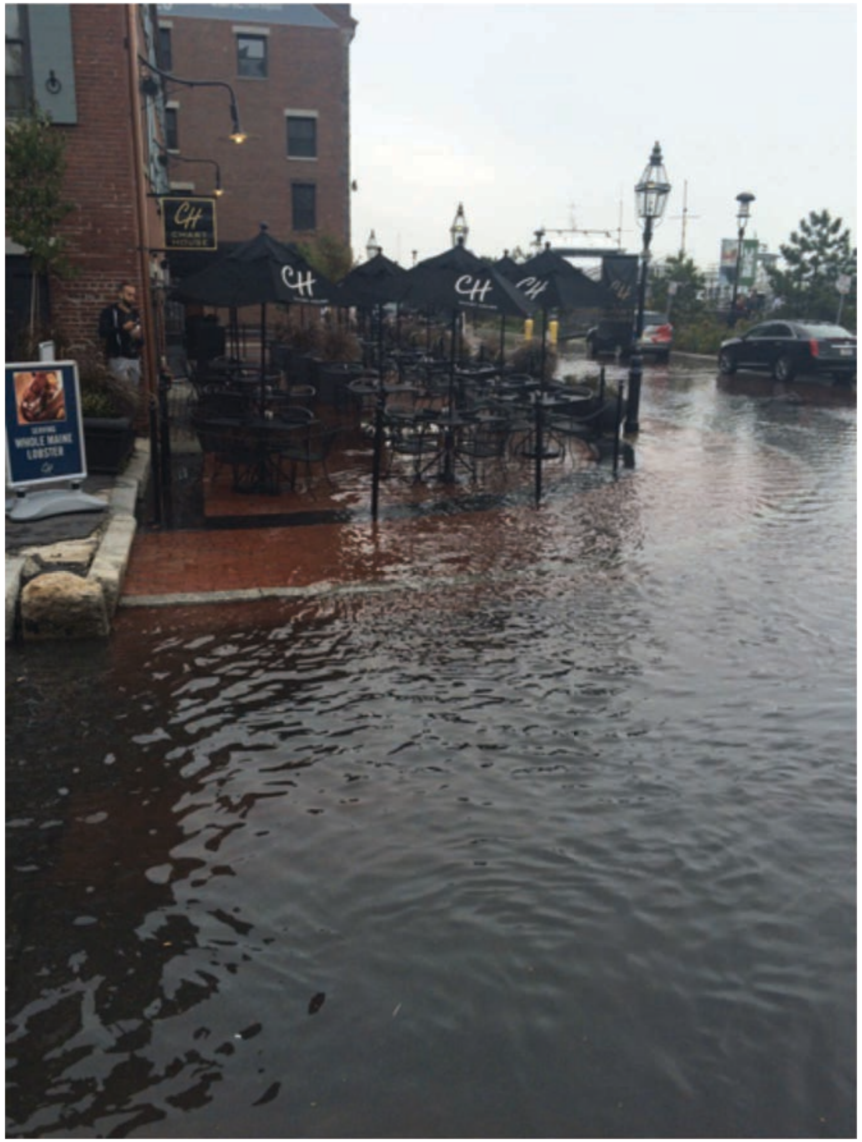
Temperature



Precipitation

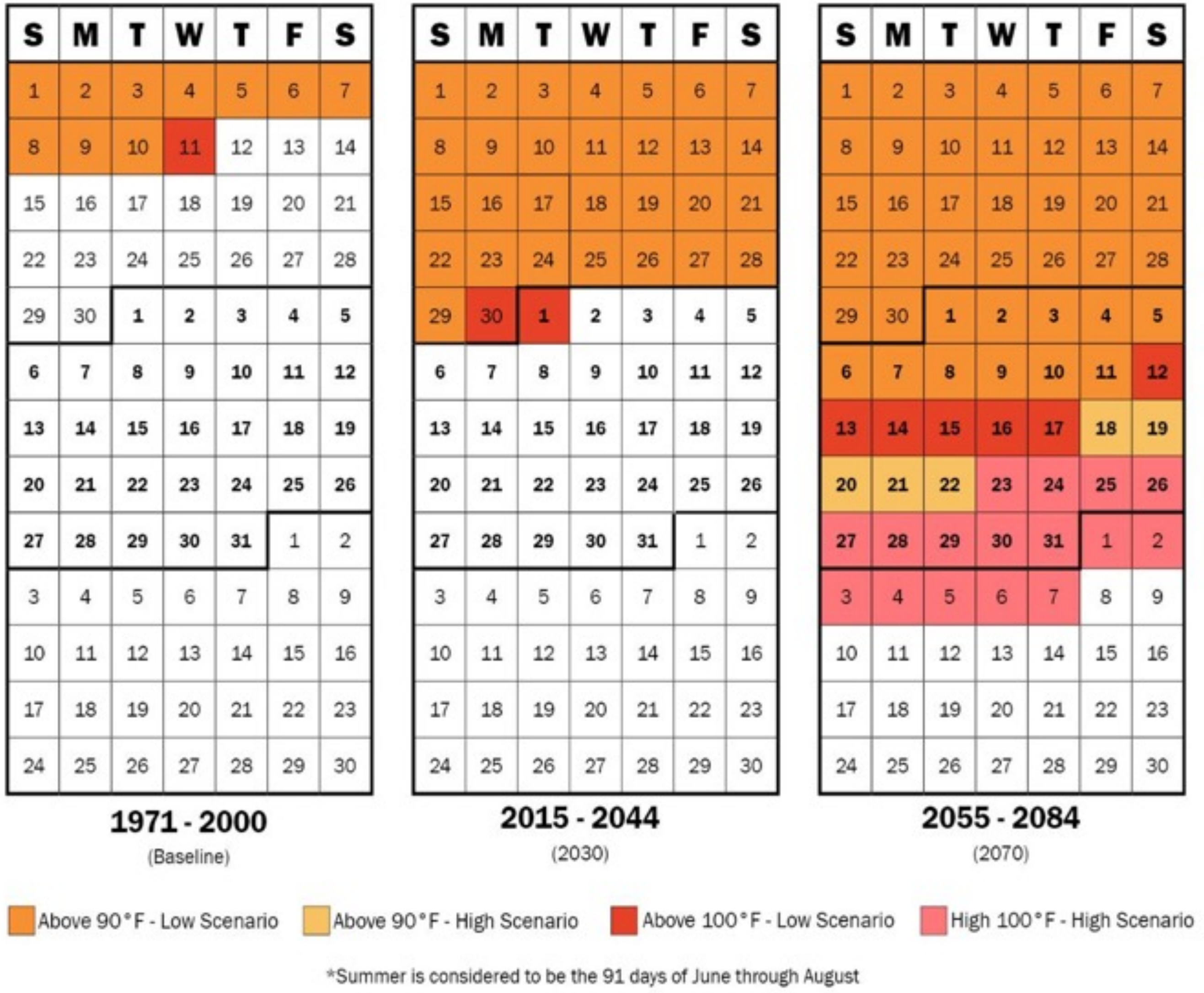
Extreme Events

Sea Level Rise/Storm Surge



Climate Change – Temperature

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



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

Climate Change- Flooding

Today

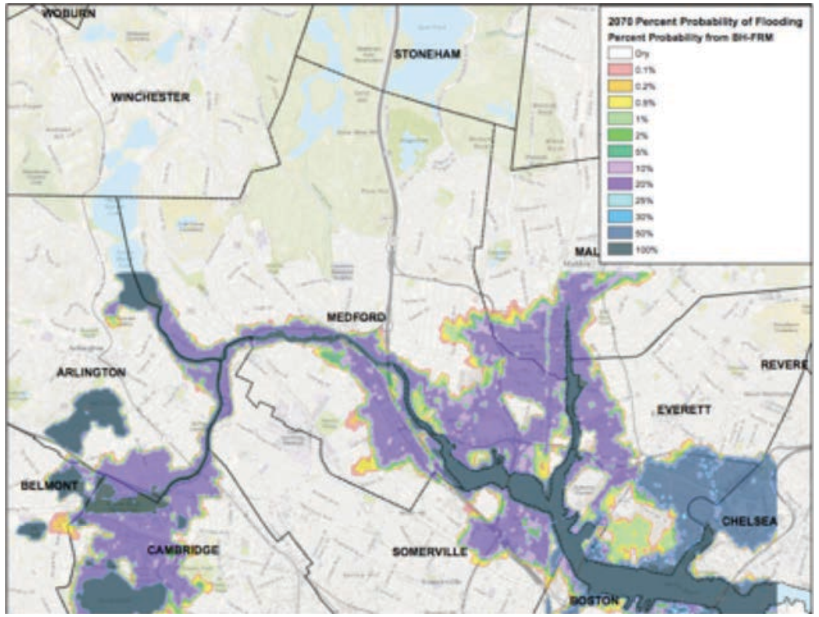
