RESILIENT FAIR HAVEN

Adaptation Strategies for the Fair Haven Neighborhood

FINAL REPORT

NOVEMBER 2023

FUSS & O'NEILL

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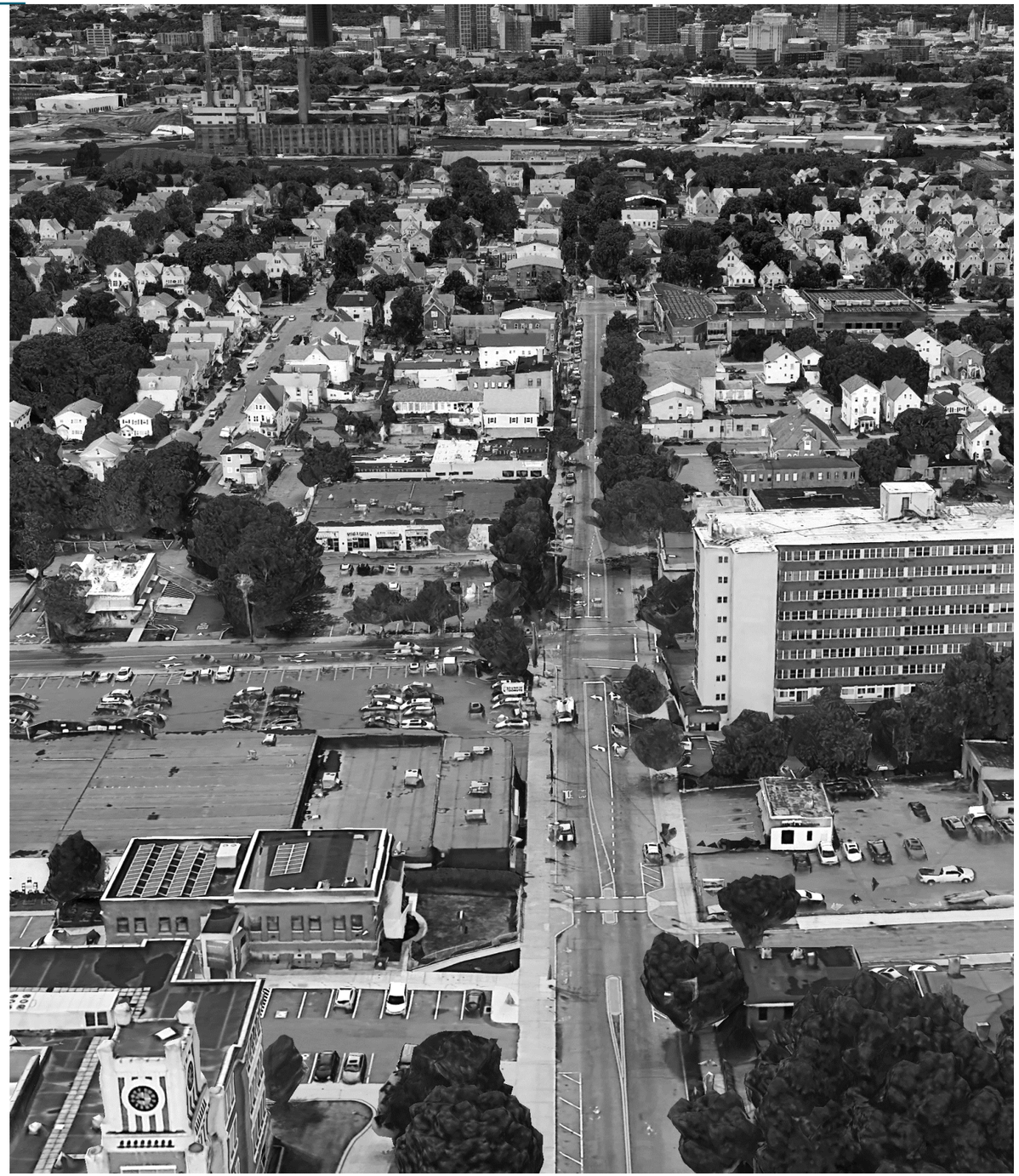
CIRCA Connecticut Institute for Resilience and Climate Adaptation

NHV New Haven

FUSS & O'NEILL

Dewberry



Grand Avenue looking West

RESILIENT
FAIR HAVEN

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EXECUTIVE SUMMARY

RESILIENT FAIR HAVEN

EXECUTIVE SUMMARY

SPANISH:

What is the purpose of this plan?
Resilient Fair Haven builds on prior planning and assessment of flood and extreme heat vulnerabilities by the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) for the Fair Haven neighborhood completed as part of Phases I and II of Resilient Connecticut. This project (Phase III of Resilient Connecticut) focuses on developing adaptation strategies to mitigate current and future climate induced impacts to community assets and transportation corridors in Fair Haven, as well as developing strategies to help mitigate the impacts of extreme heat for community residents. This plan is a culmination of these efforts. The plan:

- Summarizes the Resilient Fair Haven project and planning process undertaken
- Shares the outcomes and results of the process
- Provides a roadmap for reducing flood and heat risks for Fair Haven through identified resilience strategies and actions.

SPANISH TRANSLATION

What does this plan recommend?
A broad range of resilience strategies and actions should be leveraged to realize the vision of a more resilient Fair Haven. For neighborhood scale plans to be successful, even high-level visions need grounding in reality. The recommendations provided in this report aim to bring tangible flood risk reduction and extreme heat resilience benefits to this community over time, the strategies the project team developed are grounded in being feasible and implementable. The most exciting, innovative, and aspirational designs cannot benefit the City if they cannot be realized. Through this process it became clear to the project team that achieving the vision of a more resilient Fair Haven will require a comprehensive strategy with hybrid solutions that includes a careful balance between flood and heat resilience and community enhancement.

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Superstorm Sandy, Humphrey St Underpass / Superstorm Sandy, Humphrey St Underpass

December 23, 2022, Quinnipiac River Park / December 23, 2022, Quinnipiac River Park

Fair Haven peninsula / Fair Haven peninsula

RESILIENT FAIR HAVEN

EXECUTIVE SUMMARY

SPANISH:

What will the benefit of this plan be?

This plan seeks to reduce current and future risks due to flooding and extreme heat, now and into the future. The strategies and actions it proposes are intended to increase community resilience, enable positive transformation, and improve quality of life for the communities who live in and depend on the neighborhood of Fair Haven, especially for the neighborhoods most under-resourced communities. Thoughtful implementation of the strategies and actions contained herein could yield a wide variety of benefits for the entire neighborhood, including:

- Avoided loss of life, injuries, illnesses, mental stress and anxiety, in addition to other public health benefits
- Protection of structures, contents, and inventories
- A more sustainable economy and avoided impacts to local businesses
- Multiple ecological benefits, including restoration and expansion of existing open spaces, living shorelines, water quality enhancements, daylighting previously culverted outlets, a robust urban forest, and various habitat enhancements
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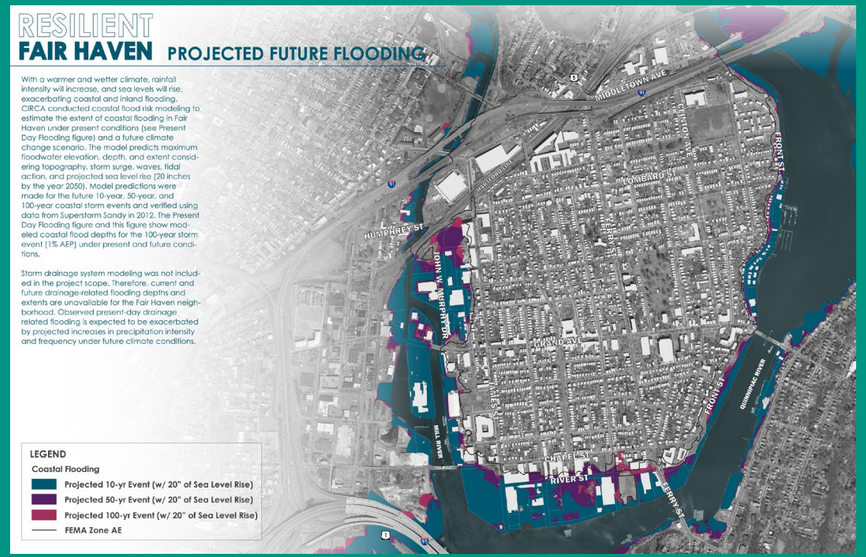
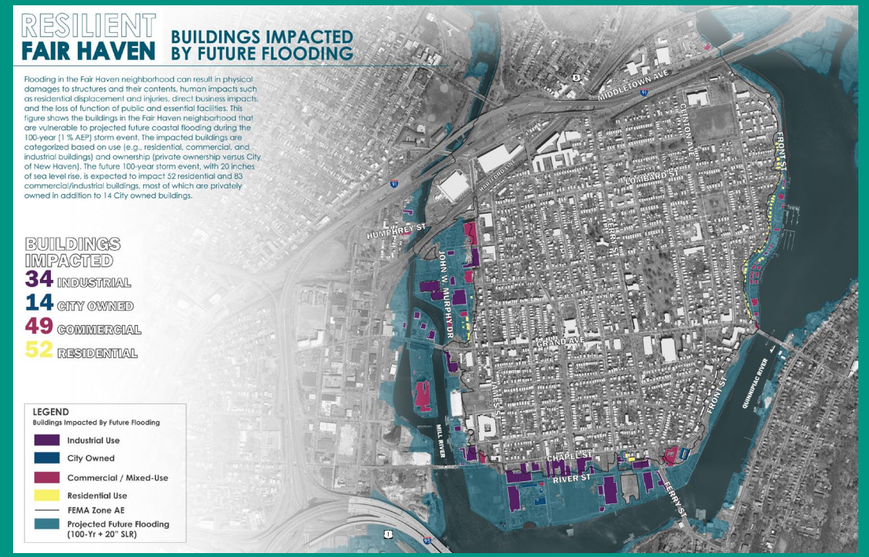
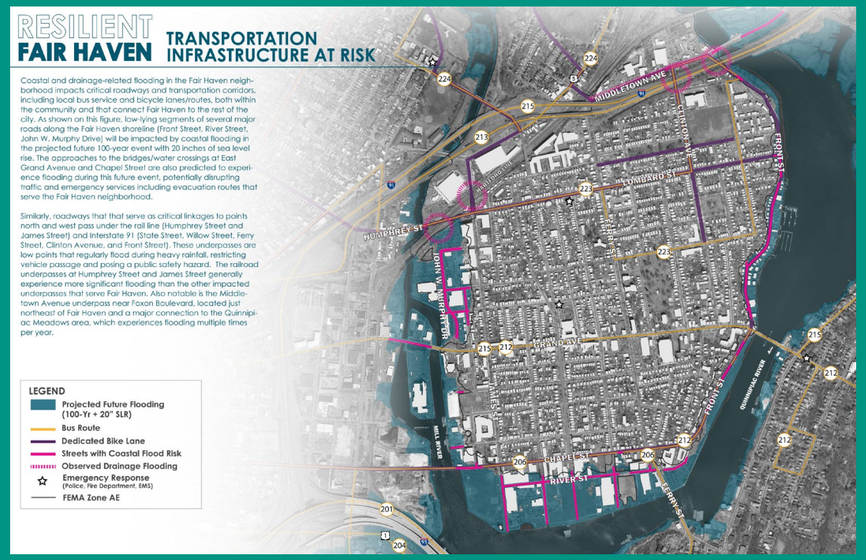


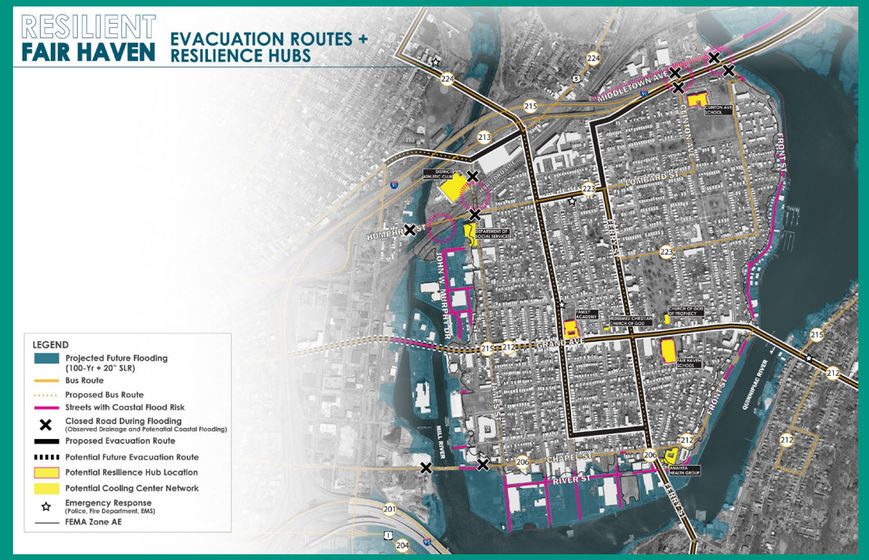
Projected Future Flooding



Buildings impacted by Future Flooding



Transportation Infrastructure at Risk



Evacuation Routes + Resilience Hubs

EXECUTIVE SUMMARY

SPANISH:

What happens next?
This plan is intended to be an actionable roadmap, providing clear next steps that should be taken to implement the identified resilience actions. It builds off ongoing resilience planning within the region and incorporates the voices and needs of all members of the region, including the most vulnerable, to provide innovative and implementable actions that increase long- and short-term resilience and enhance the value and integrity of the ecological, recreational, and economics resources of the region.

Implementation of the recommendations in this plan will require coordination between various City of New Haven departments – City Plan, Economic Development, Engineering, Parks & Public Works, Public Schools – and other organizations including CTDOT, Mill River Trail and Watershed Association, Fair Haven Community Management Team (CMT), and private property owners. Green infrastructure and cooling strategies should be implemented along the proposed cooling/resilience corridors as stand-alone retrofit projects or in conjunction with planned capital improvements such as roadway and streetscape projects as funding allows. The FAME School parking cooling improvements could be pursued independently of the other recommendations and could serve as a pilot for public schools throughout New Haven. The proposed Resilience Hub and evacuation route and road closure system are near term actions ("low-hanging fruit") that should be pursued within the next 3 years. Coordination will be necessary between the City and CTDOT (CT transit), the Connecticut Department of Emergency Management and Homeland Security (DEMHS), and private owners of proposed resilience hub facilities.

SPANISH TRANSLATION

The plan is organized into the following sections:

- Introduction – Provides an overview of the Resilient Fair Haven project, our understanding of the neighborhood and the evolution of the historical shorelines, and a summary of the planning process undertaken to complete this plan
- Current + Future Conditions Analysis – Summarizes key findings of the current and future conditions mapping and analysis which provided the basis of our understanding of current and future risks in the neighborhood
- Adaptation Options + Recommended Actions – Gives and overview of the recommended focus areas within Fair Haven, provided recommendations for evacuation routes and a network of Resilience Hubs and Cooling Centers, shares the adaptation tools explored in this planning process, and shares additional non-structural and heat focused recommendations for the entire peninsula of Fair Haven. This section also provides an overview of the two priority focus areas through concept level designs prepared through this process. The concept designs detail recommended strategies and actions for the John W Murphy Area, FAME Academy, and Clinton Park Area and outlines a roadmap to implement the identified actions including opinions of probably cost and potential funding mechanisms. The release of this plan is an important step in addressing the flood and heat risks this neighborhood faces, but what comes next is even more important.

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RESILIENT FAIR HAVEN

EXECUTIVE SUMMARY

SPANISH:

What can you do?

If you are a resident, business owner, or property owner in the neighborhood:

- Know your risk today and in the future
- Purchase and maintain flood insurance if applicable and prepare when a flood is in the forecast
- Pay attention to summer temperatures and check on vulnerable neighbors like the elderly who may be particularly at-risk during heat events
- Share this plan with your friends, family, and neighbors

If you are a representative of a community-based organization:

- • Carefully review this plan and stay informed about and involved in the implementation process by coordinating with municipal staff
- • Work with municipal staff to identify partnership opportunities that further identify resilience actions for Fair Haven
- Help raise public awareness of flood and heat risks and the Resilient Fair Haven plan through your networks

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JOHN W. MURPHY DRIVE AREA

CLINTON PARK AREA

INTRODUCTION

RESILIENT FAIR HAVEN

CONTEXT + PROJECT GOALS

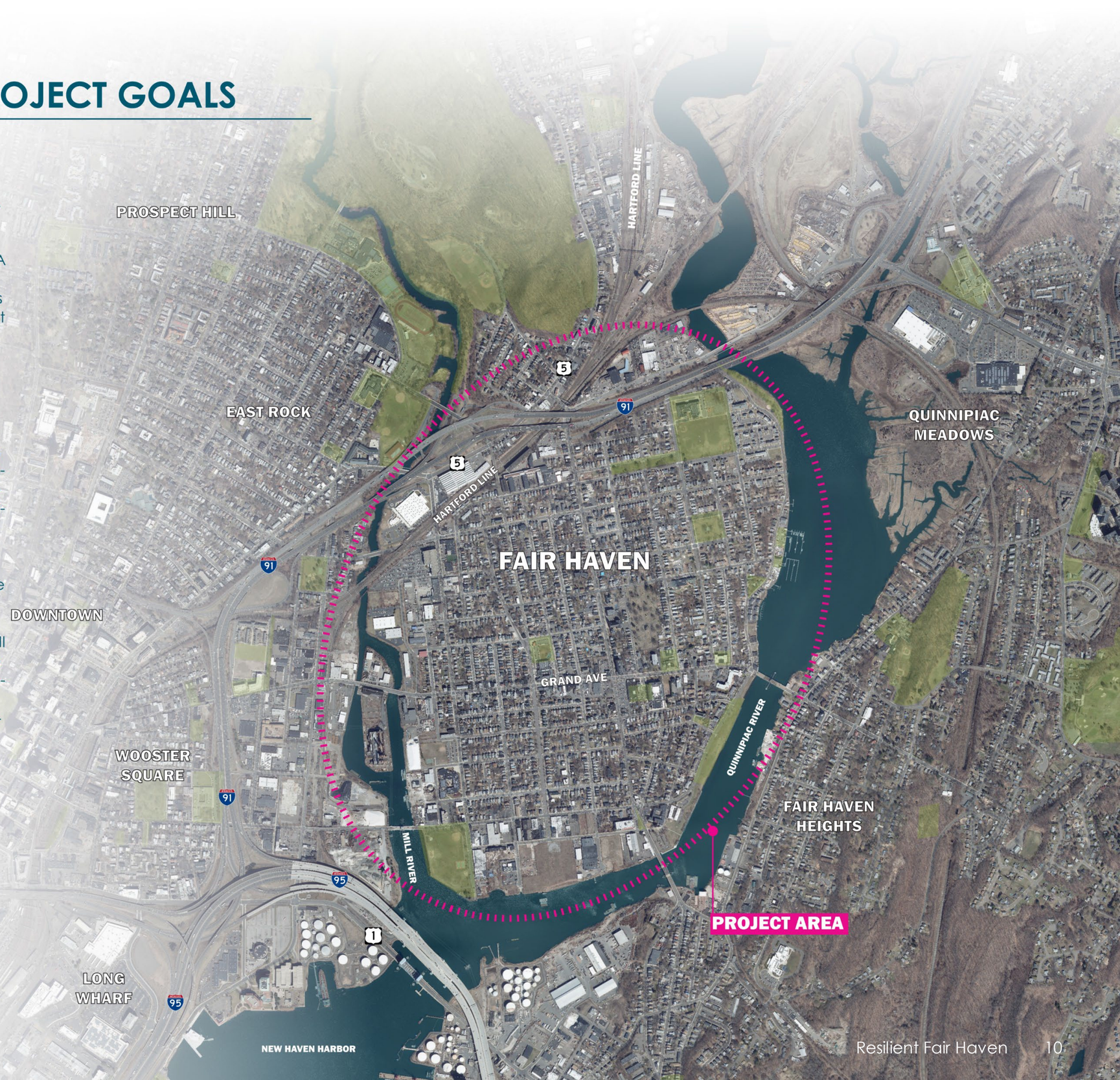
The Fair Haven neighborhood – home to nearly 14,000 residents and numerous businesses within the City of New Haven – is situated on a peninsula bounded by the Mill and Quinnipiac Rivers, which flow into nearby New Haven Harbor. The area is located between the Downtown, Wooster Square, and East Rock neighborhoods to the west and the Fair Haven Heights and Quinnipiac Meadows neighborhoods to the east, as well as near the intersection of Interstates 95 and 91 and major rail lines. A number of critical roads connect the Fair Haven neighborhood to other parts of the city via bridges and underpasses. The neighborhood also has a high percentage of residents that are either essential workers or cannot work from home. Therefore, transportation and transit are critical lifelines for the neighborhood, which includes a large Hispanic population.

Fair Haven is vulnerable to flooding from coastal storm surge, high tides, sea level rise, and heavy rainfall events given its proximity to the tidally influenced Mill and Quinnipiac Rivers and extensive urbanization. Flooding in the Fair Haven neighborhood threatens public safety and impedes access to critical lifelines and evacuation routes during storms. The neighborhood is also vulnerable to extreme heat due to the high social vulnerability within the community, combined with dense housing, high impervious cover, disconnected green spaces, and long distances to potential cooling centers and/or shelters.

This project builds on prior planning and assessment of flood and extreme heat vulnerabilities by the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) for the Fair Haven neighborhood completed as part of Phases I and II of Resilient Connecticut. This project (Phase III of Resilient Connecticut) focuses on developing adaptation strategies to mitigate current and future climate induced flooding impacts to community assets and transportation corridors in Fair Haven, as well as developing strategies to help mitigate the impacts of extreme heat for community residents.

PROJECT GOALS:

1. Develop strategies and implementable project concepts to reduce flood and heat risks
2. Work with stakeholders in Fair Haven to develop strategies and projects
3. Position projects for federal and state funding



RESILIENT FAIR HAVEN

IN CONTEXT WITH THE BIGGER PICTURE

In Fair Haven/New Haven, like elsewhere, resilience is a shared responsibility across multiple levels of government. Decisions around land use and floodplain management are subject to a hierarchy of rules and regulations at various scales of jurisdiction. With resilience layered in at multiple levels of government, this can make for a confusing web to navigate.

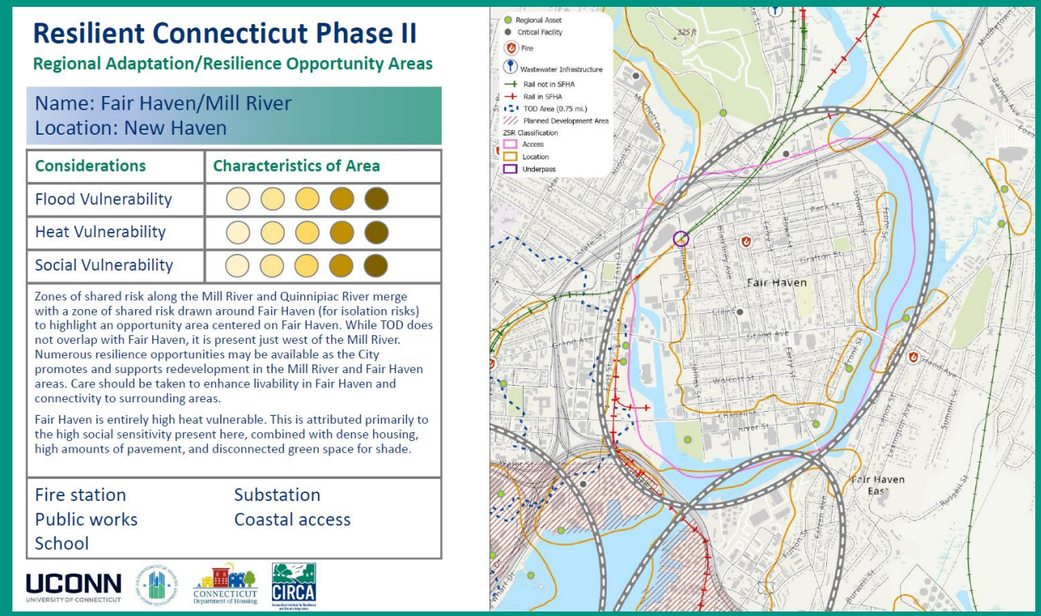
There have been, and continue to be, numerous resilience-related planning initiatives in the New Haven area over the last decade. This project looks to tie into these initiatives and plans where possible to capitalize on the work already performed and expand on the City's goals as well as the benefits that all these initiatives can together provide to the community of Fair Haven.

The graphic to the right shows just a small selection of the municipal and regional resilience initiatives in the New Haven area, including the Resilient Fair Haven project.

LEAD PLANNING ENTITIY:

1 - Save the Sound
2 - South Central Regional Council of Governments
3 - City of New Haven
4 - City of New Haven
5 - City of New Haven
6 - Connecticut Institute for Resilience & Climate Adaptation (CIRCA)
7 - City of New Haven
8 - Quinnipiac River Watershed Association

ONE PIECE OF A LARGER EFFORT



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	○ ○ ○ ● ●

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.

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.

Fire station	Substation
Public works	Coastal access
School	

UCONN UNIVERSITY OF CONNECTICUT · CONNECTICUT Department of Housing · CIRCA

RESILIENT FAIR HAVEN

HISTORICAL CONTEXT + BACKGROUND

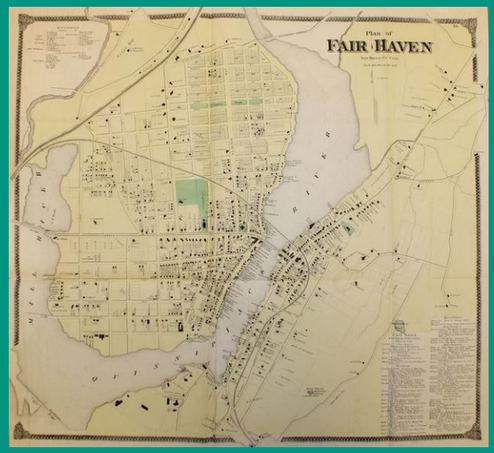
Fair Haven has a unique history shaped by the adjacent rivers and nearby New Haven Harbor. Its development and growth paralleled, yet were independent of, the New Haven Colony. The area was farmed by Native Americans prior to the first European settlements in the 1630s. During the 17th century, Fair Haven was an oystering village as the area was a source of oysters and other products of the rivers and nearby harbor. The oyster industry and related waterfront businesses thrived through the 19th century.

By the mid- to late-1800s, the oyster industry began to decline due to natural predators, a shift in the industry's base to Long Island, and an increase in pollution. During the 1860s following the Civil War, the area east of the Mill River became a street-car suburb inhabited by European immigrants, most notably Irish immigrants. In 1837, Fair Haven withdrew from the jurisdiction of New Haven and then rejoined New Haven in 1870. Following this period, Fair Haven developed rapidly, transforming from an oystering village into a mix of businesses, industry, and residential dwellings and home to many immigrant workers.

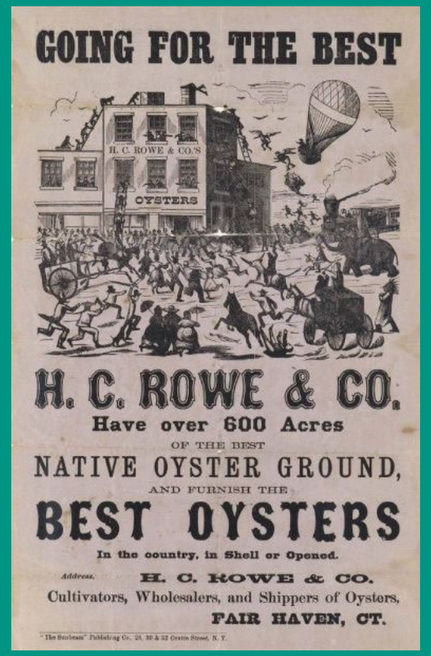
The 20th century brought more industry and the problems of industrialization to the area. Overcrowded living conditions, pollution and crime were among the challenges of this period. Many black and Latinx families migrated into Fair Haven by the 1960s. Fair Haven developed a strong sense of community as families formed a close relationship to the area. The residents of Fair Haven lived, worked, shopped, played, and worshipped close to their home.

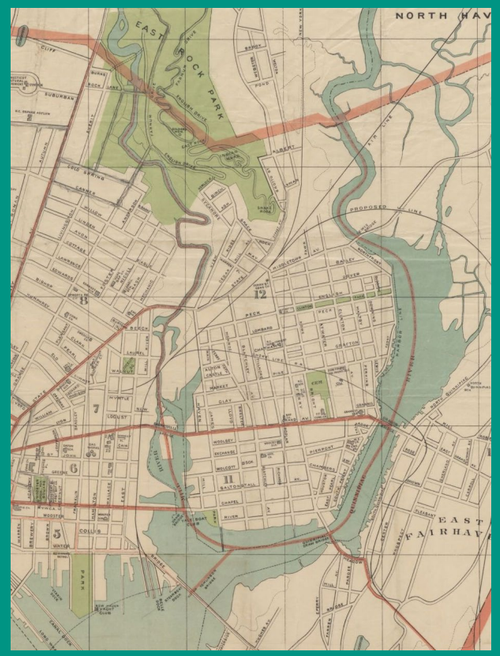
As industry moved out of Fair Haven, the community changed. Deterioration of neighborhoods increased, and people moved away for various reasons. Unlike other areas of New Haven, Fair Haven escaped, to a large degree, the downtown demolition of the 1960s. The area has retained many structures that provide a link to its past. The waterfront area along Front Street has been redeveloped in the past 20 years. Other areas of Fair Haven have been targeted for reinvestment and redevelopment, including the industrial waterfront areas along the Mill River and the Grand Avenue business district.

