Canton, MA

Municipal Vulnerability Preparedness Action Grant:

Climate Change Vulnerability and Resiliency Assessment Study

JUNE 2021

CANTON
CLIMATE RESILIENCY

Acknowledgments

Prepared For

TOWN OF CANTON,
MASSACHUSETTS

THE TOWN OF CANTON
DEPARTMENT OF PUBLIC WORKS
(DPW)

Prepared By

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SECTION 1
Executive Summary of Findings and Recommendations

The Town of Canton, MA, with the help of community stakeholders, identified inland flooding as its top priority climate hazard and, in partnership with Kleinfelder, have embarked on a *Climate Change Vulnerability and Resiliency Assessment Study,* funded by a State of MA Municipal Vulnerability Preparedness Program Action Grant RFR ENV 20 MVP 02. Often, flood mitigation studies have been focused around tidally influenced coastal communities. The Town of Canton, being completely inland, is facing a different set of challenges. Canton sits at the bottom of a valley surrounded by the Blue Hills and communities with higher watersheds.

To understand where and why flooding occurs in Town, a model was needed to predict the hydraulic and hydrologic conditions of the area. Building upon its strong Asset Management program and existing stormwater GIS, the Town enhanced existing stormwater asset inventory through field investigations focused in areas where data was needed to better connect the system hydraulically.

Once sufficient field data had been collected, a 2D hydraulic and hydrologic model (H+H model) was built to visualize and predict potential Town-wide flooding both under current and future climate conditions (i.e., 2030 and 2070). Community stakeholders and staff were engaged to vet the flood model predictions, particularly under present-day storm events.

Simultaneous to the flood modeling effort, a Risk Vulnerability Assessment (RVA) was conducted on the Town's critical assets. Assets were classified into three categories: community assets, and vertical and horizontal infrastructure assets. The RVA assessed flood exposure and vulnerability of 150+ critical infrastructure and community assets, and over 56 miles of piped drainage network, identifying the time horizon (e.g., Present Day, 2030, 2070) at which point assets become exposed and the associated flood depths at their respective locations. Using an established Risk Framework from the Town's Asset Management program, the relative risk of flooding for identified assets was evaluated. Proximity to the current and future flooding was the main "likelihood of failure" determinant. The consequence of failure of a particular asset was evaluated based upon a triple bottom line evaluation including cost, community and environmental impacts.

The modeled mitigation alternatives within this analysis include a diverse range of strategies (gray and green stormwater infrastructure for storage, road-raising, nature-based solutions, active reservoir management, non-structural land cover and regulatory change) and scales (e.g., site-specific, neighborhood, catchment, regional), as shown in **Figure 1**.

At a high level, the analysis found that modeled interventions typically did not eliminate all flooding, but in some cases significantly reduced flood depths and provided peak flow attenuation. This finding was primarily due to the drivers of flooding. In most modeled Areas of Interest (AOI), flood magnitudes are driven primarily by terrain factors (rolling topography, connectivity of rivers, streams, and natural storage areas), riverine overbank flooding (watershed-scale flows with large upstream drainage areas in and outside Canton), and localized groundwater conditions, rather than by urban runoff and catchment imperviousness.

Aside from a few specific locations (south of Memorial Field, Messinger Park), modeled large-scale storage systems (i.e., green/gray stormwater infrastructure, increased nature-based storage) did not significantly reduce or eliminate flooding associated with the 2070 10-year recurrence event within AOI. However, the package of mitigation activities do produce significant decreases in peak flow and flood depths for the 2070 100-year event.

The H+H model results indicate that Present Day and 2030 scenarios are similar in terms of flood extents and magnitudes, yet these impacts intensify greatly by 2070. This finding is important as it indicates that actions taken between now and 2070 can help reduce the scale of damages and impacts on critical infrastructure, community assets, and private property. For example, planning for future climate today leaves time for the Town to implement long-term initiatives, such as complex road-raising projects (Neponset Street at Neponset River, Rte. 138 at select crossings, and Washington Street near Pond Street), targeted regulatory/policy to reduce long-term impervious cover, and site-scale resiliency projects that will reduce flood exposure and vulnerability before the projected increases intensify.

In the meantime, specific projects (e.g., green/gray storage projects at Memorial Park and Messinger Park, pipe/catch basin improvements and distributed green infrastructure (GI) in Summer Heights and Dan Road commercial area, culvert maintenance and upsizing at Rte. 138 near D'Angelo, enhanced nature-based storage in Town conservation areas and Town-owned lands) can help the Town achieve multiple objectives (e.g., reduced nuisance flooding, improved water quality and watershed health, ecological/habitat restoration, urban heat island mitigation, and equitable infrastructure investment).

The modeling alternatives analyses can also help prioritize and inform non-structural strategies (e.g., zoning decisions, restrictions on floodable first floor/basement uses for new development or redevelopment activities, freeboard requirements above present-day standard, enhanced wetland/resource area protection standards, and expanded conservation areas) and shape community resilience programs (user group-specific toolkits, resilience hubs, assistance for green infrastructure or flood retrofits for homeowners and community/cultural resources).

Figure 1: An overview of recommended flood mitigation strategies from Canton's MVP Climate Resiliency Project.

SECTION 2
Introduction

The Town of Canton (Town) engaged Kleinfelder in 2020 to assist them with studying the potential impacts and mitigation and resiliency opportunities related to flooding throughout the Town in this *Climate Change Vulnerability and Resiliency Assessment Study (Climate Resiliency Study)*, funded by a Municipal Vulnerability Preparedness (MVP) Action Grant RFR ENV 20 MVP 02. This MVP Action Grant is administered through the Massachusetts Executive Office of Energy and Environmental Affairs (EEA). This study came as a result of the previous MVP Planning Grant work as well as the important asset management and infrastructure improvement work the Town has been performing for several years.

Canton MVP Project Planning

The Town of Canton has proactively developed initiatives to understand, evaluate, and plan for the impacts of climate change through the MVP program. With funding from MVP planning grant (FY18; $24,500), the Town conducted a Community

Resilience Building (CRB) workshop and completed its MVP Planning Report in 2019 (MVP, 2019). The MVP Planning process brought community stakeholders together to identify climate hazards and prioritize potential solutions. It also helped the community understand its critical community assets and resiliency strengths related to infrastructure, community, and the environment.

"The Municipal Vulnerability Preparedness (MVP) grant program created in 2017 as part of Governor Baker's Executive Order 569 provides support for cities and towns in Massachusetts to identify climate hazards, assess vulnerabilities, and develop action plans to improve resilience to climate change. Communities that complete the MVP Planning Grant process become designated as an MVP Community and are eligible for MVP Action Grant funding to implement the priority actions identified through the planning process." (https://resilientma.org/mvp/)

As summarized in the 2019 report (MVP, 2019), Town staff and community stakeholders identified the following as the Town's top four hazards:

- Inland Flooding
- Severe Winter Storms
- Average/Extreme Temperatures
- Other Severe Weather

Of these, stakeholders identified flooding as the highest priority hazard.

Participants in the CRB workshop noted that the Town has areas that are prone to flooding under the present-day extreme storm events and critical community assets that may be at risk or more at risk under future climate conditions. Many of the transportation routes potentially exposed to new (or exacerbated) flooding could impact people's commutes to and from professional hubs such as Boston and/or emergency access to critical medical facilities in neighboring communities. Specifically, the workshop participants identified numerous locations of concern (as shown in **Figure 2**) for inland and riverine flooding, including key emergency access routes (e.g., Neponset Street, Washington Street, Route 138/Turnpike Street, Dedham Street, and Randolph Street). It was also discussed that existing roadway drainage systems are not necessarily adequately sized or designed for future storms.

A few other recommended actions from the CRB workshop included:

- [Action B] Develop a resiliency plan for critical Town-owned buildings
- [Action D] Focus on a flooding risk assessment and pre-planning for projected flooding impacts including emergency energy supplies
- Identify evacuation routes impacted by hazards
- Identify and provide generators for facilities that serve vulnerable populations
- Ensure maintenance of dams located on private property
- Protect wells from contamination on private properties abutting wetlands, or that are part of critical watershed
- Protect water bodies adjacent to industrial sites where natural resources are particularly vulnerable during extreme precipitation events (with increased rainfall, participants were concerned that pollution from roadway, residential storage of contaminants, and industrial site runoff would exacerbate existing issues)

At the end of the MVP Planning phase, the Town reached consensus around priority actions to integrate climate resilience in the Town's planning, operations, policies, and capital programs.

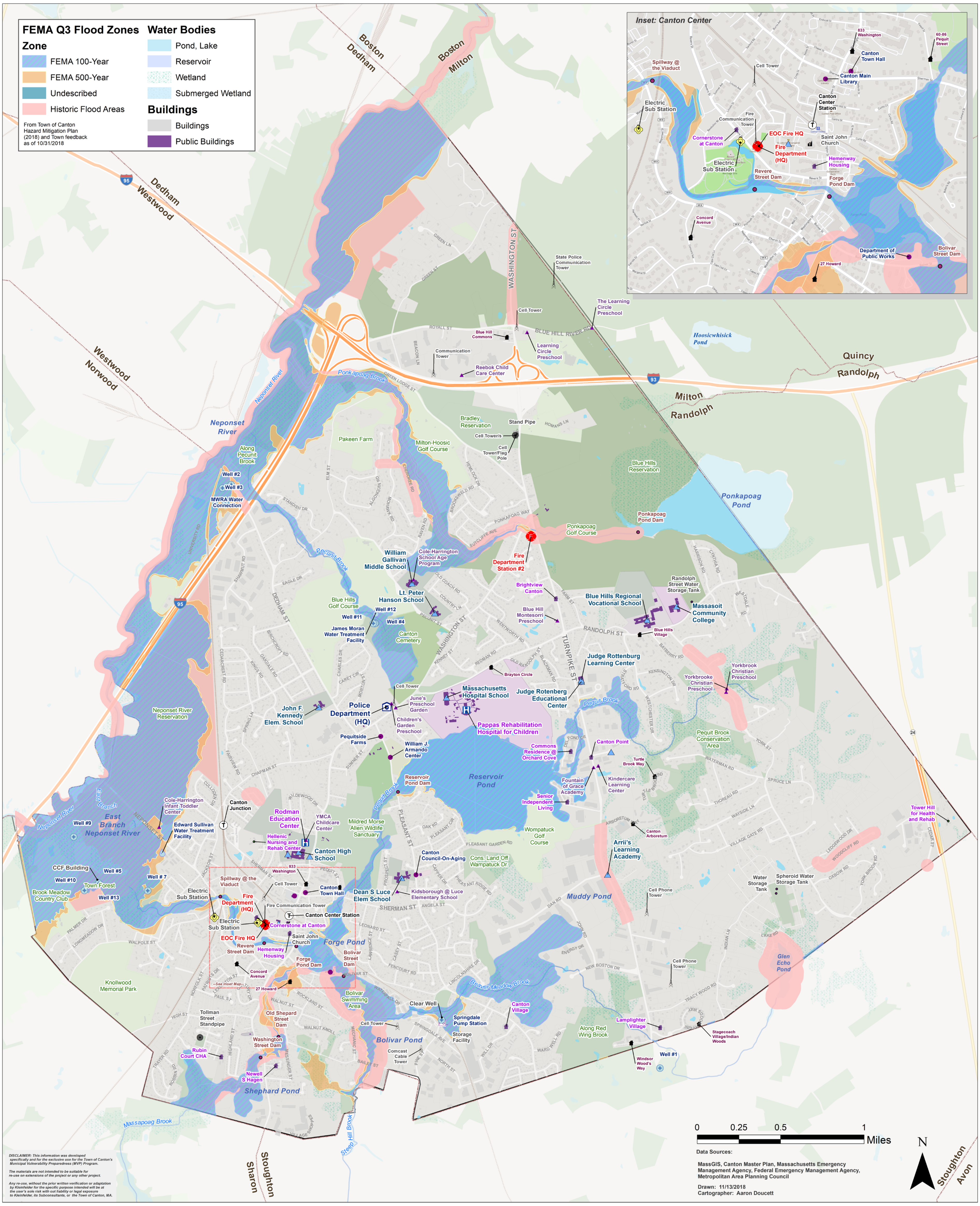

Figure 2: Canton Flood Risk Areas Previously Identified from MVP Planning Report (Kleinfelder, 2018).

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Past Work on Flooding, Hazard Mitigation, and Stormwater Management in Canton

Following intense storm events in 2006 and 2010, the Town has invested in several flood mitigation projects, dam spillway upgrades, and culvert projects that have reduced flooding near Shepard Pond Dam, Old Shepard Street Dam, Bolivar Street (near Bolivar Pond "beach" and the Town Pool), and Elm Street.

In 2014, the Town produced a Stormwater Master Plan, which accompanied Canton's Water System Master Plan and Comprehensive Wastewater Management Plan (CWMP), and demonstrated the Town's commitment and progress toward an Integrated Water Resources Management Program (IWRMP).

The Stormwater Master Plan, which included the Town's Stormwater Management Plan (SWMP) for its municipal separate storm sewer system (MS4) permit compliance, also provided a detailed drainage system condition assessment and mapping. The Master Plan included additional assessments to evaluate infrastructure investment demands for both water quality and water quantity (i.e., flooding).

Since the Stormwater Master Plan was published, the Town has begun the planning, design, and construction of numerous structural stormwater best management practices (BMPs), primarily with a focus on green infrastructure, water quality, and sustainable water management:

- A 2016 Sustainable Water Management Initiative (SWMI) Grant leveraged Massachusetts Department of Environmental Protection (MassDEP) funding to evaluate the potential of stormwater/green infrastructure (GI) retrofits, such as bioretention, at over 50 Town locations to improve baseflow and recharge, improve water quality, and provide flood storage.
- In December 2017 (in partnership with Neponset River Watershed Association (NepRWA)) the Town was awarded a 319 Grant from MassDEP and Environmental Protection Agency (EPA) to fund the construction of rain gardens and other GI at Devoll Field and Luce Elementary School.
- In 2018, with 319 Grant funding from MassDEP and EPA, the Town completed the Pequit (Upper and Lower Pequit) and Beaver Meadow Brook BMP Retrofit Project, which created a Watershed-based Plan for these watershed catchments. Elements F & G of the plan specified an interim milestone to identify an additional six to nine stormwater BMPs in these catchments by 2026.
- The Town has identified four additional priority locations (Galvin School, Hansen School, Ponkapoag Parking Lot, and Canton High School) for near-term GI projects in its Capital Improvement Plan.

In 2017, the Town incorporated stormwater drainage infrastructure into its risk assessment framework developed through its asset management program and as summarized in the *Canton Asset Management Program (CAMP) Year 3 Implementation Report,* 2017. This framework had previously been used primarily for evaluating the probability and consequence of failure of the Town's drinking water and wastewater system assets. The initial risk assessment was performed spatially and informed by several economic, environmental, and physical condition attributes (i.e., asset size and age, proximity to wetlands, recreational uses, and FEMA flood hazard areas). The Town recently updated its Hazard Mitigation Plan (HMP) in 2018 (HMP, 2018), specifically identifying Town-owned critical facilities and infrastructure assets located with the FEMA Special Flood Hazard Area (SFHA), and/or within localized hotspots with known past flooding. These facilities and past flooding hotspots are identified within Table 5-9 and Table 6-1 within the HMP, respectively.

Additionally, the Town is undertaking multiple planning efforts that could help mitigate the effects of climate related hazards. Some of these efforts include updates to the Town's Master Plan, Open Space and Recreation Plan, Emergency Management Plan (with support from Massachusetts Emergency Management Agency), and 2020 Preliminary Flood Insurance Rate Map (PFIRM) revisions (with support from FEMA), and Municipal Sustainability Committee.

Climate Change Vulnerability and Resiliency Assessment (FY20 MVP Action Grant)

A key takeaway from the 2018 MVP Planning Report identified flooding as the community's highest priority hazard. As an outcome of the MVP Planning process, the Town acted immediately on this, prioritizing an assessment of climate change impacts on flooding and potential adaptation/resiliency measures, forming the basis for the current MVP Action Grant project detailed in this report.

This current project, the Climate Resiliency Study, includes many of the core principles set out in the MVP program. The main objective of the Climate Resiliency Study has been to perform a town-wide evaluation of flooding and risk vulnerability assessment of critical infrastructure that would inform the identification of potential mitigation and/or resiliency strategies to address flood risks. The specific project scope for the FY20 MVP Action Grant included the following:

- Collect drainage system data to update the Town's GIS dataset (including pipes and manholes), based on a review of record drawings and field data collection
- Develop a detailed Town-wide two-dimensional drainage model (hydrologic and hydraulic model)
- Use model results and flood exposure maps to identify vulnerable critical infrastructure and community assets, as well as the Town's storm drain system
- Develop recommended actions and strategies to reduce flood risk to vulnerable areas, promoting equitable solutions, inclusive of nature-based solutions and green infrastructure
- Conduct public outreach and education on flooding risks as well as to share study results with the residents. Outreach efforts are highlighted in gray standalone boxes, located in various chapters throughout this report. The first box is found on Page 13.

<u>MVP Program 9 Core Principles:</u>

- Furthering a community identified priority action to address climate change impacts
- Utilizing climate change data for proactive solution
- Employing nature-based solutions (NBS)
- Increasing equitable outcomes for and supporting strong partnerships with Environmental Justice Populations and Climate Vulnerable populations
- Conducting robust community engagement
- Achieving broad and multiple community benefits
- Committing to monitoring project success and maintain the project into the future
- Utilizing regional solutions toward regional benefit
- Pursuing innovative, transferable approaches

This project was completed by the Town of Canton between January 2020 and June 2021 in collaboration with Kleinfelder. Project Team members included:

Town of Canton, MA

- Mike Trotta, DPW Superintendent
- Jay Mello, Town Engineer
- Laura Smead, AICP, Town Planner
- Lisa Grega, Assistant Town Engineer

Kleinfelder

- Courtney Eaton, PE, ENV SP, Project Manager
- Kyle Johnson, Climate Resiliency/Green Infrastructure Engineer
- Kenneth Yu, Hydrologic and Hydraulic Modeler
- Kristen Caracappa, Hydrologic and Hydraulic Modeler
- Bella Purdy, Climate Resiliency Planner
- Polly Crocker, PE, Water Resources Engineer
- Muriel Wixson, Communications and Community Outreach Lead

Massachusetts Office of Energy and Environmental Affairs

- Carolyn Mecklenberg, Regional MVP Coordinator

STAKEHOLDER ENGAGEMENT

What Canton did:

The Town developed a Flood Mitigation webpage, www.town.canton.ma.us/869/Flood-Mitigation, which features information about:

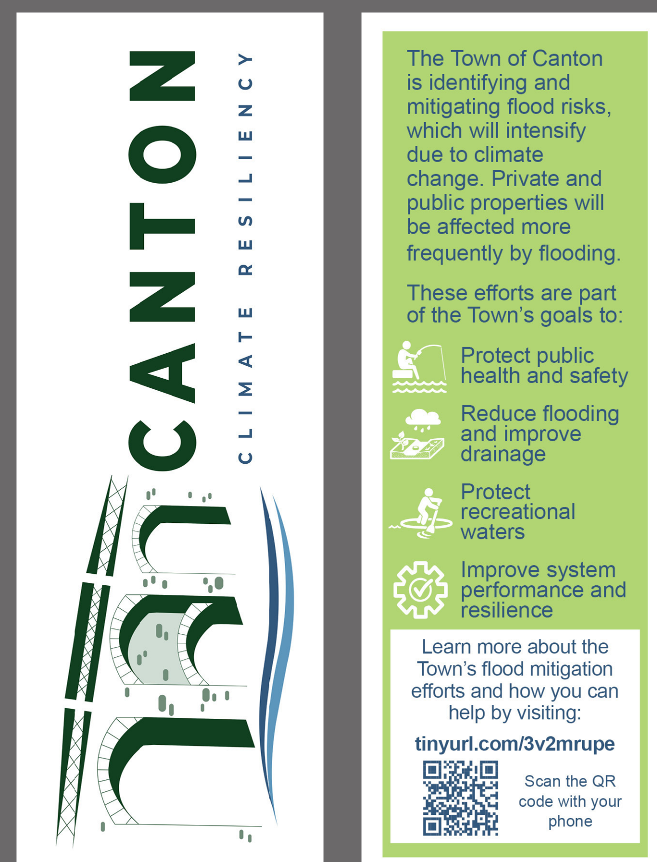
- Climate change and stormwater and what the Town is doing to address flooding
- What the Town DPW is already doing to address flooding
- How to submit feedback on flooding
- What residents and business owners can do to mitigate the effects of climate change and flooding
- Additional resources

The Town developed an evergreen bookmark that showcases the project logo especially created for this project along with a brief message on the back with a link to the Flood Mitigation webpage.

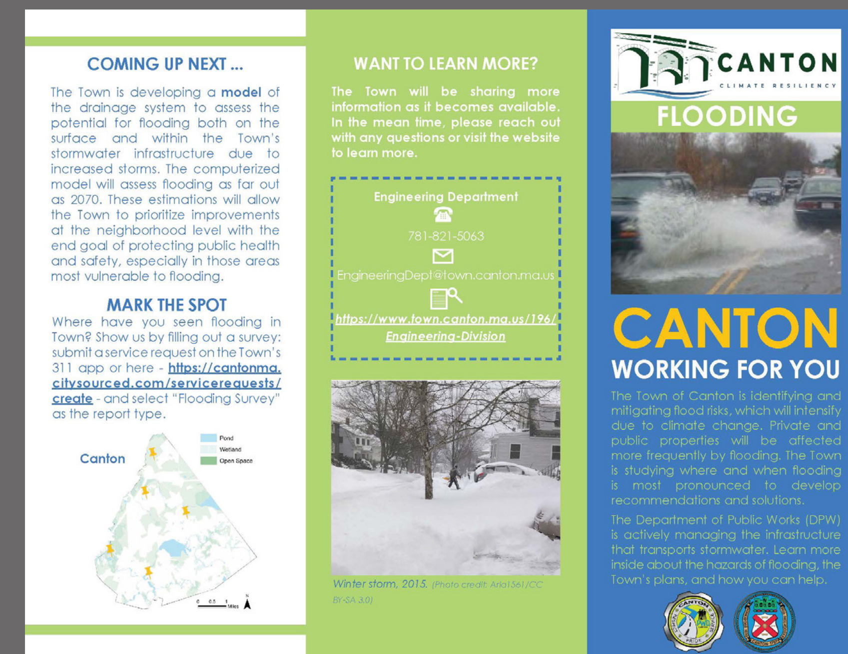
The Town also posted on its Facebook pages from December 2020 through June 2020 on the following topics related to flooding:

- December: How to fill out the flooding survey
- January: Where to find the flooding brochure on the Flood Mitigation website
- February: How clearing storm drains will help mitigate flooding
- March: A resource for building a rain barrel
- April: How to fill out the flooding survey
- May: A resource for planting a rain garden
- June: How to become a storm drain steward and help clear debris from the grate to minimize flooding

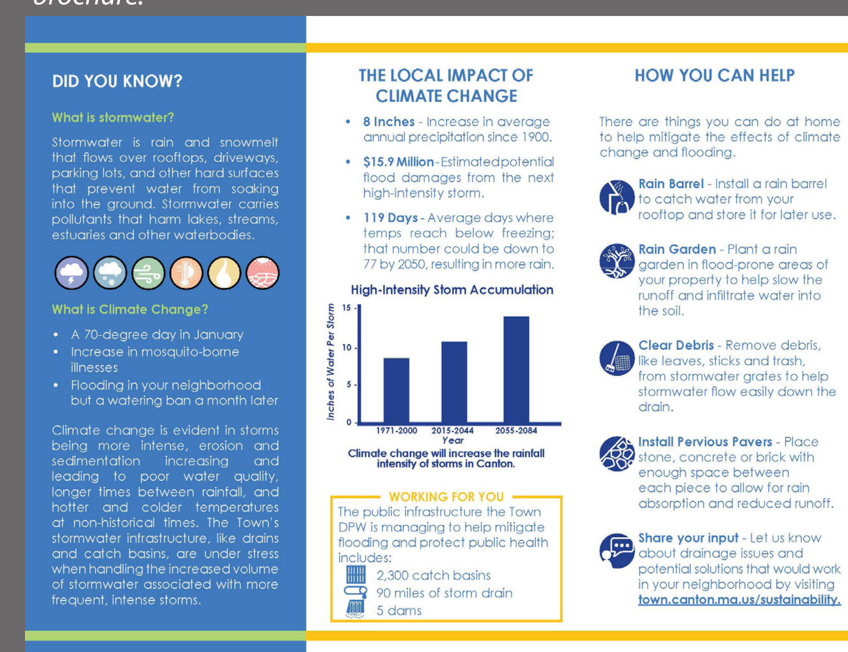
The Town also developed a brochure for viewing on the Flood Mitigation site and for neighborhood-specific distribution in the future. The brochure highlights how the Town is working to mitigate flooding; how climate change is exacerbating the issue; how residents and business owners can help; how to submit feedback; and how to learn more information about flood mitigation.



The front (left) and back (right) of the bookmark.



The outside (above) and inside (below) of the Town's flood mitigation brochure.



Next steps:

The Town's Flood Mitigation webpage will serve as a catchall page for stormwater and flooding information.

The bookmark can be printed and distributed at events, as a handout at stationary exhibits throughout Town, or as part of a mailer. The evergreen messaging allows the Town to use this material well after the grant period has passed.

The social media posts developed during the project are evergreen and could be used again in the future by the Town.

The Town can use the brochure as a template for future brochures related to flooding or other topics.

SECTION 3
Drainage Network Data Collection

The purpose of the field program was to gather invert elevation data and confirm pipe material and diameter throughout the Town of Canton's stormwater system, as well as to verify system connectivity and direction of flow. The collected drawing and field data was used to update the Town's stormwater GIS database. This stormwater database was then used to develop a calibrated hydraulic model of the Town's stormwater system, which informed the vulnerability assessment of the system to future climate conditions, specifically related to flooding. A detailed summary of the data collection and GIS database updates are included in a memo titled *Town MVP Field Data Collection in the Town of Canton*, dated February 2021. A summary of how that data contributed to the overall Kleinfelder, 2021 Climate Resiliency Study is included here.

Data Collection/Stormwater GIS Updates

Record drawing review, field investigations, and data collection were completed by Kleinfelder field staff with support from Town staff between May and September 2020. The Team focused on areas with large diameter pipes (i.e., pipes larger than 18-inch diameter) where there were gaps in the existing GIS stormwater system data that would have been critical for model connectivity. For each drainage asset surveyed, including drain manholes and pipes, data on rim elevation, depth to invert, and downstream invert elevation were collected. The field data was imported from the GPS unit (used to geolocate the surveyed data points) into Excel.

Through the GIS update and initial model development process, additional selected smaller pipes (i.e., 12- and 15-inch diameter) were also included to improve the overall model performance and resolution. In total, the field staff were able to collect data for 411 features including 392 drain manholes and 19 outfalls, helping digitize, verify, and significantly update piped drainage system data. Once the GIS database was updated with all collected relevant field information, the GIS database was integrated into PCSWMM, the hydrologic and hydraulic modeling software that was used to characterize performance of the Town's stormwater infrastructure system during present-day and future climate scenarios. After initial calibration of the model, the Team determined that sufficient field data had been collected to adequately calibrate the model at the established granularity of the model. Therefore, no further field data collection was necessary for the purposes of this study. The Town also continues to collect updated outfall information during its required stormwater system monitoring efforts and is adding that updated information into the Town's stormwater GIS database that could be used in future modeling efforts.

STAKEHOLDER ENGAGEMENT

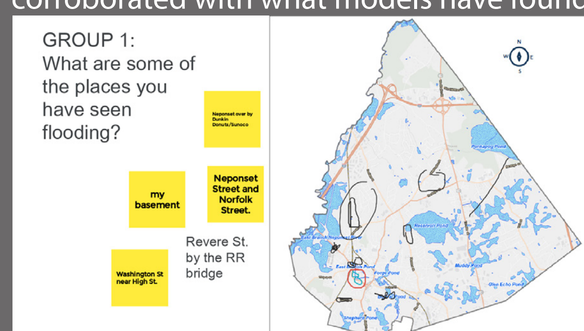
What Canton did:

The Town launched a flooding survey on its 311 app in November of 2020.
The survey asks participants for:

- Location of flooding
- Length of time flooding occurred
- How often flooding is seen in the area
- Depth of flooding
- Description of flood water

The Town received nearly 10 responses. The response area varied in location. The data from the survey responses was used to corroborate the data from the flood models.

The Town also hosted an interactive virtual public meeting on March 23, 2021, when attendees shared where they have seen flooding in Town (below). Most of the respondents identified areas in the southwest part of Town, which corroborated with what models have found.



Next steps:

The survey will remain active and will continue to serve as a useful tool for the Town's flood mitigation efforts beyond the MVP action grant lifespan.

SECTION 4
Flood Model Development

A Town-wide 1-Dimensional (1D)/2-Dimensional (2D) hydrologic + hydraulic (H+H) stormwater model was developed using EPA-SWMM based software to evaluate potential future flood impacts within the Town's boundary. The 1D-2D model served as a foundation to analyze stormwater system performance under existing conditions as well as future climate scenarios. The model was used to evaluate system performance to understand baseline flooding under current and future climate conditions as well as to explore the potential flood reduction that might be realized with proposed mitigation strategies.

The Town-wide model began with a 1D base that explicitly modeled hydraulics such as open channel and culverted flows from the major tributaries to the East Branch of the Neponset River, including Massapoag Brook, Ponkapoag Brook, Beaver Meadow Brook, Wing Brook and Steep Hill Brook. For hydrology, the model incorporates parameters such as impervious cover percentage, land use type, slope, native soil types, and other catchment characteristics. To incorporate the Town's piped infrastructure, a simplified network of the Town's drainage system was represented by a combination of drain pipes and open channels. Stormwater drainage pipes larger than or equal to 18 inches in diameter (**Figure 3**) were explicitly modeled, along with some selected 12- and 15-inch pipes that are critical to ensure the overall connectivity of the system and robustness of the hydraulics within the Town's drainage system.

The base 1D model was then improved to a 1D-2D integrated H+H model to help visualize surface flooding on a model mesh. The mesh was developed using LiDAR terrain data (source: 2011 LiDAR for the Northeast[1]) to represent surface terrain at a resolution approximately 25 to 50 feet. Modeled stormwater runoff was then linked to a gridded 2D surface mesh, representing gravity flow, head loss, and surcharge throughout river-, stream-, and piped-infrastructure networks. The 2D H+H model allows for detailed analysis, identifying where surcharge conditions may result in overbank flooding, urbanized infrastructure flooding (i.e., infrastructure capacity-driven flooding), and/or groundwater flooding.

The Town's 1D-2D integrated H+H model also includes major ponds and reservoirs, such as Bolivar Pond, Forge Pond, Shepard and Silk Mill ponds, as well as Reservoir Pond and its upstream tributaries (i.e., York and Pequit brooks). Upstream tributary areas are bounded in the model domain by the East Branch Neponset River to the west, Sharon from the southwest, Stoughton from the southeast, Randolph from the east, and Blue Hills Reservation (Milton) from the north.

