



A LONG-TERM STRATEGY FOR CLIMATE ADAPTATION AND RESILIENCE: WHAT DID WE LEARN?

**Connecticut Association of Flood Managers
Annual Conference
November 1, 2023**

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David Murphy, PE, CFM**



Mission:

CIRCA's mission is to increase the resilience and sustainability of communities vulnerable to the growing impacts of climate change on the natural, built, and human environments. Our Institute is a multi-disciplinary, center of excellence that brings together experts in the natural sciences, engineering, economics, political science, finance, and law to provide practical solutions to problems arising as a result of a changing climate

Executive Director: James O'Donnell

CIRCA's climate research focus areas:

- Coastal and inland flooding
- Extreme heat exposure and risk
- Resilience of critical infrastructure
- Innovative adaptation approaches (green infrastructure & living shorelines)
- Environmental Justice



Agenda

- Introduction to Resilient Connecticut and other Programs
- Areas of Work Statewide
- Geographic Areas of Focus for Resilient Connecticut
- A Look at Each Project
 - *Ansonia, Branford, Danbury, Fairfield, New Haven, Norwalk, and Stratford*
- Recognition of the Project Pipeline
- Closing Remarks

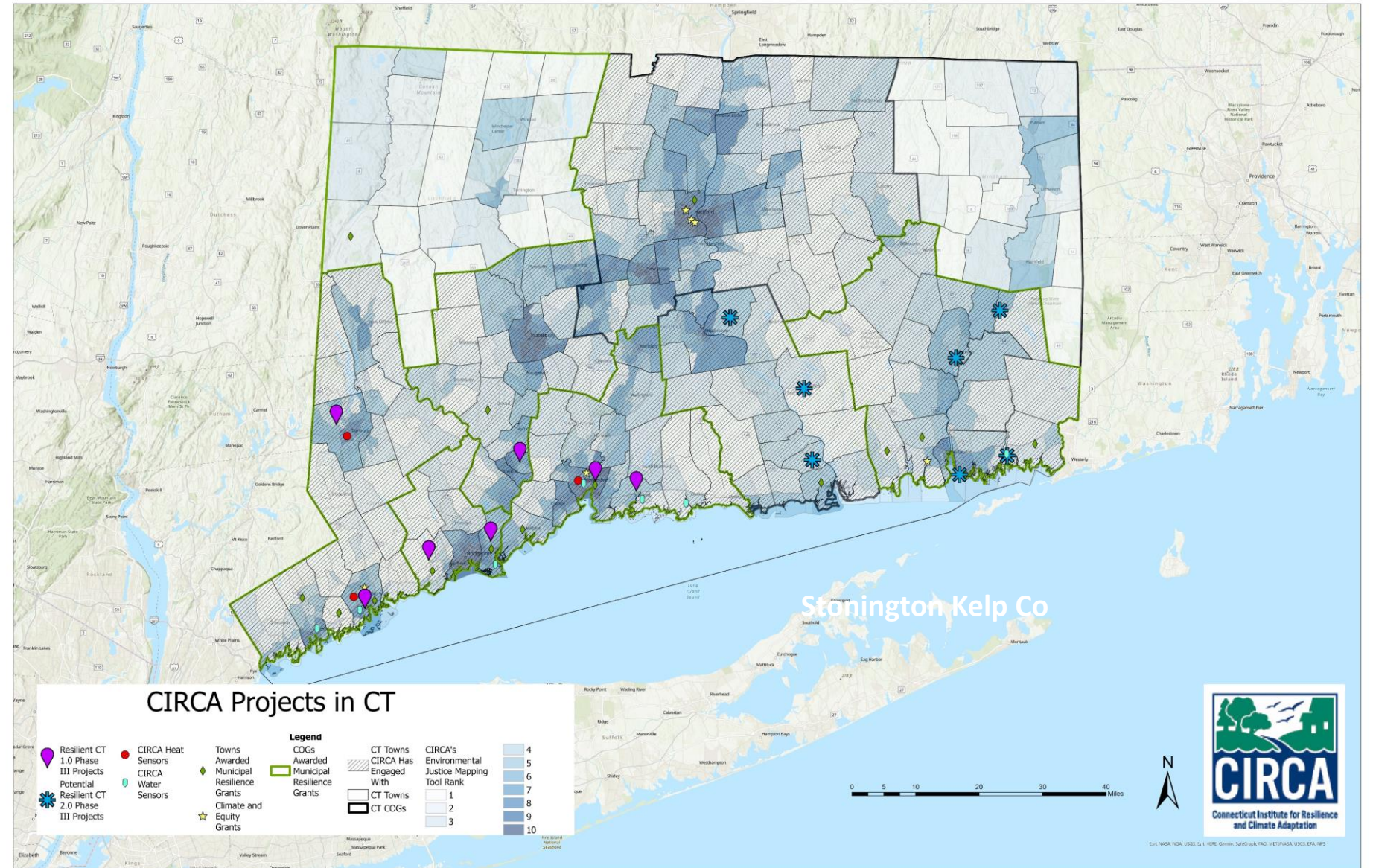
RESILIENT CONNECTICUT AND OTHER PROGRAMS

- CIRCA initiated Resilient Connecticut in Fairfield and New Haven Counties 2018 – 2023.
- Program expanded to New London, Middlesex, Hartford, and Tolland Counties in 2021-2024.
- Goals are to support development of a statewide resilience project pipeline, increase coordination across municipal, regional, and state planning.
- Data and mapping tools to support project development include Climate Change Vulnerability Index (CCVI) for flooding and heat, zones of shared risk, resilience opportunity areas.
- EJ projects include creation of a statewide EJ Screen mapping tool in partnership with DEEP/DPH and EJ community organizations, and Climate & Equity Grants program w/ DEEP.



AREAS OF WORK STATEWIDE

- The seven pilot projects (“Phase III”) are the purple icons in southwest Connecticut
- The upcoming projects under Resilient Connecticut 2.0 Phase III are the blue icons in the RiverCOG and SCCOG regions – *some are tentative*



AREAS OF FOCUS FOR RESILIENT CONNECTICUT

- The seven pilot projects attempted to address different kinds of flood risks
- Some also addressed extreme heat, though this will not be a focus today

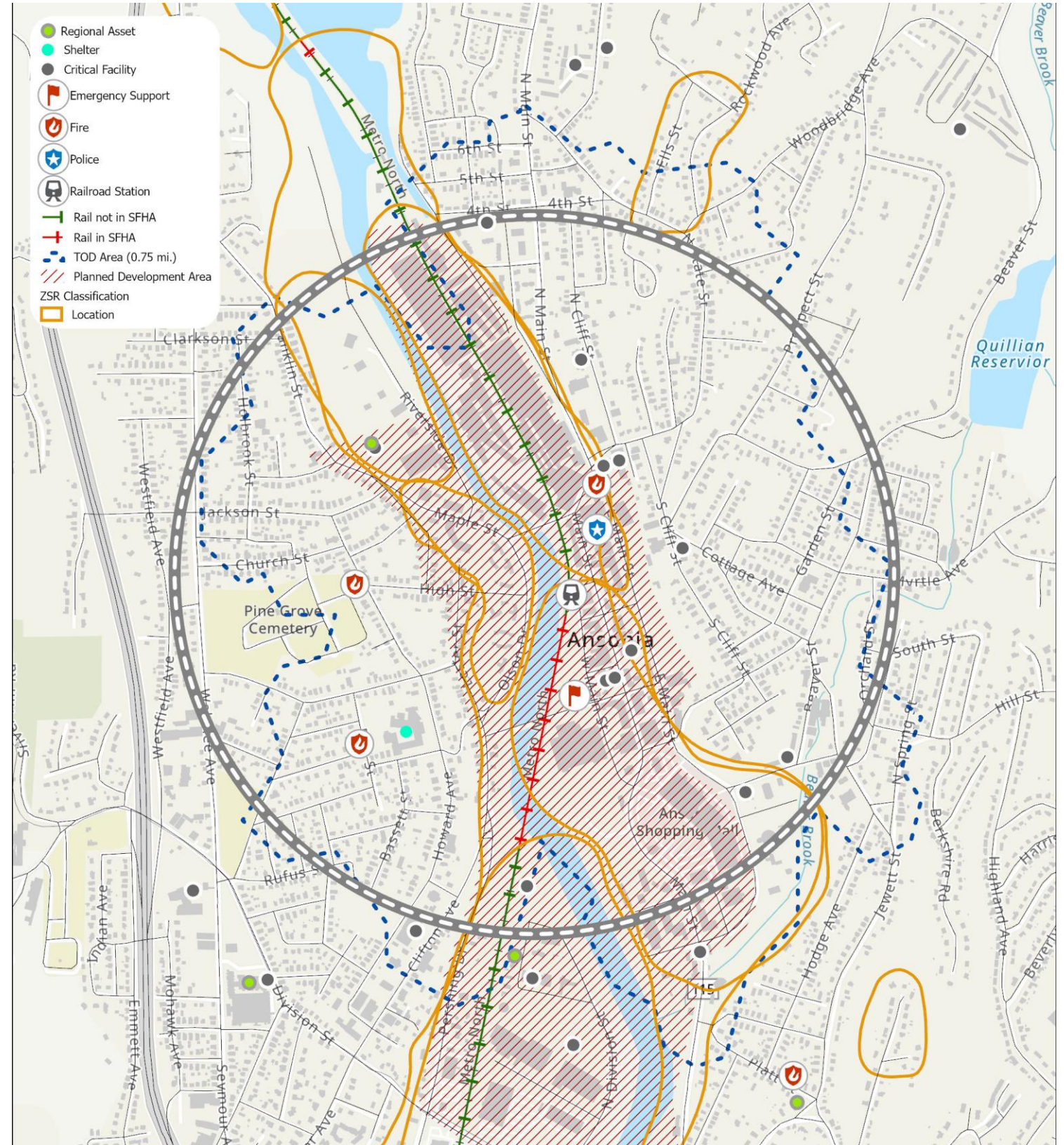
	Coastal Flood Mitigation	Riverine Flood Mitigation	Stormwater Flood Reduction	Extreme Heat Mitigation	Extreme Heat Relief
Ansonia		X		X	X
Branford	X		X		
Danbury		X	X	X	X
Fairfield	X		X		
New Haven	X		X	X	X
Norwalk	X		X	X	X
Stratford	X				

Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Ansonia
Location: Ansonia

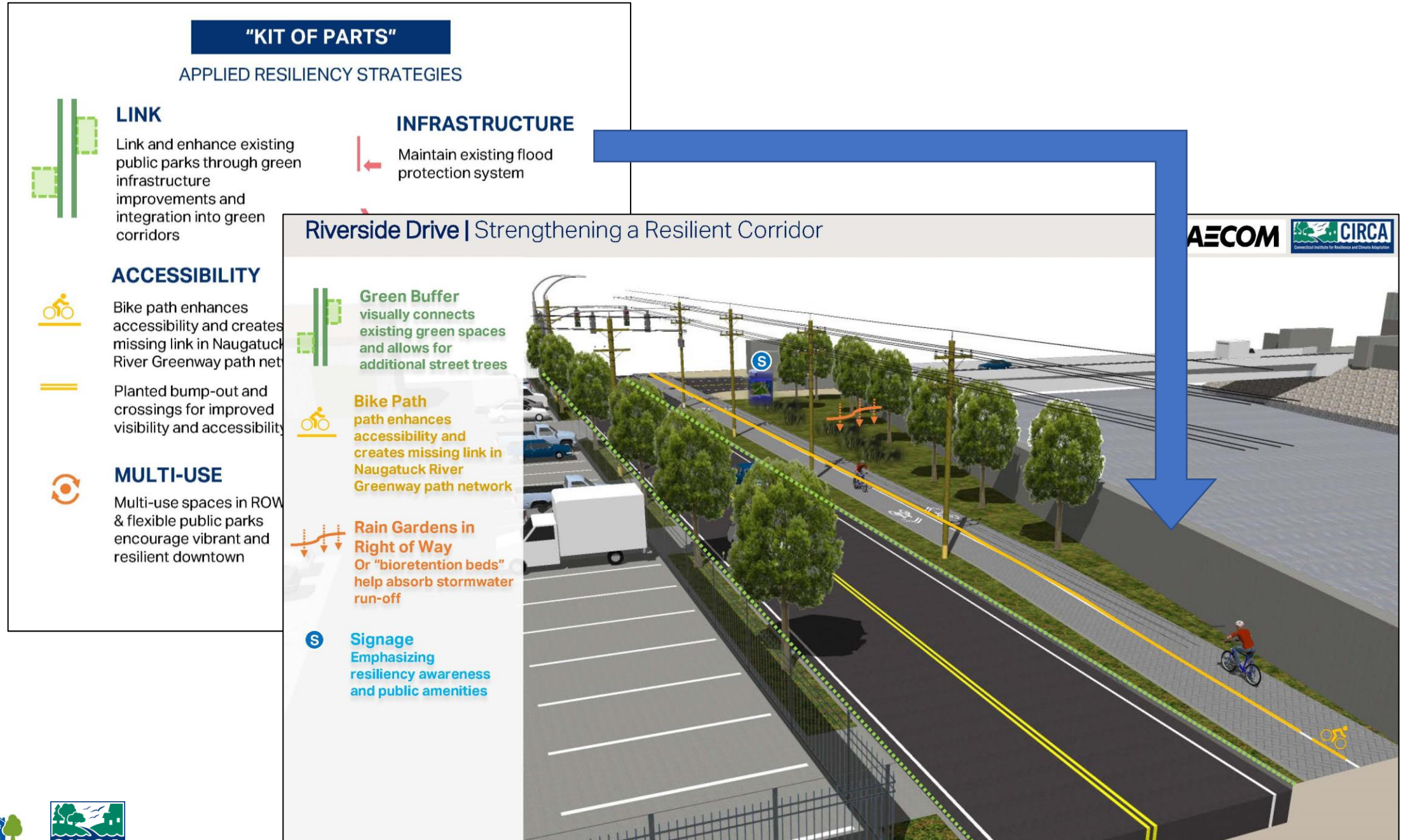
Considerations	Characteristics of Area
Flood Vulnerability	● ● ● ● ●
Heat Vulnerability	● ● ● ● ○
Social Vulnerability	● ● ● ● ○
<p>Several riverine zones of shared risk merge in Ansonia where significant redevelopment is planned, ranging from the Ansonia Brass & Copper site to the downtown area between West Main Street and East Main Street, to the Olsen Drive area on the west side of the river. With all the TOD and redevelopment planned along with new transportation corridors, the City has opportunities to incorporate resilience into many projects.</p> <p>The west bank of the Naugatuck River is heavily developed with high density of impervious surfaces and dark roofed structures. In addition, the area has high heat related social sensitivity which is a strong component of the heat vulnerability in the area.</p>	
<p>Hose co. 1, 4, and 6 Armory City Hall Rescue and medical services Valley YMCA</p>	<p>Two schools Substation Police department Ansonia Community Action Elderly housing</p>