1898

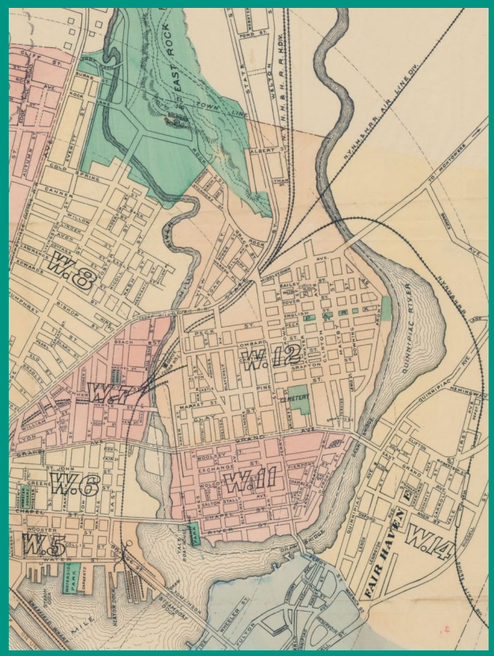


1868





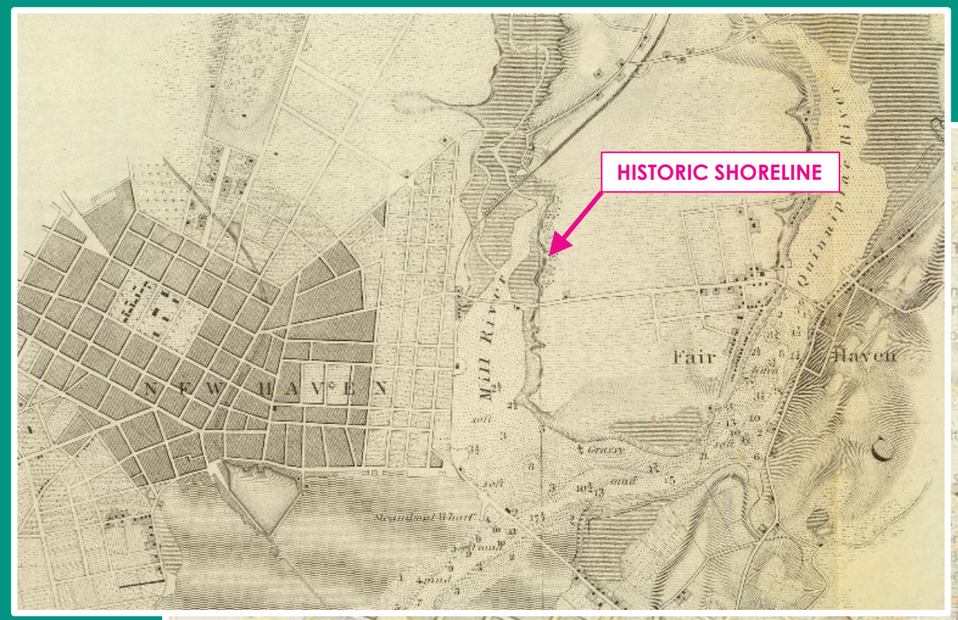
1893



1898

SOURCE: Fair Haven: An Historical and Ecological Field Study, Yale-New Haven Teachers institute, Curriculum Units by Fellows of the Yale-New Haven Teachers Institute, 1979 Volume III: Remarkable City: Industrial New Haven and the Nation, 1800-1900. https://teachersinstitute.yale.edu/curriculum/units/1979/3/79.03.05.x.html

FAIR HAVEN'S CHANGING SHORELINE



1846

The image at left is an early map of the Fair Haven area with the historic shoreline noted with a dark and undulating line. The bottom image shows this same map from 1846 projected onto the current day Fair Haven street map. From this exercise it is revealed how much of Fair Haven's waterfront areas have been built up with fill over the years to accommodate development on the peninsula. The areas which have been filled were previously open water or marsh and correlate closely to areas of present-day flooding and future projected coastal flooding.

FAIR HAVEN PRESENT-DAY FLOODING


Superstorm Sandy, Humphrey St Underpass


December 23, Haven + Clay Street Intersection


December 23, Lloyd Street Street end


December 23, Front Street Backyard Flooding


December 23, Criscuolo Park


December 23, Quinnipiac River Park

FAIR HAVEN SOCIAL VULNERABILITIES

Vulnerability is the propensity or predisposition to be adversely affected. Areas that are more vulnerable to climate change are ones where people, infrastructure, and/or ecological assets are more likely to experience harm as temperatures rise, floods worsen, and high winds increase. Vulnerability is a complex concept and encompasses a variety of elements including physical exposure, sensitivity or susceptibility to harm, and lack of capacity to cope and adapt. Understanding vulnerability helps us to make decisions about resource allocation, policy development, and project prioritization, siting, and design.

Non-English speaking, young, elderly, homeless, or physically disabled people are more likely to need support to prepare, respond to, or recover from a climate events like flooding and heat waves. Minority and elderly populations are also less likely to have equal access to financial and physical resources to do the same.

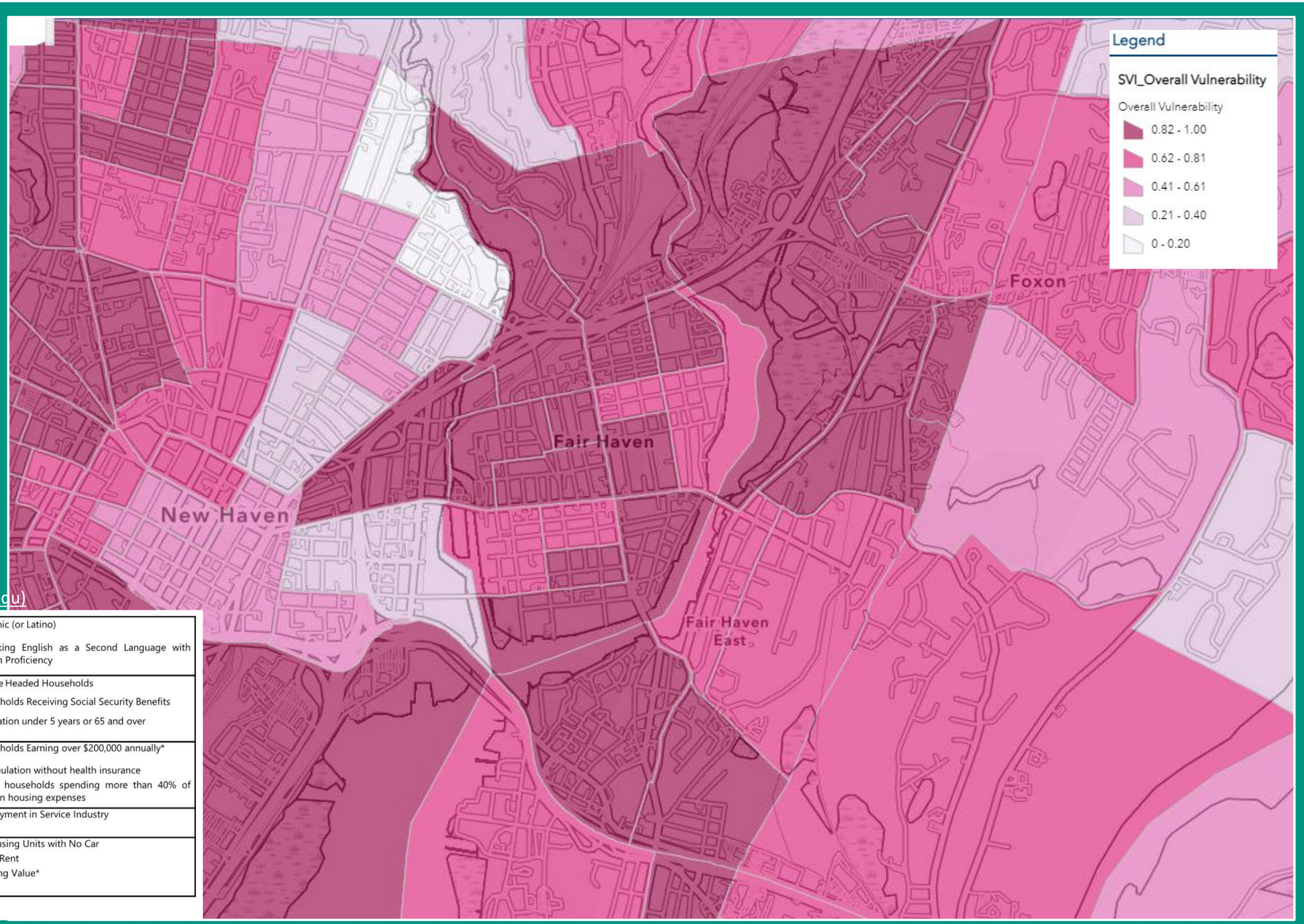
A history of exclusionary policy has inequitably distributed resources so that Black and Latinx communities are disproportionately vulnerable to flooding, high urban heat, air pollution, and proximity to hazardous waste. There are also specific communities such as the elderly and those with disabilities that are at higher risk.

SVI – Contributing Factors:

Link: Climate Change Vulnerability Index | Resilient Connecticut (uconn.edu)

Minority Status and Language	Percent Female Percent Black Percent Native American Percent Asian	Percent Hispanic (or Latino) Percent Speaking English as a Second Language with Limited English Proficiency
Household Composition & Disability	People per Unit Median Age Independent Living Difficulties Percent Children Living in 2-parent families*	Percent Female Headed Households Percent Households Receiving Social Security Benefits Percent Population under 5 years or 65 and over
Socioeconomic Status	Percent Poverty Per Capita Income* Percent Civilian Unemployment Percent with Less than 12th Grade Education	Percent Households Earning over $200,000 annually* Percent of population without health insurance Percent of all households spending more than 40% of their income on housing expenses
Labor Force	Percent Female Participation in Labor Force Percent Employment in Blue Collar Industries	Percent Employment in Service Industry
Housing Type and Transportation	Percent Unoccupied Housing Units Percent Renters Percent Mobile Homes Hospitals Per Capita **	Percent of Housing Units with No Car Median Gross Rent Median Housing Value*

* Indicates a variable where inverse percentile was used for calculations.
** Indicates county level data



Resilient Connecticut developed a Social Vulnerability Index (SVI) to aid in identifying populations that may be more vulnerable to the impacts of climate change.

Link: https://storymaps.arcgis.com/stories/d7066d4217b54cce9bbd68773c05b778

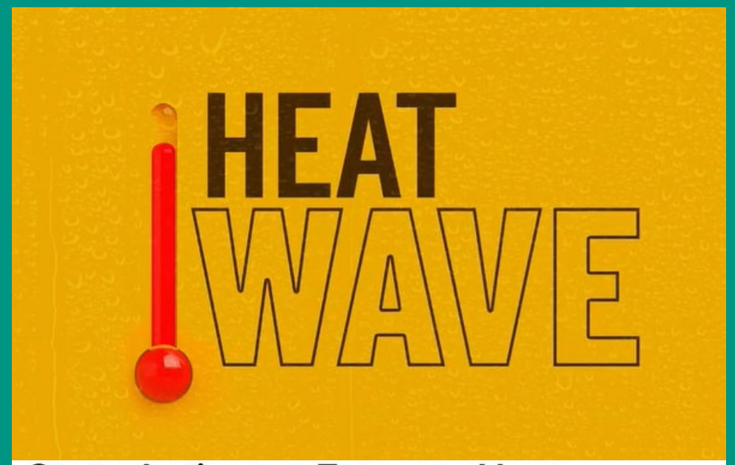
FAIR HAVEN + EXTREME HEAT

PRIMARY IMPACTS

Primary impacts from extreme heat include heat-related health effects such as heat stroke, dehydration, and dizziness. In extreme cases, these can lead to death. Primary impacts are often harder to attribute to an extreme heat event because they effect people who are already vulnerable, such as children, the elderly, and those with pre-existing medical conditions. One way to determine the overall primary impact of extreme heat is to compare hospital statistics for heat-related illnesses or deaths to standard averages. This can be done to overcome the issue of extreme heat not being recognized as the underlying cause because other ailments were also present (and exasperated by the heat).

SECONDARY IMPACTS

Secondary impacts from extreme heat are the potential delay of outside work, such as construction, during intense episodes. Even If work is not halted completely, safe working conditions would require an increase in breaks and time out of the heat. This would slow overall work. Additionally, higher temperatures increase electricity consumption due to air conditioning usage, leading to power outages. This would impact homes, businesses, and general operations throughout Fair Haven. If the power outage is extensive or occurs for a long period of time, a positive feedback loop can start. With the power out, air conditioning becomes unavailable for most. The lack of air conditioning makes people more vulnerable to the extreme heat, leading to even more heat-related health issues.



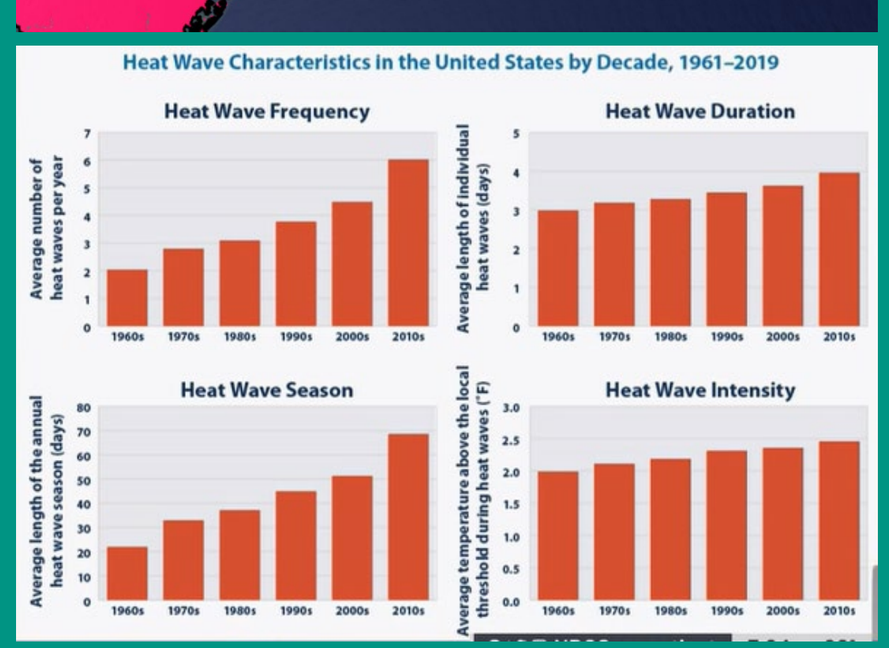
State Activates Extreme Heat Protocol, New Haven Cooling Centers Open

Cooling centers include city senior centers and all branches of the New Haven Free Public Library. Splash pads are another way to cool off.

Ellyn Santiago, Patch Staff

Posted Tue, Jul 19, 2022 at 11:23 am ET

Reply

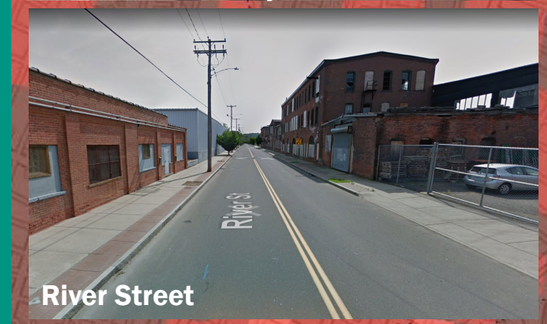


FAIR HAVEN + EXTREME HEAT

The social impact is also evident. As the mercury rises, children can't concentrate in school, pregnant women are at greater risk of miscarriage, and the elderly and people with a variety of existing health conditions are prone to develop heatstroke owing to their decreased capacity to adapt to changes in body temperature. When thermometers hit 100°F (37.78°C), the risk of injuries increases by 15% for manufacturing plant and warehouse workers*. Heat disproportionately affects the most vulnerable people, and this problem is exacerbated in densely populated urban areas.

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.

**UCLA Luskin School of Public Affairs*



CIRCA Climate Change Vulnerability Index (CCVI) Heat Vulnerability Map

Heat Contributors

Sensitivity

Social			Built
Asthma Related Emergency Visits Median Income Older than 5 with a Disability Percent below Poverty Level Average no. Per Household	Lack of Vehicle Percent Population over 65 Percent Population under 5 Speaks English less than well/not at all Percent Population	Unemployed Population Density Race and Ethnicity Percent Population over 25 without a HS Diploma	Building Density Median Structure Age Private Wells

Exposure		Adaptive Capacity		
Climate	Physical	Social	Built	Eco.
Air Quality (PM 2.5) Maximum Surface Temperatures	Impervious Surfaces Emissivity	Percent population with Health Insurance High Owner-Occupied Housing	Distance to Hospitals Distance to Shelters	Normalized Difference Vegetation Index (NDVI) Percent Mixed Forest Cover Albedo

CIRCA Climate Change Vulnerability Index – Contributing Factors

Link: https://resilientconnecticut.uconn.edu/ccvi/

RESILIENT FAIR HAVEN

PLANNING APPROACH

The planning process began in September 2022 with a project kick-off meeting where project stakeholders from CIRCA, the City of New Haven, and the project consultant team met to discuss the phased approach being implemented to develop the plan (see right), and ways to get critical community stakeholder involved in the planning process.

PHASE 1: CURRENT + FUTURE CONDITIONS ANALYSIS
During the first phase of the project, the project team completed an existing and future conditions analysis that consisted of:

- Review of previous plans for the neighborhood, City, and region
- Compiling mapping data and information from past studies on the existing conditions of the Fair Haven neighborhood
- Review coastal flood and storm surge analyses conducted by CIRCA
- Review of drainage system schematics and CIRCA provided flood elevations for critical intersections and underpasses
- Application of future projections of sea level to the existing conditions to analyze which areas will be subject to increasing frequencies of flooding by 2050
- Evaluate extreme heat risks throughout Fair Haven

PHASE 2: ADAPTATION OPTIONS + CONCEPT DESIGN
The second phase of the project built upon Phase I identify priority locations and problem areas to inform the development of strategies. With the support of the Citizen + Technical Advisory Committee, the project team narrowed in on two priority focus areas (the John W Murphy Drive Area and the Clinton Park Area) to develop realistic and implementable alternatives that are supported by stakeholders.

Adaptation options considered include but are not limited to: potential road elevations for dry egress, segments of flood protection systems, site-scale flood protection or accommodation strategies for critical community lifelines, green infrastructure for stormwater management, increasing tree canopy, reducing impervious cover for heat and flood mitigation, building retrofits for heat mitigation, developing community resilience hubs, and others and do consider the Resilient Connecticut PERSISTS decision support criteria.

PHASE 3: BENEFIT/COST ANALYSIS
During this phase, the project team developed itemized opinions of probable cost for proposed project concepts in the two priority focus areas that were used to develop benefit/cost analysis. An initial calculation of costs and benefits were prepared for the preferred project concepts and strategies and aligned the methodology applied potential funding sources such as FEMA FMA and BRIC.

PHASE 4: FINAL PLAN
Following the first two phases, the project team developed this final report to summarize the planning process and outcomes from the engagement process. The final report also provides information on next steps for preferred actions connected to timelines and funding sources which should be included.

RESILIENT FAIR HAVEN

COMMUNITY ENGAGEMENT

Community engagement was an essential part of the planning process as the residents and community stakeholders are the foremost experts on their community. The project team actively sought community feedback during the planning process, working to identify, reach out to, and incorporate feedback from diverse groups of people throughout the community.

With help from CIRCA and New Haven City staff, a Citizen + Technical Advisory Committee was also formed towards the start of the project to help guide the development of the plan. The committee was comprised of community members Board of Alders representatives, and local organizations. Members included:

Xochitl Garcia	Project Community Liaison
Claudia Herrera	Board of Alders (9-D)
Sarah Miller	Board of Alders (14-D)
Chris Ozyck	Urban Resources Initiative
Dominic Seraphin	Fair Haven Community Clinic
Janine Davey	Grand Avenue Special Services District
Nicole Davis	Save the Sound
Melissa Pappas	Save the Sound
Lys Gant	Save the Sound
J.R. Logan	Mill River Trail
Laura Bozzi	Yale School of Public Health Center on Climate Change and Health

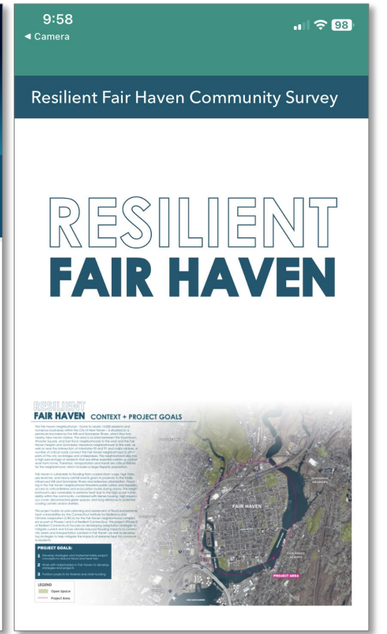
Throughout the planning process, the support of the Citizen + Technical Advisory Committee has been critical for the project team in collecting valuable community feedback. In coordination with the Committee and our Community Liaison, Xochitl Garcia, the project team reached out to potential partner organizations to ensure the engagement effectively reached and spoke to a broader audience. Flyers (see right) and other notices were also used throughout the project to make community members aware of the plan and related activities (e.g., flood risk mapping, community surveys, etc.).

The project team set up a table at several community events throughout the duration of the project, including festivals and other events that brought out large numbers of community members. At these events, the project team spoke with community members about their experiences with flooding and heat in Fair Haven, shared project information, and led activities with community youth to help them understand critical issues like flooding and water quality.

Events attended included:
Fair Haven Day
Quinnipiac Riverfest
Junta for Progressive Action Back to School Event

CIRCA maintains a project website with information accessible by the public and includes links to the community survey that anyone can access to share their feedback on the deliverables, flooding concerns, or any other concerns or questions they may have.

CIRCA Project Website



Community Survey

Project team at Community Events

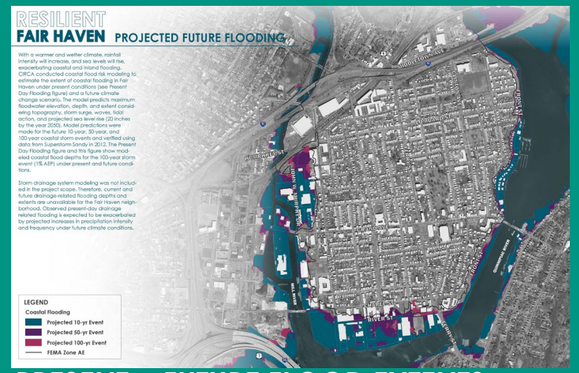
Project Flyers were produced in both English and Spanish to reach a broader audience

CURRENT + FUTURE CONDITIONS ANALYSIS

RESILIENT FAIR HAVEN

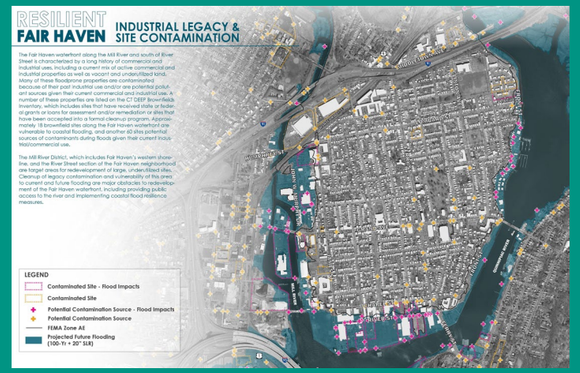
UNDERSTANDING THE RISKS

DEFINING THE RISKS



PRESENT + FUTURE FLOOD EXTENTS

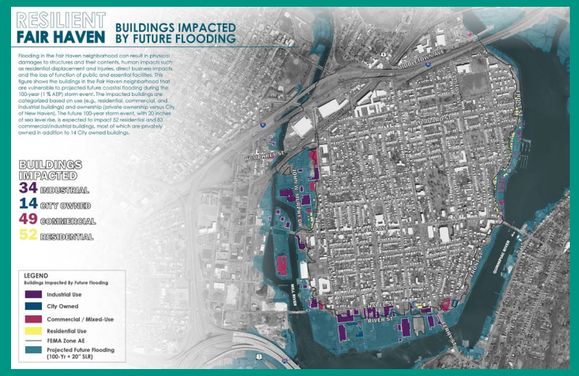
PRESENT + FUTURE FLOOD DEPTHS



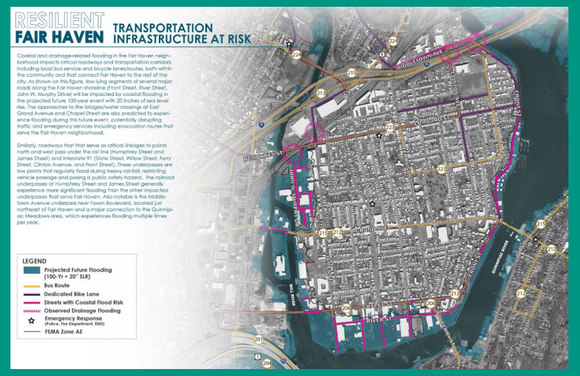
INDUSTRIAL LEGACY + CONTAMINATION

EXTREME HEAT VULNERABILITIES

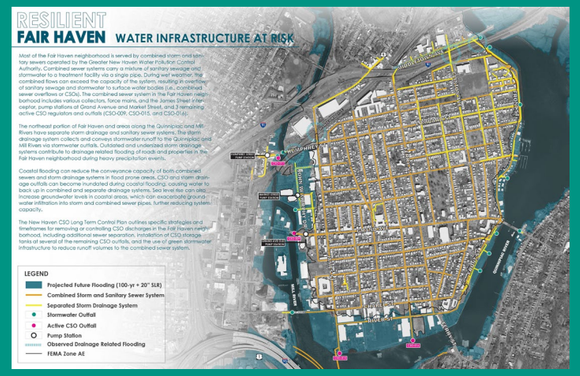
WHAT'S AT RISK?



BUILDINGS IMPACTED BY FLOODING



TRANSPORTATION INFRASTRUCTURE



WATER INFRASTRUCTURE

CRITICAL COMMUNITY ASSETS

DEFINING THE RISKS

RESILIENT FAIR HAVEN

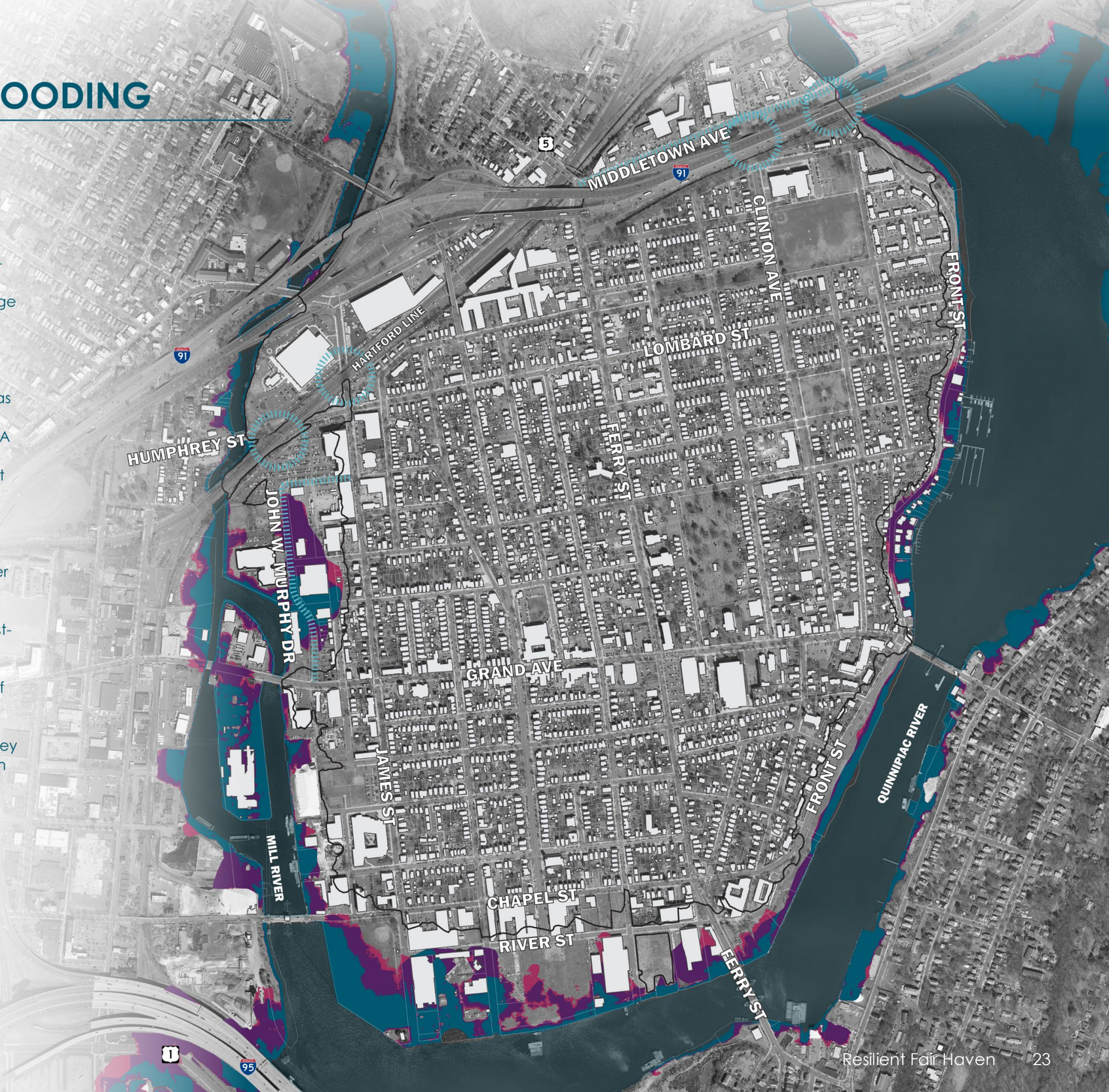
PRESENT DAY FLOODING

The Fair Haven neighborhood is vulnerable to coastal and drainage-related flooding. Coastal flooding is caused by storm surge, high tides, sea level rise, and heavy rainfall as water from the tidally influenced Mill and Quinnipiac Rivers inundates low-lying portions of the Fair Haven shoreline. Flooding and wave action from coastal storms can cause shoreline erosion and related damage to the Fair Haven waterfront, and floodwaters can inundate land along much of the shoreline, resulting in damage to infrastructure and buildings in low-lying areas. Drainage-related flooding occurs when stormwater runoff from heavy precipitation exceeds the capacity of the existing drainage system or combined storm and sanitary sewers due to the imperviousness of the landscape, topography, drainage problems, and tidal influence.

This figure shows the modeled extent of present day coastal flooding in the Fair Haven neighborhood for storm events with various recurrence intervals as described in terms of annual exceedance probability (AEP), which is the probability of a storm event being equaled or exceeded in any given year. A storm event with a 10% AEP is often referred to as the 10-year storm event. Similarly, the 50-year storm event has a 2% AEP and the 100-year storm event has a 1% AEP.

