RESILIENT DANBURY

ADAPTATION OPTIONS

FINAL REPORT
NOVEMBER 2023

CIRCA
Connecticut Institute for Resilience and Climate Adaptation
DANBURY CONNECTICUT
FUSS & O'NEILL
Dewberry

RESILIENT DANBURY

Downtown Danbury serves nearly 80,000 City residents as well as the greater Danbury region. The project area is located along Main Street (State Route 53), extending westward to Deer Hill Avenue and eastward to Town Hill Avenue, and consists of a mix of commercial corridors and high-density residential areas.

This document summarizes proposed adaptation options to address the climate vulnerabilities related to flooding and extreme heat in the downtown Danbury community.

PROJECT TEAM

CIRCA

David Murphy – Director of Resilience Engineering

John Truscinski – Director of Resilience Planning

City of Danbury

Matthew Cassavechia – Director of Emergency Management & Emergency Medical Services

Antonio Iadarola – Director of Public Works & City Engineer

Consultant Team

Fuss & O'Neill

Dewberry

Citizen + Technical Advisory Committee (CTAC)

Cpt Thomas Corbett	Community Emergency Response Team, Team Coordinator
Sharon B. Calitro, AICP	City of Danbury Planning and Zoning, Director
Susan M. Tomanio	City of Danbury Elderly Services, Director
Kara Prunty, MPA, MPH	City of Danbury Health and Human Services , Director
Jeff Rieck	City of Danbury Housing Authority, Executive Director
Tim Nolan	City of Danbury Highway Services, Superintendent
Warren Levy	City of Danbury City Council - At Large, Council Member
Joseph Cavo	City of Danbury City Council - At Large, Council Member
Vinny DiGilio	City of Danbury City Council - 2nd Ward, City Council President, Council Member
Duane E. Perkins	City of Danbury City Council - 5th Ward, Council Member
Fred Visconti	City of Danbury City Council - 5th Ward, Council Member
Paul T. Rotello	City of Danbury City Council - 6th Ward, Council Member
Dr. Derek DeLeon	Nuvance Health , Chief Academic Officer
Joseph DaSilva	Affordable Housing Development, Developer
Marlene Moranino	CT Institute for Comm. Greater Danbury Community Health Center, Board Chair
Bill Diamond	Danbury Ice Arena
Jenny Guerra	Danbury War Memorial
Mike Seelig	Danbury School District, Superintendent

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EXECUTIVE SUMMARY

RESILIENT DANBURY

PROJECT OVERVIEW

Downtown Danbury has endured decades of flooding caused by an aging, undersized drainage system, referred to as the "East Ditch." Downtown Danbury is vulnerable to the impacts of extreme heat due to large areas of impervious surfaces and lack of tree cover. Future increases in rainfall and temperature pose risks to vulnerable populations and critical assets such as affordable housing and critical roadways.

The Connecticut Institute for Resilience and Climate Adaptation (CIRCA) initiated Resilient Connecticut in 2018 as a component of the U.S. Department of Housing and Urban Development (HUD) National Disaster Resilience Competition award to the State of Connecticut. The CIRCA Resilient Connecticut Phase III – Resilient Danbury project further develops the work completed within Phases I and II, which included the assessment of flooding and extreme heat risks due to climate change, and the identification of areas of shared risk within Fairfield and New Haven Counties.

The East Ditch watershed in Danbury, CT was identified as one of these areas of shared risk. Resilient Danbury is focused on developing solutions to mitigate current and future climate-induced flooding and extreme heat impacts to community assets and critical facilities and routes within downtown Danbury.

El centro de Danbury ha soportado décadas de inundaciones causadas por un sistema de drenaje anticuado e infradimensionado, conocido como "East Ditch". El centro de Danbury es vulnerable a los impactos del calor extremo debido a las grandes áreas de superficies impermeables y a la falta de cubierta arbórea. Los futuros aumentos de las precipitaciones y la temperatura plantean riesgos para las poblaciones vulnerables y los activos críticos, como las viviendas asequibles y las carreteras cruciales.

El Instituto de Connecticut para la Resiliencia y la Adaptación al Clima (CIRCA, por sus siglas en inglés) inició Connecticut resiliente en 2018 como un componente del premio de la Competencia Nacional de Resiliencia ante Desastres del Departamento de Vivienda y Desarrollo Urbano de los Estados Unidos (HUD, por sus siglas en inglés) al estado de Connecticut. El proyecto Connecticut resiliente de fase III - Danbury resiliente de CIRCA desarrolla aún más el trabajo completado dentro de las fases I y II, que incluyó la evaluación de los riesgos de inundaciones y calor extremo debido al cambio climático, y la identificación de áreas de riesgo compartido dentro de los condados de Fairfield y New Haven.

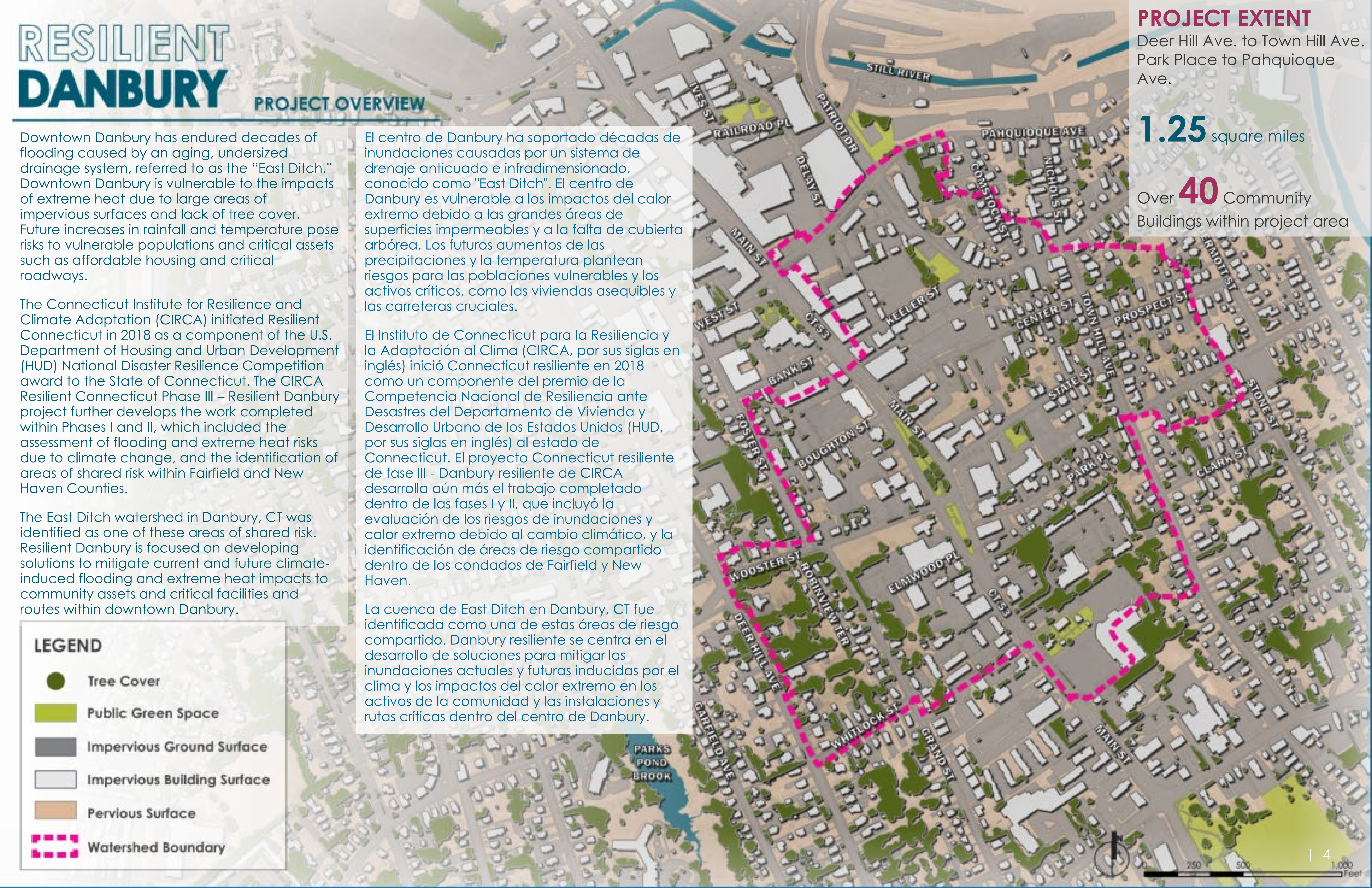
La cuenca de East Ditch en Danbury, CT fue identificada como una de estas áreas de riesgo compartido. Danbury resiliente se centra en el desarrollo de soluciones para mitigar las inundaciones actuales y futuras inducidas por el clima y los impactos del calor extremo en los activos de la comunidad y las instalaciones y rutas críticas dentro del centro de Danbury.

PROJECT EXTENT

Deer Hill Ave. to Town Hill Ave.
Park Place to Pahquioque Ave.

1.25 square miles

Over **40** Community Buildings within project area



RESILIENT DANBURY PROJECT OVERVIEW

Adaptation Options were developed to protect residents and critical facilities. Three alternatives were developed that included a combination of drainage system improvements, green infrastructure, streetscape improvements, and tree planting.

Se desarrollaron opciones de adaptación para proteger a los residentes y las instalaciones críticas. Se desarrollaron tres alternativas que incluían una combinación de mejoras del sistema de drenaje, infraestructura verde, mejoras del paisaje urbano y plantación de árboles.

Library/ Post Office/City Hall
1. UNITED STATES POST OFFICE
2. PUBLIC LIBRARY
3. CITY HALL

Religious Center
1. UNIVERSAL CHURCH
2. ALL NATION BAPTIST CHURCH
3. ST. JAMES EPISCOPAL CHURCH
4. TEMPLE BETHEL
5. STRONG GOD CHURCH
6. EMANUEL ASSEMBLY-GOD CHURCH
7. GREATER MERCY TEMPLE CHURCH
8. SACRED HEART CHURCH
9. SEVENTH DAY ADVENTIST CHURCH

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5. PLANNED PARENTHOOD
6. GREATER DANBURY COMMUNITY HEALTH CENTER
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8. DANBURY REGIONAL WIC NUTRITION PROGRAM / OLD JAIL

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3. SOUTH STREET SCHOOLS
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5. HEAD START CENTER

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2. DANBURY SKATE PARK
3. ELMWOOD PLACE

State of Connecticut
1. FAIRFIELD COUNTY COURTHOUSE
2. TRAIN STATION

Other
1. ICE RINK
2. MUSEUM AND HISTORICAL SOCIETY
3. GROCERY STORE (PRICE RITE)
4. CONNECTICUT LIGHT & POWER CO
5. BECKERIE & CO. FIRE ENGINE 9

LEGEND
- Ex. Outfalls
- Ex. Conduits
- City of Danbury Parcels
- Watershed Boundary
- Roadways

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ALTERNATIVES SUMMARY

ALTERNATIVE 1

MITIGATION ACTIONS
- Drainage system improvements

BCR < 1

ACCIONES DE MITIGACIÓN
- Mejoras en el sistema de drenaje

Relación costo-beneficio (BCR) < 1

ALTERNATIVE 2

MITIGATION ACTIONS
- Drainage system improvements
- Raingardens at 9-11 Liberty Street and the old Jail
- Raingarden and cooling stop at the Senior Center

BCR > 1

ACCIONES DE MITIGACIÓN
- Mejoras en el sistema de drenaje
- Jardines infiltrantes en 9-11 Liberty Street y la antigua cárcel
- Jardín infiltrante y centro de enfriamiento en el Centro para adultos mayores

BCR > 1

ALTERNATIVE 3

MITIGATION ACTIONS
- Drainage system improvements
- Raingarden at 9-11 Liberty Street and the old Jail
- Raingarden and cooling stop at the Senior Center
- Parking Lot improvements/ raingarden at Price Rite
- Streetscape improvements along Main Street

BCR < 1

ACCIONES DE MITIGACIÓN
- Mejoras en el sistema de drenaje
- Jardín infiltrante en 9-11 Liberty Street y en la antigua cárcel
- Jardín infiltrante y centro de enfriamiento en el Centro para adultos mayores
- Mejoras en el aparcamiento/jardín infiltrante en Price Rite
- Mejoras paisajísticas a lo largo de Main Street

BCR < 1

INTRODUCTION

RESILIENT CONNECTICUT PHASE II

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Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Downtown Danbury
Location: Danbury

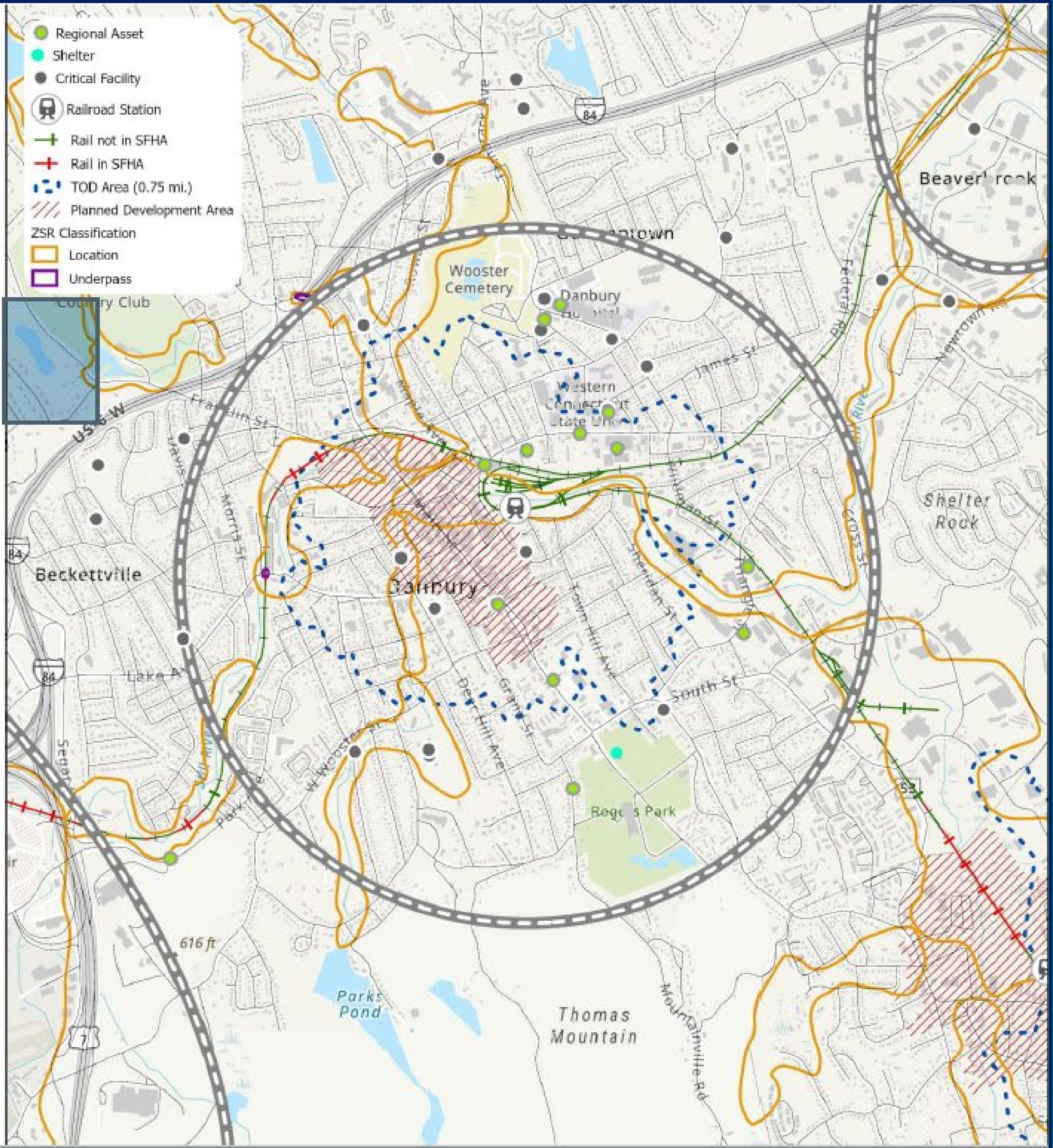
Considerations	Characteristics of Area
Flood Vulnerability	
Heat Vulnerability	
Social Vulnerability	

The center of Danbury is characterized by zones of shared risk associated with the confluence of Padanarum Brook, Kohanza Brook, and the Still River. Despite many flood risk reduction projects undertaken over decades, TOD and planned development areas are located in close proximity to – or within – these zones of shared risk. Numerous critical facilities, historic resources, and the terminus of the MetroNorth Danbury line are also located in the area. Downtown Danbury is a regional center for northern WestCOG.

Almost all of the downtown area is moderately vulnerable to heat, with the highest vulnerable area concentrate along route 53 commercial properties. Presenting few opportunities for shade or street trees, the area has high heat emittance. In addition, there is high social sensitivity throughout the area.

- City Hall
- Fire headquarters
- Hose Co. 5, 6, 7, and 9
- Danbury Hospital
- Danbury Health and Housing Dept.
- Western CT State College Police
- Assisted living facilities
- War Memorial
- Substation
- Power plant
- Museums

UCONN UNIVERSITY OF CONNECTICUT
CONNECTICUT Department of Housing
CIRCA



RESILIENT CONNECTICUT PHASE III PROJECT GOALS

IDENTIFY RESILIENCY MEASURES

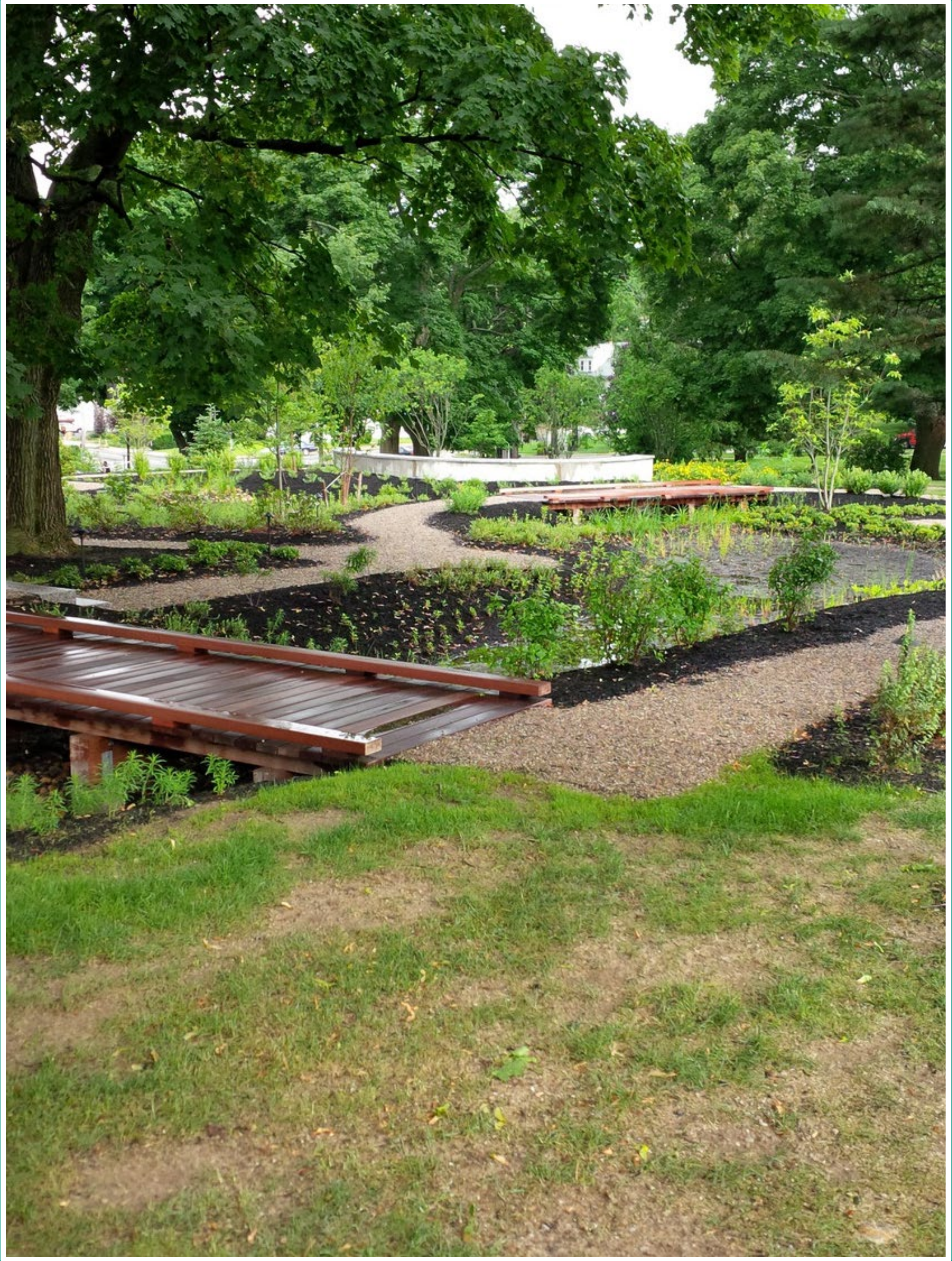
- Improve flood and heat resilience
- Leverage Nature-Based Solutions

COMMUNITY CO-BENEFITS

Collaborate with stakeholders in downtown Danbury to select strategies and projects

Develop conceptual Designs

Position projects for funding



RESILIENT DANBURY

IN CONTEXT WITH THE BIGGER PICTURE

Danbury supports resilience across multiple layers of government and through numerous initiatives aimed at both extreme heat mitigation as well as flood risk mitigation. The graphic to the right shows a selection of the municipal and regional resilience initiatives in the Danbury area, including the Resilient Danbury project. A summary of a few of these resources is provided below.

The **2017 and 2021 Hazard Mitigation Plans** detail the flooding impacts associated with the undersized drainage system in downtown Danbury. The recommendation in the plan is to construct the 2002 proposed improvements to the drainage system which consist of adding stormwater capacity to the system.

The **2019 Still River Watershed Management Plan** is focused on improving the water quality of the Still River to protect habitat and wildlife while also enhancing climate resilience and creating a community amenity.

The **2023 Plan of Conservation and Development**, developed by the City with input from the community, identifies specific goals/focus areas for growth and development over the next 10 years. Focus areas include land use and environmental resources, cultural resources, housing, economic development, mobility, services and facilities, and future land use.

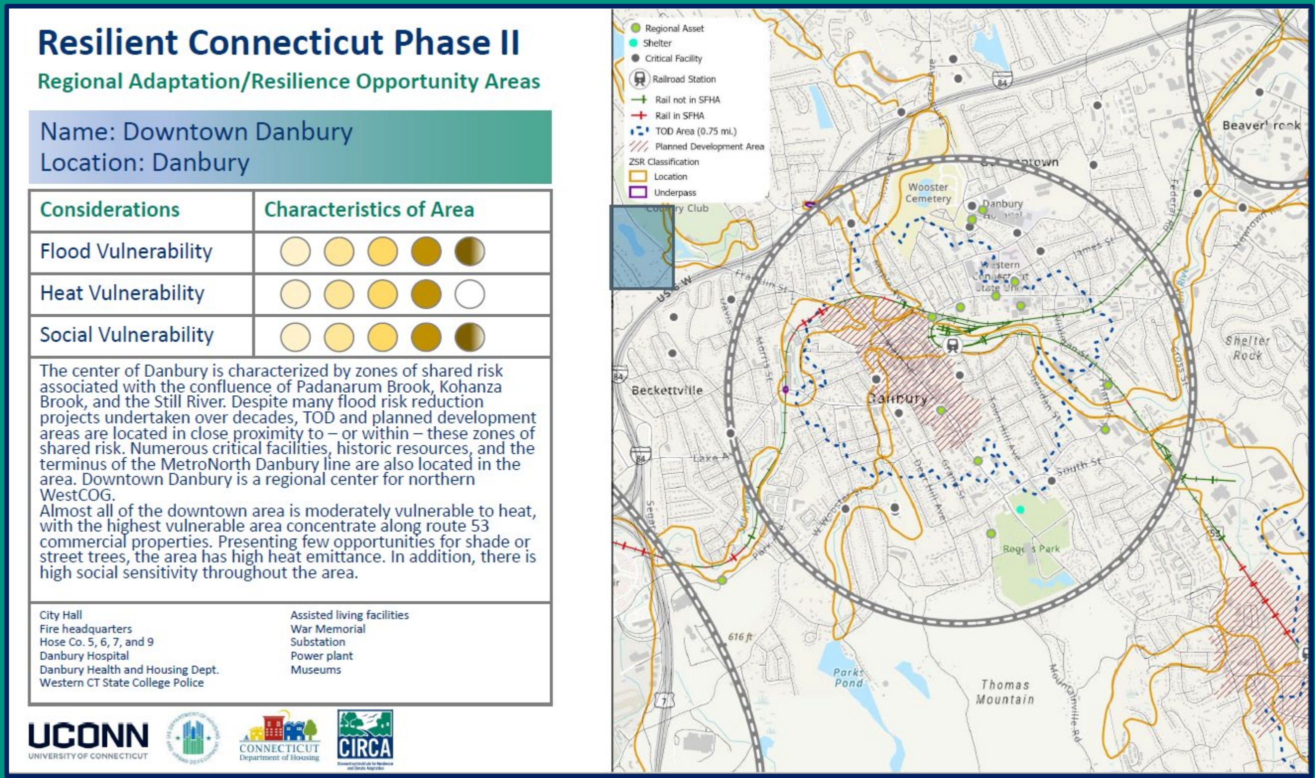
Lastly, the **City of Danbury Heat Related Emergency Analysis**, an on-going study, is focused on how extreme heat affects health. Health impacts and temperature data in downtown Danbury are currently being collected.

LEAD PLANNING ENTITIY:

1 – United States Army Corps of Engineers (USACE)
2 – Western Connecticut Council of Governments (WestCOG)
3, 4, 7, 9 – City of Danbury
5 – Federal Emergency Management Agency (FEMA)
6 – Connecticut Institute for Resilience & Climate Adaptation (CIRCA)
8 – Still River Partners and Connecticut Department of Energy and Environmental Protection (CT DEEP)

1. USACE Still River Feasibility Study
2. WestCOG Hazard Mitigation Plan
3. Danbury Transit-Oriented Development Study
4. Danbury Heat Related Emergency Analysis
5. FEMA Emergency Generators Application
6. CIRCA Resilient Danbury
7. Danbury Stormwater Management Plan
8. Still River Watershed Management Plan
9. Danbury Plan of Conservation and Development

ONE PIECE OF A LARGER EFFORT



Resilient Connecticut Phase II

Regional Adaptation/Resilience Opportunity Areas

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City Hall
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Danbury Health and Housing Dept.
Western CT State College Police
Assisted living facilities
War Memorial
Substation
Power plant
Museums

PROJECT SCOPE

The mission of Resilient Danbury is to develop a climate resilience strategy and ***implement this pilot project*** *focused on reducing risk to people, homes, businesses, and infrastructure in the downtown gateway neighborhoods from flooding and extreme heat, and to foster long-term prosperity in Danbury.*

1 Data Collection and Review

Collect and review existing data and perform constructability review of existing designs.

2 Survey

Field survey for critical drainage structure locations and elevations

3 Current & Future Conditions Analysis

Model existing stormwater system and proposed Haestad system under current and future conditions. Establish baseline for extreme heat impacts.

4 Adaptation Options and Concept Design

Identify flood- and heat-risk mitigation options and select preferred alternatives. Develop conceptual designs and renderings for the selected alternatives.