2030

2070

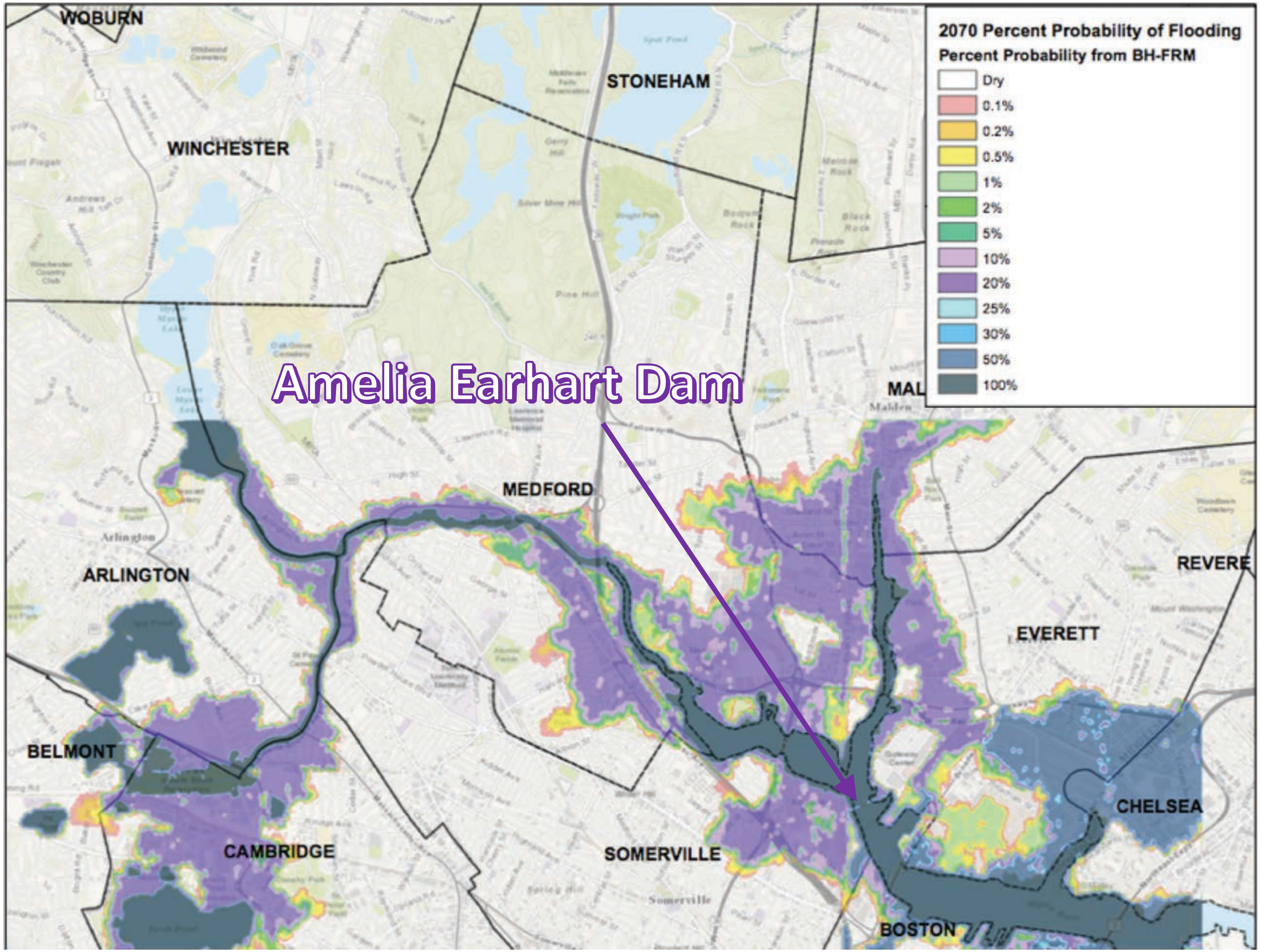
More Intense Precipitation

Increased Potential for
Inland River and Piped infrastructure
Flooding

New Additional Storm
Surge Flooding Risk when
Dam Overtops



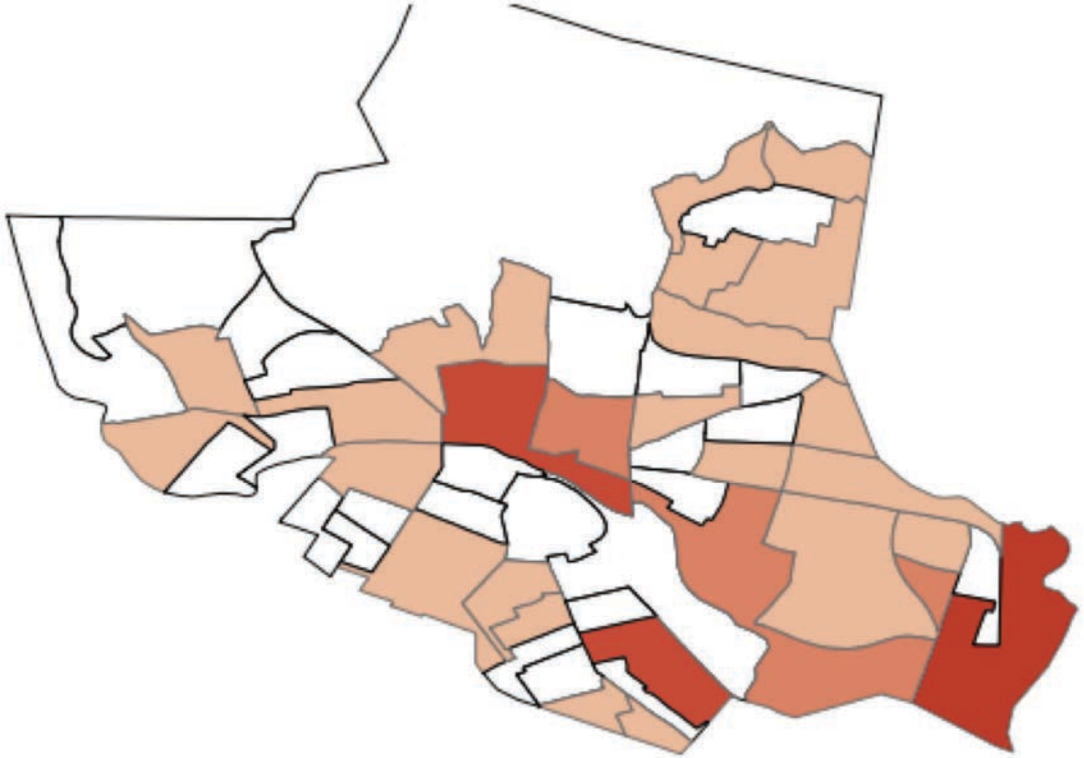
Storm Surges from Boston Harbor



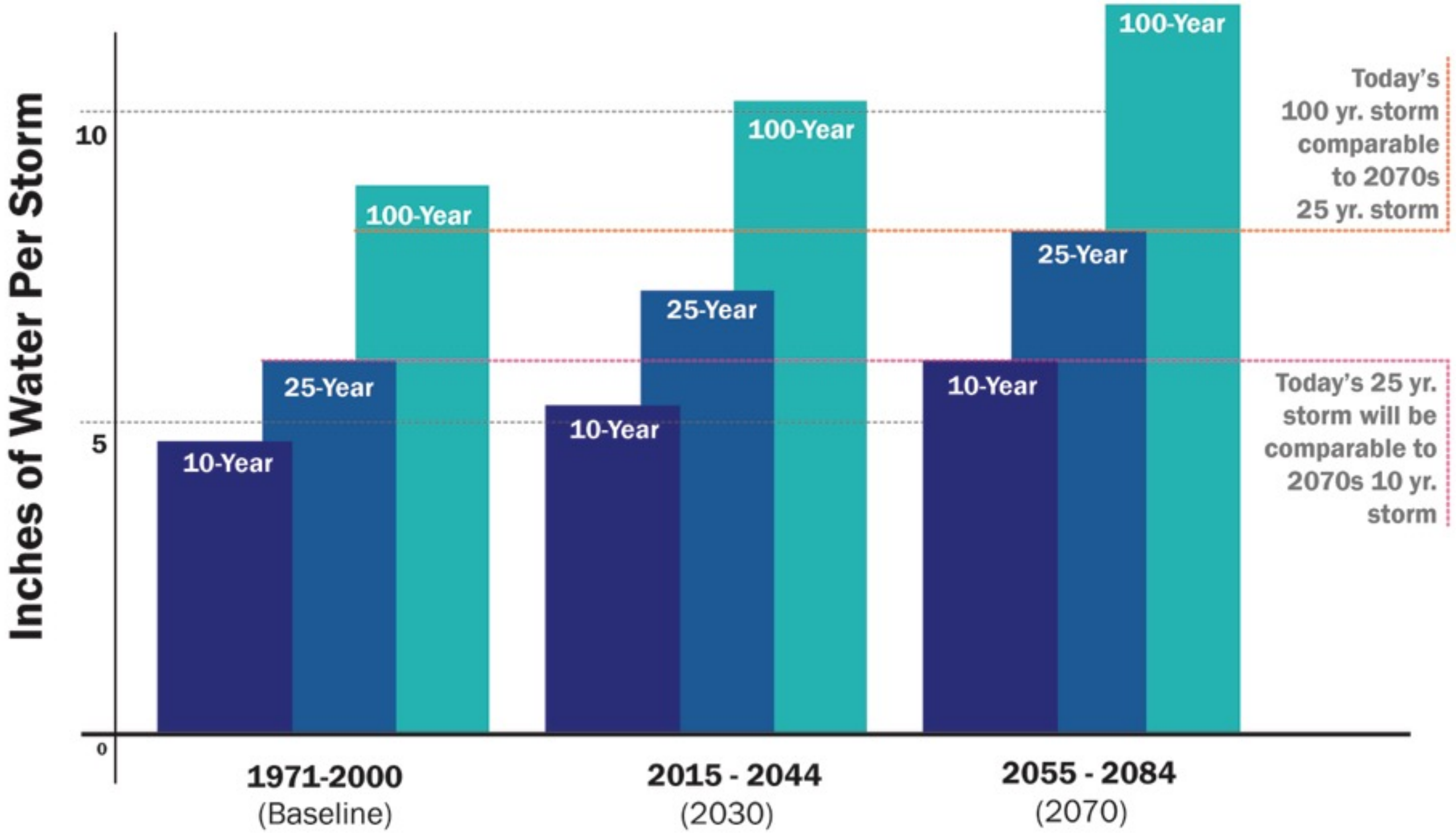
