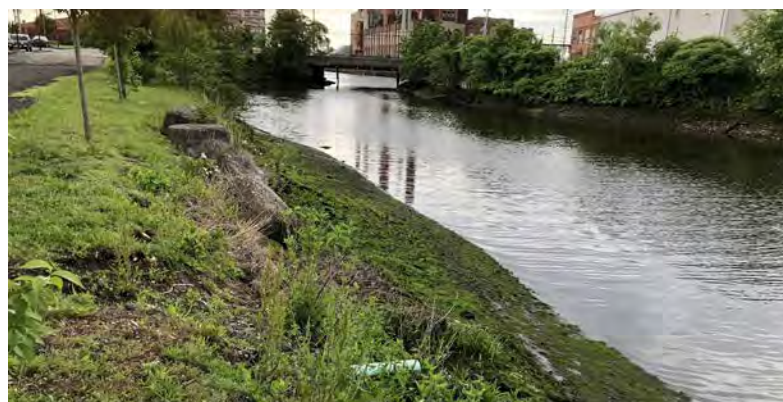




Mill River Watershed Based Plan

prepared by  FUSS & O'NEILL

SEPTEMBER 2018



 Connecticut Fund
for the Environment
Save the Sound®



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1 Introduction

1.1 Background

The Mill River and Its Watershed

The Mill River watershed covers an area of approximately 38 square miles in New Haven County. The majority of the watershed is in the municipalities of Cheshire (where the headwaters is located) and Hamden, with smaller portions in New Haven, Wallingford, North Haven, Prospect, and Bethany. The upper watershed is generally rural or suburban in nature, with development intensity increasing at the southern end of the watershed and in the vicinity of the mouth of the river.

What is a Watershed?

A watershed is the area of land that contributes runoff to a lake, river, stream, wetland, estuary, or bay. Land use activities within a watershed affect the water quality of the receiving waters.



Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

The main stem of the Mill River winds from its northern headwaters in Cheshire, south to Long Island Sound, following a similar path to route 10 through Cheshire and Hamden before bending to the east to flow into Lake Whitney and then on through New Haven to the New Haven Harbor. The Mill River is one of three major rivers that all converge in the New Haven Harbor. Its path is sandwiched between that of the Quinnipiac River to the east and the West River to the west. Several major tributaries, including Willow Brook, Shepard Brook, Butterworth Brook, Jepp Brook, Eatons Brook, and Brooksvale Stream all converge with the Mill River along its course. Other major landmarks in the watershed include Sleeping Giant State Park, East Rock Park, Naugatuck State Forest, and Quinnipiac University.

The existing physical, land use, and water quality characteristics of the Mill River watershed are further described in Section 2, and in the document entitled *Technical Memorandum 1 – Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018a) (Appendix A).

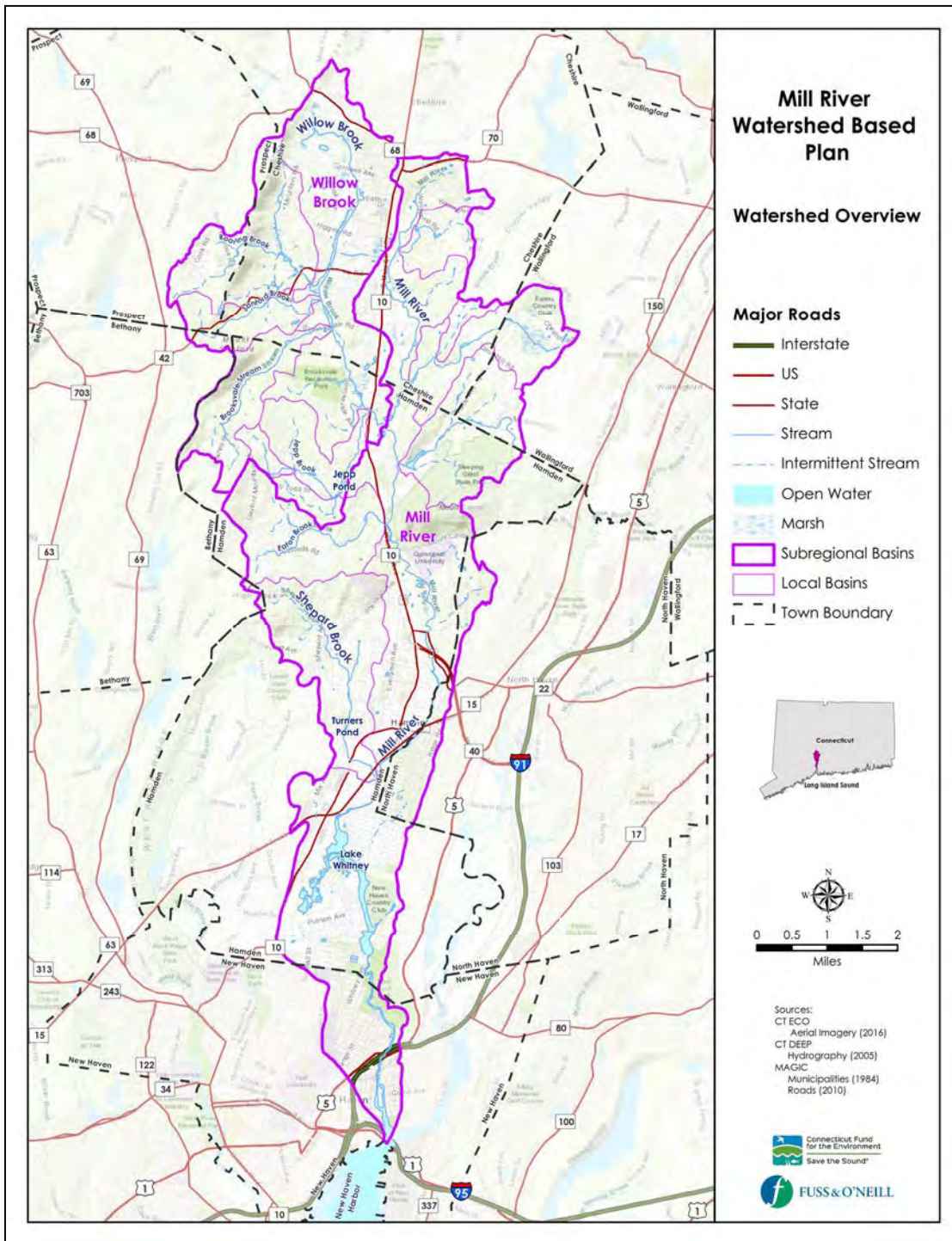


Figure 1-1. Mill River Watershed

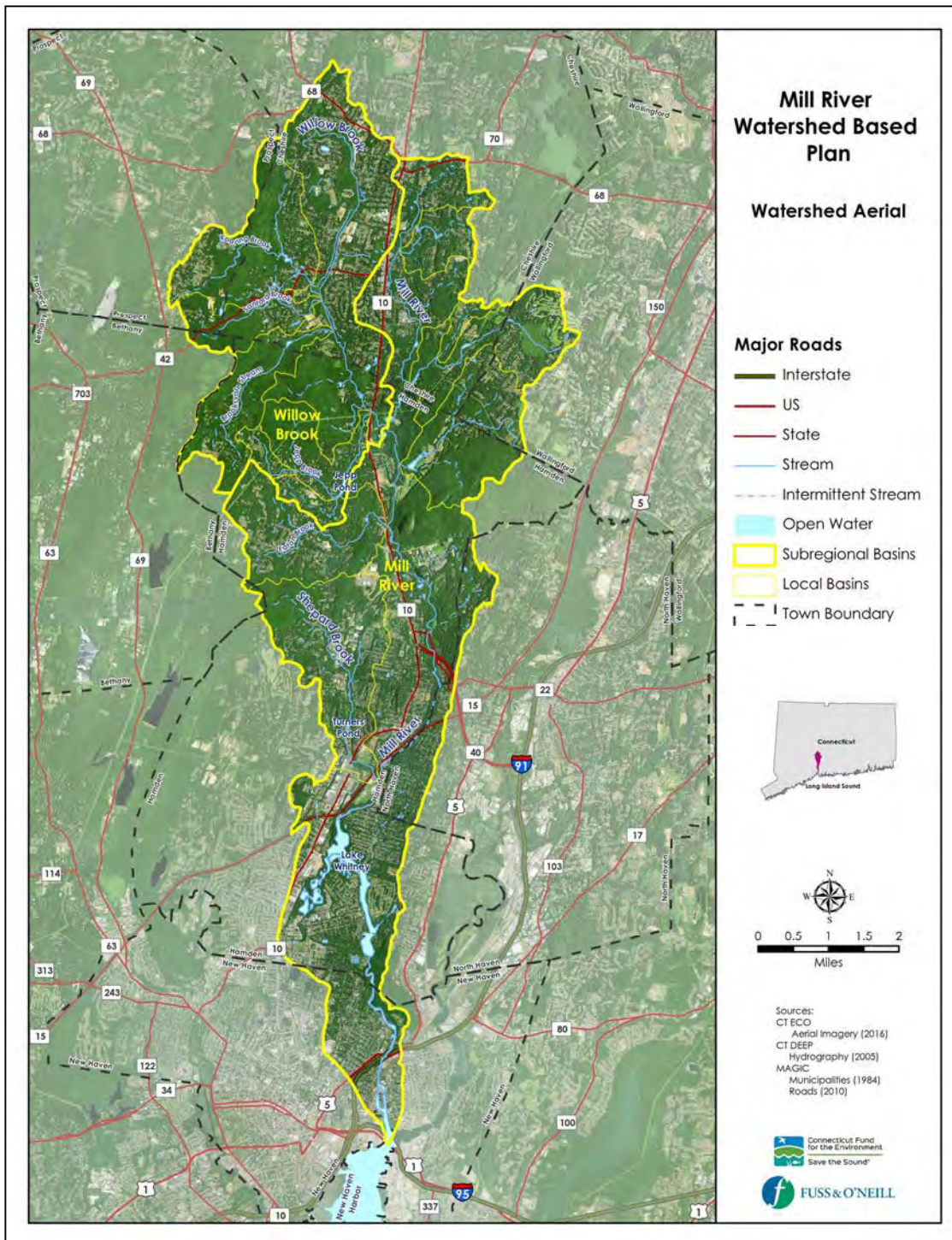


Figure 1-2. Aerial View of Mill River Watershed

Issues Facing the Watershed

Degraded Water Quality

Like many suburban and urban rivers and streams in Connecticut, including the West River and Quinnipiac River, the Mill River has been impacted by historical development and land use activities in its watershed. Water quality in multiple reaches of the Mill River and its tributaries are degraded due to elevated bacteria levels resulting from stormwater runoff, agriculture, combined sewer overflows, illicit discharges, pets, wildlife, and other sources. This has resulted in water quality “impairments,” which means that the waterbodies cannot support certain types of uses such as recreation or habitat for aquatic life. *Section 2.2* provides detailed information on impairments in specific waterbody segments.

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Mill River. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. Stormwater runoff collected by the combined sanitary and storm sewer system in the City of New Haven also contributes to Combined Sewer Overflow (CSO) discharges to the Mill River during periods of heavy rainfall, when the combined sewer system becomes overwhelmed and untreated sewage is discharged directly to the river.

The Greater New Haven Water Pollution Control Authority (GNHWPCA) is in the process of implementing a long-term plan to reduce CSOs to the Mill River, which includes traditional gray infrastructure and green infrastructure¹ approaches. In addition to GNHWPCA, the City of New Haven, private development, and other groups are implementing green infrastructure in the Mill River watershed, which will reduce CSO discharges, runoff volumes, and wet weather pollutant loads.

Limited River Access

Due to the high level of development along the river, especially commercial and industrial development along route 10 and in New Haven, access to many portions of the Mill River is limited. Improved access to the Mill River and its tributaries is needed to enhance recreational opportunities as well as public appreciation and stewardship of the river. An extensive plan to develop the Mill River Trail aims to provide this additional access [see the *Mill River Trail Framework Plan*; (Reed Hilderbrand, LLC, 2017)], and funding is in place to pursue implementation of a stretch of trail through the Fair Haven neighborhood.

1.2 Prior Watershed Planning

The Mill River has been the focus of numerous prior studies, planning efforts, and projects, which are documented by a large and diverse collection of existing reports, from formal water quality assessments, to University-sponsored research, to advocacy reports. Information from many of these documents, which are summarized in Table 1-1 beginning with the most recent documents, has been incorporated into this plan.

¹ Green infrastructure refers to systems and practices that reduce runoff through the use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). When applied to sites or neighborhoods, green infrastructure includes stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

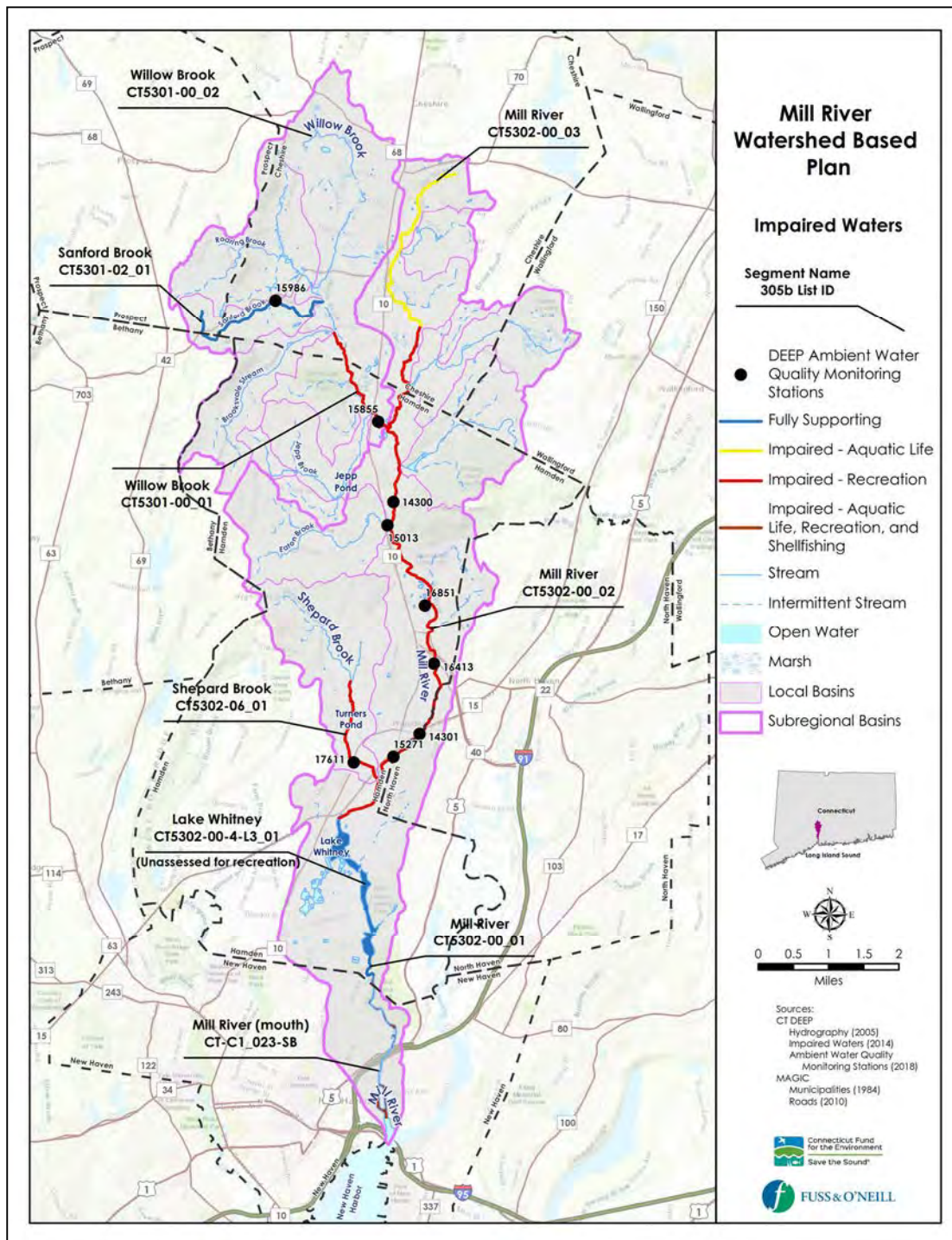


Figure 1-3. Water Quality Impairments in the Mill River Watershed

Table 1-1. Existing Documentation Related to the Mill River

Document/Information Source	Author (Date)	Notes
Public Information Meeting Presentation: New Haven CSO Long Term Control Plan	City of New Haven and GHNWPCA (2017)	Public update on the Long Term Control Plan for CSOs in New Haven, as well as rainfall conditions modeling.
Greater New Haven Water Pollution Control Authority Consent Order WC5509 Annual Progress Report: July 1, 2016- June 30, 2017	GHNWPCA (2017)	Provides updated sewer system mapping, status of all CSOs, and metering data for CSOs during the reporting period.
2016 Connecticut Integrated Water Quality Report	CTDEEP (2016)	Identifies waterbody segments that are classified as impaired relative to aquatic life, recreation, or shellfish.
Lower Mill River Water Quality Monitoring Reports	RWA (2000-2016)	Weekly, warm season measurement data for salinity and dissolved oxygen at the plunge pool, spillway, and footbridge sites.
New Haven Vision 2025: Chapter VII: Environment	City of New Haven (2015)	Chapter of the New Haven comprehensive plan dealing with environmental issues. Addresses water quality in Long Island Sound, sewage, and stormwater issues.
Connecticut Watershed Response Plan for Impervious Cover: Core Document	CTDEEP (2015)	Provides background information on the effects of stormwater on water quality, identifies 12% as a critical impervious cover threshold.
Connecticut Watershed Response Plan for Impervious Cover: Appendix 6-9—Mill River (CT5302) Summary	CTDEEP (2015)	Provides specific information on impaired segments, extant impervious cover and target reduction
New Haven Vision 2025: Status of Sewer Separation Map	GHNWPCA (2015)	Indicates area where separation of sanitary and stormwater sewers has been completed, is under construction, or under design.
Urban River Permits Review and Advocacy Recommendations for the Quinnipiac, Mill, and West Rivers	Mushinsky, M. (2015)	Report produced in conjunction with the Mill River Watershed Association of South Central Connecticut and River Advocates of South Central Connecticut. Descriptions of the three rivers in the New Haven area, water quality pollutants, relevant permits affecting water quality, and advocacy recommendations.
Public Meeting Presentation	RWA (2015)	Update on the Lake Whitney management plan and monitoring efforts.
2014 Connecticut Integrated Water Quality Report	CTDEEP (2014)	Identifies waterbody segments that are classified as impaired relative to aquatic life, recreation, or shellfish.
WUCC Report to the Commissioner	Connecticut Department of Public Health (2014)	Details recommendations for proposed alteration of the boundaries of Connecticut Public Water Supply Management Areas.
Connecticut Statewide Total Maximum Daily Load (TMDL) for Bacteria-Impaired Waters: Core Document	CTDEEP (2012)	Provides documentation for the impaired waters listing status and need for a TMDL, water quality targets, and estimated percent reductions needed to attain water quality targets.
Connecticut Statewide TMDL for Bacteria-Impaired Waters: Appendix 50—Mill River Watershed Summary	CTDEEP (2012)	Provides specific information on impaired segments, potential bacteria sources, current management activities, and recommendations for impaired segments in the Mill River subregional basin.

Document/Information Source	Author (Date)	Notes
Drinking Water Assessment and Source Protection Program	Connecticut Department of Public Health (2012)	Statewide assessment results and source water areas for public drinking water supply systems. Potential contaminant sources impacting surface or groundwater are discussed.
Mill River Freshwater Tidal Marshes: 2011 Vegetation Monitoring	Sharp, P.; prepared for RWA (2012)	Summarizes vegetation monitoring efforts from 2000-2011.
Management Plan for Lake Whitney Water Treatment Plant: Revised April 2, 2012	RWA (2012)	Recommended performance standards and mitigation/monitoring measures for the operation of Lake Whitney as a public water supply.
2000-2011 Lower Mill River Invertebrate Monitoring Report	Water Resource Services; prepared for RWA (2012)	Summarizes macroinvertebrate data for the Lower Mill River.
A Biological Assessment of Upper Lake Whitney	AECOM; prepared for RWA (2010)	Summarizes biological assessments conducted from 2004 to 2009, including studies of plankton, aquatic macrophytes, benthic macroinvertebrates, fish, and water quality.
Effectiveness of Stormwater Treatment Systems Within a Highly Urbanized Watershed	Hudak, J.P., and M.E. Ellum (2003)	Report on a stormwater treatment system designed to treat a 20-acre watershed in the vicinity of Lake Whitney.
Summary of Upper Lake Whitney Management Study: January 23, 2002	Milone & MacBroom (2002)	Summarizes monitoring efforts by the RWA to collect baseline and continuing data on Lake Whitney in conjunction with the reestablishment of the lake as a public water supply.
Polycyclic Aromatic Hydrocarbons (PAHs) in the Sediments and Fish of the Mill River, New Haven, Connecticut, USA	White, J.C. and T. Triplett (2002)	Investigation of PAHs in the segment of the Mill River from Lake Whitney to the tidegates, where the most intense use for fishing and recreation occurs.
Baseline Description of the Lower Mill River Benthos	Mador, M., A. Saar, and M. Funaro (2001)	Baseline description of watershed contributions to the health of the river, local threats and potential future issues related to ecological health. Aquatic chemistry course project from Prof. Gabe Benoit's course at Yale School of Forestry.
Environmental Evaluation: Whitney Environmental Study Team Recommendations	Hudak, J.P., S.R. Kellert, J.T. Maughan, J.L. Rogers, and P.C. Sharp (1999)	Summary of recommendations from the Lake Whitney Water Treatment Plant Environmental Evaluation, including minimum spillway flow, minimum flow releases, dissolved oxygen, spring flood releases, and ongoing ecological monitoring.
The Lake Whitney Urban Runoff Project Final Report	Hudak, J.P. (1996)	Report on planning, construction, and monitoring of a stormwater treatment system designed to address runoff from an urban outfall pipe in the vicinity of Lake Whitney.
Lake Whitney Reservoir Urban Runoff Treatment Project Phase II	New Haven County Soil and Water Conservation District (1995)	A review of existing regulations relating to watershed protection and/or water quality.

Document/Information Source	Author (Date)	Notes
Phosphorus Transport in the Mill River, New Haven County, Connecticut	Perkins, E.J. (1993)	Yale University study of processes affecting phosphorus transport in the Mill River.
Lake Whitney Stormwater Treatment Systems Map	RWA (n.d.)	Map showing locations of stormwater treatment systems in the vicinity of Lake Whitney.
Lake Whitney Project Mill River Subbasins	Unknown (n.d.)	Prioritization of subbasins for urban runoff, subwatershed descriptions, and historic outfall mapping.

1.3 Why Develop a Watershed Plan?

Save the Sound, a program of Connecticut Fund for the Environment (CFE/Save the Sound), the Connecticut Department of Energy and Environmental Protection (CTDEEP), the watershed municipalities, and other key stakeholders recognize the need to address the water quality issues facing the Mill River and its tributaries. Several of these waterbodies have impairments for recreation or aquatic life support due to elevated levels of bacteria and other pollutants. A primary step toward addressing these issues is to develop and implement a comprehensive watershed based plan. The watershed-based planning process brings together stakeholders from throughout the watershed to identify projects and practices that will satisfy United States Environmental Protection Agency (EPA) and CTDEEP requirements for watershed planning for the Mill River, and in doing so, improve water quality and restore conditions in the watershed. The watershed plan provides a blueprint to help groups within the watershed work across municipal boundaries to better protect and restore water resource conditions throughout the watershed.

The major objectives of developing a watershed-based plan for the Mill River are to:

- Characterize current watershed conditions and issues
- Identify existing water quality issues and pollutant sources
- Consolidate previous and ongoing efforts within the watershed under one plan
- Facilitate capacity-building and engage the watershed municipalities and other stakeholder groups, as well as the general public, in the watershed planning process and future plan implementation
- Promote collaboration across municipal boundaries, bringing the watershed communities and groups together to cooperate around shared issues of concern and objectives without compromising their “home rule” principles

Watershed Management

Watershed planning is a process that identifies ways to protect and restore the water quality and other natural resources in a watershed. The outcome of the watershed planning process is documented in a watershed based plan.



Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

- Create a plan that satisfies EPA and CTDEEP requirements for watershed-based plans to better position the Mill River for future grant funding from certain State and Federal sources.
- Improve water quality and de-list “impaired waters”

1.4 Watershed Management Goals and Objectives

This section presents management goals and objectives for the Mill River watershed, each of which will be developed in more detail in *Section 3* of this plan. The goals and objectives were developed over the course of the watershed planning process, with input from the Project Steering Committee, the public, and other watershed stakeholders.

- **Goal #1 – Capacity Building.** Strengthen and build local capacity to implement the watershed based plan.

Capacity Building Objectives

- § Establish a framework and lead entity for implementation of the watershed based plan
- § Promote inter-municipal coordination to formally adopt the watershed plan and coordinate and oversee watershed based plan implementation activities.
- § Promote regional collaboration to share ideas and strengthen regional watershed management efforts, particularly with groups representing the neighboring Mill River and Quinnipiac River watersheds.
- § Identify and pursue funding to implement the recommendations outlined in this plan.
- § Conduct streamwalks in priority subwatersheds to assess the condition of the streams and riparian corridors, identify retrofit opportunities and problem areas, and involve the public and volunteers as a form of outreach.
- § Prepare and implement subwatershed action plans for priority subwatersheds.



Mill River watershed management goals.

- **Goal #2 – Water Quality.** Improve the water quality of the impaired segments of the Mill River and its tributaries by reducing loadings of bacteria and other pollutants. Consistently meet water quality standards for recreation and aquatic habitat. Protect and enhance high quality and unimpaired waterbodies.

Water Quality Objectives

- § Continue water quality monitoring to identify pollution sources, follow long-term trends in water quality, and track the progress of the watershed plan.

- § Eliminate Combined Sewer Overflow (CSO) discharges to the Mill River.
- § Reduce the impacts of subsurface sewage disposal systems through proper homeowner inspection and maintenance.
- § Expand the use of green infrastructure throughout the watershed.
- § Implement municipal stormwater management programs to comply with state and federal permit requirements.
- § Protect and restore natural streamside vegetation in the watershed to protect and improve water quality.
- § Reduce bacteria loads from wildlife and pet waste.
- § Identify and remove illicit connections and non-stormwater discharges to the Mill River and its tributaries.
- § Promote sustainable lawn care practices to reduce the use of water, fertilizer, and toxic chemicals.
- § Reduce the threats to water quality from commercial and industrial land uses.

- Goal #3 – Habitat Protection and Restoration. Protect and restore terrestrial, streamside, and aquatic habitat.

Habitat Objectives

- § Protect and restore in-stream habitat for resident and migratory fish species in the Mill River and portions of Wintergreen Brook by removing barriers to fish passage.
 - § Protect and restore natural vegetated buffers along the Mill River, its tributaries, and other water bodies.
 - § Manage invasive plant species that threaten local biodiversity and ecosystem function in the watershed.
 - § Protect and restore forested areas and tree canopy within the watershed.
- Goal #4 – Sustainable Land Use, Open Space, and Public Access. Promote sustainable land use and appropriate development in the watershed while protecting and improving water quality and natural resources, enhancing public access to and connectivity of waterbodies and open space, and addressing current and future flooding problems.

Land Use, Open Space, and Public Access Objectives

- § Preserve existing open space and prioritize additional lands for open space conservation.
 - § Increase public access to the Mill River and connectivity of water bodies and open space to improve public use, appreciation, and stewardship.
 - § Strengthen municipal land use policy and regulations for broader implementation of low impact development and green infrastructure.
 - § Increase flood resilience through a watershed approach.
- Goal #5 – Education and Stewardship. Promote stewardship of the watershed through education and outreach, improved access to the Mill River and its tributaries, and citizen involvement in science, conservation, and restoration activities.

Education and Stewardship Objectives

- § Implement a green infrastructure public outreach campaign focused on citizens, businesses, and communities.
- § Provide incentives for residential “green” practices.

- § Conduct homeowner education and outreach on animal waste, sustainable lawn care and landscaping practices, streamside buffers, and septic system maintenance.
- § Promote, publicize, and support existing community engagement events that focus on the Mill River and its watershed such as the work of the Mill River Trail Advocates.
- § Conduct education and outreach for the watershed business community on pollution prevention.
- § Conduct municipal education and outreach on animal waste, parks and open space maintenance, green infrastructure, storm sewer system and BMP maintenance, and identification and removal of illicit connections.
- § Enhance youth education, community service, and environmental stewardship programs.
- § Conduct outreach to public and private institutional property owners in the watershed such as Quinnipiac University and the local schools.
- § Increase watershed stewardship signage in targeted areas.

1.5 Plan Development Process

Funding for this project was provided in part by the CTDEEP through a U.S. EPA Clean Water Act Section 319 Nonpoint Source grant. Fuss & O'Neill, Inc. was retained by CFE/Save the Sound to lead the development of the watershed based plan.

This plan has been developed consistent with EPA and CTDEEP guidance for watershed-based plans. The guidance outlines nine key elements (see text box on the following page) that establish the structure of the plan, including specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act and improve the chances for funding through other State and Federal sources. Development of the watershed based plan consisted of the following tasks.

Project Steering Committee

A Project Steering Committee was formed to guide the plan development. The Steering Committee consisted of representatives from the watershed municipalities, government organizations, educational institutions, non-profit organizations, and others who live and work within the watershed.

A series of meetings were held with the Steering Committee and other invited stakeholders to discuss issues of concern in the watershed and to identify watershed planning goals and objectives that would form the basis of the plan recommendations. The Steering Committee and other stakeholders also provided review

EPA Nine Key Elements of a Watershed-Based Plan

- a. Identify causes and sources of pollution
- b. Estimate pollutant loading to the watershed and the expected load reductions
- c. Describe management measures that will achieve load reductions and targeted critical areas
- d. Estimated amount of technical and financial assistance and the relevant authorities needed to implement the plan
- e. Develop and information/education component
- f. Develop a project schedule
- g. Describe the interim, measurable milestones
- h. Identify indicators to measure progress
- i. Develop a monitoring component

comments on draft deliverables. The watershed plan reflects the combined efforts of CFE/Save the Sound, CTDEEP, the watershed municipalities, other stakeholders, and the Fuss & O'Neill project team. Members of the Project Steering Committee and other individuals involved in the plan development process are listed in the Acknowledgments section at the beginning of this document.

Existing Watershed Conditions

A baseline assessment was performed to document the existing physical, land use, and water quality characteristics of the Mill River watershed. The project team reviewed existing watershed data, studies, and reports; and compiled and analyzed GIS mapping of the watershed and various subregional basins. The document entitled *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018a) serves as a basis for the watershed plan recommendations and also provides a background reference document to support future implementation activities within the watershed. A copy of the technical memorandum is provided in *Appendix A* of this plan.

Watershed Survey

A survey was conducted to obtain early feedback from the Project Steering Committee and other stakeholders regarding the top concerns and issues in the Mill River watershed and the desired outcomes of the watershed planning process. A summary of the survey results are presented below.

Pollutant Load Modeling

Pollutant loading models were developed for the watershed based on impervious cover data and land use information. The methods and findings of this assessment are documented in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b). A copy of the technical memorandum is provided in *Appendix B* of this plan. The pollutant loading models provide baseline estimates on overall pollutant contributions from each subwatershed, as well as breaking down the loads by source. These estimates form the basis for further load reduction modeling presented in *Section 4* of this document.

Green Infrastructure Assessment

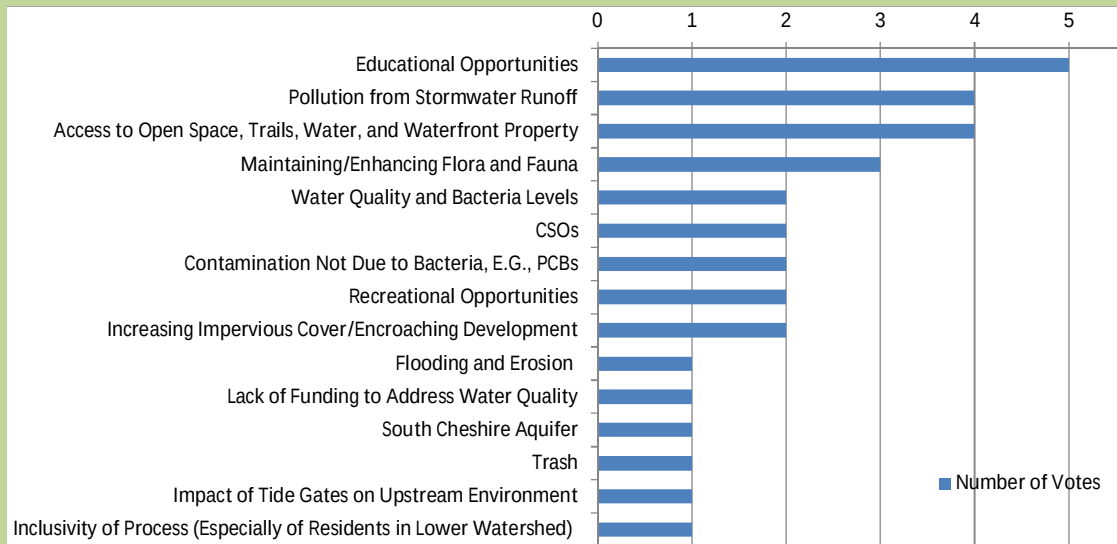
An assessment was performed to identify opportunities and develop concepts for site-specific green infrastructure retrofits in the Mill River watershed. The assessment included a screening evaluation to quickly identify areas of the watershed with the greatest feasibility for and potential benefits from green infrastructure retrofits, field inventories of the most promising green infrastructure retrofit opportunities in the watershed identified from the screening step, and development of green infrastructure concepts for selected retrofit sites. The site-specific project concepts are intended to serve as future implementation projects and examples of the types of projects that could also be implemented for other similar land uses and locations in the watershed. The methods and findings of this assessment are documented in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018c). A copy of the technical memorandum is provided in *Appendix C* of this plan.

Plan Recommendations

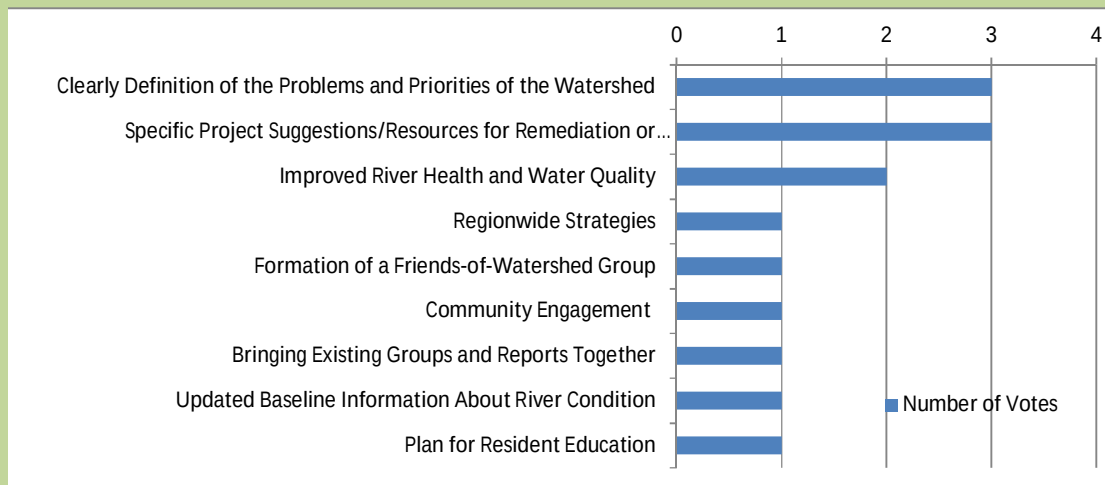
Potential management actions were identified for each of the plan goals and objectives and subsequently refined based upon input from the Project Steering Committee and other stakeholders, culminating in the management recommendations that are presented in *Section 3* of this document.

Mill River Watershed Survey Responses

Top Issues/Concerns in the Mill River Watershed



Desired Outcomes of the Watershed Planning Process



1.6 Public Participation and Outreach

Public participation and outreach was conducted as part of the watershed planning process to increase public understanding of issues affecting the watershed, to encourage participation in the development of the watershed plan, and to build support for implementation of the plan. The following public outreach activities occurred during the watershed planning process:

- March 2018 – A Project Steering Committee was formed in March 2018. An initial project kickoff meeting was held with the Steering Committee and other invited stakeholders (34 attendees in total) at the Eli Whitney Museum on March 1, 2018. A watershed survey was circulated to the stakeholders at this meeting to identify issues of concern and watershed planning priorities. An additional presentation was made to the Whitneyville Civic Association on March 18, 2018. Meeting summaries are included in *Appendix D* of this plan.
- April 2018 – A Project Steering Committee meeting was held on April 10, 2018 at Cheshire Senior Center in Cheshire. The primary purpose of the meeting was to review the watershed survey responses, baseline watershed conditions, and the watershed plan goals. *Appendix D* contains a summary of the meeting.
- May 2018 – Additional Project Steering Committee meetings were held on May 1, 2018 at the Eli Whitney Museum in Hamden, and May 29, 2018 at Cold Spring School in New Haven. The latter meeting included a screening from the film, *The Mill River—Water and Wildlife*. Meeting summaries are included in *Appendix D* of this plan.
- June 2018—Presentations on the Mill River watershed planning process were made to the New Haven Environmental Advisory Council on June 6, 2018, and to the community at Green Drinks New Haven on June 20, 2018.
- July 2018 – A Project Steering Committee meeting was held on July 10, 2018 at Cheshire Senior Center in Cheshire. The meeting centered around presentation of the pollutant loading model calculations and green infrastructure assessments. *Appendix D* contains a summary of the meeting.
- July 2018 – Fuss & O'Neill and staff from the RWA and CFE/Save the Sound conducted streamwalk assessment training on July 21, 2018 for Save the Sound, members of the Project Steering Committee, and other volunteers. The training provided volunteers with basic information on conducting stream assessments of the Mill River and its tributaries following the NRCS protocols for performing visual stream assessments in Connecticut. Further details of the stream assessments are discussed later in this plan.
- August 2018 – A steering committee meeting was held at the Eli Whitney Museum on August 21, 2018 to discuss the draft Mill River Watershed Plan and to plan public outreach events to share the plan with the greater watershed community.
- September 2018 – Two community meetings open to the public were held on September 5th and 6th, 2018. In order to accommodate residents from both ends of the watershed, the September 5 meeting was held at XXXXXXXXXXXXXXXX, while the September 6 meeting was held at Cheshire Senior Center. The workshops consisted of a presentation on the current watershed conditions and major

issues facing the Mill River watershed, followed by group discussion of local issues of importance and desired outcomes of the watershed planning process. Summaries of the meetings (main concerns, desired outcomes of the watershed plan, and project recommendations) and questionnaires completed by the workshop participants are included in *Appendix E* of this plan.

2 Watershed Characterization

2.1 Watershed Description

The Mill River watershed consists of two subregional basins: Mill River Subregional Basin (#5302) and Willow Brook Subregional Basin (#5301). Each subregional basin contains 7 local basins of varying size (Figure 1-1). The watershed covers an area of approximately 38 square miles (24,584 acres) in the municipalities of Bethany, Prospect, Cheshire, Hamden, North Haven, Wallingford, and New Haven, in New Haven County (Table 2-1). The upper watershed is generally rural or suburban in nature, with development intensity increasing at the southern end of the watershed and in the vicinity of the mouth of the river. Population density ranges from 262 people per square mile in Bethany to 6,992 people per square mile in New Haven. Cheshire and Hamden, which together make up 83% of the watershed area, have population densities of 885 and 1,884 people per square mile, respectively.

Table 2-1. Distribution of Municipalities in the Mill River Watershed

Municipality	Total Acreage of Municipality	Acreage in Watershed	% of Municipality in Watershed	% of Watershed	Population Density (people/sq.mi.)
Bethany	13,690	128	0.9	0.5	262
Cheshire	21,165	7,377	34.9	30.0	885
Hamden	21,278	13,117	61.6	53.4	1,884
New Haven	12,288	1,179	9.6	4.8	6,992
North Haven	13,510	835	6.2	3.4	1,149
Prospect	9,238	799	8.7	3.3	680
Wallingford	25,821	1,149	4.5	4.7	1,155
Watershed (total)	116,990	24,585	N/A	100.0	1,723

As noted above, the main stem of the Mill River is approximately 12.6 miles long, and stretches from Cheshire south to Long Island Sound, passing through an approximately 0.068 mi² estuary region of tidal influence, before ultimately flowing into New Haven Harbor. The largest tributary to the Mill River is Willow Brook, which drains an approximately 13 square-mile area before joining the Mill River in Hamden. Shepard Brook, Butterworth Brook, Jepp Brook, Eatons Brook, and Brooksvale Stream are additional major tributaries. Numerous smaller streams complete the network of waterbodies draining through the Mill River to New Haven Harbor. Major surface waterbodies in the watershed include Lake Whitney, Turners Pond, and Jepp Pond.

2.2 Water Quality

In compliance with section 305(b) of the Federal Clean Water Act, the state of Connecticut submits a water quality report to the EPA every two years. That report lists waterbody segments and denotes whether they have met water quality standards for certain designated uses, including aquatic life use support, recreation, and shellfish harvesting. Six river segments and one estuary segment within the Mill River Watershed were identified in the 2016 Integrated Water Quality Report (IWQR). Of these, four river segments and the estuary

are impaired for at least one use category (Figure 1-3). Two additional segments within the watershed were included in the 2014 IWQR as fully supporting or not assessed but were not reported in the 2016 update.

- Sanford Brook: Sanford Brook segment CT5301-02_01 ("Sanford Brook (Cheshire)-01") is 2.68 miles long and extends from its mouth at the confluence with Willow Brook downstream of South Brooksville Road in Cheshire, upstream to the headwaters (just upstream of Candee Road) in Prospect. It is fully supporting of both aquatic life and recreation.
- Willow Brook: Willow Brook segment CT5301-00_01 ("Willow Brook (Hamden)-01") is 1.87 miles long and extends from its mouth at the confluence with the Mill River downstream of the Willow Street crossing in Hamden, upstream to the confluence with Brooksville Stream in Cheshire, traveling along the railroad tracks. It is impaired for recreation and is not assessed for aquatic life. Willow Brook segment CT5302-00_02 ("Willow Brook (Hamden)-02") is 3.84 miles long and extends from its confluence with Brooksville Stream to the headwaters near Timber Lane, in Cheshire. The segment was included in the 2014 IWQR as not assessed for aquatic life and having insufficient information for recreation; it was not included in the 2016 IWQR.
- Shepard Brook: Shepard Brook segment CT5302-06_01 ("Shepard Brook (Hamden)-01") is 1.78 miles long and extends from its mouth at the confluence with the Mill River just downstream of Route 15, includes Turners Pond, and continues upstream to the confluence with an unnamed tributary behind the business park off Sherman Avenue and Town Walk Drive. The segment is not assessed for aquatic life and is impaired for recreation.
- Mill River: Mill River segment CT5302-00_01 ("Mill River (Hamden)-01") is 0.41 miles long and extends from the footbridge crossing to the Lake Whitney outlet dam, in Hamden. The segment is tidally affected freshwater, and is fully supporting of both aquatic life and recreation uses. Mill River segment CT5302-00_02 ("Mill River (Hamden/Cheshire)-02") is 9.06 miles long and extends from the inlet to Lake Whitney on the east side of Route 15, just downstream of Connolly Parkway in Hamden, to the Cook Hill Road crossing in Cheshire. The segment is impaired for both recreation and aquatic life. Mill River segment CT5302-00_03 ("Mill River (Cheshire)-03") is 3.09 miles long and extends from the Cook Hill Road crossing to the headwaters, just upstream of Williamsburg Drive. The segment is impaired for aquatic life; there is insufficient information to assess recreation impairments.
- Lake Whitney: The Lake Whitney segment CT5302-00-4-L3_01 ("Whitney, Lake (Hamden)") is reported in the 2014 IWQR but not included in the 2016 report. The Lake, which is an impoundment of the Mill River, covers 140.42 acres and was denoted in the 2014 IWQR as fully supporting for aquatic life and unassessed for recreation.
- Inner-Mill River Estuary: The estuary segment CT-C1_023-SB (identified in the IWQR as "LIS CB Inner-Mill River (mouth), New Haven/Hamden") covers 0.068 mi², extending northward from the mouth of the Mill River at its confluence with the Quinnipiac River in New Haven to the footbridge crossing just upstream of East Rock Road in Hamden. The estuary segment is impaired for recreation, aquatic life, and shellfish.

Further details of the impaired waterbody segments within the watershed, including causes of impairment, can be found in *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill 2018a; included in *Appendix A* of this document).

Bacteria Impairments

CTDEEP completed a “Statewide Bacteria Total Maximum Daily Load” (TMDL) for 176 impaired waterbody segments based on the 2010 Impaired Waters List (CTDEEP, 2012). The TMDL sets target pollution levels and establishes a framework for restoring water quality of the impaired segments. Only two of the bacteria impaired segments listed above are included in the approved TMDL (Mill River-02 and Shepard Brook). This is because several of the waterbody segments in the Mill River watershed that are now classified as impaired were assessed more recently than 2010. However, like the segments listed in the TMDL, the Willow Brook segment (Willow Brook-01) is also impaired for recreation due to *E. coli*, and the Inner-Mill River Estuary is impaired for recreation due to Enterococcus and fecal coliform. Based on the 2010 data included in the TMDL, the Mill River-02 segment requires a 77% reduction in geometric mean indicator bacteria (*E. coli*) levels and a 94% single sample *E. coli* reduction in order to meet the TMDL. For the Shepard Brook segment, the required percent reductions are 77% and 71%, respectively.

Potential sources of indicator bacteria identified in the TMDL include point sources, such as permitted discharges from Municipal Separate Storm Sewer Systems (MS4s), combined sewer overflows (CSOs), and industrial and commercial facilities. Additional non-point sources include stormwater runoff, failing septic systems, agricultural activities, and wastes from wildlife and pets. Stormwater discharges to MS4s and illicit discharges are two of the primary targets identified in the Statewide Bacteria TMDL for pollution reduction of freshwater segments. The TMDL also recommends removal of CSOs in New Haven for bacteria reduction in the New Haven estuaries.

Water Quality Monitoring

CTDEEP routinely monitors ambient water quality, macroinvertebrate diversity, and fisheries at various locations within the watershed (Figure 1-3). Many of these data are ultimately incorporated into the biannual IWQRs and TMDLs. Additional water quality and biological monitoring took place in the Lake Whitney portion of the watershed in conjunction with the planning and eventual opening of the new Lake Whitney Water Treatment Plant, which opened in April, 2005 (discussed in more detail in *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O’Neill 2018a; included in *Appendix A* of this document). Other studies (some published, some unpublished) have been conducted in association with local organizations or academic institutions that focus on specific water quality issues, such as polycyclic aromatic hydrocarbons in Mill River sediments and fish, phosphorus transport, and aquatic chemistry.

Impervious Cover Response Plan

The Mill River headwaters segment (CT5302-00_03) has been designated as impaired for aquatic life and fish habitat, but the cause of the impairment is unknown. This segment has been included in the *Connecticut Watershed Response Plan for Impervious Cover* (IC Response Plan) (CTDEEP, 2015), along with 15 other streams that are also impaired for aquatic life but have no known cause for the impairment. The IC Response Plan uses impervious cover as a surrogate for the suite of potential pollution sources carried by stormwater runoff, and sets a target of 11% impervious cover. The target is not a required reduction or a regulatory limit, but is meant to guide best management practices (BMPs) and low impact development (LID) within the impaired drainage areas. The current impervious cover of the watershed area corresponding to the impaired segment is 15%; meeting the target would therefore require a 27% reduction in impervious cover (CTDEEP, 2015).

2.3 Land Use and Land Cover

2.3.1 Land Cover

The distribution of land cover (physical land type) and land use (how people are making use of land) within the watershed plays an important role in shaping spatial patterns and sources of nonpoint source pollution and surface water quality. Impervious cover, in particular, is central to determining rates and volume of stormwater runoff, which is often a key contributing factor to water quality impairments.



Credit: Joseph Gerhard – Mill River, *Manton Westwood Books*, New Haven, CT, 2011

The National Land Cover Database (NLCD) provides Landsat-based, 30-meter resolution land cover data for the entire nation. The most recent national data, which are presented here, are from 2011. The University of Connecticut Center for Land Use Education and Research (UConn CLEAR) provides a more recent dataset (2015), but the NLCD data are preferred as they disaggregate developed land into more precise categories based on density of development, and provide more detailed divisions for agricultural land and other habitat types.

Based on NLCD data, approximately 47% of the watershed falls into one of the four developed land categories (Table 2-2), while 41.9% is deciduous forest land. At 55.9% developed land and 33.8% forest, the Mill River subregional basin is substantially more developed than the Willow Brook subregional basin, which has 30.6% developed land and 57.7% deciduous forest cover. This is consistent with the trend

noted above, that highly developed areas are concentrated to a large degree at the southern end of the watershed, while the northern portion of the watershed is generally less developed. This pattern is even more pronounced for land cover in the riparian zone. Vegetated riparian buffers can slow stormwater runoff, and trap sediment and other pollutants. On the other hand, riparian lands that are developed and lack a dense stand of vegetation may be especially vulnerable to water quality issues.

2.3.2 Land Use

Whereas land cover categorizes the physical landscape, land use refers to the way that humans are utilizing the land and focuses on five primary categories (commercial/mixed use, industrial, institutional, residential, open space) in addition to an 'other' category. Land use data were obtained from both the South Central Regional Council of Governments (SCRCOG) and the Naugatuck Valley Council of Governments (NVCOG). SCRCOG last updated their land use data in 2016; NVCOG last revised their data in 2017.

Residential use dominates land use across the entire watershed, comprising slightly more than half of all land use in both subregional basins (Table 2-3). Open space is the next largest category in both watersheds, but makes up nearly 1/3 of land use in the Willow Brook subregional basin compared with only 18% in the Mill River subregional basin. Commercial, industrial, and institutional uses make up a small proportion of land use in both subregional basins, but are more concentrated in the Mill River subregional basin, and tend to cluster at the southern-most end of the watershed, in New Haven.

Table 2-2. Distribution of Land Cover Types in the Mill River Watershed (NLCD 2011)

Acres			Percent			
Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed	Land Cover	Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed
23	277	300	Open Water	0.3	1.7	1.2
1,166	3,314	4,480	Developed, Open Space	14.1	20.4	18.3
1,008	2,946	3,954	Developed, Low Density	12.2	18.1	16.1
318	2,194	2,512	Developed, Medium Density	3.8	13.5	10.2
41	641	683	Developed, High Density	0.5	3.9	2.8
3.3	7.8	11	Barren	0.0	0.0	0.0
4,775	5,495	10,270	Deciduous Forest	57.7	33.8	41.9
81	300	381	Coniferous Forest	1.0	1.8	1.6
45	130	176	Mixed Forest	0.5	0.8	0.7
118	122	240	Shrub/Scrub	1.4	0.7	1.0
45	213	258	Herbaceous	0.5	1.3	1.1
153	175	328	Pasture/Hay	1.9	1.1	1.3
5.3	0.0	5	Cropland	0.1	0.0	0.0
481	431	912	Woody Wetland	5.8	2.6	3.7
7	19	26	Emergent Herbaceous Wetland	0.1	0.1	0.1
8,271	16,265	24,536	Total	100.0	100.0	100.0

2.3.3 Historic Land Use

In general, commercial/industrial land use in the watershed is a potential source of bacteria and other pollutants. As indicated in the TMDL, there are approximately 11 permitted commercial and industrial facilities in the Mill River watershed. Historic industrial land uses continue to affect the Mill River watershed through legacy contamination. One such historic site is English Station, a closed power plant located on Ball Island, near the mouth of the Mill River. Occupying nearly 9 acres, the site is known to be widely contaminated with polychlorinated biphenyls (PCBs) and other hazardous contaminants. Excavation on the site in 1997 resulted in a documented release of PCBs into the Mill River (CTDEEP, 2016) and a 2005 report noted that PCBs were present in concentrations thirty times the industrial direct exposure criteria (CTDEEP, 2016). Early stages of remediation for English Station are currently underway.

**Table 2-3. Distribution of Land Use Types in the Mill River Watershed
(NVCOG 2017, SCRCOG 2016)**

Mill River Subregional Basin	Acres		Land Use	Mill River Subregional Basin	Percent	
	Willow Brook Subregional Basin	Entire Watershed			Willow Brook Subregional Basin	Entire Watershed
810	160	971	Commercial & Mixed Use	5.1	1.9	4.0
416	25	442	Industrial	2.6	0.3	1.8
1,101	303	1,405	Institutional	6.9	3.7	5.8
2,938	2,640	5,578	Open Space	18.5	32.1	23.1
1,289	694	1,984	Other	8.1	8.4	8.2
9,367	4,413	13,781	Residential	58.8	53.6	57.0
15,923	8,237	24,160	Total	100.0	100.0	100.0

There are also known petroleum, metal, and PCB impacts to the river in the vicinity of 470 James Street due to legacy contamination from the former trolley garage (later a state bus garage), related underground storage tanks and fueling system releases. Erosion of polluted urban fill at the site has impacted sediment and water quality in the Mill River. Conceptual planning for remediation and restoration of the site is in progress.

2.4 Impervious Cover

Impervious cover (IC) refers to any surface which prevents natural infiltration of stormwater into the soil, most notably buildings and pavement. As stormwater travels across impervious surfaces, rather than sinking into the ground, it picks up pollutants (e.g. oils, sediment) from the surface and transports these materials as part of the stormwater discharge. If not treated before the stormwater drains into a waterbody, these pollutants can become a major contributor to waterbody impairments. Extensive research has documented the effects of urbanization on stream and watershed health, including studies by CTDEEP that have documented a negative relationship between upstream impervious cover and aquatic life in adjacent waters, with predictable detrimental impacts to aquatic life when impervious cover exceeds 12% (CTDEEP, 2015).

In 2017, UConn CLEAR analyzed 2012 aerial imagery to estimate the amount of total impervious cover in each local basin (Table 2-4). As a whole, the Mill River watershed has 17.2% impervious cover. At 10.2%, total impervious cover in the Willow Brook subregional basin is below the 12% threshold; the Mill River subregional basin, however, has total impervious cover of 20.8%. At the local basin scale, 6 of the 14 local basins across the entire watershed exceed the 12% threshold. The highest impervious cover in the watershed is found in the local basin that contains the main stem of the Mill River, where overall IC was 27.3%. This high percentage of IC is driven by particularly dense development in New Haven and in areas adjacent to the main stem. The local basin that contains Shepard Brook is similarly affected, with 21.2% impervious cover. Unsurprisingly, local basins that are predominantly rural and/or are less-developed tend to have impervious cover below 10%.

Table 2-4. Distribution of Impervious Cover in the Mill River Watershed (UConn CLEAR 2012)

Acres				Percent		
Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed	Impervious Surface Type	Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed
239	975	1,214	Building	2.9	6.0	4.9
365	1,523	1,889	Other*	4.4	9.4	7.7
245	890	1,135	Road	2.9	5.5	4.6
849	3,389	4,238	Total	10.2	20.8	17.2

*Includes parking lots, sidewalks, driveways, patios, swimming pools, and decks.

2.5 Open Space

Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious cover, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space is also important as habitat for native and migratory species and protection of public water supply. Open space includes preserved natural areas as well as lightly developed parks, playgrounds, and cemeteries.

An initial assessment of active and passive open space areas in the Mill River watershed was identified based on GIS information provided by NVCOG (data updated in 2017) in addition to data compiled and published by CTDEEP in 2015, including federal land, state-owned property, and other municipal and privately-owned open space. The largest open space land includes:

- Sleeping Giant State Park (1,615 acres)
- Regional Water Authority land (1,087 acres)
- Naugatuck State Forest (746 acres)
- Farmington Canal Heritage Trail (18.1 miles of linear trail)
- East Rock Park (425 acres)
- DeDominicis Property (200 acres)
- Puchalski Property (103 acres)
- Roaring Brook (87 acres)
- Hamden Fish and Game Protection Association (85.6 acres)
- Bens Homestead (63.4 acres)
- Brooksvale Farm Preserve (48 acres)

2.6 Geology and Soils

Typical of coastal watersheds in Connecticut, the topography of the Mill River watershed is quite variable, encompassing flat plains along the coast and estuaries, with a mixture of rolling hills and steep slopes to the north. The surficial geology of the watershed has been shaped by glaciation and is a major factor shaping topography, soils, and drainage characteristics within the watershed. The Mill River runs along the historic

path of a glacial meltwater stream; surficial geology along its channel is thus characterized by sand and gravel deposits.

To the east and west of the Mill River, the landscape rises and is characterized by thick glacial till (unsorted glacial deposits). On the east side of the watershed, Sleeping Giant State Park encompasses Mt. Carmel, a large drumlin with a maximum elevation of approximately 730 feet. The western slope of Mt. Carmel drains to the Mill River, while the eastern slope drains toward the Quinnipiac River. Mt. Sanford sits on the western edge of the Mill River watershed, within the Willow Brook subregional basin. At approximately 880 feet, Mt. Sanford is the highest point in the watershed; its northern and eastern slopes drain toward Willow Brook and eventually flow into the Mill River, while the southwestern slope drains toward the West River. A ridge runs northward from Mt. Sanford, forming much of the western edge of the watershed.

The City of New Haven is located on a plain at the southernmost tip of the watershed, where the Mill River meets the Quinnipiac River, New Haven Harbor, and then Long Island Sound. Much of the shoreline in this area has been reclaimed from the Sound and consists of artificial fill. The rest is glacial outwash consisting of sands and gravels over fine silts and clays.

The Natural Resources Conservation Service (NRCS) classifies soils into Hydrologic Soil Groups (HSG) that characterize a soil's runoff versus infiltration potential after prolonged wetting. Group A soils are the most well drained, meaning that they have low runoff potential and high infiltration potential. At the other extreme, Group D soils are the most poorly drained. Water movement through Group D soils is restricted, causing them to have high runoff potential and low infiltration potential. Group D soils are frequently either high in clay content or shallow soils over an impermeable layer (such as shallow bedrock or a dense glacial till) or a shallow water table. Group B and C soils complete the continuum between these extremes. Group B soils have moderately low runoff potential and unimpeded water transmission through the soil, while group C soils have moderately high runoff potential and are somewhat restrictive of water movement.

Table 2-5. Distribution of Hydrologic Soil Groups

HSG	Mill River Subregional Basin (Acres)	Willow Brook Subregional Basin (Acre)	Grand Total (Acres)	% of Watershed
A	1,859	1,054	2,913	11.9
B	6,030	3,849	9,878	40.2
C	3,638	1,412	5,051	20.5
D	4,413	1,940	6,353	25.8
Water	346	44	390	1.6
Total	16,286	8,299	24,585	100.0

Within the Mill River watershed, areas of poor infiltration potential characterized by Group D soils include Mt. Carmel, Mt. Sanford, the ridge that runs along the northwestern edge of the watershed, and significant portions of New Haven. Approximately 46% of the watershed is characterized as either Group C or Group D soils, indicating moderately high to high runoff potential, and relatively limited infiltration potential. 52% of the watershed as a whole consists of areas with Group A & B soils, which have greater infiltration potential and are generally more conducive to infiltration-based Low Impact development (LID) and green stormwater infrastructure practices. The Willow Brook subregional basin has a greater percentage of Group A & B soils than does the Mill River subregional basin (59% as compared to 48%, respectively), and is thus expected to

have somewhat better infiltration potential than the Mill River subregional basin (Table 2-5). Additionally, some of the areas of Group A & B soils in the Mill River subregional basin coincide with areas of dense development, which makes these areas potential targets for urban stormwater retrofits.

2.7 Wetlands and Endangered Species

2.7.1 Wetlands

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and plant and animal communities living in the soil and on its surface. Wetlands can vary widely in type and characteristics, but are an important feature of a watershed, providing water quality benefits by removing pollutants and mitigating flooding. Wetlands make up approximately 12% of the watershed overall. 7.4% of the Mill River subregional basin consists of poorly drained and very poorly drained soils, with an additional 3.1% alluvial and floodplain soils. The Willow Brook subregional basin has a somewhat higher percentage of poorly drained and very poorly drained soils (11.5%) and 2.7% alluvial and floodplain soils.

2.7.2 Endangered, Threatened, and Special Concern Species

CTDEEP maintains information on the location and status of endangered, threatened, and other species of special concern throughout the state through the CTDEEP Natural Diversity Database (NDDB). Activities in these areas are potentially subject to review by CTDEEP. The CTDEEP Wildlife Division may provide recommendations for avoiding impacts to listed species.

2.8 Water Infrastructure

2.8.1 Dams

There are approximately 22 dams within the watershed, including 5 on the Mill River, and 1 on Shepard Brook. Most of the dams are located in the northern part of the watershed, in Hamden, with a few each in Cheshire and Wallingford. None are located on Willow Brook. The largest and most notable dam is the Lake Whitney Dam, which was established in 1860 for drinking water, fire-fighting, and hydropower. Flows over the dam average 55 million gallons per day (mgd) (RWA, 2018), with high flows during wet months typically ranging from 100 to 300 mgd. Smaller dams may provide recreational opportunities, habitat, or other amenities, but are likely also hindering fish passage through the watershed and may alter hydrologic characteristics in ways that affect water quality.

At least two of the smaller dams along the Mill River have been partially or fully breached at some point in their history. The Axle Shop Pond Dam was reported as partially breached, and Clarke's Pond Dam was reportedly rebuilt in the mid-1980s to repair a breach.

2.8.2 Water Supply

The Mill River watershed feeds Lake Whitney, which is part of the South Central Connecticut Regional Water Authority (RWA) public water supply system. Lake Whitney was established as the water supply for the City of New Haven in 1862. The original filtration plant, built in 1906, operated until 1991 and was demolished in 2002. A new Lake Whitney Water Treatment Plant was opened in 2005, reestablishing Lake Whitney as an active water supply. In 2000, prior to the plant's opening, the RWA commissioned a series of ongoing studies to collect baseline data and monitor changes due to lake withdrawals. Operating standards were established with the intent of balancing ecological, aesthetic, and water supply interests. As part of those standards, it was established that a pre-emptive maintenance approach focused on watershed management techniques designed to control sediment loading should take priority over dredging, and periods of no flow should be minimized so as to limit disturbance to river ecology (Milone & MacBroom, Inc., 2002). The Lake Whitney Water Treatment Plant pumps approximately 3-15 mgd for the RWA under normal conditions, which supplies 45 mgd to an overall service population (i.e., both within the watershed and beyond) of approximately 430,000 people. Current operating guidelines, which were developed in part based on the recommendations of environmental monitoring studies, dictate that when lake levels are lower than 0.2 feet above the spillway, withdrawals are limited to 5 mgd except under extreme circumstances.

Groundwater serves as the primary water supply source for a significant portion of the northern half of the watershed. There are four Aquifer Protection Areas (APAs) (also referred to as "wellhead protection areas") located within the watershed. APAs are designated around active well fields in sand and gravel aquifers that serve more than 1,000 people to protect major public water supply wells.

2.8.3 Wastewater

Approximately half of the watershed area is served by sanitary sewers and half by on-site wastewater treatment systems, also referred to as septic systems. Most of these septic systems are located in the upper half of the Mill River watershed in Cheshire and the northern portion of Hamden. Failing or older, sub-standard septic systems can impact surface water and groundwater quality and can be a source of bacteria to the Mill River and other surface waterbodies. Local health directors and health districts regulate the installation of subsurface sewage disposal systems and are responsible for site inspections, plan review, the issuing of permits and inspections of all new, repair and replacement systems. The Towns of Cheshire and Prospect are part of the Chesprocott Health District, located in Cheshire, and the City of North Haven and Towns of Hamden, and Bethany are part of the Quinnipiac Valley Health District, located in North Haven. The City of New Haven and Town of Wallingford each have independent, local health departments.

Combined Sewer Overflows (CSOs) impact water quality in the lower Mill River. CSOs are designated outfalls where combined sewers (carrying both sanitary wastes and stormwater) overflow when precipitation overwhelms the combined sewer system's capacity; such overflows result in discharge of untreated sanitary wastes into receiving waters. The City of New Haven has combined sanitary and storm sewer systems that discharge untreated sewage into New Haven Harbor during periods of heavy rain. The City of New Haven has been working to address CSOs since the early 1980s, and has worked in cooperation with the Greater New Haven Water Pollution Control Authority (GNHWPCA) since regionalization in the mid-2000s. The GNHWPCA's actions are guided in large part by CTDEEP consent order WC5509, last amended in 2015. As part of the consent order, GNHWPCA has developed a Long Term Control Plan (LTCP) which impacts both the Mill River watershed and neighboring Quinnipiac River and West River watersheds. The LTCP includes closure

of some CSOs, modifications to others to ensure sewer separation, installation of additional storage, and CSO flow monitoring.

Of the 13 remaining CSOs maintained by GNHWPCHA that discharge directly to receiving waters, three discharge to the Mill River:

- CSO #009 at Grand Avenue and James Street: The weir was raised in 2015. The reported reduction in CSO discharge volume based on the modeled 2-year design storm in 2016 compared to 1997 is 0.1 million gallons. The LTCP calls for a final status of inactive.
- CSO #011 at Humphrey Street and I-91: 2017 update status indicates that sewer separation design is complete. A CSO Storage Tank is proposed as a capital improvement in the LTCP. Three additional active regulators (#010(A), #014, and #026) contribute discharges to the CSO #011 outfall.
- CSO #012 on Mitchell Drive east of Nicoll Street: The weir was raised in 2013. The reported reduction in CSO discharge volume based on the modeled 2-year design storm in 2016 compared to 1997 is 0.8 million gallons. A capacity improvement project is planned and design of that project is underway. The LTCP calls for closure of the CSO. One additional active regulator (#028) contributes discharges to the CSO #012 outfall.

Three additional CSOs that previously discharged to the Mill River were closed in 2014.

In 2017, CSO discharges resulted in 4.86 million gallons of CSO flow into the Mill River from a combined 43 overflow events (another 10.64 million gallons discharged directly to the New Haven Harbor). One CSO in particular (CSO #011) contributed the majority (81%) of the discharge volume, at 3.916 million gallons over 13 events. This made it one of the top four CSO overflows in Greater New Haven in terms of volume of discharge during the 2017 reporting period (May 2016 to April 2017). The remaining 19% of CSO discharges to the Mill River came from CSO 009 (0.855 million gallons) and CSO 012 (0.087 million gallons). CSO discharge volume to the Mill River during the 2017 reporting period was more than double that of the 2016 reporting period (2.22 million gallons). CSO discharge volume for the 2015 reporting period was 6.27 million gallons. Differences from one reporting period to the next reflect both differences in annual precipitation and changes due to CSO closures/modifications.

2.8.4 Stormwater

Urban stormwater runoff generated in developed areas from buildings, pavement, and other compacted or impervious surfaces is a significant source of pollutants to the Mill River and its tributaries. Impervious surfaces prevent infiltration of rainfall and runoff into the ground. Stormwater generated from impervious surfaces typically contains increased pollutants from the atmosphere, vehicles, industry, lawns, construction sites, humans and animals. Without treatment, these pollutants are conveyed from the impervious surfaces to storm drainage systems and eventually to the receiving waterbodies during storms. Impervious surfaces and traditional piped storm drainage systems increase the volume, peak flow rates, and velocity of stormwater runoff to receiving waters. This can contribute to channel erosion, sedimentation, and reduced stream baseflow during dry periods. The amount of impervious cover in the Mill River watershed and the implications for water quality and overall stream health is discussed in Section 5 of this technical memorandum.

In recognition of the impacts of stormwater runoff on water quality, CTDEEP regulates stormwater discharges from municipalities, commercial and industrial sites, and construction sites. As of the 2012 TMDL, permitted stormwater discharges within the Mill River subregional basin included: 1 commercial permittee, 10 industrial permittees, and 2 construction permittees. All of the municipalities within the watershed are regulated under the CTDEEP General Permit for the Discharge of Small Municipal Separate Storm Sewer Systems (MS4 Permit), and therefore are required to implement stormwater management programs centered around 6 minimum control measures, including public education and involvement, illicit discharges, land use regulatory controls for construction and post-construction runoff, impervious cover reduction, and good housekeeping and pollution prevention. The MS4 Permit, in particular, requires increasingly stringent approaches to limit stormwater pollution over the next five years, largely through addressing impervious area and illicit discharges to the stormwater system and encouraging green infrastructure and low impact development. The MS4 permit also requires all municipalities to create updated and detailed stormwater infrastructure mapping, which will help to facilitate identification and tracking of illicit discharges, storm system maintenance, and stormwater retrofits.

Green infrastructure solutions are also a key objective of the GNHWPCA strategic plan (GNHWPCA, 2017). GNHWPCA requires the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development projects within combined sewer areas in accordance with the GNHWPCA Permitting and Design Criteria Manual. GNHWPCA and the City of New Haven, working with CFE/Save the Sound and other groups, are also installing bioswales at numerous locations throughout the City within the public right-of-way to reduce runoff to the combined sewer system and reduce pollutant loads to surface waters. The City of New Haven has also adopted regulatory requirements to reduce stormwater runoff from development projects contributing to the City's combined sewer system.

2.8.5 Flood Zones

Flood zones are defined by the Federal Emergency Management Agency (FEMA) as the area below the high water level that occurs during a flood of a specified recurrence interval (e.g., the “100-year flood” is defined as having a probability of occurring once in 100 years, or a 1% chance of occurring in any single year). Similarly, the “500-year flood” has a 0.2% chance of occurring in a given year. FEMA also defines a ‘floodway’ as the stream channel and adjacent areas that carry the majority of the flood flow at a significant velocity, whereas ‘floodplain’ also includes the flood fringe or areas that are flooded without a strong current.

The region, including the Mill River watershed, has suffered flood damage in inland and coastal areas from Tropical Storm Irene (2011) and Hurricane Sandy (2012). Historic flood events that have impacted the region include the June 1982 storms in which the most severe flooding occurred along the Mill River in Hamden (and along the Wepawaug River in Orange and Milford) and the historic floods of 1955 and 1936.



Credit: Joseph Gerhard – Mill River, *Manton Westwood Books*, New Haven, CT, 2011

3 Management Recommendations

This section describes recommended actions to meet the watershed management goals and objectives outlined in *Section 1*. The recommendations include watershed-wide and targeted actions:

- Watershed-wide Recommendations are recommendations that can be implemented throughout the Mill River watershed. These basic measures can be implemented in most areas of the watershed and are intended to address nonpoint source pollution. The water quality benefits of these measures are primarily long-term and cumulative in nature resulting from runoff reduction, source control, pollution prevention, and improved stormwater management.
- Targeted Recommendations include site-specific projects and/or actions intended to address issues within specific subwatersheds or areas, rather than watershed-wide. Targeted recommendations also include actions to address common types of problems that are identified at representative locations throughout the watershed, but where additional field assessments or evaluations are required to develop site-specific recommendations. Targeted recommendations can have both short and long-term benefits.

Due to the large size of the Mill River watershed and limited field assessment scope of the watershed planning process, additional field assessments are recommended to further characterize pollutant sources and potential site-specific restoration projects. An objective of the ongoing and proposed stream assessments is to help identify additional site-specific projects and develop action plans for targeted subwatersheds.

The recommendations presented in this section are classified according to their timeframe and implementation priority. Recommendations include ongoing, short-term, mid-term, and long-term actions:

- Ongoing Actions are actions that occur annually or more frequently such as routine water quality monitoring, fundraising, and education and outreach.
- Short-Term Actions are initial actions to be accomplished within the first two years of plan implementation. These actions have the potential to demonstrate immediate progress and success and/or help establish the framework for implementing subsequent plan recommendations.
- Mid-Term Actions involve continued programmatic and operational measures, delivery of educational and outreach materials, and construction of larger retrofit and/or restoration projects between two and five years after plan adoption.
- Long-Term Actions consist of continued implementation of watershed projects, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed based plan. Long-term actions are intended to be completed between five and ten years or longer after plan adoption. The feasibility of long-term actions, many of which involve significant infrastructure improvements, depends upon the availability of sustainable funding programs and mechanisms.

The remainder of this section describes the recommended actions presented in this watershed based plan. The recommended actions are categorized according to the five major goals of this plan – (1) capacity building, (2) education and outreach, (3) water quality monitoring and assessment, (4) urban/suburban BMPs, and (5) habitat protection and restoration.

3.1 Capacity Building/Plan Oversight

Goal Statement: Strengthen and build local capacity to implement the watershed management plan.