The Town-wide H+H model includes 518 sub-catchments connected to the simplified network, which simulates the hydrology in the watershed. Most of these catchments are between 15 and 45 acres in size, with a median sub-catchment size of 28 acres. In specific areas identified during the model calibration process, additional resolution was added to the 2D surface mesh to correct overland flow paths, in proximity to recent development projects where fill conditions were not accurately captured by the LiDAR data.

The Town-wide H+H model includes 518 sub-catchments connected to the simplified network, which simulates the hydrology in the watershed. Most of these catchments are between 15 and 45 acres in size, with a median sub-catchment size of 28 acres. In specific areas identified during the model calibration process, additional resolution was added to the 2D surface mesh to correct overland flow paths, in proximity to recent development projects where fill conditions were not accurately captured by the LiDAR data.

Model Calibration / Assumptions

Kleinfelder included the entire Town of Canton and upper reaches of the Neponset River watershed into Sharon and Stoughton in the 1D model. Before a 2D surface mesh was added to the 1D model, a series of calibrations was conducted to improve the accuracy of the 1D model. 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.

Three USGS water stream gage locations with observed stream flow or depth were referenced for the calibration, summarized in **Table 1** and presented in **Figure 3**.

1 https://www.mass.gov/info-details/massgis-data-lidar-terrain-data

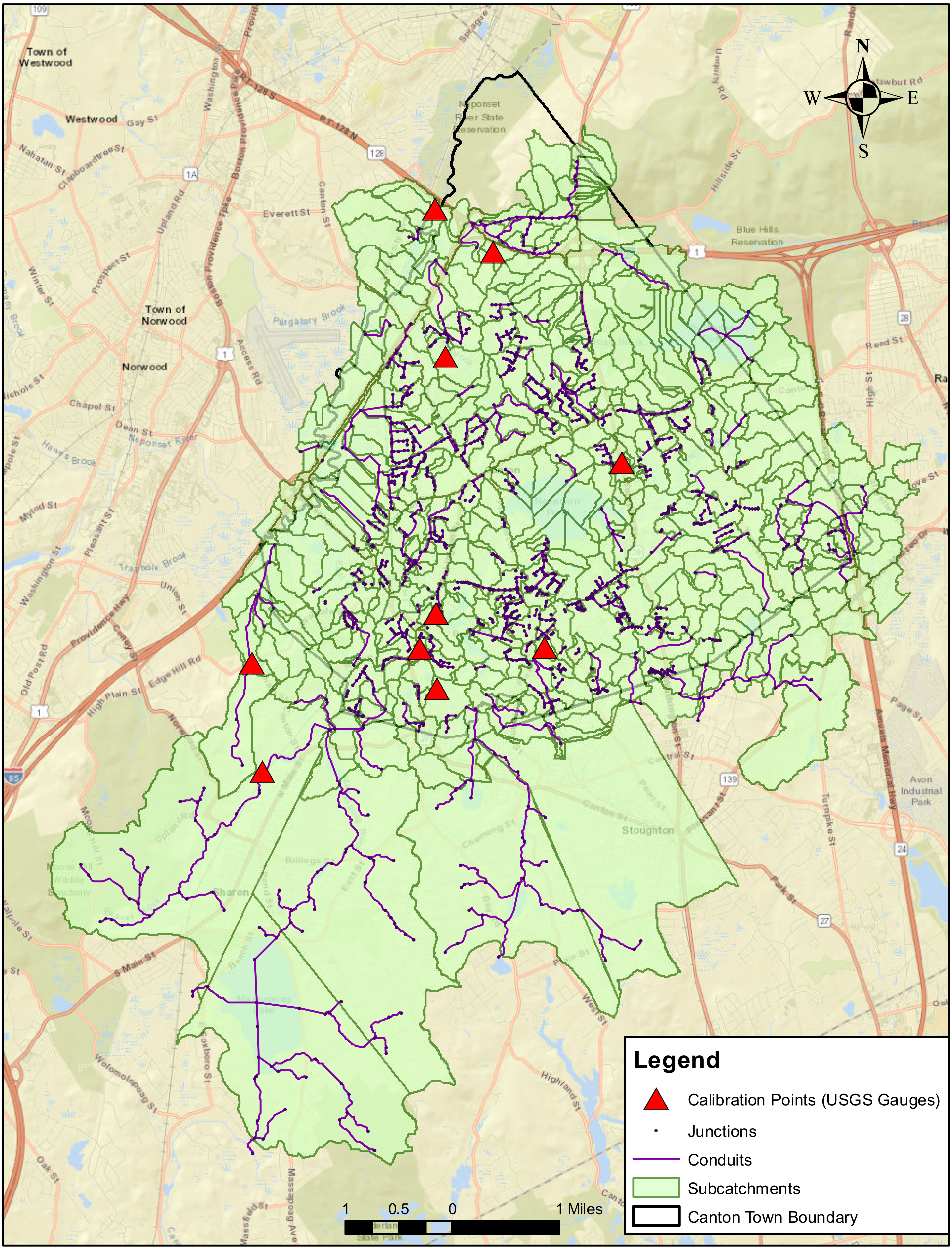


Figure 3: A simplified graphic representation of Town of Canton PCSWMM 2D H+H model.

The three USGS water stream gauge locations provide the necessary stream flow and depth data to calibration the model. Observed data from these gage locations were compared with simulation results using, and the H+H model was adjusted such that simulation results are within 10% of the observed flow data.

The Neponset River gage provides observed data to configure a boundary condition at the most downstream end of the H+H model, while the East Branch Neponset River gage provides observed data to calibrate flows immediately downstream of Forge Pond. The Ponkapoag Brook gage provides data for stream flows in the northern portion of the Town.

Note that the Town does not maintain any flow monitoring program within its drainage system. There is no observed flow or depth data available for locations upstream of Forge Pond, which encompasses a large tributary area including flows from Reservoir Pond and the eastern portion of Canton, as well as flows from Sharon and Stoughton.

Areas upstream of Forge Pond, such as Pequit Brook, Massapoag Brook, and Beaver Meadow Brook can expect to have larger flow and depth variations from observed data if such data becomes available. Should the Town acquire observed data for these areas, the data can be used to improve the calibration of the H+H model to better simulation conditions upstream of Forge Pond.

Model Validation

In addition to the aforementioned information, Kleinfelder also compared 100-year results with those shown in the FEMA FIRM maps for Canton, recently updated in 2020.

As part of this validation exercise, modeled flood extents were also compared directly to existing FEMA SFHA areas (i.e., 1% annual exceedance zones), the FEMA PFIRM maps (2020 versions; under review), and First Street Foundation's Flood Factor model. While the two FEMA sources have insurance rate implications and are focused on riverine flooding, the Flood Factor model was considered a proxy model for urbanized (pluvial) flooding as it provides future scenario modeling (2030 and 2050) that estimates

Table 1: USGS Stream Gages referenced for calibration

Stream	Gage ID	Location	Google Maps location pin
Neponset River	01105554	At Green Lodge Street	https://goo.gl/maps/Lab5eLJKo9gXKa859
Ponkapoag Brook	011055525	Upstream of Rt. 138 Crossing	https://goo.gl/maps/GKCZdonimwNSDkEEA
East Branch Neponset River	01105550	Washington Street Downstream of Forge Pond	https://goo.gl/maps/Cj94qgnhFNs

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precipitation-driven flooding at the property level. However, the Flood Factor model is a nation-wide model that generalizes urban hydrology and does not explicitly model piped infrastructure or calibrate to local waterway conditions or other catchment-scale factors (such as soil and groundwater conditions).

In general, there was a lot of agreement between all four mapping analyses (FEMA existing FIRMs, FEMA 2020 PFIRMs, First Street Foundation model, and Canton's Town-wide 2D H+H model), suggesting that a lot of the modeled/observed flooding is driven primarily by terrain and groundwater conditions, as well as riverine flooding – as opposed to urbanization and catchment imperviousness. A series of maps, comparing the Canton Town-wide model to the FEMA existing FIRMs, PFIRMs, and Flood Factor mode are provided in **Appendix A**.

Precipitation Scenarios

The Town of Canton H+H model was used to conduct simulations for a total of six (6) different storm scenarios, each focused on a 24-hour duration storm event. For three (3) distinct time horizons (Present Day, 2030, and 2070), the 10-year and 100-year recurrence events (i.e., events of 10% and 1% probability exceedance, respectively) were modeled.

Modeling precipitation variability across future timeframes is necessary in projecting future climate change impacts on storm events. States in the Northeast are already seeing large downpours increasing, with more precipitation occurring during the heaviest events[2]. This trend is projected to continue and intensify, as warmer air holds more moisture, increasing the probability of future "cloudburst" events, or larger total rainfall volumes. **Figure 4** depicts a straightforward way to visualize the scale of precipitation change between time horizons (i.e., Present Day vs. 2030 vs. 2070), and its impact on shifting the frequency of flooding events commonly used for planning and engineering design.

For the purposes of this project, to adjust for future precipitation factoring climate change, it was agreed that precipitation data generated from recent downscaling analysis performed by Kleinfelder for the City of Cambridge would be sufficient. More specifically, it was determined that the effort to downscale precipitation data specifically for Town of Canton was not necessary for the purposes of this analysis, as these two communities are in close proximity to one another geographically (under 30 miles), and any localized differences in storm magnitude would likely be outsized by the bounds of uncertainty for such projections.

Each of the storm scenarios were modeled using an SCS Type III distribution for storm profile. The total precipitation volumes used in this modeling analysis are summarized for each scenario in **Table 2**.

The scenarios and timeframes in **Table 2** were chosen for several reasons.

1. First, it was necessary to produce baseline (Present Day) scenarios with the new model, as this H+H model provides different data for present day flooding than the FEMA Flood Insurance Rate Maps (FIRM maps), which were established for flood insurance rate-setting purposes and not planning (although they are often used for such purposes).

2 https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing#tab2-images

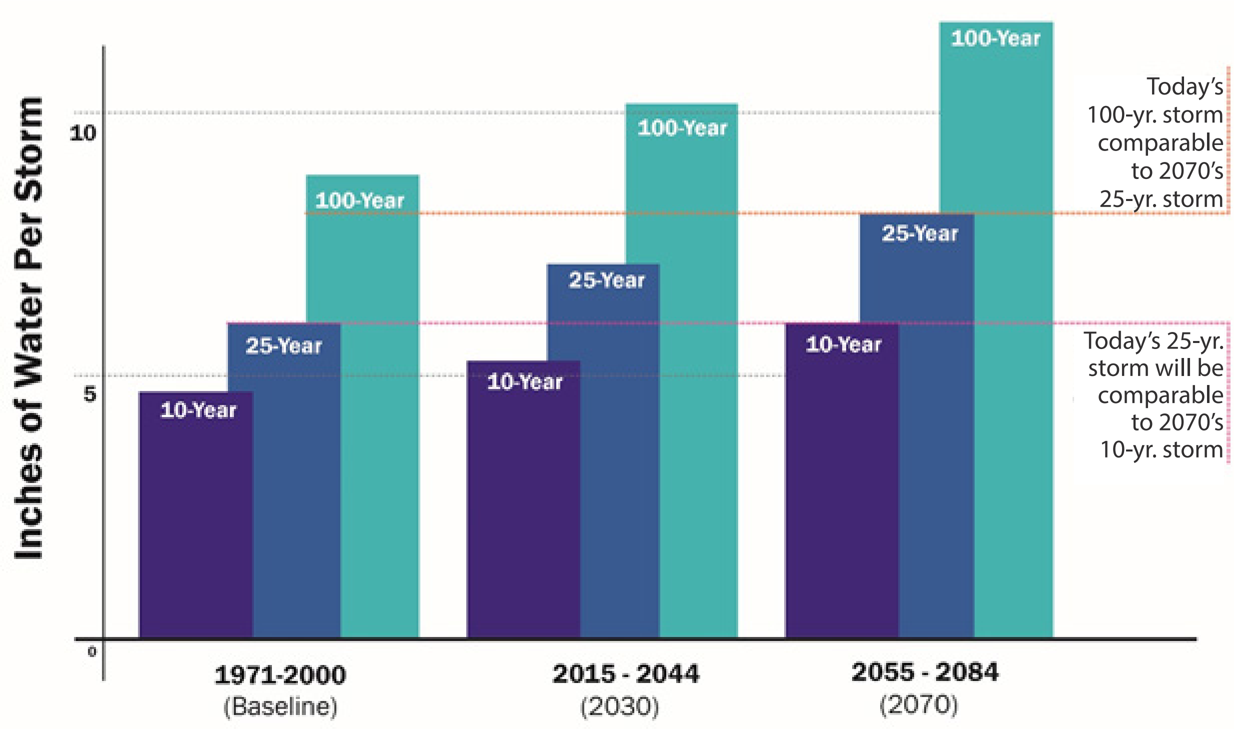

Figure 4: Projected impacts of climate change on precipitation volume during heavy events (image/data source: Cambridge CCVA Part 1; Kleinfelder based on ATMOS projections, Nov. 2015)

Table 2: Precipitation scenarios modeled for Town of Canton H+H model

Scenario (time horizon, recurrence, duration)	Total Precipitation (in.)
Present Day, 10-year, 24-hour	4.91
2030, 10-year, 24-hour	5.63
2070, 10-year, 24-hour	6.38
Present Day, 100-year, 24-hour	8.88
2030, 100-year, 24-hour	10.19
2070, 100-year, 24-hour	11.70

Significant limitations exist with the FEMA flood mapping products. For example, FEMA's flood risks maps do not factor the effects of piped infrastructure flooding and are particularly limited in areas outside the Special Flood Hazard Area (SFHA) floodplains, such as upland urbanized neighborhoods, which experience pluvial flooding. The coverage of FEMA FIRM maps are limited to large and infrequent historic events (i.e., 100- and 500-year recurrence), focusing on riverine flooding, and are not the most practical for flood mitigation planning for urban infrastructure solutions.

2. Second, it was determined that the 10-year recurrence event (i.e., the 10-year, 24-hour storm) was a proper starting point for analysis of piped infrastructure and urbanized area flooding, as most stormwater drainage systems (inlet and pipe conveyance capacity) are commonly designed by engineers for events of such frequency, as it has often been viewed as inefficient or cost-prohibitive to design for larger, rarer events. However, the impacts of climate change on precipitation amounts and storm profiles (i.e., increased rainfall intensity, flash flooding or "cloudburst" events) have been increasing in the past few decades and are at the forefront of Town personnel and residents' minds having observed — or been impacted by — flooding impacts from a recent flash flood event impacting Norwood Hospital in Canton's neighboring community in June 2020. While the H+H model's 2D grid does not yet have the necessary resolution to perform short duration storm (i.e., urban infrastructure flooding from cloudburst or flash flood events), it was determined that the 10-year recurrence event was a good basis for understanding existing stormwater drainage system performance and baseline flooding.

3. While analysis of 10-year recurrence event flooding may be more immediately beneficial in evaluating the efficacy of gray and green infrastructure strategies, it was also considered important to evaluate town-wide flooding for the 100-year recurrence event (i.e., the 1% exceedance event, or "100-year storm"). This storm event was of particular interest in Canton, given ongoing coordination with FEMA on the 2020 Preliminary Flood Insurance Rate Map (PFIRM) revisions, which have increased the extents of riverine floodplains (particularly in eastern parts of Canton, including along Ponkapoag Brook, York Brook, Pequit Brook, and Red Wing Brook).

While the FEMA maps do not include piped infrastructure flooding, the 2D H+H provides an additional dataset for comparison and confidence in floodplain mapping in these catchments.

4. Of particular interest in this MVP project was the new H+H model's ability to model future storm events, projecting the added impacts of climate change on flooding. Such scenario modeling is not included in FEMA's FIRM mapping scenarios, as the FIRM maps were developed based on stochastic data methods and do not account for the changing nature of flood risk through increased precipitation frequency and volumes with future climate change. For this effort, it was determined that future modeled storm scenarios would include the 10-year and 100-year recurrence events at two future timeframes: 2030 and 2070. This was done to evaluate the shifting flood impacts over time and to help further prioritize future actions based on the immediacy of increased flood risk at specific locations and assets.

Summary of Preliminary Flood Modeling (Baseline and Pre-Implementation model runs)

Preliminary flood modeling results were compiled for the six (6) scenarios described in the previous section and were vetted by the project team over the course of two meetings in April and May 2021, respectively. Town officials provided preliminary feedback on modeled flooding for the Present Day 10-year and 100-year floodplains, based on past observed flooding by Public Works, Planning, and other Town department staff. These preliminary modeling results were further "ground-truthed" against past known flooding hotspots (those identified in the Town's Hazard Mitigation Plan and Stormwater Master Plan), as well as other past documentation of flooding (e.g., recent web articles and anecdotal accounts from residents).

Figure 5 through **Figure 10** on the following pages show the six modeled precipitation scenarios (i.e., maps showing flood extents and depths prior to applying any modeled mitigation strategies). These flood map projections served as the basis for the remaining work of the study, as discussed in the following sections. Particularly, when overlayed with critical community infrastructure and assets, they were used to identify areas of focus for the analysis of potential flood mitigation analysis.

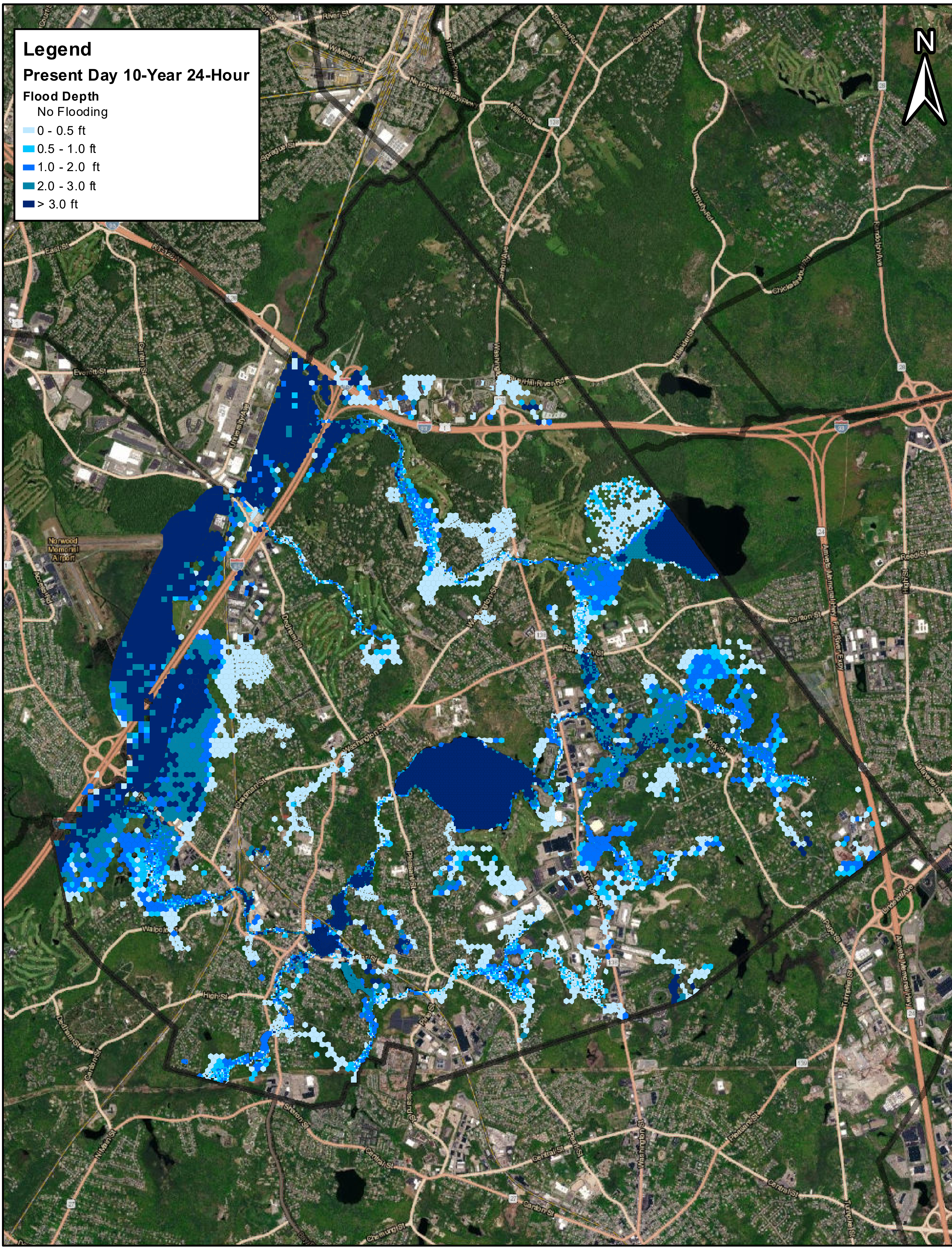

Figure 5: Present Day (Baseline) 10-year, 24-hour recurrent event modeled flooding (Precipitation = 4.91”)

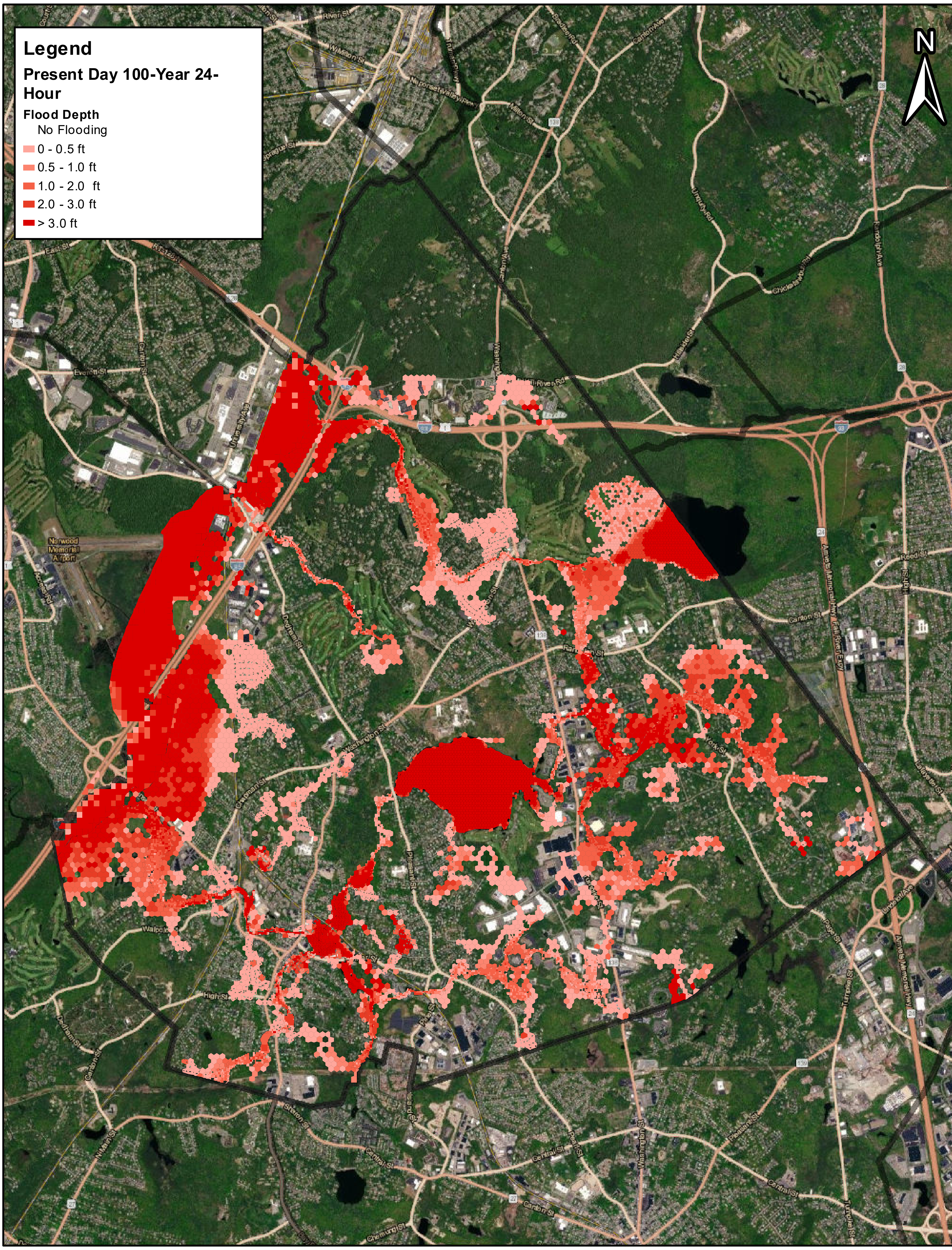

Figure 6: Present Day (Baseline) 100-year 24-hour recurrence event modeled flooding (Precipitation = 5.63")

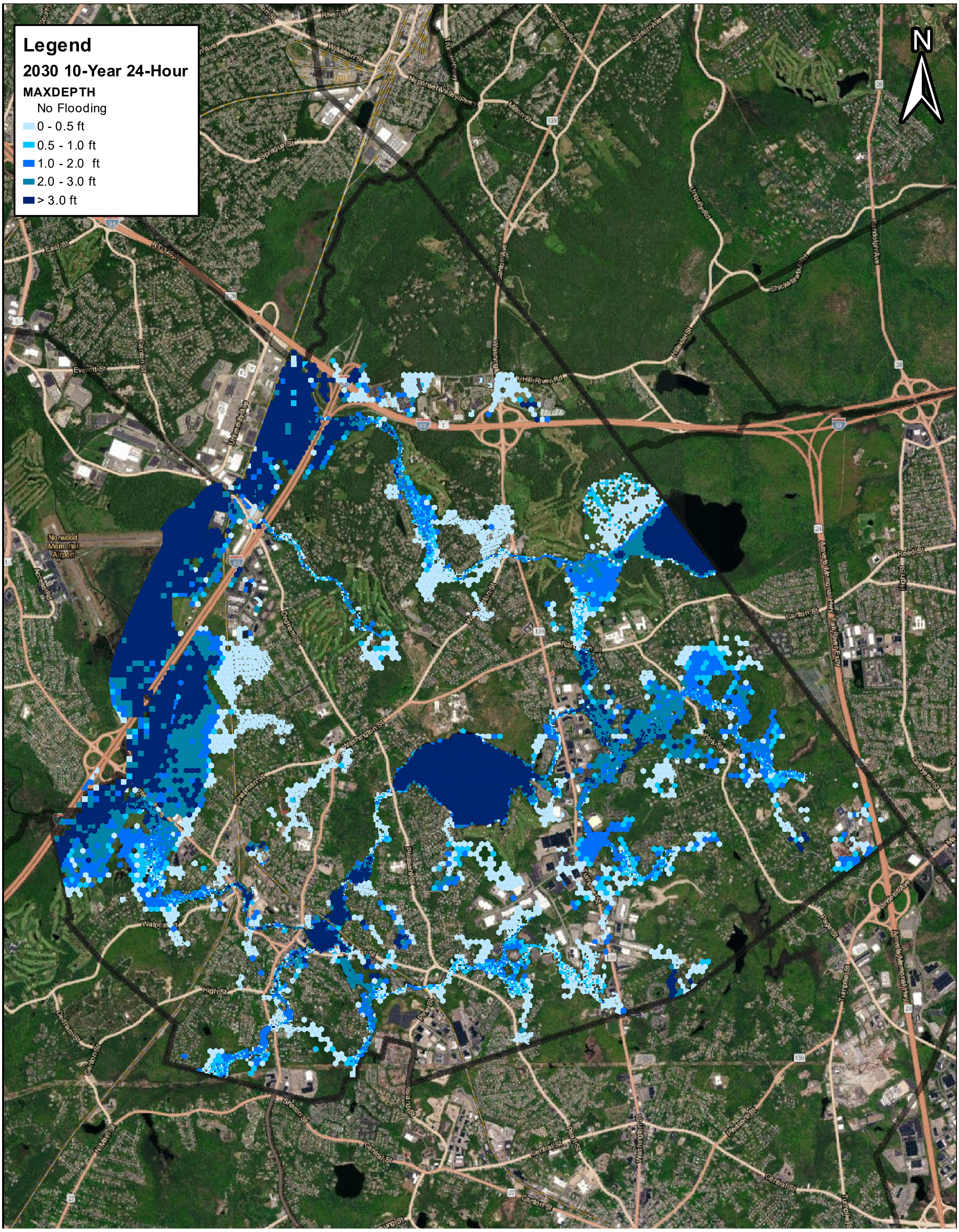

Figure 7: 2030 10-year 24-hour recurrence event modeled flooding (Precipitation = 6.38")

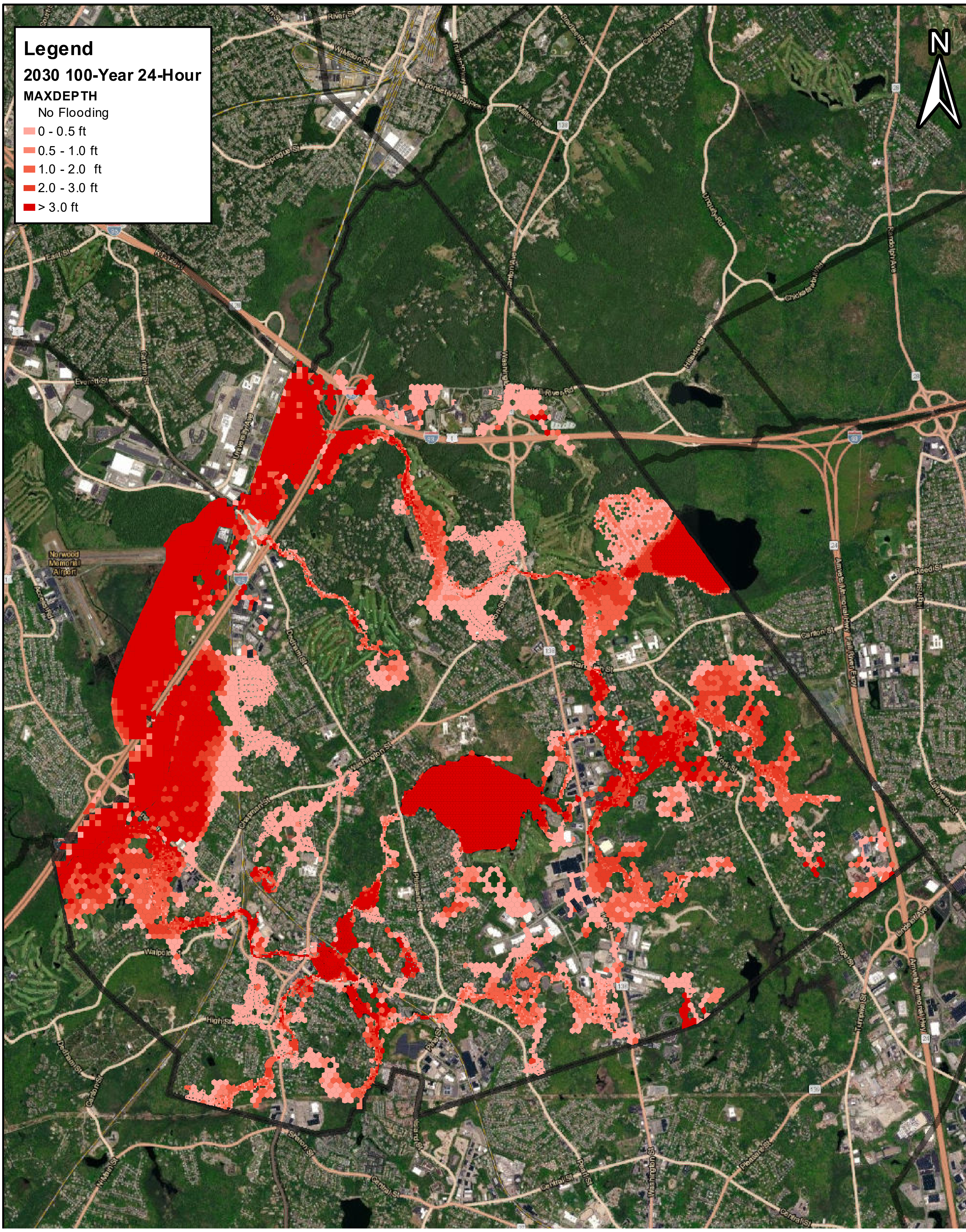

Figure 8: 2030 100-year 24-hour recurrence event modeled flooding (Precipitation = 8.88")