5 Cost/Benefit Analysis

Develop cost estimates and potential benefits for preferred alternatives based on FEMA BCA methodology.

HISTORICAL CONTEXT + BACKGROUND

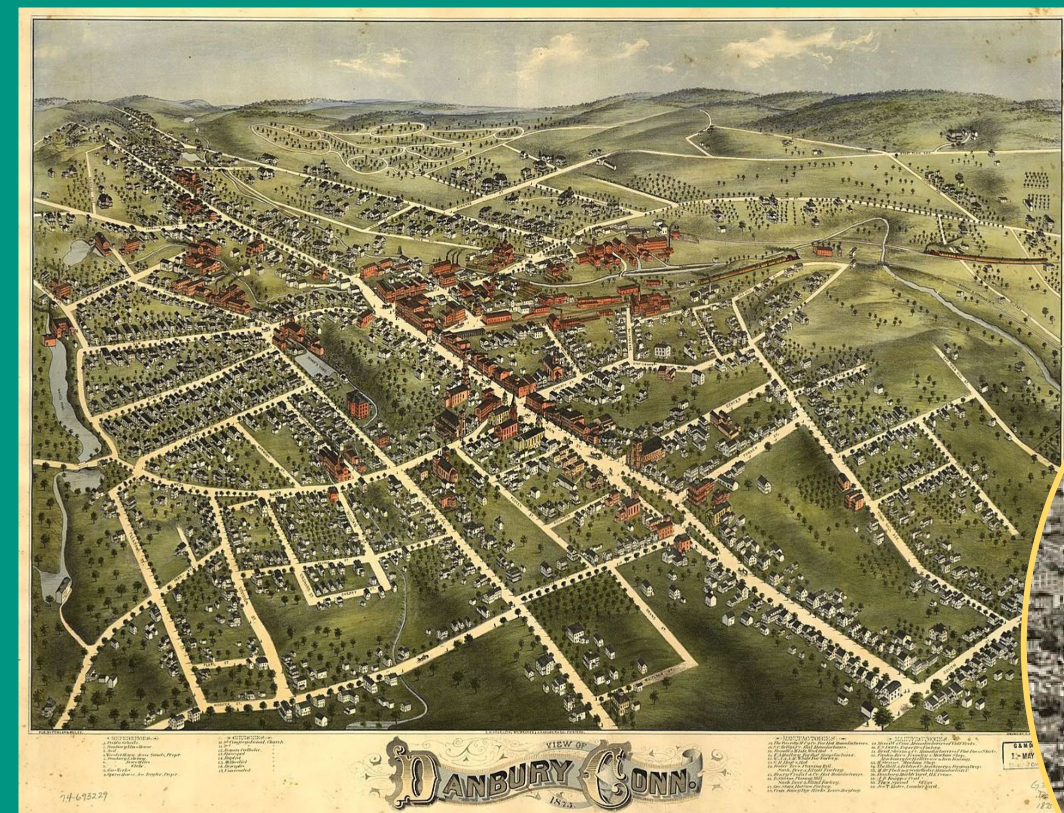
The City of Danbury was chartered as a city in 1889. At different times in its history, It was known as Beantown for the high-quality of bean crop grown there and as “hat city” when it was a center for the nation’s hat production. Danbury is situated in low-lying land south of the Berkshire Mountains and Candlewood Lake, and north of Wooster Mountain.

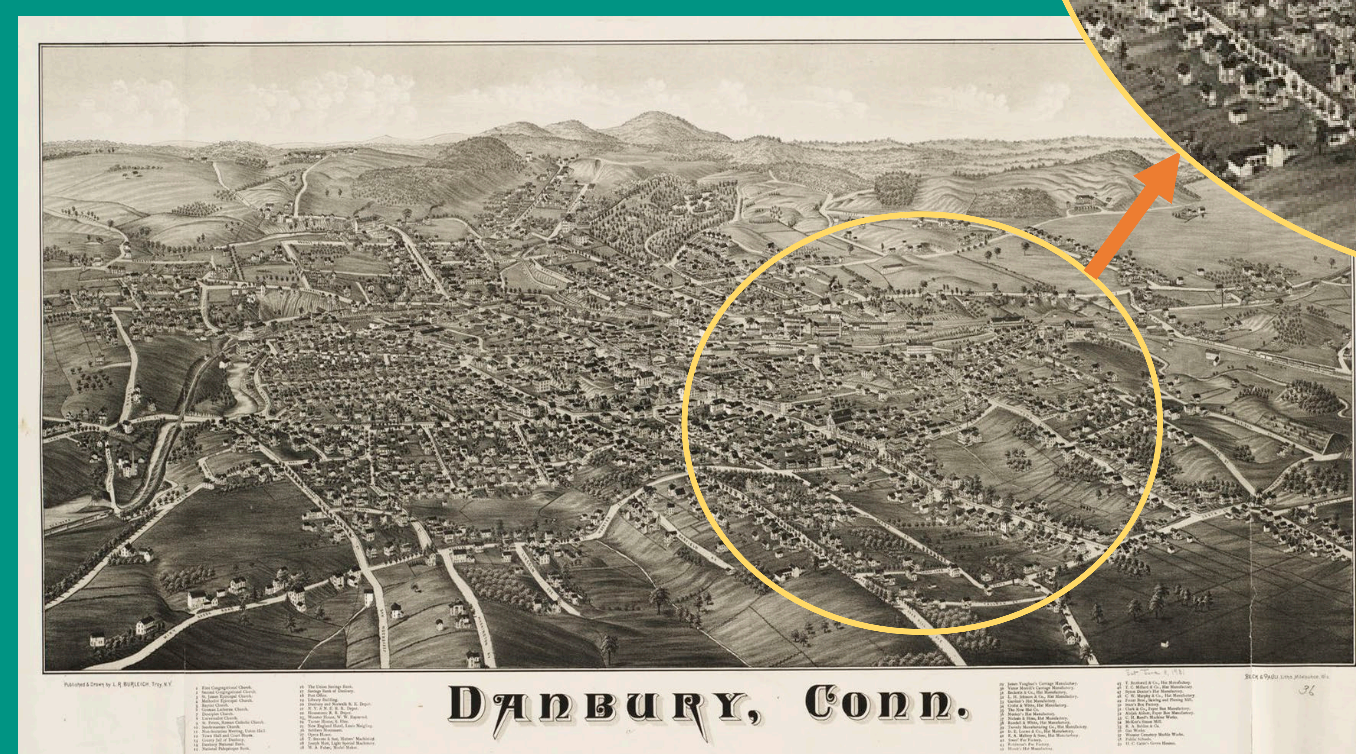
Danbury was called Pahquioque or Paquiack, which means “open plain” or “cleared land”, by the Native Americans, the Pahquioque. The colonists who later settled in this area, first called this area “Swampfield” after the wetlands in downtown Danbury, and later changed the name to “Danbury” after the town in England.

In the late 19th century, the East Ditch was constructed to convey waste and stormwater to the Still River. Part of the ditch is visible in the zoomed in excerpt of the historic map to the right.

Downtown Danbury has developed considerably since the 1800s. Development has provided increased amenities such as additional housing and commercial spaces but has also increased the impervious cover leading to higher temperatures and increased stormwater runoff. The extreme heat and flooding concerns in Danbury are expected to worsen over time. Storm frequency and intensity as well as maximum temperatures are expected to increase.

This project is focused on mitigating these impacts to the community while also providing improved amenities to downtown Danbury.





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DOWNTOWN DANBURY CURRENT-DAY EAST DITCH FLOODING


August 13th, 2001


September 16th, 2002


September 16th, 2002


June 2nd, 2022


June 2nd, 2022


June 2nd, 2022

There is significant drainage-related flooding in Downtown Danbury as shown in the photos above, which were all taken at the Main Street and Elmwood Place intersection. Flooding occurs in the streets and, under certain conditions, extends onto adjacent properties and into basements.

DOWNTOWN DANBURY SOCIAL VULNERABILITIES

Social vulnerability refers to the potential negative impacts to communities caused by flood, heat, wind, and other external stresses. Factors that increase vulnerability include poverty, lack of access to transportation, and minority status. These factors may weaken a community's ability to prevent loss and damages.

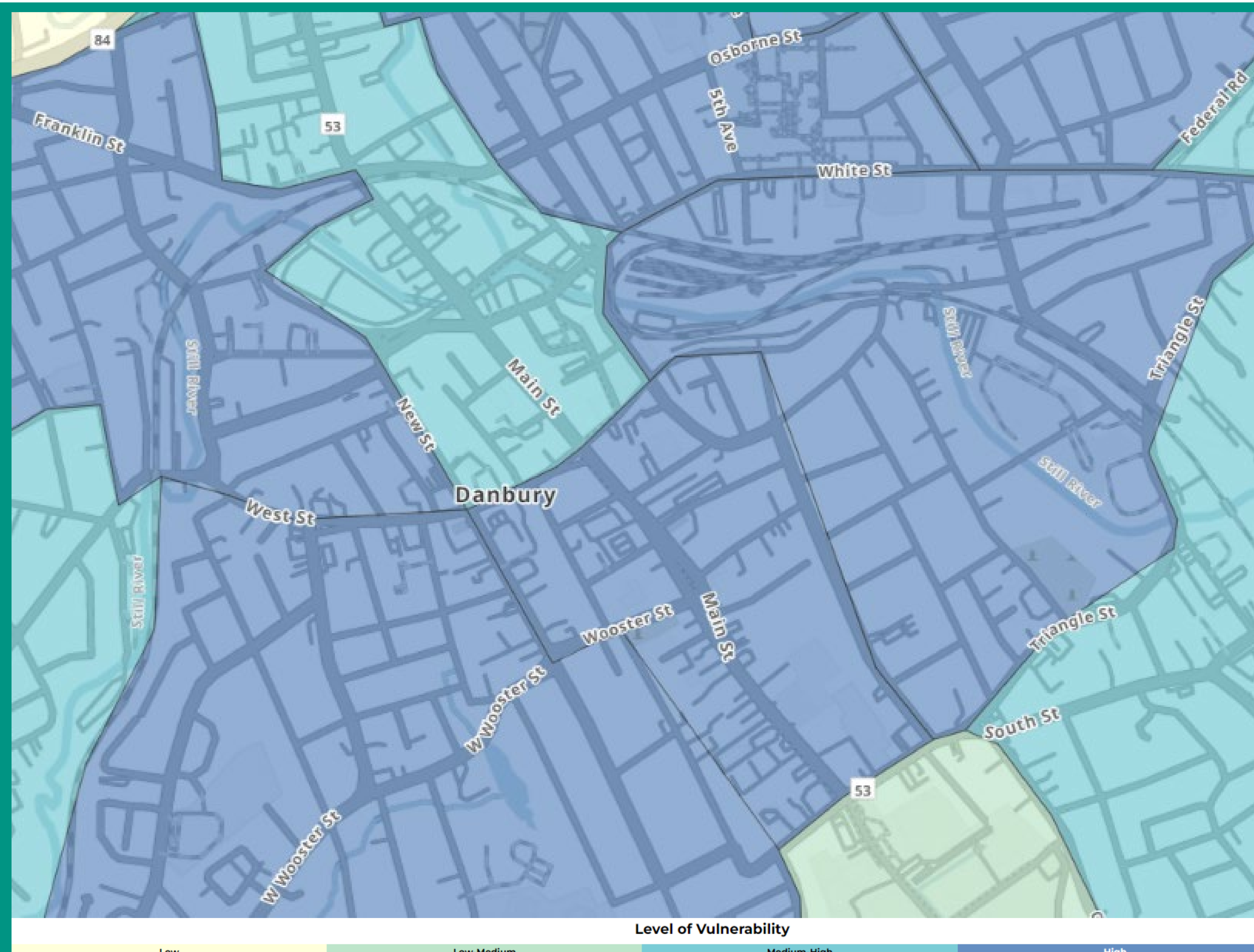
Understanding social vulnerability within the community allows emergency response planners and public health officials to identify the communities and areas that will most likely need support before, during, and after a hazardous event.

The Centers for Disease Control and Prevention (CDC) has developed a **Social Vulnerability Index (SVI)** that uses US Census data to identify vulnerability at the census tract level based on 16 social factors.

SVI – Contributing Factors:

CDC SVI Documentation 2020 | Place and Health | ATSDR

Overall Vulnerability		
	Socioeconomic Status	Below 150% Poverty
		Unemployed
		Housing Cost Burden
		No High School Diploma
		No Health Insurance
	Household Characteristics	Aged 65 & Older
		Aged 17 & Younger
		Civilian with a Disability
		Single-Parent Households
		English Language Proficiency
	Racial & Ethnic Minority Status	Hispanic or Latino (of any race) Black or African American, Not Hispanic or Latino Asian, Not Hispanic or Latino American Indian or Alaska Native, Not Hispanic or Latino Native Hawaiian or Pacific Islander, Not Hispanic or Latino Two or More Races, Not Hispanic or Latino Other Races, Not Hispanic or Latino
	Housing Type & Transportation	Multi-Unit Structures
		Mobile Homes
		Crowding
		No Vehicle
		Group Quarters



The Centers for Disease Control and Prevention (CDC) developed a Social Vulnerability Index (SVI) to aid in identifying populations that will need support before, during, and after a hazardous event. Link: CDC/ATSDR Social Vulnerability Index (SVI)

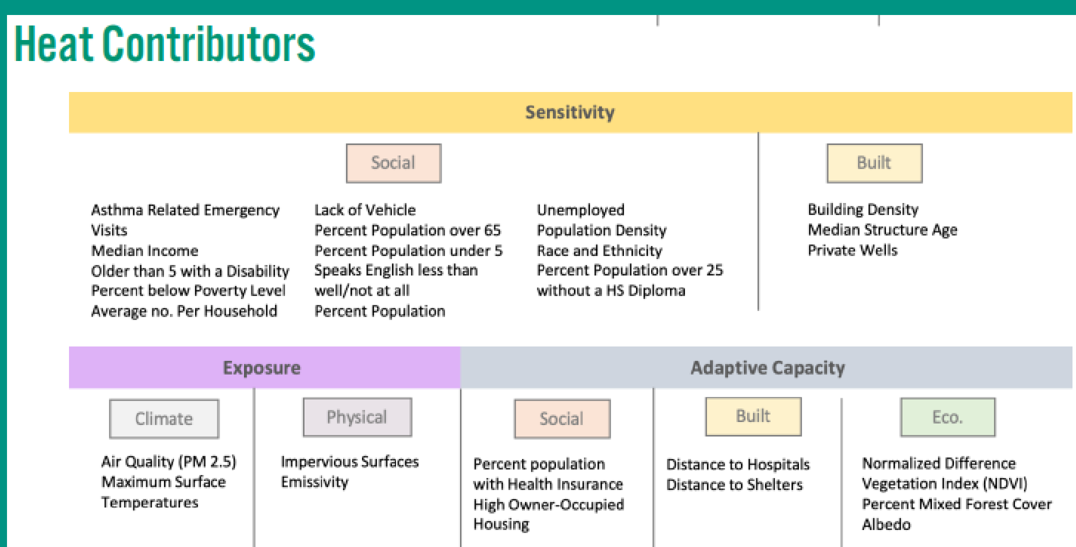
DOWNTOWN DANBURY + EXTREME HEAT

The project area has **high heat** and **moderately high heat** vulnerability, as assessed by CIRCA's Climate Change Vulnerability Index (CCVI) as shown. The high and moderately high rating is due to the high social vulnerability in the area, dense housing, high concentrations of impervious area, lack of tree cover, lack of connected green space, and lack of sufficient cooling center capacity.

Primary impacts from extreme heat include health effects such as heat stroke, dehydration, and dizziness, which can lead to death in extreme cases. Primary impacts can be harder to attribute to an extreme heat event because they may affect people who are already vulnerable, such as children, the elderly, and those with pre-existing medical conditions.

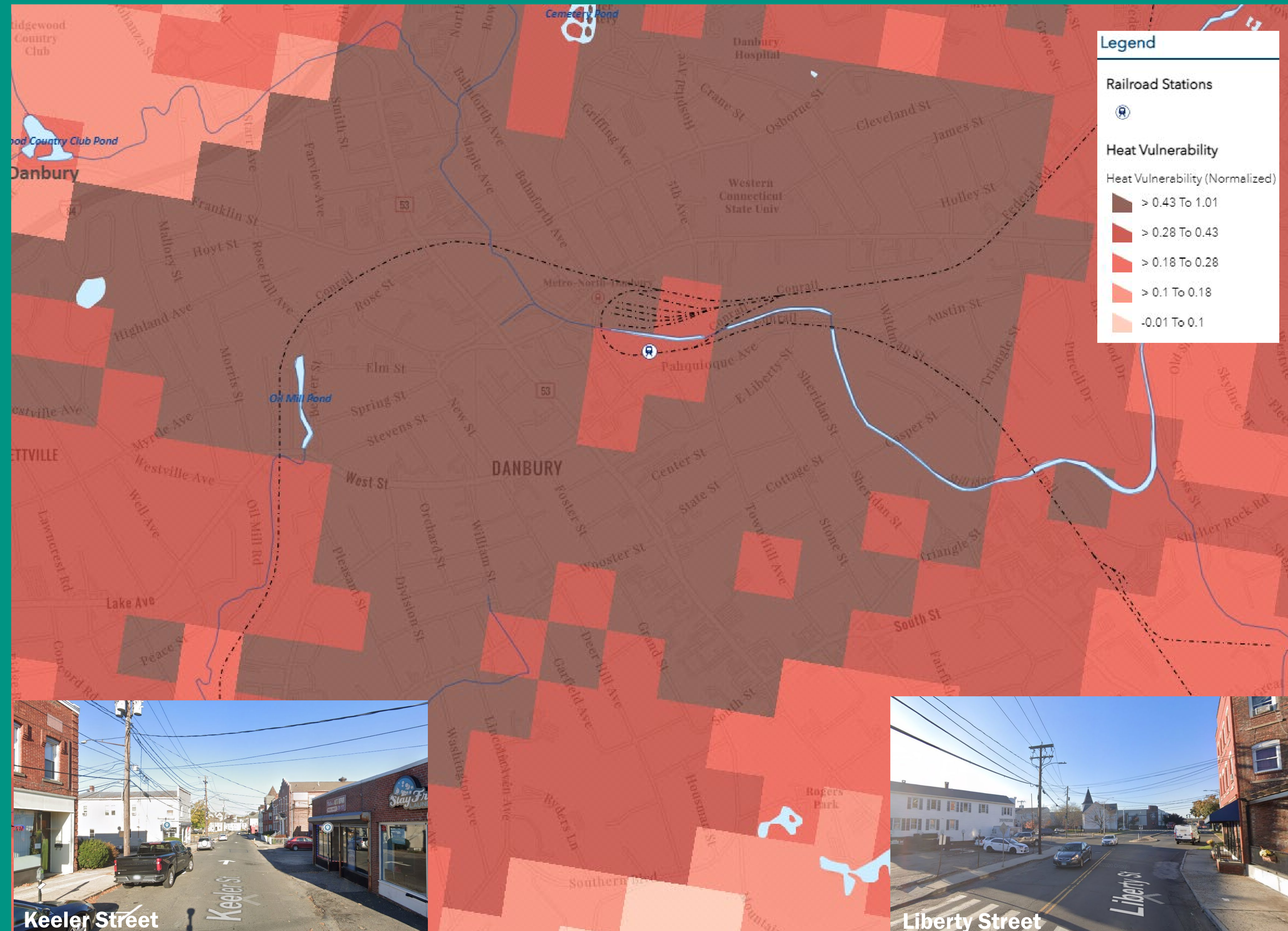
The City of Danbury is working with local private healthcare officials to track and document heat-related hospital visits and emergency response. This information will be used to target mitigation strategies within the community.

Secondary impacts include lost work time and increased electrical consumption.



CIRCA Climate Change Vulnerability Index – Contributing Factors

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



CIRCA Climate Change Vulnerability Index (CCVI) Heat Vulnerability Map

FLOOD MODELING AND VALIDATION

RESILIENT DANBURY

The existing Danbury stormwater drainage system was analyzed using the CHI PCSWMM software which integrates two-dimensional modeling of surface flooding with the EPA Stormwater Management Model (SWMM) for conveyance of flow through subsurface structures. The hydrologic properties of each subcatchment within the modeled drainage basin were determined from available topographic, land use, soils, and hydrography data. Rainfall infiltration rates were calculated using the Modified Green-Ampt Method. Soil data from the National Cooperative Soil Survey - Web Soil Survey was used to assign infiltration parameters to the soils throughout the watershed. Land use data was obtained from the Connecticut Environmental Conditions Online (CTECO). Analyses for the current and future climate conditions were completed for the 100% (1-year), 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), and 1% (100-year) annual chance storm event.[1]

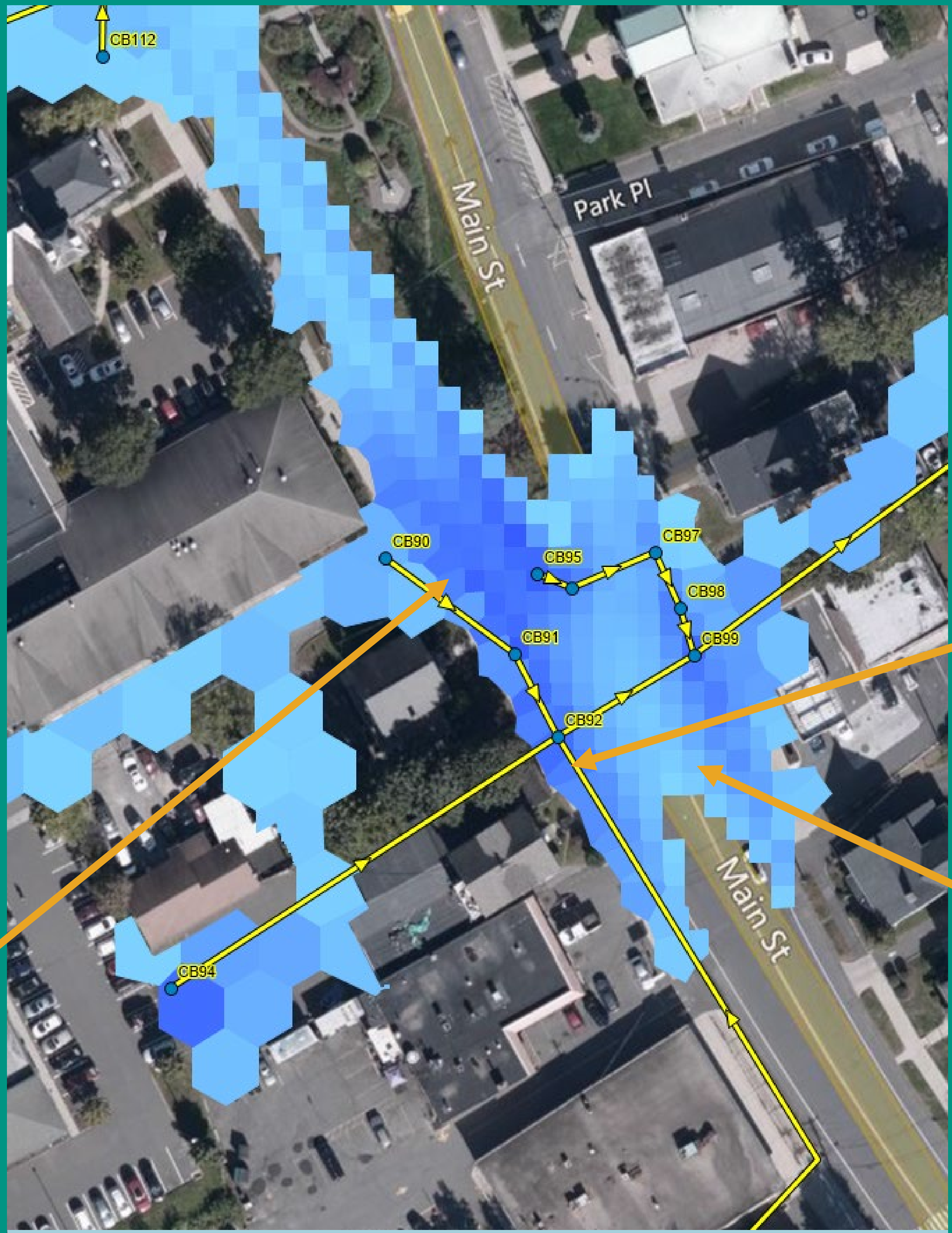
A model validation process was completed early in the flood model development. A large flooding event occurred within the watershed on June 2nd, 2022. Based on meteorological observations at a nearby airport precipitation gauge, the rainfall that occurred during this event was approximately equivalent to a 20% annual chance (5-year) storm. Photos of flooded streets captured by residents and city officials during this storm were examined; approximate flood depths and extents were calculated and compared against simulated flood depths and extents produced from the PCSWMM model. Generally, the model performed well at capturing the flood depths and extents within the areas depicted in the photographs.

For additional information on the technical analysis, please refer to the **Resilient Danbury East Ditch Flooding and Extreme Heat Mitigation Existing and Future Conditions Technical Report**.

[1] Current climate conditions were based on NOAA Atlas 14 Point Precipitation Data and Natural Resources Conservation Service Type III Synthetic Rainfall Distribution. Future climate conditions are based on the mid-century projections (2049-2069) in the 2019 Connecticut Physical Climate Science Assessment Report.

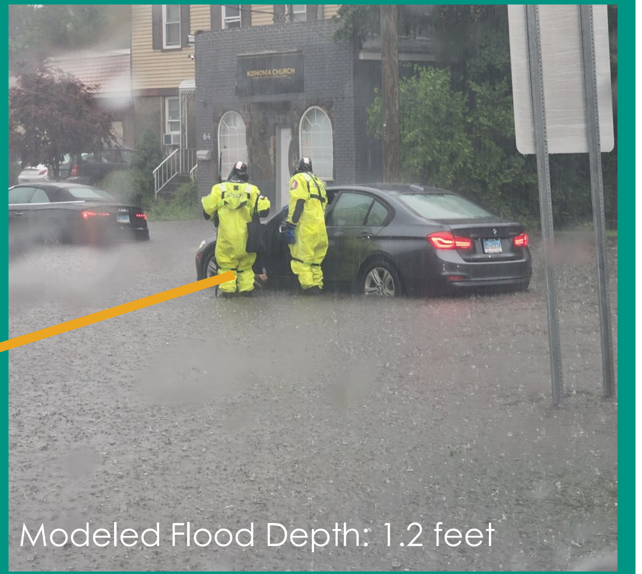
Flood Date: June 2nd, 2022

2.12 inches in 2 hours
20% Annual Chance
(5-Year) Storm
2-Hour Storm Duration



5-Year Storm (20% Chance) Modeled Flood Extents


Modeled Flood Depth: 1.6 feet


Modeled Flood Depth: 1.2 feet


Modeled Flood Depth: 0.4 feet

PUBLIC ENGAGEMENT

Public involvement and community engagement was sought throughout the process. The proposed mitigation measures will directly benefit communities with high social vulnerability. Three (3) Technical Advisory Committee meetings and three (3) public engagement events were held throughout the course of the project. The public engagement meetings are summarized below.

TABLE 1. PUBLIC ENGAGEMENT

PUBLIC WORKSHOPS	DATE	FOCUS
Public Workshop #1	In-person 4/10/2023 Roger's Park Middle School	Existing & Future Conditions
Public Workshop #2	Virtual 7/26/2023 Roger's Park Middle School	Visioning
Public Engagement #3	In-person 8/25/2023 San Gennaro Festival	Analysis

EXISTING AND FUTURE CONDITIONS ANALYSIS

RESILIENT DANBURY PROJECT OVERVIEW

WE WILL NEVER ELIMINATE FLOODING!
We can reduce depth, duration, and extent.