The success of this watershed plan will depend on effective leadership, active participation by the watershed stakeholders, and local buy-in of the plan recommendations by the watershed municipalities, in addition to funding and technical assistance. Fortunately, significant local support and human capital for watershed protection and restoration already exists within the Mill River Watershed, led by CFE/Save the Sound, the Mill River Watershed Coordinator, and other stakeholder groups. Strengthening local capacity for implementing this watershed plan, by building on the existing network of volunteers and programs, is a critical early and ongoing part of the watershed plan implementation process. *Table 3-1* summarizes Capacity Building recommendations, which are described below in greater detail.

3.1.1 Establish a Framework and Lead Entity

Recommended Actions

- The Mill River currently benefits from a funded watershed coordinator position housed within CFE/Save the Sound. The watershed coordinator should be tasked with leading watershed based plan implementation activities such as:
 - o Coordinating the efforts of plan implementation sub-committees
 - o Identifying funding sources, as well as pursuing grant funding for projects
 - o Periodically reviewing and updating action items in the plan
 - o Developing annual work plans (i.e., specific “to-do” lists)
 - o Coordinating and leading public outreach activities
 - o Hosting public meetings to celebrate accomplishments, recognize participants, review lessons learned, and solicit feedback on plan updates and next steps.
- Form watershed plan implementation sub-committees around the watershed plan goals – water quality, habitat restoration, land use/open space, and education/outreach. The sub-committees would ideally consist of volunteers with a particular interest or area of expertise in each topic.
- Hold regular meetings/forums for citizen input.
- Create and maintain a website dedicated to the Mill River watershed to serve as a centralized source of information on the watershed and based plan implementation activities.

3.1.2 Promote Inter-Municipal Coordination

Many of the recommendations in this watershed based plan can benefit from a partnership among the watershed municipalities. For example, applying jointly for grants to fund the implementation of these activities allows the sharing of grant-writing assistance, and the leveraging of match and in-kind services.

Table 3-1. Capacity Building Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Continue to support and fund a dedicated watershed coordinator position for the Mill River	CFE/SAVE THE SOUND	Ongoing	Funded watershed coordinator position	\$\$\$	Grants
2. Form watershed plan implementation sub-committees or work groups - Recruit members - Develop work plans - Hold regular forums for citizen input	Watershed Coordinator, CFE/Save the Sound, Steering Committee	0-2 years	Committee membership and work plans	\$	Grants
3. Create and maintain a Mill River watershed website	Watershed Coordinator, CFE/Save the Sound, Consultant	0-2 years	Dedicated website	\$\$\$	Grants
4. Obtain municipal endorsement of the watershed plan	Watershed Coordinator, CFE/Save the Sound	0-2 years	Memorandum of Agreement (MOA), inter-municipal agreement, compact or similar mechanism	\$	
5. Engage and involve local, state, and regional organizations. Promote grassroots involvement.	Watershed Coordinator, CFE/Save the Sound	Ongoing	Active participation in watershed plan activities by organizations	\$	
6. Identify and pursue funding - Review and prioritize funding sources - Prepare and submit grant applications	Watershed Coordinator, CFE/Save the Sound, Watershed Municipalities	0-2 years Ongoing	List of funding sources and funding pursued	\$\$	See Section 5 and Appendix G of this plan for funding sources
7. Conduct streamwalk assessments - Complete streamwalks - Compile and analyze data - Plan and conduct “track down” surveys	Watershed Coordinator, CFE/Save the Sound, and	0-2 years (repeat streamwalks every 5 yrs)	Streamwalk assessment and track down survey findings and recommendations	\$\$	

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
	Volunteers				
8. Prepare and implement subwatershed action plans	Watershed Coordinator, CFE/Save the Sound, Steering Committee	0-2 years	Subwatershed action plans prepared and implemented	\$\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment

Additionally, a watershed partnership permits the sharing of technical and human resources, volunteers, equipment, and materials. Endorsement of the watershed based plan by the watershed municipalities is an important first step in implementing the plan recommendations.

Recommended Actions

- The Mill River Watershed Coordinator, with the assistance of CFE/Save the Sound, should seek endorsement of the watershed based plan by the watershed municipalities through a Memorandum of Agreement (MOA), inter-municipal agreement, compact or similar mechanism to encourage inter-municipal coordination and accountability and to formalize the municipalities' agreement to support the watershed planning effort through funding, staff, or other resources.

3.1.3 Promote Regional Collaboration

Many watershed organizations and municipalities in Connecticut are involved in watershed management planning to meet common resource protection objectives and are faced with similar water quality issues. Lessons learned from other watershed planning efforts in Connecticut and throughout Long Island Sound, particularly groups representing the neighboring West River and Quinnipiac River watersheds, can help to improve the effectiveness of this watershed plan. This objective is to coordinate water quality planning with other watershed groups to share ideas and strengthen regional watershed management efforts. CFE/Save the Sound is already a major contributor to this coordination effort.

Table 3-2. Local, Regional and State Organizations

Local Organizations	Regional Organizations	State Organizations
· Municipal Staff and Land Use Commissions · New Haven Environmental Justice Network · The Elm City Parks Conservancy · Neighborhood Housing Services of New Haven · New Haven Land Trust · Cheshire Land Trust · Hamden Land Trust · Local Schools and Universities · Urban Resources Initiative · Greater New Haven Green Fund · Mill River Trail Advocates · Eli Whitney Museum · New Haven Parks · Friends of East Rock Park · Quinnipiac University · Community Foundation of Greater New Haven · Whitneyville Civic Association · Neighborhood Housing Services (NHS) · Local neighborhood associations	· Greater New Haven Water Pollution Control Authority · Regional Water Authority · Naugatuck Valley Council of Governments · South Central Regional Council of Governments · Southwest Conservation District · Quinnipiac River Watershed Association · River Advocates of South Central Connecticut · Greater New Haven Green Fund	· Rivers Alliance of Connecticut · American Rivers · CT Audubon Society · The Nature Conservancy · CT Forest and Park Association · Trout Unlimited · CTDEEP · CT Coalition for Environmental Justice · Bikewalk CT · Natural Resources Conservation Service (NRCS-CT) · CFE/Save the Sound

Increasingly, neighborhood groups with focuses and missions that are not specifically environmentally-focused are recognizing the synergies between their goals and watershed and ecosystem health. Pursuing partnerships with these organizations can greatly expand the scope and reach of watershed management efforts.

Recommended Actions

- Engage and involve the following local, state, and regional organizations with an interest in the Mill River watershed and other neighboring regional watershed initiatives. These groups should work together to implement this plan. Implementation is most effective when municipalities work together with volunteers and local stewards (i.e., grassroots involvement).

3.1.4 Identify and Pursue Funding

Many actions in this plan are only achievable with sufficient funding and staffing. A variety of funding opportunities should be pursued to implement the recommendations outlined in this plan.

Recommended Actions

- Review and prioritize potential funding sources that have been preliminarily identified in this watershed plan (see *Section 6*). High-priority funding sources that should be considered include:
 - o CTDEEP/EPA Section 319 Nonpoint Source Grants
 - o National Fish and Wildlife Foundation Long Island Sound Futures Fund
 - o Connecticut Clean Water Fund
 - o HUD Community Development Block Grants for green infrastructure and coastal resilience
 - o Community Foundation for Greater New Haven
 - o Stormwater utilities and other innovative stormwater program financing mechanisms
- Prepare and submit grant applications for projects identified in this plan on an ongoing basis.
- Pursue funding for ongoing, long-term water quality monitoring within the watershed.
- Advocate for state and federal funding, working jointly with other watershed organizations in the region and state.

3.1.5 Conduct Streamwalk Assessments

Visual stream assessments or streamwalks are a simplified assessment protocol to evaluate the condition of aquatic ecosystems associated with streams. They help to evaluate the overall condition of the stream, riparian buffer, and floodplain based on a consideration of in-stream habitat, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation and habitat, and floodplain encroachment. Visual stream assessments also help to identify problem areas and provide a basis for further detailed field investigation and potential restoration opportunities. Streamwalks also provide an ideal opportunity to involve the public and volunteers as a form of outreach.

Fuss & O'Neill and staff from the Regional Water Authority (RWA) and CFE/Save the Sound conducted streamwalk assessment training at Quinnipiac University on July 21, 2018 for CFE/Save the Sound, members of the Project Steering Committee, and other volunteers. The classroom and field training provided information on conducting stream assessments of the Mill River and its tributaries following the NRCS protocols for performing visual stream assessments in Connecticut
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/water/?cid=nrcs142p2_011198.

CFE/Save the Sound, members of the Project Steering Committee, members of the Cheshire Land Trust, and other volunteers conducted streamwalk assessments of selected reaches of the Mill River and its tributaries during the summer of 2018; additional streamwalks are expected to take place later in 2018. The selected reaches cover most of the length of the Mill River (although several reaches in the Lower Mill River, below Lake Whitney, require boat access) as well as impaired segments of Shepard Brook and Willow Brook.

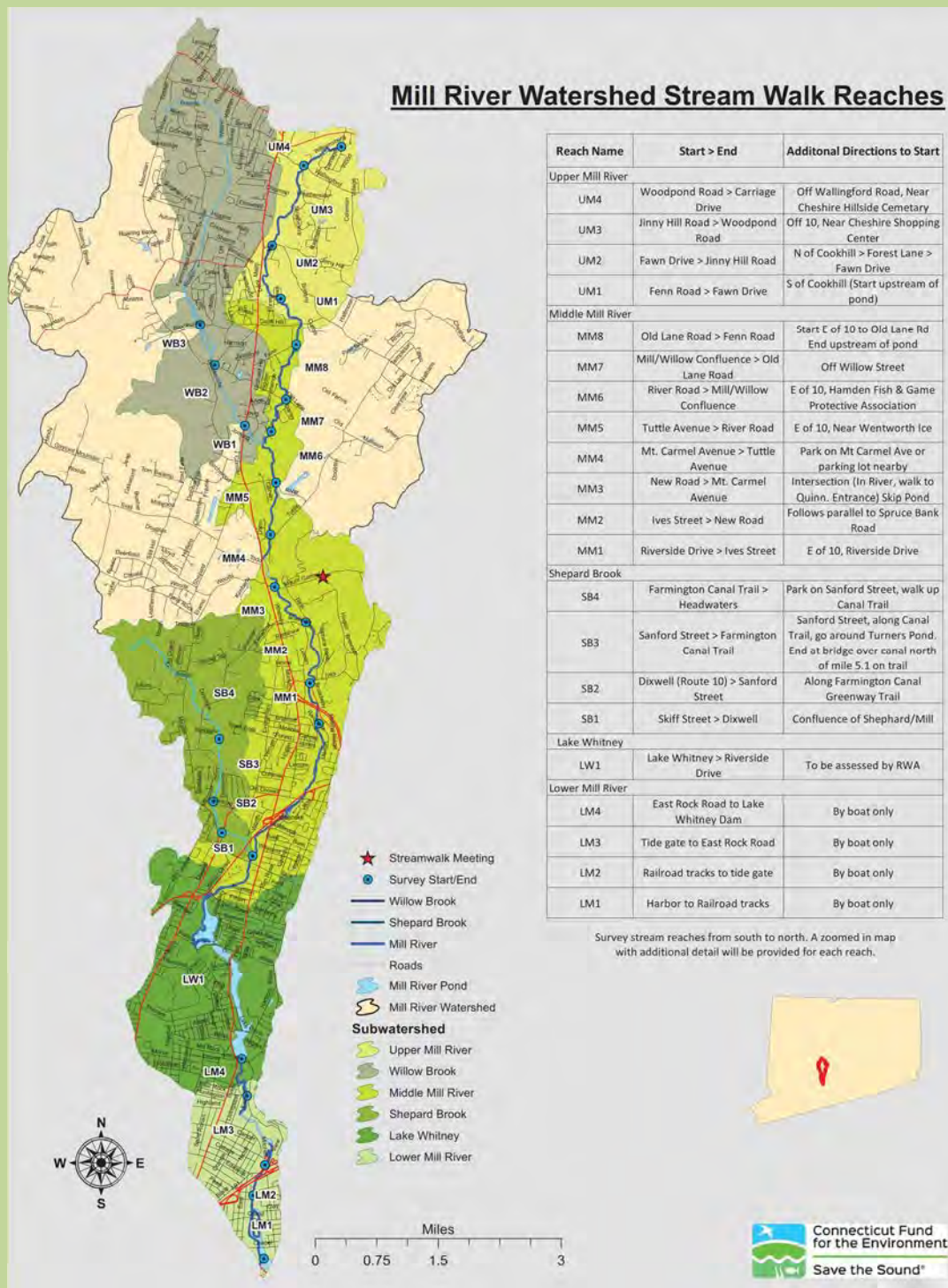
Recommended Actions

- Complete streamwalk assessment surveys of all selected reaches in the watershed using the Connecticut NRCS protocols and field data collection sheets.
- Compile and analyze the collected data.
- Following the streamwalks and evaluation of the assessment results, plan and conduct subwatershed visual “track down” surveys of identified or suspected pollution sources. Visual track down surveys are a tool commonly used by the Connecticut Conservation Districts to help identify conditions responsible for water quality impairments in streams. The goals of the track down survey are to collect information on the possible causes of impairment and recommend and implement solutions to address the identified issues of concern.
- Subwatershed stream assessments and track down surveys should be updated every five to ten years to monitor changing watershed conditions and the progress of plan implementation.



Volunteers during the Mill River Streamwalk Training, July 21, 2018

Mill River Watershed Streamwalk Reaches



3.1.6 Prepare and Implement Subwatershed Action Plans

Development and implementation of site-specific restoration and protection strategies is most effective at the subwatershed scale for larger watersheds such as the Mill River watershed. Although this watershed plan identifies a number of site-specific recommendations and green infrastructure concepts that are examples of the types of projects that could be implemented elsewhere in the watershed, the limited scope of this watershed planning effort did not allow for comprehensive field assessments of the Mill River and its entire watershed. Additional targeted watershed assessment and planning is recommended for various subwatersheds, including streamwalk assessments, track down surveys, and volunteer monitoring. These additional assessments will help to better characterize current conditions within specific reaches of the Mill River, its tributaries, and upland areas of the subwatersheds. The goal of the streamwalks and track down surveys is to develop action plans for each priority subwatershed and identify additional site-specific restoration projects.

Recommended Actions

- Prepare and implement more detailed subwatershed action plans for priority subwatersheds based on the findings of streamwalk assessments and associated track down surveys (see recommendations in previous section).
- Target subwatersheds, including major tributaries and municipalities located within each subwatershed, are summarized in *Table 3-3*. The municipalities located within each subwatershed should be encouraged to participate in development and implementation of the respective subwatershed action plans. *Table 3-3* also includes the average percent reductions in bacterial loads to meet water quality standards, as reported in the statewide bacteria TMDL for the Mill River. Higher priority subwatersheds are those watersheds containing water bodies with bacterial impairments listed in the TMDL. Lower priority subwatersheds include other water body segments with listed bacteria impairments for which a TMDL has not yet been developed.
- Subwatershed action plans could be maintained as an appendix to the overall Mill River Watershed Based Plan, relying on watershed background information, goals, and objectives contained in the larger watershed plan. A recommended framework for simplified subwatershed action plans is as follows:
 - o Subwatershed Pollutant Sources
 - o Load Reductions Needed
 - o Recommended Actions

Table 3-3. Target Subwatersheds for Development of Subwatershed Action Plans

Subwatershed	Waterbody Segment	Municipalities Located within Subwatershed	Required Percent Reduction in Bacterial Loads (TMDL)
Higher Priority (Bacteria Impairment with Approved TMDL)			
Middle Mill River	Mill River from the inlet to Lake Whitney on the east side of Route 15, just downstream of Connolly Parkway in Hamden, to the Cook Hill Road Crossing in Cheshire. CTDEEP Waterbody ID CT5302-00_02	Hamden North Haven Cheshire	77% (geomean) 94% (single sample)
Shepard Brook	Shepard Brook from its mouth at the confluence with the Mill River just downstream of Route 15, including Turners Pond and continuing upstream to the confluence with an unnamed tributary behind the business park off Sherman Avenue and Town Walk Drive. CTDEEP Waterbody ID CT5302-06_01	Hamden	77% (geomean) 71% (single sample)
Lower Priority (Impaired and TMDL Required)			
Lower Mill River	Mill River extending northward from the mouth at its confluence with the Quinnipiac River in New Haven to the footbridge crossing just upstream of East Rock Road in Hamden. CTDEEP Waterbody ID CT-C1_023-SB	New Haven Hamden	Not Applicable
Upper Mill River	Mill River from the Cook Hill Road crossing to the headwaters, just upstream of Williamsburg Drive in Cheshire. CTDEEP Waterbody ID CT5302-00_03	Cheshire	Not Applicable
Willow Brook	Willow Brook from its mouth at the confluence with the Mill River downstream of the Willow Street crossing in Hamden, upstream to the confluence with Brooksvale Stream in Cheshire. CTDEEP Waterbody ID CT5301-00_01	Hamden Cheshire	Not Applicable

3.2 Education and Outreach

Goal Statement: Promote stewardship of the watershed through education and outreach, improved access to the Mill River and its tributaries, and citizen involvement in science, conservation, and restoration activities.

A goal of this watershed plan is to modify the behaviors of individuals and the public to affect a positive change in the watershed. Often, the public is not aware of the impacts that their every-day activities can have on water quality. Public education is critical to the long-term success of watershed management because it raises awareness and reminds people of the individual actions they can take to protect and improve water quality in their watershed. This increased understanding has the additional benefit of fostering support for watershed management efforts and cultivating a long-term environmental watershed stewardship ethic, particularly with respect to the benefits of green infrastructure.

The education and outreach recommendations of this watershed plan are targeted at reaching four primary audiences, in addition to other stakeholder groups:

- Homeowners
- Municipalities and volunteer groups
- Students (K-12)/higher education
- Businesses and industry

Education and outreach recommendations that are tailored to these audiences are described in the following sections. Watershed public outreach and educational programs should build upon the successful programs and models that already exist in the watershed, elsewhere in Connecticut, and nationally.

Table 3-4 summarizes education and outreach recommendations for the Mill River watershed.

3.2.1 Implement a Public Outreach Campaign

Local and regional partners, including CFE/Save the Sound, CTDEEP, the watershed municipalities and GNHWPCA, should consider developing and implementing a watershed-based green infrastructure public outreach campaign² for the Mill River (or a regional effort for the Greater New Haven watersheds including the Mill River, Quinnipiac River, and West River) focused on citizens, businesses, and communities. The public outreach campaign could be developed based on other successful models such as EPA's "Soak Up the Rain" program, RWA's "Harvest the Rain" rain barrel program, or the award-winning "Save the Rain" initiative in Onondaga County (Syracuse), New York. Startup funding for such a campaign may be possible through CTDEEP, particularly if the campaign is developed/designed to be transferable to other watersheds or organizations or for use statewide.

Key aspects of developing a successful outreach campaign include identifying and analyzing the target audiences, drafting an effective message and branding the program, and packaging and delivering the message through a variety of media. EPA's *Getting In Step: A Guide for Conducting Watershed Outreach Campaigns* (2010) is an excellent resource for developing and implementing a successful program.

² A campaign is not a single product or event, but rather a suite of activities, materials, and distribution formats that are carefully coordinated to achieve specific goals and objectives.

The outreach campaign should target, at a minimum, watershed residents, businesses, and municipalities, including incentive programs for residential “green” practices. The recommended website dedicated to the Mill River watershed (see *Section 3.1 – Capacity Building*) could also serve as the on-line home for the public outreach initiative. The website could include downloadable educational and outreach materials on green infrastructure and other residential, business, and municipal practices to protect and improve water quality, as well as project updates, funding resources, technical resources, and current events.

The outreach campaign could also be coordinated with the public education and involvement efforts of the watershed municipalities to comply with the new MS4 Permit, as well as public education efforts associated with implementation of a municipal or regional stormwater utility.

CT NEMO Rain Garden Resources



Rain Gardens
A Design Guide for Connecticut & New England Homeowners

Home Frequently Asked Questions More Resources Contact Us UConn's NEMO Website Save the Sounds' Reduce Runoff Website

What is a Rain Garden?

A rain garden is a depression (about 6 inches deep) that collects stormwater runoff from a roof, driveway or yard and allows it to infiltrate into the ground. Rain gardens are typically planted with shrubs and perennials (natives are ideal), and can be colorful, landscaped areas in your yard. [\(learn more\)](#)

Why a Rain Garden?

Every time it rains, water runs off impervious surfaces such as roofs, driveways, roads and parking lots, collecting pollutants along the way. This runoff has been cited by the United States Environmental Protection Agency as a major source of pollution to our nation's waterways. By building a rain garden at your home, you can reduce the amount of pollutants that leave your yard and enter nearby lakes, streams and ponds. [\(read more\)](#)

You Can Make A Difference!

Site Size Design Install

Rain Garden App
A Mobile App for designing, installing, and maintaining a Rain Garden. [LEARN MORE](#)

Can I Build a Rain Garden?

- Environmental Benefits
- They are Easy to Create
- They are Attractive

Rain Garden 2014 Growing Season at UConn

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Public Outreach Campaign					
1. Develop and implement a green infrastructure public outreach campaign, including a more formal and consistent watershed signage program	CFE/Save the Sound, GNHWPCA, watershed municipalities, CTDEEP	2-5 years	Public outreach messages developed and delivered through a variety of media	\$\$\$\$	CTDEEP 319 NPS Grants
Homeowner Education and Outreach					
2. Evaluate and implement residential LID incentive programs - Identify and build upon existing programs (e.g., NHS Environmental Leadership Program, The Sound School and RWA's rain barrel program) - Evaluate feasibility of alternative programs - Pursue funding - Implement program(s)	CFE/Save the Sound, GNHWPCA, NHS, RWA	0-2 years establish program Ongoing implementation thereafter	Program(s) identified, funding secured, program established, number of homeowners participating	\$\$\$\$	Grants, future stormwater fees
3. Provide homeowner education and outreach on using LID	Municipalities, CFE/Save the Sound, UConn NEMO, NHS	Ongoing	Outreach materials disseminated	\$\$	Municipal, grants
4. Provide homeowner outreach on sustainable lawn care practices and backyard habitat	Municipalities, NHS, UConn NEMO, CFE/Save the Sound	Ongoing	Outreach materials disseminated	\$\$	Municipal, grants
5. Provide homeowner outreach on septic systems	Hamden, Cheshire, Bethany, Prospect, Wallingford	2-5 years	Outreach materials provided or made available to homeowners	\$	NFWF Long Island Sound Futures Fund, CTDEEP Supplemental Environmental Project Funds, CTDEEP 319 NPS Grants

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Outreach to Municipalities and Volunteer Groups					
6. Provide education and training for municipal employees, land use boards, and building inspectors	Municipalities (as part of MS4 Permit outreach)	2018-2021 (MS4 permit term)	Outreach completed as documented in MS4 annual Reports	\$\$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
7. Provide education and outreach to volunteers of local non-profit organizations · Cheshire Land Trust · New Haven Environmental Justice Network · The Sleeping Giant Park Association · NHS · Friends of East Rock Park · Neighborhood Associations · Eli Whitney Museum · Mill River Trail Advocates	CFE/Save the Sound, municipalities (as part of MS4 Permit outreach)	2018-2021 (MS4 permit term)	Outreach events completed	\$\$	
Outreach to Business Community					
8. Conduct outreach to commercial and industrial property owners	Municipalities (as part of MS4 Permit outreach)	2018-2021 (MS4 permit term)	Outreach completed as documented in MS4 annual Reports	\$\$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Outreach to Institutional Property Owners					
9. Conduct workshops on best practices for institutional facilities for water quality protection	CFE/Save the Sound, CTDEEP, Colleges and Universities, URI	2-5 years	Workshops developed and conducted	\$\$\$	Grants
10. Encourage participation in EPA's annual Campus RainWorks Challenge	CFE/Save the Sound, Colleges and Universities, URI	Ongoing	Student applications submitted	\$	
Community Engagement Events					
11. Engage local, state, and regional organizations in the Mill River watershed · Promote, publicize, and support existing events	Mill River Watershed Coordinator, Municipalities, CFE/Save the Sound, NHS	Ongoing	Ongoing coordination with groups, events publicized and held	\$\$	
Youth Education, Community Service, and Stewardship Programs					
12. Expand existing relationships and educational programs with schools	Mill River Watershed Coordinator, CFE/Save the Sound, Schools, URI	Ongoing	Expanded or new programming and curricula	\$\$	
13. Consider implementing a watershed-based component to the curriculum in school districts where such programs are not already in place.	CFE/Save the Sound Watershed School Districts, individual school faculty	2-5 years	Expanded or new programming and curricula	\$\$\$	
14. Continue to recruit student volunteers to participate in water quality and benthic monitoring and streamwalks	CFE/Save the Sound, Cheshire Land Trust, school faculty and students	Ongoing	Student participation in monitoring and streamwalks	\$	

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
15. Continue to collaborate with college faculty and research staff on the Mill River watershed	CFE/Save the Sound, Quinnipiac University, and other colleges and universities	Ongoing	Collaboration with research faculty and staff on Mill River projects	\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment NHS = Neighborhood Housing Services of New Haven URI = Yale University School of Forestry and Environmental Studies Urban Resources Initiative

3.2.2 Homeowner Education and Outreach

An objective of the watershed plan is to build awareness of land stewardship and management practices and reduce water quality impacts associated with residential land use, which comprises approximately 57% of the watershed land area. Successful homeowner outreach programs have been developed by other watershed groups, including Neighborhood Housing Services (NHS). NHS's Environmental Leadership Program has hosted workshops on "Climate, Health, and Neighborhoods" and "Water in Your Home and Neighborhood." NHS also has a program in the neighboring West River Watershed that allows homeowners to apply to have a free rain garden installed at their home; their website provides information and resources for DIY rain garden projects as well.

The Norwalk River Watershed Initiative (NRWI) serves as an excellent example of a watershed-focused group with a wide range of educational information available to homeowners: <http://norwalkriver.org/links/>. River Smart is another education and outreach program that provides steps homeowners can take to reduce the impact of nonpoint source pollution from residential properties. The program is led cooperatively by Housatonic Valley Association, Pomperaug River Watershed Coalition, Kent Land Trust, Weantinoge Heritage Land Trust, Rivers Alliance of Connecticut, and the Farmington River Watershed Association: <http://www.pomperaug.org/riversmart>.

Encourage the use of Residential LID Practices

Homeowners should be encouraged to implement green infrastructure or Low Impact Development (LID) practices on their properties.

- Encourage disconnection of rooftop runoff from the storm drainage system and impervious areas to reduce the quantity of runoff by redirecting the runoff to pervious lawn areas, through the use of dry wells, or through the use of rain barrels or rain gardens.
- Provide education and outreach to homeowners, neighborhood groups, and roofing contractors on disconnecting roof downspouts and installing and maintaining residential rain gardens and rain barrels. The Connecticut NEMO web site provides a wealth of information about residential rain gardens: <http://nemo.uconn.edu/raingardens/index.htm>
- Provide residential LID incentive programs such as those described in *Section 3.2.4* of this plan.

Promote Sustainable Lawn Care Practices – Homeowners and Lawn Care Professionals

Homeowners should be encouraged to use environmentally-friendly lawn care practices such as reducing or eliminating fertilizer and pesticide usage through the use of slow release fertilizers and fertilizer application timing; utilizing alternative landscaping that decreases maintenance; soil testing and non-chemical lawn care measures. Although sustainable lawn care practices will not significantly reduce bacteria loadings, they will reduce nutrient loadings, the use of toxic chemicals, and promote water conservation.

Extensive educational materials are available on these topics, including:

- CTDEEP Organic Lawn Care website:
<http://www.ct.gov/deep/cwp/view.asp?A=2708&Q=382644>
- CTDEEP Transitioning To Organic Land Care (OLC) In Your Town

http://www.ct.gov/deep/cwp/view.asp?a=2708&q=379676&deepNav_GID=1763

- Connecticut Chapter of the Northeast Organic Farming Association
<http://www.organiclandcare.net/>

Other resources include the EPA's GreenScape program, and more locally, the UCONN Cooperative Extension System's Home & Garden Education Center. The Home & Garden Education Center's web site, along with information on their soil testing services can be found at: <http://www.ladybug.uconn.edu>

Recognizing the trend toward greater use of professional lawn care services by homeowners, outreach to local landscapers and lawn care companies is an essential element of a successful lawn care outreach program. Potential outreach programs, which could be developed in partnership with local land trusts and garden clubs, could include:

- Identifying and promoting sustainable landscape provider certification programs
- Developing a placard campaign to identify lawns that implement preferred practices
- Develop a sustainable lawn care and gardening recognition and incentive program, with landscapers and homeowners highlighted on a rotating basis, or institute an alternative landscape competition. The Environmental Concerns Coalition of Milford, Connecticut, has developed a very successful organic lawn care competition and incentive program called "Freedom Lawns." A Freedom Lawn brochure developed by the Farmington River Watershed Association can be found at: <http://www.frwa.org/publications/freedomlawntips.pdf>.
- Implement a public awareness campaign modeled after the City of Middletown's Project Green Lawn to encourage residents and businesses to eliminate lawn chemicals.
<http://www.cityofmiddletown.com/content/117/121/167/1862/486.aspx>

Promote Backyard Habitat

As discussed in *Section 3.2.10*, encourage the creation of backyard buffers in residential areas near stream corridors, including the importance of maintaining healthy vegetated buffers to streams, ponds, and wetlands, and recognize the efforts of the public.

- Educate homeowners about the value and importance of stream buffers by building on existing stream buffer outreach and educational programming (e.g., public recognition programs for cooperating landowners, *Streamside Landowners' Guide to the Quinnipiac Greenway*, Audubon's backyard program, and programs from the EPA- Long Island Sound Study and Connecticut Sea Grant).

Provide Homeowner Outreach on Septic Systems

As described in *Section 3.2.6*, provide homeowners in Hamden, Cheshire, Bethany, Prospect, and Wallingford with educational materials on how to identify improperly functioning septic systems and procedures to have systems inspected, cleaned, and repaired or upgraded. Septic system educational materials offered by The Quinnipiac Valley Health District (QVHD), which serves Bethany and Hamden, should be disseminated by these towns to homeowners in their respective communities, which could also be used to meet the public outreach/education minimum control measure of the MS4 Permit and the related municipal stormwater management plans. Similar materials should be adapted or developed for use within the Chesprocott Health District (serving Cheshire and Prospect) and by the Town of Wallingford's Health Department.

Increase Watershed Stewardship Signage

Stewardship signage can increase public awareness and visibility of the Mill River and the connection between the community, the watershed, and the river. Watershed signage can take the form of kiosks in public areas, storm drain markers or stencils, anti-dumping signs, proper pet waste management signs, and roadside/stream side signage (examples include “adopt a stream/roadway” programs).

CFE/Save the Sound and local partners should consider developing a more formal and consistent watershed sign program that could be implemented as a component of the recommended green infrastructure public outreach program. The signs should incorporate a simple, yet consistent message and logo. Watershed signs are recommended in highly-visible public areas of the watershed such as municipal facilities (schools, parks, libraries, other municipal properties, commercial areas, etc.) and public access areas along the river. Implementation of such signage should be coordinated with the watershed municipalities to fulfill the required education and outreach components of the MS4 Permit.

3.2.3 Outreach to Municipalities and Volunteer Groups

A key objective of this plan is to advance local government awareness, understanding, and stewardship of the Mill River watershed. Ongoing outreach to municipal departments, staff, and volunteer board members is an important element of municipal stormwater management programs, as required by the MS4 Permit. Suggested topics include common municipal activities and operations that can impact bacteria loads to the Mill River including parks and open space maintenance, green infrastructure and LID, storm sewer system and BMP maintenance, and identification and removal of illicit connections.

- Municipalities should provide annual pollution prevention and good housekeeping training for all municipal employees whose activities potentially impact stormwater and water quality. The training should include municipal personnel with responsibility for public works, parks and recreation, building maintenance, lakes and pond management, and water/wastewater.
- Provide training for municipal reviewers (municipal land use commissions and boards, planners, etc.) of land development projects and designers (developers, architects, engineers, contractors, etc.). Suggested training topics include stream buffer protection, LID and green infrastructure, and construction erosion and sediment controls.
- Building inspectors in Connecticut must earn a requisite amount of continuing education credits each year. Existing training programs often do not address stormwater, LID, green infrastructure or erosion and sedimentation control methods. Building inspectors in each watershed municipality should be required to receive regular training on these topics. Additionally, training should also be required on sanitary sewer and stormwater connection inspections.
- Continue to invite and involve the municipal staff and land use board members in Mill River restoration efforts, outreach events, and river clean-ups.

Ongoing education and outreach to those that work as volunteers of local stewardship groups is also important. Local volunteer-based nonprofit groups such as Cheshire Land Trust and other local land trusts, Friends of East Rock Park, Mill River Trail Advocates, The Sleeping Giant Park Association, and neighborhood and watershed associations should provide opportunities for their member volunteers to participate in

seminars, presentations, and other training offered by groups such as CFE/Save the Sound, and public education provided by the watershed municipalities to comply with the MS4 Permit.

3.2.4 Outreach to Business Community

Commercial businesses along the major transportation corridors and industrial facilities in the middle and lower Mill River watershed, whether located directly adjacent to the river or in upland areas of the watershed, contribute stormwater runoff that ultimately reaches the Mill River. An objective of this plan is to advance local business awareness, understanding, and stewardship of the Mill River watershed.

- Provide outreach to commercial and industrial property owners in the watershed explaining how their activities contribute to the water quality impairments of the Mill River. Focus on activities that contribute bacteria to the Mill River, including dumpster and trash management issues.
- Continue to involve businesses in restoration efforts, outreach events, and river clean-ups.

3.2.5 Outreach to Institutional Property Owners

Management and maintenance practices at institutional facilities with large intensively managed lawn areas and expansive parking lots can have a significant impact on water quality. Several large institutional land owners are located in the Mill River watershed (e.g., Quinnipiac University and other public and private schools) and, therefore, play an important collective role in improving and protecting water quality.

- CFE/Save the Sound should consider partnering with CTDEEP and the colleges and universities in the watershed to conduct workshops on best practices for institutional facilities for water quality protection. Topics could include:
 - o Integrated Pest Management (IPM)
 - o Turf management and low fertilizer usage
 - o Protection and restoration of stream buffer areas
 - o Parking lot and road maintenance (deicing, snow management)
 - o Drainage system inspection/ maintenance (catch basins, storm drains, stormwater BMPs)
 - o Water quantity and flooding issues
 - o Low Impact Development and green infrastructure approaches
- Encourage the colleges and universities in the watershed (faculty, students, and facilities) to participate in EPA's annual Campus RainWorks Challenge, which is a national competition for student teams to design an innovative green infrastructure project for their campus showing how managing stormwater at its source can benefit the campus community and the environment.
http://water.epa.gov/infrastructure/greeninfrastructure/crw_challenge.cfm

3.2.6 Promote Community Engagement Events

Community events focused on the Mill River and its watershed are also an effective way to provide public outreach and stewardship of the Mill River. There are many community groups and organizations involved in environmental and watershed-related activities in the greater New Haven area, providing a strong base upon which to build local support and interest in the Mill River.

- The Mill River Watershed Coordinator and CFE/Save the Sound should continue to engage the many local, state, and regional organizations with an interest in the Mill River watershed, including the organizations listed in *Table 3-2* and other groups.
- Promote, publicize, and support existing community engagement events such as NHS Environmental Leadership workshops, Mill River Trail clearing and planning efforts, watershed clean ups, etc.

3.2.7 Promote Youth Education, Community Service, and Stewardship Programs

The Mill River watershed is also home to numerous public and private primary and secondary schools, many of which offer environmental education and community service programs. These existing programs and resources provide an excellent opportunity to promote youth education on issues related to watersheds, water quality, and the Mill River.

- CFE/Save the Sound should build connections and relationships with schools known to have existing environmental education programs, such as Hooker Middle School (“Schoolyard Habitat Program”), and other local schools. Other interested schools throughout the watershed communities should be identified as potential candidates for involvement in the Mill River watershed restoration efforts. Green Infrastructure projects proposed at local schools should be coordinated with teachers and students to encourage learning opportunities throughout the implementation process.
- Consider implementing a watershed-based component to the curriculum in school districts where such programs are not already in place. Use existing educational materials available through the EPA-Long Island Sound Study, Connecticut Sea Grant, CTDEEP, and area colleges. The curriculum could combine lessons, field activities, classroom experiments, and regional networking into learning activities that build shared scientific knowledge and stewardship experiences. The Farmington River Watershed (FRWA) has developed a place-based environmental curriculum consisting of 30 lessons for teachers to use at the elementary, secondary, and high school levels to communicate about the cultural, historical, wildlife, and water resources of the Farmington River Watershed. The lessons, training, and a cross-walk to current state curriculum standards are available for teachers in the watershed.
- Continue to recruit student volunteers to participate in water quality and benthic monitoring and streamwalks in the Mill River watershed.
- Encourage collaborations with college faculty and research staff to develop research activities and new student projects focused on the Mill River watershed.

3.2.8 Address Homeless Encampments

Temporary or permanent homeless encampments along waterways where human waste is disposed can be a common problem in highly urbanized areas with an urban stream corridor (ASCE, 2014). Homeless encampments along portions of the lower Mill River, especially in East Rock Park, are a recognized problem and potential source of fecal indicator bacteria to the river. Homelessness is a serious social issue and sensitive public policy issue without an immediate or clear solution. Several options exist to begin to address this issue from a water quality standpoint, based on the experience of urban communities in other parts of the U.S.:

- Support of city shelters and services to reduce homelessness
- Periodic cleanup of homeless camps near streams
- Police enforcement/sweeps
- Providing public restrooms
- Partnering with non-governmental organizations to address homelessness.

The Contra Costa County Flood Control and Water Conservation District in southern California undertook an extensive research project to understand the best approaches for addressing water quality pollution from homeless encampments (DeVuono-Powell 2013). The study found that collaboration with other agencies was the most effective approach for addressing the long-term concerns of homeless encampments (ASCE, 2014).

3.3 Water Quality Monitoring and Assessment

Goal Statement: Improve the water quality of the impaired segments of the Mill River and its tributaries by reducing loadings of bacteria and other pollutants. Consistently meet water quality standards for recreation and aquatic habitat. Protect and enhance high quality and unimpaired waterbodies.

Ongoing water quality monitoring is recommended for the Mill River watershed to refine the understanding of water quality impacts from potential point and non-point pollution sources in the watershed, to measure the progress toward meeting watershed management goals and TMDL pollutant load reductions, and ultimately support removal of the impaired segments of the Mill River and its tributaries from the CTDEEP impaired waters list. Water quality monitoring recommendations are summarized in *Table 3-5*.

Recommended Actions

- Consider establishing a volunteer water quality monitoring program for the Mill River. Volunteer monitoring promotes citizen awareness, involvement, and environmental stewardship. Volunteer monitoring can also help to identify ambient water quality and trends, fill in gaps in statewide monitoring data, and provide data for regulatory and land use decision-making. Many examples of successful volunteer monitoring programs exist around Long Island Sound. Additional information about the CTDEEP Volunteer Monitoring Program is available online at <http://www.ct.gov/deep/streamvolmon>.
- Consistent with the bacteria TMDL for the Mill River watershed, the monitoring program should be designed to accomplish two objectives: (1) source detection to identify specific sources of bacterial loading and (2) fixed station monitoring to track water quality improvements.
 - **Bacteria Source Detection** – Source detection monitoring may include visual inspection of storm sewer outfalls under dry weather conditions, event sampling of individual storm sewer outfalls, and monitoring of ambient (in-stream) conditions at closely spaced intervals to identify “hot spots” for more detailed investigations leading to specific sources of high bacteria loads. Source detection monitoring should be informed by the findings of streamwalk assessments and follow-up track down surveys. Source detection monitoring should also be implemented by the watershed municipalities as part of their “Illicit Discharge Detection and Elimination” efforts as required by the MS4 permit.

- o Fixed Station Bacteria Monitoring – Conduct routine bacteria monitoring at fixed sites along the impaired reaches of the Mill River, Shepard Brook, and Willow Brook to measure progress toward achieving the watershed plan and TMDL pollutant load reduction goals. Sampling should be scheduled at regularly spaced intervals during the recreational season. Therefore, the data set at the end of each season would include ambient values for both “wet” and “dry” conditions in relative proportion to the number of “wet” and “dry” days that occurred during the monitoring period. The TMDL calculations can be updated over time to compare the percent reductions needed under “dry” and “wet” conditions to the percent reductions that were needed at the time of TMDL adoption.

Recommended Fixed Station Bacteria Monitoring Locations – Mill River Watershed

- Mill River at Whitney Road exit at Park and Ride (TMDL station ID 5410)
- Mill River downstream of Dixwell Avenue (TMDL station ID 176)
- Mill River at first pull-off downstream of Tuttle Road (TMDL station ID 923)
- Mill River upstream of Tuttle Road (TMDL station ID 175)
- Mill River adjacent to Route 22
- Mill River 400 meters downstream of Clark's Pond
- Shepard Brook at Route 10 (TMDL station ID 6180)
- Sanford Brook near Mountaincrest Drive
- Willow Brook at Willow Street

- Also consider implementing the Riffle Bioassessment by Volunteers (RBV) Program within the Mill River watershed. The RBV program is a volunteer water quality monitoring protocol developed and administered by the CTDEEP. Volunteers are trained to assess benthic macroinvertebrates in small wadeable streams to screen local stream segments for water quality. Volunteers could include students and faculty from local schools and universities. The non-tidal portions of the Mill River and both impaired and unimpaired segments of its major tributaries are potential candidates for RBV surveys. Information on the RBV Program is available at <http://www.ct.gov/deep/rbv>.
- Develop and implement a centralized water quality database for historical and new water quality monitoring data for the Mill River watershed. The database could be made accessible to the watershed municipalities, educational groups for teaching purposes, and the general public. The database could be implemented using an existing tool such as the Global Learning and Observations to Benefit the Environment (GLOBE) Program <https://www.globe.gov/home>, which is an international science and education program that provides students and the public worldwide with the opportunity to participate in citizen science through data collection, data entry, and data visualization, or a custom software application such as the water quality database and web resource developed for the Bronx River <http://bronxriverwater.org/>.
- Pursue dedicated funding to finance future monitoring and reporting.
- Prepare a periodic “Water Quality Report Card” for the Mill River watershed modeled after similar report cards that have been prepared for other rivers and embayments around Long Island Sound and elsewhere in the U.S. The report card would provide a transparent, timely, and geographically detailed assessment of water quality for the Mill River to inform the public of water quality conditions and actions that are occurring to improve and protect water quality in the river. Report card scores are determined by comparing water quality indicators to scientifically-derived ecological thresholds or goals.

Water Quality Report Card

An example of a water quality report card developed for Hempstead Harbor on the north shore of Long Island.

<http://www.nfwf.org/whoware/mediacenter/pr/Documents/hempstead-harbor-report-card.pdf>

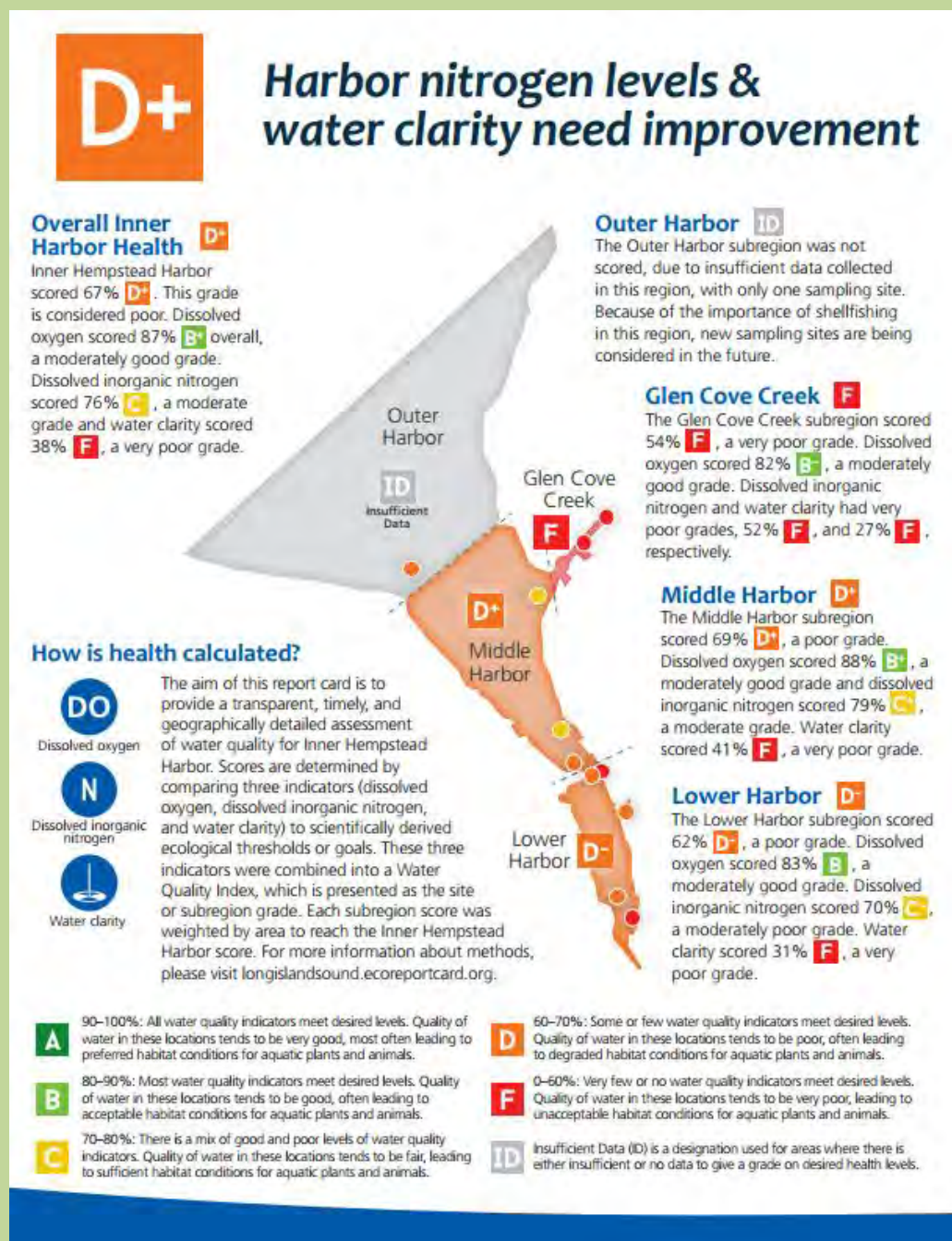


Table 3-5. Water Quality Monitoring Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Establish and implement a volunteer water quality monitoring program - Identify funding sources - Identify monitoring coordinator - Develop program with CTDEEP - Recruit volunteers - Conduct training and prepare QAPP	Mill River Watershed Coordinator, CFE/Save the Sound, CTDEEP, colleges and universities, and volunteers	2-5 years initial program development Annual monitoring	Approved QAPP, monitoring results/reports	\$\$\$	
2. Implement RBV program - Contact CTDEEP RBV Coordinator - Recruit volunteers - Conduct training and surveys	Mill River Watershed Coordinator, CFE/Save the Sound, colleges and universities, and volunteers	0-2 years and annually thereafter	Survey results/reports	\$\$	
3. Develop and implement a centralized water quality database	Mill River Watershed Coordinator, CFE/Save the Sound, and consultant	2-5 years	Functional database	\$\$\$	
4. Prepare a periodic "Water Quality Report Card"	Mill River Watershed Coordinator, CFE/Save the Sound, and consultant	2-5 years	Report cards	\$\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment CTDEEP = Connecticut Department of Energy and Environmental Protection

3.4 Urban/Suburban BMPs

Goal Statement: Promote sustainable land use and appropriate development in the watershed while protecting and improving water quality and natural resources, enhancing public access to and connectivity of waterbodies and open space, and addressing current and future flooding problems.

3.4.1 Combined Sewer Overflows

As described in *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018a), during wet weather, portions of the combined sanitary and storm sewer system in the City of New Haven become overwhelmed and combined sewage overflows to nearby receiving waters. These discharges are referred to as Combined Sewer Overflows (CSOs). There are three remaining permitted CSO outfalls to the Mill River – CSOs 009, 011, and 012. The Greater New Haven Water Pollution Control Authority (GNHWPCA) is in the process of implementing a phased plan to reduce CSOs to the Mill River, which includes traditional gray infrastructure and green infrastructure approaches.

GNHWPCA should continue to implement CSO abatement measures to further reduce CSO discharges to the Mill River consistent with its CSO abatement plan. Specific CSO-related recommendations are described below and summarized in *Table 3-6*.

Recommended Actions

- Continue to update and implement the CSO Long Term Control Plan, including short, intermediate and long term CSO control measures to achieve zero discharges from CSO outfalls for up to a 2-year, 6-hour rainfall event by 2036. CSO wet weather capacity improvements in the Mill River watershed that are identified in the GNHWPCA Long Term Control Plan include:
 - o Raising the regulator weir at CSO 009 (completed in 2015)
 - o Conducting an Infiltration and Inflow removal project at CSO 009 (completed)
 - o Completing sewer separation at CSO 009
 - o Installing a 1.3 million gallon CSO storage tank at CSO 011
 - o Closing CSO 014 (completed in 2014)
 - o Upgrading the pump station at CSO 026
 - o Closing CSO 026
 - o Raising the weir at CSO 012 (completed in 2013)
 - o Completing a capacity improvement project at CSO 012
 - o Closing CSO 012
 - o Upgrading the pump station at CSO 028
 - o Closing CSO 028
- Continue to require the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development projects within combined sewer areas in accordance with the GNHWPCA Permitting and Design Criteria Manual (retain runoff on-site for the 2-year, 6-hour rainfall event, or approximately 2.05 inches).
- Continue to collect flow monitoring data to evaluate the effectiveness of the ongoing CSO improvements in the Mill River watershed (i.e., CSO events, volumes, and pollutant loads)

3.4.2 Green Infrastructure and Low Impact Development

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Mill River. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. As discussed previously, CSOs are also a major source of pollutants to the Mill River during wet weather.

Low Impact Development (LID) is a site design strategy that maintains, mimics, or replicates pre-development hydrology through the use of numerous site design principles and small-scale treatment practices distributed throughout a site to manage runoff volume and water quality at the source. Similarly, “green infrastructure” refers to systems and practices that reduce runoff through the use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). When applied to sites or neighborhoods, LID and green infrastructure (referred to hereafter as simply “green infrastructure”) include stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

Green Infrastructure (GI) can be defined as the natural and man-made landscapes and features that can be used to manage runoff. Examples of natural green infrastructure include forests, meadows and floodplains. Examples of man-made green infrastructure include green roofs, rain gardens and rainwater cisterns.

Low Impact Development (LID) is a land development approach that is intended to reduce development related impacts on water resources through the use of stormwater management practices that infiltrate, evapotranspire, or harvest and use stormwater on the site where it falls.

In addition to reducing polluted runoff and improving water quality, GI has been shown to provide other social and economic benefits relative to reduced energy consumption, improved air quality, carbon reduction and sequestration, improved property values, recreational opportunities, overall economic vitality, and adaptation to climate change (Center for Neighborhood Technology and American Rivers, 2010; EPA Green Infrastructure Website http://water.epa.gov/infrastructure/greeninfrastructure/gi_why.cfm). For these reasons, many communities are exploring the use of and are adopting GI within their municipal infrastructure programs.

As described in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O’Neill, 2018c), GI is being implemented by the City of New Haven, GNHWPCA, private development, and other groups working in the Mill River watershed. An important objective of the Mill River Watershed Based Plan is to reduce CSO discharges, runoff volumes, and pollutant loads through the use of GI by building on the previous and ongoing GI initiatives in the watershed and region. Additional opportunities for GI retrofits in the Mill River watershed were identified during the development of this watershed plan. Ten of the highest priority site design concepts are presented in *Section 4*. Additional concepts are documented in *Appendix D of Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O’Neill, 2018c).

Table 3-6 contains a summary of green infrastructure recommendations for the Mill River watershed.

Table 3-6. Combined Sewer Overflow and Green Infrastructure Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Continue to implement CSO improvements identified in the GNHWPCA Long Term Control Plan	GNHWPCA	Ongoing	Updated 2022 LTCP, completed projects	\$\$\$\$	GNHWPCA, CWF
2. Flow monitoring to evaluate effectiveness of CSO improvements Compare modeled and measured CSO events, volumes, and pollutant loads	GNHWPCA	Ongoing	Flow monitoring reports including analysis of modeled and measured parameters	\$\$\$\$	GNHWPCA, CWF
3. Require use of GI for development projects within combined sewer areas	GNHWPCA	Ongoing	Completed projects	\$	Private
4. Implement identified GI retrofit projects on public lands - Pursue grant funding - Design and construct projects	CFE/Save the Sound, municipalities, private partners, consultants	Ongoing	Completed projects	\$\$\$\$	319 NPS Grant
5. Incorporate GI into municipal projects including “green streets” projects Work with Regional Councils of Governments to ensure that GI and LID are considered and incorporated into all plans and projects	Municipalities, NVCOG, SCRCOG, Mill River Watershed Coordinator	Ongoing	Completed projects	\$\$\$\$	
6. Evaluate and modify existing municipal land use regulations and policy to require the use of GI and LID for development projects - Conduct land use regulatory review - Implement recommendations of land use regulatory review	UConn NEMO, NVCOG, SCRCOG, municipalities, (conduct reviews)	0-2 years	Final project reports	\$\$\$\$	Long Island Sound Study
	Municipalities, consultants (implement recommendations)	2-5 years	Amendments to local land use regulations and policies	\$\$\$\$	NFWF Long Island Sound Futures Fund, CTDEEP Supplemental Environmental Project Funds, 319

Table 3-6. Combined Sewer Overflow and Green Infrastructure Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
					NPS Grants
7. Support and implement recommendations identified as part of the CT NEMO pilot project focused on incorporating Green Infrastructure practices into local projects within the South Central Basin.	CFE/Save the Sound, Municipalities, CT NEMO	Ongoing	Implementation of pilot recommendations	\$\$\$\$	
8. Pursue sustainable, long-term funding sources for large-scale GI implementation	Regional collaboration of CFE/SAVE THE SOUND, SCRCOG, NVCOG, GNHWPCA, Municipalities	5-10 years	Framework and action plan to evaluate and implement stormwater infrastructure financing	\$\$\$\$	Stormwater utilities, property tax credits and incentive rate structures, green bonds, public private partnerships, CWF

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

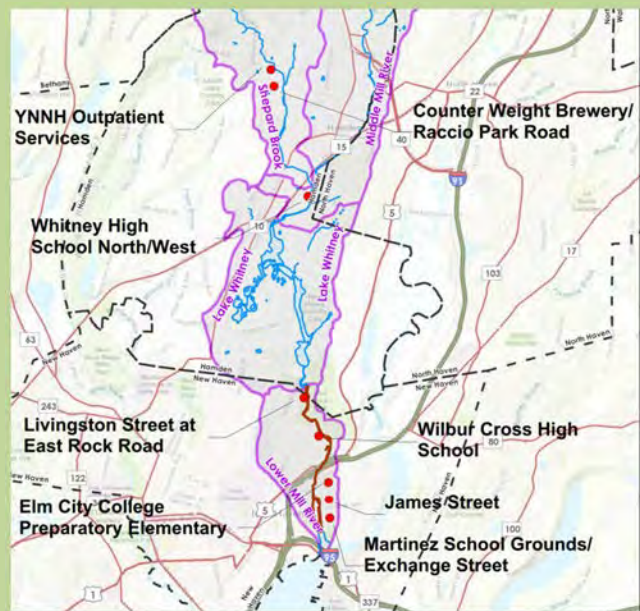
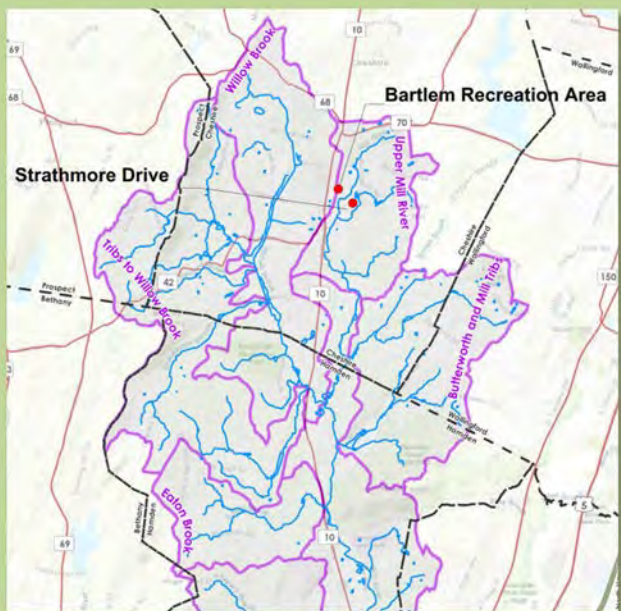
GNHWPCA = Greater New Haven Water Pollution Control Authority CFE/SAVE THE SOUND = Connecticut Fund for the Environment/Save the Sound CTDEEP = Connecticut Department of Energy and Environmental Protection NVCOG = Naugatuck Valley Council of Governments SCRCOG = South Central Regional Council of Governments CWF = Connecticut Clean Water Fund

Recommended Actions

- Pursue funding for and implement identified high-priority, site-specific GI retrofits on public lands based on the site-specific GI concepts identified in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018c) (see Section 3.5 and Appendix C). Simultaneously, pursue partnerships with businesses and homeowner associations to advance those site-specific GI concepts developed for privately owned sites. Continue to develop additional retrofit projects, including identifying potential project sites through future streamwalks, track down surveys, and subwatershed action plans.

Site-Specific Green Infrastructure Retrofits in the Mill River Watershed

An assessment was performed to identify opportunities and develop concepts for site-specific GI retrofits in the Mill River watershed. The assessment began with a screening evaluation of the approximately 230 publicly-owned parcels in the targeted subwatersheds to quickly identify areas with the greatest feasibility for and potential benefits from GI retrofits. Field inventories were then conducted at approximately 40 sites with the greatest opportunity for GI retrofits. GI concepts were prepared for 10 of the highest priority sites visited. (Note that Hamden Town Center Park is also identified as highest priority.) Details of the assessment methods, concepts, and other GI retrofit opportunities in the watershed are provided in Section 4 and also in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018c) (see Appendix C).



The watershed municipalities should incorporate GI into planned municipal projects, including roadway projects in the context of “green streets” approaches, following the City of New Haven’s “Complete Streets” initiative. The City of New Haven should update its Complete Streets Design Manual (2010) to provide urban street design standards and promote the use of GI.

- Cost-effective, large-scale implementation of GI will require non-traditional financing. Possible long-term funding sources including user fees, stormwater utilities, property tax credits or rebates, green bonds and community-based public-private partnerships. The following alternative funding approaches should be considered:
 - o Stormwater Utilities – Watershed municipalities should consider the feasibility of implementing a municipal or regional stormwater utility, incorporating lessons learned from previous and ongoing efforts by New Haven and other Connecticut communities. Critical to the success of such an effort is an effective public outreach and community stakeholder engagement program.
 - o General Fund/Property Taxes – while many issues exist with using property taxes to fund municipal stormwater management programs (e.g., property taxes are not assessed based on runoff generation, some significant runoff generators are tax-exempt, many competing priorities for general funds), tax credits or incentive rate structures could be explored that would incentivize the use of green infrastructure by property owners.
 - o Clean Water Fund – grant and loan funding from the Connecticut Clean Water Fund should be focused on implementing green infrastructure throughout New Haven’s combined sewer areas, including the Mill River watershed.

Green Infrastructure in New Haven

City of New Haven bump-out bioretention planter along Clinton Avenue (top) and typical bioswale (bottom). The City plans on installing bioswales across the City to manage stormwater runoff effectively. GNHWPCA is also installing bioswales in areas of combined sewers in New Haven. Photo credit: Dawn Henning, City of New Haven Engineering.



- o Green Bonds – Green Bonds are a growing mechanism for funding green projects, including green infrastructure and flood resilience projects. Green bonds are debt instruments issued to finance environmental projects focused on climate change initiatives. The identification and labeling of a green bond is typically based on a set of voluntary standards drafted by a consortium of investment banks that outlines the process for issuers to designate specific green projects. The guidelines specify that a bond issue qualifies as green if the issuer uses the proceeds solely for capital expenditures associated with green or climate-related environmental benefits in accordance with certain standards.
- o Public Private Partnerships –A Public Private Partnership (P3) is an arrangement between government and the private sector in which the private sector assumes a large share of the risk in terms of financing, constructing, and maintaining the infrastructure. Government repays the private sector over the long term if the infrastructure is built and maintained according to specifications. Prince George's County is implementing a P3 program to retrofit 2,000 acres of impervious surfaces in the public right of way. Private funds will finance 30% to 40% of the program costs upfront, enabling project construction to begin sooner and proceed more quickly.

3.4.3 Residential Low Impact Development

Residential land use accounts for approximately 57% of the land area in the Mill River watershed. Residential areas are a significant source of runoff and nonpoint source pollutant loads to the Mill River. The actions of individual homeowners can help to reduce runoff and pollutant loads to the combined and separate storm sewer systems in residential areas. The previous section describes larger-scale green infrastructure recommendations primarily targeted at municipalities, institutions, and private development. Low Impact Development (LID) management practices can also be implemented by homeowners on individual residential lots.

Residences in parts of the watershed generate significant quantities of rooftop runoff, which can also be a source of bacterial loads from birds and squirrels especially in areas with overhead tree canopy. Opportunities exist to disconnect residential rooftop runoff from the combined or storm drainage systems and reuse or redirect it to pervious areas through the use of rain barrels, rain gardens, and drywells.

Downspout disconnection can be a cost-effective option, in certain residential settings³, for reducing the volume and cost of stormwater that requires public management. The use of pervious materials for patios, walkways and driveways, as well as pavement removal and planting new yard trees, can also reduce impervious surfaces on residential lots and the contribution of runoff and pollutant loads to waterbodies.

Residential LID retrofits on individual lots target small areas, requiring the participation of many homeowners to make a measurable difference across a watershed. A coordinated effort is required for widespread participation in such a program, which typically includes a combination of targeted education, technical assistance, and financial subsidies to homeowners. Successful implementation of residential/small-scale LID practices therefore requires homeowner education and incentive programs.

³ In densely developed urban areas with combined sewer systems, such as parts of the Mill River watershed in New Haven, downspout disconnection (i.e., roof leader separation) can be extremely expensive and less cost-effective than other BMPs since disconnecting roof leaders from the combined sewer system often requires costly interior plumbing modifications.

Recommendations for implementation of residential LID practices in the Mill River watershed are described below and summarized in *Table 3-7*.

Recommended Actions

- Encourage disconnection of rooftop runoff from the storm drainage system by redirecting exterior roof leaders to pervious lawn areas and through the use of dry wells, rain barrels or rain gardens.
- The watershed municipalities, together with the GNHWPCA, should consider developing residential LID incentive programs to encourage implementation of LID practices by homeowners, which will help reduce the burden on municipal stormwater and wastewater infrastructure for managing runoff from residential lots. Incentives to encourage residential property owners to use LID include:
 - o Stormwater Fee Discounts or Credits – reduced fees or utility bills by installing LID practices; requires a stormwater utility or similar fee-based system
 - o Rebates and Installation Financing – funding, property tax credits (i.e., reduction in property taxes), or reimbursements to property owners who install green infrastructure
 - o Workshop and Give-Away or Discount Programs - rain barrel workshops for homeowners that provide a free rain barrel to each participating household, along with training on how to install and maintain the rain barrel. Some rain barrel companies, such as the Great American Rain Barrel Company, offer programs for communities that enable municipalities to offer discounted rain barrels through a community campaign, with convenient barrel pick-up for residents at a Town or City office (<https://www.greatamericanrainbarrel.com/community/>)
 - o Certification and Recognition Programs – certification of residential properties as watershed-friendly by implementing LID practices
 - o Municipal sponsored public workshops on how to build rain gardens emphasizing the increase in property value and curb appeal of LID landscaping

Incentive programs can also serve as a mode of public outreach. Several examples of successful residential LID incentive programs are highlighted in the following text box.

Disconnecting Roof Downspouts

Disconnecting roof downspouts is one of the easiest things homeowners can do to help reduce stormwater runoff. Disconnecting downspouts will reroute the runoff into rain barrels or permeable areas like lawns or rain garden instead of the sewer.

<http://reducerunoff.org/>
(Save the Sound).



Reroute your downspout so your yard or rain garden absorbs and filters the runoff from your roof.



Disconnecting your downspout is a simple and effective way of reducing stormwater runoff. (Photo from grandbuilding.ca)

Residential LID Incentive Programs

Lake Champlain BLUE® Certification Program
Program developed by Lake Champlain International that certifies residential properties as watershed friendly, or BLUE®, if they follow simple, yet scientifically accepted, practices that reduce water pollution runoff starting on their properties. Certified homeowners receive a BLUE certification lawn sign, increased property values, and the satisfaction of improving local water quality.

<http://www.mychamplain.net/blue-program>



Montgomery County, MD RainScapes Rewards
Montgomery County coordinates RainScapes Rewards, a rebate program used to meet part of its municipal separate storm sewer system (MS4) permit goals. The county provides rebates based on the amount of runoff captured. Residential properties are capped at \$2,500.

<https://www.montgomerycountymd.gov/DEP/water/rainscapes-rebates.html>



- Provide education and outreach to homeowners, neighborhood groups, and roofing contractors on disconnecting roof downspouts and installing and maintaining residential rain gardens and rain barrels. The Connecticut NEMO web site provides a wealth of information about residential rain gardens: <http://nemo.uconn.edu/raingardens/>
- Encourage participation among New Haven residents in the “Voluntary Non-Use of Pesticides and Synthetic Fertilizers on Lawns and Gardens” program.
- Additional homeowner education and outreach recommendations are discussed above in Section 3.2.2 of this plan.

Table 3-7. Residential Low Impact Development Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Evaluate and implement residential LID incentive programs - Identify and build upon existing programs (e.g., NHS Free Rain Garden Program, The Sound School and RWA's rain barrel program) - Evaluate feasibility of alternative programs - Pursue funding - Implement program(s)	Mill River Watershed Coordinator, CFE/SAVE THE SOUND, GNHWPCA, NHS	0-2 years establish program Ongoing implementation thereafter	Program(s) identified, funding secured, program established, number of homeowners participating	\$\$\$\$	Grants, future stormwater fees, property tax credits
2. Provide homeowner education and outreach on using LID	Municipalities, CFE/SAVE THE SOUND, UConn NEMO, NHS	Ongoing	Outreach materials disseminated	\$\$	Municipal, grants

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

GNHWPCA = Greater New Haven Water Pollution Control Authority CFE/Save the Sound = Connecticut Fund for the Environment/Save the Sound NHS = Neighborhood Housing Services of New Haven NEMO = Nonpoint Education for Municipal Officials GNHWWC = Greater New Haven Waterworks Coalition

3.4.4 Municipal Stormwater Management Programs

The stormwater collection and drainage systems within the watershed consist of drainage infrastructure operated and maintained by the watershed municipalities and the Connecticut Department of Transportation. The watershed municipalities are regulated under the CTDEEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 Permit). Stormwater discharges associated with the state drainage system are regulated under a similar MS4 permit issued specifically to the Connecticut Department of Transportation (CTDOT), which will become effective July 1, 2019.

Through their MS4 Permit stormwater management programs and other planning initiatives, the watershed municipalities have developed and implemented a variety of Best Management Practices to address stormwater quality and quantity issues associated with municipal activities as well as land development and redevelopment projects.

Construction sites that disturb one or more acres of land are regulated by the CTDEEP under the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities. Municipalities also have jurisdiction over construction sites that disturb 0.5 or more acres of land.

Municipal stormwater management recommendations are summarized in *Table 3-8*.

Recommended Actions

The watershed municipalities should continue to implement municipal stormwater management programs for their regulated MS4s, as required by the MS4 Permit. The six minimum control measures of the MS4 Permit include public education, public involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention and good housekeeping. Specific recommendations include:

- Consider developing a regional stormwater coalition to pool resources and facilitate more cost-effective compliance with the MS4 Permit. The South Central Regional Council of Governments (SCRCOG) has previously expressed interest in forming a regional coalition and might serve as a leader in forming such a coalition. There are other successful stormwater coalitions that can provide a model for the region. One example is the Central Massachusetts Regional Stormwater Coalition (<http://centralmastormwater.org/Pages/index>).
- CTDOT will be developing and implementing a Stormwater Management Plan to comply with its MS4 Permit. CFE/Save the Sound should review and comment on the draft Stormwater Management Plan during the public comment period, which is 90 days prior to the effective date of the MS4 Permit (July 1, 2019).

Updated CTDEEP MS4 Permit

CTDEEP reissued an updated MS4 Permit which took effect July 1, 2017. The new permit contains more stringent requirements than the previous permit relative to storm system mapping, illicit discharge detection and elimination, and monitoring, as well as more prescriptive requirements for discharges to impaired waters, such as the Mill River. The MS4 Permit also requires municipalities to address impervious area that is directly connected to municipal storm drain systems through tracking and reductions of impervious cover, with the ultimate goal of reducing nonpoint source pollution by lessening stormwater runoff.

Table 3-8. Municipal Stormwater Management Program Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Form a regional stormwater coalition to cost-effectively comply with the new MS4 Permit	SCRCOG, NVCOG, municipalities, consultant	0-2 years	Regional coalition established	\$\$\$\$	SCRCOG/NVCOG

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

SCRCOG = South Central Regional Council of Governments NVCOG = Naugatuck Valley Council of Governments

- CFE/Save the Sound should work collaboratively with the watershed municipalities and CTDOT during implementation of their MS4 Stormwater Management Programs to share stormwater outfall screening and monitoring results, the results of streamwalks and track down surveys, the results of illicit discharge investigations, and opportunities for GI/LID retrofits in the Mill River watershed.
- The Naugatuck Valley Council of Governments (NVCOG) should continue to explore the possibility of providing regional training and outreach materials to its member communities to facilitate sharing of resources and to more cost-effectively comply with the MS4 General Permit, borrowing from the successes of regional stormwater coalitions in Massachusetts such as the Central Massachusetts Regional Stormwater Coalition (<http://centralmastormwater.org/Pages/index>).

3.4.5 Land Use Regulations

Municipal land use plans and regulations help shape the development patterns within a watershed and can play a significant role in protecting water quality and other natural resources at the watershed scale. These commonly include municipal plans of conservation and development, zoning regulations, subdivision regulations, inland wetlands and watercourses regulations, and stormwater regulations, all of which influence the type and density of development that can occur within a watershed. Local land use regulations often vary by municipality within a watershed, and regulations are periodically revised in response to development pressure, shifts in attitude toward natural resource protection, and political and socioeconomic factors.

Because a watershed based plan encompasses multiple municipalities, a watershed-based regulations review also provides an opportunity for towns or cities to compare their regulatory mechanisms to those of neighboring municipalities. By doing so, they can evaluate the relative merits of different approaches, adopt the best models, and improve region-wide consistency in how the common water resource is managed.

The Nonpoint Education for Municipal Officials (NEMO) Program of the UConn Center for Land Use Education and Research (CLEAR) has completed reviews of land use regulations for Cheshire, Bethany, Hamden, and New Haven. NVCOG also conducted regulatory reviews for Cheshire and Prospect, two towns comprising approximately one third of the Mill River watershed. These reviews compared existing regulations to the legal authority requirements of the CTDEEP MS4 General Permit. In addition, each review looked for potential barriers to low-impact design within Town regulations (e.g., road width or parking requirements which encourage an excess of impervious area). Where relevant, the reviews provide suggestions for eliminating these barriers to further encourage LID and green infrastructure. These reviews build upon a previous review by the Mill River Watershed Association of municipal land use regulations in the Mill River, West River, and Quinnipiac River watersheds, which found that most of the municipalities surveyed require some form of green infrastructure or LID for new construction



Credit: Joseph Gerhard – Mill River, *Manton Westwood Books*, New Haven, CT, 2011

but few, if any, require retrofits for existing development (Mushinsky, 2015).