Source: Kleinfelder & Woods Hole Group for the City of Medford, February 2017

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



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)*

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.

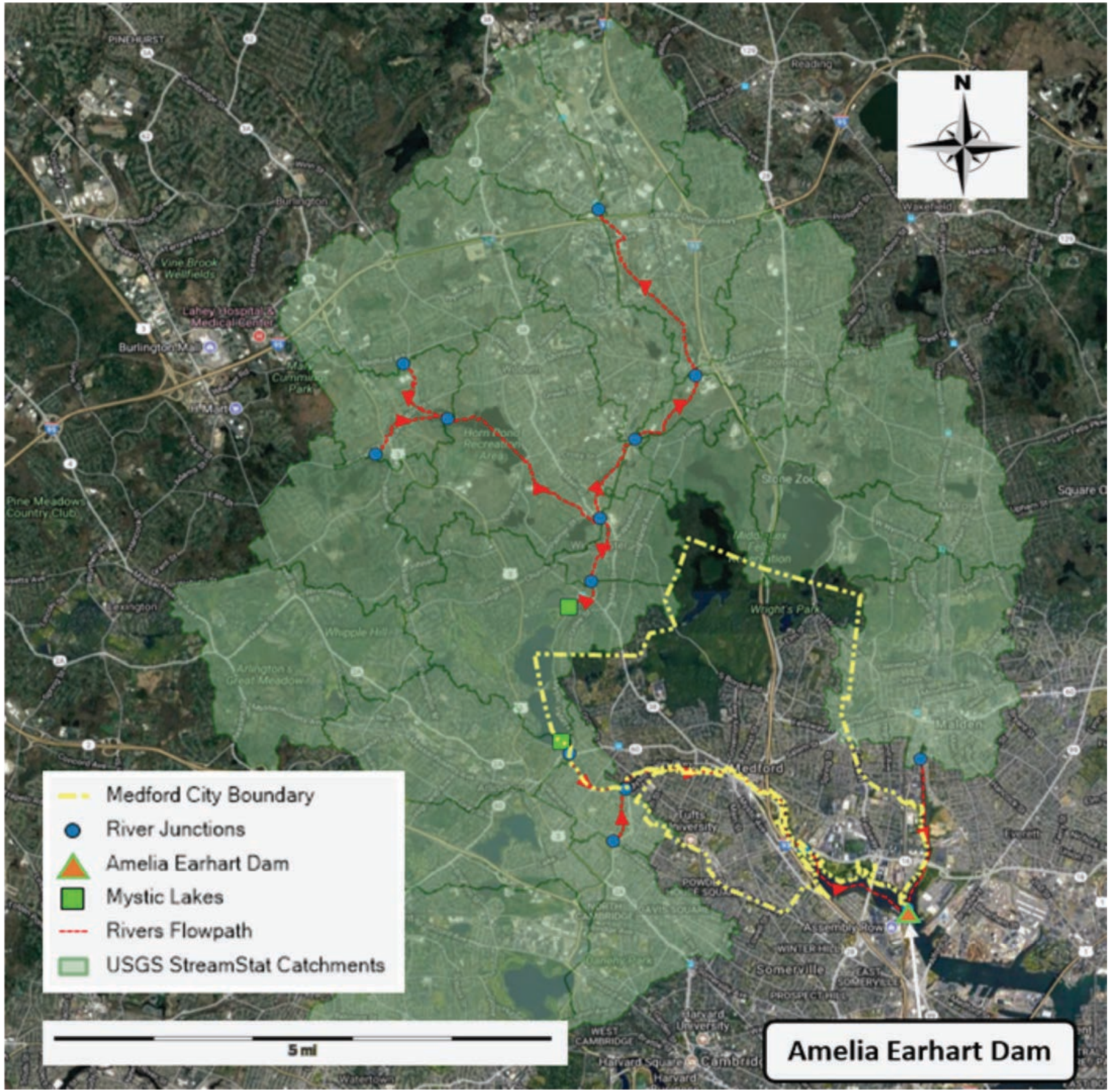
Medford System Overview

- 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).