RESILIENT ANSONIA

Flood Risk Reduction

- Recognition that the Naugatuck River flood protection system is necessary and should be maintained
- Looks for green infrastructure and complete street type solutions that can be advanced in areas protected



RESILIENT ANSONIA

Flood Risk Reduction

- This potential resilience hub is in an area of low flood risk that does not need to rely on the Naugatuck River flood protection system
- Supports significant redevelopment that is ongoing and planned
- Helps bolster the statement that Ansonia is a resilient community in its region

Resilience Center Application | Ansonia Armory



Ansonia National Guard Armory Front

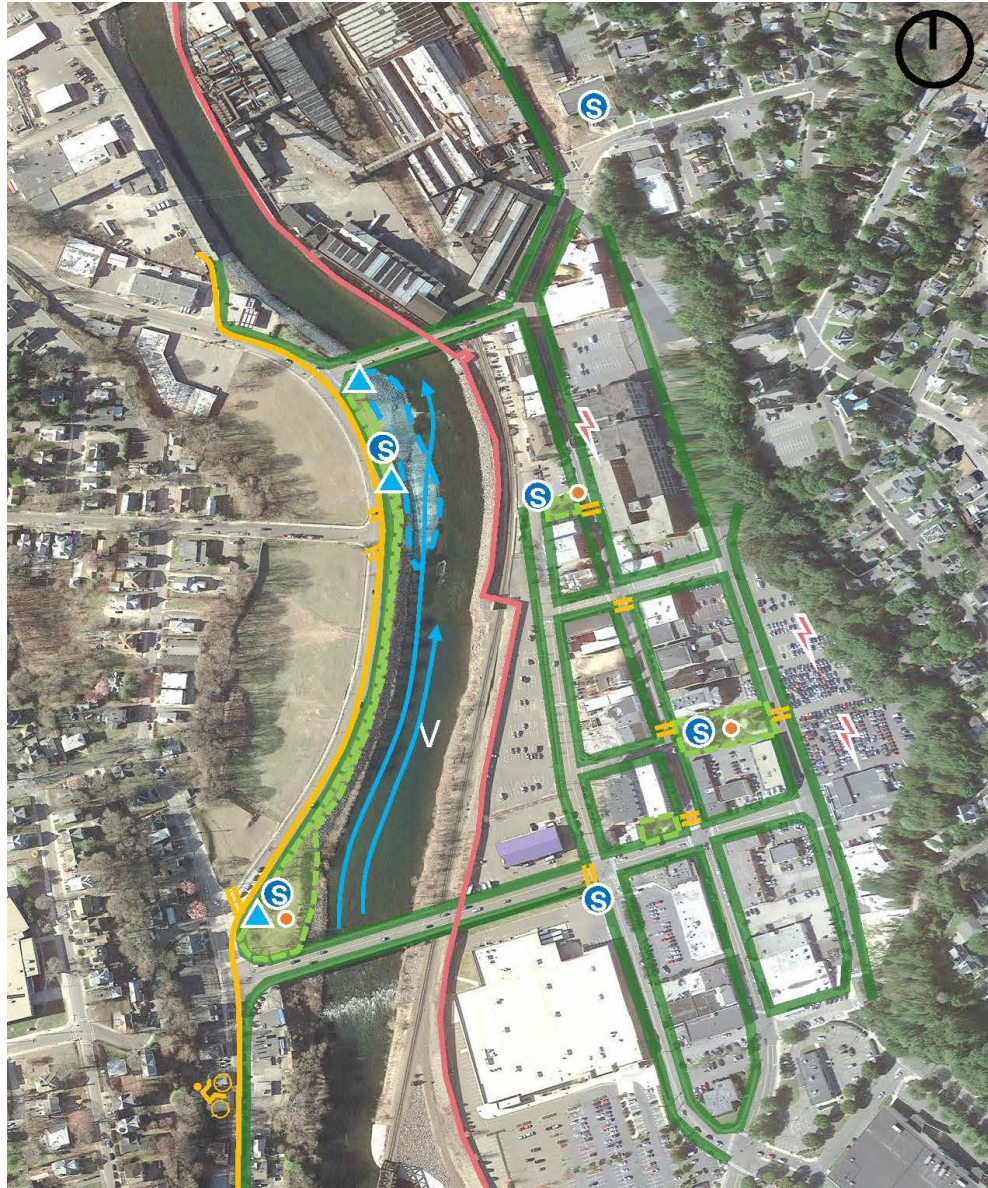


Ansonia Armory Parking Lot: Gymnasium with Accessible Entrance

Resilience Center Essential Service Considerations:

- Flexible Seating:** Provides space for seating, which can be adjusted to best meet the needs of the public
- Air-Conditioning:** Provides a cool, comfortable place to gather
- Clean Drinking Water:** Provides freely accessible drinking water
- Back-Up Generator Capacity:** Provides a reliable hub for electricity suitable for supporting the public needs
- Internet Services:** Provides reliable internet connectivity
- On-Call Medical Assistance:** Can accommodate a medical table and on-call medical staff
- Accessible Entrances & Restrooms:** Provides wheel-chair accessible accommodations and adequate restrooms
- Privacy Stalls:** Private areas reserved for nursing mothers
- Waste Management:** Location has existing waste management system which can accommodate the public

RESILIENT ANSONIA



Lessons Learned

Resilient Ansonia

- Extreme Heat: Opportunities to reduce heat exposure may be advanced using green infrastructure; respite from heat may be provided with cooling centers.
- Floods: The City must commit to continued maintenance of its Naugatuck River flood protection system, as it provides flood risk reduction in the community and reduces the need for flood insurance in existing buildings.
- Community: An existing City-owned property may be available as a new Resilience Hub.

Strategic Findings

In communities where significant re-investment is occurring at a rapid pace, opportunities to incorporate elements of climate adaptation and resilience may appear without warning. Leadership must be in place to recognize these opportunities and quickly determine which options to pursue through traditional and new funding programs.

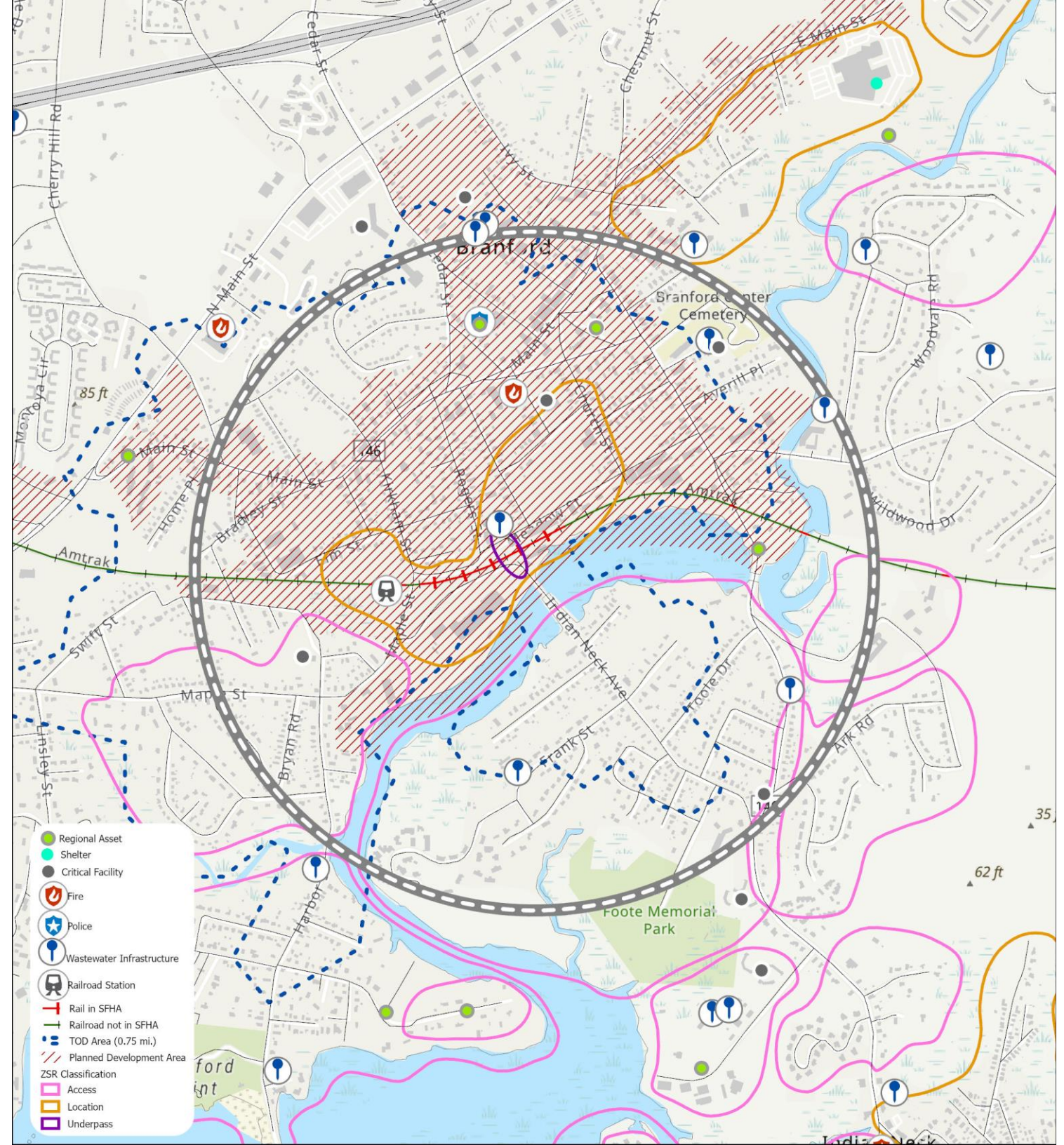
Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Branford Center

Location: Branford

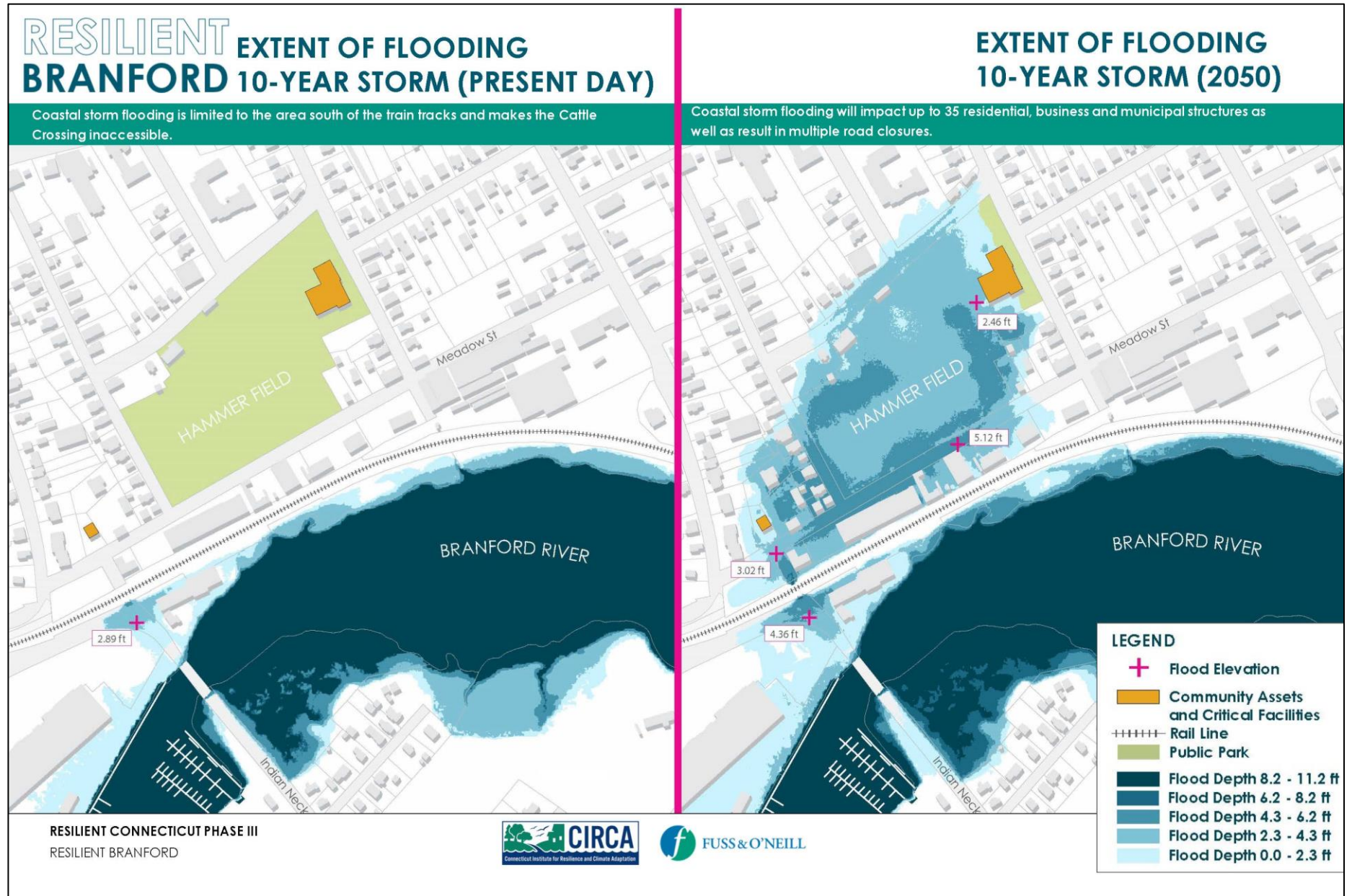
Considerations	Characteristics of Area
Flood Vulnerability	● ● ● ● ●
Heat Vulnerability	● ● ● ● ●
Social Vulnerability	● ● ● ● ●
<p>The area immediately south of downtown Branford is characterized by residential properties, commercial properties, historic resources, and transit-related land uses all within a TOD area along the Branford River. Coastal flood risks are significant, and floodwaters have entered the Meadow Street/Hammer Field area several times in the past decade. The Town wishes to pursue resilient development and flood risk reduction in this area. Branford center heat vulnerable areas are sporadic. This is mainly due to the mixed-use nature of the area. Vegetative adaptive capacity is inconsistent throughout the area, with some commercial areas providing little shade relief.</p>	
<p>Town Hall Police Dept. State Armory Pump stations</p>	<p>Fire headquarters Slincy School Coastal access</p>



