Table of Contents

Appendices

List of Figures

List of Tables

Acronyms

BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
COD	Chemical Oxygen Demand
CSCC	Connecticut State Climate Center
CRWA	Charles River Watershed Association
CTDEEP	Connecticut Department of Energy and Environmental Protection
CWP	Center for Watershed Protection
DO	Dissolved Oxygen
FBI	Family Biotic Index
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
Ft-msl	Feet above mean sea level
IDDE	Illicit Discharge Detection and Elimination
NP	Near Peak
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
PCBs	Polychlorinated Biphenyls
PE	Pre-event
RCRA	Resource Conservation and Recovery Act
RL	Rising limb
TKN	Total Kjehldahl Nitrogen
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UNH	University of New Hampshire
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United Stated Geological Society
UST	Underground Storage Tank
WMM	Watershed Management Model
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Section 1 - Introduction

1.1 Project Purpose

As a part of a plan to transform the Mill River corridor into a world class urban space, the City of Stamford, Connecticut contracted CDM Smith to develop a watershed plan by expanding upon major projects in downtown Stamford completed by the US Army Corps of Engineers (USACE) and Olin Partnership by extending the study area to the entire watershed. The Rippowam/Mill River Watershed Management and Infrastructure Program encompasses five miles of river, from the origin in the North Stamford Reservoir to Stamford Harbor.

The purpose of the Watershed Management and Infrastructure Program is to address water quality and quantity concerns in the river by assessing existing water conditions, identifying sources of pollution, and making recommendations for improvements to protect the City's investment in the downtown Mill River Park.

The project encompassed a multi-phase approach of data collection, gap analysis, preliminary goal and conceptual model development, watershed assessment and water quality monitoring, and identification and modeling of best management practices (BMPs). In addition, stakeholder involvement through public outreach was an integral component of the watershed planning process. As part of the completion of this assessment, recommended action items are provided to the City for each reach of the Mill River. This information could be considered for future stormwater and watershed improvement planning programs and Municipal Separate Storm Sewer Systems (MS4) activities.

1.2 Watershed Management Team

CDM Smith completed this document under contract with the City of Stamford in cooperation with the Stamford Water Pollution Control Authority (SWPCA), the Mill River Collaborative, and with information from the USACE and Olin Partnership studies. Public involvement was invited throughout the project development, particularly during the initial phases of the program.

1.3 Watershed Planning Process

The watershed planning process included extensive field work, data collection, modeling existing conditions, stakeholder outreach and feedback, and watershed management BMP modeling and analysis.

1.3.1 Understanding the Watershed

An extensive field investigation was conducted to assess the physical characteristics of the river and the environmental factors within the watershed. Field activities included a full river walk, water quality sampling, sediment sampling, streamflow monitoring, and geomorphological and ecological assessments. Further information on the activities, raw data, interpreted results and conclusions can be found in the Comprehensive Characterization Report dated April 19, 2011 (CDM, 2011).

Gap Analysis

Before a full assessment was conducted, historical documents, data, and city GIS information were reviewed[1] to identify gaps and shape the focus of the full field assessment. Existing data were summarized[2] along with case studies[3] on similar urban watershed restoration projects. Following the paper research portion of the gap analysis, a windshield survey was completed[4]. This survey identified areas for further investigation, potential sampling points, and a general understanding of the conditions of the river.

River Walk

In order to assess the baseline condition of the river and to identify ideal sample locations, CDM Smith deployed a field team to walk the length of the river corridor downstream of the North Stamford Reservoir dam in April 2009. The team reported general geomorphic characteristics, anomalies in the channel form and function, fundamental channel form components, and identified representative segments within each reach. The representative segments were selected based on the general characteristics of each reach and chosen based on accessibility, distance from stormwater outfalls, and distance from potential high polluting sites. The team completed an initial assessment of human impacts to the river and river corridor including:

- Bank armoring
- In-stream structures
- Over-stream structures (bridges, culverts)
- Water intakes
- Stormwater outfalls
- Stormwater outfalls with dry weather flow

The river walk was documented using GPS, field notebooks, data sheets, and observation photographs. A technical memorandum, dated February 2009 and attached to the Comprehensive Characterization Report, included a summary of all findings from this activity[2].

Water Quality Sampling

The water quality monitoring program of the river consisted of four dry-weather sampling rounds and two wet-weather sampling rounds, conducted at 18 separate sampling locations along the river over the course of 18 months starting in the fall of 2008. Sample sites were located on the main stem of the Mill River and at each of the six major tributaries: Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, Ayers Brook, Toilsome Brook (culverts), and the drain from the downtown area that discharges to the

[1] Memorandum: Rippowam/Mill River Watershed Study Task 1.4 – Project GIS Data. 1/16/2009, CDM

[2] Memorandum: Rippowam/Mill River Watershed Study Task 1.3 – Existing Conditions. 2/3/2009, CDM

[3] Memorandum: White Paper on Urban Watershed Restoration/Revitalization. 3/12/2009, CDM

[4] Memorandum: Mill River Watershed Study – Windshield Survey. 12/8/2009, CDM

former Mill Pond. Dry-weather rounds were conducted over the course of four seasons. Wet-weather rounds were collected in early summer and fall and included pre-event, rising limb, near peak, and receding limb grab samples.

Water quality samples were analyzed for an array of biological and chemical constituents including: dissolved oxygen, temperature, conductivity, pH, biological oxygen demand, metals, nutrients, bacteria, and pesticides. Specific analyses for each sample round and location were refined throughout the sampling program.

Sediment Sampling

River sediment samples were collected to characterize areas of excessive sedimentation and downstream of potential sources of water quality pollution to check for source specific pollutants of concern within the deposited sediment. Fifteen physical and ecological stream assessment locations were selected to determine the impact of potential chemical stresses on the abundance and diversity of indicator organisms. Additional samples were collected at impounded pools where large quantities of sediments were deposited. Samples were collected in May and September 2009 and analyzed for grain size distribution, and an array of chemical constituents including: metals, pesticides, herbicides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

Streamflow Monitoring Program

The stream flow monitoring program consisted of two continuous flow meters and four staff gages. The continuous flow meters collected paired stage-discharge readings in the culvert outfalls of Toilsome Brook and the Washington Boulevard drain at the Mill River dam. The program lasted 24 weeks, starting in April 2009. Staff gages were installed at four tributaries including Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, and Ayers Brook and readings were taken during each wet and dry weather sample event. These results were compared with the main stem USGS gage on each day for reference.

Geomorphological Assessment

A geomorphological assessment of the river corridor was conducted to quantify key components of channel morphology at each location (considered to be representative of the corresponding river reach). The assessment categorized landforms within the river corridor and the processes responsible for making and modifying those landforms. Additionally, pebble counts were conducted to quantify the size distribution of surficial substrate particles (sediments). Data from the pebble count provided information on the availability and size variation of substrate across various feature types, which are important aspects of benthic habitat.

1.3.2 Stakeholder Involvement

Stakeholder involvement has been central to the development of this Plan. Projects for Public Spaces (PPS) assisted CDM Smith with stakeholder involvement, public coordination and educational efforts. The goal of stakeholder involvement was to solicit input on issues and goals surrounding restoration of the Mill River watershed, cultivate stewardship by involving the public in improvement activities, and provide status updates to the community during every phase of the project. The following summarizes the public coordination efforts that were conducted:

- A project briefing meeting to neighborhood groups was also held on July 31, 2008 to introduce the project to the public.

- Coordination meeting with SWPCA and other interested parties on March 9, 2009 to provide overall program update, including summary of monitoring program results, update on modeling and next steps in the project.
- An Advisory Committee meeting was held on March 16, 2009.
- Participated in the Stamford Sustainable Garden Expo, held on May 28, 2009.
- A Working Group meeting was held on June 25, 2009 at SWPCA.
- A public workshop was held on November 12, 2009 to solicit public input on issues and goals for the project.
- Attended Long Island Sound Study alewife fish release to the Rippowam River at Cloonan Middle School on April 20, 2010.
- Attended LISS Green Cities/Blue Waters Citizens Summit on May 7, 2010 in Bridgeport.
- A project status meeting was held on April 25, 2011 with SWPCA and city staff.
- A presentation was given to the Mill River Collaborative on July 25, 2011 that summarized the project status.
- A meeting was held with Mayor Michael Pavia and his staff from the City of Stamford on December 8, 2011 to discuss the status of the Mill River Watershed Study and implementation of the Basin Management Plan.
- The initial meeting of the stakeholders for the Basin Management Plan took place on January 26, 2012.

A detailed summary of the public coordination efforts described above is provided in Appendix A.

1.3.3 Modeling and Analysis

A Watershed Management Model (WMM) was developed for the Mill River watershed to quantify known pollution sources and the loading of contaminants to the river in order to identify ideal pollution control strategies. Nonstructural controls, structural controls, and low impact development retrofits were modeled to gauge relative benefits of each option. The model was used to develop alternative management strategies of combined source and stormwater controls as part of this Plan. A summary of model development, analysis, and results can be found in Appendix B.

1.3.4 Plan Development

The US Environmental Protection Agency (USEPA) Watershed Plan Builder was used to create this Plan. The Watershed Plan Builder is a companion tool for the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* developed by the USEPA to provide municipalities, watershed groups, and private entities with an open framework that can be used to build a management plan. The USEPA recommends a comprehensive approach focused on stakeholder involvement, partnerships, and localized, watershed-specific management strategies which best meet the needs of the watershed. The USEPA checklist can be found in Appendix C.

This Plan was developed in collaboration with the City of Stamford and local stakeholders interested in addressing the needs of the Rippowam/Mill River. Over the course of several years, a comprehensive study was conducted to assess the health of the river and its response to a variety of weather conditions. This data was analyzed and presented in the *Comprehensive Characterization Report* published in 2011. From the findings presented in that report and subsequent meetings with stakeholders, the action items outlined in Section 6 and Section 7 were developed, evaluated, and applied to the sub-watersheds of the Rippowam/Mill River.

1.4 Document Overview

This Plan is organized into seven sections, as follows:

- Section 1 – Introduction
- Section 2 – Watershed Description
- Section 3 – Watershed Conditions
- Section 4 – Pollutant Source and Load Assessment
- Section 5 – Watershed Management Objectives
- Section 6 – Watershed Management Strategies
- Section 7 – Watershed Management Plan

Supporting documents are provided in trailing appendices.

This Plan was developed for the City of Stamford and local watershed management planning groups to use in future City planning and watershed management development projects. While the document provides overview and detail into the objectives and strategies of the Plan, Appendix E includes summary one-page documents which outline each suggested action item including identification of the problem, objectives, and benefits. These one-pagers were developed as a supporting resource for use during implementation of this Plan.

Section 2 – Watershed Description

The Mill River has had historic significance for the City of Stamford for hundreds of years. As a natural resource that supported development of mills along the waterway, development, increased population, and prosperity soon followed. While this resource aided in development of the surrounding area, it has also been adversely affected by that development. According to the Mill River Collaborative, water from the Mill River has historically been dammed for grist mills, fulling mills, a flax mill, a planing mill, rolling mills, a woolen mill, and other industrial purposes. The first grist mill was built in 1662 and over the course of the next century, several mills followed. While several buildings burned down in 1886, the last mill remained in operation until 1960. The following is a summary of the existing conditions within the Mill River watershed.

2.1 Physical and Natural Features

The Mill River originates in southern New York State and western Connecticut, and flows south through the City of Stamford, discharging into the waters of Long Island Sound. The Mill River watershed covers a large portion of the City of Stamford, extending into the bordering town of New Canaan, CT and into New York. The complete watershed area is approximately 37.5 square miles, including approximately 18 square miles within the City of Stamford.

2.1.1 Watershed Boundaries

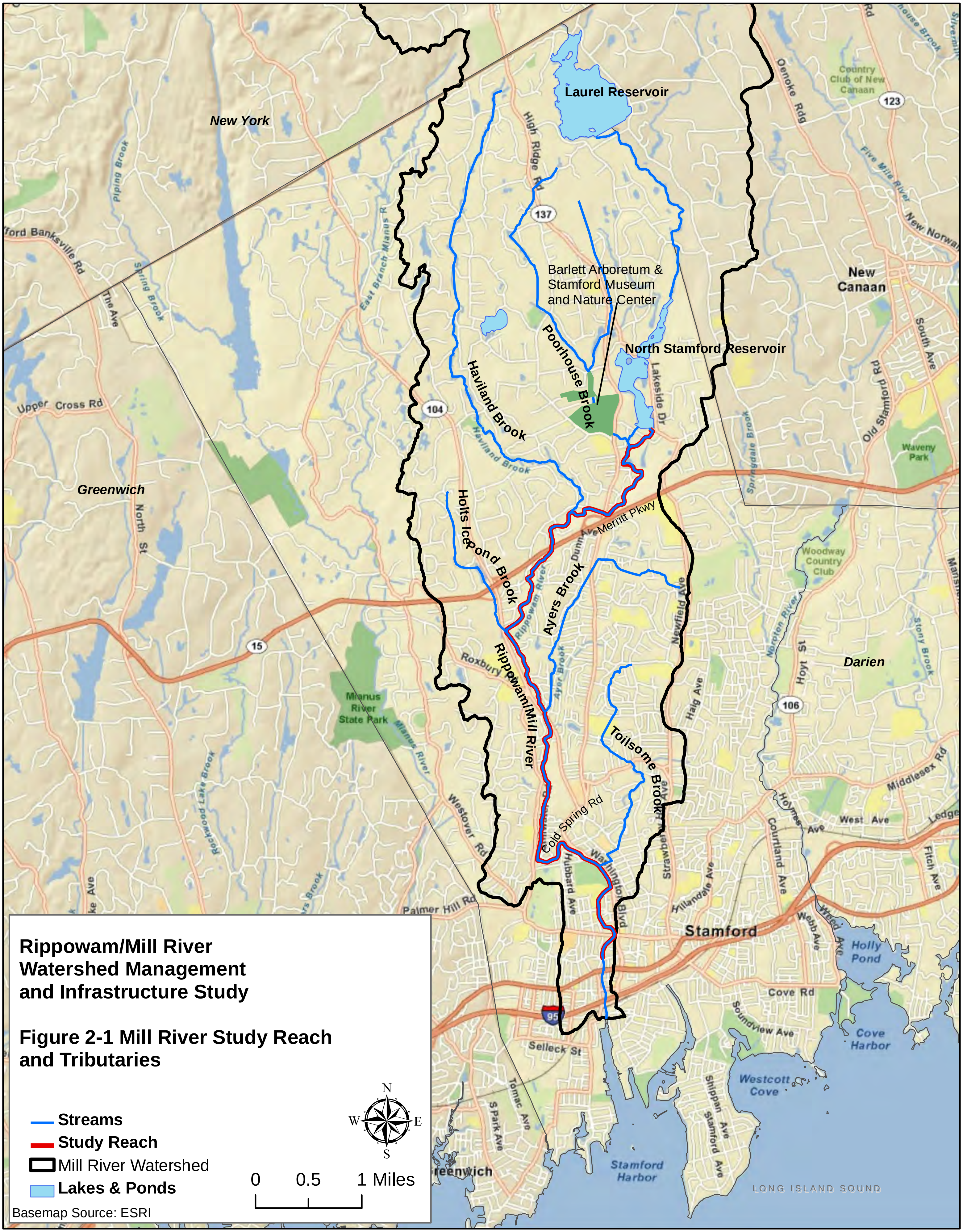
The focus of this study was the mainstem portion of the Mill River and its major tributaries within the City of Stamford, from the New York State line to the mouth of the river in Long Island Sound. The Stamford area of study is defined as the portion of the Mill River corridor downstream of the North Stamford Dam within the City of Stamford corporate limits. The limits of the watershed are shown in Figure 2-1.

For the purpose of this study, the Mill River watershed was divided into three subwatersheds based on tributaries, development, and water flow patterns. The following describes each of these areas, which are delineated in Figure 2-2.

Upper Subwatershed

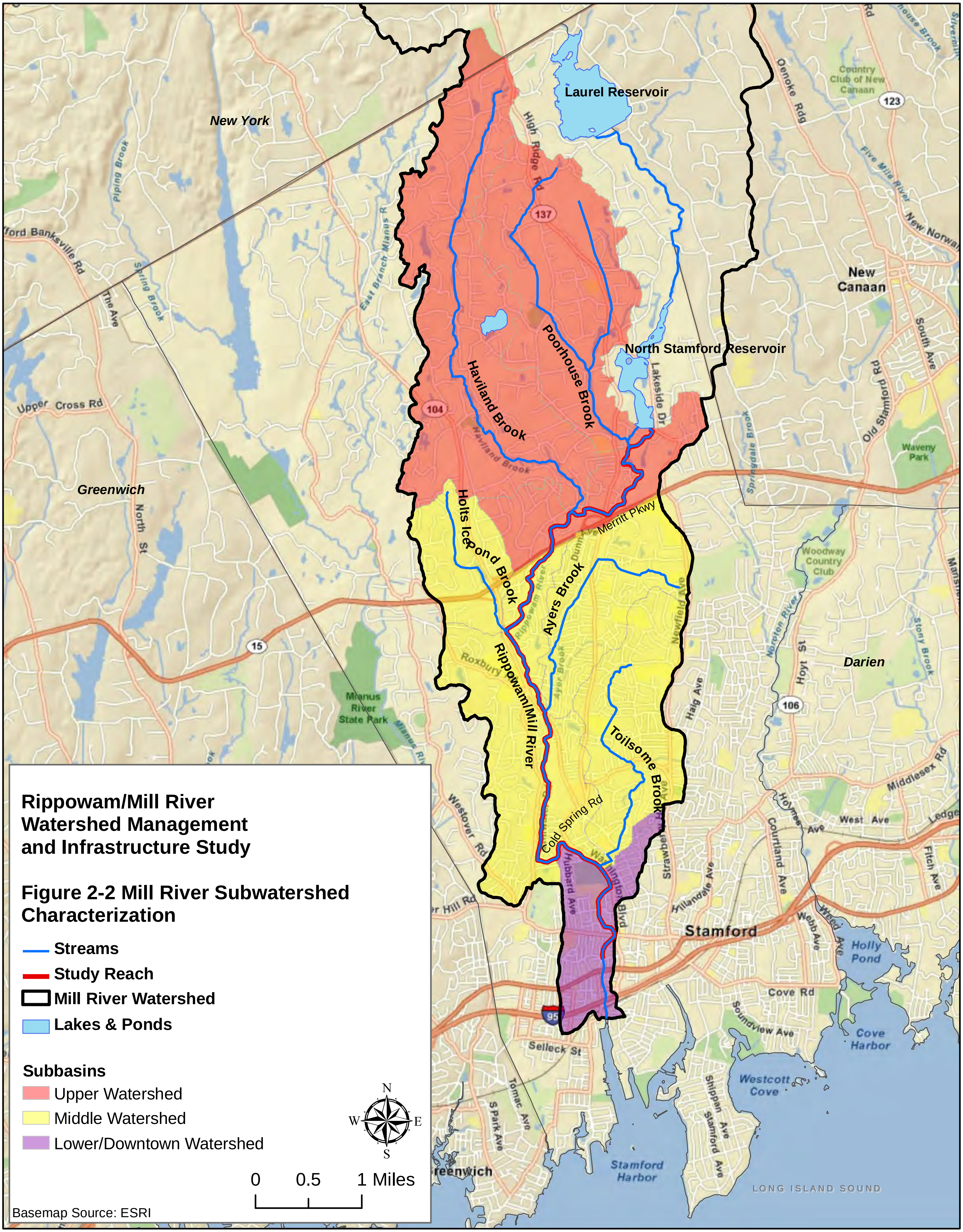
North Stamford refers to the section of river from the North Stamford Reservoir, Poorhouse Brook, and Haviland Brook to the Merritt Parkway/Route 15. Some of the land surrounding the North Stamford Reservoir, which is located eight miles upstream of the harbor, is protected under the ownership of Aquarion Water Company. Aquarion Water Company releases water from the North Stamford Dam at a rate of about 4 cubic feet per second. During storm events or periods when the water level is high, water also discharges over the reservoir spillway. Downstream of the reservoir, the Mill River flows through a residential area and remnants of forested land. Residential lawns line the river as it passes under several road crossings and meets with Poorhouse Brook and Haviland Brook. Before entering the

CDM Smith



Rippowam/Mill River Watershed Management and Infrastructure Study

Figure 2-1 Mill River Study Reach and Tributaries



Rippowam/Mill River Watershed Management and Infrastructure Study

Figure 2-2 Mill River Subwatershed Characterization

mainstem Mill River, Poorhouse Brook flows through the Bartlett Arboretum Historic Preserve and Stamford Museum and Nature Center, where approximately 200 acres of the watershed is protected from development. Two of the five reservoirs in the Stamford Reservoir system, operated by Aquarion Water Company, are impoundments of the Mill River. The Laurel Reservoir is situated in north Stamford, near the New York state line, on the border with New Canaan, CT. The North Stamford Reservoir is within the borders of the City of Stamford north of the Merritt Parkway, and downstream of the Laurel Reservoir dam.

Middle Subwatershed

The area identified as the Central Watershed includes Holts Ice Pond Brook and Ayers Brook, covering the main stem from the Merritt Parkway to the Cold Spring Road crossing. The land cover in this portion of the watershed is mixed-use, defined by medium density residential neighborhoods and densely developed commercial areas along High Ridge and Long Ridge Roads. Notable in-stream features in this reach of the river are the several low-head dams that impound the mainstem and tributaries. Six of these mainstem dams are reported and mapped, but more have been identified through field reconnaissance as part of this study.

Lower Subwatershed

The area identified as Downtown includes the section of main stem river from Cold Spring Road to Stamford Harbor. The subwatershed becomes increasingly developed south of the Merritt Parkway, where industrial and residential complexes and parking lots abut the river more frequently. At Cold Spring Road, land use abutting the river changes from mostly single-family residences to low-rise apartment complexes. Evidence of invasive species, household debris, and direct stormwater runoff from parking lots and roadways are evident in the lower reaches of the river. Toilsome Brook, an historic tributary that is now culverted and consists mainly of urban runoff, enters the mainstem at Scalzi Park, approximately two miles upstream of Stamford Harbor.

At the onset of this project, the Mill River was impounded by the Main Street Dam in downtown Stamford and lined with vertical concrete walls on both banks. This portion of the watershed is highly urban, with a majority of impervious surfaces contributing runoff directly to the river or to the drainage system that discharges to the river. Within Mill River Park, the largest park in downtown Stamford, the pond is lined on both sides just upstream of the dam.

The Mill Pond was heavily laden with scum, trash, and debris and was home to a large population of water fowl, which contributed to the poor water quality in this section of the river. Stormwater from downtown Stamford entered the river at the Main Street Dam via the Washington Boulevard drain. The US Army Corps of Engineers (USACE) has removed the Main Street Dam and restored the Mill Pond to a more natural stream.

The river becomes tidal approximately 900 feet downstream of the former Main Street Dam. The South arm of the Stamford Harbor has a mean tidal range of 7.2 feet. The watershed for this reach is a combination of residential, industrial, commercial, and city-owned parkland. Several road bridges, including the Interstate 95 Highway and a railroad trestle, span the river downstream of the former Main Street Dam.

2.1.2 Hydrology

The United States Geological Survey (USGS) maintains one real-time streamflow gage on the Mill River (gage #1209901) just upstream of the Bridge Street crossing. Data from the USGS gage show high and fast storm peaks, likely due to runoff from development, a limited and ill-defined floodplain, and steep river embankments, all which constrain river flow.

Land cover in more developed areas of the watershed is largely impervious from the multitude of parking lots, roadways, roofs, and sidewalks. This condition limits infiltration of rainfall, increases overland flow, and results in periodic high river flow over short periods of time. This is confirmed by stream gage data which shows peak flow occurring rapidly during rainfall, sometimes before the storm ends. Because of this sudden increase in the volume of water reaching the river, flow and velocity increase significantly. These extreme flows cause unstable embankments, scouring, and localized flooding. During periods of low flow, when rain events are less frequent and conditions increase evaporation, reducing overall flow throughout the river. Such conditions result in reaches and tributaries which are impassable to aquatic life and recreational activities, decreased water quality, and degraded habitat.

Climate/Precipitation

Stamford shares the diverse climate of southwestern New England. According to the Connecticut State Climate Center (CSCC), the state's climate can be summarized as follows: equal distribution of precipitation among the four seasons; large ranges of temperature both daily and annually; great differences in weather for the same season over different years; and considerable diversity of weather over a short period of time.

The CSCC collects climate data at several stations across the state, one of which is located in Stamford. The average monthly temperature ranges from 29°F in January to 74°F in July. The range of average minimum and average maximum temperatures for January and July are 19-38°F and 62-85°F, respectively.

Precipitation data are uniformly distributed throughout the year, ranging between 3.5 inches and 5 inches for any given monthly average. Snow falls primarily from December to March, with less than one inch recorded on average for the months of November and April. The annual average precipitation in Stamford has been recorded as 47.5-inches.

Surface Water Resources

According to Aquarion Water Company's 2007 Water Quality Report for the Stamford system, six reservoirs and two well fields supply approximately 99% of the 14.4 million gallons per day demand for the 97,000 people in the system. These six reservoirs include Laurel, North Stamford, Mill, Trinity, Hemlocks, and Siscowit. Because less than 20% of the five-reservoir system watershed is protected land, Aquarion regularly inspects potential pollutant sources including homes, businesses, farms, and other border properties in addition to participating in the new land development project review to ensure minimal impact to water quality.

The Connecticut Department of Public Health conducted a source water assessment of the Stamford Reservoir System in 2003. The strengths of the system are that point source pollution discharges are not present in the watershed and that the public water system has a comprehensive source protection program. The potential risk factors include the fact that diffuse or non-point contaminant sources are present in the watershed (road salt, herbicides, hazardous material spills), less than 20% of the watershed area is owned by the public water system, and local regulations or zoning initiatives for the protection of public drinking water sources do not exist.

There are two major reservoirs within the upper portion of the study area. The Laurel Reservoir is 282 feet above mean sea level (ft-msl) and the North Stamford Reservoir is 194 ft-msl, both of which are impoundments of the Mill River. These reservoirs are managed and operated by Aquarion Water Company for water supply. As a result, the study focused on the portion of the Mill River corridor downstream of the North Stamford Reservoir within Stamford city limits.

Four major tributaries are located within the study area downstream of the North Stamford Dam: Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, and Ayers Brook. Two other major tributary flows are culverted discharges to the river: Toilsome Brook culverts near Scalzi Park and the Washington Boulevard drain that empties into the Mill River. Water quality samples were collected at the mouths of these key tributaries and at nearby stormwater outfalls to assess their affect on the Mill River.

Groundwater Resources

The Mill River basin is underlain with crystalline rock and stratified drift aquifers. One aquifer protection area lies within the watershed boundaries in Stamford, just north of the Merritt Parkway near the intersection of Haviland Brook and the Mill River mainstem. The aquifer protection area within the Mill River watershed covers approximately 240 acres, or 1% of the total watershed area. The presence of stratified drift aquifers indicates the potential for significant groundwater-surface water interaction and the possibility of surface water contamination from failing septic systems and other groundwater pollution.

Flood Plains

According to the USACE, flooding occurs along the low-lying areas of the Mill River within the floodplains. Properties immediately adjacent throughout the length of the river are within local floodplains and are at risk of flooding. However, the lower portion of the river which borders Washington Boulevard is particularly flat, with a wide, shallow channel consistent with floodplain characteristics. The published FEMA floodplain for the Mill River in Stamford is shown in Figure 2-3. The FEMA map was published prior to the dam removal in the downtown area, and does not reflect any improvements to flooding as a result of the removal.

The majority of the main stem of the Mill River is within a 100- or 500-year flood zone. The 100- and 500-year floods have a 1 percent and 0.2 percent chance, respectively, of occurring on an annual basis. Other water bodies within the City are within the FEMA-designated AE Zone, which is generally delineated by the flood level resulting from storm surge flooding during a 100-year flood. Residents who live inside of the zone's boundaries are required by the federal government to purchase flood insurance and are subject to inundation during a 100-year flood.

In general, the floodplains remain somewhat undeveloped along or within private and publicly-owned land due to the potential flood hazard associated with building in sensitive areas. Minor development may include mowed lawns, greenways, parks, and other forms of undeveloped open space. According to the City, approximately 4,800 properties in Stamford are within flood hazard areas. The remainder of the floodplain consists of marshes, wetlands, and other sensitive water resources that buffer the river and absorb overflow during heavy seasonal rains. These areas are highlighted in Figure 2-4.

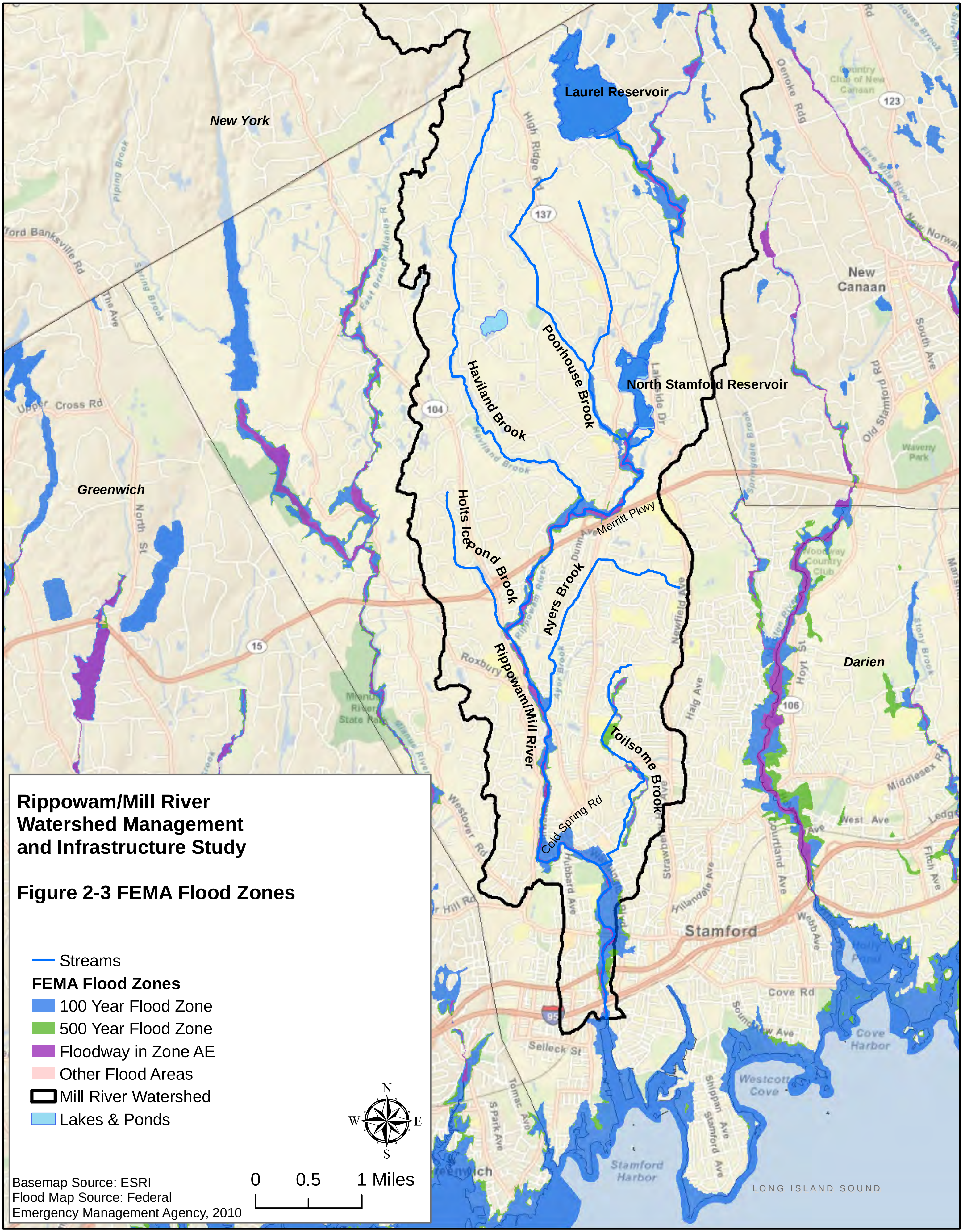


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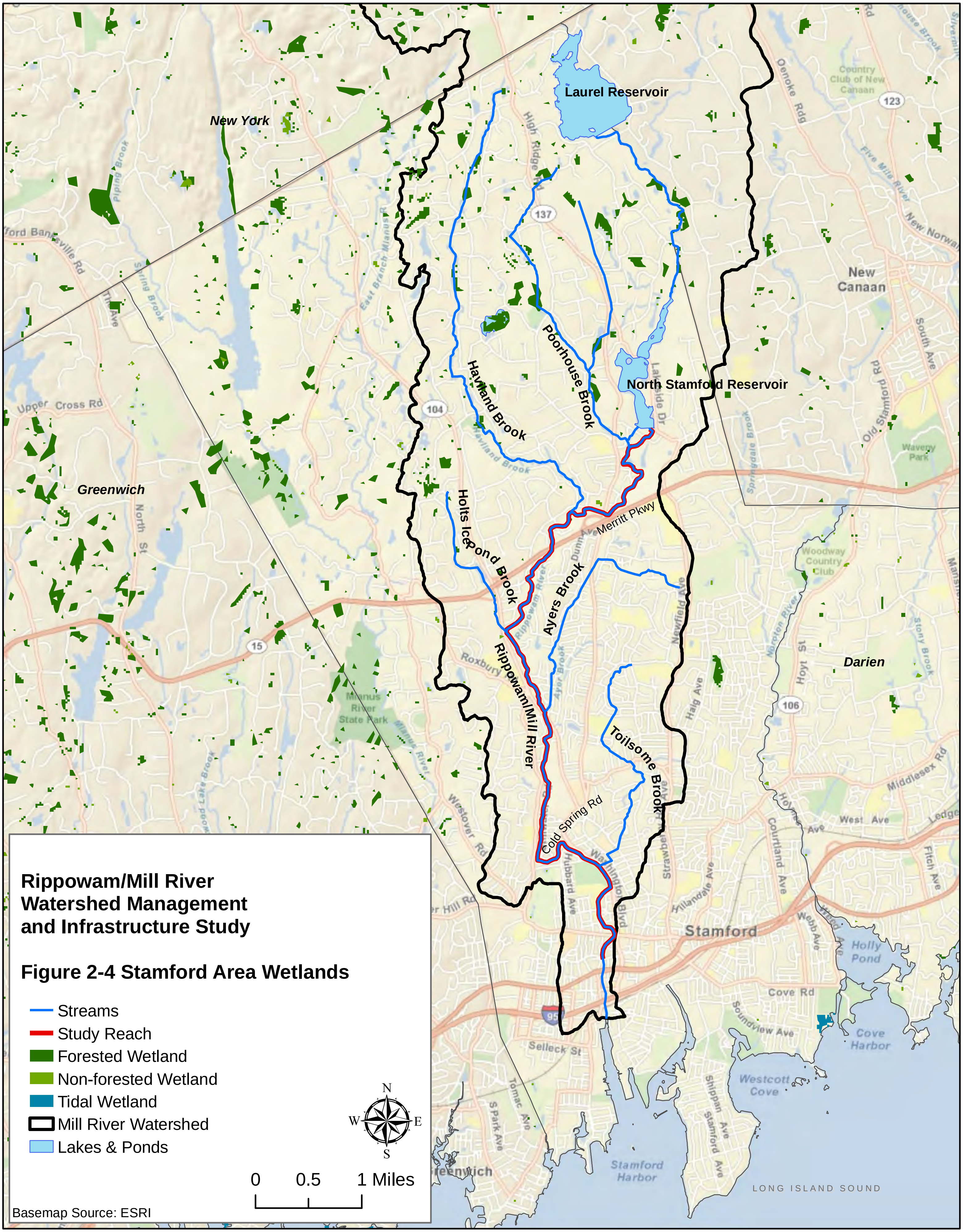
Figure 2-3 FEMA Flood Zones



Rippowam/Mill River Watershed Management and Infrastructure Study

Figure 2-4 Stamford Area Wetlands

Navigation Channels, Ports, and Harbors

The Mill River is generally not a navigable waterway as much of the stream is too shallow for watercraft to pass through. There are a few areas, however, where small recreational craft such as canoes or kayaks could be used, if access were provided at a private launch site.

Originating at the border of New York State, the river travels more than 5 miles before becoming tidal and emptying into the Stamford Harbor in Long Island Sound. The end of the river meets a small channel at the Stamford Landing Marina, which is lined with docks with small private watercraft, as well as various industrial and commercial businesses, roadways, housing developments, and single family homes. Several small islands exist within the Stamford Harbor, including Grass Island and Jack Island.

Structures

Dams have been a part of the history of the Mill River since 1708. Currently, there are eight dams located along the Mill River between the North Stamford Reservoir and Stamford Harbor. Three of those dams allow fish passage. Six of the dams are located between approximately five and six miles upstream of the river mouth. From the mouth of the river, the dams are located on Long Ridge Road, two on Arden Lane, Maltbie Avenue, Hunting Lane, Merritt Parkway, and at the North Stamford Reservoir.

In 2010, the dam formerly located on Main Street was completely removed, allowing the river to flow unconstrained through the greenway in downtown Stamford. Construction continues to improve the buffer area surrounding that segment of the river.

In addition to dams, storm drains also affect the natural processes of the river. Historically, storm drains have directed stormwater runoff from urban areas within Stamford to empty into the Mill River. As a result, water quality is degraded and foreign sediment is introduced to the riverbed, affecting plant growth and slowing biodegradation of organic material.

The main stem of the Mill River is punctuated frequently by bridges and culverts, especially in the downtown area. These river crossings can restrict flow at high flows and cause debris to build up behind the structures, possibly contributing to localized street flooding and degraded in-stream habitats. From south to north, the following roads and streets rest across the study reach of the Mill River:

- Pulaski Street
- Railroad Tracks for Stamford Station
- McCullough Street
- Connecticut Turnpike (I-95)
- Richmond Hill Avenue
- Tresser Boulevard
- Main Street
- Broad Street
- North Street
- Bridge Street
- Cold Spring Road
- Long Ridge Road
- Buckingham Drive
- Barnes Road
- Cedar Heights Road
- Merritt Parkway (Rte 15)
- Studio Road
- High Ridge Road

2.1.3 Wildlife

The diversity of wildlife generally correlates with the development and vegetation patterns along the river. Mammals such as white tail deer, woodchuck, beaver, coyote, muskrat, red fox, cottontail rabbit, and striped skunk can be found in areas suitable for spacious and generally wooded or less developed habitats. Grey squirrel is found throughout the river length. Reptiles and amphibians found within the river include 22 varieties of salamander, toad, snake, turtle, and frog.

There are 31 nesting bird species found in the greater Stamford area. The river is heavily populated with waterfowl, including Canada geese, mallard ducks, black ducks, and mute swans. Water fowl in such dense populations can pose a threat to water quality as stormwater runoff collects animal waste, contributing to high bacteria levels in receiving ponds and streams.

Several areas in the southern Mill River watershed have been identified on separate occasions as being congregation spots for waterfowl. Within Scalzi Park, waterfowl congregate in the river and floodplain just north of the Broad Street crossing and in the river and floodplain between the Toilsome Brook confluence and the Cloonan Middle School. Waterfowl were also observed at Bendels Pond at the Stamford Museum and Nature Center. Regular feeding of ducks and other water fowl has been reported near Buckingham Drive in the area that borders Mill River.

There are no federal or state listed protected or endangered species in the project area.

2.2 Land Use and Land Cover

Land use within the Mill River watershed study area is generally urban and suburban, resulting in high wet-weather flows and impaired water quality during dry- and wet-weather conditions. From north to south, the watershed transitions from primarily forested 1-2 acre lots and detached single-family dwellings in North Stamford to a more developed, urban landscape as the river flows toward downtown Stamford and the Stamford Harbor.

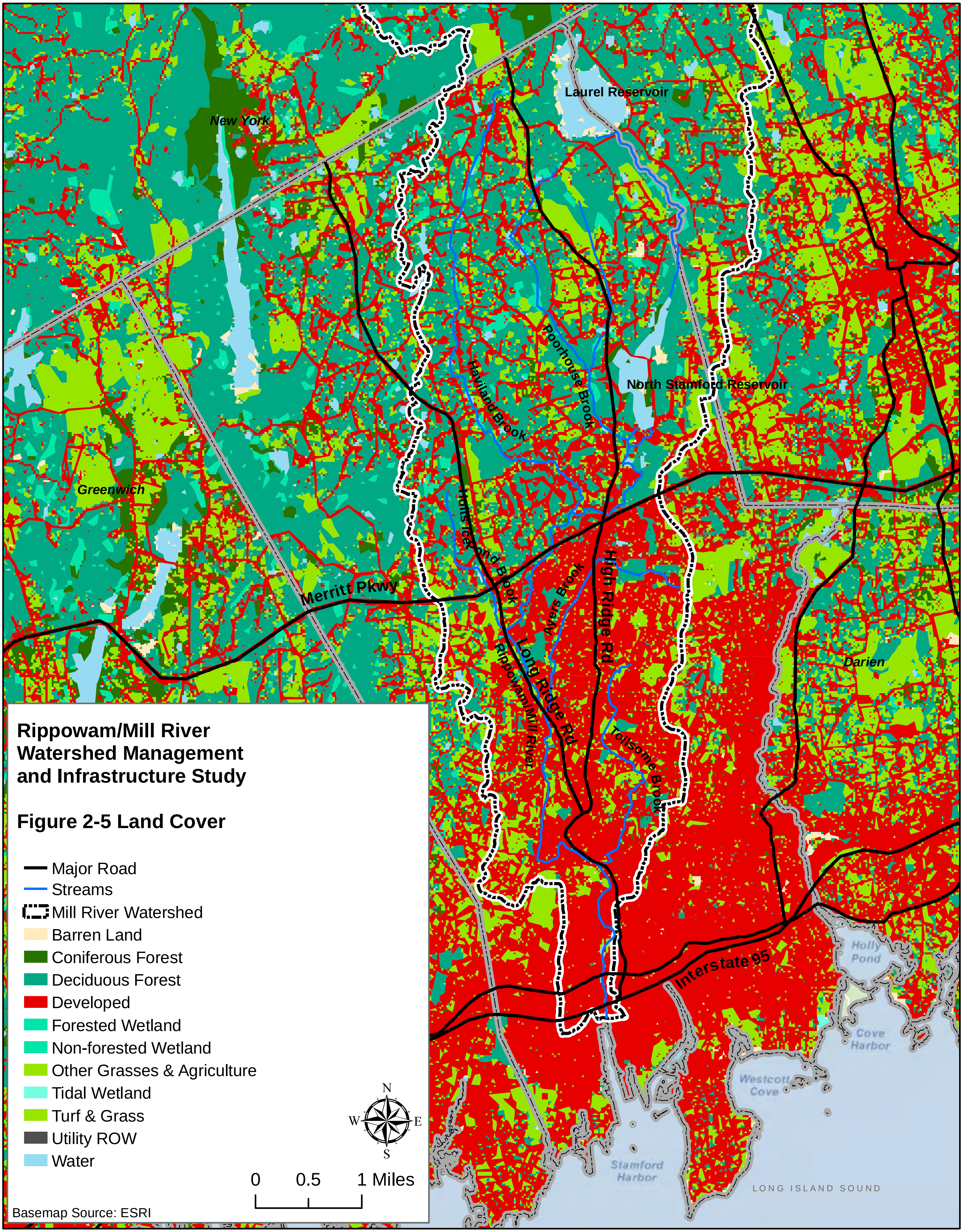
Land use within the watershed north of the Merritt Parkway is primarily low to medium density suburban. Most of the homes in the watershed north of the Merritt Parkway have onsite wastewater disposal (septic systems). In contrast, the land use south of the Merritt Parkway is densely suburban and urban, with the most highly urban and industrialized areas located near downtown Stamford. Merritt Parkway is the general separating line between onsite wastewater disposal and sanitary sewers. Many tributaries of the Mill River south of the Merritt Parkway are contained in culverts and function primarily for stormwater drainage. Downstream of the North Stamford Reservoir, watershed characteristics change significantly. Data for individual subbasins within the Mill River watershed, including varying land cover statistics, are shown in Figure 2-5. Land cover is evenly split between forested land and highly developed areas, with the forested land concentrated in the upper watershed and becoming increasingly more developed in the lower watershed.