Coastal flooding occurs on the western shore of the Quinnipiac River along Front Street and Quinnipiac River Park, as well as portions of the Fair Haven waterfront and commercial/industrial district along River Street and the lower Mill River from Criscuolo Park north to Grand Avenue and Humphrey Street. Most of Ball Island, situated within the lower Mill River and crossed by Grand Avenue, and the western shore of the lower Mill River are also prone to coastal flooding.

Observed areas of drainage related flooding, as documented by the City of New Haven, are also shown on the figure. Areas of regular drainage-related flooding in Fair Haven during larger storms and even smaller, high-intensity rainfall events include Middletown Avenue, railroad underpasses at Humphrey Street, James Street, Clinton Avenue, and Front Street, and areas along John W. Murphy Drive.



LEGEND

Coastal Flooding

- Present 10-yr Event
- Present 50-yr Event
- Present 100-yr Event

Drainage Related Flooding

- Observed Drainage Flooding
- FEMA Zone AE

RESILIENT FAIR HAVEN

PRESENT DAY 100-YEAR COASTAL FLOODING DEPTHS

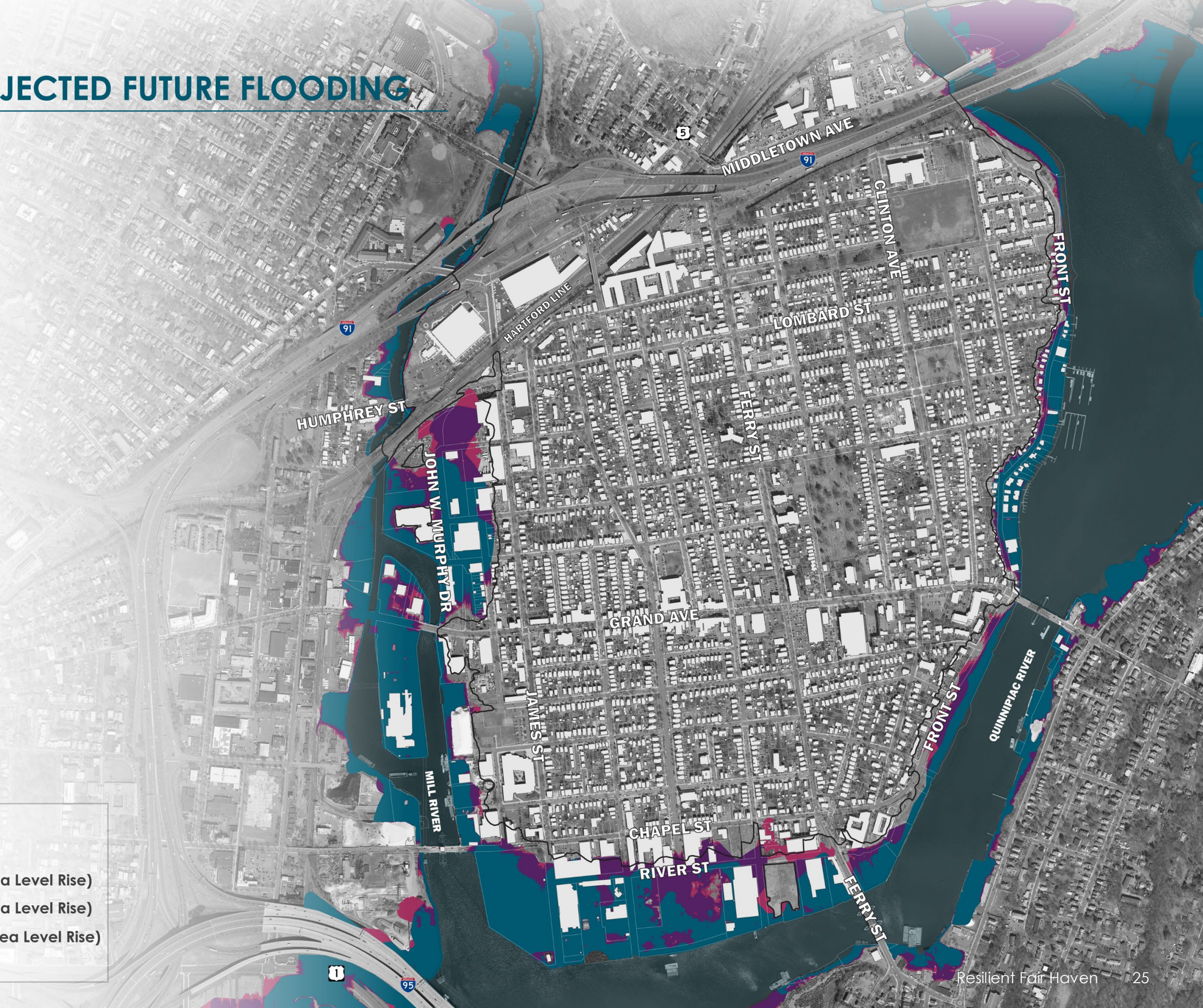
Present day coastal flooding depths for the 100-year storm event (1% AEP) generally range from less than 1 foot up to 3 feet for most of the impacted areas along the Fair Haven shoreline. Locations with greater flood depths (3-5 feet) exist in a few isolated areas.

RESILIENT FAIR HAVEN

PROJECTED FUTURE FLOODING

With a warmer and wetter climate, rainfall intensity will increase, and sea levels will rise, exacerbating coastal and inland flooding. CIRCA conducted coastal flood risk modeling to estimate the extent of coastal flooding in Fair Haven under present conditions (see Present Day Flooding figure) and a future climate change scenario. The model predicts maximum floodwater elevation, depth, and extent considering topography, storm surge, waves, tidal action, and projected sea level rise (20 inches by the year 2050). Model predictions were made for the future 10-year, 50-year, and 100-year coastal storm events and verified using data from Superstorm Sandy in 2012. The Present Day Flooding figure and this figure show modeled coastal flood depths for the 100-year storm event (1% AEP) under present and future conditions.

Storm drainage system modeling was not included in the project scope. Therefore, current and future drainage-related flooding depths and extents are unavailable for the Fair Haven neighborhood. Observed present-day drainage related flooding is expected to be exacerbated by projected increases in precipitation intensity and frequency under future climate conditions.



LEGEND

Coastal Flooding

- Projected 10-yr Event (w/ 20” of Sea Level Rise)
- Projected 50-yr Event (w/ 20” of Sea Level Rise)
- Projected 100-yr Event (w/ 20” of Sea Level Rise)
- FEMA Zone AE

RESILIENT FAIR HAVEN

PROJECTED FUTURE 100-YEAR COASTAL FLOODING DEPTHS

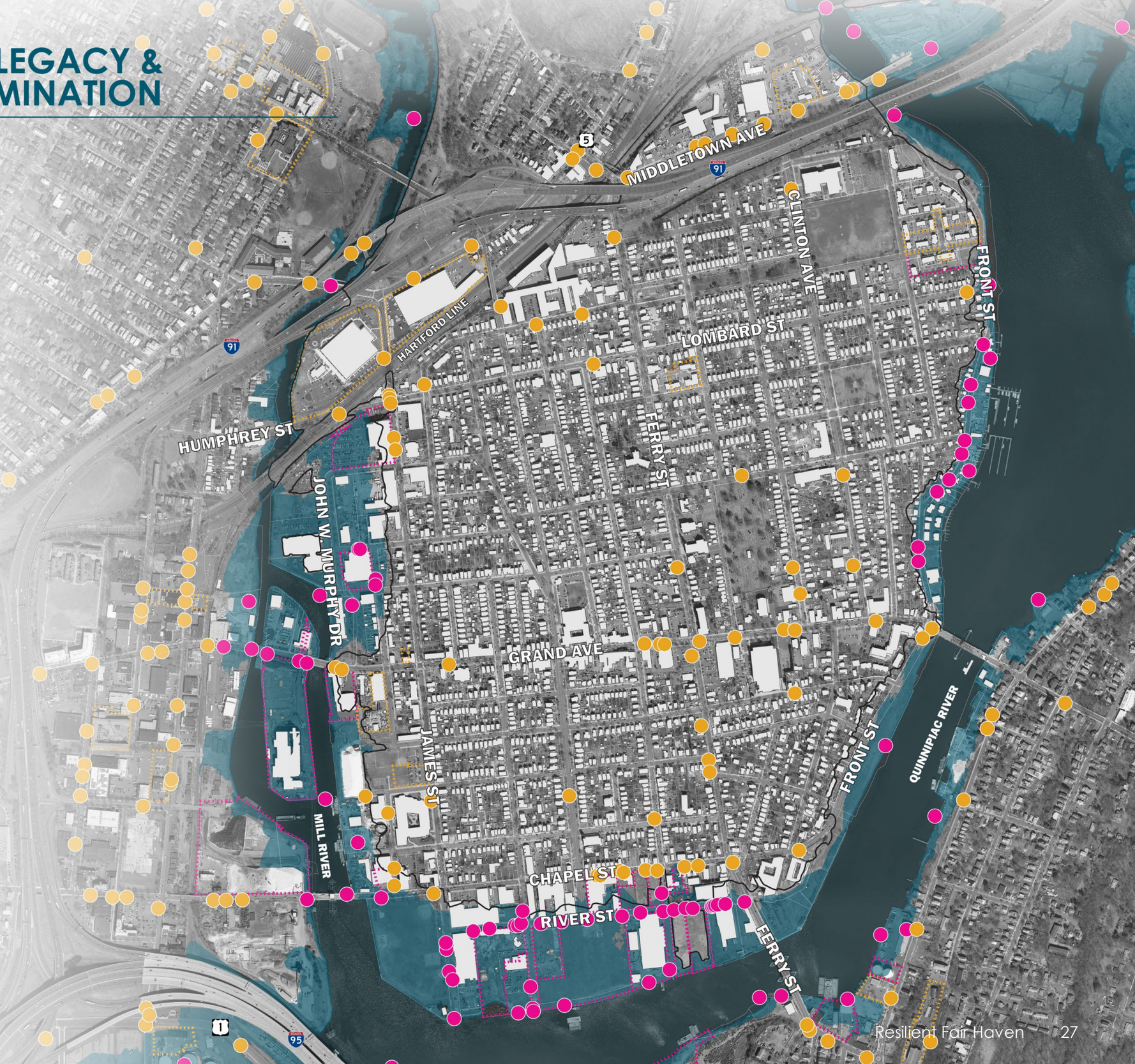
In the projected future 100-year storm event, the extent of flooding along the Fair Haven shoreline is significantly expanded compared to the present day 100-year event, encompassing most of the waterfront parcels and additional portions of critical roadways and transportation corridors linking Fair Haven to other parts of the city. The greatest increases in the extent of coastal flooding and areas with flood depths of 3-5 feet are predicted for the commercial/industrial waterfront south of Chapel Street and along the Mill River.

RESILIENT FAIR HAVEN

INDUSTRIAL LEGACY & SITE CONTAMINATION

The Fair Haven waterfront along the Mill River and south of River Street is characterized by a long history of commercial and industrial uses, including a current mix of active commercial and industrial properties as well as vacant and underutilized land. Many of these floodprone properties are contaminated because of their past industrial use and/or are potential pollutant sources given their current commercial and industrial use. A number of these properties are listed on the CT DEEP Brownfields Inventory, which includes sites that have received state or federal grants or loans for assessment and/or remediation or sites that have been accepted into a formal cleanup program. Approximately 18 brownfield sites along the Fair Haven waterfront are vulnerable to coastal flooding, and another 60 sites potential sources of contaminants during floods given their current industrial/commercial use.

The Mill River District, which includes Fair Haven's western shoreline, and the River Street section of the Fair Haven neighborhood are target areas for redevelopment of large, underutilized sites. Cleanup of legacy contamination and vulnerability of this area to current and future flooding are major obstacles to redevelopment of the Fair Haven waterfront, including providing public access to the river and implementing coastal flood resilience measures.



LEGEND

- Contaminated Site - Flood Impacts
- Contaminated Site
- Potential Contamination Source - Flood Impacts
- Potential Contamination Source
- FEMA Zone AE
- Projected Future Flooding (100-Yr + 20" SLR)

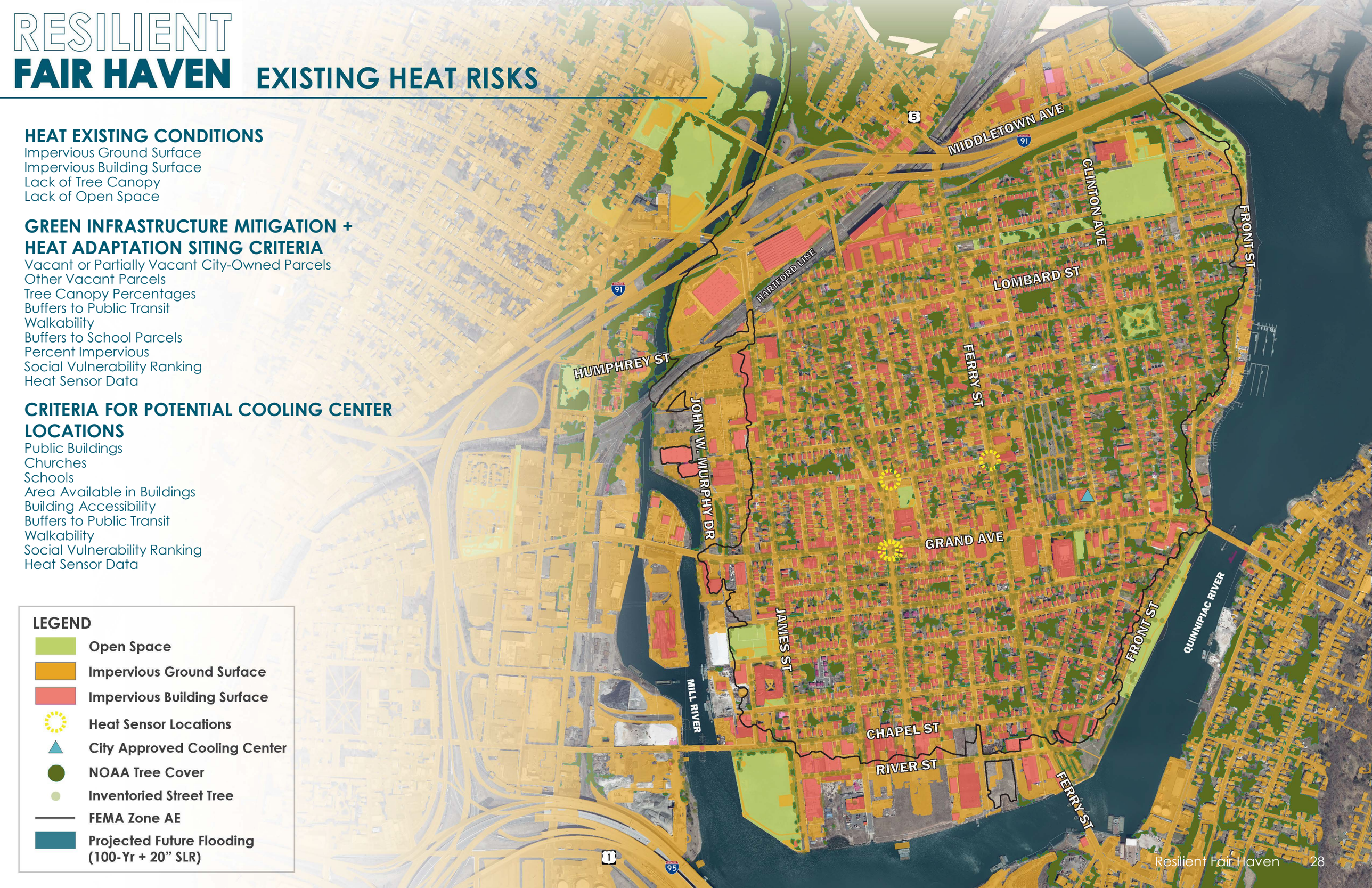
RESILIENT FAIR HAVEN

EXISTING HEAT RISKS

HEAT EXISTING CONDITIONS
Impervious Ground Surface
Impervious Building Surface
Lack of Tree Canopy
Lack of Open Space

GREEN INFRASTRUCTURE MITIGATION + HEAT ADAPTATION SITING CRITERIA
Vacant or Partially Vacant City-Owned Parcels
Other Vacant Parcels
Tree Canopy Percentages
Buffers to Public Transit
Walkability
Buffers to School Parcels
Percent Impervious
Social Vulnerability Ranking
Heat Sensor Data

CRITERIA FOR POTENTIAL COOLING CENTER LOCATIONS
Public Buildings
Churches
Schools
Area Available in Buildings
Building Accessibility
Buffers to Public Transit
Walkability
Social Vulnerability Ranking
Heat Sensor Data



LEGEND

- Open Space
- Impervious Ground Surface
- Impervious Building Surface
- Heat Sensor Locations
- City Approved Cooling Center
- NOAA Tree Cover
- Inventoried Street Tree
- FEMA Zone AE
- Projected Future Flooding (100-Yr + 20" SLR)

WHAT'S AT RISK?

RESILIENT FAIR HAVEN

BUILDINGS IMPACTED BY FUTURE FLOODING

Flooding in the Fair Haven neighborhood can result in physical damages to structures and their contents, human impacts such as residential displacement and injuries, direct business impacts, and the loss of function of public and essential facilities. This figure shows the buildings in the Fair Haven neighborhood that are vulnerable to projected future coastal flooding during the 100-year (1 % AEP) storm event. The impacted buildings are categorized based on use (e.g., residential, commercial, and industrial buildings) and ownership (private ownership versus City of New Haven). The future 100-year storm event, with 20 inches of sea level rise, is expected to impact 52 residential and 83 commercial/industrial buildings, most of which are privately owned in addition to 14 City owned buildings.

BUILDINGS IMPACTED

34 INDUSTRIAL

14 CITY OWNED

49 COMMERCIAL

52 RESIDENTIAL

LEGEND

Buildings Impacted By Future Flooding

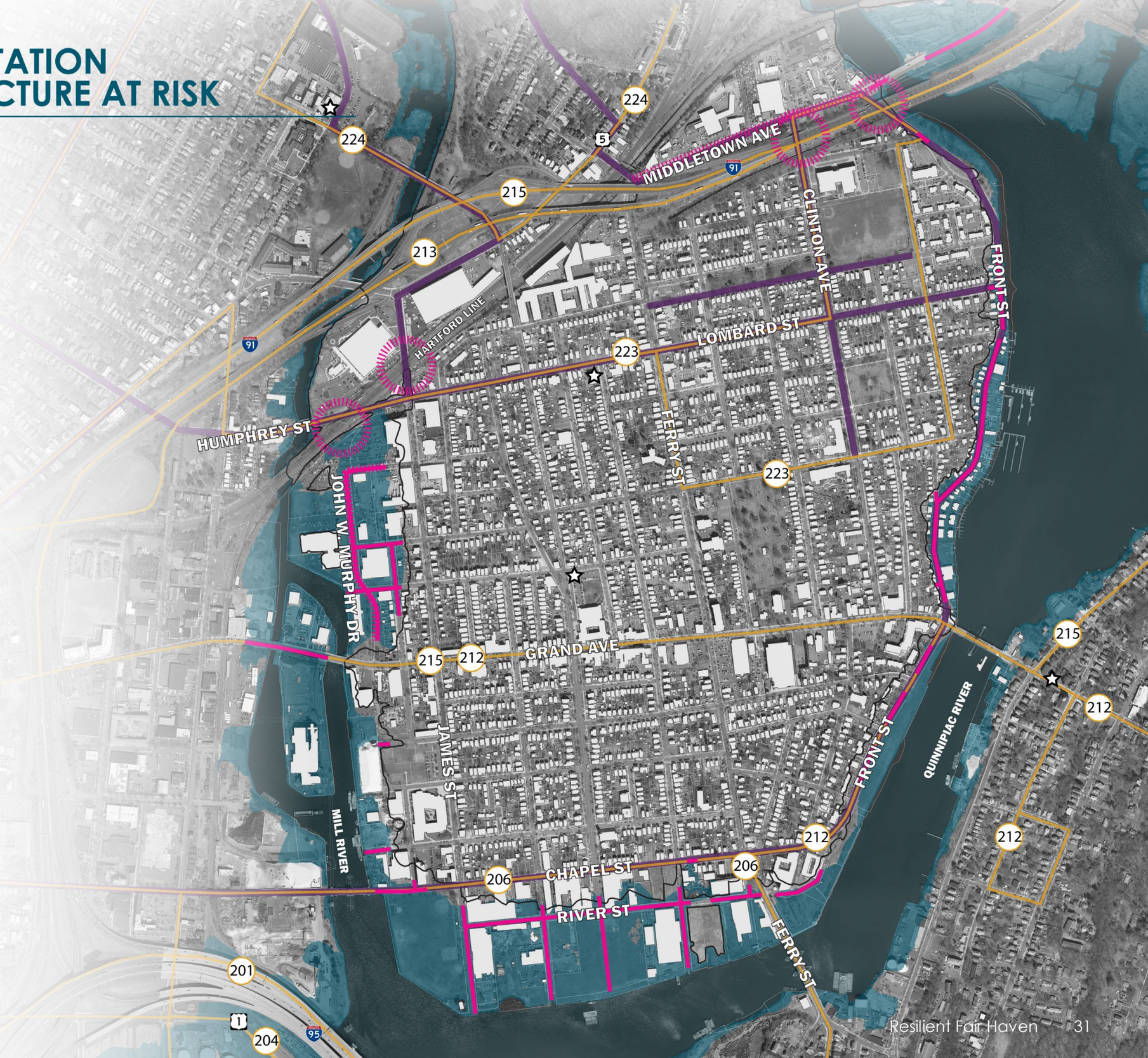
- Industrial Use
- City Owned
- Commercial / Mixed-Use
- Residential Use
- FEMA Zone AE
- Projected Future Flooding (100-Yr + 20" SLR)

RESILIENT FAIR HAVEN

TRANSPORTATION INFRASTRUCTURE AT RISK

Coastal and drainage-related flooding in the Fair Haven neighborhood impacts critical roadways and transportation corridors, including local bus service and bicycle lanes/routes, both within the community and that connect Fair Haven to the rest of the city. As shown on this figure, low-lying segments of several major roads along the Fair Haven shoreline (Front Street, River Street, John W. Murphy Drive) will be impacted by coastal flooding in the projected future 100-year event with 20 inches of sea level rise. The approaches to the bridges/water crossings at East Grand Avenue and Chapel Street are also predicted to experience flooding during this future event, potentially disrupting traffic and emergency services including evacuation routes that serve the Fair Haven neighborhood.

Similarly, roadways that that serve as critical linkages to points north and west pass under the rail line (Humphrey Street and James Street) and Interstate 91 (State Street, Willow Street, Ferry Street, Clinton Avenue, and Front Street). These underpasses are low points that regularly flood during heavy rainfall, restricting vehicle passage and posing a public safety hazard. The railroad underpasses at Humphrey Street and James Street generally experience more significant flooding than the other impacted underpasses that serve Fair Haven. Also notable is the Middletown Avenue underpass near Foxon Boulevard, located just northeast of Fair Haven and a major connection to the Quinnipiac Meadows area, which experiences flooding multiple times per year.



LEGEND

- Projected Future Flooding (100-Yr + 20" SLR)
- Bus Route
- Dedicated Bike Lane
- Streets with Coastal Flood Risk
- Observed Drainage Flooding
- Emergency Response (Police, Fire Department, EMS)
- FEMA Zone AE

RESILIENT FAIR HAVEN

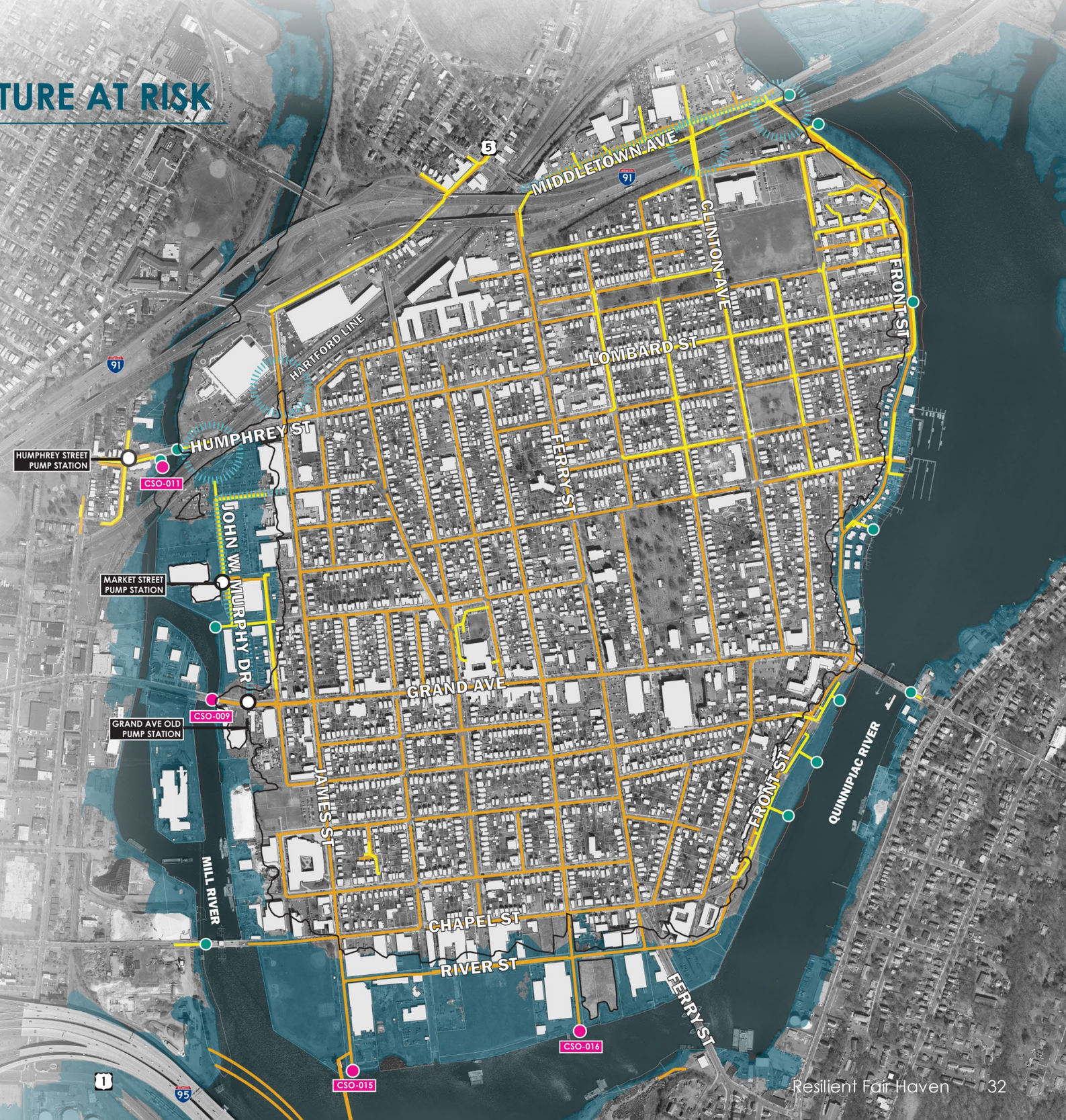
WATER INFRASTRUCTURE AT RISK

Most of the Fair Haven neighborhood is served by combined storm and sanitary sewers operated by the Greater New Haven Water Pollution Control Authority. Combined sewer systems carry a mixture of sanitary sewage and stormwater to a treatment facility via a single pipe. During wet weather, the combined flows can exceed the capacity of the system, resulting in overflow of sanitary sewage and stormwater to surface water bodies (i.e., combined sewer overflows or CSOs). The combined sewer system in the Fair Haven neighborhood includes various collectors, force mains, and the James Street interceptor, pump stations at Grand Avenue and Market Street, and 3 remaining active CSO regulators and outfalls (CSO-009, CSO-015, and CSO-016).

The northeast portion of Fair Haven and areas along the Quinnipiac and Mill Rivers have separate storm drainage and sanitary sewer systems. The storm drainage system collects and conveys stormwater runoff to the Quinnipiac and Mill Rivers via stormwater outfalls. Outdated and undersized storm drainage systems contribute to drainage related flooding of roads and properties in the Fair Haven neighborhood during heavy precipitation events.

Coastal flooding can reduce the conveyance capacity of both combined sewers and storm drainage systems in flood prone areas. CSO and storm drainage outfalls can become inundated during coastal flooding, causing water to back up in combined and separate drainage systems. Sea level rise can also increase groundwater levels in coastal areas, which can exacerbate groundwater infiltration into storm and combined sewer pipes, further reducing system capacity.

The New Haven CSO Long Term Control Plan outlines specific strategies and timeframes for removing or controlling CSO discharges in the Fair Haven neighborhood, including additional sewer separation, installation of CSO storage tanks at several of the remaining CSO outfalls, and the use of green stormwater infrastructure to reduce runoff volumes to the combined sewer system.



LEGEND

- Projected Future Flooding (100-yr + 20" SLR)
- Combined Storm and Sanitary Sewer System
- Separated Storm Drainage System
- Stormwater Outfall
- Active CSO Outfall
- Pump Station
- Observed Drainage Related Flooding
- FEMA Zone AE

RESILIENT FAIR HAVEN

CRITICAL COMMUNITY ASSETS

Fair Haven is home to diverse neighborhoods with a rich cultural heritage (Hispanic) and strong community cohesion. There are a number of critical community assets in Fair Haven that serve the local residents and businesses. In addition to infrastructure such as roads, bridges, and utilities, critical community assets are those that are most essential for a community to thrive (i.e., provide community cohesion, character, and quality of life) including schools, childcare centers, public housing, health care facilities, senior centers, libraries, emergency response services, and other governmental services. These critical community assets are also particularly important given the area's high social vulnerability. This figure shows the critical community assets within and immediately surrounding Fair Haven.

Several national and local historic districts are located within Fair Haven, reflecting the area's maritime and industrial past and emphasis on historic preservation. The Quinnipiac River and Quinnipiac Avenue Historic Districts are located in the southeastern portion of Fair Haven, while the River Street Historic District is located just east of the Mill River. Remaining examples of historically significant architecture and structures exist in these areas, some of which are vulnerable to coastal flooding.