RESILIENT BRANFORD

Flood Risk Reduction

- The underpass is the sole pathway for floodwaters reaching a neighborhood and a critical facility
- Solving future frequent flooding is the primary driver
- This project builds on a concept in the Town's 2016 Coastal Resilience Plan funded by CDBG-DR



RESILIENT BRANFORD

Flood Risk Reduction

- Four primary alternatives were evaluated
- A straightforward matrix approach was helpful to show that a “flood gate only” alternative was more achievable than a flood gate with a flood wall alongside the railroad grade

WEIGHTED COMPARATIVE ANALYSIS MATRIX						
ALTERNATIVE	MATRIX CRITERIA					OVERALL SCORE ⁷
	Capital Cost ¹	Impact to Amtrak/Private Property ²	Access Impacts ³	Effective Flood Control ⁴	Implementation Time Frame ⁵	
Criteria Weighting ⁶	3	1	2	3	2	
1. Flood Gate with Floodwall	2	1	3	3	1	2.2
2. Flood Gate-Only	3	2	3	2	2	2.5
3. Closing the Cattle Crossing	3	2	1	2	2	2.1
4. Do Nothing	1	3	3	1	3	1.9

RESILIENT BRANFORD

Lessons Learned

Resilient Branford

- Floods: Tidally influenced flooding via a railroad underpass can be minimized through construction and deployment of a gate structure.
- Community: Reducing frequent flooding (shallow flooding that will worsen over time) in the Meadow Street area is more urgent and desirable than more costly and logistically challenging efforts that could lead to FEMA map revisions.

Strategic Findings

Engagement with key stakeholders (in this case, Amtrak) should begin early and may require sustained efforts to achieve desired outcomes. Communities must be positioned to advance their climate adaptation and resilience projects leveraging local funding.

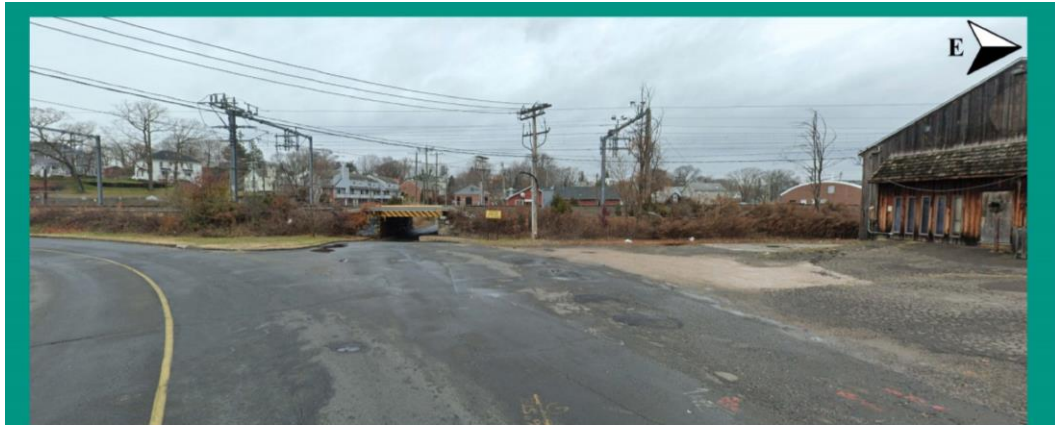


FIGURE 3: EXISTING CONDITIONS



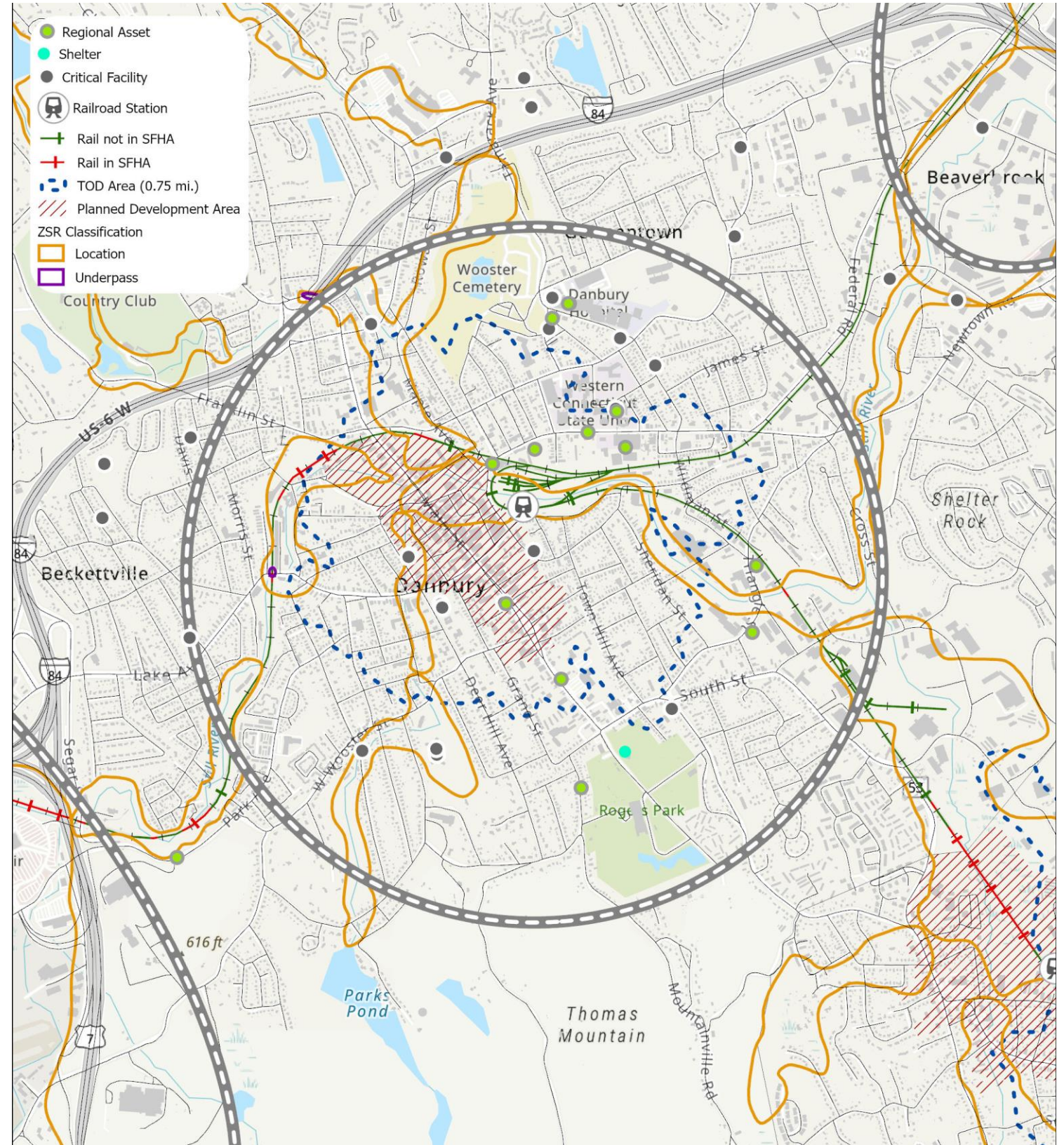
Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Downtown Danbury

Location: Danbury

Considerations	Characteristics of Area
Flood Vulnerability	● ● ● ● ●
Heat Vulnerability	● ● ● ● ○
Social Vulnerability	● ● ● ● ●
<p>The center of Danbury is characterized by zones of shared risk associated with the confluence of Padanarum Brook, Kohanza Brook, and the Still River. Despite many flood risk reduction projects undertaken over decades, TOD and planned development areas are located in close proximity to – or within – these zones of shared risk. Numerous critical facilities, historic resources, and the terminus of the MetroNorth Danbury line are also located in the area. Downtown Danbury is a regional center for northern WestCOG.</p> <p>Almost all of the downtown area is moderately vulnerable to heat, with the highest vulnerable area concentrate along route 53 commercial properties. Presenting few opportunities for shade or street trees, the area has high heat emittance. In addition, there is high social sensitivity throughout the area.</p>	
<p>City Hall Fire headquarters Hose Co. 5, 6, 7, and 9 Danbury Hospital Danbury Health and Housing Dept. Western CT State College Police Assisted living facilities</p>	<p>War Memorial Substation Power plant Museums</p>



RESILIENT DANBURY

EXISTING VS. FUTURE 1% CHANCE EVENT (100-YEAR)

Flood Risk Reduction

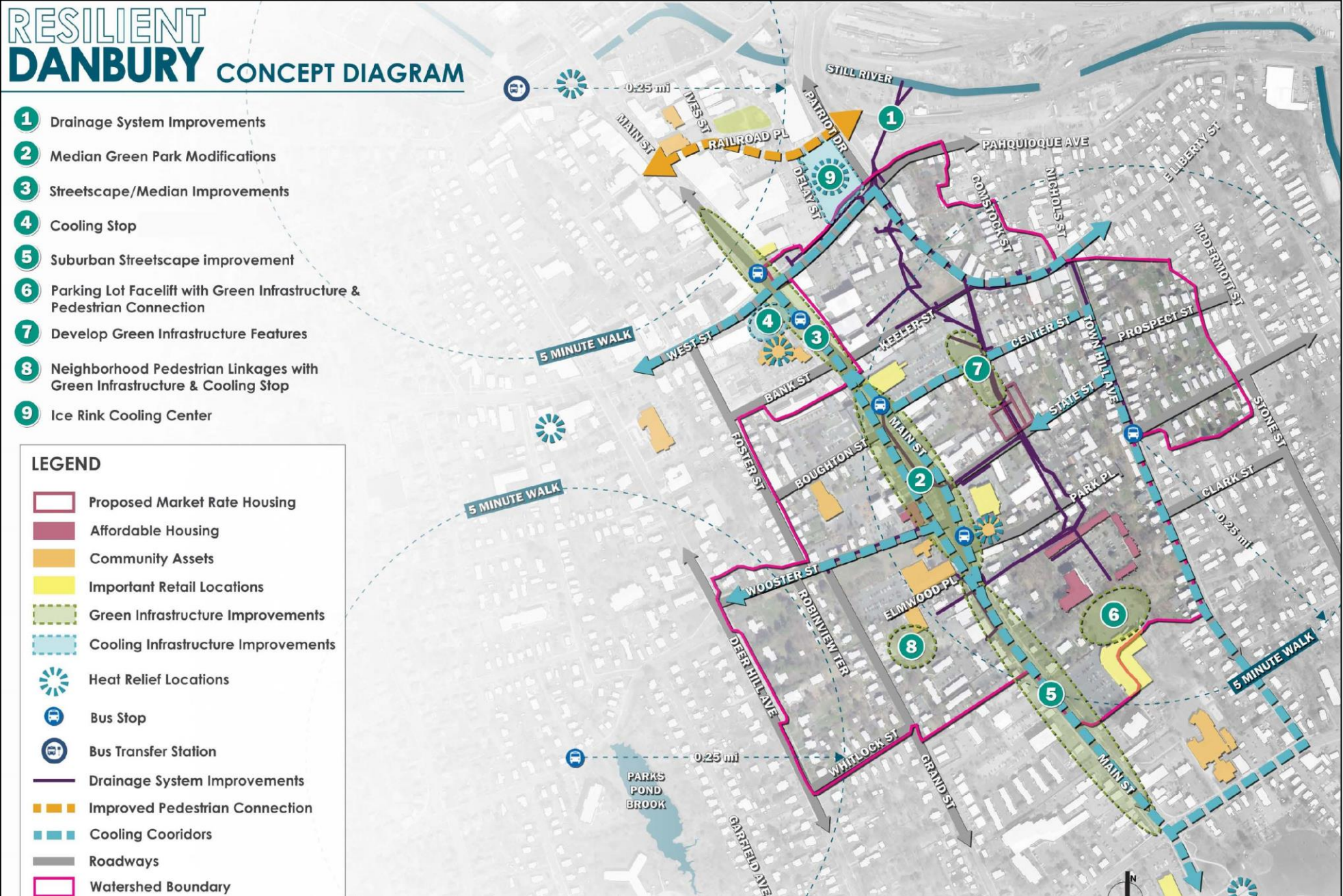
- Future precipitation volumes and intensities will lead to more parcels and streets flooded, and increasing depths of flooding in the “East Ditch” watershed
- Numerous critical facilities, existing public housing and affordable housing, and key roads will be increasingly at risk



RESILIENT DANBURY

Flood Risk Reduction

- A new master plan envisions the long-planned drainage system modifications and an extensive system of green infrastructure
- Co-benefits to managing extreme heat were important in this project



RESILIENT DANBURY



Lessons Learned

Resilient Danbury

- Extreme Heat: Opportunities to reduce heat exposure may be advanced using green infrastructure; respite from heat may be provided with cooling centers.
- Floods: Increased frequency of intense precipitation is already contributing to loss of service from critical facilities and flooding of socially vulnerable populations living in affordable housing where FEMA flood mapping is absent.
- Community: Sustained attention to climate risks can lead to simple acts (i.e., a memorandum of understanding) that formalize the use of new critical facilities.

