Municipal Vulnerability Preparedness Program Action Grant Case Study

Municipality: Dedham (Fiscal Agent), Boston, Canton, Foxborough, Medfield, Milton, Norwood, Quincy, Sharon, Stoughton, Walpole, Westwood. Additional Partner: Boston Water & Sewer Commission
Project Title: Neponset River Watershed Regional Adaptation Strategy and Flood Model
Award Year (FY): 2023
Grant Award: $ 389,457
Match: $ 129,824
Match Source: Cash and in-kind
One or Two Year Project: One
Municipal Department Leading Project: Dedham Engineering Department
Project Website URL: Neponset.org/climateadapt

Community Overview:

While the grant was awarded through the Town of Dedham, in total, twelve communities within the Neponset River Watershed participated in this project. The region is located between Foxborough and Boston and is home to approximately 330,000 people. Ten of the participating communities contain mapped Environmental Justice populations, including individuals of lower income, limited English proficiency, and people of color, and all are home to priority populations (including seniors, children and differently abled individuals).

The Neponset River Watershed communities are primarily urban/suburban, with myriad natural and recreational resources associated with the Neponset River and its tributaries, as well as nearby watersheds (including the Charles River and Taunton River watersheds). The region is the historic and present home of the Indigenous peoples of the Massachusett, Nipmuck, Pokanuket and Wampanoag Tribes.[1] The Neponset River Watershed has a rich industrial history and is economically diverse, including agriculture, manufacturing, finance, retail, education and health services.

Project Description and Goals:

The region is facing several climate-related challenges including significantly changing precipitation patterns which alternately cause severe flooding and more frequent drought, as well as more frequent heat waves and increasingly severe storms (*i.e.*, Nor'easters). All of these impacts are a hazard to the people that live and work in the region, infrastructure, wildlife and natural resources.

The project aimed to address several vulnerabilities through six primary goals/tasks:

1. Develop an integrated hydraulic and hydrologic flood model for the entire watershed. The aim of the model is to predict future flood impacts and bring consistency across watershed communities on how they are planning and governing for expected precipitation changes,

[1] *See* Native Land, available at https://native-land.ca/ (last visited May 11, 2023)

inventory planned and identify new nature-based solutions, and assess the benefits of possible large-scale nature-based solutions.

2. Provide municipal leaders and the public with improved information on where and when flooding will occur and thereby help participating communities achieve multiple projects and objectives detailed in individual MVP planning evaluations while expanding climate planning beyond individual municipal boundaries.
3. Build on the regional flood model to demonstrate its application at a neighborhood scale to address flooding impacts and prepare an actionable plan for nature-based solutions in the Manor Neighborhood of Dedham.
4. Develop a "Framework for Regional Collaboration on Climate Resilience" by consensus. The framework will consolidate regional climate impacts (not just those due to precipitation) and prioritize strategies that would benefit from a regional approach rather than community-by-community approach.
5. Promote best practices on climate resilient land use strategies through outreach and training for key municipal officials on bylaw, zoning, and other regulatory best practices.
6. Engage local residents, especially members of environmental justice and climate vulnerable populations, in identifying/confirming historical flooding concerns, evaluating alternatives for managing future flood impacts, and prioritizing opportunities for regional collaboration across the full range of climate impacts.

The project met its goals, including:

- ✓ Modeling nature-based solutions and their impact on future flood scenarios through the flood model;
- ✓ Fostering partnerships with community organizations working with environmental justice and priority populations, particularly in the Lower Neponset area, where the Project Team held a focus group designed to inform future engagement around climate resiliency;
- ✓ Providing regional benefits by modeling flooding across the entire watershed, as well as facilitating prioritization of potential regional projects on which partner communities may collaborate in the future;
- ✓ Engaging the community around climate adaptation generally as well as the project goals specifically; and
- ✓ Finishing the project on time.