Upstream Basin Model

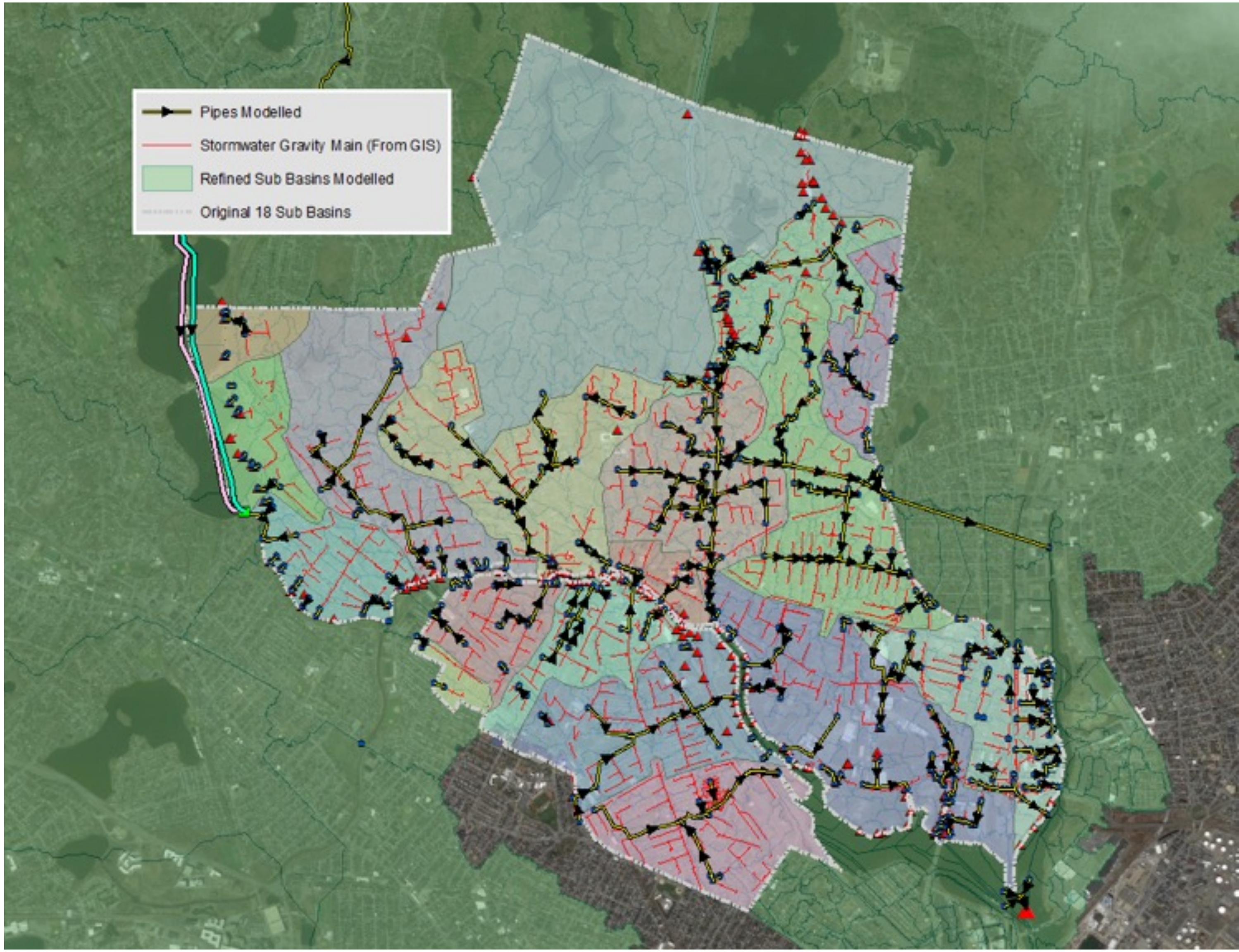
- Upstream basin delineation for the upper reaches using the USGS StreamStats delineation tool.

- 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

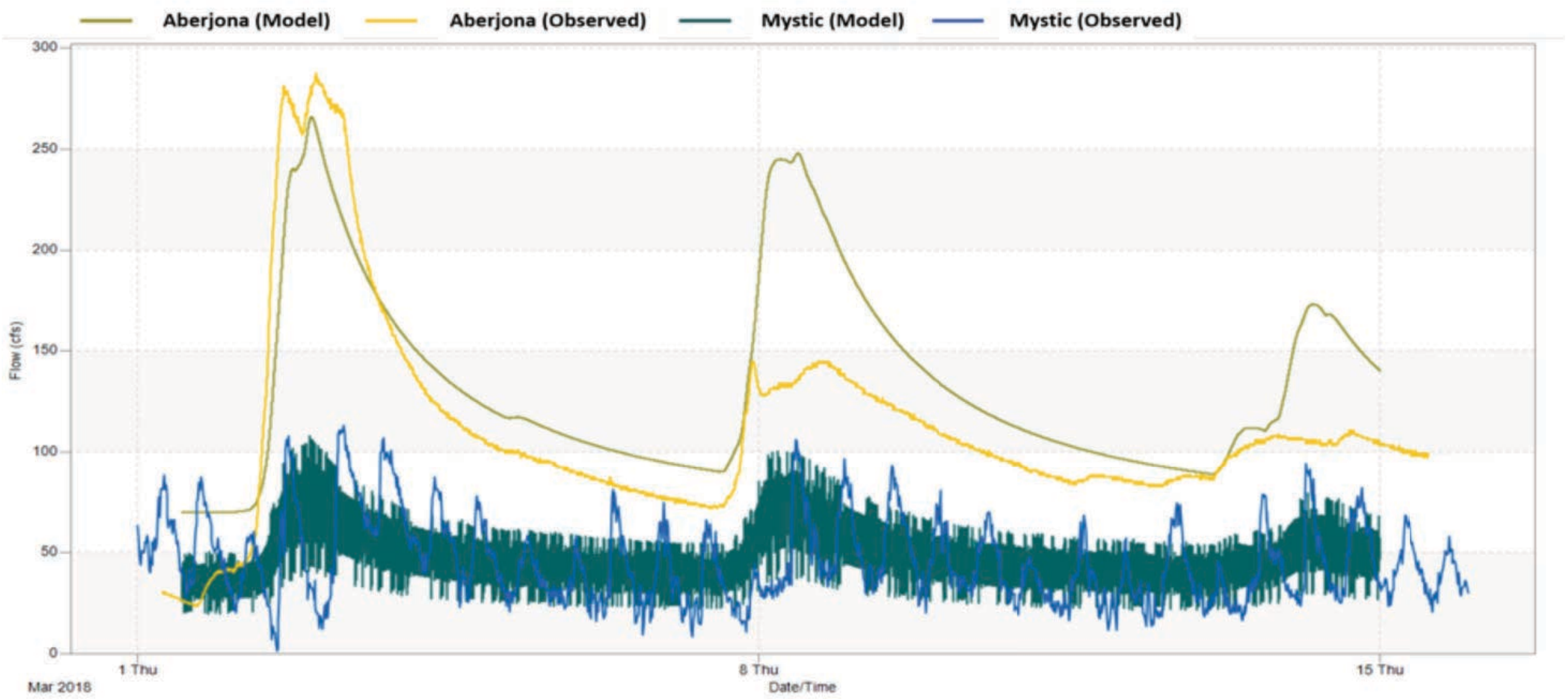


Stormwater Model Overview

- City's GIS data and MassGIS data consolidated to develop a one-dimensional (1D) hydrologic/hydraulic model.
- Drainage trunk lines greater than or equal to 18" were included in the 1D model.
- A two-dimensional (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.
- Validated model was used to simulate future scenarios (present, 2030 and 2070) of future rainfall and sea level rise and storm surge scenarios.



