SECTION 206 PROGRAM
AQUATIC ECOSYSTEM RESTORATION

MILL RIVER AND MILL POND HABITAT RESTORATION PROJECT STAMFORD, CONNECTICUT

DETAILED PROJECT REPORT

August 2004

US Army Corps of Engineers

New England District

Mill River and Mill Pond Habitat Restoration Project
Stamford, Connecticut
Detailed Project Report

EXECUTIVE SUMMARY

Introduction

This report examines the feasibility of restoring anadromous fish passage, aquatic habitat, and riparian habitat on the Mill River in Stamford, Connecticut. The project area encompasses a 2.5-mile reach through downtown Stamford to the West Branch of Stamford Harbor.

The Mill River is generally considered to be the lower eight miles of Rippowam River from North Stamford Reservoir to Stamford Harbor. The Rippowam River watershed drains 37.5 square miles that extend from just north of the New York border to Long Island Sound.

Downstream of Broad Street, near Stamford's center, the Mill River is impounded behind the Main Street Dam. This 3.5-acre area of slow-flowing water is known as Mill Pond and is located within Mill River Park. Mill Pond extends 1,100 feet from the Broad Street Bridge to Main Street Dam. The pond has a uniform width of 140 feet between concrete walls, which are approximately 15 feet high (from their footings). Main Street Dam stands 9.3 feet high with a 112-foot wide spillway. Mill River Park is a nine-acre downtown common adjacent to Stamford's financial district and residential neighborhoods.

The first dam at Mill Pond was constructed in 1642 for the original gristmill in Stamford (USACE 1985). In 1922, the present Main Street Dam was constructed in the same location. Vertical concrete retaining walls were built on the eastern and western shores of the impoundment, narrowing it into a channelized shape. The dam is currently in a deteriorated state and in need of structural repairs. The Main Street Dam prevents the passage of anadromous and freshwater fish species, including river herring (the collective name for blueback herring and alewife), to spawning habitat for 4.5 miles upstream of the dam. Without access to spawning habitat, the long-term viability of the river herring population is poor.

The Mill River watershed can be characterized as moderately urban. A considerable proportion of the watershed land surface is impervious, especially within the project area near Stamford's downtown. Storm sewers from adjacent streets drain directly into Mill River. The urban development, including structural restrictions to the river, has caused the aquatic habitat of the Mill River in the project reach to be degraded. The impounded reach of river behind Main Street Dam has detained an excessive amount of sediment and is shallow and choked with invasive aquatic plants. Mill Pond had to be dredged on a number of occasions to maintain an open-water condition. In other reaches of the river within the study area, invasive plants have spread and now dominate much of the riparian habitat and marsh wetland habitats.

Authorization

This project is authorized by Section 206 of the Water Resources Development Act of 1996, P.L. 104-303, as amended. Section 206 provides programmatic authority for the U.S. Army Corps of Engineers (USACE) to carry out aquatic ecosystem restoration projects that improve environmental quality, are in the public interest, and are cost effective. Engineering Pamphlet (EP) 1165-2-502 titled Water Resources Policies and Authorities, Ecosystem Restoration - Supporting Policy Information, provides policy guidance for Section 206 ecosystem restoration projects.

This report includes an Environmental Assessment for the proposed project. Its preparation complies with the Council on Environmental Quality and USACE regulations for implementing the National Environmental Policy Act of 1969, which requires the Federal government to consider the environmental effects of a proposed action and to consult interested agencies, groups, and the public during the planning process.

Local Sponsor

The city of Stamford is the local sponsor of this study. The city contacted the Corps in 2000 requesting that ecosystem-restoration opportunities along the lower reach of the Mill River through the city be studied by the Corps under the Section 206 Aquatic Ecosystem Restoration Program.

Project Goal

The goal of the Mill River and Mill Pond habitat restoration is to restore the aquatic and riparian resources of the river and return the Mill River to a healthy, viable, and self-maintaining river system.

Project Objectives

The following specific objectives, developed by the Corps and the city of Stamford, support the Project Goal:

- Restore instream and riparian habitat on the Mill River within the 2.5-mile reach in the city limits
- Restore anadromous fish passage to the upper reaches of Mill River
- Improve aquatic diversity and health in Mill River
- Reduce sedimentation into Mill River within the lower reach of the river
- Restore water quality to support fisheries
- Restore wetland habitat
- Improve recreational access and opportunities along the river corridor that help protect the restored habitat and provide interpretive opportunities

Formulation of Alternatives

Detailed site evaluations that involved assessing potential restoration opportunities were conducted. Locations were assessed primarily for the potential to benefit the aquatic health and function of the Mill River. Site characterization included the evaluation of 17 river cross-sections within the project area. At each location the following conditions were assessed: vegetation, erosion, channel bed substrate, wildlife, and adjacent land use. Data from each cross-section were recorded and used to evaluate sites for potential restoration.

As a result of the analysis, the following restoration measures were formulated for the lower 2.5-mile reach of the river:

- Restoration of a quarter mile of riverine and riparian habitat at the Mill Pond and Main Street Dam site and opening up anadromous fish passage to 4.5 miles (32 acres) of river habitat and restoration of riparian habitat in the park area upstream of the dam site
- Riparian habitat restoration along the river, totaling 1.53 acres, where invasive vegetation would be removed and replaced by native riparian woody and herbaceous vegetation
- Restoration of freshwater wetlands along the river reach by creating a one-acre wetland area adjacent to the river on a low-lying floodplain that now contains a parking lot at the J.M. Wright Technical School grounds
- Restoration of 0.8 acre of tidal wetlands, where invasive species, including *Phragmites*, dominate the site, by removing the invasive species, re-grading the sites to enhance tidal flushing, and planting native salt marsh vegetation
- Restoration of unrestricted river flow at Pulaski Street Bridge by removing abandoned concrete blocks and gate structures beneath the bridge, that partially block movement of anadromous fish and other aquatic species in the tidal portion of the river

Restoration of the Mill Pond and Main Street Dam site involved examining four options, treated as separate alternatives:

- No action, in which the dam and channelized, sediment-filled impoundment would remain in place
- Removal of the dam and concrete retaining walls along the river and restoring the river reach to a naturally shaped channel with a riffle pool sequence, sinuous shape, and 4 acres of riparian-vegetated floodplains along the channel
- Removal of the dam and concrete retaining walls and creating a series of stepped pools along the reach with one-foot high weirs that form still-water pools, and 4 acres of riparian-vegetated floodplains along the channel
- Construction of a fish ladder on the Main Street Dam, while leaving the dam in place, partial removal of the concrete retaining walls along the impoundment, and dredging out and widening the impoundment, and 2.9 acres of riparian habitat along the impounded reach

The restoration measures were combined in various ways to produce four alternatives, including the no-action alternative, that were analyzed in detail.

Alternative 1: No Action

No alterations to the Mill River or Mill Pond would be performed. Additionally, no actions would be performed to restore riparian areas, wetlands, saltwater marsh, and free flow along the river.

The Mill Pond landscape would remain unchanged. Sediment deposition would continue in Mill Pond, thus requiring regular dredging and maintenance by the city of Stamford. Water quality within Mill Pond would continue to be impaired. The Main Street Dam would continue to block migration and movement of anadromous and other freshwater and saltwater species that could otherwise benefit from the river. The no-action alternative would have no construction cost, but would have a high maintenance cost to maintain the existing channelized impoundment behind the dam.

Alternative 2

Alternative 2 combines the following measures:

- Removal of the Main Street Dam and concrete retaining walls and restoration of a natural stream channel through a quarter-mile reach of Mill River, thereby opening up 4.5 miles (32 acres) of riverine habitat to anadromous fish; and restoration of 4 acres of riparian habitat.
- Riparian habitat restoration along additional reaches of Mill River, totaling 1.53 acres.
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds.
- Restoration of 0.8 acre of tidal wetlands.
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge.

The dam and concrete retaining walls would be removed, and banks and floodplain sculpted to restore a riparian corridor through the city park. The configuration of the natural channel design, along with the selective placement of boulders and other rock structures in the stream channel, would restore an in-stream, pool-and-riffle sequence within the park reach. The pools would be self-maintained by natural flushing during high river flows.

Alternative 3

Alternative 3 combines the following measures:

- Removal of the Main Street Dam and concrete retaining walls and creation of a series of stepped pools through a quarter-mile reach of Mill River, including 4 acres of riparian habitat restoration
- Riparian habitat restoration along the river, totaling an additional 1.53 acres
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds
- Restoration of 0.8 acre of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

A still-water landscape would be maintained in Mill River Park by establishing a series of pools connected by small cascades. Flow control structures would be constructed, and would appear to be small natural cascades. The concrete walls around the Mill Pond would be removed and replaced with vegetated banks, functioning in a manner similar to that described in Alternative 2. On-going dredging and maintenance would be required to manage sedimentation within all six pools. The operation and maintenance costs of the pools would be the responsibility of the city of Stamford and would add costs to the total project cost.

Alternative 4

Alternative 4 combines the following measures:

- Construction of a fish ladder on the Main Street Dam, while leaving the dam in place, partially removing the concrete retaining walls along the impoundment, and dredging out and widening the impoundment, including 2.9 acres of riparian habitat restoration
- Riparian habitat restoration along the river, totaling an additional 1.53 acres
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds
- Restoration of 0.8 acre of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

The Main Street Dam and the Mill Pond would be retained. The concrete walls around Mill Pond would be partially removed and the shoreline of the pond would be reshaped and regraded. The new pond slopes would be stabilized with native upland vegetation to develop a riparian buffer zone around the pond. Fish passage would be partially restored by installing a fish ladder at the Main Street Dam. On-going dredging and maintenance would be required to manage sedimentation within the pond.

Evaluation of Alternatives

The costs and anticipated environmental benefits of the restoration measures that were combined to form the alternatives were estimated and compared in incremental cost analyses. The anticipated environmental benefits were assessed by estimating the benefits to various water-related habitats, including general riverine habitat, anadromous fish habitat (including that of alewife and blueback herring), riparian corridor, native wetlands species habitat, and migratory bird habitat. Total project costs ranged from $350,000 for the no-action alternative to over $6 million for Alternative 4 with all restoration measures. Anticipated environmental benefits ranged from 3.3 habitat units (effective habitat acres) for the no action alternative to 58.7 effective habitat acres for Alternative 2 with all the additive measures.

The incremental cost analysis demonstrated that a revised version of Alternative 2 with the addition of three out of the four additive measures is the most cost-effective alternative. The revised Alternative 2 does not include the fresh water wetlands restoration measure. The additive measures along with Alternative 2 that were found to be most cost-effective are the riparian corridor restoration, removal of the Pulaski Street Bridge obstruction, and the tidal wetlands restoration.

Recommended Alternative

The revised Alternative 2 (excluding the freshwater wetlands measure) is the recommended alternative with the following restoration measures:

- Removal of the Main Street Dam and concrete retaining walls and restoration of a natural stream channel through a quarter-mile reach of Mill River, thereby opening up 4.5 miles (32 acres) of riverine habitat to anadromous fish; and restoration of 4 acres of riparian habitat within Mill River Park
- Riparian habitat restoration along the river, totaling an additional 1.53 acres
- Restoration of 0.8 acre of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

The Mill River and Mill Pond Habitat Restoration Project would remove the Main Street Dam and the concrete retaining walls around the Mill Pond. Removing these structures would create an opportunity to restore the river channel and floodplain to Mill River Park and open 4.5 miles of the Mill River for fish passage. In total, 5.2 miles of river, from the Pulaski Street Bridge, would have restored fish passage. The restored channel would effectively transport sediment and nutrients, and restore aquatic, riverbank, and floodplain habitats.

The tidal wetlands restoration measures would restore 0.8 acre of tidal marsh habitat and contribute to restoration of marsh habitat along the Connecticut coastline. Restoring tidal wetlands would improve foraging, spawning, and sheltering habitat. The riparian habitat restoration would further enhance the productivity of the Mill River corridor by reintroducing native plant species, removing invasive plants and debris, stabilizing riverbanks, and improving the riverine habitat with shade and additional shelter and food sources. This restoration would also provide benefits of attenuating floods, removing nutrients, and improving water quality.

Habitat improvements would support local biodiversity and improve the Mill River ecosystem's health. A contiguous system of river parks, open space, and protected habitat, interlaced with a trail network, would restore a wildlife corridor and provide recreational opportunities for the residents of Stamford.

Removal of the obstruction beneath the Pulaski Street Bridge would increase movement of aquatic species within the tidal zone of the river and further improve anadromous fish passage up the river when coupled with removal of the Main Street Dam.

In accordance with Corps regulations, the recommended plan represents a cost-effective plan that reasonably optimizes environmental benefits that are in the national interest. The total project cost is estimated at $5,571,000, including planning and design costs totaling $730,000, total construction costs of $4,525,000, and real estate requirements valued at $261,000. Recreation-related construction costs of $376,000 are included in the total construction cost. Additionally, operations and maintenance costs are estimated at $7,000 per year for a 50-year life of the project. This alternative provides an aquatic habitat output of 53.9 habitat units, measured as effective habitat acres, within the study area.

Sponsor's Responsibilities

The city of Stamford, Connecticut, is the non-Federal sponsor for the Mill River and Mill Pond Habitat Restoration Project. As the local sponsor, the city of Stamford has agreed to fulfill the local cooperation requirements. A financing plan, or documentation of financial capability, is required for any non-Federal sponsor prior to execution of a Project Cooperation Agreement.

Project Implementation

As the local sponsor, the city of Stamford is required to provide 35% of total project costs relating to ecosystem restoration and 50% of recreation-related construction costs. Federal costs are estimated at $3,565,000. Stamford's cost share is estimated at a total of $2,006,000, including $261,000 in contributed value of real estate provided by the city. The sponsor is also responsible for 100% of continuing operations and maintenance costs, as well as any needed repair, rehabilitation, and replacement costs on improvements related to the project. Project sponsorship will be formalized with the execution of the Project Cooperation Agreement, which is expected in the 2005 calendar year. Construction is forecast to begin in 2005 and be completed in November 2006.

MILL RIVER AND MILL POND RESTORATION
STAMFORD CONNECTICUT
DETAILED PROJECT REPORT

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

SECTION 1. INTRODUCTION

1.1 STUDY AUTHORITY

This project is authorized by Section 206 of the Water Resources Development Act of 1996, P.L. 104-303, as amended. Section 206 authorizes the US Army Corps of Engineers (USACE) to carry out aquatic ecosystem restoration projects that improve the quality of the environment, are in the public interest, and are cost effective. USACE Engineering Pamphlet EP 1165-2-502 provides policy guidance for Section 206 ecosystem restoration projects.

1.2 STUDY PURPOSE AND SCOPE

The overarching goal of the project is to restore the aquatic and riparian resources of the Mill River to a healthy, viable, and self-maintaining river system. Where possible habitat restoration proposals take into consideration the requirements for ecological function, public open space, and recreational amenities for the city of Stamford. The immediate focus is the restoration of the reach of the Mill River flowing through downtown Stamford including the Mill River Park.

The purpose of this Detailed Project Report (DPR) and Environmental Assessment (EA) study is to:

- Document the project objective
- Display opportunities and constraints
- Describe existing and potential future conditions
- Identify alternative means to achieve the project objective
- Analyze the feasibility, effects, benefits, and costs of the alternatives
- Recommend an alternative that best meets project objectives in a cost-effective manner

This report documents the study results for the proposed Section 206 aquatic ecosystem restoration project at the Mill River and Mill Pond in the 5th Congressional District, within Fairfield County, Connecticut.

The attached EA complies with Council on Environmental Quality and USACE regulations for implementing the National Environmental Policy Act of 1969 (NEPA). NEPA requires the Federal government to consider the environmental effects of a proposed action and to coordinate with interested agencies, groups, and the public during the planning process. The EA describes the proposed action and alternatives, environmental resources in the affected area, and environmental effects of the proposed project. This report also includes a Finding of No Significant Impact (FONSI).

1.3 STUDY AREA

The Mill River is generally considered to be the lower eight miles of the Rippowam River in southwestern Connecticut, from the North Stamford Reservoir to Stamford Harbor (Figure 1). The Rippowam River watershed drains 37.5 square miles that extend from just north of the New York border to Long Island Sound. The upper watershed contains the North Stamford Reservoir, formed in 1908 with the construction of the North Stamford Dam, and created primarily for regional water supply. The land surrounding the reservoir, which forms the headwaters of the Mill River, is protected and is therefore undeveloped. The river cascades 35 feet down a spillway from the reservoir. It drops an additional 162 feet in elevation before reaching Long Island Sound, or an average of 20.4 feet per mile. The river flows eight miles through the city of Stamford, combining with Poorhouse Creek and Toilsome Brook.

The focus of the study is the reach of river from Cold Spring Road to Long Island Sound, a length of 2.5 miles. For the purposes of this study, all portions of the Rippowam River south of the North Stamford Reservoir will be referred to as the Mill River.

The Mill River is impounded behind the Main Street Dam, downstream from the Broad Street Bridge and adjacent to Stamford's central business district (Figure 2). This area of slow flowing water is known as Mill Pond. A half-mile downstream from the Main Street Dam, Mill River discharges into Long Island Sound through the West Branch of Stamford Harbor.

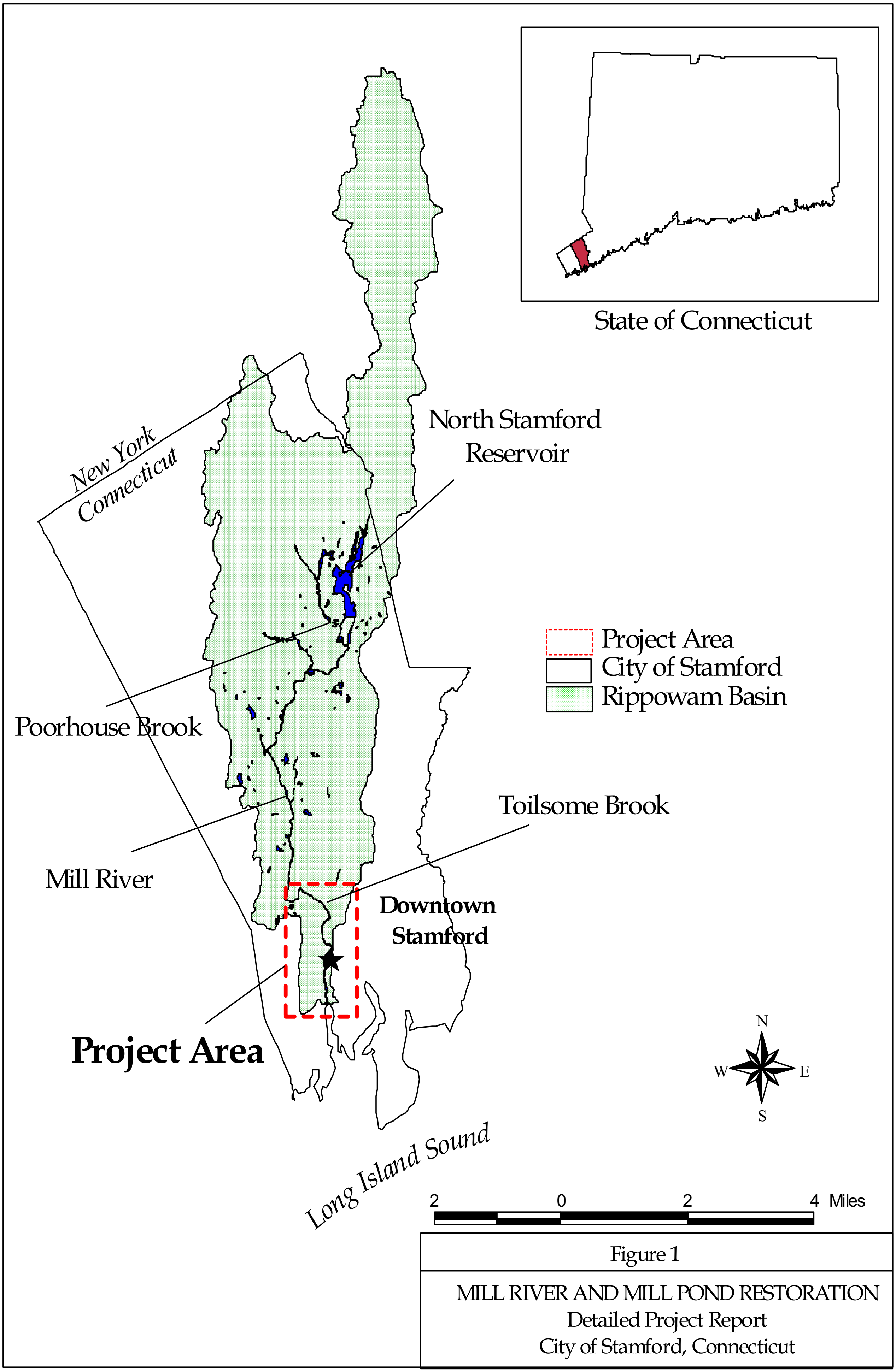


FIGURE 1: The City of Stamford and the Rippowam Basin, New York and Connecticut

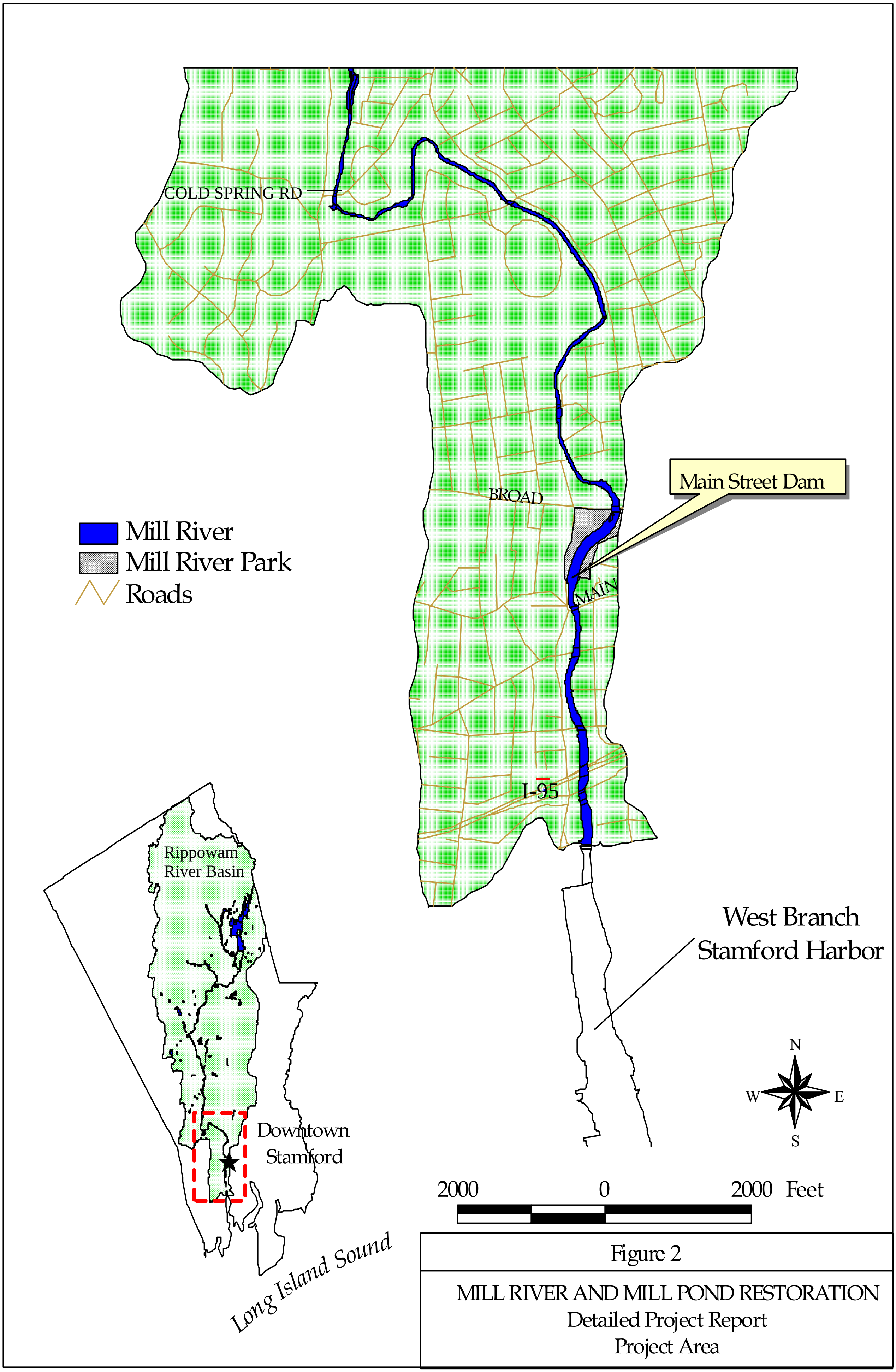


FIGURE 2: Project Area within the City of Stamford.

1.4 STUDY PROCESS

The feasibility study process was conducted in six steps: Step 1) identification of problems and opportunities; Step 2) inventorying and forecasting conditions; Steps 3) formulation of alternatives; Step 4) evaluating alternative plans; Step 5) comparing alternative plans; and Step 6) selection of the recommended plan. Below is a summary of the planning steps.

<u>Identification of Problem and Opportunities</u>
The study team 1) reviewed existing information and developed a restoration goal for the area; 2) conducted a site reconnaissance to identify problems and opportunities; 3) identified and evaluated potential restoration locations; 4) identified techniques for habitat restoration and bank stabilization; 5) outlined the approach and treatment locations for riparian and stream channel restoration; and 6) developed objectives to address the problems and opportunities.

<u>Inventory and Forecast of Conditions</u>
The team identified existing conditions along the lower 2.5 miles of Mill River. The team then forecasted the future conditions of the reach if no restoration projects were performed on the reach.

<u>Formulation and Evaluation of Alternatives</u>
Based on the restoration opportunities, objectives, and constraints and inventory, the study team developed options to address the problem areas. These options pertain to restoration issues within and along the Mill River, with an emphasis on restoring habitat within the Mill Pond area. The options were then combined in various ways to form three construction alternatives for detailed analysis along with the no-action (without project) alternative. Each option was evaluated in terms of the qualitative improvements that can be achieved, as well as cost effectiveness.

<u>Comparison of Alternatives and Selection of the Recommended Plan</u>
The Study Team estimated habitat benefits and total project costs for the restoration options and then compared the relative value of the options through a cost effectiveness and incremental cost analysis. Based on the qualitative and quantitative comparison of alternatives, the team identified the cost-effectiveness of various combined options to identify cost-effective alternatives. The team then selected a recommended restoration plan, called the National Restoration Plan, based on cost-effectiveness, acceptability, and other factors.

1.5 HISTORY OF DAM CONSTRUCTION

Mill Pond is a 3.5-acre impoundment formed by the Main Street Dam. The first dam in this location was constructed in 1641 for Stamford's original gristmill and subsequently changed ownership several times for use as a carding mill, a rolling mill, a foundry and a woolen mill. In these early years of dam operation, Mill Pond was much wider than it is today. In 1922, the city of Stamford rebuilt the dam and narrowed the pond, building 2,200 feet of 15-foot high reinforced concrete walls and filling behind them to create additional parkland (Figure 3). Today, the Stamford Housing Authority owns the Main Street Dam.

The Main Street Dam prevents the passage of anadromous fish to spawning grounds upstream. Since 1999, Save the Sound, Inc. and the Connecticut Department of Environmental Protection (CT DEP), with the support of the federal agencies National Oceanic and Atmospheric Administration (NOAA) and National Marine Fisheries Service (NMFS), had investigated methods to restore fish passage in Mill river, and they developed conceptual plans to install a small fish ladder (Alaskan steep pass ladder) at the dam. In 2000, the city of Stamford approached the USACE to investigate opportunities to improve aquatic habitat in the lower reach of the Mill River. This includes the restoration of aquatic habitat in Mill Pond behind the Main Street Dam. USACE accepted city's request and initiated the Section 206 ecosystem restoration study in 2002. This study expands the investigation of river restoration to include not only a fish ladder alternative but also dam removal alternatives and restoration of riparian areas and wetlands along the entire lower river corridor. Save the Sound, Inc., CT DEP, and NMFS are participants in this current Section 206 study and are supportive of exploring more options to river restoration than the initial fish-ladder option.

Many smaller dams have been constructed on the upper Mill River. A number of these old dams remain on the upper reach of the river, but most have been breached, allowing fish passage. For more information on dams along the river see Section 6.3 of the EA and Appendix I.