Library / Post Office

- 01 FAIR HAVEN BRANCH LIBRARY
- 02 UNITED STATES POSTAL SERVICE

Emergency Response

- 01 NEW HAVEN POLICE DEPARTMENT
- 02 NEW HAVEN FIRE DEPARTMENT ENGINE 17
- 03 NEW HAVEN FIRE DEPARTMENT ENGINE 10/TRUCK 3
- 04 YALE NEW HAVEN HOSPITAL CENTER FOR EMS

Senior Center

- 01 ATWATER SENIOR CENTER
- 02 MARY WADE HOME

Healthcare Facility

- 01 COCENTRA URGENT CARE + DEPT. OF SOCIAL SERVICES CT
- 02 NEW HAVEN PHARMACY
- 03 PIONEER REHAB DBA + PHYSICAL THERAPY
- 04 FAIR HAVEN COMMUNITY HEALTHCARE
- 05 NEW HAVEN MEDICAL CENTER

School

- 01 FARNAM NEIGHBORHOOD HOUSE + NURSERY SCHOOL
- 02 ELM CITY COLLEGE PREPARATORY ELEMENTARY SCHOOL
- 03 FAMILY ACADEMY
- 04 LITTLE ESTRELLITAS LICENSED FAMILY HOME DAYCARE
- 05 JOHN S. MARTINEZ SCHOOL
- 06 COLD SPRING SCHOOL
- 07 FAIR HAVEN SCHOOL
- 08 TITI TANIA'S DAYCARE
- 09 AUNTIE ROSE CHILDCARE DEVELOPMENT CENTER
- 10 ALL SAINTS CATHOLIC ACADEMY
- 11 LITTLE SKY FAMILY CHILDCARE
- 12 TIA HILDA'S DAYCARE LLC
- 13 CLINTON AVENUE SCHOOL
- 14 BOSS BABY LEARNING + DAY CARE

Religious Center

- 01 STRAIGHTWAY CHURCH
- 02 GLESIA SALVACION Y VIDA ETERNA
- 03 IGLESIA CRISTIANA ESTRELLA RESPLANDECIENTE DE JACOB
- 04 APOSTLE IMMIGRANT SERVICES
- 05 THE REDEEMED CHRISTIAN CHURCH OF GOD
- 06 IGLESIA DE DIOS PENTECOSTAL MI
- 07 IGLESIA BAUTISTA EL CALVARIO
- 08 CHURCH OF GOD OF PROPHECY
- 09 INSPIRATIONAL EVANGELISTIC
- 10 OUR LADY OF GUADALUPE PARISH
- 11 IGLESIA CRISTIANA DIOS DE PACTOS
- 12 IGLESIA CRISTIANA BETANIA AD
- 13 IGLESIA DE DIOS LA NUEVA JERUSALEN INC

Affordable Housing

- 01 HUD PUBLIC HOUSING
- 02 NHPD PROPERTIES

Public Open Space
(Park, Urban Farm, Community Garden)

- 01 CRISCUOLO PARK
- 02 MILL RIVER TRAIL- OPEN SPACE
- 03 JOHN S. MARTINEZ SCHOOL- OPEN SPACE
- 04 ESMERALDA PARK
- 05 WOLCOTT & LLOYD COMMUNITY GREENSPACE
- 06 WOOLSEY ST COMMUNITY GARDEN
- 07 WOLCOTT & FERRY STREET FARM
- 08 FERRY STREET TRIANGLE
- 09 QUINNIPIAC RIVER PARK
- 10 FAIR HAVEN SCHOOL- OPEN SPACE
- 11 CLINTON AVE- OPEN SPACE
- 12 GRAND ACRES COMMUNITY GARDEN
- 13 LEWIS STREET PARK
- 14 CHATHAM SQUARE PARK
- 15 ENGLISH MALL
- 16 CLINTON PARK
- 17 QUINNIPIAC RIVER FRONT ST BOAT RAMP
- 18 DOVER BEACH
- 19 FERRY STREET FARM
- 20 STALLWORTH COMMUNITY GARDEN
- 21 CHABASO BAKERY GARDEN
- 22 MARKET & JAMES STREET FARM
- 23 COMMUNITY GARDEN SHELTER & CLAY STREETS
- 24 FAMILY ACADEMY- OPEN SPACE
- 25 MILL RIVER TRAIL

LEGEND

- River Street Historic District
- Quinnipiac River Historic District
- Quinnipiac Avenue Historic District
- Public Open Space
- FEMA Zone AE

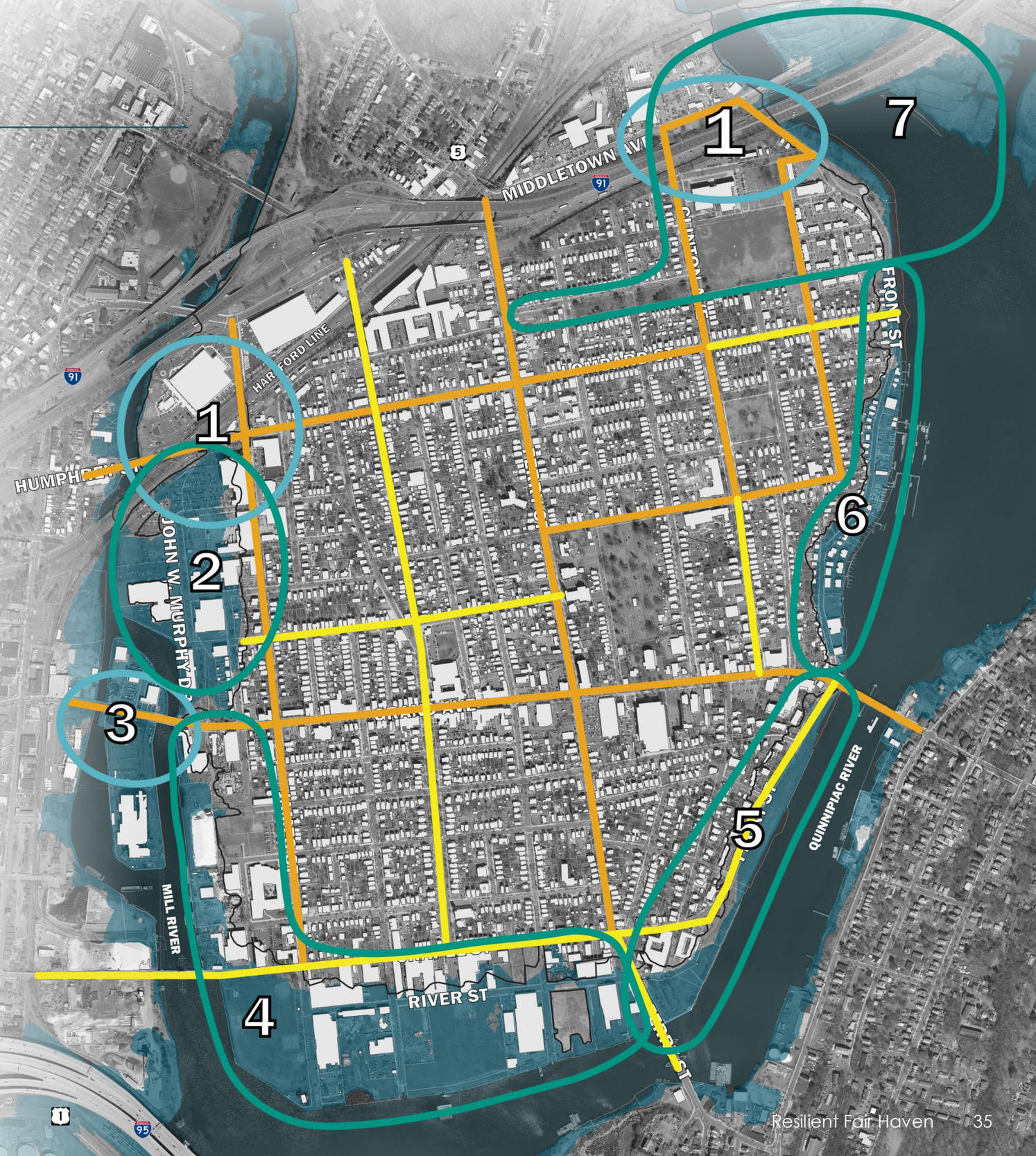
ADAPTATION OPTIONS + RECOMMENDED ACTIONS

RESILIENT FAIR HAVEN FOCUS AREAS

Several areas of focus were identified throughout the Fair Haven peninsula for development of climate adaptation strategies and implementable project concepts. These "focus areas" reflect portions of Fair Haven that are most vulnerable to flooding and extreme heat but also provide opportunities to mitigate climate impacts and enhance community resilience.

The identified focus areas include most of the Fair Haven shoreline, as well as critical roadways and corridors that connect the Fair Haven community to the rest of the City and enhance connections within Fair Haven (yellow lines on map) and can serve as cooling corridors using shading strategies and green infrastructure (orange lines on map). The Fair Haven peninsula was subdivided into the following numbered focus areas shown on the map to the right, which include shoreline areas and critical community connections:

1. **Underpasses** – drainage-related flooding at the railroad underpasses (Humphrey Street and James Street) and at the I-91 underpasses (Clinton Avenue and Front Street), which are critical connections to and from Fair Haven
2. **John W. Murphy Drive Area** – low-lying road and adjacent industrial, commercial, and residential areas and buildings along the lower Mill River susceptible to coastal and drainage-related flooding
3. **Grand Avenue & Mill River Bridges** – major gateway/connection between Fair Haven and Downtown, Wooster Square, and Mill River impacted by existing and future coastal flooding
4. **River Street Area** – heavily industrialized area along lower Mill River and Quinnipiac River; vulnerable to coastal flooding and characterized by legacy contamination and ongoing cleanup and redevelopment
5. **Quinnipiac River Park Area** – flood prone park along Quinnipiac River between Ferry Street and Grand Avenue
6. **Front Street North** – low-lying road and adjacent commercial and residential areas at risk of coastal flooding
7. **Clinton Park Area** – area encompassing Clinton Avenue School, Clinton Park, and adjacent public housing, as well as flood prone connection along Middletown Avenue to nearby shopping and commercial areas east of the Quinnipiac River



LEGEND

- Cooling Corridors
- Community Connectors
- Critical Community Connection Area
- Shoreline Focus Areas
- Projected Future Flooding (100-Yr + 20" SLR)
- FEMA Zone AE

FOCUS AREAS - SUMMARY

FOCUS AREA 1
UNDERPASSES

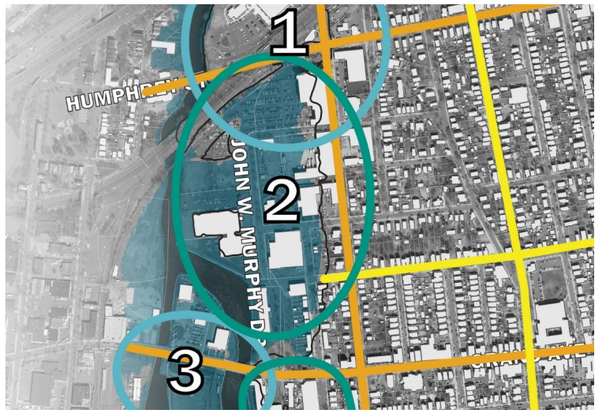
CRITICAL ASSETS
- Impacted by Coastal and Drainage Flooding: Critical neighborhood connections and egress during storm events (Humphrey Street, James Street, Clinton Avenue, and Front Street)

GOALS / NEEDS
- Improve access to critical facilities during flood events
- Reduce risks to residents during flood events

POTENTIAL BENEFITS / SOLUTIONS
- Upon more detailed analysis, drainage system could possibly be improved to reduce flooding at underpasses
- Improvement to the flood conditions here would result in safer travel during storm events
- Road closures and automated temporary traffic barriers to reduce the incidence of stranded vehicles and the need for rescues

STATUS / NEXT STEP
- This report provides short term recommendations to keep residents safe in present day flood events
- It is recommended that the City perform detailed drainage analysis and engineering at these locations to better evaluate potential long-term solutions

FOCUS AREA 2
JOHN W. MURPHY DRIVE AREA



CRITICAL ASSETS
- Impacted by Coastal, Riverine, and Drainage Flooding as well as Extreme Heat: Concentra Urgent Care, Dept of Social Services, Pump Station, Mill River Trail, Street Grid, Businesses, Residences, Family Academy

GOALS / NEEDS
- Improve access to critical facilities during flood events
- Reduce risks to residents during flood events
- Improve connections to waterfront from residential areas
- Reduce risk from extreme heat

POTENTIAL BENEFITS / SOLUTIONS
- Improvement to the flood conditions here could result in reduced risk from flooding, enhanced recreational space, ecological benefits, increased tree canopy and cooling opportunities

STATUS / NEXT STEP
- This report provides a concept level design for this area

FOCUS AREA 3
GRAND AVENUE & BRIDGES

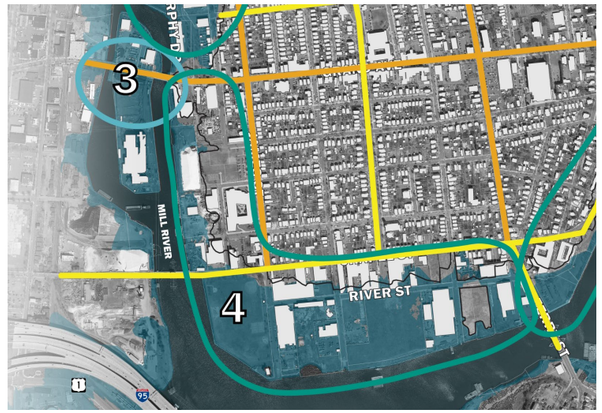
CRITICAL ASSETS
- Impacted by Coastal Flooding: Passage across the Mill River is impacted by flooding in the present and future condition. Critical connection to Downtown New Haven

GOALS / NEEDS
- Improve access to critical facilities during flood events
- Reduce risks to residents during flood events

POTENTIAL BENEFITS / SOLUTIONS
- Improvement to this transportation asset would enable critical neighborhood connections during storm events now and in the future

STATUS / NEXT STEP
- This report provides a concept level design for this area

FOCUS AREA 4
RIVER STREET AREA



CRITICAL ASSETS
- Impacted by Coastal, Riverine, and Drainage Flooding as well as Extreme Heat: Chapel Street and bus routes, John Martinez School, Cold Spring School, Criscuolo Park, contaminated parcels

GOALS / NEEDS
- Separate combined sewers
- Absorb and/or mitigate coastal surge
- Enhance resiliency of public open spaces
- Reduce risk from extreme heat
- Provide opportunities for resilient redevelopment opportunities for the City

POTENTIAL BENEFITS / SOLUTIONS
- Improvement to this area would support the City's initiative to mitigate industrial land barriers to coastal access, Increase water access, and potentially reclaim large parcels for open space and/or redevelopment

STATUS / NEXT STEP
- Redevelopment plans for this area are active with the City currently. It is recommended that the City consider detailed projections of future flood risk and rising groundwater levels in this area to better inform redevelopment decisions and resilient design strategies

RESILIENT FAIR HAVEN

FOCUS AREAS - SUMMARY

FOCUS AREA 5
QUINNIPIAC RIVER PARK AREA

CRITICAL ASSETS
- Impacted by Coastal, Riverine, and Drainage Flooding as well as Extreme Heat: Street flooding, Quinnipiac River Park

GOALS / NEEDS
- Absorb and/or mitigate coastal surge
- Enhance accessible riverfront access

POTENTIAL BENEFITS / SOLUTIONS
- Improvement to this area would support the quality of life for nearby residents by providing enhanced recreational spaces, enhanced habitat, as well as cooling opportunities along riverfront

STATUS / NEXT STEP
- The City of New Haven recently received grant funding for improvements to Quinnipiac River Park including new site furniture, re-paving, electrical and signage, stone dust paths, and water service
- The City should implement other resilience improvements, like those proposed for Dover Beach to the north, consistent with recent community input for the Quinnipiac River Park improvements including living shoreline elements and enhanced tree canopy for shade and habitat

FOCUS AREA 6
FRONT STREET NORTH

CRITICAL ASSETS
- Impacted by Coastal, Riverine, and Drainage Flooding as well as Extreme Heat: Private residences, businesses, marina, and access to river

GOALS / NEEDS
- Many private residences need building scale solutions
- Reduce street flooding

POTENTIAL BENEFITS / SOLUTIONS
- Voluntary buyouts could be a solution that the City should discuss for some of the riverfront properties
- Floodproofing at the building scale could also be beneficial

STATUS / NEXT STEP
- This area was not developed to concept level plans in this study
- Neighborhood scale outreach and discussions with property owners would be the next step to move this forward

FOCUS AREA 7
CLINTON PARK AREA

CRITICAL ASSETS
- Impacted by Coastal, Riverine, and Drainage Flooding as well as Extreme Heat: affordable housing, Clinton Avenue School, Dover Beach. Extreme heat is the driving risk in this area.

GOALS / NEEDS
- Provide cooling opportunities
- Enhance habitat and open spaces for affordable housing area
- Provide neighborhood connections and manage stormwater
- Enhance school parcels and introduce elements to reduce extreme heat impacts

POTENTIAL BENEFITS / SOLUTIONS
- Improvement to this area could result in a more resilient community through strengthening community corridors and providing gathering spaces to escape the heat
- Ecological enhancements in Dover beach could benefit both habitat and water quality as well as provide a more diverse experience for park visitors

STATUS / NEXT STEP
- This report provides a concept level design for this area

COOLING CORRIDORS / COMMUNITY CONNECTORS

CRITICAL ASSETS
- Impacted by Extreme Heat: Critical community connections for pedestrians, bicyclists, and public transportation users

GOALS / NEEDS
- Increase shade canopy
- Reduce drainage related flooding

POTENTIAL BENEFITS / SOLUTIONS
- Improvements along these corridors would reduce the risks associated with urban heat island
- Enhance urban habitat and water quality
- Provide cool connections to the various cooling shelters, resilience hubs, and critical facilities around the neighborhood

STATUS / NEXT STEP
- Elements of the cooling corridors and community connectors are incorporated into the concept level designs in this report

RESILIENT FAIR HAVEN

EVACUATION ROUTES + RESILIENCE HUBS

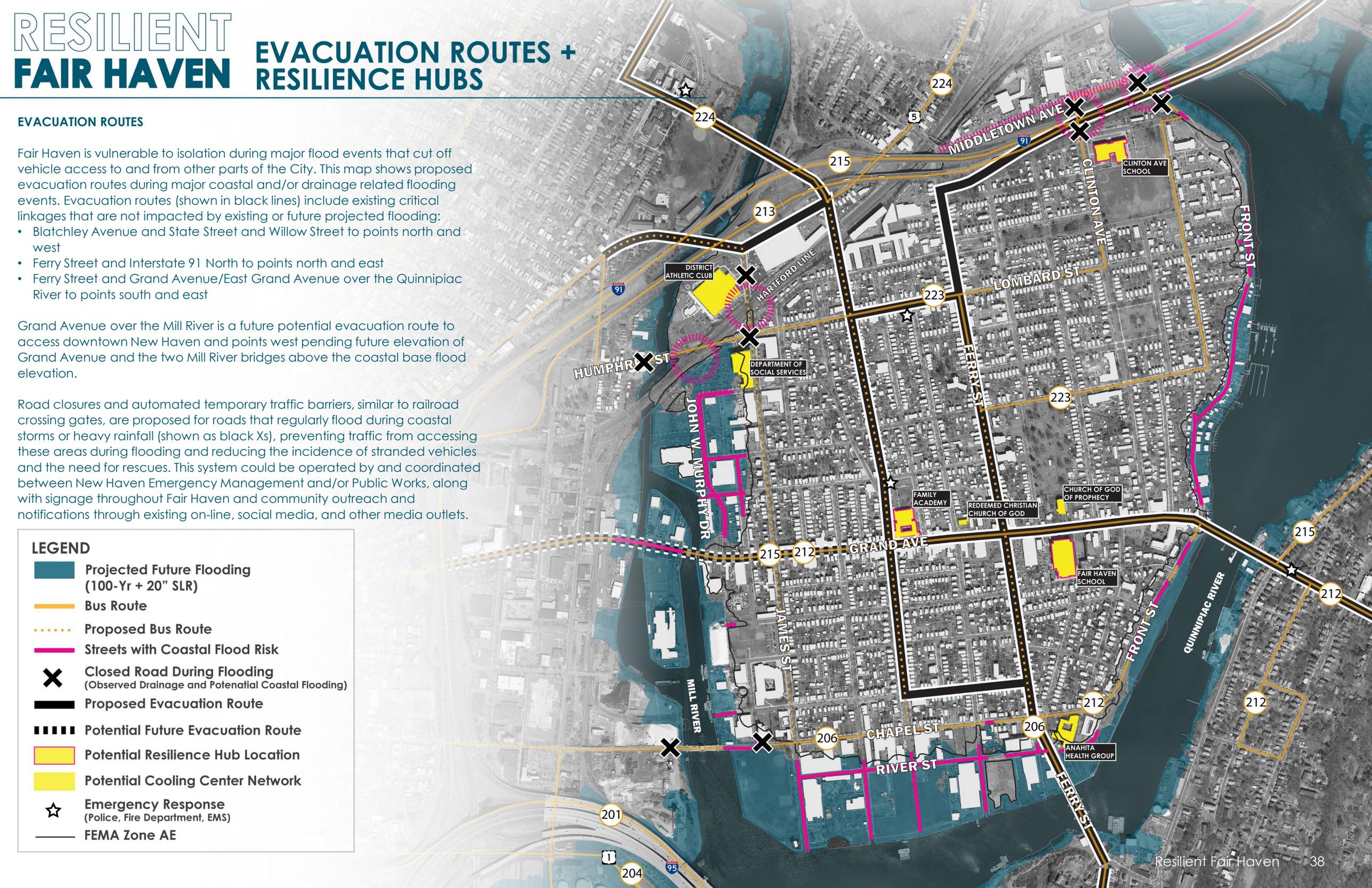
EVACUATION ROUTES

Fair Haven is vulnerable to isolation during major flood events that cut off vehicle access to and from other parts of the City. This map shows proposed evacuation routes during major coastal and/or drainage related flooding events. Evacuation routes (shown in black lines) include existing critical linkages that are not impacted by existing or future projected flooding:

- Blatchley Avenue and State Street and Willow Street to points north and west
- Ferry Street and Interstate 91 North to points north and east
- Ferry Street and Grand Avenue/East Grand Avenue over the Quinnipiac River to points south and east

Grand Avenue over the Mill River is a future potential evacuation route to access downtown New Haven and points west pending future elevation of Grand Avenue and the two Mill River bridges above the coastal base flood elevation.

Road closures and automated temporary traffic barriers, similar to railroad crossing gates, are proposed for roads that regularly flood during coastal storms or heavy rainfall (shown as black Xs), preventing traffic from accessing these areas during flooding and reducing the incidence of stranded vehicles and the need for rescues. This system could be operated by and coordinated between New Haven Emergency Management and/or Public Works, along with signage throughout Fair Haven and community outreach and notifications through existing on-line, social media, and other media outlets.



RESILIENT FAIR HAVEN

EVACUATION ROUTES + RESILIENCE HUBS

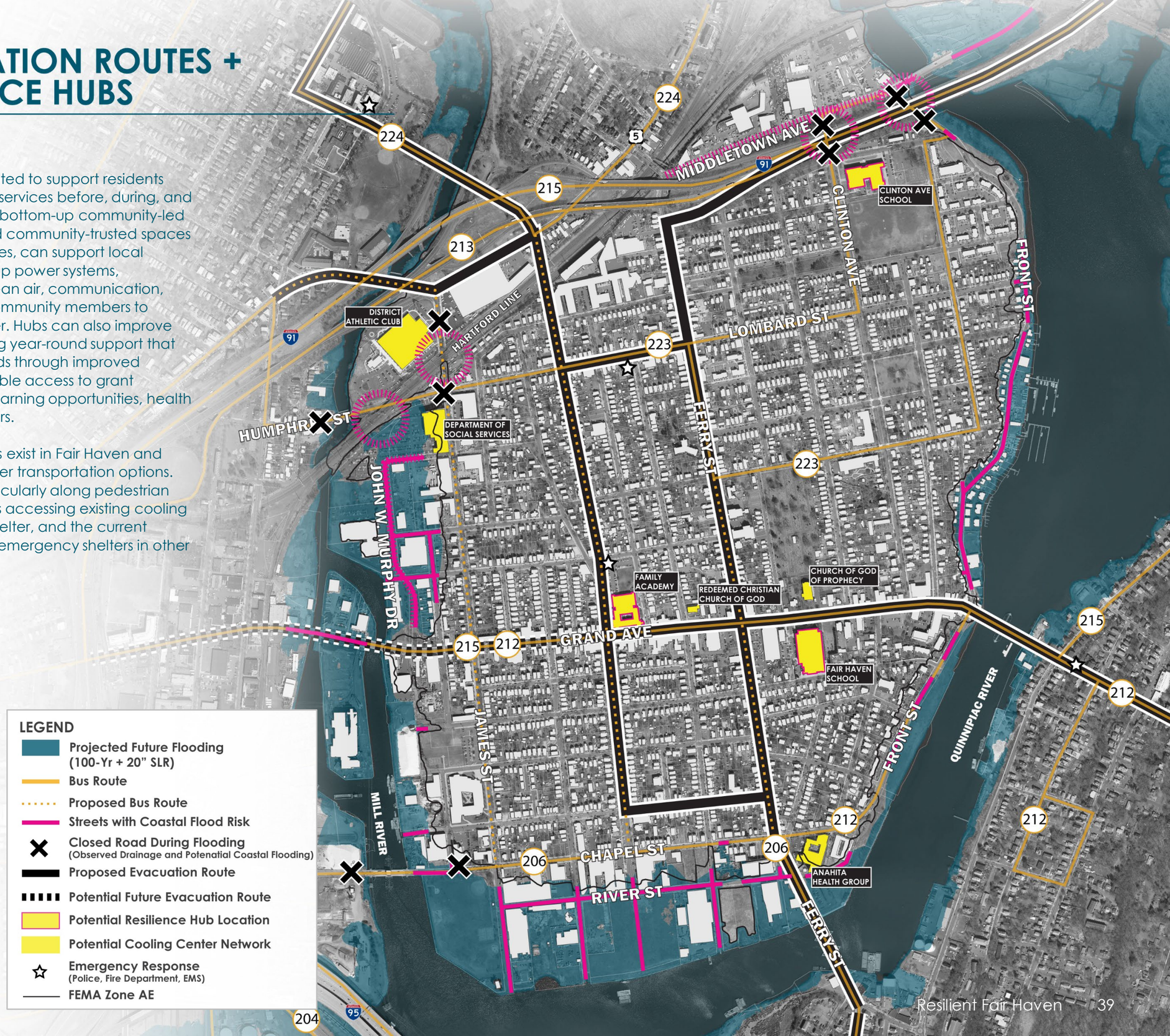
RESILIENCE HUBS

"Resilience hubs" are community-serving facilities, augmented to support residents and coordinate and supplement resource distribution and services before, during, and after a natural hazard event. Resilience hubs can increase bottom-up community-led resilience efforts by leveraging existing or newly designated community-trusted spaces or facilities. The hubs, which can take many forms and scales, can support local emergency response during disruptions with flexible back-up power systems, emergency shelter options where appropriate, cooling, clean air, communication, supply distribution, and logistical support for connecting community members to information and services before, during, and after a disaster. Hubs can also improve community connectivity and become centers for delivering year-round support that can improve preparedness and response to climate hazards through improved communication with city staff and leadership, more equitable access to grant programs, access to technical assistance, workshop and learning opportunities, health services, and workforce training opportunities, among others.

As documented in this project, numerous community assets exist in Fair Haven and many community members lack access to a vehicle or other transportation options. The amount of impervious and heat emitting surfaces, particularly along pedestrian corridors has been identified as an impediment to residents accessing existing cooling centers in the area. Fair Haven also lacks an emergency shelter, and the current approach during a major emergency is to bus residents to emergency shelters in other parts of the City.

A strategy to designate one or more existing facilities as "resilience hubs" could help to increase the options for vulnerable residents during different climate hazard events, such as prolonged heat waves, air pollution from regional wildfires, and prolonged power disruptions from major storms. As part of that designation, the City could work with existing facility owners and operators to better equip sites with flexible back-up power systems and emergency supplies, so that they can enhance New Haven's emergency management capabilities during climate hazard events. The City can also work with local community-based organizations and service providers to develop programming that can enhance residents' connection and usage of a resilience hub during every day "blue sky" conditions.

This map shows proposed resilience hub locations (FAME School, Fair Haven School, and Clinton Avenue School) along with other facilities that could form a network of cooling centers or emergency shelters. **Appendix X** contains details of an analysis of potential resilience hub locations in Fair Haven.



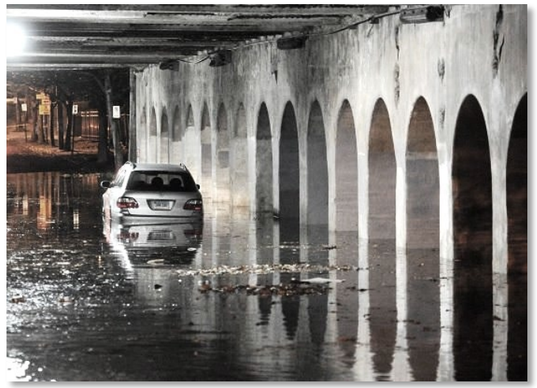
RESILIENT
FAIR HAVEN

ADAPTATION TOOLKIT

DEVELOPING A TOOLKIT

HOW DOES FLOODING WORK IN FAIR HAVEN?

As demonstrated by historic and more recent events, the Fair Haven neighborhood faces high, and increasing, risks from heavy rainfall events, coastal storm surge, and tidal flooding. Each of these presents its own challenge. Many areas in the neighborhood, as well as the City of new Haven, face flood risks from multiple sources, demanding solutions that address the ways in which these flooding sources interact to provide holistic flood risk reduction. The adaptation solutions examined in this report aim to provide layered approaches to flood risks while also providing additional benefits to the community.



Superstorm Sandy, Humphrey St. Underpass

December 23, 2022, Quinnipiac River Park

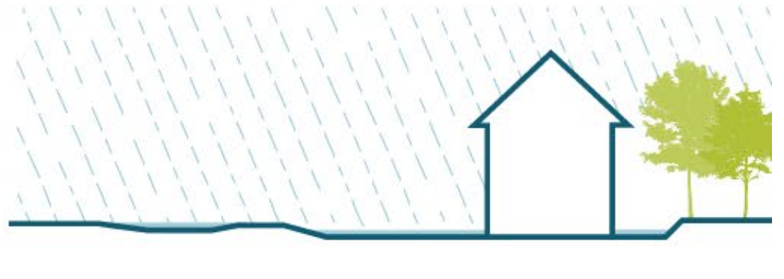
WHAT TYPES OF FLOODING DOES FAIR HAVEN EXPEREIENCE?

