FLOOD RISK MANAGEMENT

GENERAL REEVALUATION REPORT
&
ENVIRONMENTAL IMPACT STATEMENT
FOR
THE VILLAGE OF MAMARONECK

MAMARONECK & SHELDRAKE RIVER BASINS
NEW YORK

FINAL REPORT

US Army Corps of Engineers
New York District

JULY 2017

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
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EXECUTIVE SUMMARY

A severe flood risk persists in the Village of Mamaroneck based on the frequent recurrence of flood events and the associated damages sustained. The largest floods of record resulted from the storms of October 1955, June 1972, September 1975 and April 2007. In addition, there have been 19 other significant flood events from July 1889 to present. Extensive damages and loss of life have occurred during these major flood events. Damages within the Mamaroneck and Sheldrake River Basins for the June 1972 and September 1975 floods alone amounted to approximately $18,000,000 and $92,000,000, respectively, based on conditions of development at the time and October 2016 price levels. The flood waters from these storms inundated large areas of industrial, commercial and residential property in the Village of Mamaroneck.

There are over 700 structures in the study area, of which approximately 75% are residential. The area is fully developed and urbanized and because of its close proximity to NYC, is a commuting hub for the workforce in the region. Both rivers run along the two major transportation corridors that cross the Village of Mamaroneck: I-95 and the Metro-North Railroad, operated by the Metropolitan Transportation Authority (MTA). I-95, also known as the "New England Thruway," is the major highway between New York City and Boston and is the busiest transportation corridor in the Northeast. Regional access is provided by Metro-North Railroad commuter rail service and is a major commuter rail line, which is located near the confluence at Columbus Park. This line is known as the busiest commuter line in the nation. Access to the train station and I-95 is cut-off during storm events.

The April 2007 storm was a nor'easter that caused flood damage to over 300 residential and 100 commercial structures and disrupted the lives of thousands of people and was equivalent to the 1% flood event with estimated damages of well over $50,000,000. Floodwaters peak on the Mamaroneck River in approximately 4 hours and in approximately 6 hours on the Sheldrake River during the 1% flood event. The resident's evacuation time is severely restricted leading to high risk to life safety. Four hundred fifteen (415) repetitive FEMA Flood Insurance Claims in the Village of Mamaroneck have been recorded prior to the April 2007 flood. Repetitive claims are the result of long-time residents being unable or unwilling to move out of the flood risk area due to lack of real estate opportunities that are affordable. During the September 1992 flood, one person drowned when the car he was traveling in was swept away in the floodwaters while attempting to evacuate. Additionally, during the April 2007 flood, a person died in a house fire because flood waters prohibited emergency vehicles from responding to the person's home to provide emergency and medical care.

The Red Cross estimates indicated that more than 200 people were evacuated in the Village of Mamaroneck during the September 1975 flood. Additionally, several police, fire, schools, daycare, and senior care facilities are located within the 1% floodplain. With the rapid rate of rise of floodwaters, warning and evacuation activities are severely limited adding to the already high risk to life safety to residents and emergency responders. Flooded roadways pose significant life safety risks by impeding access for emergency vehicles and impeding travel to safety. Flood waters can elevate up to a depth of 8-10 feet, as recorded during the April 2007 flood, within 4-6 hours which leave evacuation, transportation, and

emergency services extremely limited, if not impossible. This is well represented by the two deaths that have already occurred. Based on the rapidness that disruptions occur, transportation and business disruptions are also devastating. Evacuation of schools, daycares, hospitals and senior care centers are at the greatest risk to an already vulnerable population because of impacted transportation that is located within the impacted area. The threat to life safety is realized while attempting to evacuate or during the height of the flood event because of the rapidness that the damaging flood waters rise.