2.2.1 Current Land Use

The following describes current land use in the City of Stamford used in the development of this Plan. Land use designations include open space, developed areas, and the portions of land which are designated wetlands, forest, and recreational areas.

Open Space

Apart from managed public space, including parks and recreational areas discussed below under recreation, there is no designated open space along the Mill River.



Rippowam/Mill River Watershed Management and Infrastructure Study

Figure 2-5 Land Cover

Wetlands

The Connecticut Department of Energy and Environmental Protection (CT DEEP) defines wetlands strictly by soil type. Wetlands include any land or submerged land, such as a swamp, marsh, or bog, which consists of soil types designated as poorly drained, very poorly drained, alluvial, or floodplain by the National Cooperative Soils Survey of the Natural Resources Conservation Service (NRCS) of the US Department of Agriculture (USDA). Wetlands naturally prevent flooding by absorbing excess water and providing an opportunity for ponding during seasonal variations and periods of excess rain. Wetlands also provide habitat for rare and protected species, provide nesting locations for waterfowl, and impede movement of potential pollutants commonly found in stormwater.

Over time, residential and commercial development has encroached into the riparian zone, resulting in extensive loss of floodplain forests along the river. Some small pockets of wetlands can still be found along the less developed banks of the middle portion of the river. Observed wetlands were found in relatively good condition, with the exception of several locations that contained predominantly invasive exotic species. Japanese knotweed (*Polygonum cuspidatum*) and oriental bittersweet (*Celastrus orbiculatus*) are the most widespread invasive species along the river.

No wetlands were found along the lower portion of the river. This is likely due to the high-density residential and commercial development throughout these downstream reaches.

Forested Areas

The origin of the river, in the upper portion of the watershed outside of the study area, is primarily wooded with limited development and mostly natural landscape. The middle to upper portion of the river includes wooded patches and some natural landscape bordered by landscaped areas and well-spaced housing. Farther downstream, the number of trees decreases as the river passes through more populated suburban areas. In downtown Stamford, forested areas give way to the abutting commercial and industrial portions of the city.

Fisheries

Upstream of the recently removed Mill Pond and Main Street Dam, the river is primarily a warm water fishery, supporting shiners, dace, and bass. CT DEEP annually stocks this portion of the river with trout and alewife. Downstream of the Mill Pond, the river supports alewife, blueback herring, and white perch. Prior to the dam removal when the field investigations took place, the dam inhibited upstream fish migration for spawning.

Recreation

Along the Mill River corridor, there are several recreational resources, including Scalzi Park, Stamford Museum and Nature Center, and the Bartlett Arboretum. Within the study area, Scalzi Park is the largest recreational facility currently situated in the Mill River corridor, located near the Bridge Street crossing on the west bank of the river. This multi-use public park, equipped with night lighting, accommodates baseball, Little League, softball, soccer, basketball, tennis, a playground, bocce courts, a fitness course, and roller hockey rinks.

The site of the former Mill Pond in downtown Stamford is surrounded by a public park which is undergoing revitalization as part of the dam removal. There is a riverside walking/biking/running trail that runs along the banks of the river intermittently between this area and Scalzi Park. The City of

Stamford recently completed a new playground facility in the downtown area along the river downstream of the former dam.

Developed Areas

The upper third of the Mill River is primarily in low-density wooded areas, where development is spaced enough to make room for natural landscape to border between properties. The middle portion of the river abuts mid-density residential areas with varying levels of development and mostly well-sized residential lots, trees, and increasing landscaped areas. The lower third of the river passes through higher density development, including downtown Stamford, where it meets the improved greenway and several parks, followed by high-density development through the commercial and industrial districts, before terminating in Long Island Sound.

Transportation

Stamford is primarily suburban, with heavily wooded areas throughout the northern portion of the watershed. Roadways are somewhat rural, with narrow lanes and limited buffers on each side. The few crossways that pass over the river are short span bridges (less than 20-feet in length) on residential, limited traffic roadways. Within the more urbanized areas, particularly downtown Stamford, roads are heavily traveled, particularly on and around the access ramps to Interstate 95, near commuter parking areas, and within the downtown shopping and restaurant areas in the City.

The City Highways Division maintains over 315 miles of roadway, according to the City of Stamford website, and as such it is the largest municipal road system in the State. Roadway maintenance includes rehabilitation projects, storm drain maintenance, snow plowing, and leaf pickup. The Highways Division also coordinates city-wide leaf pickup in recyclable paper leaf bags on designated pick-up times and allows residents to bring bagged leaves to two recycling centers. Brush, grass clippings, and bulk yard waste is not part of the collection program.

2.2.2 Desired Use

The City of Stamford intends to transform the downtown area which abuts the Mill River into a continuous greenway and outdoor recreation area. Since 2001, the City has been working with a variety of organizations, including the USACE, environmental groups, citizen action groups, and private consultants, to improve water quality in the river through a comprehensive watershed improvement plan. In the years to follow, the goal is for the water quality in the lower portion of the Mill River to improve, allowing for more opportunity for leisure and recreational activities to take place.

The Stamford Museum and Nature Center and the Bartlett Arboretum are located in North Stamford, near the confluence of Poorhouse Brook and the mainstem of the Mill River. A major increase of recreational parks and facilities is planned as part of the Mill River Park and Greenway Master Plan, published by the City of Stamford in July 2007. After the complete removal of the former Main Street Dam, the city plans to redevelop the downtown river corridor with a state-of-the-art natural, cultural, and recreational park facility. The Master Plan states:

"The recreational program elements are found throughout the park and help bring activity to different park areas at different times of the year. With an ice skating rink, dynamic fountains, a basketball court, fishing piers/overlooks and an extensive recreational path, the Mill River Park and Greenway Project offers abundant recreational experiences".

Section 3 – Watershed Conditions

Watershed health can be measured through physical observation, biological assessment, and water quality sampling. Water quality sampling results offer a measureable indication of underlying pollutant sources that may not be recognizable or fully understood by physical observation or biological assessment alone. Water quality testing is a directly comparable way to assess the condition of a water body, and its individual reaches, to prioritize impaired waters or segments.

Water quality is affected by conditions at the time of assessment. The season, stream flow, and recent rain events can all influence chemical levels at the time of sampling, making it important to sample multiple times. Water quality monitoring included four full dry-weather sampling rounds and two rounds of wet weather sampling. Sampling locations included sites located on the mainstem Mill River, between the New York State line and the Interstate-95 crossing and the six major tributaries to the mainstem.

The Mill River downstream of the North Stamford Dam is designated as Class B/A by the State of Connecticut. The Connecticut Department of Energy and Environmental Protection (CT DEEP) defines this class of surface water designation as “may not be meeting [Class A] criteria or one or more designated uses.” Class A designated uses are defined as: habitat for fish and other aquatic wildlife; potential drinking water supplies; recreation; navigation; and water supply for industry and agriculture. The Mill River has been listed as an impaired water body by CT DEEP for inadequate fish passage and for inadequate life support.

Table 3-1 2010 Impaired Waters List, CT DEEP

ID/Name	Location	Miles	Aquatic Life	Recreation	Fish Consumption
CT7404-00_01 Mill River (New Canaan/Stamford)-01	Mouth of Rippowam River, near Ponus Ridge crossing of Rippowam River, US to Laurel Reservoir Dam, just US of Reservoir Lane crossing, along New Canaan/Stamford town line.	0.74	U	U	FULL*
CT7405-00_01 Rippowam River-01	From Rippowam River West Branch dam (head of tide, US of Route 1 and Main Street crossings), US to Merritt Parkway (Route 15) crossing (mid-way between exit 34 and exit 35), Stamford.	5.22	NOT	U	FULL*
CT7405-00_02 Rippowam River-02	From Merritt Parkway (Route 15) crossing (mid-way between exit 34 and exit 35), US to North Stamford Reservoir dam outlet (US of Interlaken Road crossing.)	2.09	NOT	U	FULL*
CT7405-00_02 Rippowam River-02	From Merritt Parkway (Route 15) crossing (mid-way between exit 34 and exit 35), US to North Stamford Reservoir dam outlet (US of Interlaken Road crossing), Stamford.	2.09	NOT	U	FULL*

Note: **FULL**=Designated use supported; **NOT**=Designated use Not Supported; see 303(d) listing for details. U=Unassessed, data not sufficient for assessment.

Every two years the State of Connecticut studies water quality to identify waters where water quality is not sufficient to meet standards. In 2002, the Mill River was added to the "Impaired Waters List" by the CT DEEP under Section 303(d) of the Federal Clean Water Act. In 2010, the Mill River was designated as "use not supported" for aquatic life. Table 3-1 summarizes the CT DEEP Impaired Waters List for the Mill River.

The majority of the Mill River is non-supportive of aquatic life. Fish consumption is acceptable with the exception of saltwater species of blue crab, bluefish over 13-inches, striped bass, and weakfish, according to the CT DEEP Angler's Guide for 2011.

3.1 Water Quality Standards

Water quality standards have three elements: 1.) designated uses assigned to waters (e.g., swimming, the protection and propagation of aquatic life, drinking); 2.) criteria or thresholds that protect aquatic life and humans from exposure to levels of pollution that may cause adverse effects; and 3.) anti-degradation policy intended to prevent waters from deteriorating from their current condition. Since the Mill River is listed as an "impaired waterbody" under Section 303(d) of the Federal Clean Water Act, which identifies the need to improve water quality based on the use of the area. The following summarizes the water quality standards used for the Mill River.

3.1.1 Desired Use

The purpose of this comprehensive assessment is to determine watershed management best practices that would allow the river to be used for recreational purposes. Thus, Connecticut State water quality Standards will be used as a basis for comparison in the following discussion of water quality.

3.1.2 Numeric and Narrative Criteria

The Mill River is rated Class B/A by the State of Connecticut. This means that it must meet criteria suitable for fish and wildlife, recreation, agriculture, and industrial water supply. Dissolved oxygen (DO) should not be less than 5 mg/l. Total fecal coliform should average less than 100 colonies per 100ml over a 30-day period; the geometric mean of *Escherichia coli* (*E. coli*) must be less than 126 colonies per 100 ml. For recreational uses, taste and color must be of natural origin. Turbidity should not exceed 5NTU and no presence of suspended or settleable solids.

The data for bacteria are compared with the criteria for three designated use classifications: designated swimming, non-designated swimming, and all other recreational uses. The freshwater bacteria standard for Connecticut is based on the concentration, in cfu/100 ml, of *E. coli* bacteria. The most stringent one-time, grab sample concentration is designated swimming, at 235 cfu/ 100 ml.

Based on the Connecticut water quality Standards and B/A classification for the Mill River, the following parameters were including in the sampling:

- Bacteria
- Dissolved Oxygen
- Chlorophyll-a
- Particulate carbon and nitrogen
- Total phosphorus
- Nutrients
- Soluble Total Kjehldahl Nitrogen (TKN) and orthophosphates
- Metals and hardness
- Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)
- Solids and alkalinity
- Copper and Zinc
- Pesticides
- Polychlorinated Biphenyls (PCBs)

3.1.3 Antidegradation Policies

According to the CT DEEP Water Quality Report 2010, the Mill River is a category 5 waterbody, meaning that "available data indicate at least one designated use is not being supported and a total maximum daily load (TMDL) is needed." The rating system assigns water bodies using a five-category approach from the US Environmental Protection Agency (USEPA). Water bodies that do not meet state water quality standards are assigned into either a 4a-c or 5 category. A TMDL has not been established for this watershed. Under 305(b), ongoing assessment of the state of water bodies may allow for re-classification. For instance, if pollution control requirements are found to be more beneficial in overall reduction of contaminants, or if these control measures will allow the waterbody to meet applicable standards, the waterway may be reclassified.

3.2 Water Quality Monitoring Data

Water quality data on the Mill River was collected over the course of a multi-year field program which assessed water quality during seasonal, wet weather, and dry weather conditions. These efforts provided a range of values for varying conditions. The complete presentation and analysis of the data are included in the Comprehensive Characterization Report (CDM, 2011).

3.2.1 Previous Sampling Programs

Several small scale water quality sampling programs have been conducted in the Mill River over the past 20 years:

- The US Geological Survey (USGS) website for the gage at Bridge Street contains results of water quality data collected in the fall of 1994. The one time sampling event yielded data on a variety of metals, organic and non-organic compounds.

- CT DEEP collected similar data from the same location three times – twice in the summer of 1998 and once in the fall of 2000. Bacteria counts were also included in this sampling effort.

- As part of a program called Project SEARCH, a local high school collected water quality samples a few times per year from 1995 to 2002. These data include bacteria counts, basic nitrogen and phosphorus data, and other standard measurements.

- The US Army Corps of Engineers (USACE) collected sediment quality data from within the Mill Pond as part of the Mill River and Mill Pond Restoration Environmental Assessment. These data include metals, hydrocarbons, phenols, semi-volatile organic compounds, and polychlorinated biphenyls (PCBs) analyses. Sample analysis revealed trace metal concentrations below all applicable standards and the presence of few semi-volatile compounds. This analysis concluded that the concentrations observed were within typical ranges for urban stormwater catchments. A portion of the sediment exceeded state standards and required special handling and disposal in a designated landfill site.

3.2.2 Comprehensive Sampling Program

A comprehensive water quality sampling program was conducted from 2008 through 2010 to assess river water quality during a variety of conditions in order to characterize the general water quality of the stream system and identify target areas of concern. Water was sampled during various seasons and during dry and wet weather conditions.

Dry Weather Sampling

Dry weather water quality sampling was performed to gain an understanding of baseline conditions in the mainstem Mill River and all major tributaries during periods of dry weather flow. Dry weather water quality data collection provides an understanding of the problems and opportunities in the river and watershed as well as a basis for identification of cost effective solutions.

One full dry weather survey was performed during each season over the course of one year. In addition to the four full dry weather surveys, two partial dry weather surveys were performed for added overall understanding of the dissolved oxygen dynamics within the system during the algae growing season. The water quality surveys, in conjunction with streamflow data, were used in water quality model development and ultimately in the formulation of the basin management plan to improve the water quality and flows in the river.

Wet Weather Sampling

Wet weather water quality sampling was performed to gain an understanding of pollutant loadings in the mainstem Mill River and all major tributaries during rain events. Data collected from wet weather sampling events were used to develop a watershed loading model, which was used to evaluate alternatives for river and watershed improvements.

Two wet weather sampling events were conducted; one in the spring and one in the fall of 2009. Weather was tracked to predict storms of sufficient precipitation volume and coverage over the watershed. Storms of at least 0.5-inches of precipitation over the entire watershed were the conditions targeted for wet weather sampling. In order to isolate the conditions in the river to represent only the targeted storm event, each wet weather sampling event was targeted to follow a 72-hour period of rainfall not exceeding 0.1-inches over the watershed, or a period where flow in the river was approaching baseflow conditions.

Wet weather sampling consisted of four distinct rounds of sample collection during each of the wet weather events, corresponding to different stages of the storm flow hydrograph. Pre-event (PE) samples established a baseline for the water quality before runoff entered the stream. Rising limb (RI) samples captured the first flush of runoff. Near peak (NP) samples captured the concentrations during the time of highest flow during the storm. Receding limb (RC) samples were collected to correlate hydrograph recession with runoff pollutant levels.

3.2.3 Summary of Findings

Based on the sampling results the following pollutants of concern have been identified for the Mill River: bacteria, nutrients, and metals. Dissolved oxygen (DO) levels are low in select locations, as explained below. Sediment quality will be of concern if sediment resuspension occurs, as a result of dam removal, stream morphology alterations (managed or unmanaged). A complete analysis of the water quality and sediment quality findings from the field monitoring program can be found in the 2011 Comprehensive Characterization Report (CDM).

Bacteria

The state standards for bacteria in fresh surface waters are 235 cfu/100 ml for designated swimming and 410 cfu/100ml for non-designated swimming (single samples). Trends during dry weather suggest Poorhouse Brook, the main stem Mill River from Wire Mill Road to just south of the Merritt Parkway, Ayers Brook, Toilsome Brook, and downstream of Cold Spring Road have high levels of bacteria (generally *E. coli* > 1,000 cfu/100 ml). Tributaries had the highest bacteria levels during storm events, and the counts in the tributaries were typically greater than at the main stem stations upstream and downstream of the confluence. 38 samples collected during wet weather had bacteria levels greater than 100,000 cfu/100 ml, 28 of which were collected from tributaries or main stem stations likely directly influenced from tributary storm flow. In general, the bacteria counts spiked during the near peak hydrograph levels. Bacteria levels in the river exceed state water quality swimming standards at 31% of stations during dry weather and at 77% of the stations during wet weather sampling.

Nutrients

Primary algal production in the river is limited by phosphorus concentrations and light availability. This is generally the case in northeast freshwater streams. Nitrogen is the more abundant nutrient, from an algae growth perspective, and thus limiting phosphorus will limit algal growth. In general, ambient levels of phosphorus in the river are moderately elevated (25-50 ug/l), and are sufficient to support the pervasive bed-attached algae, but are not sufficient to elevate floating algae concentrations in most locations. This is likely due to short residence times of the water flowing through the stream system (there is not enough time for algae to grow). High phosphorus concentrations observed during wet weather sampling were likely due to stormwater runoff, or due to the potential presence of sewage flows in Ayers Brook (by way of failing septics, leaking collection systems, or illicit connections).

Concentrations of nitrogen in the tributaries were greater than in the main stem during dry weather sampling events. High levels of nitrogen in Toilsome Brook and Ayers Brook, along with high bacteria counts at these locations, signify the likely presence of wastewater. Floating algae levels throughout the river were not generally high, with the exception of releases from the reservoir and some of the small tributary ponds.

Dissolved Oxygen

Adequate DO in the stream is necessary for aquatic life, but during the warm weather, DO levels tend to range from saturated to supersaturated, indicating elevated nutrients and enhanced productivity of algae. Algal growth is supported by nutrients; algal decay consumes dissolved oxygen in the water. During the summer months, DO levels tend to be slightly under-saturated throughout the system, which means that oxygen consumption by organic material is outpacing reaeration and photosynthesis. The lowest DO levels were observed in the discharge from the North Stamford Reservoir low flow outlet. The low flow outlet releases from the lower levels of the reservoir, where DO is depleted. Adequate DO in the stream is necessary for aquatic life.

Low DO concentrations are not widespread. The mainstem river and tributaries are generally in compliance with the CT DEEP state standard of 5.0 mg/l. Of the total readings taken over the course of the monitoring program, 96% were above the state standard of 5.0 mg/l and 83% were above 7.0 mg/l. Low DO (1-3 mg/l) was observed in the discharge from the North Stamford Reservoir low flow outlet during the two sampling events when the reservoir would have been stratified (summer). These low values occur because the low flow release water is taken from a mid-depth of the stratified reservoir, where DO and temperature are low. Other low DO concentrations were observed downstream of tributary ponds, where excess algal growth may be consuming oxygen.

Metals

Metals in freshwater can be toxic to fish and other aquatic life. Metals also bioaccumulate in the food chain, resulting in levels in fish that can be toxic to humans. Copper, lead, and zinc exceeded state water quality standards in several samples. Copper exceedances occurred during dry and wet weather sampling; lead concentrations were elevated during storm events; and zinc concentrations exceeded standards at the more urbanized tributary locations during wet weather conditions (Ayers Brook, Toilsome Brook, and the downtown storm drain).

Sediment Quality Results

Sediment samples from the streambed measure larger particulates which have been introduced to the stream, but may have settled or been transported downstream. Sediment analysis data collected during spring and fall 2009 indicated a minor presence of the pesticides chlordane and lindane, at separate locations. The compounds were detected, but not in exceedance of standards. Metals were detected at levels greater than previously detected during the USACE investigation at the former Mill Pond. This suggests that metals deposition in the stream has not been limited to the previously dammed area downtown, and that resuspension of metals throughout is a possibility with stream channel disruptions (intentional or incidental).

3.3 Geomorphological Assessment

A geomorphological assessment studied features of the Mill River in order to better understand the form and physical processes within the river system. Such a study uncovers a deeper understanding of the river and its natural processes, and allows planning, nearby operations, and maintenance of the river system to be more informed. Ultimately, depending on the goal of the overall program, understanding the alluvial geomorphology allows restoration efforts to be more sustainable and long-lasting by working with the system and preventing further degradation.

3.3.1 Physical Stream Characterization

Physical stream conditions are often an indication of the biological health of a water system. In the case of the Mill River, a physical stream characterization and geomorphological study was necessary to better understand physical habitat for periphyton and benthic macroinvertebrates. Physical stream characterization was conducted as part of the full assessment of biological data within the river system. These data are a strong indication of water quality and physical health of the river. According to the USEPA, there are seven physical characteristics of a river which affect ecological resources:

- Channel Dimensions
- Channel Gradient
- Channel Substrate Size and Type
- Habitat Complexity and Cover
- Anthropogenic Alterations
- Channel-Riparian Interaction
- Riparian Vegetation Cover and Structure

The following summarizes the seven characteristics:

Channel Dimensions

Depositional features within the channel, including mid-channel, point, lateral and delta bars, are present in nearly all reaches and are clear indicators of a river out of equilibrium. These features are not extensive throughout all reaches. In general, the Mill River exhibits low to moderate sinuosity (channel length/curve valley length) with ratings between approximately 1.0 and 1.25. Sinuosity for the entire valley is 1.10. Historic USGS Quadrangles indicate that overall, sinuosity has not changed dramatically during the past 100 years or more, likely due to early anthropogenic modification and stabilization of the banks and adjacent buffers. In many locations, the river makes tight meander bends that, though present for at least the last 100+ years, would probably not be naturally stable over the long term. Examples of such meander bends are just below the Cold Spring Road crossing, and near the Holts Ice Pond Brook confluence.

Channel Gradient

The main stem study area is unconfined to semi-confined with gentle to moderate slopes. The steepest slopes and most confined reaches tend to occur in the upstream reaches. However, the river exhibits a generally consistent gradient throughout the study area until the Scalzi Park area, where slopes are at or near 0%. These slopes are consistent with a head-cutting stream where incision is occurring near the source and deposition at the bottom. The incision and deposition indicates the stream flow and gradient are not in equilibrium.

Channel Substrate Size and Type

The surficial geology of the watershed below the North Stamford Reservoir is primarily glacial till and glacio-fluvial deposits, with lesser amounts of alluvial sediments. Broadly, soils throughout the study site are characterized by udorthents and urban land soils (artificially placed fill) throughout the lower reaches of the study area and well-drained soils throughout the middle and upper reaches of the study area. Most naturally placed soils occurring within the Mill River watershed are characterized as well-drained with deep seasonally high water tables (more than 80 inches below ground surface) and low potential for flooding. Because of the sandy, loamy nature of these soils, they are also moderately to highly erodible. Pebble counts showed that, in general, the percent of sand and fine gravel decreased downstream while the percent boulders increases. A healthy habitat generally has an even distribution of various size substrate.

Habitat Complexity and Cover

Generally the habitat is better in the upstream reaches. The following summarizes the various habitats in the Mill River corridor:

- In the downtown-area reaches between Long Island Sound and Scalzi Park, instream physical habitat was rated “relatively poor” to “very poor”.
- The low- to mid- reaches show slight improvement over the downstream-most reaches, and are generally characterized as “suboptimal” or “marginal.”
- Upstream reaches are generally desirable habitat for macroinvertebrate and fish species. Banks in this reach are generally stable with the highest habitat quality at just below the North Stamford Reservoir. At least three of four velocity and depth regimes were present in each reach, enriching the habitat and making it more valuable for aquatic organisms.
- The habitat value of uppermost reach was reduced by elimination of the riparian zone along both banks of the river for commercial use by a gardening center for ornamental plant storage.

A more detailed description of the various habitats along the river corridor is provided in the 2011 Characterization Report.

Anthropogenic Alterations

Observations of historic USGS Quadrangles and aerial imagery indicate that the Mill River has followed the same general course for more than 100-years; however, straightening and modification to the channel appear to have occurred within nearly all reaches.

Channel-Riparian Interaction

Throughout the study area, both of the banks are generally heavily developed within 5- to 25- feet of the river's mean annual high water line. Undeveloped pockets do occur, but many of these areas appear to be either abandoned agricultural fields or steep slopes not suitable for development. Some of this development is associated with recent commercial/industrial or residential uses. However, the river riparian buffer also reflects historic development associated with agriculture (i.e., stone walls and revetments, drainage ditches, etc.).

The cumulative erosion impact was evaluated for each reach and the majority of reaches were assigned *high* impact ratings because of the extensive bank erosion throughout. Much of the Mill River has high potential for debris jamming and snagging primarily due to aggradation in the lower reaches and restrictions at spans and level controllers (weirs and dams).

Riparian Vegetation Cover and Substructure

A majority of the corridor land use is characterized as commercial/industrial and residential/commercial in the lower reaches and generally forested and residential above this boundary. It is important to note that much of this forest cover is actually wooded residential lots that are directly adjacent to the brook, obscured by the canopy, thereby giving the false impression that banks are undeveloped. A summary of watershed land cover by subbasin can be found in **Figure 3-1**, and clearly shows the increased development from upstream (right side of chart) to downstream (left side of chart).

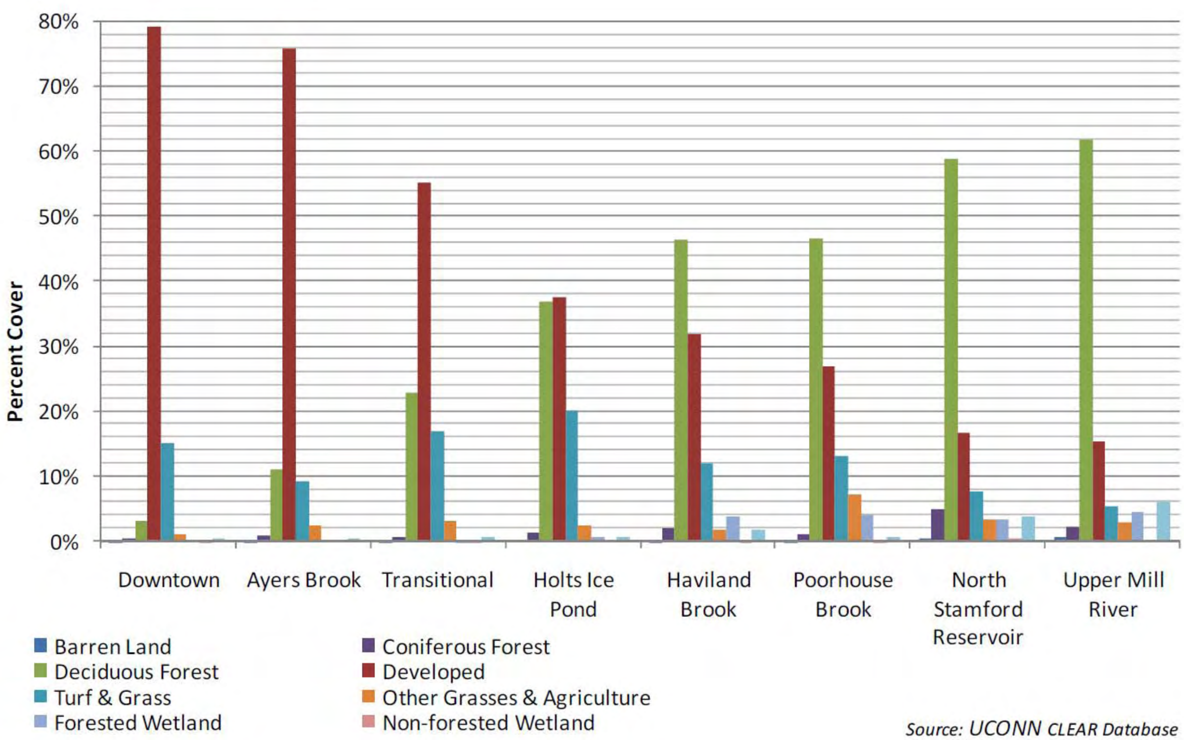


Figure 3-1. Land Cover by Subbasin within the Mill River Watershed

3.3.2 Flow Data

The Mill River has changed as a result of the development and impacts over the last decades. The following summarizes the different stream characteristics relative to flow within the river corridor.

The lower watershed responds very quickly to rain events. This is seen in the rapidly rising hydrographs at the USGS gauge (located just upstream of Toilsome Brook) and in the data from the continuous flow meters installed at culverts of Toilsome Brook and the Mill River drain. Rapid response was also observed by the field teams in the Ayers Brook subwatershed. The rapid response is due to the urbanization of the lower watershed, where 25 to 33% of the land area is developed in the subwatershed south of the Merritt Parkway to Toilsome Brook, and nearly 60% of area is developed in the downtown area. Developed land has more impervious surface than undeveloped land, causing rain to runoff quickly instead of infiltrating into the ground.

The response of the upper watershed to rain events is tempered by the many in-stream ponds along Haviland Brook and Poorhouse Brook. While the Holts Ice Pond subwatershed also has several ponds, it has two to four times the impervious cover of the upstream subwatershed, increasing peak flows but not to the same degree as in the lower subwatersheds.

Rapid response to precipitation is the cause of significant erosion throughout the river. Erosion contributes large volumes of pollutants directly to the river and tributaries, resulting in elevated pollutant concentrations during wet weather events.

North Stamford Reservoir

The North Stamford Reservoir contributes a constant flow to the river through a low flow release structure, and discharges water over its dam spillway when the reservoir is at capacity. There is evidence of algal growth and copper sulfate treatment in the reservoir. The reservoir water quality impacts the Mill River by way of the low flow release and the spillway discharge during storm events

Tributary Flow

Flow meters were installed in the culvert outfalls of Toilsome Brook and the Washington Boulevard storm drain. The flow meters at these two culverts automatically recorded continuous flow data to the Mill River for a period of 24 weeks. These data were used to characterize these subbasins and quantify pollutant loads during dry weather and wet weather periods.

Staff gages were installed at four tributaries to the river and the low-flow outlet from the North Stamford Dam. The four major tributaries are Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, and Ayers Brook. Stage measurements were taken at staff gage locations during each full and partial dry weather water quality survey and during wet weather water quality sampling. Recorded velocity measurements were used to compute the stream discharge and develop stage-discharge rating curves at each staff gage location.

Flooding

Parts of Stamford are prone to flooding. The Federal Emergency Management Agency (FEMA) completed a Flood Insurance Study (FIS) for the City of Stamford, which was updated in 1993. The following description of the principal flood problems in Stamford was given by FEMA in the FIS:

"Flooding, triggered by heavy rainfall, occurs in the floodplains and adjacent low areas along the Mianus, Rippowam, and Noroton Rivers. Encroachment into these areas by all types of construction is further aggravating the flood hazard" (16).

Flood protection measures are described in the FIS as follows:

"The COE [US Army Corps of Engineers] constructed the hurricane barrier, which protects low-lying development in the south end of the city from flooding caused by hurricanes or severe coastal storms of 500-year recurrence intervals. The City of Stamford has widened the Toilsome Brook channel between Dann Street and Dartley Street, as well as the Bracewood Lane section. Further improvements on Toilsome Brook are in the planning stage.

"The reservoirs in the study area were constructed for water supply only, therefore, the reservoirs have no significant effect in the 100- and 500- year floods.

"The Stamford Environmental Protection Board and the Connecticut Department of Environmental Protection regulate floodplain encroachment ordinances within the city and establish restrictions in floodprone areas" (16).

Wetlands

In Connecticut, wetlands are defined strictly by soil type. Wetlands are defined as any land, including submerged land, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial and floodplain by the National Cooperative Soils Survey of the Natural Resources Conservation Service (NRCS) of the US Department of Agriculture (USDA). Residential and commercial development, encroaching onto the riparian zone of the river, has contributed to the extensive loss of floodplain forests, once thriving along the system. Some small pockets of wetlands, however, can still be found along the middle reaches of the study area, mainly on the left, less developed bank of the river. High-density residential development contributed to the wetland loss along the downstream reaches of the river.

3.4 Biological Data

Physical stream conditions are often an indication of the biological health of a water system. For the Mill River, a geomorphological and ecological assessment study was performed in 2009 to better understand the health of the river. This included use of the EPA benthic macroinvertebrate protocol and the EPA periphyton sampling protocol. When correlated to development, biological data and physical characterization are effective tools for overall restoration planning.

3.4.1 Periphyton

The USEPA field-based rapid periphyton protocol was used at each of the sampling sites as a semi-quantitative assessment of benthic algal biomass and taxonomic composition. Two locations were selected within the same region as the benthic invertebrate sampling locations. The dominant algal species found in the sampling locations indicate nutrient-rich but not eutrophic conditions, and may be linked to the presence of excess phosphorus loading.

3.4.2 Benthic Macroinvertebrate

For each sample location, a benthic macroinvertebrate assessment was conducted using the USEPA Benthic Macroinvertebrates Protocol. The "Single Habitat Approach: 1 Meter Kick Net" method was selected for sample collection. The uppermost reach contained the highest total number of organisms, but a high Family Biotic Index (FBI) indicated fairly poor water quality. The reaches just downstream also exhibited similar characteristics, with high biodiversity and abundance. Moving further downstream (past the North Stamford Reservoir), the kick-net results showed a lack of biodiversity and eventually very low counts of any living organisms.

3.4.3 Fish

Fish populations were not distinctly assessed as part of this study. However, a general physical habitat assessment was conducted to gain a better understanding of the conditions affecting the full spectrum of species within the river system. That data is summarized in Section 3.3.1.

More detailed information and the supporting data relative to the analysis of the watershed are included in the Comprehensive Characterization Report (CDM, 2011).

3.5 Impaired Use

According to the CT DEEP, the Mill River is classified as an impaired waterbody habitat for fish, other aquatic life, and wildlife. The stream has not yet been assessed for impairments due to exceedances of pollutant levels above state standards. Based on the findings of the monitoring program and field observations, the likely causes of the aquatic habitat impairment are:

- excess attached algae growth from elevated nutrients
- flow and migration impediments (low head dams)
- erosion and deposition
- metals concentrations
- streambed substrate diversity

The likely causes of impairment listed above are directly linked to observed water quality concerns in the stream. Each can be attributed to increased development in the watershed, which has occurred with little regard to the effect of land use on stream water quality and habitat. Urban and suburban runoff pollutants, increased stream velocities, instream structures, and development in the flood plain lead to the causes of impairment listed above. Though not yet assessed for bacteria, the stream does not meet state water quality standards for bacteria. Elevated bacteria concentrations are also likely due to urban runoff pollution.

The following sections explore the sources of pollutants in greater depth, outline objectives for this plan to improve the health of the Mill River, and identify specific action items that aim to remediate the causes of impairment listed above.

Section 4 – Pollutant Source and Load Assessment

Evaluating the sources and relative magnitude of pollutant loads to the stream system allow for the development of a targeted management plan. Action items should be aimed at specific problems in specific areas of the watershed where the effect will be most beneficial. The Windshield Survey (Appendix D) performed as part of this project included identification of facilities and land uses that are a potential threat to water quality and opportunities for improved stormwater management within the watershed. The characteristics of the Mill River and watershed reveal that the main contributor of pollutants is stormwater runoff to the river. There are numerous management strategies to control nonpoint source pollution; the following summarizes the pollutant source and loading assessment that was completed prior to developing recommendations for management measures.

4.1 Nonpoint Sources

Nonpoint sources (NPS) include any substance or material on a commercial, residential, or public surface or roadway that is collected and transported through overland flow to a body of water. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants. Legally, this represents any sources that cannot be classified as a point source, or anything that is not easily identifiable as the source of contaminant transport to a water body. Often changes to management practices through education and outreach result in an overall reduction of nonpoint source impacts to a water source.

According to the Connecticut Department of Energy and Environmental Protection (CTDEEP), the designated authority on nonpoint source management in the state, the goal of managing nonpoint sources is to "protect public health and the environment from the impacts of nonpoint sources of pollution by promoting practices and adopting controls to reduce nonpoint sources of pollution." This can be achieved through development and implementation of stormwater best management practices (BMPs), improvements to education and incentives for controlling nonpoint sources at the municipal level, implementation of a stormwater discharge program, and development of a program to implement nonpoint source demonstration projects.

Urban/suburban runoff is the most prominent form of nonpoint source pollution in the Mill river basin. As the majority of the area south of Merritt Parkway is primarily residential with limited forest land, grass and soil, most of the stormwater which falls on these surfaces is conveyed through a stormwater drain system which empties into the Mill River.

Industrial/Commercial Land Usage

The quality of urban runoff from industrial and commercial sites is often dependent on site use, and can include chemicals, metals, or other hazardous agents. These sites are often fully impervious, creating a greater volume of runoff than suburban or residential areas.

Dirt, oil, and debris collect on the impervious surfaces of commercial and industrial sites, which include parking lots, driveways, roadways, and sidewalks. Commercial establishments, due to the nature of their business, are more likely to regularly maintain these areas in order to avoid debris buildup and unsightly driveways. Industrial establishments may be required to as part of site-wide regulated or voluntary stormwater pollution control measures.

Industrial sites which regularly conduct work with petroleum products and hazardous degreasing products, such as manufacturing facilities, transportation centers, and gas stations, are generally required to maintain additional on-site precautions to prevent migration of spills. Such precautions are necessary due to the nature of the materials, which are highly soluble and migrate quickly when introduced to water resources, creating a costly situation where environmental remediation is required and losses to aquatic life result. Dry cleaning facilities also have potential for negative environmental impacts due to the highly toxic nature of the chemicals used. While spills of any size legally require reporting to the CTDEEP and remedial investigation, small releases often go unseen and unreported. As a result, it is particularly important to maintain barriers between such industrial and commercial sites and sensitive aquatic habitats.

Regular vehicle parking lots where a number of cars may be garaged or parked for long periods of time will also accumulate some oil, gas, and other hazardous chemicals as a result of the use of vehicles. When possible, such lots are generally required to maintain a site-specific oil/water separator to catch contaminants during a storm when overland flow could otherwise convey the materials to nearby water resources.

Residential

As a general guideline, impervious surfaces are more likely to collect, absorb, and convey pollutants than pervious surfaces. Natural ground cover, grasses, gravel, rock gardens, wooden decks with drainage to grass or dirt, and vegetated gardens are all pervious alternatives. As stormwater runoff travels over impervious surfaces, in addition to collecting pollutants, the relative heat – which is naturally higher in paved surfaces than natural landscape – may increase the temperature of the runoff water, adding additional stress to receiving water aquatic systems in the summer months.

It is important to consider the residential and small scale applicability of chemical hazards resulting from petroleum products. At the household level, vehicles with leaks may introduce petroleum products to the stormwater conveyance system. Regular maintenance of vehicles, such as at-home oil changes, use of engine degreasers, grease, road salts and sands, paints, deicers, and other chemicals must be stored and handled properly to avoid contamination. Household chemicals, including grease, should be stored in well-conditioned containers and kept out of weather.

As with managing agricultural practices, chemicals used in landscaping such as insecticides, pesticides, herbicides, and fungicides can poison receiving water aquatic life and lead to dead zones, where aquatic life is unable to survive. Limiting chemical application frequency and avoiding over-application beyond recommended use will help to mitigate this risk. Additionally, overwatering will increase likelihood of transport.

Yard waste must also be managed to avoid clogging drains with debris, such as tree leaves and grass clippings. Composting and mulching yard waste is recommended whenever possible. Native plants will reduce pests and may require less irrigation or chemical applications than non-native species. When changing the landscape of a property, working with the natural contours will limit sediment transport.

Other best practices include keeping sidewalks, driveways, and parking lots clear of debris and litter, particularly areas around catch basins. Such debris can be collected by the system, transported, and washed into streams. Plastic bags, six-pack rings, bottles, and cigarette butts have been known to choke, suffocate, or disable birds, ducks, fish, turtles, and other aquatic species. Households that are adjacent to waterways should ensure filtration of overland flow by maintaining or allowing natural landscape buffer strips or gardens to divide lawn grass from the waterway.

Septic Systems

Septic systems that are overwhelmed or unmaintained may leak, introducing high concentrations of nutrients and pathogens (bacterial and viral) to nearby waterways through subsurface transport. The result is increased levels of pathogens in the surface water. There are several areas of the Mill River watershed that are not sewered and therefore rely on individual septic systems to handle residential waste. Proper maintenance of these systems is critical to ensuring that the stream meets bacterial standards for recreation.

The United States Environmental Protection Agency (USEPA) recommends that systems are checked once every 3 years, and pumped every 3 to 5 years. Limiting wastewater production by reducing overall water use can extend the life of the septic system. This can be achieved through using low flow shower heads, faucets, and toilets as well as efficiently using dish and clothing washing machines.

Sediment

Site work which involves disturbing the ground surface often leads to silt transport to the stormwater conveyance system. This silt will collect within the system traps, which are designed to prevent silt from clogging conveyance piping. However, some silt will work through the system and end up being deposited in receiving waters, leading to adverse changes to the streambed ecology and aquatic system health. As mentioned previously, silt runoff will also carry chemical contaminants including metals, which build up rather than degrading. Site work should include silt protection by fencing, hay bales, or compost berms and such is required to obtain most construction permits in the state of Connecticut. Catch basins and silt traps within the stormwater conveyance system should also be cleaned and maintained to ensure proper system function.

Stream Bank Erosion

Stream bank erosion in Stamford likely results as development encroaches on the river, limiting natural landscaping and cutting back on the vegetation which would otherwise act to reinforce the shape and limit erosion. Efforts should be made to increase frequency of natural vegetative buffers and avoid continued encroachment towards the river.

New development is anticipated to be minimal along the portion of the river south of the Merritt Parkway, as these reaches are almost fully developed. However, future development projects, particularly those that involve developing previously forested areas, should be particularly sensitive to the impacts to sediment transport and erosion that results from cut back buffers and unstable stream banks.

Silviculture

The upper portion of the watershed, north of the Merritt Parkway, consists primarily of undisturbed forested land and natural landscape. In the event that this area becomes more developed, it is essential for the health and wellbeing of the waterway for best management practices to be followed for site development. Additionally, there are several limited parcels south of the Merritt Parkway, within the study area, which have been noted as forested land. Development in these areas must take into consideration the impacts to the Mill River in order to prevent further degradation of the waterway.