PRIORITIES

1. Address Critical Transportation and Resilience Corridors
2. Reduce Flood Risk and Coordinate with Redevelopment Efforts
3. Reduce the Impacts of Extreme Heat
4. Integrate Nature-Based Solutions + Green Infrastructure with City Green and Resilience Initiatives.

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3. CITY HALL

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- Ex. Conduits
- City of Danbury Parcels
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RESILIENT DANBURY

EXISTING DRAINAGE SYSTEM: FLOOD EXTENTS FOR CURRENT 100% (1-yr), 10% (10-yr) & 1% (100-yr) ANNUAL CHANCE FLOOD EVENTS

The maximum flooding extents for each recurrence interval were determined through PCSWMM modeling. The flood extents for the 100% (1-year), 10% (10-year), and 1% (100-year) annual chance of exceedance storms under current climate conditions are shown to the right.

More detail is provided in the Resilient Danbury Current and Future Conditions Analysis Report, provided separately.

RESILIENT DANBURY

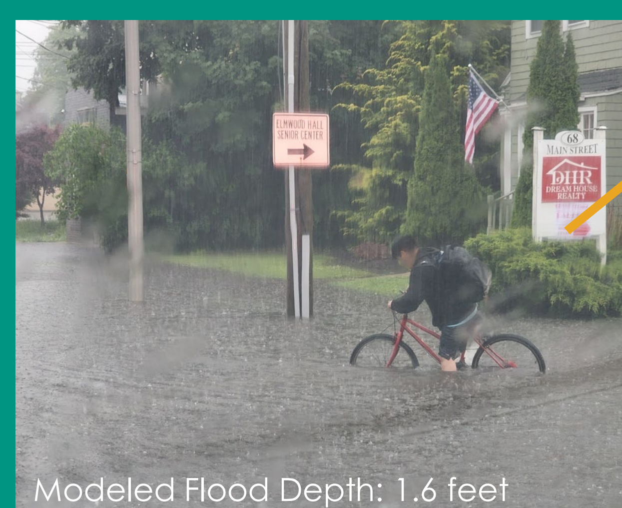
FLOOD MODELING AND VALIDATION

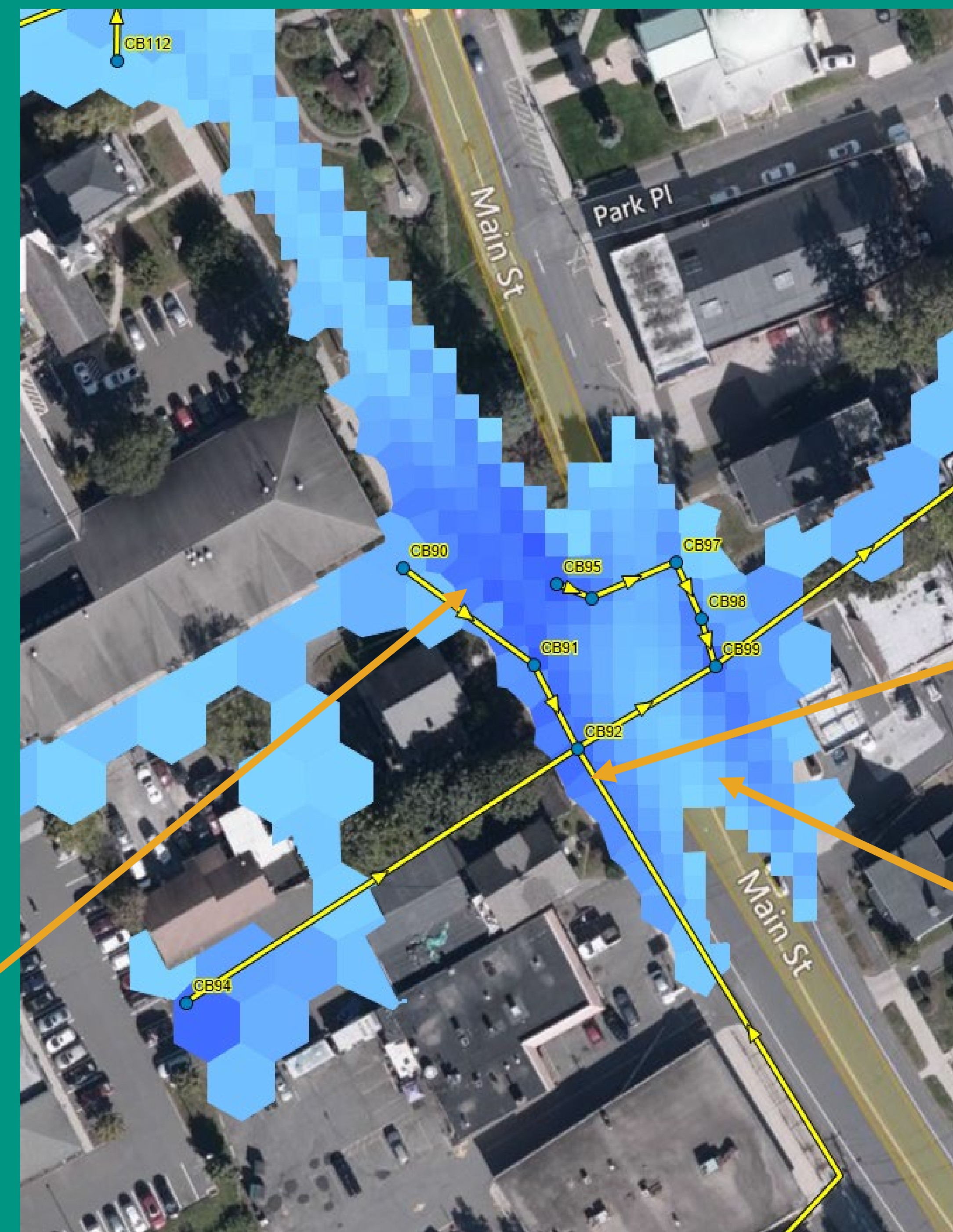
The existing Danbury stormwater drainage system was analyzed using the CHI PCSWMM software which integrates two-dimensional modeling of surface flooding with the EPA Stormwater Management Model (SWMM) for conveyance of flow through subsurface structures. The hydrologic properties of each subcatchment within the modeled drainage basin were determined from available topographic, land use, soils, and hydrography data. Rainfall infiltration rates were calculated using the Modified Green-Ampt Method. Soil data from the National Cooperative Soil Survey - Web Soil Survey was used to assign infiltration parameters to the soils throughout the watershed. Land use data was obtained from the Connecticut Environmental Conditions Online (CTECO). Analyses for the current and future climate conditions were completed for the 100% (1-year), 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), and 1% (100-year) annual chance storm event.[1]

A model validation process was completed early in the flood model development. A large flooding event occurred within the watershed on June 2nd, 2022. Based on meteorological observations at a nearby airport precipitation gauge, the rainfall that occurred during this event was approximately equivalent to a 20% annual chance (5-year) storm. Photos of flooded streets captured by residents and city officials during this storm were examined; approximate flood depths and extents were calculated and compared against simulated flood depths and extents produced from the PCSWMM model. Generally, the model performed well at capturing the flood depths and extents within the areas depicted in the photographs.

For additional information on the technical analysis, please refer to the **Appendix A PC SWMM Supporting Documentation**, and the *Resilient Danbury East Ditch Flooding and Extreme Heat Mitigation Existing and Future Conditions Technical Report,* provided as a separate report.

[1]Current climate conditions were based on NOAA Atlas 14 Point Precipitation Data and Natural Resources Conservation Service Type III Synthetic Rainfall Distribution. Future climate conditions are based on the mid-century projections (2049-2069) in the 2019 Connecticut Physical Climate Science Assessment Report.

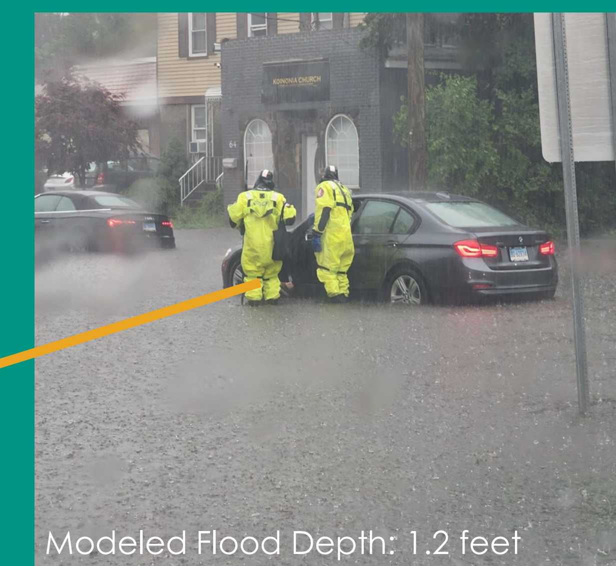

Modeled Flood Depth: 1.6 feet

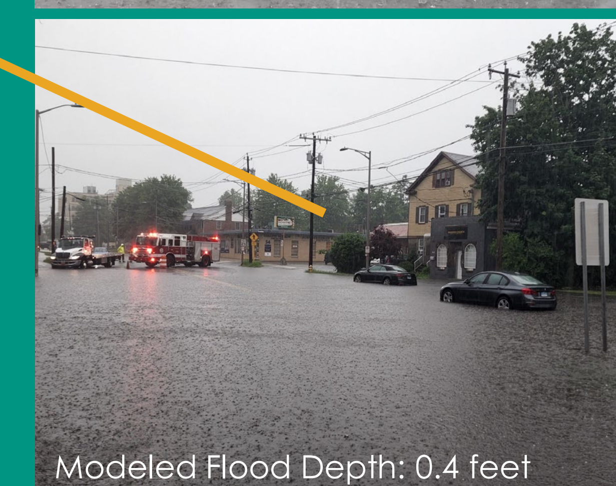


5-Year Storm (20% Chance) Modeled Flood Extents

Flood Date: June 2nd, 2022

2.12 inches in 2 hours
20% Annual Chance
(5-Year) Storm
2-Hour Storm Duration


Modeled Flood Depth: 1.2 feet


Modeled Flood Depth: 0.4 feet

RESILIENT DANBURY

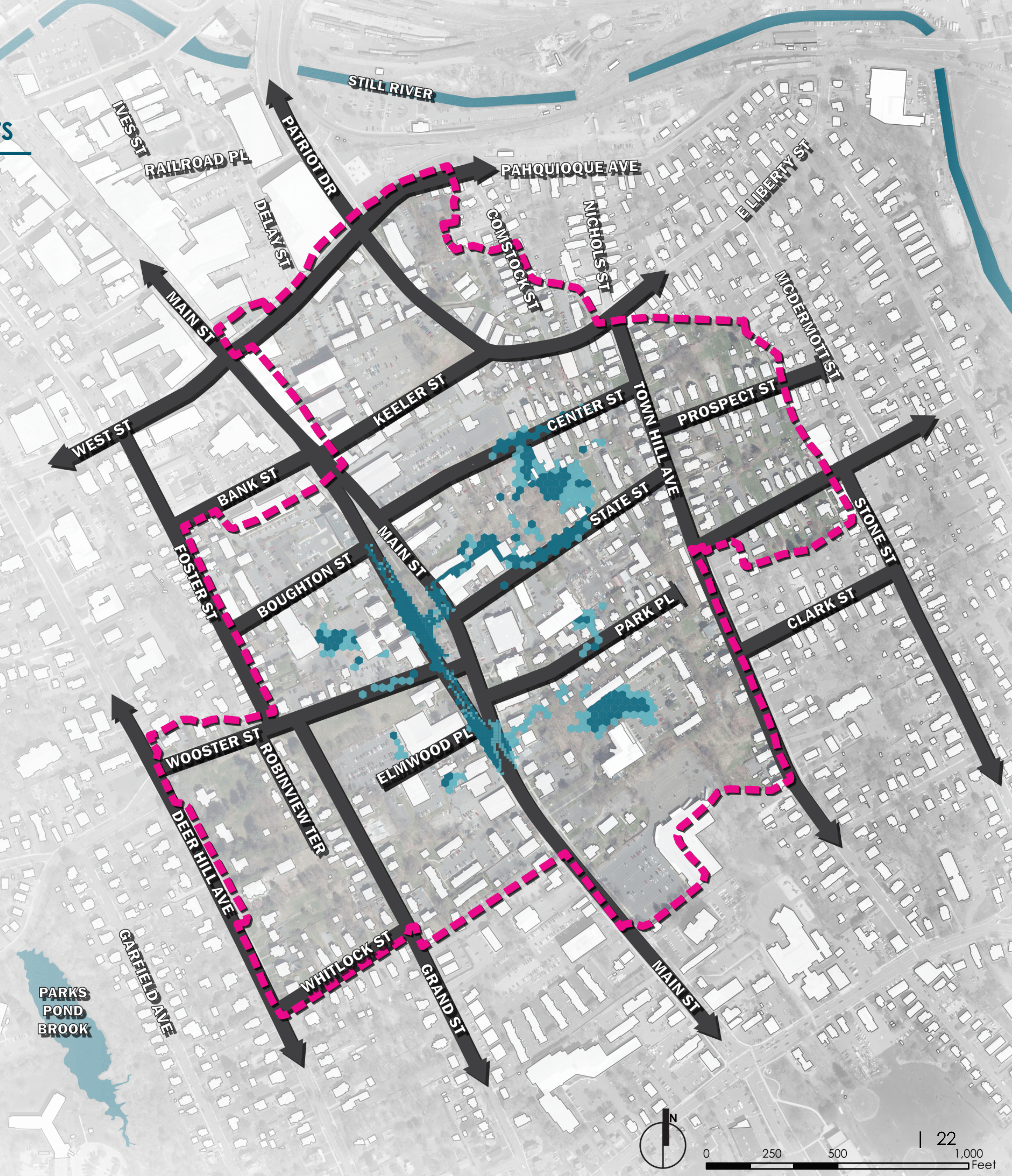
EXISTING DRAINAGE SYSTEM: FLOOD EXTENTS FOR CURRENT & FUTURE 100% (1-yr) ANNUAL CHANCE FLOOD EVENTS

The maximum flooding extents for each recurrence interval were determined through PCSWMM modeling. The maximum flood extents for the 100% (1-year) annual chance of exceedance storm under current and future climate conditions are shown to the right.

The model results show major areas of surface flooding at the following locations:

- Main Street between Boughton Street and Elmwood Place
- State Street
- Center Street

Number of Inundated Buildings	
Scenario	Annual Chance of Storm (Return Period)
	100% (1-Year)
Current Climate Conditions	17
Future Climate Conditions	37



LEGEND

- Current 100% Annual Chance Flood
- Future 100% Annual Chance Flood
- Watershed Boundary
- Roadways

RESILIENT DANBURY

EXISTING DRAINAGE SYSTEM: FLOOD EXTENTS FOR CURRENT & FUTURE 10% (10-yr) ANNUAL CHANCE FLOOD EVENTS

The maximum flooding extents for each recurrence interval were determined through PCSWMM modeling. The maximum flood extents for the 10% (10-year) annual chance of exceedance storm under current and future climate conditions are shown to the right.

The model results show major areas of surface flooding at the following locations:

- Center Street
- Park Place
- Affordable housing parking lot just south of Park Place
- Southern Main Street
- Wooster Street near the Main Street Intersection
- Liberty Street Near the intersection with Pahquioque Avenue

Number of Inundated Buildings	
Scenario	Annual Chance of Storm (Return Period)
	10% (10-Year)
Current Climate Conditions	75
Future Climate Conditions	98

LEGEND
- Current 10% Annual Chance Flood
- Future 10% Annual Chance Flood
- Watershed Boundary
- Roadways

RESILIENT DANBURY

EXISTING DRAINAGE SYSTEM: FLOOD EXTENTS FOR CURRENT & FUTURE 1% (100-yr) ANNUAL CHANCE FLOOD EVENTS

The maximum flooding extents for each recurrence interval were determined through PCSWMM modeling. The maximum flood extents for the 1% (100-year) annual chance of exceedance storm under current and future climate conditions are shown to the right.

The model results show major areas of surface flooding at the following locations:

- Center Street
- State Street
- Park Place
- The parking lot within the affordable housing complex just south of Park Place
- Southern Main Street
- Wooster Street near the Main Street Intersection
- Liberty Street Near the intersection with Pahquioque Avenue

Number of Inundated Buildings	
Scenario	Annual Chance of Storm (Return Period)
	1% (100-Year)
Current Climate Conditions	99
Future Climate Conditions	137

LEGEND

- Current 1% Annual Chance Flood
- Future 1% Annual Chance Flood
- Watershed Boundary
- Roadways

RESILIENT DANBURY

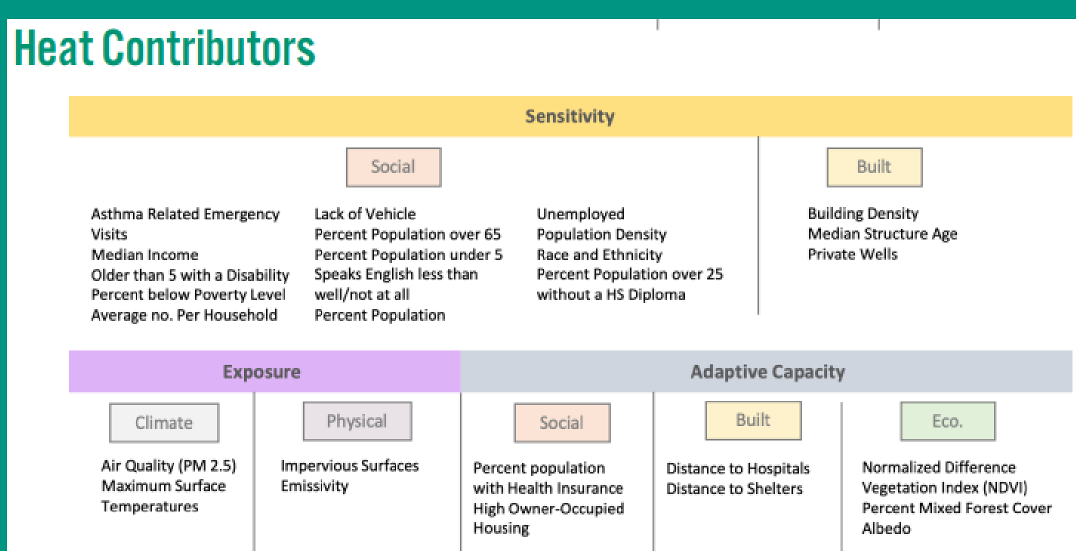
DOWNTOWN DANBURY + EXTREME HEAT

The project area has **high heat** and **moderately high heat** vulnerability, as assessed by CIRCA's Climate Change Vulnerability Index (CCVI) as shown. The high and moderately high rating is due to the high social vulnerability in the area, dense housing, high concentrations of impervious area, lack of tree cover, lack of connected green space, and lack of sufficient cooling center capacity.

Primary impacts from extreme heat include health effects such as heat stroke, dehydration, and dizziness, which can lead to death in extreme cases. Primary impacts can be harder to attribute to an extreme heat event because they may affect people who are already vulnerable, such as children, the elderly, and those with pre-existing medical conditions.

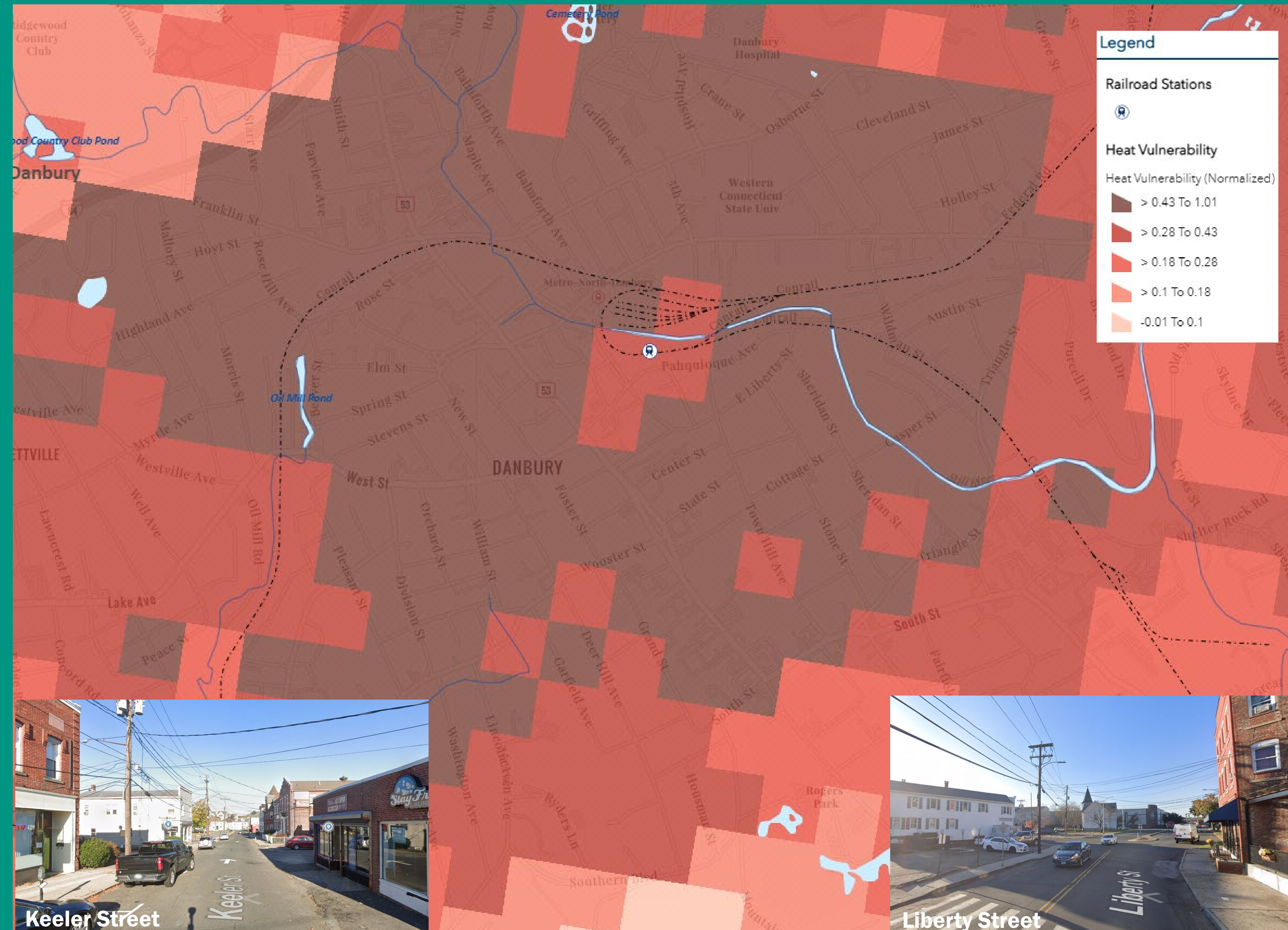
The City of Danbury is working with local private healthcare officials to track and document heat-related hospital visits and emergency response. This information will be used to target mitigation strategies within the community.

Secondary impacts include lost work time and increased electrical consumption.



CIRCA Climate Change Vulnerability Index – Contributing Factors

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



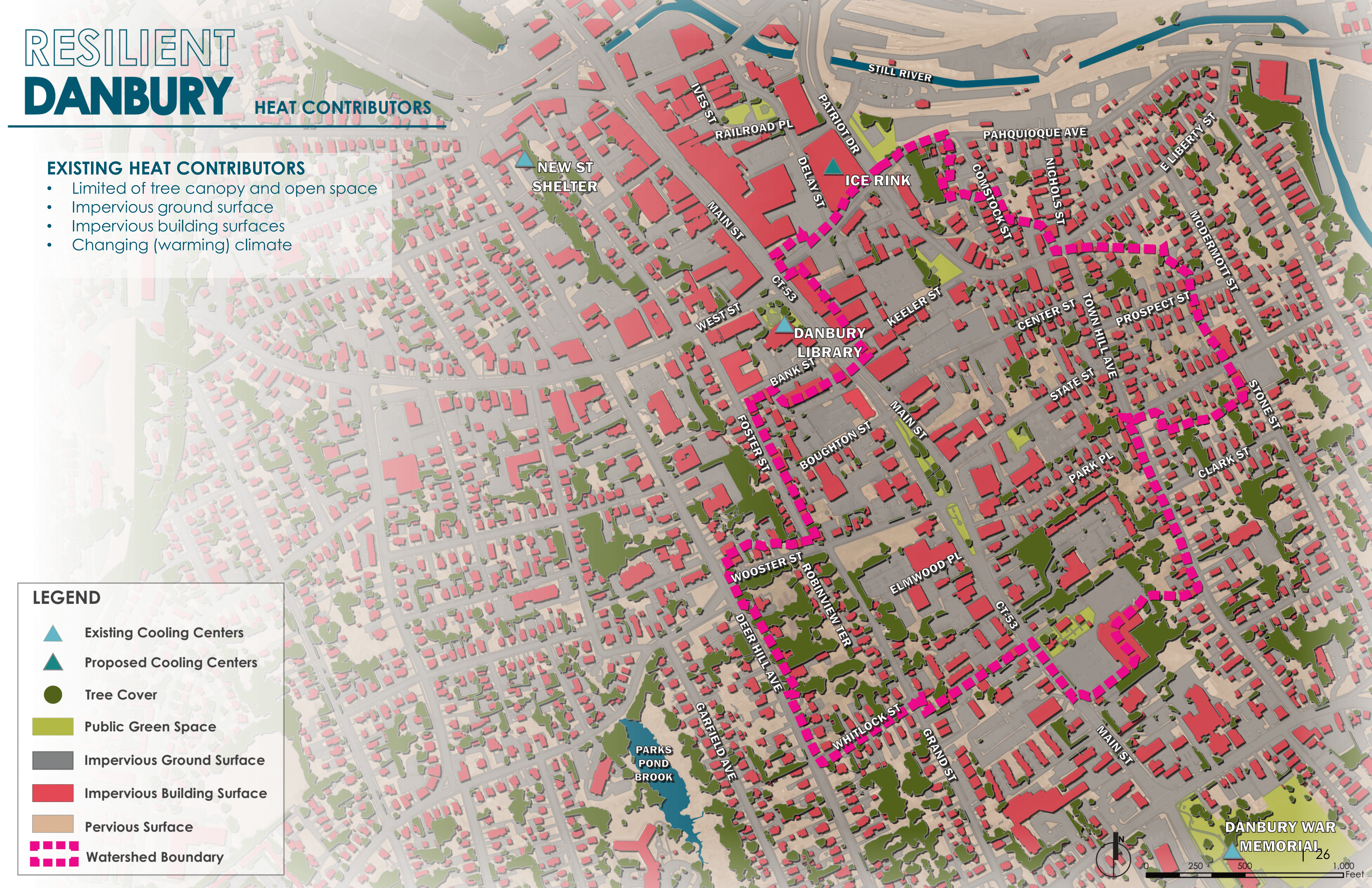
CIRCA Climate Change Vulnerability Index (CCVI) Heat Vulnerability Map

RESILIENT DANBURY

HEAT CONTRIBUTORS

EXISTING HEAT CONTRIBUTORS

- Limited of tree canopy and open space
- Impervious ground surface
- Impervious building surfaces
- Changing (warming) climate



THE SOLUTION

RESILIENT DANBURY PROJECT OVERVIEW

Visioning sessions were held to develop a Concept Diagram of Potential Mitigation Options, shown on the following page. This Concept Diagram depicts the range of recommended mitigation options.