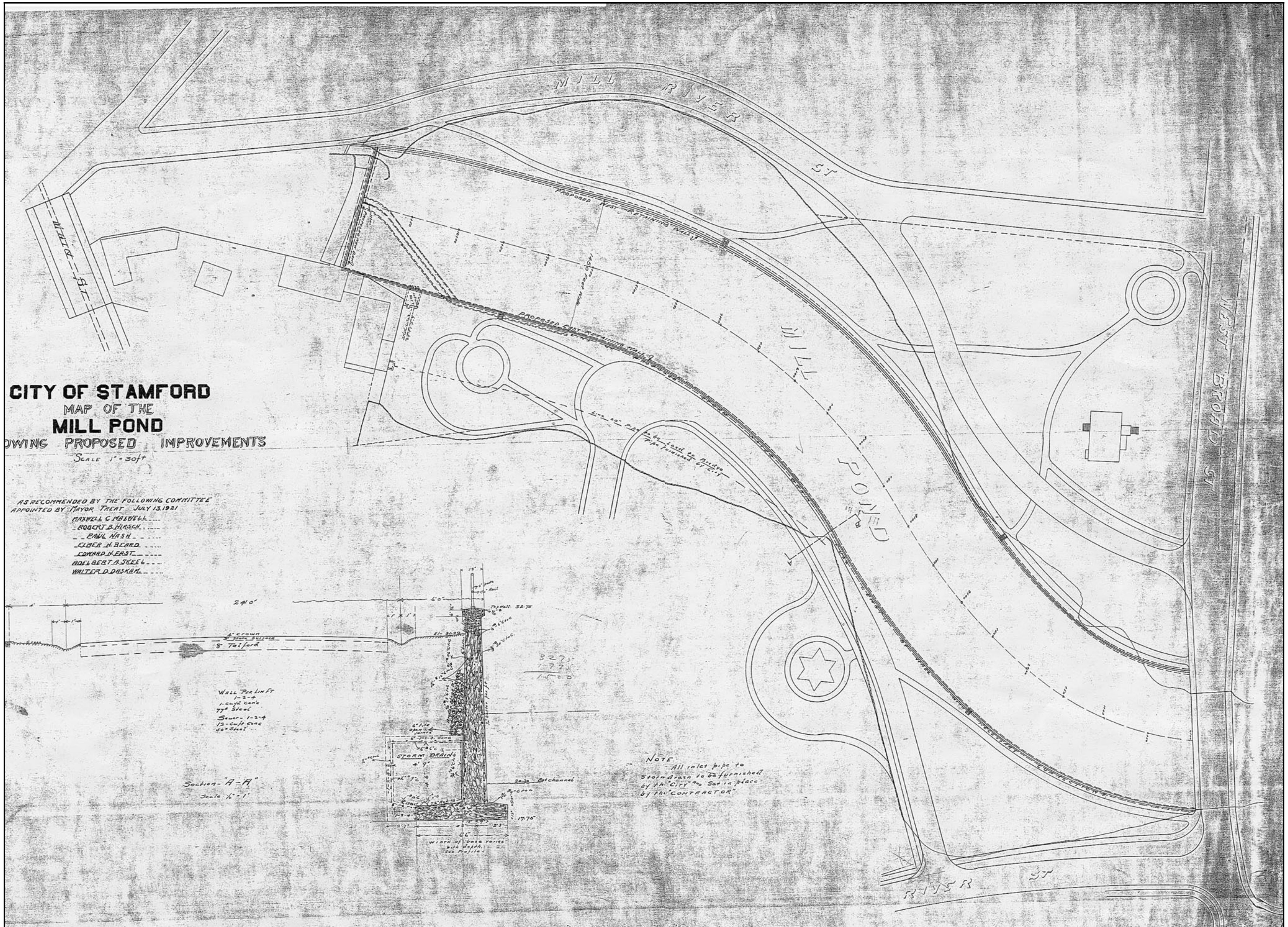


Figure 3 - Historical Plan of the Mill Pond and Main Street Dam (1922)

1.6 RESTORATION OF HISTORIC FISH MIGRATION CORRIDOR

Several anadromous fish species historically populated the Mill River and its tributaries. Anadromous fish hatch in freshwater, migrate to the ocean as juveniles, and return to freshwater as adults to spawn. The Atlantic salmon (*Salmo salmar*) once thrived in New England's coastal rivers, but by the mid-1800's the species had disappeared from rivers south of the Penobscot River in Maine (USFWS 2002). In the last twenty years salmon have been restored to the Connecticut River in moderate numbers through a process of dam removal, water quality improvement, and habitat restoration. Alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) collectively referred to as river herring have declined since the 1800's, with some return in population in the 1960's as a result of early restoration efforts (Gephard, personal communication). However, numbers continue to decline due to pollution, over fishing, and restriction of fish passage (USFWS 2002). Salmon, alewife, and blueback herring are protected under the Anadromous Fish Conservation Act. The Mill River could also support American shad (*Alosa sapidissima*), a popular sport and pan fish, as well as white perch (*Morone americana*), also very popular with anglers.

The major barrier to anadromous fish in the Mill River is the Main Street Dam. The dam is 9.3 feet high, and prevents fish from passing upstream to potential spawning habitat. Large concrete remnants of a previous structure under the Pulaski Bridge also prevent fish passage at low tide. The CT DEP is currently transporting alewife upstream of the Main Street Dam. A restored Mill River, including dam removal, would open access to an additional 4.5 miles of valuable habitat for anadromous and other freshwater and saltwater species. In total, 5.2 miles of river from the Pulaski Street Bridge would be restored to fish passage. Section 6 of the Environmental Assessment provides detail on fish species of concern and habitat.

1.7 NON-FEDERAL SPONSOR INVOLVEMENT IN THE STUDY

The city of Stamford is the non-Federal sponsor for the implementation of the accepted restoration plan. As the local sponsor, the city is required to provide 35% of total project costs along with 100% of project operation and maintenance costs. The city is also required to provide all needed lands, easements, rights-of way, relocations and disposal areas for the project. Project study participants include, the city of Stamford; CT DEP; Save the Sound, Inc.; US Fish and Wildlife Service (USFWS); US Environmental Protection Agency (USEPA), and National Marine Fisheries Service (NMFS).

SECTION 2. PROBLEMS AND OPPORTUNITIES

2.1 EXISTING CONDITIONS

The Rippowam River Watershed encompasses 37.5 square miles. The lower 8-mile reach of the Rippowam from the North Stamford Reservoir to Long Island Sound is known as the Mill River. The project area consists of a 2.5-mile length of the Mill River from Cold Spring Road downstream to the West Branch of Stamford Harbor. The study area includes the Mill Pond, an impounded reach of river, and Main Street dam, which creates the impoundment and is located approximately 500 feet upstream of Main Street Bridge. The study area also includes Mill River Park, a six-acre park that surrounds Mill Pond (Plate 1).

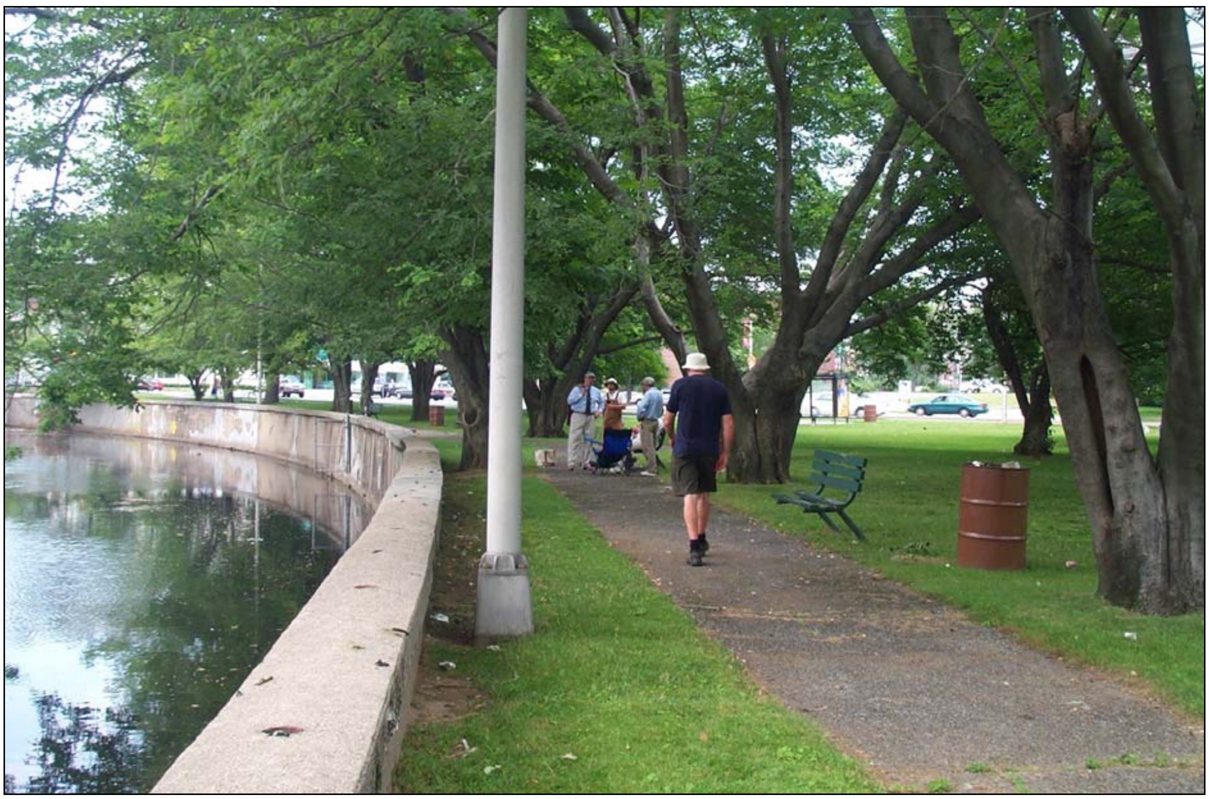


Plate 1. Mill Pond and Mill River Park

The river through the study area varies in width from approximately 40 feet from bank to bank upstream of Broad Street, to 126 feet from bank to bank at the mouth of the West Branch of Stamford Harbor. The river is estuarine south of the Tresser Bridge and tidal to the base of the Main Street Dam with a mean high water at 4.26 feet (NGVD 29). The river flows more swiftly in the upper reaches and is characterized by a narrower width at bankfull stage. The channel bed in the upper reaches is scoured and armored with gravel, cobble, and boulders. Downstream of the Main Street Dam, the Mill River flows slowly toward the river mouth in Stamford Harbor. In this lower reach, sediment deposition occurs and a short tidal shelf extends to the floodplain. The lower reach of the Rippowam Watershed is primarily urbanized, with residential areas, urban parks, commercial buildings, parking lots, and some bordering woodlands. The urban landscape often infringes directly upon the riparian buffer (FEMA 1993). The watershed surface is becoming increasingly impervious, which has caused a change in the hydrologic regime and channel morphology.

Restoration efforts are focused on rehabilitation of Mill Pond located behind the Main Street Dam (Plate 2). The concrete dam is 9.3 feet high and the impoundment behind it is defined by 15-foot high concrete floodwalls (Figure 4). The pond extends from the dam upstream to the Broad Street Bridge.
Water movement through the pond is slow, allowing sediments to fall out of suspension, creating a bed of sediments, which would require dredging every few years to maintain a pool in the impoundment. The bed is primarily unconsolidated, filled with trash, choked by aquatic plants, and is at times malodorous. Resident Canada geese flock in large numbers to the pond and adjacent park, compounding pollution issues. The pond bisects Mill River Park and separates downtown Stamford from residential neighborhoods. Mill River Park consists of a lawn with mature urban trees located directly adjacent to the pond's retaining walls.

Plate 2. Main Street Dam

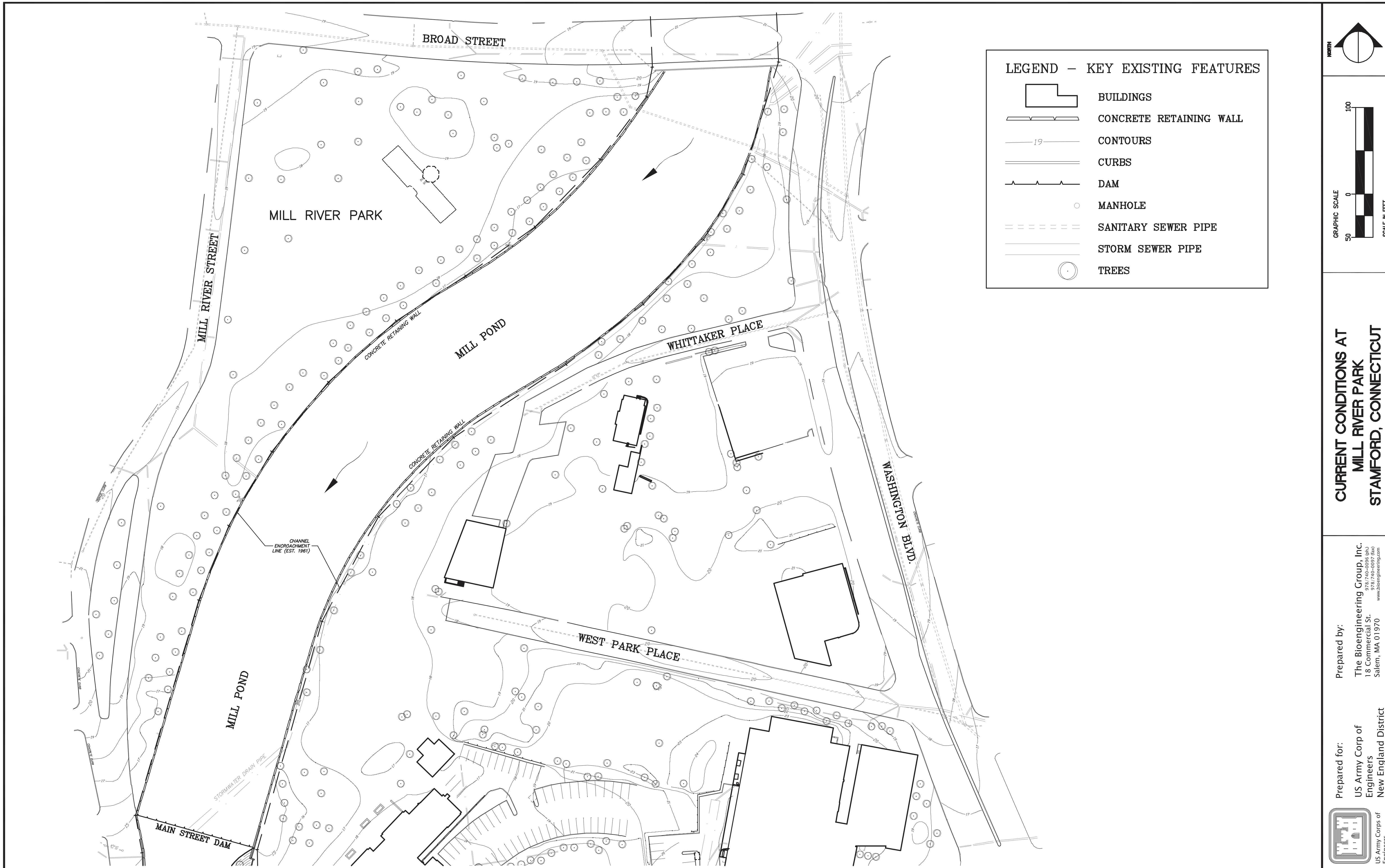


FIGURE 4 EXISTING SITE PLAN AND TOPOGRAPHIC SURVEY OF THE MILL RIVER PARK

2.2 PROBLEM IDENTIFICATION

The reconstruction of the Main Street Dam in 1922 continued the obstruction of passage for anadromous fish to upstream spawning grounds. The dam also prohibits estuarine species from foraging beyond the tidal reach. Energy flows and sediment passage are arrested at the Main Street Dam, which forms an impoundment that holds sediment and concentrates nutrients and pollutants. The pond is undergoing eutrophication, with excessive nutrient loads exacerbated by the large population of Canada geese. Low oxygen levels created by excessive levels of decaying organic matter combined with sedimentation have created a highly degraded habitat within Mill Pond.

The Main Street Dam is currently in need of repairs (Plate 3) and any construction associated with the dam or pond would require extensive modifications to ensure the stability and function of the dam. As mentioned in Section 1, conceptual plans were developed for an Alaskan steep pass fish ladder for Main Street Dam to partially restore fish passage. Those plans include a requirement for the city of Stamford to perform repairs to the dam structure prior to fish ladder installation. The fish ladder measure has been further investigated in this study and included in Alternative 4 of this study. Dam repair would continue to be required for this fish-ladder alternative. Reinforced concrete walls that confine the pond on all sides are also in need of repair (Plate 4).

Plate 3. Failing sluice gate of the Main Street dam

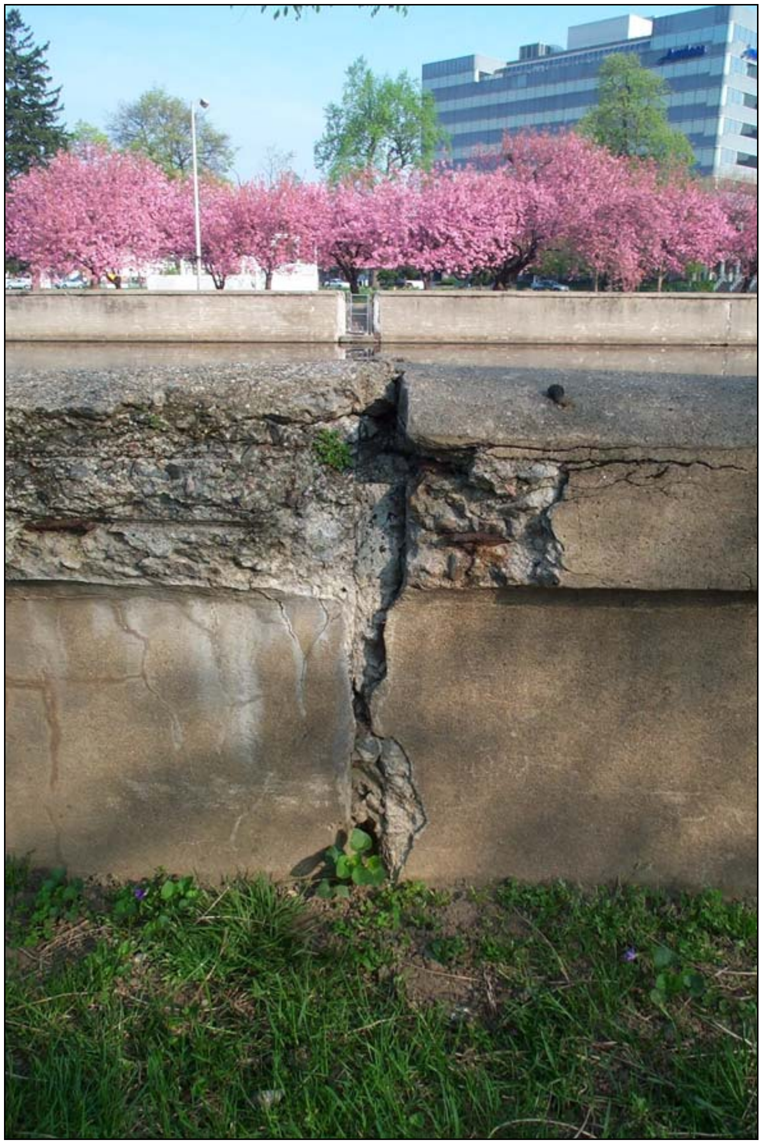


Plate 4. Cracked retaining wall of the Mill Pond impoundment

Bordering the pond, Mill River Park is equally in need of attention. The riverbanks provide minimal riparian habitat value. Existing vegetation comprises mature ornamental trees, turf grasses, and invasive weeds encroaching from neighboring lots. A double row of exotic cherry trees, which were gifted to the city and planted in 1957, provide exceptional color in the spring (Plate 5). However, they are nearing the end of their lifespan and show evidence of disease and other damages (Appendix I). The park is inhabited by urban-adapted animals, such as rodents, starlings, sparrows, and Canada geese.

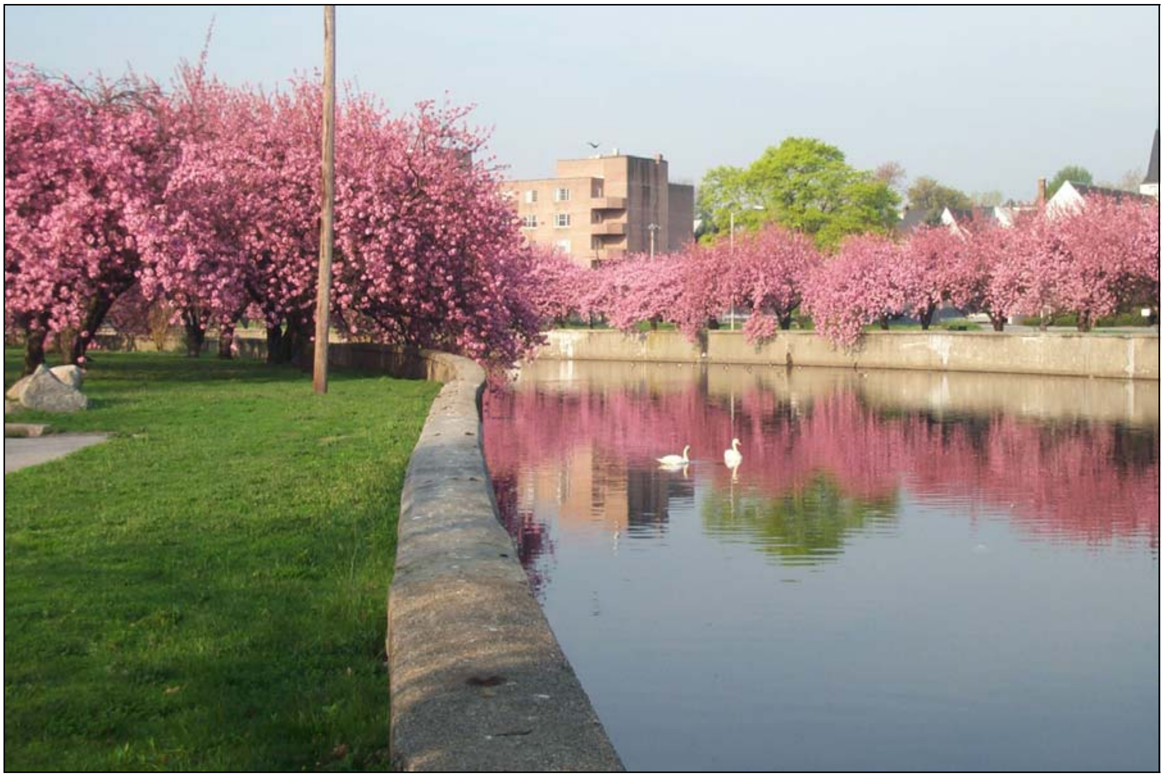


Plate 5. Mill River Park with cherry trees in full bloom

Only a short walk to downtown Stamford, this urban open space lacks physical access to the river and pedestrian connections downstream and between banks. There are no visual or physical links to Stamford's center, the University of Connecticut, surrounding residences and retail establishments, or other reaches of the river.

Anadromous fish passage and movement of other aquatic species up and down the river are further restricted by a large concrete block and an abandoned gate structure that are located in the river under the Pulaski Street Bridge, in the intertidal reach of the river. This structure is currently blocking fish from movement upstream during low and intermediate tide levels.

Some reaches of the Mill River have retained their natural banks, floodplain, and riparian buffer. However, the riparian buffers are frequently encroached upon and in some cases, residential backyards, parking lots, and buildings are at the very edge of banks. Impervious surfaces funnel stormwater into culverts, which enter directly, untreated, into Mill River. This modified hydrology leads to frequent high flows containing pollutant traces and sediment from roadways and buildings. Flooding becomes more frequent due to increased volumes associated with storm events that lead to high energy flows and corresponding erosive forces, which erode the channel bed and banks, remove bank-side and emergent vegetation, and threaten property.

The spread of exotic plant species threatens habitat value and biodiversity on the Mill River. Norway maple and tree-of-heaven out-compete native floodplain species and limit the diversity of stream bank canopy species. The woody perennial Japanese knotweed is spreading rapidly and is extremely difficult to remove once established. Knotweed grows rapidly, shading out existing stream bank vegetation and propagating vegetatively along the bank. A piece of rhizome only 1 inch long can float downstream and then establish, colonize, and completely dominate a riverbank (Seiger 1991). Additionally, in the tidal reach of the river, two floodplain benches contain a dominance of *Phragmites*, an invasive species.

The 2.5-mile corridor of Mill River currently lacks freshwater wetlands. Most of the wetlands that once existed in this lower reach were drained or filled in for development.

If the Main Street Dam and pond were to remain in place, then the dam would continue to be a liability for the city of Stamford, requiring repairs and necessitating regular dredging in the impoundment behind it. If the dam remains in place, and no accommodations for fish passage made, the dam would continue to block upstream fish movement and prevent successful re-introduction of anadromous fish to Mill River and the Rippowam Basin. Fish passage is additionally blocked at low tide by the Pulaski Street Bridge obstruction. Mill Pond would continue to exist as a concrete-lined urban pond with little to no depth and a lack of riparian habitat.

The cherry trees in Mill River Park are a concern for aesthetics as well as safety as boughs and whole trees begin to die from disease and old age (Plate 6). The cherry trees will require replacement if they are to be retained alongside the floodwalls. Terrestrial habitat is poor and will not maintain itself, requiring ongoing maintenance of exotic, ornamental, and lawn areas. The unsightly nature of the pond and the lack of connection to surrounding areas will discourage use by Stamford residents.

Plate 6. Damaged cherry tree in Mill River Park

Without restoration, the riparian corridor of the river will continue to be dominated by invasive species such as Japanese knotweed and *Phragmites*. Such species may continue to spread to other reaches and displace native riparian vegetation. As the population and density of the Stamford population grows (Office of Policy and Management, State of Connecticut), the percentage of impervious surface in the watershed will also increase. If riparian buffers are not augmented, and if the absence of upstream wetlands is not mitigated, then the river will continue to receive ever-increasing quantities of stormwater that is loaded with increasing amounts of sediment and pollutants.

2.3 ECOSYSTEM RESTORATION OPPORTUNITIES

Given the various issues present along the Mill River, many opportunities exist for aquatic ecosystem restoration and protection. The following restoration opportunities have been identified for the site:

- Improve in-stream aquatic habitat
- Restore riparian habitat
- Restore wetland habitat
- Abate impact of stormwater runoff
- Preserve and protect existing high quality habitat
- Enhance self-maintenance and sustainability

2.4 PROJECT GOAL AND OBJECTIVES

The project goal and objectives were defined based on addressing the identified problems and opportunities within the study area.

2.4.1 Project Goal

The goal of the Mill River and Mill Pond habitat restoration is to restore the river's aquatic and riparian resources and return the Mill River to a healthy, viable, and self-maintaining river system.

2.4.2 Project Objectives

The objectives of the proposed project are as follows:

- Restore instream and riparian habitat within the 2.5-mile reach in the city limits
- Restore anadromous fish passage to the upper reaches of Mill River
- Improve aquatic diversity and health in Mill River
- Reduce sedimentation
- Restore water quality to support fisheries
- Restore wetland habitat
- Improve recreational access and opportunities along the river corridor that help protect the restored habitat and provide interpretive opportunities

2.5 CONSTRAINTS

The following constraints have been identified for the Mill River study:

- Avoid adverse socioeconomic impacts
- Avoid hazardous, toxic, and radioactive waste sites
- Avoid adverse impacts to cultural and historic sites
- Avoid adverse impacts to rare, threatened, or endangered species

SECTION 3. INVENTORY AND FORECAST OF CONDITIONS

3.1 INTRODUCTION

This section provides an inventory and forecast of critical resources relevant to the problems and opportunities under consideration in the planning area. A quantitative and qualitative description of these resources is made and is used to define existing and future without-project conditions. The project life is considered 50 years, so the future without-project conditions are based on conditions up to the year 2054.

3.2 SITE CHARACTERIZATION

The first step of the evaluation process involved the characterization of the ecological conditions and restoration opportunities along the Mill River and Mill Pond. The study team conducted a detailed site assessment that involved assessing potential restoration opportunities with specific emphasis given to areas outlined by the local sponsor, the city of Stamford. Locations were assessed primarily for the potential to benefit the aquatic health and function of the Mill River. Site characterization included the evaluation of 17 river cross sections within the project area (Figure 5). Habitat assessment at each location included cataloging vegetation, erosion, river bottom quality, wildlife, and adjacent land use.

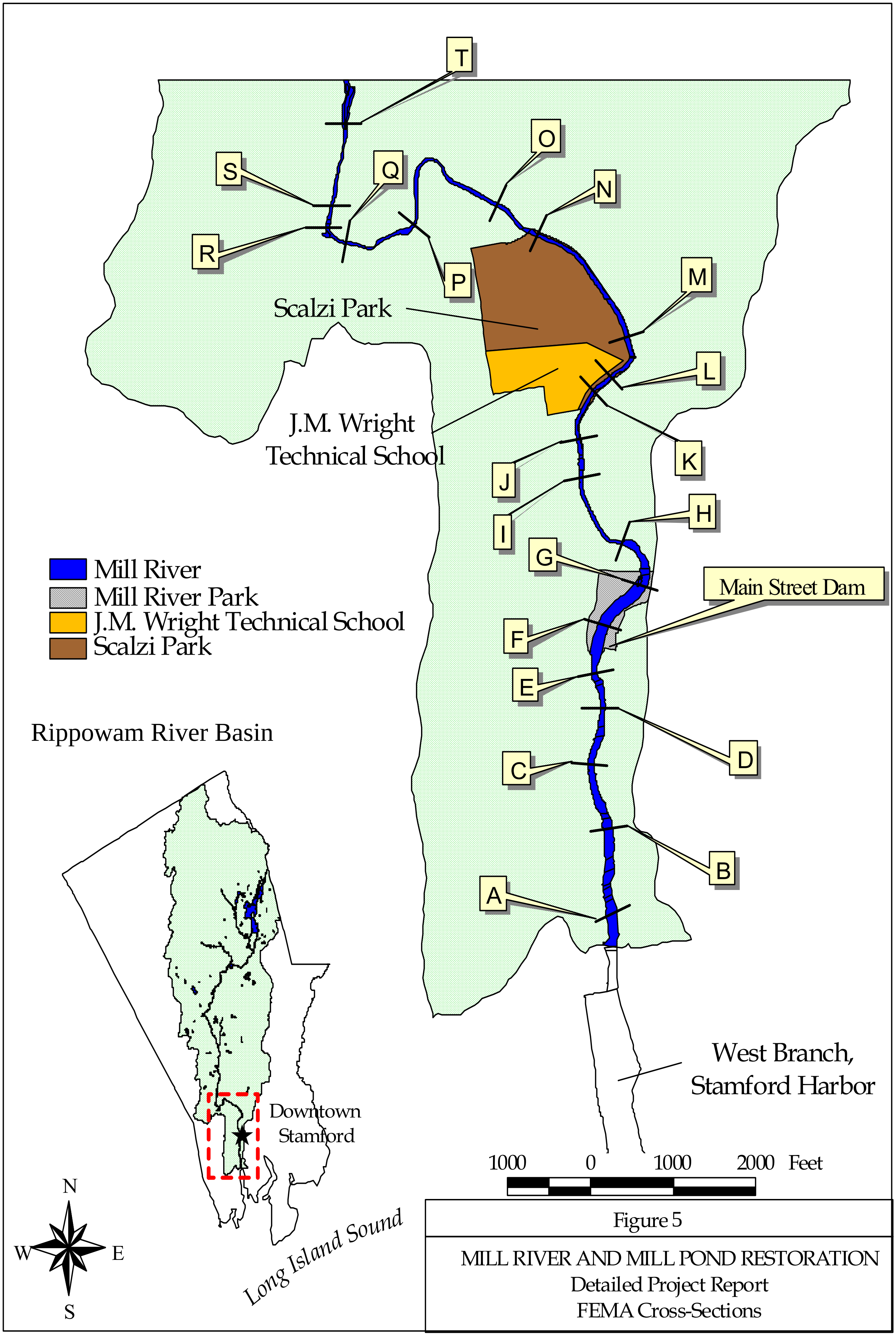


FIGURE 5: FEMA Cross-Section locations within the Project Area.