Recommended Actions

- Cheshire and Prospect should take steps to revise their land use regulations in accordance with the recommendations of the NVCOG land use regulatory reviews for each municipality. A similar land use regulatory review process is required of all Towns registered under the MS4 permit, and the other watershed municipalities should conduct a similar land use regulatory review process to identify and eliminate barriers to LID in each municipality.
- The other watershed municipalities should ensure that their land use regulations includes green infrastructure and LID stormwater requirements, including runoff reduction standards, following the lead of the City of New Haven and GNHWPCHA, particularly for new development and redevelopment of sites with large amounts of existing or proposed impervious surfaces.
- The Mill River Watershed Based Plan should be referenced by the watershed municipalities in any updates to municipal Plans of Conservation and Development (POCDs). The POCDs should emphasize that municipal land use agencies (i.e., inland wetlands and watercourses, planning and zoning, conservation) should consider the long-term protection and use of the watershed when implementing their statutory abilities to balance resource protection and development.

Table 3-9. Land Use, Open Space, and Public Access Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Land Use Regulations					
1. Implement the recommendations of the UConn/NEMO and NVCOG land use regulatory reviews	Municipalities	2-5 years	Adopted or revised land use regulations or policies	\$\$\$	
2. Watershed municipalities should adopt green infrastructure and Low Impact Development stormwater requirements	Municipalities	2-5 years	Adopted or revised land use regulations or policies	\$\$\$\$	
3. Reference the Mill River Watershed Based Plan in updated municipal Plans of Conservation and Development	Municipalities	Ongoing	Updated POCDs	\$	
Flood Resilience					
4. Implement flood protection recommendations in City of New Haven's Comprehensive Plan Update	City of New Haven	0-2 years	Updated Comprehensive Plan	\$\$\$\$	
5. Adopt a policy of no-net-loss of flood storage capacity or flood conveyance · Keep working riparian buffers intact to slow runoff velocities and help control flooding.	Municipalities	2-5 years	Revised flood hazard regulations	\$\$\$	
6. Update design storm rainfall amounts and assess the vulnerability of public and private infrastructure to climate change	Municipalities	2-5 years	Revised design storms in regulations, climate change vulnerability assessments	\$\$\$\$	
7. Implement coastal resilience measures for the tidally influenced portion of the Mill River	New Haven	5-10 years	Coastal resilience plans prepared and implementation projects completed	\$\$\$\$	Grant funding – FEMA, HUD, NOAA, CIRCA
8. Address current flood problems using federal and state agency assistance and resources	Municipalities	Ongoing	Pursue federal grants and technical assistance	\$\$\$	FEMA, HUD, NOAA, CIRCA, CTDEEP

Table 3-9. Land Use, Open Space, and Public Access Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Open Space					
9. Develop/update municipal open space conservation plans	Municipalities, land trusts	2-5 years	Open space planning document updates	\$\$\$	
10. Acquire unprotected open space	Land trusts, municipalities, RWA	Ongoing	Protected land	\$\$\$\$	Federal (USDA Forest Service and NRCS), State (CTDEEP and CTDOA), CT Land Conservation Council, and private organizations
11. Provide for public access to open space areas	Municipalities	Ongoing	Completed projects and number of sites	\$\$\$	
12. Perform an evaluation of undeveloped and underdeveloped parcels in the watershed	WRWC	2-5 years	Evaluation report with recommendations	\$\$\$	
Public Access					
13. Expand the existing Mill River Trail. Plan and create new trails to connect existing trails and open space. · Implement the Mill River Trail Framework Plan, including planned pedestrian, bike, and water trail routes	New Haven	5-10 years	New trail sections	\$\$\$\$	
14. Update the 2004 Plan for Greenways and Cycling Systems	City of New Haven	2-5 years	Updated plan	\$\$\$	
15. Develop a public access area inventory for the Mill River and its tributaries. Identify and acquire new access points.	Mill River Watershed Coordinator, CFE/Save the Sound (inventory) Municipalities, land	2-5 years	Map and listing of the areas summarizing location, size, current and potential uses, and ownership	\$\$\$	

Table 3-9. Land Use, Open Space, and Public Access Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
	trusts (acquisition)				
16. Introduce educational signage, interpretive stations, maps and online resources for new or modified public access points	Municipalities, Mill River Trail Advocates, land trusts	Ongoing	Public access locations with signage	\$\$\$	
17. Promote public access to the Regional Water Authority public water supply land	RWA	Ongoing	Increase in public access permits issued by RWA	\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

CFE/SAVE THE SOUND = Connecticut Fund for the Environment/Save the Sound FEMA = Federal Emergency Management Agency HUD = U.S. Department of Housing and Urban Development NOAA = National Oceanic and Atmospheric Administration CIRCA = Connecticut Institute for Resilience and Climate Adaptation CTDOA = Connecticut Department of Agriculture USDA = U.S. Department of Agriculture NRCS = Natural Resources Conservation Service

3.4.5.1 Increase Flood Resilience Using a Watershed Approach

Water quality is the primary focus of this watershed based plan, although water quality and quantity (i.e., flooding) issues are closely related in terms of watershed resource management. This watershed plan, although not intended as a flood mitigation plan, also addresses flooding due to the prevalence of concerns around inland and coastal flooding and the significant attention that flood mitigation has received in the watershed communities, particularly in the face of climate change and the potential for more frequent and intense storms in the future.

The flooding-related recommendations in this watershed plan are intended to enhance flood resilience⁴ by supplementing previous and ongoing flood mitigation efforts in the watershed. These recommendations focus on an integrated, watershed-based approach to addressing flooding, water quality, and habitat restoration. The emphasis is on restoring the functions, and often the forms, of the resources provided by natural riverine, wetland, and estuarine systems, which is a change from past, conventional approaches to watershed development and traditional flood control. This plan also recognizes the critical importance of wetland/marsh protection and restoration for flood resilience.

The recommendations include elements of the National Flood Insurance Program for planning and restoration of riverine corridors (insurance claims, adaptation-avoidance by elevating structures, discouraging future development activities within flood prone areas, floodplain easements, etc.), as well as other approaches such as green infrastructure, which recognize that flooding damage in urban and suburban areas is not confined to floodplains (Center for Neighborhood Technology, 2013).

Use of Green Infrastructure and Other Innovative Approaches to Urban Flooding

Green infrastructure and other techniques are recommended to address urban flooding problems in the watershed. These recommendations focus on an integrated, watershed-based approach to addressing flooding, water quality, and habitat restoration. The emphasis is on restoring the functions, and often the forms, of the resources provided by natural riverine, wetland, and estuarine systems, which is a change from past, conventional approaches to flood control.

Recommended Actions

- Continue to implement the flood protection recommendations in the City of New Haven's Comprehensive Plan Update:
 - o Continue to restrict land clearing activities and development in low-lying areas through the enforcement of the city's floodplain ordinances
 - o Encourage flood proofing of structures in areas prone to repetitive floods. Identify and seek pre-disaster mitigation funding and other sources of funding available at the state and federal level to implement flood proofing measures within the city.
 - o Review, assess, and revise the floodplain ordinances of the city periodically to protect the health, safety, and welfare of residents.
 - o Delineate Base Flood Elevations (BFEs) at the parcel level, as designated by FEMA, on official City maps and publish them on City webpage so that they can be used by residents and potential developers.
 - o Continue to update and adopt the City's Natural Hazard Mitigation Plan (updated in 2017).

⁴ "Flood resilience" is a community's ability to plan for, respond to, and recover from flooding.

- Adopt a policy of no-net-loss of flood storage capacity or flood conveyance within the watershed. Preserve and protect existing wetlands that provide flood storage and attenuation.
 - Keep working riparian buffers intact to slow runoff velocities and help control flooding.
- Remove, redesign and reduce in-channel and in-floodway structures and restore channels, floodways and floodplains. Restore floodplain storage by excavating fill and removing flood-prone structures.
- Emphasize infiltration using green infrastructure techniques, which provides water quality and other benefits in addition to reducing water volumes and decreasing peak flows to mitigate flooding.
- Incorporate updated design storm rainfall amounts into local land use regulations and policies to account for the influence of climate change.
- Ensure that future flood mitigation projects and designs include provisions for water quality and riparian/aquatic habitat restoration. Provide or maintain vegetated buffers around all watercourses and wetlands where feasible.
- Assess the vulnerability of public and private infrastructure (e.g., utilities, transportation, structures), the environment, and society (e.g., vulnerable populations) to climate change and increased frequency of extreme storms, sea level rise, etc. and develop adaptation strategies. The Massachusetts Municipal Vulnerability Preparedness Program (<https://www.mass.gov/municipal-vulnerability-preparedness-mvp-program>) and The Nature Conservancy's Community Resilience Building Framework (<https://www.communityresiliencebuilding.com/>) provide excellent resources for structuring a vulnerability assessment and prioritization process.
- Climate change tools and resources for Connecticut are available from CTDEEP (www.ct.gov/deep/climatechange) and the Connecticut Institute for Resilience & Climate Adaptation (<https://circa.uconn.edu/>).
- Engage federal and state agencies on available assistance and resources to develop and implement engineering solutions to address flood problems.

Updated Design Storm Rainfall

The National Oceanic and Atmospheric Administration National Weather Service issued updated precipitation frequency data (i.e., design storm rainfall amounts) in its Atlas 14, Volume 10 published in 2015. A similar tool for updated extreme precipitation data was developed as a joint collaboration between the Northeast Regional Climate Center and the USDA Natural Resources Conservation Services, <http://precip.eas.cornell.edu>, for New York and New England. The design storm rainfall amounts provided by these newer resources offer significant advantages over previous products since the design storm rainfall amounts are based on a much longer period of record, including future updates as new rainfall data is available.

3.4.5.2 *Preserve and Protect Open Space*

An objective of this plan is to manage, maintain, and promote existing open space and continue to protect and acquire open space that meets resource protection and recreational goals. Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious coverage, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space is also important as habitat for native and migratory species and protection of public water supply, both significant uses of open space in the Mill River watershed.

Open space in the Mill River watershed includes preserved natural areas (e.g., East Rock Park, Sleeping Giant State Park, and Regional Water Authority public water supply land) as well as lightly developed parks, playgrounds, and cemeteries. The watershed communities have identified open space protection goals and priorities primarily through their Plans of Conservation and Development.

Recommended Actions

- The watershed municipalities should develop or update existing municipal open space conservation plans. As a rule, update open space planning documents at least every five years.
- Work closely with land owners to protect and/or acquire unprotected open space as recommended in this watershed based plan, the municipal Plans of Conservation and Development, and related open space planning efforts.
- Continue to promote conservation easements as a tool to local or regional land trusts to protect, conserve, and maintain open space. Alternative funding sources and approaches for open space acquisition include state funding (e.g., Community Investment Act - Public Act 05-228), limited market rate development on a parcel to help fund the acquisition of the remainder of the parcel as open space, and transferring development rights from sensitive locations to locations better suited for development. Regardless of the mechanism, critical to the success of protecting open space land is the ability to readily leverage financing when windows of opportunity arise to acquire or preserve significant parcels.
- Plan and provide for public access to open space areas, and connect existing open spaces to avoid open space fragmentation. Obtain public access easements from property owners to link open space areas. Partner with non-profit organizations such as the local land trusts to acquire adequate vacant lands or easements to create a linked network of trails within the Mill River watershed.
- Ensure that open spaces remain available for passive recreation. Promote awareness and appropriate use of existing open space by publicizing parks, trails, community gardens, and historic landscapes as well as educational events on open space parcels.
- Encourage watershed-friendly management practices on open space parcels, including voluntary non-use of pesticides or fertilizers on lawns and gardens.
 - o Encourage golf courses to participate in Audubon International's Audubon Cooperative Sanctuary Program for Golf Courses <https://www.auduboninternational.org/acspgolf>

- Assess, improve, and restore parcels already acquired. Develop management plans for the use of acquired open space parcels.
- Proposed open space acquisitions should be evaluated based on a set of criteria that considers the environmental and physical characteristics of each property proposed for acquisition. In general, priority for open space protection should be given to properties that meet one or more of the following environmental criteria, in addition to multiple public benefits:
 - Size – Larger parcels provide greater opportunity for contiguous undeveloped areas or corridors to benefit wildlife, water quality and provide recreation.
 - Water Resources – Parcels that provide buffers for rivers and streams and associated riparian communities, headwater streams, and coastal areas.
 - Wetlands and Wildlife Habitat – Parcels that provide upland buffers around high quality wetlands and habitat areas and that support, enhance or protect biodiversity. In addition, areas of unprotected land within threatened or endangered species habitat should be made a priority for acquisition or conservation.
 - Floodplain Protection – Parcels in floodplain areas to provide habitat, protect or improve water quality, and preserve natural flood storage or function (to the 500-year flood level).
 - Streamflow Protection – Parcels that provide protection of groundwater recharge areas and headwater streams or parcels whose protection would prevent fragmentation of large forest tracts.
 - Recreation – Parcels that provide water and land-based recreational opportunities including swimming, fishing, boating, hunting, other water-access, or could accommodate multi-use trails as part of an existing or planned greenway, trail or linear park or provide connectivity of existing trail systems.
- Evaluate undeveloped and underdeveloped parcels in the watershed based upon the above factors to help identify open space protection priorities. Consider two types of open space protection – acquisition or protection through a conservation easement or restriction. Parcels that are currently undeveloped should be assigned higher priority for acquisition, while those parcels that are partially developed but have potential for future development should be assigned higher priority for a conservation restriction.

3.4.5.3 Increase Public Access to the River via the Mill River Trail

Access to many portions of the Mill River is limited due to development along the river. Improved access to the Mill River and its tributaries, including connectivity of waterbodies and open space, is needed to enhance recreational opportunities as well as public appreciation and stewardship of the river.

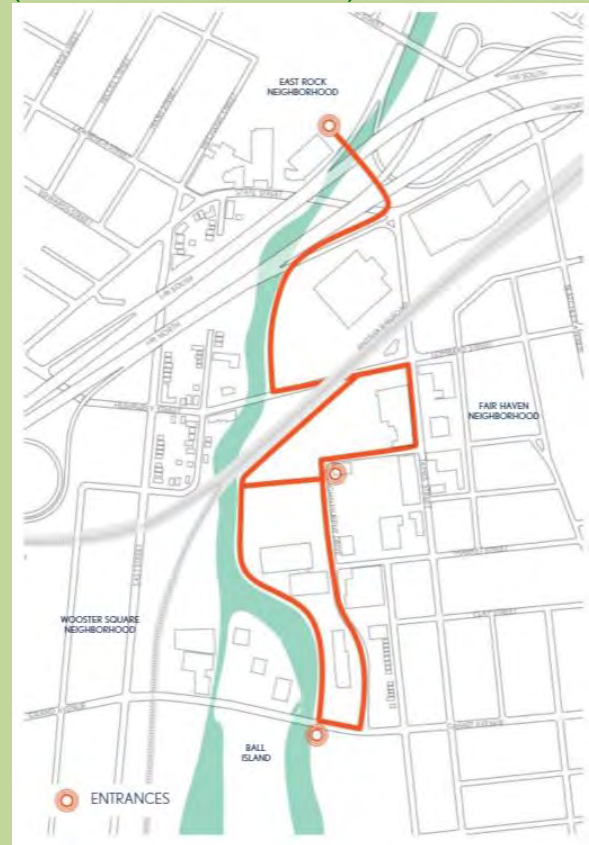
Recommended Actions

- Continue to expand the Mill River Trail, implementing the plan laid out in the *Mill River Trail Framework Plan* (Reed Hilderbrand, LLC, 2017). An approximately 1,000 foot long section of the trail adjacent to Radiall and Grand Paint was approved in April, 2018, with funding from a Connecticut Recreational Trails Grant from CTDEEP.
- Encourage continued use and stewardship at existing river access points, such as the pull off on Route 10 near Wentworth's which is used as an access point for fishing.

- Implement trail improvements at the Eli Whitney Museum, focusing on the stretch of trail from the museum property line to the Boy Scout bridge. This is an ideal location to encourage river access and education, as there is tidally-influenced fresh water marsh on one side of the trail, and the Mill River on the other.
- Work with the Mill River Trail Advocates group to increase available walk-to-school options that utilize the Mill River Trail, focusing especially on the areas served by Wilbur Cross High School, Elm City College Preparatory Elementary School, and the John Martinez School, each of which is also a site proposed for additional green infrastructure retrofits and outreach.
- Plan and create new trails to connect existing trails and open space in the Mill River watershed.
- Coordinate with outreach and education activities (*Section 3.2*) to foster an increased sense of connection between local residents and the river, particularly beginning with school-aged groups.
- Develop a public access area inventory for the Mill River and its tributaries that includes a map and listing of the areas summarizing location, size, current and potential uses, and ownership.
- Target acquisition of new access points or areas at locations that are underserved by open space or access to the river and with residential neighborhoods within walking distance. Public access areas should not adversely affect sensitive areas. Incorporate LID and other sensitive design elements into access area designs.
- Introduce educational signage, interpretive stations, laminated maps and guides, and online resources in the design of new or modified public access to waterways and open space areas.
- Promote public access to the Regional Water Authority public water supply land in the Mill River watershed as a way to educate the public about the watershed and water quality protection. The public can access the public water supply land by obtaining a permit from the Regional Water Authority.

Proposed Mill River Trail Concept

The map below depicts the Mill River Trail concept as envisioned in the Mill River Trail Framework Plan (Reed Hilderbrand, LLC, 2017).



3.4.6 Subsurface Sewage Disposal Systems

Approximately one-half of the watershed area, and approximately 11 percent of the watershed population, is served by on-site subsurface sewage disposal systems, also referred to as septic systems. Most of these systems are located in the upper portion of the Mill River watershed, in Cheshire and the northern portion of Hamden. Failing or older, sub-standard septic systems can impact surface water and groundwater quality and can be a source of bacteria to the Mill River. The Quinnipiac Valley Health District (QVHD), which serves the watershed communities of Bethany and Hamden, and the Chesprocott Health District, which serves Cheshire and Prospect, regulate the installation of subsurface sewage disposal systems and are responsible for site inspections, plan review, the issuing of permits and inspections of all new, repair and replacement systems.

Recommendations regarding subsurface sewage disposal systems are summarized in *Table 3-10*.

Recommended Actions

- Strengthen state and local regulations to require regular septic system inspection and maintenance and upgrades to sub-standard systems, such as requiring systems to pass an inspection or be upgraded upon the sale of a property.
- Continue to encourage regular maintenance of septic systems by providing homeowners with educational materials on how to identify improperly functioning systems and procedures to have systems inspected, cleaned, and repaired or upgraded. Septic system educational materials offered by QVHD should be disseminated by these towns to homeowners in their respective communities, which could also be used to meet the public outreach/education minimum control measure of the MS4 Permit and the related municipal stormwater management plans. Chesprocott Health District and municipal health departments should develop and disseminate similar educational materials.

Septic System Educational Materials for Homeowners

In addition to regulating the installation, maintenance, and repair/replacement of septic systems in their district municipalities, the Quinnipiac Valley Health District uses their website to provide homeowners with educational materials on septic system maintenance and repair <http://www.qvhd.org/>.



3.4.7 Illicit Connections and Discharges

Illicit discharges are non-stormwater flows that discharge into the stormwater drainage system or directly into surface waters. Wastewater connections to the storm drain system, sanitary sewer overflows, and illegal dumping are among the types of illicit discharges that may exist in sewered residential and commercial areas within the watershed. Identifying and eliminating these discharges is an important means of pollution source control for the watershed. Dry weather sources of bacteria such as illicit connections are the most likely to be identified and effectively managed (and to include human sources). Controlling dry weather sources of bacteria is typically more cost-effective than trying to address elevated bacteria in wet weather conditions.

Table 3-10. Subsurface Sewage Disposal Systems Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Strengthen municipal regulations regarding septic system inspection, maintenance, and repair/upgrade	Municipalities	0-2 years	Amended regulations	\$\$\$	NFWF Long Island Sound Futures Fund, CTDEEP Supplemental Environmental Project Funds, CTDEEP 319 NPS Grants
2. Provide homeowner outreach on septic systems	Municipalities, QVHD, CHD	2-5 years	Outreach materials provided or made available to homeowners	\$	Same as above

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

Table 3-11. Illicit Connections and Discharges Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Implement IDDE program consistent with new MS4 Permit · IDDE legal authority · Outfall mapping · IDDE Plan · Outfall screening and sampling · Catchment investigations and discharge removal projects · Education and outreach to municipal staff and the public	Watershed Municipalities, SCRCOG/NVCOG, consultants	2016-2022 (MS4 permit term)	Ordinance/legal mechanism, outfall map IDDE Plan, outfall screening and sampling results	\$\$\$\$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies can be realized through participation in a regional stormwater coalition

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

SCRCOG = South Central Regional Council of Governments NVCOG = Naugatuck Valley Council of Governments

All of the watershed municipalities are subject to the requirements of the CTDEEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 Permit). The MS4 Permit regulates the quality of discharges from municipal storm drainage systems. The permit requires municipalities to implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the municipal storm drainage system, as well as sanctions to ensure compliance. This includes developing and implementing an Illicit Discharge Detection and Elimination (IDDE) program to systematically find and eliminate sources of non-stormwater discharges to its municipal separate storm sewer system and implement procedures to prevent such discharges. CTDOT is also subject to similar IDDE requirements under its own MS4 Permit, effective July 1, 2019.

Recommendations relative to eliminating illicit connections and discharges to the Mill River and its tributaries are summarized in *Table 3-11*.

Recommended Actions

- The watershed municipalities should implement IDDE programs as required by the MS4 Permit, including an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the regulated municipal separate storm sewer system and an IDDE program to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.
 - o Educate municipal staff and the public about illicit discharges and the importance of eliminating or avoiding such discharges.
 - o Implement priority stream cleanups identified by streamwalks and track down surveys.
 - o Conduct follow-up illicit discharge investigations at priority outfalls identified during stormwater outfall monitoring, streamwalks, and track down surveys.

3.4.8 Commercial and Industrial Land Use

Commercial and industrial land uses have the potential for higher potential pollutant loads due to the pollutant sources associated with commercial and industrial activities and the significant runoff generated from these highly impervious sites. Most of the commercial development in the watershed is located along the major transportation corridor, Route 10, and at the southern end of the watershed in New Haven. Industrial land use is primarily concentrated in New Haven along the lower Mill River.

Recommendations related to reducing the impacts from commercial and industrial land uses are summarized in *Table 3-12*.

Recommended Actions

- Conduct outreach to commercial, institutional, and industrial property owners in the watershed explaining how their activities contribute to the water quality impairments of the Mill River.
 - o Encourage large, institutional landowners, such as Quinnipiac University, to incorporate GI and LID into all campus renovations and planning initiatives
 - o Work with local schools to incorporate GI and LID into all planned renovation and improvement projects.
- Consider establishing or strengthening municipal ordinances requiring covered trash enclosures and frequent cleaning to reduce the bacteria load associated with dumpsters, consistent with the good housekeeping requirements in the CTDEEP industrial and commercial stormwater permit programs, which apply to certain categories of industrial facilities and to larger commercial sites such as

Table 3-12. Commercial, Institutional, and Industrial Land Use Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Conduct outreach to commercial and industrial property owners	Municipalities (as part of MS4 Permit outreach)	2016-2022 (MS4 permit term)	Outreach completed as documented in MS4 annual Reports	\$\$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
2. Establish or strengthen municipal ordinances requiring covered trash enclosures and frequent cleaning	Municipalities (as part of MS4 Permit IDDE Ordinance)	2016-2022 (MS4 permit term)	New or modified ordinance or other enforceable regulatory mechanism	\$\$	
3. Strengthen CTDEEP inspection and enforcement of commercial and industrial facilities covered under the CTDEEP stormwater general permit programs	CTDEEP	2-5 years	Facility compliance reviews/ inspections and followup actions to address deficiencies	\$\$\$	CTDEEP
4. Review commercial and industrial facilities to identify sites that need coverage under the CTDEEP stormwater permit programs	CFE/SAVE THE SOUND, CTDEEP	2-5 years	Non-compliant sites identified and notified	\$\$	
5. Ensure reissued NPDES industrial water discharge permits contain provisions for TMDL implementation, LID, runoff volume reduction, and water quality protection	CFE/SAVE THE SOUND	Ongoing as draft permits are reissued	Comments submitted on CTDEEP draft permits	\$	
6. Promote green infrastructure for redevelopment of commercial, institutional, and industrial sites, including contaminated sites, institutions, and schools	City of New Haven and other watershed municipalities	Ongoing	GI requirements for large-scale commercial and industrial development parcels	\$\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

GNHWPCA = Greater New Haven Water Pollution Control Authority CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment

CTDEEP = Connecticut Department of Energy and Environmental Protection

Commercial and Industrial Land Uses in the Mill River Watershed

The commercial areas along Route 10 (below, left) contain multiple parking areas which constitute a large amount of impervious cover in the Middle Mill River subwatershed. Runoff from these areas drains to the Mill River with little or no riparian buffer to slow stormwater or filter pollutants.

Likewise, the commercial and industrial sites in the Lower Mill River subwatershed in New Haven (such as the salt storage facility shown below, right) have large amounts of impervious cover and discharge stormwater directly to the Mill River, with little or no natural vegetation along the river. Stormwater discharges from many of these industrial sites are regulated under the CTDEEP General Permit for the Discharge of Stormwater Associated with Industrial Activities, which require good housekeeping and source control best management practices.

These primarily privately-owned commercial and industrial sites throughout the watershed should also be the focus of green infrastructure (GI) retrofits or large-scale GI implementation during future redevelopment. Stream buffer restoration should also be promoted wherever possible



shopping centers. Leaking dumpsters can be a major source of fecal indicator bacteria during wet weather. Include dumpster and trash management issues in commercial and industrial outreach.

- Strengthen CTDEEP inspection and enforcement of commercial and industrial facilities in the watershed that are regulated under the CTDEEP industrial and commercial stormwater permit programs, particularly those facilities that are located adjacent to the Mill River or its tributaries.
- Review the commercial and industrial facilities in the watershed to identify sites that are subject to the CTDEEP industrial and commercial stormwater permit programs, but that are not currently registered.
- Ensure that reissued NPDES industrial water discharge permits in the watershed contain provisions for TMDL implementation, LID, runoff volume reduction, and water quality protection.

- Ensure that facilities with potential stormwater pollutant sources practice proper management and containment for water quality protection. E.g., ensure that the salt pile adjacent to the Lower Mill River at Chapel Street is properly covered.
- Cleanup and promote sustainable re-use of contaminated sites including the use of green infrastructure.

3.4.9 Wildlife and Pet Waste

Wildlife and domesticated animals within the Mill River watershed are a source of fecal indicator bacteria that can significantly impact stream water quality and be extremely difficult to control. Fecal material can be deposited directly into waterbodies, as well as from stormwater and dry-weather washing of feces deposited on the ground into storm sewers and receiving waters (ASCE, 2014). Domesticated animals (dogs and cats) and wildlife such as birds, raccoons, and rodents can be significant contributors, particularly in urban areas where open space corridors have been preserved along waterways, such as East Rock Park and Criscuolo Park in the lower Mill River, and Sleeping Giant State Park in the middle Mill River, as well as other parks, golf courses (e.g., New Haven Country Club), commercial areas, and cemeteries near waterbodies in the watershed.

Existing bans on feeding of waterfowl and pet waste (i.e., “pooper scooper”) ordinances are difficult to enforce. Furthermore, there are no easy solutions to nuisance waterfowl problems. Canada geese are persistent when they have become habituated to an area (CTDEEP, 2011). A more effective nuisance waterfowl control strategy is needed, focusing on education and outreach and other proven control methods.

Recommendations related to wildlife and pet waste are summarized in *Table 3-13*.

Recommended Actions

- Continue waterfowl deterrent efforts – habitat modification and barriers/exclusion methods – to reduce feeding of waterfowl by the public, waterfowl nesting, and terrestrial waterfowl habitat in the watershed. Creation of a vegetated buffer along ponds or streams as a form of habitat modification (to disrupt travel and sight lines) is the preferred deterrent method since it also provides water quality benefits.
- Existing regulatory controls prohibiting the feeding of waterfowl should be augmented through additional and/or more effective signage in public parks including the potential for fines. Signage should emphasize that feeding of waterfowl such as ducks, geese, and swans is harmful to their health. People feed geese and other waterfowl because they love them; emphasizing protection of waterfowl health is often the most effective strategy.
- Provide pet waste bag dispensers and disposal cans at high-use areas and conveniently spaced intervals on trails and in open space areas. Provide park and trail signs regarding pet waste disposal requirements and leash laws at the disposal cans. Consider allowing advertising on signs placed at pet waste bag dispensers and disposal cans to partially offset the cost (e.g., Poo Free Parks®). Allow natural vegetated buffers to grow alongside streams to deter pet access. Provide educational materials regarding the impact of improperly disposed pet waste. These materials should be made available in locations such as pet stores, animal shelters, veterinary offices, and other sites frequented by pet owners.

Table 3-13. Wildlife and Pet Waste Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Continue waterfowl deterrent efforts - Physical barriers - Regulatory controls - Signage - Educational programs	Municipalities (as part of MS4 Permit compliance)	2016-2022 (MS4 permit term)	Waterfowl programs implemented	\$\$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
2. Implement and enforce pet waste programs - Provide bag dispensers and disposal cans - Provide park and trail signage - Allow natural buffers to grow - Provide educational materials - Provide and maintain off-leash dog parks	Municipalities (as part of MS4 Permit compliance)	2016-2022 (MS4 permit term)	Pet waste programs implemented	\$\$	
3. Implement stormwater Best Management Practices (BMPs) at animal shelters or kennel facilities.	Municipalities (as part of MS4 Permit compliance)	2016-2022 (MS4 permit term)	Review of facility operations and BMPs implemented	\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

- Provide and properly maintain off-leash dog parks, preferably at locations that do not directly drain to receiving waters. Improperly managed dog parks can become a source of bacteria.
- Work with the watershed municipalities to ensure that their IDDE ordinances (required under the MS4 permit) include a clause regarding proper waste management and stormwater runoff control from pet shelters, kennels, and other animal-focused facilities. Animal waste, animal washing, or other animal handling activities can introduce bacteria, excess nutrients, soaps, chemicals, or sediment into waterbodies.

3.4.10 Natural Stream Buffers

Stream buffers are naturally vegetated areas adjacent to streams, ponds, and wetlands. Stream buffers help encourage infiltration of rainfall and runoff, and provide absorption for high stream flows, which helps reduce flooding and drought. The buffer area provides a living “cushion” between upland land use and water, protecting water quality, the hydrologic regime of the waterway and stream structure. Naturally vegetated buffers filter out pollutants, capture sediment, regulate stream water temperature and process many contaminants through vegetative uptake. The vegetative community of stream buffers provides habitat for plants and animals, many of which are dependent on riparian habitat features for survival. Changes to the natural riparian buffer zone can reduce the effectiveness of the buffer and contribute to water quality impairment.

An objective of this plan is to protect and restore degraded stream buffers in the watershed to enhance water quality. Recommendations related to stream buffers for water quality purposes are summarized in *Table 3-14*. Related recommendations for protection and restoration of riparian habitat, including in-stream habitat, are addressed in *Section 3* of this plan.

Geese Deterrent Methods (CTDEEP, Wildlife Division, 2009)

Habitat Modification: As long as favorable habitat is available, geese will be attracted to an area. Plant unpalatable vegetation, such as pachysandra to replace some of the mowed lawn. Allow grass to grow tall which makes it unpalatable to the geese. Plant hedges, shrubs, or visual barriers between feeding areas and water. Be sure the geese are not being fed artificially by people.

Barriers and Exclusion Methods: Low fences are very effective at keeping geese from lawns especially during June and July when geese have molted their flight feathers and are unable to fly. A 3-foot high chicken wire or weld wire fence should be used. Soft or hard nylon fences are also potential barriers.



Credit: Joseph Gerhard – Mill River, *Manton*
Westwood Books, New Haven, CT, 2011

Recommended Actions

- Encourage the creation of backyard buffers in residential areas near stream corridors, including the importance of maintaining healthy vegetated buffers to streams, ponds, and wetlands, and recognize the efforts of the public.
 - o Educate homeowners about the value and importance of stream buffers by building on existing stream buffer outreach and educational programming (e.g., public recognition programs for cooperating landowners, *Streamside Landowners' Guide to the Quinnipiac Greenway*, Audubon's backyard program, and programs from the EPA- Long Island Sound Study and Connecticut Sea Grant).
- Prioritize and implement any buffer restoration projects identified during streamwalks.
 - o Focus efforts on publicly-owned, high-profile sites such as existing parks or golf courses along the Mill River, as well as smaller tributaries, ponds, and lakes. Future streamwalks and track down surveys will help to identify additional stream buffer restoration candidates.
 - o Potential buffer restoration approaches for the watershed include installation of new buffers, widening existing buffers, invasive species removal/management, and tree planting/reforestation.
 - o Engage volunteers in riparian buffer implementation projects.
 - o Further evaluate the feasibility of buffer restoration at specific sites based on consideration of site-specific factors including site access, available land area, land ownership, soil conditions, appropriate buffer width, and native plant species.
- Provide stream buffer protection through aggressive implementation and enforcement of 100-foot setback zones in local Inland Wetlands and Watercourses regulations. Consider modifying existing land use regulations to incorporate incentives for developers to restore or establish vegetative buffers as part of new development or redevelopment.
- Ensure there are sufficient stream buffers along the limited agricultural lands (including nursery operations) in the middle and upper Mill River watershed (primarily in Hamden, Cheshire, and Wallingford). Focusing agricultural BMPs to improve buffer areas around streams will reduce the volume and improve the quality of stormwater runoff from the farm before it enters the stream. Other related conservation practices that should be considered for these farms include vegetated filter strips, stream habitat improvement and protection, and streambank protection projects. The USDA Natural Resources Conservation Service (NRCS) National Water Quality Initiative offers financial and technical assistance to farmers and forest landowners interested in improving water quality and aquatic habitats in priority watersheds with impaired streams.

Degraded Stream Buffers

Examples of degraded stream buffers along the Lower Mill River in New Haven: Criscuolo Park (top) and vicinity of Humphrey Street and Mill River Street (bottom).



Table 3-14. Stream Buffer Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Encourage backyard stream buffers · Provide homeowner education by building on existing materials and programs	Municipalities (as part of MS4 Permit compliance), CFE/SAVE THE SOUND	Ongoing	Educational materials disseminated	\$\$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
2. Implement priority buffer restoration projects	Municipalities, CFE/SAVE THE SOUND	Ongoing	Priority projects identified, funding secured, projects completed	\$\$\$	
3. Aggressively implement and enforce 100-foot setback zones in local Inland Wetlands and Watercourses regulations	Municipalities	Ongoing	Modified or updated land use regulations	\$\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment

3.5 Habitat Protection and Restoration

Goal Statement: Protect and restore terrestrial, streamside, and aquatic habitat.

Table 3-15 summarizes habitat protection and restoration recommendations for the Mill River watershed.

3.5.1 Protect and Restore In-Stream Habitat

Numerous man-made impoundments, most notably the Lake Whitney Dam, have altered in-stream and riparian habitat and restricted fish migration throughout the watershed. Of the approximately 22 dams in the watershed, most are located in the northern part of the watershed, in Hamden, with a few each in the towns of Cheshire and Wallingford. Five of the dams are located on the main stem of the Mill River. No known dams are located on Willow brook, however fish passage to Willow Brook is restricted by downstream obstacles on the Mill River.

Other issues that affect in-stream habitat in the Mill River watershed include elevated stream temperatures due to a lack of stream shading and inputs of stormwater runoff and numerous culverts on smaller streams that impede resident fish migration.

Recommended Actions

- Conduct a stream crossing (culvert and bridge) survey of the Mill River watershed for anadromous and resident fish species to identify and prioritize barriers to fish passage and opportunities for restoring fish passage. The survey should focus on areas of the watershed that have not yet been assessed, and should follow standardized protocols developed by the North Atlantic Aquatic Connectivity Collaborative <https://www.streamcontinuity.org/>.
- Revise local storm drainage design standards such that new or modified stream crossings are designed following the *Connecticut Stream Crossing Guidelines* (CTDEEP, 2008).
- Implement priority stream restoration projects identified during streamwalks and track down surveys. Address areas of stream erosion and sedimentation using appropriate bioengineering and habitat-sensitive measures.

3.5.2 Protect and Restore Forested Areas and Tree Canopy

Forest cover, including natural forest soils with irregular topography, provides numerous benefits at both the site and watershed scales. In addition to providing habitat for terrestrial and aquatic wildlife, watershed forest cover also reduces stormwater runoff and flooding, improves regional air quality, reduces stream and channel erosion, improves soil and water quality, and reduces summer air and water temperatures (USDA Forest Service, 2005).

Forested areas comprise approximately 44% of the Mill River watershed. The Willow Brook subwatershed, at the north end of the watershed, is the most heavily forested portion of the watershed, with much lower levels of tree canopy in the lower watershed. The following recommendations (summarized in Table 3-15)

Table 3-15. Habitat Protection and Restoration Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
In-Stream Habitat					
1. Conduct stream crossing surveys	CFE/SAVE THE SOUND, TNC	2-5 years	Completed surveys with prioritized recommendations	\$\$\$	Grant funding – NFWF
2. Revise local design standards for stream crossings	Municipalities	2-5 years	Revised standards	\$\$	
3. Implement priority stream restoration projects	CFE/SAVE THE SOUND, municipalities	5-10 years	Completed projects	\$\$\$\$	Grant funding – NFWF
Forested Areas and Tree Canopy					
4. Implement the tree canopy recommendations from the <i>New Haven Climate and Sustainability Framework</i> , including establishing a tree ordinance and standards for tree removal and replanting	New Haven, URI	5-10+ years	Tree ordinance, numeric or qualitative tree canopy goal and implementation criteria	\$\$\$	
5. Amend site development regulations and zoning	Municipalities, consultants	5-10 years	Amendments to local land use regulations and policies	\$\$\$	
6. Restore tree cover to tornado-damaged areas of Sleeping Giant State Park	Hamden, URI, SGPA	0-10+ years	Restored canopy	\$\$\$	
7. Implement sustainable management practices in woodlands along utility corridors	United Illuminating, Municipalities, UConn	Ongoing	Use of BMPs for tree cutting along utility lines	\$\$\$\$	
8. Protect forested land through land acquisition and conservation easements	Municipalities	Ongoing	Area of forest land acquired or preserved	\$\$\$\$	
Invasive Plant Species					
9. Implement priority invasive species management projects identified during	CFE/Save the Sound, Municipalities, URI,	Ongoing	Completed projects	\$\$\$	

Table 3-15. Habitat Protection and Restoration Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
streamwalks and track down surveys	SGPA, Mill River Trail Advocates, land trusts				
10. Educate residents, facility maintenance personnel, landscapers and local nurseries, and land use commissions about non-native invasive species	Mill River Watershed Coordinator, CFE/Save the Sound, land trusts	5-10 years	Education events and materials, number of participants and audiences reached	\$\$	
11. Involve volunteers and neighborhood groups in invasive species removal	CFE/Save the Sound, Schools, land trusts, Mill River Trail Advocates, SGPA	Ongoing	Invasive species removal, number of sites or areas restored	\$\$\$	

\$ = \$0 to \$5,000 \$\$ = \$5,000 to \$10,000 \$\$\$ = \$10,000 to \$50,000 \$\$\$\$ = Greater than \$50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment TNC = The Nature Conservancy URI = Yale School of Forestry and Environmental Studies Urban Resources Initiative SGPA = Sleeping Giant Park Association

will help protect existing forested areas and enhance the tree canopy in the more urban areas of the watershed.

Recommended Actions

- In 2018, the City of New Haven released the *New Haven Climate and Sustainability Framework*, which highlights the unequal distribution of tree canopy across the city, with some neighborhoods having up to 60% tree canopy, while others have as little as 6%. As outlined in the framework plan, the City should create a tree ordinance to establish standards for tree removal and replanting and set goals for increased tree cover.
- In addition to establishing a tree ordinance, amend existing site development regulations and zoning codes to encourage tree retention and maintenance, restrict tree removal and limit clearing during development projects, and require landscaping and parking lot shading.
- In setting new tree planting goals, the City should continue to build upon the previous tree planting goal “Tree Haven 10K.” Efforts to enhance the tree canopy in New Haven, and throughout the watershed, should focus on parcels with no or little existing tree canopy, large amounts of impervious surfaces (such as former commercial and industrial sites), and proximity to the Mill River and its tributaries.
- Sleeping Giant State Park suffered significant tree damage from tornadoes in May, 2018. Unstable trees and debris should be removed and new tree cover established in the damaged areas to facilitate natural forest regeneration.
- Implement sustainable management practices in woodlands along utility corridors. Utility companies statewide, including The United Illuminating Company (UI), continue to implement tree and forest management programs to reduce the risk of tree-related storm damage to power lines. UI should implement Best Management Practices and strategies for storm-related utility line tree cutting. The “Stormwise” vegetation management initiative and research program led by UConn and the CT Agricultural Experiment Station, partnered with various stakeholders including UI and other utility companies, is identifying management strategies to reduce the risk of tree-related power and transportation disruptions during storms while sustaining trees and forested areas and protecting wetlands and water quality.
- Demonstrate the importance of trees and vegetation as a critical component of green infrastructure and the related water quality benefits through local tree canopy demonstration projects.
- Protect existing forested land through land acquisition and conservation easements.

3.5.3 Manage Invasive Plant Species

Native vegetation plays an important role in ecosystem biodiversity. Invasive plant species, which are mostly non-native plant species that successfully out-compete native plants, are prevalent throughout the watershed. The most common invasive plant species observed in the watershed include multiflora rose, Japanese knotweed, Norway maple, purple loosestrife, common reed, and Oriental or ornamental bittersweet. Invasive species removal efforts are ongoing at East Rock Park, Sleeping Giant State Park, and other parks and open space parcels throughout the watershed.

Recommended Actions

- Focus invasive species management efforts on site-specific and targeted stream corridor improvements identified during streamwalks and track down surveys. Focus on properties that are actively maintained with opportunity and interest for control since it is impractical to successfully control or eradicate invasive plant species on unmaintained sites.
- Educate residents, facility maintenance personnel, landscapers and local nurseries, and land use commissions about the negative effects of non-native invasive species, pathways of introduction, and alternatives to invasive ornamental plants.
- Involve volunteers and neighborhood groups in invasive species removal and stream corridor improvements.

4 Site-Specific Green Infrastructure Concepts

The site-specific green infrastructure retrofit concepts presented in this section are intended to serve as potential on-the-ground projects for future implementation. They also provide examples of the types of projects that could be implemented at similar sites throughout the watershed. It is important to note that the concepts presented in this section are examples of potential opportunities, yet do not reflect site-specific project designs. Individual project proponents (e.g., municipalities, private property owners, developers) are responsible for evaluating the ultimate feasibility of, as well as design and permitting for, these and similar site-specific concepts.

Preliminary, planning-level costs were estimated for the site-specific concepts presented in this section. These estimates are based upon unit costs derived from published sources, engineering experience, and the proposed concepts. Capital (construction, design, permitting, and contingency) and operation and maintenance costs are included in the estimates. *Appendix C* includes additional pricing information, including total annualized costs based on the anticipated design life of each green infrastructure practice, and a range of likely costs, reflecting the inherent uncertainty in these planning-level cost estimates.

In some cases, costs are presented for multiple alternative project approaches, for example, both a subsurface infiltration option and a pervious pavement option⁵. Subsurface infiltration chambers are a far more expensive option, but have the benefit of increased potential infiltration capacity in certain soils and the ability to accept stormwater that is already in an underground drainage system, whereas pervious pavement is limited to infiltrating surface flows. Pervious pavement also poses increased maintenance concerns over subsurface infiltration options, as the pavement can be damaged by snow removal operations and must be kept clean of silt and other fine materials that would clog the pavement and reduce its ability to infiltrate.

Where bioretention/rain gardens are recommended, pricing assumes the 'bioretention' rate (see *Appendix C*), which utilizes contracted labor for design and implementation. Simple rain gardens can also be constructed using volunteer labor for hand-digging and planting at reduced costs that would be more in line with the 'rain garden' pricing rate (see *Appendix C*).

Preliminary sizing calculations are also provided for each practice and are based on the goal of capturing and treating/infiltrating the water quality volume (WQV), generally defined as the first one-inch of runoff from the contributing drainage area. Approximate drainage areas are provided for each practice within the designs, along with the expected WQV to be generated from that drainage area.

The table in *Appendix C, Attachment D* contains information on site characteristics and potential green infrastructure opportunities for the other sites visited during the field inventories that were deemed to have good potential for green infrastructure retrofits.

⁵ Note that pervious pavement costs presented in the plan and in *Appendix C* are based upon a porous asphalt design. More decorative alternatives, such as pervious pavers, will have increased costs (see *Appendix C*).

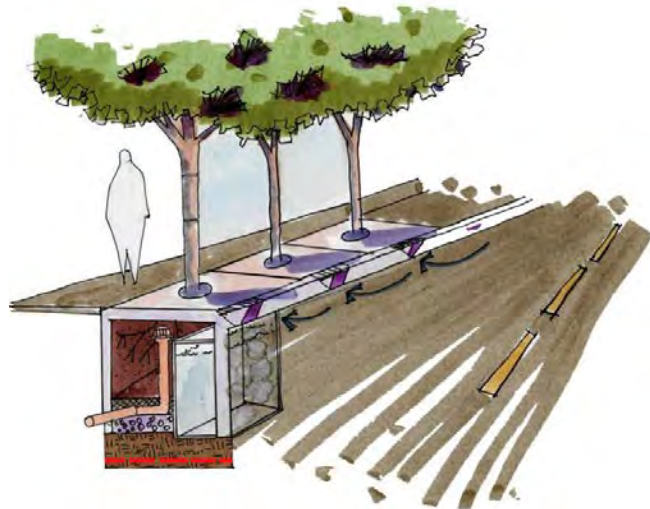
4.1 Elm City College Preparatory Elementary School

Located at 407 James Street, New Haven, Elm City Preparatory Elementary occupies an approximately 1.5-acre site at the corner of James Street and Lombard Street, in a CSO area (CSO #009). With the exception of a 0.25-acre artificial turf field, the site is entirely impervious. Existing catch basins capture parking lot runoff along the western edge of the lot. Downspouts from the building appear to be internal and to tie in to the drainage system at the downgradient catch basin before connecting to the City's stormwater infrastructure running along James Street. A broken curb at the west edge of the parking lot is currently allowing runoff to bypass the catch basins and travel down a short embankment to the sidewalk.

The sidewalk in front of the school along James Street is approximately 11 feet wide in most places. Planters with trees are incorporated into the sidewalk at 50 foot intervals; however, there is a tree missing directly in front of the school parking area.

Space is the most significant constraint at this site, as parking is tight and there is little impervious area. Existing street trees, a fire hydrant/water lines, and other utilities pose additional constraints. A variety of BMPs are recommended for this site in order to best achieve the following goals: maximize enhancement of curricular value in a limited space, maximize infiltration/treatment potential, and keep implementation costs manageable. These elements could be implemented all at once, or installed gradually as funding permits (total project costs will vary widely depending on which components are chosen).

- Tree Box Filter and Bioretention/Infiltration. A tree box filter and replacement tree are proposed for the location where a tree is currently missing. A tree box filter design with additional subsurface infiltration capacity is recommended. A curb cut from James Street would channel runoff from the street into the filter and infiltration system. It is also proposed to convert five feet of sidewalk directly adjacent to the street to bioretention areas or rain gardens with native grasses and other plantings. Additional curb cuts would direct water into these bioretention areas, which would also serve to enhance the landscape



Schematic of a typical tree box filter with underground storage capacity.

around the school. These bioretention areas could be integrated into the curriculum as demonstration sites to supplement lessons on science and the environment, and, of the BMPs proposed, would likely offer the greatest opportunity for interactive lessons (planting, maintenance, etc.). For ease of implementation and consistency with the proposed James Street design concept, the City could choose to implement their standard 5 foot by 15 foot bioswale design along the sidewalk at this location.

Estimated Cost for Tree Box Filter: \$9,000; Estimated Cost per Bioswale: \$20,000

- **Parking Lot Retrofits.** Subsurface infiltration and/or pervious pavement is proposed for the parking area to manage stormwater falling on the parking area as well as roof runoff captured by the school's gutters and downspouts.
 - o Based on available field data, using subsurface infiltration in the area adjacent to the turf play area would make it possible to intercept existing lines carrying downspout runoff and turf drainage without significantly reconfiguring these drainage systems (approximately 40,000 square feet of drainage area, and a Water Quality Volume (WQV), equal to the volume of water associated with the first 1 inch of runoff, of 3,200 cubic feet). A 1,100 square feet practice underneath the six parking spaces adjacent to the turf field would potentially allow for treatment of up to 4,150 cubic feet WQV. The existing downgradient catch basin located in the school's driveway would serve as overflow to allow any excess water to be conveyed to the storm sewer in James Street, as is currently occurring. Note that site-specific soil drainage characteristics may allow for effective use of pervious pavement without additional subsurface infrastructure, for a significantly reduced project cost (although this would make it more difficult and costly to accept stormwater from roof and turf drains and would therefore likely result in treatment of a significantly lower percentage of total site runoff). *Estimated Cost: \$108,000 (Subsurface infiltration); Estimated Cost: \$5,000 (Pervious Pavement)*
 - o To minimize costs, and to increase the variety of BMPs demonstrated on site, pervious pavement is proposed as the preferred option for the parking spaces parallel to James Street. Converting these spaces to pervious pavement would remove 2,500 square feet of pervious surface from the lot, and depending on the infiltration capacity of the soils and precise slope of the site, may be sufficient area to effectively infiltrate the roughly 800 cubic feet WQV of stormwater runoff expected from the entire 10,000 square feet main parking area, as the remainder of the surface slopes slightly to the west. *Estimated Cost: \$10,000*
- **Management of Dumpster Area.** The school's dumpsters are located in the southeast corner of the parking lot, at the top of a slope which drains to James Street. Dumpsters should always be kept closed to minimize exposure to stormwater. For additional protection, a containment system consisting of spill containment grooves could be incorporated into the pavement to further prevent pollutants from being carried into the storm drainage system. *Estimated Cost: \$0-\$1,000*

Total Estimated Cost: Approximately \$167,000; Variable, depending on components installed.

Elm City College Preparatory Elementary School

A mixture of bioretention plantings and tree box filters are proposed to replace part of the 11-foot wide sidewalks adjacent to the school parking lot (top). In the proposed conditions graphic, "CB" indicates existing catch basins. Blue arrows indicate existing surface flow patterns.



4.2 James Street

James Street was identified as a potential demonstration site for a “green streets” approach to stormwater retrofits in the road right-of-way. The site is proposed to begin at Elm City College Preparatory Elementary School (at Lombard Street), and continue south to Chapel Street. This portion of James Street represents a typical residential street in the Fair Haven neighborhood, an underserved area of New Haven. The street is also within the area served by CSO #009. In addition to providing stormwater runoff reduction and pollution control benefits, the proposed retrofits for James Street would also provide green space in the neighborhood and yield aesthetic benefits for residents. Specific siting considerations along James Street include the feasibility of working around existing utilities while simultaneously selecting sites with sufficient catchment area to justify installation costs. Bioswales or bump-outs must also be sited appropriately relative to existing catch basin infrastructure (i.e., bioswales should ideally be located right before a catch basin) in order to maximize capture of stormwater and facilitate returning overflows to the existing drainage system.

- Tree Box Filters. Additional tree box filters of the type proposed for Elm City Preparatory School are proposed for various locations along James Street. Obvious sites are locations where street trees are missing; one such site exists on the east side of James Street, immediately south of the Elm City Preparatory School. *Estimated Cost: \$9,000 per tree box filter*
- Bump-Outs or Curbside Bioswales. Two possible types of green infrastructure are proposed to provide bioretention along the length of James Street: bump-outs and curbside bioswales. Both are types of linear bioretention retrofit used alongside or within a public street, designed to collect and infiltrate/treat runoff from the adjacent roadway (see *Section 3.4.2* for examples of each). These practices consist of a stone storage layer, a soil layer designed to filter runoff, plantings, and curb cuts to allow runoff to enter and exit the system. Both bioswales and bump-outs are sized to capture and treat/infiltrate the water quality volume.
 - o Bioswales utilize space in the right of way, converting impervious area between the sidewalk and the street into bioretention. The City of New Haven is already installing bioswales throughout the downtown area and West River watershed, using a modified version of a bioswale design developed by New York City, which has a 5-foot by 15-foot footprint. At 75 square feet, this design can capture and treat approximately 276 cubic feet WQV. This is sufficient to capture the drainage from one side of an approximately 200 foot stretch of road. As with bump-outs, bioswales would be designed to accept stormwater from the street, using curb-cuts as an inlet, with existing downgradient catch basins serving to receive excess water from the BMPs' overflows.
 - o Bump-outs would replace a portion of the existing road shoulder with bioretention areas, utilizing “No Standing” zones near intersections to intercept stormwater runoff from the road. Bump-outs serve a dual purpose as traffic calming features, which can make residential streets more friendly to pedestrians and bicycles.

Bump-outs and bioswales could be used in combination along the length of James Street, or a single practice type could be repeated for a more uniform design. Pervious pavement may again be a less expensive alternative option, but would offer far fewer aesthetic benefits to the neighborhood. Several specific locations along James Street were identified as potential sites for BMP implementation in the public road right of way. In some instances, multiple potential addresses were noted in close proximity to one another (i.e., where drainage areas would overlap based on the 200 foot drainage area assumption). In these cases, the options should be evaluated during detailed site design to select the option with the least constraints or conflicts. Based on a preliminary assessment, locations shown in *Figure 8* represent locations suitable for bioswales in the public right of way.

Two additional opportunities were identified along James Street for more extensive BMP installations:

- At the southeast corner of James Street and Market Street, there is a large green parcel adjacent to the Market and James Street Farms, which is operated under the umbrella of New Haven Farms. The standardized BMPs described above could be implemented in the road right of way at this location; this site could also be proposed for a more extensive rain garden demonstration and education site.
- Rain gardens could be implemented at the condominium complex at the northeast corner of James Street and Grand Avenue, particularly at the southwest and northwest corners of the complex, although existing trees may impose siting constraints. The catch basins in the approximately 8,500 square feet parking lot could also be converted to infiltrating catch basins, with overflows being returned to the storm drain system via the existing infrastructure.

Estimated Cost: \$20,000 per Bioswale or Bump-out (lower unit pricing may be available when multiple practices are installed together; see notes in Appendix C)

Total Estimated Cost Assuming 1 Tree Box Filter and 13 Bump-Out/Bioswale Practices: \$263,000

Existing Conditions Along James Street

Typical existing conditions include degraded sidewalks and non-vegetated filter strips, some of which are proposed for conversion to bioretention practices. The images below highlight possible locations for bioretention practices in the right of way along James Street.



Proposed Green Infrastructure Retrofits for James Street

Repeating bioswales and/or bump-outs, are proposed for the public right of way, community garden, and condo complex along the length of James Street at or near the marked locations. These practices will capture and treat stormwater, reduce runoff, and transform the aesthetics of the street. The inset image demonstrates a street-view rendering of the concept.



4.3 Mill River Trail, Haven and Exchange Street Green Infrastructure

The John S. Martinez School building is located on James Street, one block south of Wolcott Street, while the parking lot and athletic fields for the school are located one block north of the school, between Wolcott Street and Exchange Street. The Martinez School and the surrounding parcels are served by CSO #015, which discharges at the confluence of the Mill and Quinnipiac Rivers. Stormwater designs for the school and parking area median have previously been developed, and the design proposed at this location focuses on the north end of the property that has not yet received attention. The proposed project will convert four blocks of degraded roadway and vacant land into a linear trail park, create a parklet that incorporates Green Infrastructure adjacent to the playfields at John S. Martinez School, and expand the Mill River Trail Phase 1 currently under construction by the City of New Haven. Design features include:

- **Trash Clean-up:** The first step to any improvement at this site should be the engagement of community volunteers in removal of trash and debris located at the west edge of the site. This opportunity could also be used to grow interest in the site and discuss further improvement options with local residents and potential project partners.
- **Pavement Removal:** Removal of pavement from the portion of Exchange Street west of Haven Street and permanent conversion from automobile access to multi modal access. This would result in a nearly 9,000 square foot reduction of impervious surface, thereby reducing surface runoff and creating space for natural infiltration.
- **Integrated Stormwater Treatment:** The modification of the site will manage runoff from over 120,000 square feet of surrounding roadway and parking lots through 42,000 square feet of green



stormwater infrastructure (GSI) practices (22,000 square feet of bioretention and 20,000 square feet of pervious trail). This will divert over 3 million gallons of stormwater from the combined sewer system each year reducing a source of impairment for the Mill River. Additionally, the GSI installations will provide urban habitat refuge for birds and other pollinators. The Trail will ultimately link Long Island Sound to East Rock Park, which has been designated as an Important Bird Area by Audubon Connecticut and is one of the most important springtime landbird stopover areas in Connecticut, thereby expanding flora and fauna habitat and creating opportunities for a diverse species to flourish.

- Mill River Trail Phase 2: This will connect Phase 1 of the Mill River Trail (currently under construction) with the recently upgraded Criscuolo Park, creating a passive recreation greenway accessing western Fair Haven's two parks and adding significant bioretention capacity along Haven Street and Mill Street.

Estimated Cost: \$300,000

4.4 Wilbur Cross High School

Wilbur Cross High School is located in the East Rock neighborhood of New Haven, immediately west of the Mill River. Not including athletic facilities, the school and parking cover nearly 10 acres in the Lower Mill River subwatershed. The school lies immediately northwest of CSO #012, but the school building and parking areas addressed here are outside of the CSO area. The proposed concept focuses on the approximately 2-acre parking lot on the southeast side of the site, along with drainage from the main portion of the high school building. It is likely that the proposed design would also intercept surface flow from the adjacent tennis courts further to the east.

The existing parking lot features extra-long, numbered bus parking spaces along the northeast and east perimeters of the lot. The parking layout maximizes available locations for bus parking, but in doing so, the layout creates two large dead spaces where parking is prohibited (see text box), both of which are located in the northeast corner of the lot. Each of these locations coincides with the location of existing catch basins. A double catch basin in the corner of the lot is the most downgradient collection point and outfalls directly to the Mill River approximately 10 feet below the parking lot grade. Roof drainage from the east side of the building appears to be connected into the drainage system at the catch basin located in the middle of the eastern edge of the parking lot.

- Parking Lot Bioretention. Proposed retrofits include the removal of pavement from the two 'dead spaces' (approximately 830 square feet and 870 square feet) in the northeast corner of the lot and conversion to bioretention to accept surface flows across the parking lot. Of the 6,900 cubic feet WQV anticipated from the approximately 87,000 square feet parking lot, the two bioretention areas would treat up to up to 6,200 cubic feet (90%) of WQV.

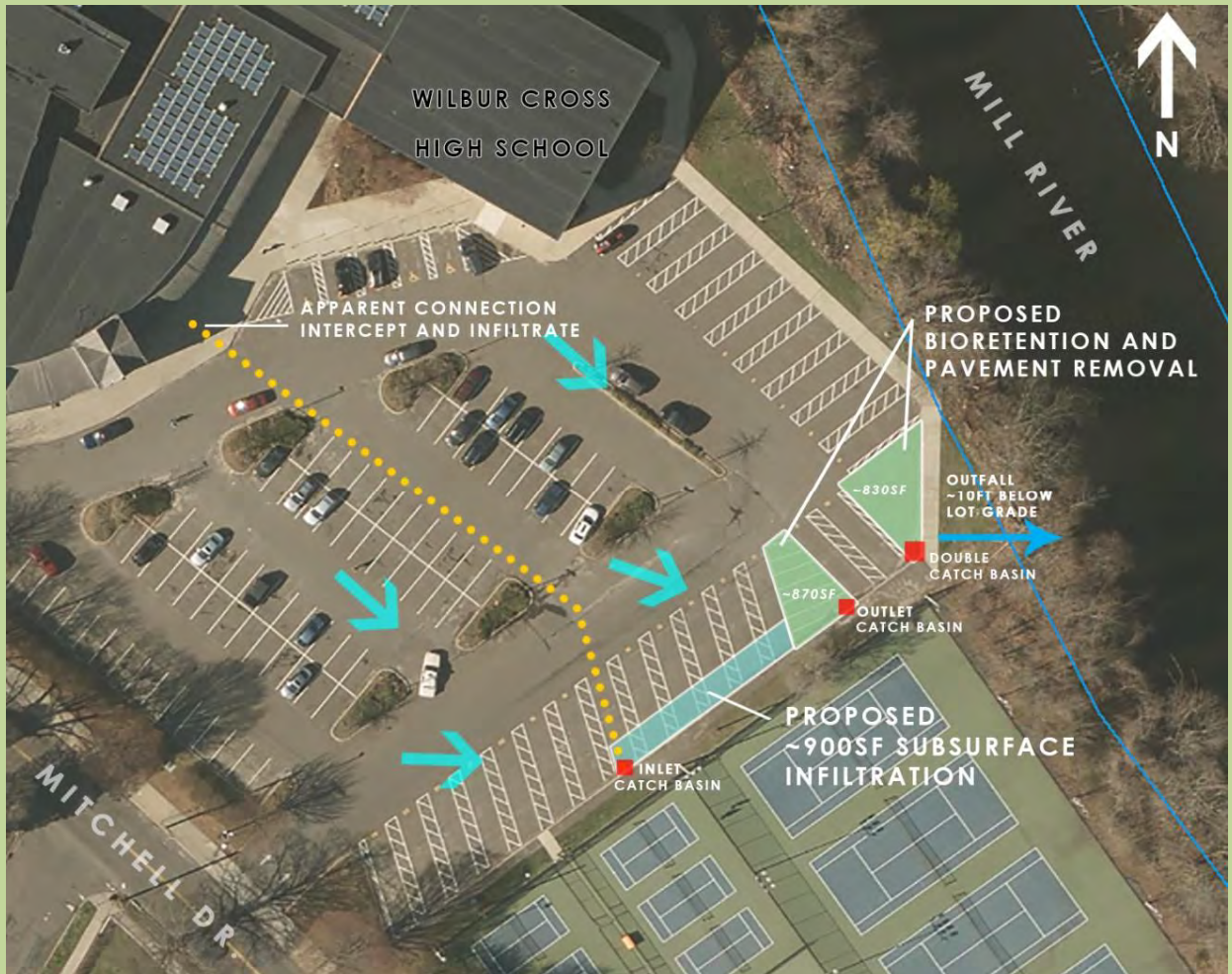
Estimated Cost: \$79,000

- Subsurface Infiltration. An additional 900 square feet of subsurface infiltration along the eastern edge of the lot would utilize the existing mid-lot catch basin as an inlet to intercept roof drainage from the approximately 44,000 square feet of building footprint, infiltrating up to 3,400 cubic feet WQV out of the approximately 3,500 cubic feet WQV expected. The next catch basin downgradient would serve as an outlet to channel excess water back into the drainage system, and the existing double catch basin would serve as an overflow outlet to the Mill River for the entire retrofit system. *Estimated Cost: \$89,000*

Total Estimated Cost: \$168,000

Proposed Versus Existing Conditions: Wilbur Cross High School

Proposed green infrastructure retrofits for Wilbur Cross High School (top) utilize the “dead spaces” where parking is prohibited amidst bus parking spaces to create bioretention areas. Subsurface infiltration chambers are also proposed to capture redirected roof drainage. In the top graphic, red squares indicate existing catch basins and blue arrows indicate existing surface flow patterns.



4.5 Livingston Street at East Rock Road

East Rock Park begins just south of Lake Whitney and follows the Mill River for over 1.5 miles. On the east side of the river, the park provides a buffer for the river that is generally wooded and at least 0.2 miles wide. On the west side of the river, the park is much narrower and less heavily wooded; the proposed concept focuses on this side of the park, particularly the borders of the park that follow Livingston Street and East Rock Road.

An existing walking trail follows the park edge along Livingston Street. Scattered catch basins along Livingston Street intercept flow from the street and carry it north toward East Rock Road. At East Rock Road, storm drains from Livingston Street join with the storm drain under East Rock Road and carry runoff east to the Mill River. The outfall for this system is located north of the East Rock Road bridge.

While the park occupies the land east of Livingston Street, the west side of the street is residential. Many downspouts appear to be connected to the drainage system, though others were disconnected.

- **Vegetated Infiltration Swale.** A short wooden fence runs along the east side of Livingston Street beginning at the intersection with Cold Spring Street and following the road northward for approximately 850 feet. A vegetated swale is proposed to promote infiltration along this stretch of Livingston, using curb cuts spaced along the swale to accept approximately 1,200 cubic feet WQV of stormwater from approximately 15,000 square feet of drainage area consisting of the northbound lane of Livingston Street. *Estimated Cost: \$61,000*
- **Bioretention Landscaping and Trail Enhancement.** A storm drain in the center of the intersection of Livingston Street and East Rock Road currently accepts stormwater flows from all four corners of the intersection, as well as flows from further west on East Rock Road. Two rain gardens/bioretention areas are proposed to accept stormwater from Livingston Street, East Rock Road, and East Rock Park Road via curbcuts located just upgradient of the existing catch basins.
 - One rain garden/bioretention area would be located on the northwest corner of the intersection (with approximate area of 250 square feet and capacity to capture and treat approximately 900 cubic feet WQV). The northwest rain garden/ bioretention area would serve a drainage area of approximately 10,000 square feet (800 cubic feet WQV), consisting of the north side of East Rock Road between Livingston Street and Everit Street, as well as a portion of the south side of East Rock Park Road. The BMP is proposed with an overflow structure that would carry excess stormwater back to one of the existing catch basins.
 - A second rain garden/ bioretention area on the southeast corner of the intersection (with approximate area of 300 square feet and capacity to capture and treat approximately 1,100 cubic feet WQV) would be located in existing open green space among trees to minimize root and tree impacts (see text box). Stormwater would enter the BMP from a curbcut located just south of the existing fire hydrant and upgradient of the existing catch basin on the east side of Livingston Road. The BMP would capture stormwater from the east side of Livingston Street from the mid-block catch basin to the curb cut, an area of approximately 14,000 square feet (1,100 cubic feet WQV). In order to preserve the existing trail, an ADA compliant boardwalk feature would allow pedestrians to connect from the corner sidewalk to the existing walking trail in the park, crossing over the rain garden/bioretention area. Additional interpretive signage would be added to the existing park sign already in place at the southeast corner of Livingston Street and East Rock Road to enable the stormwater features to serve as an

education and outreach site. The rain garden/bioretention area is proposed to contain an overflow structure that allows excess stormwater to sheetflow across vegetated land to the south and east.

- o *Estimated Cost: \$31,000 (consisting of \$26,000 for bioretention areas and \$5,000 for trail enhancement)*

Total Estimated Cost: \$92,000

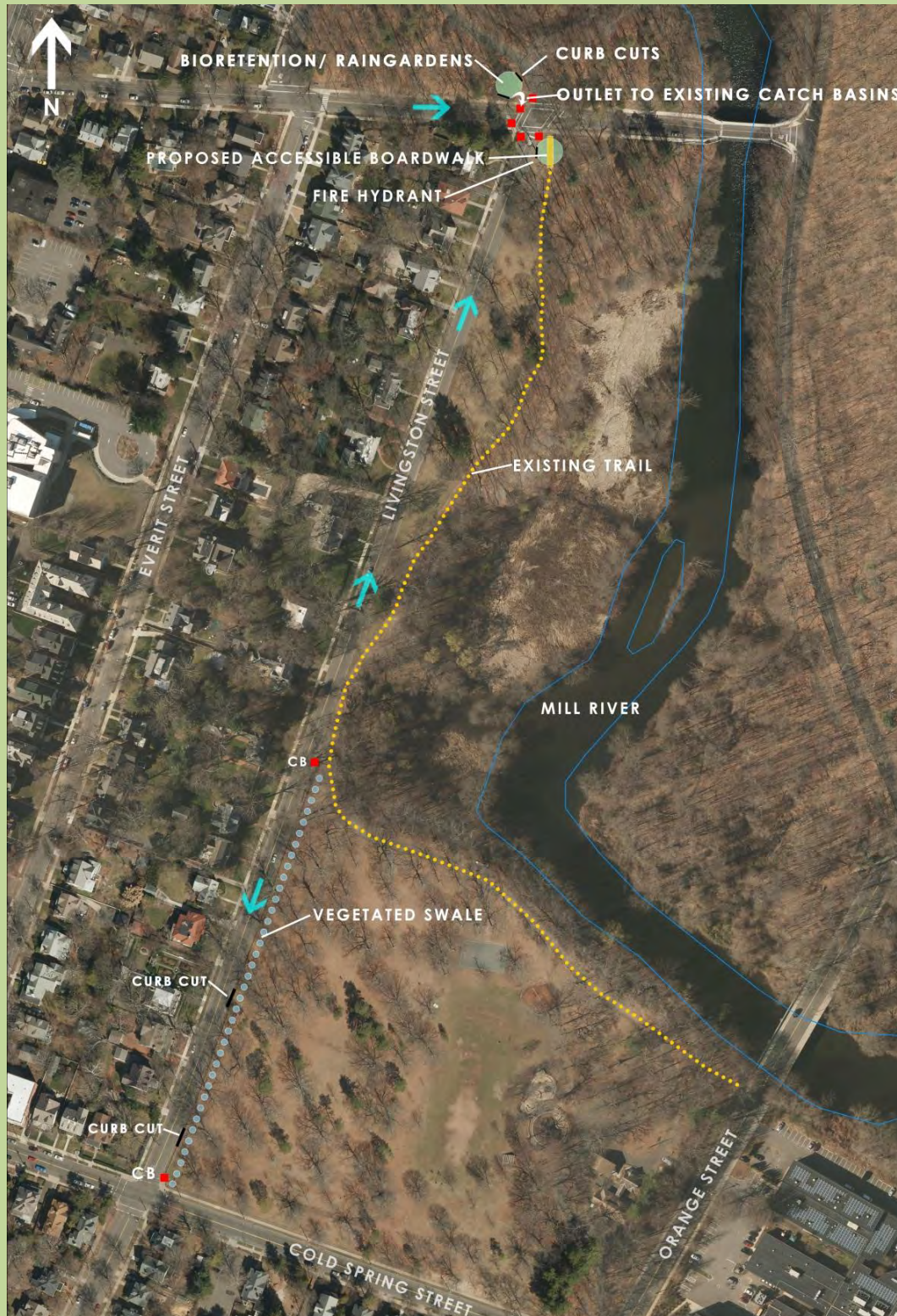
Livingston Street at East Rock Road: Existing Versus Proposed Conditions

Existing open space at the corner of Livingston and East Rock Road (top) is proposed for conversion to a raingarden/bioretention area with enhanced educational signage and an accessible boardwalk to connect the sidewalk with the existing pedestrian trail (bottom).



Green Infrastructure and Trail Enhancement: Livingston Street at East Rock Road

Proposed retrofits capture and treat stormwater drainage from portions of Livingston Street and East Rock Road, while simultaneously creating enhanced space for public outreach and education. In the graphic, red squares denote existing catch basins; blue arrows indicate existing surface flow patterns.



4.6 YNH Outpatient Services

The Yale New Haven Health System (YNHH) Outpatient Services facility is located on Sherman Avenue in Hamden, CT, on an approximately 2-acre site. Shepard Brook runs along the northeast edge of the property, and drainage from the site enters the brook approximately 2 miles upstream of its confluence with the Mill River.

The site is largely covered by impervious surfaces, including approximately 28,000 square feet of parking lot space spread between two lots, an approximately 8,000 square foot building footprint, and an additional 7,500 square feet of paved driveway. Most of the remaining space within the parcel is occupied by maintained lawn. Trees border the north and south edges of the site, forming a buffer with adjacent parcels. A few large trees line the west edge of the parcel, along Sherman Avenue. A parking lot island in the rear lot features mature trees and shrubs as well and provides some shade on the site. This island could potentially be converted to bioretention, however existing trees, sidewalks, and underground electrical located in the island would pose conflicts for such a conversion.

A series of catch basins are connected in the parking lot and carry stormwater away from Sherman Avenue and toward Shepard Brook. Downspouts from the YNH Outpatient facility are also connected to this storm drain system. The most downgradient catch basin was clogged with silt and debris during the field visit, indicating high sediment loads. Pooling in the vegetated area east of the site suggests a possible high water table, which may be contributing to pooling in the vicinity of the downgradient catch basin. Because of this, proposed BMPs are focused higher in the landscape, to ensure successful infiltration of stormwater.

Proposed Stormwater Retrofits at YNH Outpatient Services Facility

A combination of bioretention areas and pervious pavement are proposed to decrease Stormwater runoff and serve as a green infrastructure demonstration site for the Shepard Brook subwatershed in Hamden.