Fuss & O'Neill worked with CIRCA and the City to develop project alternatives based on the mitigation options identified in the Concept Diagram. These alternatives were developed with consideration given to reduction in flood impacts, viability of green infrastructure, property ownership, and community benefits.

Three (3) mitigation alternatives were developed. The primary benefit from the mitigation options comes from drainage system improvements. Green Infrastructure, streetscape improvements, and tree plantings provide additional heat, water quality, and other community benefits.

Library/ Post Office/City Hall
1. UNITED STATES POST OFFICE
2. PUBLIC LIBRARY
3. CITY HALL

Religious Center
1. UNIVERSAL CHURCH
2. ALL NATION BAPTIST CHURCH
3. ST. JAMES EPISCOPAL CHURCH
4. TEMPLE BETHEL
5. STRONG GOD CHURCH
6. EMANUEL ASSEMBLY-GOD CHURCH
7. GREATER MERCY TEMPLE CHURCH
8. SACRED HEART CHURCH
9. SEVENTH DAY ADVENTIST CHURCH

Community Center
1. LEBANON-AMERICAN CLUB
2. ECUADORIAN CIVIC CENTER
3. DANBURY COMMUNITY CENTER
4. OUR LADY OF APARECIDA PARISH - BRAZILIAN COMMUNITY CENTER

Affordable Housing
1. AFFORDABLE HOUSING
2. PROPOSED AFFORDABLE HOUSING

Healthcare Facility & Senior Center
1. COMMUNITY HEALTH CENTER OF DANBURY
2. PALACE VIEW SENIOR HOUSING
3. GREATER DANBURY COMMUNITY HEALTH CENTER
4. PHARMACY (WALGREENS)
5. PLANNED PARENTHOOD
6. GREATER DANBURY COMMUNITY HEALTH CENTER
7. ELMWOOD HALL SENIOR CENTER
8. DANBURY REGIONAL WIC NUTRITION PROGRAM / OLD JAIL

School/ Educational Centers
1. CENTER FOR EMPOWERMENT & EDUCATION
2. ST. PETER'S SCHOOL
3. SOUTH STREET SCHOOLS
4. SACRED HEART SCHOOL
5. HEAD START CENTER

Public Open Space
1. DANBURY CITY CENTER GREEN
2. DANBURY SKATE PARK
3. ELMWOOD PLACE

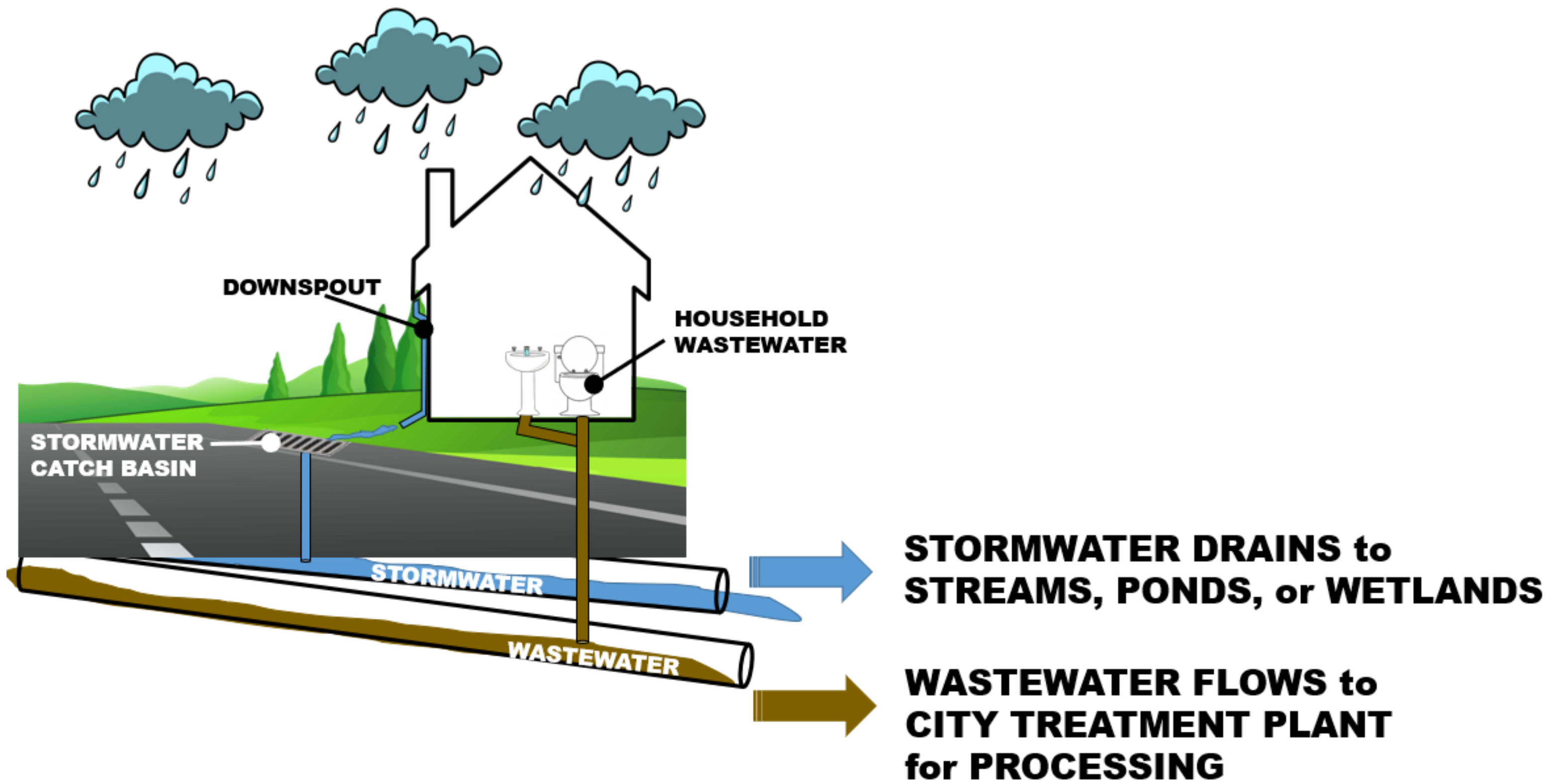
State of Connecticut
1. FAIRFIELD COUNTY COURTHOUSE
2. TRAIN STATION

Other
1. ICE RINK
2. MUSEUM AND HISTORICAL SOCIETY
3. GROCERY STORE (PRICE RITE)
4. CONNECTICUT LIGHT & POWER CO
5. BECKERIE & CO. FIRE ENGINE 9

LEGEND
- Ex. Outfalls
- Ex. Conduits
- City of Danbury Parcels
- Watershed Boundary
- Roadways

WHAT IS GREEN INFRASTRUCTURE?

FUSS & O'NEILL



Green infrastructure refers to systems and practices that **reduce** stormwater **runoff** through use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments. These practices **capture, manage, and/or reuse rainfall** close to where it falls, reducing stormwater runoff and keeping it out of drainage systems and receiving waters.

Rain Gardens: Small, shallow sunken areas of planting that collect stormwater runoff from routes, streets, and sidewalks. Rain gardens are designed to mimic the natural flow and infiltration of stormwater.

Treebox Filters: Treebox filters are often found along sidewalks, street curbs, and parking lots. The features accommodate a low volume of water.

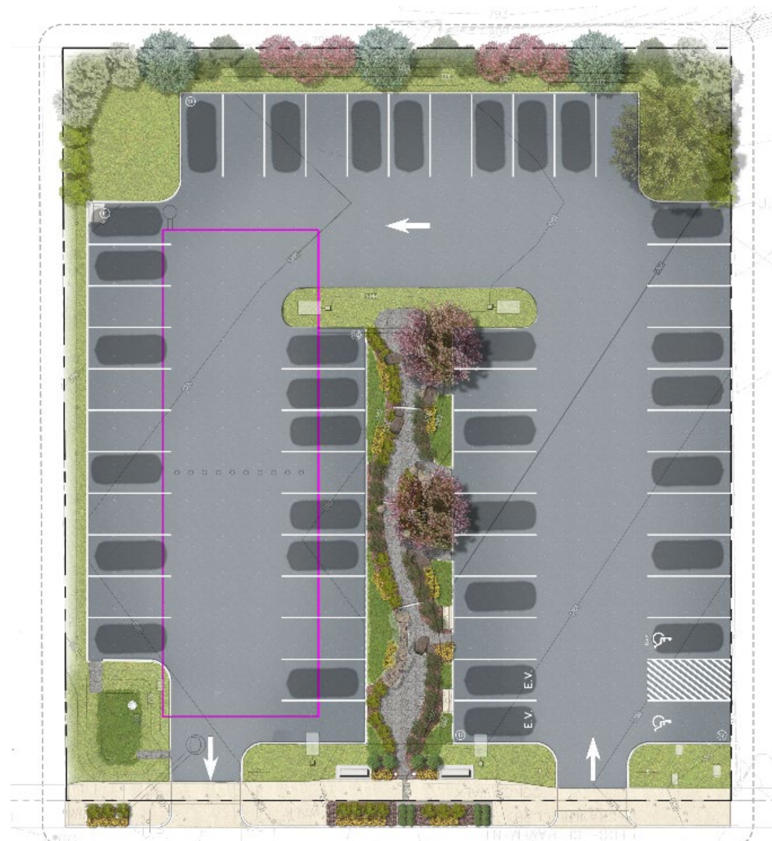
Roadside Bioswales: Bioswales are often found along road curbs and parking lots and use vegetation or mulch to slow and filter stormwater flow.

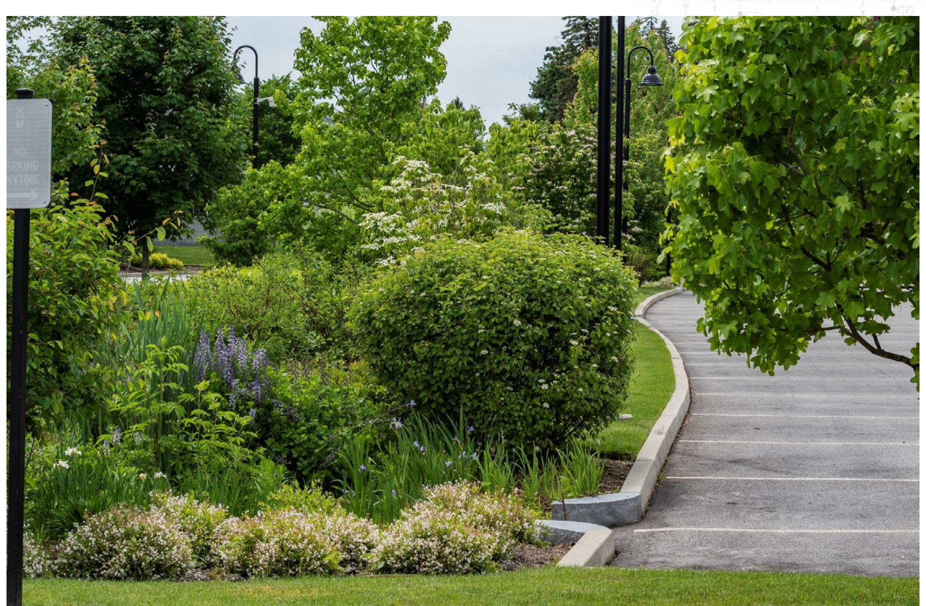
Underground Storage and Detention Systems: Underground systems are an efficient way to store, detain, and infiltrate stormwater runoff. The land above can be used for parking, parks, or other features.

BENEFITS OF GREEN INFRASTRUCTURE

FUSS & O'NEILL

- Increases flood resiliency
- Improves water quality
- Improves air quality
- Reduces streambank erosion
- Sequester carbon
- Adds aesthetic interest
- Contributes to overall economic vitality
- Helps reduce energy consumption
- Improves property values
- Promotes adaptation to climate change

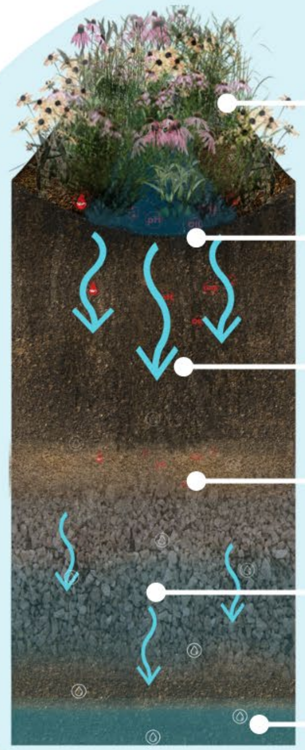




STORMWATER ON MAIN ST.

Green Infrastructure Approach to Responsible Stormwater Management

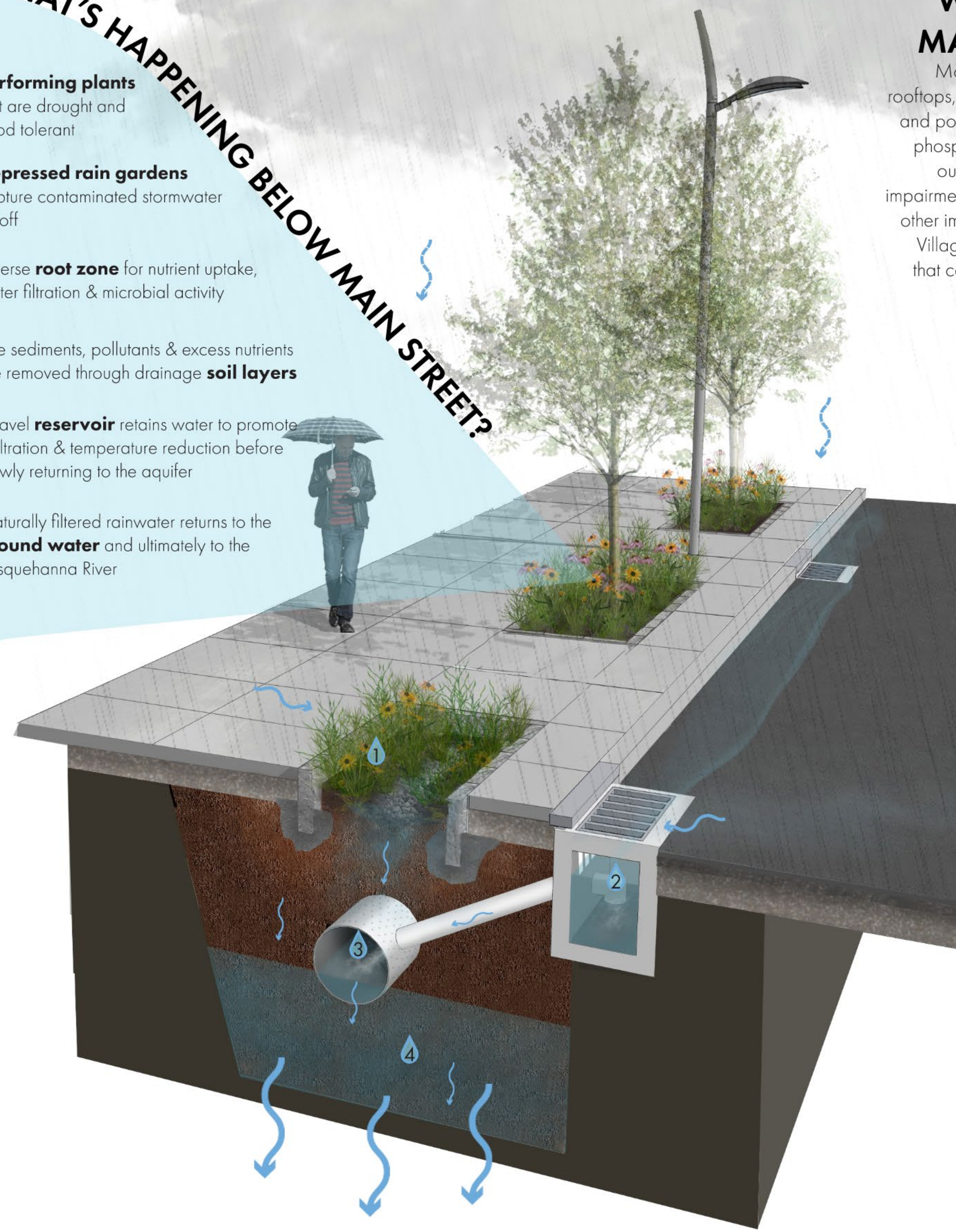
WHAT'S HAPPENING BELOW MAIN STREET?



1. **Performing plants** that are drought and flood tolerant
2. **Depressed rain gardens** capture contaminated stormwater runoff
3. Diverse **root zone** for nutrient uptake, water filtration & microbial activity
4. Fine sediments, pollutants & excess nutrients are removed through drainage **soil layers**
5. Gravel **reservoir** retains water to promote infiltration & temperature reduction before slowly returning to the aquifer
6. Naturally filtered rainwater returns to the **ground water** and ultimately to the Susquehanna River

WHY IS A RESPONSIBLE STORMWATER MANAGEMENT STRATEGY IMPORTANT?

Most stormwater runoff occurs during a rainfall or snow melt. It travels off our rooftops, along our roadways, parking lots and sidewalks picking up contaminants and pollutants before outputting into **local water systems**. Sediment, nitrogen, phosphorus, bacteria, oil and grease, trash, pesticides and metals can leak into our water systems making stormwater runoff the number one cause of stream impairment in urban areas. Runoff can cause water pollution, erosion, flooding and other impacts to the environment and the **integrity of our infrastructure.** The Village of Sidney, New York has adopted a natural, green infrastructure system that captures, cleanses and reduces stormwater runoff using **plants, soils** and **microbes.**



SYSTEM DESIGN + FUNCTION

1. **Rain Gardens** are designed to collect stormwater from impervious surfaces before reaching the existing conventional stormwater drainage system.
2. **Catch Basins** will collect storm water from the road to be pretreated by removing floating and heavy sediments before entering the green infrastructure system.
3. **Perforated Pipes** collect pretreated water from the catch basins. Water percolates into the reservoir below through openings in the pipe. If the reservoir fills, the pretreated water will flow to the connected existing conventional stormwater system.
4. **The Rain Garden Reservoir** has storage capacity to hold collected water, releasing it slowly over time. Sidney's Reservoir can hold 960 cubic yards of water. That's like filling 193,895 one gallon jugs of water!

THESE PLANTS ROOT THE SYSTEM

Stormwater Management Systems rely on vegetation to stabilize soil, filter contaminants, absorb nutrients, intercept and transpire water, and support a healthy soil biology. Diverse Root types and depths are important for performance. These species are tolerant of both wet and dry conditions!

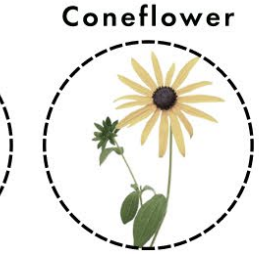

Zelkova

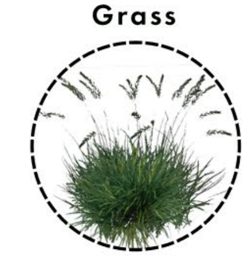

Flowering Dogwood


Purple Coneflower

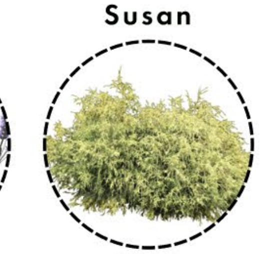

Dwarf Fountain Grass


Sea Holly


Black Eyed Susan


Tufted Hairgrass

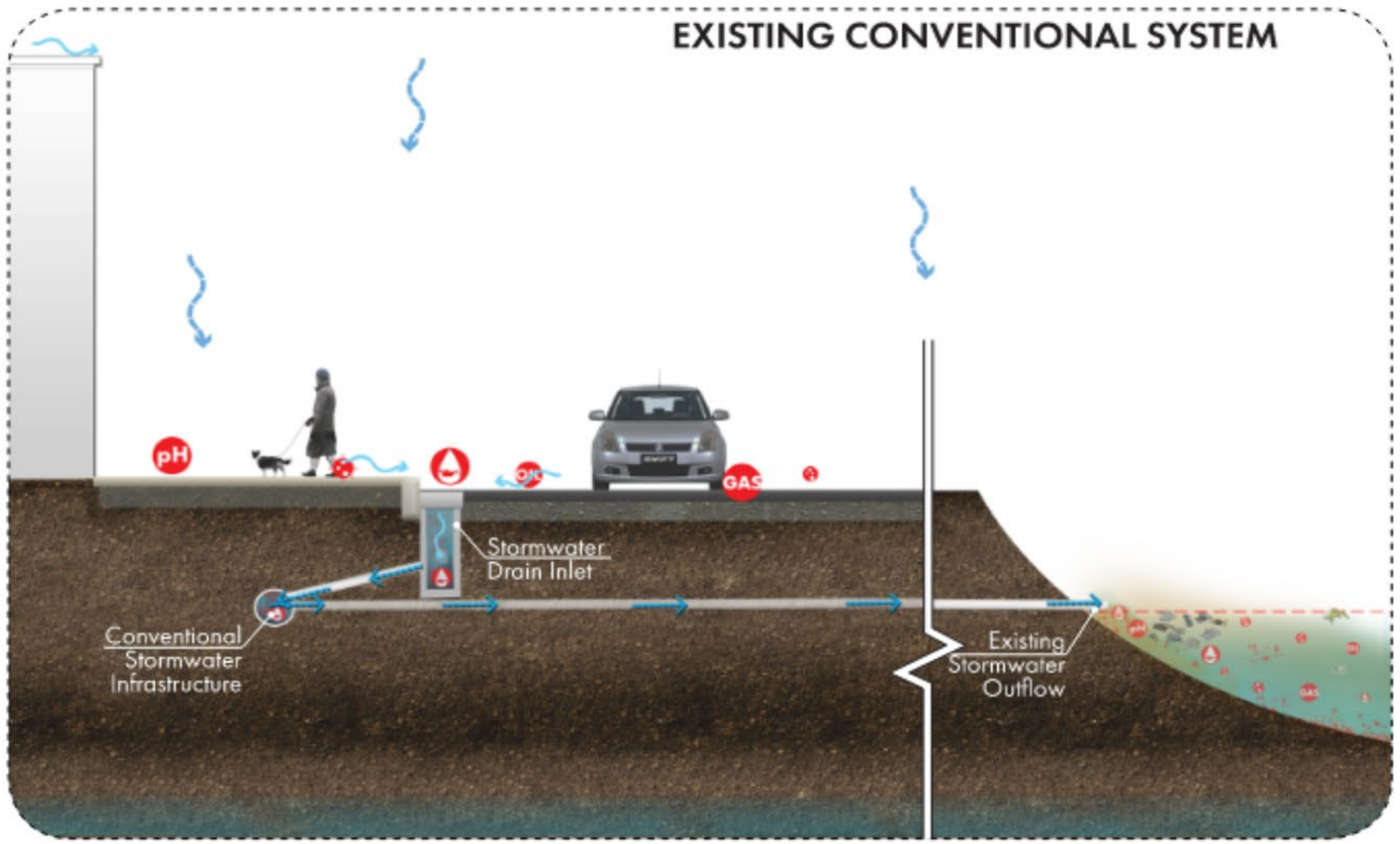

May Night Salvia


Gold Coast Juniper

INFILTRATING INFRASTRUCTURE

Improving Water Quality In Danbury

EXISTING CONVENTIONAL SYSTEM



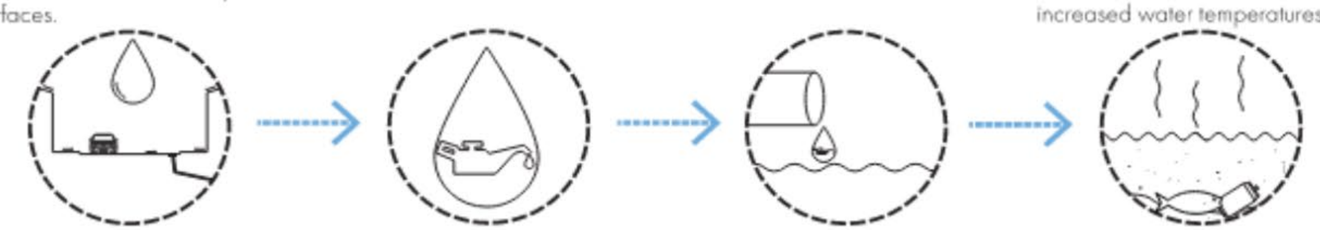
URBAN RUNOFF → CONTAMINANTS → PIPE NETWORK → UNHEALTHY RIVER

1 Urban runoff collects contaminants from rooftops, roadways, parking lots, sidewalks & other impervious surfaces.

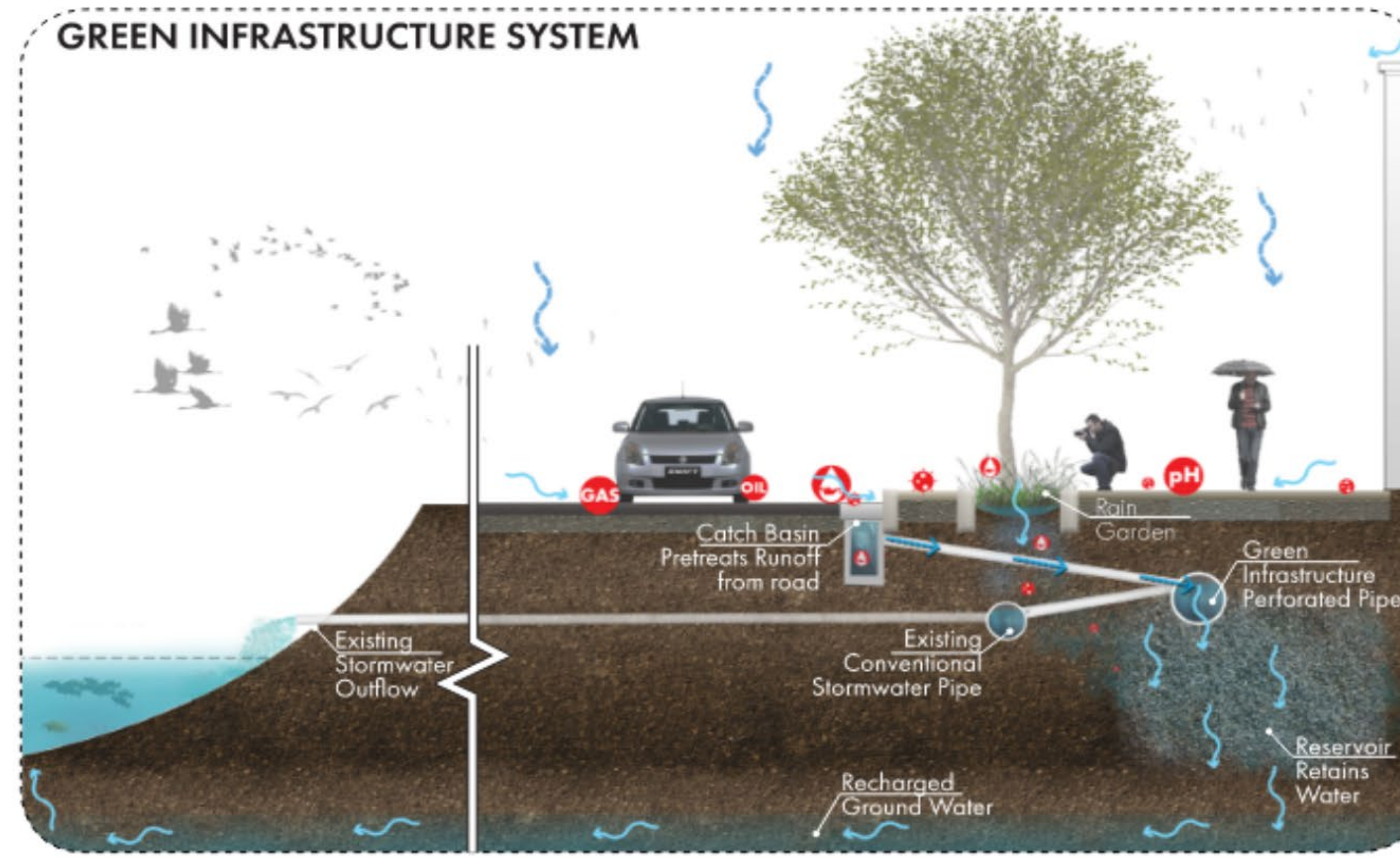
2 Chemical, nutrient and thermal contaminants are collected with runoff and directed to storm drains.