Strategic Findings

In developed city centers, green infrastructure alone cannot reduce flood losses; long-delayed infrastructure improvements must be advanced. Additional opportunities to incorporate elements of climate adaptation and resilience may appear when new affordable and market rate housing developments are proposed.

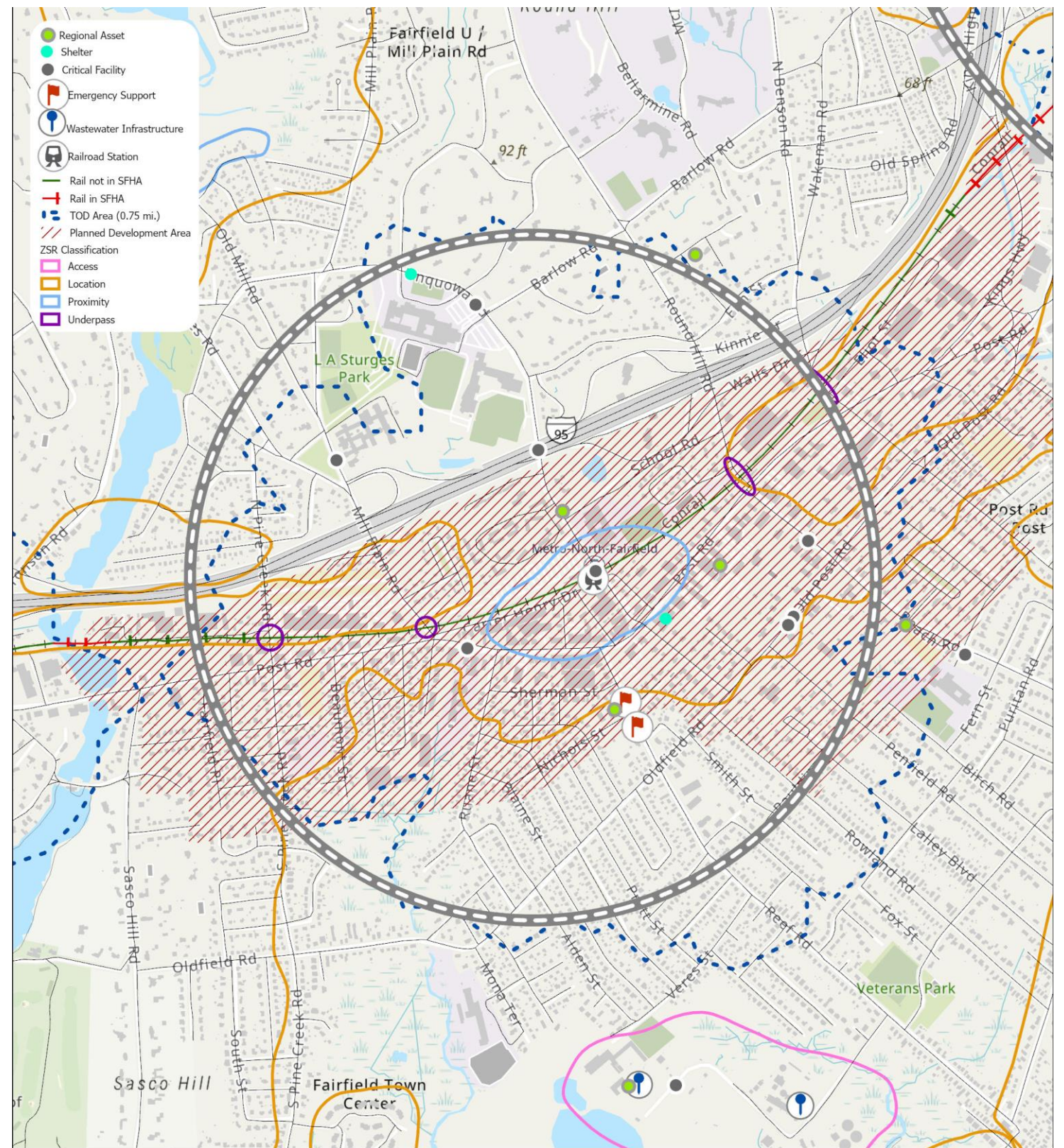
Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Downtown Fairfield

Location: Fairfield

Considerations	Characteristics of Area
Flood Vulnerability	○ ● ● ● ●
Heat Vulnerability	○ ● ● ○ ○
Social Vulnerability	○ ● ○ ○ ○
<p>Zones of shared risk include FEMA flood zones, storm surge risk areas, underpasses that can flood, and the densely developed area near the train station that is flooded by excessive stormwater generation coupled with limited drainage conveyance beneath the Post Road. These zones of shared risk nearly intersect in Fairfield's downtown, which serves as a hub connecting the roads leading from the coastal areas of risk to I-95, Amtrak, and the remainder of the town.</p> <p>Heat vulnerable areas are primarily residential south of Route 1 and can be attributed to high structure density equating to high heat emittance.</p>	
Fairfield Library Town Hall Five Schools, one shelter Police headquarters/EOC	Fire Headquarters Museums Fairfield rail station Convalescent home



RESILIENT FAIRFIELD

Resilient Fairfield | Recap of Progress to Date



Flood Risk Reduction

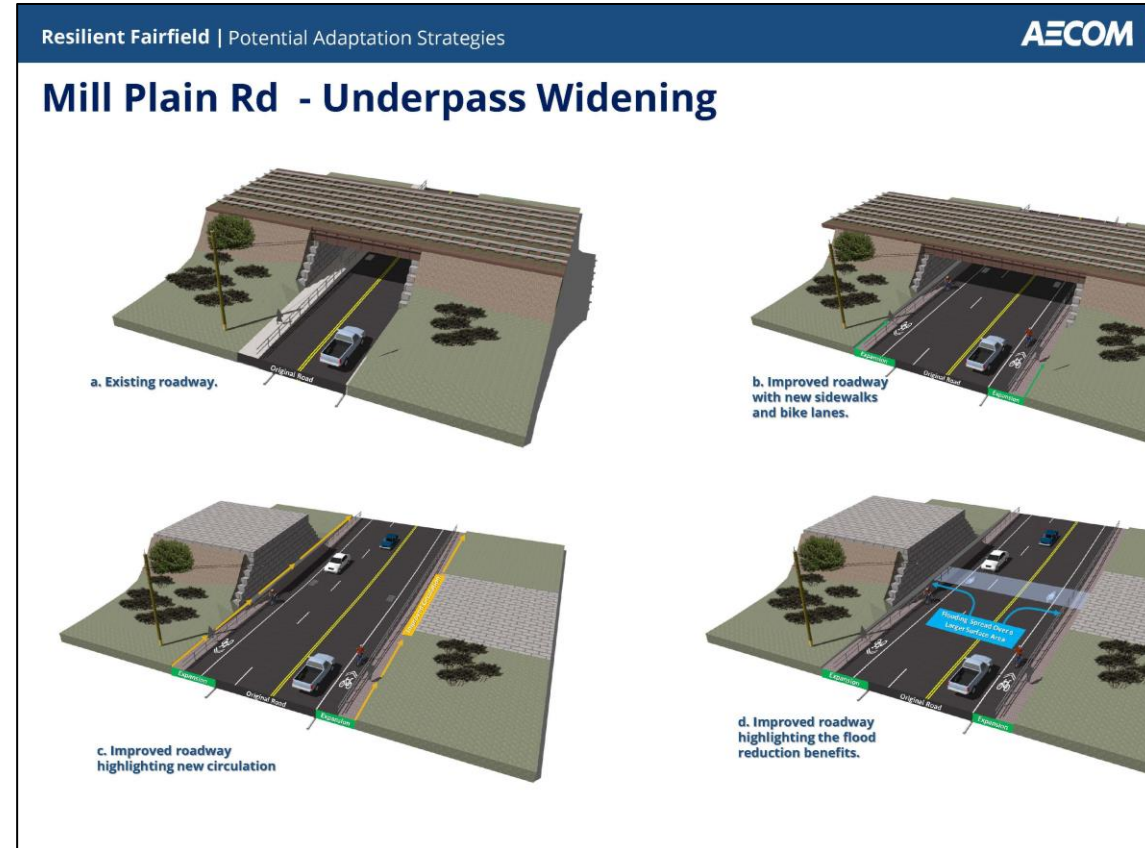
- Four railroad underpasses flood due to a combination of factors, but stormwater flooding is the most common risk for each of the four
- Sea level rise will eventually lead to more frequent flooding, or deeper flooding, of some of the underpasses



RESILIENT FAIRFIELD

Flood Risk Reduction

- 12 sets of options were scored for each of the four underpasses
- Underpass widening was advanced as a new idea because it can help address flooding as well as broader resilient corridor concepts related to mobility and safety



AECOM **CIRCA**
Connecticut Institute for Resilience and Climate Adaptation

Applicability Scoring

North Pine Street		Mill Plain Road	
Strategy	Applicability	Strategy	Applicability
Bio-Swales	Low	Bio-Swales	Medium
Permeable Pavement	Low	Permeable Pavement	High
Detention and Infiltration park	High	Detention and Infiltration park	Low
Stormwater Restoration	Low	Stormwater Restoration	High
Modifications to Network	Medium	Modifications to Network	Medium
New Pump Stations	Medium	New Pump Stations	Low
Maintenance of Existing	Medium	Maintenance of Existing	Medium
Warning and Monitoring	High	Warning and Monitoring	High
Widening of Underpass	Low	Widening of Underpass	Medium
Raising Base Elevation	Medium	Raising Base Elevation	Medium
New Overpass	Low	New Overpass	Low
Raised Railroad Elevation	Low	Raised Railroad Elevation	Low

Round Hill Road		North Benson Road	
Strategy	Applicability	Strategy	Applicability
Bio-Swales	Low	Bio-Swales	Low
Permeable Pavement	Low	Permeable Pavement	Low
Detention and Infiltration park	High	Detention and Infiltration park	High
Stormwater Restoration	Low	Stormwater Restoration	Low
Modifications to Network	Medium	Modifications to Network	Medium
New Pump Stations	Medium	New Pump Stations	Medium
Maintenance of Existing	Medium	Maintenance of Existing	Medium
Warning and Monitoring	High	Warning and Monitoring	High
Widening of Underpass	Medium	Widening of Underpass	Medium
Raising Base Elevation	Low	Raising Base Elevation	Low
New Overpass	Low	New Overpass	Low
Raised Railroad Elevation	Low	Raised Railroad Elevation	Low

RESILIENT FAIRFIELD

Lessons Learned

New Overpass Option 2



Resilient Fairfield

- Floods: Green infrastructure cannot prevent the frequent flooding that occurs in four underpasses beneath the Metro North railroad. Sources include stormwater, riverine floods, and tidally influenced flooding.
- Community: Ongoing viability of the underpasses is essential for supporting transit-oriented development (TOD) and for maintaining “resilient corridors” from the coastal floodplain to the central and northern sections of Fairfield.

Strategic Findings

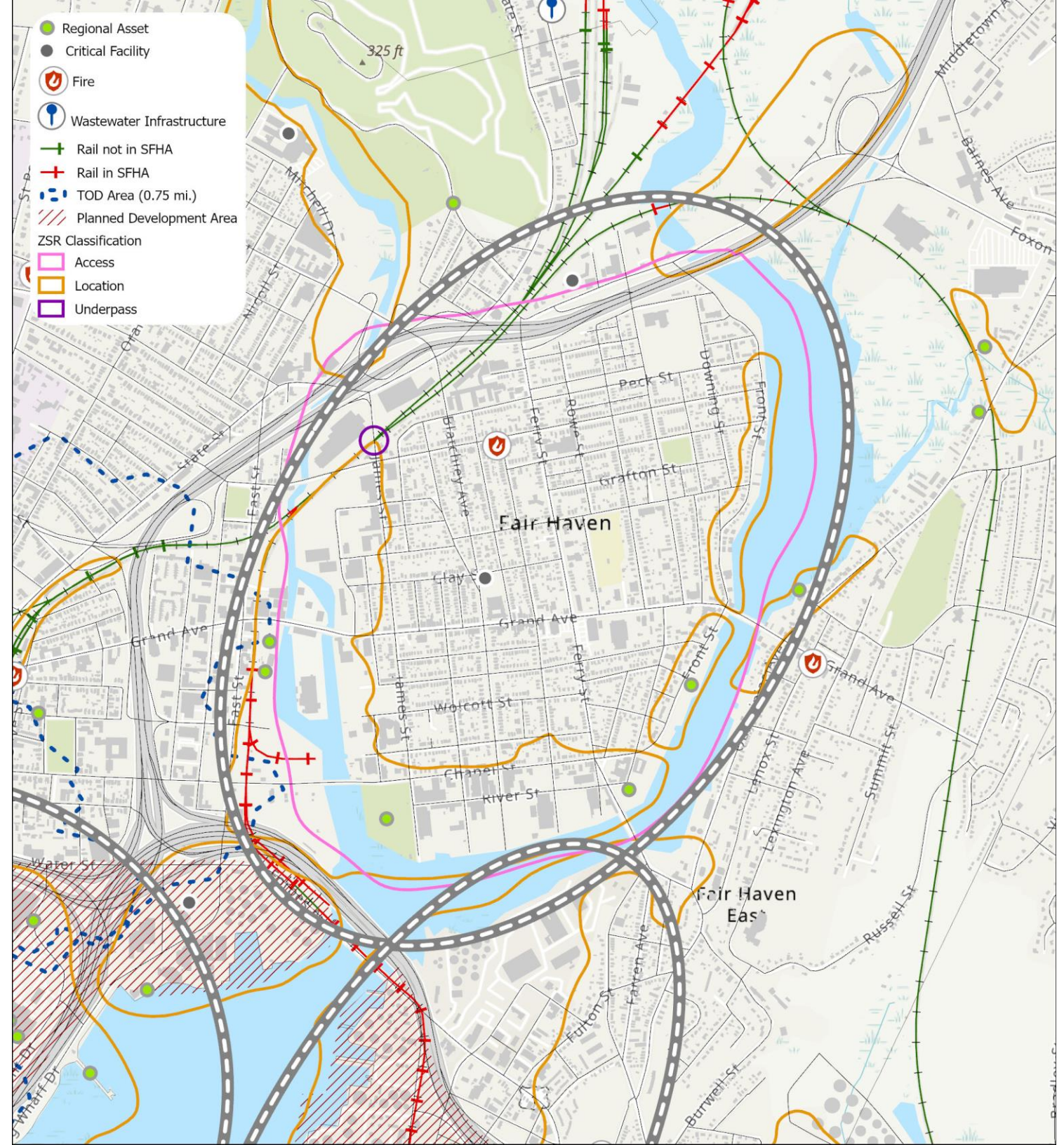
Many tools are needed to maintain access through underpasses when raising a rail bed appears impossible: drainage improvements, green infrastructure, underpass widening, warning systems, and new overpasses. Communities must work through tradeoffs to decide where to use each.

Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Fair Haven/Mill River
 Location: New Haven

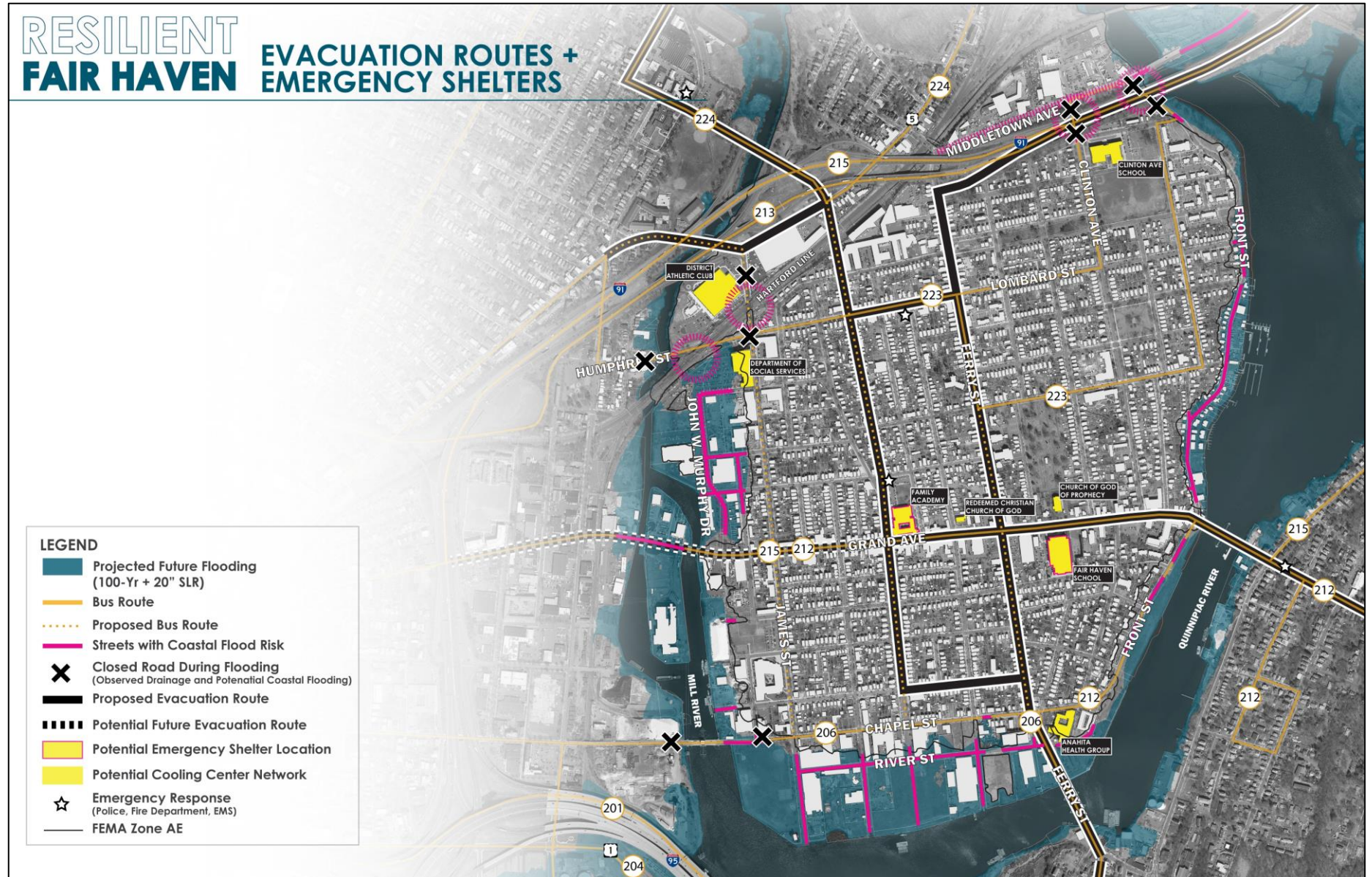
Considerations	Characteristics of Area
Flood Vulnerability	○ ● ● ● ●
Heat Vulnerability	○ ● ● ● ●
Social Vulnerability	○ ● ● ● ●
<p>Zones of shared risk along the Mill River and Quinnipiac River merge with a zone of shared risk drawn around Fair Haven (for isolation risks) to highlight an opportunity area centered on Fair Haven. While TOD does not overlap with Fair Haven, it is present just west of the Mill River. Numerous resilience opportunities may be available as the City promotes and supports redevelopment in the Mill River and Fair Haven areas. Care should be taken to enhance livability in Fair Haven and connectivity to surrounding areas.</p> <p>Fair Haven is entirely high heat vulnerable. This is attributed primarily to the high social sensitivity present here, combined with dense housing, high amounts of pavement, and disconnected green space for shade.</p>	
Fire station Public works School	Substation Coastal access



RESILIENT FAIR HAVEN

Flood Risk Reduction

- One key outcome of the study was an active statement about which roads out of Fair Haven should be the primary evacuation routes, given the number of bridges and underpasses present
- Potential shelters and cooling centers were mapped out in relation to these resilient corridors



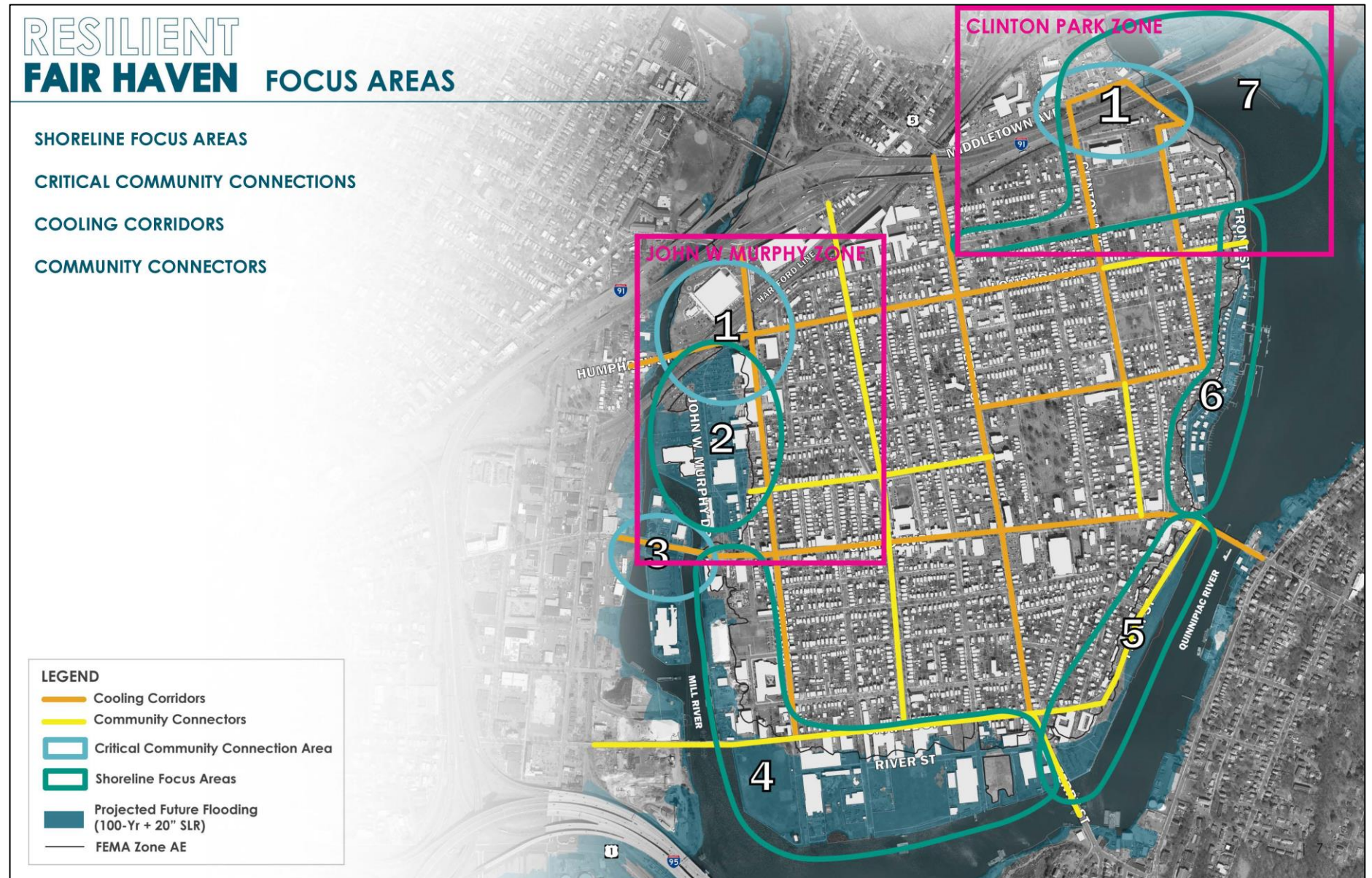
RESILIENT FAIR HAVEN

Flood Risk Reduction

- Close coordination with City Plan, Engineering, Economic Development, and stakeholders such as Save the Sound revealed that two broad areas were receiving less attention and may have unmet needs:

John Murphy Zone

Clinton Park Zone



RESILIENT FAIR HAVEN

Flood Risk Reduction

- John Murphy Drive area is alongside the tidal Mill River
- Flooding is currently a challenge and will be increasingly challenging over time

RESILIENT FAIR HAVEN

FOCUS AREA SELECTION

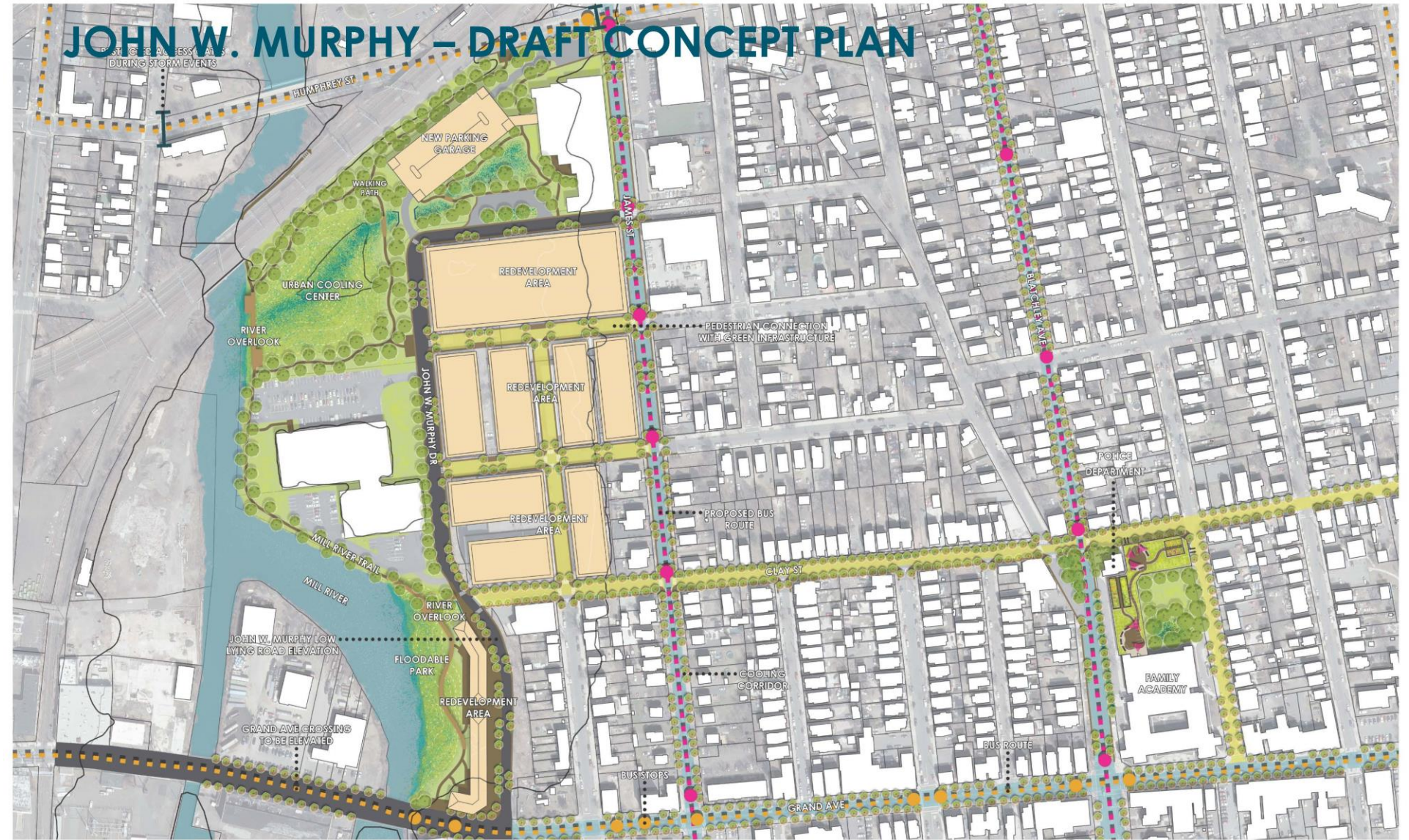


Green Spaces as Cooling Infrastructure Recreational park near social services? Parking garage?	Cooling Community Connections
Shoreline Enhancement Incorporation of Mill River current and future plans into solutions	Road Raising Grand Avenue timing?
Community Based Green Infrastructure Green roofs, subsurface, school based projects?	Low-Lying Roadway Improvements Roadway closures?