TIDAL FLOODING

Tidal flooding is the temporary inundation of low-lying areas due to high tides. Sea level rise will cause tides to be higher than they are today, and some areas will flood daily if no actions are taken.

COASTAL STORMS

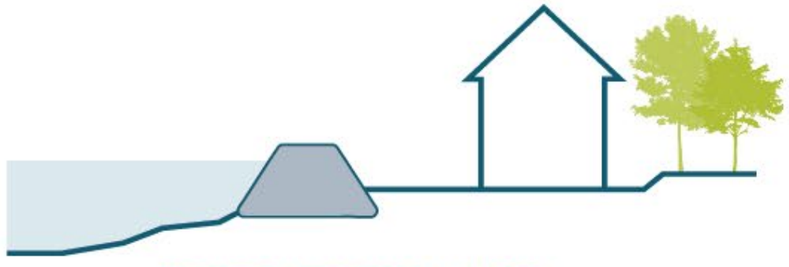
Tropical storms, hurricanes, and nor'easters can raise water levels along the coast.



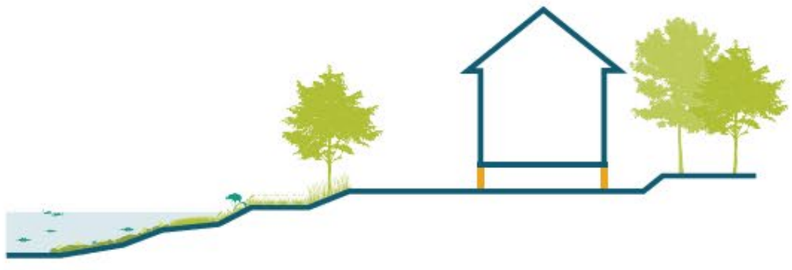
RAINFALL FLOODING

Inches of rain can fall in a few hours during the peak of a storm, causing flooding in low-lying areas. These areas might be along waterways (riverine flooding) or inland where rainfall overwhelms storm drains.

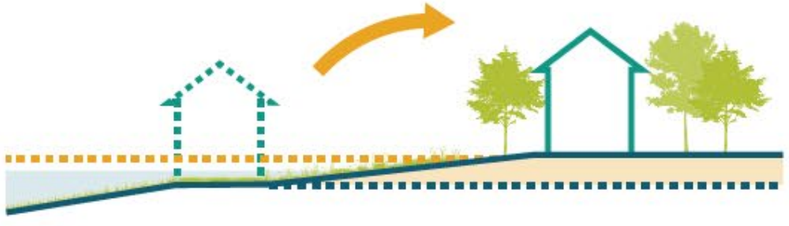
HOW CAN WE ADAPT TO FUTURE FLOODING?



PROTECT ASSETS FROM WATER



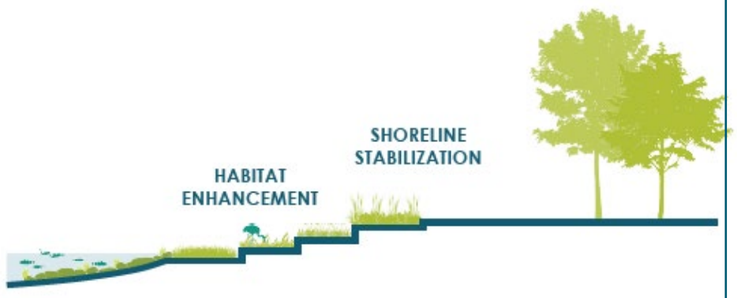
LIVE WITH THE WATER



MOVE ASSETS AWAY FROM WATER

PHYSICAL STRATEGIES CONSIDERED

NATURE-BASED STRATEGIES

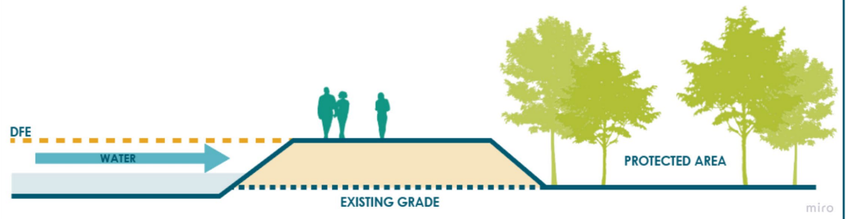


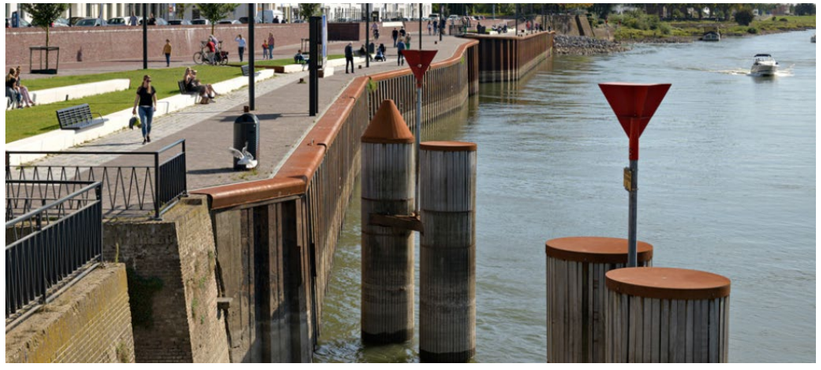
Nature-based solutions use natural systems, or features that mimic them, to reduce flood risk and provide other economic, environmental, and social benefits. Natural features include existing ecosystems, such as wetlands and salt marshes, while nature-based solutions include features like parks and living shorelines. Both can maintain or create valuable habitat, attenuate wave action, and reduce erosion.

ELEVATED BULKHEAD

Bulkheads are concrete structures along shorelines of large bodies of water that protect from flooding, wave action and erosion. an be integrated into recreational greenways and provide waterfront access to users.

ELEVATED PROMENDADE





Elevated promenades provide public access to the shoreline and are raised to the Design Flood Elevation (DFE) level to protect inland communities from coastal flooding.

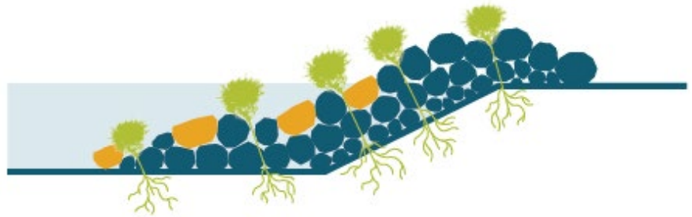
NARRATIVE SOURCE: *RESILIENT NJ – PROTECT, RESTORE, TRANSITION – A Resilience Action Plan For The Raritan River And Bay Communities' Region*

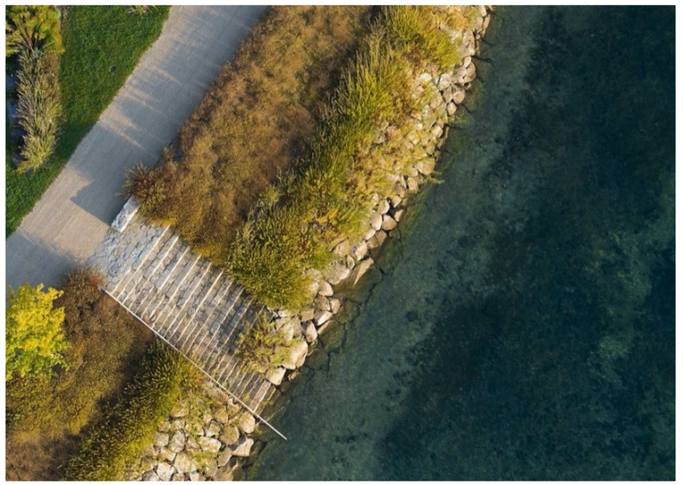
PHYSICAL STRATEGIES CONSIDERED

LANDSCAPE BERM

Berms are earthen mounds of various widths that provide flood protection and, where possible, public access to and along the waterfront. Where there is less space, berms can be narrow with a path on their crests. Where there is more space, they can widen to become elevated waterfront parks, creating places for communities to gather while simultaneously providing flood protection.

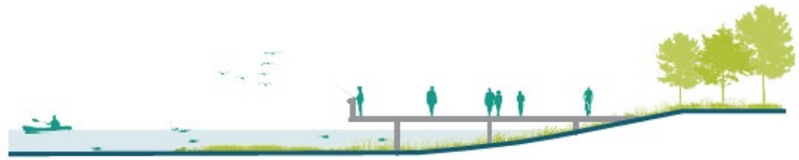
ECOLOGICALLY ENHANCED STRUCTURES





Revetments are hard sloping structures, typically constructed using natural stone, or concrete blocks designed to reduce shoreline erosion by absorbing wave energy and minimizing wave run-up. Sometimes these structured systems are necessary and can be altered as hybrid systems to incorporate ecological features providing enhanced habitat opportunities as well as enhance quality of life and water quality.

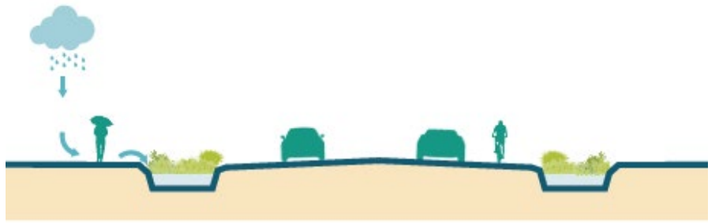
LIVING SHORELINE

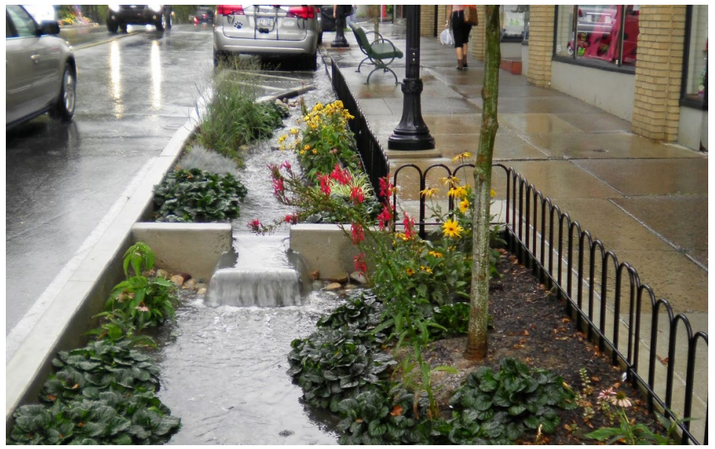


Shoreline stabilization approaches along estuarine coasts, bays, sheltered coastlines, and tributaries incorporate natural features, including vegetation or submerged aquatic vegetation alone, or hybrid systems in combination with harder shoreline structures for added stability such as stone, sand fill, rock sills and other structural and organic materials.

PHYSICAL STRATEGIES CONSIDERED

URBAN STORMWATER INFILTRATION

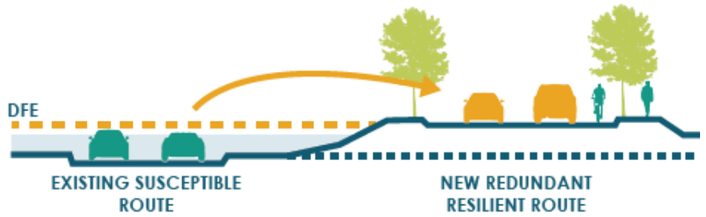




Right-of-way bioswales are vegetated drainage courses located in sidewalks to capture, detain, and infiltrate runoff from streets, allowing any excess rainwater to enter the piped stormwater system.

A rain garden collects rainwater runoff from impervious surfaces like roofs, streets, and paved surfaces, thereby reducing risk associated with rainfall flooding.

REDUNDANT EMERGENCY ROUTES



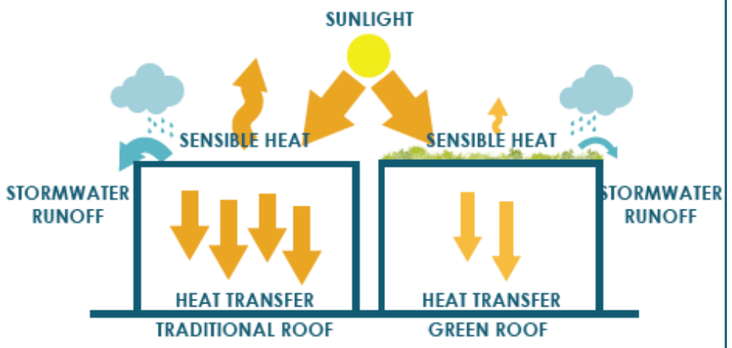
By creating redundant routes, residents and emergency services can have mobility options when other, more susceptible routes are impassible. This tool applies to instances where critical emergency routes are often compromised by floodwaters

RAISED ROADWAY

Elevating roadways to target DFE keeps transportation infrastructure dry during the flood events, maintaining evacuation routes and access for emergency services. Elevated roadways may also act as flood protection for inland communities.

PHYSICAL STRATEGIES CONSIDERED

GREEN ROOF



A green roof is a layer of growing medium for vegetation installed over a waterproofing system, slowing down runoff by retaining rainwater and gradually releasing it back into the atmosphere through condensation and transpiration. Blue roofs provide temporary water storage systems that allow for the gradual release or evaporation of stored water.

ELEVATE CRITICAL SYSTEMS

Relocating critical systems to higher floors within structures reduces the impacts of flooding on critical services and reduces recovery times. This tool increases the resilience of essential services to homes and businesses.

FLOODPROOF LEVELS BELOW DFE

Wetproofing involves sealing susceptible levels to water infiltration. This allows for flood water to move into and through these levels while limiting infiltration to the rest of the structure. Dryproofing involves fully blocking out floodwaters with both permanent and deployable structures.

STRATEGIC ACQUISITION

Strategic acquisition is the voluntary acquisition of parcels to reduce long-term flood damage and implement targeted flood protection projects at key flood pathway locations. This strategy can be selectively considered where perimeter protection or adaptation are not feasible, too costly, or detract from other essential aspects of resilience.

NON-STRUCTURAL RECOMMENDATIONS

RESILIENCE STRATEGIES FOR FUTURE CONSIDERATION

GOVERNANCE + POLICY TOOLS

LAND USE PLANNING + ZONING
Explore opportunities to include higher design standards in City ordinances such as the requirement of an elevation certificate, limited outdoor storage of materials in flood hazard areas, standards for cumulative substantial improvements and/or lower substantial improvement threshold, and/or application of standards in the 0.2% annual chance floodplain.

CREATE FUNDING PROGRAMS CITYWIDE
Develop funding programs including loans and grants that can be provided to property owners (residential, multi-family, and commercial) to support building scale mitigation through floodproofing, elevations, buyouts, green infrastructure retrofits, and energy efficiency.

REVISIT A STORMWATER AUTHORITY
A stormwater utility creates the ability to assess fees, based on a fair and equitable approximation of the contribution of stormwater runoff from a real property, which can then be used to fund stormwater programs within the governing body. A stormwater utility operates similarly to any other utility, such as a water or electric utility. This is an especially valuable tool as part of a watershed approach for flood resilience, as it facilitates implementation of stormwater management practices for new and redeveloped areas, creates incentives for retrofits on private property, and provides dedicated funding for beneficial public stormwater projects and maintenance activities. With the increasing impact of extreme rainfall events, it is recommended that the City of New Haven revisit this idea.

IMPLEMENT PUBLIC EDUCATION CAMPAIGN ON STORM SAFETY
This campaign should include both education about drainage and coastal storm risks as well as what community members should do during storms, specifically in Fair Haven detailing evacuation routes, road closures, and resilience hub locations.

WATERSHED/CITYWIDE PROBABALISTIC MODEL FOR COMPREHENSIVE FLOOD RISK ANALYSIS
The development of a fully probabilistic physics-based hydrodynamic model of the Mill and Quinnipiac watersheds (City of New Haven), which would include a complete Monte Carlo based assessment of flood risk would provide more refined AEP level conditions as well as enable the City to develop dynamic adaptation planning pathways (DAPP). DAPP's can provide a powerful adaptive and visual management tool to guide a community through the process of adapting to changing climate conditions over time. This type of probabilistic model considers pluvial, fluvial, coastal and coastal flooding as well as incorporates groundwater conditions and stormwater infrastructure systems.

PERFORM CLOUDBURST MASTERPLANNING STUDY
A cloudburst resiliency planning study analyzes best-available data related to rainfall, recommends methodologies for incorporating findings into ongoing resiliency planning initiatives, and identifies best practices for considering climate change in future neighborhood-specific planning studies. As an outcome of the study, opportunities for intervention are identified within the designated study area to provide retention and conveyance for extreme conditions, while also offering community and environmental benefits in normal conditions.

INDIVIDUAL / COMMUNITY-BASED ACTIONS

DEVELOPMENT OF CITYWIDE RESILIENCE HUBS
Resilience centers, or "Resilience hubs" are community-serving facilities, augmented to support residents and coordinate and supplement resource distribution and services before, during, and after a natural hazard event. Resilience hubs can increase bottom-up community-led resilience efforts by leveraging existing or newly designated community-trusted spaces or facilities.

EMERGENCY PREPAREDNESS
Emergency preparedness efforts include the dissemination of emergency alerts and guidance to residents and community leaders and supporting community-based emergency preparedness programs through partnerships with community organizations and faith-based institutions. Outreach in multiple languages and through trusted local leaders is key.

COMMUNITY PLANNING
One way to build adaptive capacity is to work in close collaboration with neighborhood residents and community-based organizations to identify community needs and develop strategies for improving access to necessary resources. This could include improving access to open space, improving community mobility and connectivity, or addressing food deserts—all things that help a community adapt to changing climate hazards and thrive every day.

COMMUNITY STEWARDSHIP OF GREEN SPACES
Community co-creation and stewardship of green spaces is a way to partner with community-based organizations to maintain green spaces that support community resilience while supporting education, job training, and providing volunteer opportunities.

NEIGHBORHOOD WIDE STUDY ON AIR QUALITY
Partner with the academic community, such as Yale School of Public Health Center on Climate Change and Health, and community-based organizations to conduct localized studies and public health screenings of present-day vulnerabilities to and impacts of extreme heat and poor air quality. Poor air quality in Fair haven is not merely a future issue, but rather an immediate concern of its residents now. The community is already experiencing the effects of poor air quality, especially the elderly and children

PUBLIC EDUCATION CAMPAIGNS
Start a regional education campaign with resources for individual mitigation and to promote advocacy related to additional hazards. Should involve developing and distributing accessible, multilingual information and educational materials designed to reach as many communities as possible

RESILIENT FAIR HAVEN

NON-STRUCTURAL RECOMMENDATIONS

HEAT SPECIFIC STRATEGIES FOR FUTURE CONSIDERATION

STAYING COOL AND SAFE IN PUBLIC SPACES

COMMUNITY HEAT RELIEF NETWORK
Organize and activate a network of local institutions, businesses, and community organizations who can respond during extreme heat events by offering cooling spaces and resources to residents

COOL + SAFE TRANSPORTATION
Improve access to cool, safe, and accessible routes for walking, biking or using public transit in extreme heat, including:
- More bus shelters along popular routes
- Offering free bus transportation on certain routes during Heat Health Emergencies
- Creating safer routes and traffic crossings to the waterfront and public open spaces
- Reducing idling and vehicle exhaust (which impacts air quality) by rerouting truck traffic out of residential areas

EFFICIENT AIR CONDITIONING IN SCHOOLS, LIBRARIES, AND COMMUNITY CENTERS
Improve access to air conditioning and healthy energy repairs at public schools, libraries, and recreation centers in Fair Haven and City-wide

COOLER OPEN PUBLIC SPACES
Improve access to resources that will help residents stay cool outside:
- Better lighting in park spaces to make it more accessible in the evening
- Providing cold water, shade structures, and misting fans/tents for block clean-ups and other outdoor community events
- Increase tree canopy along designated cooling corridors

STAYING COOL AND SAFE AT HOME

ENERGY EFFICIENT APPLIANCES + HOME REPAIRS
- Improve access to efficient air conditioning units and appliances
- Improve access to healthy home energy repairs and weatherization
- Explore a neighborhood/citywide program which can complete energy upgrades and repairs to homes to prevent displacement and reduce energy burden in low-income homes, including cool roof coatings and insulation installation

STRATEGIC + INCLUSIVE HEAT OUTREACH
- Improve access to information about existing utility assistance programs and resources about how to stay cool and safe during extreme heat events, including information about City-operated cooling centers, heat health tips, and Resilience Hubs
- Pilot system for alerting and checking-in on vulnerable residents during extreme heat events in Fair Haven
- Create centralized City Heat website and a schedule of social media posts to send to community-based partners to post throughout the summer

YEAR-ROUND UTILITY ASSISTANCE
Work to develop services to enable Utility Assistance to be available for the full year (and not just the winter season) to qualifying residents in low-income areas

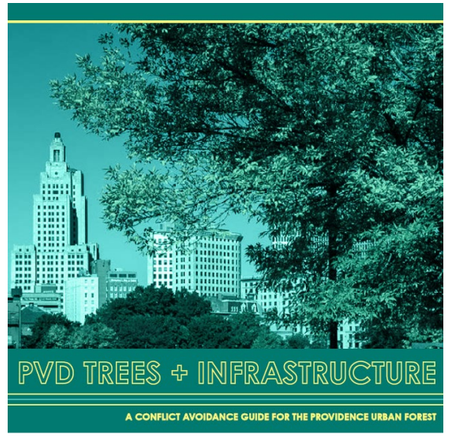
URBAN FOREST ENHANCEMENT

TREE PLANTING + CARE
Improving access to tree plantings and education about tree care and maintenance for residents in Fair Haven, including:
- Recruiting neighborhood organizations to partner with the City to host yard tree giveaways
- Expanding bilingual training and recruiting resident volunteers for street tree plantings around Fair Haven
- Increasing street trees and perimeter plantings around large industrial sites
- Providing information about tree care and street tree program applications in Spanish

EXPANDED CITY STREET TREE LIST
Update the City of New Haven Approved Street Tree List to include recommended soil volume, rooting and truck characteristics, minimum allowable tree pit size/strip size, moisture tolerance, and other helpful information to make choosing the right tree for the right place easier.

NEIGHBORHOOD GREENING
Improving access to greening and open space throughout Fair Haven, including
- Creating more gardens and parks on vacant lots that exist near residential blocks
- Targeting green stormwater infrastructure projects—such as rain gardens, tree boxes, and bioswales—on the hottest blocks in Fair Haven
- Targeting green stormwater infrastructure projects on and around industrial sites, commercial sites, and schoolyards, such as: FAME School, Fair Haven School, and Clinton Avenue School

FORMATION OF GREENCORPS
Creating a local job training program for young adults in Fair Haven to engage in leadership development, community organizing, and environmental resilience projects, including:
- Tree maintenance
- Green space enhancement
- Heat outreach
- Neighborhood clean-ups



Developing design guidelines at the City level takes a proactive approach to ensuring a healthy and robust urban forest. This guide was created to highlight solutions which may be employed to plant and retain healthy trees and provide accessible, walkable surfaces throughout the City of Providence and presents potential tools, solutions, and recommendations to reduce conflicts between tree roots and sidewalks.

Bus stops in Lexington, Kentucky, using solar technology for lighting enhancing public safety as well as public health

Green roof bus shelter in Columbus, Ohio

ADAPTED FROM: *Beat The Heat Hunting Park*

RESILIENT
FAIR HAVEN

CONCEPT ALTERNATIVES + RECOMMENDED ACTIONS

RESILIENT FAIR HAVEN FOCUS AREAS

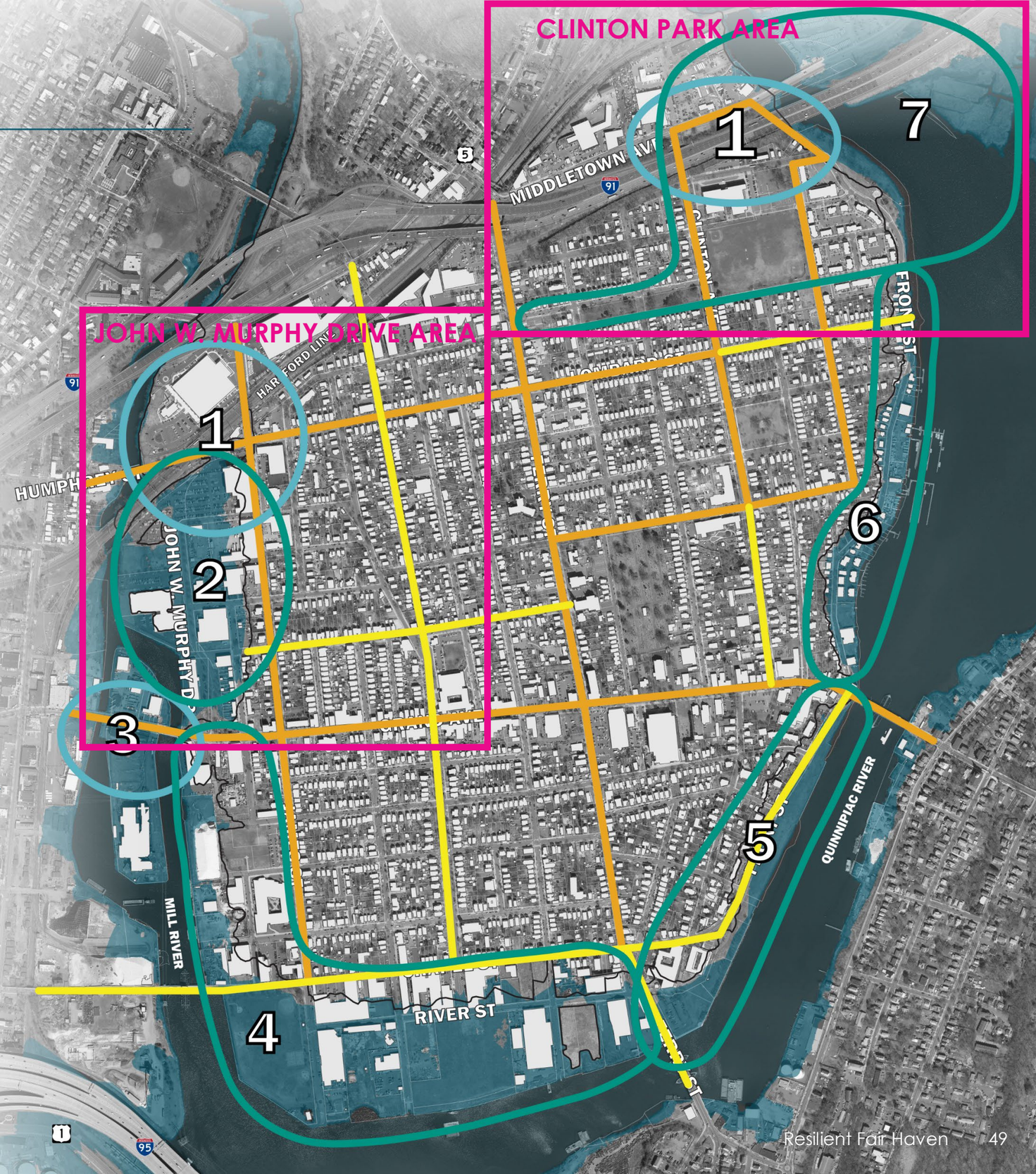
Given the limited project budget, the project team selected a subset of the focus areas identified in the previous section for development of adaptation strategies and implementable project concepts. Focus areas were prioritized and selected for concept development based on the following considerations:

- The degree of flooding and extreme heat impacts and potential for adaptation strategies to benefit vulnerable populations
- Areas that can demonstrate both coastal and drainage-related flood resilience strategies
- Opportunities for enhanced public access to the Fair Haven waterfront
- Opportunities to demonstrate green infrastructure cooling corridors and community connectors for heat resilience and other community benefits
- Input from City staff, Citizen & Technical Advisory Committee, and the community

Two overall focus areas were ultimately selected for concept development:

- **John W. Murphy Drive Area** – encompasses John W. Murphy Drive and adjacent flood prone commercial and residential areas in addition to the critical community connections at Grand Avenue (including the Grand Avenue bridges over the Mill River) and the Humphrey Street underpass. The focus area also extends to the west, encompassing portions of Clay Street, Grand Avenue, and the Family Academy of Multilingual Exploration (FAME) school at the corner of Blatchley and Grand Avenues.
- **Clinton Park Area** – includes Clinton Park, the Clinton Avenue School, English Mall, the Quinnipiac Terrace public housing complex, and Dover Beach along the Quinnipiac River. The area also encompasses the flood prone highway underpasses at Clinton Avenue and Front Street, as well as the important Middletown Avenue connection to commercial shopping areas across the river in Quinnipiac Meadows.

The River Street and Lower Mill River District focus area was not selected for concept development since this area is actively undergoing environmental remediation and redevelopment according to a long-term phased plan. The Quinnipiac River Park and Front Street focus areas were also not selected due to limited flooding impacts and/or potential for adaptation strategies. General recommendations for all focus areas are identified later in this report.



LEGEND

- Cooling Corridors
- Community Connectors
- Critical Community Connection Area
- Shoreline Focus Areas
- Projected Future Flooding (100-Yr + 20" SLR)
- FEMA Zone AE

RESILIENT FAIR HAVEN

JOHN W. MURPHY DRIVE AREA

The recommended actions for the John W. Murphy Drive Area are aimed at reducing the flood risks of this area out to the 2050 planning horizon. Below is a summary of the "Big Moves" recommended in this area. See the following pages for a rendered conceptual plan highlighting the recommended actions as well as 3D renderings on the pages that follow.

In this area the aim is to mitigate flood impacts from the Mill River as well as reduce the impacts of overtopping of the Grand Avenue bridges, which is expected to happen more often by 2050. By elevating Grand Avenue and the Mill River bridges and ensuring enhanced connectivity, we can rethink and create a gateway into Fair Haven. This concept design also explores opportunities to mitigate the flooding along John W. Murphy Drive and minimize the impacts on the inland side of the road by using the road elevation as a flood risk reduction measure itself. The concept recommends looking at the opportunity to acquire 451 Grand Avenue and create a floodable gateway park. The newly created park would provide not only reduced flood risks but also critical community open space and access and connection to the waterfront. The concept looks at various ways to enhance and create new community connections from the inland residential areas down to the water.