Results and Deliverables:

Watershed-wide Flood modeling

An integrated stormwater flood model of the Neponset River Watershed was developed by Weston & Sampson during this project that factors the combined impacts of riverine (fluvial) flooding and drainage infrastructure (pluvial) flooding from the extreme precipitation events. The model was developed using the PCSWMM modeling platform, which is based on the USEPA's Storm Water Management Model (SWMM) and includes 1-dimensional and 2-dimensional components.

This model can be used to evaluate flooding impacts from both current and future extreme rainfall events due to climate change, establish consistency across watershed communities on planning and governing for expected precipitation changes, inventory planned and identify new nature-based solutions, and assess flood reduction benefits at a regional scale of both potential watershed-wide nature-based solutions and site-specific flood mitigation projects.

The model was developed by Weston & Sampson with input from municipalities, such as stormwater infrastructure mapping, including information on existing dams, bridges, and culverts, documentation of past flooding complaints, and other hydrologic and hydraulic (H&H) studies conducted. This information, supplemented with four days of field work to verify representative data gaps related to 56 dams, 47 culverts, and 17 drainage system locations, set the stage for developing the 1-dimensional (1D) components of the flood model. The 1D model represents approximately 157,000 feet (30 miles) of river, almost 600,000 feet (114 miles) of tributary streams, 811,000 feet (154 miles) of stormwater pipes, 50 dams, and 388 culverts (road-stream crossings), as well as 4,781 subcatchments to represent drainage areas delineation across the watershed, including pervious and impervious cover. A 2-dimensional (2D) mesh was overlayed on the 1D model to develop the 2D model that better represents overland/overbank flooding, as well as to captures the instream and near-stream storage and conveyance capacity in the channels and floodplains of the Neponset River and its named tributaries. The 2D model was developed to account for greater level of detail in areas with more buildings and infrastructure.

The Neponset River Watershed Flood Model was calibrated and verified using the March 2010 flood event and September 1-2, 2021 Hurricane Ida, respectively and by using historically observed flood flows at four USGS gages in the watershed.

The calibrated and verified model was used to evaluate flooding impacts for nine different storm events (Table ES-1), both under present-day and future climate scenarios, assuming no-action:

TABLE ES-1 PRESENT AND FUTURE DAY DESIGN RAINFALL DEPTHS FOR THE 24-HR DURATION AND 48-HR DURATION DESIGN STORMS FOR THE NEPONSET RIVER WATERSHED

Return Period	Design Rainfall Depth for 24-hour duration Storm			Design Rainfall Depth for 48-hour duration Storm	
	Present Day Baseline (in) (NOAA Atlas 14)	2050 CornellIDF Projections[2] (in) (using 3°C Average Annual Temperature Change)	2070 CornellIDF Projections[2] (in) (using 4.5°C Average Annual Temperature Change)	Present Day Baseline (in) (NOAA Atlas 14)	2070 Cornell IDF Projections[2] (in) (using 4.5°C Average Annual Temperature Change)
2-yr	3.3		4.5		
10-yr	5.2	6.4	7.1	6.4	10.2
100-yr	8.2		11.1		

[2] Based on IDF projections from EEA's 2022 Climate and Hydrologic Risk Project and integrated into the State's Climate Resilience Design Standards Tool)

With no action taken:

- **There will be an increase in flooded area:** For the 10-year (10% annual chance of occurring) 24-hour storm, the total inundated area in the Neponset River watershed is likely to increase by approximately 799 acres by the mid-term (2050) planning horizon (14% increase compared to present day), and by approximately 1,235 acres by the longer term (2070) planning horizon (22% increase compared to present day. For the 100-year (1% annual chance of occurring) 24-hour storm by the longer term (2070) planning horizon, the total inundated area in the watershed is likely to increase by 15% compared to present day. The percent increases in flooded area vary by sub-basin across the watershed and are summarized in Figure ES-1 (left).
- **There will be an increase in total runoff volume**: For the 10-year (10% annual chance of occurring) 24-hour storm, the total runoff volume in the Neponset River watershed is likely to increase by approximately 1,205 MG by the mid-term (2050) planning horizon (56% increase compared to present day), and by approximately 2,132 MG by the longer term (2070) planning horizon (100% increase compared to present day). For the 100-year (1% annual chance of occurring) 24-hour storm by the longer term (2070) planning horizon, the total runoff volume in the watershed is likely to increase by 80% compared to present day. The percent increases in total runoff volume vary by sub-basin across the watershed and are summarized in Figure ES-1 (right).