3.2.1 Data Collection

The following data were collected from each cross section location.

1. Buffer Condition
   The collected data included information on surrounding land use, topography/gradient, and riparian buffer conditions.

2. Condition of In-stream Habitat
   A general rating of very natural/good habitat, moderately natural/moderate habitat quality or degraded/altered/low habitat quality was noted.

3. Habitat Assessment
   Indicators of restoration opportunities included (1) the presence of invasive or exotic plant communities, (2) riparian buffer in a natural and high quality state providing the opportunity to improve the overall habitat value, (3) high quality in-stream habitat, and (4) human impact with potential to improve degraded conditions.

4. Education and Aesthetics
   This objective characterized the feasibility and potential interactions with the community. Indicators of restoration opportunities included (1) site visibility; (2) physical access or potential access to the public by foot, bike, or car; (3) proximity of the site to a school or densely populated area; and (4) in-stream habitat of high quality with opportunities to view wildlife, native plant communities or other characteristics of a naturally functioning stream corridor.

5. Cost Considerations
   Potential feasibility and cost considerations were noted for each cross section. Components evaluated included, but are not limited to, the potential to install native buffer plants, remove/eradicate invasive species, stabilize banks, provide stormwater management, and address trash removal.

6. Cross Section Morphology
   Cross section sketches were made for each FEMA cross section within the project area.

7. River Bottom Characterization
   Pebble counts were completed for each cross section.

8. Photographic Record
   Pertinent features along the river corridor were photographed using a digital camera. Representative habitat conditions, stormwater outfalls, trash,

potential restoration locations, and negatively impacted habitats were some of the features recorded.

Appendix I contains a sample field sheet detailing the format in which information was collected for each of the categories listed above.

3.2.2 Data Analysis and Results

The data collected from each cross section were recorded and evaluated for the presence of potential restoration activities. Scores were recorded and placed into a Potential Restoration Development Worksheet. The total score for habitat assessment represented the overall rating of the site for restoration. Scores range from 0 to 8 out of a total of 8 points. Higher scores represent a greater benefit and potential for restoration. Cross-sections K, L, and M ranked the highest, with each site scoring 8. These cross sections are located directly adjacent to Scalzi Park (Figure 5). Due to the high quality of in-stream habitat and proximity to multiple schools and parks, this area is the primary area for habitat restoration. Mill River Park in downtown Stamford also ranked high with a score ranging between 6 and 7. See Appendix I for the detailed scoring of each cross section.

3.2.3 Hydrographic Survey and Site Mapping

Existing site mapping consisted of two-foot contour intervals of the Mill River Park provided by the city of Stamford, with orthophotographs and elevation contour mapping based on flight data collected in 1998. Half-foot contour intervals of bathymetry and sub-sediment of the Mill Pond were provided by CR Environmental, Inc. based on their survey work in 2001 (See Figure 6, and Appendix J)). Site investigations were carried out at locations of cross sections previously surveyed by the Federal Emergency Management Agency (FEMA) in November 1993 by Dewberry and Davis Inc. Dimensions of bridges on the river were taken by field staff to determine the hydraulic volume for the height, width, and breadth of structures. The city of Stamford Land Use Bureau provided GIS layers for the purpose of delineating watersheds according to two-foot contour intervals. See Appendix J for the complete bathymetric analysis and results.

3.2.4 Hydraulic Analyses

Hydraulic results for the existing conditions indicate that average daily streamflow velocities are insufficient to transport fine particles from behind the dam. Modeling results support the observations that considerable backwater influences occur for approximately 1,500 feet upstream of the dam. As much as 5.5 feet of sediment deposition has occurred in the impoundment. The total estimated volume of sediment behind the dam is 18,600 cubic yards based on analysis of bathymetry data and sub-sediment depth (Appendix J).

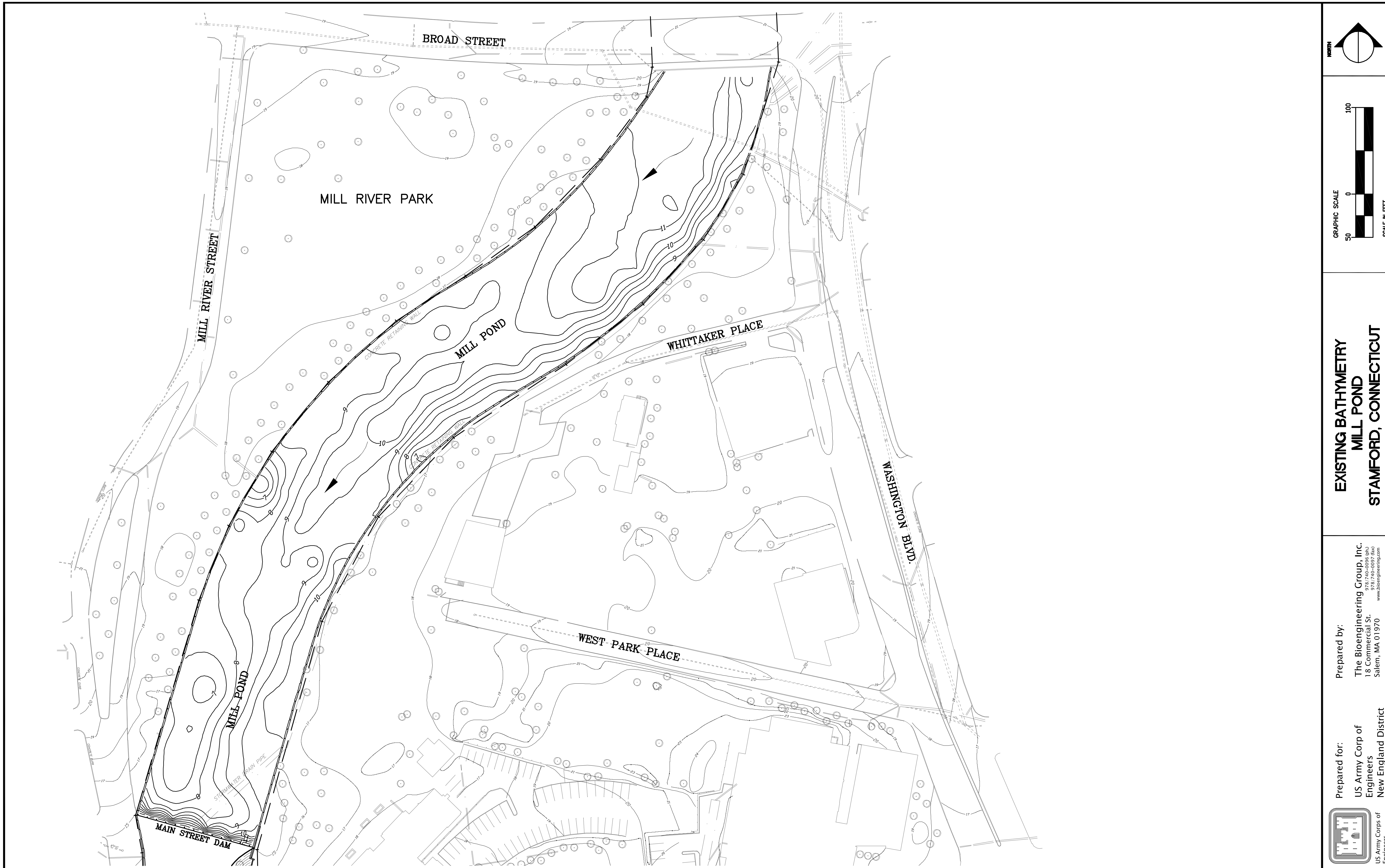


Figure 6. Bathymetric Survey of Mill Pond

Model results also show that modest flood discharges in the impoundment (discharges greater than approximately 1,100 cubic feet per second) are capable of transporting sediments that are sand-size and larger. This indicates that sediment, including some potentially contaminated sediment accumulated in the impoundment, may be transported to downstream reaches and Stamford Harbor during flood events.

3.2.5 Water Quality

The Mill River is rated by the State of Connecticut as Class B/A from the North Stamford Reservoir to Stamford Harbor (Hust, personal communication). Class B/A waters are considered suitable for fish and wildlife habitat, recreational uses, agricultural and industrial water supply, and possibly suitable for drinking water supply. Dissolved oxygen is not less than 5 mg/L at any time. Total coliforms are limited to a monthly mean of 100/100ml (Appendix K).

In 2002, the Rippowam River was added to the "Impaired Waters List" by the CT DEP according to the requirements of Section 303(d) of the Federal Clean Water Act (CT DEP 1998 and 2002b). The impairment was listed as 'inadequate aquatic life support' from Route 1 to West North Street and from West North Street to Route 15. The cause of this impairment is currently unknown. This will be a focus of further monitoring by the state.

Water quality has been tested in the Mill River upstream of the Mill Pond. Water quality tests were performed by the USGS in 1994 (USGS 2002). The CT DEP collected samples in July and September of 1998, and in October 2000 (Pizzuto, personal communication). In addition, several water quality parameters have been monitored since 1994 by students at Westhill High School as part of Project SEARCH (Sullivan, personal communication). Project SEARCH is a statewide water quality monitoring and aquatic studies program for high schools. A more in-depth discussion of these results is provided in the Environmental Assessment of this report, and results are available in Appendix K.

The North Stamford Reservoir discharges into the river following the minimum discharge requirements of the state of Connecticut. Under normal circumstances, the required discharge for the North Stamford Reservoir is about 4 cubic feet per second (Gilmore, personal communication). During heavy storm flow events, the reservoir may discharge at higher levels. Aquarion manages the water behind the reservoir so as to minimize the amount of water lost during storms. This has the effect of dampening streamflow variation in the Mill River. In addition to the North Stamford Reservoir, four tributaries provide additional base flow and stormwater flow.

The Mill River watershed is moderately urban. Much of the land surface is covered with impervious materials for roads, parking lots and buildings. Stormwater outfalls are particularly dense in the downstream reach, which is more heavily urbanized. The stormwater systems convey water from the street but provide very little opportunity for water to infiltrate the soil. Aquifers fail to recharge to sufficient levels, and the river consequently has low base flows during drier weather periods. When large rain events occur, storm sewers reduce the time of concentration of runoff in the watershed and the river reaches bank capacity in a shorter time. Rapid peak discharge, with high energy flows, results in bank erosion and flooding downstream. High sediment loads and pollutants from overland flows may affect water quality during storm events. Pollutants may include hydrocarbons and heavy metals from streets, and pesticides, fertilizers, and fecal coliform from residential gardens and urban parks.

Infringement upon riparian buffers by development reduces the ecological benefits that these areas provide, including infiltrating runoff, capturing sediment, and remediating pollutants. The lack of tree cover in some parts of the riparian corridor reduces shading and increases water temperatures, an important consideration for fish habitat. Problems have been noted with sand and salt from winter road de-icing. Refuse and evidence of intentional dumping are commonly encountered.

Water quality has been noted as best in the upstream reach, while deteriorating downstream. Sediment loading, household refuse and leaf litter affect water quality in the Mill Pond. Site investigators noted evidence of leaves being dumped into the upstream reaches of the river. The pond supports water milfoil, hydrilla, and algae, which are indicative of high nutrient loading and high biochemical oxygen demand (BOD). Resident Canada geese contribute fecal coliform to the pond and downstream areas.

3.2.6 Sediment Quality

Sediment quality characterization was based on existing sediment data that was collected in spring 2002. A total of six (6) grab sediment samples were collected from Mill Pond on March 20, 2002, between West Broad Street (to the north) and Main Street Dam (to the south). The sampling was performed to help evaluate sediment disposal options should the material be dredged. Each sample was collected approximately 120 ft to 160 ft apart, moving in an upstream to downstream direction. Sample SB-01 represents the furthest sample point upstream and SB-06 represents the furthest sample point downstream.

Premier Laboratory analyzed the samples using EPA recommended methodologies. The following constituents were measured: reactive sulfide, hexavalent chromium, semivolatile organic compounds, polychlorinated biphenyls, volatile organic compounds, extractable total petroleum hydrocarbons, phenolics, metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc), and total organic carbon. Data results displayed undetectable concentrations for most constituents, with the exception of those constituents shown in Table 1.

Table 1. Data Results Summary for Mill Pond Sediment Sampling

Sample	SB-01	SB-02	SB-03	SB-04	SB-05	SB-06
Sulfide (mg/l)	12	22	4.8	32	21	ND
Phenolics (mg/kg)	ND	ND	ND	ND	20	ND
CT ETPH (mg/kg)	620	1,700	830	1,500	750	940

Metals (mg/l):	SB-01	SB-02	SB-03	SB-04	SB-05	SB-06
Arsenic	ND	ND	ND	ND	0.36	ND
Barium	0.86	0.90	1.2	1.2	1.2	1.2
Iron	1.1	0.92	15	37	46	2.3
Manganese	2.9	2.4	7.4	1.9	8.0	8.0
Zinc	1.0	0.95	1.6	0.62	0.57	2.6

Trace Metals (mg/kg):	SB-01	SB-02	SB-03	SB-04	SB-05	SB-06
Arsenic	ND	ND	ND	1.6	1.4	ND
Barium	62	90	97	100	100	130
Cadmium	0.38	0.74	0.58	0.74	0.71	0.64
Chromium	12	18	20	21	36	25
Copper	27	44	44	53	49	51
Iron	6,700	9,000	9,000	9,500	10,000	12,000
Lead	33	52	59	68	70	73
Manganese	180	260	330	180	380	430
Mercury	0.028	ND	0.046	0.051	0.076	0.068
Selenium	ND	ND	ND	ND	1.7	ND
Silver	ND	ND	0.40	0.64	0.64	0.50
Zinc	120	190	190	220	200	220

Semivolatiles (mg/kg)	SB-01	SB-02	SB-03	SB-04	SB-05	SB-06
Benzo[a]anthracene	0.96	1.6	1.5	1.6	2.0	2.7
Benzo[a]pyrene	1.3	2.3	2.2	2.3	2.8	3.8
Benzo[b]fluoranthene	1.8	3.6	2.8	2.8	3.5	4.6
Benzo[g,h,i]perylene	0.67	ND	1.0	1.8	1.4	1.8
Benzo[k]fluoranthene	1.5	2.8	2.7	2.4	2.7	4.0
Bis(2-ethylhexyl)phthalate	1.4	2.5	1.9	1.9	2.1	2.5
Chrysene	1.7	2.9	2.7	2.8	3.3	4.5
Dibenz[a,h]anthracene	ND	ND	0.46	0.66	0.61	0.82
Fluoranthene	3.4	6.0	5.3	5.6	6.6	9.5
Indeno[1,2,3-cd]pyrene	0.68	ND	1.0	1.6	1.4	1.9
Phenanthrene	1.4	2.3	2.0	2.2	2.4	3.9
Pyrene	2.4	4.1	3.8	4.0	4.7	6.6

Polychlorinated biphenyls (mg/kg)	SB-01	SB-02	SB-03	SB-04	SB-05	SB-06
Aroclor 1254	ND	0.57	0.35	0.24	0.099	0.57

ND = not detected
Dark shaded box = Exceeds CT DEP regulatory threshold for disposal of polluted soil in residential areas (see results for semivolatiles)
Light shaded box = Exceeds CT DEP regulatory threshold for disposal of polluted soil in industrial/commercial areas (see results for semivolatiles)

Sediment quality issues in Mill Pond and Mill River are primarily associated with pollutant runoff and sedimentation. Over the years, pollutant-laden material has accumulated in Mill Pond, upriver of the Main Street Dam. Sediment analysis to date has shown that the pollutants in the pond do not reach hazardous waste levels. At present, however, limited tests indicate that some sediments exceed the CT DEP thresholds for certain semivolatiles for disposal in residential and/or industrial/commercial areas. If dredging were to occur, the city of Stamford would be required to secure appropriate permits for disposing material that exceeds these thresholds. Dredging and sediment removal would be needed to prepare the site for restoration actions and dam removal. Alternatively, removal of the Main Street Dam would eliminate sedimentation, the potential for island formation and invasive plant species colonization, and the need for dredging (other than a one-time dredging event) within the pond. For a more complete discussion of sediment quality see Section 6.3.3 of the Environmental Assessment.

3.2.7 Benthic Environment

Between 1995 and 2000 the macroinvertebrate community in the Mill River upstream of the Mill Pond was sampled in independent studies by the CT DEP and Westhill High School, Stamford, CT. No samples were taken within or downstream of the Mill Pond. The CT DEP concluded that the low percentage of intolerant species indicated that benthic (riverbed) habitats were degraded. The Westhill High School data indicated that the riverbed habitat of the Mill River within the study period was overall in good condition, with the exception of some organic pollution. For detailed information on the existing macroinvertebrate community and riverbed habitat quality, see Section 6.3.4 of the Environmental Assessment.

3.2.8 Fisheries, Shellfish, and Threatened and Endangered Species

The Main Street Dam divides the Mill River into two reaches. The reach upstream of the dam is primarily a warm-water freshwater fishery stocked with trout. The reach downstream of the dam is an estuarine fishery composed of marine and warm-water fish species.

The New England Fisheries Management Council and the NMFS have designated Long Island Sound as Essential Fish Habitat for several fish species. As Stamford Harbor is part of Long Island Sound, it is necessary to identify those species that use the harbor, the tidal mouth of the Mill River, and the freshwater reach of the Mill River at any point during their life cycles. These fish species include pollock (*Pollachius virens*), cobia (*Rachycentron canadum*), winter flounder (*Pleuronectes americanus*), windowpane flounder (*Scophthalmus aquosus*), bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), black sea bass (*Centropristis striata*), king mackerel (*Scomberomorous cavalla*), Spanish mackerel (*Scomberomorous maculates*), striped bass (*Morone saxatilis),* alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and Atlantic salmon (*Salmo salmar*). Section 6.3.5 of the Environmental Assessment contains a detailed inventory of the existing estuarine fishery downstream of the Main Street Dam.

Upstream of the Main Street Dam, the Mill River is primarily a warm-water, freshwater fishery composed mainly of shiners (*Notropis* spp.), dace (*Rhinichthys* spp.), and bass (*Micropterus* spp.), and supplemented with annual trout stockings by CT DEP. Section 6.4.3 of the Environmental Assessment contains a detailed inventory of the existing warm-water, freshwater fishery.

As discussed in Section 1, the Main Street Dam is the major barrier to anadromous fish passage in the Mill River. The dam prevents the passage of fish upstream to their spawning habitat. The dam also affects the quality of habitat in the Mill Pond by trapping sediment and concentrating pollutants and nutrients, creating an environment of high biochemical oxygen demand (BOD). A restored Mill River, including dam removal, would restore access to five miles of valuable spawning habitat for anadromous species.

3.3 FUTURE WITHOUT-PROJECT CONDITIONS

The without-project conditions are forecasted based on continuation of a trend of worsening aquatic ecosystem conditions. Fish passage will continue to be blocked, and the dam will eventually require major repairs. CT DEP may attempt to transport fish above the dam, but such efforts are expensive and generally not very effective.

The Mill Pond walls will eventually deteriorate to some degree and the pond will continue to accumulate sediment, organics, refuse, and pollutants. Infrequent dredging of the pond has occurred, leaving the pond partially to mostly full of sediments. The local sponsor may pursue limited periodic dredging of the pond. The city had been pursuing state permits in 2002 to dredge up to 9,000 cubic yards of sediment from the pond as a maintenance effort. However, regular maintenance dredging cannot be assumed due to the high cost and associated disruptions to the park and surrounding area. Therefore, the pond will probably remain partially to mostly full of sediments, and the aquatic habitat of the pond will remain degraded.

The riparian area along the pond will remain highly degraded due to the existence of the walls and fill along the channel. The deterioration of habitat quality along the Mill River will continue unabated with the potential erosion of banks and the domination of a few invasive and pollution-tolerant species.

SECTION 4. FORMULATING ALTERNATIVE PLANS

4.1 OVERVIEW OF PLAN FORMULATION PROCESS

This section outlines the process taken by the study team to formulate restoration measures and develop alternatives by combining the measures as appropriate.

4.2 IDENTIFYING RESTORATION MEASURES

The aim of the restoration activities is to restore the aquatic and riparian resources of the river corridor. Channel modification, dam construction, urbanization, ongoing development of the upper watershed, and industrial development have been identified as the primary causes of adverse ecological impacts to the stream. Habitat degradation in the stream corridor increases in the downstream direction along the Mill River from the upper reaches in Stamford to Long Island Sound.

An ecosystem approach to restoration was specifically applied to the Mill River by working toward the following intentions:

- Re-establishing fish passage to the upper reaches of the Mill River
- Increasing the river's baseflow by providing more opportunities for stormwater infiltration
- Improving the water quality of urban stormwater runoff through treatment;
- Restoring valuable wetland habitat
- Prioritizing restoration locations by habitat function and value;
- Evaluating riparian habitat health and function to best preserve, protect, and enhance biodiversity and self-regeneration
- Recommending best management practices for the Rippowam Watershed

Within the project area, the study team conducted a field investigation to identify restoration opportunities including erosion problems, degraded water bodies, in-stream habitat degradation, urban stormwater flows, potential for wetland restoration, and need for fish passage enhancement. The study team, including the city of Stamford, identified 20 locations for possible restoration activity within the project area (Figures 7 and 7a). All of the proposed restoration locations are described in Appendix I. Field evaluations focused on fish passage enhancement and habitat preservation in areas adjacent to the Mill River and Mill Pond. Using information gathered during site visits and a review of existing data, brief descriptions of each proposed restoration location site as well as general biotic and site feasibility information were documented. All site assessments were completed based on existing site conditions.

Using the environmental and economic information gathered for the watershed, screening criteria were developed to select sites for proposed restoration. Criteria for site selection included site conditions, environmental benefits, long-term viability, engineering feasibility, and cost effectiveness. See Section 4.2 for a full description of potential restoration location selection and evaluation.

Of the twenty possible restoration actions evaluated, ten were recommended for further analysis: Sites 1, 2, 6, 9, 10, 11, 12, 13, 17, and 18 (See figures 7 and 8 for locations. See also Appendix I for the complete list of potential restoration activities). Table 2 (below) describes the ten selected sites. These recommendations were based on the restoration rating, which considered such variables as habitat significance, presence/absence of exotics, instream habitat, potential for habitat improvement, and educational opportunities. These scores were used as a guideline to prioritize restoration sites for recommendation, as higher scores represented a greater benefit. On-site verification, evaluation, and professional judgment were also used in the selection process. Sites 11, and 12, and 13 were selected for their high potential for habitat restoration, including anadromous fish passage. Sites 2 and 6 were selected because they are considered to be important estuarine areas. Site 1 was selected because it has the potential to provide enhanced fish passage (a primary goal of the overall project). Sites 9, 10, and 18 were selected because they provide opportunities for riparian restoration in conjunction with wetland and floodplain areas, providing connection betweens these ecosystems. Site 17 was selected as an area to restore wetlands and floodplain in the lower river corridor.

Sites 3, 4, 5, 7, and 8 were not selected due to low restoration potential as reflected in the low restoration rating. Those with a high restoration rating that were not chosen included Site number 14 due to existing infrastructure constraints, Site 15 did not provide high potential for instream habitat, Site 19 and 20 showed good restoration potential but were not considered habitats under threat nor critical to the overall aquatic health of the Mill River.

Table 2. Potential Projects Identified During Field Investigations (See Figures 7 and 8 for Location Maps of sites)		
Site Location	**Current Conditions**	**Proposed Restoration Action**
1	Abandoned concrete blocks and gate structures directly underneath Pulaski Street Bridge. Structures block fish passage at lower tides.	Remove portions of the fish blockage to restore fish passage at low tide.
2	Tidal flat dominated by *Phragmites* sp. Area lies directly in front of city-owned property.	Tidal wetland restoration. Restore area to a tidal wetland by regrading and planting of desired vegetation. Invasive species removal.
6	Tidal flat dominated by *Phragmites* sp. Area lies directly in front of city-owned property.	Tidal wetland restoration. Restore area to a tidal wetland by regrading and planting of desired vegetation. Invasive species removal.
9	Empty lot located on the east bank of the river downstream of the Main Street Bridge. Area is dominated by invasive exotics. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Regrade lower portion to include a wetland area. Manage or remove any exotic species. Trail system to connect greenway along river corridor.
10	Floodplain located on the east bank of the river just downstream of the Main Street Bridge. Area is dominated by invasive exotics. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Regrade lower portion to include a wetland area. Manage or remove any exotic species. Connect trail system in Mill River Park to City-provided trail that connects to Main Street Bridge pedestrian crossing.
11	Retaining wall located on west bank of river directly adjacent to Mill Pond Road. Has numerous stormwater discharge pipes. Constriction made by road and wall does not allow a walkway for foot and bike traffic.	Structural reinforcement and stabilization. Vegetation planting at base of wall. Incorporate a sidewalk for pedestrian and bike traffic to connect park system.
12	Main Street dam forming Mill Pond. Dam is failing and needs structural reinforcement. Collects trash and causes sedimentation behind dam within the Mill Pond.	Remove Main Street dam and restore a geomorphologically correct river channel, which includes a number of pool and riffle sequences.
13	Mill Pond located in downtown Stamford. Currently a trap for sediment and trash. Vertical concrete walls provide little habitat value. Large population of Canada geese and mute swans.	Restore a geomorphologically correct river channel. Remove concrete walls and create floodplain that incorporates a trail/boardwalk system as well as overlooks and educational facilities. Maintain as many Cherry Trees as possible within Mill Pond Park.
17	Parking lot located on the Wright Technical School property. School is located on the west bank of the river and just south of Scalzi Park. Parking lot is adjacent to the river and near a pedestrian bridge joining the park with the east side of the river.	Create a stormwater wetland and natural teaching area to treat run off from the school grounds. Riparian restoration through planting of desirable riparian species. Manage or removal of exotic species. Trail system to connect greenway along river corridor.
18	Riparian corridor on west bank of Mill River located between Wright Technical School and Mill River. Vegetation is composed of primarily of Japanese knotweed, an invasive exotic. Provides little shading or habitat value.	Riparian restoration through planting of desirable riparian species. Manage or remove any exotic species.

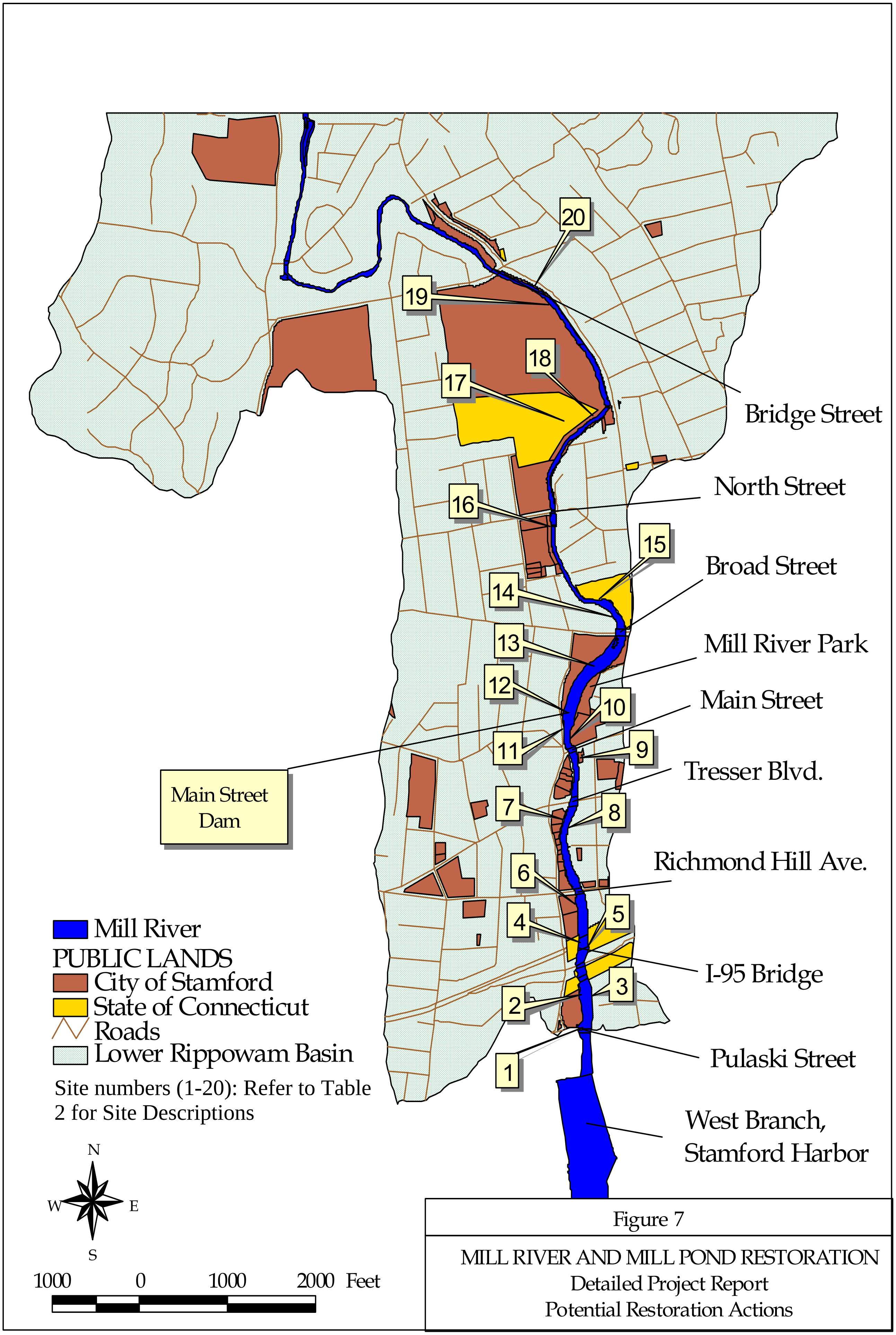


Figure 7. Locations of Potential Restoration Actions

Mill River Restoration Sites

Legend

Road Centerlines

Restoration Sites

Figure 8. Aerial Photo of Locations of potential Restoration Actions.