RESILIENT FAIR HAVEN

Flood Risk Reduction

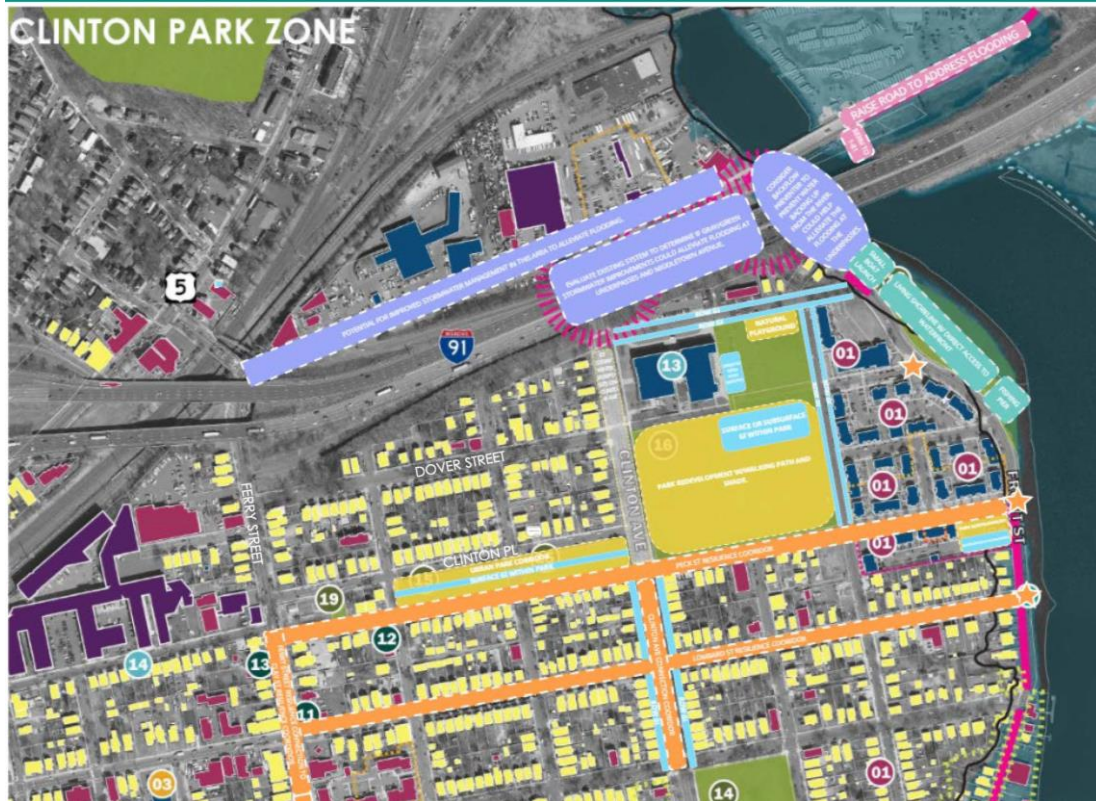
- Options include
 - ✓ Acquisitions
 - ✓ Removing parking lots
 - ✓ Elevating a road to improve its function and provide flood protection
 - ✓ Green infrastructure
 - ✓ Key connections to the interior of Fair Haven



RESILIENT FAIR HAVEN

Lessons Learned

FOCUS AREA SELECTION



Resilient Fair Haven

- Extreme Heat: Opportunities to reduce heat exposure may be advanced using green infrastructure; respite from heat may be provided with cooling centers and water access.
- Floods: Coastal floods and intense precipitation will increasingly hinder access from Fair Haven to adjacent parts of New Haven using the many bridges and underpasses.
- Community: Other pressing needs in Fair Haven have hindered sustained attention on climate adaptation and resilience planning.

Strategic Findings

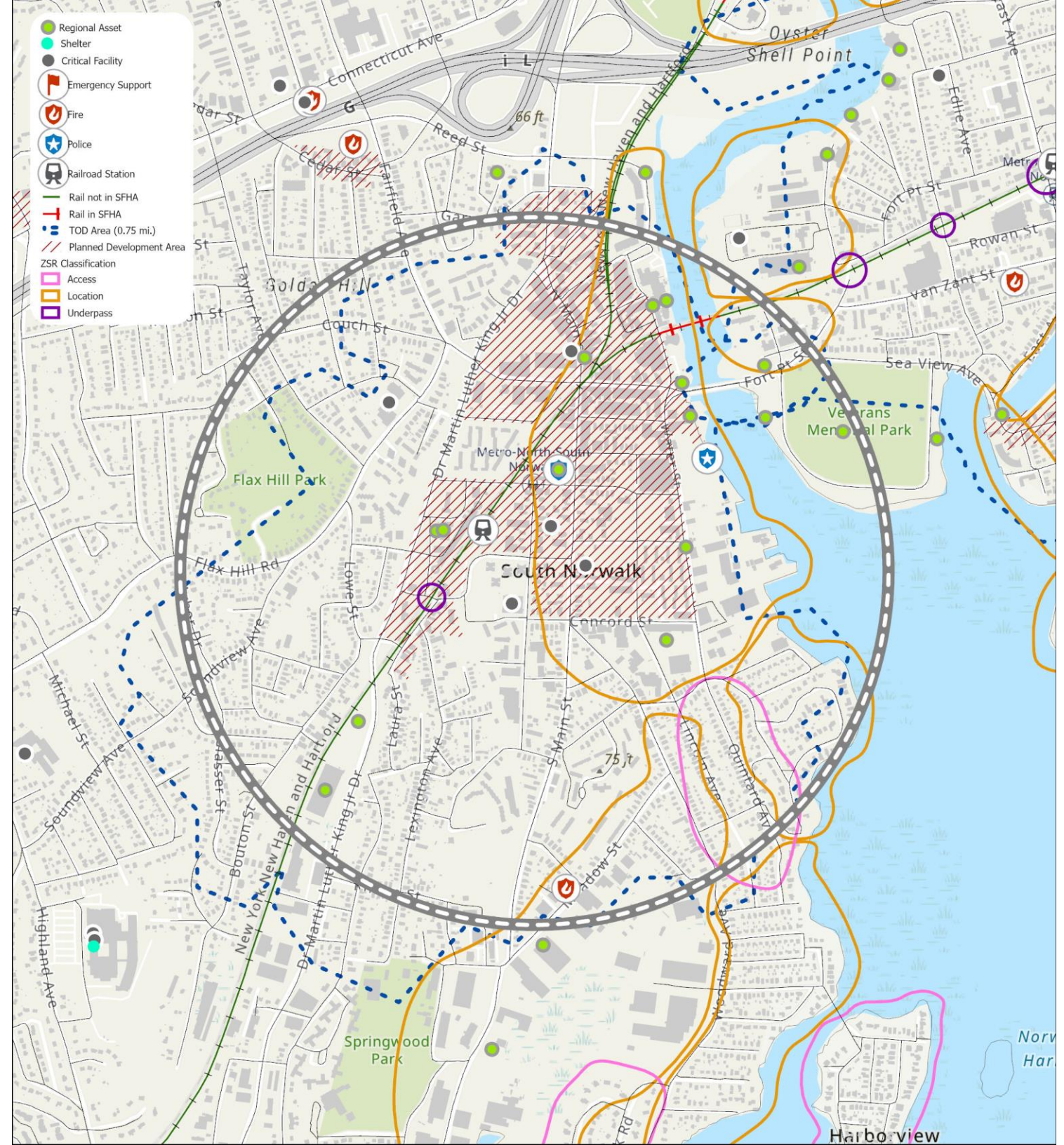
Communities with significant health, socioeconomic, and recreational needs may not have time to dedicate to climate resilience needs. To foster interest, opportunities to advance climate adaptation may need to be linked to improvements in transit, walkability, recreation, public and critical facilities, community spaces, and water access.

Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: South Norwalk
Location: Norwalk

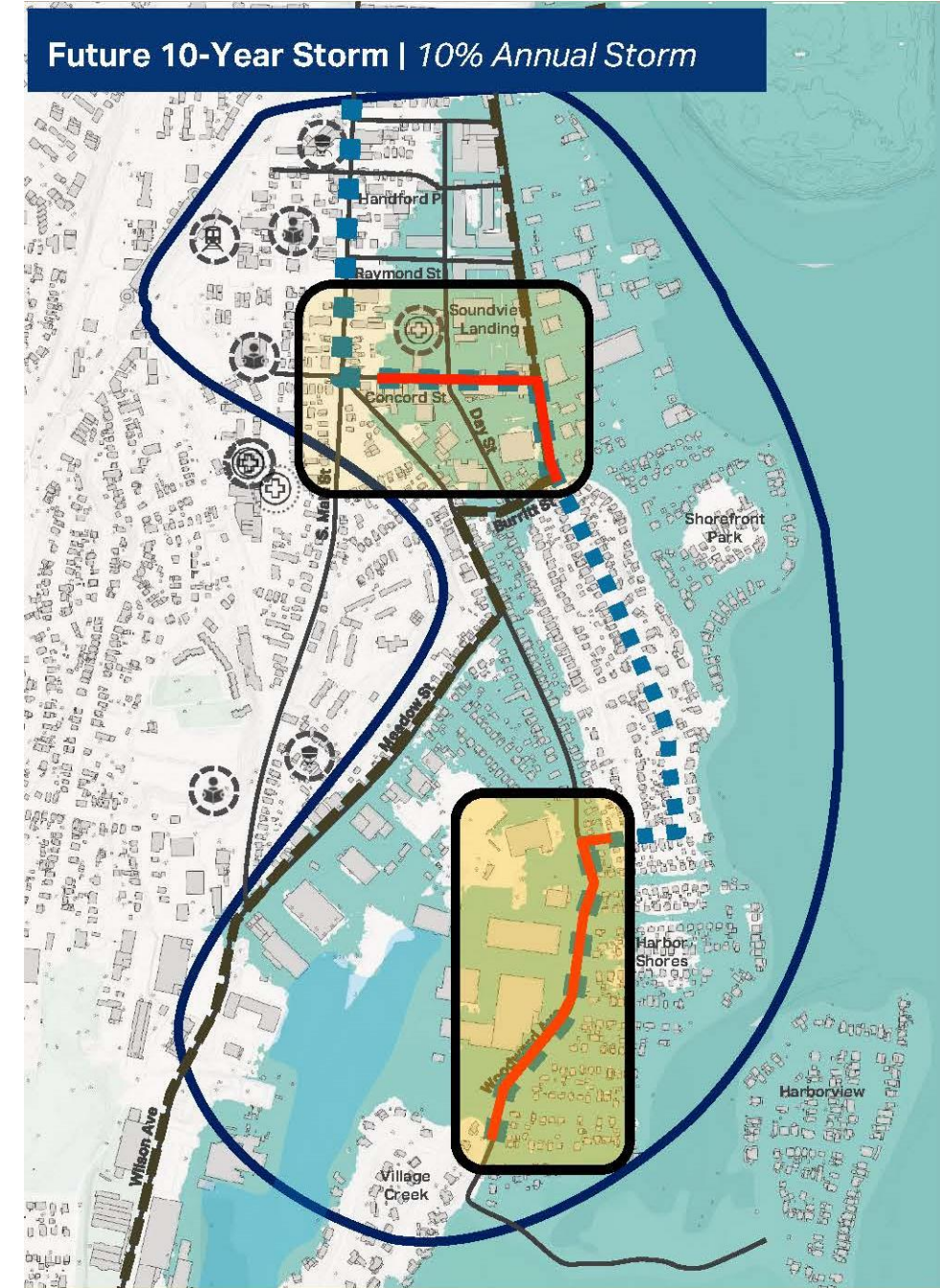
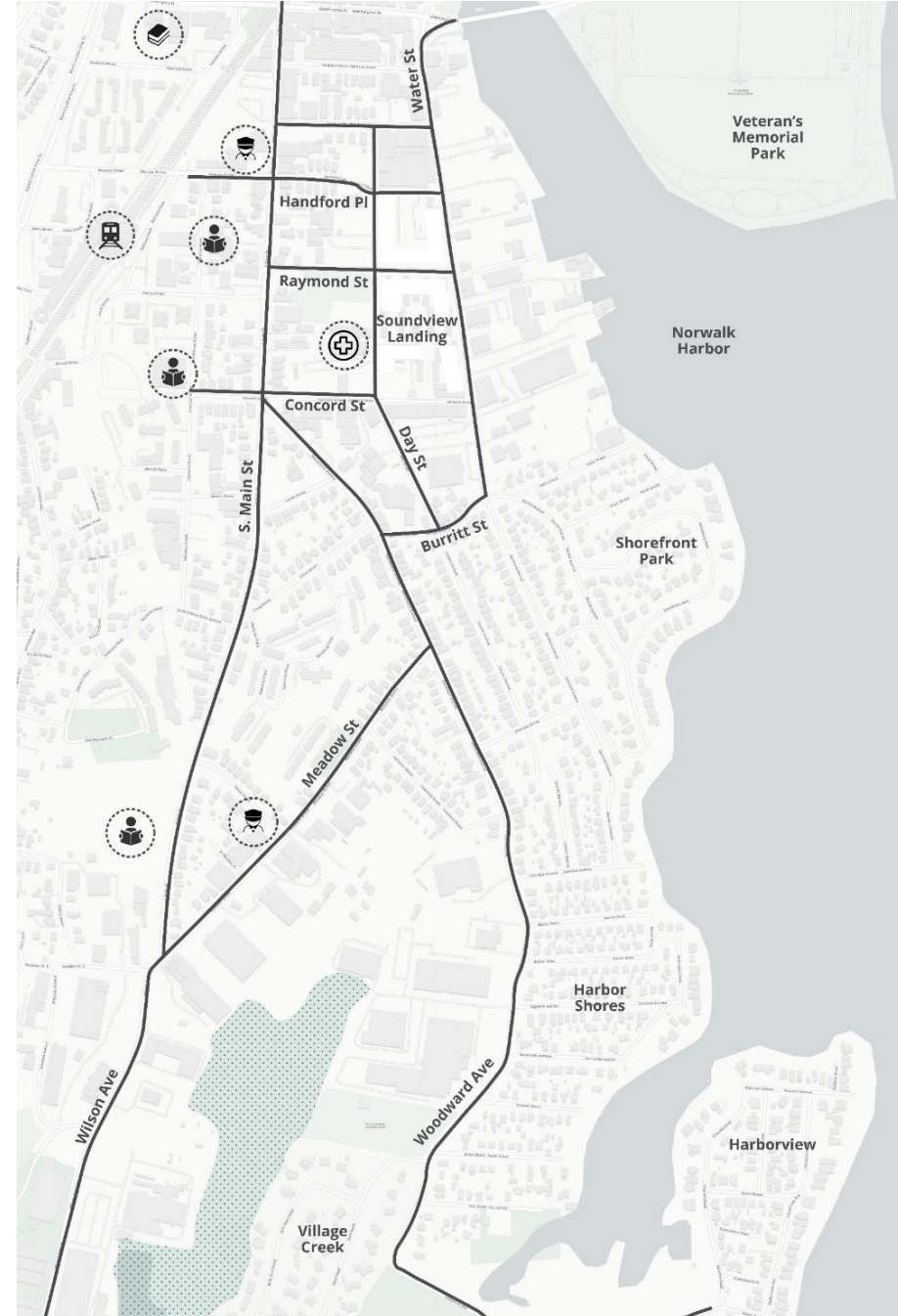
Considerations	Characteristics of Area
Flood Vulnerability	● ● ● ● ●
Heat Vulnerability	● ● ● ● ●
Social Vulnerability	● ● ● ● ●
<p>The South Norwalk area contains a major railroad station, numerous critical facilities and historic resources, regional tourist attractions, flood risk associated with the Norwalk River estuary and Norwalk Harbor, and key connections to areas to the south that can be isolated by coastal flooding. The City is evaluating challenges and opportunities associated with commercial and water-dependent properties along Water Street, all in the coastal flood zone.</p> <p>All of the SoNo area is high heat with dense commercial/industrial coverage along the waterfront with high impervious surfaces, and dense but green residential west of the railroad. This area is however high for social sensitivity contributing to the vulnerability.</p>	
Fire station 5 Police dept. Marine patrol Two schools Medical care facilities	Coastal access Substation Commerce Shipping