3 Contaminated runoff travels the pipe networks until it daylights into local water sources.

4 Local water bodies are polluted with heavy metals, algae inducing nutrients, sedimentation and increased water temperatures.



GREEN INFRASTRUCTURE SYSTEM



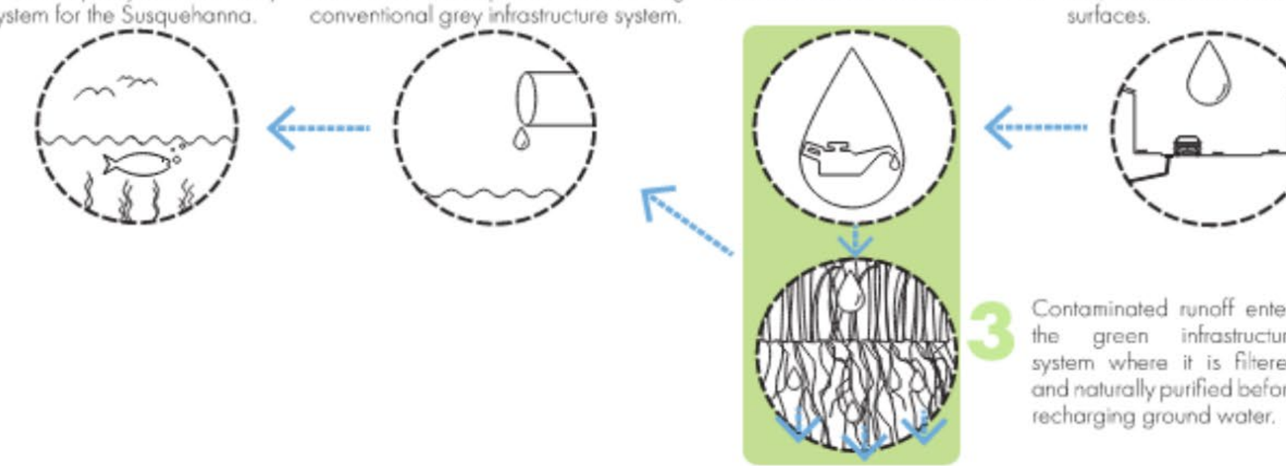
HEALTHY RIVER ← PIPE NETWORK ← CONTAMINANTS → GREEN INFRASTRUCTURE ← URBAN RUNOFF

5 A reduction of runoff entering the conventional system promotes good water quality and a healthy ecosystem for the Susquehanna.

4 Only in heavy storm events when the reservoir has reached capacity will water backup into the existing conventional grey infrastructure system.

2 Chemical, nutrient and thermal contaminants are collected with runoff and directed to storm drains.

1 Urban runoff collects contaminants from rooftops, roadways, parking lots, sidewalks & other impervious surfaces.



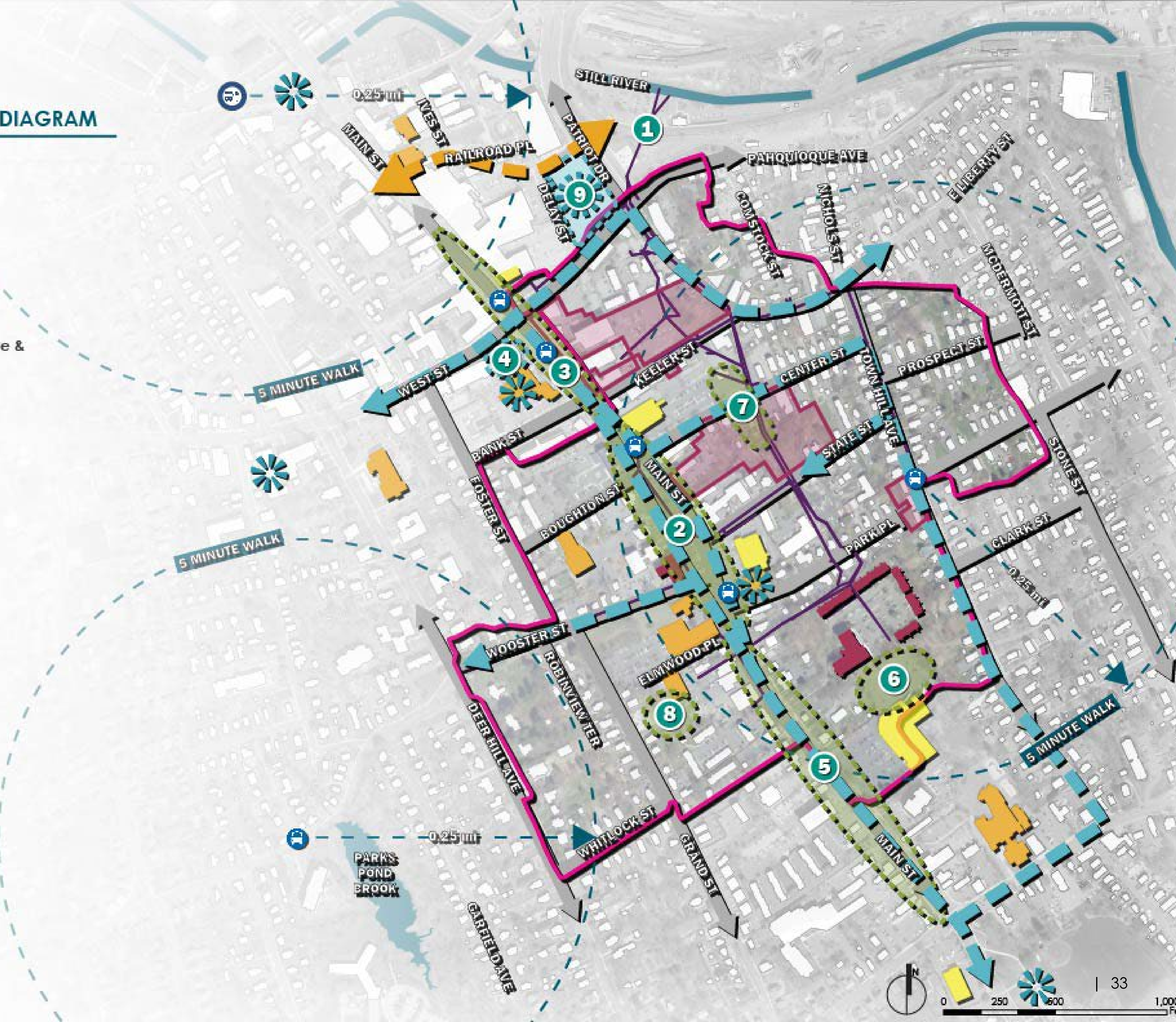
3 Contaminated runoff enters the green infrastructure system where it is filtered and naturally purified before recharging ground water.

RESILIENT DANBURY
CONCEPT DIAGRAM

1. Drainage System Improvements
2. Median Green Park Modifications
3. Streetscape/Median Improvements
4. Cooling Stop
5. Suburban Streetscape Improvement
6. Parking Lot Facelift With Green Infrastructure & Pedestrian Connection
7. Develop Green Infrastructure Features
8. Neighborhood Pedestrian Linkages with Green Infrastructure & Cooling Stop
9. Ice Rink Cooling Center

LEGEND

- Future Development Areas
- Affordable Housing
- Community Assets
- Important Retail Locations
- Green Infrastructure Improvements
- Cooling Infrastructure Improvements
- Heat Relief Locations
- Bus Stop
- Bus Transfer Station
- Drainage System Improvements
- Improved Pedestrian Connection
- Cooling Cooridors
- Roadways
- Watershed Boundary



RESILIENT DANBURY

1 Drainage System Improvements

PROPOSED DRAINAGE SYSTEM

2002	**Initial drainage system upgrade design**
2011	**Upgrade at Still River**
2012-2021	**Proposed upgrades included in Hazard Mitigation Plans**
2023	**F&O advancing design**

MITIGATION OPTIONS
DETAILS AND SECTIONS

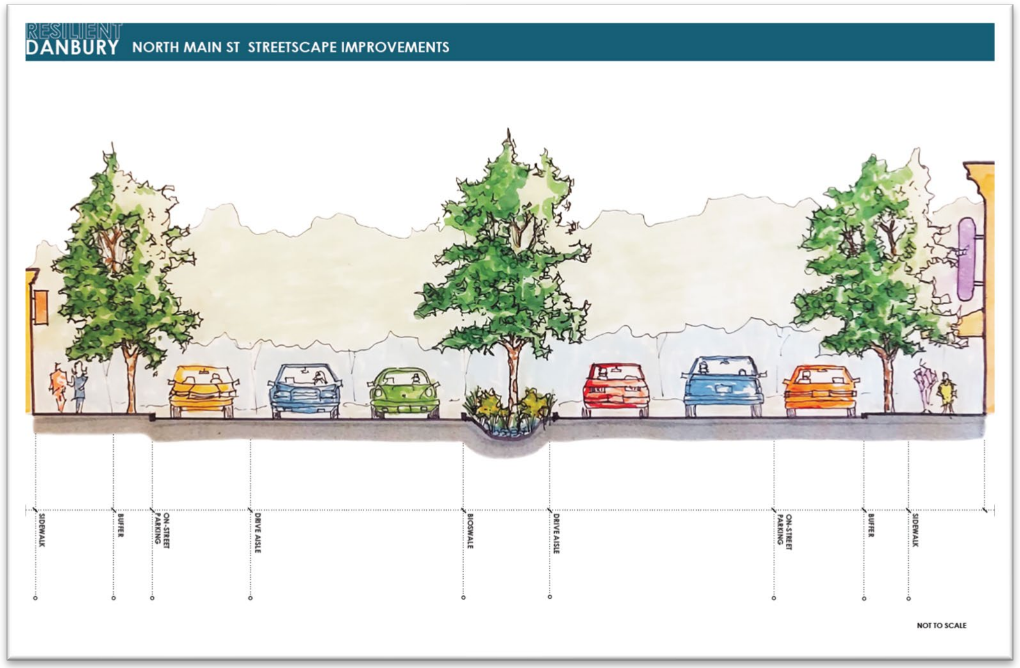
The following pages provide detail for the recommended mitigation options, including the resiliency goals and features for each area.

Proposed Green Infrastructure Areas were prioritized according to hydrologic soil group, depth to groundwater, and ability to connect to the existing drainage system, and property ownership.

City-owned properties were prioritized for implementation.

Alternatives were developed based on the recommended improvements and prioritized Green Infrastructure Areas. Flood improvement modeling results are included as Appendix A.

Benefit Cost Ratios (BCRs) were developed for each alternative, based on calculation of opinion of probable construction cost and estimated benefits.



MEDIAN GREEN PARK MODIFICATIONS

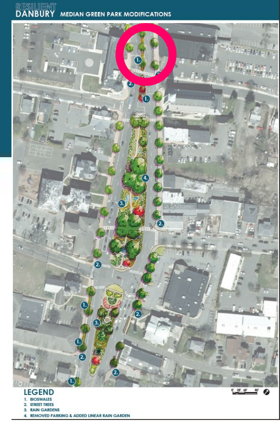
2 Median Green Park Modifications

3 Streetscape/Median Improvements

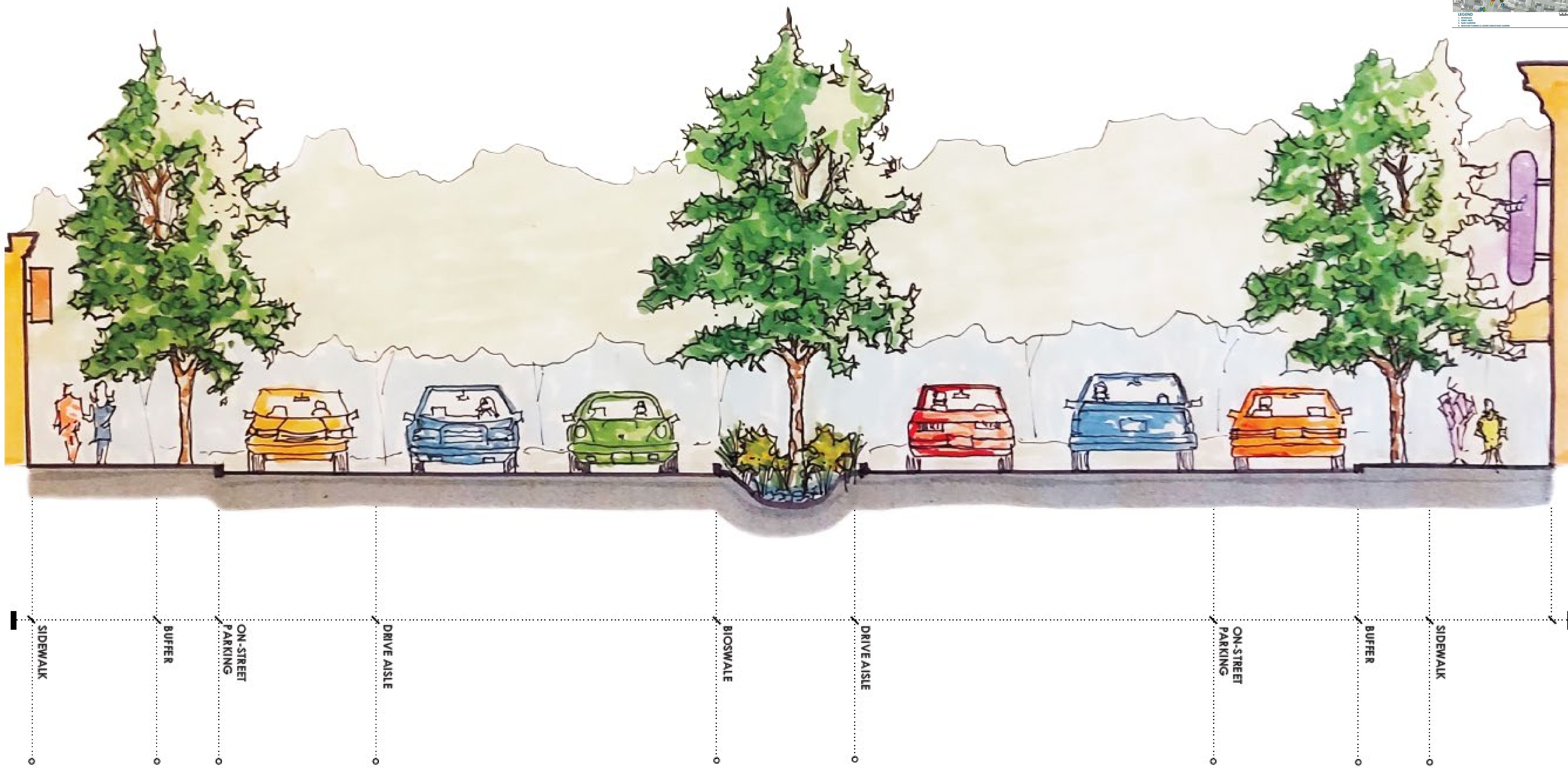
Walk and Shop

- Streetscape improvements
- Improve pedestrian experience
- Collect runoff

LEGEND
1. BIOSWALES
2. STREET TREES
3. RAIN GARDENS
4. REMOVED PARKING & ADDED LINEAR RAIN GARDEN



2 Median Green Park Modifications



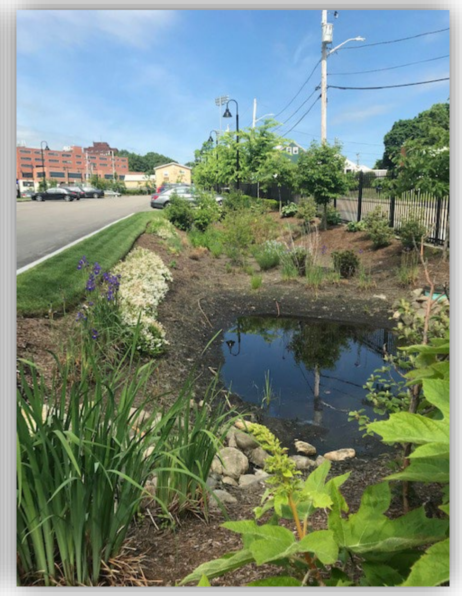
NOT TO SCALE

4 Cooling Stop

Rest and Shade

Resiliency at the Library:

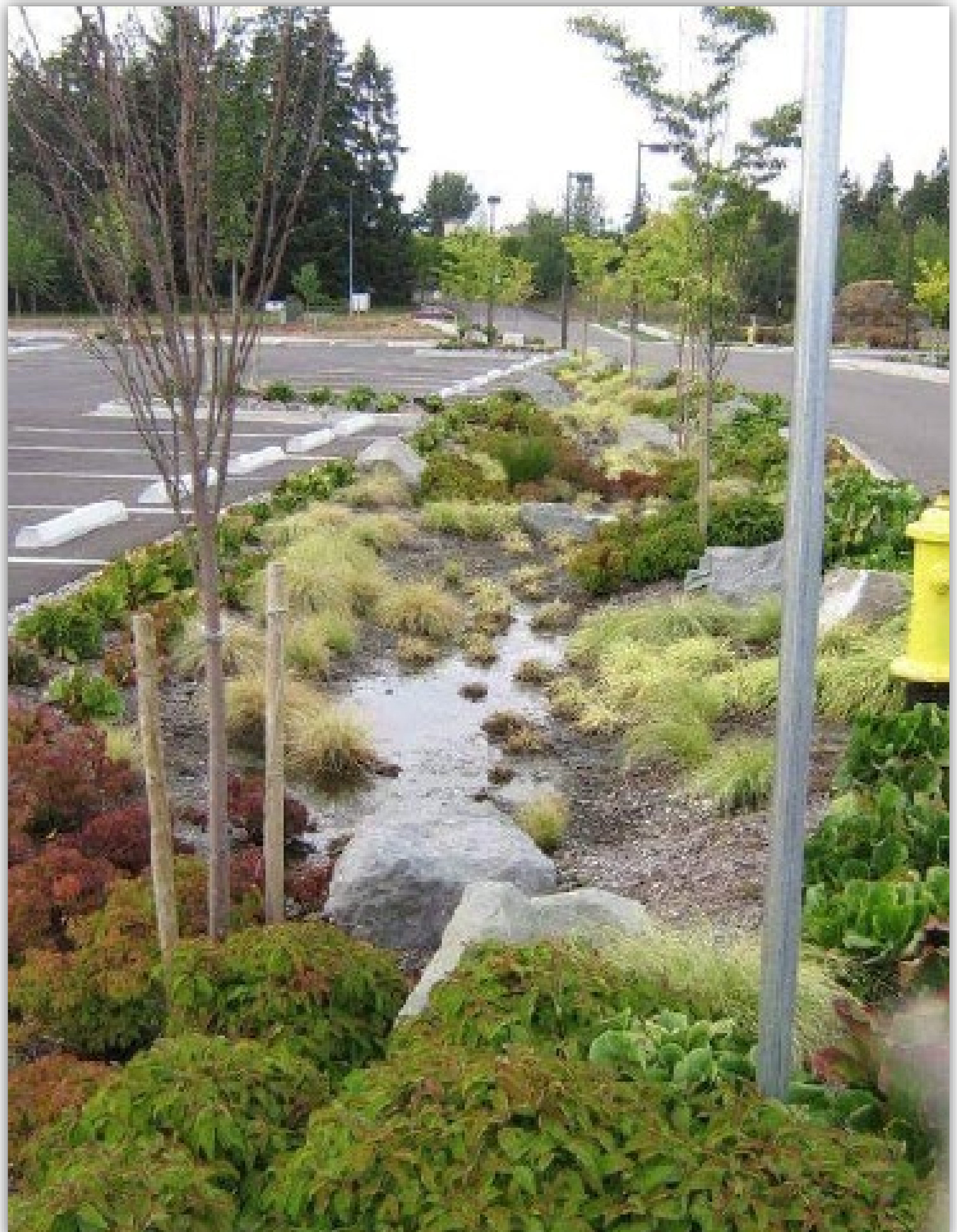
- Increase rest areas with seating
- Increase shade around library
- Incorporate stormwater management throughout



LEGEND

1. LIBRARY
2. INNOVATION CENTER
3. PARKING
4. BIOSWALE WITH SHADE TREES
5. RAIN GARDEN
6. SHADED PLAZA WITH SEATING
7. SMALL RAIN GARDENS
8. BUMP OUT
9. BIOSWALE WITH TREES IN BOULEVARD

0' 15' 30' 60'



MEDIAN GREEN PARK MODIFICATIONS

5 Suburban Streetscape Improvement

Walk and Shop

- Streetscape improvements
- Improve pedestrian experience
- Collect runoff

LEGEND

1. BIOSWALES
2. STREET TREES
3. RAIN GARDENS
4. REMOVED PARKING & ADDED LINEAR RAIN GARDEN

5 Suburban Streetscape Improvement

NOT TO SCALE

5 Suburban Streetscape Improvement

NOT TO SCALE

6 Parking Lot Facelift With Green Infrastructure & Pedestrian Connection

Reduce Impervious

- Consolidate parking lots
- Reduce impervious surface area
- Increase shaded pedestrian connections
- Incorporate stormwater management at location of underutilized back parking lot and within parking islands

LEGEND

1. PRICE RITE MARKETPLACE
2. PARKING
3. OFF SITE WET DETENTION BASIN
4. BIORETENTION AREA
5. SHADED PEDESTRIAN CONNECTION TO GROCERY STORE
6. BIOSWALE
7. PARKING ISLAND RAIN GARDENS
8. EXISTING LOADING DOCK

0' 15' 30' 60'

7 Develop Green Infrastructure Features

Collect and Treat

- Consolidate and reduce parking
- Reduce impervious area
- Increase shade
- Stormwater management throughout

LEGEND

1. BIORETENTION AREA
2. RECONFIGURED TO STANDARD PARKING DIMENSIONS TO REDUCE EXCESS PAVING
3. STREET TREES
4. PARKING ISLAND RAIN GARDENS
5. RELOCATED PARKING LOT ENTRANCE
6. TREES ADDED TO EXISTING PARKING ISLANDS
7. BIOSWALE WITH TREES

0' 15' 30' 60'

8 Neighborhood Pedestrian Linkages with Green Infrastructure & Cooling Stop

Cooling and Connecting

- Opportunity for neighborhood outdoor activity
- Features
  - Picnic pavilion
  - Open lawn
  - Splash pad
- Provides pedestrian connection between Grand Street and Main Street

LEGEND

1. SENIOR CENTER
2. OPEN LAWN
3. PUMP SHED
4. POP JET FOUNTAIN
5. SHADED BENCH SEATING
6. PICNIC PAVILION
7. PICNIC AREA
8. SHADED PEDESTRIAN CONNECTION TO GRAND ST
9. RAIN GARDENS

0' 10' 20' 40'

ADAPTATION OPTIONS SUMMARY

ALTERNATIVE 1
DRAINAGE SYSTEM IMPROVEMENTS

MITIGATION ACTIONS
- Drainage system improvements

BCR < 1

ALTERNATIVE 2
DRAINAGE SYSTEM IMPROVEMENTS + GSI

MITIGATION ACTIONS
- Drainage system improvements
- Rain garden at 9-11 Liberty Street
- Rain garden at old Jail
- Rain garden and cooling stop at the Senior Center

BCR > 1

ALTERNATIVE 3
WATERSHED IMPROVEMENTS

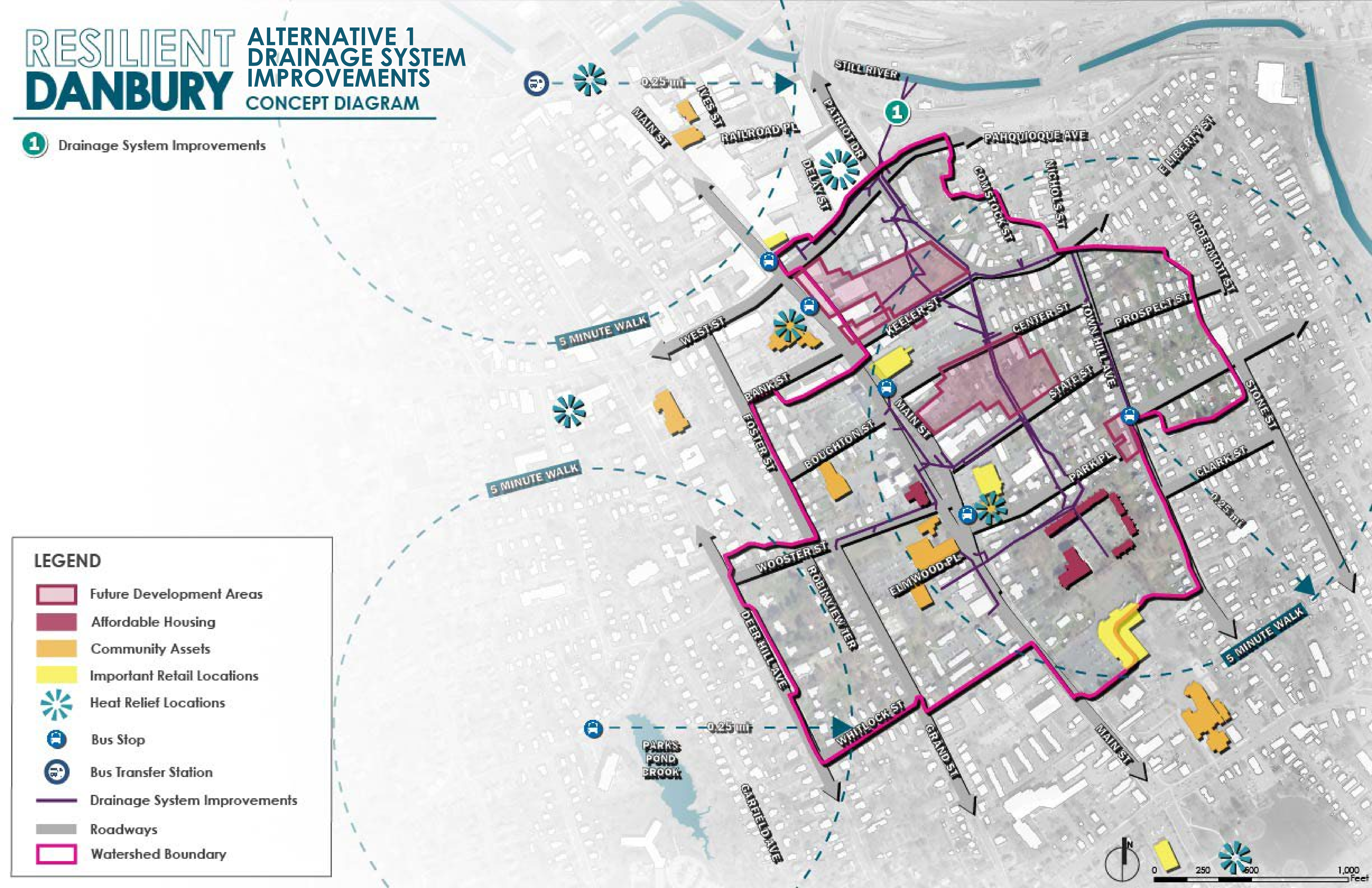
MITIGATION ACTIONS
- Drainage system improvements
- Rain garden at 9-11 Liberty Street
- Rain garden at old Jail
- Rain garden and cooling stop at the Senior Center
- Parking Lot improvements and raingarden at Price Rite
- Rain garden improvements at private development between State Street and Center Street
- Streetscape improvements along Main Street