Improper management of forests, including development of previously forested lands, can be a major contributor of sediment to stream systems. In general, natural systems with forested lands have a natural balance of sediment deposition, production, and compaction. Sediment does not often travel once deposited onto a forest floor because plant roots including trees, bushes, and undergrowth hold the soil in place. When that system is disturbed during construction activities, soil containing a high percentage of organics is often too fine to be reasonably controlled from transport. In order to manage forested lands, trees must be cleared to make room for roadways, undergrowth removed, and generally the system is upset of its natural balance.

When undergrowth is removed, particularly small bushes and border plants along stream banks, the system is deprived of the natural sediment controls that prevent sediment transport. This growth stabilizes stream banks which would otherwise erode without roots to reinforce its strength. The undergrowth also serves to shade the stream and removal of the vegetation leads to higher temperatures which change plant growth and can limit sources of food and shelter for aquatic life.

Whenever possible, it is recommended to avoid disturbing stream bank buffer areas and nearby forested areas. Before construction, the area should be surveyed for sections which require special protection, such as steep slopes and naturally sensitive forest areas, in order to avoid disturbing less stable soils and natural hills reducing the risk of severe erosion. Sensitive rock formations and streamside vegetation should be left undisturbed. Whenever possible, replanting is an essential component to natural resource recovery.

4.2 Point Sources

Point sources include direct sources of pollutants which are known to be introducing contaminants into the stream. These discharges are regulated under the National Pollutant Discharge Elimination System (NPDES) permit program under the USEPA, Phase I and Phase II Stormwater Permits, and Concentrated Animal Feeding Operations (CAFO) permits. There are no point source discharges to the Mill River within Stamford.

Illicit connections to storm sewers can act as point sources during dry weather. It was not within the scope of this study to identify stormwater outfalls that may contain illicit connections, but as part of the monitoring and reconnaissance effort field crews identified outfalls with dry weather flow.

4.3 Other Potential Pollutant Sources

Other pollutant sources were also considered under this assessment. Such sources include known hazardous waste sites such as those regulated under the USEPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), and registered brownfields properties. Such contamination can be detrimental to surface water resources and lead to environmental consequences including fish kills, severe biological degradation, and high levels of chemical contamination. During a desktop and windshield survey of the watershed, one site was discovered on the USEPA's Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) database; Scofieldtown Road Park. This landfill site is currently under investigation for remediation. Contaminants originating at this site could potentially travel through groundwater and enter the Mill River via baseflow. The monitoring program for this basin management plan did not focus on determining the extent of contamination caused by the Scofieldtown Road Park landfill.

Underground storage tanks (USTs) can be found in industrial, municipal, and residential properties. When USTs leak, as a result of age or degradation, the contents can escape into nearby soil and eventually groundwater. Major concerns would include large volume containers which contain petroleum products that easily pass through soil to groundwater and can develop large contaminant plumes that feed to surface water sources. During the desktop and windshield survey of the watershed, 200 sites with leaking USTs were identified within the watershed[1]

The desktop review and water quality sampling conducted under this assessment did not suggest any major sources of contamination beyond that of stormwater runoff in the Mill River. Therefore, there are no recommended action items aimed specifically at the remediation of impacts from the landfill or leaking USTs.

4.4 Linkage of Pollutant Loads to Water Quality

The results of water quality monitoring on the Mill River show a linkage between water quality issues in the river and known potential sources of the problems. The full water quality monitoring results are presented in the Comprehensive Characterization Report (CDM, 2011). The monitoring discovered widespread elevated levels of bacteria in the river. Table 4-1 lists the locations and times of higher bacteria trends and possible causes of each based on land use and watershed knowledge.

Table 4-1 Water Quality Trends and Sources - Bacteria

Elevated Bacteria Trend	Possible Cause/Loading Sources
Higher dry weather concentrations observed: • **Poorhouse Brook** • **Immediately downstream of the Merritt Parkway** • **Ayers Brook** • **Toilsome Brook**	Illicit connections to storm sewers Direct waterfowl fecal contamination Failing septic systems
Higher summer concentrations throughout the river	Warmer, more friendly conditions for bacteria growth More waterfowl habitat
Higher wet weather concentrations observed: • **Poorhouse Brook** • **Lower watershed** • **Tributaries (as compared to main stem)**	Improper pet waste management General urban runoff Runoff contamination from waterfowl feces

Metals were also observed at levels above the state water quality standards during the monitoring program. The source of metals pollution is generally urban/suburban runoff, particularly from roads and streets. Zinc and lead levels were both greater in stormwater samples (wet weather) and in the lower watershed, where development and impervious surfaces are more widespread. Elevated levels of copper

[1] A fact sheet on the CTDEEP Underground Storage Tank Program is available at www.dep.state.ct.us/wst/ust/ustregs.htm. Information on spill reporting and responsibility for remediation of spills is also available at www.dep.state.ct.us/wst/oilspill/resp.htm.

could be caused by natural levels within the watershed or by copper sulfate dosing within the North Stamford Reservoir (often performed to control reservoir algal growth). During one sampling event, levels of copper were greater in the reservoir discharge, indicating that it is periodically dosed with copper sulfate to control algal growth.

Nutrients are of concern for the watershed because of the direct drainage to the Long Island Sound, where high levels of nutrients cause hypoxia (lack of oxygen in the water). Observed nutrient and bacteria levels suggest that a cause of elevated contaminants in Ayers Brook and Toilsome Brook is likely sewage either from illicit connections, failing septic systems and urban runoff with pet waste. Nonpoint source runoff, laden with lawn care fertilizers, is also a very likely source in the residential and commercial portions of the watershed. As total phosphorus levels were observed coincidentally with higher suspended solids during wet weather events, they may be caused by sediment resuspension and bank erosion. Evidence of excessive algal growth in ponds was observed throughout the watershed, and the levels of algae (chlorophyll-a) measured in the river during wet weather monitoring suggests that the algae is flushed from the ponds to the streams during rain events.

4.5 Estimation of Pollutant Loads

4.5.1 Point Sources

There are no permitted point source discharges to the study area reach; however, illicit connections to storm sewers can act as point sources during dry weather. As part of the sampling program, outfalls were sampled for bacteria to identify possible illicit connections. Three outfalls in the lower watershed had observed *E. coli* concentrations above the state water quality standard for streams. The three outfalls are located near the Cold Spring Road crossing, next to Scalzi Park, and near the North Street crossing. It is likely that many more outfalls along the tributaries have dry weather flow with high bacteria counts, based on the instream sampling results in the tributaries. These outfalls were not identified or sampled as part of this study. The results of the outfall sampling are presented in the 2011 Comprehensive Characterization Report.

4.5.2 Nonpoint Sources

As part of the Basin Management Plan, a watershed loading model was developed to estimate nonpoint source contributions from the subbasins, based on annual rainfall and land cover statistics. The full model development and results are explained in the 2011 Watershed Modeling Memorandum (Appendix B). Figure 4-1 shows the results of the modeling of existing conditions in the watershed. The chart lists the total annual loading across the top, with each portion of the stacked bars representing the loading from each subbasin. These are estimates of the nonpoint source loading, taking into account failing septics but not illicit connections leaking sewage into the stream. The tributaries with more flow tend to contribute more loading, with the exception of Toilsome Brook (purple) and the Lower (downtown) Direct Drainage (orange). Toilsome Brook contributes disproportionately high amounts of BOD, fecal coliform, TKN, and total phosphorus – typical residential development pollutants. The downtown drainage contributes disproportionately high amounts of metals – typical road runoff pollutants.

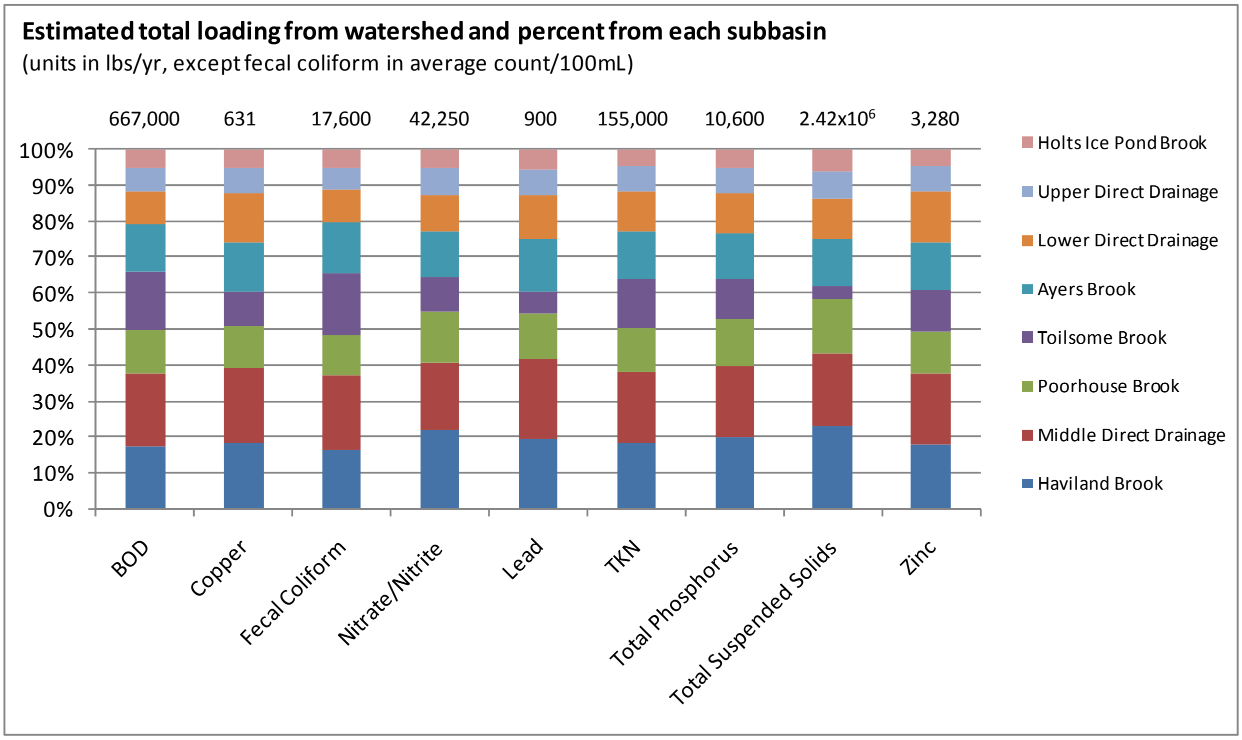


Figure 4-1 Estimated Total Nonpoint Source Loading from Mill River by Subbasin

4.6 Areas in Need of Improvement

Based on the monitoring program results and the watershed loading model, the following areas are considered in need of improvement:

Table 4-2 Identification of Areas in Need of Improvement

Identified Area	Bacteria	Metals	Nutrients	BOD	DO	Algae
Downtown drainage	X	X				
Toilsome Brook	X		X	X		
Ayers Brook	X		X			
Poorhouse Brook	X					
Lower subbasins	X		X			
Specific points on mainstem:						
Near Merritt Parkway	X					
Near Scalzi Park	X					
Near Broadway crossing	X					
Downstream of North Stamford Reservoir		X			X	
Upper watershed tributaries and ponds						X

Section 5 – Watershed Management Objectives

The goal of this basin management plan is to make the Mill River a usable natural space for the community and a healthy habitat for the species which it supports. This can only be achieved through a comprehensive approach to watershed management and pollutant mitigation. Poor stormwater quality, uncontrolled urban runoff volume, direct anthropogenic alterations to the stream, and a general lack of river and watershed stewardship are the driving causes of the current degraded state of the Mill River in Stamford. This section of the plan outlines the management objectives developed through stakeholder input and overall watershed assessment.

The results of stakeholder involvement meetings were compiled to develop eight objectives for the basin management plan. In order to achieve these objectives, several strategies were considered based on the portion of the river which is in need of attention and the actions necessary to improve the conditions. The following section is a list of the plan objectives and broad ideas for where and how they could be achieved. Section 6 provides detailed explanations of the different types of action items and a comprehensive list of recommended action items for the improvement of the Mill River watershed. Section 7 groups the action items into alternatives centered on sol ving very specific problems (e.g. reducing bacteria concentrations in the river, fostering stewardship of the river and watershed).

Objective 1. Increase public awareness, education, and community involvement

Location: Throughout the watershed for the public, North Stamford Reservoir for Aquarion Water Company.

Specific actions: Develop a comprehensive awareness, education, and community involvement plan that includes opportunities for involvement and education. Work with Aquarion Water Company to improve water quality.

Objective 2. Improve access and connection to the river, including passive and active recreational opportunities

Location: Long Ridge Rd commercial properties, Buckingham Road, Merritt Parkway corridor (near Wire Mill Road and utility substation), Cold Spring Road, wetlands boardwalk.

Specific actions: Develop a comprehensive plan for public use areas that are interesting, accessible, provide an activity such as walking or biking, promote connections between the public and the river, link with other access points, and have a consistent identity with each point throughout the length of the river.

Objective 3. Build a grassroots watershed constituency

Location: Throughout the watershed.

Specific actions: Inspire members of the community to develop a citizen-driven watershed constituency which acts as a steward of the watershed, initiates community participatory activities such as cleanups and plantings, participates in community activities to create awareness of the watershed, and generally drives the goals laid out in this plan.

Objective 4. Control and reduce high flows to promote river corridor health and reduce flooding

Location: Areas where river can be reconnected to flood plain, North Stamford Reservoir, Ayers Brook subbasin, Toilsome Brook subbasin, middle and lower direct drainage subbasins, parcel-based or neighborhood-based solutions where appropriate.

Specific actions: Develop education initiatives which focus on low impact development, explore day-lighting in Toilsome Brook, optimize flood storage reservoir operations, use floodplain for temporary storage, use parcel-based solutions in the northern watershed, and use City stormwater solutions on a neighborhood basis.

Objective 5. Improve water quality, specifically: metals, dissolved oxygen, bacteria, and nutrients

Metals

Location: Throughout the watershed (in wet weather).

Specific actions: High levels of metals can lead to regulatory concerns for the river and overall health of the river. Stormwater controls that filter overland flow from impervious areas to stormwater drains or directly to the river will reduce concentrations of metals in the river.

Dissolved Oxygen

Location: North Stamford Reservoir low flow outlet and throughout the watershed.

Specific actions: Dissolved oxygen (DO) is necessary for healthy aquatic life. The Mill River, being shallow and free-flowing in most reaches, should have adequate capacity to reaerate. The North Stamford Dam low flow outlet is discharging water with low DO to the upper reach of the study area. Additionally, nutrient abundance in the water column results in excess algal growth in slow moving sections (ponds); algal decay consumes DO. Remediation of the low DO in the North Stamford dam outlet and stormwater runoff controls and best practices to limit nutrient runoff will improve the DO levels throughout the river.

Bacteria

Location: Ayers and Toilsome Brook subbasin in dry weather; throughout the watershed in wet weather.

Specific actions: Reduction in bacteria levels will improve opportunities for recreation on the Mill River. To reduce the levels of bacteria within the river, efforts should be made to reduce the prevalence of waterfowl and develop an education and outreach campaign which focuses on pet waste management. The City should implement an illicit detection discharge and elimination (IDDE) program to uncover sources of bacteria in the storm drain system. Septic system status should be assessed throughout the watershed, with particular emphasis on properties adjacent to the river and tributaries, to ensure all systems are in working order.

Nutrients

Location: North Stamford Reservoir, northern watersheds, garden centers, and throughout the watershed in wet weather.

Specific actions: Work with local garden centers and the public as part of a focused education and outreach campaign to reduce nutrient inputs into the river during wet weather. Nitrogen reduction is important for the health of Long Island Sound. Phosphorus is important to limit algal growth within the stream. As with metals, street sweeping and regular catch basin cleanout will also help to reduce excessive nutrient loads to the river.

Objective 6. Restore instream and riparian habitat

Location: Instream at structures, floodplain, wetland restoration, and specific erosion problem areas.

Specific actions: Potential actions include installing fish ladders, removing low-head dams, creating pools and riffles, restoring riparian buffers, stabilizing banks and implementing erosion control measures.

Objective 7. Ensure sufficient low flows for habitat and aesthetics of river

Location: North Stamford Reservoir low flow release, garden center intakes, other private intakes, watershed stormwater infiltration, instream structures (rock weirs, etc).

Specific actions: Implement best management practices and low impact development techniques; work with Aquarion Water Company to increase releases from the North Stamford Reservoir; and address private water intakes, particularly at commercial garden centers.

Objective 8. Promote the City of Stamford's sustainability mission

Location: Throughout the watershed.

Specific actions: Install rain gardens, work with the Mill River Collaborative and Keep Stamford Beautiful, employ educational programs on low impact development techniques, enforce code, develop ordinances, and acquire easements.

Section 6 - Watershed Management Strategies

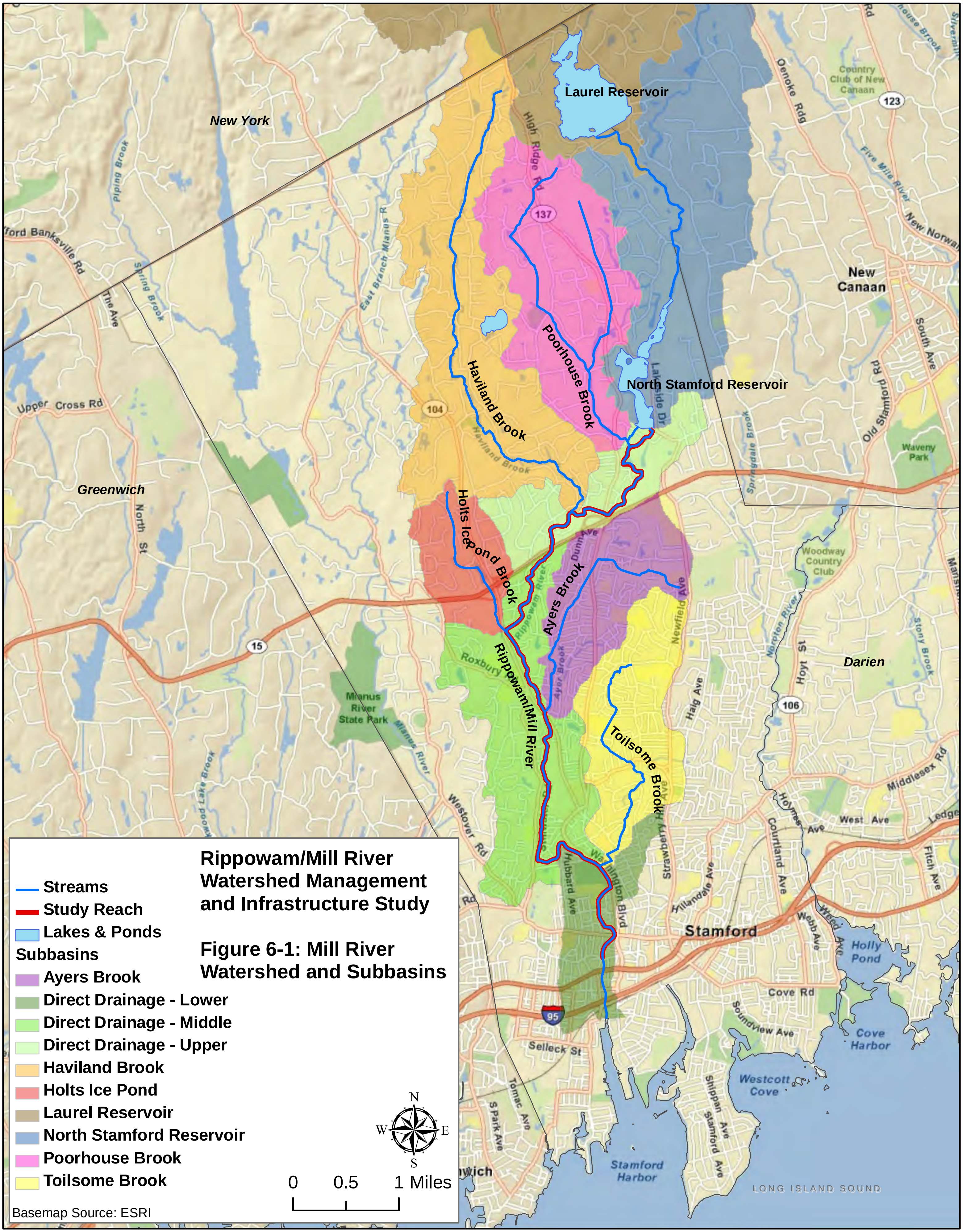
Watershed management strategies are the programs, physical controls, and regulatory mechanisms that support meeting the management objectives of this plan. Strategies may be as simple as increasing the frequency of catch basin cleanouts in high density urban areas or as complex as developing a municipal authority for comprehensive management of a municipal stormwater network. For the City of Stamford, a combination of action items were developed that will address the objectives of this basin management plan.

The selection of the action items were based on the pollutants of concern, which consist of nutrients, metal, and bacteria, and the following objectives described in Section 5:

1. Increase public awareness, educations, and community involvement
2. Improve access and connection to the river, including passive and active recreational opportunities
3. Build a grassroots watershed constituency
4. Control and reduce high flows to promote river corridor health and reduce flooding
5. Improve water quality, specifically: metals, dissolved, oxygen, bacteria, and nutrients
6. Restore instream and riparian habitat
7. Ensure sufficient low flows for habitat and aesthetics of river
8. Promote the City of Stamford's sustainability mission

In order to determine the most appropriate action items for the Mill River watershed, a comprehensive survey was conducted to identify all possible best management practices, low impact development technologies, and ordinances. Once all possibilities were identified, an assessment of each category was conducted to determine feasibility and appropriateness for the City of Stamford, based on the needs of the watershed. When possible, the action items were modeled using the Watershed Management Model (WMM) developed for the Mill River basin.

A total of 29 action items were identified for the Basin Management Plan. The action items are listed below and described in the following section according to the nature of the action item, under the categories of structural controls, nonstructural controls, and programmatic approaches. Several of the action item descriptions reference subbasins within the Mill River watershed. Subbasins are shown on Figure 6-1.



Rippowam/Mill River Watershed Management and Infrastructure Study
Figure 6-1: Mill River Watershed and Subbasins
Streams
Study Reach
Lakes & Ponds
Subbasins
Ayers Brook
Direct Drainage - Lower
Direct Drainage - Middle
Direct Drainage - Upper
Haviland Brook
Holts Ice Pond
Laurel Reservoir
North Stamford Reservoir
Poorhouse Brook
Toilsome Brook
0 0.5 1 Miles
N
S
E
W
Basemap Source: ESRI
Laurel Reservoir
North Stamford Reservoir
New York
Greenwich
New Canaan
Darien
Stamford
Haviland Brook
Poorhouse Brook
Holts Ice Pond Brook
Ayers Brook
Rippowam/Mill River
Toilsome Brook
LONG ISLAND SOUND
Stamford Harbor
Westcott Cove
Cove Harbor
Holly Pond

Structural Controls:
- Rain garden/bioretention area
- Tree filter/street Planter
- Porous pavement
- Green roof
- Sand filter

Nonstructural Controls:
- Removal of low head dams
- Modify North Stamford Reservoir low flow
- Holts Ice Pond remediation
- River bank restoration
- Riparian buffer improvements
- Removal of invasive plants
- Instream restoration
- Public access points
- Designate wildlife protection and viewing areas

Programmatic/Regulatory Mechanisms:
- Waterfowl reduction program
- Pet waste reduction program
- Community participation events
- Reduce improper yard waste dumping
- Website for public education and information
- Educational signage
- Mark stormwater grates with educational message
- Promote better commercial property stormwater practices
- Promote better residential property stormwater practices
- Bacteria source tracking
- Increase street sweeping and catch basin cleaning
- Illicit discharge detection and elimination
- Address private water intakes
- Create Mill River Watershed Association
- Regular monitoring program

6.1 Structural Controls

Structural controls are physical features installed in urban and suburban environments designed to manage stormwater runoff to surface water resources. During rain events, stormwater collects on impervious surfaces such as concrete sidewalks, paved roadways, driveways, parking lots, and building rooftops. Impervious surfaces prevent water from infiltrating into the underlying soil. Water accumulates quickly and must be conveyed from the impervious surfaces to a receiving water body or storage area where it travels in natural waterways or infiltrates into the subsurface.

Surface contaminants which accumulate through daily use of impervious surfaces, such as car oil in parking lots or sand and salt on roadways, are collected by stormwater and deposited in receiving catch basins, outlets, and receiving surface water resources. Over time, surface contaminant deposits accumulate to the detriment of natural habitats and water resources. Structural controls can address the concentration and incidence of surface contaminants introduced to surface water resources by capturing and filtering stormwater before it enters the storm drain system. An array of various structural controls impact different pollutants of concern.

Application of structural controls typically occurs in developed areas where surfaces would otherwise be impervious. For this reason, structural controls may also provide a portion of pervious surface where stormwater may naturally infiltrate into the subsurface. This reduces total flow to the storm drain system, thus reducing the peak flow rate and total output to surface water resources. Overall stormwater volume reduction also exacts less demand on stormwater infrastructure, which results in reduced flooding incidents.

The following section describes the recommended structural controls for the City of Stamford under this plan.

6.1.1 Rain Garden/Bioretention Area

A rain garden or bioretention area is a stormwater management practice that uses soils, plants, and microbes to treat stormwater before it infiltrates into soil or is discharged. In areas where stormwater accumulates quickly and in large volumes, rain gardens capture and collect water that would otherwise be directed to storm drains, accumulate in puddles, or filter downhill onto roadways. Common applications include large impervious areas, such as parking lots and urban centers, where the rain gardens replace landscaped areas.

Figure 6-2. Rain garden in an urbanized area. *Source*: Portland River Renaissance Initiative

Rain gardens are constructed as shallow, depressed areas that consist of dense native plants and soils. When rainfall occurs, directed runoff will accumulate around the organics, creating a temporary pond. Pollutants carried by stormwater are absorbed through the natural biological process of the biota. Once through the system, runoff may be discharged to an engineered drainage system or left to naturally infiltrate into groundwater.

Rain gardens are frequently used in Low Impact Development design as an efficient method of removing total suspended solids (TSS) and other pollutants that accumulate on impervious areas.

Figure 6-3. Vegetated bioretention area in Stamford (photo taken October 2009)

The overall pollutant load reduction that can be expected in the Mill River watershed from rain garden implementation was estimated using the WMM. It was assumed that through education programs the city may expect to capture 10% of runoff through on-site rain garden bioretention. The modeling also assumed that all runoff from Stamford Hospital (8 acres) and half of the city-owned property downtown (5 acres) could be routed through bioretention. **Table 6-1** shows the estimated basin-wide pollutant loading reductions that could be achieved by implementing rain gardens.

Figure 6-4. Descriptive educational sign posted at a rain garden in front of the City of Cambridge Department of Public Works Headquarters, Cambridge, Massachusetts.

Table 6-1. Modeled Pollutant Loading Reduction from Rain Gardens

Pollutant	Estimated Basin-Wide Percent Reduction in Loading
Biological Oxygen Demand	7%
Metals	4 – 7%
Fecal Bacteria	8%
Nutrients	2 – 4%
Sediment	7%

Costs vary significant depending on the size and capture area of the rain garden. An average cost range of $25,000-$51,000 per acre of tributary area, combined with the modeling assumptions described above, yields a total cost estimate of $7.4 to $15.1 million to achieve the reductions listed in Table 6-1 (CRWA, 2010; CWP, 2007). It is important to consider that this cost would be shouldered by various entities to build the individual rain gardens, including commercial property owners, residential homeowners, and the City for municipal projects.

6.1.2 Tree Filter/ Street Planter

Tree filters and street planters are a stormwater management practice that captures and treats stormwater runoff in urban areas. Similar to rain gardens, this is accomplished by using urban tree plantings, or vegetated curb plantings, as an opportunity to install a subsurface treatment system. Runoff from streets and sidewalks is directed to a subsurface pre-treatment device such as baffle box (a square, sectioned chamber connected to a storm drain) at the edge of a roadway where grit and oil from stormwater are removed. From this device, water flows to infiltration planters which typically contain bioretention filter media. The treated water then infiltrates into the ground or discharges to the storm drain system.

A less sophisticated version of this would be an urban tree or mini-planter system. Trees are typically installed along sidewalks for aesthetic reasons, but may also function as small rain gardens and treat stormwater through filtration. Artificial filters and/or infiltration basins, as described above, may be used to add additional stormwater runoff capture and treatment.

Figure 6-5. Extensive street planter along roadway in urban space. *Source*: CDM Smith Harvard University project

The overall pollutant load reduction that can be expected in the Mill River watershed from tree filter implementation was estimated using the WMM. It was assumed that the city may expect to capture 25% of runoff from impervious/urban land cover in the Ayers Brook subbasin and 6% of the runoff from impervious/urban land cover in the downtown subbasin. **Table 6-2** shows the estimated basin-wide pollutant loading reductions that could be achieved by implementing tree filters.

Table 6-2 Modeled Pollutant Loading Reduction from Tree Filters

Pollutant	Estimated Percent Reduction in Loading	
	Ayers Brook Basin	Downtown Basin
Biological Oxygen Demand	2%	2%
Metals	0 – 2%	0 – 2%
Fecal Bacteria	<1%	<1%
Nutrients	0 – 2%	1 – 2%
Sediment	2%	2%

Costs vary significantly depending on the size and capture area of the tree filter. An average cost range of $152,000 to $178,000 per acre of tributary area, combined with the modeling assumptions described above, yields a total cost estimate of $3.0 to $3.6 million to achieve the reductions listed in Table 6-2 (CRWA, 2010; CWP, 2007).

6.1.3 Porous Pavement

Porous pavement is an effective stormwater management practice that provides water quality treatment and water quantity control in otherwise largely impervious areas. On most paved surfaces, large volumes of rainwater collect particulates which accumulate on the paved surface while being diverted to a storm drain system, and eventually empty into natural water systems. When rain falls on porous pavement, it drains directly through the pavement and infiltrates into the subsurface, preventing large volumes of rain and particulates from entering natural systems.

Figure 6-6. Porous pavement parking lot constructed as part of the CDM Smith Hartford Green Capitals Project

Rainfall drains through porous pavement and aggregate layers where small particulates are filtered out. Some designs also include and infiltration reservoir comprised of larger media to allow additional treatment and storage prior to discharging to an overflow inlet, catch basin, or infiltrated directly into subsoil. In areas where infiltration is not permitted, in the case of sensitivity to pollutants or high groundwater, the system may be lined and outfitted with subdrains and conveyance to storm drains.

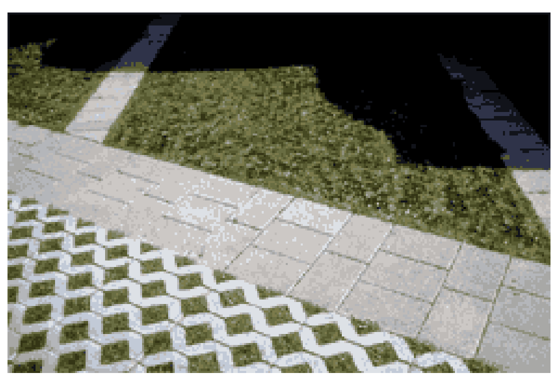


Figure 6-7. Various examples of permeable pavers or pavement brick orientation schemes. Photo courtesy of CDM Smith.

Typical uses of porous pavement include parking lots, low-use roadways, sidewalks, and commercial developments. Similarly designed systems may include porous asphalt or block modular and grid pavers, where water infiltrates in areas between blocks composed of concrete, porous concrete, brick, stone, or recycled plastic. These systems and their usage are highly variable and depend on the aesthetic, structural, or budgetary limitations of a project. However, all types of permeable paving must be used in areas with low vehicle volumes and low speed, making them ideal for parking lots, sidewalks, and bike paths.

The overall pollutant load reduction that can be expected in the Mill River watershed from porous pavement implementation was estimated using the WMM. It was assumed that the city could apply porous pavement to 10% of parking lots within commercial and high-density residential land covers within the watershed. **Table 6-3** shows the estimated basin-wide pollutant loading reductions that could be achieved by implementing porous pavement.

Table 6-3. Modeled Pollutant Loading Reduction from Porous Pavement

Pollutant	Estimated Basin-Wide Percent Reduction in Loading
Biological Oxygen Demand	4%
Metals	1 – 3%
Fecal Bacteria	<1%
Nutrients	0 – 3%
Sediment	3%

Costs vary significant depending on the size and designated use of the pavement. An average cost range of $192,000-$715,000 per acre of pavement, combined with the modeling assumptions described above, yields a total cost estimate of $20.8 to $77.3 million to achieve the reductions listed in Table 6-3 (CWP, 2007; Tetra Tech, 2009; UNH, 2009). It is important to consider that this cost would be shouldered by various entities to build the individual porous pavement lots, including commercial property owners, residential homeowners, and the City for municipal projects. These costs should also be compared to the cost of traditional resurfacing of the same areas.

6.1.4 Green Roof

A vegetated roof cover, or green roof, is a plant system installed on an otherwise impervious area that is designed to divert or delay stormwater runoff, and insulate commercial, industrial, or residential roof structures. These systems are made of hardy varieties of drought tolerant succulent plants, such as sedum, installed in planters on urban roofs.

When rain falls, water is absorbed by plants and retained within the roof structure. Excess water is released through evaporation, reducing overall peak rate and volume of stormwater runoff from the roof. The biological, physical, and chemical processes found in the plant and soil complex reduce overall impact to the urban storm drain system.

Figure 6-8. Green Roof at the Children's Museum in Boston, Massachusetts. *Source*: Photo provided by laurenmetter.com

As a secondary benefit, green roofs and rooftop gardens, may serve as an aesthetic and culturally appealing aspect of highly urban environments and are often used in public settings to increase awareness and education of stormwater needs.

The overall pollutant load reduction that can be expected in the Mill River watershed from green roof implementation was estimated using the WMM. As shown in table 6-4, the overall pollution reduction potential of green roofs in the city is small. However, the public awareness and education aspect of these features may compensate for the shortcoming in overall coverage. A fairly aggressive assumption was made in the model that every building in the city with a footprint greater than 10,000 square feet would have a green roof. **Table 6-4** shows the estimated basin-wide pollutant loading reductions that could be achieved by implementing the green roofs.

Table 6-4. Modeled Pollutant Loading Reduction from Green Roofs

Pollutant	Estimated Basin-Wide Percent Reduction in Loading
Biological Oxygen Demand	1 – 2%
Metals	1%
Fecal Bacteria	1%
Nutrients	1%
Sediment	1 – 2%

Costs of green roofs vary significantly depending on the size and type of application. An average cost range of $240,000 to $1.3 million per acre of roof, combined with the modeling assumptions described above, yields a total cost estimate of $6.0 to $34.0 million to achieve the reductions listed in Table 6-4 (CWP, 2007). It is important to consider that this cost would be shouldered by various entities to build the green roofs, including private building owners for commercial projects and the city for municipal projects.

6.1.5 Sand Filter

Similar in structure and size to small detention ponds, sand filters are designed to direct stormwater to a location where it infiltrates into the subsurface or into a pre-filter for a storm drain system. Typical applications include urban areas where limited space is available for stormwater management infrastructure, in areas with a high groundwater table, or where soils are relatively impermeable. Sand filters are also effective in removing oil and grease often collected in runoff from vehicle storage or parking areas.

Figure 6-9. Sand Filter in an urban park. *Source*: Unknown.

Basic sand filter design consists of an upper gravel or rock layer underlain by coarse to medium sand. However, more sophisticated or engineered structures are available. In areas where storage is necessary, pretreatment occurs in a subsurface settling chamber where large debris settles to the bottom of the tank. A second chamber containing a sand filter further removes smaller particles before water is either discharged to the existing drainage system or infiltrates into the soil.

Use of sand filters improves both stormwater quality and reduces runoff volumes through filtration of particulates and diversion or delay of peak flow. These improvements not only reduce the incidence of backups, but also reduce the pollutant load on receiving streams, ponds, and other water resources where stormwater is discharged.

The overall pollutant load reduction that can be expected in the Mill River watershed from sand filter implementation was estimated using the WMM. It was assumed that the city could capture 25% of the runoff from the High Ridge Rd commercial area in Ayers Brook Basin and 5% of runoff from impervious surface downtown through sand filters. **Table 6-5** shows the estimated basin-wide pollutant loading reductions that could be achieved by implementing sand filters.

Table 6-5. Modeled Pollutant Loading Reduction from Sand Filters

Pollutant	Estimated Basin-Wide Percent Reduction in Loading
Biological Oxygen Demand	4%
Metals	1 – 3%
Fecal Bacteria	2%
Nutrients	0 – 2%
Sediment	3 – 4%

Costs vary significant depending on the size and capture area of the sand filter. An average cost of $91,000 per acre of tributary area, combined with the modeling assumptions described above, yields a total cost estimate of $1.8 million to achieve the reductions listed in Table 6-5 (CWP, 2007). It is important to consider that this cost would be shouldered by various entities to build the individual sand filters, including commercial property owners and the City for municipal projects.

6.2 Nonstructural Controls

Nonstructural controls are programs which address management issues related to human activities that affect the water quality of the Mill River and its surrounding watershed. Programs may include maintenance to the river, citizen participation, adjustments to municipal services, and/or cooperation with private industrial property owners to address activities or conditions which negatively affect the river. Program-level controls and participatory activities are long-term development opportunities which will improve water quality over time.

Examples of program improvements include removal of low head dams, municipal and industrial maintenance and operations programs, illicit discharge detection and elimination (IDDE), identification and removal of private water intakes, and regular water quality monitoring. Citizen action can be utilized for organized management activities that require volunteer support, such as limited river bank restoration activities, removal of invasive plants, river cleanups, and limited instream restoration activities. Education and outreach positively influence stormwater improvements by focusing on pet waste reduction, yard waste management, and riparian buffer improvements on residential properties. Waterfowl reduction, educational signage near rivers, and improvements to public access also support continued resident involvement and ownership of urban surface water resources. If possible, developing a citizen-based watershed association would provide an authority with which to drive such programs.

The following section summarizes the nonstructural control action items recommended under this plan and outline cost considerations for implementation. Refer to Section 6.4 for cost estimates.

6.2.1 Removal of Low Head Dams

Uninterrupted flow within a river is crucial to sustaining healthy habitats, maintaining consistent temperatures, and preserving fish and benthic population migration patterns. Barriers that limit natural flow negatively affect the river by impeding sediment flushing, limiting aquatic species migration, and increasing aeration, all of which are detrimental to maintaining healthy aquatic habitat.

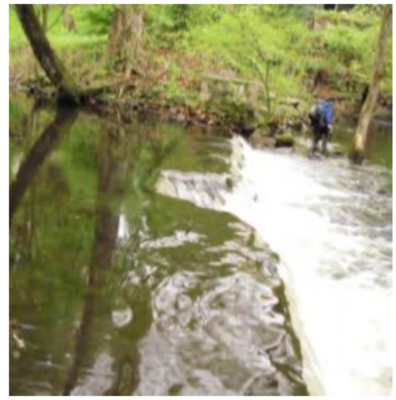


Figure 6-10. Low head dam on the Mill River

Since development along the Mill River in the 17th century, several low head dams have been constructed to provide water as a resource for industrial activities. Over time, the industrial entities have closed down while several low head dams remain in place.

A low-head dam removal program could improve the water quality and aquatic habitat within the river, increase sediment flushing, and allow reestablishment of migration patterns. Such a program could involve a study to assess removal options and anticipated cost of each option, design, sediment removal including physical removal, treatment, and disposal, water quality and sediment monitoring, and riparian buffer improvements.

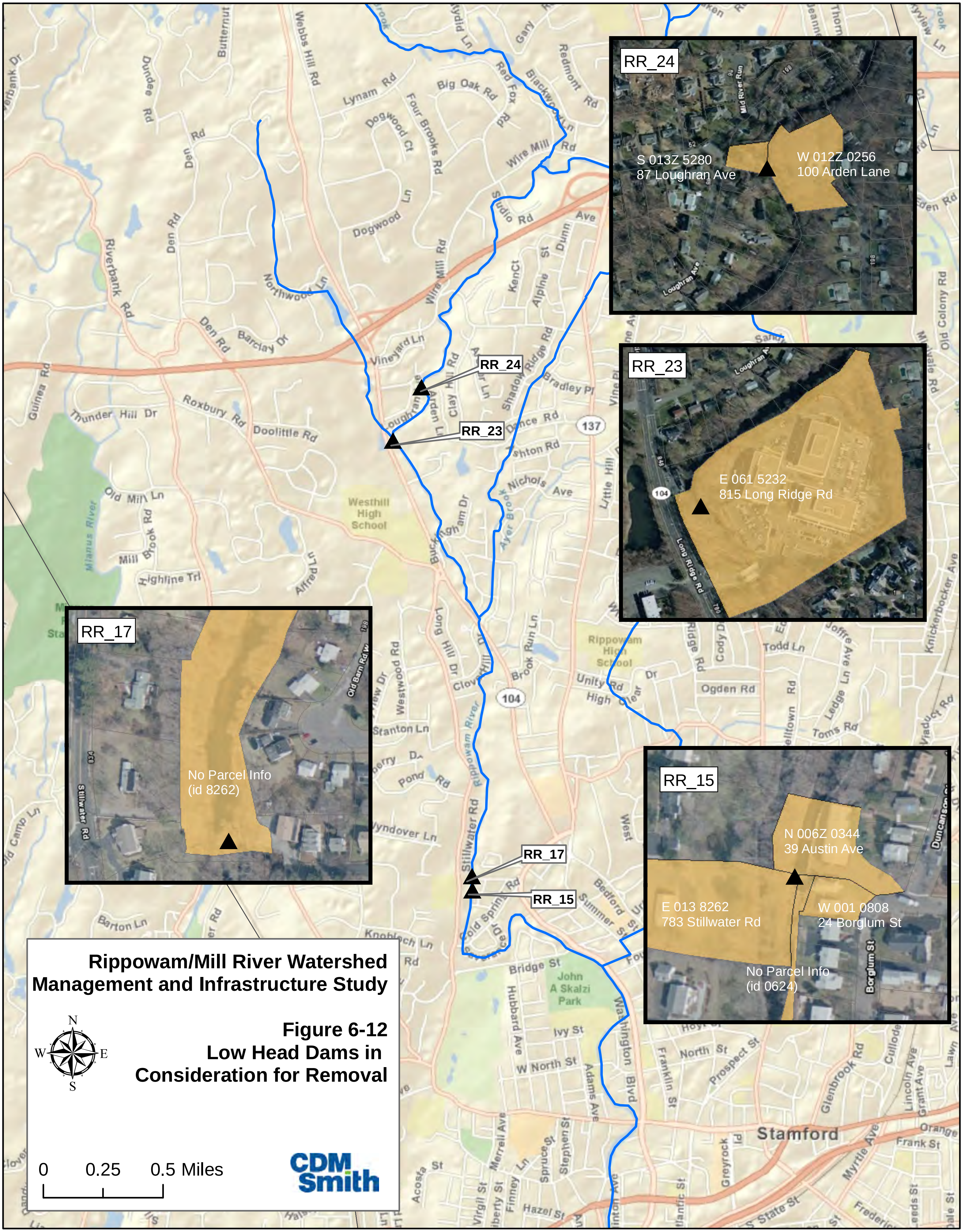
Figure 6-11 shows the locations and adjacent land parcels for the low-head dams within the study area that are candidates for removal.