- **Parking Lot Retrofits.** Approximately 5,000 square feet of pervious pavement is proposed for the 23,000 square feet rear parking area, focusing on the spaces in the center of the parking lot, where stormwater runoff could be infiltrated before reaching the most downgradient catch basin in the northeast corner of the site. In addition to reducing impervious area on this portion of the site by approximately 20%, the pervious pavement will also accept stormwater flows from more westerly sections of the parking lot, as water flows to the northeast across the site. *Estimated Cost: \$20,000*
- **Front Lawn Retrofits.** The approximately 5,000 square feet front parking lot slopes toward the front lawn area, between Sherman Avenue and the front parking lot. This lawn area also appears to receive stormwater flows from an approximately 3,000 square feet area consisting of the northbound travel lane of Sherman Avenue as it approaches the driveway from the south, and the front portion of the YNH driveway. This yields a total WQV for this portion of the site of approximately 630 cubic feet. An approximately 200 square feet bioretention area (with approximate treatment capacity of 735 cubic feet WQV) is proposed for the bumpout portion of the front lawn, with curb cuts allowing stormwater to enter from both the parking area and the driveway. *Estimated Cost: \$10,000*
- **Main Lawn Retrofits.** Approximately 600 square feet of distributed bioretention/rain garden area is proposed for the main lawn. Approximately 400 square feet of linear bioretention (approximately 5 feet wide by 80 feet long) is proposed along the north edge of the lawn to capture stormwater from the approximately 4,500 square feet of driveway area between the two parking lots. An additional triangular rain garden/bioretention feature of approximately 200 square feet is proposed for the area adjacent to the sidewalk leading from the rear parking lot to the building. Downspouts from the north side of the 8,000 square feet building would be disconnected from the storm drain system and redirected to this area. Developing the bioretention area as a rain garden would provide a landscape feature on the site, and could be supplemented with interpretative signage for public education and outreach. This area could potentially be utilized as an outdoor gathering space, either for patients waiting for appointments or for staff on break. Lower maintenance bioretention designs are equally feasible on the site, and would require only periodic cleaning in addition to mowing, which is already occurring at the proposed location. *Estimated Cost: \$28,000*

Total Estimated Cost: \$58,000

4.7 Whitney High School North/West

Area Cooperative Educational Services (ACES) operates two special education programs out of its Whitney High School North and West campuses, located immediately west of the Mill River on Skiff Street in New Haven. The Whitney North/West campus is an approximately 5-acre site, which is nearly 100% impervious. Three buildings are located on the site, which slopes from Skiff Street down toward the south end of the site and also east toward the Mill River. Parking is terraced, as noted in the concept graphic below, creating three separate tiers along the north/south gradient.

Existing east-west oriented parking islands separate the tiers; these islands are narrow and steeply sloped, making them unlikely candidates for green infrastructure practices. Existing curb cuts at the ends of these islands carry water from one tier down to the next, with stormwater eventually flowing to catch basins along the southern edges of the parking areas. Downgradient catch basins are assumed to outfall directly to the Mill River, on the far side of a chain-link fence which follows the eastern edge of the parcel.

The southeast corner of the site, adjacent to the Staff Development Building, currently contains a raised bed garden area, picnic table, and composter. A gravel swale appears to carry excess stormwater from a low point in that area to the south edge of the site and toward the Mill River.

- **Parking Lot Retrofits and Bioretention.** A combination of subsurface infiltration, pervious pavement, and bioretention is proposed to reduce stormwater runoff from the extensive parking areas on the site and provide a variety of green infrastructure demonstration sites for curricular value.
 - o Approximately 14,500 square feet of pervious pavement is proposed in the front parking lot and upper and middle tier parking areas of the main lot to reduce impervious cover on the site and infiltrate runoff from the upper two tiers of parking. *Estimated Cost: \$58,000*
 - o Approximately 500 square feet of subsurface infiltration is proposed to be located behind the Staff Development Building, intercepting flow from the existing catch basins at the low end of the parking lot, infiltrating approximately 1,800 cubic feet WQV, and returning excess stormwater to the existing drainage system at the east end of the practice. This practice would be designed to capture drainage from an approximately 20,000 square feet area including the parking area surrounding the Staff Development Building and redirected drainage from the building (approximately 1,600 cubic feet of WQV). *Estimated Cost: \$47,000*
 - o Approximately 800 square feet of bioretention is proposed in the southeast-most corner of the parking lot, requiring the removal of two parking spaces (see textbox at right). Existing catch basins in this location would be raised to serve as overflow structures. A sediment forebay is proposed for the first bioretention cell (to be located in the existing parking area) in order to minimize required maintenance of

Whitney High School North/West

A bioretention area is proposed in the open, grassed area (top) to connect an existing swale with a sediment forebay proposed for a down-gradient corner of the parking lot (middle). Tiered parking areas (bottom) will feature pervious pavement to reduce runoff volumes and decrease impervious cover.



Proposed Green Infrastructure: Whitney High School North/West

A suite of green infrastructure practices are proposed for the school campus, including approximately 16,500sf of pervious pavement, a bioretention area, and subsurface infiltration chambers. In the graphic, "CB" indicates existing catch basins and blue arrows represent existing surface flow patterns.



the downgradient bioretention area. From the sediment forebay, water would flow to a landscape feature that winds through the existing picnic/garden area, avoiding existing trees, and connecting to the existing gravel swale. The bioretention area would accept water flowing down the campus driveway, as well as flow from the lower tier parking area, including any overflow from the upper tiers (approximately 1 acre of drainage area or 3,500 cubic feet of WQV). The bioretention system would be designed to capture approximately 3,000 cubic feet WQV. Building on existing uses in this area which appear to emphasize environmentally-friendly practices (e.g., composting, raised bed gardening), the bioretention system could provide educational opportunities for students and staff in the form of signage and/or curricular connections. *Estimated Cost: \$38,000*

Total Estimated Cost: \$143,000

4.8 Counter Weight Brewery, Spring Glen Nursery, & Raccio Park Road

Counter Weight Brewery is located along the south side of Raccio Park Road, within approximately 500 feet of Shepard Brook. The building and lot occupy approximately 1-acre, with the adjacent portion of Raccio Park Road and circular turnaround adding 0.25-acres of additional drainage area. The parcel between the brewery and Shepard Brook is occupied by Spring Glen Nursery.

The roof drains on the brewery building are currently connected to the storm drainage system. A series of five catch basins in the circle and along the eastern and southern edges of the property transport stormwater away from the site, presumably to an outfall on Shepard Brook. Note that while most of this site is mapped as B soils (good infiltration), the southern edge of the site is indicated to be D soils, so additional soil testing will be especially necessary at this site in order to more precisely determine the infiltration capacity of the soils.

Existing parking lots are in poor condition, and catch basins on site were clogged with silt and debris. Existing vegetated areas and parking islands on the brewery property do not appear to receive regular maintenance, whereas planting areas on the nursery property were obviously receiving regular care.



Existing plantings along Raccio Park Road between Counter Weight Brewery and Spring Glen Nursery.

- Bioretention Area/Rain Gardens. A series of bioretention areas/rain gardens are proposed for the site:
 - o A series of three distributed bioretention areas/rain gardens are proposed within Counter Weight Brewery's parking area. A 150 square foot bioretention area/rain garden is

proposed in the existing island bumpout at the northeast edge of the front parking lot; this practice would accommodate capture of approximately 550 cubic feet of WQV and would accept stormwater flows from a portion of the 7,500 square feet front parking lot (with associated 600 cubic feet of WQV). A second 100 square feet bioretention area is proposed in the existing island bump-out at the southeast edge of the front parking lot; this practice would accommodate approximately 370 cubic feet of WQV. In addition to accepting surface runoff from the front parking lot, this practice could potentially receive flow from redirected roof leaders. A third 75 square feet bioretention area/rain garden is proposed for the existing vegetated bumpout at the southeast corner of the building. This practice could accommodate approximately 275 cubic feet of WQV and would be designed to accept flow from redirected roof leaders, with a potential roof catchment area of approximately 4,500 square feet (354 cubic feet of WQV). Overflow from this bioretention area would be directed overland toward the existing catch basin and proposed pervious pavement (see below). *Estimated Cost: \$16,000 (assuming all three areas); costs for individual practices range from \$4,000 to \$7,000*

Proposed Green Infrastructure Retrofits for Counter Weight Brewery and Raccio Park Road
A partnership between Counter Weight Brewery and Spring Glen Nursery is proposed to enhance the aesthetic appeal of the commercial park on Raccio Park Road and decrease Stormwater runoff and pollutant loads into Shephard Brook.



- o A 200 square foot linear bioretention area along the southern edge of Raccio Park Road would accept stormwater runoff from the road via a curb cut on the western end of the feature, with the potential to capture and treat approximately 735 cubic feet of WQV. To increase the drainage area, the upgradient catch basin west of the practice should be closed off; this would direct approximately 5,500 square feet of drainage area to the practice (with corresponding 435 cubic feet of WQV). While the green space between the brewery and nursery driveways and the bumpout areas mentioned above are maintained with plantings, the existing green space between the road and the main brewery parking lot is unmaintained, so this feature could be designed either with landscape enhancement or minimal maintenance as the primary goal. The bioretention area would overflow to the existing downgradient catch basin adjacent to the Counter Weight Brewery driveway.

Estimated Cost: \$10,000

- **Parking Lot Retrofits.** Approximately 2,000 square feet of pervious pavement is proposed along the eastern edge of the parking lot to reduce impervious cover and intercept additional surface flows to the two existing catch basins at the edge of the lot. Approximately 28,000 square feet of impervious area drains toward this section of the parking lot, with corresponding 2,217 cubic feet WQV. The 7,500 square feet front parking area could also be converted to pervious pavement in the future if the lot is repaved. *Estimated Cost: \$8,000 (assuming 2,000 square feet); an additional \$30,000 would be required to convert the entire front lot to pervious pavement*
- **Maintain Existing Catch basins.** Some of the catch basins at the site were observed to be clogged with silt and other debris. Periodic clearing of this debris will maintain proper functioning of the existing system, decrease pollutant loads to the storm drain system, and reduce ponding in adjacent impervious areas. *Estimated Cost: minimal; use existing brewery staff labor or volunteers*

Total Estimated Cost: \$34,000 (\$64,000 including conversion of front lot to pervious pavement)

4.9 Bartlem Recreation Area

This large municipal park is located on CT 10 (South Main Street) in Cheshire, directly across from Cheshire High School. The site is owned by the Town of Cheshire and includes lacrosse, baseball, and soccer fields, as well as a covered swimming facility and multiple parking areas. Most of the stormwater from the site drains to an approximately 36-inch outfall at the southern end of the property. These parking areas and structures comprise approximately 5-acres of directly connected impervious cover on the site. An additional 1.75-acres of maintained athletic field area likely contributes surface flows to the storm sewer system during heavy rains.

Existing catch basins are located behind the swimming pool and appear to capture overflows from the pool decks as well as stormwater runoff. Additional catch basins are located in the northern parking lot, on either side of the driveway, and in the lawn between the baseball field and swimming pool parking lot. The catch basin located at the southwest corner of the swimming pool parking lot appears to be the most downgradient catch basin before stormwater outfalls into the Mill River. An existing gravel swale carries additional overland runoff from the baseball diamond, along the south edge of the ball field, into a catch basin located in the grass adjacent to the parking lot, and ultimately through the parking lot catch basin to the outfall.

- **Linear Bioretention.** An existing short fence runs along the north edge of the baseball field, creating a lawn area approximately 15 feet wide between the fence and the curbed driveway of the

recreation area. This space is currently utilized for event parking. Approximately 300 square feet of linear bioretention is proposed toward the east end of this space to treat stormwater runoff from the driveway while preserving as much parking as possible. A curb cut will allow stormwater to flow from the road (approximately 14,000 square feet of drainage area, with 1,100 cubic feet WQV) into the proposed bioretention before reaching the existing catch basin. As the landscape slopes slightly to the east, check dams are proposed as part of the design to slow the movement of water through the bioretention feature. The bioretention area can be designed to overflow either to the existing catch basin or the proposed water quality swale (below). *Estimated Cost: \$14,000*

Vegetated Water Quality Swale. A second linear feature (2,500 square feet) is proposed between the baseball field and the swimming pool parking lot, on top of the existing storm drainage pipes. Existing catch basins would be raised to serve as overflow structures during heavy rains, and a vegetated swale is proposed along the length of the parking lot to infiltrate surface runoff from the 44,000 square feet of uncurbed parking lot (with accompanying 3,500 cubic feet of WQV) and adjacent ball field (expected to generate, at minimum, an additional 350 cubic feet or more of WQV). Effectiveness of the swale could be further enhanced by re-grading the parking lot whenever it is next repaved to encourage stormwater to flow toward the swale. Drainage from the pool roof could potentially be directed toward the swale as well, although it was not clear from the site visit how pool roof drainage is currently handled. *Estimated cost: \$36,000*

Pervious Pavement. 15,000 square feet of pervious pavement is proposed for the middle two rows of parking in the north parking lot. This conversion to pervious pavement would reduce the impervious surface of the 50,000 square feet lot by nearly 30% and decrease the volume of stormwater inputs to the existing drainage system. *Estimated Cost: \$60,000*

Bioretention/Rain Garden. A bioretention area/rain garden and native planting area of up to 1,500 square feet is proposed for the lawn area between the circular drive in front of the swimming pool and the swimming pool parking lot. A curb cut in the circle would allow stormwater to flow into the rain garden, with the existing catch basin serving as an overflow to direct excess stormwater back into the drainage system. A 300 square feet bioretention area is proposed to capture and treat runoff from the approximately 12,000 square feet of impervious drainage area (approximately 950 cubic feet of WQV) that would connect to the BMP via the proposed curb cut in the circle. Remaining area in this planting island should be converted to native plantings. Due to its location

Existing Conditions: Bartlem Recreation Area
Existing catch basins at the edge of the swimming pool parking lot at Bartlem Recreation Area channel water to an outfall to the Mill River just east of the site (top). An approximately 15 foot wide strip of grass along the main driveway is used for parking during special events (bottom).



near the pool entrance, this would likely be the most visible location at which to include educational information about the full suite of proposed green infrastructure components suggested for the site. *Estimated Cost: \$14,000 (assuming 300 square feet of bioretention; additional funds (or plant donations) may be required for native plantings to fill the entire island)*

Total Estimated Cost: \$124,000

Proposed Conditions: Bartlem Recreation Area

Pervious pavement, bioretention/rain gardens, native plantings, and vegetated drainage swales are proposed to slow the flow of water across the site, decrease impervious area, and serve as demonstration sites for a variety of green infrastructure practices at a highly utilized community park. In the concept graphic, "CB" indicates existing catch basins; blue arrows depict existing surface flow patterns.



4.10 Strathmore Drive

Strathmore Drive

Strathmore Drive is located in a residential subdivision in Cheshire that lies just east of the Mill River, across the river from the Bartlem Recreation Area and south of Wallingford Road. An unnamed tributary of the Mill River winds through the neighborhood.

Green spaces were required to be created during the development of the subdivision. Two such sites are located on Strathmore Drive, between the two ends of Buttonwood Circle. A playground occupies the green space to the west side of Strathmore Drive; on the east side of the street, the existing green space consists of a semi-circular lawn area bordered by bermed planting areas that include mature evergreen trees and shrubs. Beyond the berms is another area of lawn that backs up to residential lawns from homes on Buttonwood Circle. To the southeast, this area meets up with a wooded buffer through which the unnamed tributary stream passes through the neighborhood. The area, including the lawn and bermed planting areas, is currently maintained by the Homeowner's Association via a landscaping contractor.

- Public Green Space Retrofit.
Although located adjacent to a high point on Strathmore Drive, the semi-circular lawn forms a natural bowl in the landscape, and could be converted to an approximately 500 square foot bioretention area to collect and infiltrate runoff from approximately 11,000 square feet of catchment area on Strathmore Drive and portions of Buttonwood Circle (with corresponding 900 cubic feet of WQV). Water could be redirected from catch basins on Strathmore



Existing public green space east of Strathmore Drive.

Drive that are located at each end of the green space and directed into the bioretention area to either infiltrate or ultimately be released back into the tributary stream via an overflow swale. More detailed site survey is necessary to confirm feasibility, but available contour/elevation data indicates between a 5% and 8% slope from the catch basin locations to the depression/proposed bioretention area. It may also be possible to direct roof leaders from houses that back up to the green space into the bioretention area. If desired, the bioretention area could be designed as a rain garden to enhance the existing landscape features of this space. *Estimated Cost: \$24,000*

Total Estimated Cost: \$24,000

Proposed Bioretention Area at Strathmore Drive

In the concept graphic, "CB" indicates existing catch basins; blue arrows represent existing surface flow patterns.



5 Pollutant Load Reductions

Pollutant load reductions were estimated for the watershed plan recommendations for which pollutant loads can be reasonably quantified. Load reductions were calculated using the Watershed Treatment Model (WTM), a screening-level land use pollutant loading model, and a loading calculation known as the Simple Method (Schueler, 1987), both of which are described in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b). Anticipated pollutant load reductions associated with ongoing and future CSO abatement efforts are based on the GNHWPCA 2015 *Hydraulic Model Update* (CH2MHILL 2015).

Annual pollutant loads were estimated for the management actions described below. Predicted load reductions were calculated relative to the existing, baseline pollutant loads, which are presented in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b).

- **CSO Abatement.** Existing conditions (2017) pollutant loads reflect recent and ongoing improvements to the overflow weirs at CSO 009 and 012, and completed sewer separation at CSO 011. Two future CSO abatement scenarios were considered, consistent with the phased implementation of the GNHWPCA Long Term Control Plan for CSO discharges to the Mill River. Improvements remaining to be made under the Long Term Control Plan include sewer separation at CSO 009, and installation of a CSO storage tank at CSO 011. These improvements are ultimately predicted to reduce annual CSO volumes and the number of CSO events in a typical year to a condition of zero discharge for up to the 2-year, 6-hour rainfall event. These improvements are expected to be completed by 2036 (i.e., Long Term Control Plan – 2036 Conditions). The following table summarizes the existing and modeled Mill River CSO volumes and number of CSO events for typical year conditions⁶.

Table 5-1. Existing and Modeled CSO Conditions

Scenario	Mill River CSO Volume (Million Gallons)	Mill River CSO Events
2017 Existing Conditions (Based on Meter Data)	4.86	43
Short Term Control Plan – 2018 Modeled Conditions	4.82	12
Long Term Control Plan – 2036 Modeled Conditions	0.00	0

- **Green Infrastructure.** Continued implementation of green infrastructure is recommended throughout the watershed. Green infrastructure should continue to be implemented through retrofits of existing developed sites and roads (i.e., complete streets), and as part of new public and private development and redevelopment in the watershed, as required by existing and future land use regulations and policies. Potential pollutant load and runoff reductions were estimated for the following types of green infrastructure practices and land use settings:
 - o Implementation of proposed green infrastructure projects detailed in this report
 - o Roof leader disconnection and bioretention on commercial, institutional, and industrial land
 - o Rain barrels and roof leader disconnection on residential properties

⁶ Typical year conditions are defined as 40.63 inches of total rainfall per year, peak 15-minute intensity of 3.16 inches per hour, and 114 rainfall events per year (*Hydraulic Model Update*, CH2MHILL, 2015).

Multiple scenarios were modeled to estimate the effect of varying levels of green infrastructure implementation across the watershed, including estimates for retrofitting 10%, 25%, 50%, and 100% of the impervious area watershed-wide. The modeled effectiveness of the proposed retrofits was reduced to reflect system maintenance and design (system bypass during larger storms) factors.

- **Public Education.** Nonpoint source education programs can change behaviors that affect pollutant loads. Pollutant load reductions were estimated for pet waste education programs based on the number of dwellings, average fraction of pet-owners, pet-owners who already clean up after their pets, and average fraction willing to change their behavior. Conservative model assumptions were used to avoid over-estimating the load reduction benefits of these programs.
- **Illicit Discharge Detection and Elimination.** Illicit stormwater connection removal was considered in each subwatershed based on the existing estimated number of illicit connections associated with commercial and residential land uses. The illicit connection removal scenario conservatively assumes that 30% of the existing illicit discharges are detected and eliminated.
- **Septic System Repairs.** Septic system repairs were considered in each subwatershed based on the existing estimated number of households served by septic systems. The septic system repair scenario assumes that 20% of the failing septic systems are repaired. This scenario reflects short or mid-term recommendations to address existing failing or malfunctioning septic systems.

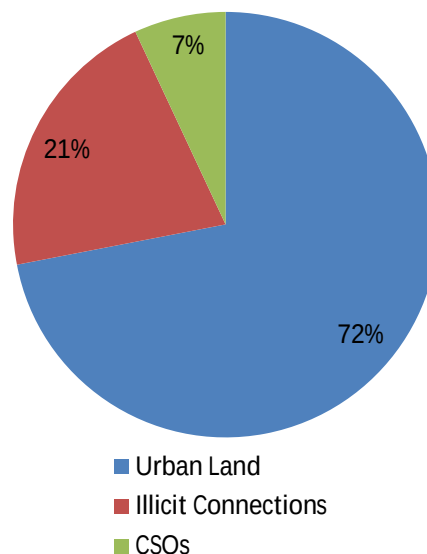
Other watershed management recommendations identified in this plan were not quantified due to the inherent limitations of screening-level pollutant load models and/or the lack of reliable information on the pollutant removal effectiveness of certain management measures.

Existing Pollutant Loads

Annual average pollutant loads for total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), total fecal coliform (FC) bacteria, and average annual runoff volume were estimated for existing conditions and future conditions assuming implementation of the watershed based plan recommendations described in the above scenarios. Existing conditions pollutant loads are described in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b), a copy of which is provided as *Appendix A* of this plan.

Although pollutant loads were estimated for nutrients, sediment, and fecal indicator bacteria, the focus of discussion for the remainder of this section is on fecal indicator bacteria, which is the primary cause of water quality impairments in the Mill River watershed.

Nonpoint source runoff accounts for approximately 72% of the modeled existing annual bacteria load to the Mill River, CSOs account for approximately 7%, and estimated illicit connections account for approximately 21% (see chart at right). It is important to note that these percentages reflect *modeled* loads based on recent and



Relative composition of annual fecal indicator bacteria loads to the Mill River.

proposed CSO improvements in the Mill River watershed. As indicated in Section 3.2.2, continued CSO flow monitoring is recommended to verify modeled pollutant loads.

Pollutant Load Reductions

Table 5-2 summarizes the anticipated pollutant load reductions for the plan recommendations for which pollutant loads can be reasonably quantified. The load reduction values presented in *Table 5-2* are for the overall Mill River watershed. Load reduction summaries for individual green infrastructure projects are provided in *Appendix F*; larger projects are broken down into individual BMP recommendations.

As indicated in *Table 5-2*, the watershed plan recommendations are predicted to result in an approximately 17% reduction in annual fecal indicator bacteria loads for the entire Mill River watershed under the Long Term Control Plan 2036 CSO abatement scenario and assuming implementation of green infrastructure for 10% of the impervious area in the watershed as well as the project designs presented in this plan. Of this 17% reduction, approximately 7% is attributable to CSO abatement, approximately 3.5% to green infrastructure, approximately 6% to elimination of illicit discharges, and the remainder to other structural and non-structural nonpoint source pollution control measures.

Varying levels of green infrastructure implementation across the watershed were modeled, including the use of green infrastructure to manage runoff from 10%, 25%, 50%, and 100% of the impervious area in residential, industrial, commercial, institutional, and transportation land uses. The results for the 10% scenario, which is considered a reasonable likely future scenario, are included in *Table 5-2*. The results for all four scenarios are presented in *Table 5-3*. The 10% retrofit scenario is predicted to result in an approximately 3% reduction in annual fecal indicator bacteria loads and 4% reduction in annual runoff volume. Higher bacteria load reductions (up to approximately 33%) could potentially be achieved by implementing green infrastructure over a larger percentage of the watershed.

Table 5-2. Modeled Annual Pollutant Load Reductions

Watershed Management Recommendation	Fecal Coliform (billion/year)	Fecal Coliform (%)	Runoff Volume (acre-feet/year)	Runoff Volume (%)
CSO Abatement (2036 levels)	187,395	6.7%	--	--
Green Infrastructure (10% of impervious area)	112,834	5.6%	1,481	4.0%
Implement all 10 GI Concepts	5,322	0.3%	84	0.2%
Public Education	14,005	0.5%	--	--
Illicit Discharge Detection and Elimination (IDDE)	174,831	6.3%	--	--
Septic Repair	383	0.01%	--	--
<i>Total</i>	473,621	17.0%	1,565	4.2%

Illicit discharge detection and elimination (IDDE) is predicted to result in annual bacteria load reductions nearly twice that of the 10% green infrastructure scenario. Even the modest 30% removal rate assumed in the model is predicted to achieve an approximately 6% reduction in annual fecal indicator bacteria loads. IDDE is also significantly more cost-effective than implementing structural stormwater retrofits, and is supported through the requirements of the CTDEEP MS4 Permit. Dry weather sources of fecal indicator bacteria are the most likely to be identified and effectively managed and more likely to include human sources. Wet weather

bacteria sources are often very costly to address and stream standards can be difficult to attain, particularly with the presence of CSOs. IDDE and other source controls focusing on dry weather bacteria sources should be aggressively implemented through municipal stormwater management programs (as required by the MS4 permit) in conjunction with green infrastructure for wet weather sources.

Table 5-3. Modeled Annual Pollutant Load Reductions for Varying Levels of Green Infrastructure Implementation

Green Infrastructure Implementation Scenario	Fecal Coliform (billion/year)	Fecal Coliform (%)	Runoff Volume (acre-feet/year)	Runoff Volume (%)
Retrofit 10% of Impervious Area	112,834	5.6%	1,481	4.0%
Retrofit 25% of Impervious Area	282,084	14.1%	3,703	10.0%
Retrofit 50% of Impervious Area	564,169	28.2%	7,407	20.0%
Retrofit 100% of Impervious Area	1,128,337	56.4%	14,813	40.0%

How Much will the Watershed Plan Recommendations Improve Water Quality?

The primary objective of this watershed plan is to address the water quality impairments in the Mill River and thereby restore the recreational uses and aquatic habitat that have been affected by poor water quality. The pollutant load evaluation suggests that significant pollutant load and runoff reductions could be achieved by implementing the plan recommendations. Implementation of the watershed management recommendations is predicted to result in an approximately 17% to 47% reduction in annual fecal indicator bacteria loads to the Mill River.

However, even if the watershed plan recommendations are fully implemented, the 47% reduction in annual fecal indicator bacteria loads will not fully satisfy the Total Maximum Daily Load (TMDL) requirements for fecal indicator bacteria reductions prescribed to restore recreation and aquatic life uses in the impaired segments of the Mill River. The TMDL analysis for fecal indicator bacteria was completed for the impaired segment of the Mill River and for Shepard Brook as part of CTDEEP's Statewide Bacteria TMDL. A TMDL is a "pollution budget" that identifies the reductions in point and nonpoint source pollution that are needed to meet Connecticut water quality standards for a particular waterbody and a strategy to implement those reductions to restore water quality. The Statewide Bacteria TMDL calls for a 77% reduction in fecal indicator bacteria loads (based on the geometric mean) to the impaired segment of the Mill River, and a 71% reduction in fecal indicator bacteria loads for Shepard Brook. This suggests that additional controls or more aggressive control strategies will be needed, beyond the modeled recommendations of this plan, to fully achieve the load reductions specified in the TMDL. Additional load reductions may be achieved through reforestation and stream buffer restoration, increasing the public awareness in the watershed of certain programs, and increased detection and elimination of illicit discharges.

It is important to note several limitations of both the TMDL load reduction estimates and the pollutant load reduction modeling. The TMDL for the Mill River segment is based on limited wet and dry weather monitoring data – 2 samples collected at each of 2 sampling locations in 1998, 45 samples collected at a third sampling location in 2003, 2004, and 2006-2009, and 8 samples collected at a fourth sampling station in 2010. At Shepard Brook, the TMDL is based on 10 samples from a single sampling location during 2010-2011. The samples were also collected at locations upstream of the influence of CSOs. Furthermore, the TMDL and modeled load reductions are not directly comparable since the TMDL loads are daily, seasonal (i.e., worst-case) values, whereas the modeled pollutant loads are annual values. Lastly, the load reductions anticipated from CSO abatement efforts are not directly comparable to the TMDL load reduction goal since the TMDL was

developed prior to recent upgrades to the weirs at CSOs 009 and 012; those updates are reflected in the existing conditions. Therefore, the modeled future CSO abatement load reductions are conservatively low when compared to the TMDL load reduction goals.

As indicated in the TMDL, progress in achieving TMDL-established goals through implementation of this watershed plan may be most effectively gauged through continued fixed-station ambient water quality monitoring. Routine monitoring should be performed at the same sites used to generate the data for the TMDL calculations, as well as at additional sites along the Mill River (see the water quality monitoring recommendations in *Section 3.2* of this plan). Sampling should be scheduled at regularly spaced intervals during the recreational season to generate a data set for each season that will include ambient values for both “wet” and “dry” conditions in relative proportion to the number of “wet” and “dry” days that occurred during the monitoring period. The TMDL calculations can be updated over time to compare the percent reductions needed under “dry” and “wet” conditions to the percent reductions that were needed at the time of TMDL adoption.

6 Funding Sources

A variety of local, state, and federal sources are potentially available to provide funding for implementation of this watershed based plan, in addition to potential funds contributed by local grassroots organizations and concerned citizens. *Appendix G* contains a list of potential funding sources and mechanisms. The table is not intended to be an exhaustive list but can be used as a starting point to seek funding opportunities for implementation of the recommendations in this watershed plan. The table of potential funding sources is intended to be a living document that should be updated periodically to reflect the availability of funding or changes to the funding cycle, and to include other funding entities or grant programs.

7 References

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Appendix A

Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan

M E M O R A N D U M

TO: Nicole Davis and Gwen Macdonald, Save the Sound

FROM: Erik Mas, P.E. and Julianne Busa, Ph.D., Fuss & O'Neill, Inc.

DATE: April 9, 2018

RE: Technical Memorandum 1 – Existing Watershed Conditions
Mill River Watershed-Based Plan

1. Introduction

Save the Sound, a program of Connecticut Fund for the Environment (CFE/Save the Sound), the Connecticut Department of Energy and Environmental Protection (CTDEEP), the watershed municipalities, and other key stakeholders are working together to address the water quality issues facing the Mill River and its tributaries by developing a watershed-based plan for the Mill River. Several of these waterbodies have impairments for recreation or aquatic life support due to elevated levels of bacteria and other pollutants. The watershed-based planning process brings together stakeholders from throughout the watershed to identify projects and practices that will satisfy United States Environmental Protection Agency (EPA) and CTDEEP requirements for watershed planning for the Mill River, and in doing so, improve water quality and restore conditions in the watershed. The watershed-based plan is funded in part by the CTDEEP through an EPA Clean Water Act Section 319 Nonpoint Source grant and utilizes the EPA's nine-element process.

An initial step in developing the watershed-based plan is to document water quality conditions and other watershed characteristics that are relevant to the water quality impairments in the watershed. This technical memorandum provides an overview of relevant watershed conditions based on a review of existing water quality data, mapping, and prior studies and planning efforts for the Mill River watershed.

2. Existing Plans and Studies

The Mill River has been the focus of numerous prior studies, planning efforts, and projects, which are documented by a large and diverse collection of existing reports, from formal water quality assessments, to University-sponsored research, to advocacy reports. Information from many of these documents, which are summarized in Table 1 beginning with the most recent documents, has been incorporated into this technical memorandum.

Table 1. Existing Documentation Related to the Mill River

Document/Information Source	Author (Date)	Notes
Public Information Meeting Presentation: New Haven CSO Long Term Control Plan	City of New Haven and GNHWPCA (2017)	Public update on the Long Term Control Plan for CSOs in New Haven, as well as rainfall conditions modeling.
Greater New Haven Water Pollution Control Authority Consent Order WC5509 Annual Progress Report: July 1, 2016- June 30, 2017	GHNWPCA (2017)	Provides updated sewer system mapping, status of all CSOs, and metering data for CSOs during the reporting period.
2016 Connecticut Integrated Water Quality Report	CTDEEP (2016)	Identifies waterbody segments that are classified as impaired relative to aquatic life, recreation, or shellfish.
Lower Mill River Water Quality Monitoring Reports	RWA (2000-2016)	Weekly, warm season measurement data for salinity and dissolved oxygen at the plunge pool, spillway, and footbridge sites.
New Haven Vision 2025: Chapter VII: Environment	City of New Haven (2015)	Chapter of the New Haven comprehensive plan dealing with environmental issues. Addresses water quality in Long Island Sound, sewage, and stormwater issues.
Connecticut Watershed Response Plan for Impervious Cover: Core Document	CTDEEP (2015)	Provides background information on the effects of stormwater on water quality, identifies 12% as a critical impervious cover threshold.
Connecticut Watershed Response Plan for Impervious Cover: Appendix 6-9—Mill River (CT5302) Summary	CTDEEP (2015)	Provides specific information on impaired segments, extant impervious cover and target reduction
New Haven Vision 2025: Status of Sewer Separation Map	GHNWPCA (2015)	Indicates area where separation of sanitary and stormwater sewers has been completed, is under construction, or under design.
Urban River Permits Review and Advocacy Recommendations for the Quinnipiac, Mill, and West Rivers	Mushinsky, M. (2015)	Report produced in conjunction with the Mill River Watershed Association of South Central Connecticut and River Advocates of South Central Connecticut. Descriptions of the three rivers in the New Haven area, water quality pollutants, relevant permits affecting water quality, and advocacy recommendations.
Public Meeting Presentation	RWA (2015)	Update on the Lake Whitney management plan and monitoring efforts.
2014 Connecticut Integrated Water Quality Report	CTDEEP (2014)	Identifies waterbody segments that are classified as impaired relative to aquatic life, recreation, or shellfish.
WUCC Report to the Commissioner	Connecticut Department of Public Health (2014)	Details recommendations for proposed alteration of the boundaries of Connecticut Public Water Supply Management Areas.
Connecticut Statewide Total Maximum Daily Load (TMDL) for Bacteria-Impaired Waters: Core Document	CTDEEP (2012)	Provides documentation for the impaired waters listing status and need for a TMDL, water quality targets, and estimated percent reductions needed to attain water quality targets.
Connecticut Statewide TMDL for Bacteria-Impaired Waters: Appendix 57—Mill River Watershed Summary	CTDEEP (2012)	Provides specific information on impaired segments, potential bacteria sources, current management activities, and recommendations for impaired segments in the Mill River subregional basin.

Table 1. Existing Documentation Related to the Mill River (continued)

Document/Information Source	Author (Date)	Notes
Drinking Water Assessment and Source Protection Program	Connecticut Department of Public Health (2012)	Statewide assessment results and source water areas for public drinking water supply systems. Potential contaminant sources impacting surface or groundwater are discussed.
Mill River Freshwater Tidal Marshes: 2011 Vegetation Monitoring	Sharp, P.; prepared for RWA (2012)	Summarizes vegetation monitoring efforts from 2000-2011.
Management Plan for Lake Whitney Water Treatment Plant: Revised April 2, 2012	RWA (2012)	Recommended performance standards and mitigation/monitoring measures for the operation of Lake Whitney as a public water supply.
2000-2011 Lower Mill River Invertebrate Monitoring Report	Water Resource Services; prepared for RWA (2012)	Summarizes macroinvertebrate data for the Lower Mill River.
A Biological Assessment of Upper Lake Whitney	AECOM; prepared for RWA (2010)	Summarizes biological assessments conducted from 2004 to 2009, including studies of plankton, aquatic macrophytes, benthic macroinvertebrates, fish, and water quality.
Effectiveness of Stormwater Treatment Systems Within a Highly Urbanized Watershed	Hudak, J.P., and M.E. Ellum (2003)	Report on a stormwater treatment system designed to treat a 20-acre watershed in the vicinity of Lake Whitney.
Summary of Upper Lake Whitney Management Study: January 23, 2002	Milone & MacBroom (2002)	Summarizes monitoring efforts by the RWA to collect baseline and continuing data on Lake Whitney in conjunction with the reestablishment of the lake as a public water supply.
Polycyclic Aromatic Hydrocarbons (PAHs) in the Sediments and Fish of the Mill River, New Haven, Connecticut, USA	White, J.C. and T. Triplett (2002)	Investigation of PAHs in the segment of the Mill River from Lake Whitney to the tidegates, where the most intense use for fishing and recreation occurs.
Baseline Description of the Lower Mill River Benthos	Mador, M., A. Saar, and M. Funaro (2001)	Baseline description of watershed contributions to the health of the river, local threats and potential future issues related to ecological health. Aquatic chemistry course project from Prof. Gabe Benoit's course at Yale School of Forestry.
Environmental Evaluation: Whitney Environmental Study Team Recommendations	Hudak, J.P., S.R. Kellert, J.T. Maughan, J.L. Rogers, and P.C. Sharp (1999)	Summary of recommendations from the Lake Whitney Water Treatment Plant Environmental Evaluation, including minimum spillway flow, minimum flow releases, dissolved oxygen, spring flood releases, and ongoing ecological monitoring.
The Lake Whitney Urban Runoff Project Final Report	Hudak, J.P. (1996)	Report on planning, construction, and monitoring of a stormwater treatment system designed to address runoff from an urban outfall pipe in the vicinity of Lake Whitney.
Lake Whitney Reservoir Urban Runoff Treatment Project Phase II	New Haven County Soil and Water Conservation District (1995)	A review of existing regulations relating to watershed protection and/or water quality.

Table 1. Existing Documentation Related to the Mill River (continued)

Document/Information Source	Author (Date)	Notes
Phosphorus Transport in the Mill River, New Haven County, Connecticut	Perkins, E.J. (1993)	Yale University study of processes affecting phosphorus transport in the Mill River.
Lake Whitney Stormwater Treatment Systems Map	RWA (n.d.)	Map showing locations of stormwater treatment systems in the vicinity of Lake Whitney.
Lake Whitney Project Mill River Subbasins	Unknown (n.d.)	Prioritization of subbasins for urban runoff, subwatershed descriptions, and historic outfall mapping.

3. Watershed Description

The Mill River watershed consists of two subregional basins: Mill River Subregional Basin (#5302) and Willow Brook Subregional Basin (#5301). Each subregional basin contains 7 local basins of varying size (Figure 1). The watershed covers an area of approximately 38 square miles (24,584 acres) in the municipalities of Bethany, Prospect, Cheshire, Hamden, North Haven, Wallingford, and New Haven, in New Haven County (Figure 2; Table 2). The upper watershed is generally rural or suburban in nature, with development intensity increasing at the southern end of the watershed and in the vicinity of the mouth of the river. Population density ranges from 262 people per square mile in Bethany to 6,992 people per square mile in New Haven. Cheshire and Hamden, which together make up 83% of the watershed area, have population densities of 885 and 1,884 people per square mile, respectively.

Table 2. Distribution of Municipalities in the Mill River Watershed

Municipality	Total Acreage of Municipality	Acreage in Watershed	% of Municipality in Watershed	% of Watershed	Population Density (people/sq.mi.)
Bethany	13,690	128	0.9	0.5	262
Cheshire	21,165	7,377	34.9	30.0	885
Hamden	21,278	13,117	61.6	53.4	1,884
New Haven	12,288	1,179	9.6	4.8	6,992
North Haven	13,510	835	6.2	3.4	1,149
Prospect	9,238	799	8.7	3.3	680
Wallingford	25,821	1,149	4.5	4.7	1,155
Watershed (total)	116,990	24,585	N/A	100.0	1,723

The main stem of the Mill River itself is approximately 12.6 miles long, winding from its northern headwaters in Cheshire, south to Long Island Sound, passing through an approximately 0.068 mi² estuary region of tidal influence, before ultimately flowing into New Haven Harbor. The largest tributary to the Mill River is Willow Brook, which drains an approximately 13 square-mile area before joining the Mill River in Hamden. Shepard Brook, Butterworth Brook, Jepp Brook, Eatons

Brook, and Brooksvale Stream are additional major tributaries. Numerous smaller streams complete the network of waterbodies draining through the Mill River to New Haven Harbor. Major surface waterbodies in the watershed include Lake Whitney, Turners Pond, and Jepp Pond. Other major landmarks in the watershed include Sleeping Giant State Park, East Rock Park, Naugatuck State Forest, and Quinnipiac University.

4. Water Quality

In compliance with section 305(b) of the Federal Clean Water Act, the state of Connecticut submits a water quality report to the EPA every two years. That report lists waterbody segments and denotes whether they have met water quality standards for certain designated uses, including aquatic life use support, recreation, and shellfish harvesting. Six river segments and one estuary segment within the Mill River Watershed were identified in the 2016 Integrated Water Quality Report (IWQR). Of these, four river segments and the estuary are impaired for at least one use category (Figure 3). Two additional segments within the watershed were included in the 2014 IWQR as fully supporting or not assessed but were not reported in the 2016 update.

- Sanford Brook: Sanford Brook segment CT5301-02_01 ("Sanford Brook (Cheshire)-01") is 2.68 miles long and extends from its mouth at the confluence with Willow Brook downstream of South Brooksvale Road in Cheshire, upstream to the headwaters (just upstream of Candee Road) in Prospect. It is fully supporting of both aquatic life and recreation.
- Willow Brook: Willow Brook segment CT5301-00_01 ("Willow Brook (Hamden)-01") is 1.87 miles long and extends from its mouth at the confluence with the Mill River downstream of the Willow Street crossing in Hamden, upstream to the confluence with Brooksvale Stream in Cheshire, traveling along the railroad tracks. It is impaired for recreation and is not assessed for aquatic life. Willow Brook segment CT5302-00_02 ("Willow Brook (Hamden)-02") is 3.84 miles long and extends from its confluence with Brooksvale Stream to the headwaters near Timber Lane, in Cheshire. The segment was included in the 2014 IWQR as not assessed for aquatic life and having insufficient information for recreation; it was not included in the 2016 IWQR.
- Shepard Brook: Shepard Brook segment CT5302-06_01 ("Shepard Brook (Hamden)-01") is 1.78 miles long and extends from its mouth at the confluence with the Mill River just downstream of Route 15, includes Turners Pond, and continues upstream to the confluence with an unnamed tributary behind the business park off Sherman Avenue and Town Walk Drive. The segment is not assessed for aquatic life and is impaired for recreation.
- Mill River: Mill River segment CT5302-00_01 ("Mill River (Hamden)-01") is 0.41 miles long and extends from the footbridge crossing to the Lake Whitney outlet dam, in Hamden. The segment is tidally affected freshwater, and is fully supporting of both aquatic life and recreation uses. Mill River segment CT5302-00_02 ("Mill River (Hamden/Cheshire)-02") is 9.06 miles long and extends from the inlet to Lake Whitney on the east side of Route 15, just downstream of Connolly Parkway in Hamden, to the Cook Hill Road crossing in Cheshire. The segment is impaired for both recreation and aquatic life. Mill River segment

CT5302-00_03 ("Mill River (Cheshire)-03") is 3.09 miles long and extends from the Cook Hill Road crossing to the headwaters, just upstream of Williamsburg Drive. The segment is impaired for aquatic life; there is insufficient information to assess recreation impairments.

- Lake Whitney: The Lake Whitney segment CT5302-00-4-L3_01 ("Whitney, Lake (Hamden)") is reported in the 2014 IWQR but not included in the 2016 report. The Lake, which is an impoundment of the Mill River, covers 140.42 acres and was denoted in the 2014 IWQR as fully supporting for aquatic life and unassessed for recreation.
- Inner-Mill River Estuary: The estuary segment CT-C1_023-SB (identified in the IWQR as "LIS CB Inner-Mill River (mouth), New Haven/Hamden") covers 0.068 mi², extending northward from the mouth of the Mill River at its confluence with the Quinnipiac River in New Haven to the footbridge crossing just upstream of East Rock Road in Hamden. The estuary segment is impaired for recreation, aquatic life, and shellfish.

Further details of the impaired waterbody segments within the watershed, including causes of impairment, are included in Table 3.

Bacteria Impairments

CTDEEP completed a "Statewide Bacteria Total Maximum Daily Load" (TMDL) for 176 impaired waterbody segments based on the 2010 Impaired Waters List (CTDEEP, 2012). The TMDL sets target pollution levels and establishes a framework for restoring water quality of the impaired segments. Only two of the bacteria impaired segments listed above are included in the approved TMDL (Mill River-02 and Shepard Brook). This is because several of the waterbody segments in the Mill River watershed that are now classified as impaired were assessed more recently than 2010. However, like the segments listed in the TMDL, the Willow Brook segment (Willow Brook-01) is also

Table 3. Impaired Waterbody Segments in the Mill River Watershed

Impaired Segment	Impaired Designated Use	Cause	TMDL Status
CT-C1_023-SB LIS CB Inner-Mill River (mouth), New Haven/Hampden	Habitat for Marine Fish Aquatic Life Recreation Commercial Shellfish Harvesting	DO saturation Enterococcus Fecal coliform	Listed as category 5: TMDL required
CT5302-00_02 Mill River (Hamden/Cheshire)-02	Recreation Aquatic Life	<i>E. coli</i> Flow alterations	Included in Statewide Bacteria TMDL approved 2012
CT5302-00_03 Mill River (Cheshire)-03	Fish Habitat Aquatic Life	Unknown Flow alterations	Listed as category 5: TMDL required
CT5302-06_01 Shepard Brook (Hamden)-01	Recreation	<i>E. coli</i>	Included in Statewide Bacteria TMDL approved 2012
CT5301-00_01 Willow Brook (Hamden)-01	Recreation	<i>E. coli</i>	Listed as category 5: TMDL required; Proposed for action plan development in 2017

impaired for recreation due to *E. coli*, and the Inner-Mill River Estuary is impaired for recreation due to Enterococcus and fecal coliform. Based on the 2010 data included in the TMDL, the Mill River-02 segment requires a 77% reduction in geometric mean indicator bacteria (*E. coli*) levels and a 94% single sample *E. coli* reduction in order to meet the TMDL. For the Shepard Brook segment, the required percent reductions are 77% and 71%, respectively.

Potential sources of indicator bacteria identified in the TMDL include point sources, such as permitted discharges from Municipal Separate Storm Sewer Systems (MS4s), combined sewer overflows (CSOs), and industrial and commercial facilities. Additional non-point sources include stormwater runoff, failing septic systems, agricultural activities, and wastes from wildlife and pets. Stormwater discharges to MS4s and illicit discharges are two of the primary targets identified in the Statewide Bacteria TMDL for pollution reduction of freshwater segments. The TMDL also recommends removal of CSOs in New Haven for bacteria reduction in the New Haven estuaries.

Water Quality Monitoring

CTDEEP routinely monitors ambient water quality, macroinvertebrate diversity, and fisheries at various locations within the watershed (Table 4; Figure 3). Many of these data are ultimately incorporated into the biannual IWQRs and TMDLs. Additional water quality and biological monitoring took place in the Lake Whitney portion of the watershed in conjunction with the planning and eventual opening of the new Lake Whitney Water Treatment Plant, which opened in April, 2005 (discussed in more detail below; Table 5). Other studies (some published, some unpublished) have been conducted in association with local organizations or academic institutions that focus on specific water quality issues, such as polycyclic aromatic hydrocarbons in Mill River sediments and fish (J.C. White, 2002), phosphorus transport, and aquatic chemistry.

Table 4. CTDEEP Water Quality Monitoring Stations

Ambient Water Quality Station ID	TMDL Station ID	Waterbody	Location
15271	5410	Mill River	At Whitney road exit at park and ride
14301	176	Mill River	Downstream of Dixwell Avenue
15013	923	Mill River	First pull-off downstream of Tuttle Road
14300	175	Mill River	Upstream of Tuttle Road
16413		Mill River	Adjacent to Route 22
16851		Mill River	400 m Downstream of Clark's Pond
17611	6180	Shepard Brook	Route 10
15986		Sanford Brook	Near Mountaincrest Drive
15855		Willow Brook	Willow Street

Impervious Cover Response Plan

The Mill River headwaters segment (CT5302-00_03) has been designated as impaired for aquatic life and fish habitat, but the cause of the impairment is unknown. This segment has been included in the *Connecticut Watershed Response Plan for Impervious Cover* (IC Response Plan) (CTDEEP, 2015), along with 15 other streams that are also impaired for aquatic life but have no known cause for the impairment. The IC Response Plan uses impervious cover as a surrogate for the suite of potential pollution sources carried by stormwater runoff, and sets a target of 11% impervious cover. The target is not a required reduction or a regulatory limit, but is meant to guide best

management practices (BMPs) and low impact development (LID) within the impaired drainage areas. The current impervious cover of the watershed area corresponding to the impaired segment is 15%; meeting the target would therefore require a 27% reduction in impervious cover (CTDEEP, 2015).

Table 5. South Central Connecticut Regional Water Authority (RWA) Monitoring Studies of Lake Whitney

Monitoring Type	Monitoring Dates/Frequency	Parameters	Main Findings
Dissolved Oxygen and Salinity	2000-present. Weekly, July to September at plunge pool, spillway, and footbridge	Dissolved oxygen Salinity	DO studies by the Authority have established a DO target level of 7 mg/L in the plunge pool when there is no flow over the spillway from Lake Whitney to the Mill River
Biological Assessment of Upper Lake Whitney	2005-2009 Annually, in June	Phytoplankton Zooplankton Aquatic macrophytes Benthic macroinvertebrates Fish Water quality	11-14 taxa of macroinvertebrates detected per year across study. Fish are dominated by planktivores (perch, shiners) and detritivores (carp), with some bass, etc. Only rooted plants exhibit more than temporary impact of drawdowns.
Benthic Biological Assessment of Lower Mill River	2000-2009 Two dates in summer (typically June and August)	Water temp Dissolved oxygen Specific conductivity Turbidity pH Flow Habitat characterization	Percentage of observations with "fairly significant" and "significant" organic pollution generally ranged from 75%-100%, though in 2009 it was only 25%.
Mill River Freshwater Tidal Marsh Vegetation Monitoring	2000-2011	Precipitation Soil Conditions Groundwater Salinity	Data indicate gradual changes are taking place primarily due to natural phenomena.
Lower Mill River Invertebrate Monitoring	2000-2011	Macroinvertebrates	Generally indicates intermediate stream community health.

5. Watershed Land Cover and Land Use

Land Cover

The distribution of land cover (physical land type) and land use (how people are making use of land) within the watershed plays an important role in shaping spatial patterns and sources of nonpoint source pollution and surface water quality. Impervious cover, in particular, is central to determining rates and volume of stormwater runoff, which is often a key contributing factor to water quality impairments.

The National Land Cover Database (NLCD) provides Landsat-based, 30-meter resolution land cover data for the entire nation. The most recent national data, which are presented here, are from 2011. The University of Connecticut Center for Land Use Education and Research (UConn CLEAR) provides a more recent dataset (2015), but the NLCD data are preferred as they disaggregate developed land into more precise categories based on density of development, and provide more detailed divisions for agricultural land and other habitat types (Figure 4).

Table 6. Distribution of Land Cover Types by Acres and Percent (NLCD 2011)

Acres			Percent			
Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed	Land Cover	Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed
23	277	300	Open Water	0.3	1.7	1.2
1,166	3,314	4,480	Developed, Open Space	14.1	20.4	18.3
1,008	2,946	3,954	Developed, Low Density	12.2	18.1	16.1
318	2,194	2,512	Developed, Medium Density	3.8	13.5	10.2
41	641	683	Developed, High Density	0.5	3.9	2.8
3.3	7.8	11	Barren	0.0	0.0	0.0
4,775	5,495	10,270	Deciduous Forest	57.7	33.8	41.9
81	300	381	Coniferous Forest	1.0	1.8	1.6
45	130	176	Mixed Forest	0.5	0.8	0.7
118	122	240	Shrub/Scrub	1.4	0.7	1.0
45	213	258	Herbaceous	0.5	1.3	1.1
153	175	328	Pasture/Hay	1.9	1.1	1.3
5.3	0.0	5	Cropland	0.1	0.0	0.0
481	431	912	Woody Wetland	5.8	2.6	3.7
7	19	26	Emergent Herbaceous Wetland	0.1	0.1	0.1
8,271	16,265	24,536	Total	100.0	100.0	100.0

Based on NLCD data, approximately 47% of the watershed falls into one of the four developed land categories (Table 6), while 41.9% is deciduous forest land. At 55.9% developed land and 33.8% forest, the Mill River subregional basin is substantially more developed than the Willow Brook subregional basin, which has 30.6% developed land and 57.7% deciduous forest cover. This is consistent with the trend noted above, that highly developed areas are concentrated to a large degree at the southern end of the watershed, while the northern portion of the watershed is generally less developed. This pattern is even more pronounced for land cover in the riparian zone (Figure 5). Vegetated riparian buffers can slow stormwater runoff, and trap sediment and other pollutants. On the other hand, riparian lands that are developed and lack a dense stand of vegetation may be especially vulnerable to water quality issues.

Land Use

Whereas land cover categorizes the physical landscape, land use refers to the way that humans are utilizing the land and focuses on five primary categories (commercial/mixed use, industrial,

institutional, residential, open space) in addition to an 'other' category. Land use data were obtained from both the South Central Regional Council of Governments (SCRCOG) and the Naugatuck Valley Council of Governments (NVCOG). SCRCOG last updated their land use data in 2016; NVCOG last revised their data in 2017.

Residential use dominates land use across the entire watershed, comprising slightly more than half of all land use in both subregional basins (Table 7; Figure 6). Open space is the next largest category in both watersheds, but makes up nearly 1/3 of land use in the Willow Brook subregional basin compared with only 18% in the Mill River subregional basin. Commercial, industrial, and institutional uses make up a small proportion of land use in both subregional basins, but are more concentrated in the Mill River subregional basin, and tend to cluster at the southern-most end of the watershed, in New Haven.

Table 7. Distribution of Land Use Types by Acres and Percent (NVCOG 2017, SCRCOG 2016)

Mill River Subregional Basin	Acres		Land Use	Percent		
	Willow Brook Subregional Basin	Entire Watershed		Mill River Subregional Basin	Willow Brook Subregional Basin	Entire Watershed
810	160	971	Commercial & Mixed Use	5.1	1.9	4.0
416	25	442	Industrial	2.6	0.3	1.8
1,101	303	1,405	Institutional	6.9	3.7	5.8
2,938	2,640	5,578	Open Space	18.5	32.1	23.1
1,289	694	1,984	Other	8.1	8.4	8.2
9,367	4,413	13,781	Residential	58.8	53.6	57.0
15,923	8,237	24,160	Total	100.0	100.0	100.0

Historic Land Use

In general, commercial/industrial land use in the watershed is a potential source of bacteria and other pollutants. As indicated in the TMDL, there are approximately 11 permitted commercial and industrial facilities in the Mill River watershed. Historic industrial land uses continue to affect the Mill River watershed through legacy contamination. One such historic site is English Station, a closed power plant located on Ball Island, near the mouth of the Mill River. Occupying nearly 9 acres, the site is known to be widely contaminated with polychlorinated biphenyls (PCBs) and other hazardous contaminants. Excavation on the site in 1997 resulted in a documented release of PCBs into the Mill River (CTDEEP, 2016) and a 2005 report noted that PCBs were present in concentrations thirty times the industrial direct exposure criteria (CTDEEP, 2016). Early stages of remediation for English Station are currently underway.

There are also known petroleum, metal, and PCB impacts to the river in the vicinity of 470 James Street due to legacy contamination from the former trolley garage (later a state bus garage), related underground storage tanks and fueling system releases. Erosion of polluted urban fill at the site has impacted sediment and water quality in the Mill River. Conceptual planning for remediation and restoration of the site is in progress.

Impervious Cover

Impervious cover (IC) refers to any surface which prevents natural infiltration of stormwater into the soil, most notably buildings and pavement. As stormwater travels across impervious surfaces, rather than sinking into the ground, it picks up pollutants (e.g. oils, sediment) from the surface and transports these materials as part of the stormwater discharge. If not treated before the stormwater drains into a waterbody, these pollutants can become a major contributor to waterbody impairments. Extensive research has documented the effects of urbanization on stream and watershed health, including studies by CTDEEP that have documented a negative relationship between upstream impervious cover and aquatic life in adjacent waters, with predictable detrimental impacts to aquatic life when impervious cover exceeds 12% (CTDEEP, 2015).

In 2017, UConn CLEAR analyzed 2012 aerial imagery to estimate the amount of total impervious cover in each local basin (Figure 7; Table 8). As a whole, the Mill River watershed has 17.2% impervious cover. At 10.2%, total impervious cover in the Willow Brook subregional basin is below the 12% threshold; the Mill River subregional basin, however, has total impervious cover of 20.8%. At the local basin scale, 6 of the 14 local basins across the entire watershed exceed the 12% threshold. The highest impervious cover in the watershed is found in the local basin that contains the main stem of the Mill River, where overall IC was 27.3%. This high percentage of IC is driven by particularly dense development in New Haven and in areas adjacent to the main stem. The local basin that contains Shepard Brook is similarly affected, with 21.2% impervious cover. Unsurprisingly, local basins that are predominantly rural and/or are less-developed tend to have impervious cover below 10%.

Table 8. Distribution of Impervious Cover by Acres and Percent (UConn CLEAR 2012)

Willow Brook Subregional Basin	Acres			Impervious Surface Type	Percent		
	Mill River Subregional Basin	Entire Watershed			Mill River Subregional Basin	Entire Watershed	
239	975	1,214	Building	2.9	6.0	4.9	
365	1,523	1,889	Other*	4.4	9.4	7.7	
245	890	1,135	Road	2.9	5.5	4.6	
849	3,389	4,238	Total	10.2	20.8	17.2	

*Includes parking lots, sidewalks, driveways, patios, swimming pools, and decks.

Open Space

Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious cover, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space is also important as habitat for native and migratory species and protection of public water supply. Open space includes preserved natural areas as well as lightly developed parks, playgrounds, and cemeteries.

An initial assessment of active and passive open space areas in the Mill River watershed was identified based on GIS information provided by NVCOG (data updated in 2017) in addition to data

compiled and published by CTDEEP in 2015, including federal land, state-owned property, and other municipal and privately-owned open space. Figure 8 shows open space land in the Mill River watershed and identifies major open space parcels. The largest open space land includes:

- Sleeping Giant State Park (1,615 acres)
- Regional Water Authority land (1,087 acres)
- Naugatuck State Forest (746 acres)
- Farmington Canal Heritage Trail (18.1 miles of linear trail)
- East Rock Park (425 acres)
- DeDominicis Property (200 acres)
- Puchalski Property (103 acres)
- Roaring Brook (87 acres)
- Hamden Fish and Game Protection Association (85.6 acres)
- Bens Homestead (63.4 acres)
- Brooksvale Farm Preserve (48 acres)

6. Physical Characteristics of the Watershed

Geology and Soils

Typical of coastal watersheds in Connecticut, the topography of the Mill River watershed is quite variable, encompassing flat plains along the coast and estuaries, with a mixture of rolling hills and steep slopes to the north. The surficial geology of the watershed has been shaped by glaciation and is a major factor shaping topography, soils, and drainage characteristics within the watershed. The Mill River runs along the historic path of a glacial meltwater stream; surficial geology along its channel is thus characterized by sand and gravel deposits.

To the east and west of the Mill River, the landscape rises and is characterized by thick glacial till (unsorted glacial deposits). On the east side of the watershed, Sleeping Giant State Park encompasses Mt. Carmel, a large drumlin with a maximum elevation of approximately 730 feet. The western slope of Mt. Carmel drains to the Mill River, while the eastern slope drains toward the Quinnipiac River. Mt. Sanford sits on the western edge of the Mill River watershed, within the Willow Brook subregional basin. At approximately 880 feet, Mt. Sanford is the highest point in the watershed; its northern and eastern slopes drain toward Willow Brook and eventually flow into the Mill River, while the southwestern slope drains toward the West River. A ridge runs northward from Mt. Sanford, forming much of the western edge of the watershed.

The City of New Haven is located on a plain at the southernmost tip of the watershed, where the Mill River meets the Quinnipiac River, New Haven Harbor, and then Long Island Sound. Much of the shoreline in this area has been reclaimed from the Sound and consists of artificial fill. The rest is glacial outwash consisting of sands and gravels over fine silts and clays.

The Natural Resources Conservation Service (NRCS) classifies soils into Hydrologic Soil Groups (HSG) that characterize a soil's runoff versus infiltration potential after prolonged wetting (Figure 9). Group A soils are the most well drained, meaning that they have low runoff potential and high infiltration potential. At the other extreme, Group D soils are the most poorly drained. Water movement through Group D soils is restricted, causing them to have high runoff potential and low

infiltration potential. Group D soils are frequently either high in clay content or shallow soils over an impermeable layer (such as shallow bedrock or a dense glacial till) or a shallow water table. Group B and C soils complete the continuum between these extremes. Group B soils have moderately low runoff potential and unimpeded water transmission through the soil, while group C soils have moderately high runoff potential and are somewhat restrictive of water movement.

Within the Mill River watershed, areas of poor infiltration potential characterized by Group D soils include Mt. Carmel, Mt. Sanford, the ridge that runs along the northwestern edge of the watershed, and significant portions of New Haven. Approximately 46% of the watershed is characterized as either Group C or Group D soils, indicating moderately high to high runoff potential, and relatively limited infiltration potential. 52% of the watershed as a whole consists of areas with Group A & B soils, which have greater infiltration potential and are generally more conducive to infiltration-based Low Impact development (LID) and green stormwater infrastructure practices. The Willow Brook subregional basin has a greater percentage of Group A & B soils than does the Mill River subregional basin (59% as compared to 48%, respectively), and is thus expected to have somewhat better infiltration potential than the Mill River subregional basin (Table 9). Additionally, some of the areas of Group A & B soils in the Mill River subregional basin coincide with areas of dense development, which makes these areas potential targets for urban stormwater retrofits.

Table 9. Distribution of Hydrologic Soil Groups

HSG	Mill River Subregional Basin (Acres)	Willow Brook Subregional Basin (Acre)	Grand Total (Acres)	% of Watershed
A	1,859	1,054	2,913	11.9
B	6,030	3,849	9,878	40.2
C	3,638	1,412	5,051	20.5
D	4,413	1,940	6,353	25.8
Water	346	44	390	1.6
Total	16,286	8,299	24,585	100.0

Wetlands

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and plant and animal communities living in the soil and on its surface. Wetlands can vary widely in type and characteristics, but are an important feature of a watershed, providing water quality benefits by removing pollutants and mitigating flooding. The extent and distribution of wetlands in the Mill River watershed are shown in Figure 10. Wetlands make up approximately 12% of the watershed overall. 7.4% of the Mill River subregional basin consists of poorly drained and very poorly drained soils, with an additional 3.1% alluvial and floodplain soils. The Willow Brook subregional basin has a somewhat higher percentage of poorly drained and very poorly drained soils (11.5%) and 2.7% alluvial and floodplain soils.

Endangered, Threatened, and Special Concern Species

CTDEEP maintains information on the location and status of endangered, threatened, and other species of special concern throughout the state through the CTDEEP Natural Diversity Database (NDDDB). Approximate locations of state and federal listed species and significant natural communities are depicted in Figure 10. Activities in these areas are potentially subject to review by CTDEEP. The CTDEEP Wildlife Division may provide recommendations for avoiding impacts to listed species. .

7. Water Infrastructure

Dams

There are approximately 22 dams within the watershed, including 5 on the Mill River, and 1 on Shepard Brook (Figure 11). Most of the dams are located in the northern part of the watershed, in Hamden, with a few each in Cheshire and Wallingford. None are located on Willow Brook. The largest and most notable dam is the Lake Whitney Dam, which was established in 1860 for drinking water, fire-fighting, and hydropower. Flows over the dam average 55 million gallons per day (mgd) (RWA, 2018), with high flows during wet months typically ranging from 100 to 300 mgd. Smaller dams may provide recreational opportunities, habitat, or other amenities, but are likely also hindering fish passage through the watershed and may alter hydrologic characteristics in ways that affect water quality.

At least two of the smaller dams along the Mill River have been partially or fully breached at some point in their history. The Axle Shop Pond Dam was reported as partially breached, and Clarke's Pond Dam was reportedly rebuilt in the mid-1980s to repair a breach.

Water Supply

The Mill River watershed feeds Lake Whitney, which is part of the South Central Connecticut Regional Water Authority (RWA) public water supply system. Lake Whitney was established as the water supply for the City of New Haven in 1862. The original filtration plant, built in 1906, operated until 1991 and was demolished in 2002. A new Lake Whitney Water Treatment Plant was opened in 2005, reestablishing Lake Whitney as an active water supply. In 2000, prior to the plant's opening, the RWA commissioned a series of ongoing studies to collect baseline data and monitor changes due to lake withdrawals (Table 4). Operating standards were established with the intent of balancing ecological, aesthetic, and water supply interests. As part of those standards, it was established that a pre-emptive maintenance approach focused on watershed management techniques designed to control sediment loading should take priority over dredging, and periods of no flow should be minimized so as to limit disturbance to river ecology (Milone & MacBroom, Inc., 2002). The Lake Whitney Water Treatment Plant pumps approximately 3-15 mgd for the RWA under normal conditions, which supplies 45 mgd to an overall service population (i.e., both within the watershed and beyond) of approximately 430,000 people. Current operating guidelines, which were developed in part based on the recommendations of environmental monitoring studies (see Table 5), dictate that when lake levels are lower than 0.2 feet above the spillway, withdrawals are limited to 5 mgd except under extreme circumstances.

Groundwater serves as the primary water supply source for a significant portion of the northern half of the watershed. There are four Aquifer Protection Areas (APAs) (also referred to as "wellhead

protection areas”) located within the watershed (Figure 10). APAs are designated around active well fields in sand and gravel aquifers that serve more than 1,000 people to protect major public water supply wells.

Wastewater

Approximately half of the watershed area is served by sanitary sewers and half by on-site wastewater treatment systems, also referred to as septic systems (Figure 12). Most of these septic systems are located in the upper half of the Mill River watershed in Cheshire and the northern portion of Hamden. Failing or older, sub-standard septic systems can impact surface water and groundwater quality and can be a source of bacteria to the Mill River and other surface waterbodies. Local health directors and health districts regulate the installation of subsurface sewage disposal systems and are responsible for site inspections, plan review, the issuing of permits and inspections of all new, repair and replacement systems. The Towns of Cheshire and Prospect are part of the Chesprocott Health District, located in Cheshire, and the City of North Haven and Towns of Hamden, and Bethany are part of the Quinnipiac Valley Health District, located in North Haven. The City of New Haven and Town of Wallingford each have independent, local health departments.

Combined Sewer Overflows (CSOs) impact water quality in the lower Mill River (Figure 12). CSOs are designated outfalls where combined sewers (carrying both sanitary wastes and stormwater) overflow when precipitation overwhelms the combined sewer system’s capacity; such overflows result in discharge of untreated sanitary wastes into receiving waters. The City of New Haven has combined sanitary and storm sewer systems that discharge untreated sewage into New Haven Harbor during periods of heavy rain. The City of New Haven has been working to address CSOs since the early 1980s, and has worked in cooperation with the Greater New Haven Water Pollution Control Authority (GNHWPCA) since regionalization in the mid-2000s. The GNHWPCA’s actions are guided in large part by CTDEEP consent order WC5509, last amended in 2015. As part of the consent order, GNHWPCA has developed a Long Term Control Plan (LTCP) which impacts both the Mill River watershed and neighboring Quinnipiac River and West River watersheds. The LTCP includes closure of some CSOs, modifications to others to ensure sewer separation, installation of additional storage, and CSO flow monitoring.

Of the 13 remaining CSOs maintained by GNHWPCA that discharge directly to receiving waters, three discharge to the Mill River:

- CSO #009 at Grand Avenue and James Street: The weir was raised in 2015. The reported reduction in CSO discharge volume based on the modeled 2-year design storm in 2016 compared to 1997 is 0.1 million gallons. The LTCP calls for a final status of inactive.
- CSO #011 at Humphrey Street and I-91: 2017 update status indicates that sewer separation design is complete. A CSO Storage Tank is proposed as a capital improvement in the LTCP. Three additional active regulators (#010(A), #014, and #026) contribute discharges to the CSO #011 outfall.
- CSO #012 on Mitchell Drive east of Nicoll Street: The weir was raised in 2013. The reported reduction in CSO discharge volume based on the modeled 2-year design storm in 2016

compared to 1997 is 0.8 million gallons. A capacity improvement project is planned and design of that project is underway. The LTCP calls for closure of the CSO. One additional active regulator (#028) contributes discharges to the CSO #012 outfall.

Three additional CSOs that previously discharged to the Mill River were closed in 2014.

In 2017, CSO discharges resulted in 4.86 million gallons of CSO flow into the Mill River from a combined 43 overflow events (another 10.64 million gallons discharged directly to the New Haven Harbor). One CSO in particular (CSO #011) contributed the majority (81%) of the discharge volume, at 3.916 million gallons over 13 events. This made it one of the top four CSO overflows in Greater New Haven in terms of volume of discharge during the 2017 reporting period (May 2016 to April 2017). The remaining 19% of CSO discharges to the Mill River came from CSO 009 (0.855 million gallons) and CSO 012 (0.087 million gallons). CSO discharge volume to the Mill River during the 2017 reporting period was more than double that of the 2016 reporting period (2.22 million gallons). CSO discharge volume for the 2015 reporting period was 6.27 million gallons. Differences from one reporting period to the next reflect both differences in annual precipitation and changes due to CSO closures/modifications.

Stormwater

Urban stormwater runoff generated in developed areas from buildings, pavement, and other compacted or impervious surfaces is a significant source of pollutants to the Mill River and its tributaries. Impervious surfaces prevent infiltration of rainfall and runoff into the ground. Stormwater generated from impervious surfaces typically contains increased pollutants from the atmosphere, vehicles, industry, lawns, construction sites, humans and animals. Without treatment, these pollutants are conveyed from the impervious surfaces to storm drainage systems and eventually to the receiving waterbodies during storms. Impervious surfaces and traditional piped storm drainage systems increase the volume, peak flow rates, and velocity of stormwater runoff to receiving waters. This can contribute to channel erosion, sedimentation, and reduced stream baseflow during dry periods. The amount of impervious cover in the Mill River watershed and the implications for water quality and overall stream health is discussed in Section 5 of this technical memorandum.

In recognition of the impacts of stormwater runoff on water quality, CTDEEP regulates stormwater discharges from municipalities, commercial and industrial sites, and construction sites. As of the 2012 TMDL, permitted stormwater discharges within the Mill River subregional basin included: 1 commercial permittee, 10 industrial permittees, and 2 construction permittees. All of the municipalities within the watershed are regulated under the CTDEEP General Permit for the Discharge of Small Municipal Separate Storm Sewer Systems (MS4 Permit), and therefore are required to implement stormwater management programs centered around 6 minimum control measures, including public education and involvement, illicit discharges, land use regulatory controls for construction and post-construction runoff, impervious cover reduction, and good housekeeping and pollution prevention. The MS4 Permit, in particular, requires increasingly stringent approaches to limit stormwater pollution over the next five years, largely through addressing impervious area and illicit discharges to the stormwater system and encouraging green infrastructure and low impact development. The MS4 permit also requires all municipalities to create updated and detailed stormwater infrastructure mapping, which will help to facilitate

identification and tracking of illicit discharges, storm system maintenance, and stormwater retrofits.

Green infrastructure solutions are also a key objective of the GNHWPCA strategic plan (GNHWPCA, 2017). GNHWPCA requires the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development projects within combined sewer areas in accordance with the GNHWPCA Permitting and Design Criteria Manual. GNHWPCA and the City of New Haven, working with CFE/Save the Sound and other groups, are also installing bioswales at numerous locations throughout the City within the public right-of-way to reduce runoff to the combined sewer system and reduce pollutant loads to surface waters. The City of New Haven has also adopted regulatory requirements to reduce stormwater runoff from development projects contributing to the City's combined sewer system.

Flood Zones

Flood hazard areas within the Mill River watershed are shown in Figure 13. Flood zones are defined by the Federal Emergency Management Agency (FEMA) as the area below the high water level that occurs during a flood of a specified recurrence interval (e.g., the "100-year flood" is defined as having a probability of occurring once in 100 years, or a 1% chance of occurring in any single year). Similarly, the "500-year flood" has a 0.2% chance of occurring in a given year. FEMA also defines a 'floodway' as the stream channel and adjacent areas that carry the majority of the flood flow at a significant velocity, whereas 'floodplain' also includes the flood fringe or areas that are flooded without a strong current.

The region, including the Mill River watershed, has suffered flood damage in inland and coastal areas from Tropical Storm Irene (2011) and Hurricane Sandy (2012). Historic flood events that have impacted the region include the June 1982 storms in which the most severe flooding occurred along the Mill River in Hamden (and along the Wepawaug River in Orange and Milford) and the historic floods of 1955 and 1936.