BCR < 1

RESILIENT DANBURY

ALTERNATIVE 1 DRAINAGE SYSTEM IMPROVEMENTS CONCEPT DIAGRAM

1 Drainage System Improvements



RESILIENT DANBURY

ALTERNATIVE 1 RESULTS
50% AEP EVENT

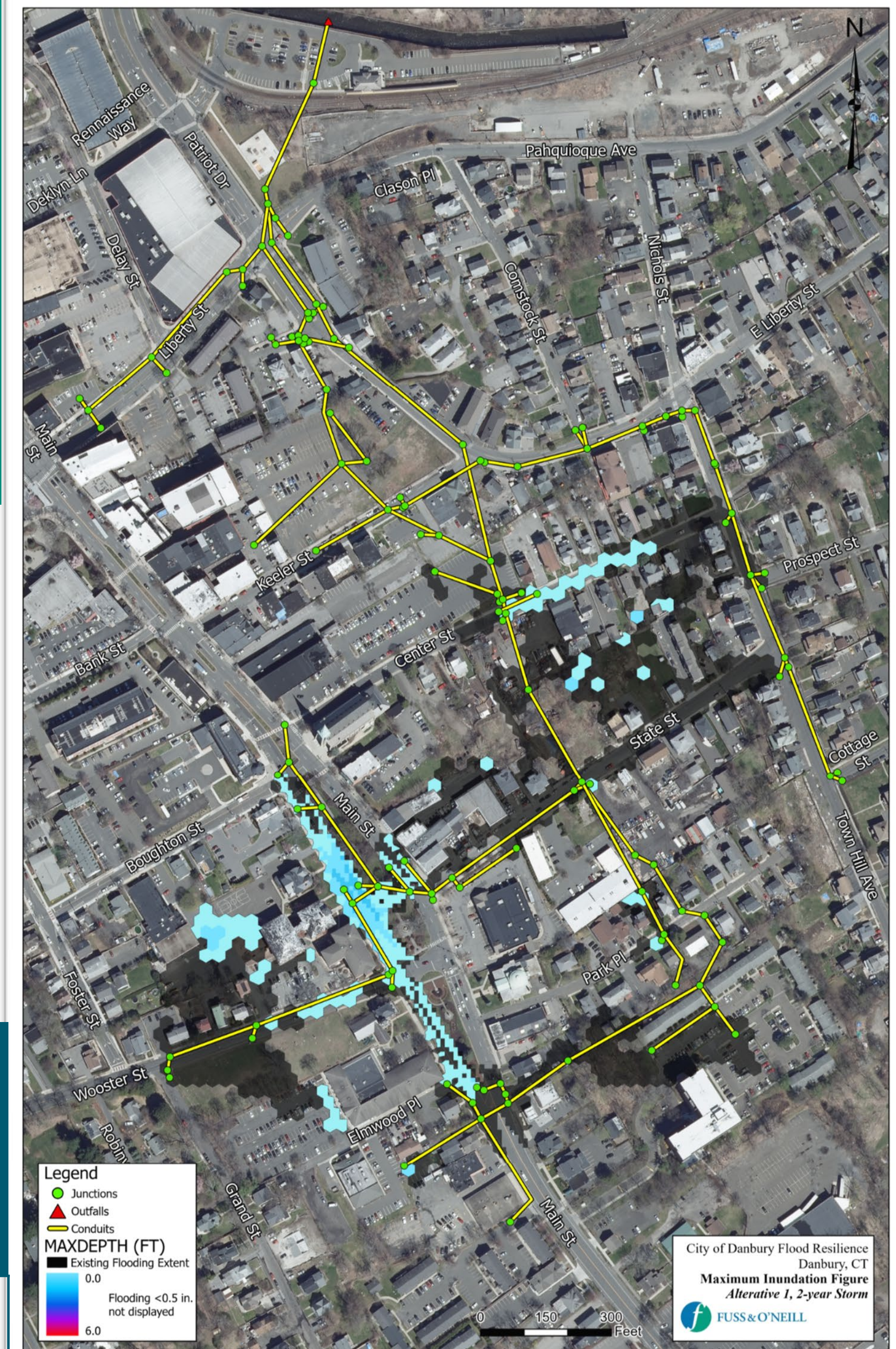
The intention of this alternative was to improve the conveyance and capacity of the pipe that routes water away from Main Street to the East Ditch mainline box conduit on State Street. The proposed stormwater management Alternative 1 consists of the following:

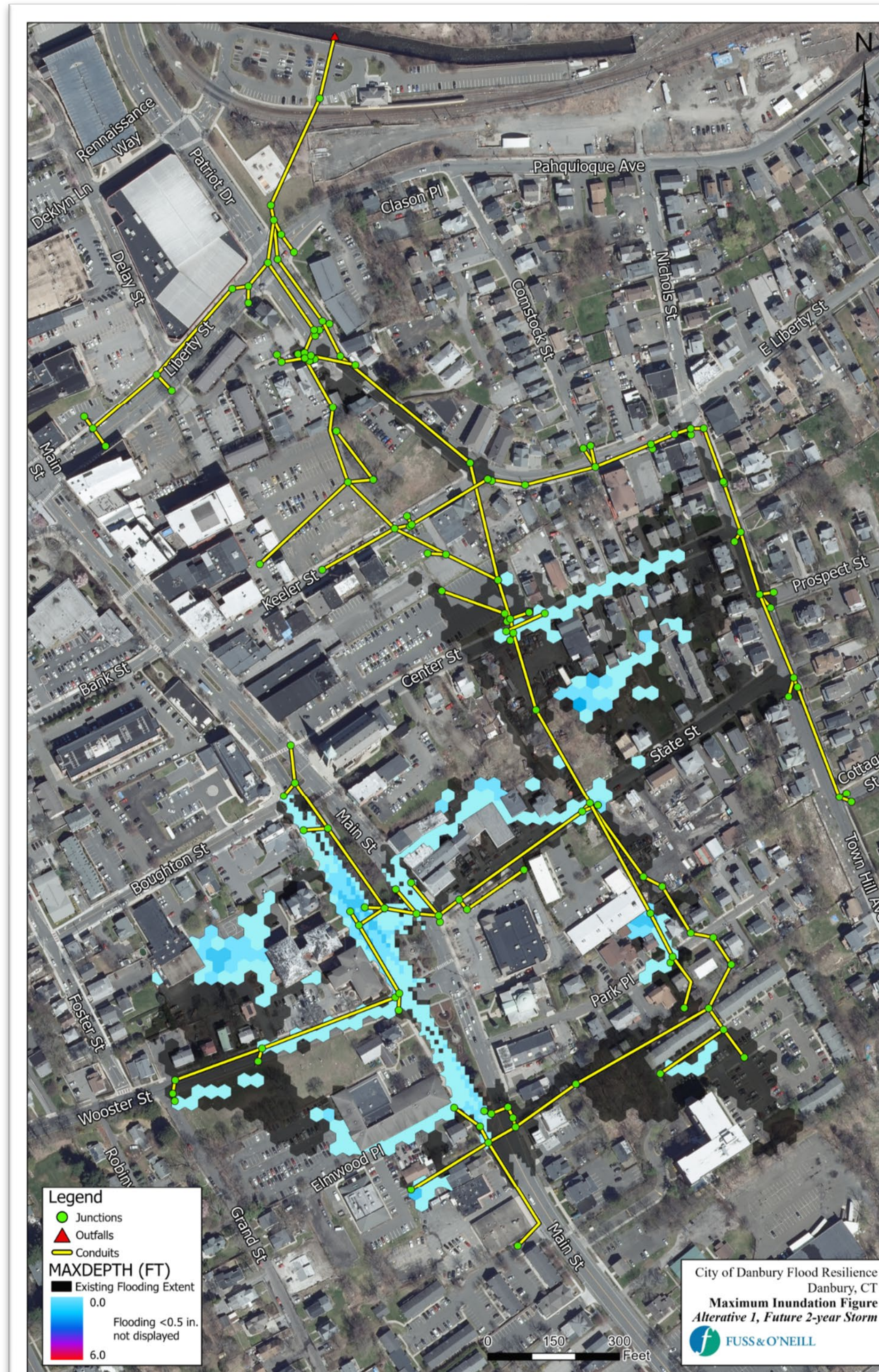
- Increase pipe size on State Street from 18" diameter to 36" diameter pipe.

The Alternative 1 design reduces flooding through the project area because of the increased pipe conveyance. The increased conveyance downstream to the East Ditch mainline also minorly reduces overall flood durations in the Main Street area. This alternative does little to reduce the overall flood depths experienced in the area.

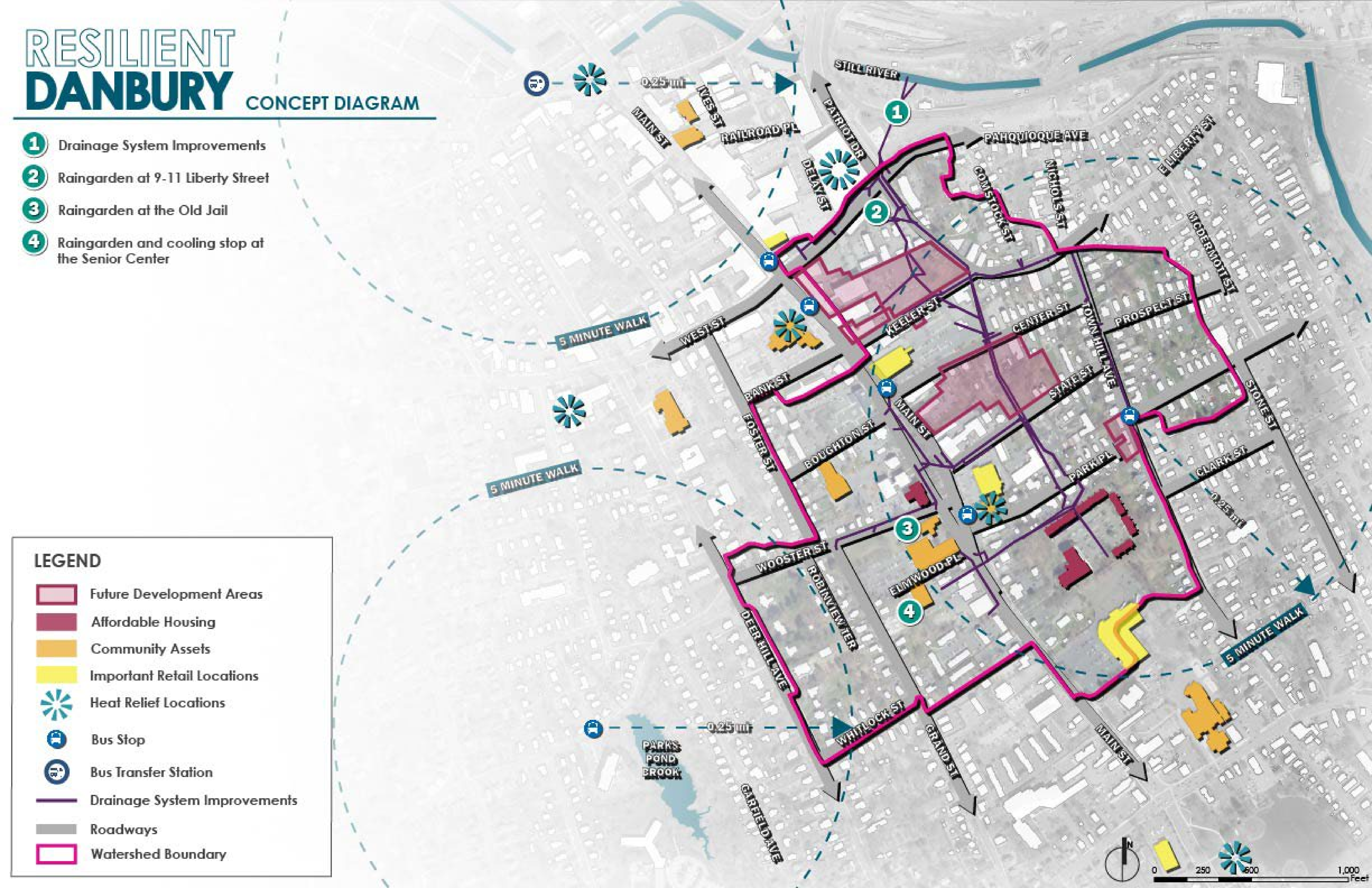
Location	PEAK FLOOD DEPTH (FT) Alternative #1 Conditions Current Climate Conditions				
	100% Annual Chance (1-Year) Storm	50% Annual Chance (2-Year) Storm	20% Annual Chance (5-Year) Storm	10% Annual Chance (10-Year) Storm	1% Annual Chance (100-Year) Storm
Northern Main Street (West Side)	1.38	1.5	1.58	1.63	1.76
Northern Main Street (East Side)	0	0	0.7	0.8	0.93
Center Street	0	0	0.53	0.89	1.77

Location	FLOOD DURATION (MIN) Alternative #1 Conditions Current Climate Conditions				
	100% Annual Chance (1-Year) Storm	50% Annual Chance (2-Year) Storm	20% Annual Chance (5-Year) Storm	10% Annual Chance (10-Year) Storm	1% Annual Chance (100-Year) Storm
Northern Main Street (West Side)	45	49	64	76	110
Northern Main Street (East Side)	0	0	11	21	42
Center Street	0	0	2	8	45





CIRCA Connecticut Institute for Resilience and Climate Adaptation
DANBURY CONNECTICUT
FUSS & O'NEILL
Dewberry


RESILIENT
DANBURY
CONCEPT DIAGRAM
1 Drainage System Improvements
2 Raingarden at 9-11 Liberty Street
3 Raingarden at the Old Jail
4 Raingarden and cooling stop at the Senior Center
LEGEND
Future Development Areas
Affordable Housing
Community Assets
Important Retail Locations
Heat Relief Locations
Bus Stop
Bus Transfer Station
Drainage System Improvements
Roadways
Watershed Boundary
STILL RIVER
0.25 mi
IVES ST
MAIN ST
RAILROAD PL
PATRIOT DR
DELAY ST
PAHQUIOQUE AVE
COMSTOCK ST
NICHOLS ST
E LIBERTY ST
MCDERMOTT ST
KEELER ST
CENTER ST
PROSPECT ST
TOWN HILL AVE
WEST ST
5 MINUTE WALK
BANK ST
STATE ST
MAIN ST
STONE ST
BOUGHTON ST
FOSTER ST
PARK PL
CLARK ST
0.25 mi
5 MINUTE WALK
WOOSTER ST
ROBINVIEW TER
ELMWOOD PL
DEER HILL AVE
5 MINUTE WALK
WHITLOCK ST
GRAND ST
MAIN ST
0.25 mi
PARKS POND BROOK
GARFIELD AVE
N
0
250
500
1,000
Feet

RESILIENT DANBURY

ALTERNATIVE 2 RESULTS
50% AEP EVENT

The intention of Alternative 2 was likewise to improve the conveyance and capacity of the pipe that routes water away from Main Street to the East Ditch mainline box conduit on State Street.

- A section of existing stormwater infrastructure on State Street was increased from an 18" to 36" diameter pipe.
- In addition, three sites were selected to install small-scale green infrastructure rain garden best management practices (BMPs).

The proposed Alternative 2 design reduces flooding through the project area as a result of the increased pipe conveyance and utilization of green infrastructure. Each rain garden has approximately 1100 ft^3 of included detention storage. The intention of these rain gardens is to capture, retain, and infiltrate a portion stormwater runoff before it travels downhill towards flood prone areas. The increased conveyance downstream towards the East Ditch mainline and the small-scale green infrastructure BMPs helped to reduce overall flood duration in the Main Street area. This alternative does little to reduce the overall flood depths experienced in the area.

PEAK FLOOD DEPTH (FT)
Alternative #2 Conditions
Current Climate Conditions

Location	100% Annual Chance (1-Year) Storm	50% Annual Chance (2-Year) Storm	20% Annual Chance (5-Year) Storm	10% Annual Chance (10-Year) Storm	1% Annual Chance (100-Year) Storm
Northern Main Street (West Side)	1.36	1.5	1.58	1.63	1.76
Northern Main Street (East Side)	0	0	0.68	0.79	0.92
Center Street	0	0	0.53	0.89	1.77

FLOOD DURATION (MIN)
Alternative #2 Conditions
Current Climate Conditions

Location	100% Annual Chance (1-Year) Storm	50% Annual Chance (2-Year) Storm	20% Annual Chance (5-Year) Storm	10% Annual Chance (10-Year) Storm	1% Annual Chance (100-Year) Storm
Northern Main Street (West Side)	43	49	64	76	110
Northern Main Street (East Side)	0	0	11	21	41
Center Street	0	0	2	8	45

RESILIENT DANBURY

ALTERNATIVE 3 WATERSHED IMPROVEMENTS CONCEPT DIAGRAM

1. Drainage System Improvements
2. Median Green Park Modifications
3. Streetscape/Median Improvements
4. Cooling Stop
5. Suburban Streetscape Improvement
6. Parking Lot Facelift With Green Infrastructure & Pedestrian Connection
7. Develop Green Infrastructure Features
8. Neighborhood Pedestrian Linkages with Green Infrastructure & Cooling Stop
9. Ice Rink Cooling Center

LEGEND

- Future Development Areas
- Affordable Housing
- Community Assets
- Important Retail Locations
- Green Infrastructure Improvements
- Cooling Infrastructure Improvements
- Heat Relief Locations
- Bus Stop
- Bus Transfer Station
- Drainage System Improvements
- Improved Pedestrian Connection
- Cooling Cooridors
- Roadways
- Watershed Boundary

RESILIENT DANBURY

ALTERNATIVE 3 RESULTS 50% AEP EVENT

The intention of this alteration was to remove the conduit constriction where the drainage system crosses under Elmwood Park at Main Street, and improve the conveyance and capacity of the pipe that routes water away from Main Street to the East Ditch mainline box conduit on State Street.

- A section of existing stormwater infrastructure from State Street to the middle of Elmwood Park was increased from 18" to 36" diameter pipe.
- The remainder of the pipe that continues west and then south to the intersection of Main Street and Wooster Street was increased from 15" to 24" diameter pipe.
- In addition to the pipe upsizing, three sites were selected to install small-scale green infrastructure rain gardens.

Each rain garden has approximately 1100 ft^3 of included detention storage. The intention of these rain gardens is to capture, retain, and infiltrate a portion stormwater runoff before it travels to the flood prone areas.

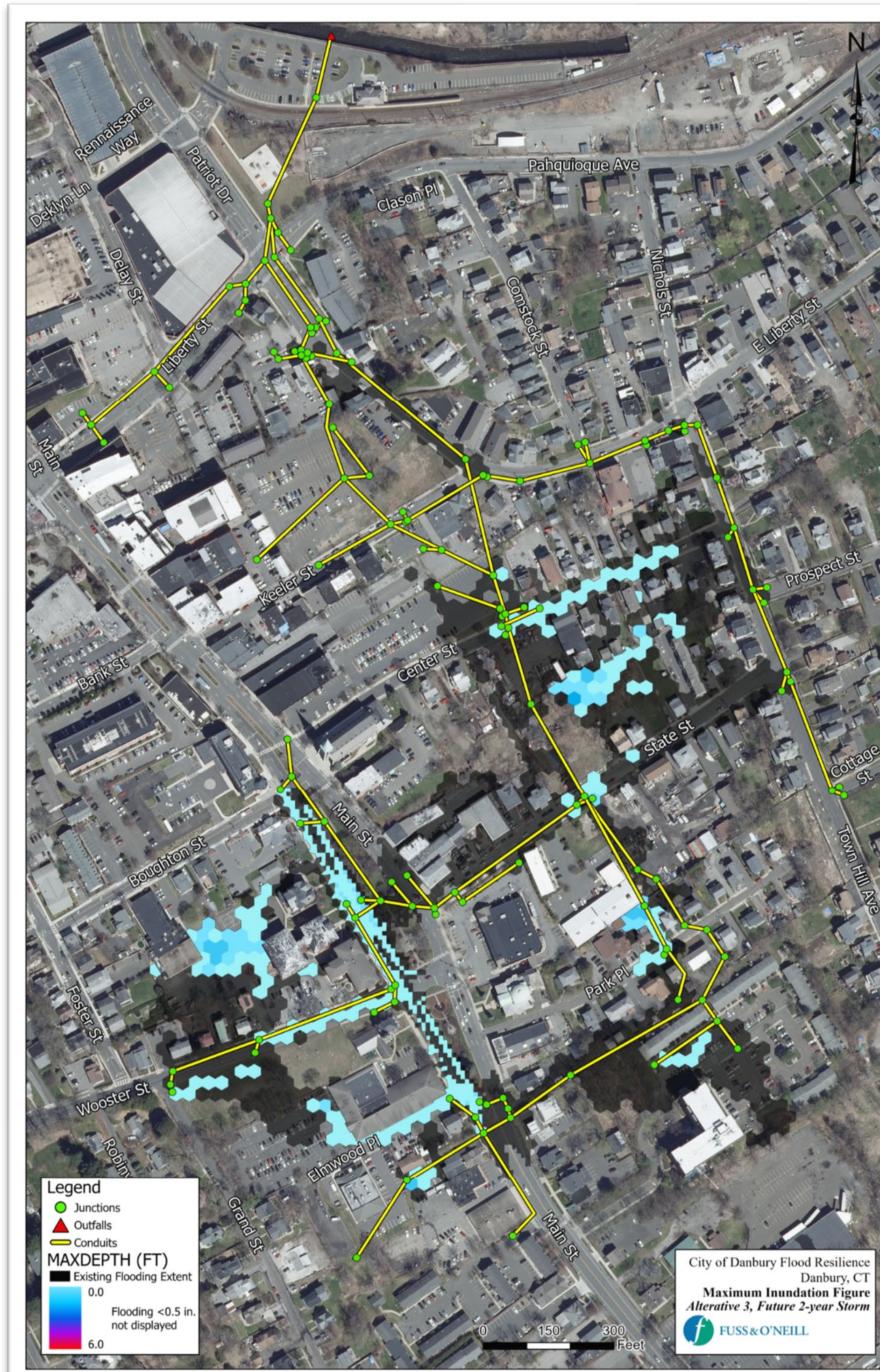
The increased conveyance around the Main Street green downstream towards the East Ditch mainline and the small-scale green infrastructure BMPs helped to significantly reduce both overall flood depths and duration in the Main Street area. The flood depth reductions become less significant during the 10-year storm event, whereas reductions to flood duration remain significant even during the 100-year storm event.

PEAK FLOOD DEPTH (FT)
Alternative #3 Conditions
Current Climate Conditions

Location	100% Annual Chance (1-Year) Storm	50% Annual Chance (2-Year) Storm	20% Annual Chance (5-Year) Storm	10% Annual Chance (10-Year) Storm	1% Annual Chance (100-Year) Storm
Northern Main Street (West Side)	0	0	0.85	1.08	1.58
Northern Main Street (East Side)	0	0	0	0	0.86
Center Street	0	0	0.54	0.89	1.6

FLOOD DURATION (MIN)
Alternative #3 Conditions
Current Climate Conditions

Location	100% Annual Chance (1-Year) Storm	50% Annual Chance (2-Year) Storm	20% Annual Chance (5-Year) Storm	10% Annual Chance (10-Year) Storm	1% Annual Chance (100-Year) Storm
Northern Main Street (West Side)	4	6	10	24	47
Northern Main Street (East Side)	0	0	0	0	21
Center Street	0	0	2	8	39



Several additional iterations of pipe capacity increases were evaluated to reduce flood depth and duration along Main Street and at Wooster Street. These include increases to pipe size running north south between Wooster Street and the drainage crossing at Main Street; increases to pipe size from State Street to Elmwood Park; and increase in pipe size running west from Elmwood Park. These iterations did not provide appreciable reduction to flood depth and duration. Given that these additional iterations primarily involve infrastructure owned by CT DOT, and recognizing the unlikelihood of expedient implementation, these additional iterations were not further optimized as part of this analysis.

RESILIENT DANBURY

BENEFIT COST ANALYSIS RESULTS

BCA Methods

A preliminary FEMA benefit cost analysis (BCA) was performed to assess the cost effectiveness of the proposed alternatives. BCA is a method that compares the future risk reduction benefits of a hazard mitigation project to its costs, resulting in 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 each alternative using the FEMA BCA tool (Version 6.0). **Table 1** summarizes mitigation actions that were included in the BCA for each alternative.

Order of magnitude opinions of probable cost for the proposed alternatives were developed from unit costs, industry standards, professional judgement, and estimated quantities. **Table 2** summarizes the estimated project costs used in the BCA. Cost opinion summary tables are included in **Appendix B BCA Supporting Documentation**.

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; flood damages avoided due to due to upgrading the existing drainage system.

Table 3 includes a summary of the calculated BCRs for the three alternatives. An explanation of the 3% and 7% discount rates, and additional details of the BCA methodology and results are provided in **Appendix B BCA Supporting Documentation.**

BCA Results

Alternative 1

Although Alternative 1 demonstrates positive benefits, it does not achieve a BCR 1.

Alternative 2

Addition of Green Infrastructure and tree plantings provides significant benefit to this proposed alternative. Based on these mitigation actions, this alternative achieves a positive BCR of 1.43 using a 3% discount rate.

Alternative 3

Alternative 3 also demonstrates significant positive benefits. However, based on the opinion of cost, the alternative does not achieve a BCR >1.

TABLE 1. BENEFIT-COST ANALYSIS MITIGATION ACTIONS

ALTERNATIVE	MITIGATION TYPE
Alternative 1	Drainage Improvements
Alternative 2	Drainage Improvements Green Infrastructure Bioretention Trees
Alternative 3	Drainage Improvements Green Infrastructure Bioretention Trees

TABLE 2. ESTIMATED PROJECT COSTS

MITIGATION SCENARIO	ESTIMATED MIN	ESTIMATED MAX
Alternative 1	$5,210,000	$11,160,000
Alternative 2	$5,740,000	$12,290,000
Alternative 3	$15,160,000	$32,170,000

TABLE 3. CALCULATED BCR

MITIGATION SCENARIO	BENEFITS		BCR	
DISCOUNT RATE	3%	7%	3%	7%
Alternative 1	$6,237,220	$3,897,844	0.67	0.46
Alternative 2	**$14,698,287**	$8,787,772	**1.43**	0.94
Alternative 3	$22,814,197	$13,919,800	0.84	0.57

RESILIENT DANBURY

IMPLEMENTATION ROADMAP

An Implementation Roadmap has been provided to guide coordination between the City and various agencies and organizations, including City of Danbury departments – Engineering, Economic Development, Emergency Management – and other organizations including CT DOT and private property owners.

The proposed flood and heat resilience improvements along Main Street and on privately owned property will require more detailed planning and engineering, substantial funding, and partnerships between the City, CT DOT, 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.