(Refer to Table 2 for description of 20 Sites.)

0 500 1,000 2,000 Feet

1:7,200

US Army Corps of Engineers®
New England District

4.2.1 City of Stamford's Greenway Planning

The city of Stamford, the non-federal sponsor, is dedicated to expanding and enhancing the Mill River riparian corridor as a wildlife passageway and urban green space. The city currently has a number of projects underway to restore the riparian corridor and floodplain of the Mill River. In 1997, the city commissioned Sasaki Associates to study the creation of a Mill River corridor (Sasaki *et al.* 1999). The proposed greenway will provide city residents with open space for recreation and public gatherings, as well as opportunities to interact visually and physically with the Mill River (Sasaki *et al.* 1998; 1999).

Greenways provide multiple environmental and cultural benefits (Ahern 1995). Restoring a contiguous open stream and its associated floodplain and riparian buffer improves local hydrology and sediment transport as well as habitat. A park system designed around a stream channel serves as a wildlife corridor and lends itself to the siting of recreational trails.

Integral to the city's plan for a greenway is restoration of the Mill River. The river would become the focal point of the park system, from which connections to downtown Stamford, commuter rail, other urban parks, and surrounding neighborhoods would be strengthened. River restoration will introduce the residents of Stamford to local biodiversity and give them the opportunity to explore a variety of habitats from estuarine wetlands to riparian floodplain.

Habitat restoration that also facilitates learning ultimately ensures the future protection and care of the natural resource. A rise in the number of watershed associations and adopt-a-stream groups demonstrates the interest of residents to the Mill River (Pinkham 2000). Educational opportunities and aesthetic resources on the Mill River have been evaluated and rated to prioritize restoration sites. A Mill River reach north of Broad Street that includes a technical college, a middle school, and an elementary school provides an excellent opportunity to teach about natural systems. This area has been targeted for efforts, including the restoration of wetlands and native riparian vegetation, as well as the retention and treatment of stormwater.

4.2.2 Watershed Best Management Practices

Urban runoff carries elevated levels of nutrients, metals, pesticides, and organic contaminants (Paul and Meyer 2001). These impacts, as well as increased sediment loads or other common urban development impacts may affect stream restoration sites (Ferguson 1991b). Consequently, urban stream restoration requires planning and analysis of sites upstream, downstream, and laterally adjacent to the restoration site.

An important component of the Mill River restoration project is the consideration of Best Management Practices (BMPs) to mitigate urban development impacts. Stormwater BMPs are commonly recommended practices to sustainably manage water resources. They may include features or methods to detain, infiltrate, and treat stormwater

(Ferguson 1991a). Combining stream restoration with on-site stormwater treatment by employing selected BMPs is generally the most successful strategy to ensure downstream water quality and habitat enhancement (Lawrence *et al.* 1996). While restoration activities may include and demonstrate key BMPs, the community is responsible for the development of watershed and urban practices to manage their water resources.

A variety of stormwater BMPs can be designed to provide some of the following benefits:

- Augment base flows through dry periods by improving groundwater recharge
- Uptake excess nutrients
- Intercept floatables (such as organic debris and trash) and sediment while slowing overland flow
- Attenuate pollutants through soil microbial activity, fixation in plant tissues, or filtration through soil materials
- Prevent erosion by intercepting runoff and moderating slopes
- Prevent increased overbank flooding while providing safe conveyance of extreme floods

Potential BMP's that can be constructed under the Section 206 program to complement and safeguard stream restoration have been identified along the length of the Mill River project area, including:

- Restoration of a filled wetland and floodplain on an overflow parking lot near the JM Wright Technical School
- Restoration of floodplain and riparian buffers and filter strips designed to improve stormwater quality and intercept and capture overland flows
- Restoration of fringe wetlands in upstream and tidal reaches to capture urban runoff

Other BMP's that would help improve water quality and protect the aquatic resources, but may not be authorized under the Section 206 program include:

- Forebay areas and infiltration basins for stormwater outfalls at many locations
- Porous paving materials utilizing cellular confinement systems
- Bioretention facilities associated with urban land use in site-specific locations inside the 100-foot river buffer

4.2.3 Identified Restoration Measures

As a result of the inventory and consideration of restoration potential and Stamford's Greenway planning, the following restoration measures were formulated for the lower 2.5-mile reach of the river:

- Mill Pond and Main Street Dam Site Restoration: Restoration of a quarter mile of riverine and riparian habitat at the Mill Pond and Main Street Dam site and opening up anadromous fish passage to 4.5 miles of river habitat (Sites 10, 11, 12, and 13) upstream of the dam and a total of 5.2 river miles (31.5 acres) from Pulaski Street Bridge

- Riparian habitat restoration along additional reaches of Mill River, totaling an additional 1.53 acres, where invasive vegetation would be removed and replaced by native riparian woody and herbaceous vegetation (Sites 9, 10, 11, and 18)
- Restoration of freshwater wetlands along the river reach by creating a one-acre wetland area adjacent to the river on a low-lying floodplain that now contains a parking lot at the J.M. Wright Technical School grounds (Site 17)
- Restoration of 0.8 acre of tidal wetlands, where invasive species, including *Phragmites*, dominate the site, by removing the invasive species, re-grading the sites to enhance tidal flushing, and planting native salt marsh vegetation (Sites 2 and 6)
- Restoration of unrestricted river flow at Pulaski Street Bridge by removing abandoned concrete blocks and gate structures beneath the bridge, that partially block movement of anadromous fish and other aquatic species in the tidal portion of the river (Site 1)

Restoration of the Mill Pond and Main Street Dam site involved examining four options, including the no-action alternative, treated as separate alternatives:

- No action, in which the dam and channelized, sediment-filled impoundment would remain in place, and no riparian habitat would be restored
- Removal of the dam and concrete retaining walls along the river and restoring the river reach to a naturally shaped channel with a riffle pool sequence, sinuous shape, and 4 acres of riparian-vegetated floodplains along the channel
- Removal of the dam and concrete retaining walls and creating a series of stepped pools along the reach with one-foot high weirs that form still-water pools, and restoration of 4 acres of riparian-vegetated floodplains along the channel
- Construction of a fish ladder on the Main Street Dam, while leaving the dam in place, partial removal of the concrete retaining walls along the impoundment, and dredging out and widening the impoundment, and restoration of 2.9 acres of riparian habitat along the pool

Removal of the dam without removing the walls was formulated, but was dropped from further consideration. This measure would create a channelized reach with walls that would need additional protection at considerable expense with no restoration benefit to the currently impounded reach. Partial wall removal is considered in Alternative 4 because the dam remains in place, and complete wall removal would compromise the structural stability of the dam.

4.3 FORMULATION OF ALTERNATIVES

The restoration measures were combined in various ways to produce four alternatives, including the no-action alternative, that were analyzed in detail. These alternatives represent a range of options from a much larger set of originally conceived actions. Design considerations for alternatives included site conditions, environmental benefits, long-term viability, engineering feasibility, and cost effectiveness (discussed in greater detail in Section 6). Each construction alternative (other than the no-action alternative) provides a specific restoration measure for the Mill River Park reach of the river. In addition, all construction alternatives include four restoration measures, which were added to the alternatives to increase habitat restoration goals.

The following represent alternatives analyzed in detail in this report for restoring the Mill River and Mill Pond in Stamford, Connecticut.

4.3.1 Alternative 1: No Action

No alterations to the Mill River or Mill Pond would be performed. Additionally, no actions would be performed to restore riparian areas, wetlands, saltwater marsh, and free flow along the river.

The Mill Pond landscape would remain unchanged. Historic cherry trees and other vegetation would remain in their current locations. The concrete walls bordering the pond and dam would remain in place, and both the walls and dam would require continued maintenance. Sediment from a variety of watershed sources (e.g., stormwater runoff) would continue to be deposited in Mill Pond, thus requiring regular dredging and maintenance by the city of Stamford. For example, the city removed 3,500 cubic yards of sediment from the pond in 1996, and the city pursued permitting in 2002 to remove up to 9,000 cubic yards in the future. However, specifically the harbor up to the Water quality within Mill Pond would continue to be impaired. The Main Street Dam would continue to block the migration of anadromous fish species to at least 4.5 miles of the Rippowam River system. The dam would also block movement of freshwater and saltwater species, since the dam is at the upper end of the tidal zone of the river. Leaving the dam in place would require immediate gate repair and continued structural reinforcement.

The no-action alternative would have no construction cost, but would have a high maintenance cost to maintain the existing channelized impoundment behind the dam.

4.3.2 Alternative 2: Dam Removal and River Channel Restoration

Alternative 2 combines the following measures:

- Removal of the Main Street Dam and concrete retaining walls and restoration of a natural stream channel through a quarter-mile reach of Mill River, thereby opening up 4.5 miles of riverine habitat to anadromous fish upstream of the dam and a total of 5.2 river miles (31.5 acres) from Pulaski Street Bridge. This option also would restore 4 acres of riparian habitat through the Mill River Park (Sites 11, 12, and 13). (See Figure 9).

- Additional riparian habitat restoration along the river, totaling an addition of 1.53 acres, at Sites 9, 10, 11, and 18 by planting native woody and herbaceous vegetation and removing exotic and invasive plant species.
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds (Site 17) (See Figure 10).
- Restoration of 0.8 acres of tidal wetlands by re-grading banks and planting native salt marsh vegetation (Sites 2 and 6).
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge to open up the river and provide unobstructed passage of anadromous fish and other aquatic species (Site 1).

To facilitate fish passage and allow continual flushing of sediment, the Main Street Dam would be removed. Concrete retaining walls would also be removed and banks sculpted to restore a riparian corridor through the city park. A stable river that effectively transports the imposed discharge and sediment load would be re-established through the former Mill Pond. The configuration of the natural channel design, along with the selective placement of boulders and other rock structures in the stream channel, would restore an in-stream pool-and-riffle sequence within the park reach. The deeper pools would be self-maintained by natural flushing during high river flows.

Sediment (approximately 18,600 cubic yards) that has collected behind the dam would be excavated. Initial sediment tests show that the sediment is not hazardous, but contains contaminants at levels that do not allow for residential disposal (see Appendix H, Sediment Chemistry Analysis). Sediment would be further tested as needed to determine the extent of contamination and the appropriate disposal methods. All materials determined inappropriate for disposal in residential and/or industrial/commercial areas would be transported to an appropriate disposal site. The Manchester Municipal Landfill in Manchester, Connecticut has already been approved by the state of Connecticut for the disposal of this material, based on state permitting determinations to date (see Appendix D, Pertinent Correspondence).

The concrete walls of the Mill Pond would be removed and replaced with gently sloping banks composed of soil stabilized by native vegetation. These vegetated banks would act as a riparian buffer providing shade to the river. A natural floodplain would be restored to provide flood storage for large discharge events without increasing established FEMA flood elevations.

The volume of sediments transported downstream to the estuary and the Federal channel post dam removal is not expected to be significant, especially considering the size of the receiving basin when compared to the size of the current impoundment. Also, the impoundment is presently aggraded with sediments and it is likely that its current trapping capabilities are greatly reduced. Therefore, post dam removal sediment delivery to the estuary and the Federal channel downstream may not be significantly greater than under the existing regime.

Dam removal would reduce the river's elevation in this reach and require bank regrading and stabilization to create a floodplain that integrates with existing park elevations. Creating a floodplain and terraces may require removing some vegetation. Passage of anadromous and freshwater fish species would be restored to the Mill River, and connections between the river and Long Island Sound would be re-established. Little maintenance would be required to sustain stream channel integrity and water quality. Trails and/or boardwalks would accommodate recreational access to the river. The arrangement of channel form, native plants, boulders, water conditions, and healthy fish and wildlife populations would create an appealing and appropriate functional greenspace in downtown Stamford.

In addition to restoration measures along the river corridor, a trail system would be constructed to replace existing trails and sidewalks displaced by the restoration measures, and to connect the greenway and parks along the river corridor. Interpretive displays could also be added at the restoration sites to improve public understanding of the restoration efforts.

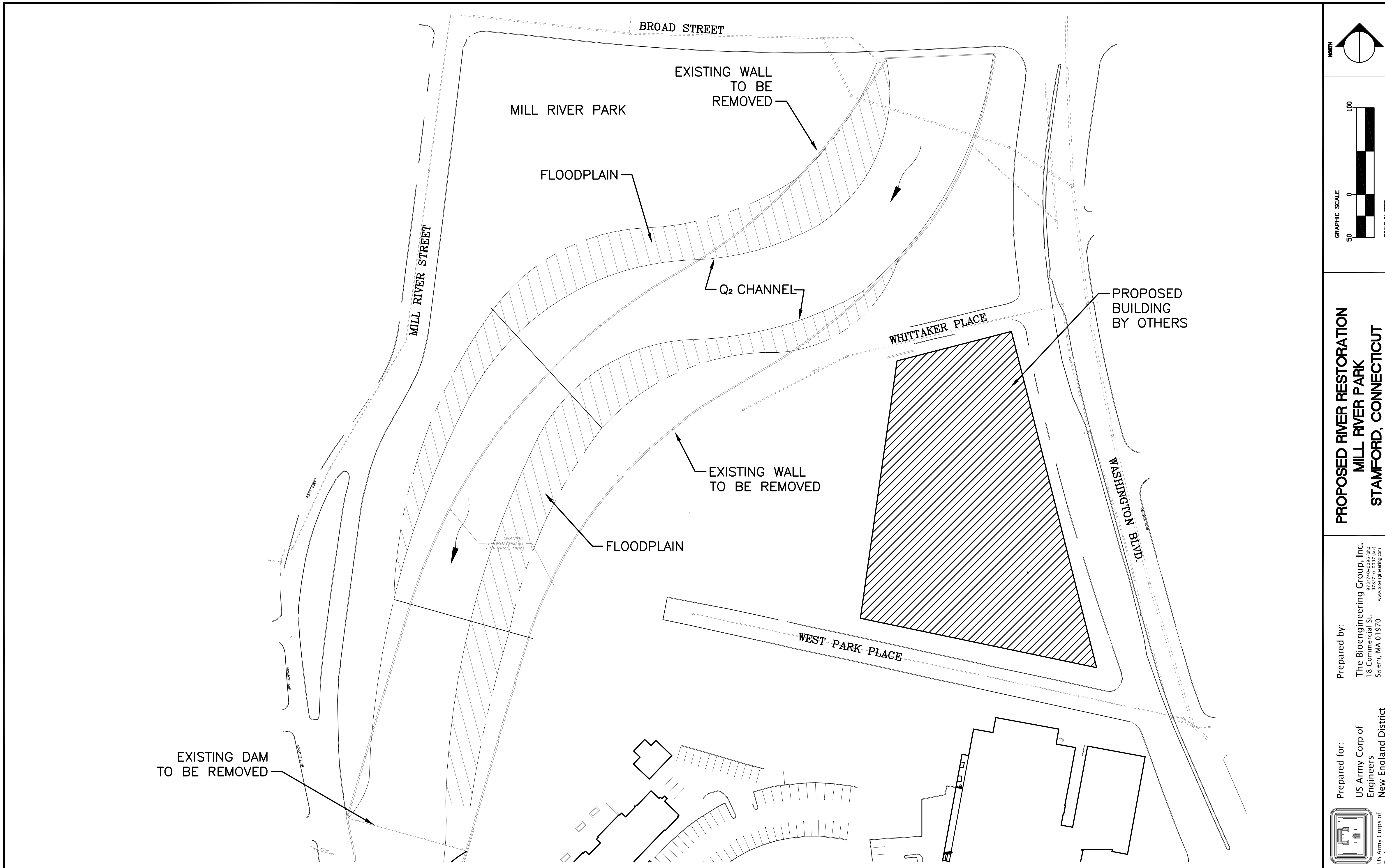


Figure 9. Alternative 2 Concept - Dam Removal and River Channel Restoration

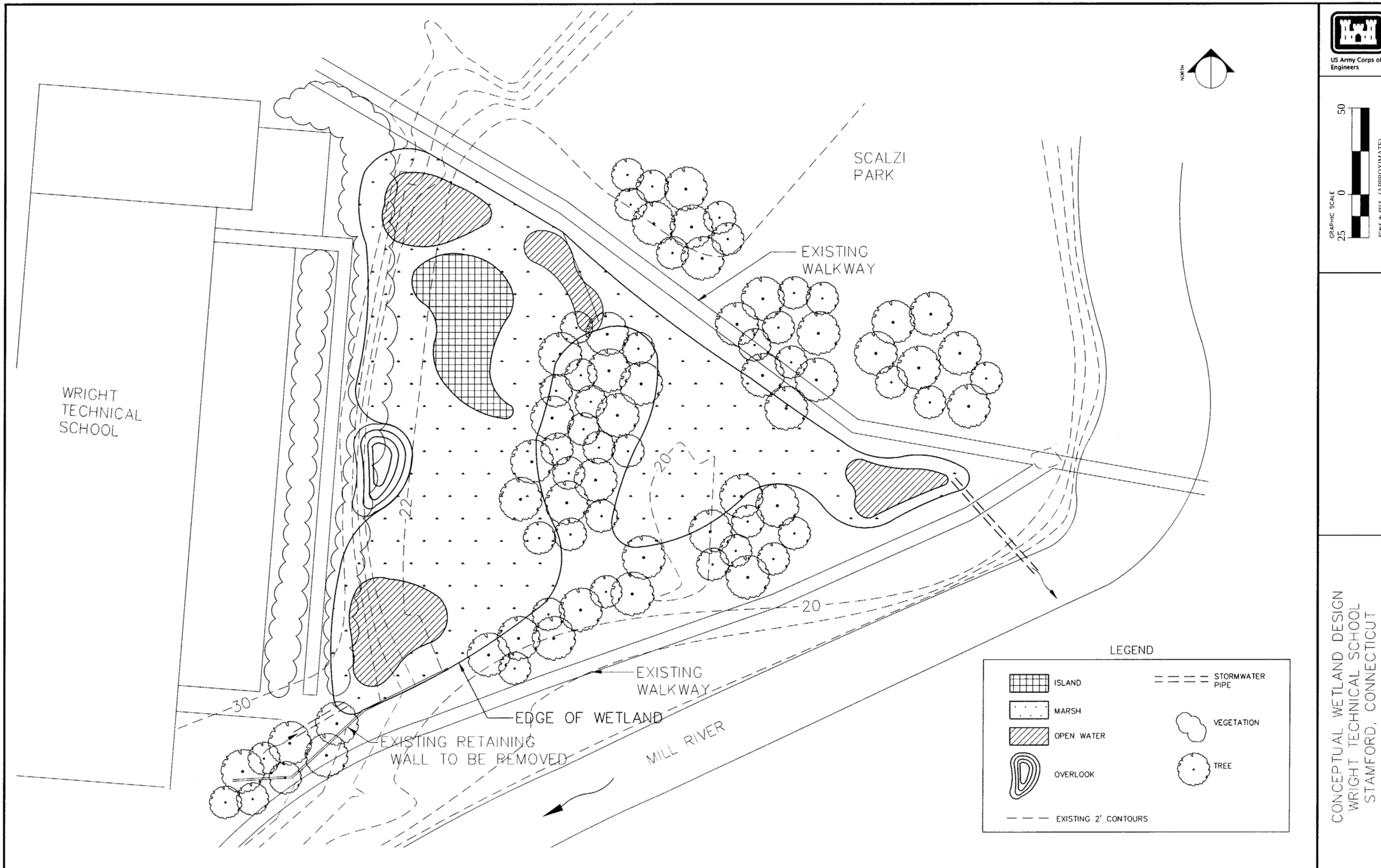


Figure 10. Conceptual Plan for Creation of Freshwater Wetland at JM Wright Technical School

4.3.3 Alternative 3: Dam Removal and Creation of Step Pools

Alternative 3 combines the following measures:

- Removal of the Main Street Dam and concrete retaining walls and creation of a series of stepped pools through a quarter-mile reach of Mill River (See Figure 11), and restoration of 4 acres of riparian habitat
- Additional riparian habitat restoration along the river, totaling 1.53 acres
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds (See Figure 10)
- Restoration of 0.8 acres of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

Dam removal and sediment removal would occur as described in Alternative 2. However, instead of the riffle-pool system in Alternative 2, a still-water landscape would be maintained in Mill River Park by constructing a series of pools connected by small cascades. Flow control structures would be constructed by using boulders, and would appear to be small natural cascades. The concrete walls around the Mill Pond would be removed and replaced with vegetated banks, functioning in the same manner as described in Alternative 2. On-going dredging and maintenance would be required to manage sedimentation within all six pools. The operation and maintenance costs of the pools would be the responsibility of the city of Stamford and would add costs to the total project cost.

Wetland habitat could be established along the margins of the pools. Passage of fish and other aquatic species would be partially restored in the Mill River, and habitat connectivity would be partially restored between the river and the ocean. Trails and/or boardwalks would accommodate recreational access to the river. The cascades between pools could have restricted passage for some species of fish and other aquatic species.

A cascade pool series was added in this alternative to create still-water pools that retain some of the still-water appearance and function of the existing impoundment behind Main Stream Dam. This cascade pool series would require constant, intensive maintenance. While passage of fish and other aquatic species would be enhanced within the Mill River compared to the no-action alternative, the success rate of passage is reduced when compared to natural stream channel restoration. Furthermore, the landscape and local gradient do not support true step-pool channel morphology. Sedimentation would be expected to occur at an accelerated rate as compared to the current Mill Pond due to the reduced size of the pools. While the uppermost pool would be designed to retain sediment and allow access for sediment removal, continued dredging of all pools would be required to ultimately control sediment buildup.

As in Alternative 2, a trail system would be constructed to replace existing trails and sidewalks displaced by the restoration measures, and to connect the greenway and parks along the river corridor. Interpretive displays could also be added at the restoration sites.

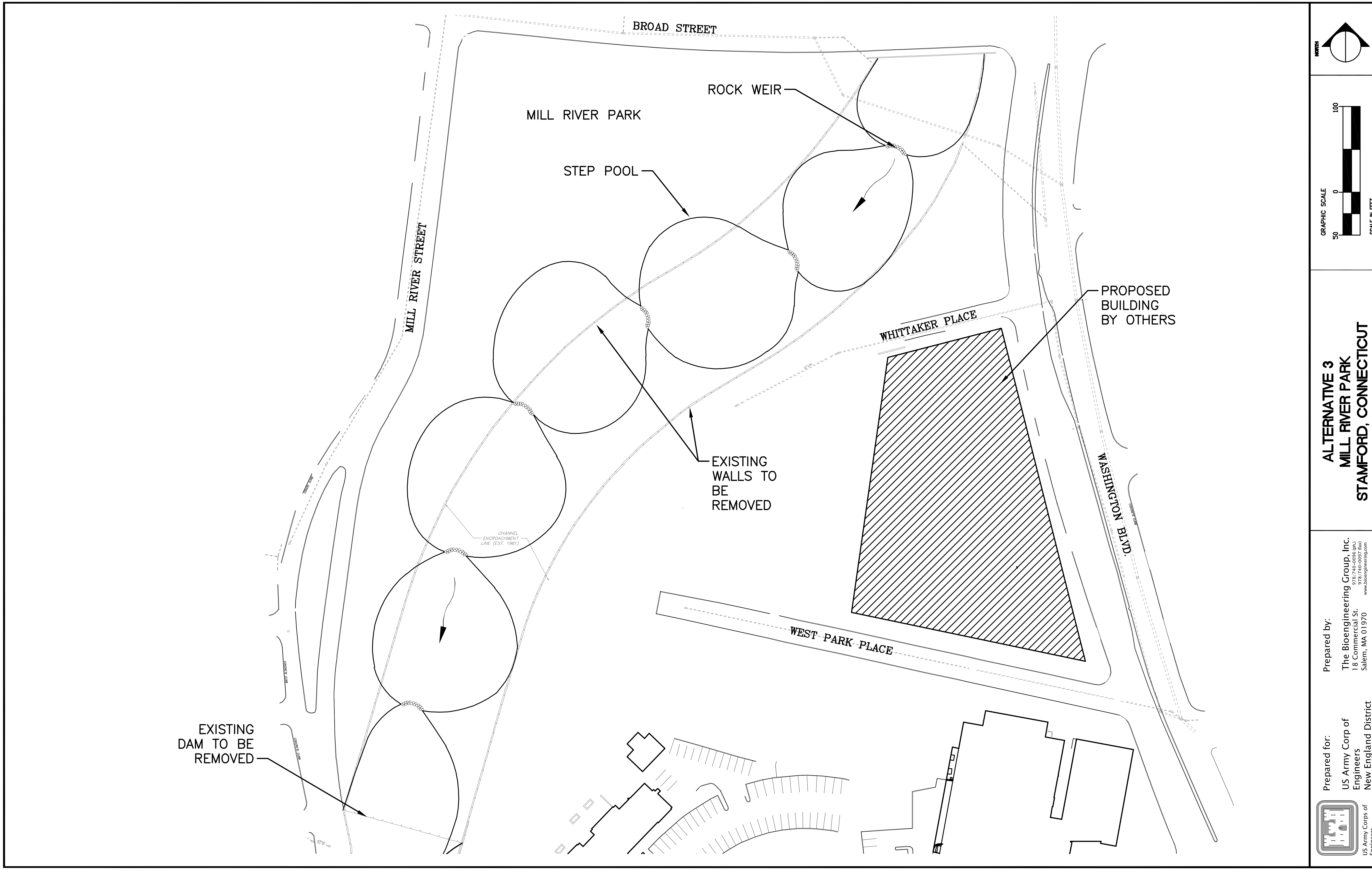


Figure 11. Alternative 3 Concept- Dam Removal and Step Pool Creation

4.3.4 Alternative 4: Partial Removal of Concrete Retaining Walls

Alternative 4 combines the following measures:

- Construction of a fish ladder on the Main Street Dam, while leaving the dam in place, partially removing the concrete retaining walls along the impoundment, and dredging out and widening the impoundment, and restoring 2.9 acres of riparian habitat along the pool (See Figure 12)
- Additional riparian habitat restoration along the river, totaling 1.53 acres
- Creating a one-acre wetland area adjacent to the river at the J.M. Wright Technical School grounds (See Figure 10)
- Restoration of 0.8 acres of tidal wetlands
- Removal of abandoned concrete blocks and gate structures beneath the Pulaski Street Bridge

The Main Street Dam and the Mill Pond would be retained and would be required to be extensively repaired. A fish ladder would be installed on the face of the dam to provide some level of anadromous fish passage. The target species would be river herring. For feasibility level analysis, a small concrete Denil-type fish ladder was chosen and would need to be designed to have a project life of at least 50 years. The specific design of this fish ladder would be provided during the plans and specifications phase of the project. The concrete walls around Mill Pond would be partially removed (approximately 1,000 feet on each side removed; 100 feet remain on each side) and the shoreline of the pond would be reshaped and regraded. Contaminated sediment (approximately 18,600 cy) that has collected behind the dam would be excavated and disposed at a designated site prior to construction. Main Street Dam would be repaired and structurally reinforced. The new shoreline would be regraded to create a floodplain connecting to the park area. The new pond slopes would be stabilized with native upland vegetation to develop a riparian buffer zone around the pond. Existing cherry trees may need to be removed. A fish ladder would be installed at the Main Street Dam to facilitate fish passage. On-going dredging and maintenance would be required to manage sedimentation within the pond. Trails and/or boardwalks would accommodate recreational access to the pond. As in Alternative 2, a trail system would be constructed to replace existing trails and sidewalks displaced by the restoration measures, and to connect the greenway and parks along the river corridor. Interpretive displays could also be added at the restoration sites.