Study Background

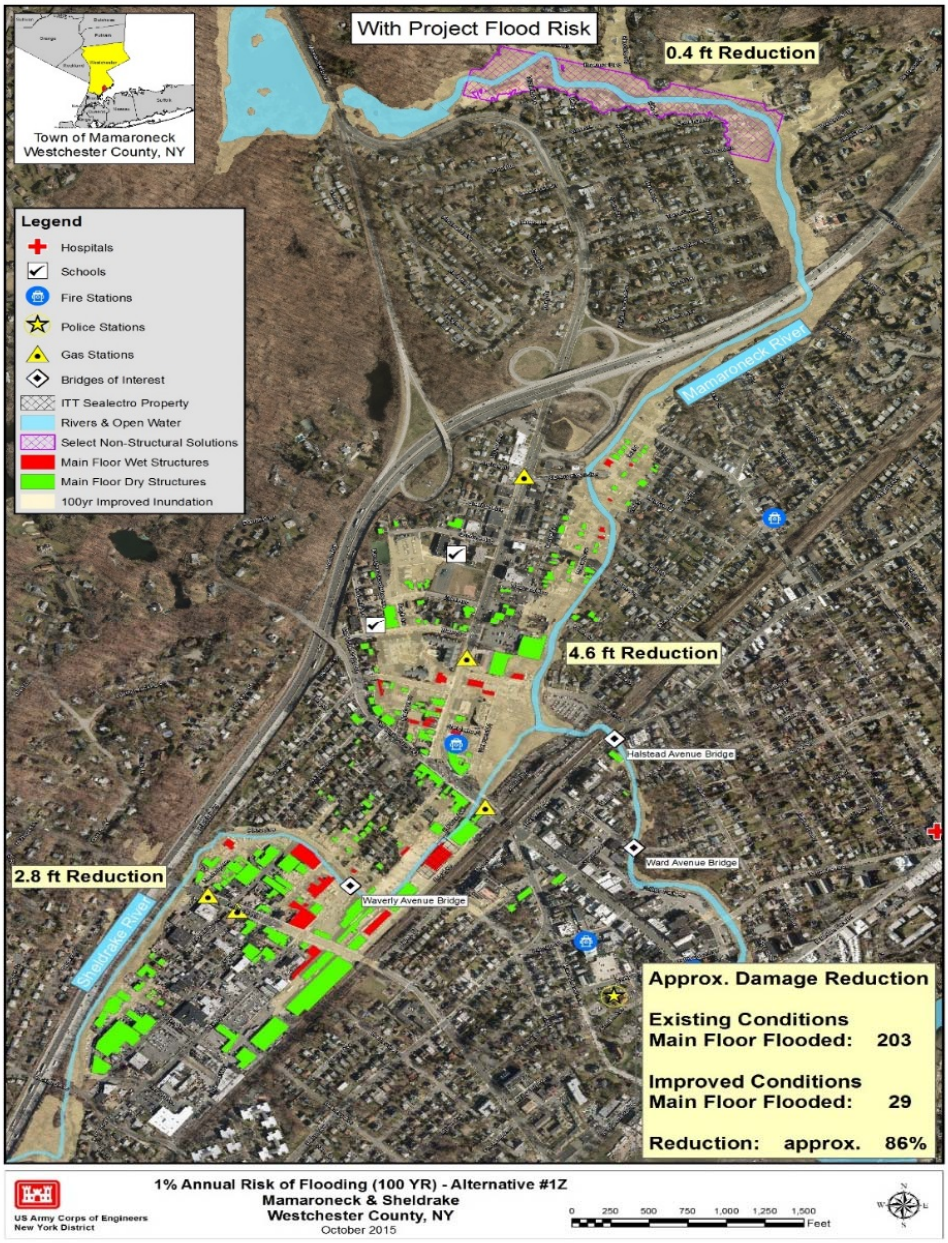
Originally, on November 17, 1986, a plan for flood risk management in the Village of Mamaroneck was authorized for construction in Section 401(a) of the Water Resources Development Act (WRDA) (PL 99-662, 99th Congress, 2nd Session). The 1989 GRR which recommended channel modification, constructing retaining walls, replacing six bridges, removing one bridge, and a diversion tunnel from Fenimore Road to the west basin of Mamaroneck Harbor. The 1989 GRR was recommended at an authorized cost of approximately $68,500,000 ($160,000,000 at October 2016 price level) but was never constructed. The 2017 GRR NED plan first cost is approximately half of the cost of the plan authorized in WRDA 1986 recommended in the 1989 GRR while providing the same project purpose and environmental outputs. The NED plan would save the federal government, non-federal partners and the local taxpayer appreciable funds for project implementation while producing the same outputs.

Recommendations

The plan recommended for construction in the 2017 Final GRR is the National Economic Development plan (NED plan) which consists of over 7,500 linear feet of channel modification work along the Mamaroneck and Sheldrake Rivers, with various channel widths and depths within the Village of Mamaroneck.

The river would be realigned at the confluence with a 25 foot wide by 8 foot high, 390 foot long culvert that would be located under the railroad station parking lot to alleviate the poor channel alignment. Trapezoidal channel improvements would consist of a natural bed channel of sloped or pitched vegetated banks. Retaining walls would be constructed in those areas where the trapezoidal channel cannot be constructed, typically where buildings, roads or other features may be affected. The channel bottom would remain natural except in the location of the Station Plaza Bridge, which currently has a concrete bottom where it crosses the Mamaroneck, and the Halstead Avenue Bridge.

Removal and replacement of existing retaining walls and utilities would be necessary along the length of the channel including Waverly Avenue Bridge and Ward Avenue Bridge. Several small bridges would be removed, including Center Avenue Bridge and two footbridges in Columbus Park, which would be replaced. In addition to channel modification along both rivers, the NED plan would have a nonstructural component along the Mamaroneck and Sheldrake rivers that includes structure elevation, ringwall levees, and/or floodproofing.