8. References

- CTDEEP. (2012). *Connecticut Statewide Total Maximum Daily Load (TMDL) for Bacteria-Impaired Waters*. Hartford: Connecticut Department of Energy and Environmental Protection.
- CTDEEP. (2015). *Connecticut Watershed Response Plan for Impervious Cover*. Hartford: Connecticut Department of Energy and Environmental Protection.
- CTDEEP. (2016). *State of Connecticut v. The United Illuminating Company Partial Consent Order Number COWSPCB 15-001*. Hartford: Connecticut Department of Energy and Environmental Protection.
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- RWA. (2018). *Whitney Environmental Management Plan*. Retrieved April 5, 2018, from Regional Water Authority: <https://www.rwater.com/conservation-stewardship/whitney-environmental-management-plan>

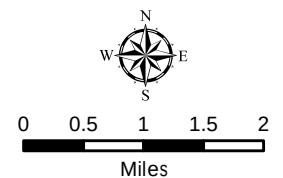
Figure 1

Mill River Watershed Based Plan

Watershed Overview

Major Roads

- Interstate
- US
- State
- Stream
- Intermittent Stream
- Open Water
- Marsh
- Subregional Basins
- Local Basins
- Town Boundary



Sources:
CTECO
Aerial Imagery (2016)
CT DEEP
Hydrography (2005)
MAGIC
Municipalities (1984)
Roads (2010)

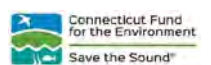
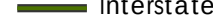
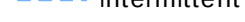
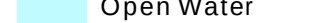


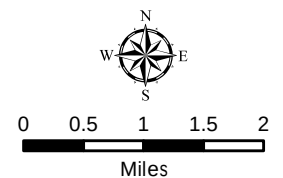
Figure 2

Mill River Watershed Based Plan

Watershed Aerial

Major Roads

-  Interstate
-  US
-  State
-  Stream
-  Intermittent Stream
-  Open Water
-  Subregional Basins
-  Local Basins
-  Town Boundary



Sources:
 CTECO
 Aerial Imagery (2016)
 CT DEEP
 Hydrography (2005)
 MAGIC
 Municipalities (1984)
 Roads (2010)

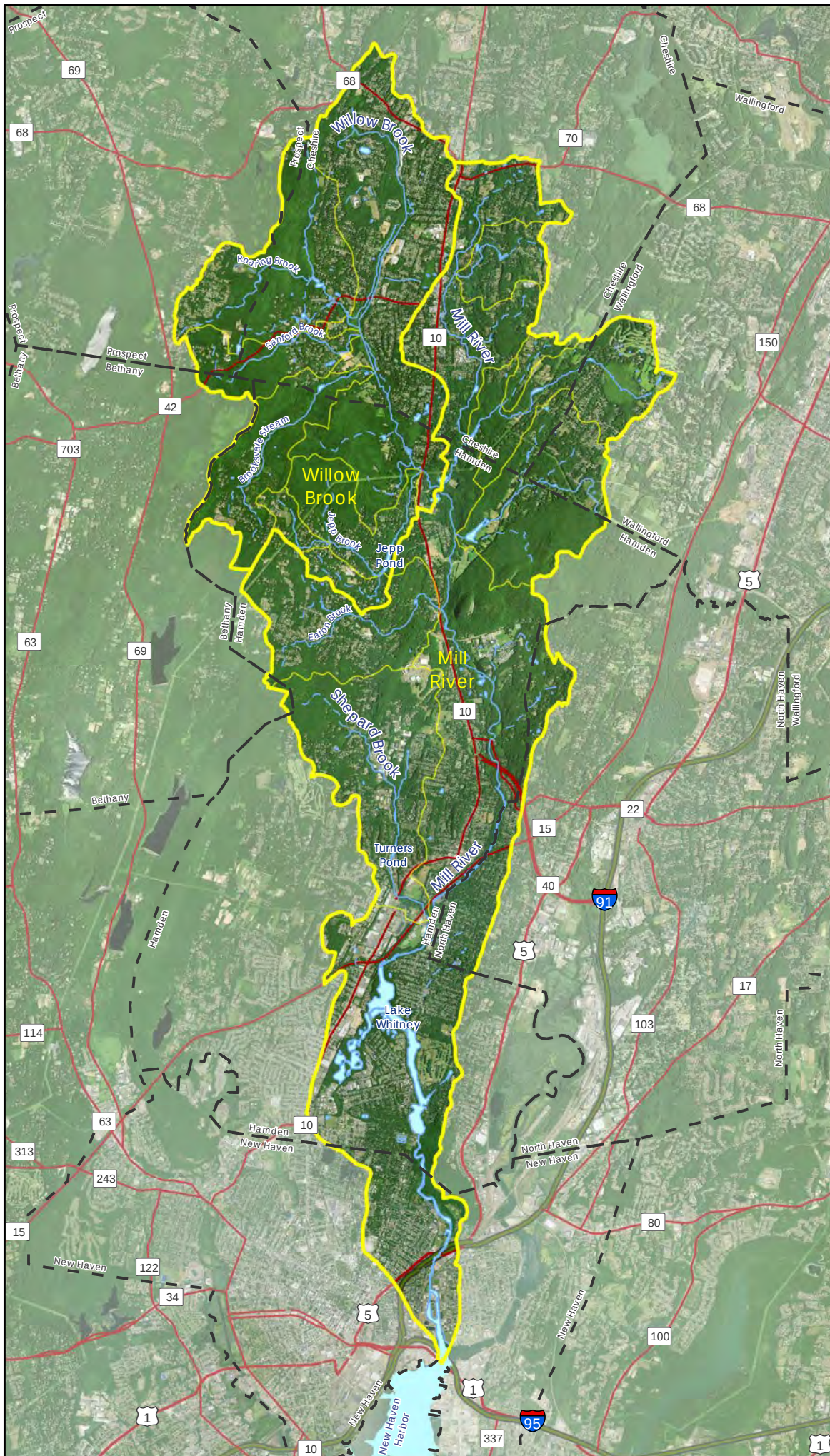
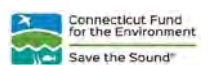


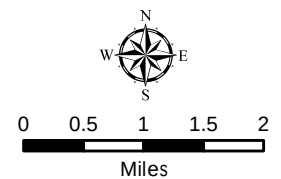
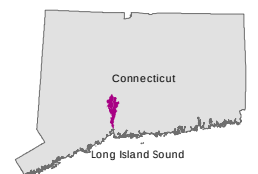
Figure 3

Mill River Watershed Based Plan

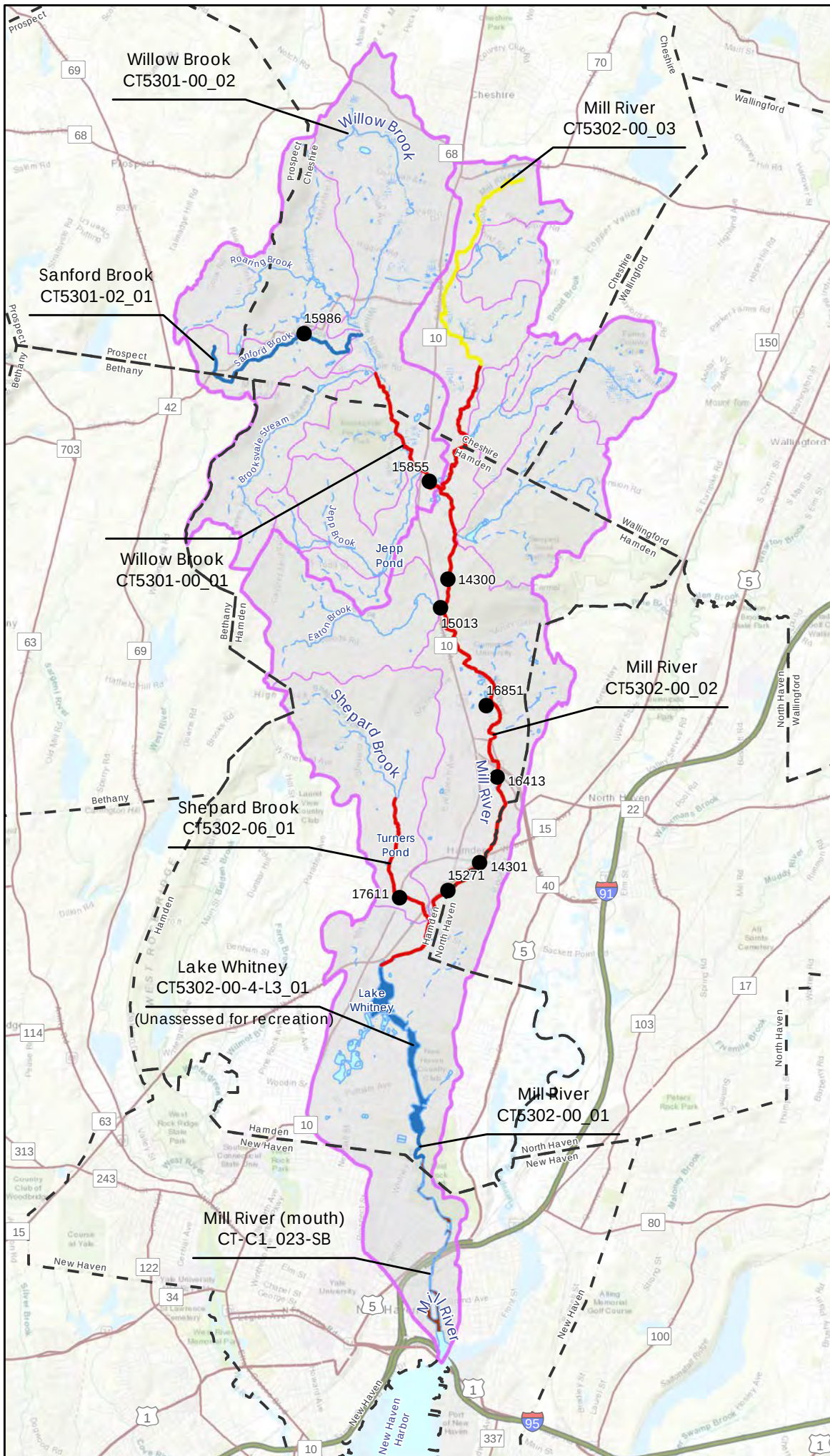
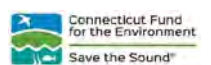
Impaired Waters

Segment Name
305b List ID

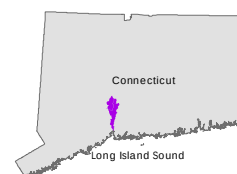
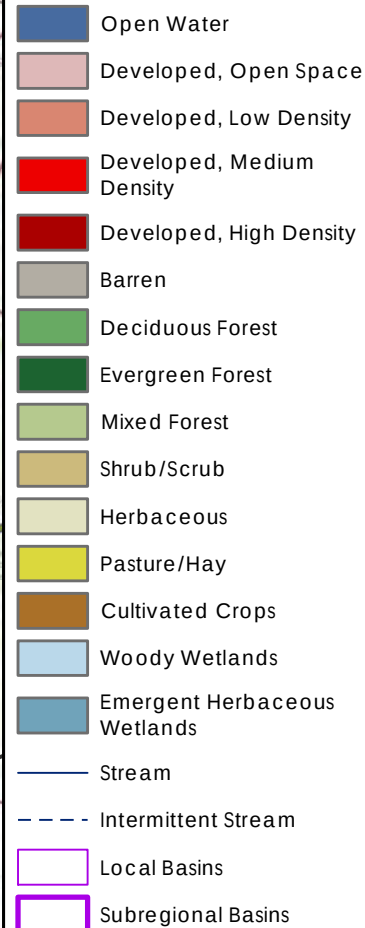
- DEEP Ambient Water Quality Monitoring Stations
- Fully Supporting
- Impaired - Aquatic Life
- Impaired - Recreation
- Impaired - Aquatic Life, Recreation, and Shellfishing
- Stream
- Intermittent Stream
- Open Water
- Marsh
- Local Basins
- Subregional Basins



Sources:
CT DEEP
Hydrography (2005)
Impaired Waters (2014)
Ambient Water Quality Monitoring Stations (2018)
MAGIC
Municipalities (1984)
Roads (2010)



Land Cover



Sources:
USGS
 NLCD (2011)
CT DEEP
 Hydrography (2005)
MAGIC
 Municipal Boundaries (1984)
 Roads (2010)

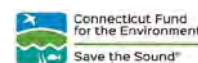


Figure 5 Mill River Watershed Based Plan

300-Foot Riparian Zone Land Cover

Land Cover Type

- Developed
- Turf and Grass
- Other Grass
- Agricultural Field
- Deciduous Forest
- Coniferous Forest
- Water
- Non-forested Wetland
- Forested Wetland
- Barren
- Utility ROW
- Stream
- Intermittent Stream
- Open Water
- Marsh
- Subregional Basins
- Local Basins



0 0.5 1 1.5 2
Miles

Sources:
UCONN CLEAR
Land Cover (2015)
CT DEEP
Hydrography (2005)
MAGIC
Municipal Boundaries (1984)
Roads (2010)

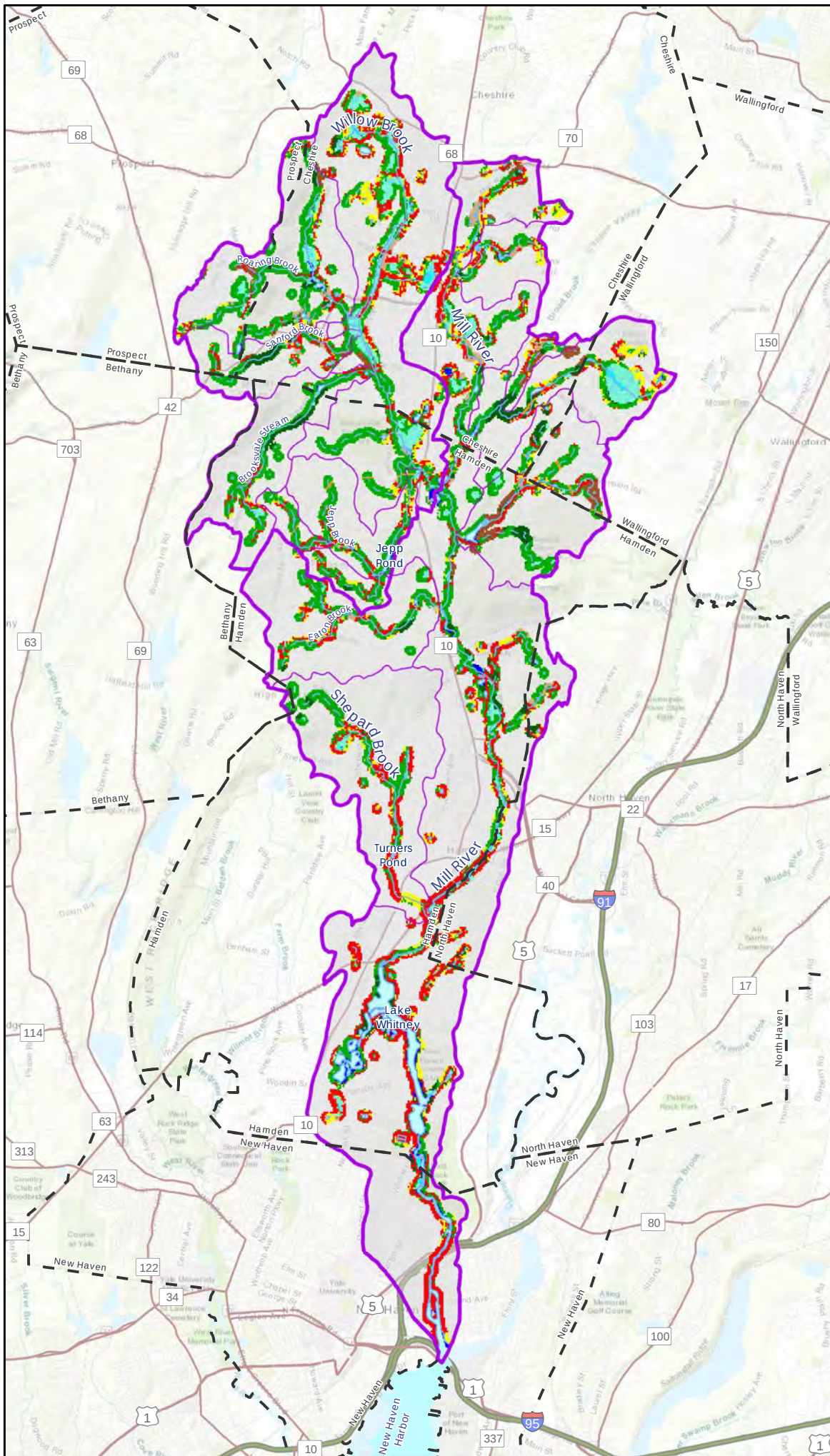
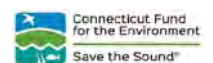


Figure 6

Mill River Watershed Based Plan

Land Use

Land Use

- Residential (all densities)
- Commercial
- Institutional
- Industrial
- Mixed Use
- Transportation and Other
- Agriculture
- Forest, Water, Open Space
- Stream
- Intermittent Stream
- Open Water
- Marsh
- Subregional Basins
- Local Basins



0 0.5 1 1.5 2
Miles

Sources:
NVCOG, SCRCOG
Land Use (2016, 2017)
CT DEEP
Hydrography (2005)
MAGIC
Municipal Boundaries (1984)
Roads (2010)

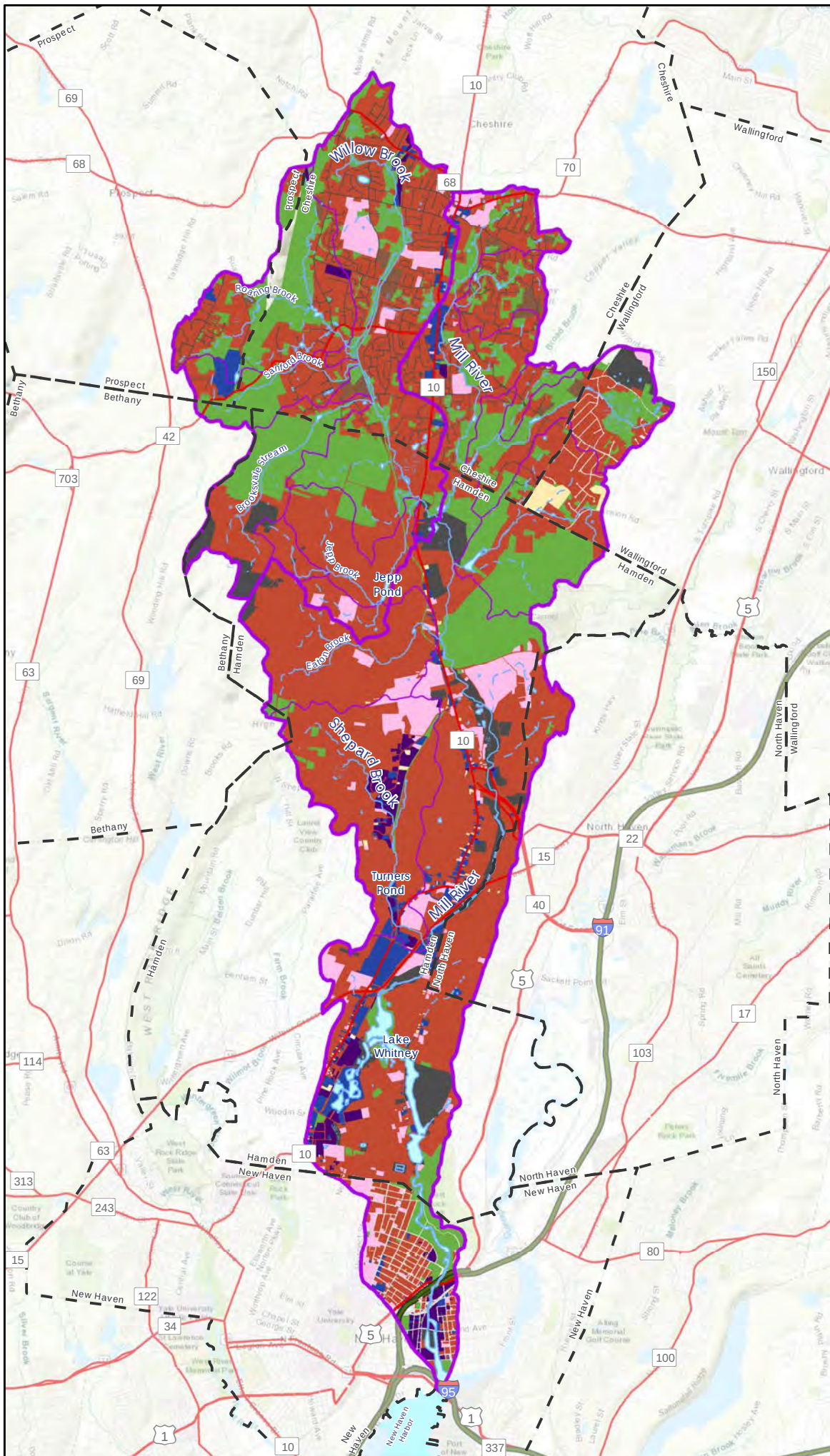
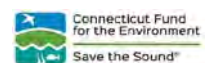
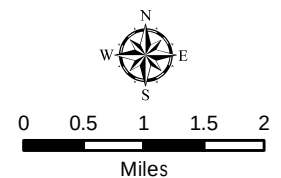
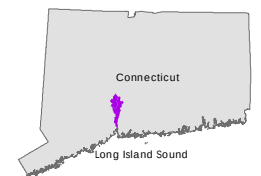
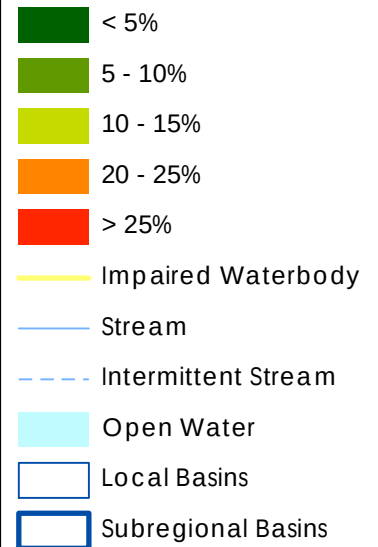


Figure 7 Mill River Watershed Based Plan

Impervious Cover

Impervious Cover by Local Basin



Sources:
CTECO
Impervious Cover (2012)
CT DEEP
Hydrography (2005)
MAGIC
Municipalities (1984)
Roads (2010)

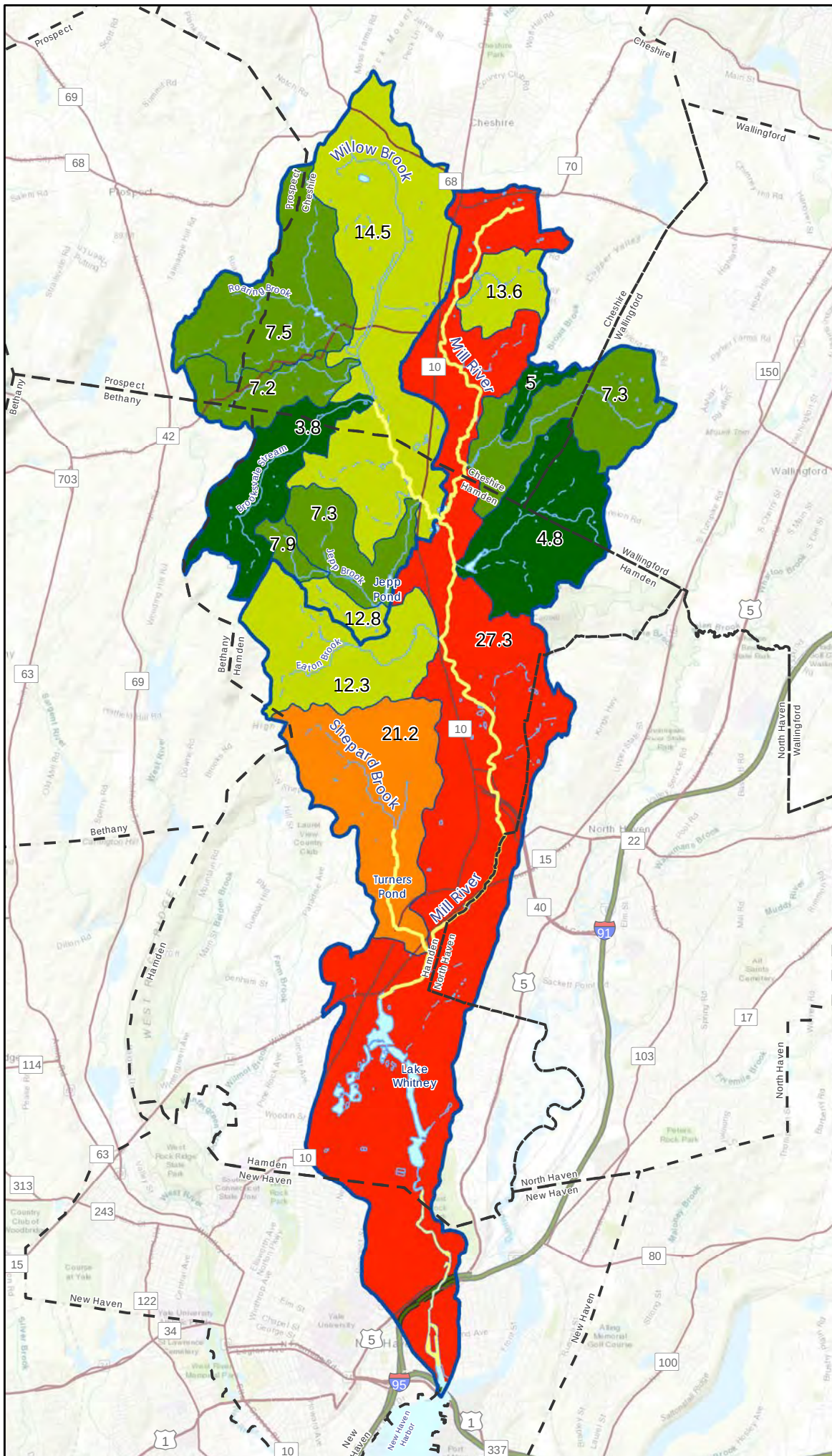
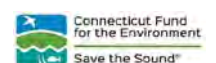


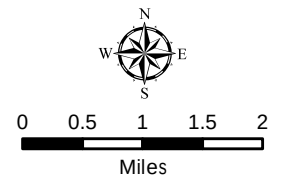
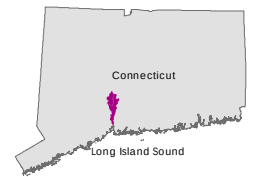
Figure 8

Mill River Watershed Based Plan

Protected Open Space

Ownership

-  Land Trust
-  Municipal
-  Private
-  State
-  Regional Water Authority
-  Stream
-  Intermittent Stream
-  Open Water
-  Marsh
-  Local Basins
-  Subregional Basins



Sources:
NVCOG
Open Space (2017)
CT DEEP
Open Space (2015)
Hydrography (2005)
MAGIC
Municipalities (1984)
Roads (2010)

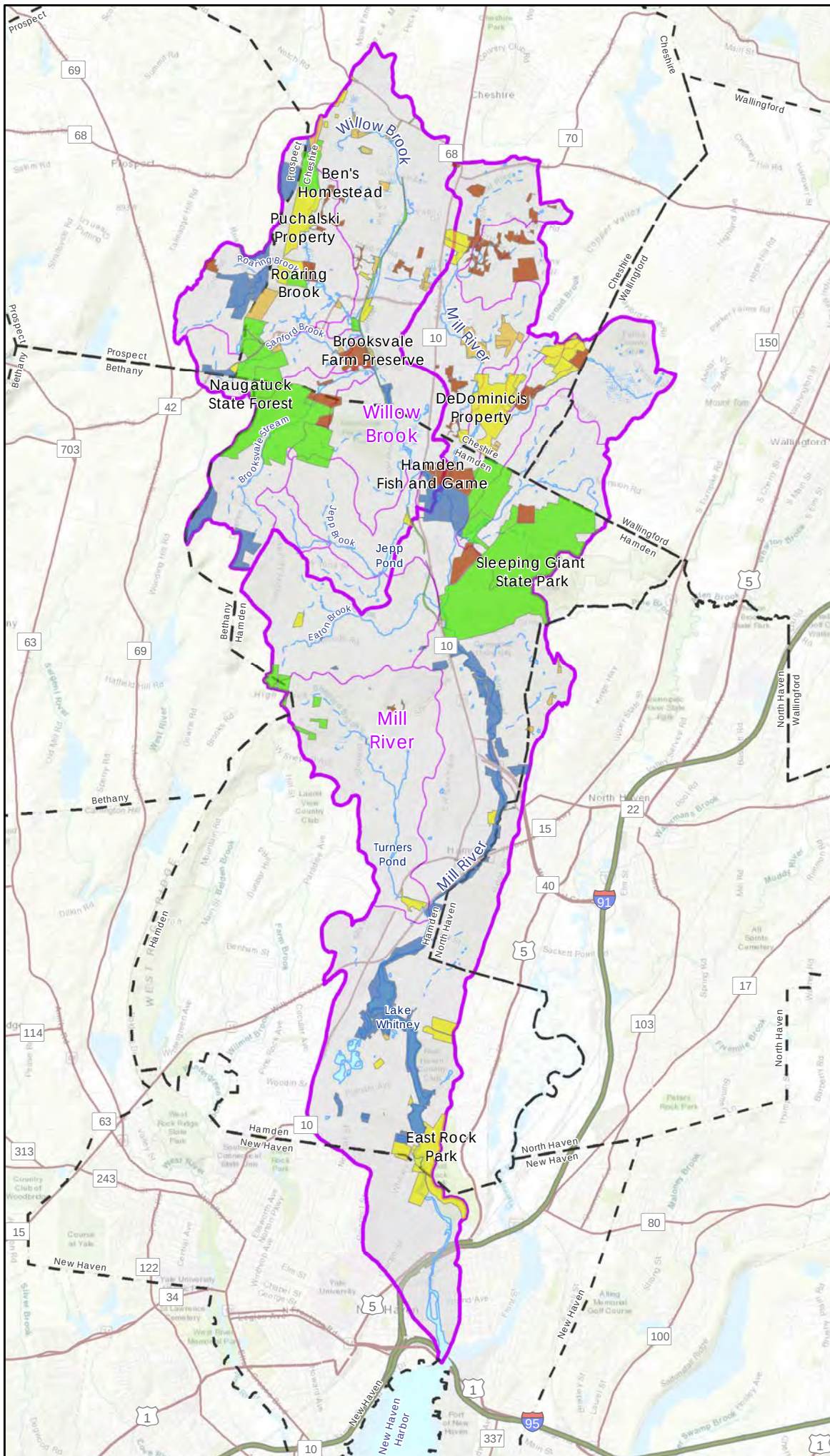
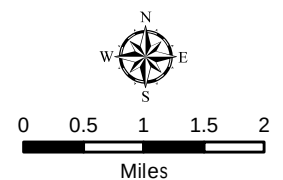


Figure 9 Mill River Watershed Based Plan

Hydrologic Soil Groups

Hydrologic Soil Group

-  A - High infiltration potential
-  B - Moderate infiltration potential
-  C - Moderately poor infiltration potential
-  D - Low infiltration potential
-  Stream
-  Intermittent Stream
-  Open Water
-  Marsh
-  Local Basins
-  Subregional Basins



Sources:
USDA SSURGO
Hydrologic Soil Groups (2017)
CT DEEP
Hydrography (2005)
MAGIC
Municipalities (1984)
Roads (2010)

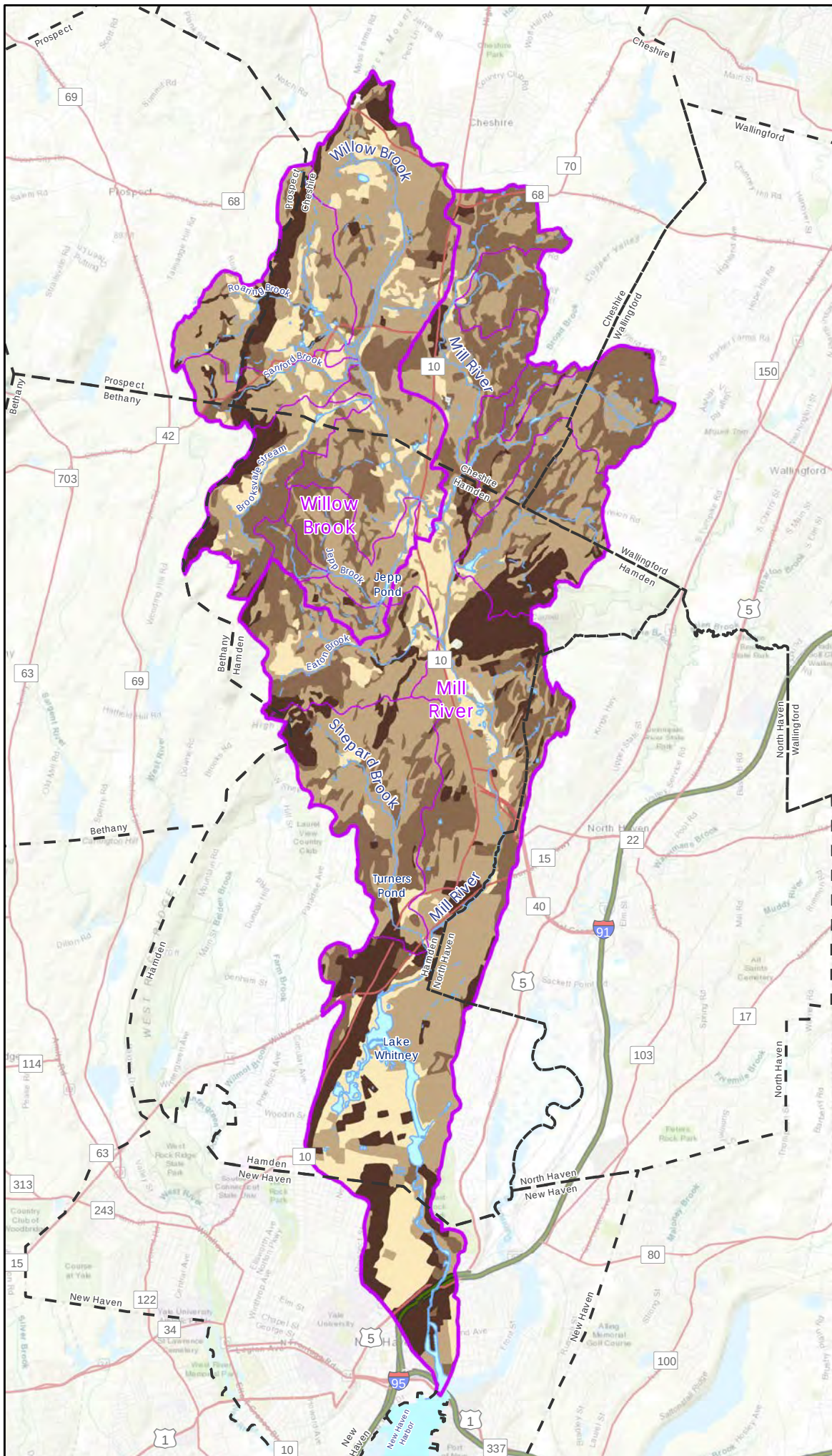
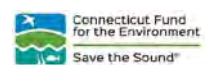


Figure 10

Mill River Watershed Based Plan

Wetlands, Forests, and Natural Diversity Database Areas

-  State and Federal Listed Species & Significant Natural Communities
-  Wetlands
-  Patch Forest
-  Edge Forest
-  Perforated Forest
-  Core Forest (<250 ac)
-  Core Forest (250-500 ac)
-  Core Forest (>500 ac)
-  Stream
-  Intermittent Stream
-  Open Water
-  Marsh
-  Subregional Basins
-  Local Basins



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Miles

Sources:
UCONN CLEAR
Forest Fragmentation (2006)
CT DEEP
Wetland Soils (2009)
Natural Diversity Database
Areas (2017)
Hydrography (2005)
MAGIC
Municipal Boundaries (1984)
Roads (2010)

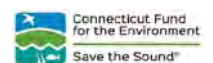


Figure 11

Mill River Watershed Based Plan

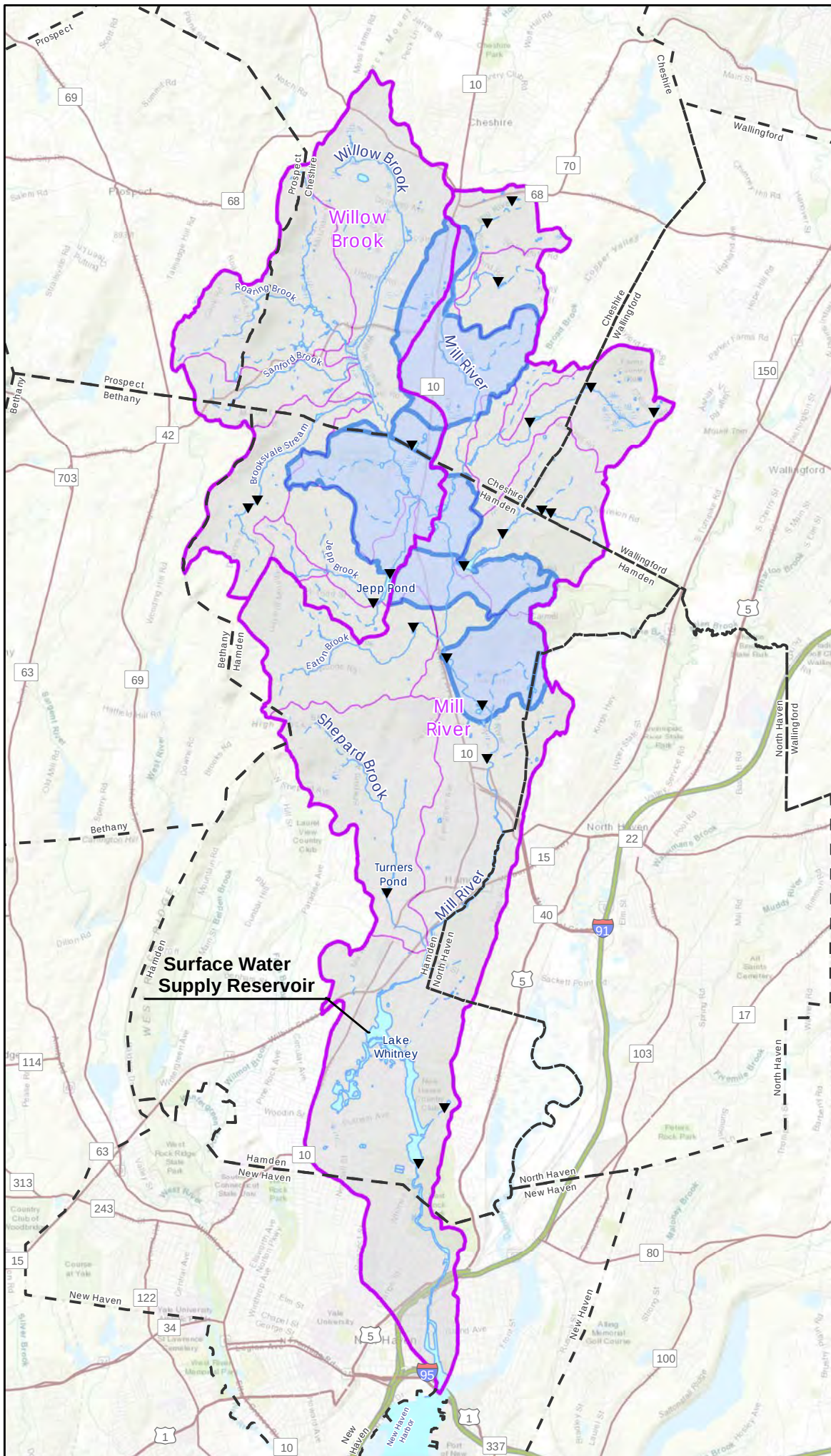
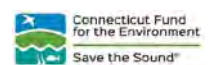
Water Resources

- ▼ Dam
- Stream
- - - Intermittent Stream
- Open Water
- Marsh
- Aquifer Protection Area - Level A
- Local Basins
- Subregional Basins



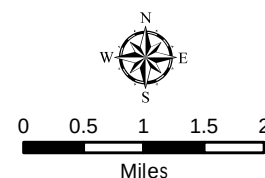
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Miles

Sources:
CT DEEP
Aquifer Protection Areas (2016)
Hydrography (2005)
Dams (1996)
MAGIC
Municipalities (1984)
Roads (2010)



Mill River Watershed Based Plan

- Combined Sewer Overflow (CSO) Locations
- Sanitary Sewer Service Area
- Stream
- Intermittent Stream
- Open Water
- Marsh
- Local Basins
- Subregional Basins



Sources:
GNHWPCA
CSO Locations (2017)
CT DEEP
Hydrography (2005)
Sewered Areas (1998)
MAGIC
Municipalities (1984)
Roads (2010)

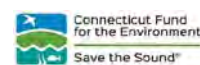
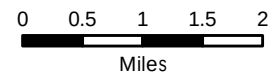


Figure 13 Mill River Watershed Based Plan

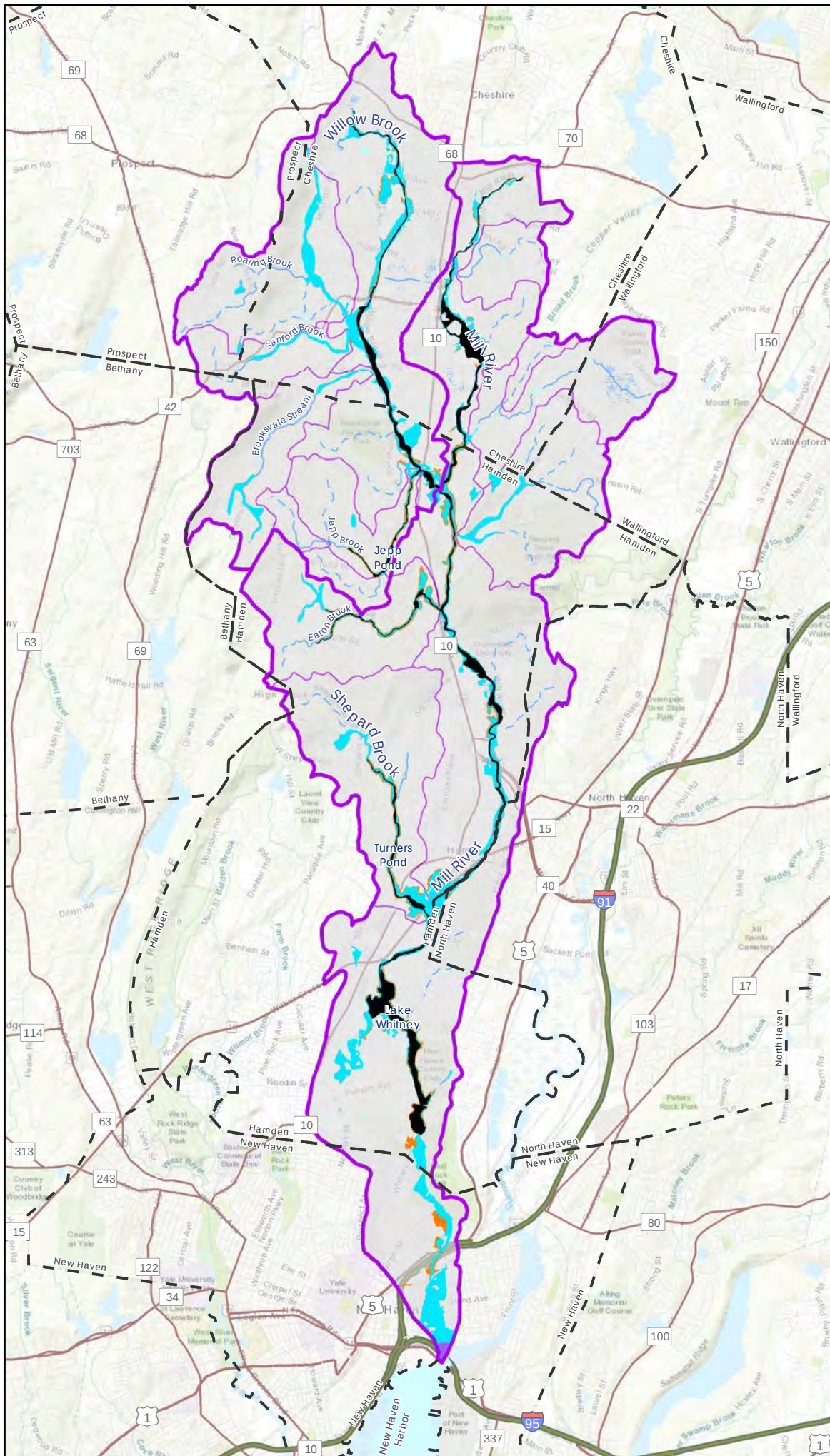
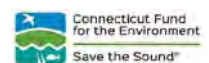
FEMA Flood Hazard Areas

Flood Hazard Zone

-  1% Annual Chance Flood
-  Regulatory Floodway
-  Coastal 1% Annual Chance Flood
-  0.2% annual chance Flood
-  Stream
-  Intermittent Stream
-  Open Water
-  Marsh
-  Subregional Basins
-  Local Basins



Sources:
FEMA
Flood Insurance Rate Map (2014)
CT DEEP
Hydrography (2005)
MAGIC
Municipal Boundaries (1984)
Roads (2010)



Appendix B

Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan

MEMORANDUM

TO: Nicole Davis and Gwen Macdonald, Save the Sound

FROM: Erik Mas, P.E, Julianne Busa, Ph.D., and Stefan Bengtson, MSc, Fuss & O'Neill, Inc.

DATE: May 16, 2018

RE: Technical Memorandum 1 – Pollutant Loading Model
Mill River Watershed-Based Plan

This memorandum summarizes the methods and results of a pollutant loading model that was developed for the Mill River watershed in support of a watershed-based plan. Pollutant loads characterize the amount or mass of a given pollutant delivered to a water body over a period of time. Estimation of pollutant loads from a watershed therefore provides insight into the relative contributions of pollutants from different land uses and land use practices within a watershed and is a key element of the EPA watershed-based planning process.

1. Introduction

The Watershed Treatment Model (WTM), developed by the Center for Watershed Protection, was used to estimate annual pollutant loads from the following subwatersheds, which are modified from the 14 Connecticut Local Drainage Basins that comprise the Mill River and Willow Brook Subregional Basins (Figure 1):

- Butterworth Brook and other Mill River Tributaries
- Eaton Brook
- Lake Whitney
- Lower Mill River
- Middle Mill River
- Shepard Brook
- Upper Mill River
- Willow Brook
- Willow Brook Tributaries

The WTM is a screening-level model that can be used to estimate the loading of pollutants to a waterbody based on land use and other activities within a watershed. Based on user-specified inputs describing characteristics of the watershed, the WTM estimates pollutant loads from various land uses and activities, as well as load reductions associated with structural and non-structural best management practices. While fecal indicator bacteria impairments are the primary focus of the watershed based plan, the WTM also provides loading estimates for other pollutants including total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN). BMPs that will be

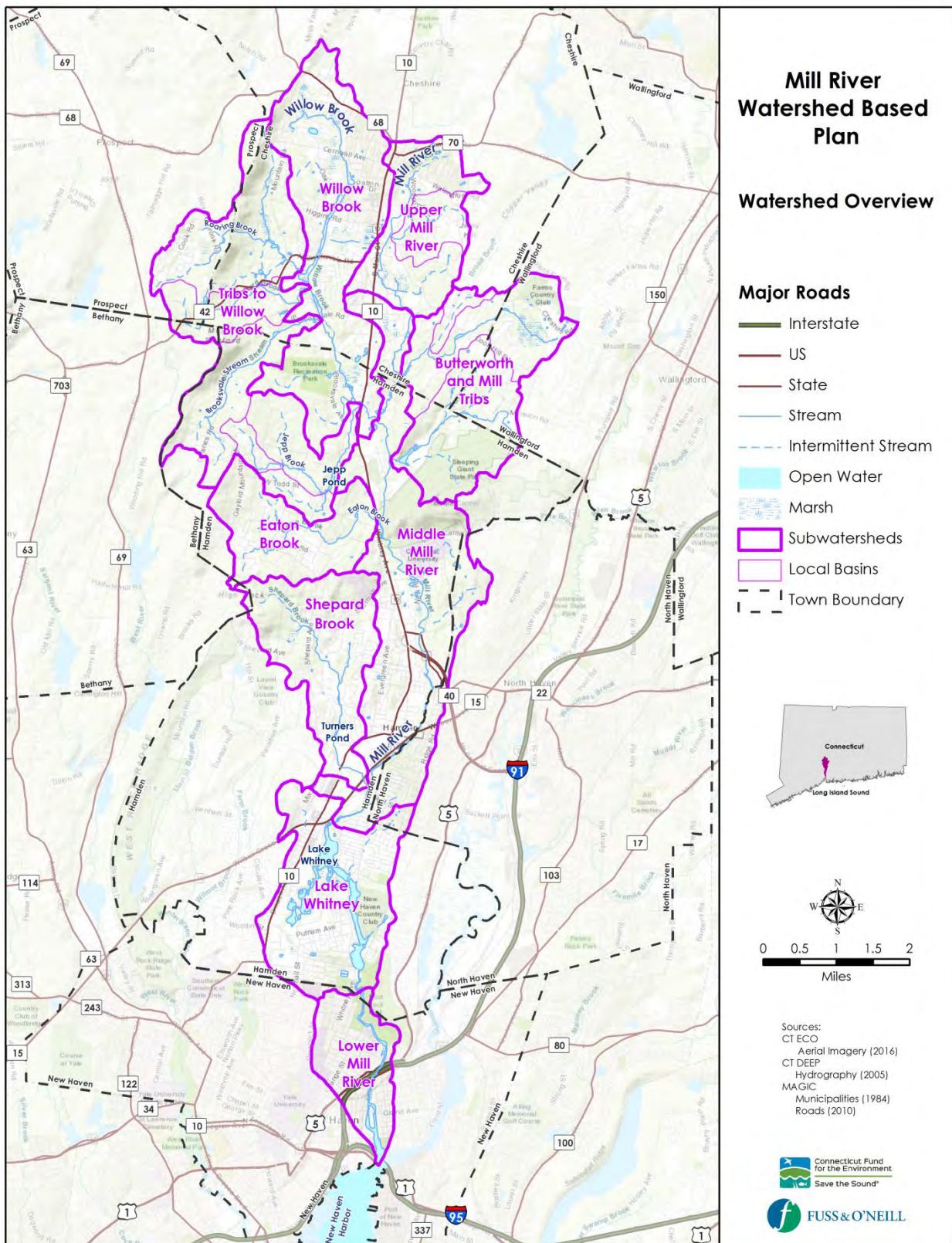


Figure 1: Mill River subwatersheds identified for use with pollutant load modeling

recommended in the watershed-based plan will not only help to reduce bacteria but may also help to reduce these other pollutants.

2. Model Inputs

Primary Sources: Land Use Nonpoint Source Runoff

Land use is considered a primary source of runoff pollutant loads in the WTM, which uses a loading calculation known as the Simple Method (Schueler, 1987) to calculate nutrient, sediment, and bacteria loads from urban land uses, and area loading factors to calculate loads from non-urban land uses. 2016 parcel-based land use data available from the Naugatuck Valley Council of Governments (NVCOG), aggregated land use data from the South Central Regional Council of Governments (SCRCOG), and U.S. Census Block-level data were adapted for use with the WTM. Impervious area for each land use category was calculated from the 2016 CTECO impervious cover dataset. Table 1 in *Attachment A* summarizes the modeled land use category and impervious area for each land use classification and provides a breakdown of existing modeled land use by subwatershed. Table 2 in *Attachment A* links land use categories from the COG data to the corresponding categories used in the model.

Model inputs were specified for each land use category, including area, impervious cover, runoff coefficient, and runoff pollutant concentrations or export coefficients. Literature-based event mean concentration (EMC) values (the mean concentration of a pollutant in stormwater runoff for each land use type) were used for all developed land use categories, while selected regional export coefficients were used for non-urban land uses. Available land use data largely did not distinguish among non-urban land uses. These were therefore aggregated into an “Open Space” category that included forested land, wetlands, and other similar land cover types. WTM default export coefficients were used for forest, utilities (i.e. electrical transmission lines), and open water land use categories. The export coefficients for agricultural land use were approximated as the area-weighted average of the export coefficients of row crop and pasture sub-categories, reflecting the different pollutant loads expected from these two types of agricultural use. Utilities were modeled under a “Rural” land use category, enabling the model to capture the impervious nature of land use in utility right of ways. Tables 3 and 4 in *Attachment A* summarize the selected EMC and export coefficient values and associated references. Average annual precipitation for the watershed (49.22 inches) was estimated from the average precipitation recorded at the Mt. Carmel station in Hamden over the period of record (1936-2018) (Northeast Regional Climate Center <http://www.nrcc.cornell.edu/>).

Secondary Sources

In addition to pollutants generated from land uses, the WTM estimates pollutant loads from other activities or sources (secondary sources) that may be present, but are not necessarily associated with a particular land use. The following secondary sources were included in the WTM for the Mill River watershed; Table 5 in *Attachment A* provides more detail on the corresponding model assumptions and Table 6 in *Attachment A* lists the relevant model inputs for each source across the watershed.

- Failing or Malfunctioning Septic Systems/Subsurface Waste Disposal Systems – While much of the Mill River watershed is served by sanitary sewers, 11% of homes have septic systems. A septic system failure rate of 1% was assumed for residential areas throughout the watershed. This rate represents an estimate based on regional failure rates and information provided by Chesprocott and Quinnipiac Health Districts. Based on a review of aerial imagery, tax assessor's database information, and land use mapping, an estimated 3% of septic systems in the watershed are within 100 feet of surface water bodies, with the values for individual subwatersheds ranging from 0-10%.
- Stream Channel Erosion – Due to the limited data available on stream channel erosion loads in the watershed, a simplified approach was used in which stream channel erosion sediment loads were estimated as a fraction of total watershed sediment load, based on overall stream channel stability. Stream channel erosion sediment loads were assumed to be 50% of the total sediment load for the watershed (reflecting “medium” stream channel degradation and stability), consistent with the model guidance.
- Livestock – This secondary source accounts for pollutant loads from animals that are confined (e.g., feedlots, stables). In the model, pollutant loads associated with pastured animals are simulated as Primary Sources (i.e., cropland land use). Livestock in the watershed are largely horses in stables and are sparse throughout the watershed. There are small and large stable operations in the watershed, estimated to range from 15 to more than 40 horses (Giant Valley Polo Club). Estimates of head per subwatershed were based on 2016 3-inch resolution aerial imagery, which was sufficiently detailed to count individual grazing horses. Tables 7 and 8 in *Attachment A* summarize livestock head counts and other model inputs for the Livestock Secondary Source.

Note that pollutant loads from domestic animals and wildlife, which are potentially significant sources of bacteria and nutrients to the Mill River given the large amount of residential land use, open space, and parkland in the watershed, are accounted for in the modeled land use pollutant export coefficients.

- Road Sanding – Sediment loads from road sanding were calculated based on a 2015 CTDOT report entitled Winter Highway Maintenance Operations. The report includes a survey of 31 municipal public works operations and reveals an average annual application rate of 6.1 tons of sand per lane mile between 2009 and 2014. Lane miles were determined from the UCONN MAGIC roads dataset (2010), which indicates road jurisdiction. Municipal roads were assumed to be uniformly two-lane. Information from Public Works staff in the municipalities, in conjunction with their most recent MS4 Annual Reports, was used to determine the extent of road sanding. Some municipalities no longer use sand in de-icing operations, while others use a mixture of sand and salt. The exact ratio of sand to salt was not reported and was assumed to be equal portions of each. The Connecticut Department of Transportation does not apply sand to state roads, so state-maintained roads were not included in the calculation of lane miles.
- Potential Illicit Connections – In areas served by sanitary sewers, illicit connections were assumed for one in every 2,000 sewered connections and 5% of businesses, consistent with

values reported in several national studies, modified to account for local conditions. Model default pollutant concentrations and daily flow values were used.

- Point Sources – Discharge Monitoring Reports obtained from the EPA's Integrated Compliance Information System (ICIS) website revealed two sites in the Lower Mill River subwatershed where water quality sample collection for bacteria or nutrients is required under a facility's NPDES permit. A number of other sites require only visual monitoring or sample collection for metals. Bacteria sampling is routinely required for wastewater treatment plants, but there are none in the watershed.
- Combined Sewer Overflows (CSOs) – Three CSOs exist in the Lower Mill River subwatershed. Since approximately 2012, the Greater New Haven Water Pollution Control Authority (GNHWPCA) has monitored these discharge locations to track when the overflows are activated and what volume is discharged. Sufficient data has now been collected by GNHWPCA that they estimated a "typical year" of discharges in the most recent Consent Agreement Annual Progress Update (GNHWPCA, 2017) to the CT Dept. of Energy and Environmental Protection (CT DEEP). These annual volume estimates are specific to each discharge location. Concentrations of bacteria, nutrients, and total suspended solids were taken from Technical Memorandum #6 of the approved CSO Long Term Control Plan (CH2MHILL, 2000) and are identical to those used in the West River Watershed Based Plan.
- Sanitary Sewer Overflows (SSOs) – SSOs occur when flow in the sanitary sewer system surpasses capacity. Discharge of untreated sewage then occurs, typically to the storm sewer system. Municipalities and/or water pollution control authorities (WPCAs) are required to report such overflows. None were reported from Wallingford, Cheshire, or North Haven sewer authorities. GNHWPCA estimated that over the past three years, some 150 gallons had been discharged from the sanitary sewer. This annual rate of 50 gallons per year was distributed equally among the four watersheds served by GNHWPCA (Middle and Lower Mill River, Lake Whitney, and Shepard Brook).
- Catch Basin Cleaning – Annual catch basin cleaning was assumed throughout the watershed, based on information provided in the most recent MS4 Annual Reports of several of the watershed communities, including Cheshire, Wallingford, Hamden, North Haven and New Haven. Catch basin capture area was based on the acreage of impervious surfaces within the watershed as calculated by the model, the percentage of the subwatershed serviced by storm sewers, and the reported proportion of catch basins cleaned.
- Street Sweeping – The watershed municipalities generally perform annual street sweeping in the spring after the winter deicing season. Annual street sweeping was assumed in the model. Mechanical sweepers and parking restrictions were also assumed.
- Riparian Buffers – The effects of riparian buffers on pollutant load reduction are calculated within the model based on the area of natural land between developed land (residential,

commercial, industrial, roadway, etc.) and the stream in each subwatershed. The widths of riparian buffers were estimated from GIS-processed land cover data.

3. Model Results

Existing Pollutant Loads

Before load reductions are applied, nonpoint source runoff associated with land use alone accounts for approximately 79% of the total nitrogen (TN) load, 43% of the total phosphorus (TP) load, 70% of the total suspended solids (TSS) load, and 74% of the fecal coliform (FC) load for the entire watershed.

Annual loads of bacteria, TP, TN, and TSS were estimated for each subwatershed individually (Figures 2, 3, and 4) and are provided in Tables 9.1 – 9.9 in *Attachment A*. The model results indicate that the three most densely developed subwatersheds, Middle Mill River, Lower Mill River, and Lake Whitney, also have the highest annual bacteria loads (Figure 2). This is unsurprising, as the primary land uses and activities in these subwatersheds have higher EMCs and pollutant loading factors (e.g., dense residential areas, industrial and commercial operations, and road sanding). TN and TP loads are highest in the Middle Mill River, Willow Brook Tributaries, and Willow Brook subwatersheds (Figure 3). TSS loads are highest in the Middle Mill River, Willow Brook, Lake Whitney, and Willow Brook Tributaries subwatersheds (Figure 4).

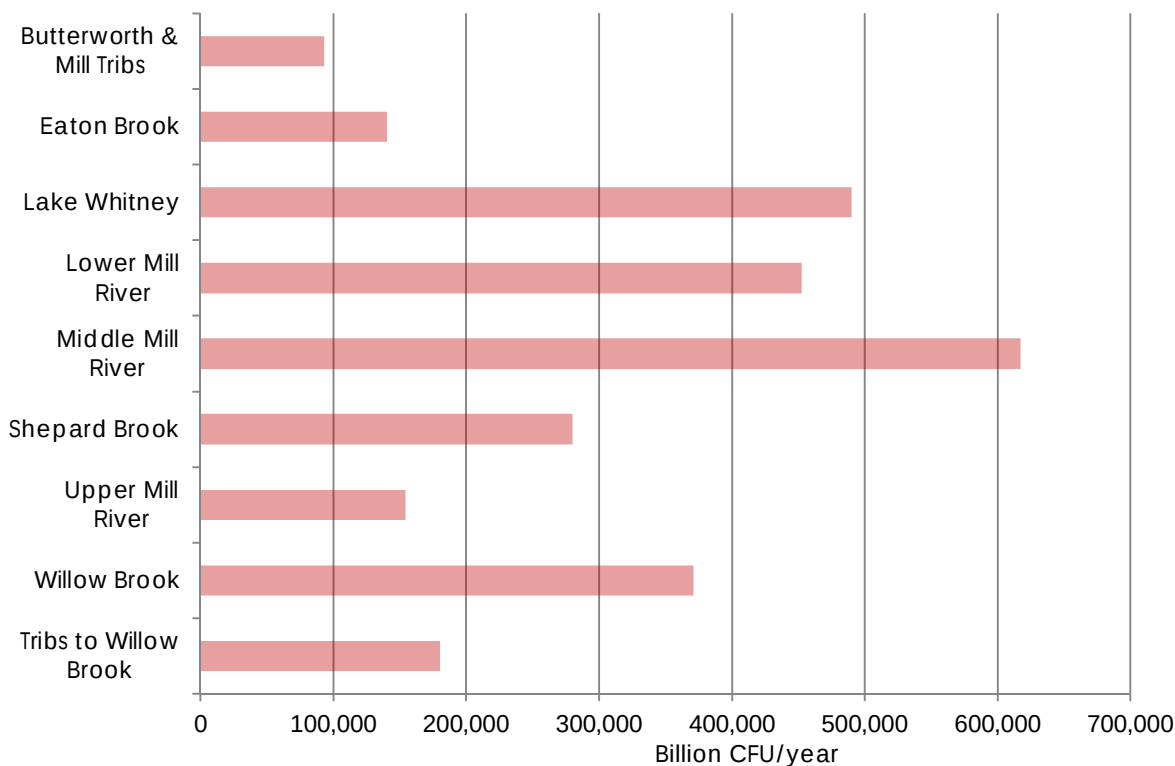


Figure 2: Modeled bacteria loads by subwatershed

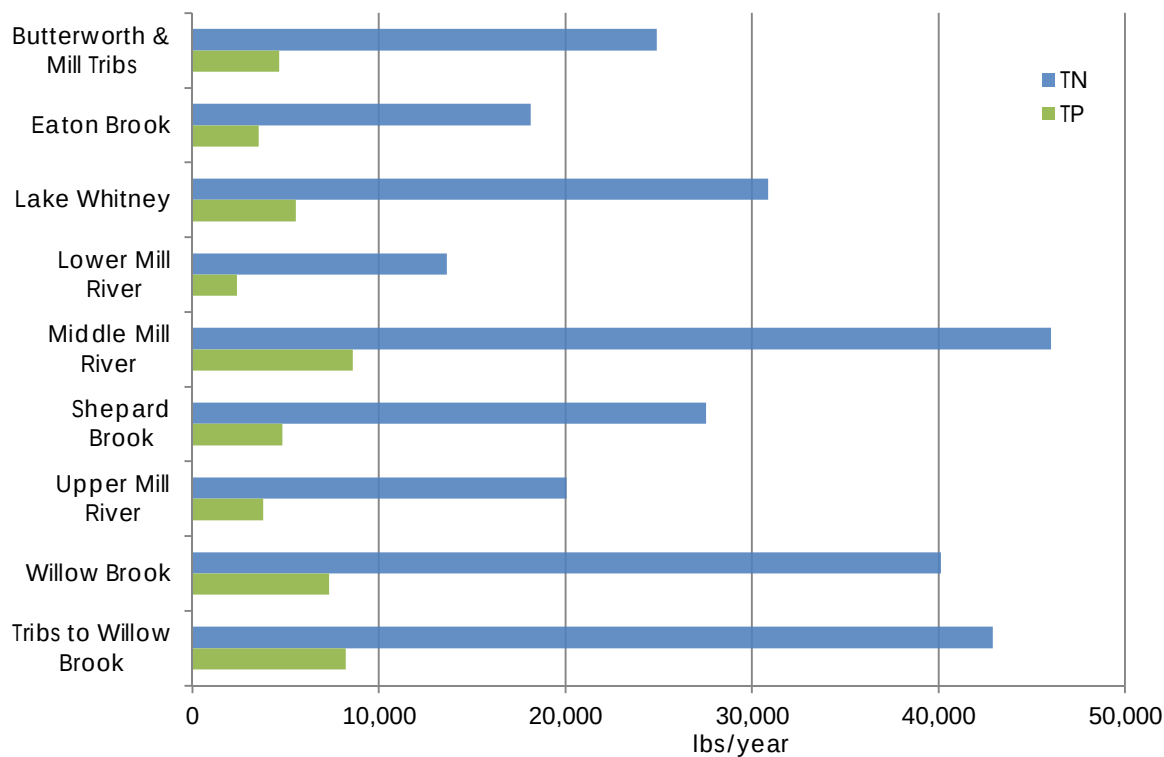


Figure 3: Modeled Total Nitrogen (TN) and Total Phosphorus (TP) loads by subwatershed

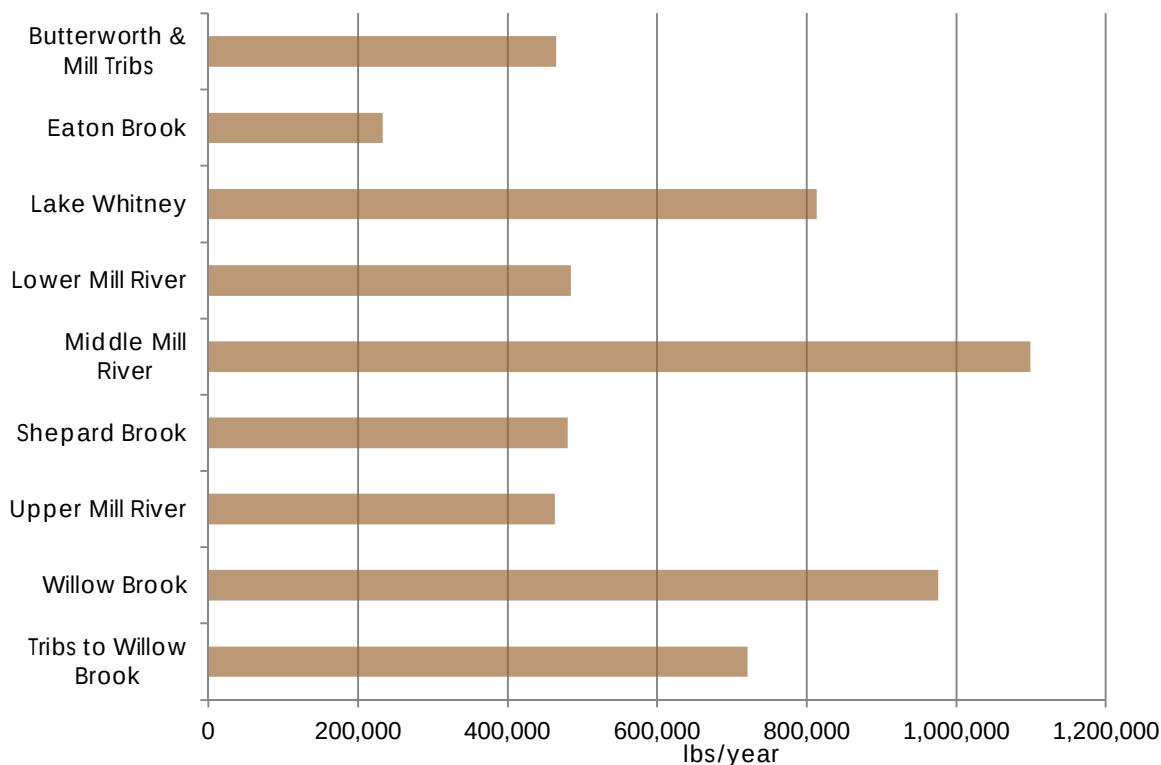


Figure 4: Modeled total suspended solids (TSS) loads by subwatershed

Existing Pollutant Yields

Watersheds differ in area, which directly influences pollutant loads – a larger watershed may have a higher load than a smaller watershed simply because it has a larger area. To remove this effect, pollutant loads were divided by the subwatershed area to derive a per-acre pollutant “yield,” which provides a better comparison of pollutant contributions among subwatersheds of varying sizes (Figures 5, 6, and 7).

Whereas the Middle Mill River has the highest annual bacteria load, after adjusting for subwatershed size, the Lower Mill River has by far the highest bacteria yield (Figure 5). This result is attributable to the contribution of CSOs, which are present in only the Lower Mill River subwatershed, and which discharge substantial concentrations of bacteria during overflow events. The Lake Whitney subwatershed has the next highest bacteria yield, reflecting the high intensity of developed land use. In general, the Mill River subwatersheds can be grouped into three categories based on bacteria yield: lower development intensity (Butterworth Brook and other Mill River tributaries and Willow Brook Tributaries), higher development intensity (Lake Whitney, Middle Mill River, and Shepard Brook), and CSO-influenced (Lower Mill River), with the remaining subwatersheds (Eaton Brook, Upper Mill River, and Willow Brook) falling somewhere between the low and high development intensity groups. The higher development intensity subwatersheds are composed of relatively larger percentages of developed land uses with higher EMCs and greater commercial development with potential for illicit connections. In contrast, the Butterworth Brook and other Mill River Tributaries subwatershed, the fourth largest of the nine subwatersheds considered in this study, has among the lowest annual loads and yields for all pollutants considered. This reflects its more forested nature (e.g., it contains Sleeping Giant State Park) and somewhat limited development relative to other subwatersheds.

As a double check on the validity of the WTM results, the modeled pollutant yields were compared with those of the U.S. Geological Survey (USGS) SPATIally Referenced Regressions On Watershed Attributes model (SPARROW) for TN and TP for the overall Mill River watershed (Moore, Johnston, Robinson, & Deacon, 2004). Comparison of the yields in Table 1 shows that there is good agreement between the two models. WTM results are within the same order-of-magnitude and slightly above the range of SPARROW values. This result is not surprising since the SPARROW results are based on data from 1993 and the intensity of development in the watershed has increased since that time.

Table 1: Comparison of TN and TP estimates

Parameter	TN	TP
WTM (lbs/acre/yr)	8.35 – 13.5	1.56 – 2.37
SPARROW (lbs/acre/yr)	>8.94	0.2 – 1.6

Most subwatersheds have similar modeled nutrient yields for TN and TP (Figure 6), though nutrient yields from Shepard Brook are slightly higher resulting from its combination of land use and relatively higher amount of turf area. As with bacteria yields, the Butterworth Brook and other Mill

River Tributaries subwatershed and Willow Brook Tributaries subwatershed have the lowest nutrient loads (Figure 6), owing again to their lower development intensity.

The Lower Mill River subwatershed has the highest modeled TSS yield (Figure 7), despite having a low suspended sediment load (a result of its being the smallest subwatershed). The variability in TSS yields across subwatersheds reflects the variability of pollutant sources and existing management practices among municipalities, but these relationships can be complex. In the Lower Mill River subwatershed, for example, the City of New Haven and CTDOT no longer use sand in their deicing practices, which reduces sediment loading, but this improvement is offset by the relatively greater concentration of impervious cover in the subwatershed, which increases sediment loading from other land uses. In subwatersheds like the Lake Whitney subwatershed, where much of the population resides in medium density single family homes, greater turf cover can have higher nutrient loads driven by turf management practices.