By elevating John W. Murphy Drive and creating a flood barrier, a level of flood risk reduction is provided on the landward side of that elevation helping to reduce risks to the existing structures, businesses, and residences there today. This could also provide the future opportunity to explore redevelopment of the industrial parcels east of John W. Murphy Drive with the goal of exploring resilient building techniques like podium buildings with first floor as parking and/or services providing a vibrant streetscape in the community.

The proposed concept calls for a reduction in impervious surfaces in the floodplain. One opportunity is explored at 370 James Street, a multi-tenant building housing primarily health and social services, businesses, and agencies. A portion of this existing parcel is a large surface parking lot in the floodplain directly adjacent to the Mill River. Acquisition of the surface parking lot to create a naturalized, floodable area would provide more flood storage volume along the Mill River. Parking for 370 James could be consolidated and accommodated in a multi-level parking deck allowing for the creation of substantial public open space resulting in reduced flood risks, enhanced habitat, accessibility to the waterfront during extreme heat events, and other community benefits.

With the improvements along the Mill River provides the opportunity to soften the edge conditions providing both resiliency to high water events and flooding while also providing increased habitat value. The softening of the shoreline would create more of a sloped edge condition that provides better attenuation and resiliency of the rise and fall of the waterfront conditions and increase the diversity of ecological systems along the river's edge by introducing marsh areas, tide pool areas, wetland areas, etc.

This concept also includes improvements to an existing 72“ drainage culvert, which currently outlets at the edge of the Mill River. The proposed design concept looks at daylighting approximately 130 feet of that culvert section allowing for improved water quality at the outlet by providing a series of step pools, providing oxygenation and reduction of sediment loads by moving the outlet back to the Clay Street extension. This would provide an educational demonstration project for water quality and habitat enhancement along the Mill River trail including signage about how the rain flows through Fair Haven back to the waterfront, for example.

JOHN W. MURPHY DRIVE AREA (CONTINUED)

One of the "big moves" explored in this plan is the development of Cooling Corridors to strengthen the streetscape corridors as a means of both enhancing social connections but also reducing the impacts of extreme heat events. These axial corridors would aid in reducing heat, reducing runoff, adding habitat, and strengthening community bonds by enhancing safety. These corridors would promote infiltration of stormwater through green infrastructure while also promoting safe and walkable, shaded routes from the interior of Fair Haven down to the waterfront, the Mill River Trail, and to the community connections that extend beyond Fair Haven's borders.

The cooling corridors running north/south aim to add to this connectivity and provide linkages which are important in tying the fabric of Fair Haven together with the goal that its residents can find safe walkable respite opportunities from their own block to an opportunity for heat relief and shade/comfort whether at the water's edge or at a cooling facility.

One place this cooling corridor is explored in this area is along Clay Street. Providing improvements to Clay Street and creating the axial connection from the FAME School down to the water would create an important safe and walkable route paralleling Grand Avenue. This is important as there are not always opportunities and space for the introduction of cooling green infrastructure along Grand Avenue and this gives residents an alternate route.

The FAME School itself is proposed as a demonstration project for a truly resilient school and neighborhood Resilience Hub. Here the design concept explores creating a learning laboratory for students as well as their families and is focused on making a safe and vibrant, green school. An elevated shade structure is introduced over the current surface parking lot. The shade structure would be connected to the school and have a green roof, providing opportunities for gardening and outdoor learning. The design explores upgrading the existing play spaces as well providing more shade and more diversification of play spaces by providing small breakout spaces for the school with the intention that the school yard would be a space for the larger Fair Haven community during non-school hours. The FAME School is intended to be utilized as a community Resilience Hub and cooling center both indoors and outdoors.

RESILIENT FAIR HAVEN

RECOMMENDED ACTIONS

1. **370 James Street Parking Lot & Urban Cooling Center -** Shade trees, parking garage, walking path, natural restoration area, plantings
   Estimated Cost: $17,500,000

2. **Mill River Trail -** Overlooks, shade trees, walking paths
   Estimated Cost: $2,000,000

3. **Outfall Improvements -** Check valve/backflow retrofit, daylighting and new headwall
   Estimated Cost: $1,000,000

4. **Floodable Park and Gateway Property -** Acquisition and demolition of building at 451 Grand Avenue (and re-location of existing business), shade trees, floodable park development
   Estimated Cost: $4,600,000

5. **John W. Murphy Drive Elevation and Flood Barrier -** Road raising and flood berm/sheet pile, interior drainage/pump station, utility relocation, shade trees, paving, fencing/guide rail, side street connections
   Estimated Cost: $25,000,000

6. **Grand Avenue Road and Bridge Elevation -** Road raising, utility relocation, paving, retaining walls, bridge elevation/replacement
   Estimated Cost: $19,900,000

7. **Cooling/Resilience Corridors -** Tree plantings, green stormwater infrastructure
   Estimated Cost: $6,000,000

8. **Family Academy of Multilingual Exploration (FAME) School Parking Lot Cooling Improvements -** Shade structure and green roof, shade trees, plantings in existing play yard
   Estimated Cost: $2,600,000

TOTAL COST (-30% TO +50% ROUNDED) $55,000,000 - $117,900,000

EXISTING CONDITIONS

RESILIENT FAIR HAVEN

COOLING CORRIDOR CLAY STREET

COOLING CORRIDOR GRAND AVENUE

POTENTIAL REDEVELOPMENT AREA

ELEVATED JOHN W. MURPHY DRIVE AS FLOOD RISK REDUCTION

FLOODABLE PARK

NEIGHBORHOOD GATEWAY

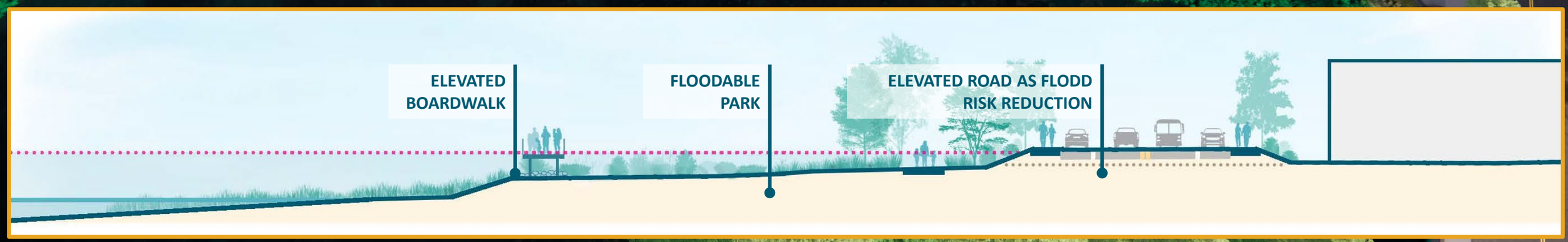
OUTFALL IMPROVEMENTS / DAYLIGHTING

ELEVATED BOARDWALK

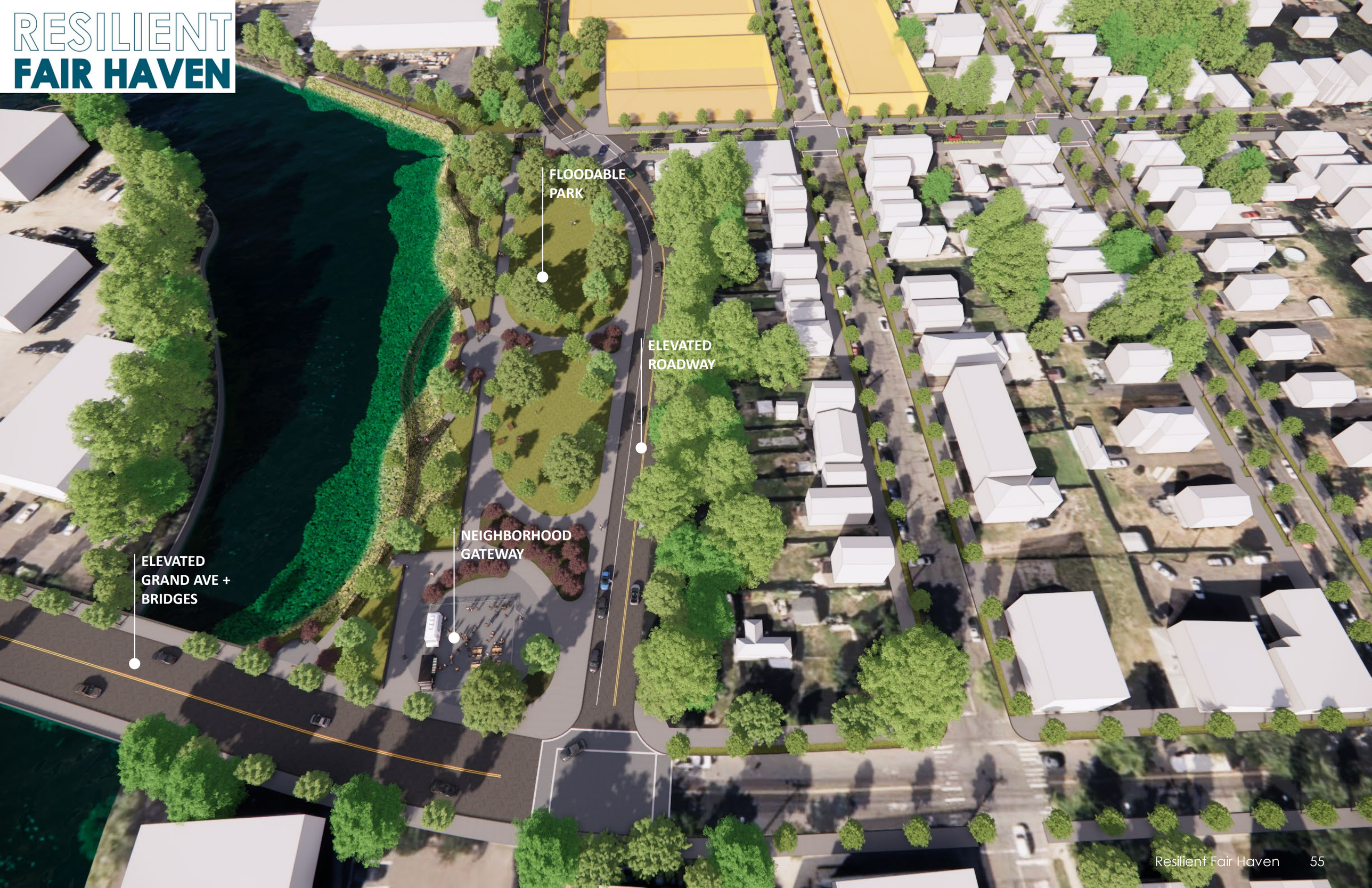
MILL RIVER TRAIL

LIVING SHORELINES

ELEVATED GRAND AVE + BRIDGES



RESILIENT FAIR HAVEN



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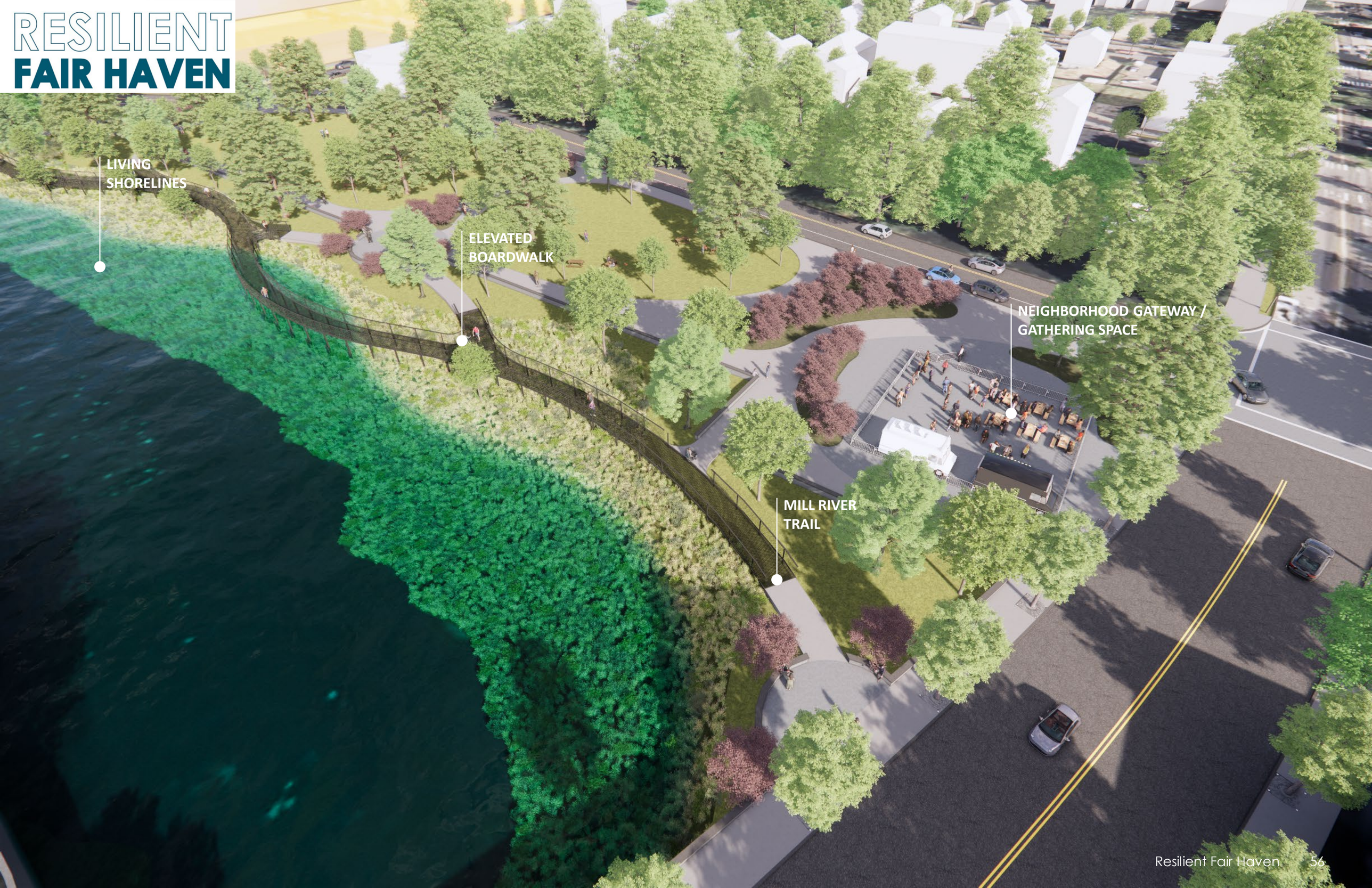

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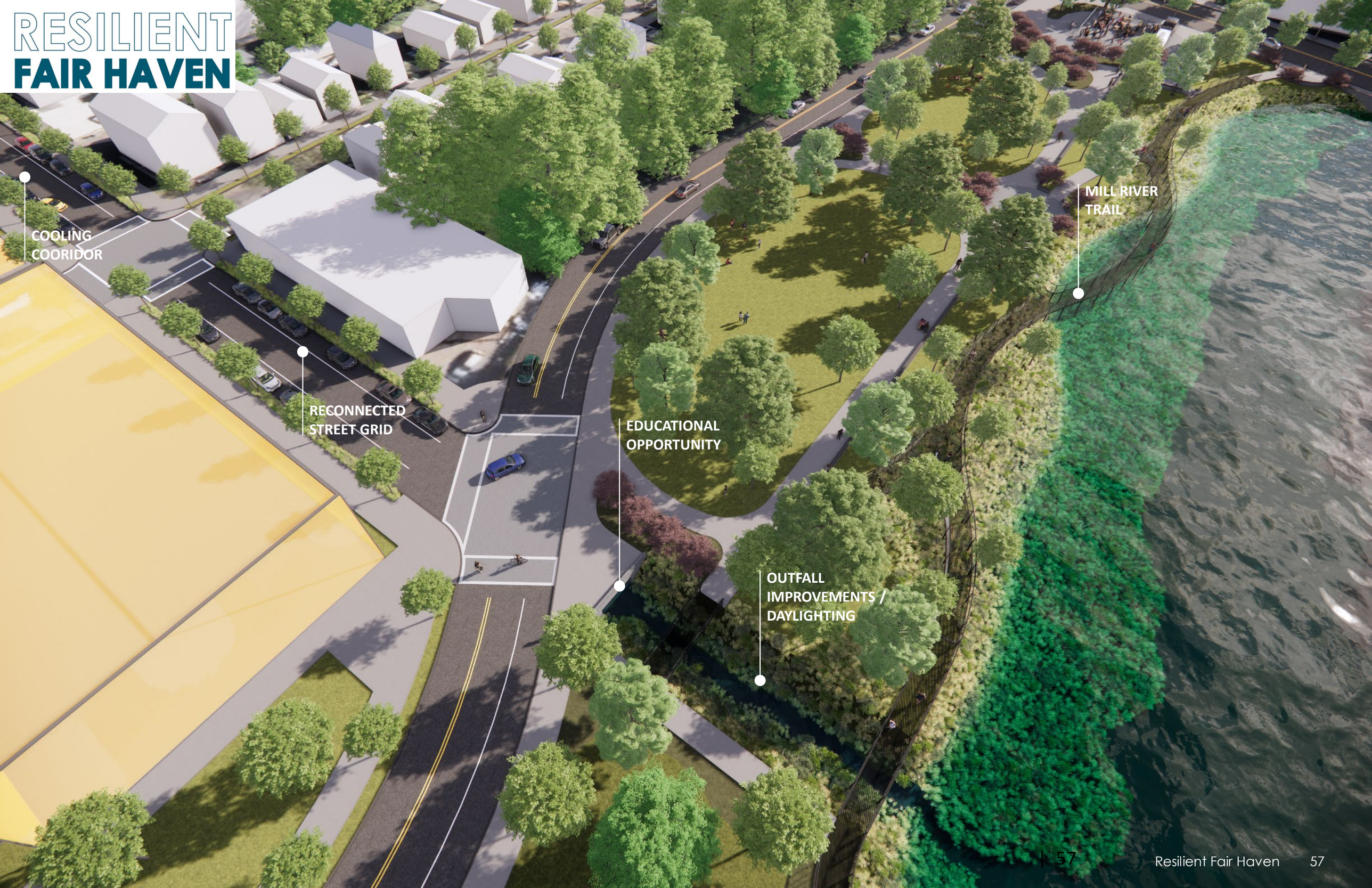
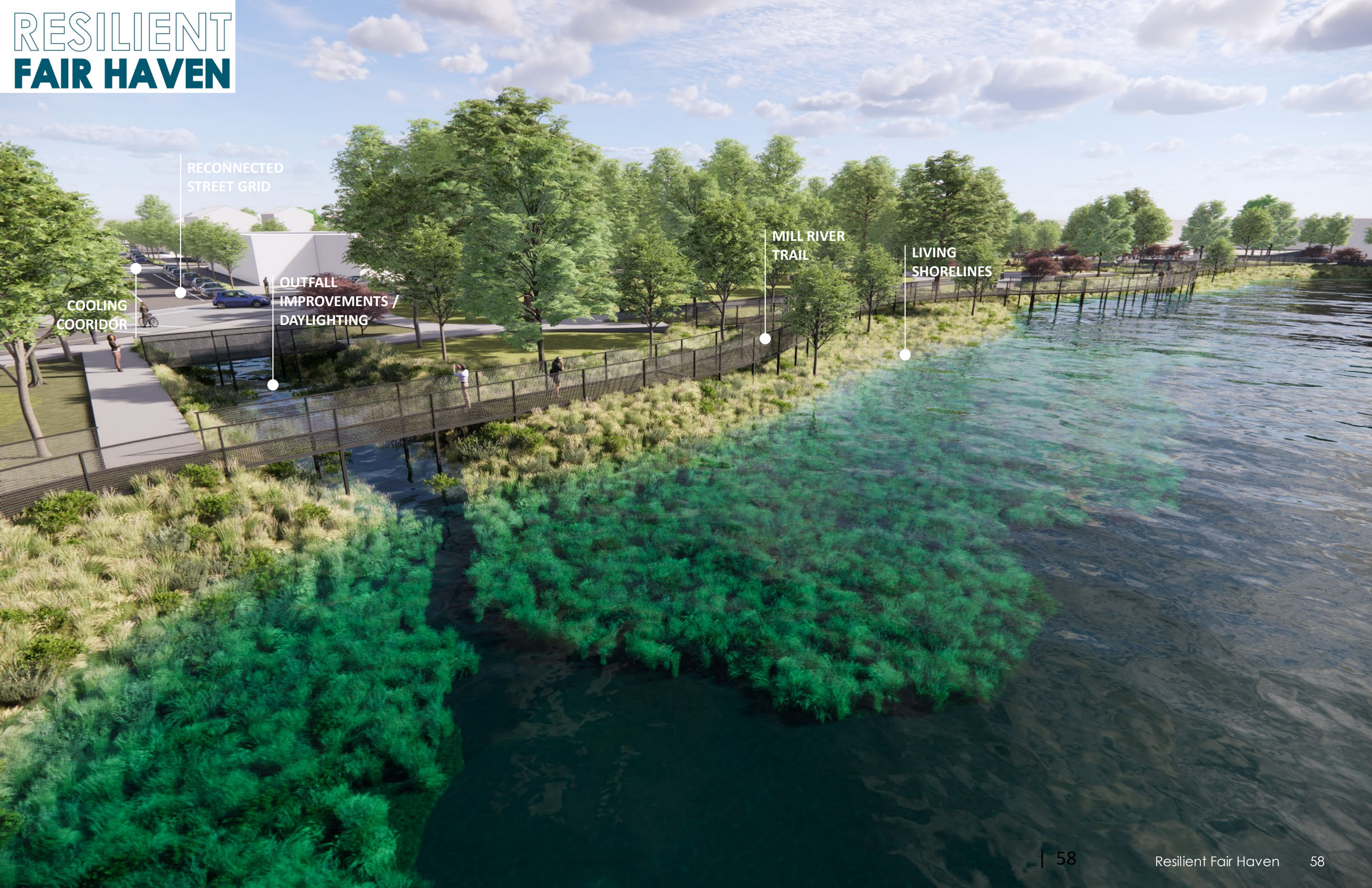
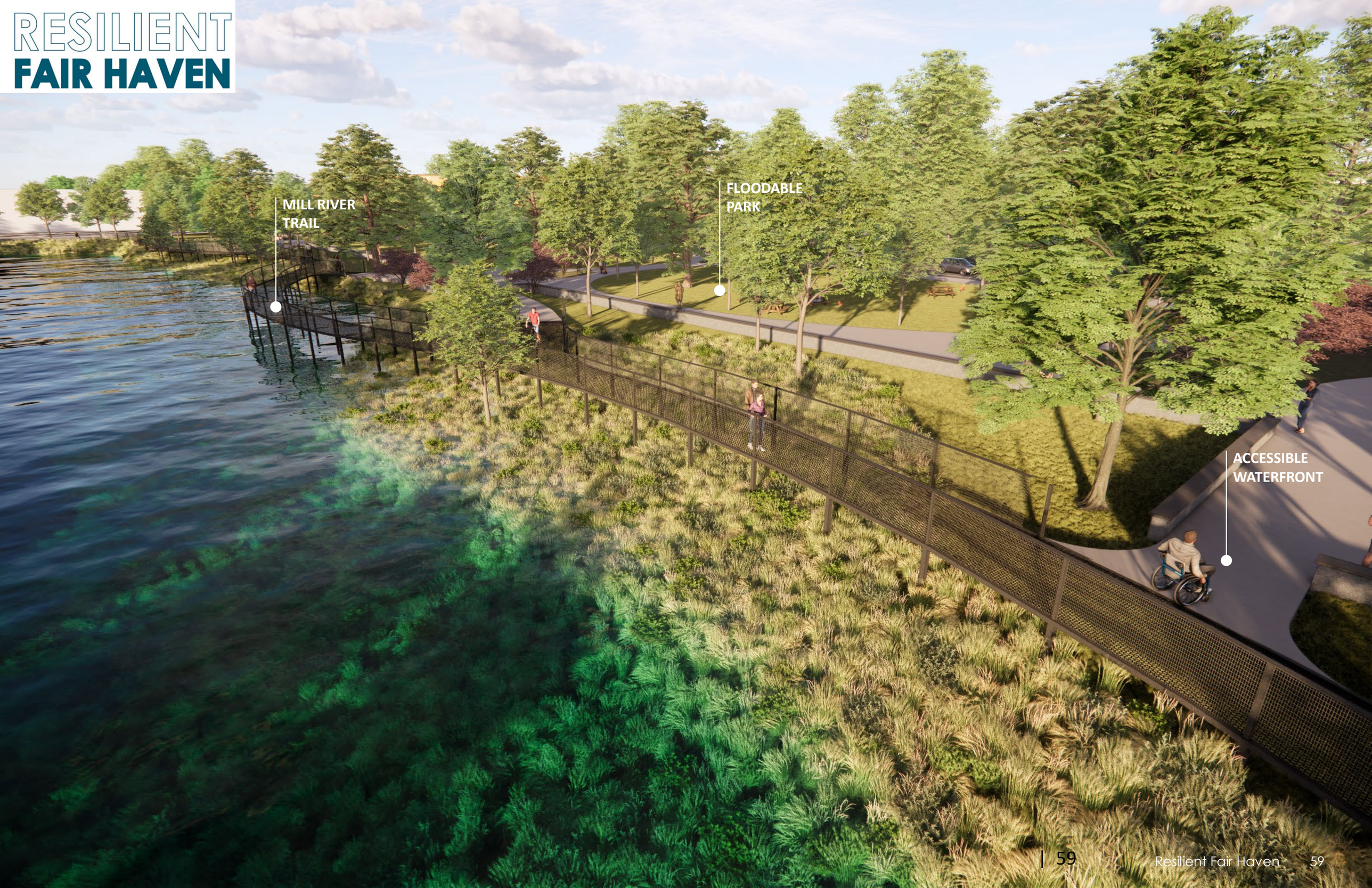



RECONNECTED
STREET GRID
COOLING
COORIDOR
OUTFALL
IMPROVEMENTS /
DAYLIGHTING
MILL RIVER
TRAIL
LIVING
SHORELINES

RESILIENT FAIR HAVEN



EXISTING CONDITIONS

RESILIENT FAIR HAVEN


OUTDOOR LIVING LAB
OUTDOOR LEARNING SPACE
SHADED PARKING AREA
SHADED PLAY SPACES
COOLING CORRIDOR

RESILIENT FAIR HAVEN

RESILIENT
FAIR HAVEN

IMPLEMENTATION ROADMAP: JOHN W. MURPHY DRIVE AREA

Implementation of the recommendations for the John W. Murphy Drive Area will require coordination between various City of New Haven departments – City Plan, Economic Development, Engineering, Parks & Public Works, Public Schools – and other organizations including CTDOT, Mill River Trail and Watershed Association, Fair Haven Community Management Team (CMT), and private property owners.

The proposed flood and heat resilience and shoreline improvements between Grand Avenue and 370 James Street will require more detailed planning and engineering, substantial funding, and partnerships between the City and private property owners. These projects are envisioned to be implemented over the next 10+ years.

Green infrastructure and cooling strategies should be implemented along the proposed cooling/resilience corridors as stand-alone retrofit projects or in conjunction with planned capital improvements such as roadway and streetscape projects as funding allows.

The FAME School parking cooling improvements could be pursued independently of the other recommendations and could serve as a pilot for public schools throughout New Haven.

IMPLEMENTATION CHALLENGES

- Agreements needed with private property owner at 370 James Street and for acquisition of property at 451 Grand Avenue
- Legacy contamination of industrial properties along Mill River
- Technical feasibility of John W. Murphy Drive road elevation/flood barrier, integration with existing road network & neighborhood as well as strengthening the neighborhood fabric and cohesion
- Technical feasibility of Grand Avenue road elevation and potential conflict with at-grade rail line west of Mill River

REGULATORY FEASIBILITY

- Remediation/management of contaminated soil and groundwater
- CT DEEP and US Army Corps of Engineers permitting for proposed shoreline improvements along Mill River

POTENTIAL FUNDING SOURCES

- CT DEEP Climate Resilience Fund (DCRF) – approximately $10 million annually for planning and development of flood and heat resilience projects
- CT DECD Community Investment Fund (CIF) – up to $175 million annually for capital projects that support economic and community development in underserved municipalities
- FEMA Building Resilient Infrastructure and Communities (BRIC) – $1 billion nationwide for community resilience projects that address flooding and extreme heat
- NOAA Climate Resilience Regional Challenge Grant (NOAA) – $575 million for regional collaborative projects that increase the resilience of coastal communities
- USFS Urban and Community Forestry Grants (USFS) – more than $1 billion nationally for projects that support urban communities through equitable access to trees. New Haven received a 2023 grant award for $362,000 to expand its urban forestry program.

RECOMMENDATIONS	ORGANIZATIONS	ACTIONS	NEAR TERM 0-3 YEARS	MID TERM 3-10 YEARS	LONG TERM 10+ YEARS
730 James Street Parking Lot & Urban Cooling Center $17,500,000	City of New Haven, Private Property Owner, Fair Haven CMT	Public private partnership between City and property owner Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
Mill River Trail, Outfall Improvements, Floodable Park and Gateway Property $7,600,000	City of New Haven, Mill River Trail & Watershed Association, Private Property Owner, Fair Haven CMT	Property acquisition (451 Grand Avenue) and remediation Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
John W. Murphy Drive Elevation and Flood Barrier $25,000,000	City of New Haven, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
Grand Avenue Road and Bridge Elevation $19,900,000	City of New Haven, CTDOT, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
Cooling/Resilience Corridors $6,000,000	City of New Haven, CTDOT (CT transit), Fair Haven CMT	Secure funding Design, permitting, and construction			
Family Academy of Multilingual Exploration (FAME) School Parking Lot Cooling Improvements $2,600,000	City of New Haven, New Haven Public Schools, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			

RESILIENT FAIR HAVEN

CLINTON PARK AREA

The recommended actions for the Clinton Park Area are aimed at addressing extreme heat risks in an area with a high percentage of socially vulnerable populations as well as ensuring that people don't get stuck, or wade into, flood waters during storm events on critical transportation connections. Below is a summary of the "Big Moves" recommended in this area. See the following page for a rendered conceptual plan highlighting the actions included in the Clinton Park Area as well as 3D renderings on the pages that follow.