Summary of the NED Plan

NED Plan Costs and Benefits

The first cost (the present value of implementation not including inflation) for the NED plan proposed in this reevaluation totals **$82,252,000** (October 2016 price level)**.** The fully funded cost of **$93,739,000** is calculated at October 2016 price level and escalated to the midpoint of construction (March 2023), at a 2.875% interest rate and is the basis of the cost share in the Project Partnership Agreement (PPA). The cost share analysis for this project is 65 percent Federal and 35 percent non-federal. The non-federal cost share includes 100% of the cost of the estimated lands, easements, right-of-way, relocations, and disposal

(LERRD) requirements. The non-federal sponsor is the New York State Department of Environmental Conservation (NYSDEC). The Federal share of the project's first cost is **$53,464,000** the non-Federal share is **$28,788,000.**

The federal government would design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-federal sponsor. The non-federal sponsor is responsible for all lands, easements, right-of-ways, and relocations and disposal areas (LERRD) costs and all operation, maintenance, replacement, repair and rehabilitation (OMRR&R) costs. The LERRD costs are applicable to the non-federal share of the initial project costs. For example, the approximate LERRD costs of **$19,145,000** borne by the non-federal sponsor are applicable to the **$28,788,000** share of non-federal project costs. The 5% minimum cash requirement by the non-federal sponsor is calculated from structural plan costs only.

Cost Apportionment

Federal Project Cost (65%)	**$53,464,000**
Non-Federal Project Cost (35%)	**$28,788,000**
Lands & Damages	$5,001,000
Relocations	$14,144,000
5% Cash Requirement	$3,976,000
Cash or In-Kind Service balance	$5,667,000
Project First Cost*	**$82,252,000**
***Does not include OMRR&R and IDC[1]**	

Calculated at October 2016 price level 2.875% interest rate

Financial Analysis

The October 2016 first cost as noted above is $82,252,000. The fully funded cost is $93,739,000 (escalated to the midpoint of construction – March 2023). Annual costs are approximately $3,646,500 and annual benefits are $3,820,500 with a benefit to cost ratio (BCR) of approximately 1.05 which yields total annual net benefits of about $174,000 for the NED plan.

NED Plan Economic Summary

	NED Plan
Total Annual Benefits	**$3,820,500**
Total Annual Costs	**$3,646,500**
Net Benefits	**$174,000**
BCR	**1.05**

Calculated at October 2016 price level and 2.875% interest rate

[1] Interest during construction

Non-Federal Responsibility

The non-federal sponsor is the cost share partner for design and construction. During the construction phase of the project, the non-federal sponsor would acquire all LERRD detailed herein. Upon construction completion the non-federal sponsor would be responsible for the operation, maintenance, replacement, repair and rehabilitation (OMRR&R) of the project.

Consideration of future work after construction that may be proposed by the non-federal sponsor on or near the Mamaroneck River and Sheldrake River, must comply with the intent, goals and objectives of the NED plan. Modification to structures by others (such as bridges) that currently exist within the project alignment must be submitted for approval to USACE to ensure that the functionality of the project is not compromised. Further, the functionality of the project due to modifications may affect the non-federal sponsor's ability to submit a request to FEMA for revisions to the Floodplain Maps for the study area.

Environmental Analysis

The GRR report includes an environmental analysis documented in detail in an accompanying Environmental Impact Statement (EIS) conducted under the National Environmental Policy Act (NEPA). The NED plan, based on the optimal plan for flood risk management in the Mamaroneck and Sheldrake River Basins as detailed in the GRR and based on NED plan criteria, will result in an overall long-term benefit to natural resources and inhabitants of the area and region due to the substantial reduction in flood risk that will be realized.

The impacts, which are expected to have negligible cumulative effects overall, are primarily associated with sedimentation, dust and waste generated by rock excavation, the clearing and grading of construction and staging sites, and other channel modifications. In addition, the channel improvements will have long-term beneficial effects on flood-induced stream channel erosion and streambed scour.

Short-term impacts to native fish and wildlife populations within the area will be limited to the construction period. No rare, threatened, or endangered species or their critical habitat will be adversely affected by the NED plan. Impacts to vegetation resulting will be minimized and mitigated by replanting of the riparian areas to pre-construction conditions, to the maximum extent feasible.

Mitigation for adverse effects to historic properties, the Ward Avenue Bridge, Metro-North Railroad Bridge, and the stone retaining walls thematic district, will include consideration of incorporation of these elements into the NED Plan and the documentation of these resources

Summary

The primary opportunity presented in the 2017 GRR is the potential to reduce future damages to property and to decrease risks to life safety. Damages to property from such storm events present a significant risk to public health and life-safety. If storm risk management measures can be incorporated, then damage to property and loss of life may be effectively reduced and even avoided. This GRR reevaluates the studies performed for the 1977 Feasibility Report and the 1989 General Design Memorandum (1989 GDM) as well as identifies and affirms federal interest in a solution for flooding in the Village of Mamaroneck.