RESILIENT SOUTH NORWALK

Flood Risk Reduction

- South Norwalk is comprised of a vibrant downtown and several smaller neighborhoods and associations that can become separated from one another during coastal flood events
- Identifying road segments to become resilient corridor was an exercise in close examination of tradeoffs



RESILIENT SOUTH NORWALK

Flood Risk Reduction

- Woodward Avenue is an intriguing potential for a resilient corridor
- Sufficient space is present alongside the roadway to allow for a partial realignment coupled with an elevation, reducing encroachment onto residential front yards and driveways



RESILIENT SOUTH NORWALK

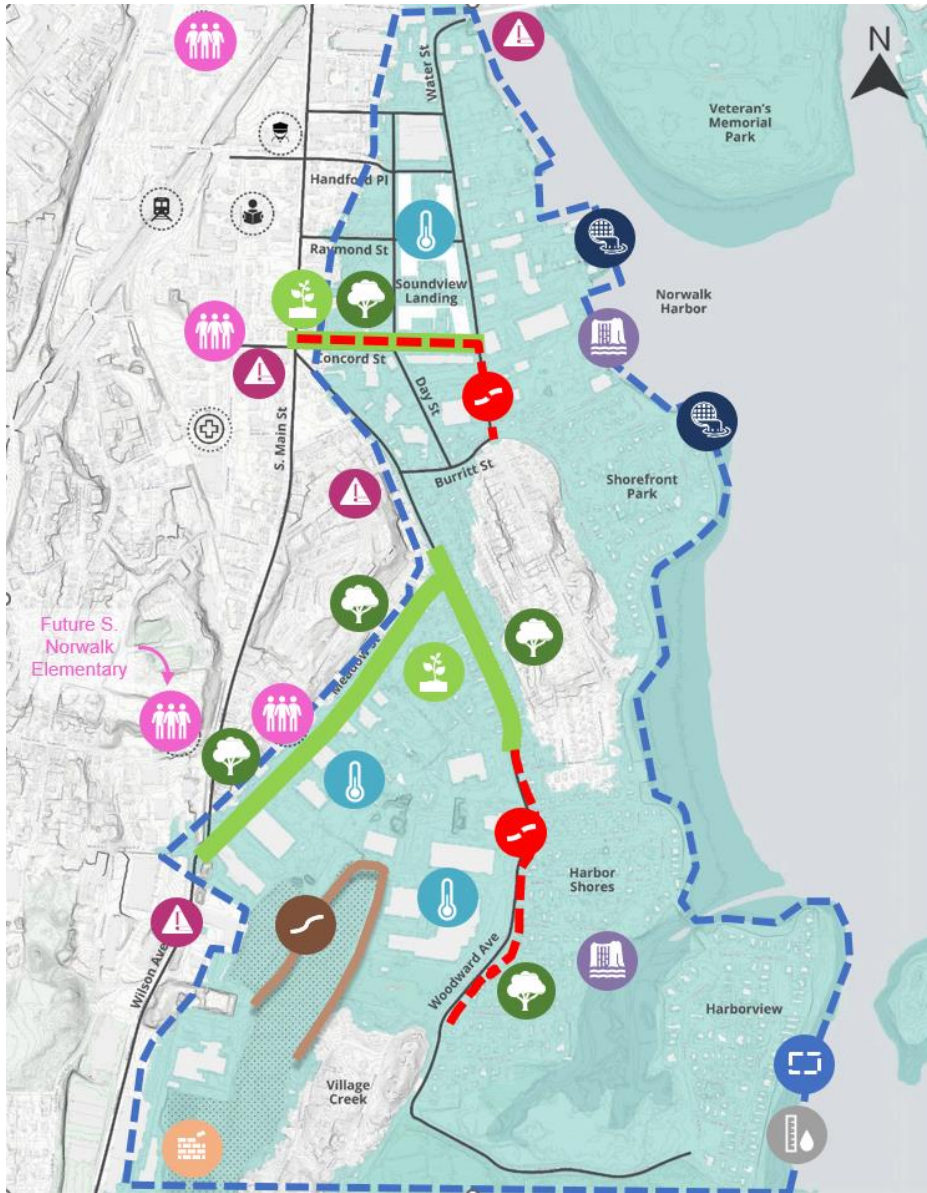
Lessons Learned

Resilient South Norwalk

- Extreme Heat: Opportunities to reduce heat exposure may be advanced using green infrastructure; respite from heat may be provided with cooling centers.
- Floods: Coastal floods will increasingly affect Water Street and impede travel between and among different neighborhoods in South Norwalk.
- Community: Redevelopment pressures and different perspectives about flood risks in South Norwalk have hindered a meaningful dialog about resilience.

Strategic Findings

Some communities may not be ready to focus on targeted climate adaptation and resilience efforts without a broader discussion taking place. In these cases, it may be necessary for external entities (e.g. CIRCA's goals for resilient corridors) to strongly advocate for desired results.



Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Airport/Lordship Gateway

Location: Stratford

Considerations	Characteristics of Area
Flood Vulnerability	○ ● ● ● ● ○
Heat Vulnerability	○ ● ● ● ● ○
Social Vulnerability	○ ● ● ● ● ○

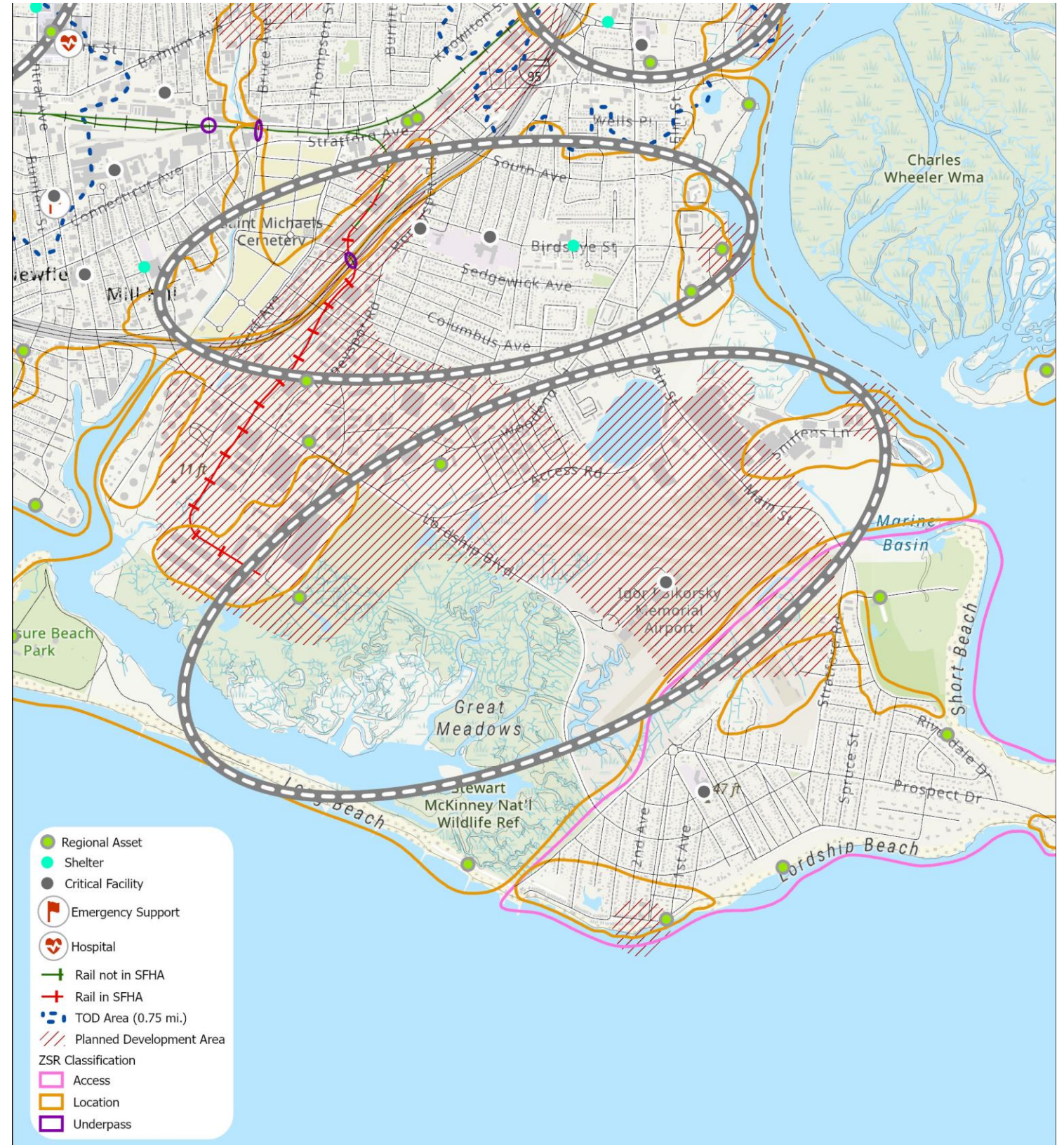
This area has significant coastal flood risk from two directions: Great Meadows Marsh (Long Island Sound) and the Housatonic River estuary. Sikorsky Airport dominates the area, and two significant roadways provide the only connection between Stratford's higher ground and the Lordship section of the town. Although TOD is not located here, the area represents a major commercial hub and key connectivity between Stratford's South End and Lordship.

Sporadic pockets of high heat vulnerability in the area can be attributed to dense, ungreened pavement, as well as the large wetland to the south of Sikorsky. While the wetland can be considered "green" the nature of a wetland having few trees does not mitigate heat to the same degree a forest or park can.