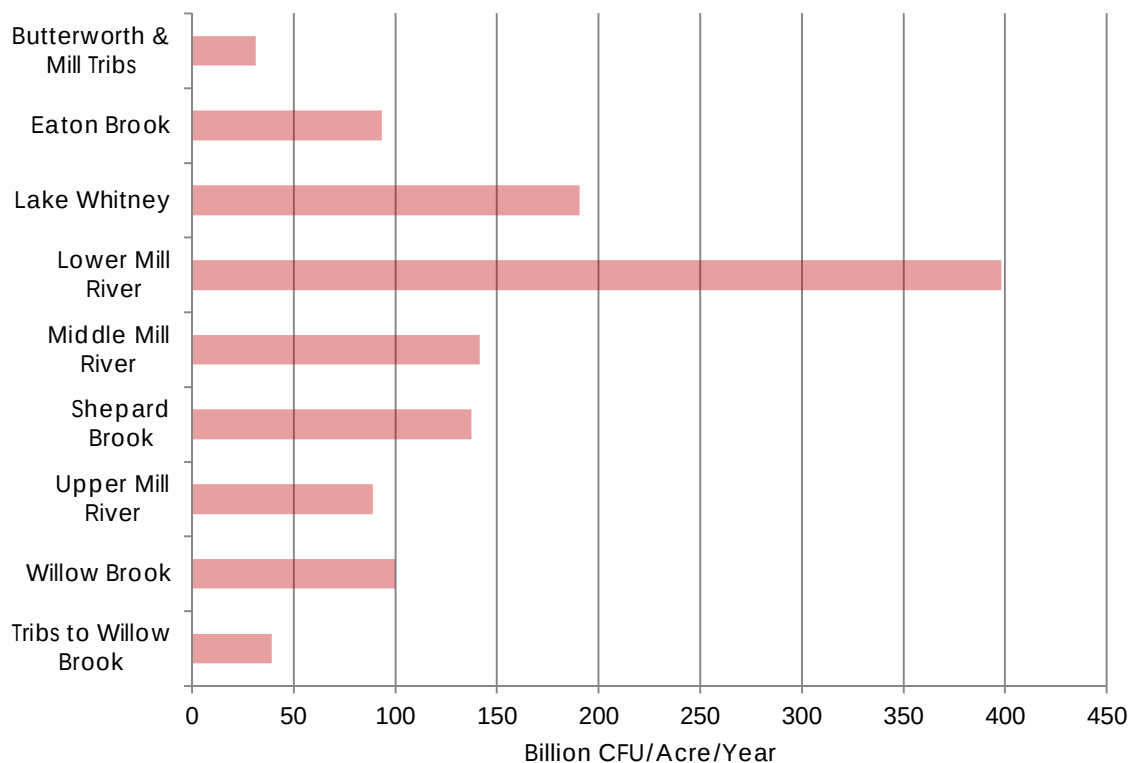


Figure 5: Modeled bacteria yields by subregional drainage basin

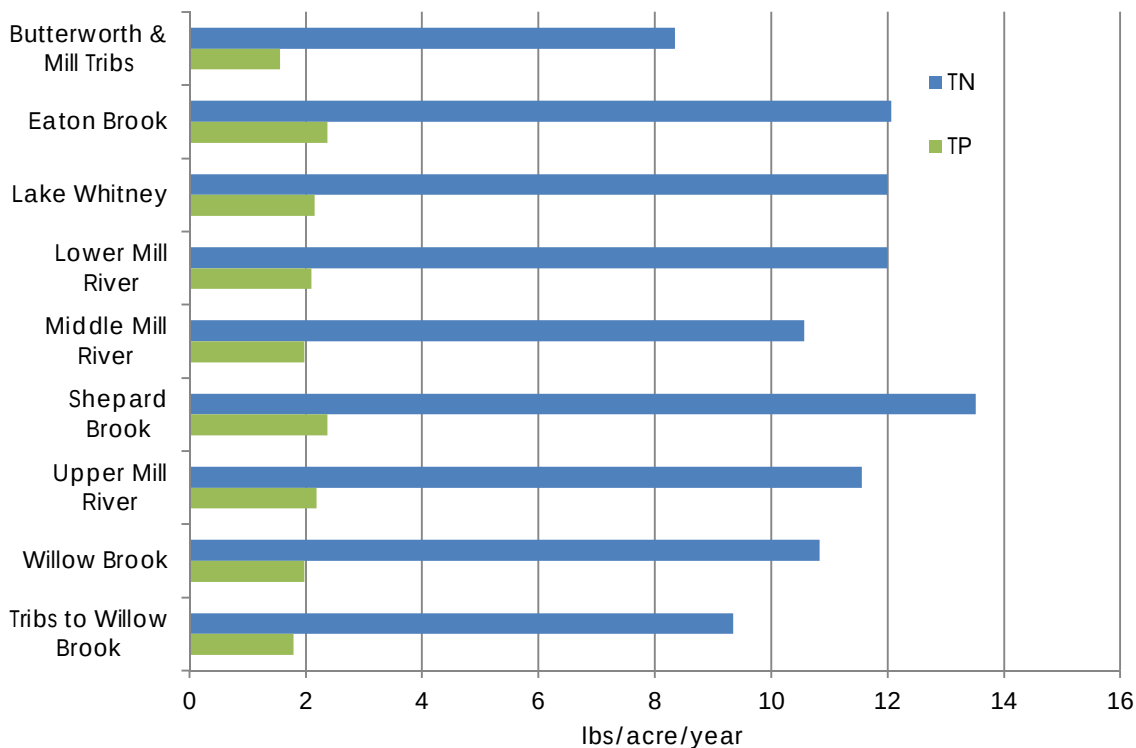


Figure 6: Modeled Total Nitrogen (TN) and Total Phosphorus (TP) yields by subregional drainage basin

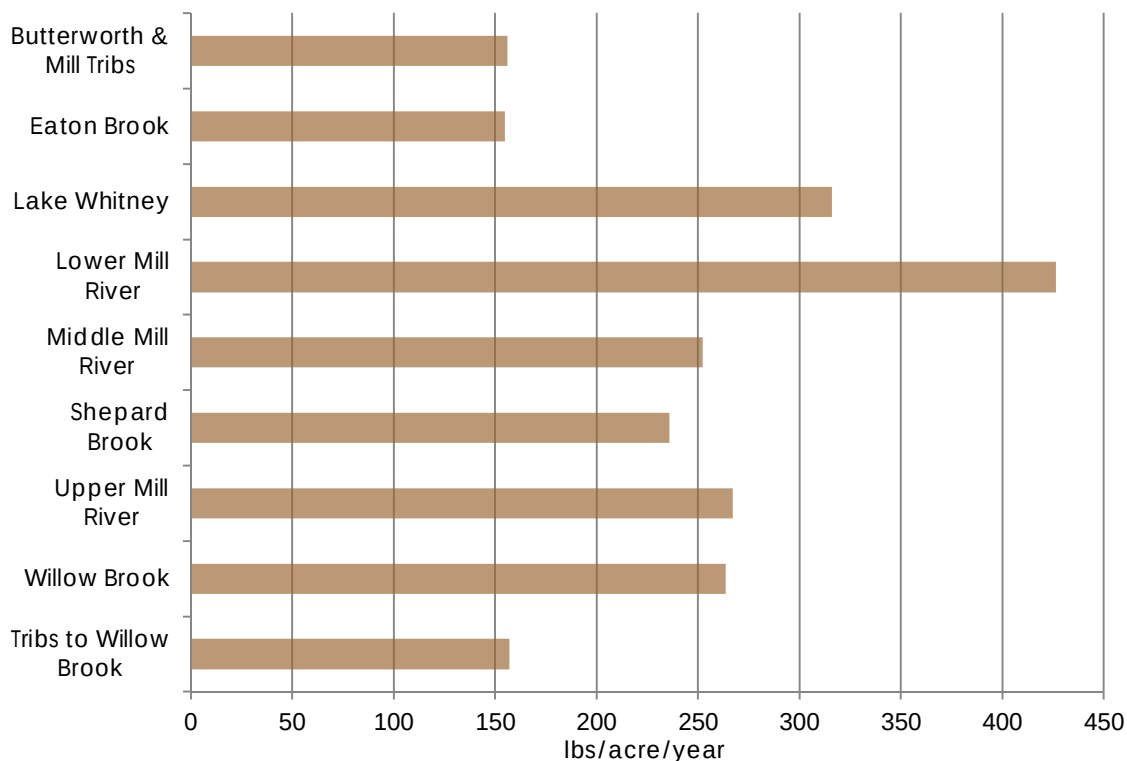


Figure 7: Modeled total suspended solids (TSS) yields by subregional drainage basin

4. Discussion

Bacteria sources in the watershed reflect both the underlying land use (e.g. residential, commercial, and industrial land) and specific activities that can result in bacteria loading to streams (e.g. CSOs, illicit discharges). The relative contribution of bacteria from different land uses and activities is well illustrated by a comparison of the modeled annual pollutant loads in the various subwatersheds (Figures 8-16). In the more-developed Lower Mill River, bacteria loading is largely driven by CSO discharges; around 40% of the annual load and yield stems from CSOs (Figure 8). Potential illicit connections contribute a further 24% of the annual bacteria load (the model generated values of 3 residential and 9 commercial or industrial illicit connections for this subwatershed based on known inputs). Urban land use contributes the rest, or roughly one-third, of the 452,000 billion CFU annual load. By contrast, in the more residential Butterworth Brook and other Mill River Tributaries subwatershed, residential land use contributes about 70% of the annual bacteria load, with forested areas contributing approximately 14% of the 93,000 billion CFU annual load (Figure 16).

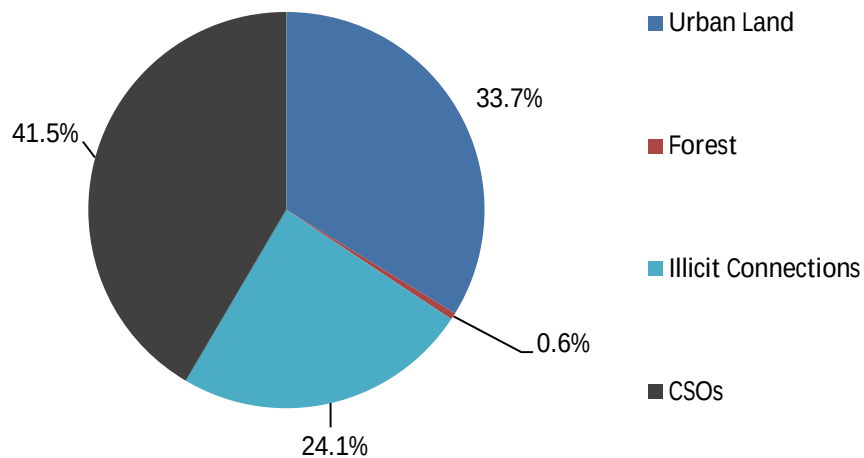


Figure 8: Relative contributions of various bacteria sources in the Lower Mill River subwatershed.
Total annual load: 452,000 billion CFU

This comparison points out some of the opportunities and challenges in watersheds with mixed land use. The modeled bacteria loads in the Lower Mill River illustrate the benefits of management measures that focus on sources of fecal indicator bacteria associated with CSO abatement, and urban stormwater runoff, including source controls, structural stormwater BMPs, education and outreach, and illicit discharge detection and elimination (IDDE). The CSO abatement and sewer separation program already in place through GNHWPCA and CT DEEP will have a positive effect on reducing or eliminating the significant CSO contribution in the Lower Mill River. In addition, despite the modest estimates of illicit connections (0.05% of the subwatershed population and 5% of the businesses served by sewer), eliminating these discrete sources of bacteria could substantially reduce bacteria loadings where sanitary-related illicit connections are present (i.e., in areas served by sanitary sewers). Implementing or continuing to implement an IDDE program, as required under Connecticut's 2017 MS4 permit, in the municipalities that comprise the watershed can be effective at reducing bacteria loads.

In the more residential subwatersheds, structural stormwater BMPs to mitigate urban runoff from residential and commercial development can be effective in reducing the impacts of land use as the primary driver of bacterial loads. Non-structural BMPs such as pet waste cleanup, septic system management in non-sewered areas, and IDDE programs in sewerred areas can help mitigate those contributions of bacteria. Where present in the watershed, agricultural and livestock sources of bacteria typically require a combination of structural and non-structural best management practices to reduce loadings, including identification of “hot spot” bacteria sources and site-specific management strategies to achieve load reductions.

Some impaired segments of Mill River and Shepard Brook are included in the Connecticut Statewide Bacteria TMDL (CTDEEP, 2012). The TMDL identifies percent reductions (Table 2) in geometric mean and single sample fecal indicator bacteria (*E. coli*) concentrations required to meet recreational water quality criteria. These percentages are for reducing fecal indicator bacteria concentrations as measured at ambient monitoring locations in each river segment (i.e., the percentages do not reflect required reductions at the end of stormwater outfalls or reductions of other pollutant loads to the river). It is also important to note that these impairments and percent reductions are based on a very limited data set consisting of a small number of samples collected at only 5 monitoring stations throughout the entire watershed, with the most recent samples dating

Table 2: Bacteria (*E. coli*) Percent Reductions to Meet TMDL

Impaired River Segment	Geometric Mean	Single Sample
Mill River (CT-5302-00_02)	74%	94%
Shepard Brook (CT5302-06_01)	77%	71%

to 2011. Given these caveats, if we assume that these percent reductions in *E. coli* concentrations translate to equivalent percent reductions in loads, then it is obvious that significant reductions in annual bacteria loads are necessary in the Mill River and Willow Brook subregional drainage basins for the impaired river segments to meet recreational water quality criteria. The pollutant loading model results provide an indication as to which sources have the greatest potential for load reductions in each subwatershed.

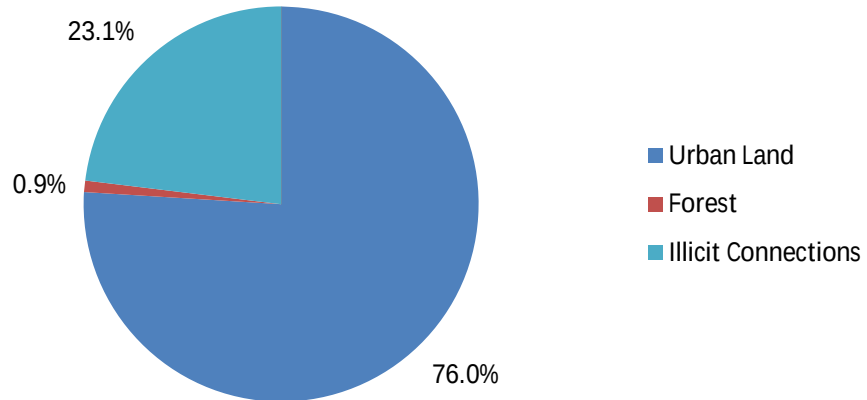


Figure 9: Relative contributions of various bacteria sources in the Lake Whitney subwatershed. Total annual load: 377,000 billion CFU

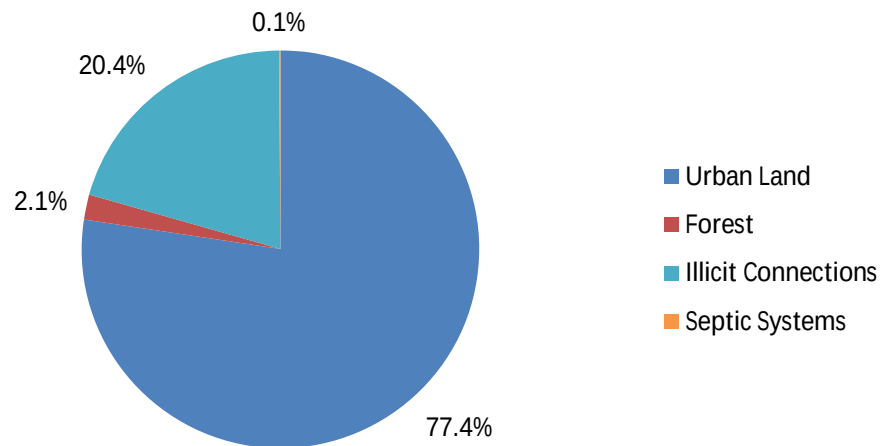


Figure 10: Relative contributions of various bacteria sources in the Middle Mill River subwatershed. Total annual load: 617,000 billion CFU

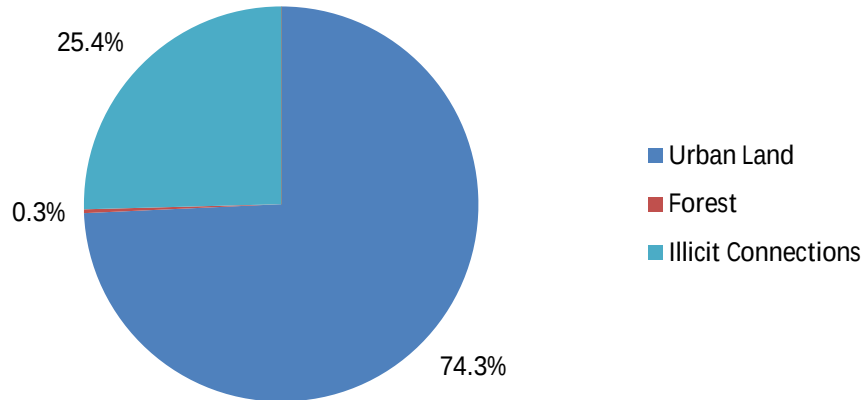


Figure 11: Relative contributions of various bacteria sources in the Shepard Brook subwatershed.
Total annual load: 280,000 billion CFU

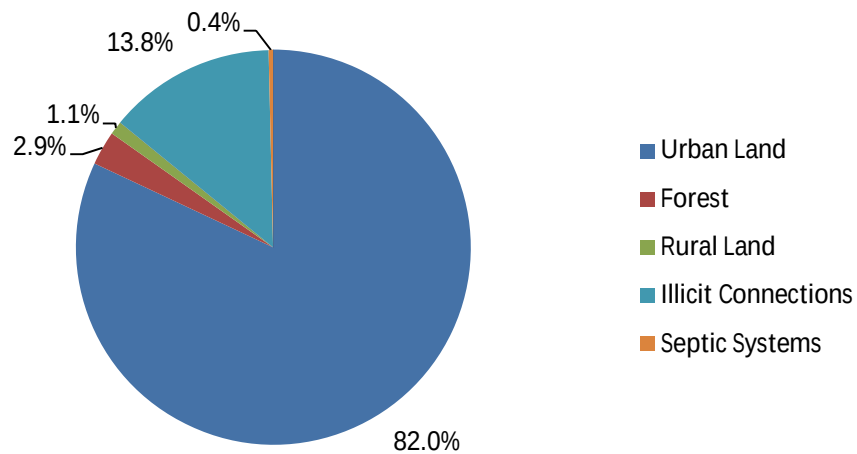


Figure 12: Relative contributions of various bacteria sources in the Willow Brook subwatershed.
Total annual load: 371,000 billion CFU

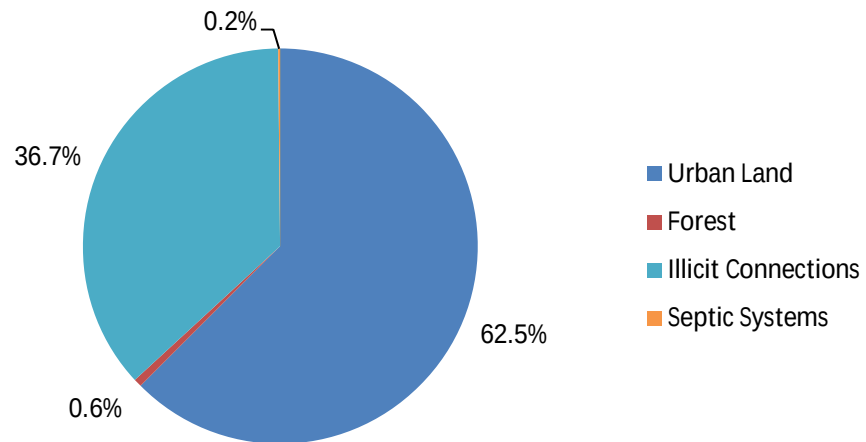


Figure 13: Relative contributions of various bacteria sources in the Eaton Brook subwatershed.
Total annual load: 140,000 billion CFU

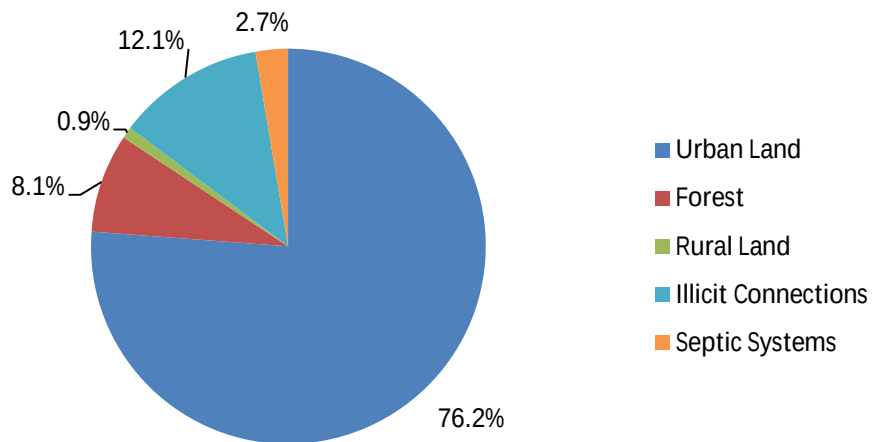


Figure 14: Relative contributions of various bacteria sources in the Willow Brook Tributaries subwatershed. Total annual load: 180,000 billion CFU

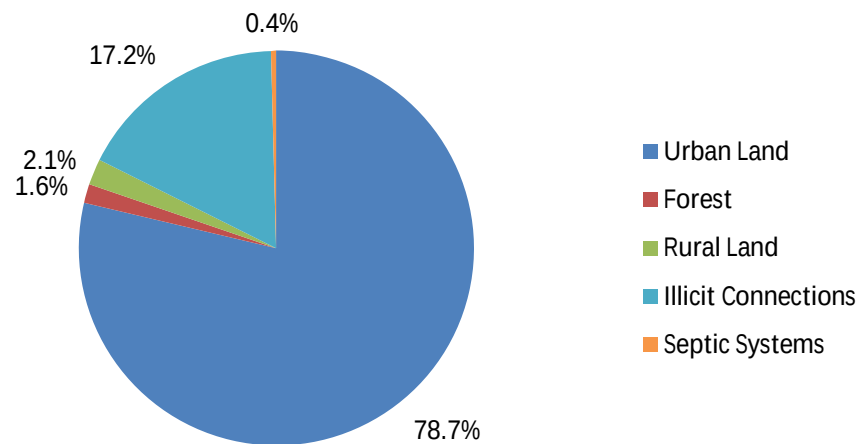


Figure 15: Relative contributions of various bacteria sources in the Upper Mill River subwatershed. Total annual load: 154,000 billion CFU

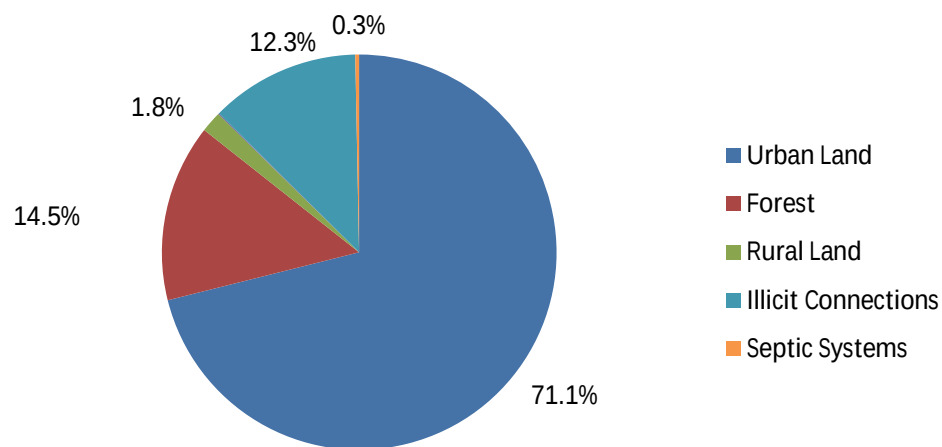


Figure 16: Relative contributions of various bacteria sources in the Butterworth Brook and other Mill River Tributaries subwatershed. Total annual load: 93,000 billion CFU

5. References

- CH2MHILL. (2000). *City of New Haven Long-Term CSO Control Plan. Technical Memorandum #6: Hydraulic Characterization Report*.
- CTDEEP. (2012). *Connecticut Statewide Total Maximum Daily Load (TMDL) for Bacteria-Impaired Waters*. Hartford: Connecticut Department of Energy and Environmental Protection.
- GNHWPCA. (2017). *Consent Order WC5509 Annual Progress Report July 1, 2016 - June 30, 2017*. New Haven, CT: Greater New Haven Water Pollution Control Authority.
- Moore, R., Johnston, C., Robinson, K., & Deacon, J. (2004). Estimation of total nitrogen and phosphorus in New England streams using Spatially Referenced Regression Models. *USGS Scientific Investigations Report 2004-5012*.

Attachment A

Watershed Treatment Model Model Parameter Values, Input Data, and Model Results

Table 1
Land Use and Impervious Cover in the Mill River Watershed
 (Values in acres unless otherwise marked)

	Land Use	Percent Impervious (%)	Butterworth Brook/other Mill River Tributaries	Eaton Brook	Lake Whitney	Lower Mill River	Middle Mill River	Shepard Brook	Willow Brook Tributaries	Upper Mill River	Willow Brook	Watershed Total
Developed	Residential - High Density	46.7	2.4	0.0	208.1	278.9	142.0	85.4	4.0	1.7	13.6	736.0
	Residential - Medium Density	32.5	17.2	8.9	814.0	63.1	841.2	206.0	48.5	134.5	572.3	2,705.5
	Residential - Medium-Low	20.3	143.1	283.8	268.6	17.1	535.9	285.4	172.5	287.6	663.2	2,657.2
	Residential - Low Density	10.2	1,091.6	1,049.9	136.4	18.1	1,003.1	941.7	2,194.5	527.4	730.4	7,693.1
	Developed Recreation	1.1	433.3	0.0	172.0	0.0	56.3	0.0	645.3	208.4	186.0	1,701.3
	Commercial	50.0	0.0	8.7	268.5	44.4	249.3	80.3	96.2	65.1	59.0	871.5
	Industrial	52.6	0.0	0.0	123.4	128.4	3.0	178.0	0.0	0.0	25.4	458.1
	Institutional	22.5	24.0	76.4	198.8	88.8	418.9	191.3	48.8	92.7	228.6	1,368.3
	Roadway/Highway	61.5	99.6	0.0	0.0	217.2	50.0	0.0	114.2	130.2	236.0	847.2
	Utilities	8.3	0.9	0.0	0.0	0.0	1.5	0.0	20.5	8.0	3.4	34.3
Rural	Cropland	8.9	41.5	0.0	0.0	0.0	0.0	0.0	22.3	76.6	97.4	237.9
	Open Space	1.8	1,129.4	75.2	382.3	219.1	1,056.7	68.6	1,220.5	203.0	881.2	5,236.0
	Water	0.4	0.0	0.0	0.0	61.0	0.0	0.0	4.6	0.7	7.2	73.6
	Sub-watershed Total		2,983.0	1,502.9	2,572.0	1,136.0	4,358.0	2,036.6	4,592.0	1,735.8	3,703.8	24,620.1

Table 2
Mill River Watershed Land Use Mapped to Modeled Land Uses

	Land Use	Modeled Land Use	Examples and Notes
Developed	Residential - High Density	High Density Residential	≥8 Dwelling Units ¹ (DU)/acre (1/8-acre lots)
	Residential - Medium Density	Medium Density Residential	2-8 DU/acre (1/2- to 1/8-acre lots)
	Residential - Medium-Low	N/A	1-2 DU/acre (1- to 1/2-acre lots) Assigned equally to Medium and Low Density Residential
	Residential - Low Density	Low Density Residential	1 or fewer DU/acre (>1-acre lots)
	Developed Recreation	Open Space	Modeled as Open Space land use, but with FC value below Low Density Residential
	Commercial	Commercial	General trades, services, offices, motels, etc.
	Industrial	Industrial	
	Institutional	Commercial	Schools, government buildings, churches, etc. Assumed to be same as commercial
	Roadway	Highway	
Rural	Utilities	Rural	Transmission lines, cell towers, electric substations, water pumping stations, etc.
	Agriculture	Cropland	
	Open Space	Forest	Reflects forested areas, wetlands, streams
	Water	Open Water	

Notes

Dwelling units were included in NVCOG parcel-based land use data. For SCRCOG, 2010 census data for occupied housing units was used. This analysis was conducted at the block level and reflects only the residential land use areas within each subwatershed.

Table 3
Developed Land Uses - Event Mean Concentrations
(TN, TP, TSS in mg/L and Fecal Coliform in MPN/100ml)

Land Use	WTM Default Values				Regional Values ¹				Selected Values			
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC
Low Density Residential	2.1	0.31	49	20,000	3.18	0.27	34	2,950	3.18	0.27	34	2,950
Medium Density Residential	2.1	0.31	49	20,000	3.5	0.41	49	12,360	3.5	0.41	49	12,360
High Density Residential	2.1	0.31	49	20,000	3.81	0.64	102	16,901	3.81	0.64	102	16,901
Highway	-	-	-	-	2.65	0.43	141	600	2.65	0.43	141	600
Commercial	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Institutional	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Industrial	2.2	0.25	81	20,000	4	0.11	42	1,467	4	0.11	42	1,467

Notes:

TN = Total Nitrogen; TP = Total Phosphorus; TSS = Total Suspended Solids; FC = Fecal Coliform

Sources:

¹BETA Group, Inc. (2006). Quality Assurance Project Plan. Development of a Watershed Based Plan for Massachusetts.

Caraco, D. and Center for Watershed Protection, Inc. (2013). Watershed Treatment Model (WTM) 2013 Documentation.

Table 4
Rural Land Uses - Export Coefficients
(TN, TP, and TSS in lb/ac/yr and Fecal Coliform in billion/ac/yr)

Land Use	WTM Default Values				Regional Values				Selected Values				Comments
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC	
Forest	2.0	0.2	100	12	2.5 ⁽¹⁾	0.2 ⁽¹⁾	100 ⁽¹⁾	12 ⁽¹⁾	2.5	0.2	100	12	Selected regional values
Rural	4.6	0.7	100	39	-	-	-	-	4.6	0.7	100	39	Selected WTM Default values
Open Water	12.8	0.5	155	-	0.4 ⁽¹⁾	0.03 ⁽¹⁾	2 ⁽¹⁾	0.4 ⁽¹⁾	0.4	0.03	2	0.4	Selected regional values
Cropland	-	-	-	-	Pasture	Pasture	Pasture	Pasture	10	0.8	300	39	Selected TN, TP, and TSS based on regional sources for pasture and row crops; FC assumed same as Rural land use
					1.9 ⁽¹⁾	0.1 ⁽¹⁾	47 ⁽¹⁾	7 ⁽¹⁾					
					7.7 ⁽²⁾	1.3 ⁽²⁾	591 ⁽³⁾						
					5.6 ⁽³⁾	0.5 ⁽³⁾							
					Row Crops	Row Crops	Row Crops	Row Crops					
					14.4 ⁽²⁾	4.0 ⁽²⁾	1997 ⁽³⁾	-					
					15.7 ⁽³⁾	0.94 ⁽³⁾							

Notes:

TN = Total Nitrogen; TP = Total Phosphorus; TSS = Total Suspended Solids; FC = Fecal Coliform

Conversion equation used for Pasture/Orchard

NSQD (2005) and MA DEP QAPP do not provide rural land use data.

Cropland export coefficients are based on regional values. This category includes both pasture and crop land. Pasture land and hay fields are about as prevalent as nurseries and row crops in the Mill River Watershed, so the selected coefficients represent an approximate average of those values.

Sources:

Maestre & Pitt and Center for Watershed Protection (2005). The National Stormwater Quality Database, Version 1.1.

Caraco, D. and Center for Watershed Protection, Inc. (2013). Watershed Treatment Model (WTM) 2013 Documentation.

Regional values identified by number:

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2. Reckhow et al. (1980): "Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients." From Lin, J. (2005) Review of Published Export Coefficient and Event Mean Concentration (EMC) Data. Converted values from kg/ha/yr to lb/ac/yr.
3. CH2M HILL (2001). PLOAD version 3.0, An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects: User's Manual.

Table 5
Sources and Model Assumptions

Parameter	Sources	Model Assumptions & Notes
Primary Sources		
Subwatershed Boundary	CTDEEP – Local basins	Smaller local basins with similar characteristics were grouped for this analysis. Where subwatershed boundaries do not follow local basins, they reflect impaired uses and follow contours based on 2000 LiDAR data
Land Use	NVCOG – Land Use 2016 SCRCOG – Land Use 2017 US Census 2010 CTECO – 2016 3-inch Orthophotography	NVCOG land use classifications were simplified for input into WTM. Acreage for various classifications was determined in ArcGIS by intersecting the land use with the Subwatersheds. NVCOG land use classifications include Medium-Low Density Residential, which was equally divided and split between Medium Density and Low Density Residential. Residential density is based on dwelling units per acre. This information was included in NVCOG parcel-based land use data. For SCRCOG, 2010 census data for occupied housing units was used. This analysis was conducted at the census block level and reflects only the residential land use areas within the Mill River watershed. SCRCOG land use included two categories of Other and Mixed Use. These areas were manually assigned to modeled land uses via aerial imagery. Most “Other” areas were combined with open space. Mixed Use was combined with Commercial. Where roadways were not included in land use coverage, the difference in area between subwatersheds and subwatershed land use coverage was assigned to the “Highway” category. Some municipalities classify this land use based on the surrounding land use (e.g. a residential street is classified as Residential)
Pollutant Event Mean Concentrations (EMCs) and Export Coefficients	WTM Default Values, Selected Regional Values used in MA Watershed Based Plan (2006)	Selected regional EMCs were used for residential, transitional, commercial, highway, and industrial land use categories. WTM default values were used for rural, powerlines, and open water land use categories.
Impervious %	CT ECO 2016	The impervious surface data set was available from CT Environmental Conditions Online (CTECO) as a statewide dataset representing impervious surfaces digitized from 2012 orthophotography. The percent impervious for land use classes in each subwatershed was determined by intersecting the raster with available land use data.
Annual Rainfall	Northeast Regional Climate Center	Weather station on Mt Carmel, Hamden. Period of record 1936-2018.
Stream Length	CTDEEP Hydrography Line	Stream lengths in each subwatershed were calculated based on intersecting the CTDEEP Hydrography Line data layer with the Subwatershed boundaries.



Parameter	Sources	Model Assumptions & Notes
Soils Information	CTDEEP Soils Data – NRCS SSURGO-Certified Soils 2009	Hydrologic Soils Group data were available from SSURGO and matched to CTDEEP soils data based on the Soil Map Unit Key (MUKey) field. Where the sum of category percentages is less than 100%, the balance is water, which does not receive HSG classification, but is most similar in infiltration characteristics to Category D. An estimate of the depth to groundwater was made by converting USDA drainage classes, which are essentially an estimate of seasonal high water table. Depth to groundwater was estimated at 3-5 ft across the watershed.
Runoff Coefficients	Virginia Erosion & Sediment Control Handbook, 1980.	Runoff coefficients for Rural Land Uses were selected from a range of values listed in the Virginia Erosion & Sediment Control Handbook. Values for Cropland ranged from 0.15 to 0.4 and from 0.12 to 0.35 for Pasture/Orchard, etc.
Secondary Sources		
General Sewage Data	GNHWPCA, North Haven WPCA, Cheshire Water Pollution Control Dept, Wallingford Sewer Division, NVCOG parcel-based land use and WTM defaults	Watershed parcels in residential areas were excluded based on proximity to sanitary sewer piping.
Nutrient Concentration in Stream Channels	Haith et al. 1992	A mid- range value of 0.15 was used for Soil P (%) and Soil TN (%). See figures 4.1 and 4.2 in the WTM 2013 Documentation.
On-Site Sewage Disposal (OSDS)	GNHWPCA, North Haven WPCA, Cheshire Water Pollution Control Dept, Wallingford Sewer Division, NVCOG parcel-based land use, Local Health Districts, and WTM defaults	All dwelling units assumed to be served by OSDS unless the parcel is within an area served by sanitary sewers. Unsewered areas were set to Clay/Mixed Soils. A failure rate of 1% was selected based on regional estimates and data on local system failure from Quinnipiac and Chesprocott Health Districts. Septic system type was set to 100% conventional, with medium maintenance. Typical separation from groundwater was assumed to be 3-5 ft. The OSDS density was set at 1-2 per acre based on calculated dwelling unit density in unsewered areas.
CSOs	GNHWPCA Consent Order WC5509 Annual Progress Report 2017 West River Watershed Based Plan, 2015	Three CSOs exist in the Mill River watershed, all within the Lower Mill River subwatershed. Meters installed at these outfalls in 2012 monitor discharge volumes for each storm event that causes a discharge. Sufficient data has now been collected for the WPCA to estimate a “typical year” of discharges based on both precipitation and on average monthly overflow events. Rather than use the default CSO contribution calculated by the WTM by applying the Simple Method, the availability of data in this watershed, coupled with estimates of pollutant concentrations applied in the neighboring West River Watershed Based Plan, allowed for the direct estimation of annual loading from CSOs.
SSOs	GNHWPCA, North Haven WPCA, Cheshire Water Pollution Control Dept, Wallingford Sewer Division	SSOs must be reported in MS4 Annual Reports. Per these reports and in discussion with relevant municipal personnel, SSOs were only reported in the GNHWPCA sanitary sewer area. In the past three years, 150 gallons of sanitary sewage has been discharged to the storm sewer system. An annual discharge of 50 gallons was assumed, and distributed evenly across all subwatersheds served by GNHWPCA.



Parameter	Sources	Model Assumptions & Notes
Illicit Connections	NVCOG Parcel-based land use 2016, Aerial imagery, Google Maps	In sewered areas, 0.5/1000 residential connections and 5% of business connections assumed to be illicit. Model defaults used for pollutant concentrations and percent wash water.
Stream Channel Erosion	NA to Non-urban watersheds.	Method 1 was selected as the method to estimate channel erosion which assumes that some fraction of the total watershed load comes from stream channel erosion. A stream degradation value of "medium" (50% of the total sediment load) was applied to each subwatershed.
Livestock	Aerial imagery	Livestock operations were sparse in this mainly urban/suburban watershed. The entire Mill River watershed was visually examined for livestock operations at a scale of ~1:5,000. Head counts were based on aerial imagery, which was sufficiently detailed to distinguish between grazing livestock types and obtain an approximate number. Nutrient loads converted from daily loads in kilograms (Ruddy et al., 2006). E. coli loads converted from daily loads reported by Borel et al. (2015), which are based on those from Wagner and Moench (2009), who incorporated daily fecal production and fecal coliform concentration into their load estimates. These loads are based on the concept of an animal unit (AU), which standardizes animals based on unit forage intake, relative to cows (Scarnecchia 1985).
Road Sanding	Winter Highway Maintenance Operations, 2015 UConn MAGIC – Connecticut Roads (2010) Municipal MS4 Annual Reports	Based on the CTDOT report, state agencies switched from sand to sodium chloride. An anonymous survey of 31 municipalities in Connecticut showed that 6.143 tons/lane mile of sand was used. This rate was multiplied by the lane miles under municipal jurisdiction to determine the amount of road sand applied per Subwatershed/WTM Area. Road miles were determined by intersection of the Connecticut Roads layer with the shape file containing the respective Subwatershed/WTM Area. Only Cheshire, Prospect, and Hamden use a mixture of sand and salt. No information is available for the ratio of sand to salt used in de-icing operations for these municipalities, so an even mixture of sand and salt was assumed. Other municipalities no longer use sand. Lane miles were doubled, because all municipal roads were assumed to be two-lane roads. The fraction of roads that are open is determined by dividing the amount of roadway that is open by the amount of road that drains to catch basins. Open sections do not have catch basins. Based on the urban/suburban nature of the study area, the length of road within the Municipal Separate Storm Sewer System (MS4) regulated area was used to estimate that 10-20% of roads were classified as open, on the assumption that urbanized areas are more likely to have closed section roads than more rural areas.
Non-Stormwater Point Sources	EPAs ICIS web data service	Daily discharge values of reported effluent concentrations on the EPA ICIS website were used for evaluating the contributing load from this source. Within the subwatersheds, most facilities do not have sampling requirements for their discharges. Several others were construction-related permits and monitored turbidity only. The rest monitored metals. Two in the Lower Mill River subwatershed, at Yale University, monitored bacteria.

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Table 6
Additional Model Inputs

	Butterworth Brook/other Mill River Tributaries	Eaton Brook	Lake Whitney	Lower Mill River	Middle Mill River	Shepard Brook	Willow Brook Tributaries	Upper Mill River	Willow Brook	Watershed Total
Road Sanding (lbs/yr) - Entire Watershed	62,625	107,975	320,982	2,756	329,598	171,934	177,291	125,152	271,683	1,567,997
% With storm drains	80	80	80	90	80	80	80	80	80	80
% Without storm drains	20	20	20	10	20	20	20	20	20	20
Total length of streams (miles)	9.61	4.11	5.49	2.77	10.91	4.30	18.20	6.08	9.22	105.19
Dwelling units	878	1,388	6,775	5,664	8,246	4,100	1,640	1,397	3,519	33,607
Percentage of dwelling units un-sewered	25.7	11.3	0.0	0.0	6.5	0.5	82.6	31.6	30	10.8
Percentage of dwelling units with onsite septic within 100 ft of surface water ¹	3.13	8.39	0.0	0.0	3.27	0.21	9.81	3.75	3.00	1.89
Residential Sewered units	652	1,231	6,775	5,664	7,792	4,079	285	970	2,463	29,962
Commercial/Business Sewered units	0	161	120	175	90	85	0	40	2	673
Hydrologic Soil Group (Percent)										
A	0.5	14.0	24.3	34.6	10.9	4.7	12.3	2.5	13.2	
B	38.2	39.1	32.7	12.2	42.6	49.9	46.0	30.6	48.8	
C	30.7	25.8	5.9	5.1	19.7	25.6	16.4	47.7	18.9	
D ²	29.9	21.1	27.4	42.4	25.6	19.6	24.9	19.0	18.5	

¹ Dwelling units with septic systems are assumed to be located within 100 feet of a waterbody based on a review of parcel-based land use and hydrography.

² Hydrologic soil group designation does not consider surface water. This area has been included under Group D which has the most similar infiltrative properties.

Table 7
Livestock Pollutant Loading Rates/Export Coefficients

Livestock	Nitrogen ¹ (lbs/animal/year)	Phosphorus ¹ (lbs/animal/year)	E. coli ² (billion cfu/AU/year)
Bovine	164	26	1,966
Equine	102	18	84
Ovine	18.5	3.2	7,165
Poultry	1.1	0.4	85

¹ Ruddy et al (2006). Loads converted from daily loads in kilograms.

² E. coli loads converted from daily loads reported by Borel et al. (2015), which are based on those from Wagner and Moench (2009), who incorporated daily fecal production and fecal coliform concentration into their load estimates. These loads are based on the concept of an animal unit (AU), which standardizes animals based on unit forage intake, relative to cows (Scarnecchia 1985).

Table 8
Estimated Head of Livestock by Drainage Basin

Livestock	Butterworth Brook/other Mill River Tributaries	Willow Brook
Bovine	0	0
Equine	45	10
Ovine	0	0
Poultry	0	0

Notes:

Head counts were based on aerial imagery, which was sufficiently detailed to distinguish among grazing livestock types and obtain an approximate number. It was assumed that most but likely not all head of livestock were grazing when aerial imagery was captured. This incorporates Giant Valley Polo Club and two hobby farms.

Table 9.1
Modeled Pollutant Loads in the
Butterworth Brook and other Mill River Tributaries Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	66,271	21,494	4,373	186,168	3,151	71.07	86.32	93.88	40.00	93.84
Low Density Residential	39,282	16,056	2,808	87,899	2,295	59.28	74.70	64.20	47.21	72.83
Medium Density Residential	20,710	2,224	536	15,940	289	31.25	10.35	12.27	8.56	9.16
High Density Residential	942	81	28	1,104	10	1.42	0.37	0.64	0.59	0.30
Commercial	-	-	-	-	-	-	-	-	-	-
Highway	1,707	2,859	956	77,894	490	2.58	13.30	21.85	41.84	15.56
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	3,629	274	46	3,331	67	5.48	1.27	1.04	1.79	2.13
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	4	4	124,753	-	-	0.02	0.08	26.80	-
Road Sanding	-	-	-	28,647	-	-	-	-	6.15	-
Forest	13,553	2,824	226	112,941	162	14.53	11.34	4.85	24.27	4.82
Rural Land	1,657	420	34	12,557	45	1.78	1.69	0.73	2.70	1.35
Livestock	28	103	12	-	-	0.03	0.41	0.26	-	-
Illicit Connections	11,448	15	3	101	-	12.28	0.06	0.05	0.02	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	296	40	7	267	-	0.32	0.16	0.14	0.06	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	81,509	23,222	4,571	452,516	3,358	87.41	93.27	98.13	97.22	100.00
Total Non-Storm Load	11,744	1,677	87	12,918	-	12.59	6.73	1.87	2.78	-
Total Load to Surface Waters	93,253	24,899	4,658	465,435	3,358	100.00	100.00	100.00	100.00	100.00

Table 9.2
Modeled Pollutant Loads in the
Eaton Brook Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	87,684	17,819	3,518	115,628	2,584	62.52	98.28	98.61	49.69	99.62
Low Density Residential	39,238	13,733	2,543	79,888	1,955	44.75	77.07	72.27	69.09	75.67
Medium Density Residential	35,012	3,219	822	24,520	416	39.93	18.06	23.37	21.21	16.12
High Density Residential	-	-	-	-	-	-	-	-	-	-
Commercial	2,000	129	23	1,670	32	2.28	0.72	0.65	1.44	1.22
Highway	-	-	-	-	-	-	-	-	-	-
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	11,434	738	130	9,550	181	13.04	4.14	3.71	8.26	6.99
Channel Erosion	-	2	2	51,810	-	-	0.01	0.04	22.27	-
Road Sanding	-	-	-	56,847	-	-	-	-	24.43	-
Forest	902	188	15	7,520	10	0.64	1.04	0.42	3.23	0.38
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	51,450	94	28	693	-	36.68	0.52	0.80	0.30	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	212	28	5	186	-	0.15	0.15	0.13	0.08	-
Open Water	-	-	-	-	-	-	-	-	-	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Total Storm Load	88,586	17,914	3,530	231,052	2,594	63.16	98.81	98.95	99.30	100.00
Total Non-Storm Load	51,667	216	38	1,631	-	36.84	1.19	1.05	0.70	-
Total Load to Surface Waters	140,254	18,130	3,568	232,684	2,594	100.00	100.00	100.00	100.00	100.00

Table 9.3
Modeled Pollutant Loads in the
Lake Whitney Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	372,531	29,728	5,428	374,912	4,536	75.98	96.34	97.86	46.11	99.05
Low Density Residential	8,041	2,325	335	18,644	350	2.16	7.82	6.17	4.97	7.71
Medium Density Residential	200,627	15,240	3,027	160,003	2,084	53.86	51.27	55.76	42.68	45.93
High Density Residential	75,978	4,595	1,309	92,244	577	20.40	15.46	24.11	24.60	12.72
Commercial	56,584	3,017	415	53,820	780	15.19	10.15	7.64	14.36	17.21
Highway	-	-	-	-	-	-	-	-	-	-
Industrial	4,249	3,108	145	24,471	372	1.14	10.45	2.67	6.53	8.20
Institutional	27,052	1,443	198	25,731	373	7.26	4.85	3.65	6.86	8.23
Channel Erosion	-	5	5	155,060	-	-	0.02	0.08	19.07	-
Road Sanding	-	-	-	243,768	-	-	-	-	29.98	-
Forest	4,587	956	76	38,228	43	0.94	3.10	1.38	4.70	0.95
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	113,193	169	38	1,176	-	23.09	0.55	0.68	0.14	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	-	-	-	-	-	-	-	-	-	-
Open Water	-	-	-	-	-	-	-	-	-	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Total Storm Load	377,118	30,210	5,487	808,146	4,579	76.91	97.90	98.91	99.39	100.00
Total Non-Storm Load	113,198	647	61	4,999	-	23.09	2.10	1.09	0.61	-
Total Load to Surface Waters	490,316	30,857	5,547	813,145	4,579	100.00	100.00	100.00	100.00	100.00

Table 9.4
Modeled Pollutant Loads in the
Lower Mill River Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	152,322	12,013	2,205	313,435	2,039	33.66	88.13	92.63	64.68	98.68
Low Density Residential	823	173	21	1,673	30	0.54	1.44	0.96	0.53	1.45
Medium Density Residential	15,705	867	147	10,984	135	10.31	7.21	6.65	3.50	6.62
High Density Residential	105,454	4,633	1,125	112,277	663	69.23	38.56	51.00	35.82	32.50
Commercial	9,689	375	44	8,082	111	6.36	3.12	1.99	2.58	5.42
Highway	3,542	3,049	715	146,858	627	2.33	25.38	32.42	46.85	30.75
Industrial	4,575	2,431	97	23,108	331	3.00	20.24	4.38	7.37	16.24
Institutional	12,533	486	57	10,454	143	8.23	4.04	2.58	3.34	7.01
Channel Erosion	-	4	4	140,355	-	-	0.03	0.18	28.96	-
Road Sanding	-	-	-	1,363	-	-	-	-	0.28	-
Forest	2,629	548	44	21,912	27	0.58	4.02	1.84	4.52	1.32
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	110,102	174	43	1,231	-	24.33	1.27	1.80	0.25	-
Septic Systems	-	-	-	-	-	-	-	-	-	-
Open Water	24	24	2	122	-	0.01	0.18	0.08	0.03	-
CSOs	187,395	868	83	6,197	-	41.42	6.37	3.47	1.28	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Point Source Discharges	0	-	-	-	-	0.00	-	-	-	-
Total Storm Load	342,371	13,183	2,325	481,194	2,066	75.67	96.72	97.65	99.29	100.00
Total Non-Storm Load	110,107	448	56	3,422	-	24.33	3.28	2.35	0.71	-
Total Load to Surface Waters	452,478	13,630	2,381	484,616	2,066	100.00	100.00	100.00	100.00	100.00

Table 9.5
Modeled Pollutant Loads in the
Middle Mill River Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	477,689	43,111	8,327	501,532	6,691	77.38	93.63	96.83	45.61	97.95
Low Density Residential	42,062	12,285	1,874	92,709	1,804	8.81	28.50	22.50	18.49	26.96
Medium Density Residential	257,722	19,774	4,161	195,390	2,638	53.95	45.87	49.97	38.96	39.42
High Density Residential	56,688	3,463	1,045	65,426	424	11.87	8.03	12.55	13.05	6.34
Commercial	57,430	3,093	451	51,928	781	12.02	7.18	5.41	10.35	11.67
Highway	860	1,030	300	38,669	181	0.18	2.39	3.60	7.71	2.71
Industrial	112	83	4	613	10	0.02	0.19	0.05	0.12	0.14
Institutional	62,814	3,383	493	56,796	854	13.15	7.85	5.92	11.32	12.76
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	7	7	230,190	-	-	0.01	0.08	20.93	-
Road Sanding	-	-	-	260,222	-	-	-	-	23.66	-
Forest	12,680	2,642	211	105,670	139	2.05	5.74	2.46	9.61	2.03
Rural Land	59	7	1	151	1	0.01	0.02	0.01	0.01	0.02
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	126,157	181	37	1,246	-	20.44	0.39	0.43	0.11	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	730	95	16	636	-	0.12	0.21	0.18	0.06	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	490,428	44,442	8,483	1,087,182	6,831	79.45	96.52	98.64	98.87	100.00
Total Non-Storm Load	126,887	1,601	117	12,464	-	20.55	3.48	1.36	1.13	-
Total Load to Surface Waters	617,315	46,043	8,600	1,099,646	6,831	100.00	100.00	100.00	100.00	100.00

Table 9.6
Modeled Pollutant Loads in the
Shepard Brook Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	207,854	27,245	4,785	264,022	3,943	74.30	98.96	99.13	54.96	99.77
Low Density Residential	36,467	10,886	1,846	80,693	1,581	17.54	39.96	38.58	30.56	40.11
Medium Density Residential	82,175	6,444	1,508	62,545	851	39.54	23.65	31.50	23.69	21.57
High Density Residential	34,557	2,157	724	40,041	262	16.63	7.92	15.12	15.17	6.63
Commercial	18,753	1,032	167	17,023	258	9.02	3.79	3.49	6.45	6.54
Highway	-	-	-	-	-	-	-	-	-	-
Industrial	6,784	5,122	281	37,288	592	3.26	18.80	5.88	14.12	15.00
Institutional	29,118	1,603	260	26,432	400	14.01	5.88	5.42	10.01	10.15
Channel Erosion	-	3	3	104,941	-	-	0.01	0.07	21.85	-
Road Sanding	-	-	-	103,776	-	-	-	-	21.60	-
Forest	823	171	14	6,857	9	0.29	0.62	0.28	1.43	0.23
Rural Land	-	-	-	-	-	-	-	-	-	-
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	71,065	108	25	753	-	25.40	0.39	0.51	0.16	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	6	3	1	22	-	0.00	0.01	0.01	0.00	-
Open Water	-	-	-	-	-	-	-	-	-	-
SSOs	5	0	0	0	-	0.00	0.00	0.00	0.00	-
Total Storm Load	208,677	27,333	4,798	478,909	3,952	74.59	99.29	99.39	99.70	100.00
Total Non-Storm Load	71,076	197	29	1,460	-	25.41	0.71	0.61	0.30	-
Total Load to Surface Waters	279,753	27,530	4,827	480,370	3,952	100.00	100.00	100.00	100.00	100.00

Table 9.7
Modeled Pollutant Loads in the
Upper Mill River Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	121,398	18,621	3,658	246,147	2,812	78.67	92.85	96.47	53.12	96.02
Low Density Residential	22,921	7,737	1,196	54,016	1,087	18.88	41.55	32.68	21.94	38.64
Medium Density Residential	66,039	5,856	1,249	53,533	747	54.40	31.45	34.13	21.75	26.57
High Density Residential	684	48	15	844	6	0.56	0.26	0.40	0.34	0.20
Commercial	15,252	949	140	14,746	229	12.56	5.10	3.83	5.99	8.15
Highway	2,274	3,145	929	109,252	530	1.87	16.89	25.38	44.38	18.84
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	14,228	886	131	13,756	214	11.72	4.76	3.57	5.59	7.60
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	3	3	110,353	-	-	0.02	0.09	23.81	-
Road Sanding	-	-	-	62,009	-	-	-	-	13.38	-
Forest	2,436	508	41	20,302	29	1.58	2.53	1.07	4.38	0.98
Rural Land	3,300	803	67	23,788	88	2.14	4.00	1.76	5.13	2.99
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	26,501	41	10	293	-	17.17	0.21	0.27	0.06	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
Septic Systems	671	79	13	526	-	0.44	0.39	0.35	0.11	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	127,135	19,280	3,737	458,190	2,929	82.39	96.13	98.54	98.87	100.00
Total Non-Storm Load	27,172	776	55	5,228	-	17.61	3.87	1.46	1.13	-
Total Load to Surface Waters	154,307	20,055	3,792	463,418	2,929	100.00	100.00	100.00	100.00	100.00

Table 9.8
Modeled Pollutant Loads in the
Willow Brook Subwatershed

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	303,955	36,635	7,033	486,740	5,482	81.96	91.32	95.76	49.87	96.44
Low Density Residential	34,932	10,718	1,588	78,870	1,552	11.49	29.26	22.58	16.20	28.32
Medium Density Residential	210,547	16,971	3,468	163,516	2,233	69.27	46.32	49.32	33.59	40.74
High Density Residential	5,469	351	103	6,465	42	1.80	0.96	1.46	1.33	0.77
Commercial	13,666	773	109	12,658	193	4.50	2.11	1.56	2.60	3.51
Highway	4,085	5,136	1,454	188,082	893	1.34	14.02	20.68	38.64	16.28
Industrial	959	745	36	5,381	86	0.32	2.03	0.51	1.11	1.56
Institutional	34,298	1,941	275	31,768	483	11.28	5.30	3.90	6.53	8.81
SSOs	-	-	-	-	-	-	-	-	-	-
CSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	7	7	226,657	-	-	0.02	0.09	23.22	-
Road Sanding	-	-	-	143,229	-	-	-	-	14.67	-
Forest	10,575	2,203	176	88,125	111	2.85	5.49	2.40	9.03	1.95
Rural Land	3,930	989	80	29,556	92	1.06	2.47	1.09	3.03	1.61
Livestock	6	23	3	-	-	0.00	0.06	0.04	-	-
Illicit Connections	51,060	72	14	487	-	13.77	0.18	0.19	0.05	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS	1,341	187	31	1,250	-	0.36	0.47	0.43	0.13	-
Open Water	3	3	0	14	-	0.00	0.01	0.00	0.00	-
Total Storm Load	318,469	38,264	7,222	962,554	5,684	85.87	95.38	98.34	98.62	100.00
Total Non-Storm Load	52,401	1,855	122	13,505	-	14.13	4.62	1.66	1.38	-
Total Load to Surface Waters	370,870	40,119	7,344	976,059	5,684	100.00	100.00	100.00	100.00	100.00

Table 9.9
Modeled Pollutant Loads in the
Willow Brook Tributaries Subwatershe

Source	Existing Loads to Surface Waters					Percent of total load				Runoff Volume (%)
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/year)	FC (%)	TN (%)	TP (%)	TSS (%)	
Urban Land	137,445	39,250	7,896	305,703	5,795	76.19	91.47	95.99	42.41	96.71
Low Density Residential	74,083	30,353	5,509	165,415	4,274	53.90	77.33	69.77	54.11	73.76
Medium Density Residential	30,816	3,317	831	23,668	424	22.42	8.45	10.52	7.74	7.32
High Density Residential	1,578	135	49	1,844	16	1.15	0.34	0.61	0.60	0.27
Commercial	21,832	1,650	286	19,998	399	15.88	4.20	3.62	6.54	6.89
Highway	1,937	3,252	1,128	88,185	549	1.41	8.28	14.28	28.85	9.48
Industrial	-	-	-	-	-	-	-	-	-	-
Institutional	7,198	544	94	6,593	132	5.24	1.39	1.19	2.16	2.27
SSOs	-	-	-	-	-	-	-	-	-	-
CSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	5	5	180,198	-	-	0.01	0.07	25.00	-
Road Sanding	-	-	-	102,254	-	-	-	-	14.18	-
Forest	14,646	3,051	244	122,048	159	8.12	7.11	2.97	16.93	2.65
Rural Land	1,672	318	32	8,758	38	0.93	0.74	0.39	1.21	0.64
Livestock	-	-	-	-	-	-	-	-	-	-
Illicit Connections	21,797	29	5	195	-	12.08	0.07	0.06	0.03	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS	4,825	256	43	1,709	-	2.67	0.60	0.52	0.24	-
Open Water	2	2	0	9	-	0.00	0.00	0.00	0.00	-
Total Storm Load	153,765	40,941	8,095	705,890	5,992	85.24	95.41	98.41	97.92	100.00
Total Non-Storm Load	26,621	1,970	131	14,985	-	14.76	4.59	1.59	2.08	-
Total Load to Surface Waters	180,386	42,912	8,226	720,875	5,992	100.00	100.00	100.00	100.00	100.00

Appendix C

Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan

MEMORANDUM

TO: Nicole Davis and Gwen Macdonald, Save the Sound

FROM: Erik Mas, P.E, Julianne Busa, Ph.D., and Stefan Bengtson, MSc, Fuss & O'Neill, Inc.

DATE: June 28, 2018

RE: Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment
Mill River Watershed-Based Plan

1. Introduction

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Mill River. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. Stormwater runoff collected by the combined sanitary and storm sewer system in the City of New Haven also contributes to three remaining Combined Sewer Overflow (CSO) discharges to the Mill River during periods of heavy rainfall, when the combined sewer system becomes overwhelmed. CSO discharges therefore contribute additional pollutant loads to the Mill River during wet weather.

Low Impact Development (LID) is a site design strategy that maintains, mimics, or replicates pre-development hydrology through the use of numerous site design principles and small-scale treatment practices distributed throughout a site to manage runoff volume and water quality at the source. Similarly, “green infrastructure” refers to systems and practices that reduce runoff through the use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). When applied to sites or neighborhoods, LID and green infrastructure (referred to hereafter as simply “green infrastructure”) include stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

In addition to reducing polluted runoff and improving water quality, green infrastructure has been shown to provide other social and economic benefits relative to reduced energy consumption, improved air quality, carbon reduction and sequestration, improved property values, recreational opportunities, overall economic vitality, and adaptation to climate change. For these reasons, many communities are exploring the use of and are adopting green infrastructure within their municipal infrastructure programs.

An important objective of the Mill River Watershed Management Plan is to reduce runoff volumes and pollutant loads through the use of green infrastructure by building on the previous and ongoing

LID and green infrastructure initiatives in the watershed and region and targeting areas of known water quality impairments.

2. Assessment Approach

An assessment was performed to identify opportunities and develop concepts for site-specific green infrastructure retrofits in the Mill River watershed. The assessment consisted of four primary tasks:

1. Identification of existing green infrastructure practices in the Mill River watershed,
2. Screening evaluation to quickly identify areas of the watershed with the greatest feasibility for and potential benefits from green infrastructure retrofits,
3. Field inventories of the most promising green infrastructure retrofit opportunities in the watershed identified from the screening step,
4. Green infrastructure concept designs for selected retrofit sites.

3. Existing Green Infrastructure Practices

There are a number of ongoing green infrastructure initiatives in the greater New Haven area. Implementation of green infrastructure is a key objective of the Greater New Haven Water Pollution Control Authority (GNHWPCA) strategic plan (GNHWPCA, 2017). GNHWPCA requires the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development and redevelopment projects within combined sewer areas (*Table 1*) in accordance with the GNHWPCA Permitting and Design Criteria Manual. GNHWPCA and the City of New Haven, working with CFE/Save the Sound and other groups, are also installing bioswales at numerous locations throughout the City within the public right-of-way to reduce runoff to the combined sewer system and reduce pollutant loads to surface waters. The City of New Haven has also adopted regulatory requirements to reduce stormwater runoff from development projects contributing to the City's combined sewer system.

The Town of Hamden has also been active in pursuing green infrastructure projects. The Town has applied for 319 funding for a project at Town Center Park which would involve installation of a stormwater treatment wetland to manage runoff from 88 acres of surrounding commercial and residential land. The Town has also adopted regulations and practices that directly support LID, including stormwater regulations that reference the DEEP stormwater manual, parking regulations that require any parking areas above and beyond the required minimum to be created with pervious materials and aim, more generally, at reducing paved surfaces, and landscape regulations that directly address stormwater quality issues. The Town has established impervious cover maximums and works closely with the RWA to coordinate stormwater efforts.

Area universities and other key facilities serve as visible demonstration sites for green infrastructure practices in and around the watershed. Over the past decade, Yale University has incorporated infiltration and water reuse at a number of buildings that are either within the Mill River watershed or contributing to the sewershed of CSO #011 (which outfalls to the Mill River). These include the Yale School of Forestry and Environmental Studies, Greenberg Conference Center, Yale School of Management, Yale Divinity School, and several science buildings (*Table 1*).

Table 1. GNHWPCA Green Redevelopment Projects

Permit Approval Year	Description	Address	Components
2007	Yale School of Forestry & Environmental Studies	Sachem & Prospect Streets*	Storage Tanks, Water Feature
2008	Albertus Magnus College Parking Lot	900 Prospect Street	Infiltrators
2008	St. Donato's Expansion	501 Lombard Street*	Infiltrators
2008	Yale Greenberg Conference Center	Prospect Street	Infiltrators
2008	Yale Ingalls Rink Expansion	73 Sachem Street	Bioswale, Tree wells, infiltrators
2008	Yale School of Management	155 Whitney Avenue	Irrigation Storage Tank, Infiltrators
2008	Yale Divinity School	409 Prospect Street	Drywells
2009	Yale Biology Building	230 Whitney Avenue	Rainwater Reuse Tank, Bioswale, Infiltrators
2011	Murray Place Housing	191 Saltonstall Avenue	Infiltrators
2012	Lovell House Apartments	45 Nash Street	Infiltrators
2012	Albertus Magnus College Drainage	700 Prospect Street	Drywells and curtain drain
2013	Yale Kline Chemistry Laboratory	285 Prospect Street*	Rainwater Reuse Tank, Infiltrators
2014	Community Building	72 James Street	Infiltrators
2014	315 Whitney Avenue	315 Whitney Avenue	Pervious Pavers, Infiltrators
2014	1040 State Street	1040 State Street	Infiltrators
2016	Yale Science Building	260 Whitney Avenue*	Infiltrators
2015	Esplanade Apartments	396 Prospect Street*	Perforated pipe, water quality chamber
2017	District NHV, LLC	470 James Street	Retention Basins
2017	Wright Lab Renovation	266 Whitney Avenue*	Rip Rap Swales
2017	Bender Showroom	335 East Street	Infiltrators
2018	New Haven Housing	703 Whitney Avenue	Infiltrators
2017	Apartments	245 Whitney Avenue*	Pavers, Rain Gardens, Infiltrators
Under Review	Unicast Development	620 Grand Avenue	Infiltrators
field visit 6/2018	St Joseph Church (St Mary's)	129 Edwards St	Infiltrators
field visit 6/2018	United Church of the Redeemer	185 Cold Spring Street	Infiltrators

* An asterisk after the address indicates sites which are outside the watershed, but inside the sewershed of CSO#11

Similarly, Quinnipiac University has incorporated permeable pavement into some of its parking areas, including an overflow lot on Sherman Avenue, and is actively exploring additional sustainability improvements. Throughout the South Central Basin, the UConn CT NEMO program is working on a pilot project focused on incorporating green infrastructure into local projects. The Regional Water Authority has been another advocate for water quality improvements in the watershed; the Whitney Water Treatment Facility features a 30,000 square foot extensive green roof that captures stormwater and reduces runoff.

During site visits, the field team also noted that Elim Park Retirement Community, one of the sites identified as a priority site during the green infrastructure screening process (described below), already managed stormwater using an existing treatment wetland and pond. There are likely

other, scattered green infrastructure practices in use on private properties throughout the watershed.

4. Assessment Methods and Findings

The remainder of this technical memorandum documents the methods and findings of the green infrastructure screening evaluation, field inventories, and concept designs.

Screening Evaluation

A GIS-based screening evaluation was conducted to quickly identify specific parcel-based locations within the watershed where green infrastructure retrofits can be implemented that would provide water quality (i.e., pollutant reduction) and quantity (i.e., runoff reduction) benefits in the watershed. The types of green infrastructure retrofits with potential applicability in the Mill River watershed include:

- Permeable pavement
- Bioretention/bioswales
- Infiltration/filtration including tree box filters
- Green/blue roofs
- Tree planting
- Water harvesting/reuse

Green infrastructure retrofit opportunities exist on sites or parcels and within street rights-of-way, as evidenced by the ongoing “green streets” or “complete streets” retrofits by the City of New Haven and the GNHWPCA. Right-of-way projects were included in the screening process; however, the primary focus of the analysis was on parcel-based green infrastructure opportunities on publicly-owned land and privately-owned institutional properties.

The following screening criteria and data sources were used to create an initial list of the most feasible sites for green infrastructure retrofits in the target subwatersheds:

- Target Subwatersheds – Subwatersheds with impaired water bodies, as defined in the 2016 Integrated Water Quality Report were prioritized, since green infrastructure retrofits in these areas would have the greatest water quality benefits. The following subwatersheds were identified as target areas for further consideration:
 - Upper Mill River
 - Middle Mill River
 - Lower Mill River
 - Willow Brook
 - Shepard Brook

The Lower Mill River subwatershed also encompasses those areas of the Mill River watershed with combined sewers, thereby providing additional benefits related to CSO discharges by reducing the amount of runoff entering the combined sewer system (*Figure 1*).

- Land Ownership – Publicly-owned (e.g., municipal) parcels are most favorable because they avoid the cost of land acquisition and provide direct control over green infrastructure construction, maintenance, and monitoring by the municipality. Other publicly-owned parcels such as schools, universities, state facilities, and federal facilities are also potential green infrastructure candidates. Certain types of private parcels (e.g., private universities, churches) may be suitable and were also included in the analysis. In the screening process, land ownership attribution was based on land use classifications from both the South Central Regional Council of Governments (SCRCOG) and the Naugatuck Valley Council of Governments (NVCOG). Approximately 489 parcels in the Mill River watershed were identified as possible sites given land use classifications of community facility, institutional, recreational, open space, or utilities. Of those parcels, 231 occur in targeted subwatersheds.¹
- Subsurface Conditions – Subsurface conditions are key considerations for green infrastructure retrofits that rely on infiltration of stormwater runoff and where runoff reduction is desired. Soil infiltration capacity, depth to groundwater, depth to restrictive layers (bedrock, dense till), soil bulk density, and inundation of soils due to flooding are important soil-based characteristics that can affect the feasibility of infiltration-based green infrastructure retrofits.² For the purposes of this desktop screening evaluation, we used hydrologic soil groups (HSGs), as mapped by the Natural Resources Conservation Service (NRCS), to identify candidate sites for green infrastructure retrofits. HSGs provide an initial estimate of infiltration rate and storage capacity of soils on a site. Sites where mapped HSGs have high infiltration rates (A and B soils) are most suitable for infiltration stormwater practices. While soil maps provide initial estimates of infiltration potential, field investigations will be necessary to verify soil conditions for final feasibility determinations and design purposes. Note also that while the analysis generally focused on sites with A and B soils, input from the steering committee led us to include a number of sites in New Haven that are mapped as D soils, but where experience has shown that the soils in fact exhibit good infiltration characteristics.

Screening Results

The most feasible sites for green infrastructure retrofits were initially defined as those where all three screening criteria coincided, based on GIS analysis. Specifically, candidate sites for green infrastructure retrofits were identified as:

- Within impaired subwatersheds; and
- On publicly-owned land or higher-priority private institutional land (e.g., churches and private schools); and
- Having HSG A or B soils (or sites in New Haven, as described above).

¹ Note that, although given a lower priority here, private properties also offer considerable opportunities for GI/LID. Individual landowners should be encouraged to pursue green infrastructure, and municipalities can further encourage adoption of GI practices through review and revision of land use regulations.

² Other site-specific factors such as land area, impervious area, drainage area, subsurface utilities, subsurface contamination, and storm drainage system capacity are also important considerations for green infrastructure retrofits.

Candidate sites were then further screened for degree of impervious cover, such that open space areas that are essentially wooded conservation land with no existing buildings, roads, or parking areas (and therefore little expectation of generating pollutants) were considered lower priority and excluded from the list.

All sites meeting the above criteria were included on a list of potential sites (*Attachment A*). These sites were further divided into higher priority and lower priority sites, with public sites given priority due to the advantage conveyed by public ownership when actually trying to fund and implement retrofit projects. The list was further refined with input from Save the Sound staff and projects suggested by the Steering Committee. The final list of priority sites (*Attachment A*) included a total of 78 sites, 38 of which were identified as higher priority, and 40 of which were identified as lower priority.

Field Inventories

Site visits were conducted at 30 of the higher priority sites, as well as 6 of the lower priority sites, with visits attended by staff from Fuss & O'Neill, Connecticut Fund for the Environment/Save the Sound (CFE/STS), or a team consisting of representatives from both organizations. Most site visits were conducted on June 12 and 13, 2018, with some follow-up visits conducted by CFE/STS the following week. The sites and adjacent street areas were walked and visually inspected for potential green infrastructure retrofit opportunities (i.e., impervious surfaces connected to the on-site drainage system, available green space to accommodate new green infrastructure practices, existing drainage features that could be enhanced or improved) and physical site characteristics such as site configuration, drainage patterns, current use, slope, landscaping, subsurface utilities, design complexity, and maintenance access considerations. Notes were recorded and photographs taken at each site.

Sites Selected for Concept Designs

Based on the findings of the field inventories, green infrastructure retrofit opportunities were identified at the majority of the sites visited. The following 10 sites were selected for development of concept designs, as these sites are believed to (1) have the greatest feasibility for green infrastructure retrofits and the greatest potential pollution reduction impact, (2) represent a cross-section of common retrofit types and serve to demonstrate a variety of green infrastructure approaches, and (3) are distributed geographically throughout the targeted areas of the Mill River watershed (*Figure 2*):

1. Elm City College Preparatory Elementary School, New Haven
2. James Street, New Haven
3. John S. Martinez School and Exchange Street, New Haven
4. Wilbur Cross High School, New Haven
5. Livingston Street at East Rock Road, New Haven
6. Bartlem Recreation Area, Cheshire
7. Strathmore Drive, Cheshire
8. YNHH Outpatient Services, Hamden
9. Whitney High School North/West, Hamden
10. Counter Weight Brewery, Spring Glen Nursery, and Raccio Park Road, Hamden

5. Site-Specific Project Concepts

The site-specific green infrastructure retrofit concepts presented in this section are intended to serve as potential on-the-ground projects for future implementation. They also provide examples of the types of projects that could be implemented at similar sites throughout the watershed. It is important to note that the concepts presented in this section are examples of potential opportunities, yet do not reflect site-specific project designs. Individual project proponents (e.g., municipalities, private property owners, developers) are responsible for evaluating the ultimate feasibility of, as well as design and permitting for, these and similar site-specific concepts.