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PERTINENT DATA

Description

The National Economic Development (NED) plan provides for flood risk management in the form of approximately 7,500 linear feet of channel modification work along the Mamaroneck and Sheldrake Rivers, with various channel widths and depths, realignment of the confluence to Mamaroneck Harbor with a 390 foot long culvert, removal and replacement of existing retaining walls and utilities would be necessary along the length of the channel including Waverly Avenue Bridge and Ward Avenue Bridge. Channel improvements would consist of a natural bed channel of sloped or pitched vegetated banks. Retaining walls would be constructed in those areas where the trapezoidal channel cannot be constructed. In addition to channel modification along both rivers, the NED plan would have a nonstructural component along the Mamaroneck and Sheldrake rivers that includes structure elevation, ringwall levees, and/or floodproofing.

General Data

The Mamaroneck and Sheldrake River Basins study area	24 square miles
Village of Mamaroneck project area	6 square miles
Structures Impacted by a 1% Flood Event	700[2]
Population of the Village of Mamaroneck	18,929
Number of structures within the 1% floodplain	700
Number of structures within the 1% floodplain with first floor damages	203

Datums

This General Reevaluation Report has been prepared with references to the National Geodetic Vertical Datum of 1929 (NGVD29). The project datum will be updated to the North American Vertical Datum of 1988 beyond the Feasibility phase. The conversion from NGVD29 to NAVD88 in Westchester County is accomplished by subtracting 1.1 feet from the original NGVD29 elevation value, or in other words NGVD29 - 1.1 ft. = NAVD88 in Westchester County.

Project Alignment

The NED plan is presented into three (3) engineering reaches based on differing design sections – Mamaroneck Upstream, Mamaroneck Downstream and the Sheldrake.

Channel Work:	
Mamaroneck Upstream	2,300 lf
Mamaroneck Downstream	2,400 lf
Sheldrake	2,800 lf
Channel Width Size:	
Mamaroneck	45 lf
Sheldrake	25-33 lf

[2] 70 percent of structures are residential, 30 percent are commercial/industrial

Retaining Walls:

Mamaroneck	1,545; 1,715 lf
Sheldrake	5,400 lf

Nonstructural:

Mamaroneck Upstream	8 structures
Sheldrake	1 structure

Culvert:

Mamaroneck Downstream	390 lf : 25 ft wide : 8 ft high

Bridge Removal/Replacement:

Ward Avenue Bridge
Waverly Avenue Bridge
2 pedestrian bridges

Project Performance

- Estimated to reduce damages by $3.4 million annually.
- 87% reduction (percent risk) in main floor flood damage of structures.
- Provides approximately a 4.6 foot reduction in water surface elevations at the confluence (Columbus Park area).
- Provides approximately a 2.8 foot reduction along the Sheldrake River.
- Provides a non-structural solution in Harbor Heights (floodproofing and/or elevation out of the 1% floodplain).
- Reduces risk of failing existing project components such as retaining walls.
- Provides flood risk management from a 2% to a 0.5% flood event.

Real Estate Requirements

- No structures will be acquired.
- 73 permanent easements to be acquired = 53 private and 20 public = 14.3 acres
- 55 temporary easements to be acquired = 47 private and 8 public = 7.8 acres
- Relocations includes the removal and replacement of 4 bridges.

LERRD Requirement

Cost Account	Account Description	NED
01	**LANDS & DAMAGES**	**$5,001,000**
02	**RELOCATIONS**	**$14,144,000**
Total LERRD		**$19,145,000**

October 2016 Price Level, 2.875% Interest Rate

Operations, Maintenance, Rehabilitation, Repair & Replacement

The Operations, Maintenance, Rehabilitation, Repair & Replacement (OMRR&R) responsibilities as part of the NED plan include an annual survey of the project alignment to ensure that the hydraulic capacity of the project is maintained. Access to the project must be maintained for inspection and maintenance purposes. The project and areas immediately upstream and downstream would be inspected annually and the removal of debris, particularly from bridges before and after a storm event, would be performed. Shoals, debris, encroachments and heavy vegetation would be removed from the channel. Riprap erosion protection would be inspected and any broken or displaced stones repaired or replaced. The culvert under the Station Plaza parking lot would be inspected yearly for cracks, movement and sediment accumulation. Large sized sediment or significant volumes of sediment would be removed. Channel retaining walls and the culvert would be inspected yearly for cracks and movement such as sliding, rotation and tilting. Vegetation would be removed from the walls and drainage openings.