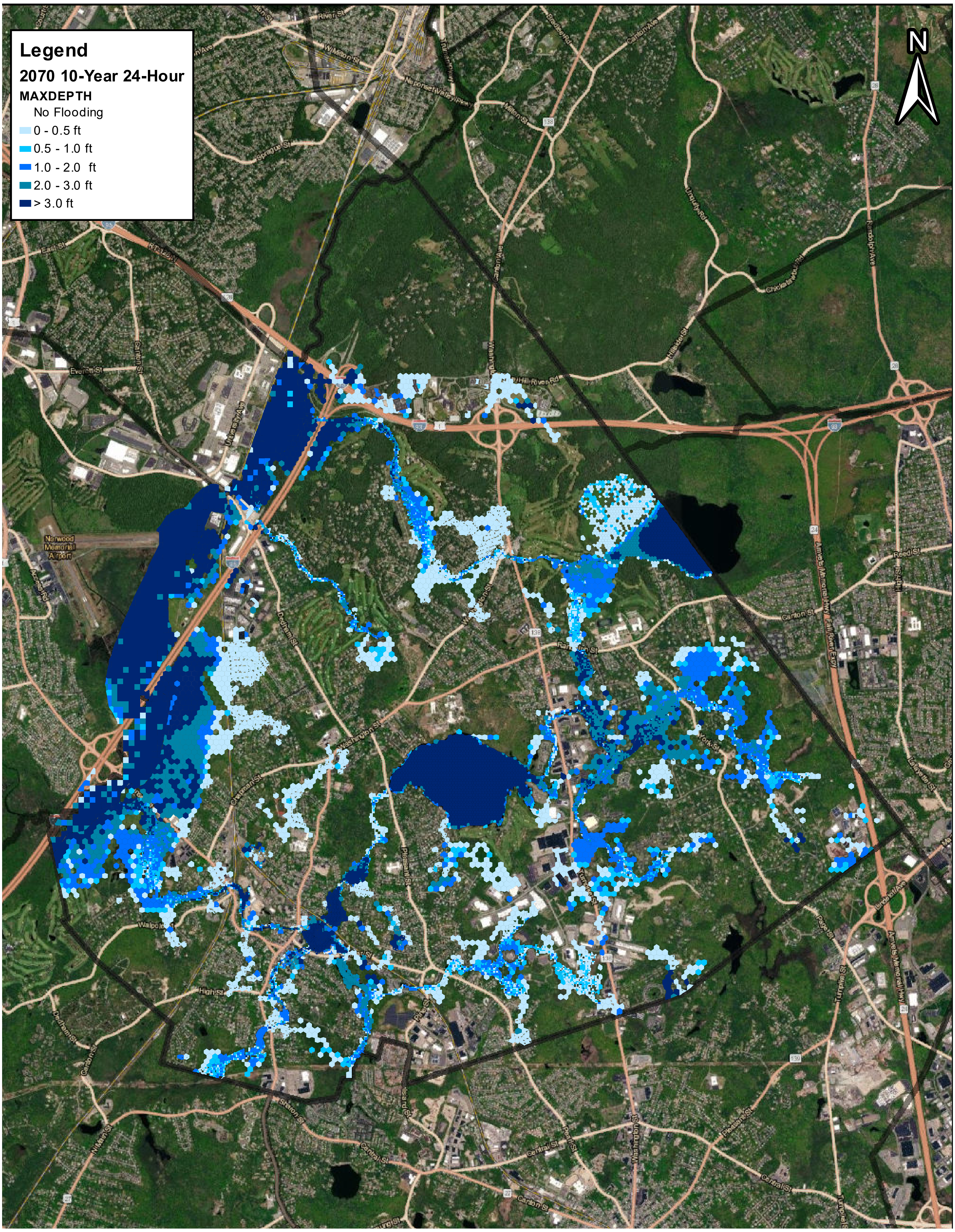

Figure 9: 2070 10-year 24-hour recurrence event modeled flooding (Precipitation = 10.19")

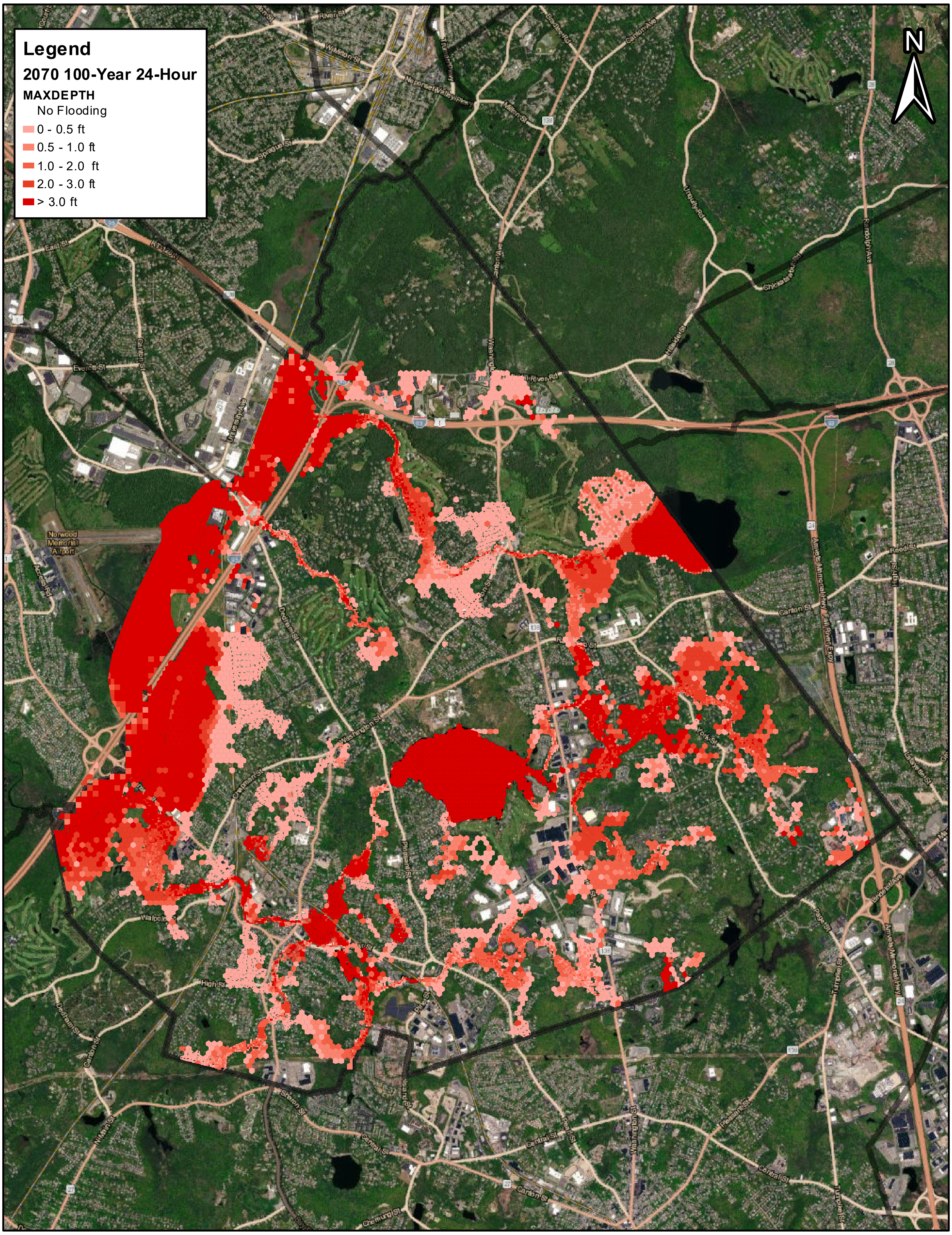

Figure 10: 2070 100-year 24-hour recurrence event modeled flooding (Precipitation = 11.70")

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SECTION 5
Risk and Vulnerability Assessment

The Town of Canton is home to a diverse range of community and infrastructure assets that support a broad array of services for residents, from the day-to-day needs to emergencies. Together, these assets create a resilient network of resources that residents can rely upon. Assets range from critical services, such as drinking and wastewater, stormwater management, electricity, telecommunications, and transportation to community-based organizations that support secure housing, health, food access, and child development. As Canton faces the increasing challenges of climate change and associated flooding, these assets provide a first line of defense to buffer against these hazards. It is important that these assets are protected from or adapted to the impacts of flooding so they can continue to serve their valuable function in Canton's society.

A flooding risk and vulnerability assessment (RVA) was performed to better understand the impact of flooding on the Town's critical assets. The RVA combined the use of flood projections with the

H+H model and more qualitative community needs. The RVA used the flood data derived from the H+H model to understand the likelihood of flooding that could occur in proximity to 153 total assets identified by Town staff and members of the community in past workshops (HMP, 2018). An assessment was performed for each asset to better understand the consequence of flooding — the quantitative and qualitative impacts of flooding to these assets, such as cost of damage, impact on public health and the environment, etc. A risk score was calculated for each asset by combining the likelihood of flooding with the consequence of flooding. The resulting overall risk value was used to create a prioritized list of assets (**Appendix B**) for future planning purposes and to inform the flood mitigation analysis and resulting recommendations of this project. Each of these steps is described in further detail in the sections that follow.

Asset Categories

Assets were identified in three main categories: community assets, infrastructure assets (vertical), and infrastructure (horizontal). The designation of vertical versus horizontal infrastructure differentiates above-grade, vertical infrastructure and facilities such as roads, dams, electrical substations, water treatment and distribution assets, etc., from oftentimes subsurface, horizontal assets, such as piped infrastructure for drinking water, sewage, and stormwater management as well as roads.

- Community assets
  - *Affordable housing* supports lower income populations in securing and maintaining housing units through direct placement in affordable housing developments or the administration of subsidies.
  - *Senior housing and nursing homes* support a population of residents who are particularly sensitive to climate changes impacts, including older adults and older adults who live alone. Senior housing provides community, assistance, and more direct access to emergency and health services.
  - *Schools and childcare assets* contribute to the health and wellbeing of Canton's youth. Not only do schools contribute to personal development, socialization, and education, they provide many students with a safe environment in which to go each day. Many students rely on the mentorship, health services, and meal assistance that schools provide. Childcare centers provide parents with the support they need so that they may continue working and bringing in their household income. Disruptions to these assets can result in economic losses at the individual or regional level, due to the inability for parents with young children to go to work during or following a climate event.
  - *Municipal services, agencies, and facilities* play a crucial role in emergency preparedness and response. For example, Town Hall is often a "command center" for emergency events, where executive decisions are made. The Town Library is also important for community resilience as it is a place for the community to gather, gain important information, and use services such as the internet for those who are without access. Fire and police serve more immediate response needs, while the department of public works and parks and recreation contribute to the everyday resilience of infrastructure and open spaces. Areas like the town garages represent a pollution concern during times of flooding, especially if near to sensitive natural areas and are also central hubs for Town staff to organize and get resources, equipment, and people to critical areas.
  - *Cultural, historic, non-profit and faith-based assets* help to solidify a community's identity,

are information hubs and can provide community gathering space and resources in time of need. In Canton, this category includes churches, historic places iconic to Canton, and non-profit community organizations such as food pantries, etc. Impacts to these types of facilities often result in inadequate support for populations at risk, which are more isolated because of limited mobility, limited income, age, or language barriers.
  - *Public health resources* are essential when a community is facing a state of emergency. This category includes hospitals as well as recovery and rehabilitation centers. Maintaining functionality for these facilities under all conditions is crucial to the basic health and safety of residents.

- Vertical Infrastructure
  - *Dams and flood control,* when effectively managed, can help prevent flooding and maintain anticipated water levels throughout a community. Dam maintenance and management is essential to maximizing flood resiliency and preventing severe impacts to infrastructure, economies, and people. Canton is also home to a private flood control level at the former Plymouth Rubber site that was included in this analysis.
  - *Communication Towers* facilitate regular connectivity, information sharing, and essential coordination.
  - *Power infrastructure* such as substations are critical to maintaining emergency response operations and continual functionality of society. The solar array field located in Canton offers a resilient power source (in addition to a decentralized network of generators) in times when centralized infrastructure is down.
  - *Wastewater and water treatment, water supply and distribution infrastructure* such as pump stations, treatment facilities, wells and storage tanks protect water quality, provide life's most vital resource – water, and if designed for resilience can aid in stormwater mitigation.
  - *Transportation facilities* such as the Massachusetts Bay Transportation Authority (MBTA) stations throughout Town provide workers regular opportunities to earn a living, connects people to each other, and a means of avoidance during times of duress.

- Horizontal Infrastructure
  - *Drainage pipe* networks traditionally transport stormwater away from populated areas but can perpetuate flooding during intense rain events.
  - *Wastewater collection pipe networks* are critical to continued containment and conveyance of sewage and represent a significant public health risk when not functioning effectively. Water distribution pipe networks are critical, like wastewater, to uninterrupted conveyance of clean drinking water which could be especially critical during emergent times and also represent a significant public health risk when not functioning properly.
  - *Roads* are important for access to and movement of people in cases of emergency. There are some roads (e.g., major arteries that connect the Town to medical facilities) that are more critical than others, but all serve the purpose of allowing residents to get to the goods and services that they need, which becomes even more important in crisis.

Methodology

Two RVAs were conducted: one for critical infrastructure and community assets (vertical assets) and another for stormwater drainage assets (horizontal assets). The consequence of flooding risk framework was slightly different for these two sets of asset categories and thus, necessitated two separate analyses. A separate analysis to review the RVA for all horizontal assets (i.e., wastewater, water and roads) was not specifically part of this study but could be done at a future time with flooding information derived from this study.

All assets were rated on a scale of one (1) to five (5) for two separate risk components:

Likelihood of Flood (LoF) and Consequence of Flooding (CoF)

To determine overall asset risk, the CoF was multiplied by LoF, and ranked based on a composite flood risk score between zero (0) and twenty-five (25), consistent with the Town's existing risk assessment framework for water and wastewater assets.

Determining LoF (Vertical and Horizontal Assets)

To determine LoF, all assets (vertical and horizontal) were rated using the same rating scale of 1 to 5 (see **Table 3**).

The LoF rating scale characterizes flood risk across multiple parameters (time horizon, flooding depth, and flood data source), with higher rating reflecting more near-term risk or greater flood depths. For example, a LoF rating of 5 (Very High) was reserved only for assets that are already exposed to over 6 inches of flooding from the Present Day, 10-year recurrence event per the H+H model. This represents significant near-term risk, as it is not unlikely that assets in this category face 6 inches of flooding once (or multiple times) prior to 2030.

The Moderate (LoF = 3) and High (LoF = 4) categories were reserved for assets that are projected within modeled flood extents from 10-year recurrence events in 2030 or 2070, or within the FEMA 100-year zone (FEMA SFHA). Since these assets may flood somewhat frequently (10-year recurrence) but at a later timeframe (2030 or 2070), the risk is less immediate but still considerable. Since FEMA's flood mapping is based on past data (not factoring climate change impacts on precipitation), the 100-year recurrence event is also considered for the Moderate category.

As noted in **Table 3** for Minor or Insignificant LoF categories, it was necessary to include a 500-foot buffer as part of some rating criteria. Since the H+H model does not include all piped infrastructure (i.e., only drain pipes greater than 12" diameter are modeled explicitly), a 500-foot buffer was included to be conservative and account for uncertainty around the edge of modeled flood extents (i.e., while a specific asset may not fall directly within a modeled flood zone, the resolution on 2D cells in model has some inherent uncertainty along the edges of flood extents). For instance, it is possible that the modeled flood extents could extend to adjacent model cells if the smaller drain pipes (i.e., 8" to 10" diameter pipes that are not modeled explicitly) that convey runoff to the larger pipes also face conveyance capacity constraints or localized flooding at low elevations. Likewise, it was not possible as part of this phase of analysis to calibrate specific model parameters (e.g., soils, groundwater depth) to the sub-catchment scale (i.e., drainage areas 15-45 acres in size). Thus, to be conservative a 500-foot buffer was applied around the 2070 100-year recurrence event (largest modeled storm event) and the FEMA 500-year zone (lowest risk FEMA flood zone).

CoF of Critical Infrastructure and Community Assets (Vertical Assets)

The methodology for evaluating CoF was derived from similar vulnerability analyses conducted by Kleinfelder for other communities also studying potential flood impacts and tailored to the needs of Canton. As seen in **Table 4**, one (1) is considered a low consequence of flooding, while five (5) is considered a significant consequence of flooding. The following

Table 3: Critical Infrastructure and Community Assets Likelihood of Flooding (LoF) Rating Scale

Rating	Insignificant	Minor	Moderate	High	Very High
	1	2	3	4	5
Canton Town-wide H+H Model Flood Projections	Asset located outside of all model projected flood areas, including a 500-foot buffer	Asset located within 500 feet buffer of 2070 100-year modeled flooding	Asset located within 2070 10-year modeled flood zone	Asset located within Present Day 10–year modeled nuisance flood zone (i.e., less than 6" depth), or within 2030 10-year modeled flood zone with 6" or greater flood depth	Asset located within Present Day 10-year modeled flood zone with 6" or more flooding
FEMA Flood Zone Proximity*	Asset located outside of all FEMA zones (100- or 500-year zones), including a 500-foot buffer	Asset located within 500-foot buffer of FEMA 500-year zones	Asset located within FEMA 100-year zone		
* Based on existing NFHL or proposed FIRM maps.					

Table 4: Physical vulnerability matrix (component of Consequence of Failure asset scoring)

Rating	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activity	Impact on Public Health & Environment
5	Whole town/city	>30 days	>$10m	Very high	Very high	Very high
4	Multiple Neighborhoods	14-30 days	$1m-$10m	High	High	High
3	Neighborhood	7-14 days	$100k-$1m	Moderate	Moderate	Moderate
2	Locality	1-7 days	$10k-$100k	Low	Low	Low
1	Property	<1 day	<$10k	None	None	None

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indicators were assessed to better understand **physical vulnerabilities** as part of characterizing CoF.

- **Area of Service Loss** – geographic scale of impact caused by an asset becoming inoperable due to flooding.
- **Duration of Service Loss** – the time that the asset is inoperable due to flood damages.
- **Cost of Damages** – the financial magnitude caused by flood damages to the asset.
- **Impact on Public Safety & Emergency Services** - the extent to which flooding impacts the ability of first responders and other providers to reach residents during an event due to access challenges caused by flooding or widespread outages.
- **Impact on Important Economic Activity** – loss of revenue or delay of industries, markets, or services that contribute to municipal or regional scale consequences. These losses could be caused by service disruptions to public transportation, wide-scale outages of drinking water, sewer systems, electricity, or telecommunication infrastructure, or closures of schools.
- **Impact on Public Health and Environment** – the everyday impact continuity of service of critical assets has on the health and wellbeing of both Canton's residents and their environment.

Consideration of Socially Vulnerable Residents

Social vulnerabilities can impact a person's sensitivity and adaptive capacity to climate change. For example, socially at-risk individuals may be further disadvantaged by structural bias or discrimination, which puts additional stress on their ability to bounce back from climate-related impacts. An individual's sensitivity to climate change impacts is influenced by their health, physical ability, socio-economic status, education level, housing situation, and location (to name a few).

Specific vulnerabilities, as well as sensitivity and adaptive capacity of community residents to flooding (among other hazards) can vary widely across geographies and between neighborhoods in the same community. Thus, it is necessary to evaluate specific community data and characterize elevated sensitivity or resource constraints at a sub-community level, such as by evaluating census tract and/or census block group-level data from the American Community Survey (ACS), or the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI). These data sources were used to perform an initial screening of population sub-groups within Canton that may be particularly sensitive to climate hazards.

Canton has several socially vulnerable population groups including adults over the age of 65, adults over the age of 65 living alone, adults with underlying health issues, and adults who are exposed workers, meaning they work in construction, engineering services, and other industries in which a portion of their work is outdoors. Each of these groups has a higher sensitivity to climate change impacts, meaning these impacts may cause greater stress on each of these population groups due to their physiological characteristics, household structure, or occupational environment. For example:

- Older adults may experience reduced mobility, changes to sensory or cognitive abilities, and reduced economic capital, each of which impacts sensitivity and adaptive capacity to climate change impacts.
- Older adults living alone are more socially isolated, without household members that can help navigate and aid in decision making during an emergency.
- Adults with underlying health conditions are more vulnerable due to their physiological condition, which may hinder their ability to respond to an emergency or may exacerbate the

physical harm they experience due to a climate-related event.

Community assets that support these socially vulnerable groups include senior housing, affordable housing, public health and medical facilities, emergency response and first responders, critical infrastructure, and municipal services.

Social Vulnerability Rating

For each asset category, two separate ratings (a Canton-specific population sensitivity rating, and an EEA Environmental Justice (EJ) neighborhood rating) were used to assess sensitive populations and equity/EJ, independently:

- **Social Vulnerability Rating:** For the Canton-specific population sensitivity rating, each asset received a rating based on whether it was in close proximity geographically to specific census block groups with one or more sensitive population sub-groups (i.e., Residents Aged +65; Age +65 living alone, or have an underlying health condition; or, exposed workers). Each of these assets received population sensitivity rating based on how many sensitive population sub-groups were present in the respective census block group, as noted in Table 4.

- **EJ Neighborhood Designation/Rating:** Canton has one environmental justice neighborhood due to a population of over 25% who identify as a race other than white. If the asset falls in the boundaries of this neighborhood, it received an EJ rating of 5. If it did not fall within this neighborhood, it got an EJ rating of 0, as noted in Table 5.

The social vulnerability and environmental justice scores were averaged to get the final composite CoF score for vertical assets.

CoF of Stormwater Drainage Assets (Horizontal Assets)

To determine CoF for horizontal assets, the same methodology was applied from the risk assessment framework previously developed for the Town's asset management program, summarized in the *Canton Asset Management Program (CAMP) Year 3 Implementation Report*, 2017. This CoF evaluation, summarized in Table 6, was performed spatially, and informed by several social, economic, environmental, and physical condition attributes (i.e., asset size, proximity to wetlands and catchments prioritized for stormwater water quality purposes, ponds with recreational uses, and FEMA flood hazard areas).

While the Town-wide H+H model results were incorporated into LoF rating for each asset, it was decided that the FEMA flood hazard areas should also remain in the CoF rating, as these zones have flood insurance implications and not all property owners carry flood insurance coverage (i.e., an economic consequence of flooding could be uninsured losses).

Table 5: Summary of Social Vulnerability CoF Ratings

	Social Vulnerability CoF Rating				
Criteria	1	2	3	4	5
Supports Sensitive Population Group	--	--	1 group	2 groups	3+ groups
EJ Neighborhood Designation	--	--	--	--	Falls within this designated neighborhood

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Table 6: Consequence of Failure Score Card

Consequence of Failure Score Card

Social (Health and Safety and Loss of Service)

			Insignificant	Minor	Moderate	High	Very High
Asset	**Criteria**	**Proxy**	**1**	**2**	**3**	**4**	**5**
Drain Pipe	Flooding Hazards in heavily populated areas	**Distance to FEMA flood area**	out of flood plain	within 500 year flood, less than 1 ft. flooding in 100 year flood	within 100 year flood	-	-
	Standing water areas - mold/mildew /air quality in heavily populated areas	**Touch Wetland area**	No	-	-	Yes	-
	Discharge to recreational body of water	**within 500 ft. of Pond**	No	-	-	-	Yes

Environmental

			Insignificant	Minor	Moderate	High	Very High
Asset	**Criteria**	**Proxy**	**1**	**2**	**3**	**4**	**5**
Drain Pipe	Potential to cause MS4 violations	**MS4 KLF catchment score**	-	Low	Medium	High	Problem

Repair/replacement cost and other damages (Economic)

			Insignificant	Minor	Moderate	High	Very High
Asset	**Criteria**	**Proxy**	**1**	**2**	**3**	**4**	**5**
Drain Pipe	Repair /replacement cost. Proxy: larger diameter, is more expensive	**Pipe Diameter**	6" or less	8"-10"	11"-16"	17"-24"	>24"

RVA Results

RVA results were developed independently for vertical and horizontal assets, as results inform several types of strategies. For vertical assets (i.e., buildings and other critical infrastructure), building adaptations and regulatory measures can be taken to bolster flood resilience. For horizontal assets, further analysis and data collection can be leveraged to prioritize gray infrastructure upgrades (e.g., pipe capacity upsizing) in flooding hotspots, as well as tailor operations and maintenance (O&M) activities to areas most sensitive.

Results for Vertical Assets

The RVA resulted in a list of critical assets prioritized by overall risk that can be found in **Appendix B** and are shown geographically in **Figure 11**. As would be expected, dam infrastructure rose to the top of the critical asset list with affordable housing and wells making up the next two largest asset categories that fall into the top 25 critical assets. The top 25 assets (excluding dam infrastructure, which will obviously experience high water levels during flood events) were determined for each risk category and color coded for further analysis with overall risk in yellow, LoF in green, and CoF in blue. Each category is further discussed in the following pages. The critical assets listed are snapshots in time and may no longer be in existence/open but were at the time the analysis was completed.

Results for Horizontal Drainage Assets

The updated risk ratings for the stormwater drainage pipe network indicate several key neighborhoods, or storm sewer trunk lines, that face heightened risk of failure. These areas, highlighted in dark purple in **Figure 12**, include (among others):

- Summer Heights neighborhood (west of JFK School)
- Areas north of Waterfall Drive (near Blake Drive, Pinewood Road, Fencourt Road)
- Areas south of Reservoir Pond along Wampatuck Drive, Pleasant Garden Road, and Pleasant Ridge Road
- Areas near Washington Street and Hickory Lane, north of Adrienne Drive
- Areas near Canton High School, Wildewood Drive and Old Meadow Lane

These locations can be viewed as areas where upsizing of pipes, catch basin coverage, or other gray infrastructure upgrades may be ideal to pair with future maintenance activities or capital projects.

A summary of piped infrastructure segments ranking as higher risk (i.e., risk scores >15 out of 25 scale) are provided in **Appendix D**.

Overall Risk **(Table 7)**

Eighty percent of the top 25 critical assets by overall risk were also within the top 25 assets by LoF indicating that flood risk was a large driver in overall risk. Two assets were in the top 25 of both LoF and CoF: the DPW Garage and Hagen Court Affordable Senior Housing facility.

Likelihood of Flooding (LoF) **(Table 8)**

Only five of the top 25 critical assets by LoF were not included in the top 25 by overall risk score, which were largely religious facilities.

Consequence of Flooding (CoF) **(Table 9)**

Many of the top 25 critical assets by CoF had low LoF; all five of the critical assets within the top 25 by CoF with a higher LoF (>3) were included in the overall top 25 assets.

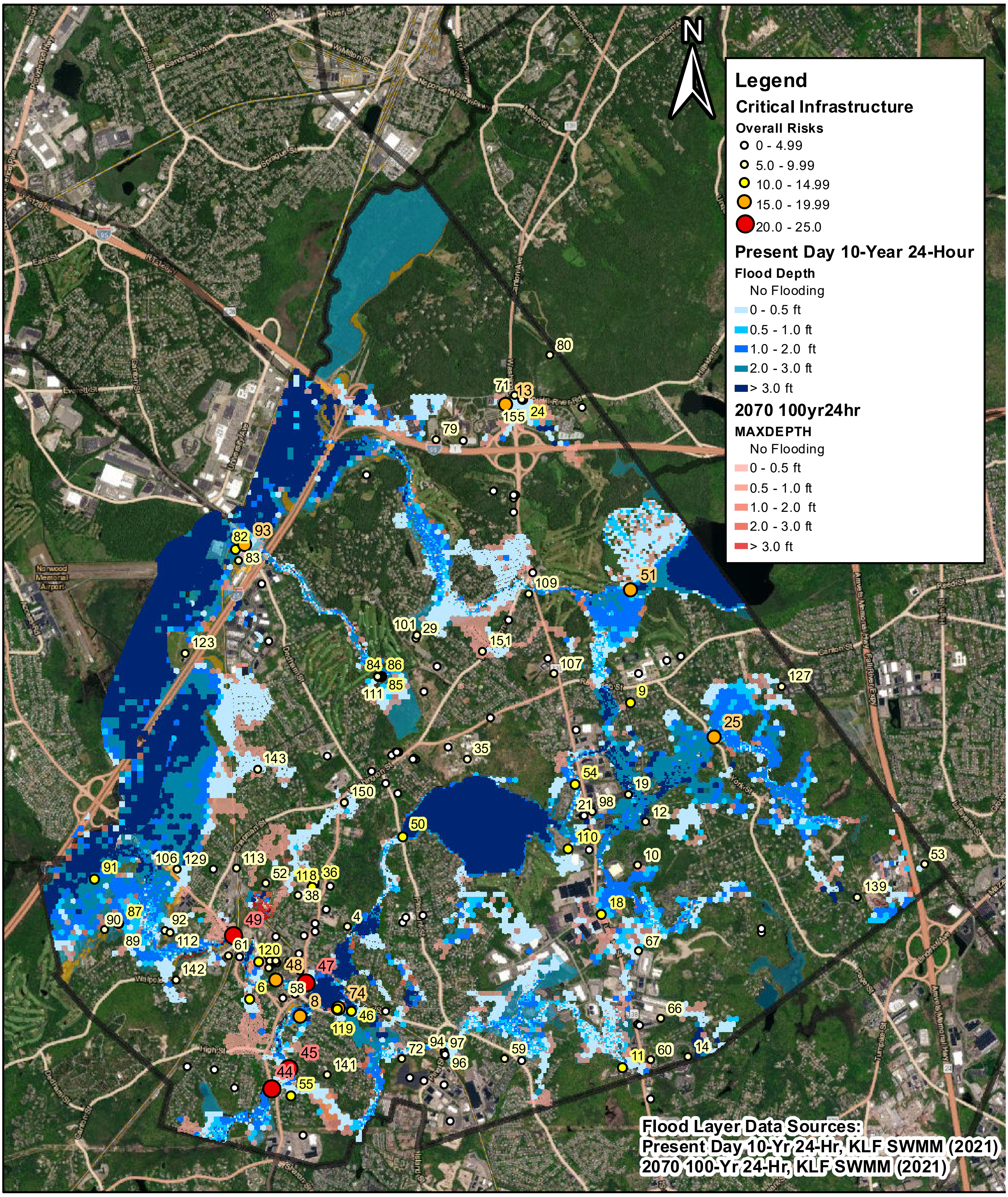

Figure 11: Canton critical assets labeled with ID and symbolized by overall risk score (corresponding asset names/IDs and flood depths are available in **Appendix B** and **Appendix C**, respectively).