One of the biggest issues in this focus area centers around the impacts from flooding of underpasses and blocked access points out of Fair Haven. The long-term physical mitigation solutions for this problem would involve the interstate highway and the railroad, which is a costly and long-term endeavor. In the shorter term, the concept proposes road closures and automated traffic barriers, similar to railroad crossing gates, to temporarily restrict vehicle access through the underpasses during high water events and reduce the incidence of stranded vehicles and the need for rescues.

The existing Dover Beach park area has a series of open spaces with structure play spaces throughout. This concept explores programmatic improvement opportunities to encourage use of the open space in a different way. Currently, the park has a hardened wall at the river's edge and this concept introduces the opportunity for an extensive and dynamic living shoreline, in some areas in front of the existing wall and in some areas allowing for the peeling back of the existing wall. This provides new access opportunities down to the river by using the existing boat launch in news ways as well as adding several other get-downs to the water's edge. This provides opportunities to access the water and use these spaces in different ways – to play and explore the floodable tide pool areas, which also reduce storm impacts and provide ecological enhancement.

Here, the goal is to maximize a multiuse landscape. Single use landscapes in a densely populated area are a thing of the past. Every green open space should provide multiuse opportunities for the user as well as maximize the function and diversity of the landscape from an ecological perspective.

The concept introduces new play areas with more splash pad opportunities and shade structures while also enhancing community connection through the establishment of a Quinnipiac Park trail extension with a long-term goal of providing full trail connection around the Fair Haven peninsula connecting to the Mill River Trail.

CLINTON PARK AREA (CONTINUED)

In the area around the Quinnipiac Terrace public housing complex, the concept looks to utilize the space's high value/ high performance landscapes, providing potential orchards for community food production, gathering spaces, shade tree improvement in open spaces but also streetscapes as well. Throughout the concept plan, shaded bus shelters are introduced as well as opportunities to expand public transit/bus routes to collect and move more people where existing bus routes are lacking.

Clinton Park and Clinton Avenue School are highly used community facilities but during school hours and on the weekends. Here we looked to provide a second example of a school as demonstration project for heat resilience as well as a community Resilience Hub. The plan looks to provide a nature-based playground at the corner of Bailey Street and Downing Street, built into the existing slopes to provide a unique experience providing diversified play for school and neighborhood children. The City could also explore the potential to convert surface parking at the school to pervious pavers or porous asphalt to use every opportunity to minimize the impacts to the site. The concept retains the current, valued uses of the recreational fields (soccer, baseball, cricket, softball, etc.) and looks to rearrange the space efficiently to maximize opportunities to utilize the edges and corners for green stormwater infrastructure and shaded areas of respite. The ball field improvements include a shaded measured loop trail that can be accessed from multiple locations from the community providing access to recreational activity onsite and aiding in community mental and physical health. Strengthening the mid-block connections between school building and the ballfields will also connect the neighborhood from the west through the school area and down to the waterfront, mimicking the axial connections that run east/west throughout the project areas with cooling corridors.

The plan also enhances the connection of the ballfields to the English Mall. The English Mall currently has a good amount of existing shade tree canopy. In this area, the concept calls for working with the existing vegetation to enhance this corridor. The plan considers adding green stormwater infrastructure opportunities and a meandering trail for passive recreation through the landscape areas, while still providing smaller gathering opportunities with the smaller turf areas to remain.

RESILIENT FAIR HAVEN

RECOMMENDED ACTIONS

1. **Dover Beach -** Trail, shade tree plantings, playground area, water play area, living shoreline, boat ramp and fishing access, plantings
   Estimated Cost: $4,300,000

2. **Public Housing Open Space Improvements -** Community orchard, small park, shade tree plantings, park redevelopment and green infrastructure in southeast open space
   Estimated Cost: $600,000

3. **Clinton Avenue School and Clinton Park -** Clinton Avenue School natural playground and green infrastructure, recreation field plantings, shade tree plantings, Clinton Park baseball and soccer fields, green infrastructure, and walking path
   Estimated Cost: $4,500,000

4. **English Mall -** Plantings (shrubs, perennials), shade tree plantings, trail, green infrastructure
   Estimated Cost: $2,100,000

5. **Cooling/Resilience Corridors -** Tree plantings and green stormwater infrastructure
   Estimated Cost: $$1,200,000

TOTAL COST (-30% TO +50% ROUNDED) $8,900,000 - $19,100,000

EXISTING CONDITIONS

RESILIENT FAIR HAVEN


ELEVATED
WATERFRONT PATH


SAFE FISHING
OPPORTUNITIES
ENHANCED TREE CANOPY
SURROUNDING PLAY SPACES

RESILIENT FAIR HAVEN


NATURE PLAYGROUND
COMMUNITY CONNECTOR
GREEN STORMWATER INFRASTRUCTURE
COOLING CORRIDOR
INCREASED SHADE OPPORTUNITIES
COOLING CORRIDOR


COOLING
CORRIDOR
COOLING
CORRIDOR
COMMUNITY
CONNECTOR
NATURE
PLAYGROUND
COMMUNITY
ORCHARD

RESILIENT FAIR HAVEN

RESILIENT
FAIR HAVEN

IMPLEMENTATION ROADMAP: CLINTON PARK AREA

Implementation of the recommendations for the Clinton Park Area will require coordination between various City of New Haven departments – City Plan, Engineering, Parks & Public Works, Public Schools – and other organizations including the Housing Authority of New Haven, Fair Haven Community Management Team (CMT), and CTDOT.

Improvements at Dover Beach, the nearby public housing, Clinton Avenue School, Clinton Park, and English Mall are envisioned to be implemented over the next 10+ years, with detailed planning (including community engagement) to be completed in the next 3 years.

Green infrastructure and cooling strategies should be implemented along the proposed cooling/resilience corridors as stand-alone retrofit projects or in conjunction with planned capital improvements such as roadway and streetscape projects as funding allows.

IMPLEMENTATION CHALLENGES

- City and community acceptance of proposed changes to existing parks and recreational facilities (Clinton Park, Dover Beach, etc.)
- Public health and safety (water quality, flow velocities near I-91 bridge) associated with enhanced public access and use of Dover Beach and the Quinnipiac River for increased water-based recreation

REGULATORY FEASIBILITY

- CT DEEP and US Army Corps of Engineers permitting for proposed shoreline improvements at Dover Beach

POTENTIAL FUNDING SOURCES

- CT DEEP Climate Resilience Fund (DCRF) – approximately $10 million annually for planning and development of flood and heat resilience projects
- CT DECD Community Investment Fund (CIF) – up to $175 million annually for capital projects that support economic and community development in underserved municipalities
- FEMA Building Resilient Infrastructure and Communities (BRIC) – $1 billion nationwide for community resilience projects that address flooding and extreme heat. The preliminary BCA for this concept indicates cost-effectiveness of the proposed mitigation actions (BCR of 1.0 or greater), making these projects eligible for BRIC funding.
- NOAA Climate Resilience Regional Challenge Grant (NOAA) – $575 million for regional collaborative projects that increase the resilience of coastal communities
- USFS Urban and Community Forestry Grants (USFS) – more than $1 billion nationally for projects that support urban communities through equitable access to trees. New Haven received a 2023 grant award for $362,000 to expand its urban forestry program.

RECOMMENDATIONS	ORGANIZATIONS	ACTIONS	NEAR TERM 0-3 YEARS	MID TERM 3-10 YEARS	LONG TERM 10+ YEARS
Dover Beach Improvements $4,300,000	City of New Haven, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
Public Housing Open Space Improvements $600,000	Housing Authority of New Haven, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
Clinton Avenue School and Clinton Park $4,500,000	City of New Haven, New Haven Public Schools, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
English Mall Improvements $2,100,000	City of New Haven, Fair Haven CMT	Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
Cooling/Resilience Corridors $1,200,00	City of New Haven, CTDOT (CT transit), Fair Haven CMT	Secure funding Design, permitting, and construction			

RESILIENT
FAIR HAVEN

IMPLEMENTATION ROADMAP: OTHER RECOMMENDATIONS

This project identified other site-specific and Fair Haven-wide resilience recommendations in addition to the recommendations for the John W. Murphy Drive and Clinton Park Areas. These include several physical, programmatic, and policy-related actions that the City and other organizations can take over the next few years to make Fair Haven more resilient to existing and future flooding and extreme heat.

Implementation of these recommendations will require coordination between various City of New Haven departments – Engineering, Emergency Management and Public Safety, Parks & Public Works – and other organizations including CTDOT, Fair Haven Community Management Team (CMT) and community service organizations, and private property owners.

The proposed Resilience Hub and evacuation route and road closure system are near term actions ("low-hanging fruit") that should be pursued within the next 3 years. Coordination will be necessary between the City and CTDOT (CT transit), the Connecticut Department of Emergency Management and Homeland Security (DEMHS), and private owners of proposed resilience hub facilities.

IMPLEMENTATION CHALLENGES

- Coordination and agreements (e.g., Memorandum of Understanding) needed with private property owners for use of private facilities as resilience hubs or as part of a network of cooling centers or emergency shelters.
- Community outreach and engagement for effective implementation of formalized evacuation routes and road closure system during major flooding and related events

REGULATORY FEASIBILITY

- CT DEEP and US Army Corps of Engineers permitting for proposed shoreline improvements at Dover Beach

POTENTIAL FUNDING SOURCES

- CT DEEP Climate Resilience Fund (DCRF) – approximately $10 million annually for planning and development of flood and heat resilience projects
- CT DECD Community Investment Fund (CIF) – up to $175 million annually for capital projects that support economic and community development in underserved municipalities.
- FEMA Building Resilient Infrastructure and Communities (BRIC) – $1 billion nationwide for community resilience projects that address flooding and extreme heat
- NOAA Climate Resilience Regional Challenge Grant (NOAA) – $575 million for regional collaborative projects that increase the resilience of coastal communities. CIRCA is in the process of seeking NOAA funding for implementation of resilience hubs in several CT communities including Fair Haven.
- USFS Urban and Community Forestry Grants (USFS) – more than $1 billion nationally for projects that support urban communities through equitable access to trees. New Haven received a 2023 grant award for $362,000 to expand its urban forestry program.

RECOMMENDATIONS	ORGANIZATIONS	ACTIONS	NEAR TERM 0-3 YEARS	MID TERM 3-10 YEARS	LONG TERM 10+ YEARS
Resilience Hub & Cooling Center Network	City of New Haven, State/Private Facility Owners, Community Service Organizations, Fair Haven CMT, CIRCA	Outreach to existing community service providers to discuss needs related to resilience hubs in Fair Haven, and detailed facility evaluation & selection Develop and execute agreements (MOU) Secure funding Implement improvements			
Evacuation Route and Road Closure System	City of New Haven, CT DEMHS, CTDOT, Fair Haven CMT	Formalize evacuation routes and closure locations Secure funding for improvements Implement systems			
Cool and Safe Transportation	City of New Haven, CTDOT, SCRCOG, Fair Haven CMT	Improve access to cool, safe, and accessible routes for walking, biking or using public transit in extreme heat			
Efficient Air Conditioning in Schools, Libraries, and Community Centers	City of New Haven	Improve access to air conditioning and healthy energy repairs at public schools, libraries, and recreation centers in Fair Haven and City-wide			
Staying Cool and Safe at Home	City of New Haven, Eversource	Energy Efficient Appliances and Home Repairs Strategic and Inclusive Heat Outreach Year-Round Utility Assistance			
Urban Forest Enhancement	City of New Haven	Improving access to tree plantings and education about tree care and maintenance for residents in Fair Haven Expand City street tree list Neighborhood greening by improving access to greening and open space Formation of GreenCorps local job training program for young adults in Fair Haven			

RESILIENT FAIR HAVEN

BENEFIT-COST ANALYSIS

BCA Methods

A preliminary FEMA benefit cost analysis (BCA) was performed to assess the cost effectiveness of proposed mitigation concepts for the Clinton Park and John W. Murphy Drive focus areas. BCA is a method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs. The result is a Benefit-Cost Ratio (BCR). A project is considered cost-effective when the BCR is 1.0 or greater.

A separate BCA was performed for the two focus areas using the FEMA BCA tool (Version 6.0). The BCA calculates costs and benefits for individual mitigation actions that comprise the flood and heat resilience concepts for each focus area. **Table 1** summarizes mitigation actions that were included in the BCA for each focus area.

Order of magnitude opinions of probable cost for the proposed mitigation concepts were developed from unit costs, based on industry standard sources and professional judgement, and estimated quantities. Estimated costs included engineering, legal, and administrative costs, which were estimated at 30% of total construction costs. The cost estimates were also broken down into mitigation costs, which were included in the BCA, and non-mitigation costs (i.e., not directly related to the project's mitigation actions), which were excluded from the BCA. **Table 2** summarizes the estimated project costs used in the BCA.

Project benefits for the various flood and heat mitigation actions were estimated using the FEMA BCA Tool. Benefits were estimated for urban trees (cooling corridors); green stormwater infrastructure including bioretention and green roofs; ecosystem services associated with living shoreline, updating urban parks, and installing trails and walking paths; flood damages avoided due to creation of a flood barrier and elevation of John W. Murphy Drive, as well as elevating Grand Avenue and the associated bridges over the Mill River; and acquisition of the Grand Paint home improvement store located at 451 Grand Avenue.

The BCA was run for both focus areas using 7% and 3% discount rates, as the FEMA BRIC grant program allows the use of the 3% discount rate in the BCA calculation. An aggregate BCR was calculated for all the mitigation actions in each focus area. BCAs were run for several versions of the John W. Murphy Drive mitigation concepts since the costs of some of the individual mitigation actions were high without a lot of quantifiable project benefits. Version 1 includes all the mitigation actions and has the highest cost. Version 2 removes the Grand Avenue mitigation action from the BCA. Version 3 removes Grand Avenue, the green roof at the FAME school, and partial daylighting of an existing drainage outfall along the Mill River. Version 4 shows how uncertainty in the planning level cost estimate is influencing the results. **Table 3** includes a summary of the aggregate BCRs for both focus areas and the various scenarios considered for John W. Murphy Drive.

Additional details of the BCA methodology and results are provided in **Appendix X**.

BCA Results

Clinton Park Area

The aggregate BCR for the Clinton Park mitigation concept ranges from 1.31 to 1.97 when using a 7% and 3% discount rate, respectively. The aggregate BCR exceeds 1.0 and therefore the overall mitigation concept is considered cost effective.

John W. Murphy Drive Area

The project cost is high for the quantifiable benefits of this mitigation concept. The aggregate BCR is less than 1.0 for most of the scenarios considered. Individual mitigation actions and certain combinations of mitigation actions can result in a BCR of 1.0 or greater. In general, removing the Grand Avenue mitigation action and the shade structure/green roof at the FAME school results in an aggregate BCR of greater than 1.0 at a 7% discount rate and using a higher ($250/sf Building Replacement Value or BRV). When a lower (3%) discount rate is used, there are more options to achieve cost effectiveness, including removing the Grand Avenue mitigation action only.

Overall, some of the proposed mitigation actions in the John W. Murphy Drive mitigation concept are likely cost effective and eligible for FEMA Hazard Mitigation Assistance grant funding, while others cannot achieve cost effectiveness as defined by FEMA and would require other sources of funding for implementation.

TABLE 1. BENEFIT-COST ANALYSIS MITIGATION ACTIONS

MITIGATION TYPE	CLINTON PARK AREA	JOHN W. MURPHY DRIVE AREA
Green Infrastructure	Trees Bioretention	Trees Bioretention Green Roof
Drainage Improvements	Ecosystem Services	Ecosystem Services
Road Elevation		John W. Murphy Drive (flood barrier) Grand Avenue and Bridges
Acquisition		451 Grand Avenue

TABLE 2. ESTIMATED PROJECT COSTS

MITIGATION SCENARIO	CLINTON PARK AREA	JOHN W. MURPHY DRIVE AREA[1]
Total Cost	$12,711,602	$78,550,636
Mitigation Total – Version 1	$11,068,118	$60,860,365
Mitigation Total – Version 2 Removing Grand Avenue	--	$40,986,520
Mitigation Total – Version 3 Removing Grand Avenue, FAME School Green Roof, and Ecosystem Services	--	$35,095,725
Mitigation Percentage of Total Cost	87%	45-77%
70% of Total Cost – Version 4 Lowest Cost in Range	$8,900,000	$55,000,000

Notes: [1] Protection to existing FEMA 100-year Base Flood Elevation (12 FT)

TABLE 3. BENEFIT-COST RATIOS

MITIGATION SCENARIO	CLINTON PARK AREA		JOHN W. MURPHY DRIVE AREA		JOHN W. MURPHY DRIVE AREA[1]	
Discount Rate	7%	3%	7%	3%	7%	3%
Version 1	1.31	1.97	0.32	0.53	--	--
Version 2	--	--	0.47	0.78	--	--
Version 3	--	--	0.53	0.89	--	--
Version 4	--	--	--	--	0.66	**1.10**
Version 2 with $250/SF BRV	--	--	0.68	**1.18**	--	--
Version 3 with $250/SF BRV	--	--	0.77	**1.35**	--	--
Version 4 with $250/SF BRV	--	--	--	--	0.95	**1.66**

Notes: [1] Uses low end of cost range (70% of estimated cost)

APPENDICES

APPENDIX A – OPINION OF PROBABLE COST

ORDER OF MAGNITUDE OPINION OF COST

FUSS & O'NEILL

SHEET:	1 OF 1
PROJECT: Resilient Fair Haven	DATE PREPARED: 11/07/23
LOCATION: New Haven, CT	ESTIMATOR: LS
DESCRIPTION: **Concept Level Cost Estimate for Clinton Park Area**	CHECKED BY: DA/EM
	PROJECT NO.: 20191105.A10

	ITEM DESCRIPTION	UNITS	NUM. OF UNITS	COST PER UNIT	TOTAL COST
1	**General Conditions**				
	Mobilization & Demobilization (5%)	LS	1	$425,500.00	$425,500
	Insurance and Bonds (5%)	LS	1	$425,500.00	$425,500
	Subtotal				**$851,000**
2	**Site Preparation**				
	Construction Survey Layout & As-Built Mapping (4%)	LS	1	$340,400.00	$340,400
	Traffic Control (1.5%)	LS	1	$127,700.00	$127,700
	Utility Coordination (2%)	LS	1	$170,200.00	$170,200
	Erosion and Sediment Control (5%)	LS	1	$425,500.00	$425,500
	Site Prep (demolition, clearing) (2%)	LS	1	$170,200.00	$170,200
	Subtotal				**$1,234,000**
2	**Clinton Park Area**				
1)	**Dover Beach**				
	8' Wide Trail	SF	6,400	$10.00	**$64,000**
	Shade Tree Plantings	EA	100	$750.00	**$75,000**
	Playground Area	Allowance	2	$150,000.00	**$300,000**
	Water Play Area	Allowance	1	$300,000.00	**$300,000**
	Living shoreline w/tide pools	SF	74,264	$25.00	**$1,856,600**
	Boat ramp + fishing access	Allowance	2	$100,000.00	**$200,000**
	Plantings (not including trees)	SF	35,394	$3.00	**$106,182**
2)	**Affordable Housing Open Spaces**				
	Community orchard Tree Planting in NE open space	EA	56	$400.00	**$22,400**
	Small park	SF	3,800	$3.00	**$11,400**
	Shade Tree Plantings	EA	25	$750.00	**$18,750**
	Park redevelopment in SE open space	SF	22,000	$3.00	**$66,000**
	Park redevelopment in SE open space - GI	SF	7,000	$40.00	**$280,000**
3)	**Clinton Avenue School and Clinton Park**				
	Clinton Ave School - natural playground	Allowance	1	$100,000.00	**$100,000**
	Clinton Ave School - GI (off-ROW)	SF	7,000	$40.00	**$280,000**
	Recreation field - plantings	Allowance	1	$60,000.00	**$60,000**
	Shade Tree Plantings	EA	100	$750.00	**$75,000**
	Clinton Park - baseball and soccer fields	Allowance	2	$100,000.00	**$200,000**
	Clinton Park - GI (off-ROW)	SF	55,000	$40.00	**$2,200,000**
	Clinton Park - walking path	LF	6,852	$10.00	**$68,520**
4)	**English Mall**				
	Plantings (shrubs, perennials)	SF	37,900	$3.00	**$113,700**
	Shade Tree Plantings	EA	95	$750.00	**$71,250**
	Trail	LF	1,000	$10.00	**$10,000**
	Green infrastructure (off-ROW)	SF	30,100	$40.00	**$1,204,000**
5)	**GI / Resilience Corridors**				
	Tree plantings (will need to assume planting density)	EA	320	$750.00	**$240,000**
	Green infrastructure (assume 5 ft width, 1/10 block length)	SF	4,180	$140.00	**$585,200**
	Subtotal				**$8,508,002**
	TOTAL CONSTRUCTION COST				$10,593,002
	ENGINEERING/LEGAL/ADMINISTRATIVE (20%)				$2,118,600
	SUBTOTAL				$12,720,000
	TOTAL COST (-30% TO +50% ROUNDED)				**$8,900,000 TO $19,100,000**

ORDER OF MAGNITUDE OPINION OF COST

FUSS & O'NEILL

PROJECT:	Resilient Fair Haven
LOCATION:	New Haven, CT
DESCRIPTION:	**Concept Level Cost Estimate for John W. Murphy Drive Area**
SHEET:	1 OF 1
DATE PREPARED:	11/07/23
ESTIMATOR:	LS
CHECKED BY:	DA/EM
PROJECT NO.:	20191105.A10

	ITEM DESCRIPTION	UNITS	NUM. OF UNITS	COST PER UNIT	TOTAL COST
1	**General Conditions**				
	Mobilization & Demobilization (5%)	LS	1	$2,426,700.00	$2,426,700
	Insurance and Bonds (5%)	LS	1	$2,426,700.00	$2,426,700
	Subtotal				**$4,853,400**
2	**Site Preparation**				
	Construction Survey Layout & As-Built Mapping (4%)	LS	1	$1,941,312.24	$1,941,312
	Traffic Control (1.5%)	LS	1	$727,992.09	$727,992
	Utility Coordination (2%)	LS	1	$970,656.12	$970,656
	Erosion and Sediment Control (5%)	LS	1	$2,426,700.00	$2,426,700
	Site Prep (demolition, clearing) (2%)	LS	1	$970,700.00	$970,700
	Subtotal				**$7,037,360**
3	**John W Murphy Drive Area**				
1)	**370 James Street Parking Lot + Urban Cooling Center**				
	Pavement removal (full depth)	SF	236,000	$5.00	**$1,180,000**
	Shade Trees	EA	100	$750.00	**$75,000**
	Parking garage (Assumes 5 Decks at 125 spots per deck)	EA	5	$1,750,000.00	**$8,750,000**
	8' Wide Walking path	LF	2,600	$80.00	**$208,000**
	Natural Restoration Area	SF	55,000	$6.00	**$330,000**
	Plantings	SF	60,100	$5.00	**$300,500**
2)	**Mill River Trail**				
	Overlooks	EA	2	$500,000.00	**$1,000,000**
	Shade Trees	EA	50	$750.00	**$37,500**
	8' Wide Walking path	LF	1,500	$80.00	**$120,000**
	10' Wide Walking path	LF	685	$90.00	**$61,650**
3)	**Outfall**				
	Outfall backflow retrofit	Allowance	1	$350,000.00	**$350,000**
	Daylighting and new headwall	Allowance	1	$250,000.00	**$250,000**
4)	**Floodable Park+ Gateway Property (no development included)**				
	Acquisition (451 Grand Avenue)	Allowance	1	$1,200,000.00	**$1,200,000**
	Demolition (disposal of classified material not assumed)	Allowance	1	$200,000.00	**$200,000**
	Shade Trees	EA	50	$750.00	**$37,500**
	Floodable park development	SF	35,500	$40.00	**$1,420,000**
6)	**John W Murphy Drive Road Raising**				
	Pavement removal	SF	72,000	$3.00	**$216,000**
	Flood Berm	CY	17,333	$97.00	**$1,681,301**
	Interior drainage/ pump station	Allowance	1	$5,000,000.00	**$5,000,000**
	Shade Trees	EA	85	$750.00	**$63,750**
	Side Slope Fill	CY	3,250	$65.00	**$211,250**
	Utility relocation/resetting utility structures	Allowance	1	$2,000,000.00	**$2,000,000**
	Sheet Pile assumes 26' depth	SF	46,800	$70.00	**$3,276,000**
	Asphalt	Ton	3,136	$170.00	**$533,120**
	Gravel Borrow	CY	2,667	$65.00	**$173,355**
	Fencing (6' tall)	LF	1,800	$100.00	**$180,000**
	Guide Rails	LF	1,800	$50.00	**$90,000**
	John W. Murphy Side Street Connections (3 @ 160 LF)	Allowance	1	$2,000,000.00	**$2,000,000**
7)	**Grand Ave Bridge Elevations**				
	Pavement removal	SF	62,700	$3.00	**$188,100**
	Fill for road raising	CY	9,500	$65.00	**$617,500**
	Utility relocation/resetting utility structures	Allowance	1	$1,500,000.00	**$1,500,000**
	Asphalt	Ton	2,730	$170.00	**$464,100**
	Gravel Borrow	CY	2,322	$65.00	**$150,930**
	Retaining Wall	LF	1,900	$500.00	**$950,000**
	Bridge Rail	LF	430	$500.00	**$215,000**
	Guide Rails	LF	1,470	$50.00	**$73,500**
	Guide Rail Transitions	LS	8	$15,000.00	**$120,000**
	Structural supports/piers/bridge deck	EA	2	$4,000,000.00	**$8,000,000**
8)	**GI / Resilience Corridors**				
	Tree plantings (will need to assume planting density)	EA	280	$750.00	**$210,000**
	Green infrastructure (assume 5 ft width, 1/10 of block length)	SF	25,000	$140.00	**$3,500,000**
9)	**Family Academy Parking Lot Cooling Improvements**				
	Green Roof / Shade structure over existing parking lot	Allowance	1	$1,500,000.00	**$1,500,000**
	Shade Trees	EA	65	$750.00	**$48,750**
	Plantings withing existing play yard	Allowance	1	$50,000.00	**$50,000**
	Subtotal				**$48,532,806**
	TOTAL CONSTRUCTION COST				$60,423,566
	ENGINEERING/LEGAL/ADMINISTRATIVE (30%)				$18,127,070
	SUBTOTAL				$78,560,000
	TOTAL COST (-30% TO +50% ROUNDED)				**$55,000,000 TO $117,900,000**

Notes

1. Estimate excludes handling and disposal of any contaminated soil

APPENDIX B – BCA BACKUP DOCUMENTATION

Dewberry

RESILIENT FAIR HAVEN NARRATIVE REPORT SUMMARY

PREPARED FOR: Sara Morrison and Erik Mas, Fuss & O'Neil

PREPARED BY: Kelly Rosofsky, John Squerciati & Scott Choquette, Dewberry

DATE: November 14, 2023

SUBJECT: Resilient Fair Haven BCA Narrative Report Summary

This memorandum provides a narrative summary of the FEMA Benefit Cost Analysis (BCA) completed for the Clinton Park and John W. Murphy Drive Projects in Fair Haven, developed by Fuss & O'Neil for the Resilient Fair Haven project. A full technical report, including the generated BCA reports and all associated back up data will be provided under a separate transmittal.

BCA Development

A FEMA benefit cost analysis (BCA) was performed to assess the cost effectiveness of proposed mitigation alternatives for the Clinton Park and John W. Murphy Drive Resilience Projects. The FEMA BCA tool (Version 6.0) is a Microsoft Excel-based software which calculates benefits based on a damage-frequency relationship. Certain hazard mitigation strategies in the BCA software are modeled and some require historic damage events or professionally developed damage projections. This memo summarizes the BCA approaches taken, the data requirements and assumptions, and the results of the BCA for the multiple proposed flood mitigation and heat mitigation project alternatives for New Haven, CT.

One BCA project was developed for each location. The BCA calculates project costs and project benefits for individual mitigation actions within a project. This was necessary for the Clinton Park and John W. Murphy project areas because these projects include multiple components. Based on the different modeled approaches in the BCA, mitigation actions were assigned as shown in Table 1.

Table 1. Benefit Cost Analysis (BCA) Mitigation Actions

	Clinton Park	John W Murphy Drive
Green Infrastructure	Trees	Trees
	Bioretention	Bioretention
		Green Roof
Drainage Improvement	Ecosystem Services	Ecosystem Services
Road Elevation		John W Murphy Drive
		Grand Avenue Bridge
Acquisition		451 Grand Avenue

Cost Summary

A summary of the total project cost is based on the Fuss and O'Neill Opinion of Probable Cost spreadsheet. The costs are broken down into line-item unit costs for each activity site within the Clinton Park or John W. Murphy project area. Additionally, general conditions, site preparation and engineer/legal/administrative cost estimates are added to the total. For the BCA these costs needed to be summarized by mitigation action activity, as opposed to being totaled by site or using the total project estimate. Each line item was checked for relevance to the mitigation objectives of the project and assigned to the mitigation actions used for the BCA, as shown in Table 1. The general line items, site prep, engineering, etc., were divided among the mitigation actions and non-mitigation scope of work based on the total construction costs for each. Mitigation action #1, that amounted to 10% of the construction cost, for instance, had 10% soft costs added to it. The resulting cost estimates are shown in Table 2. Additionally, different versions of the BCA projects were run to analyze the results. In some cases, mitigation actions were removed from the BCA which means the costs associated with those activities, such as elevating Grand Ave, would not be included in a grant application if they are excluded from the BCA The mitigation percentage of total costs is the amount included in the BCA. Other The cost line items are not directly related to the project's mitigation actions, such as building a parking garage, so these were excluded from the BCA as well.

Table 2. Project Costs

	Clinton Park	John Murphy Cost Est. 1	John Murphy Cost Est. 2
Total Cost	$12,711,602	$76,253,415	$78,550,636
Mitigation Total (Version 1)	$11,068,118	$58,563,181	$60,860,365
Mitigation Total removing Grand Ave. (Version 2)	N/A	$39,259,898	$40,986,520
Mitigation Total removing Grand Ave, Green Roof and Ecosystem Services (Version 3)	N/A	N/A	$35,095,725
Mitigation Percentage of Total Cost	87%	51-77%	45-77%
70% of Total Cost (Lowest Cost in Range) (Version 4)	$9,025,237	$53,400,000	$55,000,000

Data Collection

The data needed to run the BCA is:

- Project scope of work
- Cost data (Fuss and O'Neill Opinion of Probable Cost)
- Measurement of areas for land improvements and/or green infrastructure installations
- Count of urban trees to be planted.
- Ground surface and existing road elevations (John W. Murphy Drive and Grand Avenue)
- FEMA flood data and/ CIRCA coastal modeling of the 100-year return frequency with sea level rise (SLR) showing flood elevations or depth of flooding.
- Building properties (including building type, building area, foundation type, number of stories, first floor elevation, adjacent grade elevation, building replacement value, and number of occupants)
- Road elevation after mitigation

Analysis

A BCA was run for the Clinton Park project using both the 7% and the 3% discount rates. Both have cost ratios of over 1.0 which make them cost effective projects at this stage of development.