Igor Sikorsky Memorial Airport

Coastal access

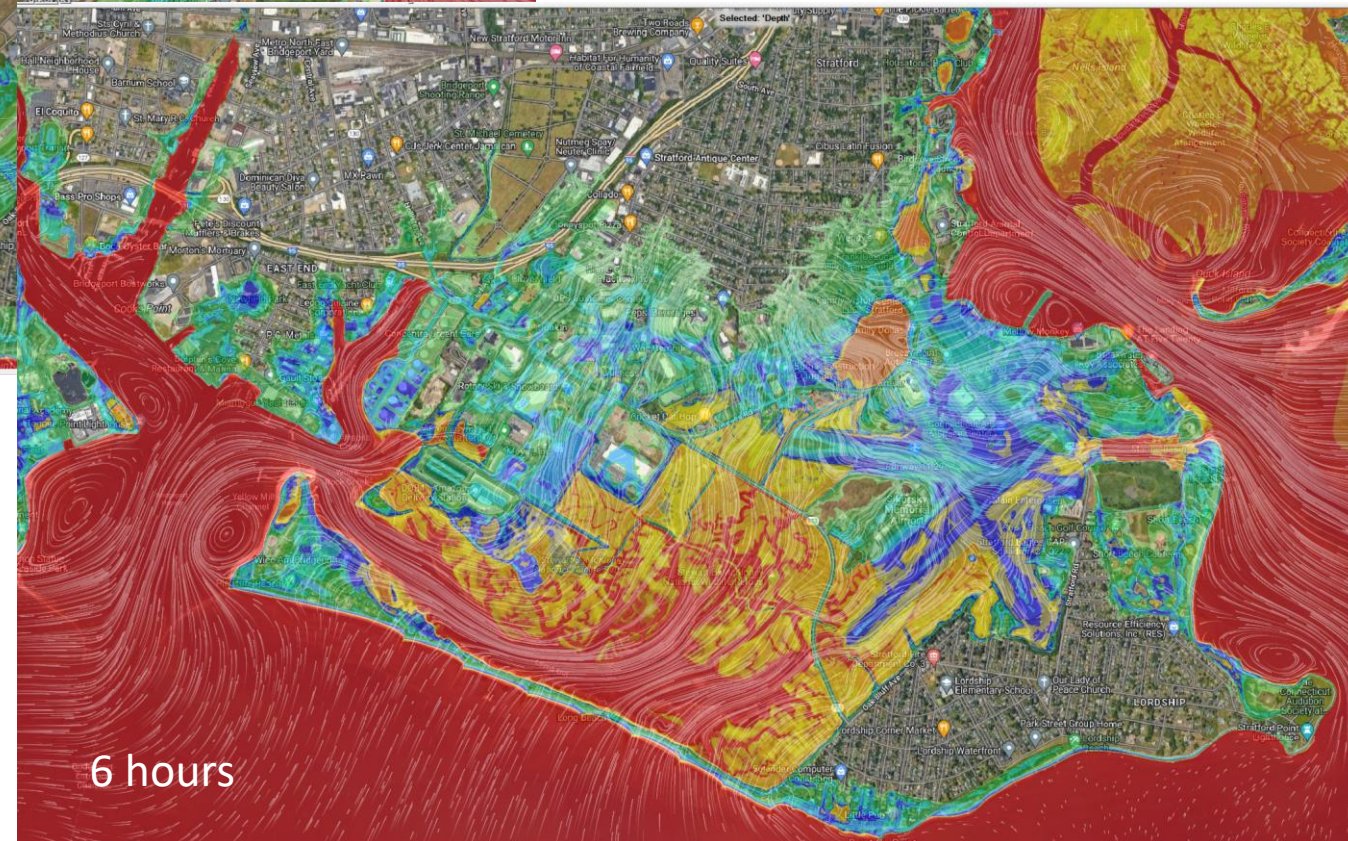
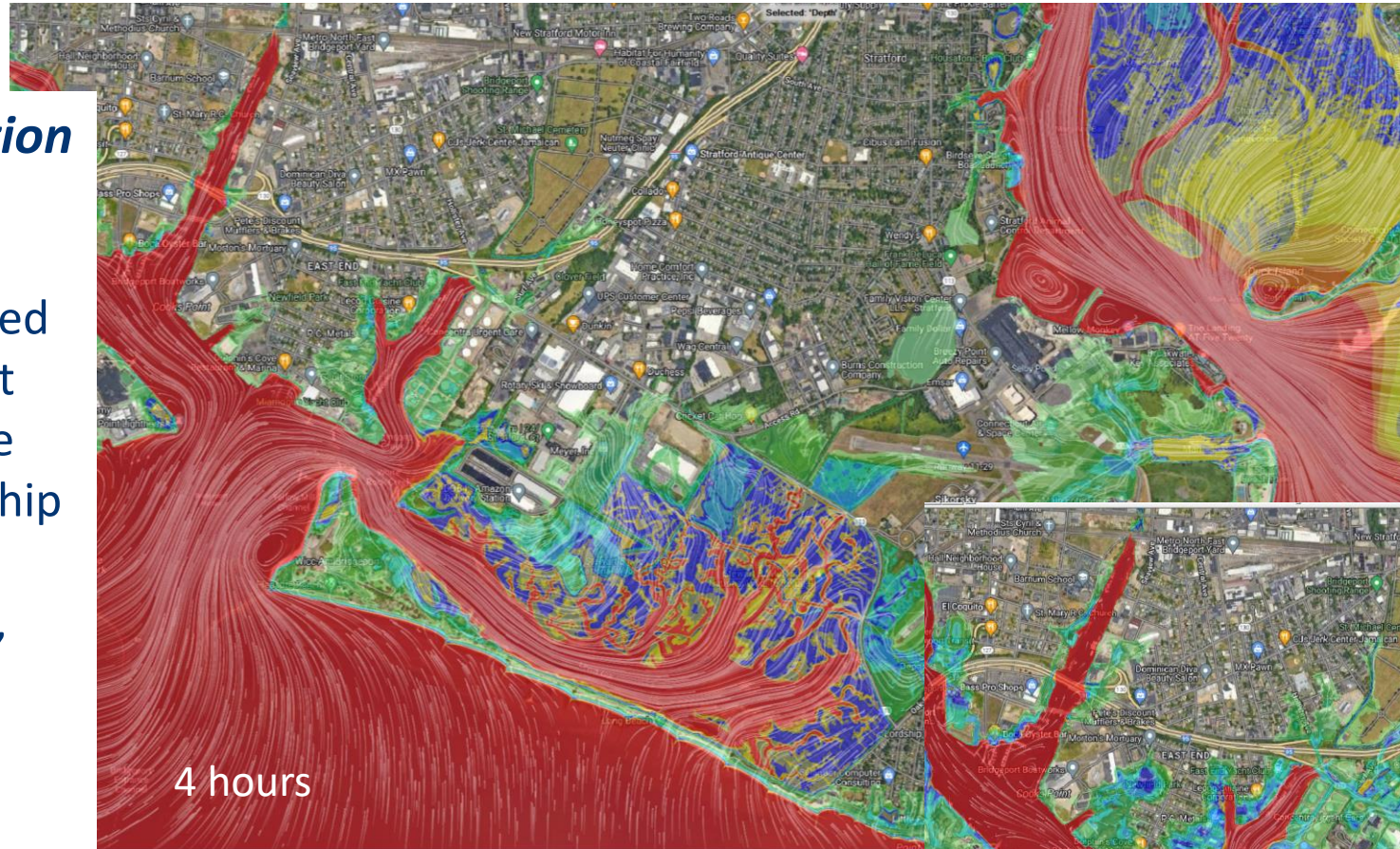
Shipping location



RESILIENT SOUTH END

Flood Risk Reduction

- Storm surge flooding is believed to be a significant future risk for the South End, Lordship Boulevard commercial area, and airport
- Coastal flood analysis shows how flood extents move landward from four to six hours in storm duration



RESILIENT SOUTH END

Flood Risk Reduction

- Access Road was advanced as a new concept in this study
- This alignment is intriguing because it reduces the need to elevate or provide protection along Lordship Boulevard and Main Street near the airport



RESILIENT SOUTH END

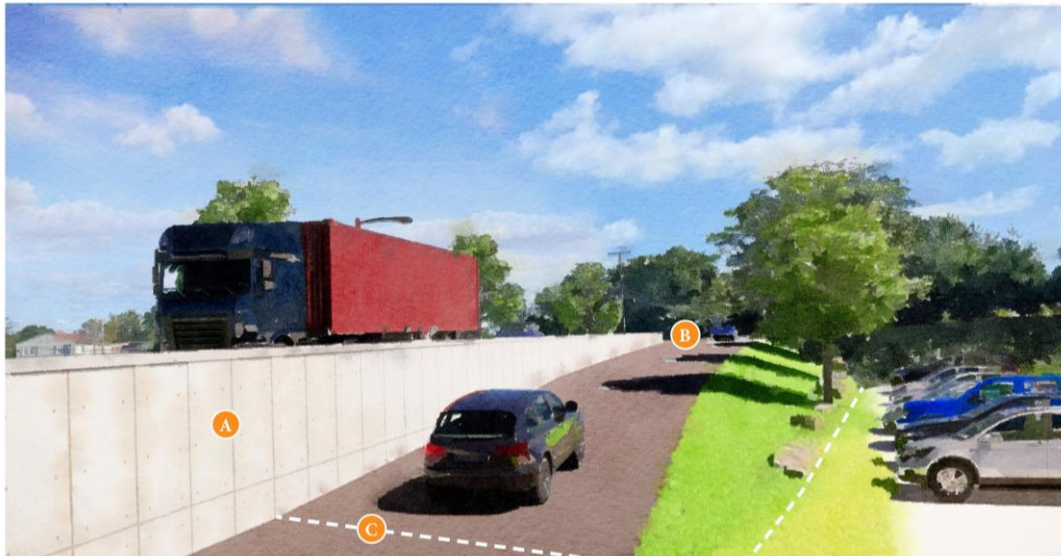
Lessons Learned

Resilient Stratford

- Floods: The Town has spent considerable time and resources advancing different segments of flood protection systems to different positions on the project pipeline, from plan view concepts to final design. Other configurations for flood protection systems – and other options for flood loss reduction – may need to be considered.
- Community: Residents of the South End may have other flood resilience concerns and needs that are unrelated to storm surge from Long Island Sound and the Housatonic River.

Strategic Findings

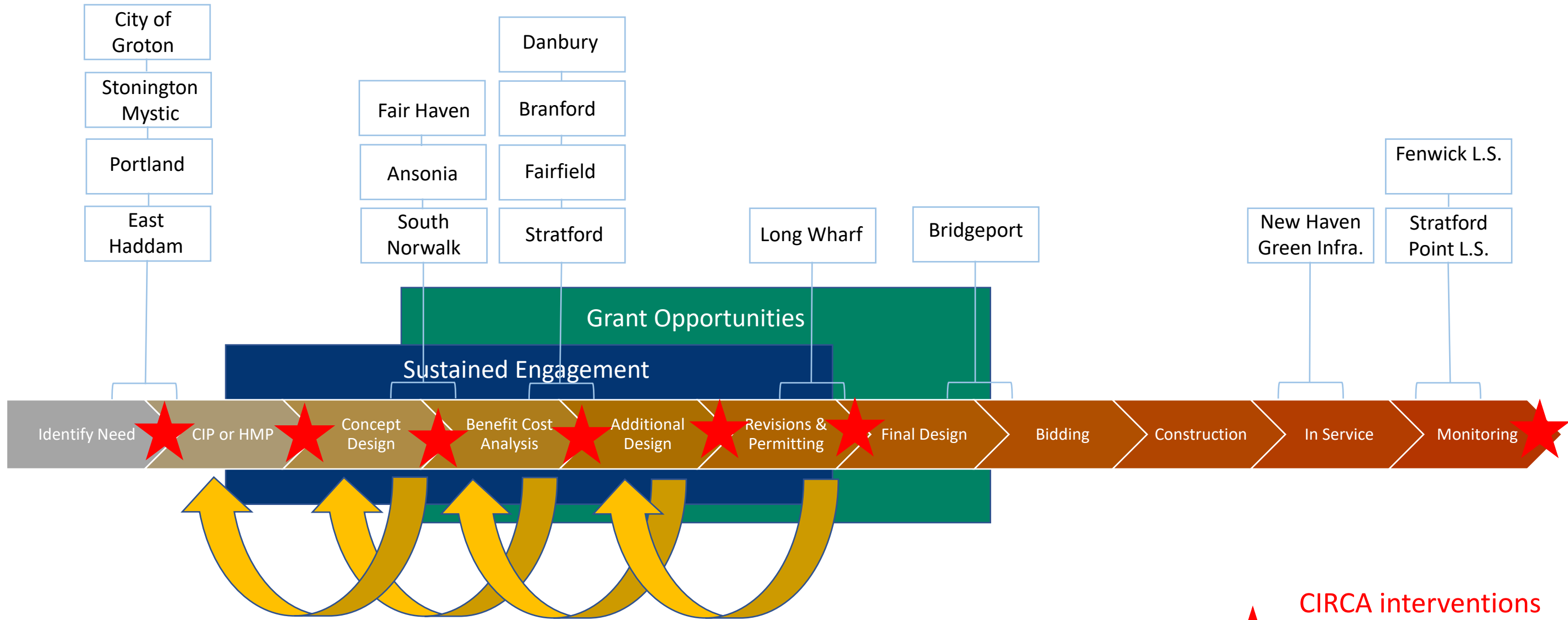
In communities where significant re-investment is planned for key properties, the uncertain timing of these investments may be hindering progress for community flood loss reduction. Options must be developed that can be effective at reducing community flood losses whether or not redevelopment of key properties occurs.



- A Concrete floodwall between lower northbound and higher southbound lane
- B Northbound and southbound lane both elevated to higher elevation
- C Existing southbound lane elevation

Flood Protection & Elevated Road
Access Road
Flood Side

RESILIENT CONNECTICUT AND THE PROJECT PIPELINE



Taking a step backward is possible and often will occur, in practice, along a project pipeline

★ CIRCA interventions and value added possible

CLOSING REMARKS

- Adaptation planning takes time
 - Planning support needed for next 20-30 years
 - Innovative approaches are needed
 - Coordination with economic activity and housing needs
 - Need to help towns win federal funds

Save the Date



Resilient Connecticut Summit
Friday, December 1, 2023

UConn School of Law
Starr Reading Room
55 Elizabeth St, Hartford, CT 06105
Details and agenda to follow