Implementation Challenges

- Drainage improvements require significant easements and have significant utility conflicts
- Agreements needed with private property owners
- Drainage and streetscape improvements along Main Street provide benefit, but are unlikely to implement due to DOT ownership

RECOMMENDATIONS	ORGANIZATIONS	ACTIONS	NEAR TERM 0-3 YEARS	MID TERM 3-10 YEARS	LONG TERM 10+ YEARS
1 Drainage System Improvements	City of Danbury, Private Property Owners	Secure remaining easements	→		
		Complete preliminary design	→		
		Secure construction funding		→	
		Final design, permitting, and construction		→	
2 Median Green Modifications	City of Danbury, CT Department of Transportation (CT DOT)	Conduct detailed planning & refine concept	→		
		Coordinate w/DOT		→	
		Secure funding		→	
		Design, permitting, and construction		→	→
3 Streetscape / Median Improvements	City of Danbury, CT Department of Transportation (CT DOT)	Conduct detailed planning & refine concept	→		
		Coordinate w/DOT		→	
		Secure funding		→	
		Design, permitting, and construction		→	→
4 Parking Lot Improvements w/Cooling Stop	City of Danbury	Conduct detailed planning & refine concept	→		
		Secure funding	→		
		Design, permitting, and construction		→	
5 Suburban Streetscape improvements	City of Danbury, CT Department of Transportation (CT DOT)	Conduct detailed planning & refine concept	→		
		Coordinate w/DOT		→	
		Secure funding		→	
		Design, permitting, and construction		→	→

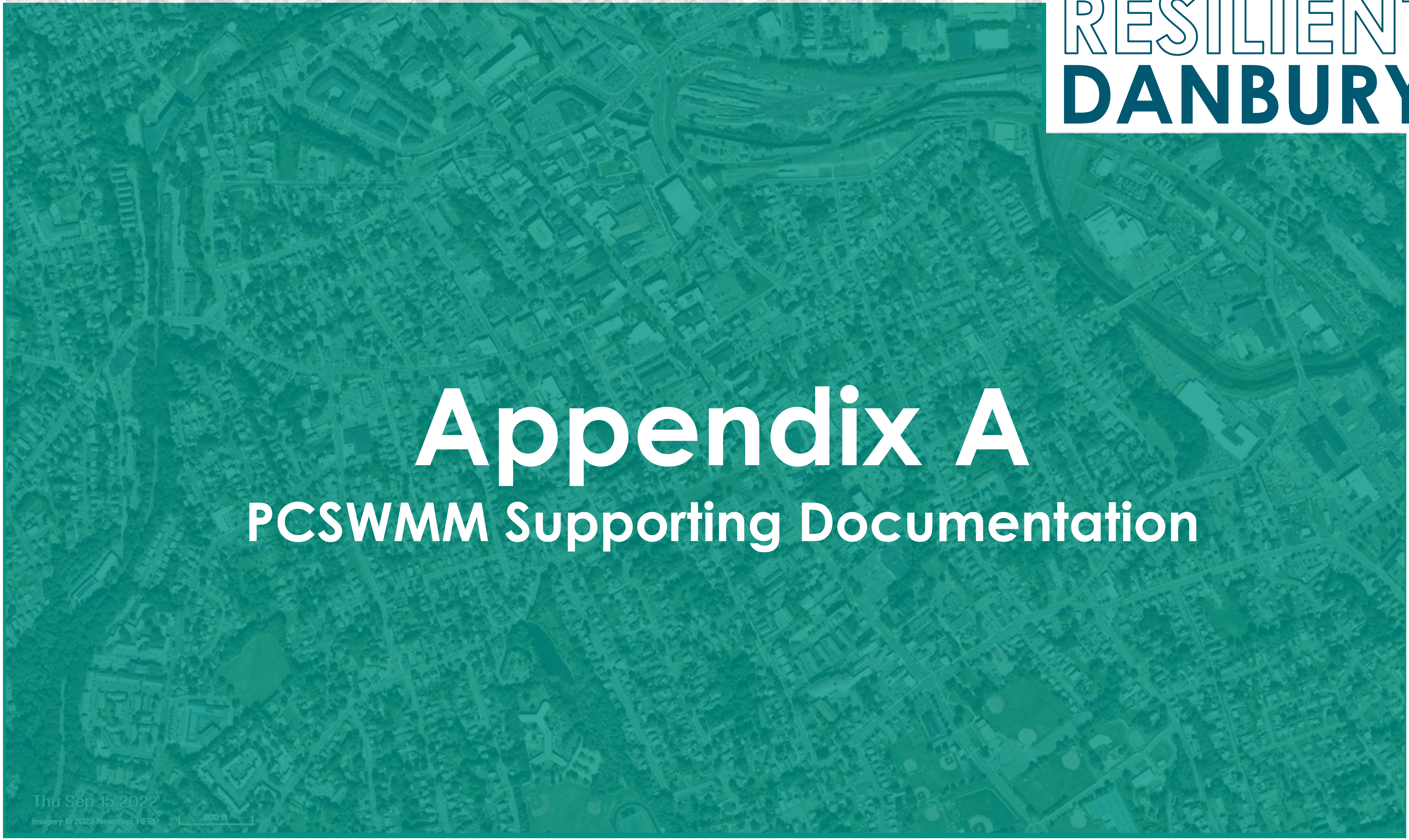
RESILIENT DANBURY

IMPLEMENTATION ROADMAP

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
- 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
6 Parking Lot Facelift w/Green Infrastructure & Pedestrian Connection	City of Danbury, Private Property Owners	Coordinate w/Private owners of Price Rite & affordable housing Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
7 Develop Green Infrastructure Features	City of Danbury, CT Department of Transportation (CT DOT)	Coordinate with private property owner between State Street & Center Street Conduct detailed planning & refine concept Secure funding Design, permitting, and construction			
8 Neighborhood Pedestrian Linkages with Green Infrastructure & Cooling Stop	City of Danbury, Community	Conduct community engagement, planning & refine concept Secure funding Design, permitting, and construction			
9 Ice Rink Cooling Center	City of Danbury, private owner	Secure MOA for use as City cooling center Secure equipment and supplies Develop operational procedure			



Appendix A

PCSWMM Supporting Documentation

Watershed Name	Outlet	Drainage Area (sqft)	Drainage Area (ac)	Flow Length (ft)	Impervious Area (sqft)	Impervious Percent (%)	Zero Storage Impervious (sqft)	Zero Storage Impervious (%)	Suction Head (in)	Conductivity	Initial Deficit	Average Slope (%)
SA_CB04	CB04	24905.27	0.57	413.22	15142.74	60.80	2693.55	17.79	6.01	0.69	0.21	16.85
SA_CB05	CB05	56381.40	1.29	353.22	29797.57	52.85	7159.39	24.03	7.28	0.56	0.19	20.71
SA_CB08	CB08	14353.89	0.33	253.96	12970.05	90.36	0.00	0.00	12.45	0.02	0.08	4.41
SA_CB09	CB09	17718.15	0.41	240.98	17514.07	98.85	4710.84	26.90	12.45	0.02	0.08	3.43
SA_CB10	CB10	7663.74	0.18	177.45	6141.93	80.14	0.00	0.00	12.45	0.02	0.08	5.21
SA_CB100	CB100	31955.83	0.73	213.55	26424.35	82.69	9167.16	34.69	3.50	0.52	0.19	4.40
SA_CB102	CB102	14546.14	0.33	379.99	7488.75	51.48	0.00	0.00	12.45	0.02	0.08	6.56
SA_CB104	CB104	9228.57	0.21	214.01	8359.55	90.58	0.00	0.00	12.45	0.02	0.08	5.61
SA_CB105	CB105	209568.10	4.81	739.66	128477.93	61.31	36524.30	28.43	11.38	0.13	0.10	4.72
SA_CB106	CB106	12184.46	0.28	658.39	11590.71	95.13	0.00	0.00	11.91	0.08	0.09	3.08
SA_CB107	CB107	20668.39	0.47	279.84	13408.31	64.87	2357.92	17.59	12.45	0.02	0.08	4.36
SA_CB108	CB108	14816.08	0.34	382.73	7058.46	47.64	0.00	0.00	12.45	0.02	0.08	6.29
SA_CB11	CB11	8177.67	0.19	191.33	6949.97	84.99	0.02	0.00	12.45	0.02	0.08	4.00
SA_CB111	CB111	257026.85	5.90	797.75	192449.22	74.88	63945.77	33.23	9.43	0.33	0.14	6.83
SA_CB112	CB112	20966.88	0.48	343.48	9432.06	44.99	1767.48	18.74	8.38	0.26	0.13	7.43
SA_CB113	CB113	4202.27	0.10	196.45	3456.93	82.26	0.00	0.00	4.33	0.86	0.25	7.29
SA_CB114	CB114	5446.66	0.13	193.58	4331.45	79.52	0.00	0.00	4.33	0.86	0.25	5.86
SA_CB115	CB115	51721.50	1.19	567.16	35606.47	68.84	6203.97	17.42	4.33	0.86	0.25	12.25
SA_CB116	CB116	570667.11	13.10	1424.03	214876.58	37.65	61963.62	28.84	4.33	0.86	0.25	13.29
SA_CB12	CB12	5946.56	0.14	128.24	5411.91	91.01	149.89	2.77	12.45	0.02	0.08	3.66
SA_CB13	CB13	3429.94	0.08	132.86	3361.22	98.00	0.26	0.01	12.45	0.02	0.08	4.51
SA_CB14	CB14	10259.31	0.24	154.31	9020.85	87.93	3106.24	34.43	12.45	0.02	0.08	3.75
SA_CB16	CB16	16745.37	0.38	162.98	13329.14	79.60	4973.99	37.32	12.45	0.02	0.08	6.57
SA_CB17	CB17	3244.42	0.07	161.92	3187.37	98.24	0.00	0.00	12.45	0.02	0.08	4.01
SA_CB19	CB19	9648.21	0.22	184.10	7858.18	81.45	1346.16	17.13	12.45	0.02	0.08	3.79
SA_CB20	CB20	6515.22	0.15	170.86	6055.71	92.95	1656.02	27.35	12.45	0.02	0.08	4.35
SA_CB21	CB21	25775.52	0.59	335.17	22429.19	87.02	8945.36	39.88	12.45	0.02	0.08	4.65
SA_CB24	CB24	96146.68	2.21	521.50	73412.72	76.35	20286.31	27.63	12.45	0.02	0.08	5.23
SA_CB25	CB25	173367.99	3.98	1054.73	107769.14	62.16	28786.01	26.71	10.27	0.23	0.12	15.75
SA_CB29	CB29	41027.99	0.94	349.01	34494.56	84.08	3563.22	10.33	12.45	0.02	0.08	4.06
SA_CB30	CB30	63397.63	1.46	487.58	60902.95	96.07	18035.06	29.61	12.45	0.02	0.08	3.20
SA_CB33	CB33	31427.60	0.72	206.70	31261.27	99.47	17222.82	55.09	12.45	0.02	0.08	6.61
SA_CB34	CB34	8313.63	0.19	338.06	6670.78	80.24	43.76	0.66	12.45	0.02	0.08	4.85
SA_CB35	CB35	11364.04	0.26	487.93	10730.78	94.43	9.66	0.09	12.45	0.02	0.08	6.11
SA_CB37	CB37	12834.18	0.29	234.86	11404.08	88.86	132.06	1.16	11.66	0.06	0.09	4.85
SA_CB41	CB41	9993.60	0.23	384.63	8968.18	89.74	876.52	9.77	4.08	0.76	0.23	9.59
SA_CB42	CB42	31752.16	0.73	443.29	25951.25	81.73	9506.99	36.63	4.30	0.80	0.24	9.81
SA_CB43	CB43	30525.28	0.70	322.69	25834.69	84.63	6917.56	26.78	3.61	0.56	0.20	10.44
SA_CB44	CB44	11627.22	0.27	244.43	8878.66	76.36	1371.70	15.45	3.51	0.52	0.19	3.97
SA_CB45	CB45	46422.25	1.07	506.06	21735.72	46.82	7820.74	35.98	4.33	0.86	0.25	11.30
SA_CB48	CB48	22906.12	0.53	349.78	11170.81	48.77	2955.67	26.46	4.33	0.86	0.25	20.63
SA_CB50	CB50	87740.02	2.01	565.99	41622.34	47.44	12693.61	30.50	4.33	0.86	0.25	7.70
SA_CB52	CB52	120867.90	2.77	588.21	63339.19	52.40	19690.31	31.09	4.33	0.86	0.25	8.64
SA_CB53	CB53	37322.80	0.86	529.29	23323.66	62.49	5952.50	25.52	4.33	0.86	0.25	8.98
SA_CB55	CB55	102052.84	2.34	584.25	58202.91	57.03	22337.86	38.38	4.33	0.86	0.25	7.69
SA_CB56	CB56	6661.22	0.15	259.60	6593.01	98.98	0.00	0.00	4.33	0.86	0.25	6.35
SA_CB58	CB58	14366.88	0.33	546.43	10926.07	76.05	0.00	0.00	4.33	0.86	0.25	7.10
SA_CB59	CB59	86486.16	1.99	575.90	45164.83	52.22	16120.48	35.69	4.33	0.86	0.25	5.56
SA_CB60	CB60	9068.52	0.21	110.43	6476.85	71.42	14.76	0.23	12.45	0.02	0.08	7.35
SA_CB64	CB64	9518.66	0.22	310.66	7401.30	77.76	910.48	12.30	12.34	0.03	0.08	4.05
SA_CB65	CB65	120057.85	2.76	631.62	109106.15	90.88	29924.31	27.43	12.45	0.02	0.08	4.65
SA_CB66	CB66	40062.04	0.92	336.53	28969.95	72.31	8486.54	29.29	9.11	0.21	0.12	7.16
SA_CB67	CB67	49636.89	1.14	505.76	44912.17	90.48	17527.49	39.03	12.45	0.02	0.08	6.86
SA_CB69	CB69	13559.08	0.31	544.27	13296.33	98.06	0.00	0.00	11.54	0.07	0.09	4.52
SA_CB70	CB70	22962.62	0.53	532.65	20969.03	91.32	2520.38	12.02	8.54	0.29	0.14	6.10
SA_CB71	CB71	87040.18	2.00	554.45	63256.92	72.68	26747.21	42.28	3.67	0.59	0.20	6.74
SA_CB73	CB73	95791.39	2.20	536.49	76548.60	79.91	8067.80	10.54	9.53	0.26	0.13	6.26
SA_CB75	CB75	45316.73	1.04	313.18	40285.15	88.90	21740.21	53.97	11.52	0.07	0.09	4.46
SA_CB76	CB76	19214.99	0.44	263.19	14841.00	77.24	1099.81	7.41	10.90	0.11	0.10	4.62
SA_CB79	CB79	9718.17	0.22	248.84	9052.72	93.15	0.00	0.00	11.42	0.08	0.09	4.54
SA_CB80	CB80	14859.51	0.34	393.59	14709.22	98.99	32.41	0.22	12.45	0.02	0.08	3.69
SA_CB81	CB81	363599.21	8.35	574.84	211517.13	58.17	81916.76	38.73	8.11	0.33	0.15	7.25
SA_CB84	CB84	277565.77	6.37	683.30	190399.86	68.60	63268.81	33.23	4.16	0.65	0.21	10.89
SA_CB85	CB85	100807.22	2.31	494.19	50144.22	49.74	20857.18	41.59	3.76	0.63	0.21	8.96
SA_CB88	CB88	151956.28	3.49	596.38	90394.23	59.49	30010.30	33.20	3.67	0.59	0.20	6.79
SA_CB89	CB89	459621.09	10.55	891.05	289561.39	63.00	65621.08	22.66	3.74	0.62	0.21	7.61
SA_CB90	CB90	189349.94	4.35	729.44	118079.75	62.36	36124.64	30.59	3.93	0.66	0.21	7.38
SA_CB91	CB91	7660.73	0.18	549.71	7413.22	96.77	0.00	0.00	8.83	0.22	0.13	2.70
SA_CB92	CB92	77109.06	1.77	575.74	68706.53	89.10	24339.67	35.43	3.57	0.55	0.20	3.88
SA_CB93	CB93	108212.93	2.48	619.27	77221.42	71.36	25909.91	33.55	3.80	0.64	0.21	7.29
SA_CB94	CB94	135162.41	3.10	527.48	69009.06	51.06	21795.12	31.58	4.12	0.77	0.23	10.79
SA_CB95	CB95	20421.64	0.47	539.74	7285.94	35.68	0.00	0.00	8.99	0.21	0.12	5.47
SA_CB96	CB96	50700.55	1.16	888.57	37501.65	73.97	0.00	0.00	6.57	0.35	0.15	3.52
SA_CB97	CB97	12673.34	0.29	232.98	8546.13	67.43	1824.55	21.35	3.50	0.52	0.19	5.60
SA_CB98	CB98	1382.38	0.03	23.29	1251.71	90.55	0.00	0.00	3.50	0.52	0.19	4.35
SA_CB99	CB99	18267.70	0.42	835.18	14952.47	81.85	44.95	0.30	3.50	0.52	0.19	4.72

NOAA Atlas 14, Volume 10, Version 3
Location name: Danbury, Connecticut, USA*
Latitude: 41.3927°, Longitude: -73.4536°
Elevation: 407.96 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.356 (0.273-0.459)	0.416 (0.318-0.537)	0.514 (0.392-0.666)	0.595 (0.452-0.775)	0.707 (0.521-0.951)	0.792 (0.572-1.08)	0.880 (0.617-1.24)	0.974 (0.653-1.40)	1.10 (0.714-1.63)	1.21 (0.763-1.81)
10-min	0.504 (0.386-0.650)	0.589 (0.451-0.761)	0.728 (0.556-0.943)	0.843 (0.640-1.10)	1.00 (0.738-1.35)	1.12 (0.811-1.53)	1.25 (0.875-1.75)	1.38 (0.926-1.98)	1.56 (1.01-2.31)	1.71 (1.08-2.57)
15-min	0.593 (0.454-0.765)	0.693 (0.530-0.895)	0.857 (0.654-1.11)	0.992 (0.753-1.29)	1.18 (0.868-1.59)	1.32 (0.954-1.81)	1.47 (1.03-2.06)	1.62 (1.09-2.33)	1.84 (1.19-2.72)	2.01 (1.27-3.02)
30-min	0.839 (0.643-1.08)	0.974 (0.746-1.26)	1.20 (0.912-1.55)	1.38 (1.05-1.79)	1.63 (1.20-2.19)	1.82 (1.32-2.49)	2.02 (1.42-2.83)	2.23 (1.50-3.20)	2.51 (1.63-3.71)	2.74 (1.73-4.11)
60-min	1.09 (0.831-1.40)	1.25 (0.961-1.62)	1.53 (1.17-1.99)	1.77 (1.34-2.30)	2.08 (1.53-2.80)	2.33 (1.68-3.17)	2.57 (1.80-3.61)	2.83 (1.90-4.07)	3.19 (2.06-4.71)	3.46 (2.19-5.20)
2-hr	1.41 (1.09-1.81)	1.64 (1.26-2.10)	2.01 (1.54-2.59)	2.32 (1.77-3.00)	2.74 (2.04-3.68)	3.06 (2.23-4.18)	3.40 (2.41-4.79)	3.79 (2.55-5.41)	4.35 (2.83-6.40)	4.82 (3.06-7.21)
3-hr	1.62 (1.25-2.07)	1.89 (1.46-2.42)	2.34 (1.80-3.00)	2.71 (2.08-3.50)	3.22 (2.40-4.31)	3.60 (2.64-4.91)	4.01 (2.86-5.66)	4.49 (3.03-6.40)	5.22 (3.39-7.65)	5.84 (3.71-8.69)
6-hr	2.02 (1.57-2.57)	2.40 (1.86-3.05)	3.02 (2.33-3.85)	3.53 (2.72-4.52)	4.23 (3.17-5.65)	4.75 (3.50-6.47)	5.32 (3.83-7.50)	6.01 (4.06-8.51)	7.06 (4.60-10.3)	7.96 (5.08-11.8)
12-hr	2.46 (1.92-3.11)	2.97 (2.32-3.76)	3.82 (2.97-4.84)	4.52 (3.50-5.76)	5.48 (4.13-7.27)	6.19 (4.58-8.38)	6.96 (5.04-9.76)	7.90 (5.36-11.1)	9.33 (6.10-13.5)	10.5 (6.75-15.5)
24-hr	2.89 (2.27-3.63)	3.55 (2.79-4.46)	4.63 (3.63-5.84)	5.53 (4.31-7.01)	6.77 (5.12-8.94)	7.68 (5.71-10.3)	8.68 (6.31-12.1)	9.88 (6.73-13.8)	11.7 (7.69-16.9)	13.3 (8.54-19.5)
2-day	3.30 (2.61-4.12)	4.09 (3.23-5.11)	5.38 (4.24-6.75)	6.46 (5.05-8.13)	7.93 (6.04-10.4)	9.02 (6.75-12.1)	10.2 (7.47-14.2)	11.7 (7.98-16.3)	13.9 (9.18-20.0)	15.9 (10.2-23.1)
3-day	3.59 (2.85-4.47)	4.45 (3.53-5.54)	5.85 (4.62-7.31)	7.02 (5.51-8.80)	8.62 (6.58-11.3)	9.80 (7.35-13.1)	11.1 (8.14-15.4)	12.7 (8.69-17.6)	15.2 (9.99-21.6)	17.3 (11.2-25.1)
4-day	3.85 (3.06-4.78)	4.75 (3.78-5.91)	6.23 (4.93-7.77)	7.46 (5.87-9.34)	9.15 (7.00-11.9)	10.4 (7.81-13.8)	11.8 (8.63-16.2)	13.4 (9.21-18.6)	16.0 (10.6-22.8)	18.2 (11.8-26.4)
7-day	4.57 (3.65-5.65)	5.56 (4.44-6.88)	7.19 (5.72-8.91)	8.54 (6.75-10.6)	10.4 (7.98-13.5)	11.8 (8.87-15.6)	13.3 (9.74-18.2)	15.1 (10.4-20.7)	17.8 (11.8-25.2)	20.1 (13.0-28.9)
10-day	5.29 (4.23-6.51)	6.34 (5.07-7.81)	8.05 (6.42-9.96)	9.48 (7.52-11.8)	11.4 (8.79-14.8)	12.9 (9.72-17.0)	14.5 (10.6-19.7)	16.3 (11.3-22.4)	19.0 (12.6-26.9)	21.3 (13.8-30.6)
20-day	7.51 (6.05-9.19)	8.67 (6.98-10.6)	10.6 (8.47-13.0)	12.1 (9.68-15.0)	14.3 (11.0-18.2)	15.9 (12.0-20.7)	17.6 (12.9-23.5)	19.5 (13.5-26.5)	22.0 (14.7-30.9)	24.1 (15.7-34.3)
30-day	9.37 (7.57-11.4)	10.6 (8.56-12.9)	12.6 (10.2-15.4)	14.3 (11.4-17.6)	16.6 (12.8-21.0)	18.4 (13.8-23.6)	20.1 (14.7-26.6)	22.0 (15.3-29.8)	24.4 (16.3-34.0)	26.2 (17.1-37.2)
45-day	11.7 (9.45-14.2)	13.0 (10.5-15.8)	15.1 (12.2-18.5)	16.9 (13.6-20.8)	19.4 (15.0-24.5)	21.3 (16.1-27.3)	23.2 (16.9-30.4)	25.1 (17.5-33.8)	27.4 (18.4-38.1)	29.1 (19.0-41.2)
60-day	13.6 (11.0-16.4)	15.0 (12.1-18.2)	17.3 (14.0-21.0)	19.2 (15.4-23.4)	21.8 (16.9-27.3)	23.9 (18.0-30.4)	25.8 (18.8-33.6)	27.7 (19.4-37.3)	30.1 (20.2-41.6)	31.7 (20.7-44.8)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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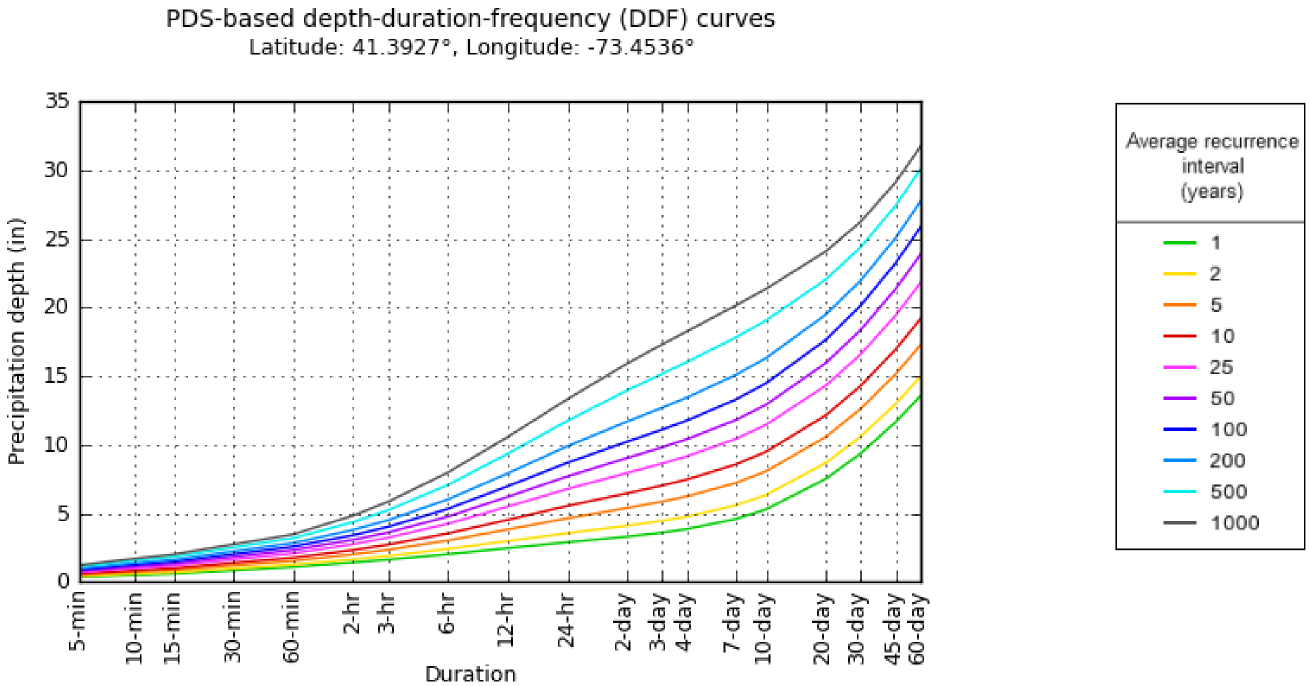
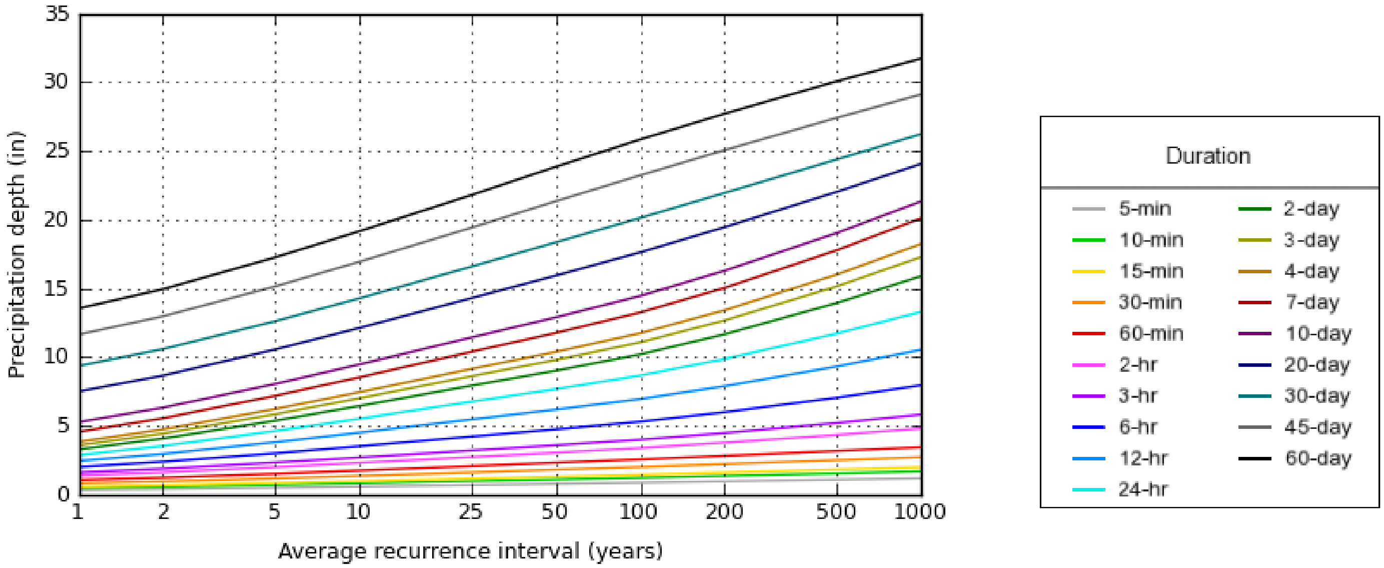
PF graphical