6.2.2 Modify North Stamford Reservoir Low Flow Outlet

Figure 6-11. North Stamford Dam low flow outlet

The current low flow outlet from the North Stamford Reservoir discharges water at a few cubic feet per second directly to the Mill River. The outlet flow often has very low dissolved oxygen, especially in the summer months when the reservoir is likely stratified and the discharge is released from the hypolimnion (lower zone of cold, oxygen-depleted water). The low flow outlet discharge is aerated fairly quickly within the Mill River to more acceptable levels of dissolved oxygen under the current low flow release. However, should the release be increased, the low dissolved oxygen would cause habitat degradation.

There are two options for increasing the dissolved oxygen in the low flow discharge: 1) relocating the take point to a higher elevation within the reservoir or 2) introducing oxygen to the water after discharge. Relocating the take point would likely be more costly than designing post-discharge aeration. Either strategy will require an active management strategy



Rippowam/Mill River Watershed Management and Infrastructure Study

Figure 6-12
Low Head Dams in Consideration for Removal

between the City of Stamford and Aquarion Water Company, the owner and operator of the reservoir. An additional study should be done to assess current conditions, characterize the impact of the discharge on the immediate and further downstream reaches, and identify strategies that can be employed to improve flow and water quality conditions for the benefit of the Mill River. Cost for either option would involve a study, design, and construction. Construction for option 1, which would relocate the discharge outlet, would be significant in comparison to option 2, which would incorporate aeration mechanisms within the stream, downstream of the outlet.

6.2.3 Holts Ice Pond Remediation

Holts Ice Pond was identified as an excessively impacted water resource in need of pollutant mitigation. The pond is eutrophic, meaning that excessive nutrient loads have resulted in excess algal growth. The excess algae prevent the pond from supporting a healthy ecosystem. The pond also discharges excess nutrients and algae to the mainstem Mill River during storm events. Uncontrolled nonpoint source loading and a long residence time within the pond are the causes of the pond eutrophication.

Remediation programs can be focused and basic, with limited benefits, or complex and far-reaching, for maximum benefits. Such a program should include consideration for downstream affects of Holts Ice Pond on the Mill River along with current and future use of abutting properties. Planning should be done to collaborate with adjacent property owners to reduce the affects of land use, including applications of fertilizers and other chemical treatments, on the Mill River.

There are two options to address the Holts Ice Pond impact on the Mill River. The first option is source control, which would include remediation of the entire pond, including removal of excessive sedimentation, through a comprehensive study, design, and construction/ implementation with buffer improvements. The second option is to address the discharge from the pond, rather than attempt to control the nonpoint sources and improve the pond itself. Under this option, the City could work with land owners along the channel that carries water from the pond to the Mill River to install constructed wetlands. Wetlands would provide nutrient uptake and mitigate high flows from the pond during storm events.

Figure 6-13 and **Figure 6-14**. Holts Ice Pond Extreme Algal Growth in Summer

6.2.4 River Bank Restoration

Unstable river banks are detrimental to the habitat, ecology, water quality, and natural geomorphology of a river. Bank instability is caused by land development, high intensity storm flows, and channel modifications. Unstable banks can release large volumes of soil and sediment during wet weather events. As soil saturation increases during a rain storm, bank stability decreases. Erosion of the bank results in sediment being carried downstream, where it will settle and degrade habitat. Bank erosion is dynamic and armoring the edges of one river reach will cause erosion elsewhere. Erosion results in water quality degradation, habitat loss, and property loss.

River bank restoration can include easing steep slopes and armored banks and increasing rooted plants to reinforce the embankment strength. This will decrease erosion and deposition, which will improve benthic and aquatic habitats, and improve the overall water quality in the river. Riparian buffer improvements, in addition to bank restoration, will increase the longevity of repairs. To implement such a program, overall cost is dependent on the height of the stream bank, the severity of armoring or erosion, and the method used to stabilize the stream bank. In general, the cost to repair river banks along the Mill River could range from $350 to $1000 per linear foot. Visual surveys of the study reach concluded that approximately 50% of the stream banks, on both sides, are armored. This is an indication of extensive need for bank restoration. The cost range for restoring 10% of the banks of the Mill River, based on linear feet of restoration and considering both sides of the river, would be $2.8 to $7.9 million.

Figure 6-15. Eroded stream bank along Mill River

6.2.5 Riparian Buffer Improvements

Riparian buffers provide filtration for sediments and particulates, add structural reinforcement to river banks, and reduce and delay the peak flow in the river. When development such as residential homes, streets, bridges, buildings, and parking lots encroach on a river, riparian buffers are often diminished.

Figure 6-16. Healthy riparian buffer and shaded stream area in Mill River

Figure 6-17. Lack of riparian buffer showing bank erosion in Mill River

A healthy riparian buffer includes a mix of native grasses, shrubbery, and trees. Vegetation helps to more evenly distribute overland runoff flow, absorb nutrients and excess water, and control concentrated runoff. Trees aid in stabilizing river banks and provide shade, reducing water temperature and providing a more suitable habitat for aquatic animal and plant species. Incorporating these elements into public land areas and encouraging residents to do the same will make a substantial difference in the quality and quantity of stormwater inputs the Mill River receives. Overall cost for this program is estimated to be minimal as cost would be voluntarily incurred by informed residents, the City, and proactive commercial land owners along the river. Cost per property and maintenance is also estimated to be minimal if native grasses, shrubbery, and trees are planted.

6.2.6 Removal of Invasive Plants

Removal of invasive plant species is essential to river habitat restoration. Non-native species endanger the environments they invade by displacing native species within the same ecological niche. This causes a ripple effect up the ecological food chain, a lack of biodiversity in the area, and alterations to the physical and chemical properties of the river.

Figure 6-18. Japanese Knotweed in bloom
Source: University of Connecticut Eastern Forest Environmental Threat Assessment Center

The invasive species known as Japanese Knotweed (Polygonum cuspidatum) was found in abundance along the Mill River. This invasive species is commonly found in areas along stream banks and roadways which are not regularly maintained. It was originally introduced in the United States for erosion control because of the species' ability to grow in a variety of soil conditions and thick underground root system which will grow back even after the plant has been cut down.

The Japanese knotweed can grow to 10-feet in height and can inhabit a variety of adverse conditions including full shade, high temperatures, high salinity, and drought. Japanese knotweed poses a significant threat to riparian areas, where it can survive severe floods and rapidly colonize scoured shores and islands. Once established, populations are extremely persistent.

In the Mill River basin, this species poses a threat because it spreads quickly, takes over entire areas, impedes access to the river, and chokes out other natural species necessary to maintain a healthy habitat. Removing these plants will make room for native plants to reestablish themselves. Currently, the City organizes annual volunteer cleanup events which remove this invasive species along the river. The cost for continuing this program is based on maintaining supplies, educating volunteers, and transporting and disposing of the plants and is estimated to be minimal.

6.2.7 Instream Restoration

Instream restoration is a broad category of improvements which may be made to enhance the quality of a stream by improving the hydrologic, geomorphic, and ecological processes of a degraded watershed system and/or replacing compromised elements of the natural river system.

In areas where fish habitat has been compromised, the habitat can be enhanced by placing materials, such as large pieces of wood or boulders, into the stream channel to increase pooling and change the

Figure 6-19. Excessive large and small debris jamming Mill River

hydrologic cycle of a specific area. Other instream restoration techniques include increasing tree plantings along the riparian zone to offer shade to otherwise exposed river areas. Or the channel itself could be dredged or manipulated in order to address specific processes which connect and sustain fish and aquatic life habitats, as appropriate, to meet the specific habitat needs of native aquatic life populations.

Within the Mill River, high sedimentation and excessive debris dumping has caused buildup throughout the stream bed, choked benthic animal and aquatic plant life populations, and altered the hydrology of the river. Debris removal should be the first step in a stream restoration program for the Mill River. The river will respond to changes in flow patterns, seeking equilibrium in its new geometry. Therefore, it is not advisable to produce major changes within the channel without a detailed geomorphological assessment of the expected outcome.

The cost for improving instream habitat is comparable to that of river bank restoration and will require minor site-specific study (to supplement results from the geomorphology study completed in 2010), design, and construction. Construction costs could include equipment access pathways, and replanting, to the river, structural reinforcement, biological plantings, and removal of trash and debris.

6.2.8 Public Access Points

Recreational activities provide residents with an opportunity to utilize all of the benefits that local resources have to offer. Public access to the water resource is an essential component to establishing the community relationship with a local water source. Access points for canoes, kayaks, and fishing will provide the community with an added incentive to maintain, preserve, and protect the river.

Figure 6-20. Public amenities along the Charles River in Boston, MA

Public access points could be installed in park areas or along the river in locations where there is enough space to park multiple vehicles and transport personal watercraft to the river using a clearly designated, spacious pathway. Signage should designate the parking area, the boat access point, and list any local ordinances and use limitations, such as limited motorized watercraft and operation hours. The new downtown Mill River Park (the former Mill Pond area) would be an excellent site for river access, particularly fishing and wading. There is a potential access point that could be developed off Buckingham Road in the middle watershed. An existing access point from the road to the floodplain at this location could be better maintained and a small boat launch may be possible. Cost of site selection and procurement, study, design, and construction of an individual public access points is highly variable and dependent on the cost of property.

6.2.9 Designate Wildlife Protection and Viewing Areas

Designated wildlife viewing areas offer an opportunity for members of the community to participate and engage in the well being of their local water resource. Such designated viewing spots could be installed along walking pathways, bike trails, parks, and other water access points. In general, wildlife viewing points require little site preparation and little infrastructure to complete. They can be as simple as a park bench and small sign in a park and incur a minimal investment to develop.

Figure 6-21. Bird watching is a passive recreational activity that promotes habitat protection and watershed stewardship. Photo courtesy of CDM Smith.

Wildlife protection areas are designated parcels of land that are intentionally preserved and undeveloped to benefit local wildlife populations. Local wildlife in Stamford includes many species of birds, small mammals, reptiles, invertebrates, amphibians, and deer. Protection areas could be designated with support from local property owners and the CT DEEP. Cost of siting and installation of basic signage and seating areas for viewing areas is generally estimated to be minimal.

6.3 Programmatic and Regulatory Mechanisms

Program-scale improvements are long-term opportunities to address water quality in Mill River and associated tributaries. These recommendations include program ideas that will improve the overall watershed health or address specific areas of concern. They are driven both from the top down and from the bottom up. The city can develop ordinances to enforce some programs, but others should be grass-roots efforts initiated by conscientious citizens of the watershed. Estimated costs associated with these programs are anticipated to be incorporated within current municipal costs. Refer to Table 6-6.

6.3.1 Waterfowl Reduction Program

Canada geese and ducks are common throughout the region during warm weather and throughout the year. Flocks congregate along surface water sources including streams, rivers, and ponds to hunt, nest, and graze. While they can be perceived as a pleasant sight in populated areas where contact with wildlife is limited, large groups of waterfowl can overpopulate a limited area and pose a threat to native species and residents, and can severely affect water quality in the boundary water resource. In addition, Canada Geese are not historically native to the northeast and have been introduced in the last hundred years as a result of a defunct hunting and repopulation program.

When waterfowl congregate in large populations, particularly in parks which are free of natural predators, water is available, and residents choose to feed them, they tend to overtake an area and build residence. Over time, they can become territorial, particularly when goslings are young. Because food is plentiful and there are no natural predators, there is no control for the population and it continues to expand to the point of overpopulation.

Figure 6-22. Canadian Geese along the Mill River

The largest threat to the Mill River is the large amount of waste produced by the large waterfowl populations. Waste is washed by rainfall runoff from grassed areas to the river, substantially increasing nutrient and bacteria levels, promoting algal growth, and severely degrading the resource. The monitoring program discovered high levels of bacteria within the Mill River, and waterfowl are a likely contributor.

Figure 6-23. Informative sign posted along the Charles River in Boston, Massachusetts

Waterfowl overpopulation is a common problem in areas throughout the country, and particularly in the northeast. A great amount of work has been done by municipalities to identify and mandate programs which manage these populations. A common partner organization to municipalities and watershed groups is GeesePeace, which is a 501(c3) non-profit corporation. Examples of municipal programs include stakeholder involvement, property owner engagement, training seminars, population stabilization, site aversion through use of a trained canine, mandated no feeding regulations, community outreach and education, advertising, public service announcements, educational videos, and posted signage.

In addition to waterfowl population reduction tactics, site work can be employed to limit the effects of excessive waste to a water body. Planting native grasses and other low-lying plants in an open space, particularly along the shore of a river or pond, will provide a buffer which catches and filters waste before it enters a water body. Such plantings also limit direct access to the water and can make waterfowl nervous, since the grass provides a cover for potential predators. Implementation of such a program is estimated to be minimal, but could be more costly depending on the level of effort required to improve signage and limit waterfowl access.

6.3.2 Pet Waste Reduction Program

Unmanaged pet waste can accumulate on the ground surface and wash off in rainfall runoff, leading to increased levels of bacteria in receiving waters following a storm event. Pet wastes may also introduce viruses and parasites to receiving water bodies, threatening public health. Pet waste is also unsightly and can deter use of public space.

Figure 6-24. Pet waste advisory sign and free pick-up bags in Stamford

Active municipal management for pet waste reduction is a two-fold process which involves education and outreach in addition to local ordinance development and enforcement. The first step is to develop an awareness campaign that champions proper pet waste removal. Education and outreach could involve informative handouts, signage, directed mailings for licensed owners, participation in community events, establishment of a local dog owners club, and presentations to local community groups and schools that stress the importance of proper pet waste disposal.

In addition to awareness and education, designating spaces for pet walking, pet curbing, and pet socializing will encourage pet owners to maintain shared public pet spaces. Such spaces could offer water, waste pickup bags, and trash containers in commonly visited public spaces such as parks and city-owned grassed areas. Over time, such spaces in other cities have been known to provide a physical space for local pet owners to congregate and develop connections with their neighbors, increasing pride and connection to their community.

The second aspect of pet waste reduction is development and enforcement of local ordinances that punish pet owners who do not properly dispose of pet waste. The level of investment is highly dependent on the severity of the issue and the level of impact pet waste has on local water resources. Fines can range from $25 for first time and up to $500 for repeat offenders. However, enforcement is highly dependent on witnessed incidents, which can be difficult and costly to regulate. Cost for implementation of a pet waste reduction program will include cost for bags, signage, waste receptacles, and enforcement. A portion of these costs could be offset through noncompliance fines.

6.3.3 Community Participation Events

Annual river cleanups sponsored by local watershed groups have been effective in many communities throughout the country as an activity that not only benefits water quality, but also improves the connection residents have to their local water resources. These cleanups incur a minimal cost for basic supplies – such as trash bags, rakes, and temporary signage - and provide regular maintenance to an extent beyond what could be accomplished by municipal employees alone. Coordination and setup is also minimal, and can generally be done on a volunteer basis.

Annual cleanups also provide an opportunity for community members to meet one another, develop a connection with the river, and increase pride in their community. River cleanups engage local schools in waste pickup, increase awareness of littering, and inspire neighborhood groups to team up and represent their organizations. Such an event could also engage local business owners through sponsorship opportunities and designated company team cleanup areas, providing an opportunity for social engagement, collaboration among employees, and increased presence of the business within the community.

In addition to cleanup events, it is important for residents to also establish a positive long-term relationship with the Mill River. Opportunities for hands-on participatory activities that improve the landscape, such as native species plantings or park renovations, allow residents to provide long-lasting impressions on the watershed. Such activities could be coordinated with local schools to provide an avenue for students to develop stewardship over the well being of the natural environment. Costs to conduct such programs are minimal and rely heavily on volunteers and donated supplies.

Figure 6-25. CDM Smith employees clean up the Potomac River in Virginia as part of an annual volunteer cleanup event

6.3.4 Reduce Improper Yard Waste Dumping

Yard waste is composed of leaves, grass, brush, weeds, and organic trimmings pulled from plants on residential properties. In Stamford, yard waste is accepted at the Scofield Town landfill. The service is free for residents who arrive in their personal vehicle and at the cost of approximately $80 per ton for commercial vehicles. In the fall, leaves are picked up by the city starting in the second week of November. Specific dates for city-wide pickup are posted on the city website and in the *Stamford Advocate* starting in early November.

Figure 6-26. Grass clipping disposal along banks of Mill River

Connecticut law requires all residential, commercial, and public/private agencies, including institutions such as schools and hospitals, to compost leaves. In most cases, this requires the entity to hire a private hauler. Residents, however, can choose to utilize city services which often include free pickup during peak leaf season or may choose to compost leaves on their property. Grass clippings can be left in place on the lawn or brought to an accepting recycling center.

However, residents often do not properly care for their yard waste. This is particularly evident in rural areas or areas along river banks where leaf piles are common. Improper yard waste dumping along river banks is against state law and it is harmful to the health of the local water resource.

Improper yard waste dumping along river banks introduces excess organic waste material and sediment to the water body. As deposited leaves decay, the process consumes dissolved oxygen in the water, creating a habitat unsuitable for aquatic species. The decomposition process also releases nitrogen and phosphorus which promote algal growth in water.

In addition to water quality concerns, sediment and erosion as a result of improper yard waste disposal can have a detrimental effect on water resources. When yard waste accumulates due to dumping, it can prevent natural vegetation from growing. This leads to unstable embankments, inhibits drainage, and promotes erosion.

Improper disposal is not limited to border properties along stream banks; leaves and yard waste should not enter storm drains. Yard waste piles left uncontained on the curb will wash to storm drains during rain events and clog the system. This leads to increased maintenance costs for the city and water quality degradation due to decreased drain system functionality.

Figure 6-27. Leaves discarded along roadway drainage route in Mill River watershed

To address improper dumping of yard waste, the City should educate residents of the detrimental effects of poor disposal practices on water resources and their property boundaries. Proper embankment management, consisting of native tree and brush plantings and maintenance, should also be part of a local education and outreach campaign. If necessary, local enforcement of state law is also an option. Cost for implementing such a program is based on developing local ordinances and setting up enforcement strategies, and may be offset through fines.

6.3.5 Develop Website for Public Education and Information

Websites are an invaluable resource for the public to learn more about local initiatives related to watershed management, best practices, education, and outreach campaigns. Developing a web presence in some capacity is an essential component of any citizen campaign, particularly for campaigns that are complex or require some level of participant training. Websites also provide legitimacy to an outreach program, particularly when managed by a volunteer organization, by offering more information on group affiliations and how the organization is structured.

The website could be developed specifically by a Mill River watershed association or a webpage could be incorporated into the existing city of Stamford website. In both cases, there are a variety of companies that specialize in environmental communications and campaigns that could assist with the development of these resources. In addition to a webpage, live updates in the form of a blog, Twitter account, Facebook page, or general interest electronic mailing list could be another resource to connect watershed constituents to the mission of improving the river.

The cost for developing a website is dependent on where the website will be hosted. If the website is hosted through the City website (this is considered option 1) the cost will be minimal and may be shared with typical web hosting costs that the City incurs on an annual basis. If, however, the website is hosted separately from the City webpage, costs could be more substantial, as shown for option 2 in Table 6-6.

6.3.6 Educational Signage

Figure 6-28. Example of educational signage from Charles River reservation in Boston, Massachusetts

Educational signage in public spaces along the river provides an opportunity for community members who use access points, recreational walking or biking paths, or park areas to learn more about their local natural resources. Such signage could include a map of the park trails, photographs of park development or historical use, a description of the history of the local area, or information on local animal or plant species. Signs can also be used to designate protected species areas or to educate citizens on local regulations such as picking up pet waste or not feeding waterfowl.

However they are used, signs are an opportunity to communicate with the public who use natural spaces and could be applied in a variety of locations and conditions to maximize resident cooperation with resource protection. Cost for designing, siting, and installing signs could be covered by the watershed association donations and sponsors.

6.3.7 Mark Stormwater Grates with Educational Message

In many cities throughout the northeastern United States, storm drains convey wet weather runoff from urban developed areas to surface water resources. Storm drains within the Mill River watershed carry stormwater to tributary streams or directly to the main stem river, which ultimately empties into the Long Island Sound. Many pollutants in stormwater originate far from the catch basin on lawns, streets, and sidewalks. However, depositing substances directly into the drains also pollutes the water. Potential direct pollutants include pet waste (bacteria), volatile compounds from paints and solvents, metals and oil from vehicles, leaf or yard waste, phosphorus from detergents, and litter. Citizens often confuse storm drains with sanitary sewers, thinking that what goes down a storm drain ends up in the same place as what goes down the toilet or sink drain. In Stamford, where these systems are separate, outreach is needed to educate citizens on how the city's infrastructure functions.

By marking stormwater grates with educational messages that communicate the end output of the drain system, citizens' awareness of the potential pollution route increases. Generally, this decreases improper storm drain disposals, but more importantly it reminds people that everyone lives and works within a watershed, which is the first step to fostering stewardship for community water resources.

Figure 6-29. Example of storm drain stencil. Source: Unknown

In Stamford, Boy Scouts have volunteered to mark catch basin grates that drain to the Long Island Sound. A broader campaign, involving additional volunteer groups, would expand this beneficial pollution mitigation and public education endeavor for a minimal cost. The City may also choose to install permanent signs in concrete sidewalk areas downtown where higher pedestrian traffic provides more visibility for educational signage and aesthetics are more important.

6.3.8 Promote Better Commercial Property Stormwater Practices

Commercial property owners could play a large role in stewardship of the Mill River by adopting low impact development strategies which offset the negative effects of an impervious developed area. This can be done by combining several strategies and making those strategies visible to the public.

Figure 6-30. Stormwater detention site with educational signage at City of Cambridge, Massachusetts Department of Public Works building

Figure 6-31. Large commercial parking lot in Stamford: a good opportunity for stormwater best management practices

Depending on the use of a commercial site, improved stormwater practices could include: porous pavement, porous pavers, rain gardens, a green roof or roof garden, tree planters, and buffer gardens.

The City of Stamford, in partnership with community groups and/or the Mill River watershed group, should work in partnership with local commercial property owners to connect them with resources and information necessary for the development of improved stormwater practices at commercial sites. The City can also adopt ordinances and incentives for commercial developers to use low impact development techniques. Cost for such improvements would be incurred by commercial property owners.

6.3.9 Promote Better Residential Property Stormwater Practices

Stamford is primarily a residential community and improved management of stormwater runoff from residential properties is an important component of this plan. Residential stormwater best practices could include low impact development strategies and best management practices, such as green roofs or rooftop gardens, incorporation of porous materials in driveways and paved property areas, incorporating rain gardens at roof leader outlets, planting natural buffer areas between manicured lawns and river embankments, properly managing leaf and yard waste, minimizing use of fertilizers and pesticides, and developing a general awareness of how household practices could affect river water quality.

Improving residential stormwater practices will require collaboration between the City of Stamford and the local watershed constituency. Education and outreach materials, events, presentations, web-based information resources, and participatory workshops will be necessary to spread awareness and understanding of best management practices, available resources, and connections with local professionals. While not all residents will actively participate in such a program, targeted engagement of boundary homes along the Mill River and its tributaries could provide a significant improvement to stormwater practices. The City may also consider developing incentives and rebate programs to assist residents with the financial burden of implementing best management practices and low impact development techniques.

Similar to other voluntary programs, costs for promoting an education and awareness-based campaign is minimal and will likely be incurred by residential property owners. Additional funding could be provided by the city to provide subsidies or reward incentives on an annual basis.

6.3.10 Bacterial Source Tracking

Bacterial source tracking is a scientific method used to determine the origin of bacterial pollution found in surface water resources. Samples collected from the stream are analyzed to determine if the fecal bacteria was produced by a human, wildlife, agriculture, or domestic pet. The technology is well-proven, but generally very expensive.

This information, while expensive, could allow the city to take corrective action against illicit connections and develop a more targeted management approach. For example, knowing that waterfowl are a much larger source of bacteria than dogs would allow the city to target management strategies toward waterfowl control and not expend resources on pet waste programs. Bacteria source tracking results can also provide focus for a city-wide Illicit Discharge Detection and Elimination program. Such a program is costly, but costs are projected to decline as such programs become more commercially viable.

6.3.11 Increase Street Sweeping and Catch Basin Cleaning

Street sweeping and catch basin cleaning have tremendous benefits to receiving surface water sources by preventing sand, salt, litter, metals, volatile organic compounds, oils, fertilizers, pesticides, and other hazardous materials from being introduced to the surface water resource. Proper street sweeping involves vacuum removal of the surface material followed by appropriate disposal.

Figure 6-32. Debris on Stamford residential street that would be removed by street sweeping

Figure 6-33. Poorly maintained catch basin grate in downtown Stamford

Maintaining storm drain catch basins, which can become laden with sediment and debris despite the very best street sweeping efforts, is imperative to ensuring proper functioning of the system. Debris clogging storm drainage routes can cause flooding and can result in higher sediment loads to the river during large storms. Cost for increased street sweeping would be incurred through an increase in current road maintenance budgets.

6.3.12 Illicit Discharge Detection and Elimination

As part of the Phase II MS4 requirements, Stamford is required to develop an illicit discharge detection and elimination (IDDE) program. Currently the City does not have a comprehensive IDDE program. The following is excerpted from EPA's NPDES website[1], giving an explanation of illicit discharges and sources of additional information.

> *Illicit discharges are generally any discharge into a storm drain system this is not composed entirely of stormwater. The exceptions include water from fire fighting activities and discharges from facilities already under an NPDES permit. Illicit discharges are a problem because, unlike wastewater which flows to a wastewater treatment plant, stormwater generally flows to waterways without any additional treatment. Illicit discharges often include pathogens, nutrients, surfactants, and various toxic pollutants.*
>
> *Phase II MS4s are required to develop a program to detect and eliminate these illicit discharges. This primarily includes developing:*

Figure 6-34. Wash water from a commercial car wash discharging down a storm drain is an example of an illicit discharge. *Source*: EPA

[1] http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=3

- *a storm sewer system map,*
- *an ordinance prohibiting illicit discharges,*
- *a plan to detect and address these illicit discharges, and*
- *an education program on the hazards associated with illicit discharges.*

An effective illicit discharge program needs to be both reactive and proactive. The program is reactive in addressing spills and other illicit discharges to the storm drain system that are found. The program must also be proactive in preventing and eliminating illicit discharges through education, training and enforcement.

Additional information on this minimum measure, including the stormwater Phase II regulatory requirements[2] for IDDE and a fact sheet on the IDDE minimum measure[3] is also available.

6.3.13 Address Private Water Intakes

Figure 6-35. Private water intake on the Mill River (May 2009)

An often-overlooked negative impact that land development in a watershed can have on the associated streams is decreased base flow. Increased impervious surfaces reduce the amount of stormwater that infiltrates into the shallow groundwater, therefore decreasing the groundwater-fed base flow in streams. Low flows during dry summer months are natural for a stream, but further decreases in low flows – due to any factor - can be detrimental. The developed watershed of the Mill River causes decreased summer base flows. Private, unregulated withdrawals from the river can decrease these flows further. During field visits and sampling events, staff observed mobile units withdrawing large volumes of water from the river as well as private, permanent intakes along the stream banks. In an effort to preserve the already-diminished baseflow in the Mill River, the city could implement a program to seek out and regulate these private withdrawals. The costs associated with such a program would include associated staffing and administrative costs.

6.3.14 Create Mill River Watershed Association

Many of the topics outlined in this section have discussed the formation of a local watershed association. Watershed associations have proven to be very effective in promoting major cleanup actions and water quality improvements in urban watersheds throughout New England. In order to implement many of the nonstructural controls outlined in this section, the City should consider working in partnership with local community groups to help inspire a community-driven volunteer watershed association for the Mill River.

Figure 6-36. Example of educational signage and park development as part of the outreach/education campaign by Charles River Watershed Association in Boston, Massachusetts.

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[2] http://cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_regulatory.cfm#minmeasure3
[3] http://www.epa.gov/npdes/pubs/fact2-5.pdf

The Mill River watershed association could be responsible for working with the city to: develop web resources, manage outreach and education campaigns, organize river cleanup events, and organize other events, initiatives, and development strategies that would increase water quality and improve the river for the benefit of the community. Development improvements that the watershed association could propose include increased visibility of the river, increased community use and participation along the river through bike paths, walking paths, dog parks, wildlife viewing areas, recreational access points, educational signage, and other long-term strategies that benefit the overall health of the Mill River.

6.3.15 Regular Monitoring Program

A regular monitoring program should be established to gauge the short- and long-term benefits of the action items recommended in this plan. The program should include targeted monitoring of problem areas identified in the Comprehensive Characterization Report and Section 4 of this plan. The monitoring should also include regular collection of water quality samples from throughout the river system to periodically assess the conditions and compare to the baseline established by this study.

Figure 6-37. Winter sample collection on a Mill River tributary

A volunteer monitoring program, with adequate training of field personnel, is a cost-effective approach to this task. Overall annual cost could include equipment (sampling bottles, labels, storage, and monitoring equipment), transportation, sample analysis (which could be supported by the City wastewater treatment facility), and training. In addition, a one-time or occasional routine review of the sampling program could be supported by a consulting firm to provide feedback on water quality, sample locations, and continued advancement of the watershed management program.

6.4 Summary of Action Items

Costs ranges associated with each action item are listed in **Table 6-6** below. Each of the action items described above is summarized in **Table 6-7**. This table lists the relevant report section, the action item name, a short description of the benefits, the category, locations where the action item may be applicable, the parties likely involved in implementation, the activities involved (e.g. design, constriction), the plan objectives addressed by the action item, and the relative cost. Several of the action items refer to particular reach numbers of the study area stream where the action item could be implemented; **Figure 6-38** is a map of the reach numbers. The relative costs are presented in ranges as follow:

Table 6-6. Cost Range Explanation for Implementation of Action Items

Cost Range	Explanation
$	No cost or minimal cost to the city (other parties involved would bear the cost, or the action item would fit in with existing programs
$$	Up to $100,000
$$$	Up to $500,000
$$$$	Greater than $500,000

The cost estimates provided in this document are planning-level estimates; the actual cost of each action item will depend upon many factors outside the scope of this planning effort.

In addition to Table 6-7, Appendix E contains a fact sheet for each action item. These sheets may be useful for public communication, quick reference, or compiling applications for funding (grants and loans).

City of Stamford
Rippowam/Mill River Watershed Study
Table 6-7. Summary of Action Items, Benefits, and Project Objectives

Report Section	Action Item	Benefits[1]	Category[2,3]	Applicability[4]	Parties Involved[5]				Engineering/ Design	Construction	Related Objectives[6]	Relative Cost[7]	Unit
					City of Stamford	Private Entities	Volunteers	Watershed Constituency					
6.1.1	Rain garden/bioretention area	Filter and reduce total runoff and pollutants	Structural BMP	Mall, Hospital, Commercial, Residential and Municipal Properties	X	X			X	X	4, 5, 6, 7, 8	$$-$$$$	Per model assumptions
6.1.2	Tree filter/street Planter	Filter and reduce total runoff and pollutants	Structural BMP	High Ridge Road, Long Ridge Road, Hubbard Area, Mall, Commercial areas, General		X			X	X	4, 5, 6, 7, 8	$$$$	Per model assumptions
6.1.3	Porous pavement	Filter and reduce total runoff and pollutants	Structural BMP	Mall (Long Ridge Rd), Scalzi Park, Commercial/ Residential/ Municipal Properties with impervious surface	X	X			X	X	4, 5, 6, 7, 8	$$$-$$$$	Per model assumptions
6.1.4	Green roof	Filter and reduce total runoff and pollutants	Structural BMP	Mall (Long Ridge Rd), Commercial properties, General	X	X			X	X	4, 5, 6, 8	$$$-$$$$	Per model assumptions
6.1.5	Sand filter	Filter and reduce total runoff and pollutants	Structural BMP	Commercial/ Municipal Properties with impervious surface	X	X			X	X	4, 5, 6, 7, 8	$$$$	Per model assumptions
6.2.1	Removal of low head dams	Removes barriers, allowing species migration and river flow to follow natural patterns	Nonstructural Control	Specific structures identified throughout river	X				X	X	2, 6	$$$	Per Dam Removed
6.2.2	North Stamford Reservoir - modify location of low flow outlet	Higher oxygen content in water flowing to river from North Stamford Reservoir	Nonstructural Control	North Stamford Reservoir Outlet	X	X			X	X	5, 6	$$$$	Total - move outlet
	North Stamford Reservoir - install aeration controls in river			Downstream of Outlet								$$$	Total - reaeration
6.2.3	Holts Ice Pond - source control and pond remediation	Improvements to the hydraulics and water quality of the Holts Ice Pond discharge would reduce its negative impacts on the main river.	Nonstructural Control	Holts Ice Pond	X	X			X	X	4, 5, 6	$$$$	Option 1 - pond remediation
	Holts Ice Pond - discharge remediation			Downstream of Pond								$$	Option 2 - discharge remediation
6.2.4	River bank restoration	Prevents excessive sedimentation and maintains structural borders	Nonstructural Control	General Location			X	X	X	X	5, 6	$$$	Total
6.2.5	Riparian buffer improvements	Buffers mitigate negative effects of stormwater runoff by reducing flow velocity and sequestering pollutants.	Nonstructural Control	Education, Ordinance, General			X	X	X	X	4, 5, 6	$	Annual
6.2.6	Removal of invasive plants	Restores ecological health of river corridor and watershed.	Nonstructural Control	Ayers Brook, Reaches 3-7, Reach 9, General Location			X	X			6	$	Annual
6.2.7	Instream restoration	Restores natural functions of stream.	Nonstructural Control	Reaches 1-2, 3-8, General Location			X	X	X	X	4, 6	$$$	Total
6.2.8	Public access points	Improve public accessibility and awareness though park areas, boat launches, and walking pathways.	Nonstructural Control	Reach 10, Scalzi Park, General	X			X	X	X	1, 2	$$	Annual
6.2.9	Designate wildlife protection and viewing areas	Improves public accessibility and awareness.	Nonstructural Control	Reach 18, Scalzi Park, General	X			X			1, 2, 3, 6	$	Annual
6.3.1	Waterfowl reduction program	Reduces source of bacteria pollution.	Programmatic/Regulatory	Education, Reach 1, Scalzi Park, General Location	X		X	X			1, 2, 5	$	Annual
6.3.2	Pet waste reduction program	Reduces source of bacteria pollution.	Programmatic/Regulatory	Education, Ordinance, Scalzi Park, General	X		X	X			1, 2, 5	$	Annual
6.3.3	Community participation events	Improve aesthetics and river ecology through cleanup events, plantings, and other programs	Programmatic/Regulatory	River Clean Up Day, Signage, Education			X	X			1, 2, 6	$	Annual
6.3.4	Reduce improper yard waste dumping	Reduces source of nutrients and solids pollution.	Programmatic/Regulatory	Education, Signage	X	X		X			1, 5, 6	$	Annual
6.3.5	Website for public education and information	Improves public accessibility and awareness.	Programmatic/Regulatory	Within City webpage	X			X	X		1, 2, 3	$	Annual
				Separate webpage								$$	Total

City of Stamford
Rippowam/Mill River Watershed Study
Table 6-7. Summary of Action Items, Benefits, and Project Objectives

Report Section	Action Item	Benefits[1]	Category[2,3]	Applicability[4]	Parties Involved [5]				Engineering/ Design	Construction	Related Objectives[6]	Relative Cost [7]	Unit
					City of Stamford	Private Entities	Volunteers	Watershed Constituency					
6.3.6	Educational signage	Improves public accessibility and awareness.	Programmatic/Regulatory	Education	X			X			1, 2, 3	$	Annual
6.3.7	Mark stormwater grates with educational message	Improves public awareness and reduces pollution.	Programmatic/Regulatory	Install permanent signs into concrete near storm drains	X						1, 5, 6	$$ - $$$	Option 1
				Spray paint message								$	Option 2
6.3.8	Promote better commercial property stormwater practices	Reduces source of solids pollution.	Programmatic/Regulatory	Ordinance, BMP Enforcement, Education	X	X		X	X		5, 6	$	Annual
6.3.9	Promote better residential property stormwater practices	Reduces source of solids, bacteria, and nutrients pollution.	Programmatic/Regulatory	Ordinance, BMP Enforcement, Education, Subsidies	X	X		X	X		1, 5, 6, 8	$-$$$	Annual
6.3.10	Bacteria source tracking	Step towards reducing sources of bacteria pollution.	Programmatic/Regulatory	Toilsome and Ayers Brooks, Program	X				X		5	$$$$	Total
6.3.11	Increase street sweeping and catch basin cleaning	Reduces source of solids and metals pollution.	Programmatic/Regulatory	General Location	X						5, 6	$	Annual
6.3.12	Illicit discharge detection and elimination	Step towards reducing sources of bacteria pollution.	Programmatic/Regulatory	Program	X				X	X	5, 6	$$$$	Total
6.3.13	Address private water intakes	Restores natural river flows.	Programmatic/Regulatory	Existing Permit, Ordinance, Garden Center at Reservoir	X	X					1, 7	$$	Annual
6.3.14	Create Mill River Watershed Association	Establishes venue for action, improves public accessibility and awareness.	Programmatic/Regulatory	Program	X			X			1, 3	$	Total
6.3.15	Regular monitoring program	Evaluates progress toward Basin Management Plan goals, and assesses health of river.	Programmatic/Regulatory	Program	X			X	X		5, 8	$$	Annual

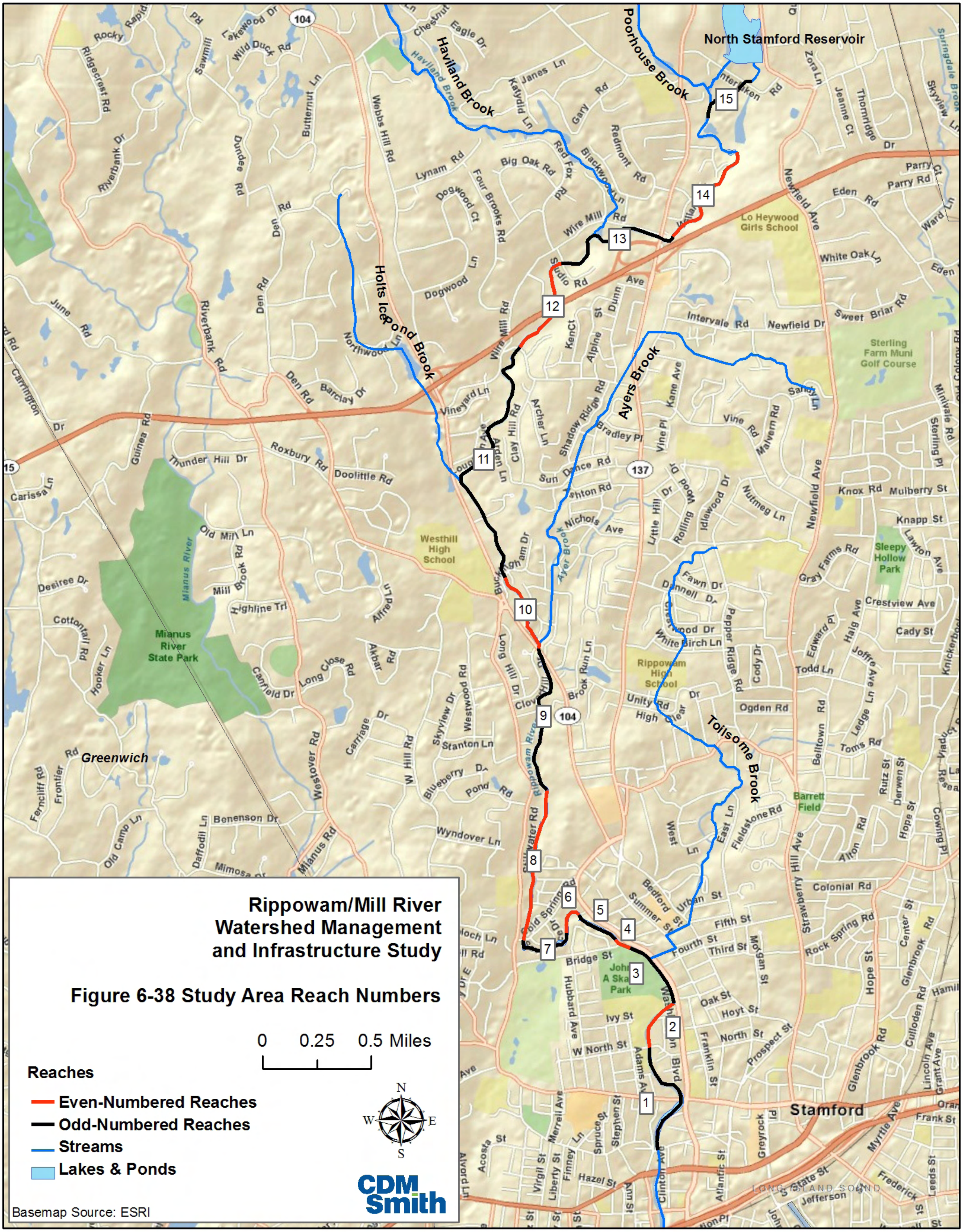
Notes

(1) Benefits description is general and not comprehensive. Refer to relevant text within the Basin Management for further description.
(2) Structural BMPs are well-known best management practices often considered for retrofit to existing stormwater conveyance or for new, low-impact development (LID)
(3) Nonstructural controls may be programs or physical changes that are not considered structural BMPs, but have a direct and physical positive impact on the river
(4) Applicability refers to the general area within the Mill River Watershed where known issues determined during Phase I could be remedied; other areas may also be candidates for the action item
(5) Parties involved are generally assigned based on the nature of the action item and suggested as a guideline
(6) Objectives are as follows:

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river (including passive and active recreation opportunities)
3. Build a grassroots watershed constituency
4. Control and reduce high flows to promote river corridor health and reduce flooding
5. Improve water quality, specifically: metals, dissolved oxygen, bacteria, and nutrients
6. Restore instream and riparian habitat
7. Ensure sufficient low flows for habitat and aesthetics of river
8. Promote the City of Stamford's sustainability mission

(7) Opinion of Probable Cost per item is general and relative; not directly comparable across Action Items; costs will be quantified and evaluated in detail for final Plan

$ no cost or minimal cost to the city
$$ up to $100,000
$$$ up to $500,000
$$$$ greater than $500,000
n/a = cost estimate not available at this time; too many variables to provide reasonable estimate before final Plan is developed



Rippowam/Mill River Watershed Management and Infrastructure Study

Figure 6-38 Study Area Reach Numbers

References

Charles River Watershed Association (CRWA) for Franklin, Massachusetts. “Stormwater Management Plan for Spruce Pond Brook Subwatershed”, 2010.

Center for Watershed Protection (CWP). “Urban Stormwater Retrofit Practices”, Manual 3 of Urban Subwatershed Restoration Manual Series, August 2007.

Tetra Tech. “Optimal Stormwater Management Plan Alternatives: A Demonstration Project in Three Upper Charles River Communities”, December 2009.

University of New Hampshire Stormwater Center “2009 Biannual Report”, 2009.