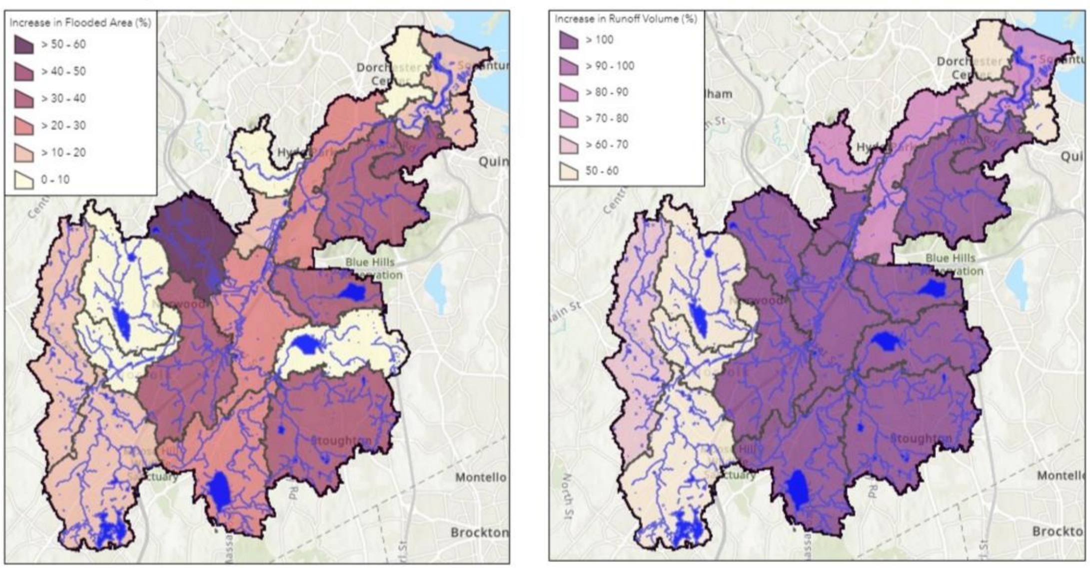

FIGURE ES-1: WATERSHED-WIDE MODEL RESULTS: % INCREASE IN FLOODED AREA (LEFT) AND % INCREASE IN RUNOFF VOLUME (RIGHT) BETWEEN BASELINE AND PROJECTED 2070 FLOODING FOR THE 10-YEAR 24-HR STORM EVENT

Three different flood mitigation scenarios were assessed using the Neponset River Watershed Flood Model to quantify the flood reduction benefits for the 2070 10-yr 24-hr design storm:

- **Scenario 1**: Reducing Impacts from what has already been developed with green infrastructure solutions + Additional stormwater management requirements for large parcels.
- **Scenario 2**: Reducing Impacts from what has already been developed with green infrastructure solutions + Expanding natural systems
- **Scenario 3**: Reducing Impacts from what has already been developed with green infrastructure solutions + Effective stormwater management in areas that might be developed

With action taken, there is the potential to reduce the flooded area and total runoff volume projected, compared to no action. Modeling across three scenarios demonstrated which options may provide the greatest flood reduction potential as a whole but also within specific sub-basins of the watershed.