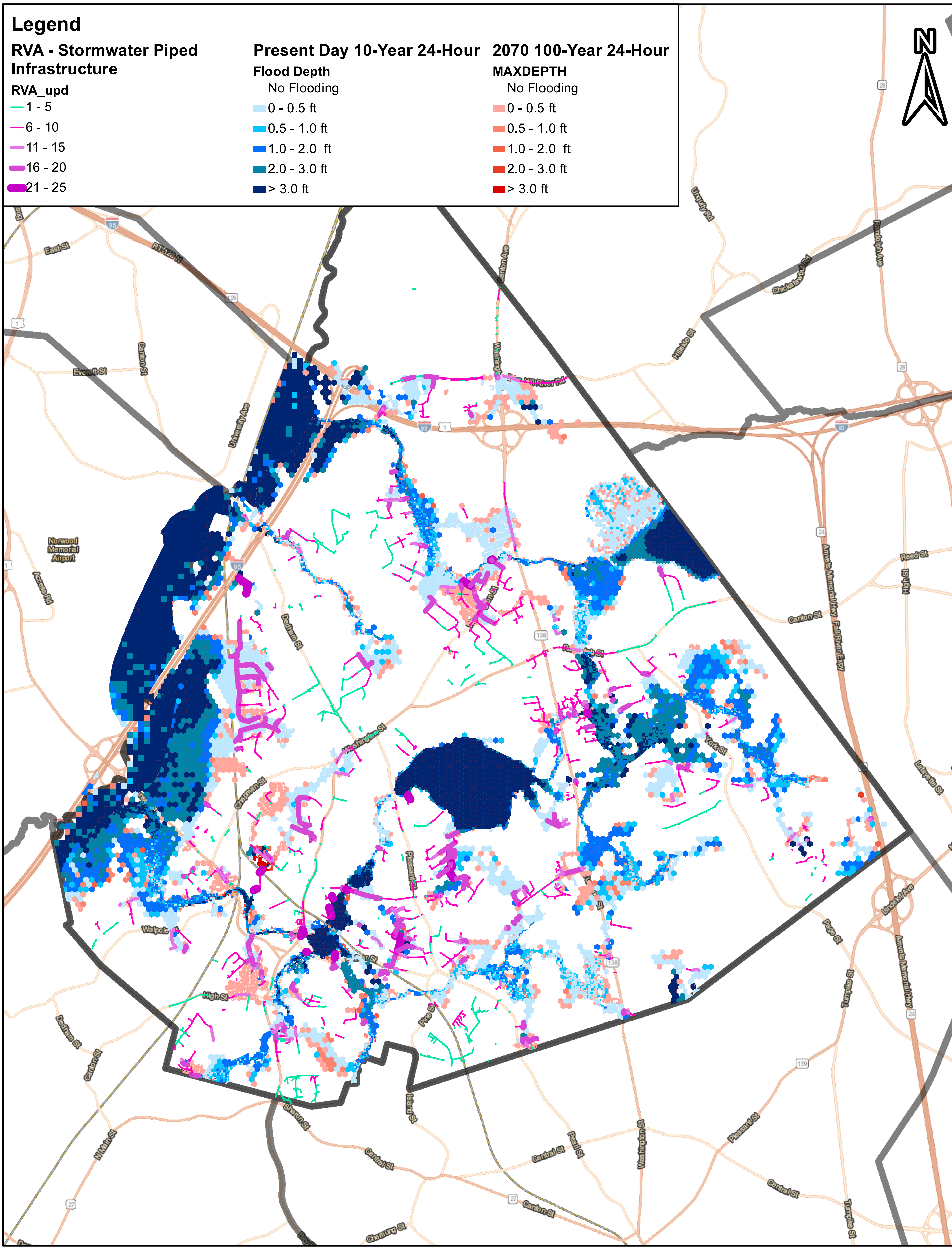

Figure 12: Updated Risk Assessment Results for Stormwater Piped Infrastructure based on RVA.

Table 7: Top 25 assets by overall risk (excluding dams). Green cells indicate asset was also in the top 25 for LoF and blue indicate asset was also in the top 25 for CoF

			(R) = Likelihood of Flooding (LoF) x Consequence of Failure (CoF)										
					Consequence of Failure							Equity Considerations	Social Vulnerability Indicators
Asset Program	Location	ID	Overall Risk (R) Score (LoF x CoF)	Likelihood of Flooding	CoF Average	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activity	Impact on Public Health & Environment	Overlap with EEA EJ population (Y/N)	Supports one of the following sensitive populations: Residents +65, +65 living alone, or have an underlying health condition; or, exposed workers. Supports 1 = 3, supports 2 = 4, supports 3+ =5
Municipal	Department of Public Works & Public Works Garage	74	18.6	5	3.714	5	3	2	5	5	3		3
Well	MWRA Water Connection	93	18.3	5	3.667	5	2	2	5	5	3		
Affordable Housing	Blue Hill Commons (Royal Avenue)	13	18.1	5	3.625	2	3	3	4	3	4	5	5
Affordable Housing	27 Howard	8	17.1	5	3.429	2	3	3	4	3	4		5
Private Flood Control Lever	Former Plymouth Rubber Site	120	15.0	5	3.000	2	5	3	3	2	3		
Well	Well #2	82	15.0	5	3.000	3	4	2	3	2	4		
Well	Well #9	91	15.0	5	3.000	3	4	2	3	2	4		
Affordable Senior Housing	Newell S Hagen Court	55	14.9	4	3.714	2	3	3	5	3	5		5
Affordable Housing	Blue Hills Village	9	14.5	4	3.625	2	3	3	4	3	4	5	5
School	Rodman Education Center	36	13.7	3	4.571	5	1	6	5	5	5		5
Affordable Housing	Concord Avenue	6	13.7	4	3.429	2	3	3	4	3	4		5
Senior Housing	Canton Point (Senior Independent Living)	110	13.7	4	3.429	2	3	3	4	2	5		5
Food Support	Canton Food Pantry	118	12.9	3	4.286	5	4	4	5	2	5		5
Communication Tower	Cell Tower (1 Blue Hill River Road)	64	12.0	4	3.000	3	2	2	4	4	3		
Well	Well #12	84	12.0	4	3.000	3	4	2	3	2	4		3
Well	Well #4	85	12.0	4	3.000	3	4	2	3	2	4		3
Well	Well #11	86	12.0	4	3.000	3	4	2	3	2	4		3
Well	Well #5	87	12.0	4	3.000	3	4	2	3	2	4		
Well	Well #13	88	12.0	4	3.000	3	4	2	3	2	4		
Municipal	Richard A Stein Animal Shelter	119	11.7	5	2.333	4	3	4	1	1	1		
School	Rodman Early Elementary Center/ Canton Public Schoo	36	10.7	3	3.571	5	3	2	4	4	4		3
Child Care	Learning Circle PreSchool	24	10.7	4	2.667	3	3	2	3	2	3		
Affordable Housing	Windsor Wood's Way (Pequit Village)	11	10.3	3	3.429	2	3	3	4	3	4		5
Senior Housing	Commons Residence at Orchard Cove	54	10.3	3	3.429	2	3	3	4	2	5		5
Cultural Asset	Paul Revere Heritage Site (104 Revere Street)	115	10.0	4	2.500	2	3	4	2	2	2		

Table 8: Top 25 assets by LoF (excluding dams). Yellow cells indicate asset was also in the top 25 for overall risk and blue indicate asset was also in the top 25 for CoF.

			(R) = Likelihood of Flooding (LoF) x Consequence of Failure (CoF)										
					Consequence of Failure							Equity Considerations	Social Vulnerability Indicators
Asset Program	Location	ID	Overall Risk (R) Score (LoF x CoF)	Likelihood of Flooding	CoF Average	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activity	Impact on Public Health & Environment	Overlap with EEA EJ population (Y/N)	Supports one of the following sensitive populations: Residents +65, +65 living alone, or have an underlying health condition; or, exposed workers. Supports 1 = 3, supports 2 = 4, supports 3+ =5
Municipal	Department of Public Works & Public Works Garage	74	18.6	5	3.714	5	3	2	5	5	3		3
Well	MWRA Water Connection	93	18.3	5	3.667	5	2	2	5	5	3		
Affordable Housing	Blue Hill Commons (Royal Avenue)	13	18.1	5	3.625	2	3	3	4	3	4	5	5
Affordable Housing	27 Howard	8	17.1	5	3.429	2	3	3	4	3	4		5
Private Flood Control Lever	Former Plymouth Rubber Site	120	15.0	5	3.000	2	5	3	3	2	3		
Well	Well #2	82	15.0	5	3.000	3	4	2	3	2	4		
Well	Well #9	91	15.0	5	3.000	3	4	2	3	2	4		
Municipal	Richard A Stein Animal Shelter	119	11.7	5	2.333	4	3	4	1	1	1		
Affordable Senior Housing	Newell S Hagen Court	55	14.9	4	3.714	2	3	3	5	3	5		5
Affordable Housing	Blue Hills Village	9	14.5	4	3.625	2	3	3	4	3	4	5	5
Affordable Housing	Concord Avenue	6	13.7	4	3.429	2	3	3	4	3	4		5
Senior Housing	Canton Point (Senior Independent Living)	110	13.7	4	3.429	2	3	3	4	2	5		5
Communication Tower	Cell Tower (1 Blue Hill River Road)	64	12.0	4	3.000	3	2	2	4	4	3		
Well	Well #12	84	12.0	4	3.000	3	4	2	3	2	4		3
Well	Well #4	85	12.0	4	3.000	3	4	2	3	2	4		3
Well	Well #11	86	12.0	4	3.000	3	4	2	3	2	4		3
Well	Well #5	87	12.0	4	3.000	3	4	2	3	2	4		
Well	Well #13	88	12.0	4	3.000	3	4	2	3	2	4		
Child Care	Learning Circle PreSchool	24	10.7	4	2.667	3	3	2	3	2	3		
Cultural Asset	Paul Revere Heritage Site (104 Revere Street)	115	10.0	4	2.500	2	3	4	2	2	2		
Church	Trinity Episcopal Church	155	9.1	4	2.286	3	2	2	1	1	3		4
Water Distribution	Clear Well	94	8.7	4	2.167	2	3	2	2	2	2		
Church	Randolph Hebrew Center	150	8.6	4	2.143	3	2	2	1	1	3		3
Church	Tabernacle Of Glory Boston Campus	159	8.6	4	2.143	3	2	2	1	1	3		3
Cultural Asset/Community Organizaton	Spanish Cultural Association	143	7.3	4	1.833	2	2	2	1	2	2	5	

Table 9: Top 25 assets by CoF (excluding dams). Green cells indicate asset was also in the top 25 for LoF and yellow indicate asset was also in the top 25 for overall risk.

			(R) = Likelihood of Flooding (LoF) x Consequence of Failure (CoF)										
					Consequence of Failure							Equity Considerations	Social Vulnerability Indicators
Asset Program	Location	ID	Overall Risk (R) Score (LoF x CoF)	Likelihood of Flooding (LoF)	CoF Average	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activity	Impact on Public Health & Environment	Overlap with EEA EJ population (Y/N)	Supports one of the following sensitive populations: Residents +65, +65 living alone, or have an underlying health condition; or, exposed workers. Supports 1 = 3, supports 2 = 4, supports 3+ =5
Hospital	Pappas Rehabilitation Hospital for Children	35	9.4	2	4.714	5	4	4	5	5	5		5
Water Treatment	Edward Sullivan Water Treatment Facility	112	9.3	2	4.667	5	4	4	5	5	5		
School	Rodman Education Center	36	13.7	3	4.571	5	1	6	5	5	5		5
Water Treatment	James Moran Water Treatment Facility	111	8.9	2	4.429	5	4	4	5	5	5		3
Food Support	Canton Food Pantry	118	12.9	3	4.286	5	4	4	5	2	5		5
MBTA	Canton Junction	113	8.6	2	4.286	5	3	4	4	5	4		5
MBTA	Canton Center Station	114	4.3	1	4.286	5	3	4	4	5	4		5
Emergency Operations Center	EOC Fire HQ	26	8.3	2	4.143	5	1	3	5	5	5		5
Fire Station	Fire Department Station #2 (Ponkapoag Fire Station)	109	8.0	2	4.000	5	1	2	5	5	5		5
Wastewater Pump Station	Bailey Ct WW Pump Station	141	8.0	2	4.000	5	3	4	4	4	4		
Wastewater Pump Station	Walpole Street WW Pump Station	142	8.0	2	4.000	5	3	4	4	4	4		
Wastewater Pump Station	Trayer Rd WW Pump Station	140	4.0	1	4.000	5	3	4	4	4	4		
Affordable Senior Housing	Lamplighter Village	60	7.8	2	3.875	2	3	3	5	3	5	5	5
Wastewater Pump Station	Rockwood Rd WW Pump Station	139	7.7	2	3.857	5	3	4	4	2	4		5
Wastewater Pump Station	Chapman Knoll WW Pump Station	138	3.8	1	3.833	5	3	4	4	3	4		
Municipal	Department of Public Works & Public Works Garage	74	18.6	5	3.714	5	3	2	5	5	3		3
Affordable Senior Housing	Newell S Hagen Court	55	14.9	4	3.714	2	3	3	5	3	5		5
Affordable Senior Housing	Hemenway School Housing	58	7.4	2	3.714	2	3	3	5	3	5		5
Affordable Senior Housing	Canton Village	59	7.4	2	3.714	2	3	3	5	3	5		5
Fire Station	Fire Department (HQ)	27	7.4	2	3.714	5	1	2	5	5	3		5
School	William Galvin Middle School	29	7.4	2	3.714	5	3	2	4	4	4		4
Housing Authority Senior Housing	Julius Rubin Court	56	3.7	1	3.714	2	3	3	5	3	5		5
Municipal	Town Hall	77	3.7	1	3.714	5	2	3	3	5	3		5
Municipal/Environment/Health	Pequitside Farm (Conservation/Board of Health offices)	3	3.7	1	3.714	5	2	3	3	3	5		5
Police Station	Police Department (HQ)	28	3.7	1	3.714	5	1	2	5	5	3		5

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Results for Horizontal Drainage Assets

The updated risk ratings for the stormwater drainage pipe network indicate several key neighborhoods, or storm sewer trunk lines that face heightened risk of failure. These areas - highlighted in dark purple in **Figure 17** - include (among others):

- Summer Heights neighborhood (west of JFK School)
- Areas north of Waterfall Drive (near Blake Drive, Pinewood Road, Fencourt Road)
- Areas south of Reservoir Pond along Wampatuck Drive, Pleasant Garden Road, and Pleasant Ridge Road
- Areas near Washington Street and Hickory Lane, north of Adrienne Drive
- Areas near Canton High School, Wildewood Drive, and Old Meadow Lane

These locations can be viewed as areas where upsizing pipes, catch basin coverage, or other gray infrastructure upgrades may be ideal to pair with future maintenance activities or capital projects.

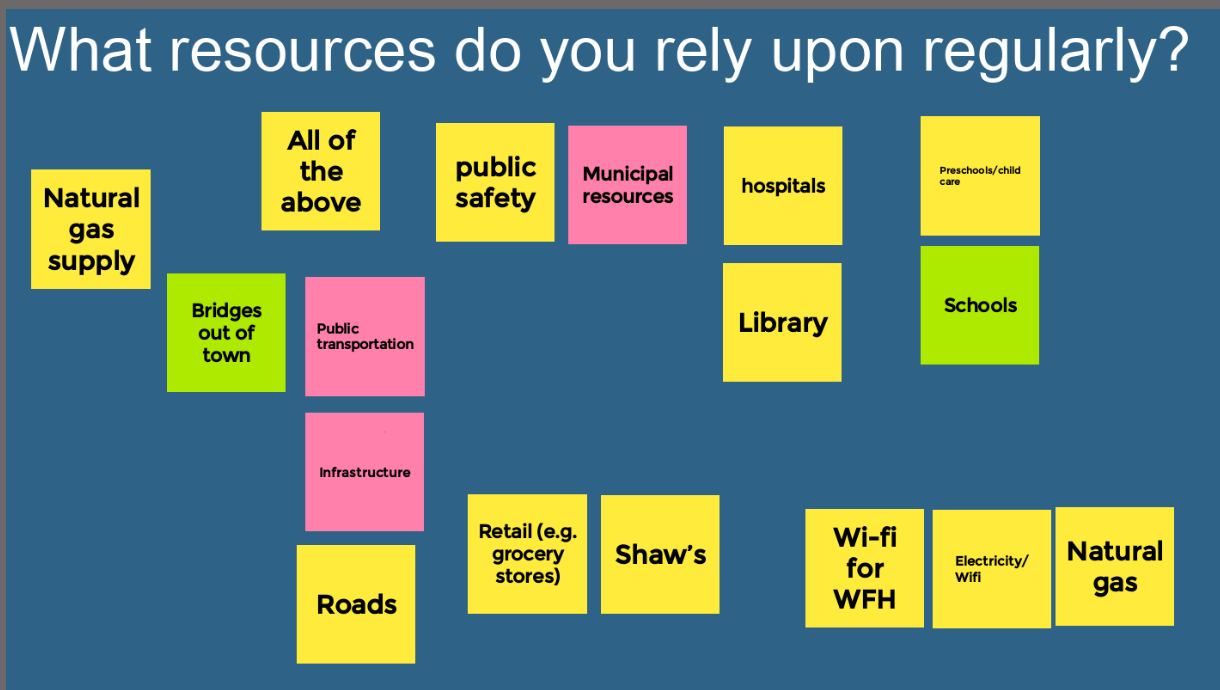
A summary of piped infrastructure segments ranking as higher risk (i.e., risk scores >15 out of 25 scale) are provided in **Appendix D**.

The results of the RVA (in conjunction with the results and input of **Section 3** and **Section 6**) and public stakeholder feedback on observed flooding hotspots identified during the Town's MVP Flood Mitigation Workshop (public event held March 23, 2021; see **Figure 13**), were used to select the areas of interest for further study in **Section 6** (Areas of Interest & Field Investigations).

STAKEHOLDER ENGAGEMENT

What the Town did:

The Town hosted an interactive virtual public meeting on March 23, 2021, and asked attendees what resources they rely upon regularly and during a time of crisis. Responses (below) were diverse and were incorporated into the development of the Risk and Vulnerability Assessment.



SECTION 6
Areas of Interest and Field Investigations

The project team brought together the flood modeling projections, RVA results, and community input to identify key areas of flooding for further analysis to develop actionable recommendations for the Town. To do this, all the data layers developed from **Sections 3**-**5** were overlaid and analyzed to identify which critical assets may experience flooding in the future (**Table 10**), where acute hazardous and extensive nuisance flooding was projected to occur, and where those drivers aligned with the community's areas of concern (**Figure 13**). A full list of all assets impacted by each storm event is included in **Appendix C**.

Over a dozen areas of interest were identified and a preliminary modeling sensitivity analysis was performed to determine if altering stormwater flows would help mitigate flooding issues (see **Section 8** for a full description of the sensitivity analysis). Results from the preliminary analysis and discussion with Town staff on April 22, 2021, helped the team narrow to nearly a dozen sites to visit and assess for

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potential mitigation strategies in the field (**Figure 14**). The Kleinfelder team and Town staff conducted a site visit on April 29, 2021, to visually inspect potentially impaired areas and share information that could be used to inform the modeling effort (**Table 11**, **Figure 14**). A full write up of each site with full-scale maps are included in **Appendix F** (Site Notes and Field Maps).

After conducting site visits, the team also assessed expansive open spaces upstream of flooding using a desktop mapping analysis for additional implementation of potential large-scale natural flood mitigation projects (**Table 11**, **Appendix E**).

Mitigation strategy ideas generated during the site visits and identified in the open space assessment were further explored using the H+H model, described in **Section 8**. The suite of flooding solutions available to the Town of Canton are described in the following section.

Table 10: Critical assets and flooding depths *(see Appendix C for address locations)*

Asset ID	Location	Depth of Flooding (above ground surface, per 2013 LiDAR)					
		Present Day, 10-year	Present Day, 100-year	2030, 10-year	2030, 100-year	2070, 10-year	2070, 100-year
49	Spillway @ the Viaduct (Canton Viaduct)	13.14	14.28	13.22	14.55	13.49	14.86
91	Well #9	2.94	3.48	2.95	3.72	3.06	4.02
120	Former Plymouth Rubber Site (Private Flood Control Lever)	0.67	2.21	2.21	2.68	1.08	3.22
74	Department of Public Works Garage	1.1	2.99	1.58	3.29	1.34	3.15
93	MWRA Water Connection	2.03	2.54	2.04	2.78	2.14	3.08
119	Canton Animal Control (Richard A. Stein Animal Shelter)	0.99	2.14	1	2.44	1.27	2.78
82	Well #2	1.57	2.08	1.58	2.32	1.68	2.62
8	27 Howard	2.08	2.37	2.12	2.47	2.16	2.57
52	Hellenic Nursing and Rehab Center	0	0	0	0	0	1.06
94	Clear Well	0.12	0.5	0.15	0.66	0.21	0.86
87	Well #5	0	0.19	0	0.39	0.05	0.68
88	Well #13	0	0.19	0	0.39	0.05	0.68
89	CCF Building	0	0.19	0	0.39	0.05	0.68
10	Canton Arboretum	0	0.23	0	0.43	0	0.65
54	Commons Residence @ Orchard Cove	0	0.5	0	0.56	0	0.64
6	Concord Avenue	0.09	0.3	0.12	0.36	0.14	0.44
150	Randolph Hebrew Center	0.17	0.27	0.18	0.31	0.19	0.36
115	Paul Revere Heritage Site	0.02	0.13	0.02	0.21	0.04	0.31
13	Blue Hill Commons	0.04	0.13	0.06	0.15	0.08	0.18
20	Cole-Harrington Early Learning Center	0.05	0.12	0.06	0.14	0.07	0.16

Table 10: Critical assets and flooding depths *(see Appendix C for address locations)* (continued)

Asset ID	Location	Depth of Flooding (above ground surface, per 2013 Lidar)					
		Present Day, 10-year	Present Day, 100-year	2030, 10-year	2030, 100-year	2070, 10-year	2070, 100-year
36	Rodman Education Center	0.05	0.12	0.06	0.14	0.07	0.16
105	YMCA Childcare Center	0.05	0.12	0.06	0.14	0.07	0.16
118	Canton Food Pantry	0.05	0.12	0.06	0.14	0.07	0.16
71	Cell Tower (1 Blue Hill River Road)	0.04	0.11	0.05	0.12	0.06	0.16
24	The Learning Circle Preschool	0.04	0.06	0.05	0.12	0.06	0.14
155	Trinity Episcopal Church	0.04	0.06	0.05	0.12	0.06	0.14
159	Tabernacle Of Glory Boston Campus	0.04	0.03	0.02	0.07	0.05	0.08
55	Newell S Hagen	0.04	0.06	0.04	0.07	0.05	0.07
84	Well #12	0.03	0.05	0.03	0.05	0.03	0.06
85	Well #4	0.03	0.05	0.03	0.05	0.03	0.06
86	Well #11	0.03	0.05	0.03	0.05	0.03	0.06
111	James Moran Water Treatment Facility	0.03	0.05	0.03	0.05	0.03	0.06
143	Spanish Cultural Association	0.01	0.03	0.01	0.04	0.02	0.05
11	Windsor Wood's Way	0.01	0.03	0.02	0.04	0.02	0.04
151	St. Gerard Majella Parish	0	0.01	0	0.02	0.01	0.04
110	Canton Point (Senior Independent Living)	0.01	0.02	0.01	0.02	0.01	0.02
112	Edward Sullivan Water Treatment Facility	0	0	0	0.01	0	0.01
128	Neponset River Watershed Association	0	0	0	0	0	0.01

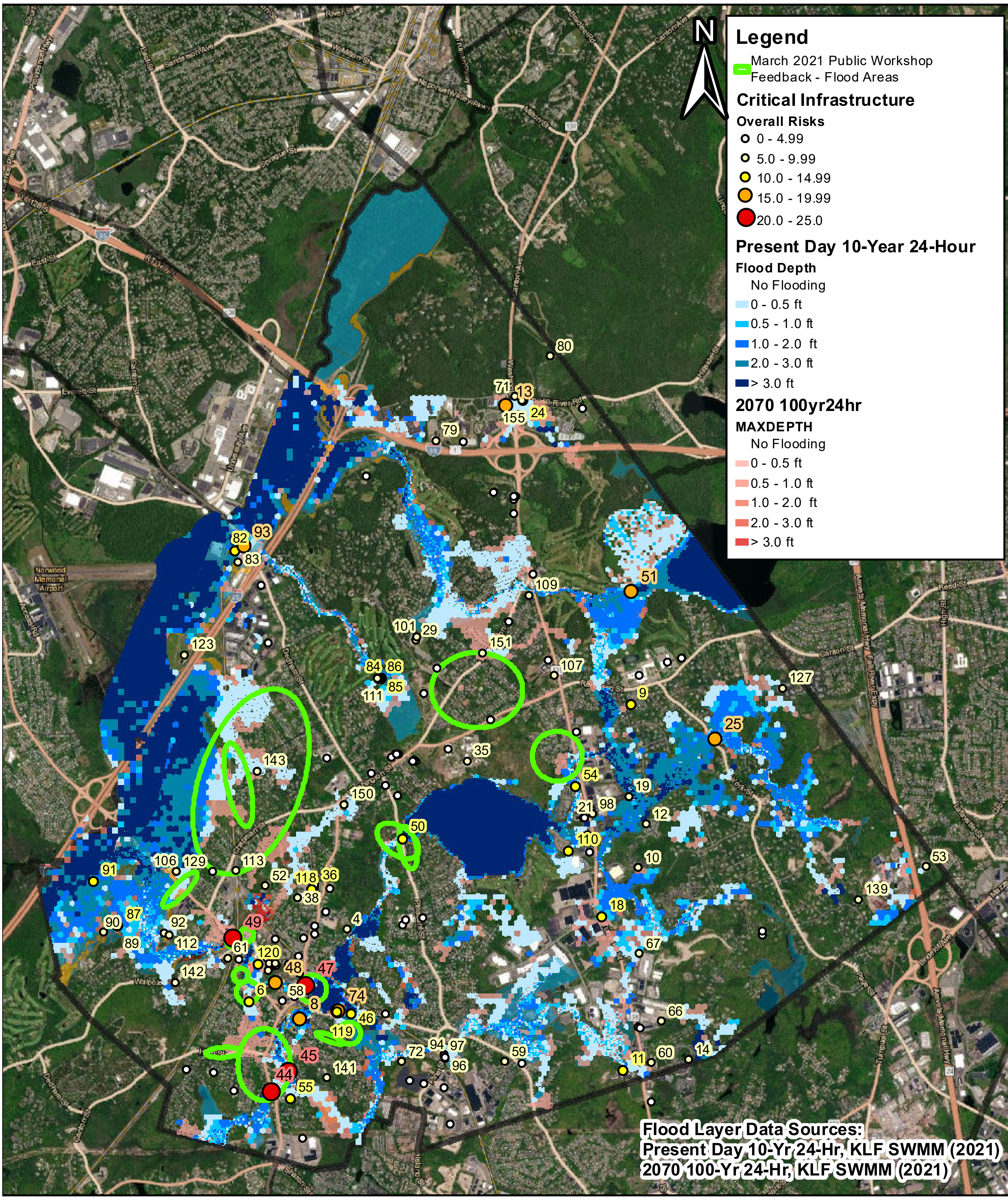

Figure 13: A re-creation of the feedback received from attendees on known flooding areas during the March 2021 Public Workshop.

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Table 11: Areas of interest for potential flood mitigation strategies

Areas of Interest Visited by Kleinfelder and Town Staff				
No	**Site Name**	**Reason for Visit**	**Potential For Retrofit?**	**Notes**
1	Neponset Street at Neponset River	Evaluate low-lying portion of road near Dunkin Donuts and the 1st Lt. Arthur E. Farnham, Jr., and Sgt. Thomas M. Connolly, Jr. Memorial Park (former airport; filled site) to discuss road-raising feasibility and modeled water surface elevations.	Raising the road was deemed a viable option that could improve flooding conditions (see **Section 8** for further information on subsequent modeling analysis)	• When Town rehabbed in late '90s and early '00s, Town considered road raising previously when State redid Neponset Street, but there was pushback from Conservation Commission. They have a study on Neponset based on traffic and safety improvements for pedestrians • Key mobility/emergency access implications to nearby medical facility • Observed 4"-8" of water in 2010 floods
2a	Washington Street & High Street	Evaluate potential upstream green/gray flood mitigation opportunities near High Street		Did not visit this site, as it seemed very similar to 2b and is at higher elevation. H+H modeling indicates increased future flooding in this area, which may be primarily driven by drainage system not having sufficient conveyance capacity to Massapoag Brook
2b	Washington Street near Shepard Pond	• Evaluate potential for road-raising along segment that has faced past flooding. • Discuss recent dam upgrades/outlet controls to determine if they may or could help to alleviate flooding.	• This site is also a site to consider retrofitting the downstream controls (or future pump bypass) to add Active Reservoir Management (forecast-based controls and pumping to pre-release or accelerate gravity drainage to Massapoag Brook). • It was noted that when the bridge is next due for structural repair, it may be opportune time to raise Washington Street to an elevation above projected roadway flooding. The Town is also thinking of doing some improvements for pedestrian/cyclist mobility – and is being considered for a Complete Streets-type project. • Washington Street is a Town-owned roadway, and there are few adjacent private parcel areas where road-raising would impact (homes have existing setbacks and no driveways off Washington Street), which could make fill/elevation more feasible.	• The roadway bridge itself was not touched by spillway and dam upgrades in 2018. The earthen dam was extended and fortified with riprap along Washington Street near Pond Street. • The spillway upgrades seem to have addressed localized flooding impacting roadway for the time being, but the low-lying streets are of concern.
3a	Bolivar Pond near DPW Garage and Canton Animal Shelter	Evaluate vulnerability of DPW Garage facility, Canton Animal Shelter, parking lots, equipment, and buildings along south edge of Forge Pond. Discuss operations of dams/outlet controls with Town. Evaluate suitability/feasibility of retrofitting existing control structure (concrete dam with stoplogs),	• Some localized drainage issues are projected by model, but may be offset by added on-site storage. • Flood barrier retrofits do not appear to be needed for buildings and salt storage shed at this time.	• Confirmed localized low-elevation spots at DPW facility next to Forge Pond. • Flooding has not previously backed up from Forge Pond to the northern parking lot or any buildings. • Also visited Bolivar Street at Bolivar Pond and Town "beach" and pool where recent improvements were made after roadway flooding overtopped the spillway at the "Town beach" in 2010.