Section 7 - Watershed Management Plan

7.1 Basin Management Plan Framework

The scope of this management plan is to identify problems within the Mill River watershed and stream network and recommend a set of action items that will address those issues. Due to cost, construction and other obstacles, the ability to implement each action item varies. The keystone of this plan is the formation of a Mill River Watershed Association that would relieve the City of Stamford of the burden of organizing activities that are best accomplished from a grassroots approach. The following section describes five alternatives that are designed to focus a set of action items on targeted goals. The lists are not prioritized within the alternatives; the action items were chosen as the group that would best address the stated mission of the alternative. The alternatives themselves are also not prioritized; it is to be the decision of the city and other future planning organizations how to best focus efforts in the watershed, knowing the issues described in this plan and in previous Mill River Program deliverables.

7.2 Action Plan

Planning Alternatives

This Basin Management Plan identifies more than 30 action items aimed at meeting the following 8 core objectives that were developed by project stakeholders:

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
3. Build a grass roots watershed constituency
4. Control and reduce high flows to promote river corridor health and reduce flooding
5. Improve water quality, specifically: metals, dissolved oxygen, bacteria, and nutrients
6. Restore instream and riparian habitat
7. Ensure sufficient low flows for habitat and aesthetics of the river
8. Promote the City of Stamford's sustainability mission

In many cases a single action item aims at meeting multiple objectives. While this plan does not rank the importance of the 8 objectives explicitly, the implementability of the plan depends on identifying specific action items aimed at smaller-scaled alternatives. The following sections identify action items that are targeted to improve individual issues within the watershed. The alternatives for which action items are identified are:

1. Reduce bacteria concentrations in the main stem Mill River
2. Reduce nutrient loading from the Mill River watershed
3. Reduce metals loading from the Mill River watershed
4. Improve physical river habitat
5. Foster watershed and river stewardship within the community

The subsequent sections briefly describe each alternative and provide a concise tabulation of the expected benefits and estimated costs of action items targeted toward the alternative theme. Each action item is fully explained in Section 6 of this plan and corresponds with each fact sheet in Appendix E.

Alternative 1: Reduce Bacteria Concentrations in Mill River

Elevated bacteria levels are a human health concern. Citizens can come into contact with waterborn pathogens by touching or accidentally ingesting river water, or by consuming plants and animals from the river environment. The sources of bacteria pollution in the Mill River are direct and indirect (runoff), including illicit storm drain connections, failing septic systems, unmanaged pet waste, waterfowl, and generally unmanaged urban runoff. The action items listed in Table 7-1 are targeted toward reducing bacteria levels in the Mill River.

Table 7-1: Action Items Aimed at Reducing Bactera in Mill River

Action Item	Expected Benefits	Parties Involved
Rain Garden/ Bioretention	Estimated basin-wide reduction of bacteria load: 8%	City of Stamford, Land owners
Sand Filter	Estimated basin-wide reduction of bacteria load: 2%	City of Stamford, Land owners
Green Roof	Estimated basin-wide reduction of bacteria load: 1%	City of Stamford, Land owners
Waterfowl Reduction Program	Lower bacteria levels in river	City of Stamford, Watershed constituency
Pet Waste Reduction Program	Lower bacteria levels in river	Watershed constituency, Pet owners
Reduce illicit yard waste dumping	Reduced nutrient pollution to streams	City of Stamford, Residents, Landscapers
Bacteria/DNA Source Tracking	Knowledge of effective solutions	City of Stamford
Increase Street Sweeping and Catch Basin Cleaning	Estimated basin-wide reduction of bacteria load: 5%	City of Stamford
Illicit Discharge Detection and Elimination	MS4 requirement, lower bacteria levels in river	City of Stamford

Alternative 2: Reduce Nutrient Loading from Mill River Watershed

High nutrient loading to the Mill River has two negative effects: 1) nutrient enrichment in the stream impedes habitat through excess algal growth and related dissolved oxygen sag, and 2) excess nutrient loading to the Long Island Sound is the cause of hypoxia and is the focus of federal and state regulation. Nutrients enter the stream system from watershed runoff and, to a lesser extent, illicit connections to the storm drains. The action items listed in Table 7-2 are targeted toward reducing nutrient loading to streams from the Mill River watershed.

Table 7-2: Action Items Aimed at Reducing Nutrient Loading from Watershed

Action Item	Expected Benefits	Parties Involved
Holts Ice Pond Remediation	Local improved pond conditions, less pollutant loading to main stem river	City of Stamford, Land owners
Rain Garden/ Bioretention	Estimated basin-wide reduction of nutrient load: 2-4%	City of Stamford, Land owners
Tree Filter	Estimated reduction of nutrient load: • Ayers Basin 0-2% • Downtown Basin 1-2%	City of Stamford, Land owners
Porous Pavement	Estimated basin-wide reduction of nutrient load: 0-3%	City of Stamford, Land owners
Sand Filter	Estimated basin-wide reduction of nutrient load: 0-2%	City of Stamford, Land owners
Green Roof	Estimated basin-wide reduction of nutrient load: 1%	City of Stamford, Land owners
Riparian Buffer Improvements	Reduced nutrient pollution to streams	Watershed constituency, City of Stamford
Reduce illicit yard waste dumping	Reduced nutrient pollution to streams	City of Stamford, Residents, Landscapers
Improve commercial and residential stormwater practices	Reduced nutrient pollution to streams	Watershed constituency, Residents, Business owners
Subsidies or reward incentives for residential LID	Reduced nutrient pollution to streams	City of Stamford, Residents
City ordinances for new development LID	Reduced nutrient pollution to streams	City of Stamford, Land developers

Alternative 3: Reduce Metals Loading from Mill River Watershed

Metals in the aquatic environment at levels greater than naturally occurring are toxic to fish and other organisms. Metals will bioaccumulate in the food chain, resulting in higher levels in organisms near the top. Water quality samples from the Mill River have shown levels of copper, lead, and zinc above the Connecticut state water quality standards. Copper can be naturally occurring in high levels in the watershed. Lead and zinc are common urban and street runoff pollutants. The action items listed in Table 7-3 are targeted toward reducing metals loading to streams in the Mill River watershed.

Table 7-3: Action Items Aimed at Reducing Metals Loading from Watershed

Action Item	Expected Benefits	Parties Involved
Rain Garden/ Bioretention	Estimated basin-wide reduction of metals load: 4-7%	City of Stamford, Land owners
Tree Filter	Estimated basin-wide reduction of metals load: Ayers Basin 0-2% Downtown Basin 0-2%	City of Stamford, Land owners
Porous Pavement	Estimated basin-wide reduction of metals load: 1-3%	City of Stamford, Land owners
Sand Filter	Estimated basin-wide reduction of metals load: 1-3%	City of Stamford, Land owners
Green Roof	Estimated basin-wide reduction of metals load: 1%	City of Stamford, Land owners
Improve commercial stormwater practices	Reduce metals pollutant loading to streams	City of Stamford, Business owners, Property managers
Increase Street Sweeping and Catch Basin Cleaning	Estimated basin-wide reduction of metals load: 2-5%	City of Stamford

Alternative 4: Improve Physical River Habitat

In addition to marginal water quality, the Mill River's physical habitat condition impairs its ecological health. Much of the stream has been altered anthropogenically; bank armoring, low head dams, culverting, and unnatural diversions are common throughout the watershed. The watershed and river corridor are significantly developed, and bringing them back to unmodified habitats is not possible. However, there are options for improving the existing habitat conditions to promote growth and encourage native flora and fauna to flourish. The action items in Table 7-4 are targeted toward improving the physical habitat of the Mill River.

Table 7-4: Action Items Aimed at Improving the Mill River's Physical Habitat

Action Item	Expected Benefits	Parties Involved
Removal of low-head dams	Improved fish passage and natural stream processes	City of Stamford, Land owners
Change location of reservoir low flow outlet	Increased dissolved oxygen levels downstream of reservoir	Aquarion water Company, City of Stamford
River bank restoration	Reduce sediment erosion, restore natural stream processes	City of Stamford, Land owners
Removal of invasive plants	Improve habitat for native species	Watershed constituency, Land owners
Instream restoration	Creation and improvement of aquatic habitat	City of Stamford, Watershed constituency
Annual river cleanup	Improve physical habitat marred by trash and debris	City of Stamford, Watershed constituency
Designate wildlife protection and viewing areas	Protect wildlife habitat	City of Stamford, Watershed constituency
Address private water intakes	Preserve streamflow for aquatic species	City of Stamford

Alternative 5: Foster Stewardship within the Community

For decades, the Mill River has been overlooked by the residents of the City of Stamford,at times used for irrigation water or as a place to dispose of lawn waste. Many residents of the community have not had a reason to give much thought to the river in its current state. River and watershed stewardship is the keystone to a successful watershed improvement program. Watershed associations and volunteer groups can organize river cleanups, educate others in the community, and garner support for initiatives to change the behavior and attitude towards the river. The action items in Table 7-5 are targeted toward fostering stewardship for the watershed and river within the community.

Table 7-5: Action Items Aimed at Fostering Watershed Stewardship

Action Item	Expected Benefits	Parties Involved
Annual river cleanup	Improve habitat and water quality, connect residents with river	City of Stamford, Watershed constituency
Develop website for public education and information	Disseminate information, rally volunteers, and garner financial support	City of Stamford, Watershed constituency
Mark stormwater grates with educational message	Reduce illegal dumping, remind residents of river	City of Stamford, Watershed constituency
Public river access	Connect residents with river	City of Stamford, Watershed constituency
Designate wildlife protection and viewing areas	Improve habitat, connect residents with river	City of Stamford, Watershed constituency
Create Mill River Watershed Association	Organize river and watershed improvements	City of Stamford, Watershed constituency

7.3 Success Tracking and Evaluation

The City of Stamford, or its designee, should publish regular reports on the status of watershed improvements resulting from the implementation of this plan. A vital component in evaluating the success of many of the recommended action items is a regular and comprehensive monitoring program. The monitoring program should be comprised of two basic components: 1) targeted assessments of problem areas, and 2) overall basin-wide assessments.

Targeted assessments should be designed to track the progress of specific areas in the watershed and stream where problems have been identified. These studies may include, but are not limited to, the following:

- Sampling for bacteria within Toilsome Brook and Ayers Brook to discover hot-spots and target management activities
- Wet and dry-weather sampling of stormwater outfalls to identify cross-contamination and characterize runoff
- Main stem nutrient sampling bracketing suspected nonpoint source hot-spots (garden centers, landscaped communities and commercial developments)

A program to track the overall progress of the basin may include a weekly or monthly sample collection effort at targeted locations within the watershed. A large database (spanning both time and location) of water quality data from the Mill River and tributaries would aid in identifying successful programs and other problem areas outside the scope of the Mill River Program. Volunteer monitoring programs are commonly used for this type of effort.

7.4 Potential Funding Sources

The City of Stamford is eligible for several federal and state grants that fund the types of improvements recommended for the Mill River Watershed. These programs are applied for on an annual basis and are geared towards projects that emphasize stewardship and environmental protection. Table 7-6 provides a description of each program and its applicability to potential improvement activities within the Mill River Watershed.

Table 7-6. Potential Funding Sources

Details	Description	
Grant Program	**Nonpoint Source Management Grant Program**	
Description	CT DEEP	Under this program, CT DEEP accepts proposals for the prevention, control and/or abatement of nonpoint source pollution. Under Section 319 of the Clean Water Act (§319 C.W.A.), the U.S. EPA awards a grant annually to the CT DEEP to fund eligible projects that support the implementation of the Connecticut's Nonpoint Source Management Program. These funds are limited and a competitive bid process is used to ensure that the most appropriate projects are selected for funding.
Applicable Projects	Stormwater	
Grant Program	**Transportation Enhancement (TE) Activities**	
Description	U.S. Department of Transportation	TE activities offer funding opportunities to help expand transportation choices and enhance the transportation experience through 12 eligible TE activities related to surface transportation, including pedestrian and bicycle infrastructure and safety programs, scenic and historic highway programs, landscaping and scenic beautification, historic preservation, and environmental mitigation.
Applicable Projects	Stormwater, Recreation	
Grant Program	**Sustainable Communities Regional Planning (SCRP) Grants**	
Description	U.S. Dept. of Housing and Urban Development	SCRP Grants support metropolitan planning efforts that integrate housing, land use, economic and workforce development, transportation, and infrastructure investment. Emphasis is placed on investing in partnerships that integrate separate disciplines into a multi-dimensional project.
Applicable Projects	Community Development	
Grant Program	**Land & Water Conservation Fund (LWCF)**	
Description	National Park Service	The LWCF Program provides matching grants to States and local governments for the acquisition and development of public outdoor recreation areas and facilities. The program is intended to create and

Details	Description	
Applicable Projects	Recreation	maintain a nationwide legacy of high quality recreation areas and facilities and to stimulate non-federal investments in the protection and maintenance of recreation resources across the United States.
Grant Program	**Recreational Trails Program (RTP)**	
Description	U.S. Dept. of Transportation, CT DEEP	The RTP provides funds to the States to develop and maintain recreational trails and trail-related facilities for both nonmotorized and motorized recreational trail uses. This program provides funding to the CT DEEP, which will forward applications to the Park and Recreation Directors or the First Elected Officials of each municipality for consideration. Funding ratios are 80 percent federal and 20 percent local.
Applicable Projects	Recreation	

Appendix A Public meetings: Project Briefing to Neighborhood Groups

On July 31, 2008 the SWPCA in cooperation with the City of Stamford and project consultant CDM Smith met with representatives of the Stamford Partnership, North Stamford Association, Hampton Inn, and Projects for Public Spaces (PPS) to brief them on the Rippowam/Mill River Watershed Management and Infrastructure Program. A PowerPoint presentation summarizing the program goals, current scope of work, major tasks, and related projects was provided.

A discussion with questions and answers followed the presentation. Discussion topics included infrastructure improvements recommended as a result of the program, notification to private abutting properties of river access during sampling events, and improved opportunities for public access and recreation.

Sustainable Gardening Expo

The City of Stamford-sponsored Sustainable Gardening Expo took place on May 21, 2009 at Stamford City Hall to offer citizens more information about how the city leaders, environmental agencies, and professionals are working to improve water quality and reclaim the natural environment downtown. Participants included the Mill River Collaborative, Stamford Nature Center, SWPCA, The Bartlett Arboretum, and local landscaping and tree service companies.

CDM Smith and PPS, in cooperation with SWPCA, developed several posters and provided handouts for participants to encourage and promote stewardship of Stamford watersheds and responsible riverbank lawn management through use of native plants in streamside buffer gardens CDM Smith and PPS also conducted a brief citizen survey to gage local perspectives of stream water quality and stormwater runoff. Results of the survey demonstrated the importance residents hold on returning natural vegetation to the stream banks of the Rippowam River, improving water quality, and making it a usable space where they can appreciate the natural environment, hold public events, and utilize biking and walking trails.

World Water Monitoring Day

On August 19, 2009, representatives of the Stamford Land Use Bureau, SWPCA, and CDM Smith met to discuss World Water Monitoring Day on September 18, 2009. While SWPCA was primarily responsible for working with students to conduct the water quality testing, this meeting allowed various entities to take advantage of the opportunity to coordinate with the ongoing study. This provided an opportunity for students to try water quality sampling through the lens of a professional watershed study in their community.

Workshop at Scalzi Park

On November 12, 2009 CDM Smith and PPS held a public workshop to solicit input on issues and goals surrounding restoration of the Mill River watershed. Approximately 25 local residents and stakeholders were in attendance representing such organizations as Connecticut Department of Energy and Environmental Protection (CT DEEP), the Regional Plan Association, Scalzi Riverwalk Nature Preserve, Long Island Sound Study, Soundwaters, the Mill River Collaborative, and the SWPCA. CDM Smith gave a brief presentation on the current status of extensive field monitoring and data collection efforts, as well as next steps for preparation of a watershed management plan. PPS presented benchmark river development projects from around the world and introduced the format for the breakout groups which served as the forum for public input regarding the watershed. Questionnaires containing the same five questions as those addressed in the breakout group were also distributed to attendees at the workshop.

Breakout group feedback suggested watershed management must focus on improving overall water quality, redesigning the riverbanks so that they more closely resemble the natural habitat, and addressing issues with stormwater management. A combination of education, outreach, and enforcement was targeted as an important part of changing individual practices that are detrimental to the health of the river. In order to effectively address this, the group felt that there was a need for robust partnerships between local stakeholders. The groups also said that they would like to see habitat sensitive amenities that encourage responsible use of the river for activities such as swimming, kayaking, and biking throughout the watershed.

Advisory Committee Meetings

An advisory committee was formed in 2008 to provide opportunity for stakeholder involvement at various decision points, following deliverables, and for project direction. The committee included representatives from the City of Stamford, SWPCA, PPS, and CDM Smith. Advisory committee meetings were held in July 2008, March 2009, and March 2010.

Through the annual meetings, the group was able to highlight opportunities for public outreach and events, keep various stakeholders engaged in the study, and allow for a more informed project direction and management of outcomes.

Mill River Collaborative Coordination Presentation

A presentation on the Mill River Watershed Study was given to the Mill River Collaborative on July 25, 2011. Topics covered in the meeting included the City's 3-pronged approach of dam removal, urban park restoration and greenway development; and the status of the Basin Management Plan being developed for the Mill River.

City of Stamford Briefing

A meeting was held with Mayor Michael Paiva and his staff from the City of Stamford on December 8, 2011 to discuss the status of the Mill River Watershed Study and implementation of the Basin Management Plan. As part of this meeting, a stakeholder group was identified to provide vital feedback on the contents of the Basin Management Plan and potential implementation of the recommendations.

Stakeholder Meeting

The initial meeting of the stakeholders for the Basin Management Plan took place on January 26, 2012. This group consisted of City employees and members of the Mill River Collaborative. The goal of this meeting was to review with all of the members the work that had been completed to date, review the preliminary recommendations included in the Plan and obtain input from the stakeholders relative to the validity and potential implementation of each recommendation. This group will be utilized to review the draft Plan and provide comments prior to finalizing the Plan.

Appendix B Watershed Management Model: Memorandum

To: *Mill River Watershed Study Project Team*

From: *CDM Smith*

Date: *April 4, 2012*

Subject: *Mill River Watershed Management Model Development and Results*

This memo discusses the development of the Watershed Management Model (WMM) for the Mill River basin. This model provides an estimate of the mass loading, to receiving water, of user specified pollutants. WMM is an event mean concentration (EMC) land used based model that can provide an estimate of annual mass loading.

This memo will discuss WMM in general terms, and then discuss the specific set up of the model to represent the Mill River basin. Finally there will be a discussion of the various best management practices (BMP) being considered for pollutant reduction.

The Watershed Management Model

The WMM uses a database platform to estimate annual or seasonal pollutant loads from many sources within a basin. Data required to use the WMM include storm water EMCs for each pollutant type, land use, and average annual precipitation. In addition, the areas served by septic systems identified, annual baseflow and average baseflow concentrations, and point source flows and pollutant concentrations. It is also possible to include average combined sewer overflows (CSOs) and concentrations if applicable. The following summarizes some of the features of the WMM:

- Estimates annual storm water runoff pollution loads and concentrations for nutrients (total phosphorus, dissolved phosphorus, total nitrogen), heavy metals (lead, copper, zinc, cadmium), oxygen demand (BOD_5), sediment (total suspended solids, total dissolved solids), and bacteria (fecal coliforms, *E. coli*) based upon EMCs, land use, percent impervious, and annual rainfall;

- Estimates stormwater runoff pollution load reduction due to partial or full scale implementation of onsite or regional BMPs;

- Estimates annual pollution loads from stream baseflow;

- Estimates point source loads for comparison with relative magnitude of other basin pollution loads;
- Estimates pollution loads from failing septic tanks; and
- Applies a delivery ratio to account for reduction in runoff pollution load due to uptake or removal in stream courses.

Pollution control strategies that may be identified and evaluated using the Watershed Management Model include:

- Nonstructural controls (e.g., land use controls, buffer zones, etc.);
- Low Impact Development (LID) retrofit (e.g., rain garden, tree filters, porous pavement, etc.); and
- Structural controls (e.g., onsite and regional detention basins, grassed swales, dry detention ponds, etc.).

The model provides a basis for planning-level evaluations of the long term (annual or seasonal) basin pollution loads and the relative benefits of pollution management strategies to reduce these loads. The WMM evaluates alternative management strategies (combinations of source and treatment storm water controls) to develop a proposed municipal storm water management plan.

Within a given basin, multiple subbasins can be evaluated. Subbasins are typically subdivided by tributary areas, outfalls, or other receiving water body within a basin. However, subbasins can be delineated based on non-hydrologic boundaries such as jurisdictional limits. This provides decision makers with information regarding the relative contribution of pollution loadings from various areas within a basin which can be used for targeting control measures to those areas which are responsible for generating the majority of the pollutant load.

Basins and Pollution Sources

A basin is the land area which supplies all of the water that eventually flows into downstream receiving water such as a river, lake, or reservoir. The major sources of water in a basin typically include rainfall runoff from the basin surface and seepage into streams from groundwater sources.

The major sources of pollutants in a basin are typically storm water runoff pollution from urban and agricultural areas and discharges from wastewater treatment plants (WWTPs) or industrial facilities. Storm water runoff pollution, traditionally referred to as "nonpoint source pollution" (NPS), discharges into streams at many dispersed points. A WWTP discharge or industrial process wastewater discharge typically referred to as "point source pollution," releases pollution into streams at discrete points.

Rainfall/Runoff Relationships

Nonpoint pollution loading factors (lbs/acre/year) for different land use categories are based upon annual runoff volumes and event mean concentrations (EMCs) for different pollutants. The EMC is defined as the average of individual measurements of storm pollutant mass loading divided by the storm runoff volume. One of the keys to effective transfer of literature values for nonpoint pollution loading factors to a particular study area is to make adjustments for actual runoff volumes in the basin under study. In order to calculate annual runoff volumes for each subbasin, the pervious and impervious fractions of each land use category are used as the basis for determining rainfall/runoff relationships. For rural/agricultural (nonurban) land uses, pervious land represents the major source of runoff or stream flow, while impervious areas are the predominant contributors for most urban land uses.

Annual Runoff Volume

WMM calculates annual runoff volumes for the pervious/impervious areas in each land use category by multiplying the average annual rainfall volume by a runoff coefficient. A runoff coefficient of 0.9 is typically used for impervious areas (i.e., 90% of the rainfall is assumed to be converted to runoff from the impervious fraction of each land use). A pervious area runoff coefficient of 0.10 is typically used. The total average annual surface runoff from land use L is calculated by weighting the impervious and pervious area runoff factors for each land use category as follows:

$$R_L = [C_P + (C_I - C_P)\, IMP_L] * I \quad \textit{(Equation 1)}$$

Where:

R_L = total average annual surface runoff from land use L (in/yr);
IMP_L = fractional imperviousness of land use L;
I = long-term average annual precipitation (in/yr);
C_P = pervious area runoff coefficient; and
C_I = impervious area runoff coefficient.
Total runoff in a basin is the area-weighted sum of R_L for all land uses.

Nonpoint Pollution Event Mean Concentrations

The Watershed Management Model estimates loads from pollutants which are most frequently associated with nonpoint pollution sources, including, but not limited to:

- Oxygen Demand
  - Biochemical Oxygen Demand (BOD_5)
- Sediment
  - Total Suspended Solids (TSS)
  - Total Dissolved Solids (TDS)
- Nutrients
  - Total Phosphorus (TP)
  - Dissolved Phosphorus (DP)
  - Total Kjeldahl Nitrogen (TKN)
  - Nitrate + Nitrite (NO3 +NO2)
- Heavy Metals
  - Lead (Pb)
  - Copper (Cu)
  - Zinc (Zn)
  - Cadmium (Cd)
- Bacteria
  - Fecal Coliform (F-Coli)
  - *E. coli*

These pollutants and their impacts on water quality and aquatic habitat are described below.

Oxygen Demand: Biochemical Oxygen Demand (BOD_5) is caused by the decomposition of organic material in storm water which depletes dissolved oxygen (DO) levels in slower moving receiving waters such as lakes and estuaries. Low dissolved oxygen is often the cause of fish kills in streams and reservoirs. The degree of DO depletion is measured by the BOD_5 test that expresses the amount of easily oxidized organic matter present in water.

Sediment: Sediment from nonpoint sources is the most common pollutant of surface waters. Many other toxic contaminants adsorb to sediment particles or solids suspended in the water column. Excessive sediment can lead to the destruction of habitat for fish and aquatic life.

Total suspended solids (TSS) is a laboratory measurement of the amount of sediment particles suspended in the water column. Excessive sediment pollution is primarily associated with poor erosion and sediment controls at construction sites in developing areas or unstable channels throughout river systems.

Nutrients: Nutrients (phosphorus and nitrogen) are essential for plant growth. Within a water supply reservoir, impoundment, lake, or other receiving water, high concentrations of nutrients can result in overproduction of algae and other aquatic vegetation. Excessive levels of algae present in a receiving water is called an algal bloom. Algal blooms typically occur during the summer when sunlight and water temperature are ideal for algal growth. Water quality problems associated with algal blooms range from simple nuisance or unaesthetic conditions, to noxious taste and odor problems, oxygen depletion in the water column, and fish kills. In addition, algal blooms are positively related to the levels of trihalomethanes (a suspected carcinogen) in drinking water. Collectively, the problems associated with excessive levels of nutrients in a receiving water are referred to as eutrophication impacts. Control of nutrients discharged to streams can severely limit algal productivity and minimize the water quality problems associated with anthropogenic eutrophication.

Heavy Metals: Heavy metals are toxic to humans and are subject to State and Federal drinking water quality standards. Heavy metals are also toxic to aquatic life and may bioaccumulate in fish. Lead, copper, zinc and cadmium are heavy metals which typically exhibit higher nonpoint pollutant loadings than other metals found in urban runoff. The presence of these heavy metals in streams and reservoirs in the basin may also be indicative of problems with a wide range of other toxic chemicals, like synthetic organics, that have been identified in previous field monitoring studies of urban runoff pollution (USEPA,1983b).

Bacteria: Bacteria occurring in stormwater runoff is a cause for concern as it can possibly pose a health risk. Typically an indicator organism, such as fecal coliform is used to estimate the presence of bacteria. The source of bacteria in runoff can either be naturally occurring in runoff or can be anthropogenic in origin. As an example, water fowl and wildlife can be the cause of naturally occurring bacteria; combined sewer overflows or contamination from inadequately maintained septic systems can be the cause of anthropogenic sources.

Event Mean Concentrations

Over the past 30 years, nonpoint pollution monitoring studies throughout the U.S. have shown that annual "per acre" discharges of urban storm water pollution (e.g., nutrients, metals, BOD_5) are positively related to the amount of imperviousness in the land use (i.e., the more imperviousness the greater the nonpoint pollution load) and that the EMC is fairly consistent for a given land use. The EMC is a flow-weighted average concentration for a storm event and is defined as the sum of individual measurements of storm water pollution loads divided by the storm runoff volume. The EMC is widely used as the primary statistic for evaluations of storm water quality data and as the storm water pollutant loading factor in analyses of pollutant loadings to receiving waters.

Nonpoint pollution loading analyses typically consist of applying land use specific storm water pollution loading factors to land use scenarios in the basin under study. Runoff volumes are computed for each land use category based on the percent impervious of the land use and the annual rainfall. These runoff volumes are multiplied by land use specific mean EMC load factors (mg/L) to obtain nonpoint pollution loads by land use category. This analysis can be performed on a subarea or basin-wide basis, and the results can be used for performing load allocations or analyzing pollution control alternatives, or for input into a riverine water quality model.

Selection of nonpoint pollution loading factors depends upon the availability and accuracy of local monitoring data as well as the effective transfer of literature values for nonpoint pollution loading factors to a particular study area.

EMC monitoring data collected by the USEPA's Nationwide Urban Runoff Program (NURP) and the Federal Highway Administration (FHWA) were determined to be log normally (base e) distributed. The log normal distribution allows the EMC data to be described by two parameters, the mean or median which is a measure of central tendency, and the standard deviation or coefficient of variation (standard deviation divided by the mean) which is a measure of the dispersion or spread of the data. The median value should be used for comparisons between EMCs for individual sites or groups of sites because it is less influenced by a small number of large values which is typical of lognormally distributed data. For computations of annual mass loads, it is more appropriate to use the mean value since large infrequent events can comprise a significant portion of the annual pollutant loads.

To estimate annual pollutant loads discharged to receiving waters from a municipality, median EMCs are converted to mean values (USEPA, 1983b; Novotny, 1992) by the following relationship:

$$M = T * ((1 + CV^2))^{1/2} \qquad \textit{(Equation 2)}$$

where:

M = arithmetic mean;
T = median; and
CV= coefficient of variation = standard deviation/mean.

Nonpoint Pollution Loading Factors

WMM estimates pollutant loadings based upon nonpoint pollution loading factors (expressed as lbs/ac/yr) that vary by land use and the percent imperviousness associated with each land use. The pollution loading factor M_L is computed for each land use L by the following equation:

$$M_L = EMC_L * R_L * K \qquad \text{(Equation 3)}$$

where:

M_L = loading factor for land use L (lbs/ac/yr);
EMC_L = event mean concentration of runoff from land use L (mg/l); EMC_L varies by land use and by pollutant;
R_L = total average annual surface runoff from land use L computed from Equation 4-1 (in/yr); and
K = 0.2266, a unit conversion constant.

By multiplying the pollutant loading factor by the acreage in each land use and summing for all land uses, the total annual pollution load from a subbasin can be computed. The EMC coverage is typically not changed for various land use scenarios within a given study basin, but any number of land use data sets can be created to examine and compare different land use scenarios (e.g., existing versus future) or land use management scenarios.

BMP Pollutant Removal Efficiencies

The Watershed Management Model applies a constant removal efficiency for each pollutant to all land use types to simulate treatment BMPs. These removal efficiencies are often the result of comparing manufacturer's estimates with independent studies. It is also necessary to make some accounting of the percent coverage of a particular BMP.

Calculation of Pollutant Loading Reduction from BMPs

The effectiveness of BMPs in reducing nonpoint source loads is computed for each land use in each subbasin. Up to five BMPs per land use can be specified. The percent reduction in nonpoint pollution per pollutant type in each subbasin of the basin is calculated as:

$$P_{L,SB} = (AC_{1,SB}(REM_1) + (AC_{2,SB}(REM_2) + (AC_{3,SB}(REM_3) + (AC_{4,SB}(REM_4) + (AC_{5,SB}(REM_5) \qquad \text{(Equation 4)}$$

where:

$P_{L,SB}$ = percent of annual nonpoint pollution load captured in subbasin SB by application of the five BMP types on land use L;

$AC_{1,SB}$; $AC_{2,SB}$;
$AC_{3,SB}$; $AC_{4,SB}$; = fractional area coverage of BMP types 1 through 5 on subbasin SB; $AC_{5,SB}$

REM_1; REM_2 = REM_3; REM_4; REM_5	removal efficiency of BMP types 1 through 5 respectively; REM; varies by pollutant type but not by land use or subbasin.

Equation 4 enables the user to examine the effectiveness of various BMPs and the degree of BMP coverage within a basin. Coverage might vary depending upon whether the BMP is applied to new development only, existing plus new development, etc. Also, topography may limit the areal coverage of some BMPs.

The nonpoint pollution load from a basin is thus computed by combining Equations 3 and 4 and summing over all land uses and all subbasins, i.e.

$$MASS = \sum_{SB=1}^{N} \sum_{L=1}^{15} M_{L,SB} (1 - P_{L,SB}) \qquad (Equation\ 5)$$

where:

MASS = annual nonpoint pollution load washed off the basin in lbs/yr.

The resultant model is a very versatile yet simple algorithm for examining and comparing nonpoint pollution management alternatives for effectiveness in reducing nonpoint pollution.

Failing Septic Tank Impacts

Many of the residential developments within the U.S. rely on household septic tanks and soil absorption fields for wastewater treatment and disposal. The nonpoint pollution loading factors for low density residential areas, which are typically served by septic tank systems, are based on test basin conditions where the septic systems were in good working order and made no significant contribution to the monitored nonpoint pollution loads. In fact, septic tank systems typically have a limited useful life expectancy and failures are known to occur, causing localized water quality impacts. This section presents a method for estimating average annual septic tank failure rates and the additional nonpoint pollution loadings from failing septic systems.

To estimate an average annual failure rate, the time series approach proposed by the 1986 USEPA report Forecasting Onsite Soil Absorption System Failure Rates was used. This approach considers an annual failure rate (percent per year of operation), future population growth estimates, and system replacement rate to forecast future overall failure rates. Annual septic tank failure rates reported for areas across the U.S. range from about 1% to 3%. For average annual conditions, it is conservative to assume that septic tank systems failures would be unnoticed or ignored for five years before repair or replacement occurred.

Therefore, during an average year, 5% to 15% of the septic tanks systems in the basin are assumed to be failing.

This is consistent with the results of a survey conducted in Jacksonville, Florida, by the Department of Health and Rehabilitative Services. Of more than 800 site inspections, about 90 violations had been detected. Types of violations detected were typically: (1) drain field located below groundwater table, (2) direct connections between the tile field and a stream, and (3) structural failures. The violation rate of 11% is consistent with the average year septic tank failure rate and period of failure before discovery/remediation. The "impact zone" or the "zone of influence" for failing septic tanks can be assumed to be all residential areas that are not served by public sewer.

Pollutant loading rates for failing septic systems were developed from a review of septic tank leachate monitoring studies. The range of concentrations of total-P and total-N based upon literature values are as follows:

	Total-P	Total-N
Low	1.0 mg/L	7.5 mg/L
Medium	2.0 mg/L	15.0 mg/L
High	4.0 mg/L	30.0 mg/L

Annual "per acre" loading rates for septic tank failures from low density residential land uses were then estimated assuming 50 gallons per capita per day wastewater flows. The loading rates can be applied to the percentage of all non-sewered residential land uses with failing septic tanks. The septic tank loading factors are included in the runoff pollution loading factors. The range of percent increases in annual per acre loadings attributed to failing septic tanks is:

	Total-P	Total-N
Low	130%-180%	120%-150%
Medium	160%-250%	140%-200%
High	220%-400%	180%-310%

To assess the increase in surface runoff load due to failing septic tanks, WMM considers a multiplication factor. This multiplication factor is applied to the phosphorus (dissolved P, total P) and nitrogen (TKN, NO_2+NO_3-N) parameters.

Consequently, the load from a residential area with failing septic tanks is:

(surface runoff load without failing septic tanks) x

((multiplication factor) x (% of area with failing septic tanks/100%) + (1 - (% of area with failing septic tanks)/100%))

Despite the large increase in annual loading rates, septic tank failures typically have only a limited impact on overall nonpoint pollution discharges. This is because the increased annual loading rates are applied only to the fraction of non-sewered residential development that are predicted to have a failing septic tank system during an average year. Based upon this methodology, failing septic tank systems typically would contribute less than 10% of total nonpoint loadings.

Model Limitations

The WMM was developed to estimate the relative changes in nonpoint source pollutant loads (average annual or seasonal) due to changes in land use or from the cumulative effects of alternative basin management decisions (e.g. treatment BMPs). The models should be applied to appropriate spatial (basin wide) and temporal (average annual or seasonal) scales. It is not appropriate to use these input/output models for analysis of short-term (i.e., daily, weekly) water quality impacts. It is also not appropriate to use WMM to estimate absolute loads for a given outfall system without specific monitoring data for that system.

WMM Data Analysis

There are eight major subbasins in the Mill River Basin as shown in **Figure 1**. These subbasins range in size from approximately 580 to 2,500 acres in total area. The following sections describe how land use, BMP, septic tank, and other data was obtained and processed to perform the pollution loading analysis.

Land Use

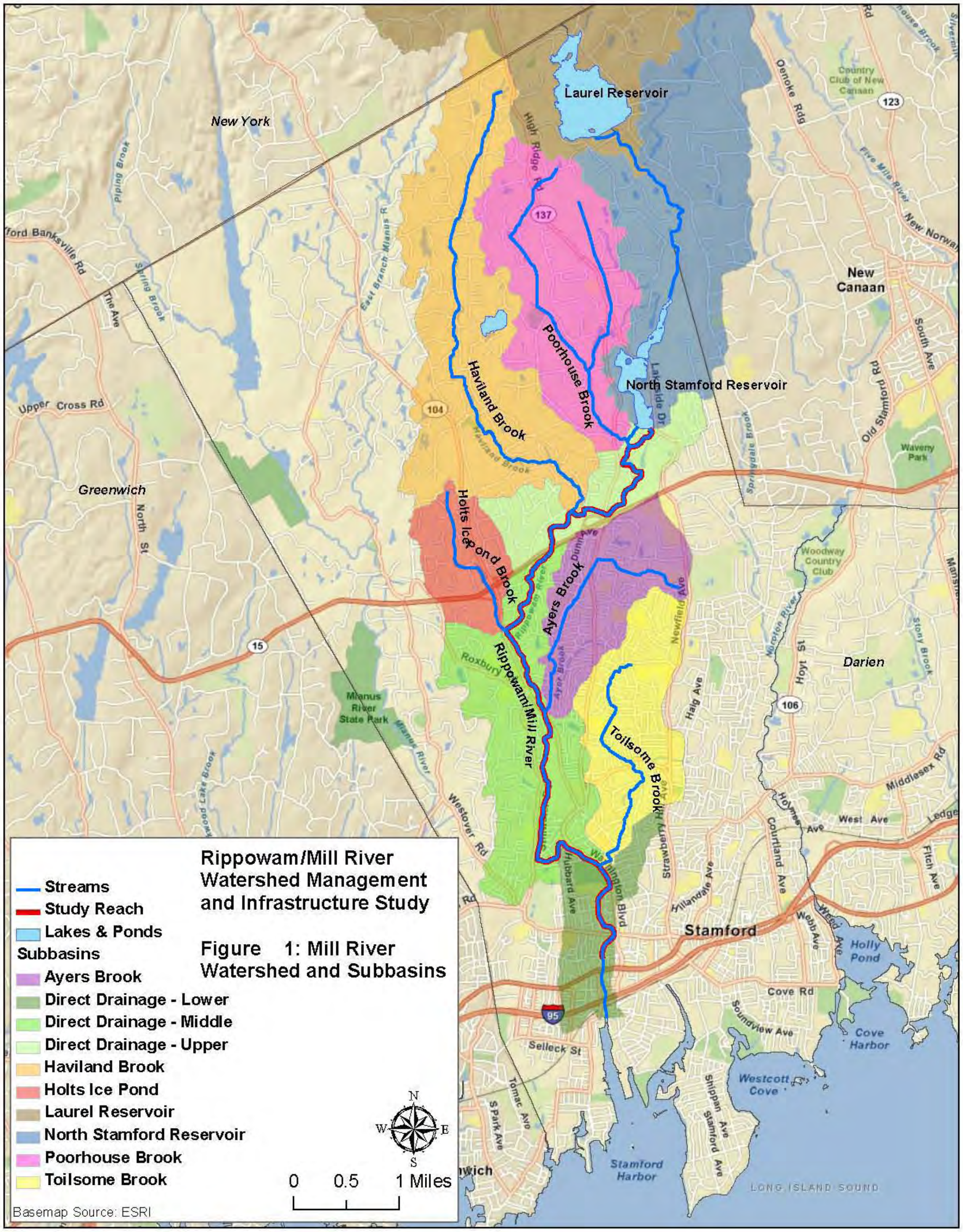
Land use shape files were obtained from the City and imported into the GIS software package Arcview Version 9.3©. Subbasin (which were delineated for a previous effort) shape files were combined with the land use shape files to determine the land use distribution by subbasin.

Table 1 presents the acreages of each of the eight land use categories in the major basins for present land use conditions. Generally these land uses are fairly standard with the exception of commercial/high density residential and impervious/urban. These land uses represent the urbanized portion of the study area. **Figure 1** shows the locations of the subbasins.

Table 1: Land Use in Mill River Basin (acres)

Subbasin	Commercial/HD Residential	Forest	Impervious/ Urban	MD Residential	Open Land	Road	Water	Wetland	Total
Ayers	168	157	36	396	38	162	7	9	972
Haviland	312	1,376	0	367	62	251	61	105	2,534
Holts Ice Pond	45	232	3	154	53	77	8	5	577
Mainstem1	135	10	184	104	53	139	19	5	648
Mainstem2	256	266	31	590	143	273	26	10	1,595
Mainstem3	133	354	1	130	20	101	17	6	762
Poorhouse	130	855	3	332	138	168	21	67	1,714
Toilsome	172	82	39	533	103	181	0	6	1,116
Total	1,351	3,332	296	2,607	610	1,352	158	212	9,918

Runoff coefficients for pervious and impervious areas were universally defined to be 0.9 for impervious areas and 0.1 for pervious areas. The refinement in the volume of runoff associated with each basin was due to the weighted value of the percent impervious determined for each basin as a function of that basin's land use.


Rippowam/Mill River Watershed Management and Infrastructure Study
Figure 1: Mill River Watershed and Subbasins
Streams
Study Reach
Lakes & Ponds
Subbasins
Ayers Brook
Direct Drainage - Lower
Direct Drainage - Middle
Direct Drainage - Upper
Haviland Brook
Holts Ice Pond
Laurel Reservoir
North Stamford Reservoir
Poorhouse Brook
Toilsome Brook
0 0.5 1 Miles
N
S
E
W
Basemap Source: ESRI
Laurel Reservoir
North Stamford Reservoir
Haviland Brook
Poorhouse Brook
Holts Ice Pond Brook
Ayers Brook
Rippowam/Mill River
Toilsome Brook
New York
Greenwich
New Canaan
Darien
Stamford
Stamford Harbor
Westcott Cove
Cove Harbor
Holly Pond
Long Island Sound

Percent Directly Connected Imperviousness

The percent directly connected impervious (DCIA) for each land use was also a parameter that required some consideration. The US Environmental Protection Agency (EPA) developed guidance to estimate the percent DCIA based upon impervious areas for New Hampshire small MS4 Permits. As the geographic locations are similar, this guidance was used to estimate the DCIA in the Mill River basin.

The guidance provides an estimate of the total imperviousness for standard land uses as well there are a number of relationships that can modify the total imperviousness based upon the degree of connectedness. These relationships were first documented in Sutherland, 2000. These relationships estimate the DCIA as a function of the total imperviousness and the degree of connectivity of the total imperviousness to the collection system. **Table 2** presents these relationships.

Table 2: Sutherland Relationships between Impervious Area and DCIA

Watershed Selection Criteria	Assumed Land Use	Equation (where IA(%) ≥ 1.0)
Average - Mostly storm sewered with curb and gutter, no dry wells or infiltration, residential rooftops not directly connected.	Commercial, Industrial, Institutional/Urban public, Open land, and Medium density residential.	$DCIA = 0.1(I.A.)^{1.5}$
Highly connected - Same as above, but residential rooftops connected.	High density residential	$DCIA = 0.4(I.A.)^{1.2}$
Totally connected - 100% storm sewered with all IA connected.	---	DCIA = IA
Somewhat connected - 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration.	Low density residential	$DCIA = 0.04(I.A.)^{1.7}$
Mostly disconnected - Small percentage of urban area is storm sewered, or 70% or more infiltration/disconnected.	Agricultural, forested	$DCIA = 0.01(I.A.)^{2.0}$

* adapted from EPA 2011

Making use of these relationships and impervious areas noted in the EPA 2011, **Table 3** presents the DCIA values used in the WMM.