Upstream Basin Model

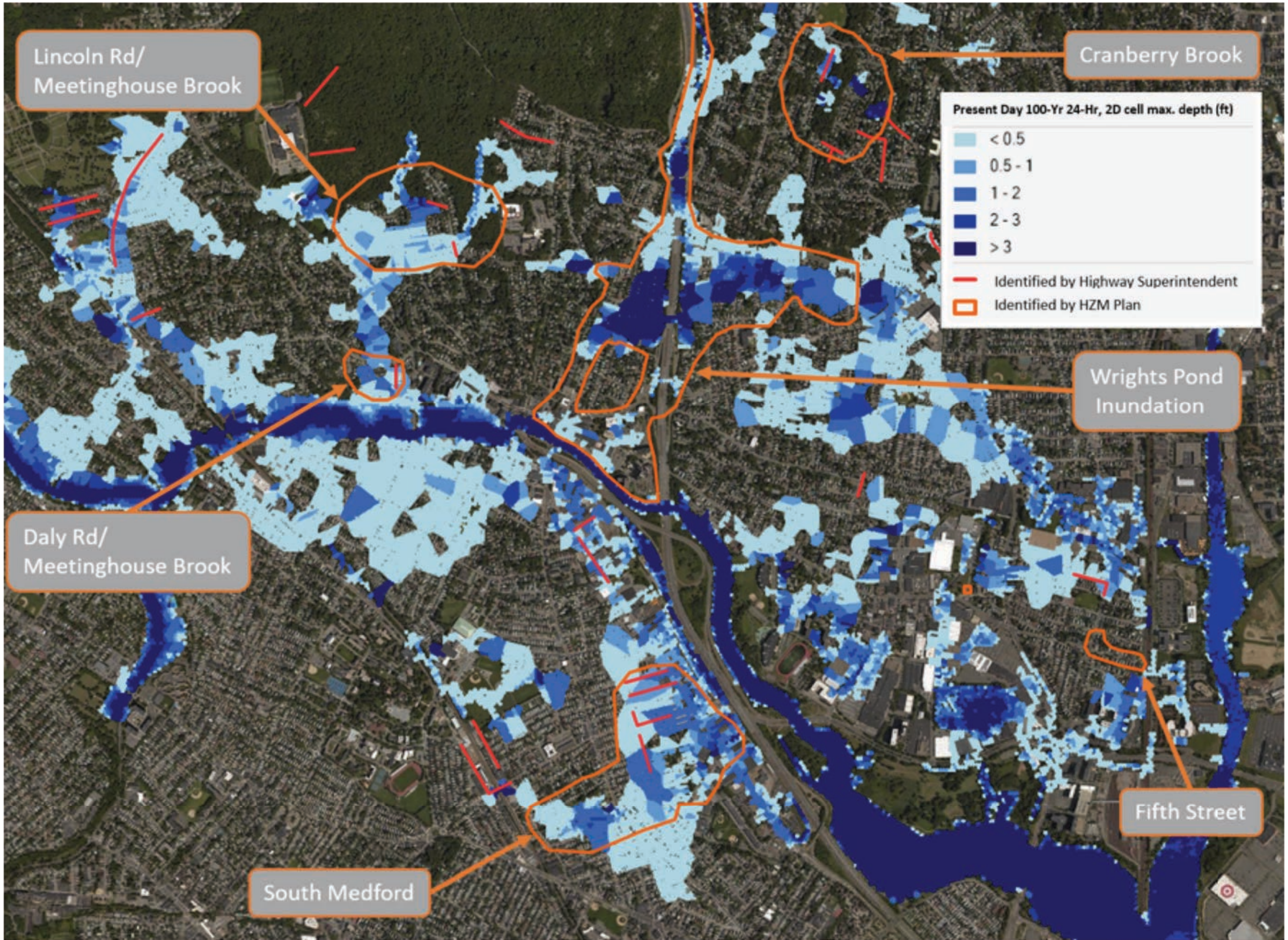


March 2nd Storm	Aberjona River		Mystic River	
	Model	Observed	Model	Observed
Maximum Flow (cfs)	265.9	288	108.1	113
Mean Flow (cfs)	149.6	143.6	53.18	57.4
Total Flow (ft^3)	43,050,000	43,700,000	15,300,000	17,460,000

2D Model Development

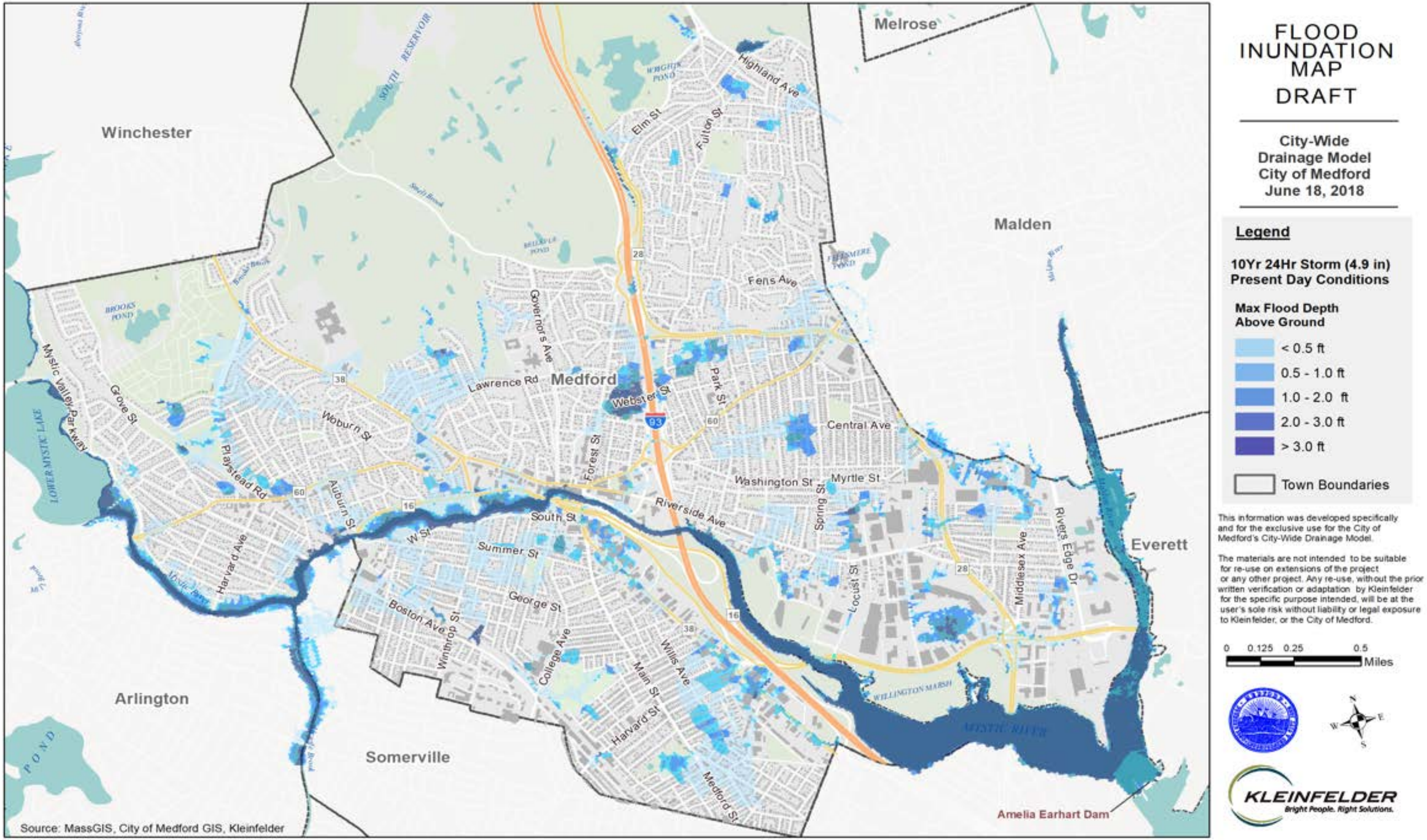
- 2D mesh was generated to simulate and visualize flooding on the ground surface using
  - Digital terrain model (DTM)
  - River bathymetry
  - Building Footprints
- Bathymetry data used to develop river cross sections and help to improve flow interactions along the Mystic and Malden Rivers.
- Buildings footprints are acknowledged in the 2D surface mesh to ensure that the flood flow paths recognize the buildings as obstruction.