Total OMRR&R Annual Cost $357,000/year (October 2016 price level)

Economics

Project First Cost*	$ 82,250,000
Fully Funded Cost (fully funded to mid-point of construction)**	$ 93,740,000[3]
Average Annual Cost***	$3,650,000
Total Annual NED Benefits	$3,820,000
Net NED benefits	$174,000
Benefit to Cost Ratio	1.05
Base Year	2021

* Estimates based on Oct 2016 price levels
** Midpoint of construction March 2023
*** Annualized over the 50-year period of analysis using the FY17 Federal Discount rate of 2.875 %

Cost Apportionment

Federal Project Cost (65%)	**$53,464,000**
Non-Federal Project Cost (35%)	**$28,788,000**
Lands & Damages	$5,001,000
Relocations	$14,144,000
5% Cash Requirement	$3,976,000[4]
Cash or In-Kind Service balance	$5,667,000
Project First Cost*	**$82,252,000**
***Does not include OMRR&R and IDC**	

October 2016 Price Level, 2.875% Interest Rate

[3] Non-federal sponsor cost share for Project Partnership Agreement will utilize the Fully Funded Cost
[4] 5% cash requirement is calculated from structural costs only

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ABBREVIATIONS AND ACRONYMS

%	*Percent*
01:02.5	*One Vertical On Two-And-A-Half Horizontal*
1:03	*One Vertical On Three Horizontal*
§	*Section*
°C	*Degrees Celsius*
°F	*Degrees Fahrenheit*
µg/m^3	*Micrograms Per Cubic Meter*
a.m.	*Between Midnight And Noon*
AAD	*Average Annual Damages*
AADT	*Average Annual Daily Traffic*
ac	*Acre(S)*
ACHP	*Advisory Council On Historic Preservation*
AMSL	*Above Mean Sea Level*
ANSI	*American National Standards Institute*
APE	*Area Of Potential Effect*
AQCR	*Air-Quality Control Region*
ASA	*Assistant Secretary Of The Army*
BCR	*Benefit To Cost Ratio*
BERH	*Board Of Engineers For Rivers And Harbors*
BMPs	*Best Management Practices*
CAA	*Clean Air Act*
CEQ	*Council On Environmental Quality*
CERCLA	*Comprehensive Environmental Response, Compensation, And Liability Act*
CFR	*Codes Of Federal Regulations*
cfs	*Cubic Feet Per Second*
cm	*Centimeter(S)*
CMP	*Coastal Management Program*
cms	*Cubic Meters Per Second*
CO	*Carbon Monoxide*
CO_2	*Carbon Dioxide*
CS	*Coastal Shoals*
CSRA	*Cost And Schedule Risk Analysis*
CW	*Civil Works*
CWA	*Clean Water Act*
CWBS	*Cost Work Breakdown Structure*
dB	*Decibel(S)*
dBA	*A-Weighted Decibel(S)*

DDT	*Dichlorodiphenyltrichloroethane*
DEIS	*Draft Environmental Impact Statement*
District	*United States Army Corps Of Engineers, New York District*
DNL	*Day-Night Sound Level*
DO	*Dissolved Oxygen*
EAD	*Equivalent Annual Damages*
EC	*Engineer Circular*
EFH	*Essential Fish Habitat*
EGM	*Economic Guidance Memorandum*
EIS	*Environmental Impact Statement*
EJ	*Environmental Justice*
EQ	*Engineering Quality*
ER	*Engineering Regulation*
ESCP	*Erosion And Sediment Control Plan*
FEMA	*Federal Emergency Management Agency*
FR	*Feasibility Report*
FRM	*Flood Risk Management*
ft	*Foot/Feet*
FY	*Fiscal Year*
GDM	*General Design Memorandum*
GHG	*Greenhouse Gas*
GIS	*Geographic Information Systems*
GMSL	*Global Mean Sea Level*
GRR	*General Reevaluation Report*
ha	*Hectare(S)*
HEC	*Hydrologic Engineering Center*
HEC FDA	*Hydrologic Engineering Center Flood Damage Reduction Analysis*
HEC FIA	*Hydrologic Engineering Center Flood Impact Analysis*
HEC-RAS	*Hydraulic Engineering Center, River Analysis System*
HQUSACE	*Headquarters U.S. Army Corps Of Engineers*
HTRW	*Hazardous, Toxic And Radioactive Wastes*
I	*Interstate*
IBI	*Index Of Biological Integrity*
IM	*Intertidal Marsh*
in	*Inch(Es)*
IPCC	*Intergovernmental Panel On Climate Change*
km	*Kilometer(S)*
km^2	*Square Kilometers*
L_{eq}	*Equivalent Sound Level*