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Table 11: Areas of interest for potential flood mitigation strategies (continued)

Areas of Interest Visited by Kleinfelder and Town Staff				
No	**Site Name**	**Reason for Visit**	**Potential For Retrofit?**	**Notes**
3b	Forge Pond Dam	See 3a	Did not visit site due to time constraints.	
4	Massapoag Brook at Messinger Park	Evaluate potential for sub-surface storage below ball field, or nature-based solution at eastern edge of park along Massapoag Brook (i.e., constructed wetland or offline storage).	Combination of large storage system with nature-based solution such as stream restoration seemed feasible, however, there is very little grade change between the park and the open channel brook, which could limit the scale of potential off-line storage. (See **Section 8** for further information on subsequent modeling analysis)	• This is a privately owned park with public maintenance agreement. • Aside from the Brook itself, there is potential in managing upstream areas. However, getting MS4 drainage to this location could be a challenge to re-route significant flow from the north/east of the site. There is a ridge north of Walnut Street and a 36" drain line servicing Walnut Street, Walnut Knolls, and Beverly Hill that could be re-routed, but would likely require an easement. • Stream did not appear to be culverted at any point (Town confirmed) • Town is interested in biodiversity enhancement and sustainable practices such as rainwater harvesting
5a	Massapoag Brook near Tolman conservation lands	Evaluate condition of vegetated (forested) areas off Trayer Road for potential large natural storage system, as the Town has ownership of limited upstream land areas above the Massapoag Brook floodplain.	Limited opportunities.	
5b	Massapoag Brook near Shepard Pond	Evaluate opportunities for wetland restoration, constructed stormwater wetlands, nature-based solutions along Massapoag Brook south of Shephard Pond to border with Town of Sharon.	Limited opportunities.	• Mix of land ownership upstream of Shephard Pond. • Most of the area is already existing wetland, aside from spot upland areas, including Canton Fish & Game at 25 Nasir Ahmad Rd., Town-owned rear parcel behind 132-140 Washington St. ("Conservation Land off Highland" near Mansfield Pond), and upland portions of private parcel at 100 Washington St.
5c	Massapoag Brook near Bailey Court Conservation Area	See 5a/b	Did not visit this site due to time constraints.	

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Table 11: Areas of interest for potential flood mitigation strategies (continued)

Areas of Interest Visited by Kleinfelder and Town Staff				
No	**Site Name**	**Reason for Visit**	**Potential For Retrofit?**	**Notes**
6a, 6b	Summer Heights, neighborhood West of JFK School (Cedarcrest and Kings, Fairview Avenue)	Investigate flooding hotspot identified by community members during workshops. DPW also frequently maintains roadways in this area during winter due to icy roads from groundwater flooding.	Detention-based BMPs or pervious pavement GI may be viable along Cedarcrest Road (no mature trees on east side of street may allow for pervious pavements), however, high groundwater table at bottom of hill in neighborhood could be prohibitive. It is possible that pervious paving in public ROW, with detention-based storage such as rainwater harvesting and bioretention, may alleviate roadway icing during winter. Detention-based storage in upstream neighborhood areas (Kings Road, Spring Lane) may also help alleviate modeled nuisance flooding for ~2-year to 10-year recurrence events (see **Section 8** for further information on subsequent modeling analysis).	• This area includes a high groundwater zone that may be caused by a natural spring or perched water table. • Groundwater flow was observed (absent significant rain) from lawn areas between Snowflake Lane and Fall Lane.
7	Turnpike Street/Rte. 138 at Pequit Brook (near D'Angelo) and downstream wetland areas	Culvert upsizing could possibly alleviate flooding.	Not much room for mitigation within area we could see from D'Angelo parking lot – but replacement of undersized culvert with box culvert seems appropriate (see **Section 8** for further information on subsequent modeling analysis).	• Undersized or obstructed culvert, with sustained high flows on the downstream end of the culvert; not sure what's causing a back-up/ slight back-flow conditions • Was completely submerged on our visit – it had rained the night before, but had not yet rained that day
8	Turnpike Street/Rte. 138 and Dan Road, Dan Road commercial area	Wanted to assess options for road-raising/berm/distributed GI to alleviate flooding.	Potential for GI in business parking lots or in street. Rainwater harvesting for mechanical processing or car washing may be considered (see **Section 8** for further information on subsequent modeling analysis).	• Large industrial park with lots of impervious surface, wide roads with trucking traffic, etc. • No stormwater ponds visible – need to further evaluate where stormwater is going
9	Turnpike Street/Rte. 138 & York Brook, near Canton Point Road	Culvert upsizing could possibly alleviate flooding.	Did not visit this site due to time constraints.	• Private roadway
Areas of Interest Identified with Desktop Analysis				
10	Memorial Playground			• Could prevent flooding downstream Sherman Street and transportation facility. Potential for additional opportunity at the nearby High School.
11	D. Forbes Estate			• On town boarder, but within the Bolivar contributing area with no projected flooding. Also near East Branch of the Neponset River – could potentially mitigate flows during wet weather.
12	Conservation Land East of Devoll Park			• Open area adjacent to Beaver Meadow Brook, projected to experience some flooding but could potentially provide more storage during wet weather.

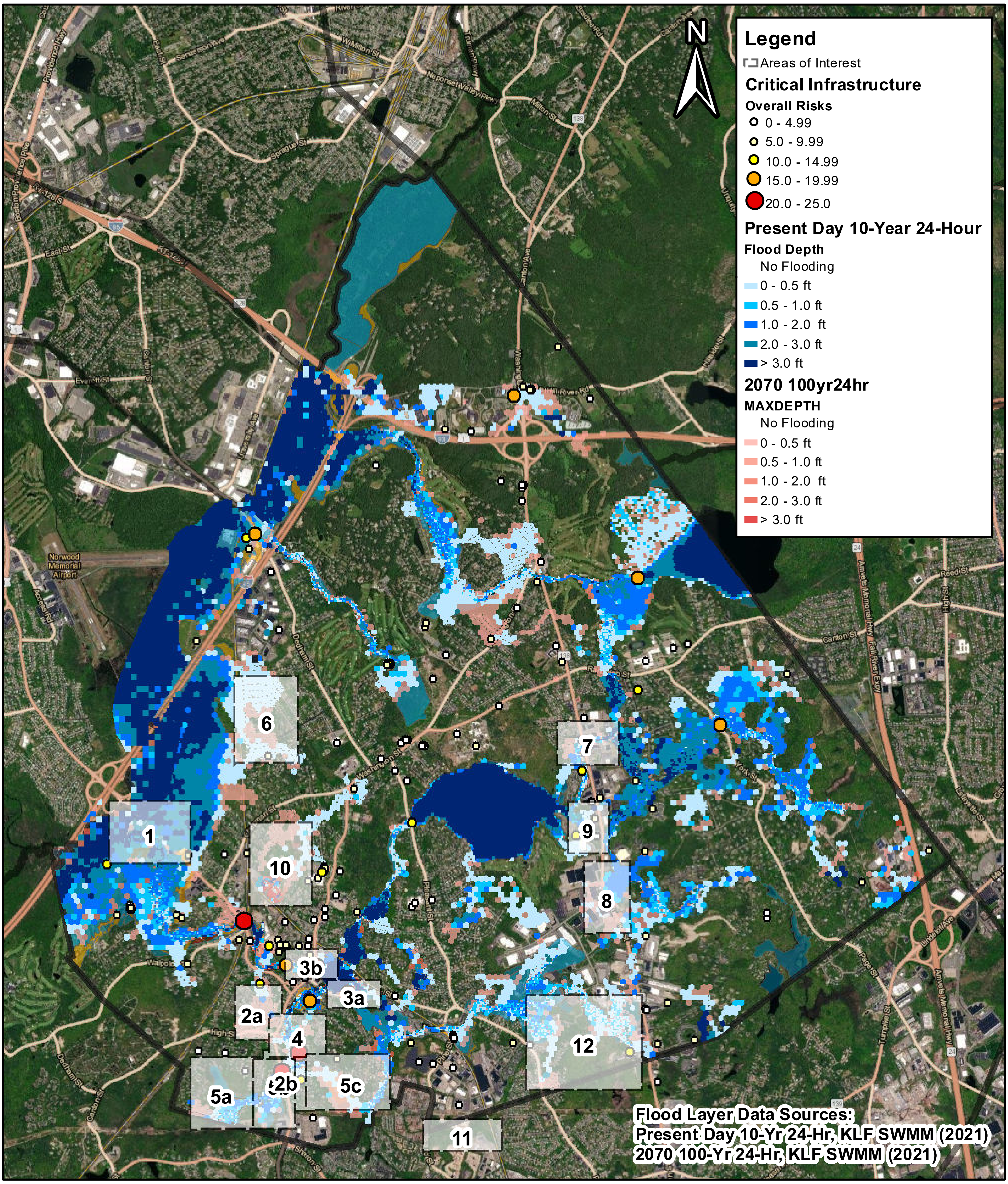

Figure 14: Areas of Interest Assessed by the project team.

SECTION 7
Potential Flooding Mitigation Strategies

Gray Infrastructure

In the context of stormwater and flooding solutions, gray infrastructure refers to man-made, constructed assets such as pipes, pumps and dams, which are designed to capture and transport stormwater off and away from impervious surfaces to control floodwaters. Gray infrastructure is a conventional approach to stormwater management that tends to deliver one function (stormwater management) that most municipalities are equipped to design, construct, and maintain in some capacity.

Green Infrastructure

Green infrastructure is defined in Section 502 of the Clean Water Act as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate,

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or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters." This includes assets such as rain gardens, detention ponds, infiltration trenches, permeable pavement, and rainwater harvesting systems. Green infrastructure is an established stormwater management approach that can deliver multiple benefits (stormwater management, habitat creation, beautification, etc.), which can require specialized maintenance by municipalities. For further information on green infrastructure, see the Boston Water and Sewer Commission's BMP Guidance Book[3].

Nature-Based Solutions

Nature-based solutions (NbS) include the restoration of floodplains, streams, and rivers and the construction of new wetlands to manage stormwater, oftentimes at a neighborhood or regional scale. For more information on nature-based solutions see EEA's MVP toolkit for NbS[4], the FEMA guidance Building Community Resilience with Nature-Based Solutions[5] or the 2019 MVP project for the Town of Brockton: Nature-Based Solutions for Flood Resiliency[6].

Building Adaptations & Retrofits (Floodproofing Structures)

A suite of building adaptations for homes, businesses and other structures is available to protect against flooding. This includes not only engineered adaptations such as floodproof windows and doors, but it also includes adaptations such as elevating utilities and other key assets off basement floors or to the top floor of a building. Preceding an extreme weather event, deployable flood barriers can be set up around a building or key flooding areas to prevent floodwater from even reaching the property at all. For further examples of building adaptation measures, view FEMA's "Homeowner's Guide to Retrofitting"[7].

Community Resilience Programs, Incentives, and Education

The idea that small actions can add up to large impacts is particularly relevant for municipal flood resiliency. Many towns and cities across the country are encouraging landowners to implement flood reduction strategies through various incentive/grant and educational programs. By armoring their own properties with various flood adaptation strategies or reducing overall stormwater flows with green infrastructure, small scale interventions across a large area can have significant flood resiliency impacts.

Examples include:

- *Cambridge Flood Preparedness Toolkit*[8]: These

3 https://www.bwsc.org/sites/default/files/2019-01/stormwater_bmp_guidance_2013.pdf

4 https://resilientma.org/mvp/content.html?toolkit=nature_based

5 https://www.fema.gov/sites/default/files/2020-09/fema_Riskmap-nature-based-solutions-guide-2020_071520.pdf

6 https://brockton.ma.us/wp-content/uploads/2021/05/Executive-Summary_Brockton.pdf

7 "Homeowner's Guide to Retrofitting" from FEMA at https://www.fema.gov/sites/default/files/2020-08/FEMA_P-312.pdf

8 https://www.mass.gov/info-details/municipal-vulnerability-preparedness-program-action-grant-projects#cambridge-

resources include educational information for the public on how to assess flood risk for their home or business as well as a list of actions that they can take to mitigate and prevent the impacts of future flooding. A description of each action is provided with information on why it may help, when they can implement it, and the estimated cost range for the given action. Resources to help with how they can implement it are also given. To assess their risk, a link to a flood map is provided so they may determine if their property lies in an identified flood zone. The toolkit also prompts readers to think about their personal risks, such as finances or family members at greater risk (poor health, children, seniors), and the potential impacts a flood could have on their home or business. Potential actions, risks, and impacts are tailored to specific property types (home, small or large businesses, renters). Potential actions for smaller businesses and homeowners include installing porous pavement, elevating critical utilities or items off the basement floor, cleaning storm drains near the property, etc. For larger businesses, potential actions might include creating a business continuity plan or assessing their real estate portfolio.

- *FEMA Flood Preparedness Materials and Brochures*[9]: FEMA offers educational materials on flood preparedness, including a brochure titled "Protect Your Property From Flooding." The brochure covers action items homeowners can take to mitigate or prevent the impacts of flooding inside and outside the home and includes links to additional resources.
- *Medford Social Resiliency Program*[10]: This program aims to assess Medford's ability to withstand climate events from a public health perspective utilizing a combination of municipal and grassroots community input. Resource Hubs provide programming, structure, power, communication, and operations support to residents in the event of a flood or other disaster.
- *Onondaga Country Save the Rain Program*[11]: What started as a comprehensive stormwater management plan intended to reduce the amount of pollution that flows into Onondaga Lake and its tributaries and is quickly becoming a way of life in Onondaga County that also reduced stormwater volumes county-wide.
- *San Francisco Floodwater Grant*[12]: Reimbursement program for making property improvements that help protect against flooding in areas with known flooding issues.

Regulation and Zoning

Many regulatory and/or zoning policies can help to mitigate flooding by encouraging smart growth and requiring stormwater management or flood proofing in new or redevelopment. Each of these concepts are described in the paragraphs that follow:

Zoning

Zoning regulations that restrict development in areas known (or anticipated via modeling) to flood can be a low-cost strategy for flood mitigation.

9 https://www.ready.gov/floods

10 http://www.medfordma.org/resiliency-hubs/

11 https://savetherain.us/

12 https://sfwater.org/index.aspx?page=681

An increasingly common approach being taken by municipalities in Massachusetts and around the nation is to redefine floodplain overlays (and/or freeboard requirements for critical and non-critical structures), based on modeled flood scenario extents and depths. For instance, the City of Boston is implementing both an Inland Flood Resilience Zone and a Coastal Flood Resilience Zoning Overlay based on modeling from the Boston Water & Sewer Commission's Inundation Viewer and Massachusetts Department of Transportation's (MassDOT) Massachusetts Coastal Flood Risk Model (MC-FRM), respectively.

A similar measure in Canton may require legislative changes and likely coordination with the Town's Planning Department and Building Division. Canton's current Flood Plain Overlay District (FPOD) defines Flood Hazard Areas as consistent with Federal Flood Plain Districts and Special Flood Hazard Areas (per FEMA FIRM maps).

Wetlands Protection, Riverfront Areas, and Climate Resilience

For municipalities like the Town of Canton, the first line of defense against flood is often its natural infrastructure, including wetland areas, natural river and stream floodplains, conservation lands, and other natural storage areas. Canton, like other municipalities, enforces local wetland protections via the Massachusetts State Wetlands Protection Act (WPA) that protect these areas from encroaching development or other activities that disturb the condition and functionality of these resource areas.

In recent years, recognizing the growing threat of climate change to resource areas, a growing number of municipalities are enacting stricter standards than the State's WPA standards. For example, Arlington, Lexington, and Boston are among other Massachusetts municipalities that have already updated (or are in the process of updating) local regulations to be more stringent than the State standards.

There are several ways in which enacting stricter standards (such as smaller buffer zones or greater performance standards) or redefining key terms used in the WPA can help achieve greater climate resilience. For example, the Wetlands Protection Act MGL Chapter 131, Section 40 defines the term "Riverfront Area" as a buffer that is delineated from the mean annual high-water line, which is typically a site-specific elevation based on visual high-water marks from past events. However, such requirements and definitions are based on past storms and climatology. As climate impacts increase, riverine discharge and mean annual high flows can be expected to also increase. Improved tools (such as Canton's H+H model, which accounts for future flows by projecting climate change impacts) can help project future riverine and stream water surface elevations during large storm events, such as the annual high-water event in 2030 or 2070. Such projections can be helpful when revisiting regulatory definitions for local wetland, riverine, and stream protections and help form the basis for updates and other forward-thinking regulations.

Enhanced post-construction stormwater regulations

The post-construction requirements of the stormwater treatment permit require that new and redevelopment projects that disturb more than 1 acre of land to manage stormwater on-site using green infrastructure for treatment. Adding volume reductions requirements and/or reducing the threshold that triggers these requirements would encourage the reduction of stormwater volumes from development over time. The Town of Dedham requires stormwater permits for projects as small as

500 sf[13] and Washington DC is requiring stormwater compliance for large interior retrofit projects[14].

Flood-smart development regulations

Implementing flood-proof development regulations can range from requiring greater (higher) freeboard for built infrastructure assets to requiring higher street elevations in priority redevelopment areas to prevent property damage and improve quality of life over longer-term planning horizons.

Currently (per the Town's development regulations), "(new) construction or substantial improvements of residential structures within a Federal Flood Plain District (herein defined) shall have the lowest floor (including basement) elevated to or above the one hundred (100) year flood level as shown on the maps hereinafter described. Non-residential structures within Federal Flood Plain District shall either be similarly elevated or, together with attendant utility and sanitary facilities, be flood proofed watertight to or above the one hundred (100) year flood level."

Canton's current Flood Plain Overlay District (FPOD) defines Flood Hazard Areas as consistent with Federal Flood Plain Districts and Special Flood Hazard Areas (per FEMA FIRM maps). However, it is evident from the proposed FEMA PFIRM updates (2020 draft maps) that large portions of Present Day flood zones (or modeled future flood zones per the Canton H+H model) are not represented in the effective FEMA FIRM maps (effective FIRM dates for panels covering Town of Canton are currently from 4/3/1978, or 6/4/1987 for East Canton). (As of this report's publication, the Town is currently in the 90-day appeal period for PFIRM and associated Flood Insurance Study (FIS) documents[15].)

An option that the Town may consider is to increase freeboard requirements for critical and non-critical structures based on modeled flood scenario extents and depths. Recognizing that the frequency and magnitude of major precipitation events are increasing, more and more cities and towns have recently updated their local freeboard requirements (extending applicability FEMA 500-year zones, modeled flood extents, or increasing the height of freeboard based on locally modeled flood depths).

The Town FPOD bylaws currently require that basement floor elevation (or the lowest floor elevation) for any structures in the FEMA SFHA (i.e., FEMA 100-year zone) "be at least fifty two (52) feet above said Mean Sea Level" and that "safe vehicular and pedestrian movement to, over, and from the premises is provided on ways having a minimum elevation of no less than forty nine (49) feet above said Mean Sea Level", based on elevations at the Neponset River at Canton River[16].

13 https://www.dedham-ma.gov/departments/conservation/stormwater-management

14 https://doee.dc.gov/swregs

15 https://www.town.canton.ma.us/897/Flood-Insurance-Rate-Map-FIRM

16 Town of Canton, MA Flood Plain Overlay District (FPOD) Section 9.1 bylaw (amended 2017) https://www.town.canton.ma.us/DocumentCenter/View/3407/Zoning-By-Laws---2017-Amended-through-ATM-2017-PDF?bidId=

SECTION 8
Modeling Mitigation Analysis

Overview of Modeled Mitigation Scenarios

Three (3) flood mitigation scenarios were modeled, each containing a bundle of flood mitigation strategies (e.g., infrastructure projects, pond/reservoir operations, and/or catchment-scale implementation of nature-based solutions). The numerical progression of scenarios generally involves an increase in scale of implementation and potential expenditure (i.e., Scenario 3 is the most aggressive target implementation level modeled in this analysis).

These scenarios (summarized in **Table 12**) demonstrate a comparison of the magnitude of mitigation benefits at differing levels of implementation and are thus not direct alternatives to each other.

For each modeled scenario, projects/actions were packaged in discrete catchments to best compare individual strategies at different target levels of implementation. However, some of the larger mitigation strategies, such as catchment-

Table 12: Summary of modeled alternatives and corresponding flood mitigation strategies

Scenario 1	Flood mitigation strategies
Neponset Street	Raise Neponset Street roadway above modeled WSE to protect from 2070 10-year event
Pequit Brook	Upsize culvert at Turnpike Street/Rte. 138 (Upper Pequit Brook) - increase size to 10'W X 6'H (modeled ~25% cross section increase)
Memorial Field area	Memorial Field area (Distributed GI) - 10% implementation (i.e., 10% of directly-connected impervious area routed through GI)
Nature-based storage	Add natural storage or downstream control structure for Bailey Conservation Area (for flow attenuation/slow release)
Scenario 2	**Flood mitigation strategies**
Neponset Street	Raise Neponset Street roadway above modeled WSE to protect from 2070 10-year event
Pequit Brook	Upsize culvert at Turnpike Street/Rte. 138 (Upper Pequit Brook) - increase size to 12'W X 6'H (~50% cross section increase)
Bolivar Pond	Active Reservoir Management pre-release flows (i.e., 1 ft. pre-event drawdown at Bolivar Pond)
Beaver Meadow Brook	Remove impervious runoff from Dan Road commercial catchment by 25% (i.e., 25% of directly connected impervious area routed through GI)
Nature-based storage (Beaver Meadow Brook)	Add 1 MG of upstream storage at one location in Beaver Meadow Brook (i.e., along Redwing Brook)
Memorial Field area	Memorial Field area (Distributed GI) - 25% implementation

scale implementation of distributed GI or nature-based storage, have compounding benefits (i.e., downstream benefits are the results of multiple strategies in the same catchment). For this reason, it is important for future efforts to evaluate cost effectiveness or cost-benefit of individual projects/ actions for each individual strategy, as the Scenarios have not been optimized and specific strategies/ target implementation levels can be mixed-and-matched in future modeling analyses.

Scenario Modeling Results - Discussion

Town-wide Results

The modeling analysis conducted under both the 10-year and 100-year 2070 storm conditions was then compared back to baseline (i.e., present day). Both the flood extents as well as the flood depths were noted in this comparison. Typically, stormwater improvement and infrastructure would use the 10-

Table 12: Summary of modeled alternatives and corresponding flood mitigation strategies (continued)

Scenario 3	Flood mitigation strategies
Neponset Street	Raise Neponset Street roadway above modeled WSE to protect from 2070 10-year event
Pequit Brook	Upsize culvert at Rte. 138 (Pequit Brook) - increase diameter to 48" (i.e., double pipe culvert)
Bolivar Pond	Active Reservoir Management pre-release flows (i.e., 2 foot pre-event drawdown at Bolivar Pond)
Beaver Meadow Brook	Remove impervious runoff from Dan Road commercial catchment by 50% (i.e., 50% of directly connected impervious area routed through GI)
Nature-based storage (Beaver Meadow Brook)	Add 1 MG of upstream storage at 3 locations in Beaver Meadow Brook (i.e., 1 MG each at: conservation lands at D. Forbes Estate, along Redwing Brook, area east of Devoll Park)
Memorial Field area	Memorial Field area (Distributed GI) - 50% implementation (i.e., 50% of directly connected impervious area routed through GI)
Memorial Field	1 MG storage added below ball field(s) and/or parking lot(s)
Messinger Park	1 MG storage added below ball field, managing flow from upstream (Silk Mill Pond discharge)

year storm condition as the design basis for sizing of components (e.g., culverts, pipes, outfalls, etc.).

Therefore, these results were of particular interest. Flood projections under the 2070 10-year conditions (as shown in Figure 15) indicated that flooding will be of concern within the focus areas previously identified; however, generally, the Town's drainage infrastructure will keep the majority of stormwater within existing water bodies and drainage networks. Figure 15 represents both absolute flood depth (depicted in gradations of blue) and extents as well as the change in flood depth (depicted in gradations of purple shading) between the baseline conditions and the projected potential flood reduction with the inclusion of mitigation strategies included in Scenario 3.

When comparing the 2070 100-year flood conditions with baseline, however, the projected flood impacts are more dramatic. This is not entirely surprising given total precipitation nearly doubles between the 2070 10-year (Precipitation = 6.38") and 2070 100-year (Precipitation = 11.70") storms for future conditions. Though the Town may choose to design for the future 10-year storm, for purposes of this study, the 100-year condition was used to show the more significant potential benefits of the flood mitigation strategies considered. Figure 16 illustrates the 2070 100-year storm projected flood reduction under Scenario 3. At this scale, the change in flood depth (represented by purple shading) might not look dramatically different, but in looking at several of the proposed mitigation strategies in more detail, there appears to be greater benefit of these proposed

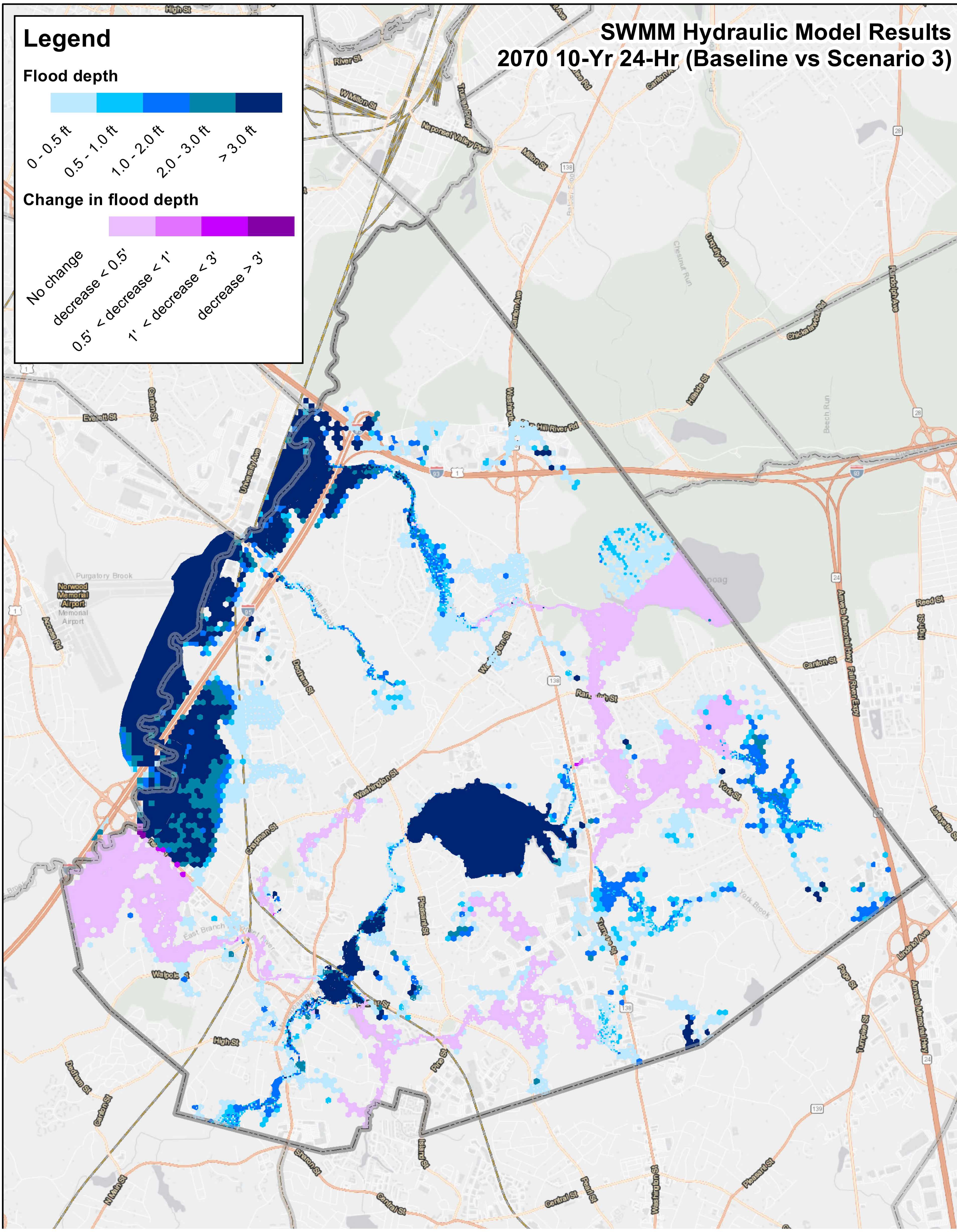

Figure 15: Scenario 3 mitigation strategies results in a moderate potential flood depth reduction over baseline conditions

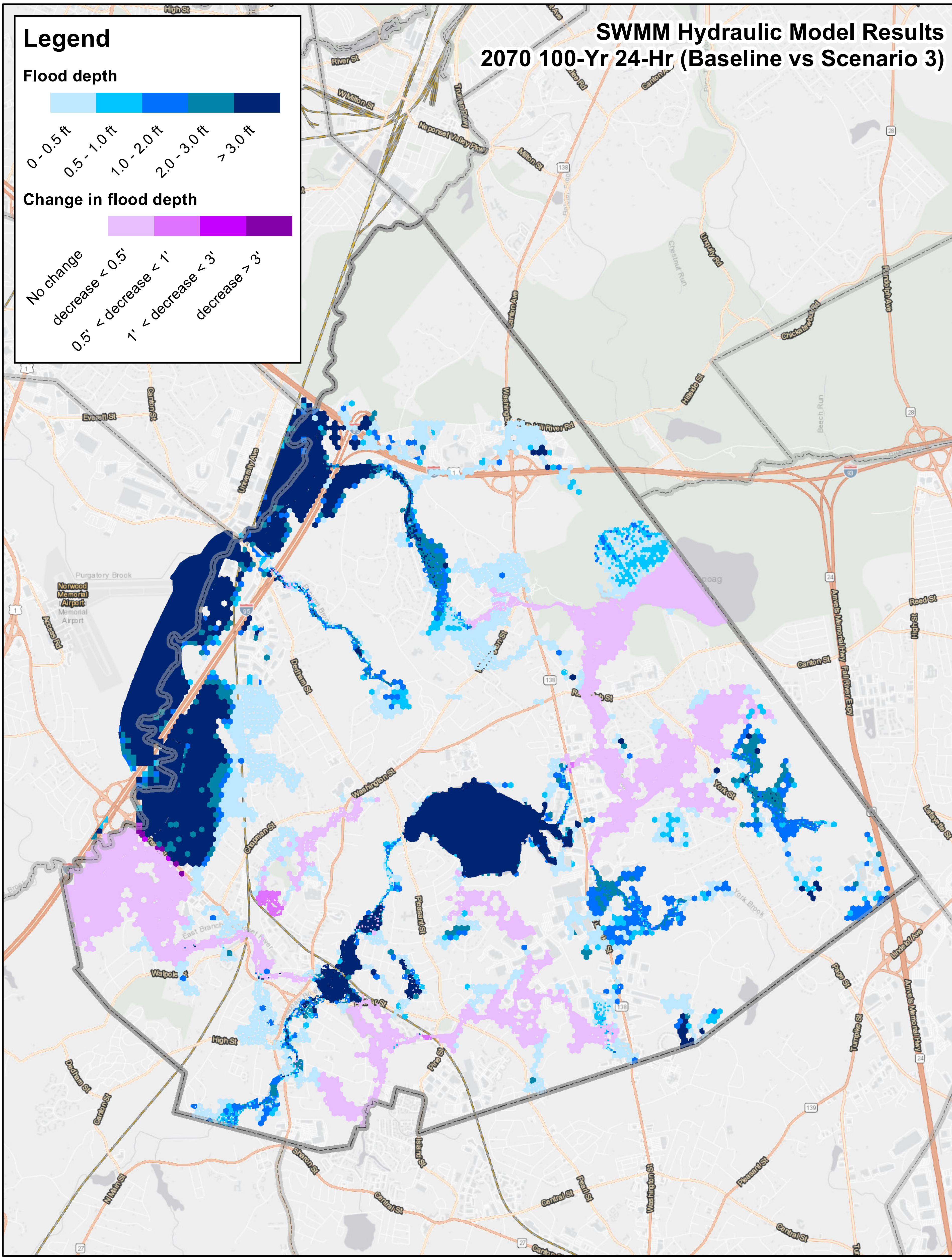

Figure 16: Comparing the flood levels projected under 2070 100-year storm event with baseline looks similar to the 10-year event in extent but with lower overall flood depths realized.

strategies during the 2070 100-year storm. Therefore, the detailed discussion of strategies will be focused on modeling performed under the 2070 100-year storm event conditions.