2D Model Validation/Verification

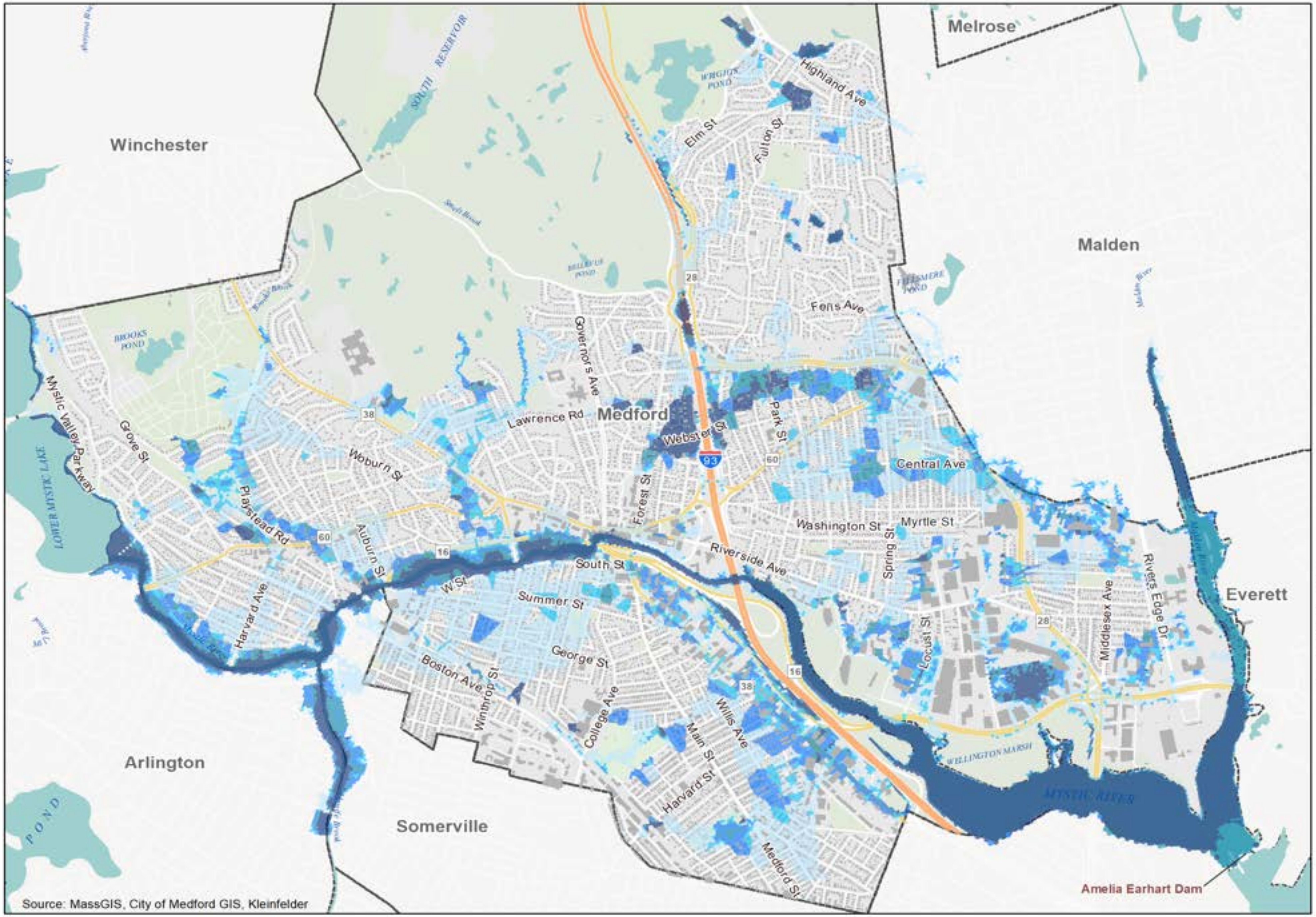


Future Scenario Simulations

	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	



FLOOD INUNDATION MAP
DRAFT
City-Wide Drainage Model City of Medford June 18, 2018
Legend
10Yr 24Hr Storm (4.9 in) Present Day Conditions
Max Flood Depth Above Ground
< 0.5 ft
0.5 - 1.0 ft
1.0 - 2.0 ft
2.0 - 3.0 ft
> 3.0 ft
Town Boundaries
This information was developed specifically and for the exclusive use for the City of Medford's City-Wide Drainage Model.
The materials are not intended to be suitable for re-use on extensions of the project or any other project. Any re-use, without the prior written verification or adaptation by Kleinfelder for the specific purpose intended, will be at the user's sole risk without liability or legal exposure to Kleinfelder, or the City of Medford.
0 0.125 0.25 0.5 Miles
KLEINFELDER
Bright People. Right Solutions.
Winchester
Melrose
Malden
Everett
Arlington
Somerville
Medford
Highland Ave
Elm St
Fulton St
Fens Ave
Governors Ave
Lawrence Rd
Webster St
Park St
Central Ave
Woburn St
Mystic Valley Parkway
Grove St
Playstead Rd
Auburn St
Forest St
Washington St
Myrtle St
Riverside Ave
South St
Spring St
W St
Summer St
Harvard Ave
Boston Ave
Winthrop St
George St
College Ave
Main St
Willis Ave
Harvard St
Medford St
Locust St
Middlesex Ave
Rivers Edge Dr
LOWER MYSTIC LAKE
BROOKS POND
SOUTH RESERVOIR
WRIGHTS POND
WELLINGTON MARSH
MYSTIC RIVER
Amelia Earhart Dam
Source: MassGIS, City of Medford GIS, Kleinfelder



FLOOD INUNDATION MAP DRAFT

City-Wide Drainage Model
City of Medford
June 18, 2018

Legend

100Yr 24Hr Storm (10.2 in)
Year 2030 Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