- At the watershed scale, Scenario 2, which included green Infrastructure solutions, wetland restoration, and upland/pond storage, resulted in the largest reduction in total runoff volume during the 2070 10-year design storm, totaling 41% (compared to no-action). Scenarios 1 and 3 resulted in reductions of 27% and 24%, respectively.
- There is considerable spatial variability in flood reduction benefits associated with the three nature-based scenarios across the various sub-basins of the watershed, with some sub-basins responding favorably to a particular solution while others are barely impacted. For example, Scenario 2 has the greatest flood reduction potential for the Ponkapoag and Massapoag Brook sub-basins, where total runoff volume is expected to decrease by 54%, while in other sub-basins, like Boston – Ashmont and Dedham – Manor and Greenlodge, total runoff volume was reduced by 29%, nearly half, during the same design storm. Figures ES-2 and ES-3 illustrate some of the spatial differences in flood reduction benefits across the 20 sub-basins of the watershed.
- Scenarios 1 and 3 had similar benefits when comparing total runoff volume on a watershed-wide scale, as well as at the sub-basin scale. For example both Scenario 1 and 3 produced a 28% and 31% reduction for sub-basins Boston – Ashmont and Boston – Dorchester. On the other hand, some sub-basins experienced significantly different reductions to those two scenarios. For example Neponset – 1A (Main Street) to Neponset Reservoir experienced a 40% reduction under Scenario 1 but experienced a smaller 31% reduction under Scenario 3.
- In general, Scenario 2 produced the largest flood reduction benefits compared to the other scenarios, in terms of both flooded area and total runoff volume, both a watershed-wide scale and in most individual sub-basins. Ponkapoag Brook, for instance, experienced a 54% reduction in total runoff volume under Scenario 2 compared to 19 and 17% reductions under Scenarios 1 and 3, respectively. However, some sub-basins, actually benefited less from Scenario 2 than the others. For instance, the Neponset – 1A (Main Street) to Neponset Reservoir sub-basin experienced a 40% reduction in total runoff volume under Scenario 1 and a 38% reduction under Scenario 2.