Preliminary, planning-level costs were estimated for the site-specific concepts presented in this section. These estimates are based upon unit costs derived from published sources, engineering experience, and the proposed concept designs. Capital (construction, design, permitting, and contingency) and operation and maintenance costs are included in the estimates, and total annualized costs are presented based on the anticipated design life of each green infrastructure practice. A range of likely costs is presented for each concept, reflecting the inherent uncertainty in these planning-level cost estimates. A detailed breakdown of these estimated costs is included in *Attachment C*.

In some cases, costs are presented for multiple alternative project approaches, for example, both a subsurface infiltration option and a pervious pavement option³. Subsurface infiltration chambers are a far more expensive option, but have the benefit of increased potential infiltration capacity in certain soils and the ability to accept stormwater that is already in an underground drainage system, whereas pervious pavement is limited to infiltrating surface flows. Pervious pavement also poses increased maintenance concerns over subsurface infiltration options, as the pavement can be damaged by snow removal operations and must be kept clean of silt and other fine materials that would clog the pavement and reduce its ability to infiltrate.

Where bioretention/rain gardens are recommended, pricing assumes the 'bioretention' rate (see Appendix C), which utilizes contracted labor for design and implementation. Simple raingardens can also be constructed using volunteer labor for hand-digging and planting at reduced costs that would be more in line with the 'raingarden' pricing rate (see Appendix C).

Preliminary sizing calculations are also provided for each practice and are based on the goal of capturing and treating/infiltrating the water quality volume (WQV), generally defined as the first one-inch of runoff from the contributing drainage area. Approximate drainage areas are provided for each practice within the designs, along with the expected WQV to be generated from that drainage area.

The table in *Attachment D* contains information on site characteristics and potential green infrastructure opportunities for the other sites visited during the field inventories that were deemed to have good potential for green infrastructure retrofits.

³ Note that pervious pavement costs presented in the memo and in Appendix C are based upon a porous asphalt design. More decorative alternatives, such as pervious pavers, will have increased costs (see Appendix C).

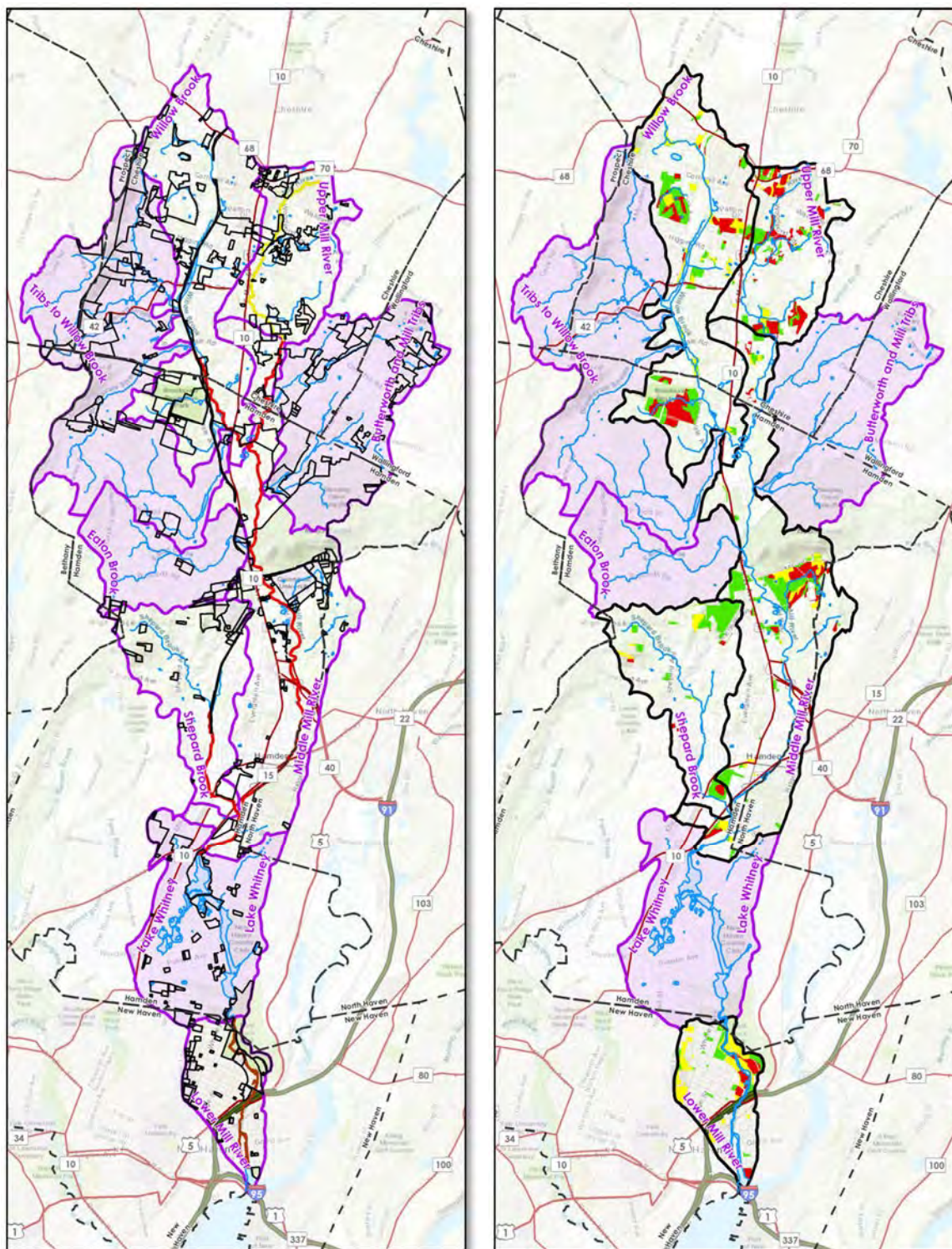


Figure 1. Maps of screening criteria. Impaired subwatersheds are outlined, while non-impaired subwatersheds are masked in purple. On the left, parcels meeting the land ownership are outlined in black. On the right, only the subset of parcels within impaired watersheds is depicted; parcel color reflects the subsurface conditions: green indicates A or B soils, yellow areas are labeled as D soils, but includes areas of urban soils known to have good infiltration, and red indicates areas of C soils or limited infiltration potential.



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Elm City College Preparatory Elementary School

Located at 407 James Street, New Haven, Elm City Preparatory Elementary occupies an approximately 1.5-acre site at the corner of James Street and Lombard Street, in a CSO area (CSO #009). With the exception of a 0.25-acre artificial turf field, the site is entirely impervious. Existing catch basins capture parking lot runoff along the western edge of the lot. Downspouts from the building appear to be internal and to tie in to the drainage system at the downgradient catch basin before connecting to the City's stormwater infrastructure running along James Street. A broken curb at the west edge of the parking lot is currently allowing runoff to bypass the catch basins and travel down a short embankment to the sidewalk.

The sidewalk in front of the school along James Street is approximately 11 feet wide in most places. Planters with trees are incorporated into the sidewalk at 50 foot intervals; however, there is a tree missing directly in front of the school parking area (*Figure 3*).

Space is the most significant constraint at this site, as parking is tight and there is little impervious area. Existing street trees, a fire hydrant/water lines, and other utilities pose additional constraints. A variety of BMPs are recommended for this site in order to best achieve the following goals: maximize enhancement of curricular value in a limited space, maximize infiltration/treatment potential, and keep implementation costs manageable. These elements could be implemented all at once, or installed gradually as funding permits (total project costs will vary widely depending on which components are chosen).

- **Tree Box Filter and Bioretention/Infiltration.** A tree box filter and replacement tree are proposed for the location where a tree is currently missing (*Figure 3*). A tree box filter design with additional subsurface infiltration capacity is recommended (*Figure 5*). A curb cut from James Street would channel runoff from the street into the filter and infiltration system. It is also proposed to convert five feet of sidewalk directly adjacent to the street to bioretention areas or rain gardens with native grasses and other plantings. Additional curb cuts would direct water into these bioretention areas, which would also serve to enhance the landscape around the school. These bioretention areas could be integrated into the curriculum as demonstration sites to supplement lessons on science and the environment, and, of the BMPs proposed, would likely offer the greatest opportunity for interactive lessons (planting, maintenance, etc.). For ease of implementation and consistency with the proposed James Street design concept, the City could choose to implement their standard 5 foot by 15 foot bioswale design along the sidewalk at this location (*Figure 6*). *Estimated Cost for Tree Box Filter: \$9,000; Estimated Cost per Bioswale: \$20,000*
- **Parking Lot Retrofits.** Subsurface infiltration and/or pervious pavement is proposed for the parking area (*Figure 4, Figure 6*) to manage stormwater falling on the parking area as well as roof runoff captured by the school's gutters and downspouts.
 - o Based on available field data, using subsurface infiltration in the area adjacent to the turf play area would make it possible to intercept existing lines carrying downspout runoff and turf drainage without significantly reconfiguring these drainage systems (approximately 40,000sf of drainage area, and 3,200cf WQV). An 1,100sf practice underneath the six parking spaces adjacent to the turf field would potentially allow for

treatment of up to 4,150cf WQV. The existing downgradient catch basin located in the school's driveway would serve as overflow to allow any excess water to be conveyed to the storm sewer in James Street, as is currently occurring. Note that site-specific soil drainage characteristics may allow for effective use of pervious pavement without additional subsurface infrastructure, for a significantly reduced project cost (although this would make it more difficult and costly to accept stormwater from roof and turf drains and would therefore likely result in treatment of a significantly lower percentage of total site runoff). *Estimated Cost: \$108,000 (Subsurface infiltration); Estimated Cost: \$5,000 (Pervious Pavement)*

- o To minimize costs, and to increase the variety of BMPs demonstrated on site, pervious pavement is proposed as the preferred option for the parking spaces parallel to James Street. Converting these spaces to pervious pavement would remove 2,500sf of pervious surface from the lot, and depending on the infiltration capacity of the soils and precise slope of the site, may be sufficient area to effectively infiltrate the roughly 800cf WQV of stormwater runoff expected from the entire 10,000sf main parking area, as the remainder of the surface slopes slightly to the west. *Estimated Cost: \$10,000*
- Management of Dumpster Area. The school's dumpsters are located in the southeast corner of the parking lot, at the top of a slope which drains to James Street. Dumpsters should always be kept closed to minimize exposure to stormwater. For additional protection, a containment system consisting of spill containment grooves could be incorporated into the pavement to further prevent pollutants from being carried into the storm drainage system (*Figure 6*). *Estimated Cost: \$0-\$1,000*

Total Estimated Cost: Variable, depending on components installed.



Figure 3 Sidewalk in front of Elm City College Preparatory Elementary School, with missing tree.



Figure 4. Parking lot at Elm City College Preparatory Elementary School.

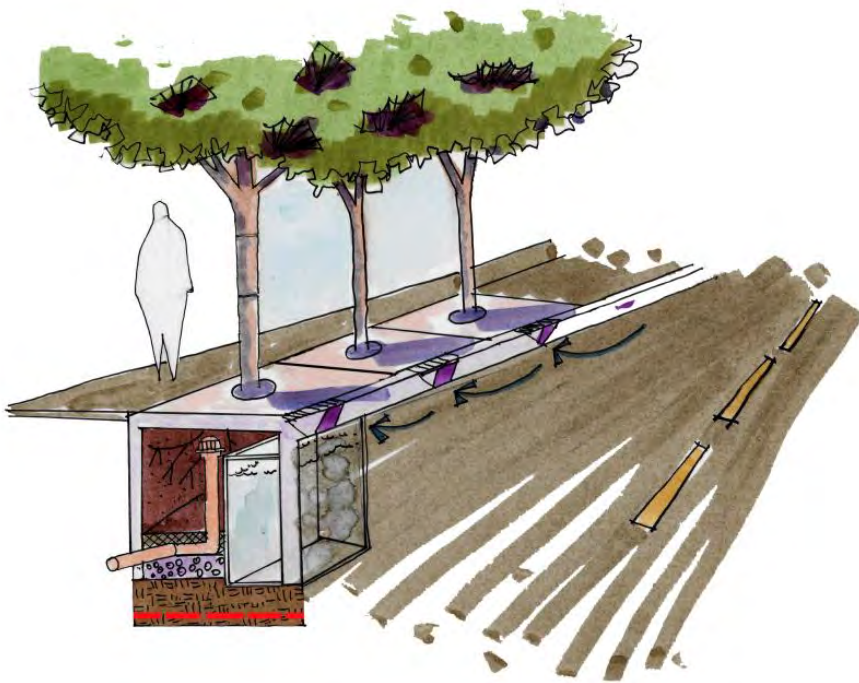


Figure 5. Schematic of a typical tree box filter with underground storage capacity.



Figure 6. Proposed green infrastructure retrofits for Elm City College Preparatory Elementary School. CB indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

James Street

James Street was identified as a potential demonstration site for a “green streets” approach to stormwater retrofits in the road right-of-way. The site is proposed to begin at Elm City College Preparatory Elementary School (at Lombard Street), and continue south to Chapel Street. This portion of James Street represents a typical residential street in the Fair Haven neighborhood (*Figure 7*), an underserved area of New Haven. The street is also within the area served by CSO #009. In addition to providing stormwater runoff reduction and pollution control benefits, the proposed retrofits for James Street would also provide green space in the neighborhood and yield aesthetic benefits for residents. Specific siting considerations along James Street include the feasibility of working around existing utilities while simultaneously selecting sites with sufficient catchment area to justify installation costs. Bioswales or bump-outs must also be sited appropriately relative to existing catch basin infrastructure (i.e., bioswales should be located ‘downstream’, ideally right before a catch basin) in order to maximize capture of stormwater and facilitate returning overflows to the existing drainage system.

- Tree Box Filters. Additional tree box filters of the type proposed for Elm City Preparatory School are proposed for various locations along James Street. Obvious sites are locations where street trees are missing; one such site exists on the east side of James Street, immediately south of the Elm City Preparatory School. *Estimated Cost: \$9,000 per tree box filter*
- Bump-Outs or Curbside Bioswales. Two possible types of green infrastructure are proposed to provide bioretention along the length of James Street: bump-outs and curbside bioswales (*Figure 8*). Both are types of linear bioretention retrofit used alongside or within a public street, designed to collect and infiltrate/treat runoff from the adjacent roadway. These practices consist of a stone storage layer, a soil layer designed to filter runoff, plantings, and curb cuts to allow runoff to enter and exit the system. Both bioswales and bump-outs are sized to capture and treat/infiltrate the water quality volume.
 - o Bioswales utilize space in the right of way, converting impervious area between the sidewalk and the street into bioretention. The City of New Haven is already installing bioswales throughout the downtown area and West River watershed, using a modified version of a bioswale design developed by New York City, which has a 5-foot by 15-foot footprint. At 75sf, this design can capture and treat approximately 276cf WQV. This is sufficient to capture the drainage from one side of an approximately 200ft stretch of road. *Figure 9* shows a typical bioswale that was installed in New Haven. As with bump-outs, bioswales would be designed to accept stormwater from the street, using curb-cuts as an inlet, with existing downgradient catch basins serving to receive excess water from the BMPs’ overflows.
 - o Bump-outs (*Figure 10*) would replace a portion of the existing road shoulder with bioretention areas, utilizing “No Standing” zones near intersections to intercept stormwater runoff from the road. Bump-outs serve a dual purpose as traffic calming features, which can make residential streets more friendly to pedestrians and bicycles.

Bump-outs and bioswales could be used in combination along the length of James Street, or a single practice type could be repeated for a more uniform design (*Figure 8*). Pervious pavement may again be a less expensive alternative option, but would offer far fewer aesthetic benefits to the neighborhood. Several specific locations along James Street were identified as potential sites for BMP implementation in the road right of way. In some instances, multiple potential addresses were noted in close proximity to one another (i.e., where drainage areas would overlap based on the 200 foot drainage area assumption). In these cases, the options should be evaluated during detailed site design to select the option with the least constraints or conflicts. Based on a preliminary assessment, locations shown in *Figure 8* represent locations suitable for bioswales in the public right of way.

Two additional opportunities were identified along James Street for more extensive BMP installations:

- At the southeast corner of James Street and Market Street, there is a large green parcel adjacent to the Market and James Street Farms which is operated under the umbrella of New Haven Farms. The standardized BMPs described above could be implemented in the road right of way at this location; this site could also be proposed for a more extensive raingarden demonstration and education site.
- Raingardens could be implemented at the condominium complex at the northeast corner of James Street and Grand Avenue, particularly at the southwest and northwest corners of the complex, although existing trees may impose siting constraints. The catch basins in the approximately 8,500sf parking lot could also be converted to infiltrating catch basins, with overflows being returned to the stormdrain system via the existing infrastructure.

Estimated Cost: \$20,000 per Bioswale or Bump-out (lower unit pricing may be available when multiple practices are installed together; see notes in Appendix C)

Total Estimated Cost Assuming 1 Tree Box Filter and 13 Bump-Out/Bioswale Practices: \$263,000



Figure 7. Existing conditions along James Street, New Haven highlighting possible locations for bioretention practices in the right of way along James Street.



Figure 8. Proposed green infrastructure retrofits for the public right of way, community garden, and condos along James Street. Figure depicts the general concept design of repeating bioswales and/or bump-outs. Locations as marked represent the conceptual pattern, and are matched to suggested locations as much as possible given the scale, but do not necessarily match precisely to specific recommended sites. The inset image demonstrates a street-view rendering of the concept.



Figure 9. (above)
Bioswale installed in the
City of New Haven.
Credit: Dawn Henning,
City of New Haven
Engineering



Figure 10. (left) Example
Bump-Out bioretention
planter installed by the
City of New Haven on
Clinton Avenue. Credit:
Dawn Henning, City of
New Haven Engineering.

John S. Martinez School Grounds and Exchange Street

The Martinez School building is located on James Street, in the block south of Wolcott Street, while the parking lot and athletic fields for the school are located in the block immediately north of the school, between Wolcott Street and Exchange Street. Like the previous two sites, the Martinez School and surroundings are in the area served by CSO #009. Stormwater designs for the school and parking area median have previously been developed⁴, but the design proposed here focuses on the north end of the property, where the school grounds abut a proposed, future section of Mill River Trail and a mix of residential and industrial land uses to the north.

West of Haven Street, Exchange Street has been blocked off with several large boulders to prevent vehicle traffic from entering (*Figure 11*); this section of the roadway is proposed to become part of the Mill River Trail. At present, the pavement in this section is in disrepair and there is no drainage infrastructure located along this stretch of Exchange Street. Trash and water currently collect at the far west end of Exchange Street where the road terminates into a chain link fence with concrete barriers/wall beyond.

- **Trash Clean-up.** The first step to any improvement at this site should be the engagement of community volunteers in removal of trash and debris located at the west edge of the site. This opportunity could also be used to grow interest in the site and discuss further improvement options with local residents and potential project partners.
- **Pavement Removal.** Removal of pavement from the portion of Exchange Street west of Haven Street and permanent closure of the road would result in a nearly 9,000 square foot reduction of impervious surface, thereby reducing surface runoff and creating space for natural infiltration. Assuming pavement is not contaminated beyond typical road surface pollutants (e.g., petroleum products), this project could be conducted in partnership with the City of New Haven as a stand-alone action at relatively minimal expense.
- **Integrated Stormwater Treatment and Trail Improvements.** Once pavement is removed, bioretention areas and trail improvements are proposed to create an aesthetically pleasing entrance point for a future segment of the Mill River trail. A series of bioretention areas/rain gardens (*Figure 12*) with native plantings would be braided together with the trail, creating an urban oasis at the edge of the Martinez school athletic fields (*Figure 13*). Existing storm drainage from the northern edge of the school parking lot and the catch basin at the northeast corner of Exchange Street and Haven Street could be redirected to the bioretention cells. Overland sheet flow from the athletic fields would also be captured and treated. While water would be accepted along the east-west length of the system, water entering the up-gradient bioretention cells to the east would overflow into down-gradient cells further west in step-wise fashion. Preliminary information suggests that the system can be sized to accommodate typical precipitation events. Excess stormwater during extreme events could be allowed to flow overland, as is currently the case at the

⁴ Save the Sound, Connecticut Fund for the Environment (2012). Green Infrastructure Feasibility Scan for Bridgeport and New Haven, CT.

site, or could potentially be directed back into the existing storm drain system. *Estimated Cost: \$90,000*



Figure 9. Existing conditions at the intersection of Exchange Street and Haven Street, New Haven.

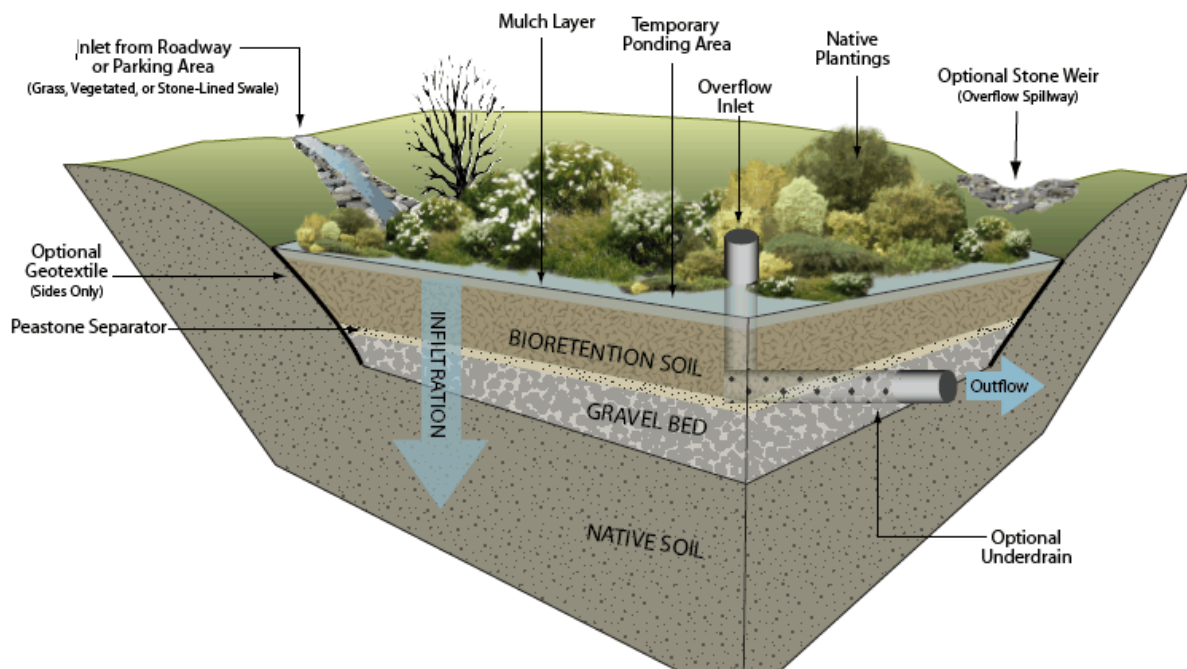


Figure 10. Bioretention schematic.



Figure 11. Proposed green infrastructure retrofits for the John S. Martinez School Grounds, Exchange Street, and Mill River Trail Site.

Wilbur Cross High School

Wilbur Cross High School is located in the East Rock neighborhood of New Haven, immediately west of the Mill River. Not including athletic facilities, the school and parking cover nearly 10 acres in the Lower Mill River subwatershed. The school lies immediately northwest of CSO #012, but the school building and parking areas addressed here are outside of the CSO area. The proposed concept design focuses on the approximately 2-acre parking lot on the southeast side of the site, along with drainage from the main portion of the high school building. It is likely that the proposed design would also intercept surface flow from the adjacent tennis courts further to the east.

The existing parking lot features extra-long, numbered bus parking spaces along the northeast and east perimeters of the lot. The parking layout maximizes available locations for bus parking, but in doing so, the layout creates two large dead spaces where parking is prohibited (*Figure 14*), both of which are located in the northeast corner of the lot. Each of these locations coincides with the location of existing catch basins. A double catch basin in the corner of the lot is the most downgradient collection point and outfalls directly to the Mill River approximately 10 feet below the parking lot grade. Roof drainage from the east side of the building appears to be connected into the drainage system at the catch basin located in the middle of the eastern edge of the parking lot.

- **Parking Lot Bioretention.** Proposed retrofits include the removal of pavement from the two 'dead spaces' (approximately 830sf and 870sf) in the northeast corner of the lot and conversion to bioretention to accept surface flows across the parking lot. Of the 6,900cf WQV anticipated from the approximately 87,000sf parking lot, the two bioretention areas would treat up to up to 6,200cf (90%) of WQV (*Figure 15*).

Estimated Cost: \$79,000

- **Subsurface Infiltration.** An additional 900sf of subsurface infiltration along the eastern edge of the lot would utilize the existing mid-lot catch basin as an inlet to intercept roof drainage from the approximately 44,000sf of building footprint, infiltrating up to 3,400cf WQV out of the approximately 3,500cf WQV expected. The next catch basin downgradient would serve as an outlet to channel excess water back into the drainage system, and the existing double catch basin would serve as an overflow outlet to the Mill River for the entire retrofit system.

Estimated Cost: \$89,000

Total Estimated Cost: \$168,000



Figure 12. One of the two 'dead spaces' where parking is prohibited amidst bus parking spaces at the Wilbur Cross High School parking lot.

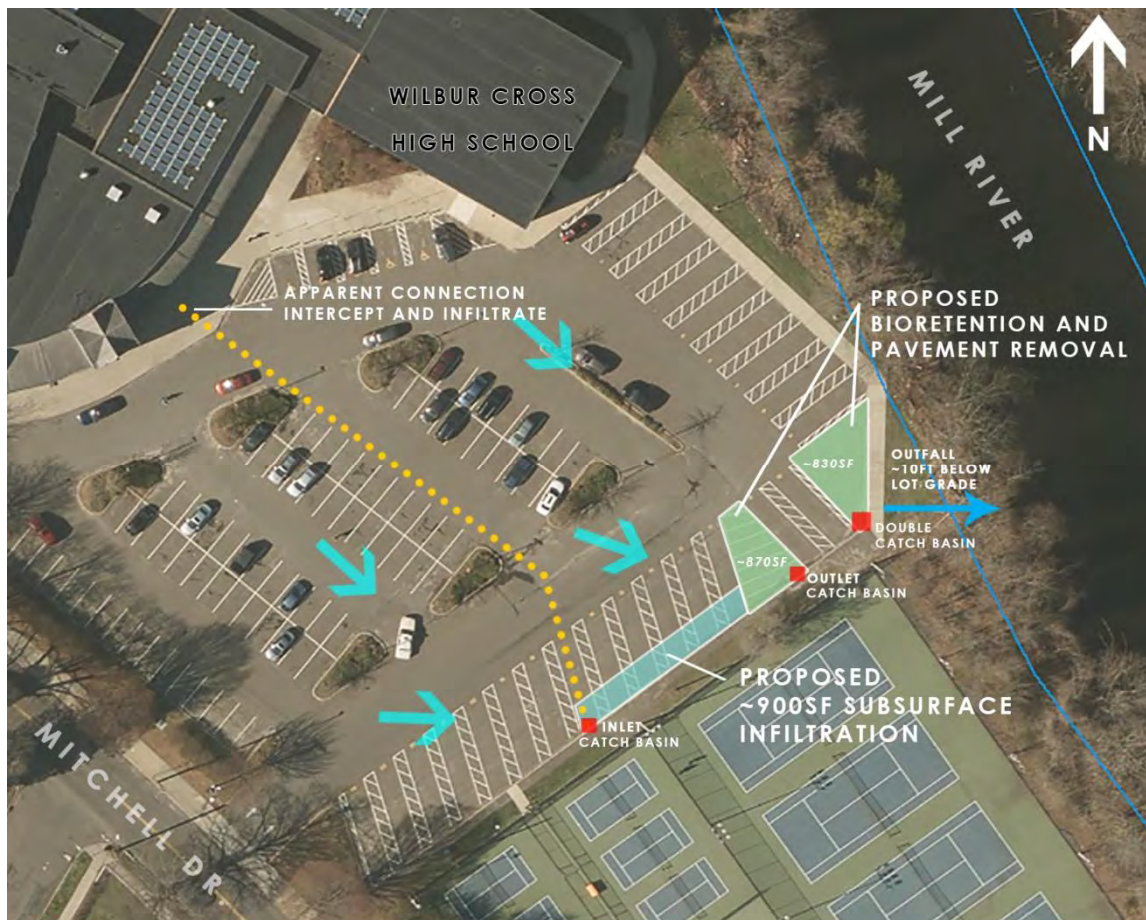


Figure 13. Proposed green infrastructure retrofits for Wilbur Cross High School. Red squares indicate existing catch basins. Blue arrows indicate existing surface flow patterns.

Livingston Street at East Rock Road

East Rock Park begins just south of Lake Whitney and follows the Mill River for over 1.5 miles. On the east side of the river, the park provides a buffer for the river that is generally wooded and at least 0.2 miles wide. On the west side of the river, the park is much narrower and less heavily wooded; the proposed concept design focuses on this side of the park, particularly the borders of the park that follow Livingston Street and East Rock Road.

An existing walking trail follows the park edge along Livingston Street (*Figure 16*). Scattered catch basins along Livingston Street intercept flow from the street and carry it north toward East Rock Road. At East Rock Road, storm drains from Livingston Street join with the storm drain under East Rock Road and carry runoff east to the Mill River. The outfall for this system is located north of the East Rock Road bridge.

While the park occupies the land east of Livingston Street, the west side of the street is residential. Many downspouts appear to be connected to the drainage system, though others were disconnected.

- **Vegetated Infiltration Swale.** A short wooden fence runs along the east side of Livingston Street beginning at the intersection with Cold Spring Street and following the road northward for approximately 850 feet. A vegetated swale is proposed to promote infiltration along this stretch of Livingston, using curb cuts spaced along the swale to accept approximately 1,200cf WQV of stormwater from approximately 15,000sf of drainage area consisting of the northbound lane of Livingston Street. *Estimated Cost: \$61,000*
- **Bioretention Landscaping and Trail Enhancement.** A storm drain in the center of the intersection of Livingston Street and East Rock Road currently accepts stormwater flows from all four corners of the intersection, as well as flows from further west on East Rock Road. Two raingardens/bioretention areas are proposed to accept stormwater from Livingston Street, East Rock Road, and East Rock Park Road via curbcuts located just upgradient of the existing catch basins.
 - o One raingarden/bioretention area would be located on the northwest corner of the intersection (with approximate area of 250sf and capacity to capture and treat approximately 900cf WQV). The northwest raingarden/ bioretention area would serve a drainage area of approximately 10,000sf (800cf WQV), consisting of the north side of East Rock Road between Livingston Street and Everit Street, as well as a portion of the south side of East Rock Park Road. The BMP is proposed with an overflow structure that would carry excess stormwater back to one of the existing catch basins.
 - o A second raingraden/ bioretention area on the southeast corner of the intersection (with approximate area of 300sf and capacity to capture and treat approximately 1,100cf WQV) would be located in existing open green space among trees to minimize root and tree impacts (*Figure 18*). Stormwater would enter the BMP from a curbcut located just south of the existing fire hydrant and upgradient of the existing catch basin

on the east side of Livingston Road. The BMP would capture stormwater from the east side of Livingston Street from the mid-block catch basin to the curb cut, an area of approximately 14,000sf (1,100cf WQV). In order to preserve the existing trail, an ADA compliant boardwalk feature would allow pedestrians to connect from the corner sidewalk to the existing walking trail in the park, crossing over the raingarden/bioretenention area (*Figure 17*). Additional interpretive signage would be added to the existing park sign already in place at the southeast corner of Livingston Street and East Rock Road to enable the stormwater features to serve as an education and outreach site. The raingarden/bioretenention area is proposed to contain an overflow structure that allows excess stormwater to sheetflow across vegetated land to the south and east.

- o *Estimated Cost: \$31,000 (consisting of \$26,000 for bioretention areas and \$5,000 for trail enhancement)*



Figure 14. Existing conditions at Livingston Street (foreground) and East Rock Road, showing open space where bioretention is proposed and the existing walking trail.



Figure 17. Proposed bioretention area and trail improvements in East Rock Park.

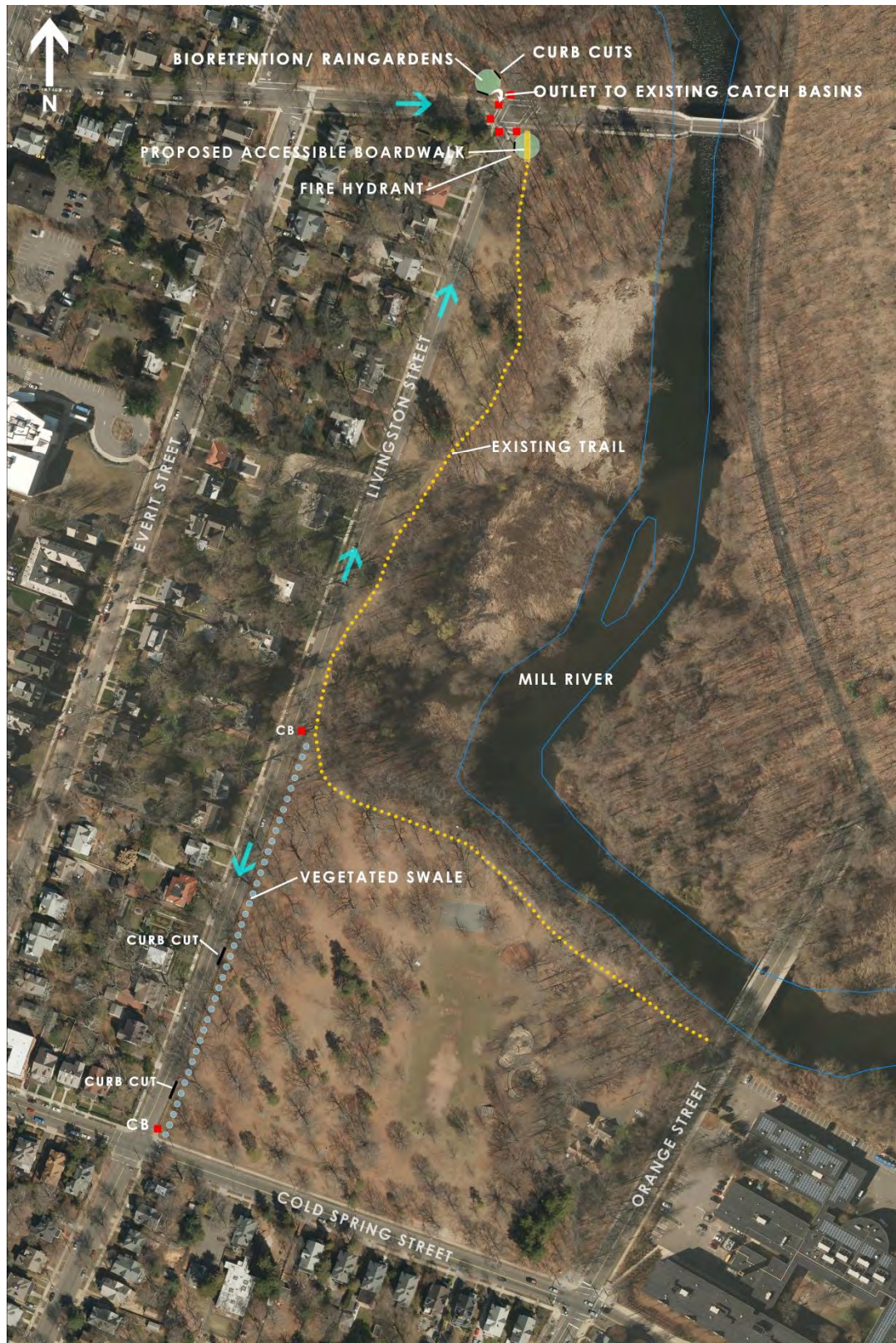


Figure 18. Proposed green infrastructure retrofits for Livingston Street at East Rock Road. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

YNHH Outpatient Services

The Yale New Haven Health System (YNHH) Outpatient Services facility is located on Sherman Avenue in Hamden, CT, on an approximately 2-acre site. Shepard Brook runs along the northeast edge of the property, and drainage from the site enters the brook approximately 2 miles upstream of its confluence with the Mill River.

The site is largely covered by impervious surfaces, including approximately 28,000sf of parking lot space spread between two lots, an approximately 8,000sf building footprint, and an additional 7,500sf of paved driveway. Most of the remaining space within the parcel is occupied by maintained lawn. Trees border the north and south edges of the site, forming a buffer with adjacent parcels. A few large trees line the west edge of the parcel, along Sherman Avenue. A parking lot island in the rear lot features mature trees and shrubs as well and provides some shade on the site. This island could potentially be converted to bioretention, however existing trees, sidewalks, and underground electrical located in the island would pose conflicts for such a conversion.

A series of catch basins are connected in the parking lot and carry stormwater away from Sherman Avenue and toward Shepard Brook. Downspouts from the YNHH Outpatient facility are also connected to this storm drain system. The most downgradient catch basin was clogged with silt and debris during the field visit, indicating high sediment loads. Pooling in the vegetated area east of the site suggests a possible high water table, which may be contributing to pooling in the vicinity of the downgradient catch basin. Because of this, proposed BMPs are focused higher in the landscape, to ensure successful infiltration of stormwater.

- **Parking Lot Retrofits.** Approximately 5,000sf of pervious pavement is proposed for the 23,000sf rear parking area, focusing on the spaces in the center of the parking lot, where stormwater runoff could be infiltrated before reaching the most downgradient catch basin in the northeast corner of the site (*Figure 19*). In addition to reducing impervious area on this portion of the site by approximately 20%, the pervious pavement will also accept stormwater flows from more westerly sections of the parking lot, as water flows to the northeast across the site. *Estimated Cost: \$20,000*
- **Front Lawn Retrofits.** The approximately 5,000sf front parking lot slopes toward the front lawn area, between Sherman Avenue and the front parking lot. This lawn area also appears to receive stormwater flows from an approximately 3,000sf area consisting of the northbound travel lane of Sherman Avenue as it approaches the driveway from the south, and the front portion of the YNHH driveway. This yields a total WQV for this portion of the site of approximately 630cf. An approximately 200sf bioretention area (with approximate treatment capacity of 735cf WQV) is proposed for the bumpout portion of the front lawn, with curb cuts allowing stormwater to enter from both the parking area and the driveway. *Estimated Cost: \$10,000*
- **Main Lawn Retrofits.** Approximately 600 sf of distributed bioretention/rain garden area is proposed for the main lawn. Approximately 400sf of linear bioretention (approximately 5 feet wide by 80 feet long) is proposed along the north edge of the lawn to capture

stormwater from the approximately 4,500sf of driveway area between the two parking lots. An additional triangular raingarden/bioretention feature of approximately 200 sf is proposed for the area adjacent to the sidewalk leading from the rear parking lot to the building. Downspouts from the north side of the 8,000sf building would be disconnected from the storm drain system and redirected to this area. Developing the bioretention area as a rain garden would provide a landscape feature on the site, and could be supplemented with interpretative signage for public education and outreach. This area could potentially be utilized as an outdoor gathering space, either for patients waiting for appointments or for staff on break. Lower maintenance bioretention designs are equally feasible on the site, and would require only periodic cleaning in addition to mowing, which is already occurring at the proposed location (Figure 19). *Estimated Cost: \$28,000*

Total Estimated Cost: \$58,000



Figure 15. Proposed green infrastructure retrofits for YNHH Outpatient Services Facility. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Whitney High School North/West

Area Cooperative Educational Services (ACES) operates two special education programs out of its Whitney High School North and West campuses, located immediately west of the Mill River on Skiff Street in New Haven. The Whitney North/West campus is an approximately 5-acre site, which is nearly 100% impervious. Three buildings are located on the site, which slopes from Skiff Street down toward the south end of the site and also east toward the Mill River. Parking is terraced, creating three separate tiers along the north/south gradient (*Figure 20*).

Existing east-west oriented parking islands separate the tiers; these islands are narrow and steeply sloped, making them unlikely candidates for green infrastructure practices. Existing curb cuts at the ends of these islands carry water from one tier down to the next, with stormwater eventually flowing to catch basins along the southern edges of the parking areas. Downgradient catch basins are assumed to outfall directly to the Mill River, on the far side of a chain-link fence which follows the eastern edge of the parcel.

The southeast corner of the site, adjacent to the Staff Development Building, currently contains a raised bed garden area, picnic table, and composter. A gravel swale appears to carry excess stormwater from a low point in that area to the south edge of the site and toward the Mill River.

- **Parking Lot Retrofits and Bioretention.** A combination of subsurface infiltration, pervious pavement, and bioretention is proposed to reduce stormwater runoff from the extensive parking areas on the site and provide a variety of green infrastructure demonstration sites for curricular value.
 - o Approximately 14,500sf of pervious pavement is proposed in the front parking lot and upper and middle tier parking areas of the main lot to reduce impervious cover on the site and infiltrate runoff from the upper two tiers of parking. *Estimated Cost: \$58,000*
 - o Approximately 500sf of subsurface infiltration is proposed to be located behind the Staff Development Building, intercepting flow from the existing catch basins at the low end of the parking lot, infiltrating approximately 1,800cf WQV, and returning excess stormwater to the existing drainage system at the east end of the practice (*Figure 21*). This practice would be designed to capture drainage from an approximately 20,000sf area including the parking area surrounding the Staff Development Building and redirected drainage from the building (approximately 1,600cf of WQV). *Estimated Cost: \$47,000*
 - o Approximately 800sf of bioretention is proposed in the southeast-most corner of the parking lot, requiring the removal of two parking spaces (*Figure 22*). Existing catch basins in this location would be raised to serve as overflow structures. A sediment forebay is proposed for the first bioretention cell (to be located in the existing parking area) in order to minimize required maintenance of the downgradient bioretention area. From the sediment forebay, water would flow to a landscape feature that winds through the existing picnic/garden area, avoiding existing trees, and connecting to the existing gravel swale (*Figure 23*). The

bioretention area would accept water flowing down the campus driveway, as well as flow from the lower tier parking area, including any overflow from the upper tiers (approximately 1 acre of drainage area or 3,500cf of WQV). The bioretention system would be designed to capture approximately 3,000cf WQV. Building on existing uses in this area which appear to emphasize environmentally-friendly practices (e.g., composting, raised bed gardening), the bioretention system could provide educational opportunities for students and staff in the form of signage and/or curricular connections. *Estimated Cost: \$38,000*

Total Estimated Cost: \$143,000



Figure 16. Tiered parking, with existing conveyances that transport stormwater from the upper tiers to lower tiers.

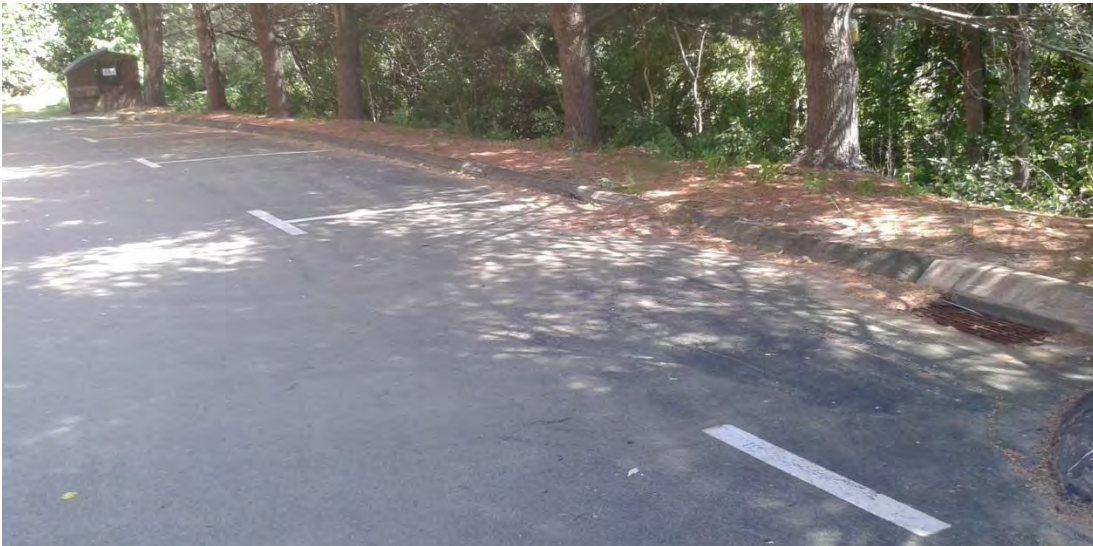


Figure 17. Proposed location for subsurface infiltration behind the Staff Development Building. The downgradient catch basin (near the dumpster) would serve as an overflow for the system and outfalls to the Mill River.



Figure 18. Proposed location of sediment forebay (top) and bioretention areas (bottom).



Figure 19. Proposed green infrastructure retrofits for Whitney High School North/West. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Counter Weight Brewery, Spring Glen Nursery, and Raccio Park Road

Counter Weight Brewery is located along the south side of Raccio Park Road, within approximately 500 feet of Shepard Brook. The building and lot occupy approximately 1-acre (*Figure 24, Figure 25*), with the adjacent portion of Raccio Park Road and circular turnaround adding 0.25-acres of additional drainage area. The parcel between the brewery and Shepard Brook is occupied by Spring Glen Nursery.

The roof drains on the brewery building are currently connected to the storm drainage system. A series of five catch basins in the circle and along the eastern and southern edges of the property transport stormwater away from the site, presumably to an outfall on Shepard Brook. Note that while most of this site is mapped as B soils (good infiltration), the southern edge of the site is indicated to be D soils, so additional soil testing will be especially necessary at this site in order to more precisely determine the infiltration capacity of the soils.

Existing parking lots are in poor condition, and catch basins on site were clogged with silt and debris. Existing vegetated areas and parking islands on the brewery property do not appear to receive regular maintenance, whereas planting areas on the nursery property were obviously receiving regular care.

- Bioretention Area/Rain Gardens. A series of bioretention areas/rain gardens are proposed for the site:
 - o A series of three distributed bioretention areas/raingardens are proposed within Counter Weight Brewery's parking area. A 150sf bioretention area/rain garden is proposed in the existing island bumpout at the northeast edge of the front parking lot; this practice would accommodate capture of approximately 550cf of WQV and would accept stormwater flows from a portion of the 7,500sf front parking lot (with associated 600cf of WQV). A second 100sf bioretention area is proposed in the existing island bump-out at the southeast edge of the front parking lot; this practice would accommodate approximately 370cf of WQV. In addition to accepting surface runoff from the front parking lot, this practice could potentially receive flow from redirected roof leaders. A third 75sf bioretention area/rain garden is proposed for the existing vegetated bumpout at the southeast corner of the building. This practice could accommodate approximately 275cf of WQV and would be designed to accept flow from redirected roof leaders, with a potential roof catchment area of approximately 4,500sf (354cf of WQV). Overflow from this bioretention area would be directed overland toward the existing catch basin and proposed pervious pavement (see below). *Estimated Cost: \$16,000 (assuming all three areas); costs for individual practices range from \$4,000 to \$7,000*
 - o A 200sf linear bioretention area along the southern edge of Raccio Park Road would accept stormwater runoff from the road via a curb cut on the western end of the feature (*Figure 26*), with the potential to capture and treat approximately 735cf of WQV. To increase the drainage area, the upgradient catch basin west of the practice should be closed off; this would direct approximately 5,500sf of drainage area to the practice (with corresponding 435cf of WQV). While the green space between the brewery and nursery driveways and the bumpout areas mentioned

above are maintained with plantings (*Figure 24*), the existing green space between the road and the main brewery parking lot is unmaintained, so this feature could be designed either with landscape enhancement or minimal maintenance as the primary goal. The bioretention area would overflow to the existing downgradient catch basin adjacent to the Counter Weight Brewery driveway. *Estimated Cost: \$10,000*



Figure 20. Existing conditions at Counter Weight Brewery, looking toward the brewery building from the circle on Raccoo Park Road.

- **Parking Lot Retrofits.** Approximately 2,000sf of pervious pavement is proposed along the eastern edge of the parking lot to reduce impervious cover and intercept additional surface flows to the two existing catch basins at the edge of the lot. Approximately 28,000sf of impervious area drains toward this section of the parking lot, with corresponding 2,217cf WQV. The 7,500sf front parking area could also be converted to pervious pavement in the future if the lot is repaved. *Estimated Cost: \$8,000 (assuming 2,000sf); an additional \$30,000 would be required to convert the entire front lot to pervious pavement*
- **Maintain Existing Catch basins.** Some of the catch basins at the site were observed to be clogged with silt and other debris. Periodic clearing of this debris will maintain proper functioning of the existing system, decrease pollutant loads to the storm drain system, and reduce ponding in adjacent impervious areas. *Estimated Cost: minimal; use existing brewery staff labor or volunteers*

Total Estimated Cost: \$34,000 (\$64,000 including conversion of front lot to pervious pavement)



Figure 21. Existing conditions at Counter Weight Brewery, showing clogged catch basin (left) and degraded asphalt parking lot (right).



Figure 22. Proposed green infrastructure retrofits for Counter Weight Brewery and Raccio Park Road. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Bartlem Recreation Area

This large municipal park is located on CT 10 (South Main Street) in Cheshire, directly across from Cheshire High School. The site is owned by the Town of Cheshire and includes lacrosse, baseball, and soccer fields, as well as a covered swimming facility and multiple parking areas. Most of the stormwater from the site drains to an approximately 36-inch outfall at the southern end of the property. These parking areas and structures comprise approximately 5-acres of directly connected impervious cover on the site. An additional 1.75-acres of maintained athletic field area likely contributes surface flows to the storm sewer system during heavy rains.

Existing catch basins are located behind the swimming pool and appear to capture overflows from the pool decks as well as stormwater runoff. Additional catch basins are located in the northern parking lot, on either side of the driveway, and in the lawn between the baseball field and swimming pool parking lot (*Figure 27*). The catch basin located at the southwest corner of the swimming pool parking lot appears to be the most downgradient catch basin before stormwater outfalls into the Mill River. An existing gravel swale carries additional overland runoff from the baseball diamond, along the south edge of the ball field, into a catch basin located in the grass adjacent to the parking lot, and ultimately through the parking lot catch basin to the outfall.

- **Linear Bioretention.** An existing short fence runs along the north edge of the baseball field, creating a lawn area approximately 15 feet wide between the fence and the curbed driveway of the recreation area (*Figure 28*). This space is currently utilized for event parking. Approximately 300sf of linear bioretention is proposed toward the east end of this space to treat stormwater runoff from the driveway while preserving as much parking as possible (*Figure 29*). A curb cut will allow stormwater to flow from the road (approximately 14,000sf of drainage area, with 1,100cf WQV) into the proposed bioretention before reaching the existing catch basin. As the landscape slopes slightly to the east, check dams are proposed as part of the design to slow the movement of water through the bioretention feature. The bioretention area can be designed to overflow either to the existing catch basin or the proposed water quality swale (below). *Estimated Cost: \$14,000*
- **Vegetated Water Quality Swale.** A second linear feature (2,500sf) is proposed between the baseball field and the swimming pool parking lot, on top of the existing storm drainage pipes. Existing catch basins would be raised to serve as overflow structures during heavy rains, and a vegetated swale is proposed along the length of the parking lot to infiltrate surface runoff from the 44,000sf of uncurbed parking lot (with accompanying 3,500cf of WQV) and adjacent ball field (expected to generate, at minimum, an additional 350cf or more of WQV) (*Figure 29*). Effectiveness of the swale could be further enhanced by re-grading the parking lot whenever it is next repaved to encourage stormwater to flow toward the swale. Drainage from the pool roof could potentially be directed toward the swale as well, although it was not clear from the site visit how pool roof drainage is currently handled. *Estimated cost: \$36,000*
- **Pervious Pavement.** 15,000sf of pervious pavement is proposed for the middle two rows of parking in the north parking lot. This conversion to pervious pavement would reduce the impervious surface of the 50,000sf lot by nearly 30% and decrease the volume of stormwater inputs to the existing drainage system. *Estimated Cost: \$60,000*



Figure 23. Existing catch basins at the edge of the swimming pool parking lot at Bartlem Recreation Area. The space between the parking lot and ball field is proposed for conversion to a vegetated swale.



Figure 24. Roadside area proposed for linear bioretention.

- **Bioretention/Rain Garden.** A bioretention area/rain garden and native planting area of up to 1,500sf is proposed for the lawn area between the circular drive in front of the swimming pool and the swimming pool parking lot. A curb cut in the circle would allow stormwater to flow into the rain garden, with the existing catch basin serving as an overflow to direct excess stormwater back into the drainage system. A 300sf bioretention area is proposed to capture and treat runoff from the approximately

12,000sf of impervious drainage area (approximately 950cf of WQV) that would connect to the BMP via the proposed curb cut in the circle. Remaining area in this planting island should be converted to native plantings. Due to its location near the pool entrance, this would likely be the most visible location at which to include educational information about the full suite of proposed green infrastructure components suggested for the site. *Estimated Cost: \$14,000 (assuming 300sf of bioretention; additional funds (or plant donations) may be required for native plantings to fill the entire island)*

Total Estimated Cost: \$124,000



Figure 25. Proposed green infrastructure retrofits for Bartlem Recreation Area. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Strathmore Drive

Strathmore Drive is located in a residential subdivision in Cheshire that lies just east of the Mill River, across the river from the Bartlem Recreation Area and south of Wallingford Road. An unnamed tributary of the Mill River winds through the neighborhood.

Green spaces were required to be created during the development of the subdivision. Two such sites are located on Strathmore Drive, between the two ends of Buttonwood Circle. A playground

occupies the green space to the west side of Strathmore Drive; on the east side of the street, the existing green space consists of a semi-circular lawn area bordered by bermed planting areas that include mature evergreen trees and shrubs (*Figure 30*). Beyond the berms is another area of lawn that backs up to residential lawns from homes on Buttonwood Circle. To the southeast, this area meets up with a wooded buffer through which the unnamed tributary stream passes through the neighborhood. The area, including the lawn and bermed planting areas, is currently maintained by the Homeowner's Association via a landscaping contractor.

- Public Green Space Retrofit. Although located adjacent to a high point on Strathmore Drive, the semi-circular lawn forms a natural bowl in the landscape, and could be converted to an approximately 500sf bioretention area to collect and infiltrate runoff from approximately 11,000sf of catchment area on Strathmore Drive and portions of Buttonwood Circle (with corresponding 900cf of WQV) (*Figure 31*). Water could be redirected from catch basins on Strathmore Drive that are located at each end of the green space and directed into the bioretention area to either infiltrate or ultimately be released back into the tributary stream via an overflow swale. More detailed site survey is necessary to confirm feasibility, but available contour/elevation data indicates between a 5% and 8% slope from the catch basin locations to the depression/proposed bioretention area. It may also be possible to direct roof leaders from houses that back up to the green space into the bioretention area. If desired, the bioretention area could be designed as a rain garden to enhance the existing landscape features of this space. *Estimated Cost: \$24,000*

Total Estimated Cost: \$24,000



Figure 26. Sidewalk along Strathmore Drive and public lawn area, with bermed plantings in background.



Figure 27. Proposed green infrastructure retrofits at Strathmore Drive. "CB" indicates existing catch basin. Blue arrows indicate existing surface flow patterns.

Attachment A

Green Infrastructure Retrofit Screening Results Potential Retrofit Sites

List of Potential Sties for Green Infrastructure Retrofits: Mill River Watershed

Site Name	Municipality	Impaired Segment	Ownership	Hydrologic Soil Group	Priority Level	Sewer Type
1st Presbyterian	New Haven	Y	Private	A	Lower	Separate
350 Chapel St, Suzio York Hill	New Haven	Y	Private	B	Lower	Separate
Ball & Socket Arts	Cheshire	Y	Private	B	Lower	Separate
Bartlem Rec Area	Cheshire	Y	Public	B	Higher	Separate
Bates Dr	Cheshire	Y	ROW	B	Higher	Separate
Behind China Buffet, Route 10	Hamden	Y	Private	B	Lower	Separate
Bromley Ct	Hamden	Y	ROW	B	Higher	Separate
Celentano/Yale Divinity	New Haven	Y	Private	D	Lower	Separate
Cheshire Academy	Cheshire	Y	Private	B	Lower	Separate
Cheshire HS/Municipal	Cheshire	Y	Public	D	Higher	Separate
Cheshire Lutheran	Cheshire	Y	Private	A	Lower	Separate
Cheshire Public Safety	Cheshire	Y	Public	B	Higher	Separate
Cheshire Public Works	Cheshire	Y	Public	D	Lower	Separate
Cheshire Schools HQ/St Peters	Cheshire	Y	Public/Private	B	Higher	Separate
Cheshire United Methodist	Cheshire	Y	Private	B	Lower	Separate
Corporate Park, Raccio Park Road	Hamden	Y	ROW	B	Higher	Separate
Covenant Evangelical	New Haven	Y	Private	A	Lower	Combined
Criscuolo Park	New Haven	Y	Public	C	Lower	Combined
CT Bus Depot	New Haven	Y	Private	D	Lower	Separate
CT10 in Cheshire/Big Y	Cheshire	Y	ROW/Private	D	Lower	Separate
Dixwell Ave	Hamden	Y	ROW	B/D	Higher	Separate
Dixwell/Shepard/Skiff	Hamden	Y	ROW	D	Higher	Separate
East Rock Neighborhood	New Haven	Y	ROW	A	Higher	Separate
Eli Whitney Museum	Hamden	N	Public	C	Lower	Separate
Elim Park Retirement Community	Cheshire	Y	Private	B	Lower	Separate
Farnam Court	New Haven	Y	Public	D	Higher	Separate
Foote School	New Haven	Y	Public	D	Lower	Separate
Foster Day School	North Haven	Y	Private	B	Lower	Separate
Hamden Hall	Hamden	N	Private	D	Lower	Separate
Hamden Municipal Campus (including Middle School)	Hamden	Y	ROW/Public	A	Higher	Separate
Hamden Public Works garages	Hamden	Y	Public	B	Higher	Separate
Hooker Elementary	New Haven	Y	Public	A	Higher	Separate
Industrial park	Cheshire	Y	ROW	B/D	Higher	Separate
James Street	New Haven	Y	ROW	B/D	Higher	Combined
Jinny Hill, King, Mansion	Cheshire	Y	ROW/Private	B	Lower	Separate
Jocelyn Sq	New Haven	Y	Public	D	Higher	Separate
John S Martinez Magnet School	New Haven	Y	Public	B	Higher	Combined
Legion Field	Hamden	Y	Public	B	Higher	Separate
Livingston St @ Cold Spring	New Haven	Y	ROW	A	Higher	Separate
Livingston St @ East Rock	New Haven	Y	ROW	A	Higher	Separate
Mill River Daycare/Elm City College Preparatory Elementary School	New Haven	Y	Public	D	Higher	Combined

List of Potential Sties for Green Infrastructure Retrofits: Mill River Watershed

Site Name	Municipality	Impaired Segment	Ownership	Hydrologic Soil Group	Priority Level	Sewer Type
New Haven CC	Hamden	N	Private	B	Lower	Separate
Norton School	Cheshire	Y	Public	B	Higher	Separate
Oak Ave, Rustic Ln	Cheshire	Y	Land Trust	B	Lower	Separate
Olin Powder Farm	Hamden	N	Land Trust	A	Lower	Separate
Orange/Humphrey	New Haven	Y	ROW	D	Higher	Combined
Our Lady of Mt Carmel campus	Hamden	Y	Private	B	Lower	Separate
Quinnipiac Parking Lot	Hamden	Y	Private	B	Lower	Separate
Quinnipiac University	Hamden	Y	Private	B	Lower	Separate
Radiall America	New Haven	Y	Private	C	Lower	Separate
Ridge Road Elementary	North Haven	Y	Public	B/D	Higher	Separate
Southwick Condominium Complex/Thompson Gardens West	Cheshire	Y	Private	A	Lower	Separate
Spring Glen School	Hamden	Y	Public	D	Higher	Separate
St Bridget's	Cheshire	Y	Private	B	Lower	Separate
St Joseph Catholic	New Haven	Y	Private	A	Lower	Separate
St Stanislaus	New Haven	Y	Private	A	Lower	Combined
St Thomas	New Haven	N	Private	A	Lower	Separate
St Thomas Becket Church	Cheshire	Y	Private	B	Lower	Separate
Strathmore Dr	Cheshire	Y	ROW	B	Higher	Separate
First Unitarian Universal Church	New Haven	Y	Private	A	Lower	Separate
United Church	New Haven	Y	Private	A	Lower	Combined
United Church/Temple Beth Sholom	Hamden	Y	Private	B	Lower	Separate
United Way	New Haven	Y	Private	D	Lower	Combined
USPS	Hamden	Y	ROW	B	Higher	Separate
Walnut St Mill River St	New Haven	Y	Private	D	Lower	Combined
Washington Ave	Hamden	Y	ROW	D	Higher	Separate
Wentworth's	Hamden	Y	Private	A	Lower	Separate
West Woods Bible Chapel	Hamden	N	Private	B	Lower	Separate
Whitney / Washington ROW	Hamden	Y	ROW	B	Higher	Separate
Whitney HS East	Hamden	Y	Public	D	Higher	Separate
Whitney HS North/West	Hamden	Y	Public	D	Higher	Separate
Wilbur Cross HS/Athletic Complex	New Haven	Y	Public	D	Higher	Separate
Willow St and Mitchell Dr	New Haven	Y	Private	D	Lower	Combined
Wooster Square Neighborhood	New Haven	Y	ROW	D	Higher	Separate
Worthington Hooker School	New Haven	Y	Public	A	Higher	Separate
YNHH Outpatient	Hamden	Y	Private	B	Higher	Separate
Zentek Farms	Cheshire	Y	Private	A	Higher	Separate

**** Blue shading indicates sites where field visits were conducted**

Attachment B

Maps of Potential Green Infrastructure Retrofit Sites

Mill River Watershed Based Plan

LID/Green Infrastructure Assessment

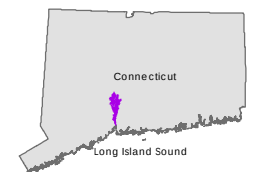
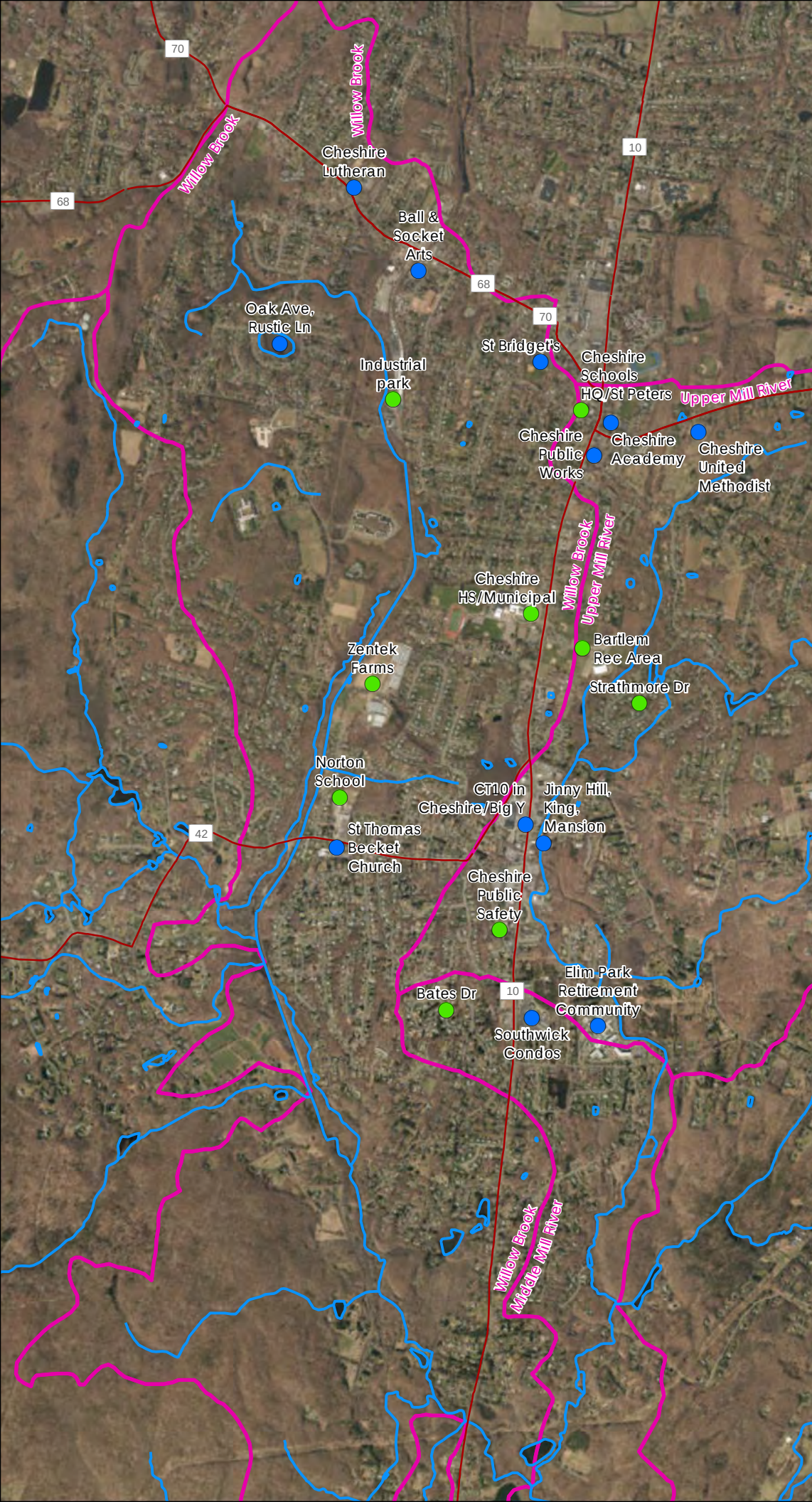
Upper Watershed

Potential Sites

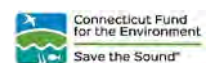
- Higher Priority
- Lower Priority

Water Body

Subwatersheds Boundary



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Miles



Mill River Watershed Based Plan

LID/Green Infrastructure Assessment

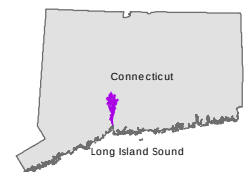
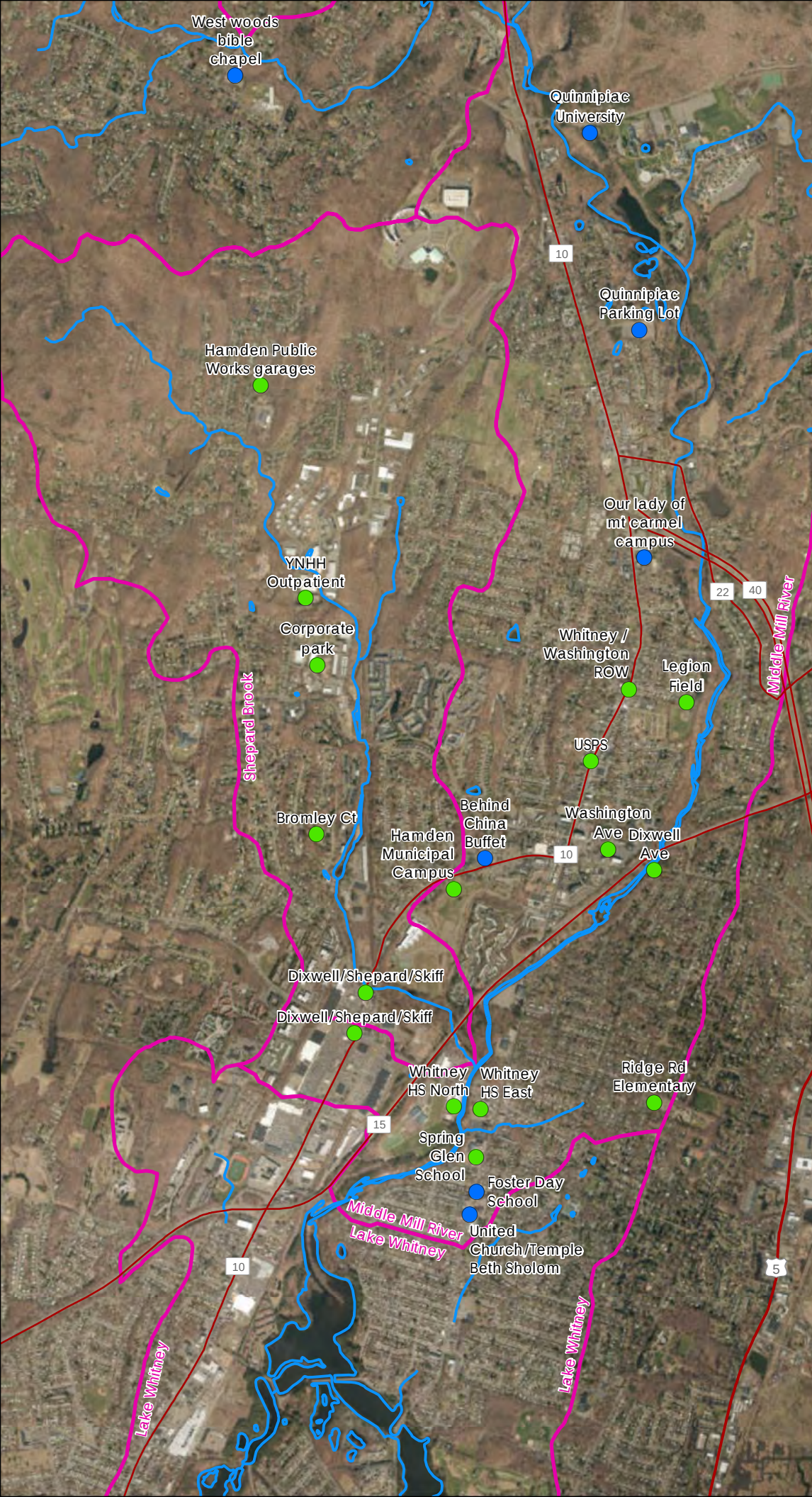
Middle Watershed

Potential Sites

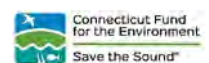
- Higher Priority
- Lower Priority

Water Body

Subwatersheds Boundary



0 0.25 0.5 0.75
Miles



Mill River Watershed Based Plan

LID/Green Infrastructure Assessment

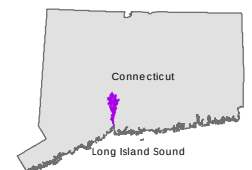
Lower Watershed

Potential Sites

- Higher Priority
- Lower Priority

Water Body

Subwatersheds Boundary



0 0.25 0.5 0.75
Miles

Attachment C

Green Infrastructure Cost Estimates

Order of Magnitude Cost Range															
Location and Element	Construction				Planning and Design		Cost Range			Life Cycle					
	Unit Cost	Unit	Quantity	Cost (2018\$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M (\$/yr)	Total Capitalized Cost/yr over lifespan	
Elm City College Preparatory Elementary															
1	Tree Box Filter	\$6,576.00	ea	1	\$6,576	30%	\$1,970	\$9,000	\$6,000	\$14,000	15	\$810	4%	\$30	\$840
2	Curbside Bioswales	\$15,000.00	ea	2	\$30,000	30%	\$9,000	\$39,000	\$27,000	\$59,000	15	\$3,510	4%	\$140	\$3,650
3	Subsurface Infiltration Chambers- adjacent to turf field	\$20.00	cf of runoff treated	4,150	\$83,000	30%	\$24,900	\$108,000	\$76,000	\$162,000	20	\$7,950	4%	\$320	\$8,270
	Alt-3 Pervious Pavement - adjacent to turf field	\$3.07	sf	1,100	\$3,376	30%	\$1,010	\$5,000	\$4,000	\$8,000	20	\$370	4%	\$10	\$380
4	Pervious Pavement - parking stalls parallel to James Street	\$3.07	sf	2,500.00	\$7,672	30%	\$2,300	\$10,000	\$7,000	\$15,000	20	\$740	4%	\$30	\$770
5	Management of Dumpster Area	\$600.00	ea	1	\$600	30%	\$180	\$1,000	\$1,000	\$2,000	15	\$90	4%	\$0	\$90
Total							\$167,000	\$117,000	\$252,000						
James Street															
1	Tree Box Filters	\$6,576.00	ea	1	\$6,576	30%	\$1,970	\$9,000	\$6,000	\$14,000	15	\$810	4%	\$30	\$840
2	Bump-outs	\$15,000.00	ea	6	\$90,000	30%	\$27,000	\$117,000	\$82,000	\$176,000	15	\$10,520	4%	\$420	\$10,940
2	Curbside Bioswales	\$15,000.00	ea	7	\$105,000	30%	\$31,500	\$137,000	\$96,000	\$206,000	15	\$12,320	4%	\$490	\$12,810
Total							\$263,000	\$184,000	\$396,000						
Mill River Trail, Haven and Exchange Street Green Infrastructure															
1	Bioretention Areas and Trail Improvements	\$230,500.00	ea	1	\$230,500	30%	\$69,150	\$300,000	\$210,000	\$450,000	15	\$26,980	4%	\$1,080	\$28,060
Total							\$300,000	\$210,000	\$450,000						
Wilbur Cross High School															
1	Bioretention Areas	\$35.62	sf	1,700	\$60,554	30%	\$18,170	\$79,000	\$55,000	\$119,000	15	\$7,110	4%	\$280	\$7,390
2	Subsurface Infiltration Chambers	\$20.00	cf of runoff treated	3,400	\$68,000	30%	\$20,400	\$89,000	\$62,000	\$134,000	20	\$6,550	4%	\$260	\$6,810
Total							\$168,000	\$117,000	\$253,000						
Livingston Street at East Rock Road															
1	Vegetated Water Quality Swale	\$10.96	sf	4,250	\$46,580	30%	\$13,970	\$61,000	\$43,000	\$92,000	16	\$5,240	4%	\$210	\$5,450
2	Bioretention Areas	\$35.62	sf	550	\$19,591	30%	\$5,880	\$26,000	\$18,000	\$39,000	15	\$2,340	4%	\$90	\$2,430
3	Trail Enhancement and boardwalk/bridge	\$3,500.00	ea	1	\$3,500	30%	\$1,050	\$5,000	\$4,000	\$8,000	15	\$450	4%	\$20	\$470
Total							\$92,000	\$65,000	\$139,000						
YNHH Outpatient Services															
1	Pervious Pavement	\$3.07	sf	5,000	\$15,344	30%	\$4,600	\$20,000	\$14,000	\$30,000	20	\$1,470	4%	\$60	\$1,530
2	Front Lawn Bioretention Area	\$35.62	sf	200	\$7,124	30%	\$2,140	\$10,000	\$7,000	\$15,000	15	\$900	4%	\$40	\$940
3	Main Lawn Bioretention Areas	\$35.62	sf	600	\$21,372	30%	\$6,410	\$28,000	\$20,000	\$42,000	15	\$2,520	4%	\$100	\$2,620

Order of Magnitude Cost Range															
Location and Element	Construction				Planning and Design		Cost Range			Life Cycle					
	Unit Cost	Unit	Quantity	Cost (2018\$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M (\$/yr)	Total Capitalized Cost/yr over lifespan	
Total							\$58,000	\$41,000	\$87,000						
Whitney High School North/West															
1	Pervious Pavement	\$3.07	sf	14,500	\$44,498	30%	\$13,350	\$58,000	\$41,000	\$87,000	20	\$4,270	4%	\$170	\$4,440
	Subsurface infiltration--behind Staff		cf of runoff												
2	Development Building	\$20.00	treated	1,800	\$36,000	30%	\$10,800	\$47,000	\$33,000	\$71,000	20	\$3,460	4%	\$140	
3	Bioretention Area	\$35.62	sf	800	\$28,496	30%	\$8,550	\$38,000	\$27,000	\$57,000	15	\$3,420	4%	\$140	\$3,560
Total							\$143,000	\$101,000	\$215,000						
Counter Weight Brewery, Spring Glen Nursery, and Raccio Park Road															
1	Rain Garden Trio- within parking area	\$35.62	sf	325	\$11,577	30%	\$3,470	\$16,000	\$11,000	\$24,000	15	\$1,440	4%	\$60	\$1,500
2	Bioretention Area/ Rain Garden- Raccio Park Road	\$35.62	sf	200	\$7,124	30%	\$2,140	\$10,000	\$7,000	\$15,000	15	\$900	4%	\$40	
3	Pervious Pavement	\$3.07	sf	2,000	\$6,138	30%	\$1,840	\$8,000	\$6,000	\$12,000	20	\$590	4%	\$20	\$610
Add-on lot	Additional Pervious Pavement- front lot	\$3.07	sf	7,500	\$23,016	30%	\$6,900	\$30,000	\$21,000	\$45,000	20	\$2,210	4%	\$90	\$2,300
Total							\$34,000	\$24,000	\$51,000						
Bartlem Recreation Area															
1	Linear Bioretention	\$35.62	sf	300	\$10,686	30%	\$3,210	\$14,000	\$10,000	\$21,000	15	\$1,260	4%	\$50	\$1,310
2	Vegetated Water Quality Swale	\$10.96	sf	2,500	\$27,400	30%	\$8,220	\$36,000	\$25,000	\$54,000	15	\$3,240	4%	\$130	\$3,370
3	Pervious Pavement	\$3.07	sf	15,000	\$46,032	30%	\$13,810	\$60,000	\$42,000	\$90,000	20	\$4,410	4%	\$180	
4	Bioretention Area/Raingarden	\$35.62	sf	300	\$10,686	30%	\$3,210	\$14,000	\$10,000	\$21,000	15	\$1,260	4%	\$50	\$1,310
Total							\$124,000	\$87,000	\$186,000						
Strathmore Drive															
1	Bioretention Area	\$35.62	sf	500.00	\$17,810	30%	\$5,340	\$24,000	\$17,000	\$36,000	15	\$2,160	4%	\$90	\$2,250
Total							\$24,000	\$17,000	\$36,000						
Total							\$1,373,000	\$963,000	\$2,065,000						

Notes:

Rate of Inflation used = 2%

Interest (discount) rate used = 6%

*Projects are proposed for these locations already. Costs estimated in this table are for adding ecological and water quality elements to the assumed original purpose of the proposed projects.