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0 0.125 0.25 0.5 Miles

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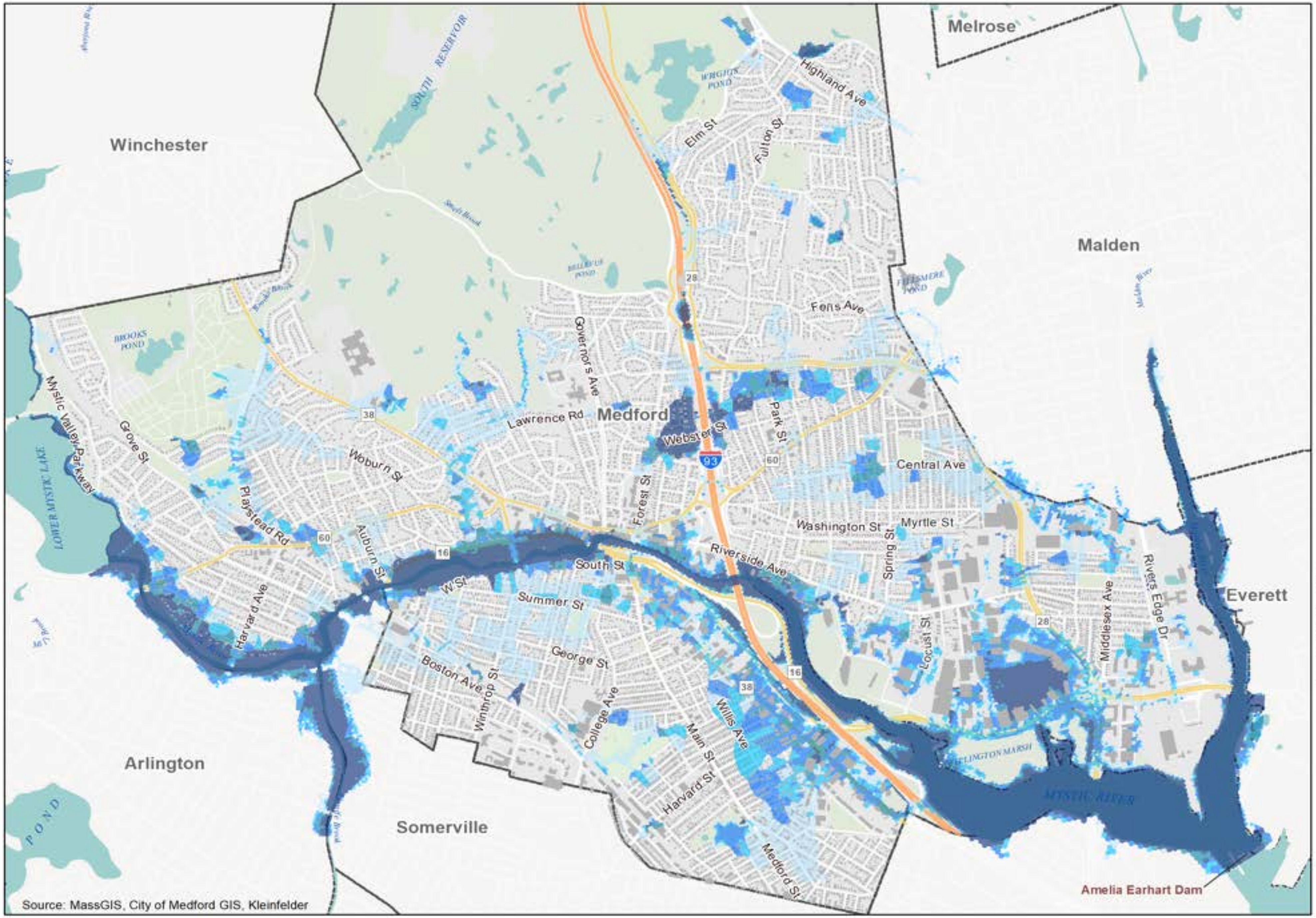

FLOOD INUNDATION MAP DRAFT

City-Wide Drainage Model
City of Medford
June 18, 2018

Legend

Year 2070 Condition
10Yr-24Hr (6.4 in)
100 Yr Surge w/ SLR

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

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0 0.125 0.25 0.5 Miles

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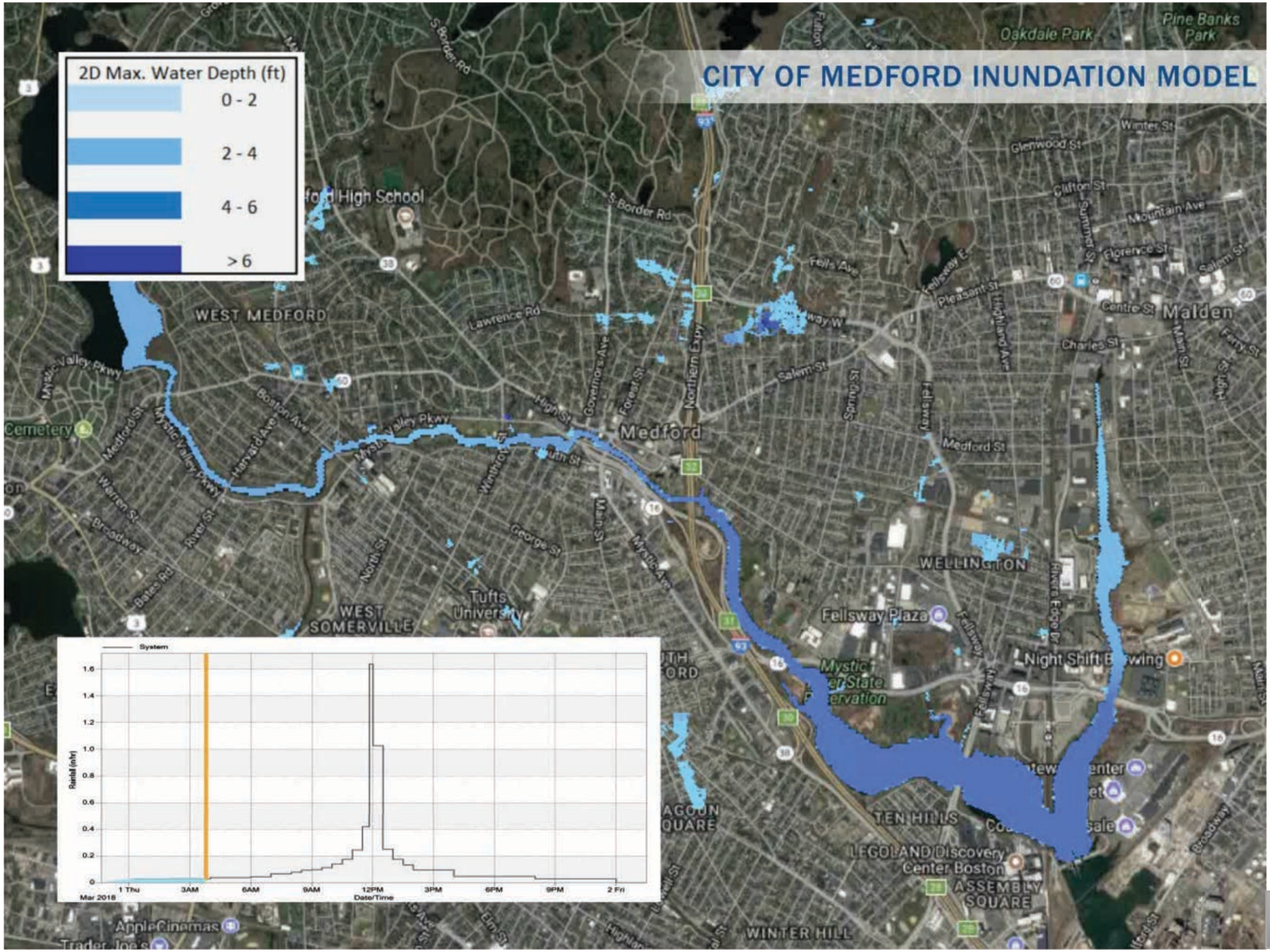
Visualization of Results