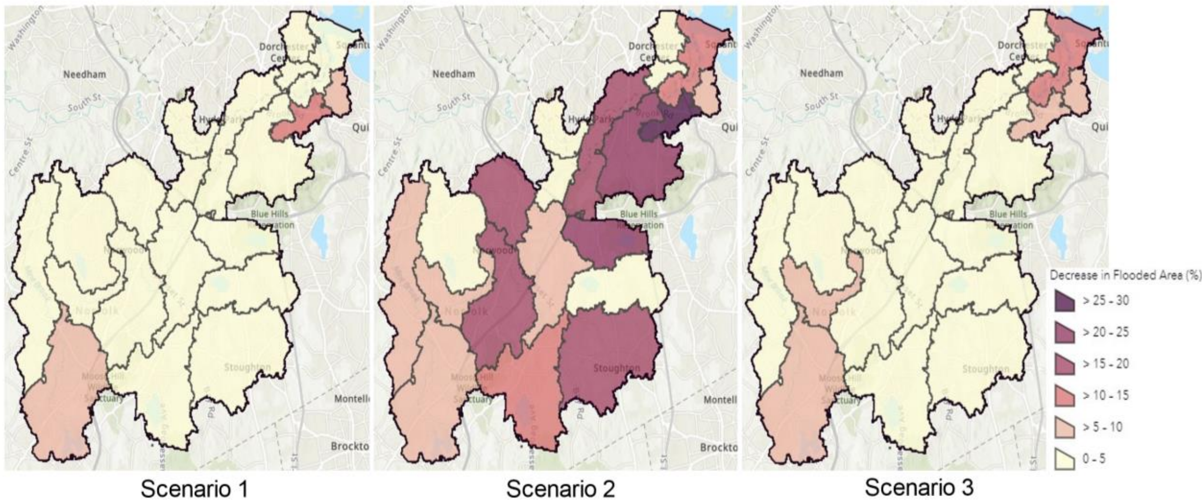

FIGURE ES-2: PERCENT DECREASE IN FLOODED AREA BY SUBWATERSHED

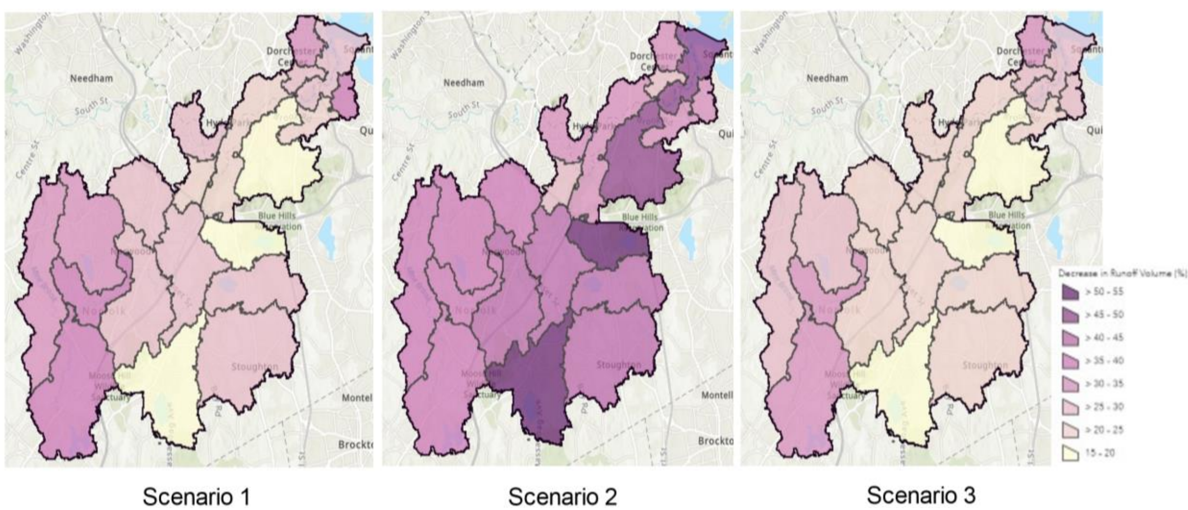

FIGURE ES-3: PERCENT DECREASE IN RUNOFF VOLUME BY SUBWATERSHED

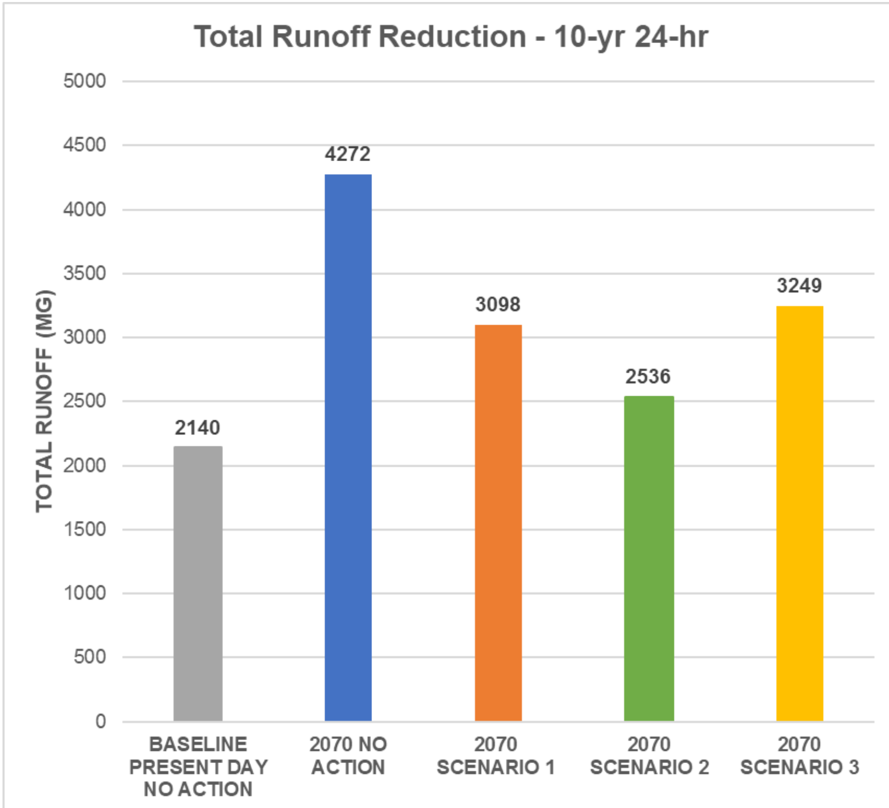

FIGURE ES-4: REDUCTION IN TOTAL RUNOFF VOLUME FROM SCENARIO 1, 2 AND 3 FOR THE NEPONSET RIVER WATERSHED DURING THE 10-YEAR DESIGN STORM

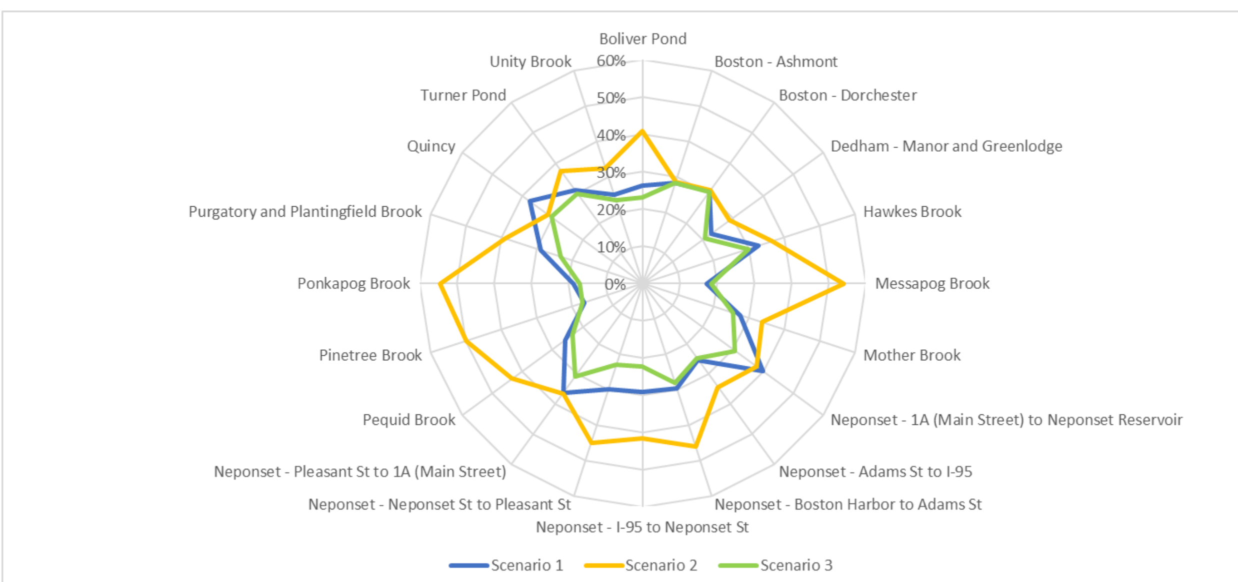

FIGURE ES-5 EFFECTIVENESS OF NATURE-BASED SOLUTIONS, ON A SUB-BASIN BASIS, IN TERMS OF TOTAL WATERSHED RUNOFF VOLUME DURING THE 2070 10-YEAR DESIGN STORM (RADAR CHART)

Co-Benefits and Priorities

In addition to providing flood-mitigation, the strategies outlined above provide myriad ecosystem co-benefits. Co-benefits are generally considered to be beneficial outcomes from the implementation of any one of the strategies outlined above that are not directly related to flood mitigation. Co-benefits of these projects include reducing localized temperatures, improving water quality in waterbodies, increasing groundwater recharge, improving air quality, adding biodiversity and/or pollinators, sequestering carbon, saving energy, creating recreation, gathering, or education; and increasing value of land/property.