NOAA Atlas 14, Volume 10, Version 3

Created (GMT): Mon Nov 14 19:03:33 2022

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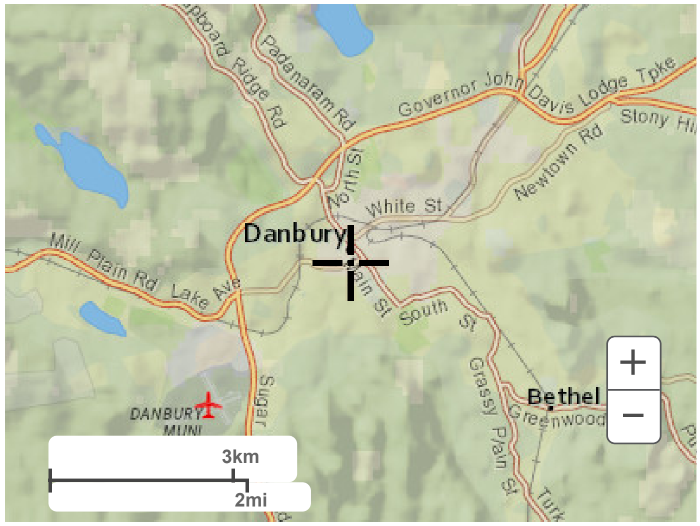
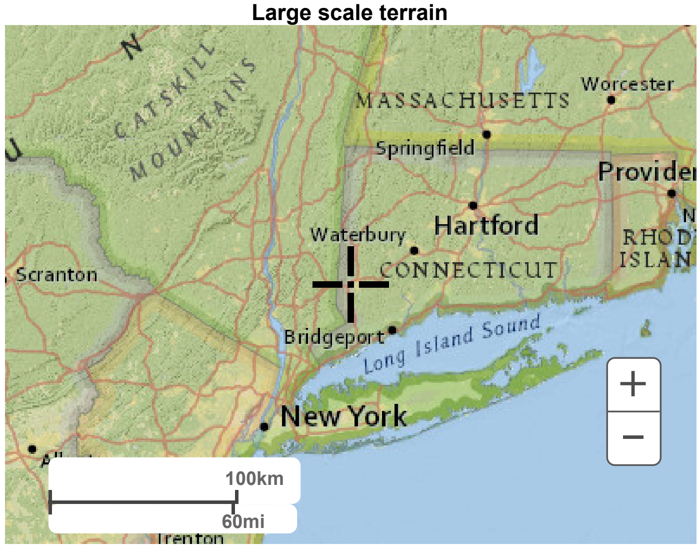
Maps & aerials

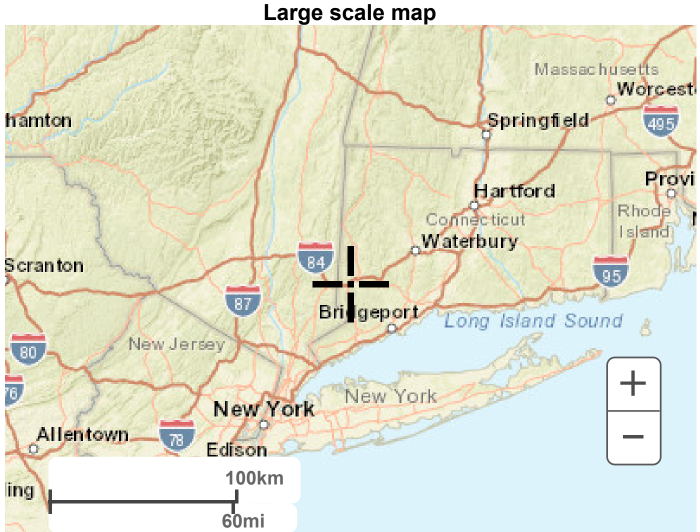
Small scale terrain



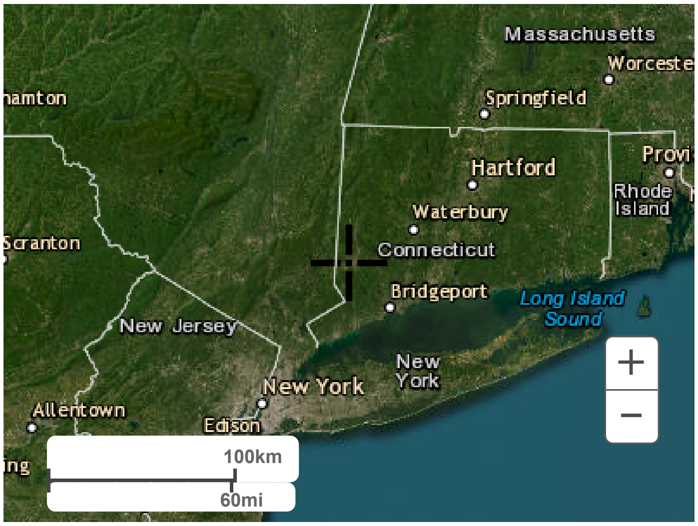
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
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Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

CIRCA Resilient Danbury

Future Precipitation Projections Summary

Storm Event (24-hr duration)	Current NOAA Atlas 14 Precipitation Depth (in)	Future Precipitation Mid-century CT PCSAR Projections (%)	Future Precipitation Mid-century CT PCSAR Projections (in)	Future Precipitation Late Century CT PCSAR Projections (%)	Future Precipitation Late Century CT PCSAR Projections (in)	Future Precipitation Mid Century RMAT Projections (%)	Future Precipitation Mid Century RMAT Projections (in)	Future Precipitation Late Century RMAT Projections (%)	Future Precipitation Late Century RMAT Projections (in)
1	2.89	27%	3.67	22%	3.53	8%	3.12	20%	3.47
2	3.55	27%	4.51	22%	4.33	8%	3.83	20%	4.26
5	4.63	27%	5.88	22%	5.65	8%	5.00	20%	5.56
10	5.53	49%	8.24	31%	7.24	8%	5.97	20%	6.64
25	6.77	59%	10.76	36%	9.21	8%	7.31	20%	8.12
50	7.68	76%	13.52	42%	10.91	8%	8.29	20%	9.22
100	8.68	91%	16.58	49%	12.93	11%	9.63	27%	11.02

Notes:

1. Mean value used from the PCSAR projections for design storms not listed in Table 4.5.
2. The projections for the 20-year storm were used for the 25-year storm as the baseline values were within range and the frequencies similar.
3. Recommended projections highlighted in yellow.

Source: NOAA Atlas 14 for Danbury, CT (accessed November 14, 2022)

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.356 (0.273-0.459)	0.416 (0.318-0.537)	0.514 (0.392-0.666)	0.595 (0.452-0.775)	0.707 (0.521-0.951)	0.792 (0.572-1.08)	0.880 (0.617-1.24)	0.974 (0.653-1.40)	1.10 (0.714-1.63)	1.21 (0.763-1.81)
10-min	0.504 (0.386-0.650)	0.589 (0.451-0.761)	0.728 (0.556-0.943)	0.843 (0.640-1.10)	1.00 (0.738-1.35)	1.12 (0.811-1.53)	1.25 (0.875-1.75)	1.38 (0.926-1.98)	1.56 (1.01-2.31)	1.71 (1.08-2.57)
15-min	0.593 (0.454-0.765)	0.693 (0.530-0.895)	0.857 (0.654-1.11)	0.992 (0.753-1.29)	1.18 (0.868-1.59)	1.32 (0.954-1.81)	1.47 (1.03-2.06)	1.62 (1.09-2.33)	1.84 (1.19-2.72)	2.01 (1.27-3.02)
30-min	0.839 (0.643-1.08)	0.974 (0.746-1.26)	1.20 (0.912-1.55)	1.38 (1.05-1.79)	1.63 (1.20-2.19)	1.82 (1.32-2.49)	2.02 (1.42-2.83)	2.23 (1.50-3.20)	2.51 (1.63-3.71)	2.74 (1.73-4.11)
60-min	1.09 (0.831-1.40)	1.25 (0.961-1.62)	1.53 (1.17-1.99)	1.77 (1.34-2.30)	2.08 (1.53-2.80)	2.33 (1.68-3.17)	2.57 (1.80-3.61)	2.83 (1.90-4.07)	3.19 (2.06-4.71)	3.46 (2.19-5.20)
2-hr	1.41 (1.09-1.81)	1.64 (1.26-2.10)	2.01 (1.54-2.59)	2.32 (1.77-3.00)	2.74 (2.04-3.68)	3.06 (2.23-4.18)	3.40 (2.41-4.79)	3.79 (2.55-5.41)	4.35 (2.83-6.40)	4.82 (3.06-7.21)
3-hr	1.62 (1.25-2.07)	1.89 (1.46-2.42)	2.34 (1.80-3.00)	2.71 (2.08-3.50)	3.22 (2.40-4.31)	3.60 (2.64-4.91)	4.01 (2.86-5.66)	4.49 (3.03-6.40)	5.22 (3.39-7.65)	5.84 (3.71-8.69)
6-hr	2.02 (1.57-2.57)	2.40 (1.86-3.05)	3.02 (2.33-3.85)	3.53 (2.72-4.52)	4.23 (3.17-5.65)	4.75 (3.50-6.47)	5.32 (3.83-7.50)	6.01 (4.06-8.51)	7.06 (4.60-10.3)	7.96 (5.08-11.8)
12-hr	2.46 (1.92-3.11)	2.97 (2.32-3.76)	3.82 (2.97-4.84)	4.52 (3.50-5.76)	5.48 (4.13-7.27)	6.19 (4.58-8.38)	6.96 (5.04-9.76)	7.90 (5.36-11.1)	9.33 (6.10-13.5)	10.5 (6.75-15.5)
24-hr	2.89 (2.27-3.63)	3.55 (2.79-4.46)	4.63 (3.63-5.84)	5.53 (4.31-7.01)	6.77 (5.12-8.94)	7.68 (5.71-10.3)	8.68 (6.31-12.1)	9.88 (6.73-13.8)	11.7 (7.69-16.9)	13.3 (8.54-19.5)
2-day	3.30 (2.61-4.12)	4.09 (3.23-5.11)	5.38 (4.24-6.75)	6.46 (5.05-8.13)	7.93 (6.04-10.4)	9.02 (6.75-12.1)	10.2 (7.47-14.2)	11.7 (7.98-16.3)	13.9 (9.18-20.0)	15.9 (10.2-23.1)
3-day	3.59	4.45	5.85	7.02	8.62	9.80	11.1	12.7	15.2	17.3

Source: Connecticut Physical Climate Science Assessment Report (August 2019)

Table 4.5 Multi-model ensemble of flood risk indices. State-averaged multi-model ensemble statistics of projected changes for the 1-day and 5-day maximum precipitation (R1d and R5d). These includes the mean and threshold values for different recurrence intervals (10, 20, 50, and 100 years), and their future changes. Units: inches. The percentage values in parenthesis are relative changes, and the values in bold font after the semicolon are future recurrent time (in years) for the reference threshold values. All changes are statistically significant and projected with model consensus.

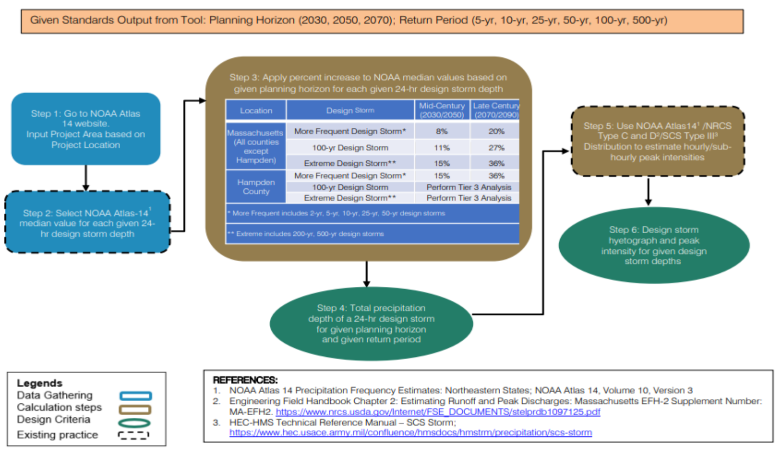
Variables	1970-99 Reference	2040-69 Changes	2070-99 Changes
R1d_mean	2.8±0.1	0.7±0.2 (27%)	0.6±0.2 (22%)
R1d_10	4.1±0.2	2.0±0.8 (49%); **3**	1.3±0.8 (31%); **4**
R1d_20	4.7±0.2	2.8±1.3 (59%); **5**	1.7±1.2 (36%); **9**
R1d_50	5.7±0.3	4.3±2.4 (76%); **15**	2.4±2.2 (42%); **27**
R1d_100	6.6±0.4	5.9±3.7 (91%); **42**	3.1±3.2 (49%); **55**
R5d_mean	4.5±0.3	0.9±0.4 (20%)	0.8±0.3 (19%)
R5d_10	6.5±0.6	2.4±1.1 (38%); **3**	1.7±0.5 (27%); **4**
R5d_20	7.3±0.8	3.4±1.7 (46%); **6**	2.2±0.7 (30%); **7**
R5d_50	8.5±1.0	5.2±3.0 (53%); **15**	3.0±1.2 (43%); **26**
R5d_100	9.6±1.2	7.1±4.4 (75%); **38**	3.7±1.7 (39%); **48**

Summary: Flood Risk

In summary, results for all flood risk indices suggest a statistically significant increase of flood risks in the future, with continuous increase in the number of days with heavy precipitation and in the amount of heavy precipitation. However, the heaviest event of each year, including R1d and R5d, is found to peak in mid-century and level off or even decrease afterwards. This leveling off is not expected from our theoretical understanding. Instead, it may be a reflection of specific regional features of atmospheric circulation, multi-decadal variability of the climate, or deficiencies in statistical downscaling and bias correction, and is a topic that warrants further investigation. In addition, it should be noted that climate model resolution of extremes is challenging due to the generally coarse resolution of the GCMs and the finer spatial scale of many extreme events, and the northeast region is no exception. It is therefore desirable to revisit these projected changes based on the upcoming finer-resolution CMIP6 projections.

[Source: Resilient Massachusetts Action Team (RMAT) Climate Resilience Design Standards (July 2022)](#)

Climate Resilience Design Standards and Guidance – Comparative Precipitation Methodology Report
Version 1.2, July 2022



Location	Design Storm	Mid-Century (2030/2050)	Late Century (2070/2090)
Massachusetts (All counties except Hampden)	More Frequent Design Storm*	8%	20%
	100-yr Design Storm	11%	27%
	Extreme Design Storm**	15%	36%
Hampden County	More Frequent Design Storm*	15%	36%
	100-yr Design Storm	Perform Tier 3 Analysis	
	Extreme Design Storm**	Perform Tier 3 Analysis	

* More Frequent includes 2-yr, 5-yr, 10-yr, 25-yr, 50-yr design storms

** Extreme includes 200-yr, 500-yr design storms

***Figure A-3:** Regionalized percent increase methodology to assess projected total precipitation depth and peak intensity for 24-hr design storms (used past versions of the Tool (April 2021 – April 2022)*

RESILIENT DANBURY

Appendix B

BCA Supporting Documentation

Dewberry

RESILIENT DANBURY NARRATIVE REPORT SUMMARY

PREPARED FOR: Elsa Loeman, Fuss & O'Neil

PREPARED BY: John Squerciati & Scott Choquette, Dewberry Engineers Inc.

DATE: November 13, 2023

SUBJECT: Danbury East Ditch BCA Narrative Report Summary

This memorandum provides a narrative summary of the FEMA Benefit Cost Analysis (BCA) completed for the East Ditch Drainage and Green Infrastructure alternative developed by Fuss & O'Neil for the Resilient Danbury 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 East Dich Resilience Project. 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 three proposed drainage improvement/heat mitigation project alternatives for Danbury, CT.

One BCA project was developed for each alternative. The BCA calculates project costs and project benefits for individual mitigation actions within a project. Based on the different modeled approaches in the BCA, project alternatives were assigned as shown in Table 1 below.

Table 1. Benefit Cost Analysis (BCA) Project Alternatives

Alternative 1	Alternative 2	Alternative 3
Drainage Improvement (50-100 properties protected)	Drainage Improvement (50-100 properties protected)	Drainage Improvement (50-100 properties protected)
	Green Infrastructure	Green Infrastructure
	Bioretention (2 acres)	Bioretention (4 acres)
		Urban Trees (175 trees)

Cost Summary

A summary of the total project cost is based on the Fuss & O'Neill Opinion of Probable Cost spreadsheets for Alternatives 1, 2 and 3. The costs are broken down into line-item unit costs of site preparation, site improvements and general conditions. Additionally, general conditions, site preparation and engineer/legal/administrative cost estimates are added to the total. For the purposes of the BCA, the line-item unit costs needed to be summarized by mitigation action activity. Each line item was checked for relevance to the mitigation objectives of the project and assigned to a mitigation action to be entered into the BCA. The final line items related to construction, contingencies, and engineering/permitted were assumed to be related to the drainage improvements which typically account for most if not all the total projects. Finally, the present value of annualized maintenance costs was added to the mitigation activity cost. The resulting cost estimates are shown in Table 2 on the following page, showing total project costs at a both a 7% discount rate and a 3% discount rate.

Table 2. Alternative Project Costs

	Alternative 1	Alternative 2	Alternative 3
Drainage Improvement	$7,440,000	$7,690,000	$20,470,000
Drainage Improvement Maintenance – 1% Cost over 50 years, 7% Discount Rate	$1,026,776	$1,061,277	$2,825,013
Drainage Improvement Maintenance – 1% Cost over 50 years, 7% Discount Rate	$1,914,224	$1,978,619	$5,266,883
Green Infrastructure - Bioretention	-	$500,000	$1,000,000
Bioretention Maintenance – 1% cost over 35 years, 7% Discount Rate	-	$64,738	$129,477
Bioretention Maintenance – 1% cost over 35 years, 3% Discount Rate	-	$107,436	$214,872
Green Infrastructure – Urban Tree Plantings	-	-	$175,000
Urban Tree Maintenance – 1% cost over 25 years, 7% Discount Rate	-	-	$20,394
Urban Tree Maintenance – 1% cost over 25 years, 3% Discount Rate	-	-	$30,473
Total Mitigation Project Cost – 7% Discount Rate	**$8,466,776**	**$9,316,015**	**$24,619,884**
Total Mitigation Project Cost – 3% Discount Rate	**$9,354,924**	**$10,276,055**	**$27,157,228**

Data Collection

The used to run the BCA included:

- Project scope (s) of work for the three alternatives
- Cost data (Fuss & O'Neill Opinion of Probable Cost)

- Fuss & O'Neil stormwater models and associated inundation areas and depths for the 5, 10, 25, and 100-year future rainfall return frequencies.
- Building properties (including building type, building area, foundation, number of stories, first floor elevation, adjacent grade elevation, building replacement value, and number of occupants)
- Measurement of areas for land improvements and/or green infrastructure installations (Alternatives 2 and 3 only)
- Count of urban trees to be planted (Alternative 3 only)
- Estimated residential building populations – for estimating social benefits.

This data was collected from Fuss and O'Neill, open-source GIS data, tax assessor property cards, the U.S. Army Corp of Engineers National Structure Inventory, and industry-based estimates.

Analysis Results

A BCA was run for Danbury drainage improvement project Alternative 1 using both the 7% and the 3% discount rate. Both have benefit-cost ratios (BCRs) of less than 1.0, which indicates project Alternative 1is not cost-effective on its own.

A second BCA was run for the drainage improvements and green infrastructure project Alternative 2 using both the 7% and the 3% discount rate. The benefit-cost ratio (BCR) was slightly less than 1.0 at the 7% discount rate but was cost-effective at the 3% discount rate, which indicates project Alternative 2 may be cost-effective under the correct circumstances.

A third BCA was run for drainage improvement and green infrastructure project Alternative 3 looking at both the 7% and the 3% discount rate. Both have benefit-cost ratios (BCRs) of less than 1.0, which indicates project Alternative 1is not cost-effective.

The BCA results for the three project alternatives are summarized in Table 3 below.

Table 3. Benefit Cost Ratios (BCR) and Results

BCA Discount Rate	Alternative 1 BCR	Alternative 2 BCR	Alternative 3 BCR
7% Discount Rate	0.46	0.94	0.57
3% Discount Rate	0.67	1.43	0.85

ORDER OF MAGNITUDE OPINION OF COST	FUSS & O'NEILL *Disciplines to Deliver*	SHEET: 1 OF 1
PROJECT:		DATE PREPARED: 09/05/06
LOCATION:		ESTIMATOR: xxx
DESCRIPTION:		CHECKED BY: xxx
		PROJECT NO.: ####.###.###

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

	ITEM DESCRIPTION	UNITS	NUM. OF UNITS	COST PER UNIT	TOTAL COST
1	**Site Preparation**				
	Mobilization & Demobilization	LS	1	$250,000.00	$250,000
	Sediment Control	LS	1	$175,000.00	$175,000
	Insurance and Bonds	LS	1	$250,000.00	$250,000
	Site Prep	LS	1	$100,000.00	$100,000
	Subtotal				**$775,000**
2	**Site Improvements**				
	Drainage System Improvements	LF	2,785	$1,000.00	$2,785,000
	Utility Modifications	LF	2,000	$500.00	$1,000,000
	Subtotal				**$3,785,000**
3	**General Conditions**				
	Construction Survey Layout & As-Built Mapping	LS	1	$20,000.00	$20,000
	Traffic Control	DAYS	28	$1,000.00	$28,000
	General Conditions	LS	1	$250,000.00	$250,000
	Utility Coordination	LS	1	$100,000.00	$100,000
	Subtotal				**$398,000**
TOTAL CONSTRUCTION COST					$4,960,000
CONTINGENCY (25%)					$1,240,000
SUBTOTAL					$6,200,000
ENGINEERING/PERMITTING (20%)					$1,240,000
SUBTOTAL					**$7,440,000**
	TOTAL COST (-30% TO +50% ROUNDED)				$5,210,000 TO $11,160,000

ORDER OF MAGNITUDE OPINION OF COST	FUSS & O'NEILL *Disciplines to Deliver*	SHEET: 1 OF 1
PROJECT: Resilient Downtown Gateway		DATE PREPARED: 09/26/06
LOCATION: Danbury, CT		ESTIMATOR: EL
DESCRIPTION: Resilient Downtown Gateway flood risk and extreme heat reduction.		CHECKED BY: NA
		PROJECT NO.: 20191105.B10

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

	ITEM DESCRIPTION	UNITS	NUM. OF UNITS	COST PER UNIT	TOTAL COST
1	**Site Preparation**				
	Mobilization & Demobilization	LS	1	$250,000.00	$250,000
	Sediment Control	LS	1	$175,000.00	$175,000
	Insurance and Bonds	LS	1	$250,000.00	$250,000
	Site Prep	LS	1	$100,000.00	$100,000
	Subtotal				**$775,000**
2	**Site Improvements**				
	Drainage System Improvements	LF	2,785	$1,000.00	$2,785,000
	GI Improvements	AC	2	$250,000.00	$500,000
	Utility Modifications	LF	2,000	$500.00	$1,000,000
	Subtotal				**$4,285,000**
3	**General Conditions**				
	Construction Survey Layout & As-Built Mapping	LS	1	$20,000.00	$20,000
	Traffic Control	DAYS	28	$1,000.00	$28,000
	General Conditions	LS	1	$250,000.00	$250,000
	Utility Coordination	LS	1	$100,000.00	$100,000
	Subtotal				**$398,000**
TOTAL CONSTRUCTION COST					$5,460,000
CONTINGENCY (25%)					$1,365,000
SUBTOTAL					$6,825,000
ENGINEERING/PERMITTING (20%)					$1,365,000
SUBTOTAL					**$8,190,000**
	TOTAL COST (-30% TO +50% ROUNDED)				$5,740,000 TO $12,290,000

ORDER OF MAGNITUDE OPINION OF COST		SHEET: 1 OF 1
PROJECT: Resilient Downtown Gateway	FUSS & O'NEILL *Disciplines to Deliver*	DATE PREPARED: 09/26/06
LOCATION: Danbury, CT		ESTIMATOR: EL
DESCRIPTION: Resilient Downtown Gateway flood risk and extreme heat reduction.		CHECKED BY: NA
		PROJECT NO.: 20191105.B10

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

	ITEM DESCRIPTION	UNITS	NUM. OF UNITS	COST PER UNIT	TOTAL COST
1	**Site Preparation**				
	Mobilization & Demobilization	LS	1	$652,500.00	$652,500
	Sediment Control	LS	1	$350,000.00	$350,000
	Insurance and Bonds	LS	1	$350,000.00	$350,000
	Site Prep	LS	1	$275,000.00	$275,000
	Subtotal				**$1,627,500**
2	**Site Improvements**				
	Drainage System Improvements	LF	2,785	$1,000.00	$2,785,000
	GI Improvements	AC	4	$250,000.00	$1,000,000
	Utility Modifications	LF	2,000	$500.00	$1,000,000
	Streetscape Improvements	LF	3,814	$2,000.00	$7,628,000
	Subtotal				**$12,413,000**
3	**General Conditions**				
	Construction Survey Layout & As-Built Mapping	LS	1	$25,000.00	$25,000
	Traffic Control	DAYS	28	$1,000.00	$28,000
	General Conditions	LS	1	$233,000.00	$233,000
	Utility Coordination	LS	1	$100,000.00	$100,000
	Subtotal				**$386,000**
TOTAL CONSTRUCTION COST					$14,430,000
CONTINGENCY (25%)					$3,607,500
SUBTOTAL					$18,037,500
ENGINEERING/PERMITTING (20%)					$3,607,500
SUBTOTAL					**$21,645,000**
	TOTAL COST (-30% TO +50% ROUNDED)				$15,160,000 TO $32,470,000