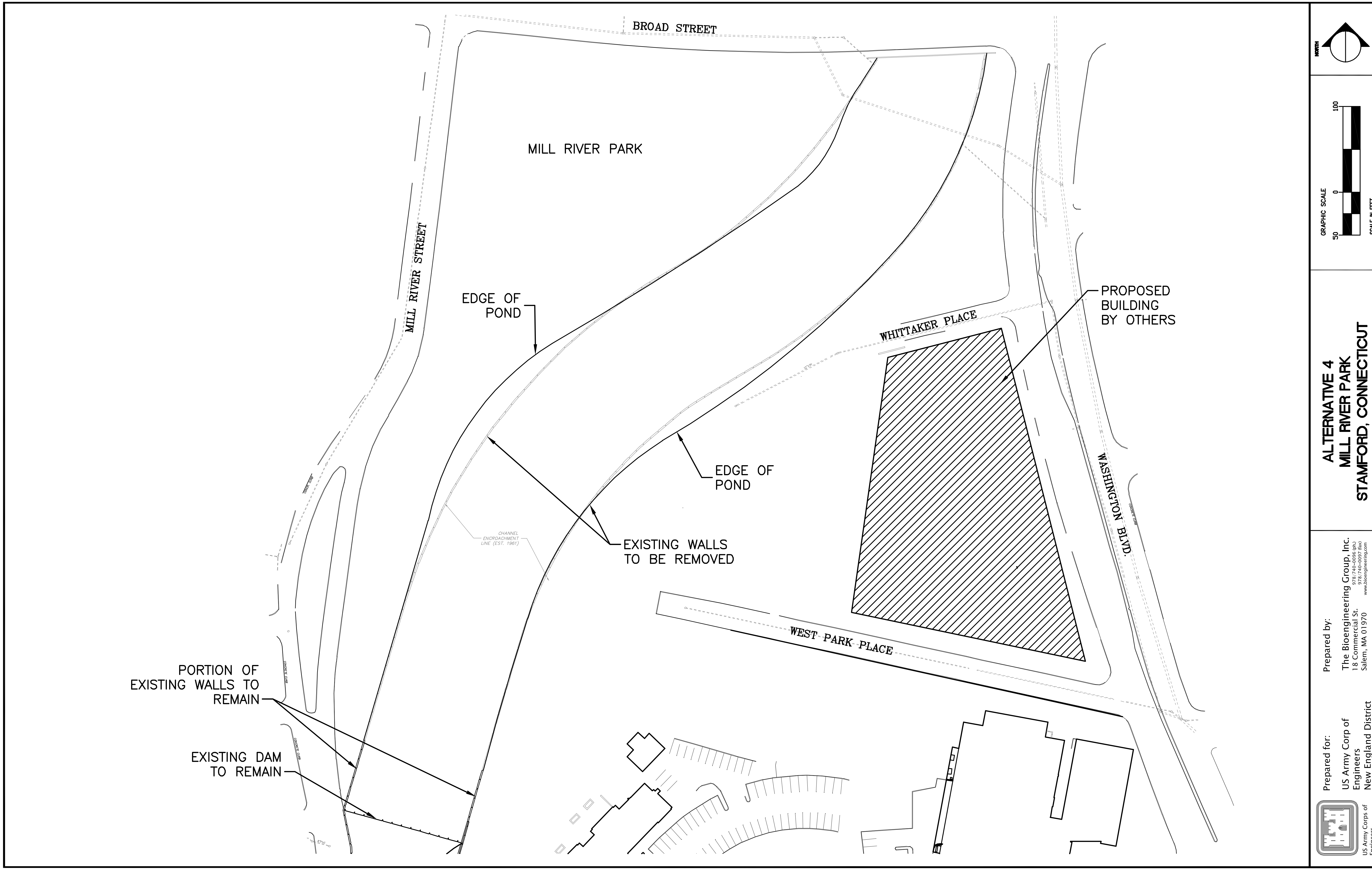


Figure 12. Alternative 4 Concept- Partial Removal of Concrete Retaining Walls

Table 3 outlines the components of each alternative investigated.

Table 3. Components of the Restoration Alternatives.

PROJECT COMPONENTS	NO ACTION	ALT #2	Alt #3	ALT #4
Operate and Maintain Dam	X			X
Continual Removal of Sediments	X		X	X
Dam Removal		X	X	
Removal of Existing Sediments	X	X	X	X
Restore River Channel		X		
Create Step Pools			X	
Remove Fish Passage Block in Harbor		X	X	X
Tidal Wetland Restoration		X	X	X
Freshwater Wetland Creation		X	X	X
Riparian Restoration and Exotic Species Removal		X	X	X
Install, Operate and Maintain Fish Ladder				X

SECTION 5. EVALUATION OF ALTERNATIVES

5.1 INTRODUCTION

This section details the conditions resulting should various alternatives be applied. For a more complete description of the environmental impacts and benefits of restoration see Section 7 of the Environmental Assessment. The analyses address the potential issues of water and sediment quality, habitat improvement, aesthetics, preservation of important resources, and recreation.

Under Alternatives 2 and 3, the dam and walls at Mill Park would be removed and the former area of the Mill Pond would be reshaped to restore floodplain habitat and fringe wetlands and to allow visual and physical access to the water. Alternative 2 restores a stream channel through the park area.

Alternative 3 includes the creation of a series of pools through the park. These step pools would have small rock weir structures composed of boulders with an average drop in grade of 1 foot. These pools would retain sediment and create additional maintenance needs. Alternative 4 involves retaining the dam, partial removal of the walls encompassing Mill Pond, regrading the area, and installing a fish ladder.

5.2 HYDRAULIC AND SEDIMENT TRANSPORT EVALUATION

The purpose of the hydraulic and sediment transport investigations is to evaluate hydraulic and sediment transport implications of the various restoration alternatives for the lower reach of Mill River, with emphasis on Mill Pond Park and Mill Pond. The following section provides a summary of the hydraulic and sediment transport findings. More detailed analysis is documented in the Hydrology and Hydraulics Appendix (Appendix B) of this report.

The study scope includes estimating the hydraulic and sediment transport implications of Alternative 1 (no action); Alternative 2 (removing the Main Street Dam and regrading the affected channel into riffles and pools); Alternative 3 (removing the Main Street Bridge and regrading the affected channel into stepped pools); and Alternative 4 (leaving the dam in place and partially removing the walls within the park). In particular, channel modifications considered under Alternatives 2 and 4 were reviewed for their impact on flood elevations. For the purposes of this study, Alternative 3 was considered to have similar effects on the flood elevations as that of Alternative 2.

Hydraulic analyses were performed using the U.S. Army Corps of Engineers HEC-RAS hydraulic model. Analyses include flow, channel velocity, top width, energy gradients, shear stress, and minimum particle size for incipient motion. Hydraulic conditions in the vicinity of Mill Pond Park were analyzed for the 1, 2, 10, 50, 100, and 500-year floods, as well as average daily flow, representing a non-flood scenario. Shear stress and particle stability analyses were performed for the three alternatives. While the focus of the restoration efforts is in the vicinity of Mill Pond, hydraulic analyses were extended from 550 feet upstream of Long Island Sound to approximately 2.5 river miles upstream from the Main Street Dam since the study area encompasses this entire reach. Including this entire reach in the model insured that hydraulic parameters were available for all restoration measures considered in addition to the basic alternatives.

5.2.1 Background

The Main Street Dam impounds the Mill River to form Mill Pond within Mill Pond Park, and the impoundment extends upstream of the Broad Street bridge. The crest elevation of the dam is approximately 12.5 feet (NGVD 29). The park is approximately 6.4 acres and the pond within the park is about 3.5 acres (140 feet wide by 1100 feet long), with depths ranging from 1 to 5.5 feet. The pond is constrained within concrete walls that are approximately 15 feet high for the full length of the park.

The dam disrupts sediment transport and is causing channel aggradation within the impoundment. As much as 5.5 feet of sediment deposition has occurred. The total estimated volume of sediment behind the dam is 18,600 cubic yards (Appendix J).

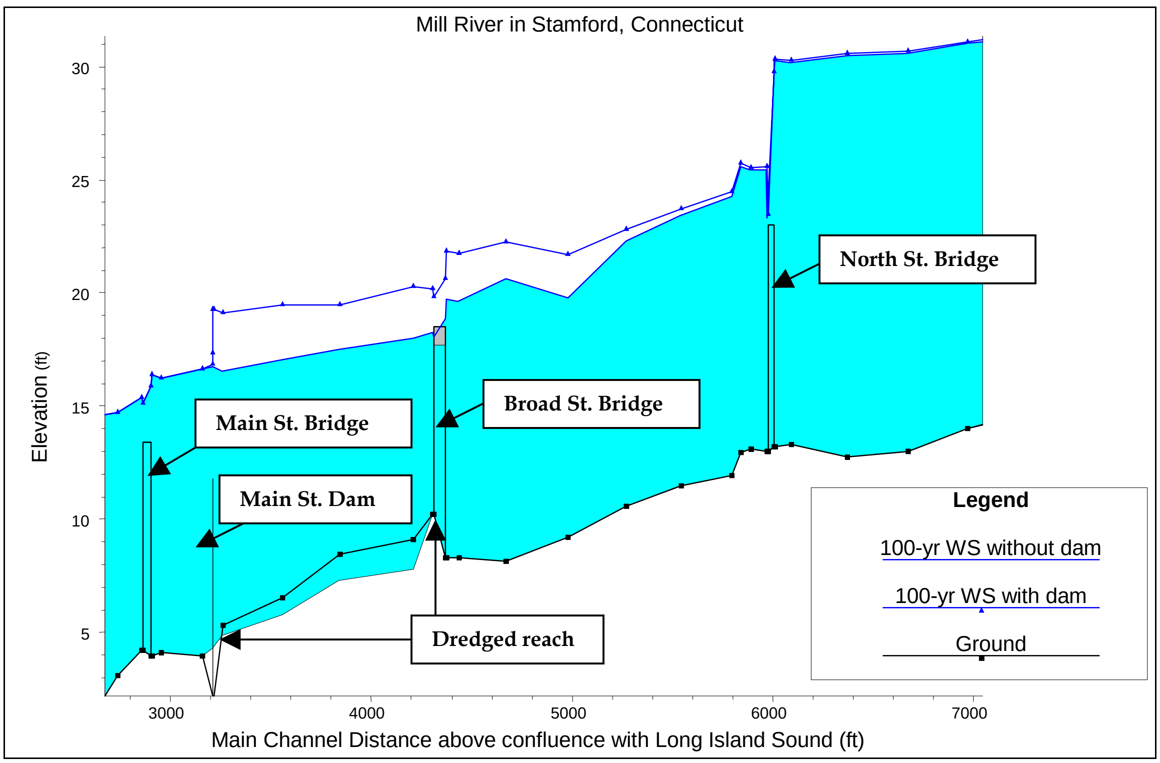
5.2.2 Summary of Findings

HEC-RAS hydraulic model results indicate that established FEMA flood elevations (existing conditions and no action) would be either maintained or reduced for the restoration alternatives that propose modifications (See Figure 13).

For Alternative 2, HEC-RAS model results indicate that established flood elevations would be reduced significantly if Main Street Dam and the walls along Mill Pond Park were removed, and the channel bottom dredged (See Figure 13). For example, at the 100-year recurrence interval, peak water surface elevations would be lowered by between approximately 2.0 and 2.6 feet between the location of the (removed) dam and Broad Street, located approximately 1,000 feet upstream. The reduction in the 100-year flood level would be approximately 1.6 feet at the upstream end of the current impoundment (approximately 330 feet upstream of Broad Street). Water levels associated with normal flows, as indicated by the modeling of average daily flows, would be reduced by several feet, especially in the reach extending from the damsite to Broad Street. In addition, for Alternative 2, the lateral extent of flooding in downtown Stamford would be reduced for the 100-year recurrence interval flood, as shown in Figure 14.

For Alternative 4, HEC-RAS model results indicate that peak water surface elevations associated with all major floods would be reduced by only a small amount upstream of Main Street Dam if the walls along the Mill River Park were removed and the dam remained in place. For example, at the 100-year recurrence interval, peak water surface elevations would be lowered by approximately 0.5 feet between dam and Broad Street, located 1100 feet upstream of the dam. The reduction in the 100-year flood level would be approximately 0.4 feet at the upstream end of the impoundment, with the reduction in water level dwindling to 0.1 feet at a location 1500 feet upstream of the Broad Street Bridge. Water surface elevations of normal flows would be unchanged by removal of the walls.

Figure 13: Water Surface Profiles for the 100-Year Frequency Discharge (Feet, NGVD) for scenarios with and without Main Street Dam.



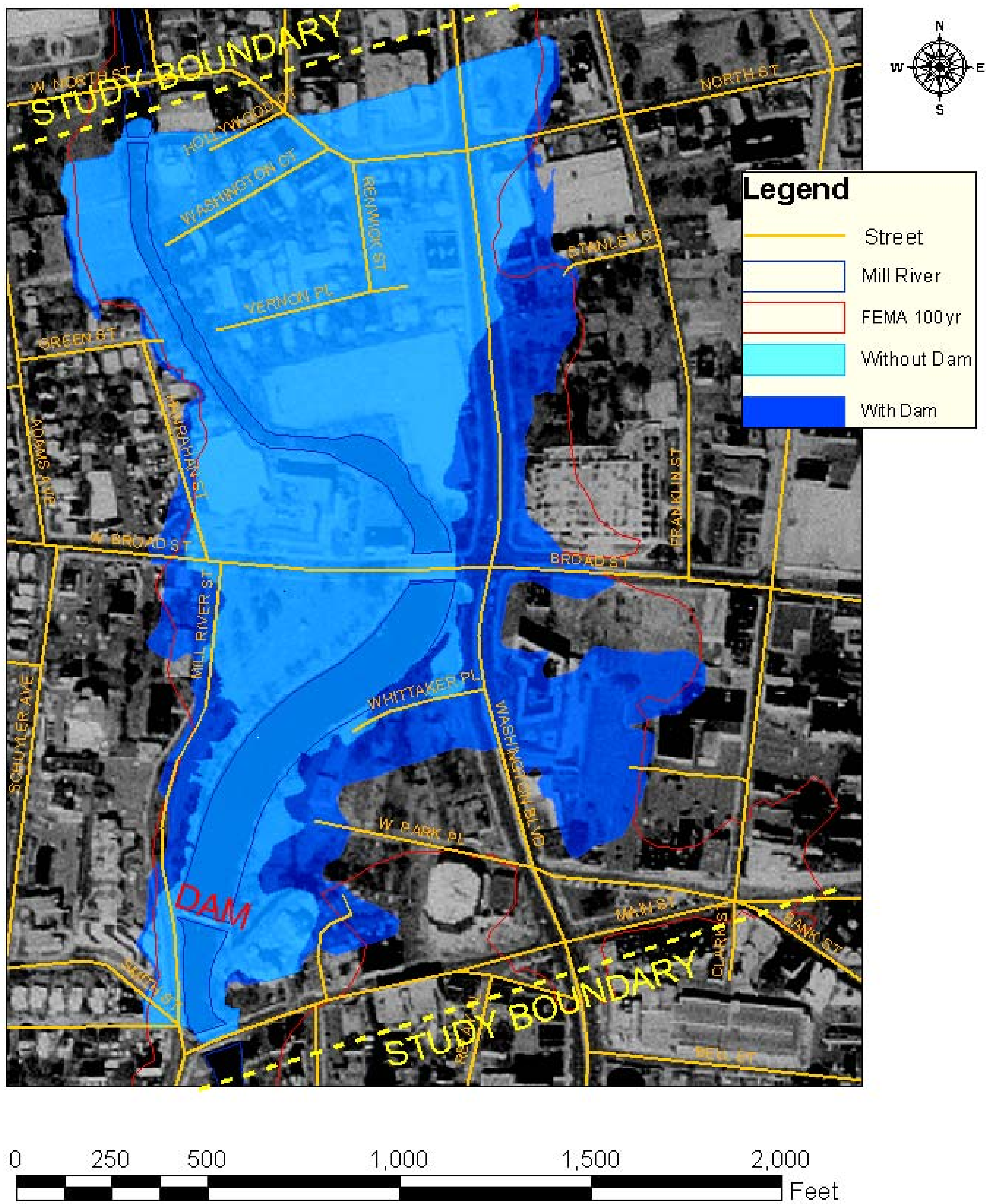


Figure 14. 100-Year Floodplain Boundaries with and without Main Street Dam

An analysis was conducted on effects of tides on the project reach. The analysis concluded that for the dam-removal alternatives, the reach of river currently submerged by Mill Pond would not experience any tidal fluctuations during normal tides, since the restored river channel would range from approximately 5 – 8 feet NGVD (as compared to a mean spring high water elevation of 4.9 feet NGVD, for example).

Sediment transport analyses indicate that siltation would continue to occur in the impoundment if the dam were left in place (Alternatives 1 and 4). Results show that dam removal (Alternatives 2 and 3) would considerably improve sediment transport in the Mill Pond Park reach such that deposition of fine-grained sediments would be stemmed or greatly reduced.

Sediment transport analysis of Alternative 1 (with-dam) indicates that during average daily flows, sands, clays, and silts should pass through upstream reaches of the Rippowam River, but settle in the stilled waters of Mill Pond impoundment, as confirmed by field observations. Sediment transport analysis of Alternative 2 (removing the Main Street Dam) indicates that sediment transport would revert to its natural cycle, with sand, fines, and clay largely passing through the former impoundment reach without settling during normal flows. For Alternative 2, the channel bottom could be expected to resemble that of the reference reaches upstream of Mill Pond, where sediments consist largely of gravel, and the channel is self-maintaining.

Channel water velocities and shear stresses associated with Alternative 4 (removal of walls only) were found (in the HEC-RAS model) to be virtually the same as those of Alternative 1. Therefore, the particle stability analyses indicate that siltation would occur during normal flows within the impoundment for Alternative 4, similar to the condition for Alternative 1.

During storm events (two-year occurrence intervals or larger), the analysis shows that sediments up to gravel size would be transported through Mill Pond with the dam in place. Therefore, the river would transport sediment to Stamford Harbor during storm events whether or not the dam is in place. In Alternative 1, the only amount of sediment not reaching the harbor is the amount the city chooses to dredge from Mill Pond. In Alternatives 2 through 4, the reduction in sediment would be at least 18,600 cubic yards, since these alternatives require full dredging of Mill Pond prior to dam removal.

Alternative 3, with the construction of step pools retained by low-elevation weirs, would probably collect some sediment in the constructed pools during normal flows, due to the reduced flow velocities in the pools. The volume of sediment and rate of sedimentation would depend on the configuration of the constructed pools.

5.3 ENVIRONMENTAL EVALUATION

Environmental effects are summarized below for Alternatives 2, 3, and 4. The environmental effects of the no-action alternative are summarized in Section 3.3, Future Without-Project Conditions. More detailed information on ecosystem effects of the restoration measures and the no-action alternative is contained in Appendix D, Incremental Analysis.

5.3.1 Environmental Evaluation of removing the Main Street Dam (Alternatives 2 and 3)

Currently, the Mill Pond provides highly degraded habitat for aquatic resources and attracts a large population of Canada geese. The primary environmental benefit to removing the Main Street Dam (Alternatives 2 and 3) is the restoration of fish passage and the upstream river channel, in particular the reconnection of anadromous fish species to their spawning grounds in upper reaches. The breaching of the dam would restore the reach's stream flow, tidal influence, and sediment transport. Habitat connectivity would assist the movement of terrestrial species through the riparian corridors. Aquatic species could range between river, estuarine, and marine environments. The confluence of marine and riparian ecosystems is highly productive and valuable for biodiversity. The restoration of riparian habitat and a riffle-and-pool channel morphology will be less attractive to Canada geese and more attractive to a diversity of native birds.
The re-establishment of a more natural river channel north of Main Street would restore sediment transport processes. This would improve water quality by decreasing sedimentation and eutrophication in the currently impounded reach during normal flows. In addition, increased flow velocities would improve benthic habitat through exposure to flowing water and higher levels of dissolved oxygen. Removal of the dam and retaining walls would allow for the restoration of natural banks and emergent vegetation that would assist the uptake of nutrients and the capture of pollutants from overland flow. Terracing would imitate a floodplain and allow riparian plantings to provide habitat, shade, and a buffer for the river corridor.

The pond would be drained, and sediment that is impounded behind the dam would be dredged before dam removal. This would limit the possibility of excessive turbidity downstream during construction. Turbidity during construction would be contained as much as practicable using erosion control measures. The sediment behind the Main Street Dam is not considered hazardous but may not be suitable for residential disposal. An appropriate site for disposal, such as the municipal landfill in Manchester, Connecticut, would be identified before construction. Sedimentation controls and best management practices would be applied during construction. Construction would be timed to coincide with low flow periods.

5.3.2 Environmental Evaluation of Alternative 4

Currently, the Mill Pond provides highly degraded habitat for aquatic resources and attracts a large population of Canada geese. With Alternative 4 (Partial Removal of Concrete Retaining Walls – Dam Remains), the Main Street Dam is retained and the associated retaining walls are partially removed (complete removal of the walls would compromise the structural stability of the dam). The partial wall removal would allow possibilities for reshaping the pond to a slightly more natural, curvilinear form and augmenting the banks with riparian vegetation and fringe wetlands. During construction, there would be a temporary disturbance to waterfowl, however the pond would remain attractive to the large geese population.

The Main Street Dam would require repairs to retrofit a fish ladder and to ensure structural stability. To avoid impacts to FEMA flood elevations, the pond banks would be sloped to provide an equivalent flood conveyance through the park. This limits pond reshaping and preserving adjacent trees. As in Alternatives 2 and 3, the pond would be drained and dredged prior to construction. Likewise, the sediment would be disposed of in an appropriate site, such as the municipal landfill in Manchester, Connecticut. Turbidity would be contained as much as practicable using erosion control measures. After construction, periodic dredging would maintain a deep pool. Otherwise, during normal flow periods, sediment would accumulate in the pond. With a deeper pool configuration, the pond would be inhabited by warm-water fish however, this resource would be periodically disrupted by maintenance dredging.

Dredging would require river access for a heavy vehicle and disruption of bed sediments and benthic habitats on a regular basis. Periodic dredging would reduce the amount of sediment eventually reaching Stamford Harbor by up to the amount of sediment dredged, and could slightly reduce the sedimentation rate in the harbor. However, this method of reducing sedimentation in Stamford Harbor is impractical due to the high levels of environmental impacts of dredging in the river and disruptions to the city on a regular basis as well as the high cost and inefficiencies of removing relatively small amounts of sediment from the pond in an urban setting.

Under Alternative 4, wetland habitat and floodplain vegetation would stabilize banks and restore habitat around the pond and within the park. Sediment would need to be detained before reaching constructed wetlands, as there may be insufficient flow to flush particles downstream, and dredging of wetlands in a park setting would be problematic.

Fish passage would be facilitated through the placement of a fish ladder at the Main Street Dam. Restoration of stream banks and the planting of emergent and riparian vegetation would serve to uptake nutrients and provide temperature moderation, shelter, and forage for many aquatic species. The reshaping of banks to preserve the floodplain would require the loss of upland habitat in the park and the removal or relocation of existing cherry trees along the Mill Pond.

5.4 GEOTECHNICAL EVALUATION

The predominant upper soils identified at the Mill Pond site are sandy loam, sand, and gravels. The main subsoil stratum comprises sand and gravel glacial deposits (see Appendix C). Granular fill material is also expected behind the retaining walls. In general, the material itself should be easy to excavate, grade, shape, haul, and stockpile. However, due to the geological randomness of many soil formations it is likely that some large cobbles, boulders, and rock outcrop formations can be found on this site, mostly at a distance away from the retaining wall fill.

For Alternatives 2 and 3, excavation to remove the Main Street Dam should not present any major geotechnical problems. Likewise, excavation at the pond site for regrading and reshaping the banks should not present any major geotechnical problems. After clearing of brush, excavation of the sands, silty sands, and gravels to the shallow depths required should proceed without difficulty.

SECTION 6. COMPARISON OF ALTERNATIVES

6.1 INTRODUCTION

The following criteria were utilized to compare various combinations of alternatives and restoration measures: (1) benefits to the aquatic ecosystem, (2) project costs, including construction costs, real estate values, and operations and maintenance costs-benefit analysis, and (3) other benefits to the public that could weigh in on importance and acceptability of the project, including flood damage reduction benefits.

6.2 COMPARISON OF ENVIRONMENTAL BENEFITS

To measure the benefits of each alternative, a series of habitat criteria were identified. Values were assigned to the criteria for each of the various alternatives, and the total value was calculated. (See Appendix E for further details.)

The primary goals of the project are improvement of aquatic habitat, improvement of water quality, and restoration of anadromous fisheries. Four supplemental habitat criteria were identified: riparian corridor habitat, habitat for migratory birds, habitat for wetland species, and native habitat diversity.

The first three habitat criteria (water quality, aquatic habitat, and anadromous fish habitat) were broken down into basic requisites for aquatic life. Three requisites related to water quality were identified: dissolved oxygen, temperature, and flow. Aquatic habitat was broken down into four component requisites: spawning substrate, in-stream cover, forage, and benthic invertebrates. Habitat requisites for anadromous fisheries were identified as upstream passage and spawning habitat for both alewife and blueback herring.

To determine the existing habitat conditions and the benefits of restoration activities, individual values (used as an index of habitat quality) were assigned to seven habitat criteria for each alternative and additive measure. Values ranging from 0 to 1 were assigned with a value of 0 as the poorest condition, and a value of 1 as the optimal condition. The assigned value for each habitat criterion was then multiplied by a weighting factor (acres) to determine "Habitat Units" (HU's) for each Alternative. The HU's calculated for the no-action alternative represent existing habitat conditions or the future without project conditions.

The seven habitat criteria used in this incremental analysis include: aquatic habitat, improvement of water quality, restoration of anadromous fisheries, riparian corridor habitat, habitat for migratory birds, habitat for wetland species, and native habitat diversity. The first three habitat criteria (water quality, aquatic habitat, and habitat for anadromous fisheries) were further broken down into basic requisites for aquatic life (the requisites were averaged to calculate the value for the habitat criteria). Each habitat criterion value was multiplied by the number of acres affected by the individual alternative (Alternatives 2, 3, and 4) or additive measure (i.e. tidal wetland restoration, freshwater wetland creation, riparian corridor restoration, etc.) to determine Habitat Units (HU's). HU's for each habitat criteria were then added to determine total HU's for each alternative or additive measure.

For the no-action alternative and Alternatives 2, 3, and 4, weighted acreage represents acres specifically in the Mill River Park area for each habitat criteria (with the exception of anadromous fish habitat, which takes into account the entire restored reach of 5.2 miles). Acreage figures for additive measures represent the site-specific areas proposed for restoration (again, with the exception of anadromous fish habitat, which takes into account the entire restored reach of 5.2 miles).

HU's for the no-action alternative represent the habitat value of existing conditions in the Mill River Park area, and HU's for Alternatives 2, 3, and 4 represent the expected habitat value of the Mill River Park with implementation of each alternative. For additive measures, the habitat value of the existing condition was considered so that HU's represent the increase in habitat value should the action be undertaken. Although proposed restoration improvements have some ecological benefits outside of the proposed restoration sites (i.e. water quality, wildlife habitat, etc.), the majority of the benefit occurs site-specifically. Quantitative and qualitative habitat changes are necessary to determine cost-effective restoration measures through the incremental analysis methodology. Appendix E provides a complete discussion of these criteria, along with their values and an explanation of their ranking.

The predicted habitat units for each proposed alternative were considerably better than the habitat units of the no-action alternative. The improved habitat unit expected after project completion was calculated by subtracting the habitat unit of the no-action alternative from the score of the other alternatives. The predicted habitat units for each alternative are outlined in Table 4. In addition to the habitat units presented in Table 4, four additive measures add habitat units to each alternative in any combination in a linear fashion (see Table 4 a).

Table 4. Comparison of Alternatives Using Anticipated Habitat Value

Evaluation Criteria	Alternatives			
	1	2	3	4
Aquatic Habitat	0.9	1.7	1.1	1.3
Water Quality	0.9	1.7	0.9	0.7
Habitat for Anadromous Fish	0.0	26.0	22.8	14.2
Riparian Corridor Habitat	0.3	4.0	3.0	2.9
Habitat for Wetland Species	0.0	0.4	0.4	0.3
Native Habitat Diversity	0.0	4.4	4.4	2.8
Potential Habitat for Migratory Birds	1.2	5.8	5.8	4.1
Total	**3.3**	**43.9**	**38.4**	**26.2**

Table 4 a. Comparison of Additive Measures Using Anticipated Habitat Value (values represent increase over existing habitat)

Evaluation Criteria	Additive Measures			
	Removal of Fish Blockage at Pulaski St Bridge	Tidal Wetland Restoration	Riparian Corridor Restoration (Including Invasive Plant Removal)	Freshwater Wetland Creation
Aquatic Habitat	0.1	0.5	0.9	0.8
Water Quality	0.0	0.2	0.4	0.8
Habitat for Anadromous Fish	1.6	0.0	0.0	0.0
Riparian Corridor Habitat	0.0	0.6	1.1	1.0
Habitat for Wetland Species	0.0	0.6	1.1	1.0
Native Habitat Diversity	0.1	0.6	1.1	0.8
Potential Habitat for Migratory Birds	0.1	0.6	1.1	0.8
Total	**1.8**	**3.1**	**5.1**	**4.8**

6.3 COMPARISON OF COSTS

For the purpose of comparison, various project costs are displayed below, including study and design costs, construction costs, real estate values attributable to the project costs, monitoring costs, and operations and maintenance costs. The values of the real estate needed for the project, including lands, easements, rights-of-way, relocations, and disposal sites (LERRDS), and those real estate values that are considered project costs, are explained in more detail in Appendix G.

Construction costs were estimated through the use of MCACES software program, RS Means 2003 cost guides, and verbal and written quotations from suppliers and contractors. Table 5 provides estimated construction quantities for major items for each alternative.

Table 5. Estimated Construction Quantities for Major Items for Each Alternative

Mill River Park restoration	**Alternatives**			
	1	**2**	**3**	**4**
Total Construction Site (Acres)	6	6	6	6
Dam Removal (cubic yards)	0	178	178	0
Retaining Wall Removal (cubic yards)	0	2,200	2,200	2,200
Sediment Removal from Pond (cubic yards)	0	18,600	18,600	18,600
Earthwork – Regrading (cubic yards)	0	26,200	26,200	26,200
Remove Obstruction at Pulaski Street Bridge				
Remnant Dam Removal (Pulaski St.) (cubic yards)	556			
Freshwater Wetlands Creation				
Area Impacted (acres)	1.0			
Soil Excavation (cubic yards)	8,100			
Asphalt (Parking lot and Sidewalk) Demolition (cubic yards)	585			
Tidal Wetlands restoration				
Area Impacted (acres)	0.8			
Soil Excavation (cubic yards)	3,900			
Riparian Restoration				
Revegetation - Total Area (acres)	1.53			
Invasive plant Removal (acres)	0.36			

Table 6 provides a summary of construction costs, operation and maintenance costs, and other project costs. An MCACES software cost analysis is displayed in Appendix F.