Table 3: Land Use Impervious Area Assumption

Land Use	Watershed Selection Criteria	DCIA
Forest/Rural Open	Mostly disconnected	1.0
Urban Open	Mostly disconnected	1.2
Medium Density Residential	Average	23.4
Highways	Totally connected	50.0
Water/Wetland	Totally connected	95.0
Impervious/Urban	Highly connected	55.5
Commercial/High Density Residential	Highly connected	58.3

Pollution Removal Efficiencies

The intent of this project is to include and quantify the impact of low impact development (LID) best management practices (BMP) on the existing mass loading to the Mill River. LID BMPs include the following: rain gardens, tree filters, porous pavement, green roofs, sand filter, street sweeping, catch basin cleaning, and public education. In general there are two types of benefits to be realized by these types of BMPs: 1) a reduction of the volume of stormwater runoff generated, and 2) reduction of concentration of the various pollutants.

A component of many LID BMPs is to mimic predevelopment hydrology, i.e. the development of spatially distributed incremental storage/treatment facilities as opposed to centralized wet ponds. In this manner, runoff is captured locally, often at its source. This allows for a decentralized treatment model, also the subsequent infiltration, if possible, proceeds in a more diffuse manner. Depending upon the level of implementation, this component of the BMPs may result in a significant reduction in the post development runoff volume/rate. It is noted that a direct implication of a reduction in runoff volume is provides a proportional reduction in pollutant mass loading. Examples of BMPs that exhibit this component are pervious pavement and rain gardens.

The other component of LID BMPs is the actual pollutant concentration reduction. This often proceeds via vegetation uptake, biochemical conversion, or settling of solids (with or without associated constituents). The effectiveness of pollutant reduction is a direct function of the configuration of the BMP. Examples of this type of BMP are tree filters and rain gardens. The reduction in pollutant concentration is often a function of many factors including, but not limited to: incoming pollutant concentration, type of vegetation present in the BMP, and residence time of the runoff entering the BMP. Often the manufacturer will provide estimates of pollutant load reduction.

Another important consideration is the relative level of treatment being provided. As an example, one could imagine that a single rain garden may be quite effective when treating the runoff from a single lot, or perhaps, several lots. The effect of this single rain garden would likely be inconsequential if it sought to treat the runoff from several city blocks. It is necessary to design and implement an adequate number of facilities to provide pollutant reduction indicated by the manufacturer's estimates.

In order to estimate the reduction in runoff volume, the Sutherland Equations were used with three land uses that are likely to be retrofitted with LID BMPs. These three land uses are: medium density residential (MDR), commercial/high density residential, and impervious/urban. It was assumed that the watershed selection criteria would shift from average (MDR), and highly connected (commercial/high density, and impervious/urban) to somewhat connected. This would result in a reduction of DCIA to 19.4, 46.4, and 43.4 percent respectively. Currently, only this component is used in quantification of the reduction in pollutant loading in the model.

A literature search was done to quantify the pollutant concentration reduction from implementing LID BMPs, these pollutant load reduction efficiencies will be used in the final version of the analysis. These values are presented in **Table 4**.

Table 4: Pollutant Concentration Reductions from Management Practices

Management Option	Total Phosphorus	Total Nitrogen	TSS	Copper	Other Metals (Pb, Zn, Cd)	Bacteria
Rain Garden/Bioretention	50%	50%	85%	75%	75%	70%
Tree Filter	70%	70%	90%	80%	80%	0%
Porous Pavement	65%	40%	85%	85%	65%	0%
Sand Filter	50%	30%	80%	55%	80%	37%
Green Roof	45-60% reduction in runoff from roofs					

Note: Percent reductions apply to runoff going through BMP

Event Mean Concentration Values

For this study, the EMC values were obtained from three general sources. CDM maintains a database of EMC values for the entire country. Periodically additional values are included in this database, and regional extractions are created. Recently, as a part of a CDM research and development project, Wolosoff and Greene 2010, estimated EMC values for 6 regions of the Country. Region 1 corresponds to the northeast. The values provided in this memo were used as available. An internet search resulted in a table of EMC values that were used in the Niantic River Watershed Protection Plan. As this river is located in Connecticut, these values were used. The remainder values were the default values from WMM. These values for the seven land use categories are presented in **Table 5**. The source is indicated on this table.

Table 5: Event Mean Concentrations Used in Mill River Watershed Model

Land Use	Pollutant Event Mean Concentration										
	BOD (mg/l)	TSS (mg/l)	TP (mg/l)	DP (mg/l)	TKN (mg/l)	NOx (mg/l)	Pb (mg/l)	Cu (mg/l)	Zn (mg/l)	Cd (mg/l)	F-Coli[1]
Commercial/HDR	29.5	77.75	0.41	0.13	1.3	0.55	0.038	0.026	0.141	0.003	1.21E+11
Forest/Rural Open	3.0	51.0	0.11	0.03	0.9	0.80	0.000	0.000	0.000	0.000	1.36E+09
Highways	3.1	25.7	0.18	0.22	1.5	0.25	0.049	0.037	0.156	0.003	2.72E+09
Impervious/Urban	24.3	72.0	0.37	0.12	1.2	0.47	0.037	0.037	0.213	0.004	9.04E+10
Medium Density Residential	11.5	54.5	0.26	0.27	1.5	0.53	0.040	0.023	0.121	0.004	1.86E+11
Urban Open	3.0	51.0	0.11	0.03	0.9	0.80	0.014	0.000	0.040	0.001	2.27E+10
Water/Wetlands	4.0	6.0	0.08	0.04	0.8	0.59	0.011	0.007	0.030	0.001	1.36E+09

Notes: 1 - units are #/100mL * conversion factor (4.535e6) to result in #/year in WMM results

Wolosoff's memo

WMM default

Niantic River Watershed Protection Plan

Rainfall Data

Rainfall data for the Mill River basin was obtained from the long term average for US Historical Climatology Network Station #067970 (Stamford, CT). The long term average was determined from 104 years of data (1905 to 2009). The long term average was 47.5 inches.

Septic Tank Usage

Septic tanks are used in many areas of the Mill River Basin for sewage disposal, primarily in older residential areas. The estimated percentage of each major subbasin served by septic tanks is presented in **Table 6**. Sewer service coverage maps were provided to CDM by the Stamford Water Pollution Control Authority. These maps, coupled with city parcel data, led to the values presented below.

Table 6: Percentage of Mill River Basin on Septic Systems

Land Use Type	Ayers	Haviland	Holts Ice Pond	Mainstem1	Mainstem2	Mainstem3	Poorhouse	Toilsome
Commercial/HD Residential								
Area (acres)	6.9	312.3	41.7	0.0	15.5	112.9	129.5	1.4
% Of Area:	4%	100%	93%	0%	6%	85%	99%	1%
MD Residential								
Area (acres)	8.2	366.9	122.7	0.0	88.2	121.2	328.4	2.6
% Of Area:	2%	100%	80%	0%	15%	93%	99%	0%

For existing land use conditions, septic tank impacts were estimated for medium density residential and commercial/high density residential land uses (i.e., only the residential land uses were considered to be served by septic tanks. The WMM assesses the impact of failing septic tank by applying a multiplication factor to the surface runoff load. This multiplication factor was calculated as the ratio of the annual unit loading rate (i.e. lbs/ac/year) of the estimated septic tank failure loading compared to the stormwater runoff annual unit loading. This multiplication factor was applied only to the total phosphorus, nitrogen (TKN, NO_2+NO_3), BOD, and F-Coli parameters.

The factor used for total phosphorus was 3.2 for MDR and 3.9 for commercial/HDR. The factor used for the nitrogen was 1.8 for MDR and 1.9 for commercial/HDR. The factor used for the BOD was 1.8 for MDR and 3.0 for commercial/HDR. Finally, the factor for F-Coli was 10.0 for MDR and 17.4 for commercial/HDR.

To assess the increase in runoff load due to failing septic tanks, WMM considers the multiplication factor (discussed above), the percent septic tank coverage, and the percent failure rate. The percent failure rate assumed for this study was 10%.

Baseflow Volume and Pollutant Concentrations

In addition to calculating runoff loading from subwatersheds, the WMM takes into account the baseflow volume and concentration in the stream. It is important to accurately estimate the baseflow contributions to flow and pollutant loading to bound the level of improvement that can be expected from stormwater management options. The field program for the Mill River study provided ample data in the form of pollutant concentrations to estimate baseflow loads. The program included six dry weather sampling events: one event in each of the four seasons targeting low flow, dry weather conditions, and two pre-wet weather event sampling rounds. The average of all dry weather samples for each parameter was used as the baseflow concentration in the model; the values are shown in Table 7. In the WMM, the baseflow represents all flow not originating as rainfall in one of the study subwatersheds. This includes natural stream baseflow as well as the flow from the upstream boundary, the North Stamford Dam. The baseflow was estimated using a standard baseflow separation technique with the USGS gage data.

Table 7: Estimated Baseflow Values

Parameter	Units	Estimated Value for Model
Flow	(ac-ft/yr)	9,535
BOD	lbs/yr	41,517
Copper	lbs/yr	286
Dissolved Phosphorus	lbs/yr	569
Fecal Coliform	counts/yr	1.09E+07
Nitrates	lbs/yr	20,519
Lead	lbs/yr	99
TKN	lbs/yr	12,651
Total Phosphorus	lbs/yr	1,182
Total Suspended Solids	lbs/yr	116,583
Zinc	lbs/yr	357

WMM Results

The final output from the WMM for the purposes of assessing management options for the Mill River watershed are the loadings from each subbasin. **Figure 2** shows the fraction of loading from each subbasin, for each parameter, used as the baseline existing conditions for the analysis.

The WMM was used to evaluate the expected pollutant loading reductions resulting from structural BMPs presented in the Watershed Management Plan. The levels of implementation of the BMPs (listed in Table 4 of this memorandum) were projected based on a consolidation of knowledge about the watershed, key focus areas, and land use patterns. A wide variety of implementation options were evaluated in the model; the most comprehensive were selected for inclusion in the Watershed Management Plan. These pollutant loading reduction results may be used by the city to select BMPs targeted at a specific pollutant of concern or targeted at a particular area of the watershed. The results may also assist the city in evaluating the benefit of implementing BMPs.

Section 6 of the Watershed Management Plan includes a description of all action items included in this study. For each modeled structural BMP action item, there is a description of the representation of the BMP in the WMM and a summary of the pollutant loading reduction. **Tables 8a through 8e** also show the percent reductions.

Figure 2: Pollutant Loading by Subbasin

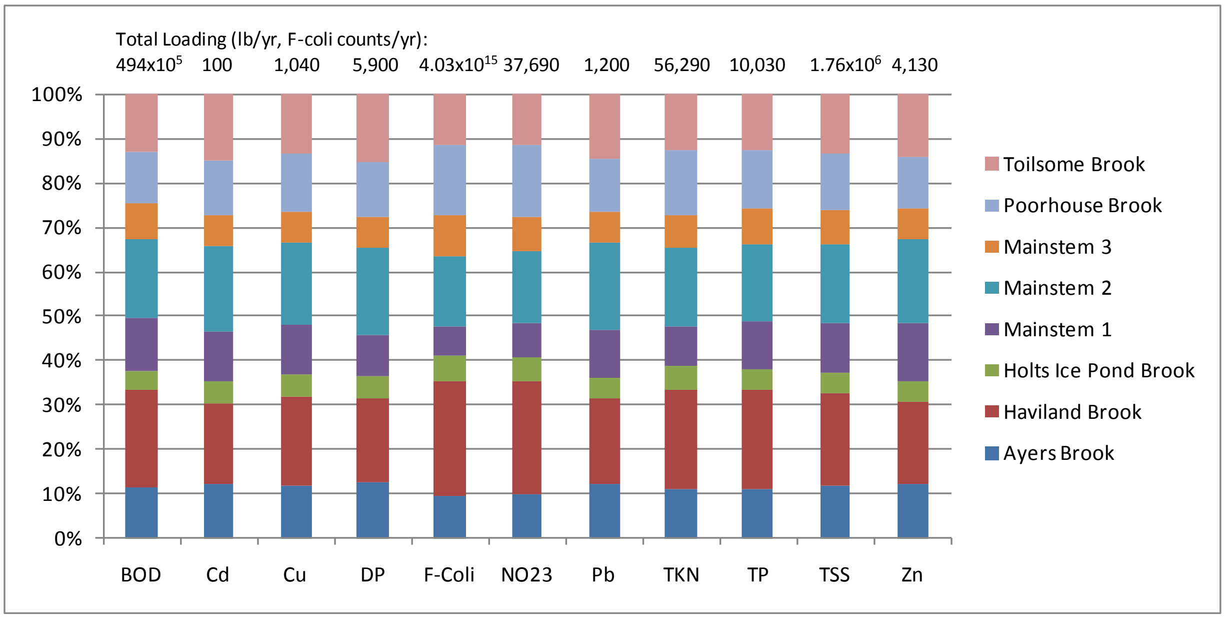


Table 8a: Estimated Pollutant Loading Reduction from Rain Gardens

Pollutant	Estimated Basin-Wide % Reduction in Loading
Biological Oxygen Demand	7%
Metals	4-7%
Fecal Bacteria	8%
Nutrients	2-4%
Sediment	7%

It was assumed that through education programs the city may expect to capture 10% of runoff through on-site rain garden bioretention. The modeling also assumed that all runoff from Stamford Hospital (8 acres) and half of the city-owned property downtown (5 acres) could be routed through bioretention.

Table 8b: Estimated Pollutant Loading Reduction from Tree Filters

Pollutant	Estimated % Reduction in Loading	
	Ayers Brook Basin	Downtown Basin
Biological Oxygen Demand	2%	2%
Metals	0-2%	0-2%
Fecal Bacteria	<1%	<1%
Nutrients	0-2%	1-2%
Sediment	2%	2%

It was assumed that the city may expect to capture 25% of runoff from impervious/urban land cover in the Ayers Brook subbasin and 6% of the runoff from impervious/urban land cover in the downtown subbasin.

Table 8c: Estimated Pollutant Loading Reduction from Porous Pavement

Pollutant	Estimated Basin-Wide % Reduction in Loading
Biological Oxygen Demand	4%
Metals	1-3%
Fecal Bacteria	<1%
Nutrients	0-3%
Sediment	3%

It was assumed that the city could apply porous pavement to 10% of parking lots within commercial and high-density residential land covers within the watershed.

Table 8d: Estimated Pollutant Loading Reduction from Green Roofs

Pollutant	Estimated % Reduction in Loading in Downtown Basin
Biological Oxygen Demand	1-2%
Metals	1%
Fecal Bacteria	1%
Nutrients	1%
Sediment	1-2%

A fairly aggressive assumption was made in the model that every building in the city with a footprint greater than 10,000 square feet would have a green roof. The overall pollution reduction potential of green roofs in the city is small. However, the public awareness and education aspect of these features may compensate for the shortcoming in overall coverage.

Table 8e: Estimated Pollutant Loading Reduction from Sand Filters

Pollutant	Estimated Basin-Wide % Reduction in Loading
Biological Oxygen Demand	4%
Metals	1-3%
Fecal Bacteria	2%
Nutrients	0-2%
Sediment	3-4%

It was assumed that the city could capture 25% of the runoff from the High Ridge Rd commercial area in Ayers Brook Basin and 5% of runoff from impervious surface downtown through sand filters.

References

Sutherland, 2000. *Methods for Estimating Effective Impervious Cover*. Article 32 in the Practice of Watershed Protection, Center for Watershed Protection, Elliot City, MD.

USEPA, April 2011, *Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for New Hampshire Small MS4 Permit*, EPA, Washington, DC.

Wolosoff, S. and A. Greene, *Compilation of a National Storm Event Mean Concentration (EMC) Database*, Internal CDM R&D Memo, 2010.

Appendix C: 9 Element Watershed Based Plan Component Checklist for CWA Grant Funding[1]
Watershed Management Plan Title:
Waterbody ID, Hydrologic Unit Code, Watershed Boundary Data Set, or Hydrologic Response Unit:
River Basin:
County(ies):
Title of TMDL: a) A TMDL for This Watershed is ("X" as applicable): ( ) Approved ( ) In Draft b) No TMDL Has Been Developed to Date: ( )
Comments:

[1]In order to be eligible for CWA Section 319 incremental* grant (watershed protection) funding - or to submit a Section 319 grant proposal - a copy of the EPA approved 9 element watershed based plan and this completed checklist must be on file with the Connecticut Department of Environmental Protection's Bureau of Water Protection and Land Reuse. Components and formatting of this checklist may change in response to federal grant funding, grant guideline revisions, or other program initiatives or purposes as deemed appropriate by EPA/CT-DEP. Note that preparation or submittal of an EPA 9 Element watershed based plan, or this checklist, does not obligate the EPA or CT DEP to partially or fully fund any part of a watershed based plan or recommended implementation project.

* Incremental grant background: Congress enacted Section 319 of the Clean Water Act in 1987, establishing a national program to control nonpoint sources of water pollution. During the last several years EPA has been working with the States to strengthen its support for watershed-based environmental protection by encouraging
local stakeholders to work together to develop and implement watershed-based plans appropriate for the particular conditions found within their communities. In particular, EPA and the States have focused attention on waterbodies listed by States as impaired under Section 303(d) of the Clean Water Act. Toward this end States must use $100 million ($1 million for Connecticut) of Section 319 funds (referred to as "incremental funds") to develop watershed-based plans that address nonpoint source impairments in watersheds that contain Section 303(d)-listed waters and implement recommendations incorporated in these plans.

Component (A) **Identification of Pollutant Causes and Sources**	**Yes**	**No**	**Chapter, Section, Table, List, etc.**	**Page No.(s)**
I. The plan identifies the pollutant *causes* and *sources* <u>or</u> groups of similar sources that will need to be managed to achieve the load reductions identified in this watershed based plan or a TMDL, including page number where load reductions are found in this plan.) <u>Comments</u>:				

Component (B) **Pollutant Load Reduction Estimates**	**Yes**	**No**	**Chapter, Section, Table, List, etc.**	**Page No.(s)**
I. The plan provides estimates of load reductions needed to delist water bodies identified in the watershed based plan. <u>This is a requirement of the Watershed Based Plan.</u> <u>Comments</u>:				
II. The plan provides *estimates* of potential load reductions for each pollutant cause or source, or groups of similar sources that need to be managed. (If "No" or "N/A" provide comments below.) <u>Comments</u>:				
III. A model (as outlined in Attachment B.IV.) is used to *estimate* pollutant load reductions (assumptions and limitations should be stated). <u>Comments:</u>				

Component (C) Best Management Practices	**Yes**	**No**	**Chapter, Section, Table, List, etc.**	**Page No.(s)**
I. The plan provides locations where *potential* BMPs may be implemented. Comments				
II. The plan identifies *potential* BMPs to be installed in "critical" areas. Comments: This is a requirement of the Watershed Based Plan				

Component (D) Financial and Technical Assistance	**Yes**	**No**	**Chapter, Section, Table, List, etc.**	**Page No.(s)**
I: The plan provides estimates of the financial and technical assistance that will be needed to implement the plan. This is a requirement of the Watershed Based Plan. Comments: This section will include BOTH estimates and potential funding sources for project implementation costs AND Annual maintenance costs of the project.				
II: The plan identifies sources and authorities that will be relied upon to implement the plan. Comments:				

Component (E) Education and Outreach	**Yes**	**No**	**Chapter, Section, Table, List, etc.**	**Page No.(s)**
I. The plan provides an information/education component that will enhance public understanding of the plan and encourage their early and continued participation in project development. Note: This education and outreach component must link the information to model demonstration or pilot projects that stakeholders can implement post WBP development.				

Component (F) Plan Implementation Schedule	Yes	No	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan provides a schedule for implementing management measures. (Applicant should base implementation timetable on BMPs in "Component C" above.) <u>Comments</u>:				

Component (G) Interim Milestones	Yes	No	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan provides a list or description of interim milestones for determining whether NPS management measures are being implemented.				

Component (H) Monitoring and Assessment	Yes	No	Chapter, Section, Table, List, etc.	Page No.(s)
I. A set of criteria that can be used to determine whether loading reductions are being achieved over time and progress is being made towards attaining water quality standards. <u>Comments</u>:				

Component (I) Plan Implementation Effectiveness	Yes	No	Chapter, Section, Table, List, etc.	Page No.(s)
I. A monitoring component to evaluate the effectiveness of the implementation efforts over time measured against the criteria established under item (H). <u>Comments</u>: The WBP must note that revisions will be made to improve the effectiveness of implementation efforts if monitoring shows no improvement post BMP efforts.				

Watershed Management Plan Component Checklist
for CWA Grant Funding*
Acknowledgment

I/we, the undersigned, believe that the watershed plan addresses Elements "a-i" of the EPA approved watershed based plan model elements - particularly those elements pertaining to broadly estimating pollutant load reductions that may result from implementation of best management practices - as presented in the, "*Nonpoint Source Program and Grants Guidelines for States and Territories*. Federal Register. October 23, 2003. (Volume 68, Number 205. pp. 60658-60660). http://www.epa.gov/fedrgstr/EPA-WATER/2003/October/Day-23/w26755.htm

I/we acknowledge that information provided by this checklist is based on a dynamic watershed based plan. Certain components of the 9 element watershed based plan (and this checklist) may need to be updated as data and information improves.

The signatory(ies) below are under no obligation to partially or fully fund or implement a watershed based plan, or any part thereof, unless funded by an EPA/CT-DEP approved Section 319 grant in accordance with an approved Section 319 workplan.

This checklist is submitted for CWA Section 319/CT-DEP Nonpoint Source Program grant program purposes by:

______________________________ ____________
Signature/Title Date

______________________________ ____________
Signature/Title Date

*This CWA Grant Funding Source includes, but is not limited to, CWA Section 319 grant funding.

- Attachment -
9 Element Watershed Based Plan Component Checklist
Helpful Notes and Examples

Component (A): Identification of Pollutant Causes and Sources

I. Causes *may* include low dissolved oxygen, organic enrichment, nutrients, ammonia, pathogens, siltation, pH, metals, habitat alteration, turbidity, pesticides, priority organics, etc.

Sources or "groups of similar sources" *may* include agriculture (pasture grazing; animal feeding operations; crop production, irrigation, etc.), urban/construction (stormwater runoff; industrial/municipal discharges, impervious surfaces, etc.), silviculture (forest planting/harvesting), land disposal (illegal dump; littering, septic tanks/septage disposal, etc.), resource extraction (surface mining); flow regulation/modification; etc.

Component (B): Pollutant Load Reduction Estimates

I. The load reduction estimates needed to delist water bodies identified in the watershed based plan may be incorporated from a previously approved CT TMDL or TMDL currently being drafted by DEP. TMDL parameters may include organic enrichment/dissolved oxygen (OE/DO), pathogens, nutrients (Total Nitrogen (TN) / Total phosphorus (TP), siltation, pH, metals, etc., and should be expressed as pounds/yr, tons/yr, percent, etc. Load reduction data may be descriptive or in tabular/list format.

II. Load reduction *Estimates* of each pollutant load reduction *to be targeted* by the plan should be included. For Section 319 funding purposes, pre-implementation BMP estimates of nitrogen, phosphorus, and sediment load reductions must be provided, if applicable. Estimates should be expressed as *number, pounds, tons, acres, miles, etc*.

Estimates are *predicted* load reductions expected from pre-implementation BMPs for a particular *cause* (e.g., siltation, nutrients) and/or *source* (e.g., agriculture, pasture grazing)
Example:

Pollutant:	Unit	Pre-BMP	Post-BMP	% Reduction Estimate
Sediment	tons/acre	12.69	6.8	47
Organic N	pounds/acre	14.8	11.46	23
Nitrate (NO_3)	pounds/acre	2.22	1.75	47
Organic P	pounds/acre	2.44	1.30	11
Soluble P	pounds/acre	0.19	0.08	57

III. Load reduction *estimates* may be determined using models (e.g., EPA Region 5, Step L, SWAT, IPSI, RUSLE, etc), technical/research references, or WQ monitoring and assessment data. Model assumptions and limitations should be stated.

Note: Pollutant load reductions for most on-the-ground management measures can usually be estimated using desktop models or water quality monitoring data for BMPs such as stream bank restoration, cover crops, buffers, nutrient management, seeding and mulching, etc. Estimates of load reduction associated with education and outreach (public involvement; behavior/attitudes changes), technical assistance, land-use ordinances, habitat/biological responses, etc., may not be easily discernable. *However, demonstration projects and pilot projects would have pollutant load reduction models for stakeholders to follow.*

Note: Pre- and post-BMP implementation nitrogen, phosphorus, and sediment load reduction estimates, *as applicable to the project*, are *required* for Section 319 grant funding.

Component (C): Best Management Practices

I. Location of Potential BMPs: This section refers to the *anticipated* locations, if known (pre-BMP implementation). *Potential* sites should be identified using a narrative description; photos, land use/topographic map, etc. Lat/Long and GPS coordinates should also be included, if BMP sites are obvious and definite.

Example:

TMDL Causes: Siltation, Nutrients

TMDL Sources: Agriculture, Pasture Grazing

BMP Location: Farmland Approx. *(X)* Miles (*direction*) of (*Town*), *Tributary to* (*Name)* River.

II. Description of Potential BMPs: The plan should provide a management practice description; numbers, types, etc. in Critical Areas of Concern in the Watershed

Example:

Problem: Approx. 75 head of beef cattle with unrestricted access to the (*name of impaired waterbody*), grazing on 30 acres of unimproved pasture land.

Solution: Install NRCS Conservation Practice Standard 914. Livestock Fencing: 6,680 feet.

Note: Because some "best" management practices may involve the establishment of committees, hiring coordinators, planning, monitoring/assessments, developing local ordinances, regulation/enforcement, providing technical assistance, establishing citizen volunteers, conducting outreach/training, Load Reductions Estimates as a result of these types of measures may be difficult to quantify. It is acknowledged that BMPs are *estimates* and *may* need to be modified over time as new information is derived, land use's change, and as the watershed plan is implemented. CT-DEP supports 319 grant outreach and education projects that include demonstration projects and pilot projects for stakeholders to more fully understand the process of NPS implementation.

Component (D): Financial and Technical Assistance

I. Estimates of the financial and technical assistance

Example 1:

Technical Assistance: Riparian buffers for erosion and sedimentation control to the stream. Project total cost = $10,000.

Financial Assistance:

A. Section 319 Grant Funding (60% of total cost)

a. Riparian Plants (detailed listing, count, description and costs of plantings by Applicant included) $4,000.00

b. Design of Buffered area to ensure long-term maintenance $2,000.00

B. In Kind Services: (40% of total cost)

a. Staff to plant riparian buffer on conservation property $2,500.00

b. Staff to educate residents about importance of riparian buffers to NPS improvements and distribute state brochures on LID $1,500.00

Example 2:

Technical Assistance: Three Rain Gardens for stormwater quality and quantity management at three primary municipal facilities in watershed towns. Project total cost = $20,000

Financial Assistance:

A. Section 319 Grant Funding (60% of total cost)

a. Rain garden plantings (detailed listing, count, description and costs of plants by Applicant attached to application) $10,000.00

b. Design of Rain Garden to ensure plants will thrive in specific soils and location. Design will also ensure long-term maintenance of the rain garden. $2000.00

B. Municipal Cash Match (40% of total cost)

a. Additional rain garden plantings and materials to install rain garden (detailed listing of plants and additional materials attached to application) $6,000.00

b. Workshop for town residents to educate on benefits of rain gardens and proper long term care for these types of gardens. $2,000.00

II. Watershed plan stakeholders should be identified, and roles and responsibilities defined. *A source* refers to a federal, state, or local agency; or landowners/landusers, citizen volunteers, foundations/grants/loans/donations, etc., that will provide watershed plan implementation services/funding.

Authorities include bur are not limited to laws, rules, regulations, grant/loan programs, etc., that may be necessary to implement the watershed plan,

Component (E): Education and Outreach
Education and Outreach may be "*watershed-scale*" in scope and include, "Partnership" meetings and conferences; school/civic club/service organization presentations; news articles/feature stories; displays, fairs/festivals; tours/field days; agency/citizen cooperation in selection, design, and implementation of management measures, conservation practice "sign-ups" etc.

Implementation Efforts may also be more "*site specific focused*" or "*small-scale*". These projects may include "pilot projects" to encourage additional, larger projects within a specific community, "small scale projects" to address a portion of a larger project site, or "site specific/mini-watershed projects" to address a focused watershed in the larger scale Watershed Based Plan.

Component (F): Plan Implementation Schedule
An implementation schedule refers to tasks that ensure that the watershed plan's goals and objectives will be achieved in an expeditious manner.
Example A:
Milestone 1: Stakeholder will hire a Watershed Project Coordinator by date.
Milestone 2: *10,000 Rain Gardens* will be installed by the Stakeholder by date.

Example B: Management measures in "**F**" and "Interim" milestones in "**G**" below may be combined into a "Milestone Table" or List, as presented below:

No.	Activities and Interim Practices to Assure that Project Implementation is Timely and Reasonable	Milestone Schedule	Responsible Entity
1. 1a. 1b. 1c.	Milestone: Conduct an area-wide watershed project outreach campaign to inform citizens about the project, its benefits, to encourage enthusiasm and input, and to build and sustain project support for the duration of the project period Interim Measure: Develop a stakeholder "contact list" to provide quarterly communication via telephone, e-mail, website, personal contact, meetings, etc. Interim Measure: Document all correspondence with stakeholders, citizen info. request, and records of meetings for the duration of the project period Interim Measure. Coordinate the development and distribution of newsletter articles, brochures, etc, with the Watershed Project Steering Committee	Begin: MM/DD/YY End: MM/DD/YY Begin: MM/DD/YYEnd: MM/DD/YY Begin: MM/DD/YY End: MM/DD/YY Begin: MM/DD/YY End: MM/DD/YY	FRWA with DEP support FRWA/Subcontractor FRWA FRWA
2.	Etc.		
2a.	Etc.		

Component (G): Interim Milestones
Interim refer to step-wise or intervening measures that ensure the implementation schedule ("F" above) will be achieved, and may include: **RFPs/contracts executed**; hiring a coordinator, to coordinate specific types/number/dates management practices are to be installed, to identify specific BMP sites/site preparation; various stakeholder coordination/information delivery approaches; monitoring/assessments; outreach/training materials to be produced/distributed; etc.

Examples:
Interim Milestone 1: The FRWA will issue an RFP to hire a Watershed Project Coordinator by date.
Interim Milestone 2: The Stakeholder will execute a contract to install 10,000 rain gardens by date.
Interim Milestone 3: The Stakeholder will conduct coordinated *semi-annual* site visits with DEP to ensure BMPs are properly maintained.

Note: Interim Measure(s) may be combined in a tabular format as per *Example "B"* under Component "**F**" above.

Component (H): Monitoring and Assessment
Note: The following items are examples of a watershed monitoring and assessment component. One or more may apply to any particular watershed plan.

a) Water quality samples and stream assessments to assess load reductions will be collected post-BMP implementation (monthly*, quarterly, semiannually, etc,*) by (*agency/cooperator name*).
b) Water quality samples and stream assessments for the *watershed/impaired waterbody name* will be collected post-BMP implementation on or before *date* by (*agency/cooperator name*).
c) Post-BMP implementation data may be compared with any previously collected water quality data and watershed information to determine if pollutant load reductions have been achieved. If no water quality improvements are noted, the watershed plan may be revised, and/or the types, numbers, locations, etc, of BMPs modified by stakeholders.
d) Post-BMP implementation data may be compared with any previously collected water quality data and watershed information to determine the scope of pollutant loadings. If non-impaired waters are threatened, the watershed plan may be revised, and/or the types, numbers, locations, etc, of BMPs modified by stakeholders to protect against further degradation.
e) Post-BMP water quality monitoring data may be compared with NPS TMDL targets to determine if NPS pollutant load reductions have been achieved. If no load reductions have been achieved, the TMDL may be reassessed, as needed.
f) Information collected from CT-DEP 5-year rotational basin assessments, as well as trend, reservoir, or other water quality monitoring programs - may be used to assess basin-wide and targeted watershed pollutant loading. This data may be used to determine if load reductions are being achieved over time as a result of BMPs installed. If water quality standards are not being met during the 5-year period for a targeted 303(d) listed impaired

water, stakeholders may re-evaluate management practice targeting and effectiveness and/or whether the TMDL should be revised.

g) The development of load reduction success indicators (to include meeting water quality standards) will be a collaborative effort among watershed stakeholders. Evaluation criteria developed by stakeholders may be reviewed (*semiannually/annually*) as BMPs are installed.

h) Establishment and implementation of monitoring activities will be coordinated with watershed project partners pre- and post-BMP implementation. Load reduction success may be based on an evaluation of available data and information collected over time. If load reduction criteria are not progressing as expected, stakeholders may revise and re-distribute the watershed plan within (*X*) months of the evaluation.

i) If monitoring indicates load reduction expectations are not being achieved incrementally for the resources available/expended, watershed stakeholders may investigate the effectiveness of selected BMP practices, and may revise the watershed plan.

Note: All plans/proposals that include an environmental monitoring component and submitted for 319 grant funding, must have an approved Quality Assurance Plan before Clean Water Act funding (including but not limited to Section 319 funding) can be expended.

Component (I): Plan Implementation Effectiveness

I. Effectiveness monitoring "over time" may include on-site visits (citizens/resource agency/professional BMP installation or site assessments), documentation of BMP types/numbers/sites; cooperative stakeholder reviews of watershed plan/TMDLs; installation of new/innovative/improved BMPs not proposed in the original plan; water quality monitoring scheme presented in "H" above, etc.

Notes: A process for Revisions to the WBP must be added included in this section to explain how planning efforts will be revised if implementation is not as effective as originally calculated.

Appendix D: Memorandum

To: *Jeanette Brown, Stamford WPCA*

From: *Karen Kelley and Jamie Lefkowitz*

Date: *December 8, 2009*

Subject: *Mill River Watershed Study – Windshield Survey*

As part of the effort to develop a basin management plan for the Mill River Watershed in Stamford, CT, CDM has conducted a desktop/windshield survey of the lower watershed. The purpose of this activity is to summarize the potential threats to water quality within the watershed. This survey focuses on the watershed south (downstream) of the North Stamford Reservoir. The northern portions of the watershed were similarly surveyed in 2003 as part of Connecticut's Source Water Assessment Program. This memorandum includes a summary of the following, accompanied by photographs and maps from the desktop/windshield survey:

- Facilities identified as potential threats to water quality
- Land use trends throughout the southern watershed
- Opportunities for improved stormwater management in the southern watershed

Potential Threats to Water Quality

The following lists identify businesses and facilities within the watershed that may directly impact water quality. Extensive reconnaissance has not been conducted at each site to evaluate if and how the potential threats may be causing water quality problems. The facilities listed below are shown in Figures 1 and 2.

Animal Farms/Petting Zoos

Potential water quality problems can arise at these locations from improper control of stormwater runoff and direct bacterial pollution to surface waters by free-ranging animals.

- Runabout Farm – 46 Acre View Drive – This is a private business, housing typical petting zoo animals (goats, chickens, rabbits, cats, etc) as well as ponies and horses. The farm is approximately one acre.

- Stamford Museum and Nature Center – 39 Scofieldtown Rd – The museum and nature center is home to farm animals and exotic animals, housed in buildings and outdoors. The Museum and Nature Center occupies approximately 84 acres surrounding Bendels Pond, which is part of Poorhouse Brook. The pond is home to numerous swans and other waterfowl – wild and domesticated. Water exits Bendels Pond over a spillway and seepage channel, flows under High Ridge Rd, through another impounded area, and meets with the mainstem Mill River. The primary purpose of the facility is education.

Solid Waste Facilities/Landfills

Uncontrolled solid waste and landfill facilities pose a threat to groundwater, surface water, and soil contamination.

- Scofieldtown Road Park – Scofieldtown Rd and Rock Rimmon Rd – This park is the site of a former city landfill. The unlined landfill opened in the 1930s as a residential dump for household waste, and in 1949 began accepting industrial waste. The landfill was nominally closed in 1968, and capped with soil in 1974 and converted to a park and recycling and leaf composting facility. The landfill does not have an impermeable cap. At the recycling center, an above-ground storage tank was used to store sodium chlorite solution used for winter road maintenance activities, and a salt shed was used to store road salt.

  According to the December 2008 Final Site Reassessment Report issued by USEPA (USEPA, 2008), numerous complaints were filed in the late 1960s by local residents about the park concerning exposed refuse, rat infestation, refuse in an adjacent unnamed stream and wetland area that feeds Poorhouse Brook, and a dump fire. The site was listed in the Comprehensive Environmental Response Compensation Liability Information System (CERCLIS) database in May 1986 (CERCLIS No. CTD981214299). Between 1980 and the present, the Connecticut Department of Environmental Protection, City of Stamford, and EPA have conducted numerous environmental investigations of the property.

  In 1988, CT DEP observed hundreds of tires and several rusted drums, some of which contained resins, paint-like materials, and other waste materials. In 1996, a study performed on behalf of EPA found rusted drums and leachate discharging to an unnamed stream that becomes Poorhouse Brook east of Scofieldtown Road.

  The City recently closed the Scofieldtown Road Park, after groundwater and soil contamination was found above the state limit. The landfill is estimated to be between 10 and 18 acres with a waste depth of 10 to 30 feet.

  Since February 1997, water quality sampling at nearby residential wells has revealed pesticide levels above state drinking water action levels, including dieldrin and chlordane. Residential well testing is ongoing at this time.

Gas Stations and Auto Repair Shops

There are numerous gas stations and auto repair shops within the Mill River watershed. Facilities are continually opening, closing, and undergoing construction. These facilities can impact groundwater, surface water, and soil in a variety of ways, including improper disposal of chemicals, uncontrolled stormwater runoff, and leaky underground storage tanks. Figure 1 shows the approximate location of the gas stations and auto repair shops identified through desktop and windshield surveys in September 2009.

Dry Cleaners

Dry cleaners that perform, or once performed, onsite laundering could be a threat to water quality due to the potential for improper disposal of dry cleaning chemicals. The dry cleaning facilities shown in Figure 1 have not been identified as facilities that have or have had onsite dry cleaning operations, nor has any reconnaissance been done to evaluate their chemical disposal practices.

Garden Centers

Garden centers can be a source of water quality contamination from the uncontrolled storage and use of large quantities of pesticides and fertilizers as well as sediment loading from inadequate control of stormwater runoff from mulch and soil piles.

- Eden Farms Nursery and Garden Center – 947 Stillwater Rd: Facility is approximately 4.8 acres and has outdoor growing areas and displays.
- Exquisite Environments Garden Center – 1351 Stillwater Rd: Facility is approximately 1.2 acres and has outdoor displays.
- Designs by Lee, Inc – 129 Interlaken Rd: Facility is approximately 7.2 acres and has outdoor growing areas and displays.
- High Ridge Nursery – 1854 High Ridge Rd: Facility is approximately 1.5 acres.
- Shanti Bithi Bonsai – 3047 High Ridge Rd: Facility is approximately 0.4 acres.

Animal Hospitals/Kennels

Uncontrolled feces from dog recreation areas can be a source of bacteria pollution in stormwater runoff. Detailed reconnaissance has not been done at any of the facilities listed below to evaluate their waste disposal or stormwater control practices.

- Bulls Head Animal Hospital – 28 Long Ridge Rd
- Canine Athletic Club, Inc – 143 Cold Spring Rd

- Lucky Leash Canine Care – 2 Hoover Ave
- High Ridge Animal Hospital – 868 High Ridge Rd

Wildlife

Dense populations of waterfowl in the watershed pose a threat to water quality. Runoff picks up the animals' feces and may contribute to high bacteria levels in receiving ponds and streams. Several areas in the southern Mill River watershed have been identified on separate occasions as being congregation spots for waterfowl:

- Scalzi Park
- In the river and floodplain just north of the Broad St crossing
- In the river and floodplain between the Toilsome Brook confluence and the Cloonan Middle School
- Bendels Pond at the Stamford Museum and Nature Center

Regular feeding of ducks and other water fowl by residents adjacent to the Mill River also has been reported near Buckingham Drive.

Hazardous Waste Sites

CT DEP maintains a list of sites throughout the state that are classified as contaminated or potentially contaminated. Based on the September 2009 reporting from CT DEP, there are over 800 sites in Stamford on the list. Figure 2 shows the 325 Stamford sites that lie within the Mill River watershed. The descriptions given by CT DEP for the listed sites are as follows ("Hazardous Waste Facilities" as defined by CGS Section 22a-134f, source-www.ct.gov/dep/lib/dep/site_clean_up/sites/site_definitions.pdf):

- CERCLIS – 1 site (Scofieldtown Road Park)

CERCLIS sites are potential hazardous waste sites in Connecticut that the U.S.EPA is evaluating under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund. These sites are included in EPA's CERCLIS database. This database, the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS), is the national database and management system EPA uses to track activities at hazardous waste sites considered for cleanup. Note that the list does not include sites that EPA evaluated and determined that no further remedial actions are necessary.

- Inventory of Hazardous Waste Disposal Sites – 1 site (Newfield Cleaners)

These are sites which may pose a threat to the environment or public health and are listed on the Inventory of Hazardous Waste Disposal Sites ("the Inventory"), pursuant to Section 22a-133c of the Connecticut General Statutes (CGS).

- Leaking Underground Storage Tanks – 200 total sites

These are residential and commercial sites with releases of petroleum products from underground storage tanks. A fact sheet on the CT DEP Underground Storage Tank Program is available at www.dep.state.ct.us/wst/ust/ustregs.htm. Information on spill reporting and responsibility for remediation of spills is also available at www.dep.state.ct.us/wst/oilspill/resp.htm.

  - Pending **-** The leaking tank has been discovered and reported to DEP, 12 sites.
  - Investigation - Investigation of the release is underway, 9 sites.
  - Remediation Started - Remediation of the release to address emergency conditions is underway, 18 sites.
  - Completed **-** Remediation of the emergency conditions caused by a release has been completed. This designation does not mean that all contamination from a leaking tank has been remediated in accordance with State standards, 161 sites.

- Property Transfer – 123 total sites

Property Transfer sites are sites that have filed either a Form III or Form IV pursuant to CGS 22a-134a through 134d, inclusive. Forms III and IV are files when a discharge, spillage, uncontrolled loss, seepage or filtration of hazardous waste of a hazardous substance has occurred at the site. A fact sheet on the Property Transfer Program is available at www.dep.state.ct.us/pao/perdfact/proptran.htm.

Land Use Trends

The portion of the Mill River watershed covered in the windshield survey (from the Merritt Parkway corridor to the southern extent of the watershed) can be segmented based on land use trends. The observed trends are described below and shown in a series of maps and photographs, Figures 3-6 and Tables 1-4.