LER	*Lands, Easements, And Rights-Of Way*
LERRD	*Lands, Easements, Right-Of-Way, Relocations, And Disposal*
LGA	*La Guardia Airport*
LISS	*Long Island Sound Study*
LOP	*Level-Of-Protection*
LOS	*Level Of Service*
LZ	*Littoral Zone*
m	*Meter(S)*
MBTA	*Migratory Bird Treaty Act*
mi	*Mile(S)*
mi^2	*Square Miles*
MLW	*Mean Low Water*
MOA	*Memo Of Understanding*
MSC	*Major Subordinate Command*
MSFCMA	*Magnuson-Stevens Fishery Conservation And Management Act*
MTA	*Metropolitan Transportation Authority*
n.d.	*No Date*
NAAQS	*National Ambient Air Quality Standards*
NAVD	*North American Vertical Datum*
NED	*National Economic Development*
NEPA	*National Environmental Policy Act*
NEPA	*National Environmental Policy Act*
NERO	*Northeast Regional Office*
NFIP	*National Flood Insurance Program*
NJIS	*New Jersey Impairment Score*
NO_2	*Nitrogen Dioxide*
NOAA	*National Oceanic And Atmospheric Administration*
NO_x	*Oxides Of Nitrogen*
NRC	*National Research Council*
NRHP	*National Register Of Historic Places*
NYCPCC	*New York City Of Panel Of Climate Change*
NYDOS	*New York Department Of State*
NYSDEC	*New York State Department Of Environmental Conservation*
NYSDOH	*New York State Department Of Health*
NYSDOS	*New York Department Of State*
NYSECL	*New York State Environmental Conservation Law*
NYSHPO	*New York State Historic Preservation Office*
NYSM	*New York State Museum*

O_3	*Ozone*
OASA(CW)	*Office Of Assistant Secretary Of The Army For Civil Works*
OMRRR	*Operations, Maintenance, Replacement, Repair And Rehabilitation*
OPRHP	*Office Of Parks, Recreation And Historic Preservation*
OSE	*Other Social Effects*
OSHA	*Occupational Safety And Health Administration*
OST	*On Screen Take-Off*
p.m.	*Between Noon And Midnight*
PCB	*Polychlorinated Biphenyls*
PCBS	*Polychlorinated Biphenyls*
PDT	*Project Delivery Team*
PEM	*Palustrine Emergent (Wetland Type)*
PFO	*Palustrine Forested (Wetland Type)*
PGA	*Peak Ground Acceleration*
PL	*Public Law*
PM_{10}	*Particulate Matter Less Than 10 Microns In Diameter*
$PM_{2.5}$	*Particulate Matter Less Than 2.5 Microns In Diameter*
PPA	*Project Partnership Agreement*
ppb	*Parts Per Billion*
ppm	*Parts Per Million*
Project	*Mamaroneck And Sheldrake Flood Risk Management Project*
PSS	*Palustrine Scrub-Shrub (Wetland Type)*
RBP	*Rapid Bioassessment Protocol*
RED	*Regional Economic Development*
RHA	*River And Harbors Act*
SAV	*Submerged Aquatic Vegetation*
SC	*Saline Surface Waters*
SFHA	*Special Flood Hazard Area*
SIP	*State Implementation Plan*
SLC	*Sea Level Change*
SLR	*Sea Level Rise*
SO_2	*Sulfur Dioxide*
SO_x	*Oxides Of Sulfur*
SPF	*Standard Protection Flood*
spp.	*Two Or More Species*
SWPPP	*Stormwater Pollution Prevention Plan*
TSP	*Tentatively Selected Plan*
U.S.	*United States*

USACE	*United States Army Corps Of Engineers*
USC	*United States Code*
USEPA	*United States Environmental Protection Agency*
USFWS	*United States Fish And Wildlife Service*
USGS	*United States Geological Survey*
V/C	*Volume To Capacity Ratio*
VE	*Value Engineering*
VE Zone	*Velocity Zone*
VLM	*Vertical Land Movement*
VOC	*Volatile Organic Compounds*
vpd	*Vehicles Per Day*
vph	*Vehicles Per Hour*
WAC	*Watershed Advisory Committee*
WC	*Westchester County*
WCJWW	*Westchester County Joint Water Works*
WJWW	*Westchester Joint Water Works*
WPA	*Works Progress Administration*
WRDA	*Water Resources And Development Act*
WSEL	*Water Surface Elevation*

1. INTRODUCTION & AUTHORITY

A severe flood risk persists in the Village of Mamaroneck based on the frequent recurrence of flood events and the associated damages sustained. The poor flow capacity, channel bends and the small size of the bridges for the Mamaroneck River and Sheldrake River are key reasons for the frequent flooding in the Village of Mamaroneck. These constrictions cause the most extensive flood "pool" leading to significant flood damages and creating back water upstream of the confluence.

The federal government authorized the USACE to study water resource problems and potential solutions along the Mamaroneck and Sheldrake rivers in the Village of Mamaroneck, Westchester County, New York under resolutions adopted September 14, 1955 and November 14, 1955 by the United States Senate Committee on Public Works, and a resolution adopted June 13, 1956 by the United States House of Representatives Committee on Public Works (USACE New York District 2011a). Following the disastrous floods of June 1972 and September 1975, local interests requested federal assistance.