Costs should be used for planning purposes only based on screening-level evaluations of site characteristics. Construction costs could vary significantly.

Unit Costs Table

Element	2018 Adjusted Cost	Unit	Cost	YEAR	Source
Green Infrastructure Elements					
New Haven Curbside Bioswale	\$ 15,000.00	ea			Actual construction cost provided by CFE for the Edgewood School bioswale construction (2014) - \$15,000 for contractor plus \$5,000 of in-kind services provided by City of New Haven. Recent bids for West River Bioswales were approximately \$15,000 per bioswale for up to 92 bioswales.
Large Bioretention Retrofit	\$ 13.10	cf of runoff treated	\$ 10.50	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-3
Small Bioretention Retrofit (<0.5 acre)	\$ 35.62	sf	\$ 32.50	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Rain Garden	\$ 7.98	sf	\$ 7.28	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Water Quality Swale	\$ 10.96	sf	\$ 10.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Porous Asphalt	\$ 3.07	sf	\$ 2.80	2012	UNH Stormwater Center 2012 Biennial Report, Page 12
Permeable Pavers	\$ 10.96	sf	\$ 10.00	2012	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-5
Reinforced Gravel Parking	\$ 5.48	sf	\$ 5.07	2013	http://www.boddingtonsonline.com/products/grass-ground-reinforcement/grass-reinforcement-protection/bodpave-85-permeable-gravel-pavers.php ; Added \$2/sf for installation
Subsurface Infiltration	\$ 20.00	cf of runoff treated	\$ 20.00	2018	Fuss & O'Neill, City of Pawtucket Grant Application, 2018.
Green Roof	\$ 25.21	sf	\$ 23.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Blue Roof	\$ 5.48	sf	\$ 5.00	2012	NYC Department of Environmental Protection (2012), Rooftop Detention: A Low-Cost Alternative for Complying with New York City's Stormwater Detention Requirements and Reducing Urban Runoff.
Subsurface Gravel Wetland	\$ 23.93	cf of runoff treated	\$ 21.83	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Pond Retrofit	\$ 13,852.80	impervious acre of runoff treated	\$11,100.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-2
French Drain/Infiltration Trench	\$ 19.97	lf	\$ 16.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Tree Box	\$ 6,576.00	ea	\$ 6,000.00	2012	UNH Stormwater Center 2012 Biennial Report, adjusted based on professional judgement, inflation, and materials cost.
Constructed Wetland	\$ 5.08	sf	\$ 4.07	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Restoration Elements					
Riparian Buffer Restoration	\$ 12,166.62	ac	\$ 10,543	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon.
Stream Channel Restoration	\$ 14,232.28	ac	\$ 12,333	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon.
Remove Invasive Species	\$ 3,692.80	acre	\$ 3,200	2010	Professional Engineering Experience
Tree Planting	\$ 500.00	ea			Street tree cost
Construction Elements					
6" to 12" Rip Rap	\$ 49.32	CY	\$ 45.00	2012	Professional Engineering Experience
Outlet Structure	\$ 4,500	ea	\$ 4,500	2013	Professional Engineering Experience
Manhole	\$ 2,500	ea	\$ 2,500	2013	Professional Engineering Experience
Dam Removal	\$ 19,848.80	ea	\$ 17,200	2010	Selle, Andy (2010). Dam Removal – A Primer, Presentation; \$17,200 is median for dams 1-3 feet high.
Educational Signage	\$ 1,200	ea	\$ 1,200	2013	Professional Engineering Experience

Inflation Rates Table

Inflation from	Inflation to	Percent
2006	2018	24.80%
2010	2018	15.40%
2011	2018	11.80%
2012	2018	9.6%
2013	2018	8.0%

<http://www.usinflationcalculator.com/>

Attachment D

Other Green Infrastructure Retrofit Opportunities in the Mill River Watershed

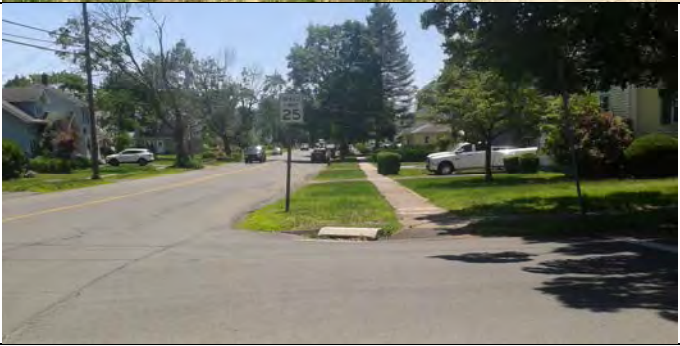
Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Cheshire HS	Cheshire	Large amount of impervious cover, multiple parking areas. Internal roof drainage from buildings.	Disconnect roof downspouts. Potential for infiltration or bioretention using existing landscaped areas in front lawn, just west of entrance, and/or under fire lane by gym. Replace impervious parking lots with pervious pavers. Low-lying area behind operations/maintenance building could also receive water.	
Cheshire Public Works/Town Hall	Cheshire	Large parking lot, drains via catch basins. Catch basin in NE corner of parking lot was observed to have moderate flow, despite no rain in past 24h. Dumpsters without secondary containment adjacent were located adjacent to another catch basin.	Potential for subsurface infiltration under NE corner at catch basin.	
Route 10 Corridor	Cheshire	Large amount of impervious cover, multiple parking areas many of which back up to the Mill River with little or no Riparian Buffer	Decrease impervious cover throughout Route 10 Corridor.	

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Quinnipiac University - Albert Schweitzer Institute	Hamden	Paved parking lots with no storm drains next to Mill River	Install educational rain garden to capture runoff from the front parking area.	
Quinnipiac University – Bobcat way parking areas	Hamden	Extensive parking areas with curbed planted islands	Potential for bioretention in existing landscaped area with catch basin adjacent to each island	
Alice Peck School	Hamden	Roof leaders and parking lot drain to paved open channel. Renovations to the school are expected during 2019.	Potential for bioretention and swale between parking lot and baseball field.	

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo	
Hamden Public Works	Hamden	Large parking lot drains to low point on south side of lot. Discharges to eroded channel into wet, wooded area south of site. No curbing or catch basins.	Bioretention or created wetland at south side of parking lot. Replace parking lot with pervious pavers.		
Whitney Washington ROW	Hamden	Bituminous island at intersection.	Potential to install bioretention cell or infiltration practice and/or remove impervious cover.		
USPS Whitney Ave	Hamden	Existing catch basins full of sediment. Roof leaders buried, discharge to catch basin on property.	Disconnect roof downspout. Potential for subsurface infiltration in parking lot, under pervious pavement. Bioswale or linear bioretention between parking lot and road.		
Washington Ave between Lincoln and Harding	Hamden	Wide ROW, no curb, sediment collecting at grass edge. Onstreet parking.	Linear bioretention or bioswales along west side of street. Bioswales where practicable elsewhere on Washington Ave. Replace parking lanes on either side of street with pervious pavement.		

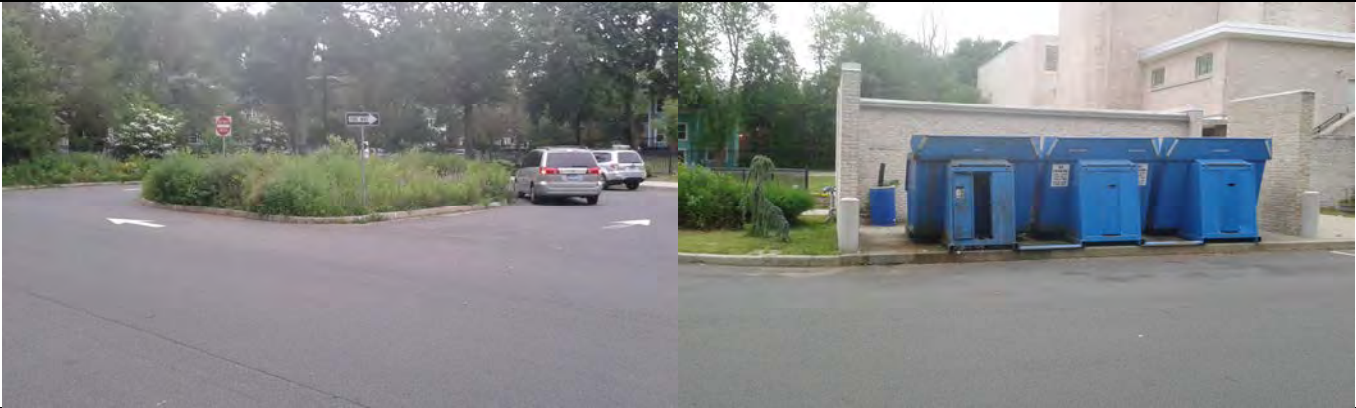
Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo	
Hamden Municipal Campus	Hamden	Large parking lots at Hamden Senior Center, Library, Middle School, and Town Hall.	Develop a Municipal Campus Stormwater Masterplan.		
Dixwell Ave./ Shepard Ave./ Skiff Street	Hamden	Busy intersection near many large parking lots and commercial center.	Potential for bioretention or infiltration in ROW island and linear practices in ROW. Paved ROW could, at minimum, be replaced with pervious cover.		
Ridge Road Elementary	Hamden	Cracked pavement in parking lot, may be due for repaving.	Regrade parking lot, remove western curb and install bioretention or infiltration practice. Potential to replace parking lot with pervious pavers.		
Spring Glen School	Hamden	Medium sized parking lot, recent pavement, trees in median.	Potential for bioretention in existing landscaped area with catchbasin adjacent to lower play area. Rain garden at SW corner of site.		

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Town Center Park	Hamden	Town Park that receives runoff from 88 acres or surrounding urban land use (commercial and residential). Impervious cover is estimated to be 21%.	Installation of best management practices (BMPs) that slow, treat, capture, and filter the stormwater before it reaches the Pardee Brook diversion channel and Shepard Brook. The designs consist of reinforcing the existing plunge pool with a boulder overflow weir; installing a sediment filter riverbed, a stormwater treatment pond, constructed wetland and rain garden; and restoring the meadow area to create an emergent marsh. This series of engineered but natural stormwater management practices will reduce pollutant loading and erosion entering Pardee Brook **High Priority Project	
RWA Water Center	Hamden	Hard packed access road with downspout discharging to access road	Install Rain barrel to capture roof runoff. Potential for demonstration bioretention.	
Eli Whitney Museum	Hamden	Hard pack and paved parking area with catch basins discharging directly to river; curbed island and planters in the center of parking lot	Potential to retrofit curbing and islands in the center of the parking lot to be used for bioretention. Potential to install bioswales in grass areas along the paved driveway. Potential to install rain barrels to capture water from existing building and reuse onsite.	

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Hooker Middle School	New Haven	Church converted to school in 2009. Island in turnaround. Catch basins in parking lot, including beneath dumpsters. Former PTA constructed native habitat, but now is not maintained (invasives present). School has signage about native habitat and outdoor classroom.	Potential for green roof above main entrance, bioretention in island and at lower elevation on property in existing, unmaintained habitat garden. Recommend native plantings in bioretention. Rain garden by eastern gate. Secondary containment around dumpsters.	
Hooker Elementary School	New Haven	Moderately old street/sidewalk, possibly separated sewer/past CSO. Buried roof leaders to catchbasins.	Linear bioretention to subsurface infiltration along Canner, east of Livingston. Replace paved ROW area on Livingston, south of the school, with bioretention; connect to low points of playground via trench drain or replace with pervious pavers.	
Jocelyn Square Park	New Haven	Broken 6' wide sidewalk on north side of park. Drainage existing along Humphrey. Leaching catch basin in private parking lot across Humphrey, at 175 Humphrey St.	Bioswale in ROW between utility poles. Potential for subsurface storage/infiltration under paved park entrance.	
Humphrey Street and Mill River Street	New Haven	Large parking area comprised of sand, gravel and pavement, which slopes towards the Mill River. The stream bank is eroded with no riparian area.	Potential for living shoreline	

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Radiall America	New Haven	Large parking lot, buried roof leaders	Disconnect roof leaders, bioretention in existing landscaped areas.	
United Way	New Haven	Large parking area, landscaped islands.	Bioretention in islands.	
Haven Street	New Haven	Existing drainage along Haven Street captures private driveway.	Potential for bioretention to capture road runoff and stormwater from residential properties and to serve as connection to the Mill River Trail.	

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Fair P.A.C Housing	New Haven	Large parking lot and connected roof leaders	Potential for retention in the vegetated areas in the front and rear of the building	
St James Unity	New Haven	Buried roof leaders, underutilized parking area.	Disconnect roof leaders, potential for pervious pavement.	
Yale Divinity	New Haven	Buried roof leaders, potential evidence of gray water from building in catch basins along driveway between Divinity School buildings and adjacent conference center. Drainage system appears to drain east towards large landscaped area and potentially out to Whitney Ave. Possible existing infiltration basins at conference center.	Potential for curb cuts to bioretention, potential for subsurface infiltration, disconnect roof leaders.	
First Unitarian Church	New Haven	Buried roof leaders, compacted gravel. Paved play area sheet flow to parking lot.	Potential for subsurface infiltration.	
Orange/Edward Canner/Foster	New Haven	Cracking pavement. Possibly separated sewer/past CSO area. No Standing Anytime signs on all corners.	ROW bump-out bioretention or bioswale at intersection without removing on-street parking or infringing on bike lane. Potential for pervious pavers in parking/cycling lane.	

Mill River Watershed – Other Green Infrastructure Opportunities

Site Location	Municipality	Existing Conditions	Recommendation	Photo	
James and River Street	New Haven	Curbed bump out with gutter	Potential to retrofit bump out for use as bioswale. Location next to Criscuolo park also offers potential for education and outreach.		
Criscuolo park	New Haven	Heavily used urban park and playing fields	Potential for riparian plantings and demonstration rain garden.		

Appendix D

Project Steering Committee Meeting Summaries

Mill River Watershed-Based Plan: Public Meetings

3/1/2018 – Kick-off Meeting at the Eli Whitney Museum – Save the Sound presented an overview of the Mill River watershed and types of impairments identified; the objectives for developing a watershed based plan; and timeline of the planning process. Attendees divided into small groups and were invited to discuss their interests in the river and what was important for them to see in the plan. It was noted that the most important part of the planning process is to develop a plan that can be moved forward to implementation.

3/18/2018 – Save the Sound made a presentation to the Whitneyville Civic Association about the Mill River watershed planning process and the objectives for developing a watershed based plan.

4/10/2018 – Steering Committee Meeting at the Cheshire Senior Center – Fuss & O'Neill, Inc. made a presentation reviewing Technical Memorandum #1: The State of the Watershed; scope and timeline for the project; and the next steps in planning process. The steering committee expressed interest in self-organizing to conduct stream-walks that would not otherwise have been included in the project scope.

5/1/2018 – Steering Committee Meeting at the Eli Whitney Museum – Members of the West River Watershed Coalition (WRWC) were invited to discuss successes and lessons learned from the West River Watershed Plan, and how the group functions as a watershed-based coalition. The steering committee discussed potential implementation projects for the Mill River Watershed Plan and the opportunity to submit a proposal for Hamden Town Center Park to CTDEEP EPA 319 Program for consideration for the 2018 funding cycle.

5/29/2018 - Steering Committee Meeting at the Cold Spring School- A section of the film *The Mill River – Water and Wildlife* by Florence S. McBride was previewed. Tech Memo #2: Pollution load model was reviewed and GNHWPCHA and the Regional Water Authority discussed their respective activities in the watershed and how the watershed plan could compliment their efforts.

6/6/2018 – New Haven Environmental Advisory Council (EAC) - A presentation was made to the EAC about the Mill River watershed planning process; the objectives for developing a watershed-based plan; and how the plan could compliment the council's and the city's initiatives in the Mill River watershed.

6/20/2018 – Green Drinks New Haven - A presentation was made by Save the Sound to the community about the Mill River watershed-based plan, the objectives and potential implementation projects. As the midpoint in the planning process, the community was asked for feedback and if there was anything else that should be considered going forward in the planning process.

7/10/2018 – Steering Committee Meeting at the Cheshire Senior Center - Fuss & O'Neill, Inc. presented on the screening-level model used to estimate pollutant loads within the watershed and the primary sources. Technical Memorandum #3: The State of the Watershed, was reviewed, which highlights the major tasks of the green infrastructure assessment and existing practices in the watershed. The steering committee reviewed the screening criteria used to prioritize potential project locations. The 10 sites for which concept designs were developed were discussed in detail.

8/21/2018 - Steering Committee Meeting at the Eli Whitney Museum - The steering committee reviewed and discussed the draft Mill River Watershed Plan and to plan public outreach events to share the plan with the greater watershed community.



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Mill River Watershed Plan Project Kick-Off Meeting - Summary

March 1, 2018

1. Welcome from Gwen Macdonald, with an overview of how Save the Sound became involved in the watershed plan for the Mill River and previous work that had been done in the West River Watershed.
2. A brief presentation was given by Nicole Davis, which provided a summary of the Mill River watershed and identified impairments; the objectives for developing a watershed based plan; an overview of the planning process; the EPA's 9 Elements for watershed planning and the scope and schedule for the Mill River Watershed Plan. It was noted that the most important part of the planning process is to develop a plan that can be moved forward to implementation. Save the Sound is committed to moving beyond plan development and into implementation. A copy of the presentation will be made available by request. A list of available studies and reports for the watershed was also shared and the stakeholders were asked to identify any existing information that may be missing.
3. Following the presentation, introductions of the group were made. Each person in attendance was asked to introduce themselves, who they are with and why they were interested in the Mill River Watershed (Please see attached list of attendees). Chris Malik with DEEP commented on the state's desire to delist impaired water bodies and also shared the desire to support the plan. He indicated that they would like to see projects included that can be implemented.
4. Following introductions the stakeholders broke out into smaller groups to discuss
 - a. What is important in the watershed?
 - b. What do you want to see in the plan?
 - c. What information is available?
 - d. Anyone else who should be here?

When discussing who else should be present in the planning process a concern was raised regarding municipal involvement. Most individuals present expressed the desire for municipalities to be involved in the planning process as well as staying involved to implement projects. (Below is a summary of the discussion from each group)

5. The stakeholders came back together to summarize what was important in each group. The conversations in each group were slightly different but seemed to center around the same basic themes. There was a consensus that protecting the watershed was important and that more extensive public education opportunities were needed to expand connectedness to the river. The need for better access and opportunities to use the river recreationally were important along with expanding conservation and recreation opportunities. Clean drinking water was identified as an important use along with reducing storm water. The



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need to address CSO's was discussed in every group along with the benefits of using measures to reduce runoff as a tool to reduce CSO inputs.

6. The meeting concluded with a What's Next for the watershed and the steering committee:

The next Steering Committee meeting will be established via doodle poll

<https://doodle.com/poll/ptuu3hxn8ixc96q>

- a. , with the intention of holding the meeting in Cheshire and then alternating meeting locations between the up and lower watershed.
- b. One of the desired outcomes of the plan is to form a steering committee that will hopefully evolve into a watershed coalition focused on plan implementation. Anyone interested in being a part of the steering committee for the plan was asked to let Nicole know. Kendall Barberry asked how often the steering committee was going to meet. The intention was to meet monthly or more often as needed during the planning process.
- c. A watershed questionnaire was developed by Fuss and O'Neil to help guide the plan. Copies of the survey were provided at the meeting and will be sent out by email.

Small Group Discussion

Group 1

- What is important in the watershed?
 - o Want the shad back
 - o Fishable
 - o Clean drinking water
 - o Access to the river
 - o Mill river blue trail south of I-91
 - o Increase Buffer
 - o Reduce Runoff from Asphalt
 - o Bird Corridor
 - East rock park is an Important bird area
 - o Pervious surfaces
 - Incentivize Porous Surfaces
 - Guidelines for Porous surfaces
 - o Recreational space
 - o Swimmable
 - o Education about Water Quality
- What do you want to see in the plan?
 - o Presentations
 - Example projects
 - Presentations by municipal officials about how they intend to comply with storm water regulations and incorporate green infrastructure
 - o Discussion and analysis of regulations
 - e.g. UCONN in West River



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- MS4 requirements for municipalities
- Projects
 - Planting native trees and shrubs
 - Pollinators
 - Trash Clean up/how to change behavior/clean ups as a lesson
 - Use Social Media
- Focused subcommittees, similar to west river watershed coalition
 - Access Committee
- Anyone else who should be here?
 - Trout Unlimited
 - Elected officials

Group 2

- What is important in the watershed?
 - Addressing the major problems
 - Storm water Runoff
 - CSOs
 - Golf Course Runoff
 - Leaking sewer pipes
 - Contaminated sites/sediment
 - Nutrients and contamination other than bacteria
 - Cause of pollutants
 - land use
 - Industrial runoff
 - Illegal dumping
 - RWA withdrawals
- What do you want to see in the plan?
 - Address heavily contaminated sites
 - English Station
 - New Haven Clock Factory
 - Gateway terminal
 - Simkin
 - Olin Powder Farm
 - Contributors of NPS
 - Schools
 - Gateway terminal
 - Public Education
 - Rain barrels
 - Schools
 - Canoe Trips
 - Access to the river
 - Mill River Trail
 - Access upstream
 - Recreation
- Anyone else who should be here?
 - Farmers



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- o More residents across the watershed/ Fair haven residents
- o Fishermen

Group 3

- What is important in the watershed?
 - o Trout stream at the head waters
 - o There needs to be broader sense of connection to the river that will activate people to use the river and increase stewardship
 - o Hamden has adopted use based codes, which helps to establish conservation and natural areas within a traditional residential or commercially zoned area: could that be expanded to Cheshire and other municipalities
 - o The potential for source to sound trail.
 - Difficult landscape between Armory and Wait Street
 - Above Dixwell has potential to open up for trail
 - o Concerns about trail and other problems associated with additional trail
 - RWA has actually seen a reduction of trash on recreational trails – police themselves
- What do you want to see in the plan?
 - o Infiltration of storm water
 - Take advantage of CSO communities and the push for reduction
 - o Municipalities involved long term
 - o Evolving plan that people can continue to add projects too
 - o Increased connectivity and access
 - Look to the River as a mode of transportation
 - o A document that will add credibility to the river as a community asset
 - o Concerns that the plan will focus on the lower watershed. Projects need to connect upper and lower watershed together
 - o Signage for existing and built trails
- What information is available?
 - o Several years ago there was an active Mill River Association, efforts seemed to diminish when the person who had taken the lead suddenly passed away. If someone were to take the lead the efforts are likely to revive
 - o A lot of green initiatives in Hamden right now
 - o SCRCOG - disaster mitigation plan, POCD
 - Open Space plan targeting land for conservation
 - Available as GIS resource
 - o Cheshire land trust has some GIS data
 - 500' Buffer around river and impervious surface (~13% with in buffer)
 - o Are there any successful watershed plan efforts that could be used as an example to help guide this group and this plan
- Anyone else who should be here?
 - o The District
 - o The Boat House
 - o Civic associations



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Kick Off Meeting Attendees		
Name	Organization	Email
Aaron Goode	Green Fund	aaron.goode@gnhgreenfund.org
Aicha Woods	Mill River Trail	aichawoods@gmail.com
Anthony Allen	Tipping Point	anthony@atippingpoint.org
Anthony Zemba	FHI	azemba@fhiplan.com
Arabelle Schoenberg	New Haven Land Trust	arabelle.schoenberg@newhavenlandtrust.org
Bill Brown	Eli Whitney	wb@eliwhitney.org
Carl Amento	SCRCOG	camento@scrcog.org
Chris Malik	DEEP	christopher.malik@ct.gov
Christina Kane	The Grove	christina@grovenewhaven.com
Corrie Folsom-Okeefe	Audobon CT	cfolsom-okeefe@audobon.org
Daniel Barvir	New Haven Parks	dbarvir@newhavenct.gov
David Shimchick	FERP	dschimchick@comcast.net
Dawn Henning	City Of New Haven	dhenning@newhavenct.gov
Eliza Valk	Reed Hilderbrand	eliza@reedhilderbrand.com
Gary Zrelak	GNHWPCA	gzrelak@grnhwpc.com
Joe Peters		josephpeters@sbcglobal.net
Joy Vanderlek	Cheshire Land Trust	joyvlek@gmail.com
JR Logan	Mill River Trail	johnrichardlogan@gmail.com
Karolina Ksiazek	NH City Plan	kksiazek@newhavenct.gov
Kendall Barberry	Former Watershed Resident	kendall.barberry@gmail.com
Kevin Mccarthy	Friends Of East Rock Park	worldtravelers1982@gmail.com
Kim Digiovanni	Quinnipiac University	kimberly.digiovanni@quinnipiac.edu
Lee Cruz	Community Foundation Of Greater New Haven	lcruz@cfgnh.org
Mateo		
Mark Foran	Whitneville Civic Association	jmark4n@mac.com
Nancy Rosembalm	Hamden Land Trust	nancy.rosenbaum@sbcglobal.net
Pamela Roach	Cheshire Land Trust	pdricciroach@gmail.com
Ron Walters	RWA	rwalters@rwater.com
Nisarg (Niz) Bhartkumar Vyas	UNH	nvyas2@unh.newhaven.edu
Anna Marshall	Save the Sound	amarshall@savethesound.org
Kevin Dahms	Save the Sound	kdahms@savethesound.org
Annalisa Paltauf	Save the Sound	apaltauf@savethesound.org
Gwen Macdonald	Save the Sound	gmacdonald@savethesound.org
Nicole Davis	Save the Sound	ndavis@savethesound.org

Connecticut Fund for the Environment/Save the Sound
Mill River Watershed Based Plan
Steering Committee Meeting Notes

4/10/18 6-8pm at Cheshire Senior Center, Cheshire, CT.

Notes transcribed by Annalisa Paltauf and Julianne Busa
Presentation by Erik Mas, Fuss & O'Neill, Inc.

1. Welcome, introductions and review of agenda by Nicole; turned floor over to Erik Mas for presentation.
2. Project Objectives and Planning Process
 - a. Erik Mas provided a brief review of the objectives of the planning process and the nine-elements of an EPA Watershed-Based Plan.
3. Summary of the Watershed Survey
 - a. 7 responses total
 - b. Top issues: education and outreach; stormwater runoff; open space, trails, and waterfront access; water quality and bacteria; CSO's; recreation; flooding and erosion
 - c. Desired outcomes: clearly defining issues and priorities; site-specific projects; improve water quality; community engagement; residential education and outreach

A question was asked regarding what was driving the schedule for the plan, which is the funding source and the expiration of funds. Chris Malik added that the state was fortunate to find 319 money available for planning and wanted to take advantage of the opportunity.

4. Review of the Technical Memorandum #1: The State of the Watershed
 - a. Erik summarized the existing watershed conditions that are detailed in Technical Memorandum #1, including highlights of the mapping. The memo is an assessment of existing conditions and a review of available information that will help identify issues and prioritize goals.
 - b. It was noted that additional data is needed, particularly for open space mapping and wastewater. Steering Committee members are asked to please help fill in these gaps—information is particularly welcome from those from the land trusts with access to open space parcel information.
 - c. Findings include:
 - i. The Mill River Watershed is 38 square miles; the river is 12.6 miles long. It includes the tributaries of Willow Brook, Shepard Brook, Butterworth Brook, Jepp Brook, Eatons Brook, and Brooksvale Stream.
 - ii. The Mill River Watershed is a diverse urban watershed with different settings ranging from rural forested river to urban.
 1. Forested lands in upper parts of the watershed have a higher water quality than downstream.
 2. Downstream areas are impacted by development – both historic and current, including old mill dams and relics of industry, as well as impacts from urbanization.
 3. There are 2 sub-regional watersheds with 14 local basins, which span 7 municipalities. Most of the watershed is in the town of Hamden (50%), followed by Cheshire (30%), and the remaining in New Haven (5%), Bethany, North Haven, Prospect, and Wallingford.

iii. Land Use & Land Cover

1. Land use – what is on the ground, how it is being used. 57% of watershed land use is residential; 23% open space and forested areas; the rest a combination of commercial, institutional (i.e. Quinnipiac University), industrial, and agricultural.
2. Land cover – what is covering the land from an aerial perspective. 44% of watershed land cover is considered forested areas; about 47% is developed or paved; about 5% is wetlands/open water.
 - A question was raised regarding how forested lands were determined. Erik indicated that it was based on an analysis of aerial photographs by NLCD. Methodology and definitions are available on the [NLCD website](#)
3. On the map, red = hardscape, anything built or developed; green = forest; yellow = turf, grass, lawn, cemeteries, etc.
4. Impervious cover
 - Impervious cover is a good surrogate for measuring water quality and stream health.
 - i. As imperviousness increases, the streams become more degraded. Pavement generates runoff during storms. Because the land is paved, the water can't soak up into the ground and usually ends up in a stream, which causes it to be flashy (or flood more quickly). When water can soak into the ground, it improves groundwater—which contributes to base flows in rivers, and reduces flashiness.
 - A discussion about how water quality was defined and the use of instream aquatic life (fish and macroinvertebrates) to identify poor water quality. The question of how flow impacted water quality monitoring was raised and Erik discussed how the reduction of impervious cover and increased infiltration can help ground water recharge and help reduce low flow events.
 - UCONN has done state-wide analysis estimating impervious cover.
 - i. Stream water quality degrades as impervious cover increases.
 1. At 10% impervious cover you start to see impact to water quality and stream conditions.
 2. 25-60% - non-supporting range.
 3. In CT – the lower threshold to impact streams is 12%.
 - Willow Brook has about 10% impervious cover; 6 of the 14 local basins exceed the 12% threshold.
5. Riparian Corridor: 300 foot buffer on either side of stream centerline – filters runoff, provides shade and habitat, prevents flooding. Lower half of the watershed's riparian corridor is the most developed, also Cheshire center and Route 10 corridor.
6. Forests, Wetlands, and Critical Habitat.
 - Core Forest (highest value for habitat) includes Sleeping Giant State Park, Naugatuck State Forest). Edge Forest buffers the Core Forest and is a transition zone.
 - 12% of watershed is wetlands.

- Notable critical habitat: East Rock Park is important stopover area for migratory song birds.
- iv. Pollutant loads – i.e. how much bacteria is getting to the Mill River annually.
 1. How much bacteria are being loaded based on land use, CSO discharge, septic systems, etc.
 - Pollutant sources in the watershed include stormwater runoff, illicit discharges (i.e. sewer-related dumping), CSO's, septic systems (failing and malfunctioning systems), wildlife and pet waste.
- v. Water quality monitoring
 1. DEEP conducted water quality testing on Mill River, Shepard Brook, Willow Brook, and Sanford Brook (tributary of Willow Brook).
 - Several segments have high water quality, meaning they meet standards for recreation, support aquatic life (determined by macroinvertebrate sampling), and shellfishing.
 - Other segments are impaired for one or more of the standards.
- vi. Geology and soils
 1. This is important because it influences the river itself, but also because it will influence our ability to do green infrastructure and low impact development in different parts of the watershed, due to infiltration rates/ability.
 - A&B soils – high infiltration capacity; sandy; well-draining
 - C&D soils – less infiltration capacity; dense glacial till; ledge/rock
 - 50% of the watershed is A/B soil, therefore conducive to stormwater infiltration and green infrastructure projects.
 - i. Note: the map shows south of I-91 as having D soil, but per Dawn Henning the soil is actually very sandy like the rest of New Haven.
- vii. Public Water Supply
 1. RWA manages the public water supply in the watershed.
 2. Surface water: Lake Whitney; groundwater aquifers: in Cheshire and Hamden
- viii. Dams & Barriers to fish passage
 1. 22 dams registered in the watershed; 5 on Mill River; 1 on Shepard Brook
 2. Other barriers include remnant dams, the tide gates at I-91
 3. Dams and impoundments can affect water quality, but also a habitat-related concern
- ix. Wastewater
 1. Large portion of the watershed is served by sanitary sewers, managed by the Greater New Haven Water Pollution Control Authority (GNHWPCA), although the northern portion of the watershed has septic systems.
 2. CSO's are a problem in the lower watershed. CSOs that discharge to the Mill River remain active at three locations: 009, 011, 012.
 - CSO Long-Term Control Plan: separate the sewer system; flow-monitoring; upgrade systems; use green infrastructure BMP's.
 3. New private development in areas served by the GNHWPCA combined sewer system must install stormwater infiltration systems or retain stormwater on-site as a permit requirement.

5. Next Steps:

- a. Once remaining data has been gathered, Fuss & O'Neill will begin work on the pollutant loading models for the watershed to simulate annual loads of pollutants: bacteria, sediment, and nutrients. They will also be beginning to develop more specific siting suggestions for LID and GI projects.
 - i. Ultimately the plan will include numerous watershed-wide and site-specific recommendations, including design concepts for ten sites
- b. Steering Committee members are asked to please submit their project ideas as soon as possible so that these can be taken into consideration.
- c. Steering Committee members are also asked to assist in collecting information on existing practices/BMPs in the watershed
 - i. Nicole will be reaching out to members about their ideas
 - ii. NVCOG has done a review of regulations in their municipalities related to Green Infrastructure
- d. Steering Committee Meeting #2 scheduled for Tuesday, May 1. Location to be held somewhere in the Fair Haven section of New Haven.
- e. Both Erik Mas and Chris Malik (CTDEEP) emphasized the accelerated nature of the planning schedule, which is being driven by funding constraints.
 - i. The DEEP 319 grant runs out at the end of September which is why we have a tight timeline.

6. Additional Discussion Points:

- a. Definition of what constitutes forest cover in the mapping and how this relates to residents' on the ground knowledge of cover and land types
- b. How water flow is reflected in and relates to impairment classification
- c. Concerns about issues such as CSOs and whether infiltration and inflow assessments of particular sewer lines have been performed and how this might impact the watershed planning work
 - i. Erik Mas and Dawn (City of New Haven) noted that MS4 permit requirements require illicit discharges and other issues to be addressed by the municipalities over the next several years.
 - ii. Chris Malik reiterated that the goal of the watershed plan is to address *non-regulated* (i.e. nonpoint sources) discharges
- d. Discussion of existing municipal requirements for reducing Directly Connected Impervious Area (DCIA) and recommendations for new or modified land use regulations as a potential outcome of the plan
- e. Members of the steering committee expressed interest in self-organizing to conduct stream-walks that would not otherwise be included in the project scope. Elsa/Cheshire Land Trust volunteered to lead this effort.
 - i. The Cheshire Land Trust expressed interest in doing stream walks if they could find someone to do a training. Chris Malik mentioned that NRCS had done them in the past, but wasn't sure if they were able to conduct stream walk trainings at the moment.
- f. Discussion of the scope (financial and time-based) of the project and the need to limit the more detailed designs to 10 sites vs. the ability to include more sites in less detail.
 - i. Chris Malik reiterated that while it helps to have sites in the plan for later funding, there can be language emphasizing the iterative nature of site-choice and that sites not included will not be preemptively excluded from funding opportunities
- g. The implementation timeline was discussed
 - i. Plan should include some actions for immediate progress/support-building
 - ii. Some implementation ideas will be on a 2-5 year timeline

- iii. Some with longer (5-10 year) horizons
- h. Concern was expressed from several members of the group about the lack of representation from the Towns of Hamden and Cheshire. Many in the group felt this would be problematic going forward and agreed to reach out, as citizens, to encourage Town representation.

Connecticut Fund for the Environment/Save the Sound
Mill River Watershed Based Plan
Steering Committee Meeting Notes

7/10/18 6-8pm at Cheshire Senior Center, Cheshire, CT.

Notes transcribed by Julianne Busa

Presentation by Erik Mas and Julianne Busa, Fuss & O'Neill, Inc.

1. Welcome and Housekeeping

- a. Review of agenda by Nicole
- b. Discussion of upcoming meeting dates and summer festivals
- c. Brief review of goal to get municipalities to sign on to the plan
- d. Discussion of desire to keep the group going once the plan is complete to push for implementation
- e. Update on Sleeping Giant. STS will draft a letter to encourage incorporation of LID during rebuilding efforts.
- f. Stream Walk is planned for July 21
- g. Announcement that the CT Audubon/Army Corps of Engineers Wetland In-Lieu Fee program (ILF) has accumulated \$142K for the South Central Coast basin and received no applications last year. This amount and any additional money that comes in during the interim will be available for the next grant round, which is expected to open in February 2019, with letters of interest due in Mid-April. There is an additional possibility of an OSWO grant match. The top priorities for the ILF funding are preservation, followed by restoration, and the money can be used for land acquisition.

2. Pollutant Loading Model

- a. Erik Mas provided a brief review of the objectives of the planning process
- b. Erik described the screening-level model used to estimate pollutant loads and determine how much bacteria comes from different portions of the watershed and what sources it comes from.
- c. Erik detailed the two different types of model inputs: primary sources—which capture pollutants associated with land use, and secondary sources—which include sewers, CSOs, etc. He also provided an explanation of the various assumptions and calculation factors (Event Mean Concentrations and Export Coefficients) that were used in the model to assign pollutant values to each of the sources and land use categories.
 - i. Erik noted that assumptions related to septic failure were based on input from the two health districts in the watershed, and reflected fairly typical assumptions.
 - ii. CSO discharge information input into the model was based on “typical year” estimates generated by GNHWPCA from their monitoring data.
- d. Erik presented the results of the model via a series of bar charts and pie charts.
 - i. Bar charts were presented in pairs, demonstrating the estimated loads for each subwatershed, as well as the ‘pollutant yields’. The latter values correct for the size of each subwatershed and allow for apples-to-apples comparisons of pollutant outputs from various subwatersheds. The Lower Mill River subwatershed exhibits the highest pollutant yields for bacteria and suspended solids, both of which are attributable in part to CSO contributions.

The data do not show substantial differences in nitrogen and phosphorus pollutant yields across subwatersheds.

- ii. Erik presented paired pie charts that demonstrated the relative bacteria sources for each subwatershed. The first set of charts showed the percentage of bacteria attributable to: urban land, forest, rural land, illicit connections, CSOs and septic systems. The second set of graphs presented a more specific breakdown of the urban land category to show contributions from low, medium, and high density residential areas, as well as commercial, highway, industrial, and institutional categories.
- iii. For the Lower Mill River subwatershed, Erik noted that the model estimates that 40% of bacteria load in that watershed comes from CSOs, but even if these were eliminated, there is still a significant load from land uses, particularly high density residential. The model also indicates that nearly 25% of the bacteria in that subwatershed comes from potential illicit connections. These findings (and the similarly high contributions from land use and potential illicit connections across all subwatersheds) underscore the message that stormwater runoff is a key driver of water quality impairments in the Mill River and highlight the important role that the MS4 regulations could play in alleviating both potential illicit connections and stormwater runoff as pollutant sources.
- iv. Erik pointed out that, across subwatersheds, the model results indicate that septic system failure is not a major bacteria source relative to other pollutant sources.

3. Green Infrastructure Assessment

- a. Julie Busa described the major tasks of the green infrastructure assessment and provided some examples of existing practices in the watershed, including GNHWPCA's implementation of their 2008 design guidelines.
- b. Julie explained the various screening criteria that were used to develop a list of potential sites and included maps of all of the priority sites that were targeted for field visits.
- c. Julie then walked through one-by-one the 10 sites for which concept designs were developed, providing some additional context for the various site photos and design concepts that were presented in Tech Memo 3.
- d. Steering Committee Members participated in discussion of the sites and designs. Major discussion points included:
 - i. Noting that, at the Bartlem Recreation Area, the area along the driveway that was proposed for linear bioretention is used as vendor parking during the annual festival. This may pose a conflict for the design, or it may be feasible to relocate the parking to another location.
 - ii. It was also noted that the former farm parcel directly south of the baseball field at Bartlem Recreation Area is being developed as an open space and recreation parcel. Based on existing topography, the drainage from the two sites is likely isolated by a berm that runs between the two.
 - iii. The New Haven Parks Department has expressed reservations with the Livingston Street and East Rock Road concept because of the perceived level of maintenance involved relative to the current mowing practice. For this site, Julie also noted that new information about the drainage infrastructure at the east edge of this site would likely require some amendments to the design if it were to go forward into a next-level feasibility study.
 - iv. At the Counter Weight Brewery/Raccio Park Road/Spring Glen Nursery site, Nicole added additional information about the current conditions at the Spring Glen Nursery site that

suggest potential for additional BMPs on the nursery property. It was noted that private partnerships would be vital to the success of that project.

- v. Erik and others noted the ongoing bioswale project in which GNHWPCA and the City of New Haven are installing approximately 200 bioswales throughout the West River Watershed and in the downtown area, projects which were driven, in part, by work done as part of the West River Watershed planning process. The James Street project proposed for the Mill River Watershed would be an extension of that project that would bring it over into the Fair Haven neighborhood.
- vi. Chris Malik (CTDEEP) noted that he was pleased to see a list of additional project sites and notes included as an Appendix to the plan, and he encouraged that any additional sites and ideas be referenced in the final plan. This led to some discussion of how to incorporate elements, like the Stream Walk, which might not be fully completed by the September deadline.

4. Next Steps:

- a. Fuss & O'Neill will begin work on assembling all of the information gathered to date into the draft watershed plan. This should be available for review in mid-August.
- b. There will be a 30-day public review period once the draft is prepared. The two public sessions on September 5th and 6th will fall in the middle of this comment period.
- c. Once the comment period closes, Fuss & O'Neill will finalize the plan in advance of the late-September funding deadline.

Appendix E

Community Workshop Meeting Summaries

Appendix F

Pollutant Load Reduction Model Results

Estimated Pollutant Load Reductions												
Location and Element	Pollutant Load - L (lbs)				Removal Rates - Decimal %				Load Reduction - L (lbs)			Load Reduction FC (Billion Colonies)
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	
Elm City College Preparatory Elementary												
1 Tree Box Filter	1.42	0.12	33.78	32.56	0.90	0.30	0.55	0.70	1.28	0.03	18.58	22.79
2 Curbside Bioswales	1.42	0.12	33.78	32.56	0.55	0.30	0.90	0.70	0.78	0.03	30.40	22.79
3 Subsurface Infiltration Chambers-adjacent to turf field	15.78	1.28	375.31	361.77	0.65	0.65	0.90	0.95	10.26	0.83	337.78	343.68
4 Pervious Pavement - parking spots parallel to James Street	3.94	0.32	93.83	90.44	0.90	0.40	0.40	0.95	3.55	0.13	37.53	85.92
Total									15.87	1.03	424.29	475.18
James Street												
1 Tree Box Filters	2.92	0.49	78.30	59.13	0.90	0.30	0.55	0.70	2.63	0.15	43.07	41.39
2 Curbside Bioswales or Bump-Outs	2.92	0.49	78.30	59.13	0.55	0.30	0.90	0.70	1.61	0.15	70.47	41.39
Total									4.24	0.29	113.54	82.78
Mill River Trail, Haven and Exchange Street Green Infrastructure												
1 Bioretention Areas and Pervious Trail	47.30	3.80	1125.90	1085.30	0.55	0.30	0.90	0.70	26.0	1.2	1,013.3	759.7
Total									26.00	1.20	1013.30	759.70
Wilbur Cross High School												
1 Bioretention Areas	34.32	2.78	816.29	786.84	0.55	0.30	0.90	0.70	18.88	0.83	734.67	550.79
2 Subsurface Infiltration Chambers	17.36	1.41	412.84	397.94	0.65	0.65	0.90	0.95	11.28	0.91	371.55	378.04
Total									30.16	1.75	1106.22	928.83
Livingston Street at East Rock Road												
1 Vegetated Water Quality Swale	12.19	2.05	326.26	246.38	0.90	0.30	0.55	0.70	10.97	0.61	179.44	172.47
2 Bioretention Areas	19.50	3.28	522.02	394.21	0.55	0.30	0.90	0.70	10.72	0.98	469.82	275.95
Total									21.69	1.60	649.26	448.41
YNHH Outpatient Services												
1 Pervious Pavement	9.07	0.74	215.80	208.02	0.90	0.40	0.40	0.95	8.17	0.29	86.32	197.61
2 Front Lawn Bioretention Area	3.16	0.26	75.06	72.35	0.55	0.30	0.90	0.70	1.74	0.08	67.56	50.65
3 Main Lawn Bioretention Areas	1.78	0.14	42.22	40.70	0.55	0.30	0.90	0.70	0.98	0.04	38.00	28.49
Total									10.88	0.41	191.88	276.75

Estimated Pollutant Load Reductions													
Location and Element		Pollutant Load - L (lbs)				Removal Rates - Decimal %				Load Reduction - L (lbs)			Load Reduction FC (Billion Colonies)
		TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	
Whitney High School North/West													
1	Pervious Pavement	42.96	3.48	1021.78	984.91	0.90	0.40	0.40	0.95	38.66	1.39	408.71	935.66
2	Subsurface infiltration--behind Staff Development Building	7.89	0.64	187.65	180.88	0.65	0.65	0.90	0.95	5.13	0.42	168.89	171.84
3	Bioretention Area	17.18	1.39	408.71	393.96	0.55	0.30	0.90	0.70	9.45	0.42	367.84	275.77
Total									53.24	2.23	945.44	1383.27	
Counter Weight Brewery, Spring Glen Nursery, and Raccio Park Road													
1	Rain Garden Trio- within parking area	4.73	0.38	112.59	108.53	0.55	0.30	0.90	0.70	2.60	0.12	101.33	75.97
2	Bioretention Area/ Rain Garden- Raccio Park Road	2.17	0.18	51.60	49.74	0.55	0.30	0.90	0.70	1.19	0.05	46.44	34.82
3	Pervious Pavement	11.05	0.90	262.72	253.24	0.90	0.40	0.40	0.95	9.94	0.36	105.09	240.57
Add-on	Additional Pervious Pavement- front lot	2.96	0.24	70.37	67.83	0.90	0.40	0.40	0.95	2.66	0.10	28.15	64.44
Total									16.40	0.62	281.01	415.80	
Bartlem Recreation Area													
1	Linear Bioretention	0.47	0.04	11.27	68.03	0.55	0.30	0.90	0.70	0.26	0.01	10.15	47.62
2	Vegetated Water Quality Swale	1.06	0.09	25.15	213.81	0.90	0.30	0.55	0.70	0.95	0.03	13.83	149.67
3	Pervious Pavement	1.64	0.13	39.02	242.97	0.90	0.40	0.40	0.95	1.48	0.05	15.61	230.82
4	Bioretention Area/Raingarden	21.85	1.98	424.87	58.31	0.55	0.30	0.90	0.70	12.02	0.59	382.38	40.82
Total									14.71	0.68	421.97	468.92	
Strathmore Drive													
1	Bioretention Area	22.23	2.64	676.56	132.13	0.55	0.30	0.90	0.70	12.23	0.79	608.90	92.49
Total									12.23	0.79	608.90	92.49	
Grand Total									205.42	10.61	5755.81	5332.15	

Appendix G

Potential Funding Sources

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
EPA and WEF National Municipal Stormwater and Green Infrastructure Awards Program	The National Municipal Stormwater and Green Infrastructure Awards program, led by the Water Environment Federation (WEF) through a cooperative agreement with the U.S. Environmental Protection Agency (EPA), has been established to recognize high-performing regulated Municipal Separate Stormwater Sewer Programs (MS4s). The objective of the program is to inspire MS4 program leaders to seek new and innovative ways to meet and exceed regulatory requirements in a manner that is both technically effective as well as financially efficient. Recognition of innovative approaches is also a highlight of this program.	http://www.wef.org/ms4awards/
EPA Urban Waters Small Grants Program	Funds research, investigations, experiments, training, surveys, studies, and demonstrations that will advance restoration of urban waters by improving water quality through activities that also support community revitalization and other local priorities. Projects proposed for funding must take place entirely within specific Eligible Geographic Areas.	http://www2.epa.gov/urbanwaters/urban-waters-small-grants
EPA Healthy Communities Grant Program	EPA New England's main competitive grant program to work directly with communities to reduce environmental risks to protect and improve human health and the quality of life.	http://www.epa.gov/region1/eco/uep/hcgp.html
EPA Environmental Education Grants	The Grants Program sponsored by EPA's Office of Environmental Education (OEE), Office of External Affairs and Environmental Education, supports environmental education projects that enhance the public's awareness, knowledge, and skills to help people make informed decisions that affect environmental quality.	https://www.epa.gov/education/environmental-education-ee-grants
FEMA (Federal Emergency Management Agency) Preparedness (Non-Disaster) Grants	FEMA provides state and local governments with preparedness program funding to enhance the capacity of their emergency responders to prevent, respond to, and recover from a range of hazards.	http://www.fema.gov/preparedness-non-disaster-grants
EPA Smart Growth	EPA helps communities improve their development practices and get the type of development they want. We work with local, state, and national experts to discover and encourage development strategies that protect human health and the environment, create economic opportunities, and provide attractive and affordable neighborhoods for people of all income levels.	https://www.epa.gov/smartgrowth/epa-smart-growth-grants-and-other-funding

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
FEMA Hazard Mitigation Assistance	FEMA's Hazard Mitigation Assistance grant programs provide funding to protect life and property from future natural disasters. · Hazard Mitigation Grant Program (HMGP) assists in implementing long-term hazard mitigation measures following a major disaster. · Pre-Disaster Mitigation (PDM) provides funds for hazard mitigation planning and projects on an annual basis. · Flood Mitigation Assistance (FMA) provides funds for projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis.	http://www.fema.gov/hazard-mitigation-assistance
USFS Land and Water Conservation Fund	The Land and Water Conservation Fund (LWCF) provides money to federal, state and local governments to purchase land, water and wetlands for the benefit of all Americans.	http://www.na.fs.fed.us/watershed/gp_innovation.shtm
National Forest Foundation	Through its on-the-ground conservation programs, the National Forest Foundation supports action-oriented projects that directly enhance the health and well-being of America's National Forests and Grasslands and that engage the public in stewardship.	https://www.nationalforests.org/grant-programs
United States Fish and Wildlife Service (USFWS)	The USFWS administers a variety of natural resource assistance grants to governmental, public and private organizations, groups and individuals.	http://www.fws.gov/grants/
USFWS North American Wetlands Conservation Act (NAWCA)	NAWCA provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife.	https://www.fws.gov/birds/grants/north-american-wetland-conservation-act/how-to-apply-for-a-nawca-grant.php
USFWS National Coastal Wetlands Conservation Grant Program	The NCWCGP provides States with financial assistance to protect and restore these valuable resources. Projects can include (1) acquisition of a real property interest (e.g., conservation easement or fee title) in coastal lands or waters (coastal wetlands ecosystems) from willing sellers or partners for long-term conservation or (2) restoration, enhancement, or management of coastal wetlands ecosystems. All projects must ensure long-term conservation.	http://www.fws.gov/coastal/coastalgrants/

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
USFWS Partners for Fish and Wildlife Program	The Partners Program provides technical and financial assistance to private landowners and Tribes who are willing to work with USFWS and other partners on a voluntary basis to help meet the habitat needs of Federal Trust Species. The Partners Program can assist with projects in all habitat types which conserve or restore native vegetation, hydrology, and soils associated with imperiled ecosystems such as longleaf pine, bottomland hardwoods, tropical forests, native prairies, marshes, rivers and streams, or otherwise provide an important habitat requisite for a rare, declining or protected species.	http://www.fws.gov/partners/
Office for Coastal Management/ National Oceanic and Atmospheric Administration	This competitive grant program funds projects that are helping coastal communities and ecosystems prepare for and recover from extreme weather events, climate hazards, and changing ocean conditions.	http://www.coast.noaa.gov/resilience-grant
NRCS Conservation Reserve Program	The Conservation Reserve Program (CRP) pays a yearly rental payment in exchange for farmers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality.	http://www.nrcs.usda.gov/programs/crp/
NRCS Environmental Quality Incentives Program (EQIP)	For implementation of conservation measures on agricultural lands.	https://www.nrcs.usda.gov/wps/portal/nrcs/main/ct/programs/financial/eqip/
NRCS Emergency Watershed Protection (EWP) Program	The Emergency Watershed Protection (EWP) Program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, wind-storms, and other natural occurrences. EWP is an emergency recovery program which responds to emergencies created by natural disasters. It is not necessary for a national emergency to be declared for an area to be eligible for assistance. EWP is designed for installation of recovery measures. Activities include providing financial and technical assistance to remove debris from stream channels, road culverts, and bridges, reshape and protect eroded banks, correct damaged drainage facilities, establish cover on critically eroding lands, repair levees and structures, and repair conservation practices.	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
NRCS Floodplain Easement Program	NRCS is providing up to \$124.8 million in Emergency Watershed Protection Program-Floodplain Easement funding to help prevent damages from future storm events in Connecticut and other states affected by Hurricane Sandy. NRCS purchases the permanent easements on eligible lands and restores the area to natural conditions. The program complements traditional disaster recovery funding and allows NRCS to purchase a permanent easement on lands within floodplains that sustained damage from Sandy.	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/home/?cid=stelprdb1143958
NRCS Healthy Forests Reserve Program	For restoring and enhancing forest ecosystems	http://www.nrcs.usda.gov/programs/hfrp/proginfo/index.html
U.S. Department of Housing and Urban Development (HUD)	The Community Development Block Grant (CDBG) program is a flexible program that works to ensure decent affordable housing, provide services to the most vulnerable in our communities, and create jobs through the expansion and retention of businesses. CDBG-financed projects could incorporate green infrastructure into their design and construction. The Disaster Relief Appropriations Act of 2013 (Pub. L. 113–2) allocated \$5,400,000,000 of Community Development Block Grant disaster recovery (CDBG–DR) funds for the purpose of assisting recovery in the most impacted and distressed areas declared a major disaster due to Superstorm Sandy	https://www.hud.gov/program_offices/comm_planning/communitydevelopment/programs
CTDEEP Section 319 Grant Program	Clean Water Act Section 319 funds to effectively and efficiently address nonpoint source pollution are available to municipalities, nonprofit environmental organizations, regional water authorities/planning agencies, and watershed associations.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325594&deepNav_GID=1654
CTDEEP Section 604(b) Grant Program	Under the federal Clean Water Act, Section 604(b) funds are awarded to CTDEEP to carry out water quality management planning including revising water quality standards; performing waste load allocation/total maximum daily loads, point and non-point source planning activities, water quality assessments and watershed restoration plans.	http://www.ct.gov/deep/cwp/view.asp?a=2688&Q=458026&depNav_GID=1511

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
CTDEEP Connecticut Clean Water Fund	The Connecticut Clean Water Fund (CWF) is the state's environmental infrastructure assistance program. The fund was established in 1986 to provide financial assistance to municipalities for planning, design and construction of wastewater collection and treatment projects. This program was developed to replace state and federal grant programs that had existed since the 1950s. The 1987 amendments to the Federal Clean Water Act required that states establish a revolving loan program by 1989. The fund was modified in 1996 to include the Drinking Water State Revolving Fund (DWSRF) to assist water companies in complying with the Safe Drinking Water Act by providing low cost financing. The CWSRF currently includes set-asides or reserves categories for green infrastructure, river restoration and small communities wastewater (including decentralized).	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325576&deepNav_GID=1654%20
Connecticut Lakes Grant Program	Provides matching grants for lake restoration projects to municipalities, lake authorities, and lake taxing districts at lakes that are available to the general public for recreation. Funds for the Lakes Grant Program are made available through authorizations of the State Legislature and allocated by the State Bond Commission. The Lakes Grant Program requires a 25% match for studies and a 50% match for implementation of control measures. When funding is available for the Lakes Grant Program, notification is provided to every municipality in Connecticut and to groups who have previously inquired about funding for lake management projects.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=332726&depnave_gid=1654
Long Island Sound Study - Long Island Sound Research Grant Program	To support research that will enhance scientific understanding of Long Island Sound, and provide information needed by managers to protect and effectively manage the Sound and its valuable resources. Available to Connecticut academic institutions.	http://longislandsoundstudy.net/research-monitoring/lis-research-grant-program/
CTDEEP Recreational Trails Grants Program	Since 2015, CTDEEP's recreational trails program has provided funding to non-profits, municipalities, state departments and tribal governments in support of trail construction and/or restoration projects, accessibility improvements, purchase of trail maintenance equipment, land acquisition, and educational programs. Requests should be under \$1million, and a 20% match is required.	http://www.ct.gov/deep/cwp/view.asp?a=2707&q=513740&deepNav_GID=1650

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
CTDEEP Long Island Sound License Plate Program	Section 14-21e of the Connecticut General Statutes (CGS) authorizes the issuance of the Long Island Sound license plate by the Department of Motor Vehicles, while CGS Section 22a-27k establishes the Long Island Sound Fund to be administered by the Department of Energy and Environmental Protection into which proceeds from the sale of the plates are deposited.	http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635
CTDEEP Open Space and Watershed Land Acquisition	The Open Space and Watershed Land Acquisition (OSWA) Grant Program provides financial assistance to municipalities and nonprofit land conservation organizations to acquire land for open space and to water companies to acquire land to be classified as Class I or Class II water supply property.	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav_GID=1641
CTDEEP Recreation and Natural Heritage Trust Program	The Recreation and Natural Heritage Trust program was created by the Legislature in 1986 in order to help preserve Connecticut's natural heritage. It is the CTDEEP's primary program for acquiring land to expand the state's system of parks, forests, wildlife, and other natural open spaces.	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1641
CTDEEP Urban Forestry Grant Programs	America the Beautiful Urban Forestry Grants: Grants of up to \$12,000 are available to assist municipalities and non-profits in local urban forestry efforts. Urban Forestry Outreach Grant: Grants for non-profit organizations in urbanized areas to foster outreach in these areas.	http://www.ct.gov/dep/cwp/view.asp?a=2697&q=322872&depNav_GID=1631&depNav=
CT OPM Small Town Economic Assistance Program (STEAP)	Funds economic development, community conservation and quality of life projects for localities that are ineligible to receive Urban Action (CGS Section 4-66c) bonds. This program is administered by the Office of Policy and Management. STEAP funds are issued by the State Bond Commission and can only be used for capital projects. Eligible projects include projects involving environmental protection. STEAP fnds were recently award to the Town of Bolton for preparation of a management plan for Bolton Lakes.	http://www.ct.gov/opm/cwp/view.asp?Q=382970

Mill River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
Connecticut In-Lieu Fee Program	The National Audubon Society, Inc., through its Connecticut program (Audubon Connecticut) is the sponsor of an In-Lieu Fee Program for aquatic resource compensatory mitigation required by Department of the Army authorizations. Audubon Connecticut administers a competitive grant funding program, soliciting proposals for wetland and waters restoration, enhancement, creation and/or preservation.	http://ct.audubon.org/conservation/in-lieu-fee-program http://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/CT/
American Rivers – NOAA Community-Based Restoration Program Partnership	These grants are designed to provide support for local communities that are utilizing dam removal or fish passage to restore and protect the ecological integrity of their rivers and improve freshwater habitats important to migratory fish.	https://www.fisheries.noaa.gov/national/habitat-conservation/strategic-habitat-restoration
FishAmerica Foundation Conservation Grants	FishAmerica, in partnership with the NOAA Restoration Center, awards grants to local communities and government agencies to restore habitat for marine and anadromous fish species. Successful proposals have community-based restoration efforts with outreach to the local communities.	https://www.fishamerica.org/grants/
NFWF Five Star and Urban Waters Restoration Grant Program	The Five Star and Urban Waters Restoration Program seeks to develop nation-wide-community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. The program focuses on the stewardship and restoration of coastal, wetland and riparian ecosystems across the country.	http://www.nfwf.org/fivestar/Pages/home.aspx
NFWF Long Island Sound Futures Fund	The Long Island Sound Futures Fund supports projects in local communities that aim to protect and restore the Long Island Sound. It unites federal and state agencies, foundations and corporations to achieve high-priority conservation objectives. Funded activities demonstrate a real, on-the-ground commitment to securing a healthy future for the Long Island Sound.	http://longislandsoundstudy.net/about/grants/lis-futures-fund/

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Funding Source	Description	Reference
Corporate Wetlands Restoration Partnership (CWRP)	The Corporate Wetlands Restoration Partnership (CWRP) is an innovative private-public initiative aimed at preserving, restoring, enhancing and protecting aquatic habitats throughout the United States. Bringing together corporations, federal and state agencies, non-profit organizations and academia, the CWRP allows members to contribute in a fundamental way to crucial projects involving America's coastal and inland aquatic resources and support related education programs. Since its inception in 1999, CWRP has aided in the restoration of more than 64,000 acres and 1,050 stream miles through the monetary donations and in-kind services of its corporate partners.	http://www.cwrp.org/
Trout Unlimited Embrace A Stream	Embrace-A-Stream (EAS) is a matching grant program administered by TU that awards funds to TU chapters and councils for coldwater fisheries conservation.	http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream
Community Foundation for Greater New Haven	A variety of competitive funding opportunities for non-profit groups are offered by The Community Foundation for Greater New Haven.	http://www.cfgnh.org/Grant/AboutourGrantmaking/tabid/189/Default.aspx
The Kresge Foundation	This foundation's environment program launched an initiative that funds community driven efforts, directing support toward 1) climate resilience in coastal cities and regions; 2) climate resilience in low-income communities; 3) sustainable water-resources management in a changing climate; and 4) urban energy resilience. The Kresge Foundation provides funding through invited applications, as well as unsolicited proposals. Eligibility: U.S. based 501(c)(3) organizations (and Canadian equivalents). Government entities are also eligible.	www.kresge.org/programs/environment
Wildlife Conservation Society Climate Adaptation Fund	Provides \$2.5 million in funding annually, with awards ranging from \$50,000 to \$250,000. The program focuses on projects that promote functionality of ecosystems, long-term conservation impact, and landscape-scale impacts. All projects must conduct on-the-ground implementation; research and planning are not funded.	https://www.wcsclimateadaptationfund.org/program-information/

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Grant Search Resources

Please also see the following grant search resources for assistance in finding additional state, federal, local, and private sources of funding related to nonpoint source pollution management:

- Grants.gov
<http://grants.gov/>
- Federal Assistance Listings
<https://www.cfda.gov/>
- CTDEEP Watershed and Stormwater Funding Website
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1
- EPA Funding Sources for Watershed Protection and Restoration
<https://www.epa.gov/nps/funding-resources-watershed-protection-and-restoration>
- EPA Watershed Funding
<http://water.epa.gov/aboutow/owow/funding.cfm>
- EPA Green Infrastructure Funding Website
<https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities>
- Foundation Center: Philanthropy News Digest
[http://philanthropynewsdigest.org/rfps/\(search\)/?tags_interest\[\]=environment](http://philanthropynewsdigest.org/rfps/(search)/?tags_interest[]=environment)
- USDA National Agriculture Library: Water Quality Information Center
https://www.nal.usda.gov/waic/water-quality#quicktabs-waic_water_quality=2

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Other Nonpoint Source Funding Opportunities

Congressional Appropriation - Direct Federal Funding
State Appropriations - Direct State Funding
Membership Drives Membership drives can provide a stable source of income to support watershed management programs.
Donations Donations can be a major source of revenue for supporting watershed activities, and can be received in a variety of ways.
User Fees, Taxes, and Assessments Taxes are used to fund activities that do not provide a specific benefit, but provide a more general benefit to the community.
Rates and Charges State law authorizes some public utilities to collect rates and charges for the services they provide.
Stormwater Utility Districts A stormwater utility district is a legal construction that allows municipalities to designated management districts where storm sewers are maintained in order to the quality of local waters. Once the district is established, the municipality may assess a fee to all property owners.
Impact Fees Impact fees are also known as capital contribution, facilities fees, or system development charges, among other names.
Special Assessments Special assessments are created for the specific purpose of financing capital improvements, such as provisions, to serve a specific area.
Property Tax These taxes generally support a significant portion of a county's or municipality's non-public enterprise activities.

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Other Nonpoint Source Funding Opportunities

Excise Taxes These taxes require special legislation, and the funds generated through the tax are limited to specific uses: lodging, food, etc.
Bonds and Loans Bonds and loans can be used to finance capital improvements. These programs are appropriate for local governments and utilities to support capital projects. Green Bonds are a growing mechanism for funding green projects, including green infrastructure and flood resilience projects. Green bonds are debt instruments issued to finance environmental projects focused on climate change initiatives. The identification and labeling of a green bond is typically based on a set of voluntary standards drafted by a consortium of investment banks that outlines the process for issuers to designate specific green projects. The guidelines specify that a bond issue qualifies as green if the issuer uses the proceeds solely for capital expenditures associated with green or climate-related environmental benefits in accordance with certain standards.
Investment Income Some organizations have elected to establish their own foundations or endowment funds to provide long-term funding stability. Endowment funds can be established and managed by a single organization-specific foundation or an organization may elect to have a community foundation to hold and administer its endowment. With an endowment fund, the principal or actual cash raised is invested. The organization may elect to tap into the principal under certain established circumstances.
Emerging Opportunities for Program Support for Water Quality Trading Allows regulated entities to purchase credits for pollutant reductions in the watershed or a specified part of the watershed to meet or exceed regulatory or voluntary goals. There are a number of variations for water quality credit trading frameworks. Credits can be traded, or bought and sold, between point sources only, between NPSs only, or between point sources and NPSs.
Mitigation and Conservation Banks Created by property owners who restore and/or preserve their land in its natural condition. Such banks have been developed by public, nonprofit, and private entities. In exchange for preserving the land, the “bankers” get permission from appropriate state and federal agencies to sell mitigation banking credits to developers wanting to mitigate the impacts of proposed development. By purchasing the mitigation bank credits, the developer avoids having to mitigate the impacts of their development on site. Public and nonprofit mitigation banks may use the funds generated from the sale of the credits to fund the purchase of additional land for preservation and/or for the restoration of the lands to a natural state.

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Other Nonpoint Source Funding Opportunities

Public Private Partnerships (P3s)

Innovative financing mechanisms are being explored at the national level, particularly tapping into the resources of the private sector through public-private partnerships (P3s). Traditionally, water and wastewater infrastructure has been funded through municipal bonds, with help from EPA State Revolving Loan funds, while stormwater is typically funded either through its limited share of local general funds or stormwater utilities. The Chesapeake Bay states are exploring P3s to meet TMDL obligations for nutrients and sediment. A P3 is an arrangement between government and the private sector in which the private sector assumes a large share of the risk in terms of financing, constructing, and maintaining the infrastructure. Government repays the private sector over the long term if the infrastructure is built and maintained according to specifications. Prince George's County, Maryland is implementing a P3 program to retrofit 2000 acres of impervious surfaces in the public right of way. Private funds will finance 30% to 40% of the program costs upfront, enabling project construction to begin sooner and proceed more quickly. This program is part of the County's Watershed Protection and Restoration Program.



Connecticut Fund
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Save the Sound®



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