Table 6. Estimated Project Costs for each of the alternatives and additional measures that could be added to the alternatives.

	Primary Alternatives				**Additional Measures**			
	No Action	**Mill Pond Park - Channel Restoration Alt 2**	**Mill Pond Park - Step Pools Alt 3**	**Mill Pond Park - Fish Ladder Alt 4**	**Pulaski Street**	**Tidal Wetlands**	**Riparian Corridor**	**Fresh-water Wetlands**
Study Costs	$350,000	$350,000	$350,000	$350,000	$0	$0	$0	$0
Plans and Specifications	$0	$315,000	$315,000	$315,000	$20,000	$27,000	$18,000	$25,000
Construction (includes 15% Contingency)	$0	$3,597,000	$3,723,000	$3,503,000	$150,000	$272,000	$64,000	$358,000
Engineering and Design during Construction (8% of Construction Cost)	$0	$108,000	$116,000	$105,000	$4,000	$8,000	$2,000	$11,000
Construction Management (6% of Construction Cost)	$0	$286,000	$290,000	$270,000	$12,000	$18,000	$4,000	$29,000
Total Construction Costs	$0	$3,991,000	$4,129,000	$3878,000	$166,000	$298,000	$70,000	$398,000
Real Estate Value *[1]	$0	$185,000	$185,000	$185,000	$20,000	$45,000	$11,000	$351,000
Post Construction Monitoring (1% of total project cost)	$0	$48,000	$50,000	$47,000	$2,000	$4,000	$1,000	$8,000
Total Project Shared Costs	$0 (no project)	$4,889,000	$5,029,000	$4,775,000	$208,000	$374,000	$100,000	$782,000
Periodic Operations and Maintenance (O&M) Costs *[2]	$1,500,000 per 10 years *[3]	$5,000 per year *[4]	$1,500,000 per 10 years; plus $5,000 per year *[5]	$1,500,000 per 10 years; plus $6,000 per year *[6]	$0	$1,000 per year *[7]	$1,000 per year *[8]	$1,000 per year *[9]

NOTES:
*1– Sponsor is required to provide real estate needs and can credit the real estate value toward the sponsor's cost share.
*2– Operations and maintenance costs are not cost shared and are the responsibility of the sponsor.
*3– Dam and Pond Operation and Maintenance including dredging of pond sediments every 10 years, and maintaining the structural integrity of concrete retaining walls and dam, and maintenance of the sluice gate.
*4 – Estimated operation and maintenance of restored habitats included stream banks, riparian vegetation, and channel.
*5 – Estimated operation and maintenance of restored habitats included pool banks, riparian vegetation, and freshwater wetland. Includes dredging pools at a cost of $1,500,000 every ten years.
*6 – Dam and Pond Operation and Maintenance including dredging of pond sediments every 10 years at a cost of $1,500,000 as well as the maintenance of stream banks, management of restored habitat, and fish ladder maintenance $1,000/ year over 50 years.
*7 – Estimated annual maintenance of tidal wetlands, including controlling invasive weeds.
*8 – Estimated annual maintenance of riparian corridor, including controlling invasive weeds.
*9 – Estimated annual maintenance of freshwater wetlands, including controlling invasive weeds.

Costs that are eligible for federal funding and cost-sharing under the Section 206 Authority include project study costs; plans and specifications costs; the cost or value of real estate, easements, and rights-of-way; project construction costs; and monitoring costs (up to 1% of the project cost). All operations and maintenance costs are the responsibility of the sponsor. Costs that are eligible for cost sharing between the federal government and the sponsor (the city of Stamford) are normally split 65% federal, 35% sponsor. An exception to this 65%/35% cost sharing is the construction cost of recreational components to the project that are eligible under the Section 206 Program. Recreation-related construction costs are shared 50% federal, 50% sponsor. More information on cost sharing and eligibility are found in Corps Engineer Regulations (ER 1105-2-100 and ER 1165-2-501).

Of Alternatives 2, 3, and 4, the least expensive alternative is Alternative 2, with cost-shared project costs amounting to $4,889,000. Alternative 2 has the lowest cost for construction and lowest cost in long-term operations and maintenance requirements. Alternative 4 has both the highest construction cost and O&M costs. Alternative 4 has additional expenses of a fish ladder and stabilizing the remaining portion of retaining wall. Alternative 3 has additional construction costs over Alternative 2 due to the cost of the step pool construction and series of small weirs for the pools. Alternatives 3 and 4 both have dredge maintenance costs that add significant costs to the total project costs for these alternatives.

The cost-shared project costs of the additional measures range from $100,000 for the riparian corridor restoration, to $782,000 for the freshwater wetlands restoration. The freshwater wetlands restoration has a relatively high real estate cost of $351,000.

Operations and maintenance costs, the responsibility of the sponsor, include repair and maintenance of the dam in Alternatives 1 and 4, and they also include the cost of periodic dredging of sediments behind the dam in Alternatives 1 and 4 and within the constructed pools in Alternative 3. Operations and maintenance costs also include maintenance of the restored habitats, including control of invasive weeds.

If the dam remains in place, short and long-term operations and maintenance costs would be incurred. The Main Street Dam is nearly 80 years old, and it is anticipated that it will need major repair or replacement in the near-term. It is assumed that under Alternative 4, major maintenance or a full replacement of the dam would be required.

Of all four primary alternatives, including the no-action alternative, Alternative 2 is the least-cost option for the sponsor, while Alternative 4 is the most expensive.

6.4 INCREMENTAL ANALYSIS

An incremental analysis is presented in Appendix E. A summary of the results is included in this section of the report. The incremental analysis measured the environmental benefits of the proposed alternatives. Because the goal of this Section 206 project is to restore degraded habitat, the desired output is the restoration of the historic riparian corridor with its associated anadromous fisheries as well as improvement of the water quality of the Mill River.

With the estimated benefits and costs developed from the concept designs, cost effectiveness and incremental analyses were performed. These two analyses are techniques used to evaluate project alternatives for ecosystem restoration studies. The purpose of these analyses is to ensure that the economically efficient, least-cost solution is identified for each possible level of environmental output. These analyses also show how the incremental cost increase changes when levels of environmental output increase.

6.4.1 Comparing Habitat Output

Habitat Units ranged from 3.3 for the no-action alternative to 43.9 for Alternative 2, which had the highest level of habitat improvement. Additive Measures provide additional habitat improvements in the project area of 1.8 for removal of the fish blockage, 3.1 for tidal wetland restoration, 5.1 for riparian corridor restoration and 4.8 for freshwater wetland creation. These additional measures were added to the Alternatives (except for the no-action alternative) in a linear fashion to achieve a more comprehensive restoration goal.

Alternative 2 had the highest HU score. The restoration proposed in this alternative is most comparable to the biological community found in a healthy watershed. A diverse array of species within a balanced community would be found on the site with the implementation of this alternative. Alternatives 3 and 4 scored lower than alternative 2. Restoration of the site following the design of alternatives 3 or 4 would not create as much species or community diversity. The no-action alternative, alternative 1, scored substantially lower than all the other outlined plans. With this alternative, the physical characteristics of the site would not change.

6.4.2 Incremental Cost Analysis

The costs of the alternative restoration plans are compared with the environmental benefits, within the framework of an incremental cost analysis, to identify the most cost-effective alternatives. An incremental cost analysis examines how the costs of additional units of environmental output increase as the level of environmental output increases. For this analysis, the environmental outputs are measured in habitat units. The analysis is in accordance with IWR Report 95-R-1, Evaluation of Environmental Investments Procedures Manual-Interim: Cost Effectiveness and Incremental Cost Analyses, May 1995; and ER 1105-2-100, Planning Guidance Notebook, Section 3-5, Ecosystem Restoration, April 2000. The computer program IWR-PLAN, developed for the Institute for Water Resources (IWR), was used to conduct the analysis.

An incremental cost curve can be identified by displaying cost-effective solutions. Cost-effective solutions are those plans that provide a level of habitat output,, or number of habitat units, for the least cost. A plan is cost effective if there are no others that cost less and provide the same, or more, habitat units. Alternatively, for a given cost, there will be no other plans that provide more habitat units.

The primary restoration measures to improve environmental conditions in the Mill River and Mill Pond, as shown in Table 7, include 1) no action; 2) removal of the dam, sediment, and retaining walls and restoration of the river channel with riffles and pools; 3) removal of the dam, sediment, and walls, and creation of step pools; and 4) removal of sediment, partial removal of walls, and installation of a fish ladder. Additional measures that may be added to the primary measures are 5) removing fish passage blockage at Pulaski Street Bridge, 6) tidal marsh restoration, 7) riparian corridor restoration, and 8) freshwater wetland creation. These additional measures are not analyzed independently, but only in conjunction with the primary Alternatives 2, 3, or 4.

Project description, project cost, and the number of habitat units created by each plan are shown in Table 7. Costs are shown as economic costs and are discounted to the present value at an interest rate of 5 $^5/_8$%. This interest rate, as specified in the Federal Register, is to be used by Federal agencies in the formulation and evaluation of water and land resource plans for the period October 1, 2003 to September 30, 2004. The project economic life is considered to be 50 years. Project cost (economic cost) derivation is shown in detail in Appendix E.

Table 7. Restoration Measures Cost and Output

No	Description	Cost*[1] ($000)	HU (acres)
1	No Action	1,926	3.3
2	Restore River Channel	4,727	43.9
3	Create Step Pools	6,801	38.4
4	Install Fish Ladder	6,558	26.2
5	Remove Fish Passage Blockage at Pulaski Bridge	213	1.8
6	Tidal Restoration	400	3.1
7	Riparian Corridor Restoration	119	5.1
8	Freshwater Wetland Creation	818	4.8

*1 – Costs are shown as economic costs and are discounted to the present value at an interest rate of 5 $^5/_8$%.

The total economic costs and habitat unit outputs were derived for all possible combinations of alternatives and additive measures and were compared with each other. Of the 50 combinations of measures analyzed, nine combinations were cost effective and 4 were best buy. The cost-effective plans are shown in Table 8.

Table 8. Cost-Effective Plans

Alternatives	HU	Cost
		($000)
1	3.3	1,926
2	43.9	4,727
2+7	49.0	4,846
2+5+7	50.8	5,060
2+6+7	52.1	5,246
2+5+6+7	53.9	5,459
2+5+7+8	55.6	5,877
2+6+7+8	56.9	6,064
2+5+6+7+8	58.7	6,277

In Table 8, the plans are arranged by increasing output of habitat units. Alternative 3 (create step pool) and Alternative 4 (install fish ladder) are not cost effective when compared to Alternative 2 (restore river channel), because Alternative 2 provides more habitat units than these other plans at a lower cost. This cost comparison can be readily seen by reference to Table 7. As shown in Table 8, Alternative 1 is the no-action plan, and the cost shown for this plan is for long-term operations and maintenance of the existing pool. Alternative 2 is river channel restoration. The remaining alternatives add various combinations of Alternatives 5(removal of fish passage blockage), 6 (tidal restoration), 7 (riparian corridor restoration), and 8 (freshwater wetlands creation).

Best buy plans are a subset of cost-effective plans. For each best buy, plan there are no other plans that will provide at least the same level of output at a lower incremental cost. The analysis identified four best buy plans, as shown in Table 9.

Table 9. Incremental Cost Curve of Best Buy Plans

Alternatives	Habitat units (HU)	Cost	Average Cost	Incremental Cost	Incremental Output	Incremental Cost Per Output
		($000)	($000/HU)	($000)		($000)
2+7	49.0	4,846	99	4,846	49.0	99
2+5+7	50.8	5,060	100	213	1.8	118
2+5+6+7	53.9	5,459	101	400	3.1	129
2+5+6+7+8	58.7	6,277	107	818	4.8	170

Also shown in Table 9 are the corresponding incremental cost, incremental output, and incremental cost per incremental output. Incremental cost is the increase in cost of each successive plan. Incremental output is the increase in output of each successive plan. Incremental cost per output is the change in cost per incremental output when proceeding to plans with higher output Usually, the no-action alternative (also known as the without-project alternative), is a best buy plan. However, for this analysis the no-action alternative results in an economic cost of $1,926,000 for operations and maintenance over the 50-year period. The high cost for little output causes the no-action alternative to have a high incremental cost and to not be a best-buy plan.

The question that is asked at each increment is whether the additional gain in environmental benefit is worth the additional cost. The first increment provides an additional 49 HU with an incremental cost of $99,000 per HU. This increment would restore the river channel and provide for riparian corridor restoration. The second increment would add the removal of the fish passage blockage at the Pulaski Bridge to the first increment. The second increment would provide an additional 1.8 HU at an incremental cost of $118,000 per HU. The third increment would add tidal wetland tidal restoration to the second increment. This increment would provide an additional 3.1 HU at an incremental cost of $129,000 per HU. The fourth, and final, increment would provide an additional 4.8 HU with an incremental cost of $170,000 per HU. The fourth increment adds freshwater wetland creation to the third increment.

6.4.3 National Economic Development Benefits

Though the primary goal of this project is environmental restoration, the alternatives provide additional benefits at various levels to the National economic development in the form of flood damage reduction. Alternatives 2 and 3 would reduce flooding in the reaches of the Mill River upstream of the Main Street Dam. For the 100-year event, water surface levels would be lowered by between 2.0 and 2.6 feet between the removed dam and Broad Street located approximately 1,100 feet upstream (See Appendix B). The economic benefits resulting from these reductions in flood levels were not specifically calculated for the dollar values of these benefits because this project is being conducted under the Ecosystem Restoration Program (Section 206 of Water Resources Development Act), which addresses National environmental restoration outputs, and economic development benefits are not defined as a primary goal of this project.

6.5 RECOMMENDATIONS

Since this project is federally funded through the Section 206 program, a plan that best meets national interests must be identified under Corps of Engineers regulations (ER 1105-2-100). This national plan, called the National Environmental Restoration (NER) Plan, reasonably maximizes environmental benefits, is cost effective, and provides aquatic habitat restoration benefits that are in the national interest. The NER plan must meet planning objectives and constraints and reasonably maximize environmental benefits while passing tests of cost effectiveness, significance of outputs, acceptability, completeness, cost efficiency, and effectiveness. The plan must also have a reasonable cost in context with other similar projects (Corps Regulations ER 1105-2-100, Appendix E). Corps regulations allow federal funding to be contributed to support the project to the maximum allowed when the NER plan is chosen as the proposed plan. Locally preferred plans can also be funded (partially or in whole) if they are determined to be best buy plans through incremental analysis and meet other planning criteria.

Four plans are identified as best-buy plans and can all be considered for the NER recommended plan. The first three plans have relatively similar incremental costs, ranging from $99,000 to $129,000 per HU, and these costs are within the normal range of restoration projects in the North Atlantic Division. The plan that includes the restoration of the river channel at Mill Park (Alternative 2) along with riparian corridor restoration, removal of the fish blockage at Pulaski Street Bridge, and tidal wetlands restoration is selected as the NER recommended plan. The total economic cost is estimated at approximately $5.5 million with a total HU output of 58.7. This alternative, with the additive measures, is in the national interest because it provides for effective anadromous fish passage, waterfowl habitat, and tidal wetlands restoration. This plan is carried forward in this report as the recommended alternative.

The next increment, the addition of the freshwater wetlands has a large jump in incremental cost, up to $170,000 per HU. This increment, which involves restoration of one acre of wetlands for a total project cost of over $700,000, is more expensive than similar projects in North Atlantic Division. Therefore, the wetlands restoration measure is not recommended at this time, given the costs identified in this report.

Alternative 2 with the three additive measures, as noted above, appears to meet selection factors of cost efficiency and effectiveness. For this alternative to be brought forward as the recommended plan into a final report, the plan must be acceptable to the city of Stamford, as the sponsor, and state and other federal resource agencies. In 2002 and 2003, Connecticut Department of Environmental Protection and U.S. Fish and Wildlife Service provided letters of support for this alternative. In January 2004, Stamford agreed to the recommended plan for public review.

The additional incremental cost of tidal wetlands restoration is justified because wetlands along the Long Island Sound of the Atlantic Ocean are critical to the ecological function of the northeastern Atlantic coastline. Federal Agencies, including the Department of the Army, and Connecticut State agencies have signed a Resolution under the Coastal America Program to address constricted coastal embayments along the Connecticut coast. As stated in this Resolution, "Marshes along the Connecticut coast have historically been an exceptionally productive and biologically diverse ecosystem important to the economics and aesthetics of the Northeast and the Nation." The Resolution further states that the acreage of these key habitats for fish, shellfish, birds, and wildlife has greatly declined over the last century. Therefore, restoration of wetlands along the Connecticut coast as proposed in this study, are in the National interest and are vital steps to help stop this coastal ecosystem from further degradation.

Additional benefits in the national interest include flood damage reduction. Alternative 2 would provide some level of flood damage reduction in the downtown Stamford (See Appendix B for more information). The 100-year computed water surface elevation would be reduced by at least 2 feet for approximately 1,000 feet upstream of the Main Street Dam, with smaller reductions further upstream in the current impoundment. Though this benefit is not specifically measured in the incremental analysis, it is an important additional benefit that would result from implementation of Alternative 2.

SECTION 7. DESCRIPTION OF RECOMMENDED ALTERNATIVE

7.1 DESCRIPTION OF THE RECOMMENDED PLAN

The recommended plan for ecosystem restoration of the 2.5-mile Mill River corridor in Stamford, Connecticut has the following restoration measures:

- Restoration of the river channel at Mill River Park, including dam removal and restoring the channel to a riffle-and-pool morphology, as in Alternative 2 (includes Sites 11, 12, 13)
- Restoration of 1.53 acres of the riparian corridor through planting of native woody and herbaceous vegetation and removal of exotic and invasive plant species [Site 9 (0.15 acres), Site10 (1.02 acres) and Site 18 (0.36 acres)]
- Restoration of two 0.4-acre tidal wetland through re-grading banks and planting native salt marsh vegetation (Site 2 and Site 6)
- Removal of abandoned concrete blocks and gate structures directly beneath the Pulaski Street Bridge to restore fish passage (Site 1)
- Incorporation of a trail system to connect the greenway and parks along the river corridor (Sites 10, 11, 12, 13) (Removal of the dam and walls affects existing pedestrian walkways and trails. These walkways would be re-established for public safety purposes and connection to other existing sidewalks, trails, and open space areas downstream of the dam.)

The recommended actions involve nine sites along the lower 2.5 miles of Mill River (Sites 1, 2, 6, 9, 19, 11, 12, 13, and 18) of the 20 sites identified in this study. The recommended actions, along with current conditions, for each of the nine sites are described in Table 10. The locations and topography of the nine sites are shown in Figures 15, 16, and 17. All restoration activities would be completed within the riparian corridor and on publicly held lands.

The recommended alternative includes the removal of the Main Street Dam and concrete retaining walls within Mill River Park. Removing the Main Street Dam would facilitate fish passage, as well as re-establish a natural stream channel with restored in-stream habitat through the downtown reach of the Mill River. The configuration of the natural channel design, along with the selective placement of boulders and other rock structures in the stream channel, would re-establish a pool-and-riffle sequence within the park reach. Deeper pools in the flowing stream would be self-maintained by natural flushing during high river flows. The vertical concrete walls would be removed and a well-vegetated, natural floodplain would be restored that would serve as a riparian buffer for the aquatic habitat, provide flood storage for large discharge events, create public open space, and improve access to the river.

Removing the Main Street Dam would restore passage for a broad range of fish and other aquatic species to the Mill River by re-establishing habitat connectivity between the river and the ocean. By establishing a geomorphologically stable channel within the park that approximates naturally occurring conditions in the watershed, the reach would be self-maintaining. Trails and/or boardwalks would accommodate recreational access to the river and protect banks and riparian vegetation from disturbance.

Table 10. Recommended Restoration Actions

Potential Projects Identified During Field Investigations		
Site Location	**Current Conditions**	**Proposed Restoration Action**
1	Abandoned concrete blocks and gate structures directly underneath Pulaski Street Bridge. Structures block fish passage at lower tides.	Remove portions of the fish blockage to restore fish passage at low tide.
2	Tidal flat dominated by *Phragmites* sp. Area lies directly in front of city-owned property.	Tidal wetland restoration. Restore area to a tidal wetland by regrading and planting of desired vegetation. Invasive species removal.
6	Tidal flat dominated by *Phragmites* sp. Area lies directly in front of city-owned property.	Tidal wetland restoration. Restore area to a tidal wetland by regrading and planting of desired vegetation. Invasive species removal.
9	Empty lot located on the east bank of the river downstream of the Main Street bridge. Area is dominated by invasive exotics. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Regrade lower portion to include a wetland area. Manage or remove any exotic species. Trail system to connect greenway along river corridor.
10	Floodplain located on the east bank of the river just downstream of the Main Street bridge. Area is dominated by invasive exotics. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Regrade lower portion to include a wetland area. Manage or remove any exotic species. Connect trail system in Mill River Park to City-provided trail that connects to Main Street Bridge pedestrian crossing.
11	Retaining wall located on west bank of river directly adjacent to Mill Pond Road. Has numerous stormwater discharge pipes. Constriction made by road and wall does not allow a walkway for foot and bike traffic.	Structural reinforcement and stabilization. Vegetation planting at base of wall. Incorporate a sidewalk for pedestrian and bike traffic to connect park system.
12	Main Street dam forming the Mill Pond. Dam is failing and needs structural reinforcement. Collects trash and causes sedimentation behind dam within Mill Pond.	Remove Main Street dam and restore a natural river channel, which includes a number of pool and riffle sequences.
13	Mill Pond located in downtown Stamford. Currently a trap for sediment and trash. Vertical concrete walls provide little habitat value. Large population of Canada geese and mute swans.	Restore a natural correct river channel. Remove concrete walls and restore floodplain that incorporates a trail/boardwalk system as well as overlooks and educational facilities. Maintain as many cherry trees as possible within Mill Pond Park.
18	Riparian corridor on west bank of Mill River located between Wright Technical School and Mill River. Vegetation is composed primarily of Japanese knotweed, an invasive exotic. Provides little shading or habitat value.	Riparian restoration by planting of desirable riparian species. Manage or remove any exotic species.

Mill River Recommended Restoration Sites

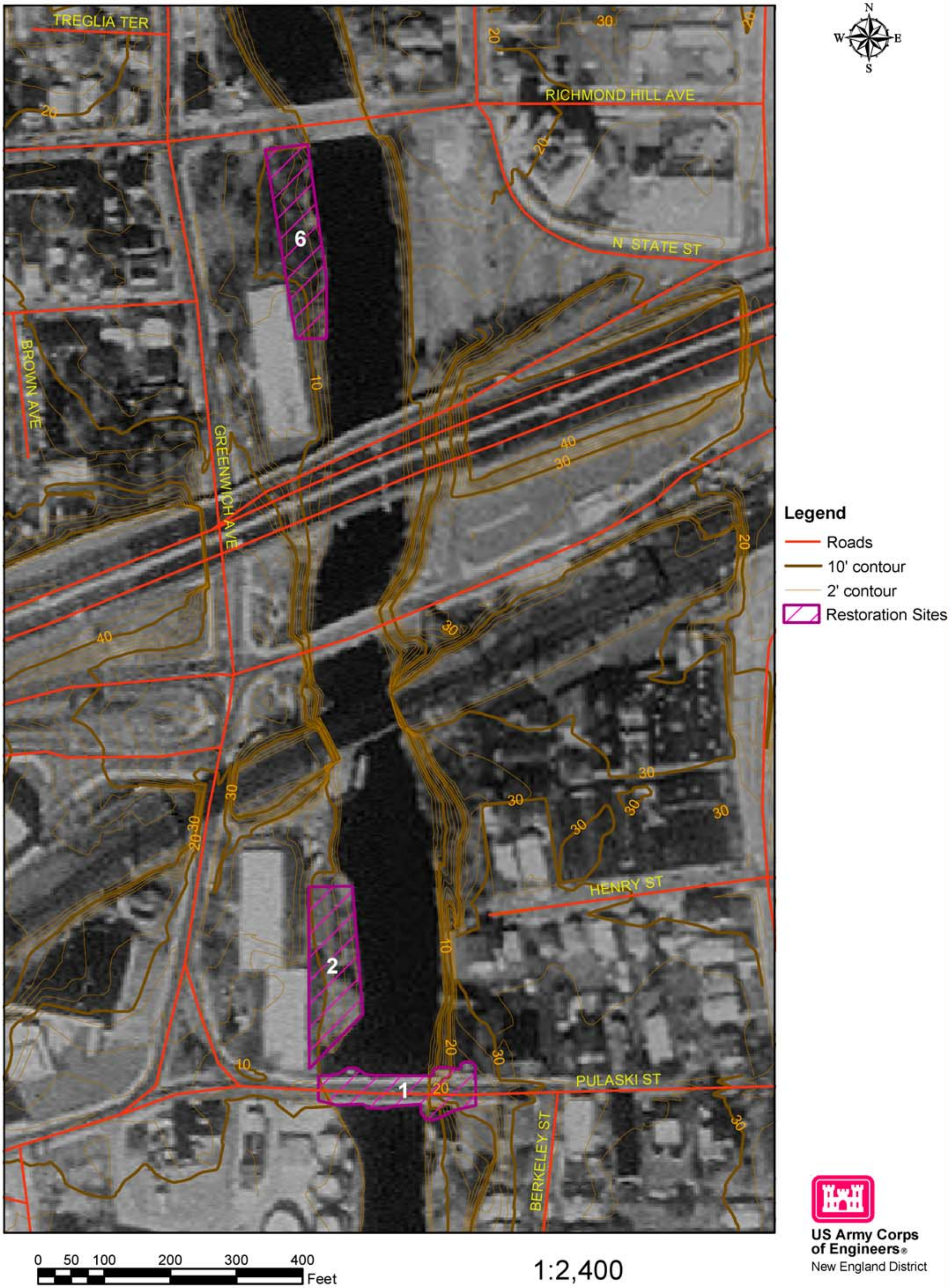


Figure 15. Recommended Mill River Restoration Locations (Sites 1, 2, and 6) (Map 1 of 3)

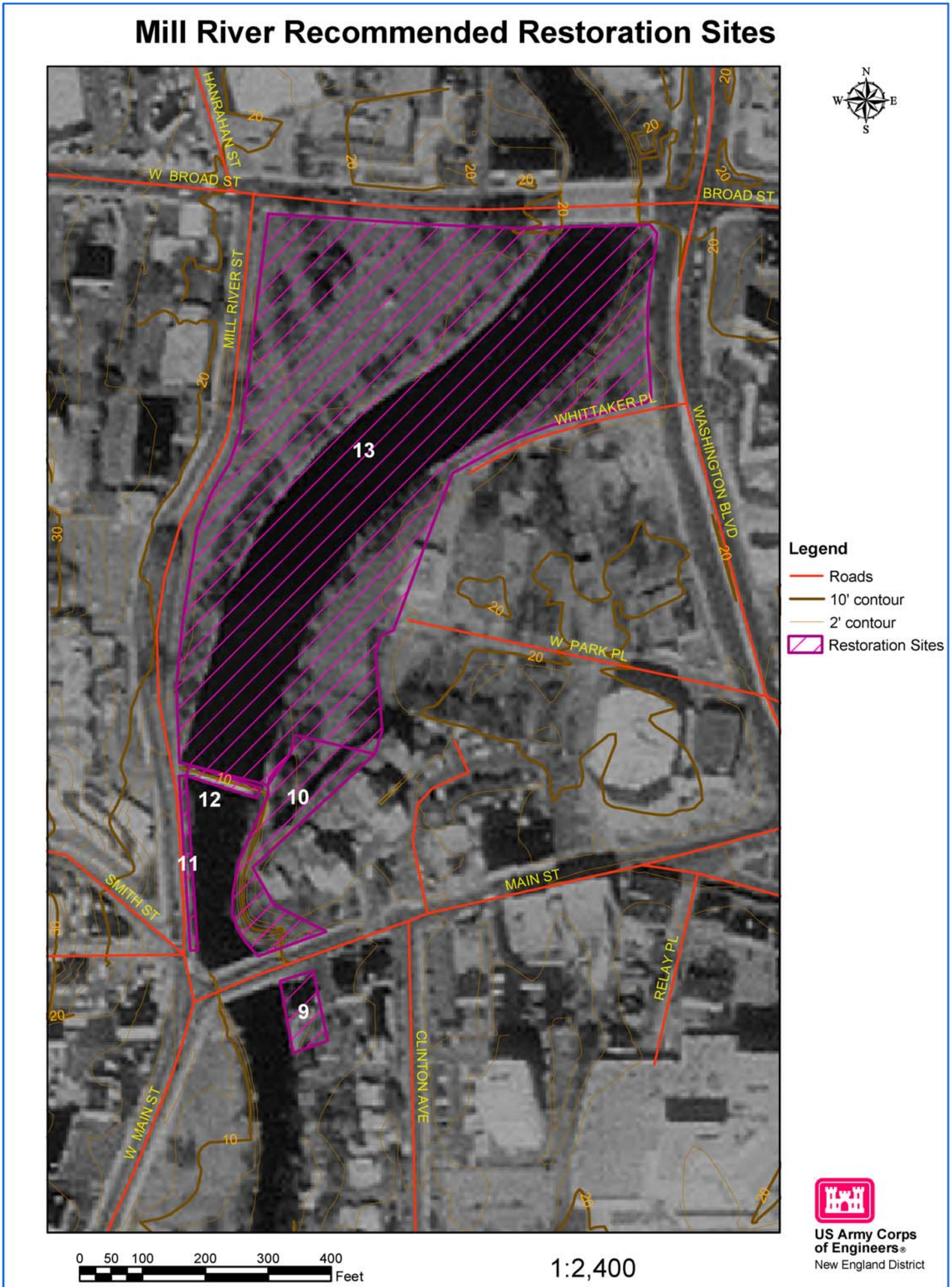


Figure 16. Recommended Mill River Restoration Locations (Sites 9, 10, 11, 12, and 13) (Map 2 of 3)