In April 1976, the Chief of Engineers, granted approval for the preparation of an interim report for the Mamaroneck and Sheldrake rivers under the Westchester County Streams Survey Investigation. The USACE conducted a feasibility study and completed the *Feasibility Report for Flood Control, Mamaroneck and Sheldrake River Basins and Byram River Basin* in October 1977 (USACE New York District 1977). The recommended plan for the Mamaroneck and Sheldrake River Basin was determined to be economically favorable. This plan was authorized for construction on November 17, 1986 in Section 401(a) of the Water Resources Development Act (WRDA) (PL 99-662, 99th Congress, 2nd Session), as follows:

> *The project for flood control, Mamaroneck and Sheldrake River Basins, New York and Connecticut, and Byram River Basin, New York and Connecticut: Report of the Chief of Engineers, dated April 4, 1979, at a total cost of $68,500,000, with an estimated first federal cost of $51,400,000 and an estimated first non-federal cost of $17,100,000. Such project shall include flood protection for the Town of Mamaroneck as recommended in the report of the Division Engineer, North Atlantic Division, dated March 28, 1978.*

The Village of Mamaroneck project was one of three independent plans that was analyzed in the October 1977 feasibility report but the only plan to be authorized under WRDA 1986. The other projects noted in the October 1977 feasibility report were the Sheldrake River in the Town of Mamaroneck, New York, and the Byram River in the area of Greenwich, Connecticut and Port Chester, New York, neither of which were authorized in WRDA 1986. These latter two projects are not addressed in this Report.

A General Design Memorandum (1989 GDM) for the Village of Mamaroneck project was completed in 1989. However, this project was not constructed due to concerns related to costs and concerns of the non-federal sponsor and other local interested parties and therefore did not advance any further.

Interest in the project was renewed following several flood events, particularly two events in the spring of 2007. In May 2007, a Presidential Disaster Declaration (Federal Emergency Management Agency [FEMA]-1692-DR, New York) was issued for most of the Lower Hudson Valley as well as other affected counties in the state, including Westchester County, in response to severe flooding resulting from the April 15–16 Nor'easter. Subsequent to the issuance of the disaster declaration, on May 25, 2007, the "U.S. Troop Readiness, Veterans' Care, Katrina Recovery, and Iraq Accountability Appropriations Act, 2007" was signed into law by the President as PL 110-28. Title V, Chapter 3, pages 51–53 of PL 110-28 states "For

an additional amount for 'Investigations' for flood damage reduction studies to address flooding associated with disasters covered by Presidential Disaster Declaration FEMA-1692-DR, $8,165,000, to remain available until expended."

On March 1, 2010, a Design Agreement for the project was executed between New York State Department of Environmental Conservation (NYSDEC) and the Department of the Army to cost share a General Reevaluation Report (GRR) to determine a technically feasible, environmentally acceptable and economically justified solution to the flood risk that plagues the study area from flood damage based on National Economic Development (NED) plan criteria.

The purpose of this document is to evaluate alternatives per Engineering Regulation 1105-2-100 §4.1 (b), which requires the preparation of post-authorization change reports when economic, engineering, or environmental conditions have changed in the study area. This GRR has been prepared to document the economic investigations, engineering analyses, and environmental considerations conducted to formulate a project for the Village of Mamaroneck, which would reduce the damaging effects of severe storms to life and property.

1.1 Study Area

The Mamaroneck and Sheldrake River Basins watersheds are approximately 24 square miles in area, and are located along the northwestern coast of Long Island Sound within the New York City metropolitan area. The Mamaroneck and Sheldrake River Basins are located entirely in Westchester County and contains portions of the Village and Town of Mamaroneck, the City of White Plains, the Village and Town of Harrison, Village of Larchmont, the City of Rye, North Castle, and the Village of Scarsdale, New York. The combined watershed of the Mamaroneck and Sheldrake Rivers have a total drainage area of approximately 24 square miles. Delineation of the 0.5% floodplain in the Mamaroneck and Sheldrake River Basins indicates the majority of the structures within the floodplain are located in the Village of Mamaroneck (Figure 1 - Mamaroneck & Sheldrake River Basins Watershed Map).

The Mamaroneck and Sheldrake River Basins is heavily urbanized and developed. The lower reaches of the Mamaroneck and Sheldrake rivers within the Village of Mamaroneck study area consist of low-, medium- and high-density residential neighborhoods as well as varied commercial (retail and office) and light industrial properties.

The majority of the study area is developed land dominated by structures, roads, and other impermeable surfaces. Many structures, backyards, roads, and developed areas (e.g., parking or storage areas) are constructed or maintained up to the edge of the streambanks. The Mamaroneck and Sheldrake river channels provide a narrow band of open water and undeveloped riparian areas that wind through the mostly developed residential and commercial areas.