North of Merritt Parkway

The land use in this area is primarily heavily wooded and medium density residential. Non-residential properties include 2 gas stations/repair shops, 3 dry cleaners, a petting zoo, a school, the Stamford Museum and Nature Center and a garden center. The Scofieldtown Park landfill is located just north of this land use area in the upper watershed where a similar survey was conducted in 2003 as part of Connecticut's Source Water Assessment Program. The terrain is hilly, with frequent outcrops of bedrock. Hydrologically, the area is marked by small streams and drainage channels that appear to have intermittent flow, and flow in and out of small ponds and wetland areas. This land use area encompasses the downstream portions of the drainage basins for Mill River tributaries Poorhouse Brook and Haviland Brook, as well as the upstream portion of the Holts Ice Pond Brook subbasin. Unmanaged stormwater, both in terms of quantity and quality, may be contributing to erosion and pollution problems in the Mill River, which is the final destination of most of these pond outlets and drainage channels. The Holts Ice Pond sub-basin is an example of this issue. There are also many ponds that appear to be hydraulically isolated from the larger drainage system. These may be manmade ponds or natural depressions in the landscape. During the time of the windshield survey (end of summer) many of these ponds were laden with excessive algal growth and completely green in color. Stormwater flows from impervious surfaces to storm drains and collector streams via roadside channels that are vegetated, rock-lined, grassy, or culverted under roads and driveways. The majority of private landscaping does not include any visible watershed best management practices (BMPs), though a few rain gardens were noted in one neighborhood. The widespread use of private landscaping services is evident throughout the North Stamford area, and may contribute to excessive pesticide, herbicide, and fertilizer use; however, the landscaping services and garden center also provide an opportunity for larger-scale BMP implementation.

During low flow periods, private water intakes at commercial and residential areas may have a noticeable impact on flow quantity. Landscaping trucks have been observed withdrawing water from the river on several occasions.

South of Merritt Parkway, Residential Areas

The residential development south of the Merritt Parkway is less wooded and more densely populated than the land north of the Parkway. Two main commercial thoroughfares, High Ridge and Long Ridge Roads, run north to south and split the residential development into three segments. The commercial development along these two roads is described in the next section. The terrain is both hilly and flat, generally becoming more flat towards the south. Small streams and drainage channels lead to more significant tributaries, namely Ayers Brook and Toilsome Brook, which flow in and out of culverts while passing through densely populated neighborhoods and receiving stormwater runoff directly from street drains. Street drains are a likely source of stormwater runoff quality and quantity problems in the Mill River. Just as is the case north of the Merritt Parkway, ponds with excessive algal growth are plentiful in the residential areas. Closer to downtown, just north of Broad Street, there are numerous apartment complexes. Non-residential properties in the area include a garden center adjacent to the Rippowam River, 3 gas stations/repair shops, and several office parks and schools. The majority of office parks north of downtown are clustered along the main commercial thoroughfares, although there is a large industrial/office complex off High Ridge Road just south of the Merritt Parkway. Large office complexes that are not implementing BMPs can be a source of pollution in the river due to high volumes of unmitigated runoff from large impervious surfaces: parking lots and roofs.

There are several private residential communities within this portion of the watershed that may be venues for promoting BMPs to reduce negative effects of stormwater runoff. There are also several small municipal parks, as well as Scalzi Park, which directly abuts the river just north of downtown. Geese populations roam freely on park grass, likely contributing to bacteria pollution loads from stormwater runoff into the Mill River.

South of Merritt Parkway, Commercial Areas

Long Ride Road and High Ridge Road are the two main thoroughfares in the Mill River watershed, running from downtown to north of the North Stamford Reservoir. The majority of commercial development on both roads is found near the downtown shopping district and just south of the Merritt Parkway. Commercial entities that may pose direct threats to Mill River water quality include 10-15 gas stations/repair shops, 10-15 dry cleaners, and one small florist/garden center. A significant fraction of each corridor is largely residential, with similar characteristics described in the previous section. The areas of dense commercial development, mostly strip mall shopping centers, are almost entirely covered in impervious surfaces: parking lots, sidewalks, and roofs. Amongst the residential and strip mall shopping centers are large office buildings with extensive lawns and parking lots and garages. There are opportunities for BMPs in the commercially developed land along these two thoroughfares, which would likely have a positive effect on water quality and stormwater quantity entering the mainstem and tributaries to the Mill River.

Urban Residential/Downtown Stamford

The watershed south of Broad Street on the west side of the river is primarily urban residential development, and east of the river is largely part of downtown Stamford. The majority of land cover in both areas is impervious, making stormwater management a key issue for this part of the watershed, regardless of specific land use. The potential for pollutant loading from street runoff is high in many places, and could be improved through the use of proper sediment management at construction zones, street sweeping, refuse management and litter control, and landscape BMPs such as vegetated swales and rain gardens in place of concrete drainage and curbed medians. Litter, debris, and geese are plentiful along the river corridor and floodplain in this area, and are also threats to water quality.

References:

1) "Officials knew for decades that Scofieldtown Park was contaminated" Stamford Advocate. September 27, 2009.
2) "Scofieldtown dump yields 'unintended consequences'" Stamford Advocate. September 22, 2009
3) Final Site Reassessment Report for Scofieldtown Road Park. USEPA Region 1. December 23, 2008.

Jeanette Brown, Stamford WPCA
December 8, 2009

Figure 1: Potential Water Quality Threats in the Mill River Watershed

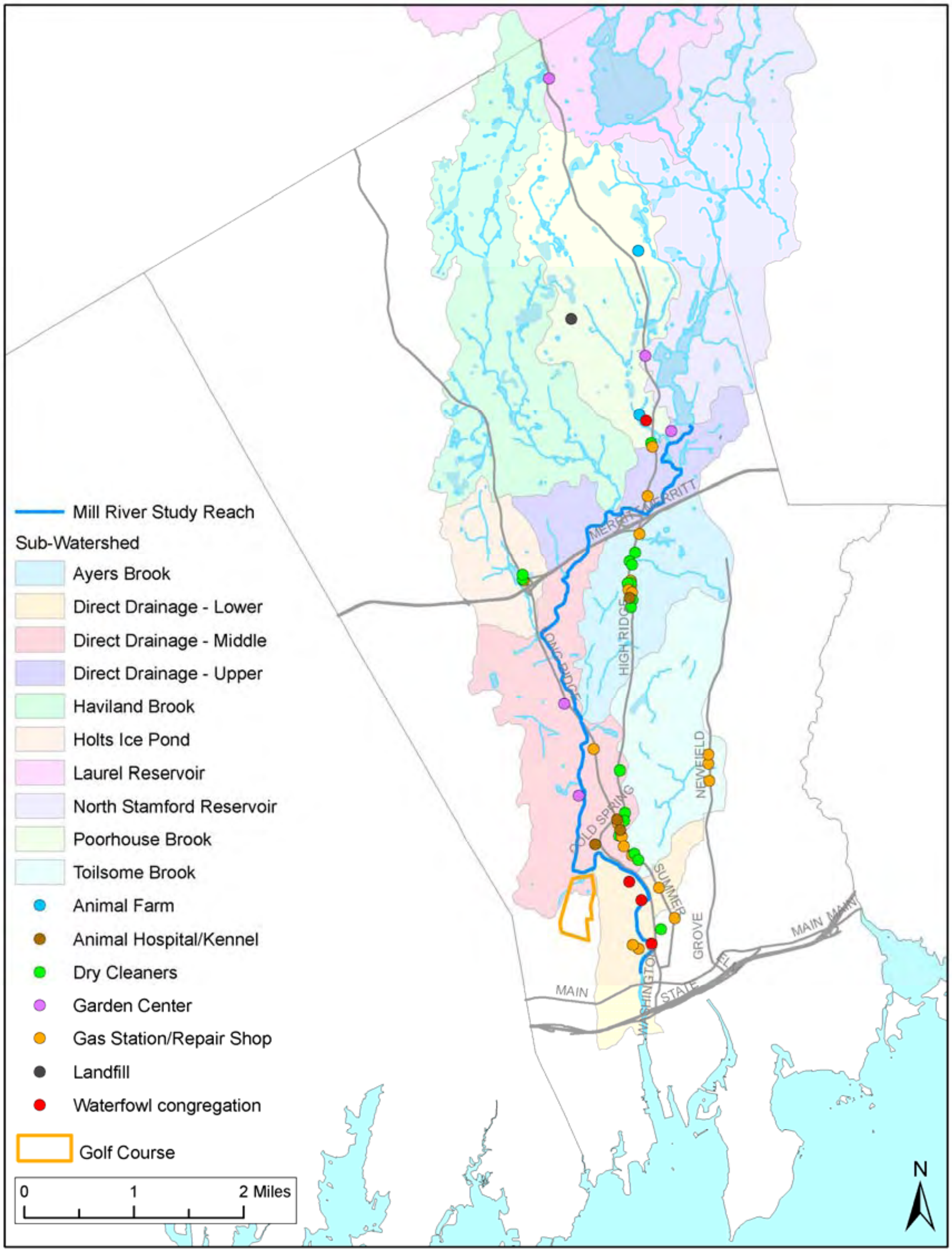
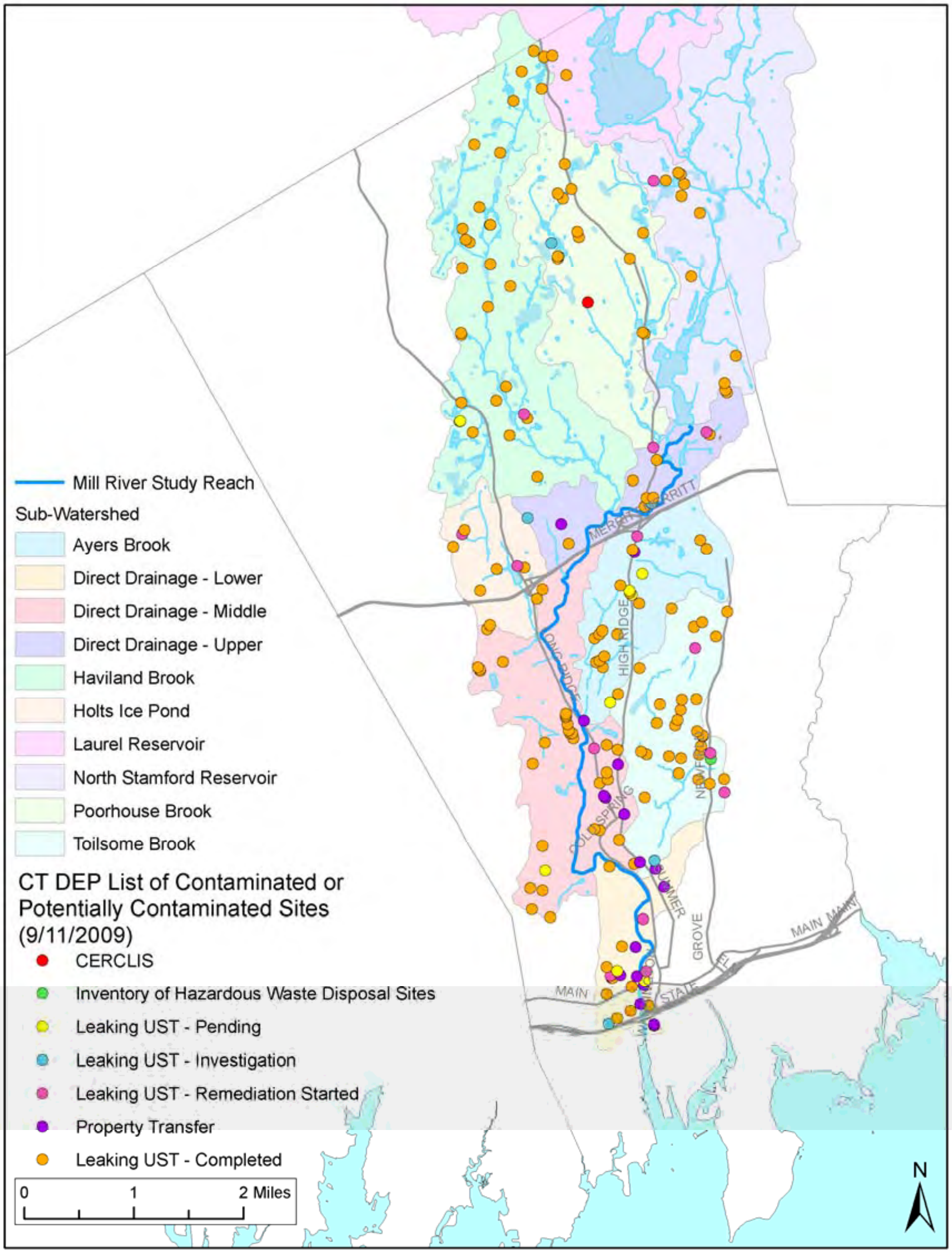


Figure 2: Hazardous Waste Sites in the Mill River Watershed



Jeanette Brown, Stamford WPCA
November 30, 2009

Figure 3: Land Use Area – North of Merritt Parkway

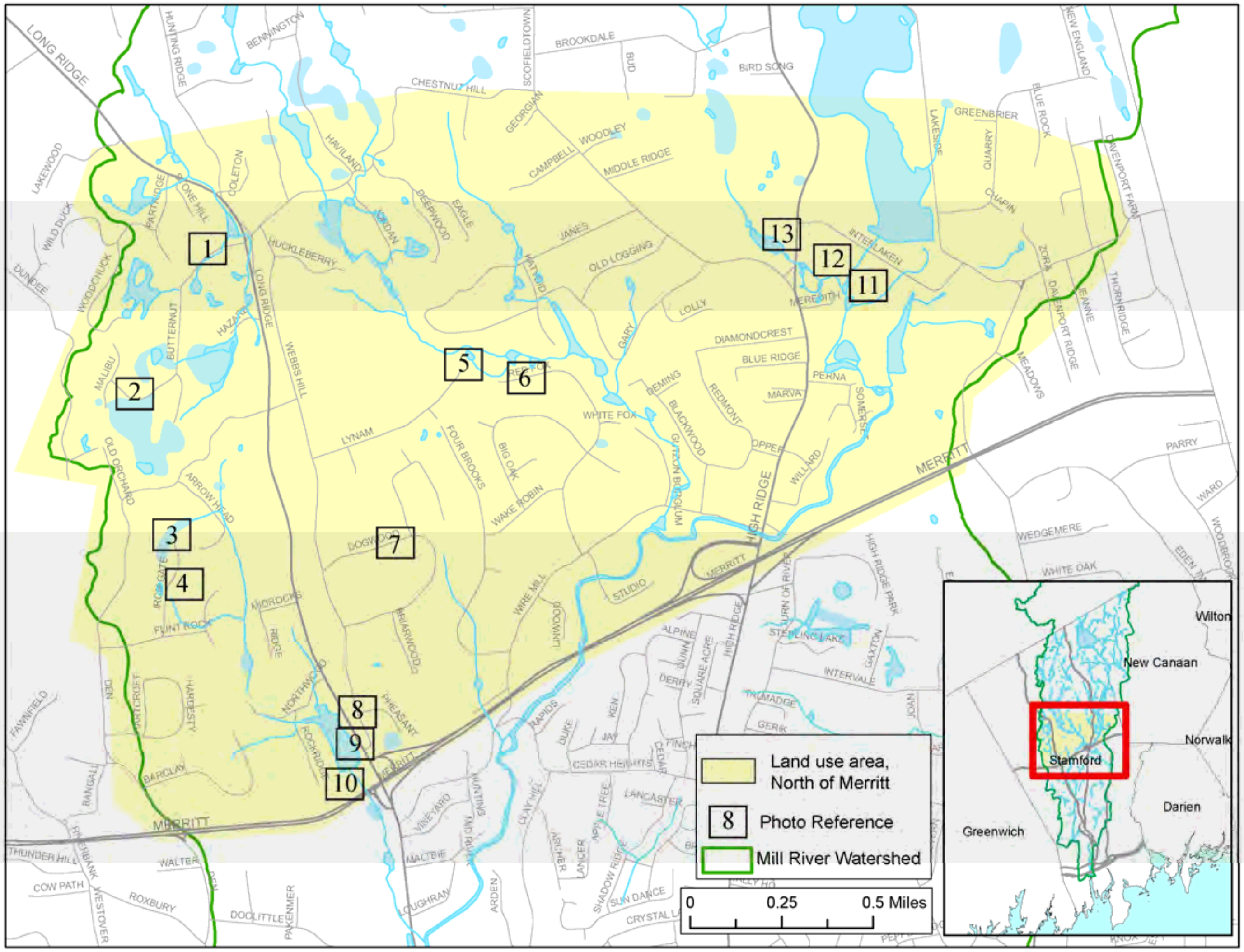


Table 1
North of Merritt Parkway
Photographs correlate with map shown in Figure 3

Area	Image Number	Image	Description
North of Merritt	1		Rain garden, private property
North of Merritt	2		Rain garden, private property
North of Merritt	3		Pond with algal growth
North of Merritt	4		Pond with algal growth and stormwater drain
North of Merritt	5		Typical roadside stormwater inlet

Table 1
North of Merritt Parkway
Photographs correlate with map shown in Figure 3

Area	Image Number	Image	Description
North of Merritt	6		Paved stormwater collection channel, leading to a pond
North of Merritt	7		Erosion control measures: silt fence at home construction site
North of Merritt	8		Parking lot storm drain
North of Merritt	9		Holts Ice Pond
North of Merritt	10		Holts Ice Pond outlet

Table 1
North of Merritt Parkway
Photographs correlate with map shown in Figure 3

Area	Image Number	Image	Description
North of Merritt	11		Garden center mulch piles
North of Merritt	12		Garden center water intake
North of Merritt	13		Bendels Pond, in Stamford Museum and Nature Center, part of Poorhouse Brook tributary

Figure 4: Land Use Area – South of Merritt Parkway, Residential Areas

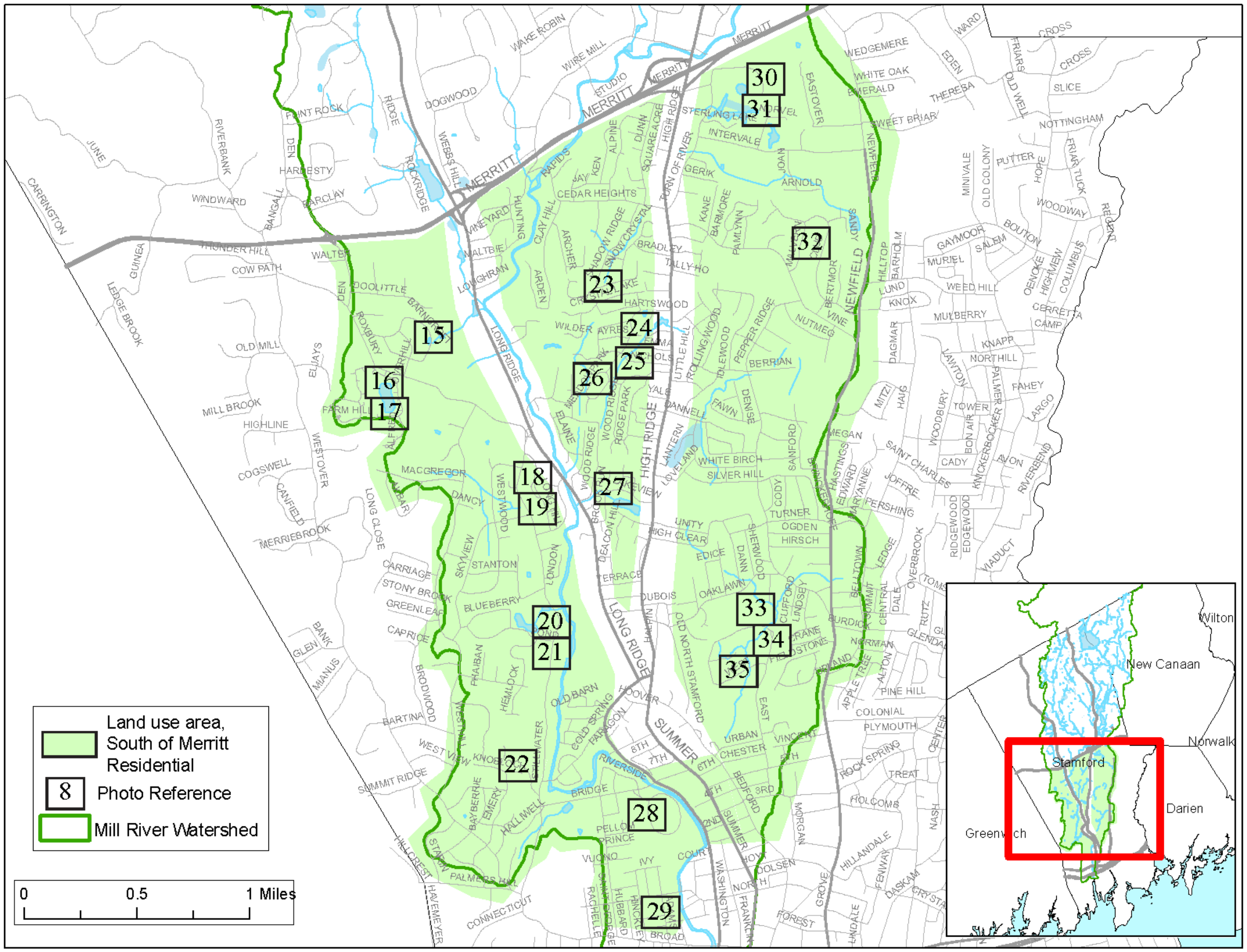


Table 2
South of Merritt Parkway, Residential Areas
Photographs correlate with map shown in Figure 4

Area	Image Number	Image	Description
South of Merritt - Residential	15		Pond with excessive algal growth
South of Merritt - Residential	16		Wetland area in private community
South of Merritt - Residential	17		Pond with algal growth, in private community
South of Merritt - Residential	18		Dense residential street
South of Merritt - Residential	19		Typical residential property

Table 2
South of Merritt Parkway, Residential Areas
Photographs correlate with map shown in Figure 4

Area	Image Number	Image	Description
South of Merritt - Residential	20		Garden center on Stillwater Rd, at river's edge
South of Merritt - Residential	21		Garden center on Stillwater Rd, at river's edge
South of Merritt - Residential	22		Typical residential property
South of Merritt - Residential	23		Culvert carrying baseflow at headwaters of Ayers Brook
South of Merritt - Residential	24		Small tributary to Ayers Brook

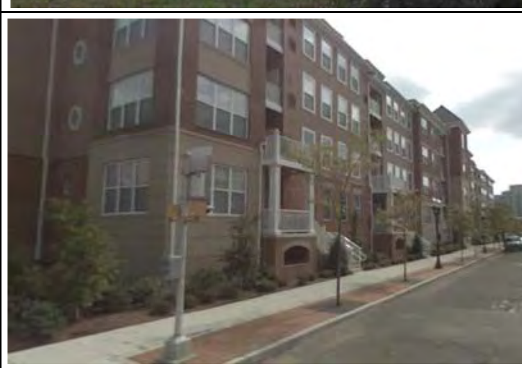
Area	Image Number	Image	Description
South of Merritt - Residential	25		Stormwater drainage to small stream
South of Merritt - Residential	26		Lawn clippings near wetland/floodplain area
South of Merritt - Residential	27		Leaves raked or blown into street
South of Merritt - Residential	28		Scalzi Park geese
South of Merritt - Residential	29		Apartment complexes

Table 2
South of Merritt Parkway, Residential Areas
Photographs correlate with map shown in Figure 4

Area	Image Number	Image	Description
South of Merritt - Residential	30		Office park median
South of Merritt - Residential	31		Office park, parking lot
South of Merritt - Residential	32		Typical residential property
South of Merritt - Residential	33		Baseflow at headwaters of Toilsome Brook
South of Merritt - Residential	34		Stormwater drainage to small stream in private community

Table 2
South of Merritt Parkway, Residential Areas
Photographs correlate with map shown in Figure 4

Area	Image Number	Image	Description
South of Merritt - Residential	35		Stormwater drainage to small stream in private community

Jeanette Brown, Stamford WPCA
December 8, 2009
Figure 5: Land Use Area – South of Merritt Parkway, Commercial Areas

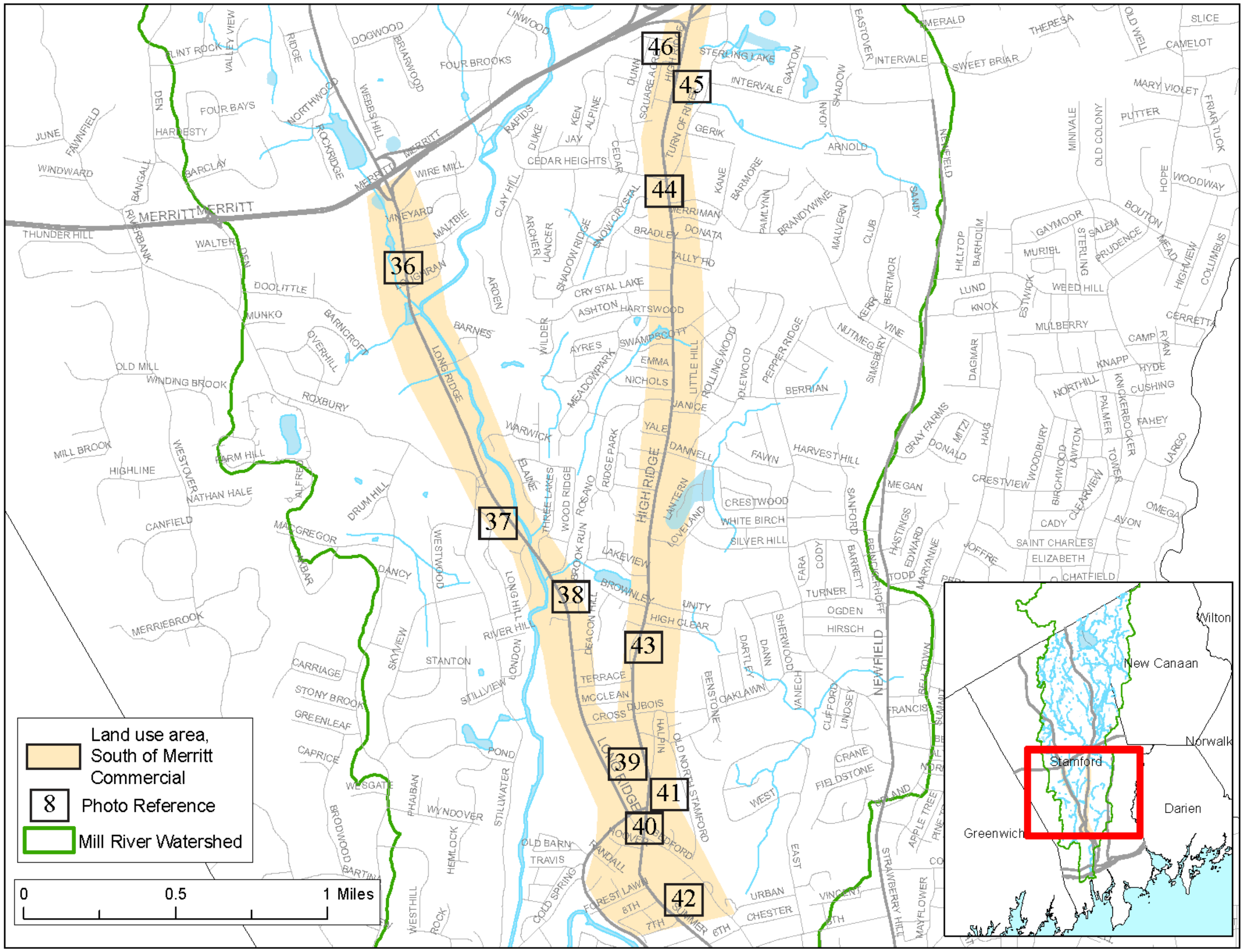


Table 3
South of Merritt Parkway, Commercial Areas
Photographs correlate with map shown in Figure 5

Area	Image Number	Image	Description
South of Merritt - Commercial	36		Long Ridge Rd near the Merritt Parkway, less commercial development
South of Merritt - Commercial	37		Long Ridge Rd office building
South of Merritt - Commercial	38		Long Ridge Rd at transition from majority residential to majority commercial development
South of Merritt - Commercial	39		Shopping district and new commercial development
South of Merritt - Commercial	40		Shopping district

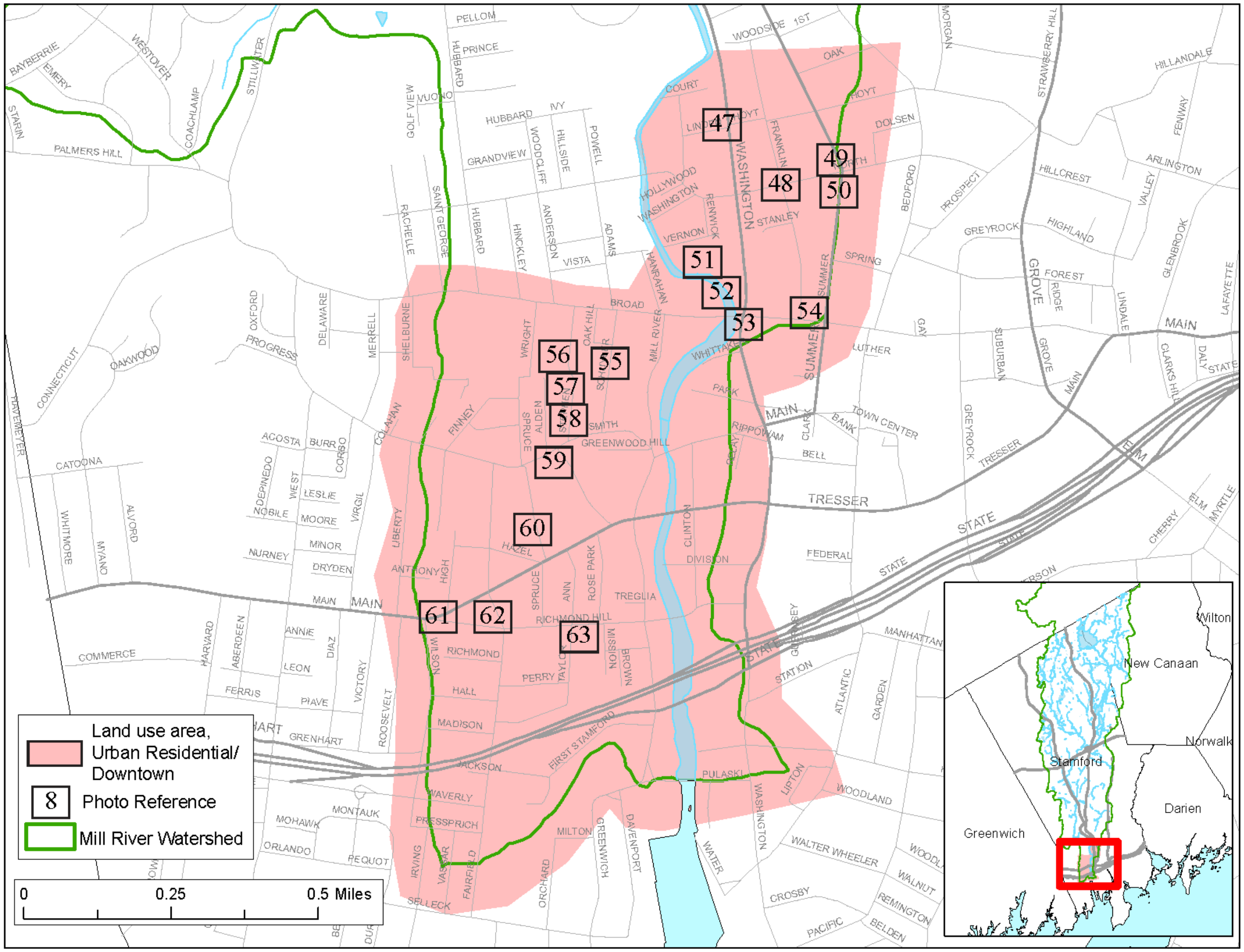
Table 3
South of Merritt Parkway, Commercial Areas
Photographs correlate with map shown in Figure 5

Area	Image Number	Image	Description
South of Merritt - Commercial	41		Strip mall landscaping on High Ridge Rd
South of Merritt - Commercial	42		Shopping plaza impervious surface and stormwater drain
South of Merritt - Commercial	43		Stormwater collection culvert, opportunity for stormwater BMP
South of Merritt - Commercial	44		Typical impervious cover on High Ridge Rd, just south of Merritt Parkway
South of Merritt - Commercial	45		Aerial image (Google, 2009), commercial district on High Ridge, opportunity for BMPs to reduce impervious area

Table 3
South of Merritt Parkway, Commercial Areas
Photographs correlate with map shown in Figure 5

Area	Image Number	Image	Description
South of Merritt - Commercial	46		Office building on High Ridge Rd

Jeanette Brown, Stamford WPCA
December 8, 2009
Figure 6: Land Use Area – Urban Residential/Downtown

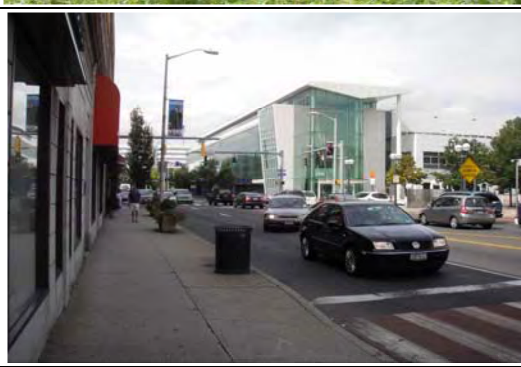
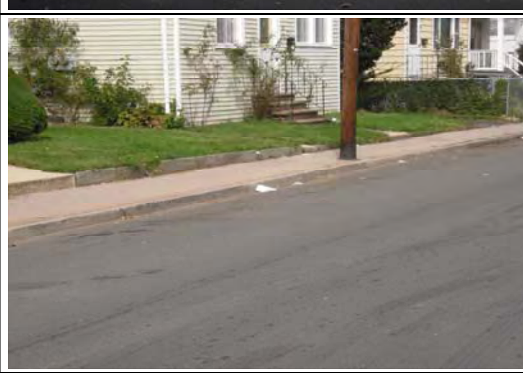


December 8, 2009

Table 4
Urban Residential/Downtown Stamford
Photographs correlate with map shown in Figure 6

Area	Image Number	Image	Description
Urban/Downtown Stamford	47		Office buildings near downtown
Urban/Downtown Stamford	48		Uncontrolled sediment from street construction
Urban/Downtown Stamford	49		Uncontrolled sediment from street construction
Urban/Downtown Stamford	50		Uncontrolled sediment from street construction
Urban/Downtown Stamford	51		Trash near river

Table 4
Urban Residential/Downtown Stamford
Photographs correlate with map shown in Figure 6

Area	Image Number	Image	Description
Urban/Downtown Stamford	52		Geese in river
Urban/Downtown Stamford	53		Geese on river banks
Urban/Downtown Stamford	54		Downtown Stamford impervious area
Urban/Downtown Stamford	55		Large impervious lots
Urban/Downtown Stamford	56		Street sweeping opportunity

Area	Image Number	Image	Description
Urban/Downtown Stamford	57		Street sweeping opportunity
Urban/Downtown Stamford	58		Street sweeping opportunity
Urban/Downtown Stamford	59		Landscaped median in urban area, opportunity for BMP
Urban/Downtown Stamford	60		Urban gardening area
Urban/Downtown Stamford	61		Covered sand storage

Table 4
Urban Residential/Downtown Stamford
Photographs correlate with map shown in Figure 6

Area	Image Number	Image	Description
Urban/Downtown Stamford	62		Geese on park grass
Urban/Downtown Stamford	63		Urban residential development near downtown

Appendix E: Action Items
Action 1.1: Rain Garden/ Bioretention Area

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat
7. Ensure sufficient low flows
8. Promote sustainability mission of City of Stamford

Problem: High Runoff and Pollutants

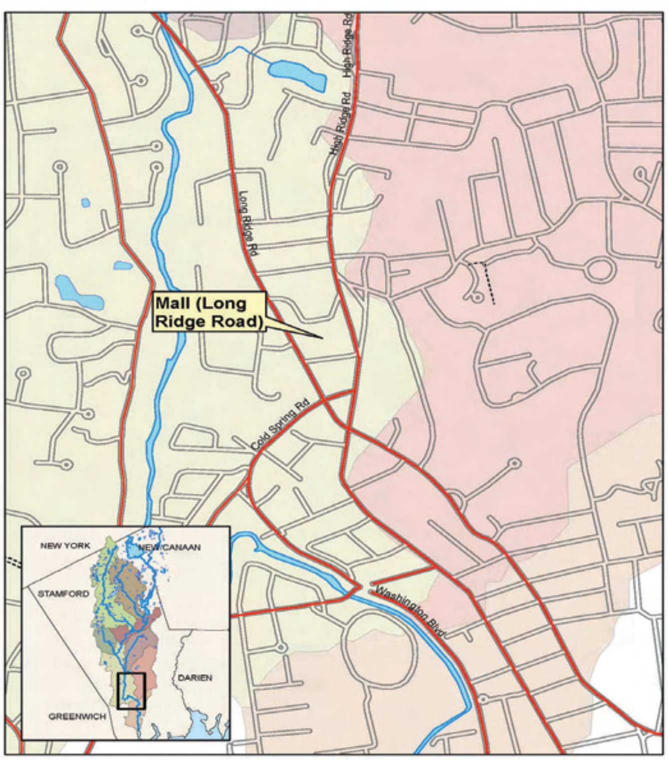
Rain on impervious surfaces such as concrete roadways, sidewalks, and building footprints increases stormwater volume and transports pollutants through the drainage system to surface water resources, adversely affecting receiving water quality and aquatic habitat.

Pollutant	Estimated Basin-Wide % Reduction in Loading
Biological Oxygen Demand	7%
Metals	4-7%
Fecal Bacteria	8%
Nutrients	2-4%
Sediment	7%

Brief Description of Action

Rain gardens could be installed in medium to high density residential and developed urban areas where stormwater accumulates quickly and in large volumes such as parks, parking lots, and urban centers. Example locations for future rain garden are Scalzi Park (shown above) and the Stamford Hospital.

Action Item Summary



Expected Benefits

Rain gardens capture and collect water that would otherwise enter the storm drain system. Pollutants are naturally filtered by native plants, soil, and microbes and water is directed to infiltrate at point of capture, reducing demand on stormwater infrastructure and reducing adverse affects of common pollutants on surface water resources. Water that naturally infiltrates returns to base flow in the stream, improving low-flow conditions.

Responsible Parties

- City of Stamford
- Commercial/Residential Land Owners

Cost

\$4-\$6/ft^3 (construction only)

Action 1.2: Tree Filter/ Street Planter

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat
7. Ensure sufficient low flows
8. Promote sustainability mission of City of Stamford

Problem: High Runoff and Pollutants

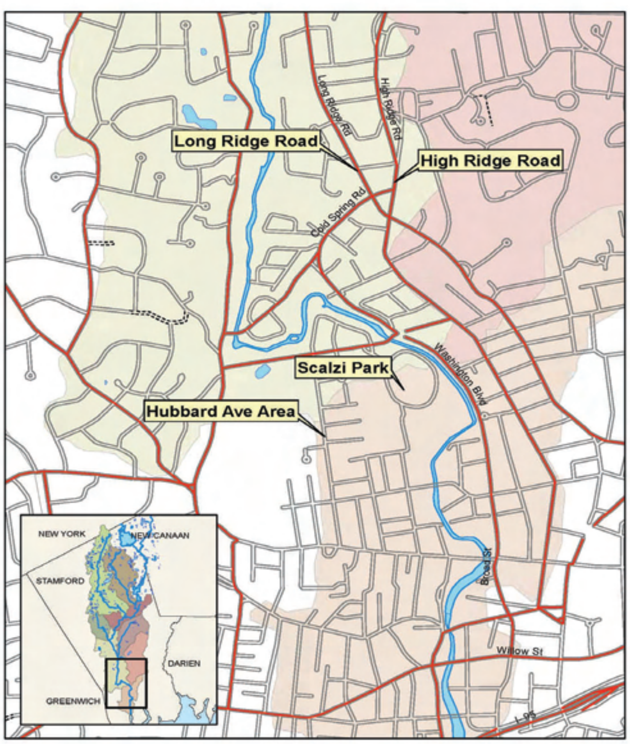
Rain on impervious surfaces such as concrete roadways, sidewalks, and building footprints increases stormwater volume and transports pollutants through the drainage system to surface water resources, adversely affecting receiving water quality and aquatic habitat.

Pollutant	Estimated % Reduction in Loading	
	Ayers Brook Basin	Downtown Basin
Biological Oxygen Demand	2%	2%
Metals	0-2%	0-2%
Fecal Bacteria	<1%	<1%
Nutrients	0-2%	1-2%
Sediment	2%	2%

Brief Description of Action

Tree filters or street planters could be installed in medium to high density residential and developed urban areas where stormwater accumulates quickly and in large volumes such as parks, parking lots, and urban centers. The Ayers Brook and Downtown basins and the Long Ridge Rd and High Ridge Rd commercial areas would benefit from tree filters.

Action Item Summary



Expected Benefits

Tree filters pre-filter water before it enters the storm drain system through a subsurface chamber containing filter media or by trees underlain with soil. Water is directed to infiltrate at point of capture, reducing demand on stormwater infrastructure and the adverse affects of common roadway pollutants.

Responsible Parties

- City of Stamford
- Commercial Property Owners

Cost

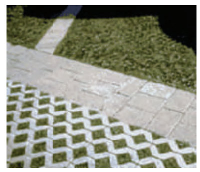
\$71-\$101/ft^3

CDM Smith

Action 1.3: Porous Pavement

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat
7. Ensure sufficient low flows



Problem: Excessive Urban Runoff

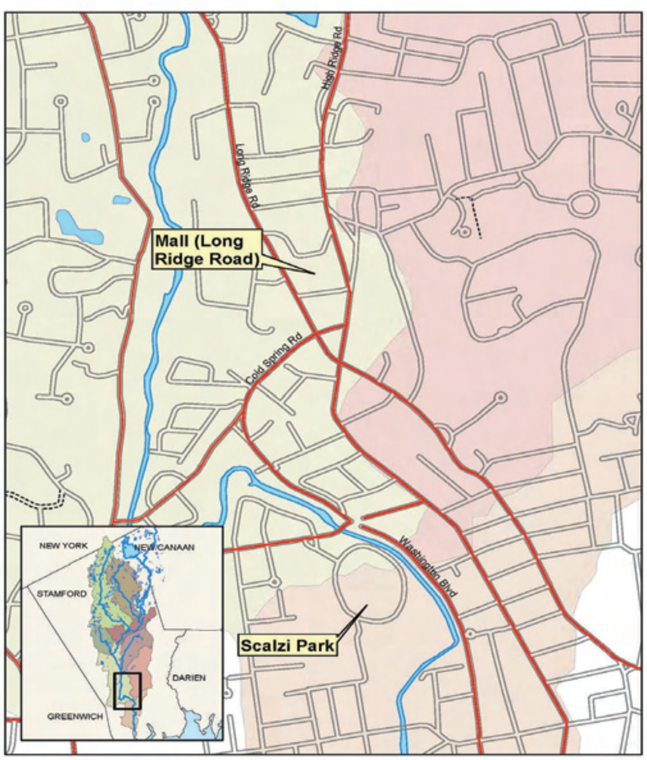
Impermeable pavements in urban areas increase surface runoff which is conveyed offsite to receiving surface water resources. Runoff contains harmful pollutants including heavy metals, alkali-chlorides, and suspended solids which adversely affect receiving water habitat.