Mill River Recommended Restoration Sites

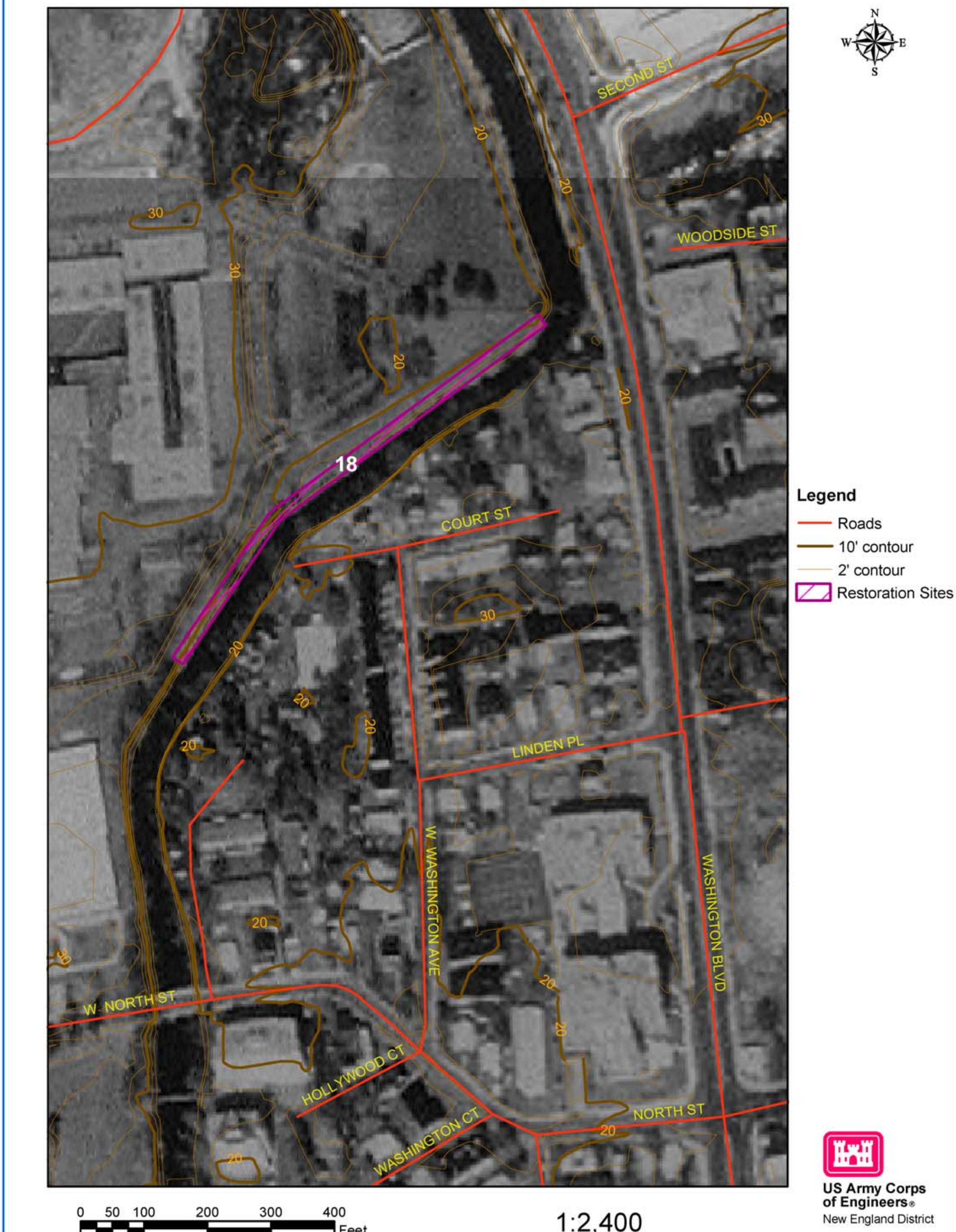


Figure 17. Recommended Mill River Restoration Locations (Site 18) (Map 3 of 3)

7.1.1 Mill River Park Ecosystem Restoration (Sites 11, 12, and 13)

The majority of restoration activity would be focused on Mill River Park and the removal of the Main Street Dam and associated retaining walls (Sites 11, 12, and 13). A preliminary design for the Mill River Park restoration is shown in Figures 18 and 19. Accumulated sediment behind the Main Street Dam would be excavated and the channel re-graded and re-shaped to restore a natural stream channel within the park. The in-stream riffle-pool sequence between the Broad Street Bridge and the present location of the dam would be established by the design channel's gently meandering thalweg (center of low-flow channel).

Approximately 18,600 cubic yards of sediment would be removed from Mill Pond. The sediment to be excavated may require additional testing to verify permitted disposal. All materials determined inappropriate for disposal in residential and/or industrial/commercial areas would be transported to an approved site, such as Manchester Municipal Landfill in Manchester, Connecticut. The cost for sediment disposal is discussed in more detail in section 6.3. For more information on sediment quality see section 3.2.6. The restoration of natural channel banks and floodplains would be accomplished by re-grading approximately 26,000 cubic yards of soil material currently located behind the retaining walls to shape the new channel valley profile. An additional 2,000 cubic yards of loam would be placed on the site to help re-establish vegetation.

The channel's planform configuration, gradient, and cross-section geometry are designed to provide a geomorphologically stable channel that would improve fish passage and habitat (Figures 8 and 9, Section 4). The concept design for a geomorphologically stable channel above the dam was developed at a feasibility level of detail using available data, including cross sections from FEMA flood insurance studies (1993) for reference reaches upstream and downstream of the impoundment; bathymetric and sub-sediment elevations surveyed in the Mill River Park reach (Appendix J); hydrologic data from FEMA (1993) and the city of Stamford (2001); and a map of the project area provided by the city that shows topography and infrastructure. Design-level specifications would require more detailed field surveys of the project area to gather the necessary geomorphic and geotechnical information. Further hydrologic, hydraulic, and sediment transport and disposal analyses may also be needed to support design-level specifications.

Determining appropriate bankfull channel dimensions is critical for establishing a geomorphologically stable channel. For a large variety of rivers throughout North America, bankfull channel cross-section geometry has been shown to correspond with a discharge that has a recurrence interval of approximately 1.5 years in the annual flood series (Dunne and Leopold, 1978). Data for the 2-year recurrence interval discharge (Q2) were available for the reference cross section downstream of the project area. These data were used to approximate the bankfull discharge and estimate appropriate bankfull channel cross-section dimensions of the project area design channel. The bankfull channel geometry can also be approximated by using regional curves derived for the Eastern United States that relate bankfull channel dimensions with drainage area (Dunne and Leopold, 1978). The channel geometry estimated using the regional curves is similar to that determined using the Q2-flood levels. Dimensions of the upstream reference cross section (for which no Q2 data were available) were also compared to the project area design channel using the Q2-flood levels and found to be similar.

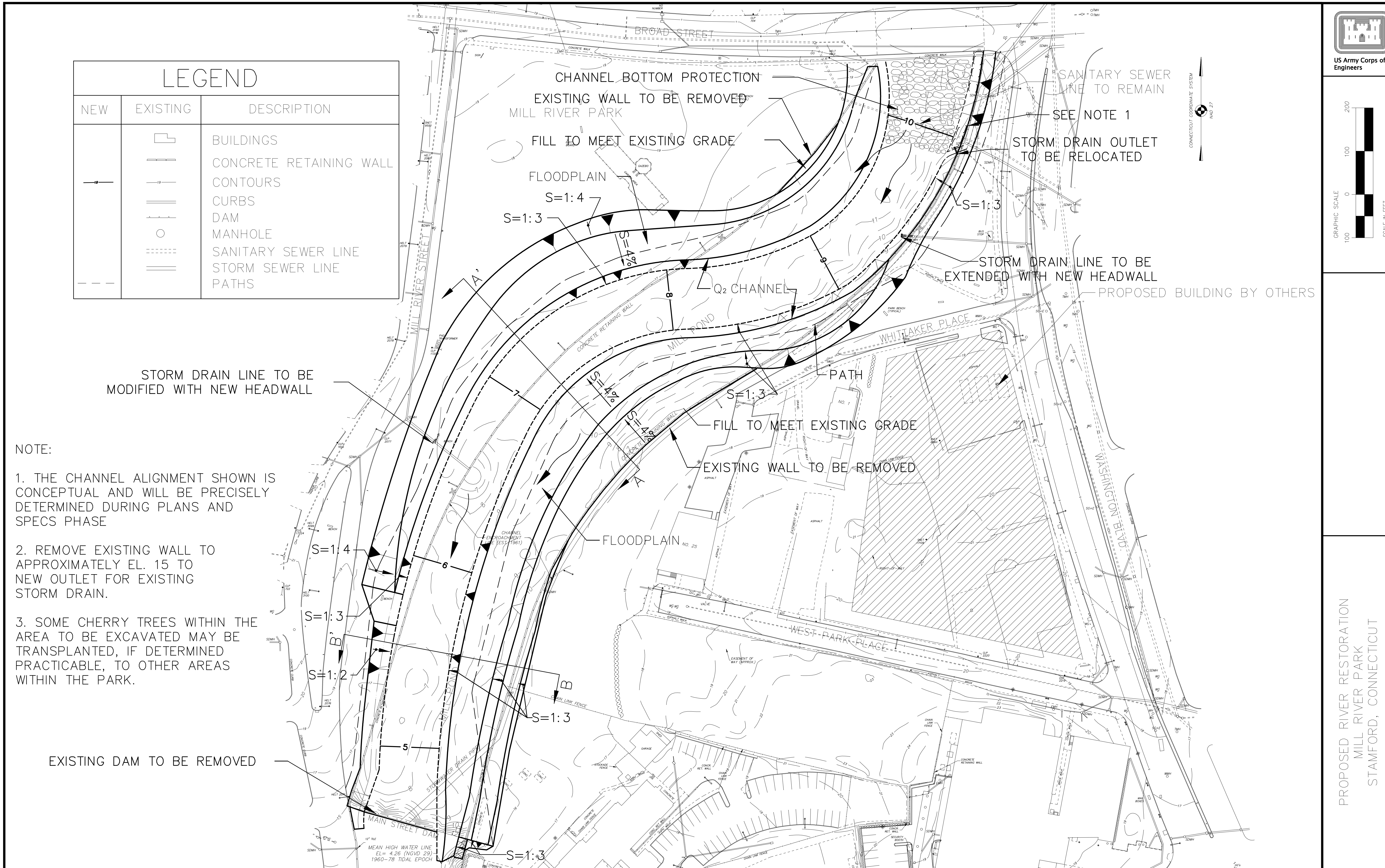


FIGURE 18 Proposed Mill River Channel Restoration and Dam Removal within Mill River Park

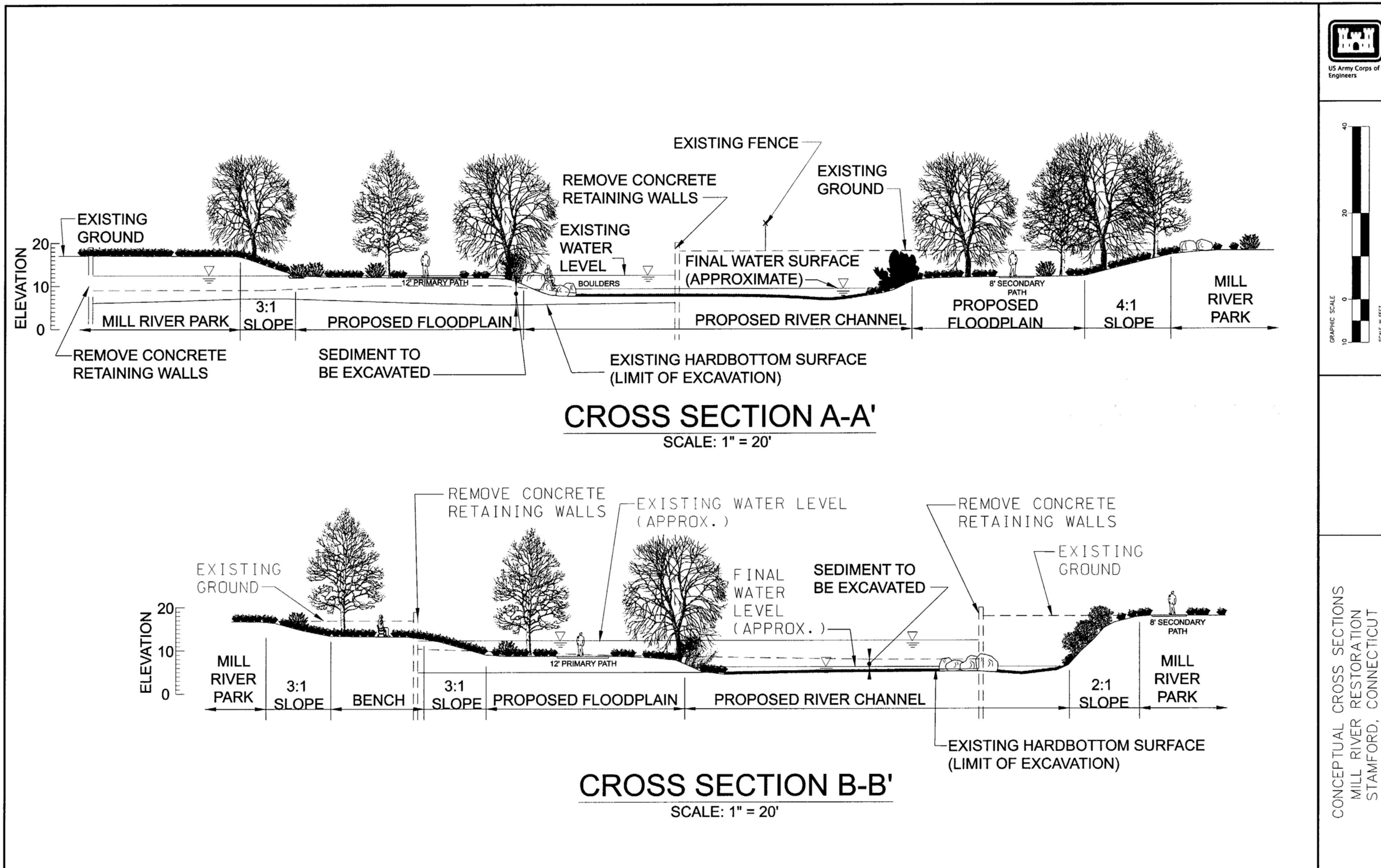


Figure 19. Cross Sections of Proposed Restoration and Dam Removal within Mill River Park (See Figure 15 for locations of cross sections)

Bathymetry and sub-sediment elevations at the plotted FEMA cross sections within the park, as well as bed elevations estimated from the upstream and downstream reference FEMA cross sections, were used to establish bed elevations that reasonably approximate the pre-impoundment channel gradient, while at the same time accommodating project constraints. Inspection of topographic maps of the lower Rippowam basin, combined with an understanding of the regional physiography and stream channel patterns, guided the design of the planform geometry.

The new channel configuration will allow for passage of anadromous fish species identified as potential inhabitants of the study area. Furthermore, it will provide unrestricted access to approximately 5.2 linear miles of aquatic habitat, which has not existed for over 350 years because of a series of dams constructed at the site.

A constraint that affects the river profile is a buried sewer pipe that underlies the park and impoundment a short distance (approximately 70 feet) downstream of the Broad Street Bridge (See Figure 18). The sewer tile imposes a constraint on bed elevation and may necessitate some channel protection in the vicinity of the pipe to protect the pipe from exposure and damage. According to Utility information provided by the city of Stamford, the elevation of sewer line under the river (approximately 9.2 feet at top of tile pipe) is below the final proposed elevation of the channel bed (approximately 10 feet) at the location of the sewer crossing. As shown in Section 5.2 and Appendix B, FEMA flood elevations are not increased by this modification.

A stormwater drain that currently runs along the east side of Mill Pond and outfalls through the face of the dam would be partially removed during excavation (see Figure 18). The outfall of this stormwater drain would be relocated within the park, and the design would include appropriate protection measures, grating, visual screening, and a sediment trap (if necessary). Another storm drain currently drains into the pond through the retaining wall on the west side of the pond, and the outfall of this pipe would be redesigned and relocated with the wall removed. Details on the location and design of the relocated stormwater drain pipes and outfalls would be designed during the plans and specifications phase of the project.

The retaining wall directly downstream of Main Street Dam on the west side of the river (Site 11) may need additional stone protection and reinforcement after the dam is removed. This wall is connected to the dam and wall upstream of the dam. Additionally, the river flow would need to be diverted away from the wall after the dam is removed, because the river takes a bend to the east at this wall and the wall is on the outside of the bend, where higher flow velocities may be encountered.

The banks of the restored channel within the park would be protected, as appropriate, with bioengineering methods and boulders. The configuration and types of bank protection measures will be designed during the plans and specifications phase of the project. Bioengineering methods may include stone-reinforced toes, coir fascines, live stakes, and erosion-control fabric. Engineering Manual (EM) 1110-2-1205 (U.S. Army Corps of Engineers 1989) states that herbaceous or woody vegetation may be used to protect channel side slopes and other bank areas where velocities are not expected to exceed 6 to 8 feet per second. The Maximum-recorded velocities sustained for root wads with large clumps of willows averaged 8.7 feet per second (Allen, 1997). Similar bioengineering techniques would be utilized in the proposed project design. The design would tailor vegetation types and bioengineering structures to flow velocities that can be sustained. Flow velocities in the project area are calculated to be an average of 7 feet per second for the 100-year event, and these flows are within the range of recommended guidelines. However, additional soil stabilization measures are recommended to further stabilize the project area and reduce vulnerabilities during the vegetation establishment period.

Bank stabilization and floodplain restoration would be primarily achieved through the planting of native vegetation, including trees, shrubs, and herbaceous riparian and wetland species Table 11 lists potential plantings for tree species within the newly restored floodplain. Table 12 lists potential plants for banks and floodplains.

Table 11. Potential Tree Species for Floodplain Restoration within Mill River Park

Scientific Name	Common Name
Acer saccharinum	Silver maple
Betula allegheniensis	Yellow birch
Betula nigra	River birch
Carpinus caroliniana	Ironwood
Fraxinus pennsylvanica	Green ash
Juglans nigra	Black walnut
Magnolia virginiana	Swamp magnolia
Nyssa sylvatica	Black gum
Ostrya virginiana	Hop hornbeam
Pinus strobus	White pine
Platanus occidentalis	Sycamore
Populus tremuloides	Quaking aspen
Prunus serotina	Black cherry
Quercus bicolor	Swamp white oak
Salix nigra	Black willow
Tilia americana	Basswood
Viburnum prunifolium	Blackhaw viburnum

Table 12. Potential Herbaceous and Shrub Species for Bank Stabilization and Floodplain Restoration

Scientific Name	Common Name
Herbaceous Perennials	
Chelone glabra	White turtlehead
Caltha palustris	Marsh marigold
Iris versicolor	Blue flag
Leersia oryzoides	Rice cut grass

Scientific Name	Common Name
Herbaceous Perennials	
Lobelia cardinalis	Cardinal flower
Mimulus ringens	Monkey flower
Peltandra virginica	Arrow arum
Pontederia cordata	Pickerel weed
Carex stricta	Tussock sedge
Carex crinita	Fringed sedge

Scientific Name	Common Name
Shrubs/Woody Vines	
Alnus serrulata	Alder
Cephalanthus occidentalis	Buttonbush
Clethra alnifolia	Summersweet
Cornus amomum	Silky dogwood
Cornus sericea	Red osier dogwood
Ilex glabra	Inkberry
Ilex verticillata	Winterberry
Itea virginica	Virginia sweetspire
Kalmia angustifolia	Sheep laurel
Rhododendron periclymenoides	Pinxterbloom azalea
Rhododendron viscosum	Swamp azalea
Spiraea alba	Meadowsweet
Spiraea tomentosa	Hardhack spirea
Vaccinium angustifolium	Lowbush blueberry
Vaccinium corymbosum	Highbush blueberry
Viburnum trilobum	American cranberry bush
Vitis riparia	River grape

A detailed survey of the trees adjacent to the retaining walls was performed (See Appendix I). Of a total of 100 trees surveyed, 80 trees are kwanzan oriental cherry. Most of the trees (85 of the 100 surveyed) are between 30 and 60 years old, including 79 out of the 80 cherry trees. In general, the cherry trees within the park showed various levels of deterioration due to age, growth limitations, and disease. Growth limitations identified during field investigations include proximity to paved and concrete sidewalks, other structures, and other trees.

Removal of the walls and excavation as part of the river channel restoration would require removal of a number of cherry trees within the park. Many trees are located directly adjacent to the retaining walls, some within one foot of the walls. Those trees that have trunk or root structures in proximity to the retaining walls could be damaged during the construction phase and could require removal. The number of trees to be removed would be dependent upon the final alignment of the channel, floodplain, and banks. Of the trees identified for removal in the final design, some may be transplanted to new locations in the park, subject to the capability of the trees to survive transplanting. However, the survey indicated that over half the cherry trees might not be in a condition to survive transplanting. Replanting cherry trees throughout the new park would be the decision of the city of Stamford. For more information on the condition and health of cherry trees within Mill River Park, see Appendix I.

7.1.2 Landscape Design and Recreational Components

Redesign of the Mill River Park, in conjunction with the restoration of the river corridor, presents an important opportunity to restore a functional relationship between the city and Mill River, i.e., to re-integrate cultural and ecological processes. Regulations for the ecosystem restoration authority under which this project is being conducted allow recreational development to be included as part of the project, as long as it is compatible with the ecosystem restoration purpose of the project (see Regulations ER 1165-2-501 and ER 1165-2-502 for more information). The proposed recreational improvements meet these requirements. They include the following:

- A hard-surfaced path to replace the existing sidewalk along the pond, which would allow pedestrian flow and connect the trail system to the City's sidewalks and trails
- Gravel surface trails and wooden boardwalks allowing pedestrian access to the river's edge
- Overlooks on the river's edge constructed of boulders to provide viewing opportunities of the river
- Signs and kiosks to provide information and interpretation
- Benches and trash receptacles

These facilities would allow people to enjoy and learn about the restored riverine environment. They would also help to protect the site from pedestrian-related impacts by providing paths and access points in appropriate locations and minimizing trampling of vegetation and erosion caused by informal trails.

The design and location of cultural elements in the park would relate to ecological and hydrologic cycles and events. The strategic placement of recreational paths (as well as their material properties) would be designed to withstand flooding while also providing controlled public access to and enjoyment of the restored site. The lower elevations of the restored floodplain surfaces would be subject to flooding with an average two-year recurrence interval; therefore, trails and other improvements on the floodplain portions would need to be designed to withstand this interval of flooding. Wooden boardwalks and river-rock piers would be constructed adjacent to the river's edge, and would be designed to withstand flooding while allowing public access to and viewing of the river. Asphalt paths would delimit the edges of typically flood-free zones. A path on the west side of the river would be connected to the City's trail and sidewalk system along Mill River Street, including the City-provided trail connecting to Main Street Bridge pedestrian crossing. A system of smaller, secondary trails would provide opportunities for a more intimate experience of the river system, allowing direct access to key habitat features, as well as the water itself. The kiosks and signs would provide information about the restored site and opportunities for interpretation of the restored ecosystem and history of the area.

The city could also add other recreational and cultural elements to the restored corridor that do not deter from the ecosystem function and are not included in the shared-cost restoration project. These additional elements could include public art works.

The city of Stamford would have the opportunity to re-develop those portions of the park outside the restored corridor. This re-development would not be cost-shared as part of the restoration project. Potential additions to the park outside the restored area (that would not be cost-shared) could include landscaped plantings, including groves of ornamental cherry trees; overlooks to the river corridor; performing arts space, multipurpose open space for picnicking and informal outdoor sports; a community garden and orchard; a farmers market; and a multipurpose paved area that could accommodate uses such as parking and market or craft festivals.

7.1.3 Tidal Wetland Restoration

Two sites for tidal wetland restoration are found south of the Main Street Dam. These areas are both approximately 0.4 acres in size, are currently dominated by *Phragmites*, and provide little habitat value (Plate 7).

The proposed restoration is expected to enhance the habitat available for Mill River fish and wildlife. Native marsh vegetation would be restored, allowing the system to be utilized by additional avian and marine species. Additional information, including existing site plan and topography, salinity levels, and tidal range, needs to be determined before final design can be completed.

The tidal, brackish environment of a salt marsh supports unique and abundant communities of plants and animals specially adapted to life in the sheltered waters of the estuary. Estuarine and salt marsh systems are among the most productive ecosystems on Earth, producing more organic matter than forest, grassland, or agricultural lands of comparable size. The restored tidal wetland habitat would help support a wide array of wildlife including shorebirds, fish, crabs, clams and other shellfish, marine worms, sea birds, and reptiles. The restored wetlands may benefit humans through activities such as recreation, education, and aesthetic values.

Plate 7. Area dominated by *Phragmites* within tidal reach of Mill River

Phragmites australis, also known as common reed, is a tall perennial grass found on all continents except Antarctica. It is characterized by its towering height of up to 14 feet, and its stiff wide leaves and hollow stem. Its feathery and drooping inflorescences form on the top of the plant and resemble plumes. *Phragmites* flowers from July to October but inflorescences may remain visible throughout the year, making the plant easily identifiable. *Phragmites* is a colonial plant, spreading by rhizomes (underground stems) and capable of forming large stands or colonies arising from one or a few seeds or plant pieces. These colonies form along the margins of streams and in marshes and ditches. They can form in brackish water and in disturbed areas, allowing them to out compete other more desirable plants (Marks *et al.* 1993). *Phragmites* has a low ecological value for fish and wildlife habitat combined with a low aesthetic value for people. Because of an abundance of dry matted organic matter, *Phragmites* stands are a constant fire threat that poses a public safety and maintenance concern. A constant tidal flush through a system can eliminate or prohibit the growth of *Phragmites* in a salt marsh system due to its inability to withstand high salinity levels.

The physical form, or morphology, of a site is important to salt marsh restoration, since the physical form interacts with site hydrology to produce conditions favorable for salt marsh plant growth. Salt marsh morphology is determined by such attributes as elevation, slope, micro- and macrotopography, and the presence/absence of channels. A list of potential plant species for tidal wetland areas is listed in Table 13.

Table 13. Potential Plant Species for Tidal Wetland Areas Restoration

Scientific Name	Common Name	Habitat Type
Distichlis spicata	Spike grass	High marsh
Iva frutescens	High-tide bush	High marsh
Juncus gerardii	Black grass	High marsh
Panicum virgatum	Switchgrass	Marsh/upland edge
Scirpus robustus	Salt marsh bulrush	Marsh/upland edge
Spartina alterniflora	Smooth cordgrass	Low marsh
Spartina patens	Salt hay grass	High marsh
Spartina pectinata	Slough grass	Marsh/upland edge

As part of the tidal marsh restoration, a gravel trail and boardwalk are proposed for construction along the upper margins of the marsh areas. This trail system replaces existing trails along the river, and it is necessary to limit pedestrian use in the area and protect the restored sites from trampling and informal trail development. The trail system would also provide opportunities for interpretation and education about the marsh ecosystem.

7.1.4 Riparian Corridor Restoration

Riparian corridor restoration would provide ecological benefits to the aquatic, riparian, and terrestrial ecosystems. Ecological benefits include moderation of stream temperature, bank stabilization, and maintenance of the floodplain.

Riparian restoration includes removal of invasive species and rehabilitation of noteworthy trees within the corridor. The primary invasive species of concern are Japanese knotweed and purple loosestrife. Japanese knotweed in particular is a persistent and fast growing exotic species that has colonized whole sections of the riparian corridor, inhibiting native vegetation and limiting diversity. Management techniques include chemical and manual removal and planting of fast growing groundcover and shade trees. The short-term success of exotics management depends on continual maintenance for specified areas.

Riparian corridor restoration is proposed for the Mill River, including 4.0 acres in the Mill River Park and 1.53 acres (Sites 9, 10, and 18) totaling approximately 5.53 acres. Hardwood and floodplain species would be planted and exotic species removed within a 20-foot corridor adjacent to the river channel and within Scalzi Park. All of the other riparian areas impacted by construction will be restored as well. Restoration would include planting native riparian species where canopy cover is less than 80%. All plantings would be performed in the appropriate season and upon completion of any earthmoving activities in the area. A qualified expert would assess the exact location and density of riparian plantings during the design phase. Table 14 lists potential plants for riparian planting.

As part of the riparian corridor restoration, a gravel trail is proposed for construction along the upper margins of the riparian area. As in the tidal marsh area, this trail system replaces pedestrian trails existing along the river, and it is necessary to limit pedestrian use along the river and protect the restored sites from trampling and informal trail development.