Infrastructure Mitigation Results

Memorial Field

Distributed green infrastructure (distributed GI) along with sub-surface stormwater storage has the potential to reduce the nuisance flooding around the high school and as far south as Sherman Street and the MBTA Transit Station. Modeled results indicated that a level of 10% reduction of directly connected impervious area (DCIA) within Memorial Field could reduce flood depths by up to 0.5 inches over the flood extents. By reducing DCIA up to 50% and adding approximately 1 million gallons (MG) storage, flood depth could be reduced by more than 1 foot near the MBTA station and across Sherman Street.

Figure 17 represents the absolute flood depth and extents projected in Scenario 1 with the mitigation strategies in place while **Figure 18** shows the relative change in flood depth over baseline. Likewise, **Figure 19** represents the absolute flood depth and extents after implementation of Scenario 3 measures while **Figure 20** shows the relative change in flood depth over baseline.

Neponset Street Roadway Improvement

Only one mitigation strategy was modeled for improvement along the portion of Neponset Street that is subject to future flooding (near the I-95 interchange), which was to raise the roadway elevation to just above the 2070, 10-year storm event elevation (as determined from the water surface elevation (WSE) analysis). Both the 2070 10-year and 100-year storm were modeled with this proposed improvement. The results under the two modeled storm events were similar, indicating little added benefit to raising the roadway above the 2070 10-year projected WSE.

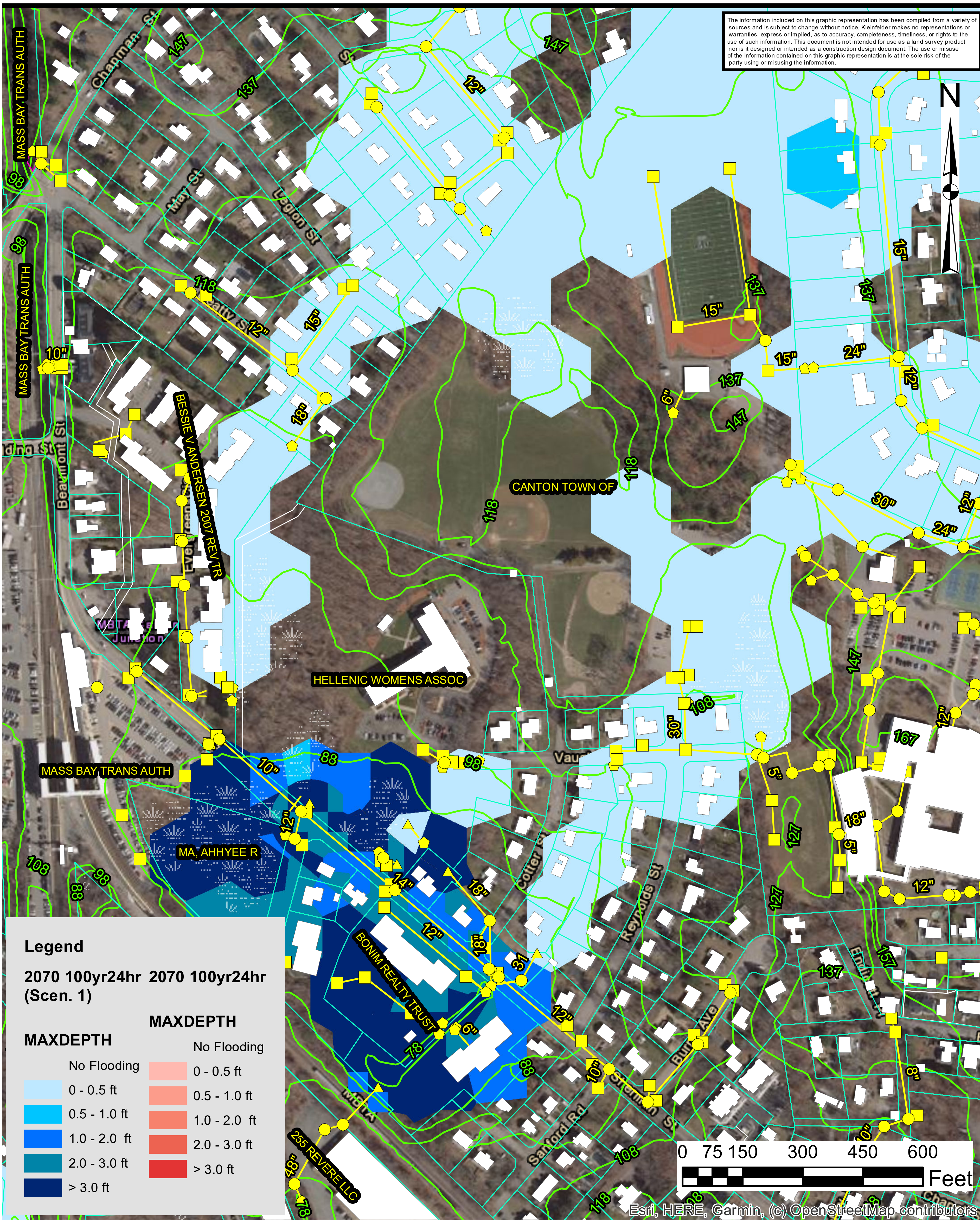

Figure 17: Flood extents and depth projected for 2070 100-year storm event in Memorial Field / Sherman Street under Scenario 1.

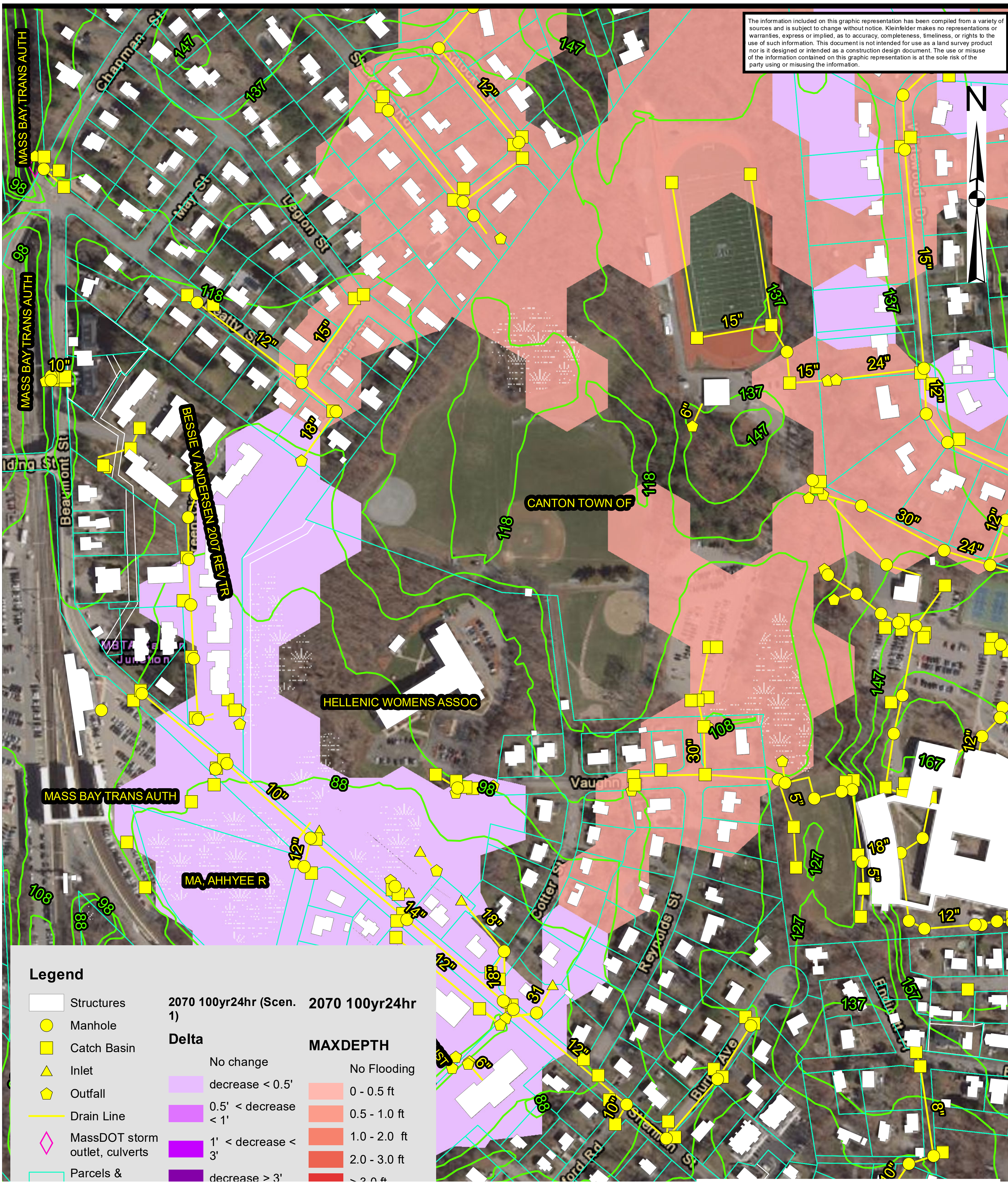

Figure 18: Relative decrease in flood depth over baseline projected for 2070 100-year storm event in Memorial Field / Sherman Street under Scenario 1.

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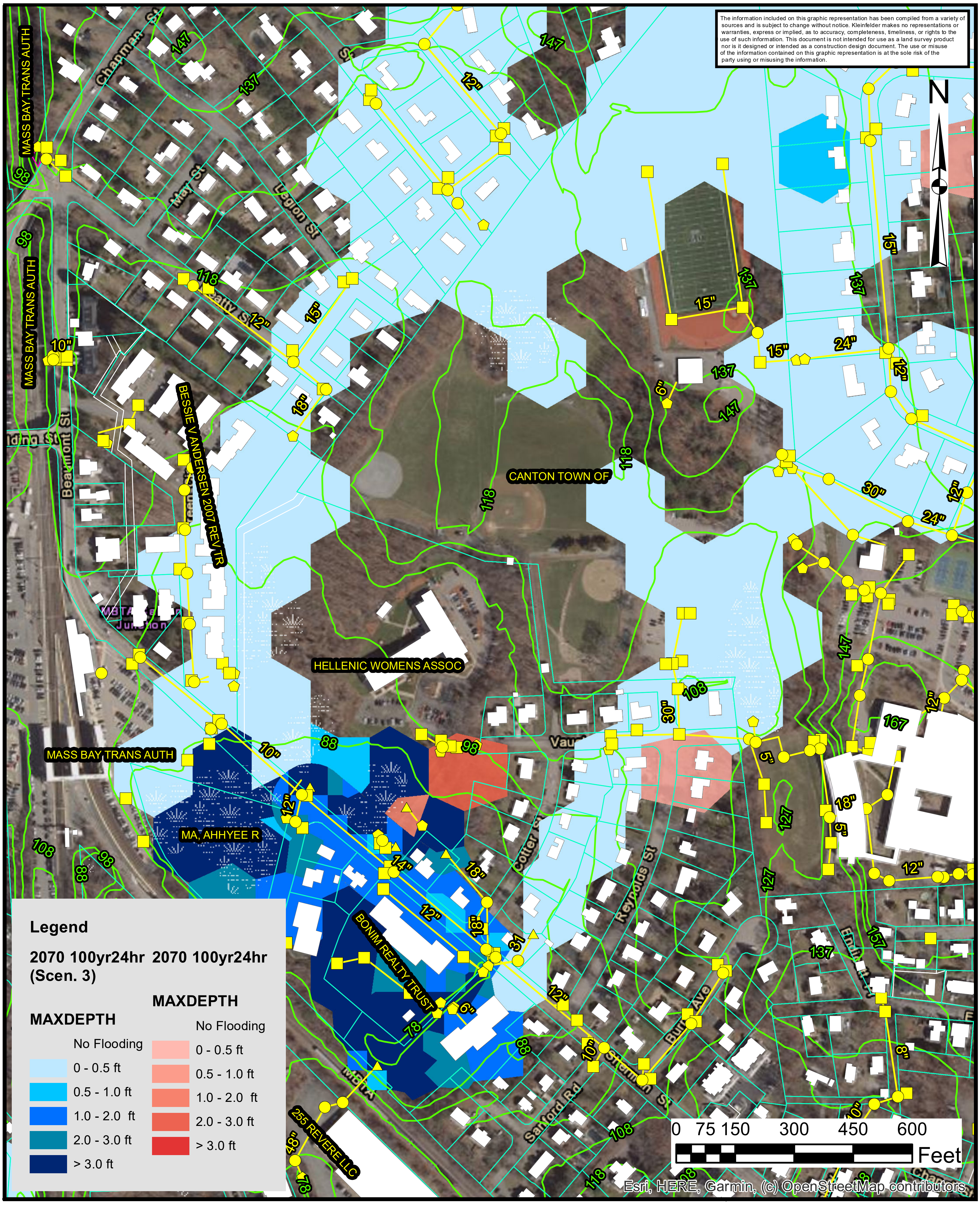

Figure 19: Flood extents and depth projected for 2070 100-year storm event in Memorial Field / Sherman Street under Scenario 3.

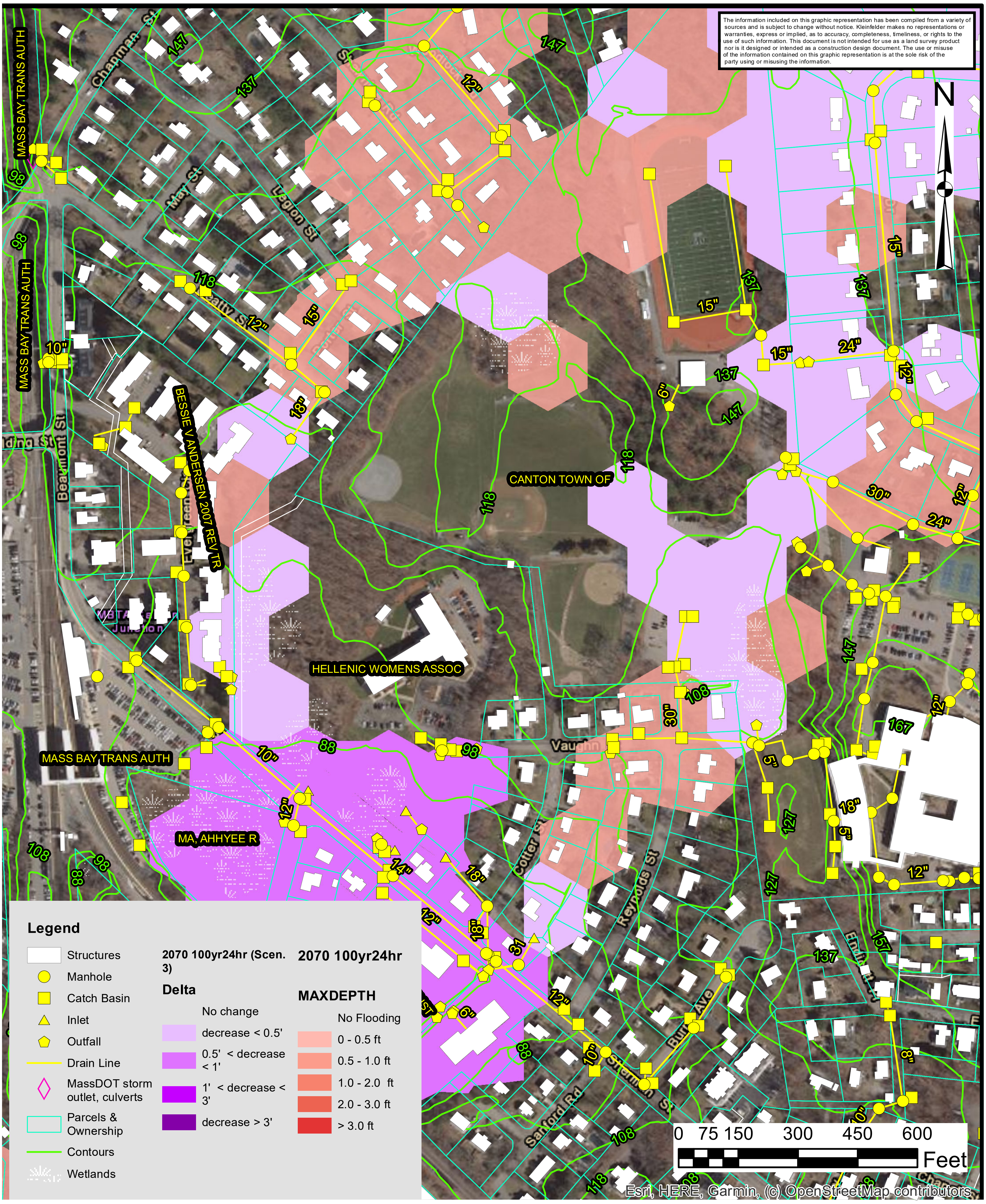

Figure 20: Relative decrease in flood depth over baseline projected for 2070 100-year storm event in Memorial Field / Sherman Street under Scenario 3.

From **Figure 21**, the red shaded areas (or absence of blue) along the roadway indicate that little to no flooding is projected to occur at this proposed higher roadway surface elevation. This can be seen even more clearly in **Figure 22** with the presence of dark purple shading along the roadway alignment, indicating a projected decrease in flooding depth of 1–2 feet. The light purple shading shown to the south of the roadway is resulting from other nearby sub-catchment mitigation measures also modeled in Scenario 3 and is not necessarily tied to the roadway improvements.

Pequit Brook (Turnpike Street/Rte. 138 near D'Angelo)

In the area where the Pequit Brook crosses beneath Turnpike Street (near D'Angelo), potential flooding has occurred historically and is being projected to occur during future storm events both at this point of intersection of road and stream but also up into businesses and homes to the east of this intersection as well. Upon a visit to the site, the culvert seemed at its capacity even during a minor precipitation event (see **Figure 23**). From the recent photo, there appears to be a potential issue with capacity that is causing enough restriction to back up upstream causing the potential for flood.

Increasing the capacity of the culvert at 25%, 50%, and 100% over baseline conditions was modeled to see the potential in flood reduction for the area. Even for Scenario 1, a 25% increase in capacity or decrease in restriction, there was reduction in nuisance flooding over a significant area of the sub-catchment basin. Though **Figure 24** shows the extents of flooding in close proximity to the culvert are unchanged over the

Figure 23: The culvert condition at Pequit Brook and Turnpike Street during the April 2021 site visit.

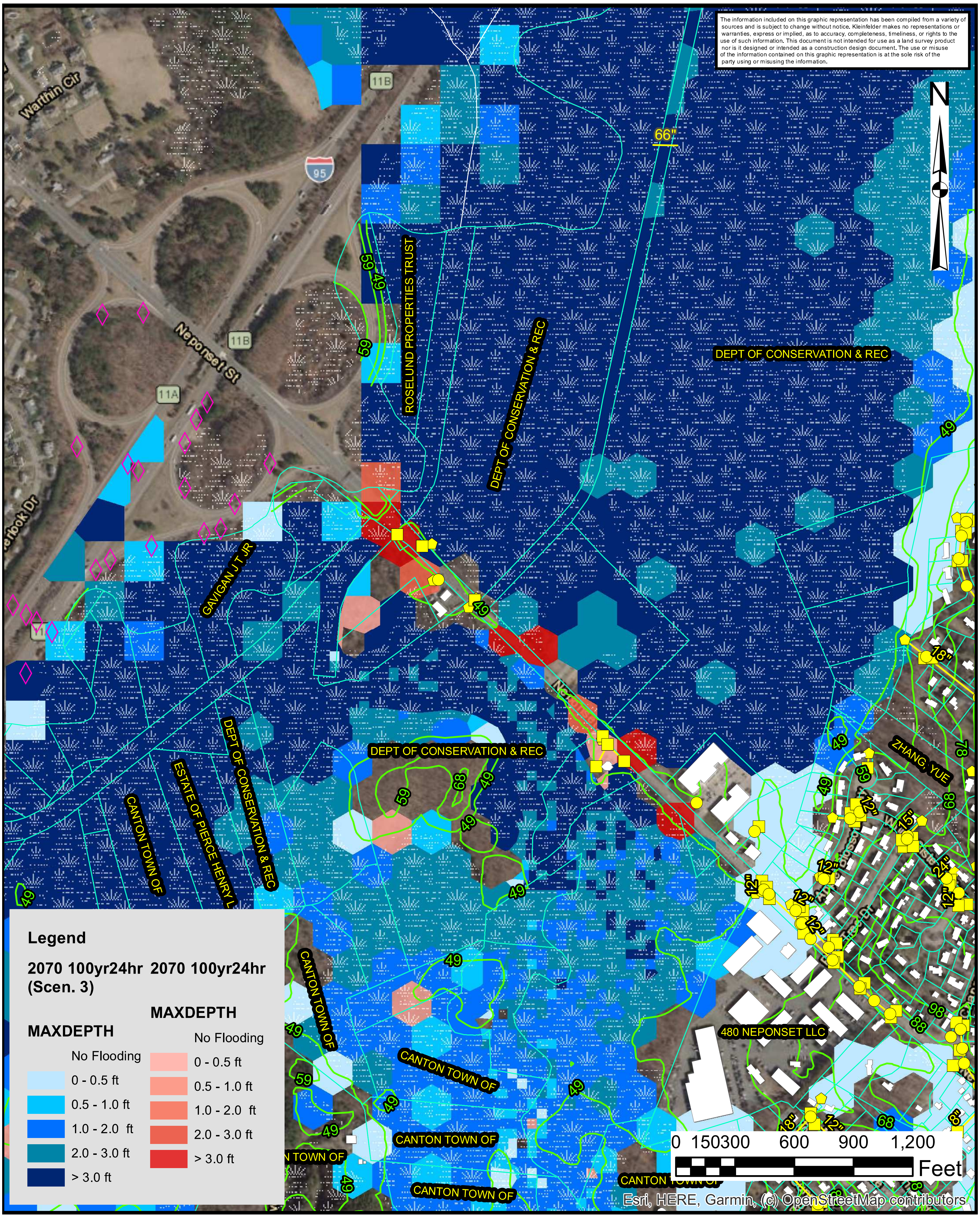

Figure 21: Flood extents and depth projected during the 2070 100-year storm event at Neponset Street / I-95 under Scenario 3.

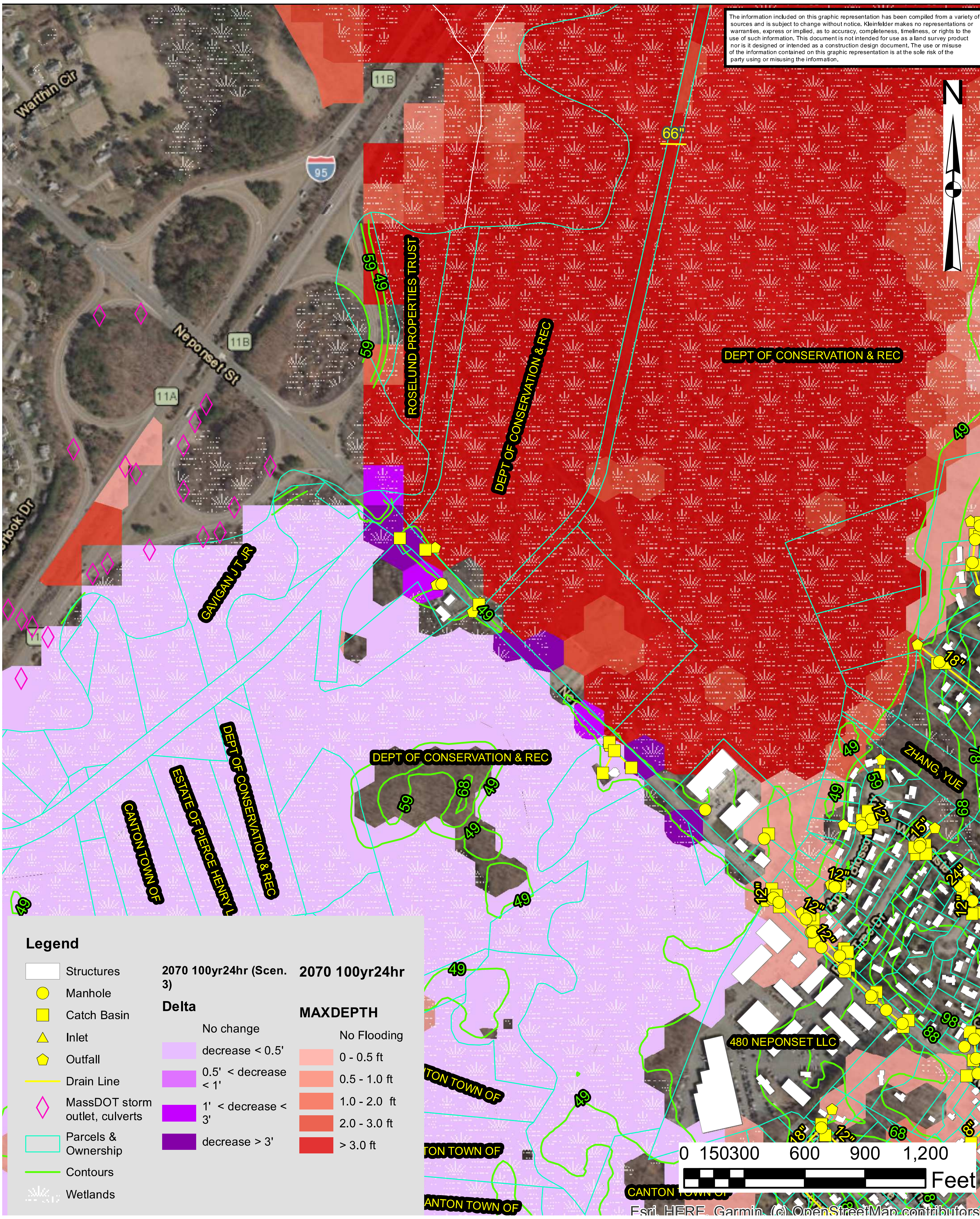

Figure 22: Relative decrease in flood depth over baseline projected during the 2070 100-year storm event near Neponset Street/ I-95 under Scenario 3.

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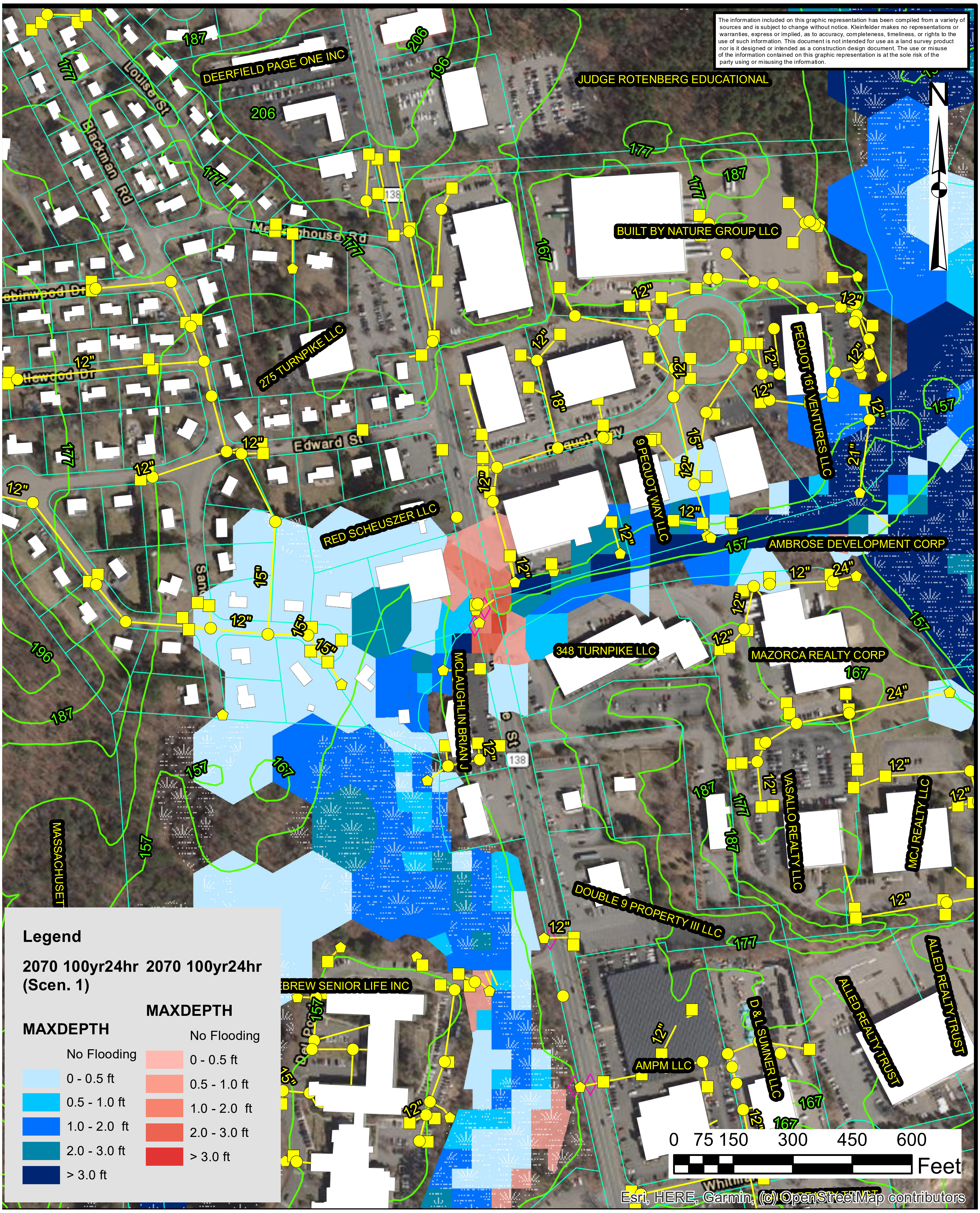

Figure 24: Flood extents and depth projected for the 2070 100-year storm event near Pequit Brook / Turnpike Street under Scenario 1.