Pollutant	Estimated Basin-Wide % Reduction in Loading
Biological Oxygen Demand	4%
Metals	1-3%
Fecal Bacteria	<1%
Nutrients	0-3%
Sediment	3%

Brief Description of Action

Porous pavement may be installed in parking lots, light use roadways, driveways, sidewalks, and commercial developments where impervious surfaces are prevalent as in medium to high residential and urban settings. Examples include Scalzi Park, residences, and the commercial areas on Long Ridge Rd and High Ridge Rd.

Action Item Summary



Expected Benefits

Permeable pavements increase rain water infiltration, decrease stormwater peak flows, and improve overall stormwater quality before discharge to surface water resources.

Responsible Parties

- City of Stamford
- Commercial/Residential Property Owners

Cost

$192,000-$715,000 per acre

CDM Smith

Action 1.4: Green Roof

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat
8. Promote sustainability mission of City of Stamford

Problem: Excessive Stormwater Runoff

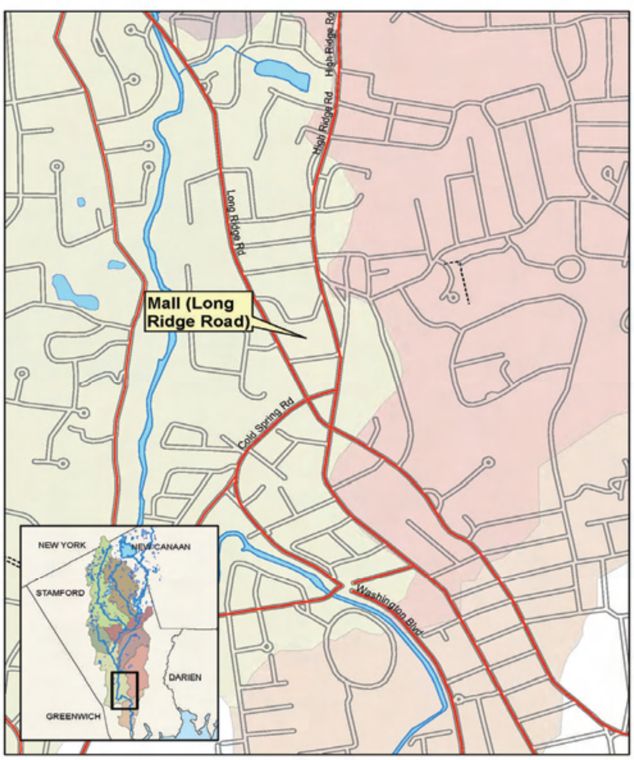
Impermeable roofs shed water quickly, leading to high volumes of stormwater to be conveyed offsite. This water is discharged to receiving surface water resources, introducing harmful pollutants and sediment to the river.

Pollutant	Estimated % Reduction in Loading in Downtown Basin
Biological Oxygen Demand	1-2%
Metals	1%
Fecal Bacteria	1%
Nutrients	1%
Sediment	1-2%

Brief Description of Action

Green roofs could be installed on a commercial or residential building in medium to high density residential and urban settings which contain a high percent of impervious surfaces.

Action Item Summary



Expected Benefits

Green roofs collect, store, and filter stormwater from impervious surfaces before it enters the drain system. While a portion of water is retained, the delayed peak flow assists in reducing demand to infrastructure.

Responsible Parties

- City of Stamford
- Commercial/Residential Property Owners

Cost

$240,000-$1,300,000 per acre of roof

Action 1.5: Sand Filter

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat
7. Ensure sufficient low flows
8. Promote sustainability mission of City of Stamford

Problem: High Runoff and Pollutants

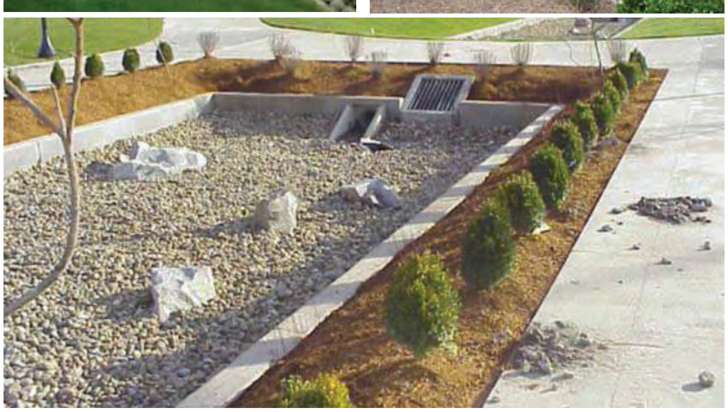
Impermeable pavements in urban areas increase surface runoff which is conveyed offsite to receiving surface water resources. Runoff contains harmful pollutants including heavy metals, alkali-chlorides, and suspended solids which adversely affect receiving water habitat.

Brief Description of Action

Sand filters are appropriate in locations where ground-water is high, soils are relatively permeable, or in areas with limited space. Design typically includes an upper gravel or rock layer underlain by coarse to medium sand.

Pollutant	Estimated Basin-Wide % Reduction in Loading
Biological Oxygen Demand	4%
Metals	1-3%
Fecal Bacteria	2%
Nutrients	0-2%
Sediment	3-4%

Action Item Summary



Expected Benefits

Sand filters pre-filter stormwater before discharge to a storm drain system, improving stormwater quality and delaying discharge to the system. This reduces peak flow and peak flow related backups. Sand filters also remove oil, grease, and particulates from stormwater, improving water quality.

Responsible Parties

- City of Stamford
- Commercial Property Owners

Cost

$34-$91/ft³

CDM Smith

Action 2.1: Removal of Low Head Dams

Target Objectives

2. Improve access and connection to the river
6. Restore instream and riparian habitat

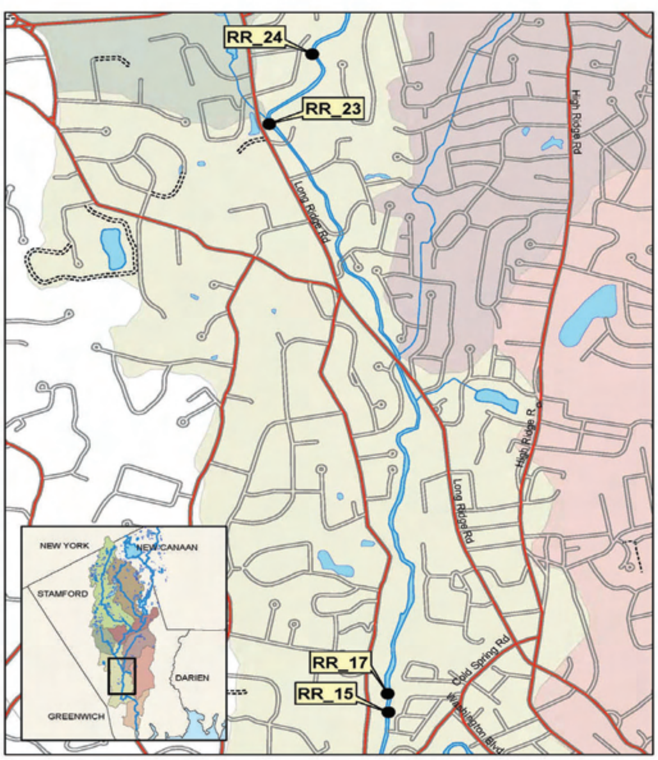
Problem: Disruption of Species Migration and River Flow

The existing low head dams create a barrier for the natural patterns of the river by disrupting natural flow patterns, leading to temperature fluctuations, excessive algal growth, and limited species migration.

Brief Description of Action

This action recommends the removal of low head dams along the Mill River that are dilapidated, abandoned, and no longer serve their intended purpose.

Action Item Summary



Expected Benefits

By removing low head dams, the river will be more navigable for aquatic species, provide a healthier habitat through less sediment buildup, and maintain an even and low temperature. In order to restore the natural flow of the river, these defunct structures must be removed.

Responsible Parties

- City of Stamford

Cost

Up to $500,000

Action 2.2: Change North Stamford Dam Outlet

Target Objectives

5. Improve water quality
6. Restore instream and riparian habitat
7. Ensure sufficient low flows

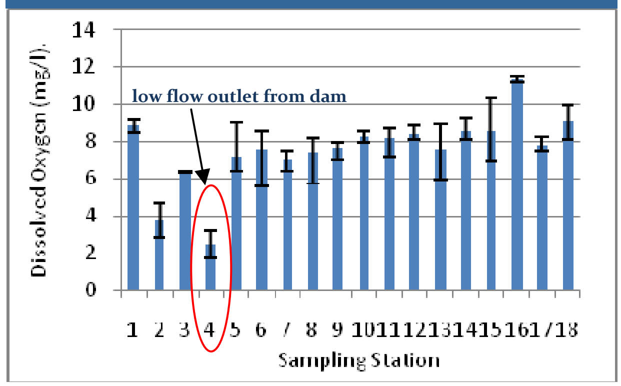
Problem: Low Dissolved Oxygen

The low flow outlet from the North Stamford Dam discharges water with very low dissolved oxygen and temperature during summer months when the reservoir is stratified. Sufficient oxygen is necessary to sustain aquatic life.

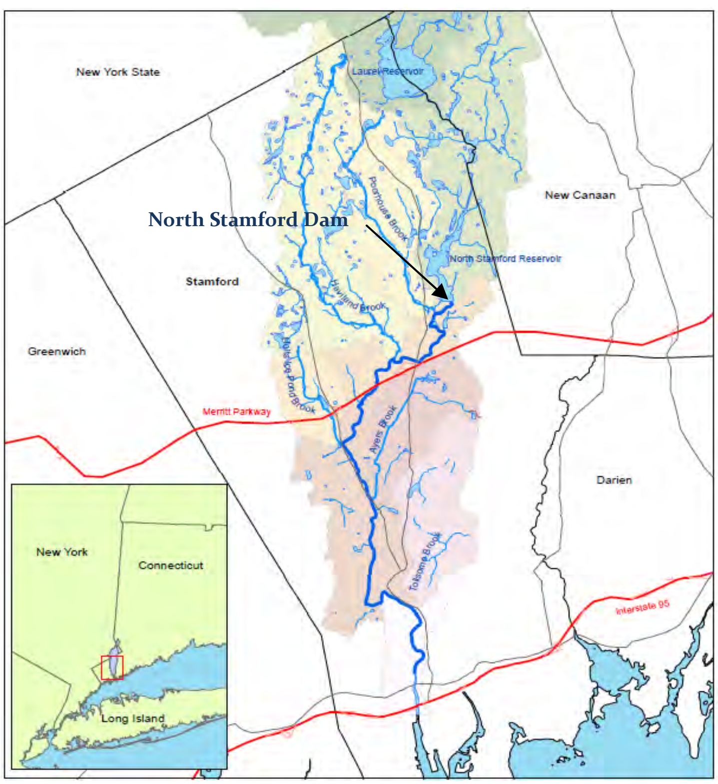
Brief Description of Action

The low flow outlet should be relocated to discharge flow from a higher elevation in the reservoir, or actively managed as conditions change.

Min, Max and Average of Summer DO Measurements



Action Item Summary



Expected Benefits

Increasing the concentration of dissolved oxygen in the outlet flow would improve the habitat for fish and other aquatic life in the downstream reach of river. In addition, the low flow outlet could potentially be a source of low flow augmentation.

Responsible Parties

- Aquarion Water Company
- City of Stamford

Cost

Up to $500,000

CDM Smith

Action 2.3: Holts Ice Pond Remediation

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat

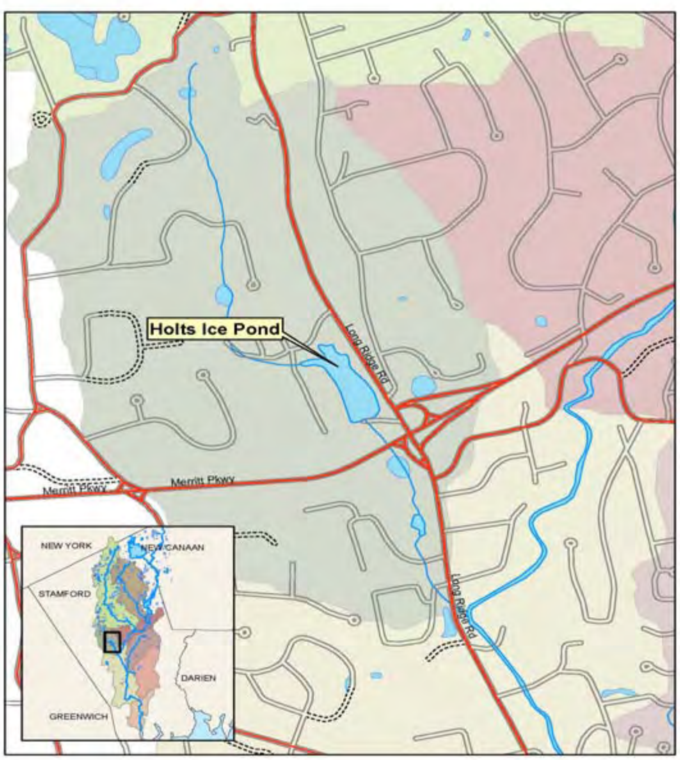
Problem: Eutrophication

Holts Ice Pond becomes eutrophied during warm weather months due to high nitrogen inputs from surrounding land use.

Brief Description of Action

Holts Ice Pond should be assessed to increase flushing, establish source control to the pond, remove built up sediment, and improve land management practices in the surrounding area.

Action Item Summary



Expected Benefits

The Holts Ice Pond is in a state of extreme eutrophication where nutrients spur excessive algae growths, which later decompose and become toxic to aquatic life. By addressing pollutant sources which contribute to eutrophication and improving flushing within the pond, conditions within the pond, and the river, will improve.

Responsible Parties

- City of Stamford
- Land owners

Cost

Up to $500,000

CDM Smith

Action 2.4: River Bank Restoration

Target Objectives

5. Improve water quality
6. Restore instream and riparian habitat

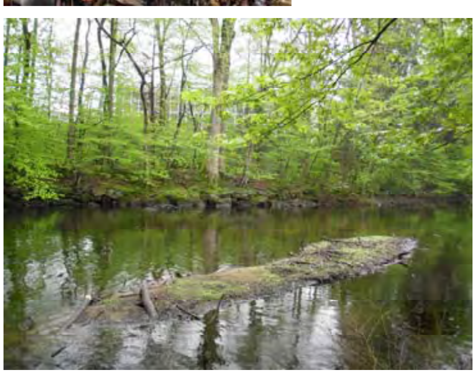
Problem: Bank Instability

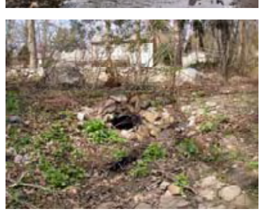
Excessive sedimentation, erosion, and bank armoring are the result of unstable embankments. Over time, sediment deposition decreases water quality, chokes benthic communities, and degrades aquatic specie habitat.

Brief Description of Action

Decreasing slope angles, filling gaps, and introducing rooted plants will aid in restoring river bank stability. In addition, riparian buffer improvements will provide long-lasting benefits to river banks.

Action Item Summary





Expected Benefits

The restructuring of river banks would reduce erosion and incidence of armored river banks, reducing sedimentation and deposition while improving benthic and aquatic specie habitat.

Parties Involved

- City of Stamford
- Watershed Constituency

Cost

Based on a cost of $350-$1000 per linear foot of stream bank, restoring 10% of the Mill River will cost $2.8 to $7.9 million.

Action 2.5: Riparian Buffer Improvements

Target Objectives

4. Control and reduce high flows to reduce flooding
5. Improve water quality
6. Restore instream and riparian habitat

Problem: Degraded Riparian Buffers

Unshielded banks, encroaching development, and heavily landscaped border areas lead to erosion and an influx of sediment, nutrients, and other materials to the river.

Brief Description of Action

Planting native grasses, trees, and shrubs while allowing for unmanaged undergrowth along river banks will improve the quantity and quality of stormwater and pollutants which enter the River.

Action Item Summary

Sediment Intrusion

Silt Fence

Failed Erosion Control

Algal Growth

Expected Benefits

Improving riparian buffers along the river will reduce pollutant loading, peak flow, and erosion while absorbing pollutants. It will also serve to provide habitat, shade, and cover for the river, aquatic species of plants and animals, and other wildlife.

Responsible Parties

- City of Stamford
- Watershed Constituency
- Land Owners

Cost

None to Minimal

CDM Smith

Action 2.6: Removal of Invasive Plants

Target Objectives

6. Restore instream and riparian habitat

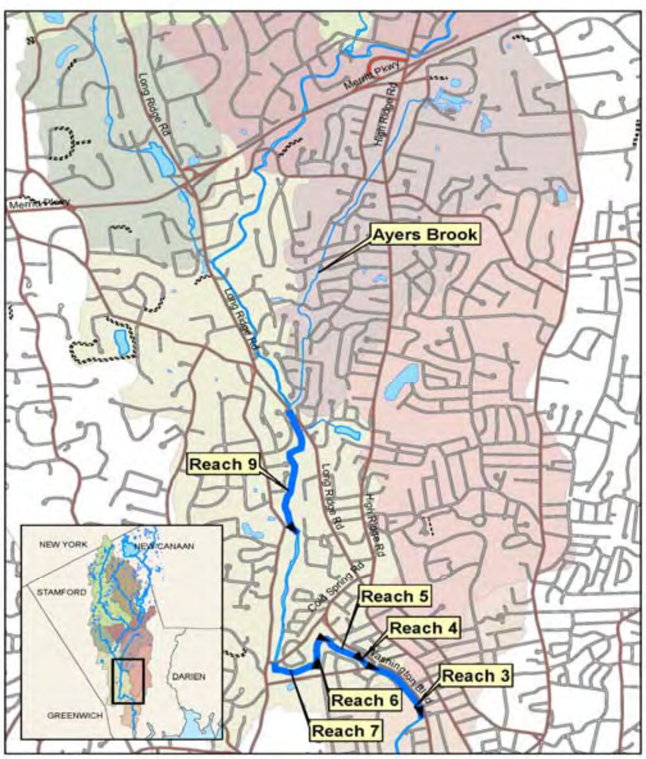
Problem: Non-Native Plant Overgrowth

Non-native invasive (NNI) plants endanger the environments they invade by displacing native species within the same ecological niche. This causes a ripple effect up the ecological food chain, a lack of biodiversity in the area, and alterations to the physical and chemical properties of the river.

Brief Description of Action

Japanese Knotweed is an invasive species which exists throughout the Rippowam/Mill River. Removal programs include community action group support,

Action Item Summary



Expected Benefits

Removal of invasive plants will help to restore the natural environment of the river by encouraging the growth of native species, increasing area biodiversity, and helping to restore the river's chemical properties.

Responsible Parties

- Watershed Constituency
- Land Owners

Cost

None to Minimal

CDM Smith

Action 2.7: Instream Restoration

Target Objectives

4. Control and reduce high flows to reduce flooding
6. Restore instream and riparian habitat

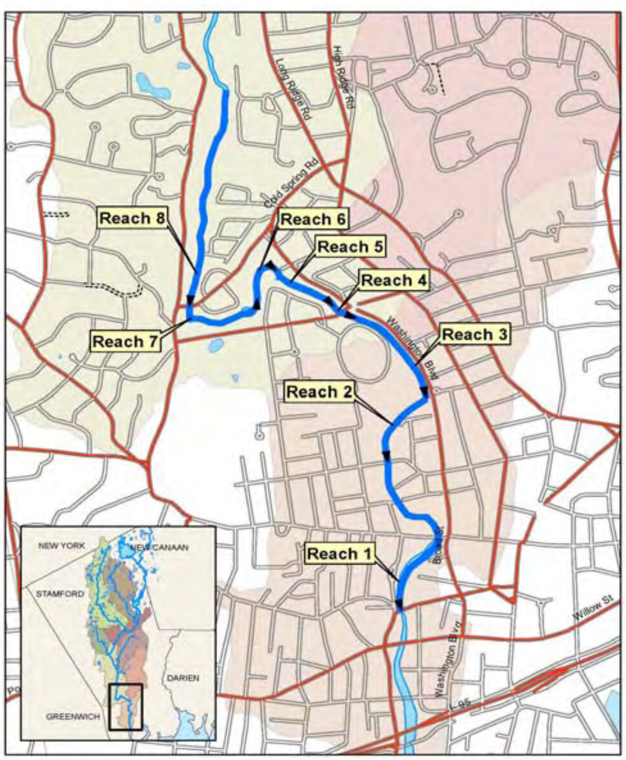
Problem: Excessive Sediment and Debris Buildup

High sediment and excessive debris buildup has altered the hydrology of the river, causing streams to be disconnected from the river, choking benthic animal and aquatic plant life populations, and inhibiting fish migration and leading to flooding.

Brief Description of Action

Large accumulation of sediments and debris should be removed, annual cleanup programs should be instituted, and a comprehensive maintenance program should be established.

Action Item Summary



Expected Benefits

Removing large sediment pockets will immediately improve the hydrology of an affected area, however long term strategies which reconnect benthic animal and aquatic plant life populations will enhance the overall river health.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

Up to $500,000

Action 2.8: Public Access Points

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river

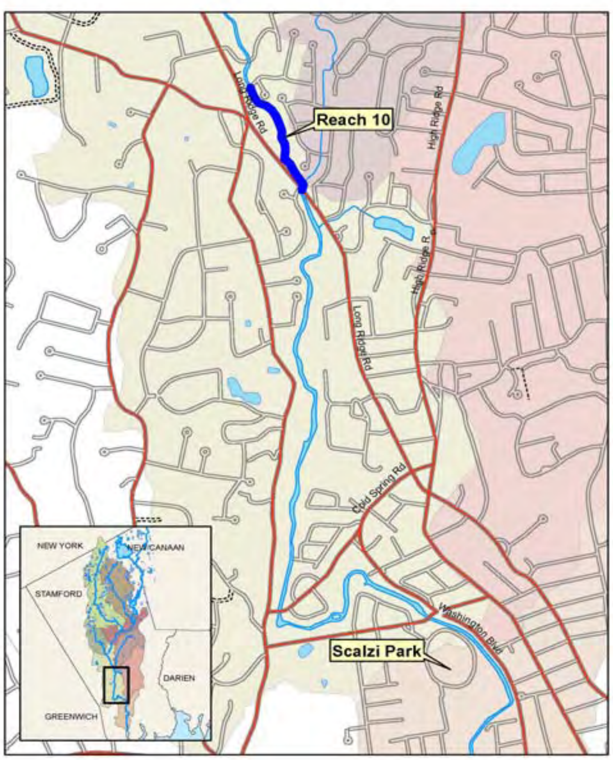
Problem: Public Awareness and Accessibility

Urban rivers are neglected elements of the natural environment which are largely ignored if they are not accessible by the public.

Brief Description of Action

Increasing access points to the river, including walkways, bike paths, boat launches, wildlife viewing areas, and parks will improve the community relationship with the river and increase stewardship.

Action Item Summary



Expected Benefits

Increasing public access to natural resources leads to an increased sense of pride and ownership in the health and well-bring of the river and lead to greater public efforts on its behalf and indirectly benefits water quality and reduced sedimentation initiatives.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

Up to $100,000

CDM Smith

Action 2.9: Designate Wildlife Protection and Viewing Areas

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
3. Build a grassroots watershed constituency
6. Restore instream and riparian habitat

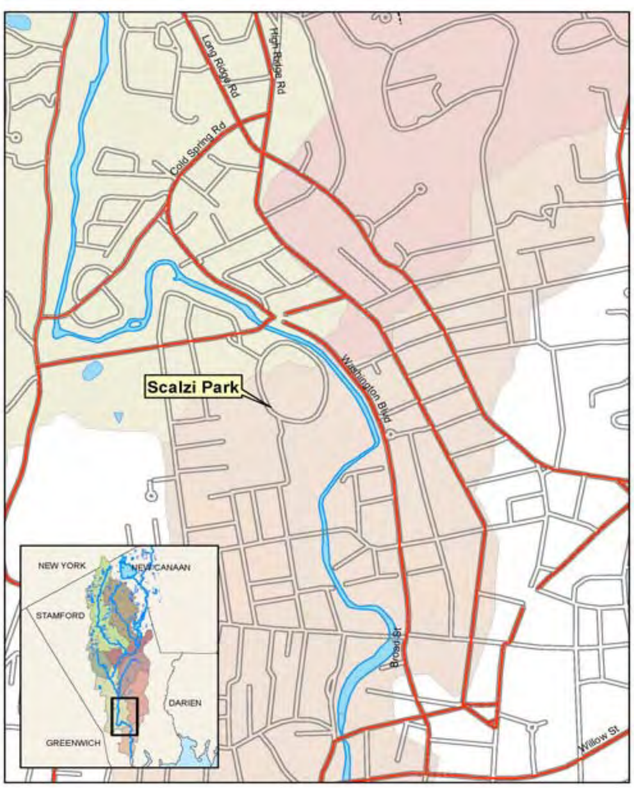
Problem: Public Accessibility and Awareness

Disconnect between City residents and the Rippowam/Mill River leads to choices which negatively influence the river.

Brief Description of Action

Attractions such as wildlife viewing areas, benches in parks, educational signage, bird watching sites, and river walkways should be created to allow residents the opportunity to enjoy their local environment.

Action Item Summary



Expected Benefits

Increasing public usage can lead to a greater sense of pride and ownership in the health and well-bring of the river and lead to greater public efforts on its behalf.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to Minimal

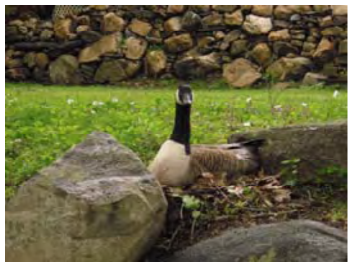
Action 3.1: Waterfowl Reduction Program

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
5. Improve water quality

Problem: Waterfowl Over-Population as a Bacteria Source

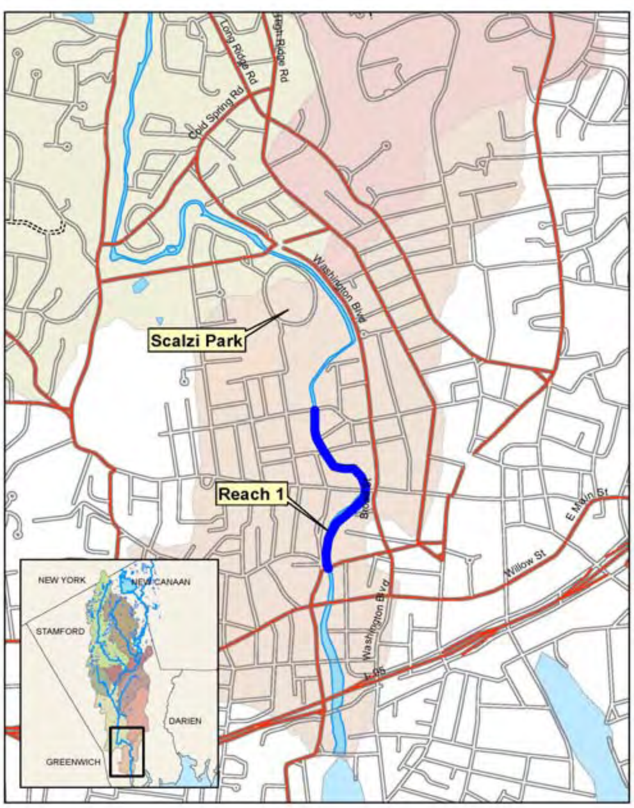
Waterfowl waste introduces concentrated and excessive amounts of bacteria, disease, and nutrients to the river leading to severely degraded aquatic habitat, promoting algae growth, and limiting aquatic species.



Brief Description of Action

Local regulations must be instituted to prevent feeding, public outreach must including education and information related to the detrimental affects of waterfowl populations to water resources, and riparian buffers should be planted to control the bacterial runoff.

Action Item Summary



Expected Benefits

Reducing the affects of waste from waterfowl would reduce the amount of bacteria and algae and increase the dissolved oxygen content of the river and improve the aquatic habitat for animal and plant species.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to Minimal

CDM Smith

Action 3.2: Pet Waste Reduction Program

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
5. Improve water quality

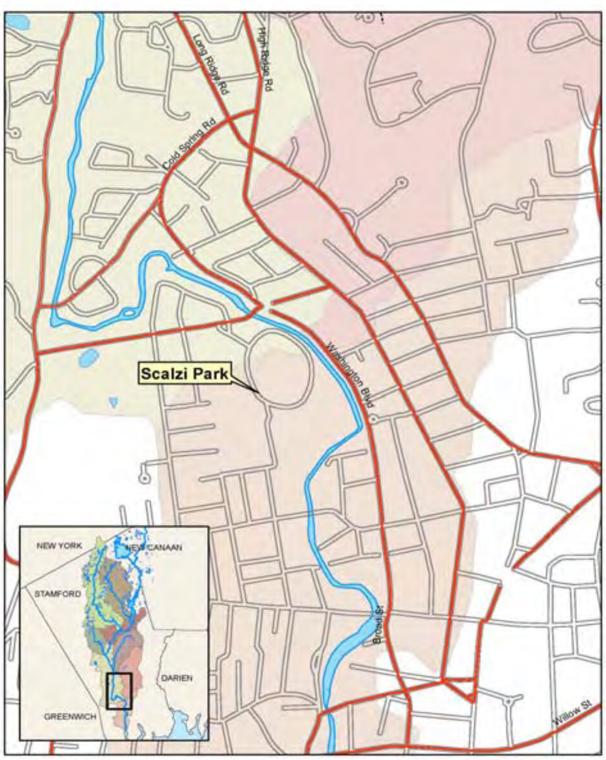
Problem: High Bacteria Pollution

Runoff carrying pet waste contributes to high levels of bacteria and algae. This pollutes the river and reduces the dissolved oxygen, negatively affecting the habitability of the river basin.

Brief Description of Action

A public education program should be implemented to make residents aware of the negative effects of mis-managed waste.

Action Item Summary



Expected Benefits

Properly managing pet wastes will reduce the amount of bacterial pollution that enters the river basin.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to Minimal

CDM Smith

Action 3.3: Community Participatory Events

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
6. Restore instream and riparian habitat

Problem: Disregard for River as a Resource

Disregard for the river as a community resource leads to trash and litter deposited along the river or roadway often migrates into the river, causing harm to the river's ecology and aquatic life.

Brief Description of Action

Annual river cleanups, tree plantings, and other community participatory events should be developed to engage local residents in the welfare of the river as a natural resource in the community.

Action Item Summary

Expected Benefits

Such events will allow stakeholders to develop long term relationships with the river and get them engaged in its wellbeing. Overall, such events will improve the aesthetics and ecological health of the river while fostering local partnerships and personal investment in the river's future.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to Minimal

CDM Smith

Action 3.4: Reduce Improper Yard Waste Disposal

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
6. Restore instream and riparian habitat

Problem: Illicit Yard Waste

Improperly disposed yard waste, commonly dumped in buffer areas behind residences and along stream banks, leads to excessive sediment intrusion, changes stream flow, disrupts wildlife habitat, and increases flooding along river banks. Improper yard waste disposal can also add lawn chemical pollutants and trash to the river.

Brief Description of Action

Reduce illicit yard waste disposal through education on affects on river habitat, awareness of local ordinance, and enforcement of ordinance in addition to increasing embankment buffer plantings.

Action Item Summary

Expected Benefits

Reduction of illicit yard waste in the river will decrease sedimentation, reduce chemical pollutants in river, and improve water quality and habitat.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to Minimal

CDM Smith

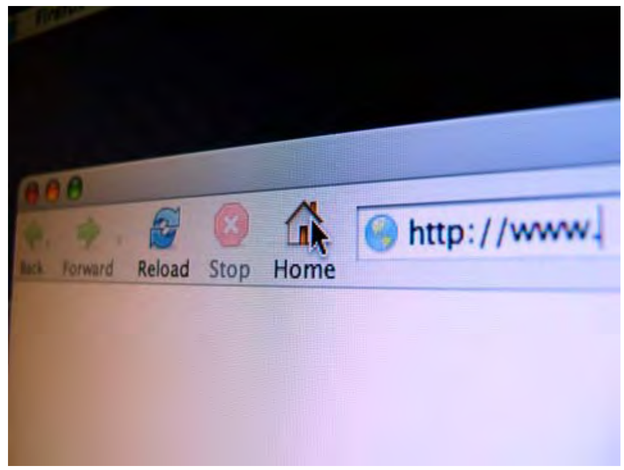
Action 3.5: Develop Website for Public Education and Information

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
3. Build a grassroots watershed constituency

Problem: Public Accessibility and Awareness

Lack of awareness of how resident activities influence the health and habitat of the river leads to mismanagement of yard waste, buffer areas, and public spaces, resulting in excessive sedimentation and degradation of water quality.



Brief Description of Action

A website should be developed to provide reference materials and electronic resources for interested residents to educate themselves on best management practices, river and habitat restoration, and events.

Action Item Summary


Image: Jeff Woelker

Expected Benefits

A website will allow residents to become informed on how their choices influence river habitat and what they can do to improve and protect the Mill River by managing their yards, habits, and participating in events This website could allow residents and business owners to proactively engage in river restoration.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

Up to $100,000

CDM Smith

Websites

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psabcontent.com

Action 3.6: Educational Signage Near River

Target Objectives

1. Increase public awareness, education, and community involvement
2. Improve access and connection to the river
3. Build a grassroots watershed constituency

Problem: Public Accessibility and Awareness

Lack of public awareness on how Human and pet activities contribute to the pollution of the Rippowam/Mill River leads to pollution, degraded river habitat, and increased degradation.

Brief Description of Action

Signs should be installed near the river promoting education on the history, ecology, and benefits of this resource as well as education on how to protect and care for it. The river area should be easily accessible.

Action Item Summary

Expected Benefits

By increasing river access and educational river signage, the City of Stamford and the Watershed Constituency will support continued resident involvement and ownership of the river.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to Minimal

Quantitative Benefits

5% reduction in targeted pollutants

CDM Smith

Action 3.7: Mark Stormwater Grates With Educational Message

Target Objectives

1. Increase public awareness, education, and community involvement
5. Improve water quality
6. Restore instream and riparian habitat

Problem: Lack of Awareness of Stormwater Outfalls

Lack of resident awareness on stormwater conveyance results in chemical, biological, and bacterial contamination from stormwater catch basins which drain directly into the Rippowam/Mill River.

Brief Description of Action

Stormwater grates should be marked with educational messages to increase awareness of stormwater influence on surface water resources so residents are aware of how their choices affect the River.

Action Item Summary

Expected Benefits

Educational messages on grates will increase public awareness of stormwater conveyance to surface water resources. This low cost action can be implemented by local community groups. The messages will promote public awareness and discourage dumping, leading to a reduction in stormwater pollution.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

None to $500,000, depending on the extent the program is implemented.

Quantitative Benefits

5% reduction in targeted pollutants

Sources

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effectively

Action 3.8: Improve Stormwater Practices at Commercial Sites

Target Objectives

5. Improve water quality
6. Restore instream and riparian habitat

Problem: Solids Pollution

Expansive impervious surfaces such as parking lots collect litter, waste from vehicles, and other surface contaminants which are washed into catch basins and deposited in the

Brief Description of Action

Stormwater best management practices such as porous pavement, green roofs, rain gardens, tree plantings, and other forms of stormwater pre-filtration decrease the negative influence developed areas have on the river.

Action Item Summary

Expected Benefits

Incorporating stormwater best management practices will improve stormwater quality. In addition to pollutant removal, structural BMPs can remove high amounts of TSS and reduce total peak discharge.

Responsible Parties

- City of Stamford
- Business Owners

Cost

None to Minimal

CDM Smith

Action 3.9: Improve Stormwater Practices—Residential

Target Objectives

1. Increase public awareness, education, and community involvement
5. Improve water quality
6. Restore instream and riparian habitat

Problem: Pollution of Solids, Bacteria, and Nutrients

Runoff from residential properties introduces contamination, sediment, bacteria, chemicals, and litter to the river, degrading water quality and aquatic habitat.

Brief Description of Action

An outreach and education campaign should target residential best management practices and low impact development strategies to improve overall stormwater quality and limit sediment and litter in the river.

Action Item Summary

Expected Benefits

Overall decrease in pollution, yard waste, and litter entering the river, while increasing resident awareness of their influence on overall water and habitat quality and inspiring stewardship of this local resource.

Responsible Parties

- City of Stamford
- Land Owners

Cost

None to $500,000, depending on the extent the program is implemented.

Action 3.10: Bacteria/DNA Source Tracking

Target Objectives

5. Improve water quality

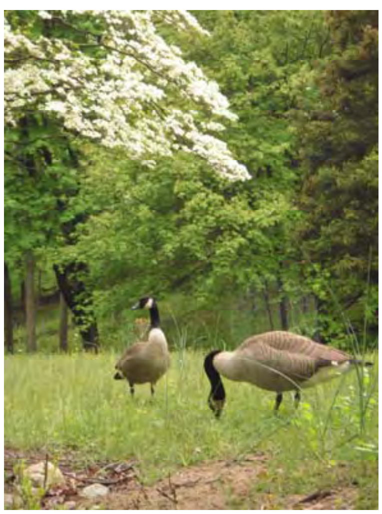
Problem: Bacterial Source Unknown

Unknown sources of fecal matter can introduce disease and nutrients to surface water resources, promote algal growth, and decrease dissolved oxygen levels in water and lead to conditions unsuitable for recreational activities.

Brief Description of Action

Conducting a bacteria source tracking study will reveal which species (humans, farm animals, pets) the bacteria originates from so that source elimination efforts can be directed accordingly.

Action Item Summary



Expected Benefits

Identifying the source of the bacteria will inform a targeted reduction program in areas where bacteria counts are high. This will lead to overall reduction of bacteria in the river, increase dissolved oxygen, and decrease algal growth.

Responsible Parties

- City of Stamford

Cost

$10-$100 per isolate (depending on method used)

CDM Smith

Action 3.11: Increase Street Sweeping and Catch Basin Cleaning

Target Objectives

5. Improve water quality
6. Restore instream and riparian habitat

Problem: Solids and Metals Pollution

Litter, including organic waste, leaves, and litter, accumulates along roadways and curbs, washes into storm drains, and increases sediment deposits at outfalls along the river.

Brief Description of Action

Assess current street sweeping program and frequency and increase cleaning frequency in areas where organics and litter accumulate quickly. Catch basins should be routinely cleaned of large solids.

Action Item Summary

Expected Benefits

Cleaning the streets and catch basins in greater frequency will help decrease the amount of litter, larger particles, and which would otherwise enter the drainage system and be deposited in the river, improving receiving water quality by decreasing sedimentation.

Responsible Parties

- City of Stamford

Cost

None to Minimal

CDM Smith

Action 3.12: Illicit Discharge Detection and Elimination

Target Objectives

5. Improve water quality
6. Restore instream and riparian habitat

Problem: Illicit Discharge

Illicit sewer connections to the storm drain system, floor drain connections, leaking water mains, leaking septic systems, and roof leaders introduce additional water to the storm drain system and can introduce bacteria and other hazardous contaminants to receiving waters.

Brief Description of Action

An illicit discharge detection and elimination program should be conducted and implemented to assess the City's storm drain system to eliminate illicit pipe connections.

Action Item Summary

Expected Benefits

A system-wide survey will allow the City to identify specific, significant sources of bacteria, preventing future inputs to the river, improving water quality, and restoring habitat in affected areas.

Responsible Parties

- City of Stamford

Cost

>$500,000

CDM Smith

Action 3.13: Address Private Water Intakes

Target Objectives

1. Increase public awareness, education, and community involvement
7. Ensure sufficient low flows

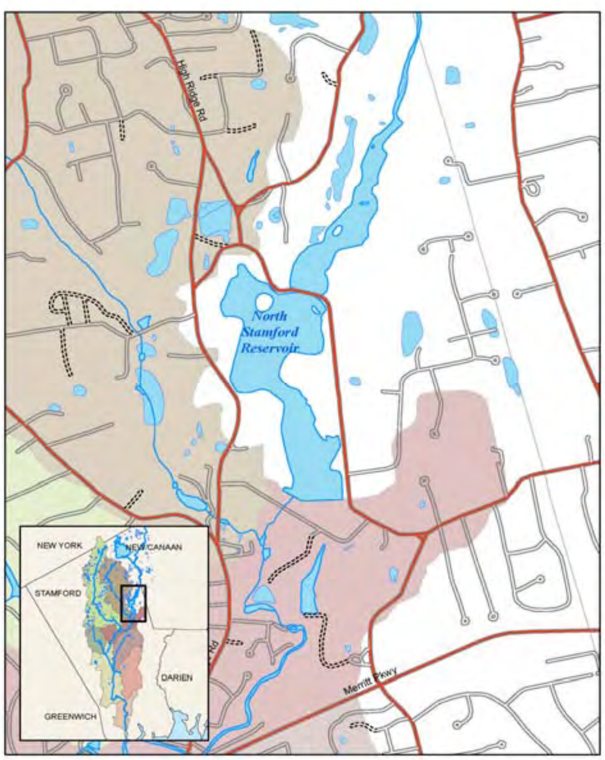
Problem: Private Water Intakes

Private water intakes reduce the overall flow of the river, limiting recreational activities and disrupting natural processes.

Brief Description of Action

Regulations will be developed to establish water withdrawal limits and a permitting process will be established to regulate withdrawals.

Action Item Summary



Expected Benefits

By limiting water withdrawals, the City will be able to maintain more active control of the river and establish a minimum flow which will allow the river to maintain natural processes and support aquatic life.

Responsible Parties

- City of Stamford

Cost

Up to $100,000

CDM Smith

Action 3.14: Create Mill River Watershed Association

Target Objectives

1. Increase public awareness, education, and community involvement
3. Build a grassroots watershed constituency

Problem: Community Involvement

The current condition of the Rippowam/Mill River is degraded. In order to improve overall river health, the river requires an independent community-driven steward to lead restoration efforts.

Brief Description of Action

A citizen-based community organization should be developed to steward restoration efforts, collaborate with the City, and engage local residents and businesses to lead in implementing these action items.

Action Item Summary

Expected Benefits

Creation of the Mill River Watershed Association will establish a venue for action, improve public accessibility and awareness of issues pertaining to the health of the Mill River, and provide a platform for resident involvement and ownership of this community resource.

Responsible Parties

- Watershed Constituency

Cost

None to Minimal

Action 3.15: Regular Monitoring Program

Target Objectives

5. Improve water quality
8. Promote sustainability mission of City of Stamford

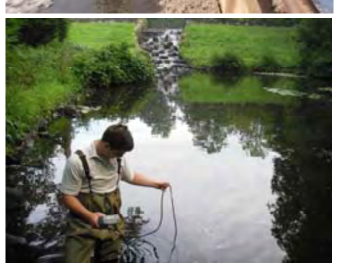
Problem: Inconsistent Environmental Data

In order to assess the performance of action items on improving overall habitat quality in the Rippowam/Mill River, a regular monitoring program must be established to gauge direction of future efforts.

Brief Description of Action

The watershed association should establish a volunteer annual monitoring program during a variety of river conditions: during rain events, low flow, after rain events, to assess the performance of action items.

Action Item Summary



Expected Benefits

Establishing a regular monitoring program will provide information to direct future restoration efforts and assess performance of implemented action items.

Responsible Parties

- City of Stamford
- Watershed Constituency

Cost

Up to $100,000