Table 14. Potential Plant Species for Riparian Restoration

Scientific Name	Common Name	Type
Acer saccharinum	Silver maple	Tree
Alnus serrulata	Alder	Shrub
Betula allegheniensis	Yellow birch	Tree
Betula nigra	River birch	Tree
Caltha palustris	Marsh marigold	Herbaceous perennial
Carpinus caroliniana	Ironwood	Tree
Cephalanthus occidentalis	Buttonbush	Shrub
Chelone glabra	White turtlehead	Herbaceous perennial
Clethra alnifolia	Summersweet	Shrub
Cornus amomum	Silky dogwood	Shrub

Table 14. (cont.) Potential Plant Species for Riparian Restoration

Scientific Name	Common Name	Type
Cornus sericea	Red osier dogwood	Shrub
Fraxinus pennsylvanica	Green ash	Tree
Ilex glabra	Inkberry	Shrub
Ilex verticillata	Winterberry	Shrub
Iris versicolor	Blue flag	Herbaceous perennial
Itea virginica	Virginia sweetspire	Shrub
Juglans nigra	Black walnut	Tree
Kalmia angustifolia	Sheep laurel	Shrub
Leersia oryzoides	Rice cut grass	Herbaceous perennial
Lobelia cardinalis	Cardinal flower	Herbaceous perennial
Magnolia virginiana	Swamp magnolia	Tree
Mimulus ringens	Monkey flower	Herbaceous perennial
Nyssa sylvatica	Black gum	Tree
Ostrya virginiana	Hop hornbeam	Tree
Peltandra virginica	Arrow arum	Herbaceous perennial
Pinus strobus	White pine	Tree
Platanus occidentalis	Sycamore	Tree
Pontederia cordata	Pickerel weed	Herbaceous perennial
Populus tremuloides	Quaking aspen	Tree
Prunus serotina	Black cherry	Tree
Quercus bicolor	Swamp white oak	Tree
Rhododendron periclymenoides	Pinxterbloom azalea	Shrub/vine
Rhododendron viscosum	Swamp azalea	Shrub/vine
Salix nigra	Black willow	Tree
Spiraea alba	Meadowsweet	Shrub/vine
Spiraea tomentosa	Hardhack spirea	Shrub/vine
Tilia americana	Basswood	Tree
Vaccinium angustifolium	Lowbush blueberry	Shrub/vine
Vaccinium corymbosum	Highbush blueberry	Shrub/vine
Viburnum prunifolium	Blackhaw viburnum	Tree
Viburnum trilobum	American cranberry bush	Shrub/Vine
Vitis riparia	River grape	Shrub/vine

7.1.5 Removal of Obstruction at Pulaski Street Bridge

Currently, a large concrete platform and abandoned weir structure exist under and slightly upstream of Pulaski Street Bridge (see Plate 8). The affected reach of channel is approximately 300 feet. This structure becomes a complete impediment to fish passage during mid to low tides, so anadromous fish and other aquatic species have limited upstream passage only during high tides. The recommended plan includes removal of all of the abandoned structure in the river and restoring the natural stream channel through the affected reach. The construction requires staging area setup along the channel's edge, demolition of the concrete structure (estimated 556 cubic yards), and hauling and disposal of the concrete at a suitable location selected by the city of Stamford.

Plate 8. Concrete obstruction under Pulaski Street Bridge on the Mill River in Stamford, CT. This abandoned structure blocks fish passage during mid and low tides.

7.2 DESIGN ASSUMPTIONS

The following assumptions are made for consideration in finalizing the recommended plan and during the plans and specifications phase:

1. Additional site-specific topographic, hydrologic, geotechnical, and geohydrological information will be required for each site during the design and specifications phase.
2. The public outreach process may result in the identification of revisions to the recommended plan.
3. Removal of the Main Street Dam and retaining walls would occur during a low flow period. Water diversion would be necessary during construction. A water diversion and control plan would be developed during the design phase.
4. Erosion and sedimentation control would be required at all restoration locations to prevent migration of sediments downstream. Due to fluctuating water levels in the tidal area downstream, a floating silt curtain would be used to enclose the work area.
5. Approximately 18,600 cubic yards of sediment built up behind the dam would be removed before dam removal, and the sediment would be disposed of at one or more approved sites. If necessary, sediment would be additionally tested. All materials determined inappropriate for disposal in residential and/or industrial/commercial areas would be transported to an approved site such as the Manchester Municipal Landfill. The cost estimate in this report assumes disposal of all 18,600 cubic yards in the Manchester Landfill.
6. The 2,200 feet of retaining walls are assumed to be almost completely removed, and the cost estimate reflects removal and disposal of all the wall material, including the footings. However, as a cost saving measure, portions of the walls could remain in place where those portions of walls are below final grade. The estimated quantity of wall to be removed is based on the cross sectional designs shown in the historical plan (Figure 3).
7. All other wood, metal, concrete, and miscellaneous debris from the demolition of the dam, retaining walls, and associated structures would be disposed of off-site at an approved site selected by the project sponsor. The material is assumed to be uncontaminated, or easily cleaned, and be suitable for upland disposal or recycling.
8. Approximately 26,000 cubic yards of material, currently behind the retaining walls of the pond will be regarded to form the subgrade of the new channel floodplains and upper terraces. This material is assumed to be suitable for this purpose. Some sorting out of larger material is assumed.
9. Control of resident geese would be needed during planting and landscaping, and would be continued through key growth years for the restoration areas.
10. Restoration of the tidal wetlands is estimated to require excavation 3 feet of plant material and soil from of 0.8 acres of riparian area currently vegetated with Phragmites. This sediment has an estimated volume of 3,900 cubic yards and is assumed to be suitable for upland disposal. Further testing may be necessary to determine this suitability and to finalize the location of the disposal site. Approximately 1,300 cubic yards of loam or topsoil would be added to the wetlands sites after excavation.

7.3 PRELIMINARY CONSTRUCTION REQUIREMENTS

Restoration of a free flowing river would require the following:

1. Placement of sediment control and flow control structures and draining the impoundment
2. Dewatering, excavation, and disposal of sediment from behind the dam
3. Demolition, removal, and disposal of the concrete dam structure (560 cubic yards)
4. Demolition, removal, and disposal of the concrete retaining walls (up to 2,300 cubic yards)
5. Demolition, removal, and disposal of concrete sidewalk (approximately 500 cubic yards)
6. Removal of existing trees in areas to be excavated, including the possible transplanting of select cherry trees along the pond (those that are healthy and can be dug successfully without substantial damage)
7. Excavation, filling, regrading, and stabilization of over 2,200 feet of channel to achieve an appropriate bankfull channel geometry, planform, and channel gradient that creates a free-flowing stream in the former Mill River Park
8. Partial removal of at least two storm drains and construction of at least two relocated outfalls into the river
9. Placement of channel bed materials, including gravel, cobbles, and boulders
10. Protection of the sewer tile pipe that crosses under the river by placing appropriately sized rock material over and downstream of the pipe
11. Placement of boulders and bioengineering treatments along the banks and within the floodplain
12. Construction of gravel and paved trails to replace existing sidewalks and trails, construction of boardwalks to access the edge of the river, and installation of other recreational improvements, such as kiosks and benches
13. Revegetation of the riparian corridor with native plant species
14. Post-construction monitoring

Restoration of the two tidal wetland sites (0.8 acres total) would require the following:

1. Excavation of approximately 3 feet of overbank sediments and Phragmites vegetation and roots from the two tidal benches (3,900 cubic yards)
2. Top dressing the sites with 6 inches of loam or topsoil (1,300 cubic yards)
3. Mulching and placement of erosion control matting and other erosion control methods
4. Revegetation with native tidal marsh plantings
5. Installation of gravel trails with boardwalk sections along the upper edge of the tidal marsh

Restoration of 1.53 acres of riparian corridor would require the following:

1. Removal of invasive vegetation (approximately 0.36 acres)
2. Planting native vegetation: tree saplings and herbaceous plantings
3. Erosion control matting and mulch installation
4. Installation of an overlook and gravel foot paths along the riparian corridor

Removal of the concrete blockage at Pulaski Street Bridge would require:

1. Demolition and excavation of approximately 560 cubic yards of concrete from the river channel with removal taking into consideration low tide periods
2. Hauling and disposal of the concrete material in a site designated by the city of Stamford

Construction would take approximately 12 months to complete, including 20 working days for mobilization and dewatering; 20 working days for sediment removal and relocation; 80 working days for demolition and disposal; 20 working days for excavation, grading, mechanical work and slope stabilization; 50 working days for planting, exotic species removal, and walkway construction; and 20 working days for cleanup and demobilization.

Disturbed areas above the bankfull channel elevation would be revegetated using native riparian vegetation as indicated on the planting plan. Before final grading, topsoil, amended as needed, would be spread and fertilized to provide an appropriate planting medium with a minimum total organic content of 4-6 percent. Soil would be tested to ensure adequate fertility before planting. Planting would be limited to the spring planting season from April 15 to June 15.

7.4 MONITORING

Monitoring of the restoration sites both prior to construction and following restoration will allow the federal government and the local sponsor to quantify and evaluate the affects of restoration. Monitoring would occur throughout the construction period and three to five years after construction completion to ensure that the river channel has been restored successfully and anadromous fish passage is successful. One monitoring requirement includes ensuring the survival of planted riparian and wetland species. Another requirement would be to ensure that the river channel and banks are stable. Monthly visits to the site during the initial growing season would ensure that plant materials are appropriately established and would allow quick remedial action if necessary. Visits to evaluate plant success would include an evaluation of the bioengineering treatments used to stabilize the channel. Fish and other aquatic life would be monitored during appropriate seasons to evaluate the effectiveness of restoring the aquatic habitat and to ensure that anadromous fish passage is successful. Site visits would be needed following major storm events that produce near, or greater than, bankfull conditions, or until the vegetation matures.

Federal cost sharing of monitoring costs is limited under Corps Regulation ER-1105-2-100, Appendix F. Cost-shared monitoring costs are normally limited to a maximum of 1% of the total project costs. The cost-shared monitoring costs are estimated to be $55,000. Monitoring would be conducted over at least the first three years after project construction is completed.

7.5 OPERATIONS AND MAINTANENCE

As with all ecologically based projects, long-term success requires continued operations and maintenance of the restored sites. Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) would be the sole responsibility of the non-Federal sponsor.

Wetland berms and any flow control structures would be checked for operation and maintenance needs. The control of resident Canada geese populations would also be a key component to the success and viability of the Mill River Park restoration. The sites need to be inspected periodically for invasive weed reintroduction. Any invasive weeds that are returning to the sites would need to be removed.

The sponsor would also be responsible for maintenance and repair of the trails, piers, boardwalks, signs, and other improvements that are part of the project.

7.6 REAL ESTATE REQUIREMENTS

Real estate costs in the study area are reflective of real estate values in urban centers of the Northeastern United States. USACE policy guidance generally requires acquisition of real estate in fee for restored sites. The recommended plan includes four major elements to the Mill River and Mill Pond Habitat Restoration Project, which are river corridor restoration in Mill River Park, riparian corridor improvements, tidal wetland restoration, and removal of impediments to fish passage. These four elements occur on nine different sites, which are composed of 12 real estate parcels. For this project, parts of two parcels (0.99 acres total) are proposed for the fee title to be held by the city of Stamford: part of Scalzi Park (0.36 acres) and part of Roger Smith Park (0.63 acres). The city owns the two parks and would be credited for any reduced appraised value to the parcels as a result of restoration restrictions and operations and maintenance requirements. Portions of nine parcels affected by the project require temporary construction easements totaling 4.21 acres to provide access to the restoration sites. These access sites are owned by the city of Stamford (some through its Housing Authority), the State Department of Education, and the State Department of Transportation.

An estimate of the affected values of the real estate to be acquired or held for the project implementation is presented in the Real Estate Report (Appendix G). The total real estate value of affected properties is estimated at $256,000. An additional $5,000 is added to the total cost of real estate for costs associated with real estate acquisition, for a total real estate contribution of $261,000. For purposes of valuing the temporary construction easements, an estimate of 10% of the per-acre land value of the parcel was used, based on communication with local officials. See Appendix G for more information.

7.7 TOTAL PROJECT COST ESTIMATE

Estimated total project cost-shared cost of $5,571,000 includes the costs of the DPR and EA ($350,000), plans and specifications ($380,000), construction ($ 4,525,000), real estate values that can be cost-credited by the sponsor ($261,000), and post-construction monitoring (55,000). Table 15 outlines the costs.

Construction-cost estimates are shown in Table 16. Appendix F provides greater detail of construction costs. Construction costs include field overhead (10%), home office overhead (6%), profit (10%), bond (1.5%), and contingency (15%). Escalation costs are not included. USACE project management expenses were estimated at approximately 11% of total project costs. Project management includes engineering ad design during construction, estimated at $122,000, and construction management, estimated at $320,000. Construction costs were estimated using the Unit Price database file in the MCASES software program, the 2003 RS Means construction cost guides, and verbal and written cost estimates, including written estimates for dewatering and disposal of the Mill Pond sediments. An MCACES-software cost analysis is provided in Appendix F.

Total recreational improvement costs that are eligible for cost sharing are estimated at $376,000 including the pro-rated costs of Engineering and Design During Construction and Construction Management. Eligible recreational improvement costs are limited under the Section 206 program to 10% of the ecosystem restoration costs. The $376,000-cost meets this cost limit, since total restoration-related costs are $5,195,000.

Table 15. Preliminary cost summary for Proposed Project.			
	Subtotals		TOTAL
PROJECT STUDY COSTS		$350,000	
PLANS AND SPECIFICATIONS		$380,000	
CONSTRUCTION COSTS			
Mill Pond Park Restoration – River Channel Restoration to Riffle/Pools	$3,597,000		
Removal of Obstruction at Pulaski Street	$150,000		
Riparian Corridor Restoration	$64,000		
Tidal Wetlands Restoration	$272,000		
Engineering and Design During Construction (Approx. 3% of Construction Costs)	$122,000		
Construction Management (Approx. 8% of Construction Costs)	$320,000		
TOTAL CONSTRUCTION COSTS		$4,525,000	
REAL ESTATE VALUE		$261,000	
POST-CONSTRUCTION MONITORING		$55,000	
TOTAL PROJECT-SHARED COSTS			$5,571,000
TOTAL OPERATIONS AND MAINTENANCE COSTS	$7,000 per year for 50-year project life		

Note: a 15-percent contingency cost is built into all cost estimates. Included in Construction costs are: Recreational Improvement Construction Costs of $339,000, plus 3% Engineering and Design Costs of $10,000 and 8% Construction Management Costs of $27,000, for total Recreational Improvement Costs of $376,000.

Table 16. Proposed Project Construction Costs.
The cost estimates shown below for the proposed project include costs for Mill Pond Park restoration with riffle/pool restoration, obstruction removal at Pulaski Street Bridge, tidal wetlands restoration, and riparian corridor restoration.

Restoration Measure	Construction Item		Subtotals	Totals
Mill Pond Park Restoration - Alternative 2 - Restore River Channel to Riffle/Pool	Mobilize/Demobilize - Total		$90,000	
	Impoundment Sediment Testing, Excavation, and Disposal [18,600 cubic yards (c.y.)]		$1,873,000	
	Relocate Utilities and Structures [500 linear feet (l.f.) total plus two outfalls]		$211,000	
	Dam Removal (556 c.y.)		$120,000	
	Reinforce Stonewall below dam (100 l.f.) with stone protection		$18,000	
	Channel Restoration	Retaining Wall (2,200 c.y.) and Sidewalk Demolition (500 c.y.)	$300,000	
		Earthwork (26,200 c.y.)	$299,000	
		Channel Bank Restoration (2,200 l.f.)	$125,000	
		Channel Bed Restoration (2,777 c.y.)	$108,000	
		Subtotal Channel Restoration	$832,000	
	Vegetation Restoration	Tree Removal for Transplant (50 each)	$30,000	
		Restoration Plantings (6 acres total, including 366 trees and 1.1 acres of shrubs and herbaceous plantings)	$180,000	
		Subtotal Vegetation Restoration	$210,000	
	Recreational Improvements	Pedestrian Trail/boardwalk System (Assumes 4,300 l.f. total gravel and bituminous trails and 1,000 l.f boardwalk and foot bridges)	$136,000	
		Recreational and Interpretive Improvements (signs, benches, trash receptacles, wooden overlook)	$107,000	
		Subtotal recreational Improvements	$243,000	
	Total - Mill Pond Restoration			**$3,597,000**
Remove Obstruction at Pulaski Street Bridge	Site Demolition (556 c.y.)		$134,000	
	Hauling and Disposal (556 c.y.)		$16,000	
	Total - Remove Obstruction at Pulaski Street			**$150,000**
Restore Tidal Wetlands	Earthwork (5,800 c.y. total excavation and fill)		$70,000	
	Invasive Vegetation Control (0.8 acre)		$50,000	
	Planting Native Species (0.8 acre total)		$44,000	
	Bank Stabilization (600 linear feet)		$27,000	
	Recreational Improvements (Assumes 1,500 l.f. gravel trail and 700 l.f. boardwalk)		$81,000	
	Total – Tidal Wetlands Restoration			**$272,000**
Restore Riparian Corridor	Invasive Vegetation Removal (0.36 acre)		$6,000	
	Bank Stabilization and Plantings (1.53 acres total)		$43,000	
	Recreational Improvements (Assumes 870 l.f. gravel trail and overlook)		$15,000	
	Total – Riparian Corridor Restoration			**$64,000**
Total Construction Costs				**$4,083,000**

Note: Costs include 15% contingency, 10% field overhead, 6% home office overhead, 10% profit, and 1.5% bond.

SECTION 8. PROJECT IMPLEMENTATION

The implementation and overall success of the Mill River and Mill Pond Habitat Restoration involves the cooperation and commitment of the USACE and the non-Federal sponsor.

8.1 NON-FEDERAL SPONSOR

The city of Stamford, Connecticut is the non-Federal sponsor for the Mill River and Mill Pond Habitat Restoration Project. As the local sponsor, the city of Stamford has agreed to fulfill the local cooperation requirements. A financing plan, or documentation of financial capability, is also required for any non-Federal sponsor prior to execution of a Project Cooperative Agreement (PCA). Project sponsorship will be formalized with the execution of the PCA. A letter of intent from the city of Stamford is included in Appendix D.

8.2 PERMITS REQUIRED

The following permits, at a minimum, are required for project construction:

- Water quality certification from CT DEP pursuant to Section 401 of the Clean Water Act
- Stream Channel Encroachment from the CT DEP
- Water Diversion from the CT DEP
- CZM consistency determination from CT Office of Long Island Sounds Program pursuant to the Coastal Zone Management Act
- Section 404(b)(1) evaluation, provided as an attachment to the Environmental Assessment in this report

Other required permits may be identified during the review process and during the plans and specifications phase.

8.3 PROJECT COST SHARING AND APPORTIONMENT

For all aquatic habitat restoration projects funded by the USACE, project costs must be shared between the local sponsor and the USACE. This study was authorized by Section 206 of the Water Resources Development Act of 1996, Public Law 104-303, and by Section 210 of WRDA 1999, which modifies portions of the earlier law. The applicable provisions read as follows:

SEC. 206. AQUATIC ECOSYSTEM RESTORATION.
(a) GENERAL AUTHORITY. – The Secretary may carry out an aquatic ecosystem restoration and protection project if the Secretary determines that the project ---
(1) will improve the quality of the environment and is in the public interest; and
(2) is cost-effective.
(b) COST-SHARING. – Non-Federal interests shall provide 35 percent of the cost of construction of any project carried out under this section, including provision of all lands, easements, rights-of-way, and necessary relocations.
(c) AGREEMENTS. – Construction of a project under this section shall be initiated only after a non-Federal interest has entered into a binding agreement with the Secretary to pay the non-Federal share of the costs of construction required by this section and to pay 100 percent of any operation, maintenance, and replacement and rehabilitation costs with respect to the project in accordance with regulations prescribed by the Secretary.
(d) COST LIMITATION. – Not more than $5,000,000 in Federal funds may be allotted under this section for a project at any single locality.

Recreational features may be added to the project and cost shared between the federal government and the local sponsor if they meet criteria in Corps of Engineers Engineering Regulations ER 1105-2-100 and ER 1165-2-501 and Engineering Pamphlet EP1165-2-502, Appendix B. Recreational features that meet the criteria are eligible for cost sharing at 50% federal, 50% local sponsor.

As the local sponsor, the city of Stamford is required to provide 35% of total project costs relating to ecosystem restoration and 50% of construction costs relating to recreation features that are eligible for cost sharing. The city of Stamford is also responsible for 100% of operation and maintenance costs for the 50-year life of the project. The Federal share is 65% of total project costs relating to ecosystem restoration and 50% of construction costs relating to recreational features that are eligible for cost sharing. Total project costs include the costs of the DPR and EA, plans and specifications, and construction. The non-Federal sponsor’s 35% cost share obligation can be in the form of a cash contribution, in-kind services, or credit for lands, easements, rights-of-way, relocations, and disposal areas (LERRDs). Prior to signing the PCA, the non-Federal sponsor must have secured funds to complete the non-Federal cost-sharing portion.

8.4 NON-FEDERAL COOPERATION REQUIREMENTS

The requirements of the non-Federal sponsor for the implementation of the proposed restoration project as outlined for Section 206 projects have been discussed with the city of Stamford. The city understands that they must enter into a legally binding PCA with USACE. Under the terms of this PCA, the non-Federal requirements for implementation of the projects are outlined as follows:

(a) Provide a minimum 35 percent of the separable project costs allocated to environmental restoration as further specified below:
(1) Provide a minimum 35 percent of plans and specifications phase costs, following execution of a project cooperation agreement.
(2) Provide, during construction, any additional funds needed to cover the non-Federal share of plans and specifications phase costs.
(3) Provide all lands, easements, rights-of-way including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project.
(4) Provide, during construction, any additional costs as necessary to make its total contribution equal to at least 35 percent of the separable project costs allocated to environmental restoration.
(b) For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in accordance with applicable Federal and State laws and any specific directions prescribed by the Government.
(c) Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project or the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.
(d) Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.
(e) Hold and save the Government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.
(f) Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as will properly reflect total project costs and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 C.F.R. Section 33.20.
(g) Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Government determines to be necessary for the construction, operation, and maintenance of

the project, except that the Non-Federal Sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

(h) Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines to be necessary for the constriction, operation, or maintenance of the project.

(i) To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

(j) Prevent future encroachments on project lands, easements, and rights-of-way, which might interfere with the proper functioning of the project.

(k) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance, of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

(l) Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

(m) Not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

8.5 FINANCIAL ANALYSIS

Table 17 summarizes the estimated total project costs. The total project cost of $5,571,000 (estimate) is within the Section 206 maximum total project cost of $7,700,000. The local sponsor would contribute $2,006,000 as its cost share, which includes 35% of total restoration-costs and 50% of recreation-related costs that are authorized for cost sharing (Table 18). In addition, the local sponsor is responsible for 100% of annual operations and maintenance and any needed repairs, rehabilitation, and replacement of improvements, and these costs are not cost-sharable with the Federal government. The non-Federal share of the total project costs can be paid in cash contributions, the value of LERRDs, and/or in-kind contributions. Total federal costs are estimated to be $3,565,000. Federal budget needs over the next several fiscal years are shown in Table 19.

Table 17. Cost Sharing of Total Project Costs (in thousands of dollars, rounded)

Task	Restoration Cost *2	Recreation Cost*3	Total Costs	Non-Federal Share *4	Federal Share*5
Detailed Project Report and Environmental Assessment	$350		$350		
Plans and Specifications	$380		$380		
Total Construction Costs	$4,149	$376	$4,525		
Post Construction Monitoring	$55		$55		
LERRDs*1 Value	$261		$261		
Total Project Costs	**$5,195**	**$376**	**$5,571**		
Total Restoration-related Costs*2	**$5,195**		**$5195**	**$1,815**	**$3,377**
Total Recreation-related Costs*3		**$376**	**$376**	**$188**	**$188**
Total Contributions	**$5,195**	**$376**	**$5,571**	**$2,006**	**$3,565**

*1 LERRDs are part of total project costs and can be credited toward sponsor's contribution.

*2 Total restoration costs are split 35% non-federal, 65% federal, including study costs, plans and specification costs, and restoration-related construction costs, LERRDS value contributed by the sponsor, and monitoring costs.

*3 Total recreation-related construction costs are split 50% non-federal, 50% federal.

*4 Non-federal share is 35% of total restoration cost plus 50% of recreation cost. Costs are contributed after signing of the PCA

*5 Federal share is 65% of total restoration cost plus 50% of recreation cost.

Table 18. Non-Federal Requirements of Total Project Costs (in thousands of dollars)

Contributions to Non-Federal Share	Amount
LERRDs	$261
Cash*1	$1,745
Work-in-Kind	To be determined
Total Contribution	**$2,006**
Annual, Recurring Costs over Life of Project	**Amount**
Annual Operations and Maintenance*2	$7,000 per year

*1 The cash amount is subject to final total project costs, and may be adjusted based on actual appraised values of LERRDS obtained after plans and specifications are completed. The cash amount may also be reduced by the value of any work-in-kind conducted after the PCA is signed and that the Corps and city of Stamford agree to include in the project.

*2 Annual operations, maintenance, repair, replacement, and rehabilitation must be paid for by the local sponsor. They are not cost-sharable with the Federal government and are not included in the local sponsor costs attributed to its 35% share. The amount shown is an estimate and is subject to change based on final design and actual operations and maintenance requirements.

Table 19. Federal Funding Needs

Task	Total Costs	Federal Share	Federal Funding Needs			
			FY03	FY04	FY05	FY06+
Detailed Project Report and Environmental Assessment*1	$350	$350	$175	$175		
Plans and Specifications*1	$380	$380		$190	$190	
Total Construction Costs	$4,525	$2,799				$2,799
Post Construction Monitoring	$55	$36				$36
LERRDs*2 Value	$261					
Total Contributions	**$5,571**	**$3,565**	**$175**	**$365**	**$190**	**$2,835**

*1 The DPR/EA and plans and specifications are initially paid for by the Federal government. The 35% non-Federal share of their costs is recovered during the construction phase. This cost also includes the cost of permitting and compliance.

***2** LERRDs are entirely the responsibility of the local sponsor.

SECTION 9. SCHEDULE FOR ACCOMPLISHMENTS

The next phase of project implementation is scheduled to begin in July 2004, subject to USACE approval of the Detailed Project Report. A Project Cooperation Agreement (PCA) between the city of Stamford and USACE is scheduled to be fully negotiated and executed by June 2005, subject to satisfactory completion of plans and specifications. This PCA is contingent upon the non-Federal sponsor securing the required cost-share not accounted for by LERRDs. Once funds have been provided by USACE -HQ through the Continuing Authorities Program, the plans and specifications phase of the project will begin.

Development of plans and specifications is expected to run from August 2004 to March 2005. Project construction will be implemented after review and certification of plans and specifications. With funding available, construction should be expected to run during the 2005 and 2006 Federal fiscal years. The construction phase would begin with the construction procurement process. The construction contract is tentatively scheduled to be awarded in October 2005. Physical construction could begin in November of 2005, and could be completed by the end of November 2006. A summary of the project schedule is provided in Table 20. This schedule is preliminary and subject to change.

Table 20. Mill River and Mill Pond Habitat Restoration Schedule Summary (Subject to Change)

Fiscal Year (FY)	Month-Year	Project Milestone
	July 2004	Complete Feasibility Phase
	Aug 2004	Begin plans and specifications
FY 05	Mar 2005	Complete plans and specifications
	Jun 2005	Execute PCA
	Aug 2005	Appraisal and Acquisition
	Aug 2005	Advertise construction contract
FY 06	Oct 2005	Award construction contract
	Nov 2005	Begin physical construction
FY 07	Nov 2006	Complete physical construction
FY 07-10		Monitor project

SECTION 10. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

10.1 FINDINGS AND CONCLUSIONS

The Main Street Dam on the Mill River in Stamford, Connecticut degrades the aquatic environment by blocking the passage of anadromous fish and altering the habitat behind the dam. In-stream habitat within Mill Pond is impacted due to low water velocity, siltation, lack of shade, shallow conditions, and apparent eutrophication. Nutrient levels, combined with the long residence time of water in Mill Pond, contribute to elevated water temperatures, algal blooms, growth of aquatic invasive species, and apparent low dissolved oxygen. Removing the Main Street Dam will enable the free passage of anadromous fish 4.5 miles upstream from the current impoundment and restoration of 5.2 miles of river in total, as well as restoring 4 acres of riparian habitat within the Mill Pond reach.

The following additional restoration actions will provide considerable gain in water quality and in-stream habitat for the Mill River corridor:

- Restoration of an additional 1.53 acres of riparian corridor through planting of native woody and herbaceous vegetation and removing exotic and invasive plant species along the riparian corridor
- Restoration of 0.8 acres of tidal wetlands along the estuarine reach of Mill River
- Restoration of fish passage near the mouth of the river by removing large concrete blocks from beneath Pulaski Street Bridge

As a recreational component to the project, a trail system will be constructed through the restoration sites to connect the greenway and parks along the river corridor. This trail system will replace the existing sidewalk along Mill Pond and the informal trail system along Mill River in the restoration sites. The trail system will protect the restoration sites from human impacts and provide opportunities for interpretation and enjoyment of the restored natural river setting.

Cost effectiveness and incremental analyses were performed to evaluate the benefits of project alternatives. The recommended alternative rated the highest, with an output of 53.9 habitat units measured as effective habitat acres, by enhancing the aquatic and riparian habitats and in-stream water quality of the Mill River. The purpose of these analyses is to ensure that the economically efficient, least-cost solution is identified for each possible level of environmental output. The Mill River restoration project reasonably maximizes environmental benefits, is cost effective, and provides aquatic habitat restoration benefits that are in the national interest.

10.2 RECOMMENDATION

I recommend that the ecosystem restoration project described in this report be approved and implemented under the authority of Section 206 of the Water Resource Development Act of 1996 (PL 104-303). In my judgment, the proposed project is a justifiable expenditure of Federal funds. The total estimated cost of the project is $5,571,000, not including operations and maintenance. Federal costs for the project are estimated to be $3,565,000. The city of Stamford is the non-federal sponsor of this project, and the non-federal contributions toward the project, excluding operations and maintenance, are estimated to be $2,006,000. Operations and maintenance, estimated at $7,000 per year for the 50-year life of the project, would be the responsibility of the city of Stamford.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are authorized for implementation funding.

Thomas L. Koning
Colonel, Corps of Engineers
District Engineer

SECTION 11. REFERENCES

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