The public stated an interest in all of these co-benefits. Many people were particularly supportive of the heat reduction provided by trees and from eliminating impervious surfaces like parking lots. Generally, creation of wildlife habitat was popular with the public, including creating space for bees and pollinators through conservation and restoration actions. Water quality along with the stream flow needed for native fish was supported, as well. Reduction of traffic and more pedestrian friendly spaces with rain gardens, were important to the public.

The community partners reviewed co-benefits and voted on the most important co-benefits for evaluating benefits of flood reduction strategies moving forward. The top five co-benefits identified were:

1. Improved public health/quality of life
2. Improved water quality
3. Reduced localized temperatures
4. Increased groundwater recharge
5. Recreation/education/gathering

Community partners were also asked to rank the most important criteria for selecting flood reduction solutions and ranked the following as most important:

1. Flood reduction from model
2. Feasibility
3. Cost effectiveness
4. Co-benefits
5. Fundability
6. Promotes equity
7. Community support
8. Maintenance effort/frequency

Dedham's Manor Neighborhood

The watershed-wide flood model was refined to a higher resolution for the Manor Neighbor, a flood prone area in Dedham. The model was similar to the Neponset River watershed-wide model, but the 1D and 2D inputs were refined within the project area to include significantly greater spatial detail. The model included individual catch basins and manholes and storm drains as small as 8-inches in diameter.

A finer 2D mesh was used to provide a more detailed representation of flooding extents and depths throughout the Manor Neighborhood.

Flood mitigation strategies were then developed that may help mitigate the impact of current and future flooding in the neighborhood. The refined model helped to identify high priority areas and drainage systems within the neighborhood that would benefit the greatest from flood mitigation. Through a desktop analysis, a series of potential locations and flood mitigations strategies were developed. Next, field investigations were completed to gather more information for each of the potential project locations. Lastly, Dedham staff and residents in the Manor Neighborhood weighed in on the potential mitigation strategies and which would be more feasible and effective for the community.

Three final concepts were modeled to assess their effectiveness at reducing flooding in the Manor Neighborhood. The three concepts were:

1. employing small-scale green infrastructure throughout the Manor Neighborhood drainage area
2. constructing large green infrastructure and underground storage projects on two large town-owned parcels, and
3. retrofitting existing stormwater outfalls which discharge to the adjacent Neponset river wetlands with backflow prevention devices.

An implementation plan for flood mitigation in the Manor neighborhood, which included the future permitting and cost of the mitigation projects, as well as the associated long term maintenance cost and effort, was compiled.

Collaborative Framework Development

The Project Team reviewed and synthesized approximately 46 local plans and reports, including partner communities' MVP Planning reports, hazard mitigation plans, open space and recreation plans and climate action plans to identify climate adaptation priorities. These priorities were synthesized into an overlap matrix, and municipal officials serving on the Framework Steering Committee were convened for a meeting to help further prioritize the adaptation actions in the matrix. Based on this exercise, a draft Framework Document was compiled by the Framework Team, and a second meeting was convened in order to facilitate discussion of the proposed Framework and further refine it. The Final document was circulated to the participating communities and will be discussed in further detail with each town during Phase 2 of the project.

Community Engagement

Community engagement activities included:

- Stakeholder mapping. At the start of the project, the Project Team worked with partner communities and identified community-based organizations working within environmental justice communities and other priority populations. A list was compiled and will be kept as a living document to engage effectively with marginalized communities and ensure their inclusion in projects moving forward.