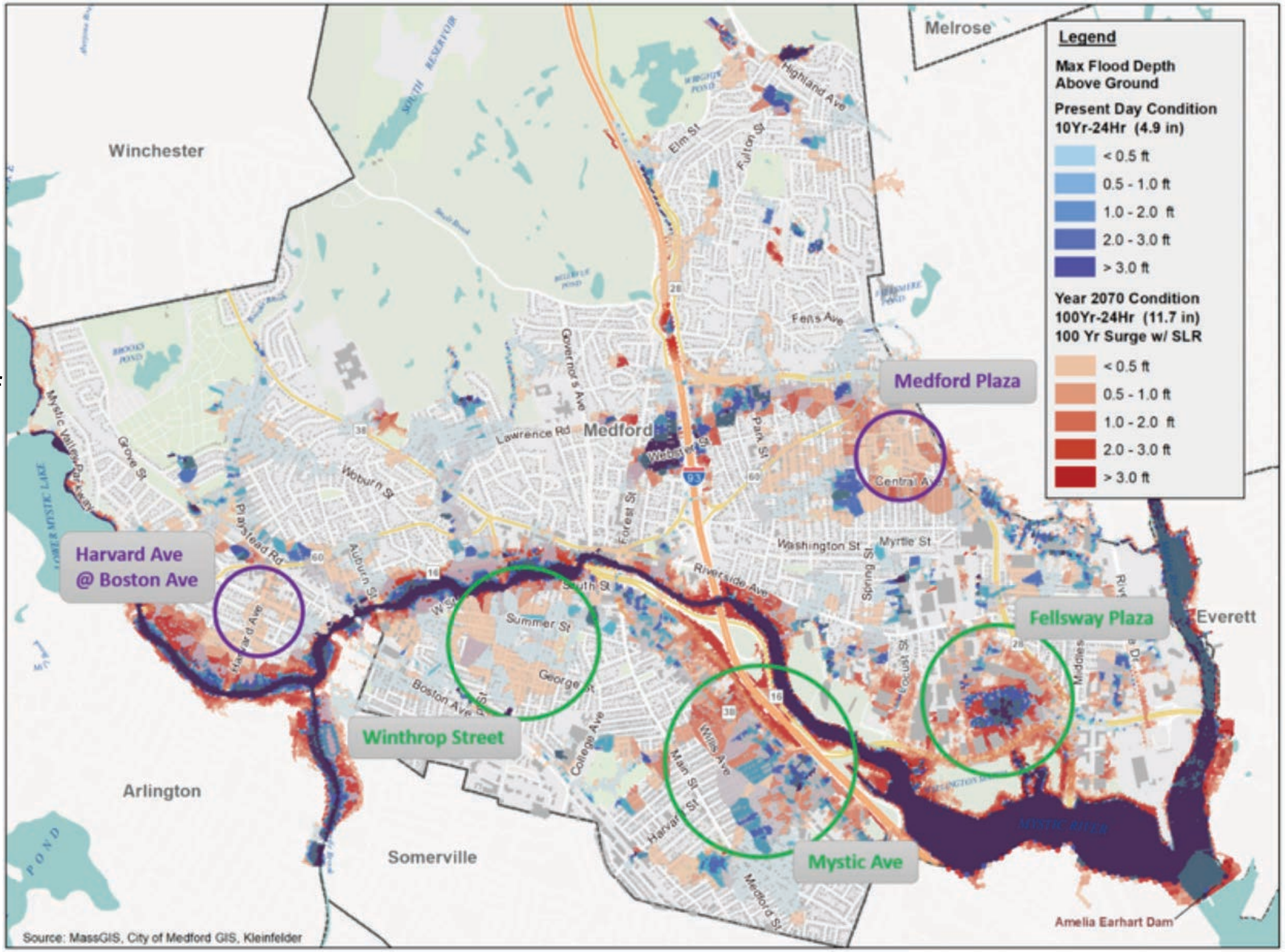


https://earth.google.com/web

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



Impacts – Critical Infrastructure

Impacts – Critical Infrastructure

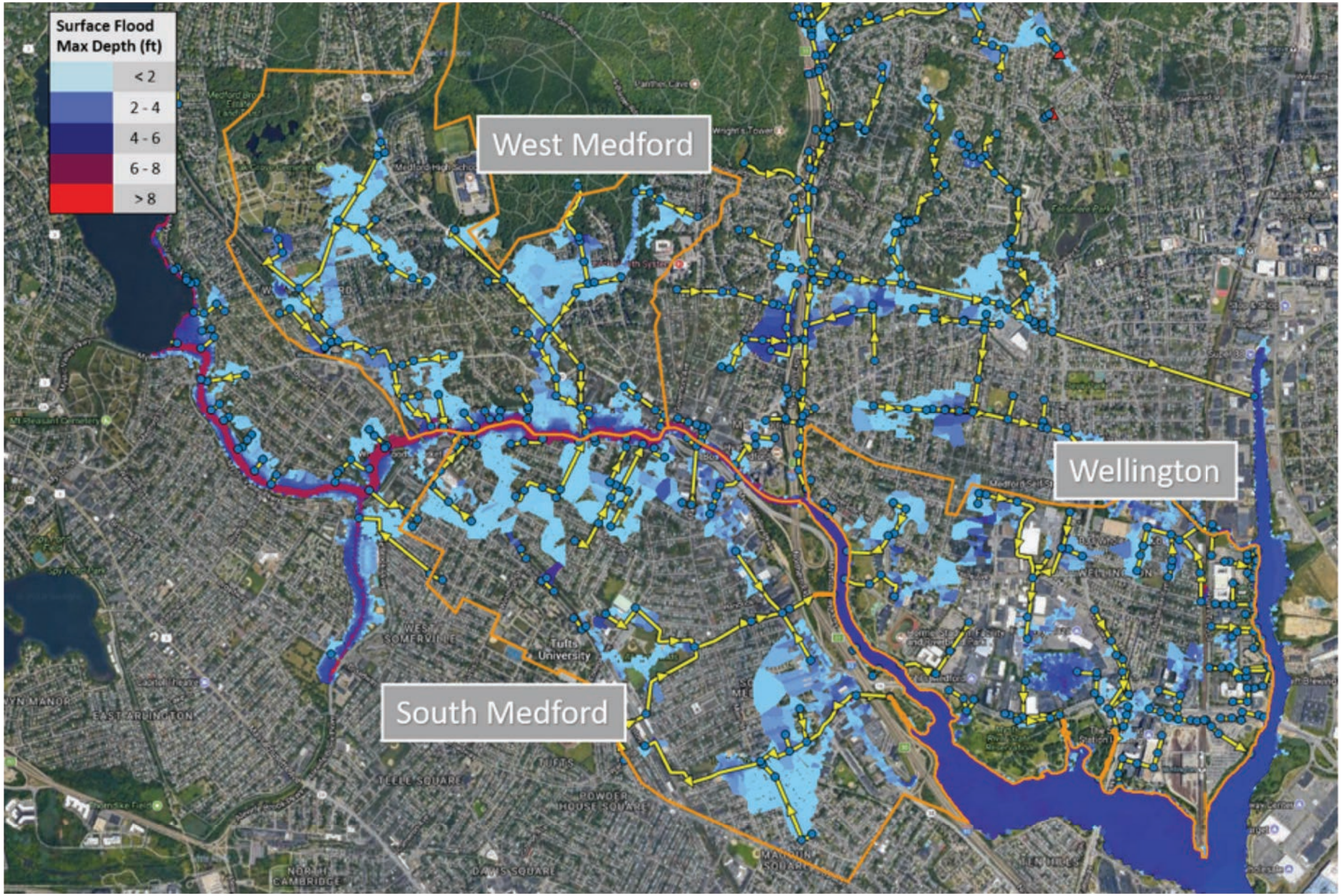
Storm Scenario	2)	6)	7)		2)	6)	7)		2)	6)	7)
	2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked		2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal 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

Types of Flood Mitigation Strategies to be Evaluated

<u>Neighborhood-Wide Flow Reduction and Flood Attenuation Alternatives</u>

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

<u>Gray Infrastructure Flood Mitigation Options:</u>

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

<u>Green Infrastructure Options</u>

- 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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