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baseline conditions, **Figure 25** shows the extent of the reduction in nuisance flooding (indicated by the purple shading). This figure also shows that several businesses and residents may experience lesser flooding in the future by right-sizing this culvert as well as reduced risk of roadway overtopping at other low-lying crossings (indicated in **Figure 25**). Surprisingly, increased culvert capacity did not result in significantly different flood reduction benefits over the Scenario 1 conditions. However, additional modeling with more resolution around this area should be conducted to determine the right size for future conditions.

Sub-Catchment Mitigation Results

In addition to the specific infrastructure mitigation strategies described, Kleinfelder also looked for opportunities and areas in Town that would be good candidates for sub-catchment scale nature-based solutions or green infrastructure. One area in particular that showed promise is the area south of the Town center along the Massapoag and Meadow Brooks. These sub-catchments drain through the Shepard Pond, Bolivar Pond, Forge Pond network and have the potential to affect many neighborhoods and critical asset on its way to Neponset River. Several of the specific mitigation measures considered are discussed further herein.

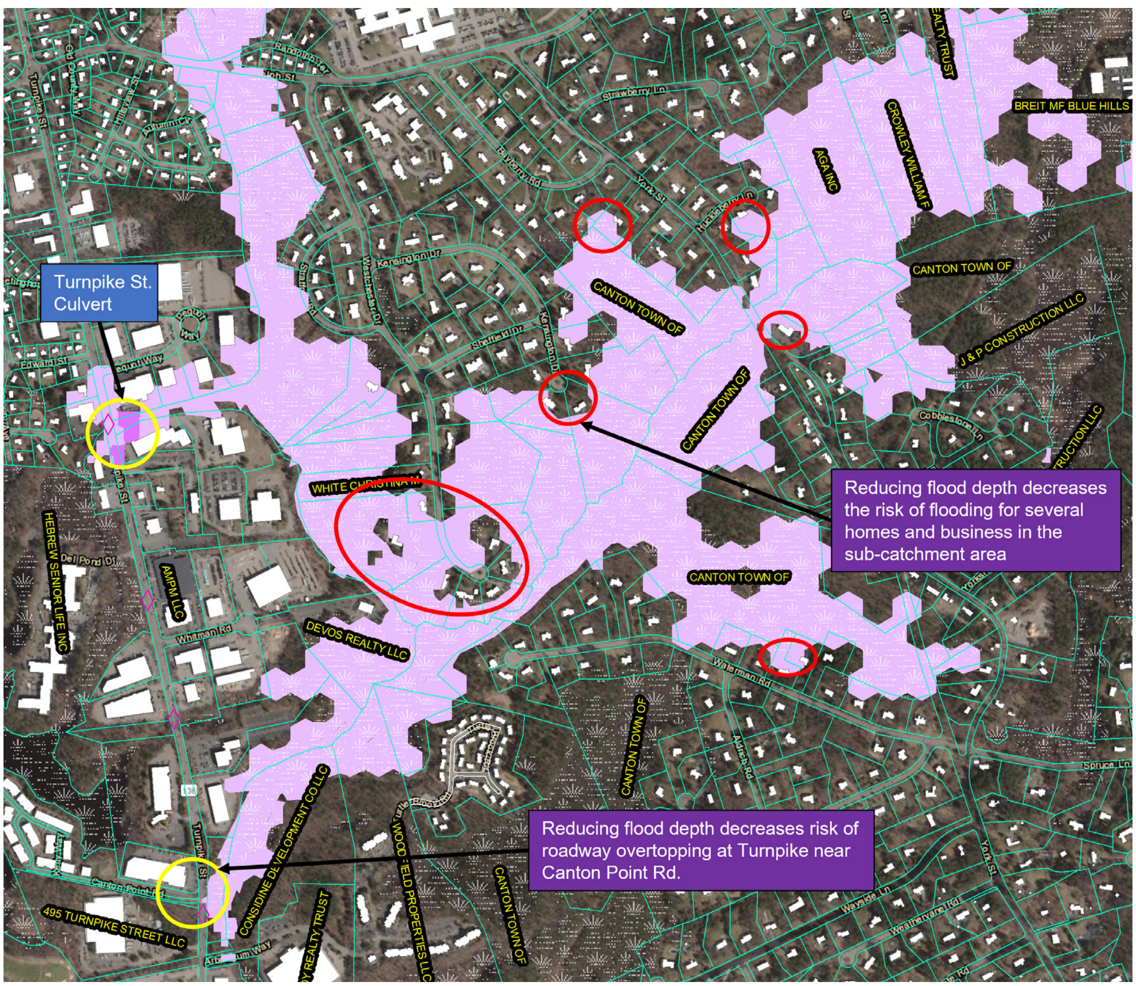

Figure 25: Relative decrease in flood depth over baseline projected during the 2070 100-year storm event near Pequit Brook/ Turnpike Street culvert under Scenario 1 (25% increase in capacity).

Figure 26 shows the projected flood depth and extents of a 2070 100-year storm event, pre- and post-mitigation strategy implementation, for Scenario 1, which included only one nature-based storage solution along the Steep Hill Brook/Bailey Court Conservation Area.

Figure 27 shows the projected flood depth and extents the same storm, pre- and post-mitigation strategy implementation, for Scenario 3, which included seven (7) nature-based storage solutions along the Steep Hill Brook/Bailey Court and Meadow Brook conservation areas.

Figure 28 and **Figure 29** show the reduction in flood depth over baseline during the 2070 100-year storm event for Scenario 1 and Scenario 3, respectively.

Figure 26 through **Figure 29** can be used as reference in understanding the following detailed results summaries, categorized by sub-catchment area:

Bolivar Pond/Forge Pond Active Reservoir Management

Bolivar Pond is noted by Town staff to be a "flashier" pond in that WSE can experience quick changes related to storm events. There is a significant drainage volume that moves through this pond and onto Forge Pond. More active management of this pond, such as pre-releasing some of the water to drawdown the WSE before a forecasted large storm event, could provide some of the flooding in proximity to this pond. The model was used to investigate the pre-release of 1 foot and 2 feet of water (i.e., starting the WSE at 1 foot and 2 feet below the modeled dam surface elevation). The drawdown of 2 feet showed the most benefit in flood depth reduction in proximity to Bolivar Pond without noticeable detriment to Forge Pond, which has a higher holding capacity. Additional drawdown (greater than 2 feet) would likely provide improved benefit; however, structural changes could be needed at the existing outlet structure to allow for that to occur.

Beaver Meadow Brook, downstream of Dan Road commercial catchment area

A reduction in the DCIA in and around the Dan Road commercial/business park area was also modeled. The stormwater from this area enters the sub-catchment through Beaver Meadow Brook. Increasing the level of imperviousness reduction did not resolve all nuisance flooding in the immediate area but it did begin to indicate benefit in peak flow and flood depth reduction. **Figure 30** illustrates the peak flow and depth during the modeled storm duration at a particular model junction near the outlet of the Dan Road area into the Beaver Meadow Brook.

Nature-Based Storage

In order to capture more of the peak flow of the modeled storm event, nature-based strategies, simplified as 1-MG of storage, were added within the model sub-catchment. The exact form of these solutions has yet to be decided but the particular locations, parks, and conservation areas, were selected because they offer opportunities for the inclusion of nature-based solutions such (i.e., bioretention or swale, enhance wetland, etc.) with less effort than a more urban or residential area might. The function of these storage solutions is to reduce the peak flow during the modeled storm event. For Scenario 1, 1-MG storage was included along the Steep Hill Brook, near the Bailey Court Conservation Area. For Scenario 3, three 1-MG of storage was added along the Beaver Meadow Brook at Devoll Park, D. Forbes Estate and near Red Wing Brook. As with many of the modeled mitigation strategies, the flood extents are not drastically reduced but the flood depth is decreasing indicating potential benefit with these types of strategies within

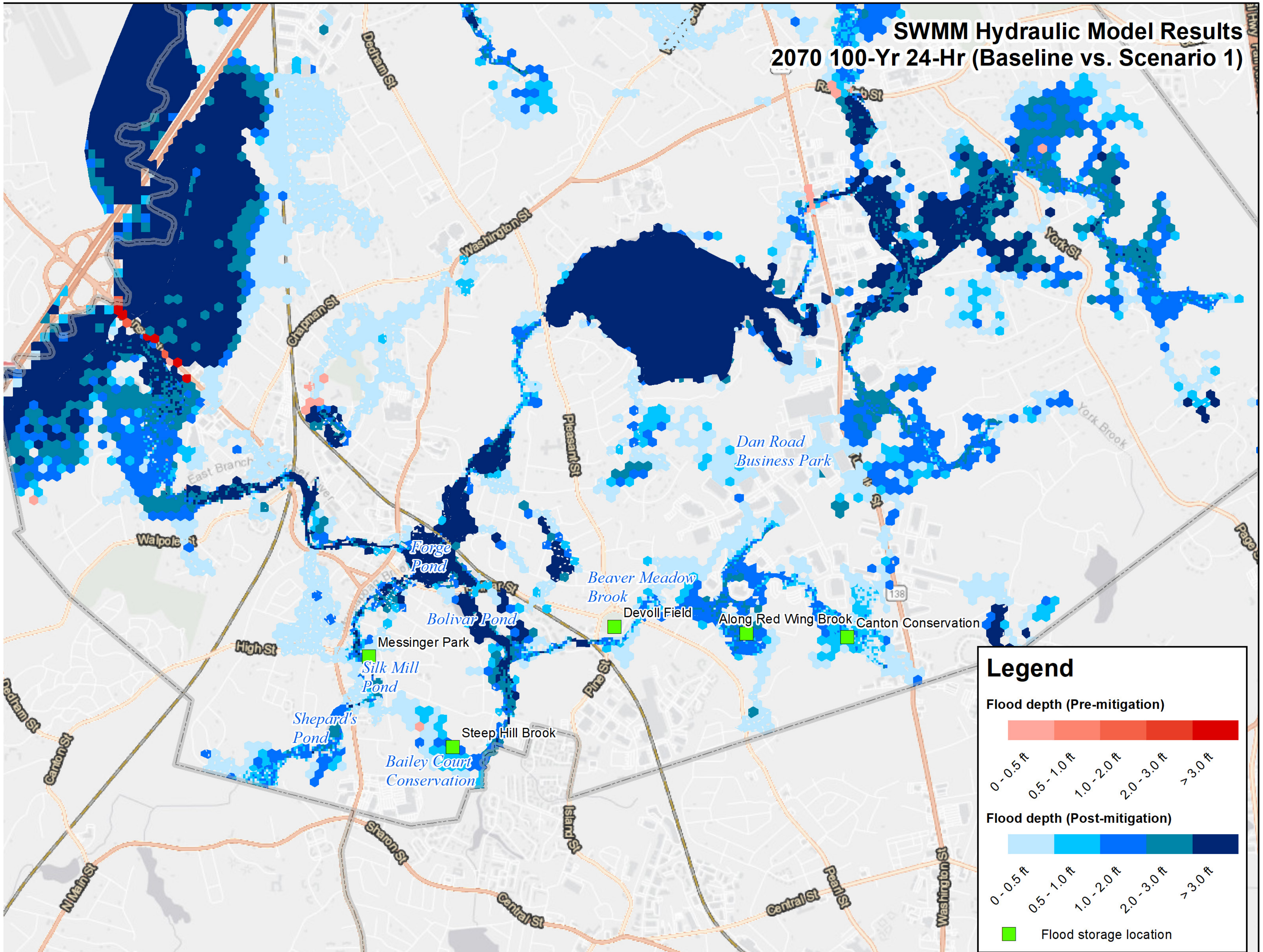

Figure 26: Flood extents and depth projected both pre- and post-mitigation during the 2070 100-year storm event in the Massapoag/Beaver Meadow Brook sub-catchment under Scenario 1.

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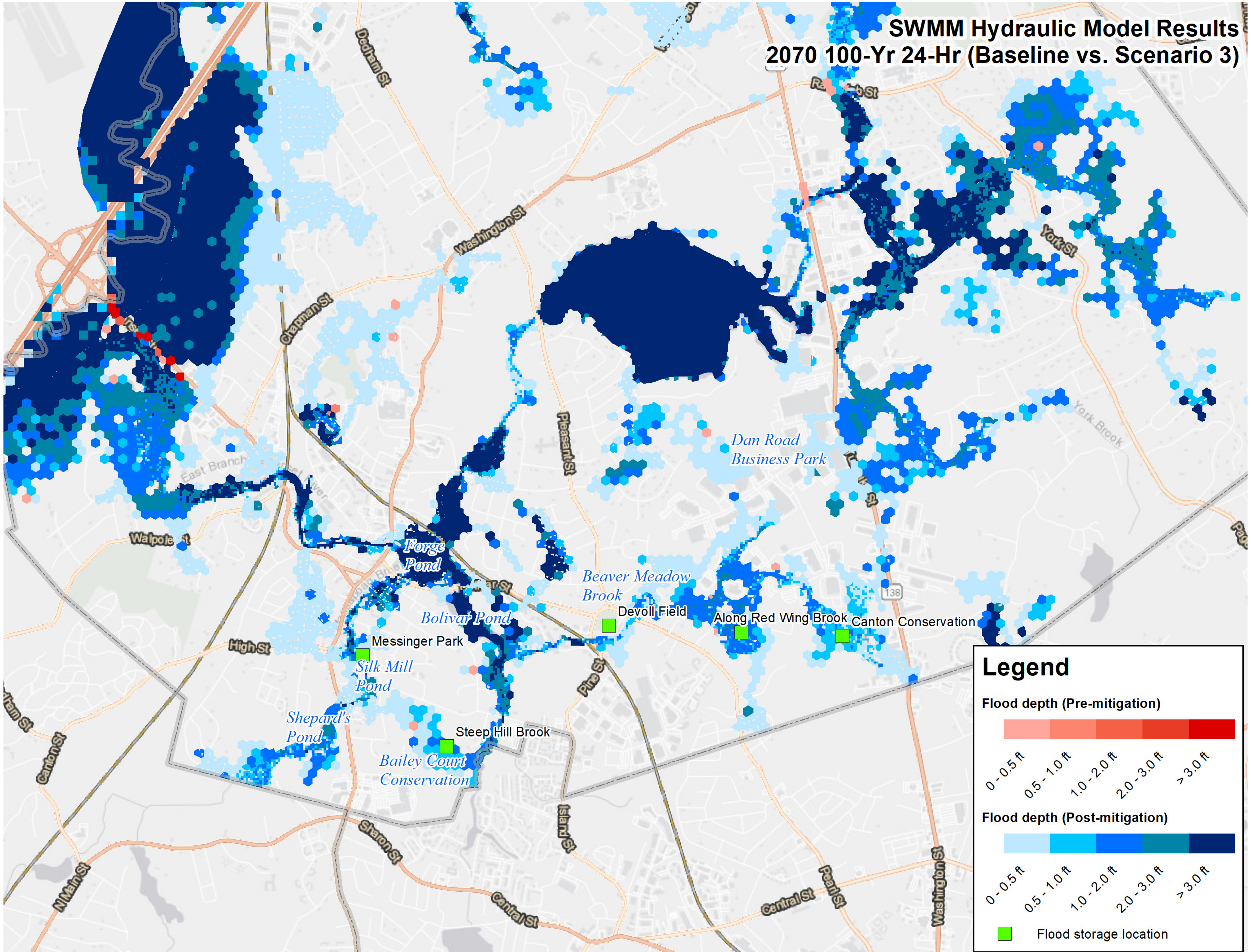

Figure 27: Flood extents and depth projected both pre-and post-mitigation during the 2070 100-year storm event in the Massapoag/Beaver Meadow Brook sub-catchment under Scenario 3.

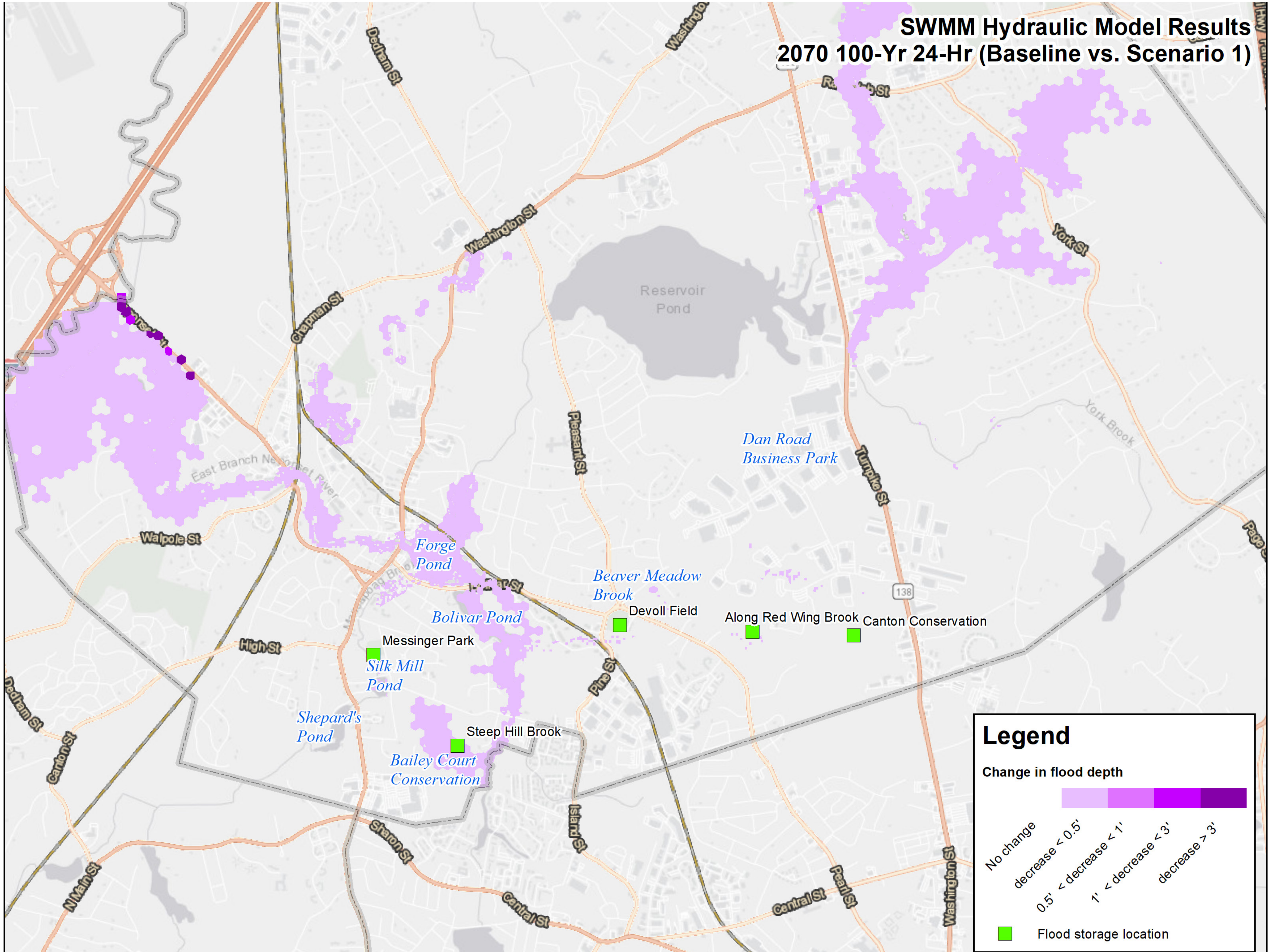

Figure 28: Relative decrease in flood depth over baseline projected during the 2070 100-year storm event under Scenario 1 in the Massapoag/Beaver Meadow Brook sub-catchment.

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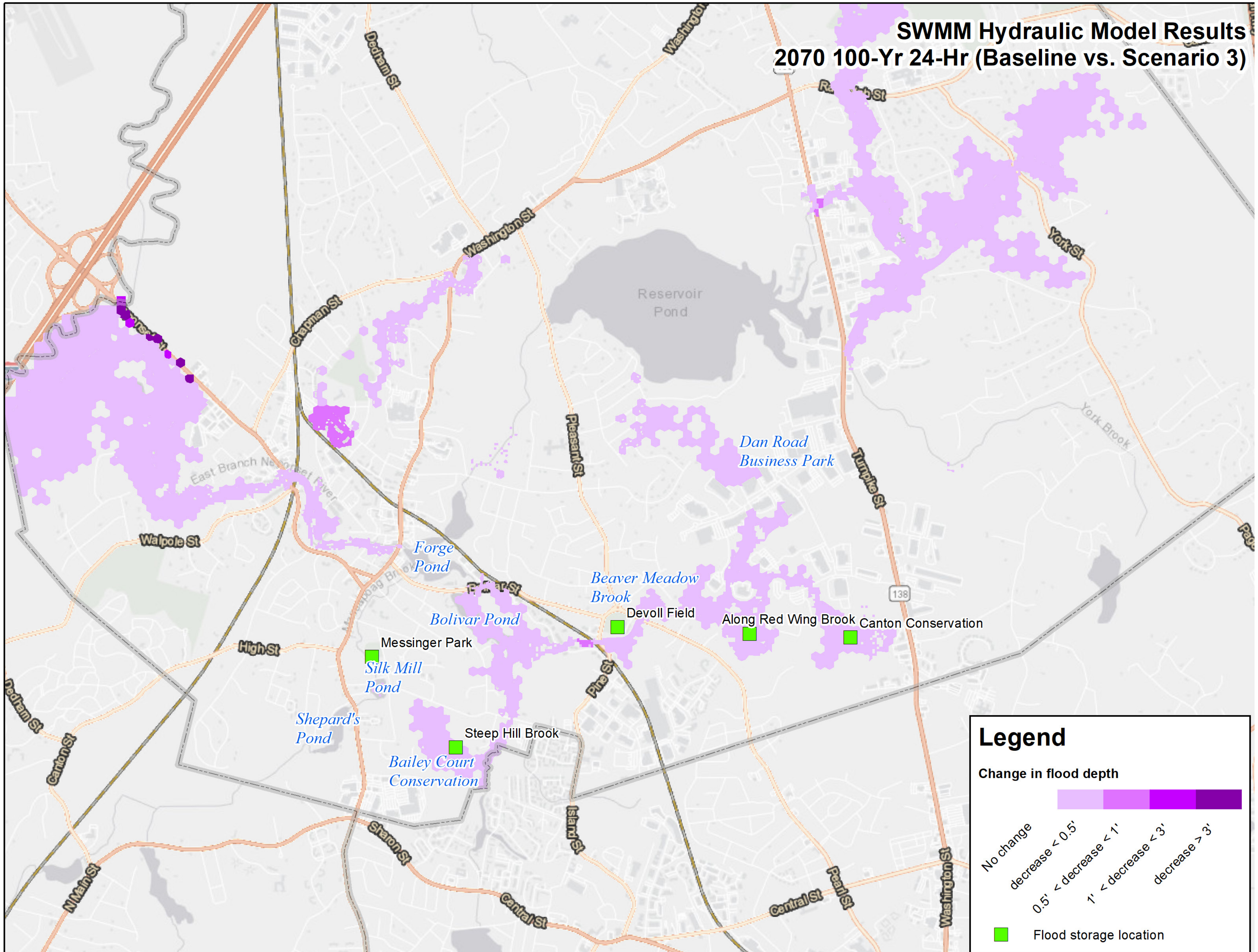

Figure 29: Relative decrease in flood depth over baseline projected during the 2070 100-year storm event under Scenario 3 in the Massapoag/Beaver Meadow Brook sub-catchment.

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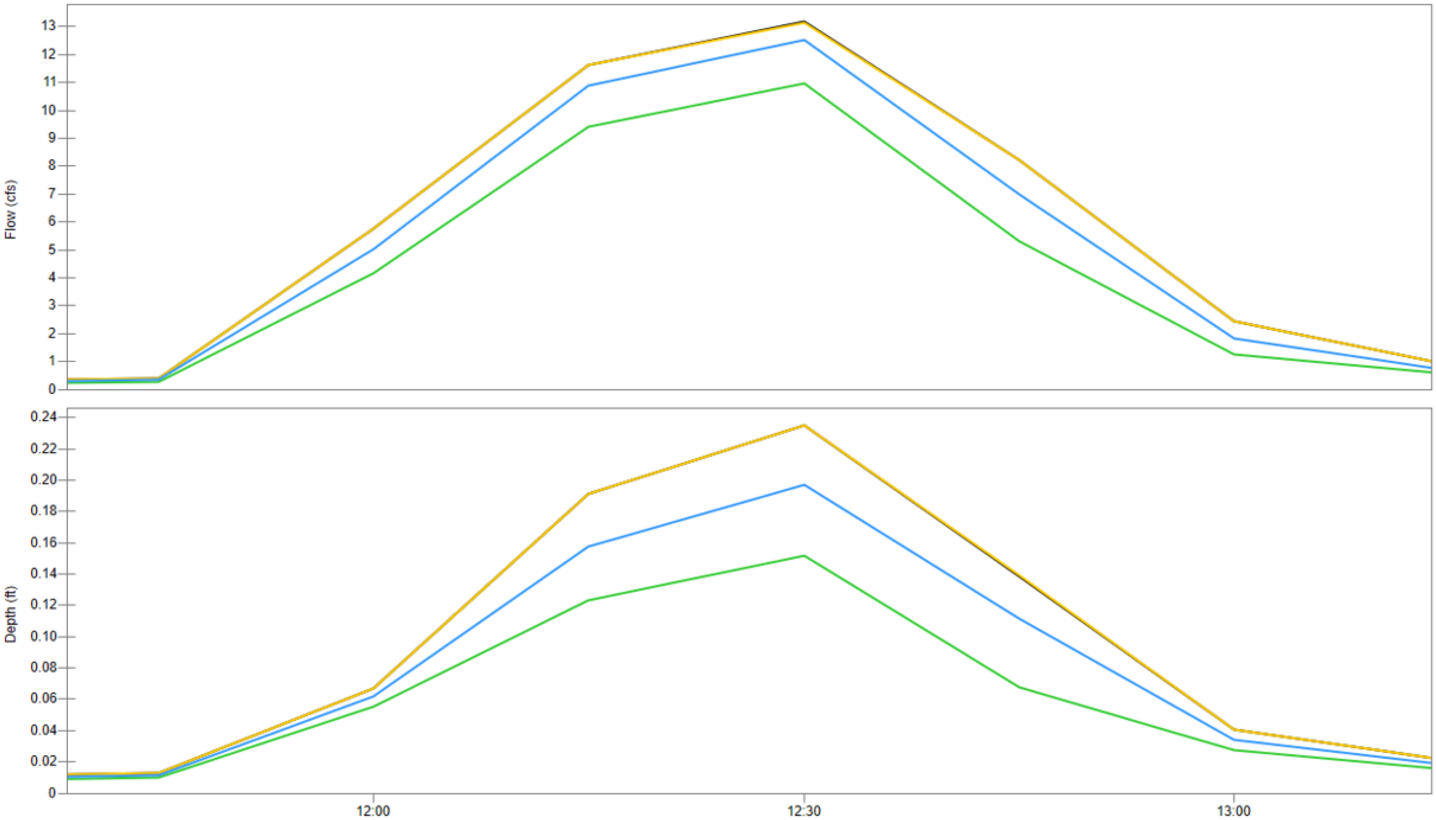


Figure 30: Projected peak flow and depth decrease at a model junction near the outlet of the Dan Road Business Park during the 2070 100-year storm event under Scenario 3 (50% reduction in DCIA).

this sub-catchment area. This portion of Beaver Meadow Brook drains into Bolivar Pond and then into Forge Pond. Drawing the peak flows off Bolivar Pond allows more holding capacity in Bolivar Pond, which ultimately leads to less flooding in adjacent areas.

Messinger Park

The final opportunity considered was a combination of nature-based storage along Massapoag Brook and subsurface storage at Messinger Park. The Massapoag Brook runs directly through the edge of the park, as shown in Figure 31, on its way to Forge Pond. This site has ample opportunity to marry a nature-based storage solution with open space already being used for community benefit as a park and recreation area. However, the modeling of storage in this location showed minimal benefits if upstream flow routing (flows out of Silk Mill via the existing control structure) is not further modified.

As shown in Figure 29, the mitigation strategies at Messinger Park do not indicate much, if any, flood depth change in the vicinity of this area (as modeled). However, there may be considerable upstream benefits (not modeled as part of Scenarios in this project) at localized flood areas within the 2070 100-year event flood zones.

For example, there may be upstream benefits if some of the nearby drain pipe network is re-routed and managed at the park (e.g., piped drainage or overland from Washington Street, Walnut Street,

Figure 31: Massapoag Brook sits at the edge of Messinger Park and offers potential for nature-based flood mitigation strategies as well as community and public benefits.

High Street, Pierce Place, Highland Street, Everland Way, Walnut Knoll, Beverly Place, Belcher Street, Rockland Street, Howard Street, Mechanic Street, Century Drive). Figure 32 includes a schematic representation of potential drain pipe re-routing, which were not modeled, but could be considered for a future project.

In general, data resolution (e.g., invert elevations at Silk Mill Pond, drainage pipe sizes, inverts, and connectivity within this sub-catchment) is currently limited, making it difficult to make definitive conclusions, or optimize a storage concept at this location. Finer model resolution is needed in this Massapoag Brook area to better understand and define the baseline conditions and true potential benefits.