- Virtual Lower Neponset Focus Group. The Project Team hosted a virtual meeting which included participants from the Lower Neponset River region, representing environmental justice neighborhoods in Boston (Hyde Park and Mattapan). The meeting included discussion about climate impacts, priority concerns in the community, and gaps in community resources that might bolster climate resilience. The primary community liaisons (2 individuals) were compensated for their time spent on organizing and recruiting participants for the focus group.
- Virtual Regional Public Meetings. Two regional public meetings were held. The first introduced the project and, through facilitated discussion, obtained public feedback on flood experiences across the watershed. The second introduced the flood model, provided a status update of other project deliverables and obtained feedback on not only the project, but primary climate concerns of participants, to be further explored in Phase 2 of the project.
- Manor Neighborhood meetings. The Project Team held two in-person meetings with residents of Dedham's Manor Neighborhood. These meetings focused on flooding in the Manor Neighborhood and potential nature-based solutions to reduce it and improve conditions in the area.
- In-person meeting with Readville Neighborhood Watch. Adjacent to the Manor Neighborhood, the Readville Neighborhood of Boston experiences similar flooding issues. The Project Team joined a regularly-scheduled neighborhood meeting to discuss the project and opportunities for building resilience in Readville.
- Public survey. An online public survey was promoted to obtain information about flood experiences across the watershed.
- Elementary school Programming. NepRWA staff visited 97 classes to provide information concerning stormwater flooding and pollution in the context of climate change, as well as the importance of water conservation to 4th and/or 5th graders in each participating community.

Note that each of these public meetings and surveys were publicized in English, Haitian Creole, Portuguese (Brazil), and Spanish via physical fliers, distribution through community organizations, local cable programming, project website, and social media. Press releases (English-only) were also distributed to regional and local publications. Additionally, each student participating in the school program received a brochure for discussion with their families in the same languages.

Climate Resilient Land Use Policy Workshop

Thoughtful land use policies and municipal regulations are critical in keeping current and future residents out of harm's way and minimizing the environmental, infrastructure, and societal impacts of a changing climate as well as future municipal and private sector climate adaptation costs. The Project Team facilitated a technical assistance workshop for partner communities to showcase local land use tools and policies that could strengthen local regulatory authority to address climate impacts. The workshop included an orientation to MAPC's Cliamte Resilience Land Use Toolkit, and presentations highlighting some "best practices" around zoning (permitting and site plan review), floodplain overlays and stormwater management regulations. After the presentations, breakout groups were established to allow participants to engage in a deeper-dive discussion with presenters and practitioners on each topic.

Lessons Learned:

- Despite providing multilingual resources, few utilized the survey or requested interpretation at the meetings in a language other than English. Messaging to these communities needs to be further investigated and more effective means identified.
- There would be a benefit to communities if there was an improved way to track reports of localized flooding that included more detail (when, where, why, how long, how fast, what date/time, what rainstorm, etc.) on a regional level.
- Restoring areas of wetlands and waterbody function have the potential to positively impact the built environment by reducing flooding.
- Wide ranging retrofits of impervious cover using green stormwater infrastructure will make a difference in reducing future potential flood depths and extents, particularly on the sub-basin scale, for small storm events.
- Imposing enhanced stormwater management restrictions, above current practices, on new and redevelopment are a critical part of the equation to long-term flood mitigation.
- This project showed municipal staff these take aways but more work is needed to reach elected and appointed officials with not only educational information about climate impacts and adaptation opportunities, but also the economic benefits of prioritizing them in the near term as they allocate local resources.

Partners and Other Support:

Special thanks to Jason Mammone, Dedham Town Engineer, for leading this project and bringing regional partners together.

Community Partners

The Project Team is grateful to staff members of each partner community who materially participated in one or more core components of this project:

- City of Boston, Environment Department
- Boston Water & Sewer Commission
- Town of Canton
- Town of Dedham
- Town of Foxborough
- Town of Medfield
- Town of Milton
- Town of Norwood
- City of Quincy
- Town of Sharon
- Town of Stoughton
- Town of Walpole
- Town of Westwood

The Project Team included:

- The Metropolitan Area Planning Council (MAPC)
- Neponset River Watershed Association (NepRWA)
- Weston & Sampson

Special thanks to Vivien Morris and Jessie Dambreville of the Edgewater Neighborhood Association for supporting engagement in the Lower Neponset region.

And thank you to Carolyn Mecklenberg and the Municipal Vulnerability Preparedness (MVP) Program, without which this ambitious project could not have been completed.

Project Photos