The BCA for the John W. Murphy Drive project area (Version 1) includes all the applicable mitigation costs for the project, even the mitigation actions that yield low benefits. A project BCR is the sum of the mitigation action's benefit and cost results. It is also known as an aggregate BCR. These project types can achieve cost effectiveness without all the mitigation action BCRs being above 1. Therefore, the BCR of Version 1 is, roughly, the highest that can be achieved for the largest potential grant funding request.

There are two cost estimates. Cost Estimate #1 is the John W. Murphy Road elevation to 11.5 FT (CIRCA modeled 100-year BFE + SLR) and Cost Estimate #2 is the road elevation of 12.5 FT (FEMA 100-year BFE). The project cost increases between Cost Estimate #1 and Cost Estimate #2, but the benefits increase as well. The cost estimate was refined by Fuss and O'Neill in November 2023 and the difference between Cost Estimate #1 and #2 is minimal, an approximate $2M difference. For that reason, it makes the most sense to analyze the Cost Estimate #2 since it yields higher benefits for the singular John W. Murphy Road elevation mitigation action.

A revision was made, in BCA Version 2, to remove the Grand Avenue bridge elevation from the mitigation actions in the aggregate BCA. This reduces the overall project cost but increases the BCR because the benefits of the Grand Ave mitigation action are almost 0, in terms of physical damages.

BCA Version 3 was created after looking at the individual BCR results of the project and realizing that some project actions, such as adding green roof elements, had high construction costs without a lot of quantifiable project benefits. When added to the other mitigation activities, this mitigation action in the BCA brought down the aggregate BCR. The same was true for the ecosystem services benefit which was included in a drainage improvement mitigation action. Grand avenue, the green roof and the ecosystem services benefit mitigation actions were all removed in Version 3 which yielded a higher aggregate BCR.

BCA Version 4 was created to show how the cost estimate is influencing the results. Cost Estimate #2 (Version 2) was reduced by 30% to represent the lower value in the cost estimate range, $55,000,000. This was applied to the project costs as well as to the annual maintenance estimates in the BCA. Grand Avenue is removed from this BCA, but the ecosystem services and green roof costs are included.

Finally, the BRV was derived from actual tax assessment information of structural value and living area. The FEMA default of $100 was used if the calculated cost per square foot was below this value, and

nothing higher than $250 was used. Instead of using a different BRV for each impacted structure in the road elevation and acquisition mitigation action analysis, a straight $250 BRV was used for all structures. This improved the benefits for both the John W. Murphy Road elevation and the acquisition actions.

Table 3. Benefit Cost Ratios (BCR) and Results

	Clinton Park		John Murphy Cost Est. 1		John Murphy Cost Est. 2		John Murphy Cost Est. 2-Lowest Cost in Range	
Discount Rate	7%	3%	7%	3%	7%	3%	7%	3%
Version 1	1.31	1.97	0.32	0.53	0.32	0.53		
Version 2	--	--	0.48	0.79	0.47	0.78		
Version 3	--	--	--	--	0.53	0.89		
Version 4	--	--	--	--			0.66	**1.1**
Version 2 with $250 BRV	--	--	0.68	1.18	0.68	**1.18**		
Version 3 with $250 BRV	--	--	--	--	0.77	**1.35**		
Version 4 with $250 BRV	--	--	--	--			0.95	**1.66**
Version 2	Removes Grand Avenue mitigation action from BCA							
Version 3	Removes Grand Avenue, Green Roof, and Ecosystem Services mitigation actions from BCA							
Version 4	Uses 71% of the total of Cost Estimate #2 which was the lower amount in the range (~$55,000)							

As shown in Table 3, all BCAs were analyzed using both the 7% and the 3% discount rate. For BRIC the 3% rate may be used in the BCA calculation.

Results

The project cost is high for the quantifiable benefits of this project. Therefore, the BCR is less than 1 in most cases. A BCR of 1.0 or higher is needed to prove cost effectiveness.

7% Rate

If the cost can be reduced significantly, such as in Version 4 with the $250 BRV, the project is close to a BCR of 1.0 at the 7% discount rate and over 1.0 for the 3% discount rate. A combination of Version 3 and Version 4 can get this aggregate BCR over 1.0. The combination, if only Grand Ave and the Green Roof mitigation actions are removed, gives an aggregate BCR of 1.01. If Grand Ave and the ecosystem services benefits are removed, the aggregate BCR is 1.03. If all three are removed, it is a BCR of 1.09.

In order for the project to be cost effective, therefore, at the 7% discount rate:

- The project cost needs to be much closer to the lowest value in the total project cost range.
- Project costs must be removed from the BCA which lowers the amount that can be included in a grant. The aggregate project cost may be only 45% of the total project cost ($55M).
- A BRV of $250 would have to be supported.

3% Rate

There are more options to achieve cost effectiveness when the lower discount rate is used. The full project, including Grand Avenue, is not cost effective under either cost estimate. When Grand Avenue is removed, the project is only cost effective when a $250 BRV is used. If this BRV cannot be supported, then the only option is to lower the project cost to a value close to the lowest estimate in the range, Version 4.

If a $250 BRV can be supported, then there are two additional BCR projects that can be considered. Version 2 removes Grand Avenue only and the total aggregate BCR is 1.18. (Project cost is approx. $40M). Version 3 drops the total BCR cost even further but brings the BCR up to 1.35. (Project cost is approx. $35M).

DEWBERRY PROJECT NO. **50159862**

RESILIENT FAIR HAVEN

Technical Report for Benefit Cost Analysis (BCA) Methodology for Heat Mitigation Alternatives in the Clinton Park Section of Fair Haven

NOVEMBER 14, 2023

Dewberry

ORIGINAL

SUBMITTED BY
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SUBMITTED TO
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Table of Contents

This report is provided to document details of the methodology and assumptions used to develop data necessary for the completion of Benefit Cost Analysis for extreme heat adaptation and green infrastructure adaptations for the area known as Clinton Park in the Fair Haven section of the City of New Haven, Connecticut. FEMA's BCA Module Version 6.0 was used for the analysis.

1. Fair Haven Clinton Park Project Area

Locations

- Clinton Park 41.317882 North, -72.891089 West
- Dover Beach 41.319235 North, -72.888175 West
- English Mall 41.316774 North, -72.894076 West
- Community Orchards 41.319347 North, -72.889321, West
- Front Street Underpass under I-91 41.320199 North, -72.890299 West

2. Mitigation Action #1- Green Infrastructure- Urban Trees

Modeled damages approach for Extreme Temperature and Green Infrastructure (GI) - Urban Trees mitigation action type. Project is to plant trees in the city to create cooling corridors. The following model inputs were selected:

- Project Useful Life (PUL) = 25 years (FEMA Standard Value)
- Project Cost = $ 840,268 (includes engineering, site prep, general conditions, and construction- Source: Fuss & O'Neil's Statement of Probable Costs)
- Maintenance Cost = $2,812/year (assumes 0.5% of construction cost annually)

Standard Benefits

- Number of trees = 696. From Fuss and O'Neill Opinion of Probable Cost estimate line-item count for shade trees across all actions taken in the Clinton Park project area.

3. Mitigation Action #2- Green Infrastructure- Bioretention

Modeled damages approach for Extreme Temperature and GI - Bioretention mitigation action type. Project is to add plantings in existing or new urban open space.

- PUL = 35 years (FEMA Standard Value)
- Project Cost = $7,125,371 (includes engineering, site prep, general conditions, and construction - Source: Fuss & O'Neil's Statement of Probable Costs)
- Maintenance Cost = $ 47,690/year (assumes 1% of construction cost annually)

Standard Benefits

- Total Project Area = 176,574 SF. From Fuss and O'Neill Opinion of Probable Cost estimate line-item count for Green Infrastructure and Plantings across all actions taken in the Clinton Park project area.

4. Mitigation Action #3- Ecosystem Services Benefits

Professional expected damages approach for Riverine Flood and Non-Residential Building Drainage Improvement mitigation action type. The goal of this mitigation action type is to single out the costs and benefits for the ecosystem services benefits included in the larger Clinton Park project area. This includes creating a living shoreline, updating urban parks, and installing trails and walking paths.

- PUL = 25 years (using the lowest FEMA Standard Value of the other mitigation action types to be conservative)
- Project Cost = $3,102,478 (includes engineering, site prep, general conditions, and construction - Source: Fuss & O'Neil's Statement of Probable Costs)
- Maintenance Cost = $10,382/year (assumes 0.5% of construction cost)

No damages before and after mitigation.

Standard Benefit- Ecosystem Services

- Total Project Area = 114,316 SF
- Percent Land Use = 100% urban green open space

The project area has been estimated from the areas entered in the line items of the Fuss & O'Neil Opinion of Probable Cost.

5. Individual and Aggregate BCR Results

These three mitigation actions are analyzed together in one aggregate BCA. The aggregate BCR is the sum of all the benefits divided by all the costs. The total Benefit Cost Ratio (BCR) is 1.31.

The green infrastructure urban trees mitigation action has the highest individual BCR, at 9.80. The reason for the high BCR is that the project cost is relatively low (<$1 million) for the benefits the trees produce, in terms of the default benefit value in the BCA (>$ 8 million.)

The green infrastructure bioretention mitigation action also produces a high number of benefits, based on the default values in the BCA toolkit (> $6 million), however the estimated BCA costs are also high (>$7 million). The BCR for the bioretention mitigation action is 0.84. The total BCA cost is the present-day value of the cost to design and construct the mitigation action, but also the cost to maintain it over the project useful life. Green infrastructure has a maintenance cost that can add hundreds of thousands of dollars to the BCA cost. (In this case the annual maintenance cost was estimated at 1% of the construction estimate. In a final BCA this maintenance cost would need to be justified and defended.)

The final mitigation action is a drainage improvement project which was added to the aggregate BCA just to count the costs and benefits of the ecosystem services benefits the project is producing. Ecosystem services benefits may be counted when land use is changed. The BCR for this individual mitigation action is low, 0.15, but the costs may exceed the areas that are being converted in the project scope. Only costs that are directly related to land use changes (i.e., from pavement to green open space) would need to be considered. Additionally, the cost estimate did not include an area for every potentially eligible activity. When lump sum estimates were used instead of unit costs and areas, there was no benefit added in the BCA despite the cost being added. This is because the benefit is calculated based on acres or square feet converted so all areas must be known. Both reasons indicate that this individual BCR is likely conservatively estimated.

Together, the aggregate BCR is over 1 so all the mitigation action project costs can be considered in a funding application, if desired. Aggregate BCRs can show that projects are cost effective even when individual parts are resulting in BCRs of less than 1.

DEWBERRY PROJECT NO. **50159862**

RESILIENT FAIR HAVEN

Technical Report for Benefit Cost Analysis (BCA) for Flood and Heat Mitigation Alternatives in the John W. Murphy Drive Project Area of Fair Haven

NOVEMBER 14, 2023

Dewberry

ORIGINAL

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This report is provided to document details of the methodology and assumptions used to develop data necessary for the completion of Benefit Cost Analysis for extreme heat adaptation and flood mitigation alternatives in the vicinity of John W. Murphy Drive in the Fair Haven section of the City of New Haven, Connecticut. FEMA's BCA Module Version 6.0 was used for the analysis.

1. Fair Haven John W. Murphy Drive Project Area

Locations

- John W Murphy Dr 41.310909 North, -72.905561 West
- Grand Avenue 41.308521 North, -72.906027 West
- Family Academy Garage 41.310379 North, -72.898792 West
- Urban Cooling Center 41.312728 North, -72.906035 West
- Acquisition at 451 Grand Avenue, New Haven, CT 06513

2. Mitigation Action #1- Green Infrastructure- Urban Trees

Modeled damages approach for Extreme Temperature and Green Infrastructure (GI) - Urban Trees mitigation action type. Project is to plant trees in the city to create cooling corridors. The following model inputs were selected:

- Project Useful Life (PUL) = 25 years (FEMA Standard Value)
- Project Cost (includes engineering, site prep, general conditions, and construction- Source: Fuss & O'Neil's Statement of Probable Costs)
    - Cost Estimate 1 = $764,742
    - Cost Estimate 2 = $764,744
- Maintenance Cost = $2,362.5/year (assumes 0.5% of construction cost annually)

Standard Benefits

- Number of trees = 630. From Fuss and O'Neill Opinion of Probable Cost estimate line-item count for shade trees across all actions taken in the Clinton Park project area.

3. Mitigation Action #2- Green Infrastructure- Bioretention

Modeled damages approach for Extreme Temperature and GI - Bioretention mitigation action type. Project is to add plantings in existing or new urban open space.

- PUL = 35 years (FEMA Standard Value)
- Project Cost (includes engineering, site prep, general conditions, and construction - Source: Fuss & O'Neil's Statement of Probable Costs)
    - Cost Estimate 1 = $6,232,044
    - Cost Estimate 2 = $6,232,057
- Maintenance Cost = $38,505/year (assumes 1% of construction cost)

Standard Benefits

Total Project Area = 85,100 SF. From Fuss and O'Neill Opinion of Probable Cost estimate line-item count for Green Infrastructure and Plantings across all actions taken in the John Murphy project area.

4. Mitigation Action #3- Green Infrastructure- Green Roof

Modeled damages approach for Extreme Temperature and GI- Green Roofs mitigation action type. Project is to install a green roof/ shade structure over the existing parking lot at the Family Academy Parking Lot Cooling Improvements.

- PUL = 35 years (FEMA Standard Value)
- Project Cost -Includes engineering, site prep, general conditions, and construction (Source: Fuss & O'Neil Statement of Probable Cost).
    - Cost Estimate 1 = $2,427,753
    - Cost Estimate 2 = $2,427,758
- Maintenance Cost = $7,500/year (assumes 0.5% of construction cost)

Standard Benefits

- Total Project Area = 28,000 SF. From Google Earth rounded measurements of existing parking lot. (70 FT x 180 FT) + (70 FT x 220 FT) = 28,000 FT

5. Mitigation Action #4- Murphy Drive Roadway Elevation

Professional expected damages approach for Riverine Flood and Roads & Bridges Elevation mitigation action type. Project is to raise the road to be above the 100-year flood elevation. This also creates a berm that protects the residential and commercial properties behind the road. Since there is no post mitigation modeling, the BCA assumes the berm provides full protection to the buildings behind it.

Cost Estimate #1: The CIRCA modeled future 100-yr + sea level rise (SLR) flood elevation varies from 10.06 to 10.53 FT. The roadway will be elevated to one foot above that so approximately 11.5 FT.

Cost Estimate #2: Elevation will be to the FEMA 100-year BFE which is 12 FT.

- PUL = 50 years (FEMA Standard Value)
- Project Cost -Includes engineering, site prep, general conditions, and construction (Source: Fuss & O'Neil Statement of Probable Cost).
    - Cost Estimate 1 = $24,106,425
    - Cost Estimate 2 = $25,833,015
- Maintenance Cost = $74,471/year (assumes 0.5% of Construction Cost #1) and $79,805/year (0.5% of Construction Cost #2)

Road Properties

- Year Road Built = unknown
- Estimated number of one-way trips per day = 1,000
- Additional time per trip = 2 minutes (measured with directions on google maps)
- Additional miles = 0.5 (measured with directions on google maps)

Traffic monitoring count not available on John Murphy Drive. On James Street and Grand Avenue, the totals were 4,500 and 14,400 respectively. Both are busier roads than Murphy Drive so 1,000 was estimated as the daily number of one-way trips. Traffic Monitoring Volume and Classification Information Traffic Count Data (ct.gov)

James Street:

StationID	NWHN-676
AADT	4,500
AADT Year	2018

Building Data Collection

Data was collected for the building currently in the CIRCA modelled 100-year + sea level rise (SLR) inundation area, which has a greater extent and fully includes the FEMA mapped 100-year inundation area. Building footprint polygons were provided by Fuss & O'Neil. To produce an inventory of the buildings that would be impacted, the 100-year flood depth with SLR polygon file provided by CIRCA was brought into ArcGIS Pro and overlayed on top of the building footprint data. Buildings intersecting with the future 100-year flood depth with SLR were selected for analysis. A total of 51 buildings were selected for analysis.

Occupancy type, foundation type, number of stories, first-floor height (FFH), first-floor elevation (FFE), and building area were needed to complete the BCA. A Google Street View analysis was performed for each building to gather occupancy type, foundation type, number of stories, and FFH, as those data points were not provided in the CIRCA building footprint shapefile. FFH was estimated using a half foot per step on the risers leading up to the front door. The building area was initially determined using National Structure Inventory (NSI) data but with many gaps in the NSI data, the New Haven, CT, Property Records database was used to gather building areas. When building area was available in both datasets they were compared for general consistency. During the Google Street View analysis, miscellaneous buildings such as sheds or garages were deleted from the building inventory.

Once the initial data gathering was performed, FFE and water surface elevation (WSE) were needed to calculate the depth of flooding in the structure. To calculate FFE, a 2018 Digital Elevation Model (DEM) was downloaded from the state GIS repository to determine ground elevation. A building centroid layer, created using the Feature to Point data management tool in ArcGIS Pro, was overlayed with the DEM. The tool Extract Multi Values to Points was then used in ArcGIS Pro to extract ground elevation values from the DEM to the building centroids, creating a new point layer. A join was then performed to join the ground elevation data included in the newly created point layer to the original building centroid points. This ground elevation data was then exported to a CSV and attributed to each identified building in a master Excel sheet, including all building data. FFE was then calculated by adding ground elevation to the FFH.

Flooding scenarios analyzed included 10-, 50-, and 100-year flooding events with SLR. Each polygon provided for these flood scenarios had gridcodes associated with them. Each gridcode represented flood depth in ft. For example, a gridcode of 1 represented 1 to 2 ft of flooding, and so 1.5 ft would be used as an average estimate. A building-by-building visual analysis on ArcGIS Pro was used to select the max gridcode intersecting with each building for each scenario. Similar calculations were completed using the water surface elevation for the FEMA 100-year event, for further analysis.

Expected Damages Before Mitigation

Once the flood depths inside the buildings were determined, the damages were estimated based on building type and selecting the appropriate Depth Damage Function (DDF) from the BCA toolkit. There are different DDFs whether the structure is residential or commercial, whether there is a basement or not, and the usage of the building. For instance, the building type COM 1 is retail and there are subcategories of the type of retail, such as grocery, service station, furniture, which establish a better fitting DDF. The damage categories that can be estimated with the DDF is physical building damage, contents damage, and displacement.

Building characteristics, such as number of stories, occupancy type, and total area were taken from GIS data and tax assessor records. Flood model information was also obtained through CIRCA's GIS site. Physical damage was calculated as the DDF percentage of damage, per foot of flood depth, times the structure's Building Replacement Value (BRV). The BRV used is the New Haven Property Records for structural value divided by the building area or $100/sf (FEMA default) if under $100 or capped at $250 if over $250. Content damage is estimated the same way. The DDF percentage of damage for contents, per foot of flood depth, is multiplied by the adjusted BRV. The BRV is adjusted based on a percentage of the full BRV due to the building type and usage. For instance, residential structures can use 100% of the BRV for determining the contents damage but office buildings use 14% of the building value as the contents value.

Displacement costs for residential properties use a lodging and meals per diem and number of persons per household to determine the cost per day to be displaced. The 2022 Census data show 2.5 persons per household for New Haven. It was assumed that one family of 2.5 lives in each residential structure to be conservative. (There may be more if there are more than one unit in each building.) It was also assumed that the lodging cost could be shared, so the meal per diem was multiplied by 2.5. The total residential displacement cost per day is $286.50. ($114 lodging + $69 meals x 2.5 = $286.50)

Displacement costs for commercial properties used the FEMA default values in the software for the rental of temporary space, monthly, and a one-time displacement cost. These are in dollars per square foot, so the size of the structure is included in the calculation.

All the calculations are shown in the accompanying spreadsheet, Murphy Zone_Estimate of Damages_10_12_23.

The total damages to the 12 structures protected by the berm created by raising John Murphy Drive is entered into the BCA DFA table in the column, Flooded Structures.

Two additional damages are entered as optional damages, Road Closure and Road Damage. Currently these are placeholders because information needs to be obtained about the effort public safety and/or the department of public works goes through to close the road when it is flooded. After flood waters subside there may be road or drainage structure damage and/or mud or other debris that needs to be cleared. The costs to both shut down the road, Road Closure, and repair the road, Road Damage, may be included in the BCA.

Loss of function benefits for the roadway were removed from the BCA because the durations were difficult to estimate, and the benefits are very low.

Expected Damages After Mitigation

After mitigation, for Cost Estimate #1, the level of protection is up to the 100-year event so the damages before mitigation or the 10 and 50-year events are reduced to $0 but the 100-year event damages remain. For Cost Estimate #2, the level of protection includes the 100-year flood event. The damages after mitigation are entered in at the 500-year event and these damages equal the 100-year event before mitigation estimates.

6. Mitigation Action #5- Grand Avenue Roadway Elevation

Professional expected damages approach for Riverine Flood and Roads & Bridges Elevation mitigation action type. Project is to raise the road to be above the 100-year flood elevation. Grand Avenue provides access to and from Fairhaven. The future 100-year elevation is approximately 10.3 FT, and the road will be raised to 11.5 FT.

- PUL = 50 years (FEMA Standard Value)
- Project Cost -Includes engineering, site prep, general conditions and construction
    - Cost Estimate 1 = $19,303,282
    - Cost Estimate 2 = $19,873,845
- Maintenance Cost = $59,633/year (0.5% of Construction Cost #1) and $61,395/year (0.5% of Construction Cost #2)

Road Properties

- Year Road Built = 1900 (placeholder)
- Estimated number of one-way trips per day = 14,400
- Additional time per trip = 4 minutes (measured with directions on google maps)
- Additional miles = 1 (measured with directions on google maps)

Traffic monitoring data is obtained from this website: Traffic Monitoring Volume and Classification Information Traffic Count Data (ct.gov) The station selected is close to the project site.

Grand Avenue:

StationID	NWHV-553
AADT	14,400
AADT Year	2018

Expected Damages Before and After Mitigation

The main project benefit is to keep the road open during flood events. Before mitigation there is an estimated 2-day road closure due to flood depths associated with the 100-year FEMA BFE and after mitigation it can be assumed that the road will remain open at the 100-year event but will be closed for the 500-year event.

7. Mitigation Action #6- Acquisition

Professional expected damages approach for Riverine Flood and Non-Residential Building Acquisition mitigation action type. Project is to acquire the paint store located at 451 Grand Avenue, New Haven, CT 06513. After, the property site will be incorporated into the floodable park.

- PUL = 100 years (FEMA Standard Value)
- Project Cost -Includes engineering, site prep, general conditions, and construction (based on tax appraised value).
    - Cost Estimate 1 = $2,265,903
    - Cost Estimate 2 = $2,265,908
- Maintenance Cost = $0. There are no maintenance costs after acquisition.

Building Properties

- Year Property was built = 1998

Information on this facility was taken from tax assessment information. The property card was obtained from this website and is in the attached documentation.
https://gis.vgsi.com/newhavenct/Parcel.aspx?Pid=9922

Expected Damages Before and After Mitigation

The flood depths were obtained from GIS models for the 10-year, 50-year and 100-year riverine flood events. The depth of flooding above the FFE was determined for each event based on the ground elevation adjacent to the structure, the estimated FFE based on pictures of the property and basement type, and the flood elevations. The DDF that was chosen for this property type is COM 1 Convenience Store as the closest property type to a paint store. Because the DDF estimates damages to the nearest foot of flood damage, the 50-year and the 100-year estimates are the same as the elevations are less than a half foot apart.

The building footprint is 18,720 SF according to the property card. This area was entered as an ecosystem services benefit in the BCA. The total area, 18,720 SF, will become urban green open space.

8. Mitigation Action #7- Ecosystem Services Benefits

Professional expected damages approach for Riverine Flood and Non-Residential Building Drainage Improvement mitigation action type. The goal of this mitigation action type is to single out the costs and benefits for the ecosystem services benefits included in the larger John Murphy project area. This includes converting surface parking lots to green urban parks, trails, and restored nature.

- PUL = 25 years (Took the lowest FEMA Standard Value of the other mitigation action types to be more conservative)
- Project Cost -Includes engineering, site prep, general conditions and construction (based on the Fuss & O'Neil Statement of Probable Costs).
    - Cost Estimate 1 = $3,463,029
    - Cost Estimate 2 = $3,463,036
- Maintenance Cost = $10,698 (assumes 0.5% of construction cost)

No damages before and after mitigation.

Standard Benefit- Ecosystem Services

- Total Project Area = 95,285 SF
- Percent Land Use = 100% urban green open space

The project area has been estimated from the areas entered in the line items of the Fuss and O'Neill Opinion of Probable Cost. It underestimates the area because some line items were lump sum, so these areas were unknown and not included.

9. Results

The aggregate BCR for the seven mitigation actions together is under 1.0. This means the project, in aggregate, is not cost effective when using the FEMA BCA tool. However, each mitigation action can be looked at independently to determine how many benefits it contributes. Mitigation actions can be turned off and on to analyze different combinations to see if any combination of actions in the project are cost effective. When actions are turned off, however, and excluded from the BCA, the project costs for these actions cannot be considered for a potential grant.

The John W. Murphy Road elevation project, and other hazard mitigation actions in the project area, have a mitigation project total of approximately $60 million. The benefits are green infrastructure measures, protection of flooded properties and roadways, ecosystem services benefits and others. Unfortunately, the benefits total only about $20 million, when all mitigation actions are included.

The Grand Avenue bridge elevation does not contribute a lot of benefits to the aggregate BCA and has a very high cost. **Version 2** was run in the BCA to remove this mitigation action. The results are an aggregate BCR of 0.78 (using the 3% discount rate and cost estimate #2.) In an attempt to raise this BCR, an updated building replacement value (BRV) was used. $250 was assigned to all the protected and acquired properties in the project. This increased the benefits for the John W. Murphy Road elevation mitigation action and the acquisition mitigation action. The aggregate BCR, with the Grand Avenue structure still removed, is 1.18 (3% discount rate.). Based on our experience conducting BCAs in New Haven County, we believe the BCA of $250 is a realistic, if not conservative, replacement value that can be defended.

Using a BRV that is derived from tax assessment data, the aggregate BCR may be increased by decreasing the project cost. The project cost used in this technical memo is in the middle of a range of project probable costs. To get to the lower end of the range, the cost estimate is reduced by 30%. This is approximately $55 M instead of $78M for cost estimate 2. If the lower project cost is used, the aggregate BCR is 1.10 (3% discount rate.)

Another option is to remove other mitigation actions that are not contributing enough benefits in the aggregate BCR. Removing the green roofs mitigation action and the ecosystem services benefits in the drainage improvement mitigation action, and excluding the Grand Avenue mitigation action, the aggregate BCR is 1.35 (3% discount rate) when a $250 BRV is used.

FEMA has been accepting the 3% discount rate for its Building Resilient Infrastructure and Communities (BRIC) grant program. This indicates there are options for proving cost effectiveness with the John W. Murphy project. It should be noted, that when mitigation actions are removed from the project BCA, these costs cannot be included in a funding application. Project estimates that come in much higher during construction can also affect a grant award. The BCA should be as accurate as possible at the time of application.

Completed BCA tool generated reports, back up materials and the actual BCA exports are included with this report.

APPENDIX C – RESILIENCE HUB AND COOLING CENTER RANKING

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RESILIENCE HUB + COOLING CENTER RANKING

Cooling Center Options	Address	City Owned? (Y/N)	Size of Building (sq. ft)	Building Size ranking (20% weight)	Inside the Flood Hazard	Flood Ranking (20% weight)	Buffer for Bus Route that Parcel Intersects (100, 200, 300, 400, 500)	Buffer to Major Transportation Routes	Transportation Ranking (10% weight)	Drive Time Ranking (10% weight)	SVI	SVI Ranking (15% weight)	% Tree Cover along roads on walk from bus to building	Tree Cover Ranking (10% weight)	Final Ranking
John S. Martinez School	100 James St.	Y	72,948	5	No	5	400	Minor Road	3	5	0.7643	2	1.16%	2	**3.6**
Family Academy	255 Blatchley Ave.	Y	48,258	4	No	5	100	Major Road	5	5	0.9489	5	1.47%	2	**4.5**
Fair Haven School	164 Grand Ave.	Y	66,885	5	No	5	100	Major Road	5	5	0.9284	5	8.73%	4	**4.9**
Atwater Senior Center	26 Atwater St.	Y	11,914	2	No	5	300	Minor Road	3	5	0.8339	3	0.12%	1	**3.2**
Strong School	69 Grand Ave.	Y	19,584	2	No	5	100	Major Road	5	5	0.7263	2	4.34%	3	**3.75**
Clinton Avenue School	293 Clinton Ave.	Y	45,999	4	No	5	100	Minor Road	3	5	0.8544	4	3.88%	3	**4.25**
District Athletic Club	470 James St.	N	107,352	5	No	5	300	Major Road	5	5	0.9009	5	1.64%	2	**4.4**
Iglesia Universal (Church)	300 Lombard St.	N	3,270	1	No	5	100	Major Road	5	5	0.803	3	0.00%	1	**3.5**
Straighway Church	37 Market St.	N	2,595	1	No	5	>500 ft	Minor Road	3	5	0.9582	5	17.98%	5	**3.4**
The Redeemed Christian Church of God	245 Grand Ave.	N	4,155	1	No	5	100	Major Road	5	5	0.9489	5	7.48%	4	**4.1**
Church of God of Prophecy	155 Grand Ave.	N	10,308	2	No	5	100	Major Road	5	5	0.8339	4	6.10%	4	**4.15**
Concentra Urgent Care/Department of Social Services	370 James St.	N	49,410	4	No	5	100	Major Road	5	5	0.9582	5	0.52%	1	**4.4**
Anahita Health Group LLC	1 Brewery Sq.	N	38,797	3	No	5	100	Major Road	5	5	0.9284	5	3.21%	3	**4.4**

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