Other Areas of Interest (AOI)

Flood modeling results for Scenario 1, Scenario 2, and

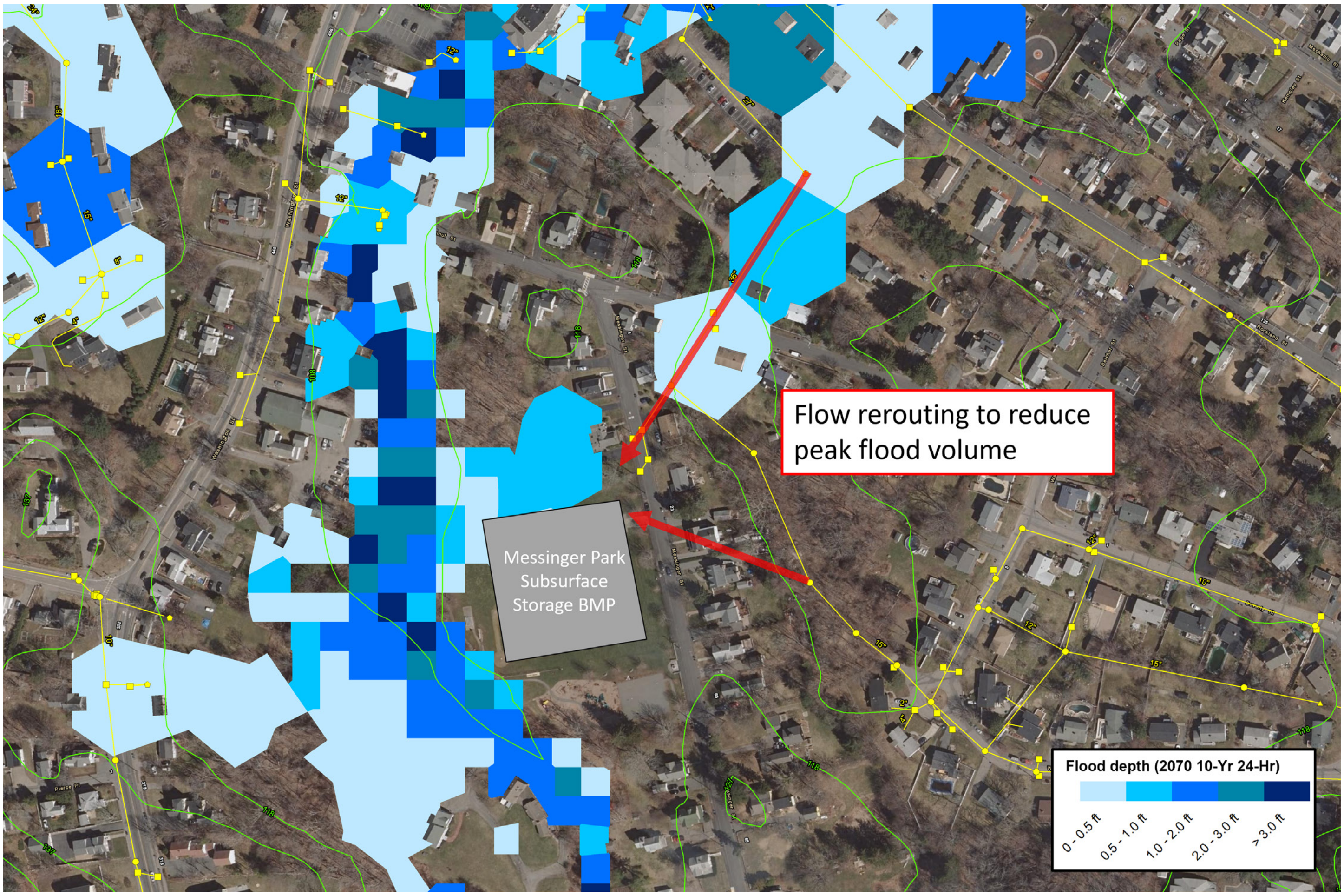


Figure 32: Schematic of potential re-routing of stormwater piping to proposed storage facility beneath Messinger Park (2070 10-year flood extents shown).

Scenario 3 for all other AOIs are included in **Appendix H**, **Appendix G**, and **Appendix I**, respectively.

Vulnerable road crossings and culverts – multiple locations

Virtually all the existing FEMA NFHL (100-year) and 500-year flood zones in town are located near major bodies of water and wetlands. In many of these zones, it has been communicated that the flood frequency is greater than the 100-year flood event.

Per the Town's latest Hazard Mitigation Plan update (HMP, 2018), Town officials believe that many of the Town's more frequent flooding problems outside of the Neponset River floodplain are related to insufficient or inoperable flood management structures, such as culverts, dams and drain pipes that are not large enough to quickly transport flood waters away from Town streets and neighborhoods and toward the nearby wetlands. Until the current project's modeling effort, some of these flood zones had previously not been studied as a system.

CANTON
CLIMATE RESILIENCY

The H+H modeling analysis indicates that there are several roadway crossings and/or drainage culvert locations where future flooding depths and frequency are projected to increase with climate change. These include:

- Turnpike Street/Rte. 138 culvert (near D'Angelo and Pequot Way)
- Pleasant Street (at Pequit Brook downstream of Reservoir Pond, and east of Devoll Field)
- University Road and Dedham Street to Neponset River
- Washington Street bridge (south of Pond Street, downstream of Shepard Pond spillway)
- Randolph Street (west of Blue Hills Regional Technical School, between Hillsview Street and Randolph Terrace)
- Neponset/Walpole Street at Canton Viaduct

The modeling analysis was used to identify WSEs for projected future flood events, including the 2070 10-year, 24-hour and 2070 100-year, 24-hour recurrence events. WSEs were identified at specific locations were the modeled flood depths encroached key roadway crossings and trafficked routes.

A summary of WSEs at Present Day and 2070 timeframes for these storm events at specific roadway crossings is provided in **Appendix J**.

<u>Regional Analysis – Model Sensitivity</u>

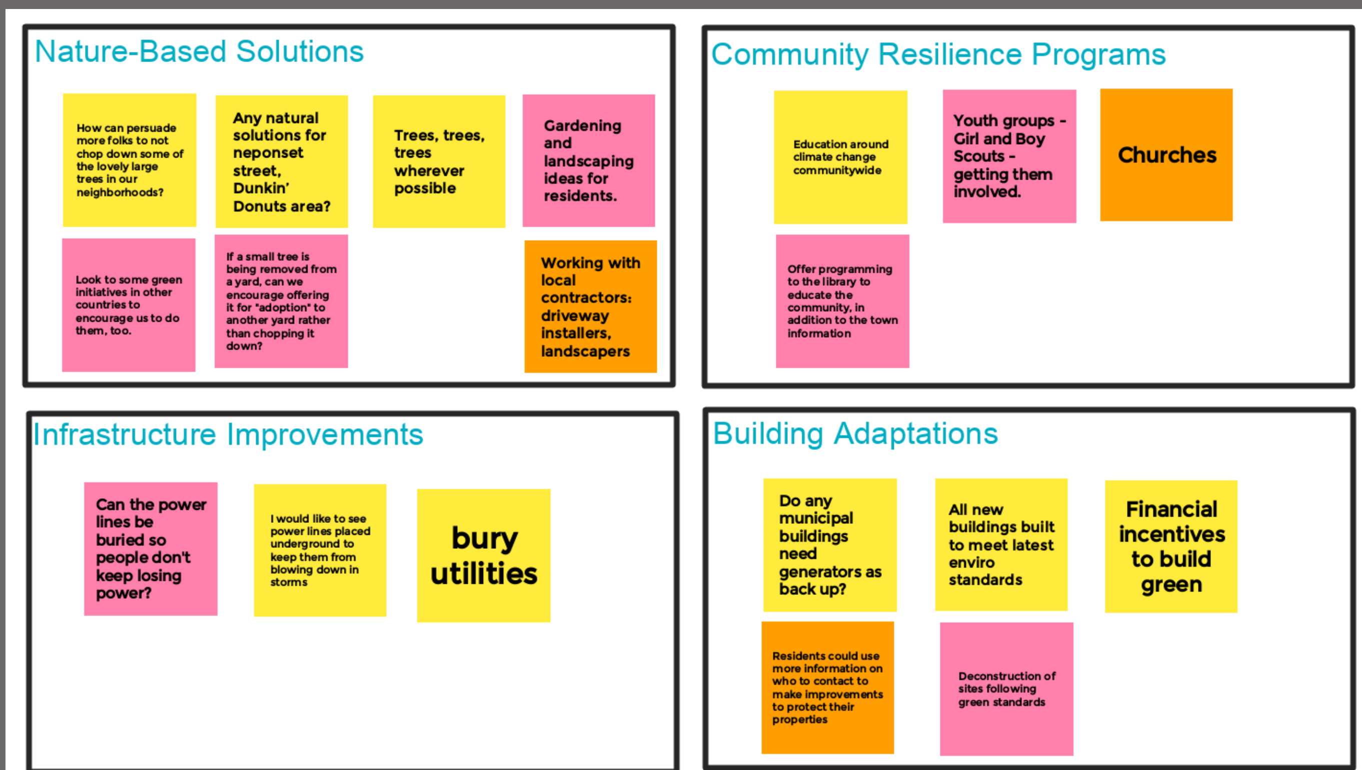
Additionally, a sensitivity analysis was performed to test the sensitivity of Massapoag Brook flooding downstream of Silk Mill Pond (near Rockland, Mechanic, and Howard streets). This analysis found that even a 25% reduction in peak flow rate (simulating aggressive regional implementation of Lake Massapoag pre-releases and flow-reducing upstream strategies in the Town of Sharon) did not produce any significant modeled benefits at these locations during a 2070 10-year or 2070 100-year recurrence event. This sensitivity analysis indicates that the localized Massapoag Brook flooding issues (between Silk Mill Pond and Forge Pond) may be driven by conveyance capacity issues (narrow stream channel, insufficient inlet/pipe conveyance capacity) than total precipitation and regional flows from upstream.

It is recommended that further hydraulic analysis be conducted in this area, including improved calibration (gauging of wet weather flows leaving Silk Mill Pond versus to Bailey Court Conservation Area) and potential optimization (timing/extent of flow releases from Lake Massapoag in Sharon). Further hydraulic analysis for Massapoag Brook could include simulation of green and gray infrastructure strategies for management of localized drainage from nearby catchments draining to Massapoag Brook downstream of Silk Mill Pond outlet structure (e.g., piped drainage or overland from Washington Street, Walnut Street, High Street, Pierce Place, Highland Street, Everland Way, Walnut Knoll, Beverly Place, Belcher Street, Rockland Street, Howard Street, Mechanic Street, Century Drive).

STAKEHOLDER ENGAGEMENT

What the Town did:

During the Town's interactive virtual public meeting on March 23, 2021, attendees were asked what flood mitigation strategies they would like to see implemented for nature-based solutions, community resilience programs, infrastructure improvements, and building adaptations. Feedback (right) varied and was considered in the development of the final recommended strategies.



SECTION 9
Recommended Flood Mitigation Strategies

Based upon analyses described in the previous sections that results from the RVA and mitigation strategy identification and further modeling effort, Kleinfelder, in close coordination with the Town, developed recommendations for the Town to consider further, as summarized in **Table 13**. The recommendations were broken down by type – nature-based solutions, community resilience, infrastructure improvements and building adaptation – all of which were described in more detail in previous sections of this report. Through the work on this study, Kleinfelder identified a number of areas and opportunities that could be explored further to understand better the specific needs and benefits of these potential strategies for flood reduction/mitigation.

Recommended Infrastructure Improvement Projects

Though improvement of the Pequit Brook culvert on Route 138 requires significant coordination with

Table 13 : Recommended Strategies summarized by Type of Solution

Category	Strategy / Location	Relative Cost
Nature Based Solutions	- Distributed GI near Memorial Field	$$
	- Memorial Field Sub-Surface Storage	$$$
	- Distributed GI / redevelopment along Dan Road Commercial Corridor	$$
Community Resilience	- Continue public outreach / education	$
	- Incorporate flood resiliency in capital planning	$
	- Enhancement of Post Construction / Stormwater Regulations	$
Infrastructure Improvements		
	- Incorporate flood resiliency into DPW capital & maintenance planning	$
	- Prioritize condition assessment of stormwater infrastructure in high-risk flood areas	$
	- Stormwater infrastructure upsizing near JFK School	$$
	- Accelerate coordination with MassDOT for low-lying road crossings and culvert upgrades along Turnpike / Rt 138 Corridor	$$$
	- Neponset Road – Elevation adjustment	$$$$
Building Adaptations	- Design retrofits for selected facilities serving vulnerable populations (Affordable / Senior Housing)	$
	- Building / property adaptation of area around Public Works Garage	$$
Conceptual Design / Feasbility and Optimization Study	- Massapoag Brook Sub-Catchment H+H Study, suitability of use of Messinger Park	$
	- Flood storage feasibility / capacity of conservation lands within Beaver Meadow Brook / Bailey Ct Conservation area	$
	- Building adaptation / regulation (i.e., pervious area, free board requirements) of critical assets / private residents in residential flooding areas	$$
	- Active Dam Management / Regional Coordination with Neighboring Communities	$$

Notes:
Relative Cost: $ = <$500K $$ = $500K - $1M $$$ = $1M - $5M $$$$ = > $5M

MassDOT and long lead time on design, there are discussions of potential improvement to this roadway in the near term. These were put on hold due to the recent pandemic but could be resurrected again in the next 5 years. In addition, the HMP has discussed grouping hydraulic analyses of multiple flood-prone area crossings into one package, so there maybe opportunity to address multiple culverts along this route for potential flood reduction benefit.

Recommended nature-based solutions

The distributed GI and nature-based storage near Memorial Field offers potential multiple benefits and opportunities related to flood reduction as well as public outreach and education in conjunction with Canton High School. Flood reduction in this area would alleviate nuisance flooding near the MBTA station, which is a critical asset for the community. In talking with the Town, improvements in this area could also have positive impact in residential neighborhoods close to the Town center as well.

Additional nature-based opportunities could be considered in the Dan Road business/commercial area. This could be achieved through zoning requirements placed upon re-development when commercial property changes hands to require more pervious area for each lot.

Recommended critical infrastructure and community assets for building adaptations

Based on the results of the RVA for critical community and vertical assets, nine (9) assets resulted in high risk scores. This indicates these properties have near- and mid-term vulnerabilities related to flooding. Those assets are summarized in **Table 14**.

These properties should be further evaluated for the addition of potential building adaptations such as elevating utilities and other key assets off basement floors or to the top floor of a building. Preceding an extreme weather event, deployable flood barriers could also be set up around a building or key flooding areas to prevent floodwater from even reaching the property at all.

Priority gray infrastructure recommendations (future asset management, data collection informed by RVA for piped infrastructure)

It is recommended that near-term asset management activities for the stormwater system prioritize condition assessment and verify drainage pipe/structure sizing in the areas identified in **Section 5** (see **Figure 17**).

At this time, the risk assessment methodology does not incorporate pipe physical condition data (based on field assessments and future CityWorks data collection). As this data becomes available, it can be added/integrated into the LoF rating criteria.

For example, any pipe segments that need repairs or replacement (on the basis of physical condition) should also be checked against those pipe infrastructure assets ranked as high risk through this RVA. If there is overlap, future gray infrastructure upgrades (e.g., repairs/replacement/retrofits) should consider ways to simultaneously increase performance and improve localized flood mitigation outcomes, such as pipe upsizing (instead of replacement in-kind) or bundling subsurface repairs with surface improvements. For example, if pipe repairs/replacement activity are to result in earth-disturbing activities, these are opportunities to consider surface-based strategies (e.g., addition of inlets or double-grated catch basins to improve surface runoff conveyance, or replacement of existing paved surfaces with curb bumpouts, bioswales, stormwater tree pits or other green infrastructure).

Table 14: Flood-prone critical infrastructure and community assets with near- to mid-term risk

Asset (Location)	Type	Description
27 Howard	Affordable housing/ DHCD funding	2 to 2.5 feet of modeled flooding for Present Day to 2070 10-year events
DPW Garage Facility Site, Canton Animal Shelter (150 Bolivar St.)	Municipal facility	3 to 3.15 feet of modeled flooding for Present Day 100-year and 2070 100-year events, respectively; low-lying assets on parcel may require deployable flood barriers for largest events
Canton Arboretum/Woodfield Commons	Affordable housing	3 to 8 inches of flooding at roadway entrance
Commons Residence @ Orchard Cove	Affordable housing	Roadway access may be impeded through only site entrance
Concord Avenue	Affordable housing	Up to 0.5 feet of modeled flooding across apartment complex
Randolph Hebrew Center	Community asset	0.5 to 1 feet of modeled flooding for Present Day to 2070 10-year events in the back of property and nuisance flooding along Washington Street
Newell S. Hagen	Affordable, senior housing	A few inches of nuisance flooding and higher risk piped infrastructure in near vicinity
Hellenic Nursing and Rehab Center	Public health	Access via Sherman Street impeded for 2070 100-year event (south of Memorial Field)

Regional Coordination

In examining and understanding the role of Canton's many ponds and water bodies, it becomes apparent the importance of dam management toward flood reduction goals. Also understanding that many of these impoundments take drainage from neighboring communities highlighted the opportunity of regional collaboration and coordination in managing the stormwater. Stormwater doesn't stop at the Town boundary and must be considered at the watershed level to be most effective. Kleinfelder heard from Town officials that they do coordinate with Sharon somewhat before large storm events but the project team recommends that a more coordinated approach be explored possibly through the Neponset River Watershed Association or its partners.

Programmatic Recommendations

Town's Capital Project Planning Process

The Town of Canton can make immediate procedural and/or policy changes to begin accounting for flood resiliency in its own capital projects. Utilizing the data and resources provided in this Action Plan, the Town could require the consideration of projected flood-prone areas in the planning, design, and delivery of City-led projects. For example, when repaving a street in an area with known or anticipated flooding (or within the drainage area thereof), the Town could require a stormwater management assessment for potential pipe upsizing, green infrastructure BMPs, or other strategies to reduce stormwater volumes. It should be noted that this approach to capital project delivery can also be beneficial for meeting permit stormwater treatment requirements and may be worth implementing within stormwater system drainage areas as well.

This programmatic approach often requires additional funding and administrative capacity to complete and can therefore require the adoption of legislation by the municipality so that departments across the Town's governmental structure are required to incorporate stormwater management elements.

Education

Educating residents about flooding risks and the steps they can take to protect themselves and their property is essential in the face of climate change. **Section 7** describes many available resources that the Town could promulgate within the Canton community, or custom resources, materials, and presentations could be developed to provide Canton-specific considerations while educating the public about the Town's efforts to prepare for climate change and alleviate flooding.

Zoning

Modeled WSEs indicate that flooding extents and depths will increase in areas of Canton over the next 50 years, which are not currently captured in existing FEMA FIRM flooding extents. As described in **Section 7**, restricted development in areas of known flooding can prevent public health hazards, destruction of private property, and future litigation. Further refinement of the H+H model developed in the course of this study is required in order to designate appropriate zoning regulations.

New & Redevelopment Regulations

Enhanced regulation of new and redevelopment helps to share the burden of preparing for climate resiliency across public and private sectors. The project team suggests that the Town consider adopting stricter post-construction stormwater regulations that require the reduction of stormwater volume from new development and/or reducing the project threshold so that more projects be required to apply. Again, these regulations will not only create a more flood-resilient Canton, but also contribute toward compliance with the stormwater treatment permit. The Town should consider the current political climate as well as additional administrative costs for permit review, approval, and enforcement of potential new development.

Flood-smart development regulations that require building the implementation of flood-resilient strategies such as higher freeboard or elevated infrastructure is most appropriate in known or anticipated flooding areas. Further refinement of the H+H model developed in the course of this study is required in order to designate areas that would be appropriate for flood-smart regulations.

Community Resilience Programs

Community resilience programs (see **Section 7** for examples) can provide an opportunity for the community to contribute toward flood mitigation and play a part in climate resiliency for Canton. If funding is available and the community is interested, Town-wide programs that promote the implementation of stormwater management via green infrastructure can provide multiple benefits besides flood mitigation including heat island reduction, habitat creation, beautification, etc. However, with more finite resources, the strategic implementation of community resilience programs informed by sound data is crucial. The project team would encourage a town-wide incentive program for green infrastructure that could be funded using stormwater utility funds. However, prioritizing funding in areas of flooding (or areas that drain to flooding) may be preferred, in which case further refinement of the H+H model developed in the course of this study would be required. See **Section 10** for more detail.

Recommended Areas of Further Study

In the process of completing this study, Kleinfelder identified a few areas of potential and promise toward reducing flooding, but the model results were not of sufficient resolution to make a recommendation toward a cost-effective and beneficial solution. Areas that could be investigated further with a higher H+H resolution model include the Massapoag Brook between Silk Mill Pond and Forge Pond, active reservoir management (e.g., Bolivar Pond) and the nature-based storage in Bailey Court Conservation Area, Beaver Meadow Brook, Steep Hill Brook, along Red Wing Brook (identify suitable lands for bioretention, infiltration, and/or wetland restoration).

Prioritizing near term asset management and data collection for gray stormwater infrastructure will achieve a better understanding of the condition and capacity of drainage pipes/structures. At this time, the risk assessment methodology does not incorporate pipe physical condition data (based on field assessments and future Cityworks data collection). As this data becomes available, it can be added/integrated into the LoF rating criteria. It is recommended that near-term asset management activities for the stormwater system prioritize condition assessment and verify drainage pipe/structure sizing in areas in **Figure 12**.).

SECTION 10
Next Steps

This project's extensive data collection, RVA, and H+H modeling effort - robustly informed by Town staff and public stakeholder feedback - has resulted in a diverse portfolio of strategies that Canton can implement to build climate/flood resiliency over the coming decades. In consultation with Town staff, the project team has prioritized specific strategies and key follow-on analyses (as detailed in the preceding report sections) and has recommended target phasing for implementation.

Recommended strategies were characterized in **Table 14** based on risk profile (i.e., time horizon of increased flood risk, as per RVA), magnitude of mitigation benefits (per scenario modeling), potential expenditures, and strategy type (e.g., nature-based solutions, community resilience, infrastructure projects, building adaptations, areas for further study).

Recommended strategies were further prioritized based upon a variety of factors, including: potential cost-benefit based on projected flood modeling results, lead time of development of project or program, and opportunity cost of current or future grant funding. Specific strategies were further prioritized into the near- or mid-term timeline, reflecting additional upfront coordination, or near-term opportunities for collaboration (i.e., leveraging timing of MassDOT roadway project along Turnpike Street/Rte. 138 for flood-resilient road crossings and culvert upgrades).

It is anticipated that some of these future projects, follow-on analyses, or policy development can be with supported by grant funding for resiliency. Specific near-term supportive actions that the Town can take to align with existing funding sources include, but are not limited to:

- Explore viability of grant funding through US EPA Section 319 Nonpoint Source Competitive Grants Program 19 Grant (or similar funding streams) for infiltration/detention storage BMPs at Memorial Field. (Similar funding sources (such as MassDEP 604b grants) could help inform project scoping at Messinger Park.)
- These specific park locations are both within Canton's Watershed-based Plan catchments for Pequit Brook and Beaver Meadow Brook (see **Figure 33**). Watersheds with an approved WBP are eligible for funding of design and implementation via 319 Grants from US EPA, including green infrastructure. While primarily created for Sustainable Water Management Initiative (SWMI) and water-quality purposes, the MassDEP-approved WBP for Pequit Brook and Beaver Meadow Brook recommends identifying additional stormwater BMPs in these watersheds.
- The Town can collaborate with MassDOT on specific roadway crossings that are vulnerable in the long-term given climate projections. Potential projects, such as culvert upsizing at Turnpike Street/Rte. 138 near D'Angelo and Pequot Way) or future road-raising activities (at Neponset River or along Rte. 138 at low-lying crossings) may take significant lead time and coordination with multiple stakeholders. Anticipated MassDOT roadway improvements, such as between Randolph Street and Stoughton Town Line, may be an opportune time to address projected increases in flooding at known hotspots along this route (e.g., 749 Turnpike St. near Gulf Oil, near Bank of Canton, near Canton Point Road private roadway).
- Include "future road-raising project at Neponset Street at Neponset River" in the Town's next Hazard Mitigation Plan update.
- Explore viability of grant funding through another MVP Action Grant that contains a detailed H+H study for Massapoag Brook. This effort may also be paired with a future Messinger Park flood mitigation project, and survey and suitability analyses of nature-based solutions in Town-owned land, conservation lands, and public/private open spaces (conservation land off Tolman, north of Old Shepard Pond, along Red Wing brook, Bailey Court Conservation Area, D. Forbes Estate).
- Initiate regional conversation for future MVP Action Grant (Regional Project), to include regional analysis and optimization of Town of Sharon/Lake Massapoag pre-release (active reservoir management) and large-scale natural storage/wetlands in Sharon, upstream of Canton town boundary, as well as potential nature-based storage strategies in Red Wing Brook, and Steep Hill Brook in the Town of Stoughton.
- Explore viability of Asset Management grants to pair stormwater system condition assessment activities with data collection for future gray infrastructure projects to mitigate nuisance flooding in select neighborhoods highlighted by the RVA.
- Target MAPC Accelerating Climate Resiliency grant (or similar grant funding) for packaging of survey and design of building-level adaptation retrofits for flood-exposed affordable and senior

Table 14: Prioritized recommendations for flood mitigation strategies reviewed with the Town

Priority	Category	Strategy / Location	Relative Cost	Grant Funding?
Near Term (0 - 5 years)	Infrastructure Improvements	- Accelerate coordination with MassDOT for low-lying road crossings and culvert upgrades along Turnpike / Rt 138 Corridor	$$$	Yes
	Infrastructure Improvements	- Incorporate flood resiliency into DPW capital & maintenance planning	$	
	Infrastructure Improvements	- Prioritize condition assessment of stormwater infrastructure in high-risk flood areas	$	Yes
	Nature-Based Improvement	- Distributed GI near Memorial Field	$$	Yes
	Community Resilience	- Continue public outreach / education	$	Yes
	Community Resilience	- Incorporate flood resiliency regulation into Town regualtions/by-laws for new/re-development	$	
	Conceptual Design	- Massapoag Brook Sub-Catchment H+H Study, suitability of use of Messinger Park	$	Yes
	Feasibility / Optimization	- Active Dam Management / Regional Coordination with Neighboring Communities	$$	Yes
Intermediate Term (5 - 10 years)	Infrastructure Improvements	- Stormwater infrastructure capacity upgrades near Summer Heights (near JFK School)	$$	
	Nature-Based Improvement	- Memorial Field Sub-Surface Storage	$$$	Yes
	Community Resilience	- Enhancement of Post Construction / Stormwater Regulations	$	
	Building Adaptations	- Design / implement building-level flood retrofits at most vulnerable affordable, housing, municipal and community assets	$	Yes
	Conceptual Design	- Flood storage feasibility / capacity of conservation lands within Beaver Meadow Brook / Bailey Ct Conservation area	$	Yes
	Conceptual Design	- Building adaptation / regulation (i.e., pervious area, free board requirements) of critical assets / private residents in residential flooding areas	$$	Yes(1)
Long Term (Beyond 10 years)	Infrastructure Improvements	- Neponset Road – Elevation adjustment	$$$$	
	Nature-Based Improvement	- Distributed GI / redevelopment along Dan Road Commercial Corridor	$$	Yes
	Building Adaptations	- Building / property adaptation of area around Public Works Garage	$$	Yes

Notes:
Relative Cost: $ = <$500K $$ = $500K - $1M $$$ = $1M - $5M $$$$ = > $5M
(1) Funding available for analysis/adopting climate-informed standards.

housing units, and community resources. Consider these (and similar sources of funding) for advancing non-structural flood mitigation strategies (e.g., zoning for climate resiliency, including inland flood resilience overlays, regulatory adjustments for freeboard in flood zones, flood preparedness toolkits for residents).

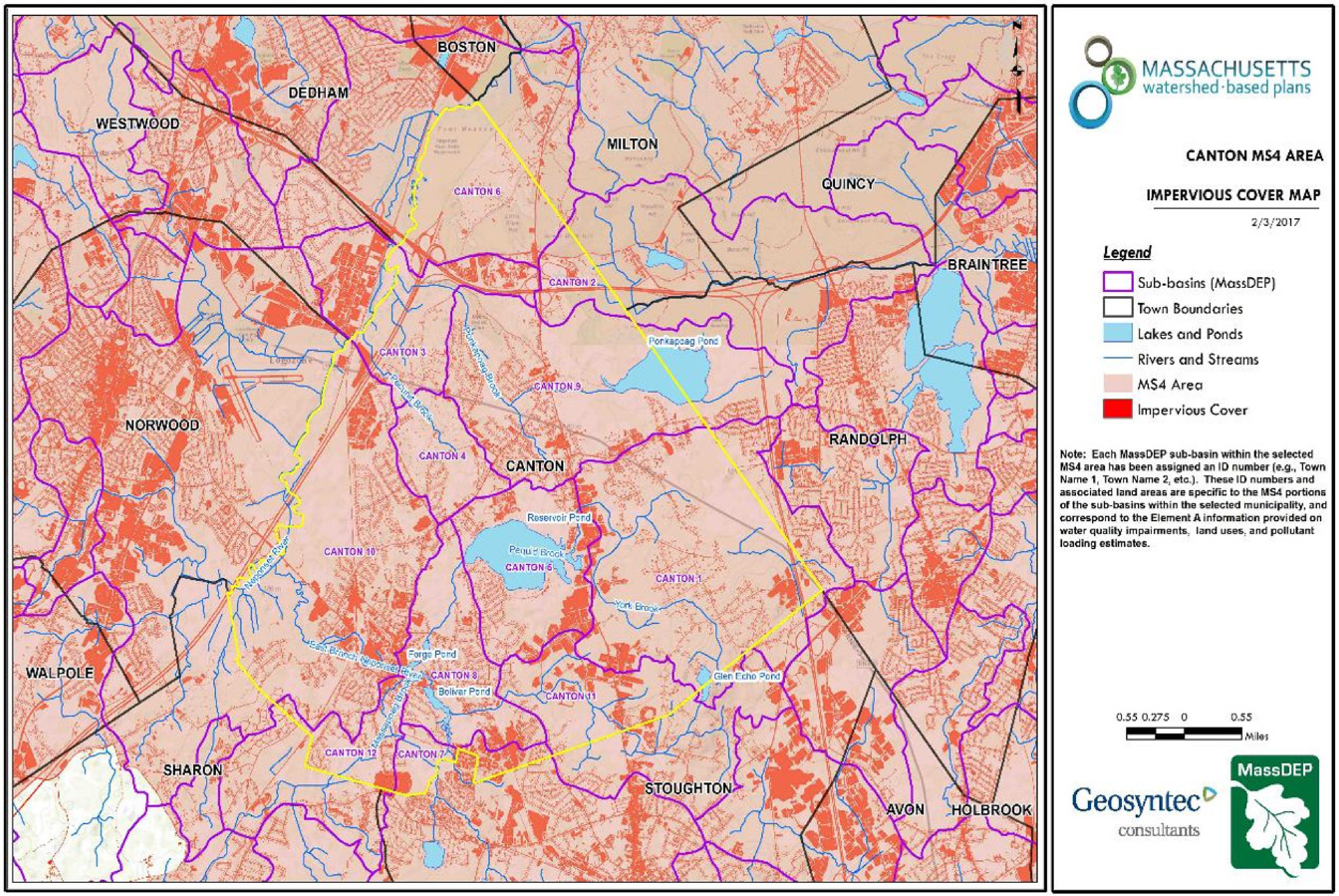


Figure 33: Pequit Brook and Beaver Meadow Brook study area from Watershed-based Plan (Geosyntec, 2018).

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