The Mamaroneck River can be summarized as a narrow, partially shrub- and tree-lined river that ranges in width from 30 feet (upstream) to 50 feet wide where it discharges into the Long Island Sound. The upper reaches of the Mamaroneck River upstream of I-95 are bordered by more extensive upland and floodplain forests and shrub dominated areas, which include larger stands of riparian forest. The lower reaches of the Mamaroneck are more commonly channelized and bordered by retaining walls.

The Sheldrake River is typically narrower and more constrained by surrounding development. The upper reaches are similarly shrub- and tree-lined, but the lower reaches are more commonly confined to retaining

walls with limited riparian habitat with the channel width ranging from 5 to 15 feet. Both the Mamaroneck River and the Sheldrake River are shallow during normal flow with depth of the channels less than 5 feet.

The two rivers are commonly used as physical dividing lines between land use zones.

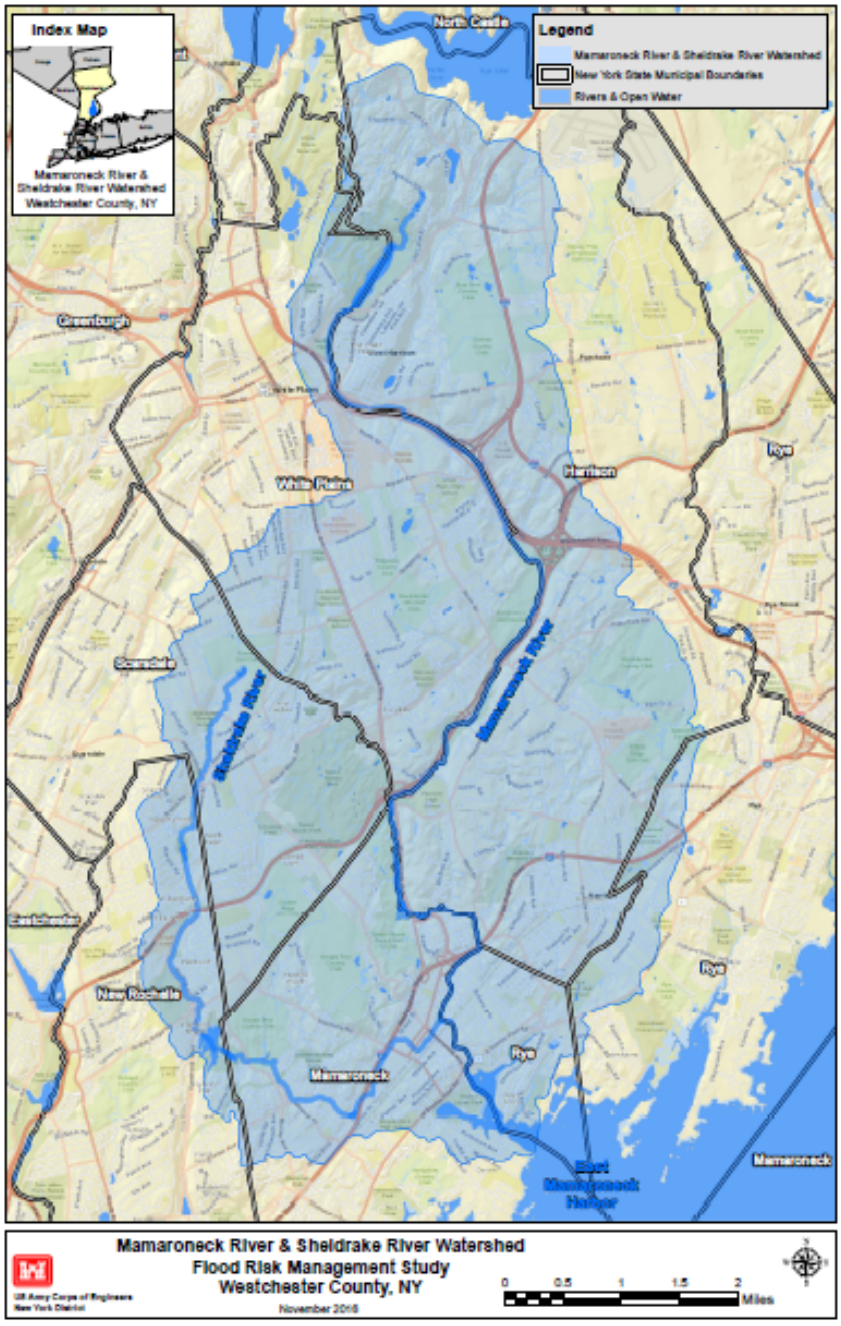

Figure 1 - Mamaroneck & Sheldrake River Basins Watershed Map

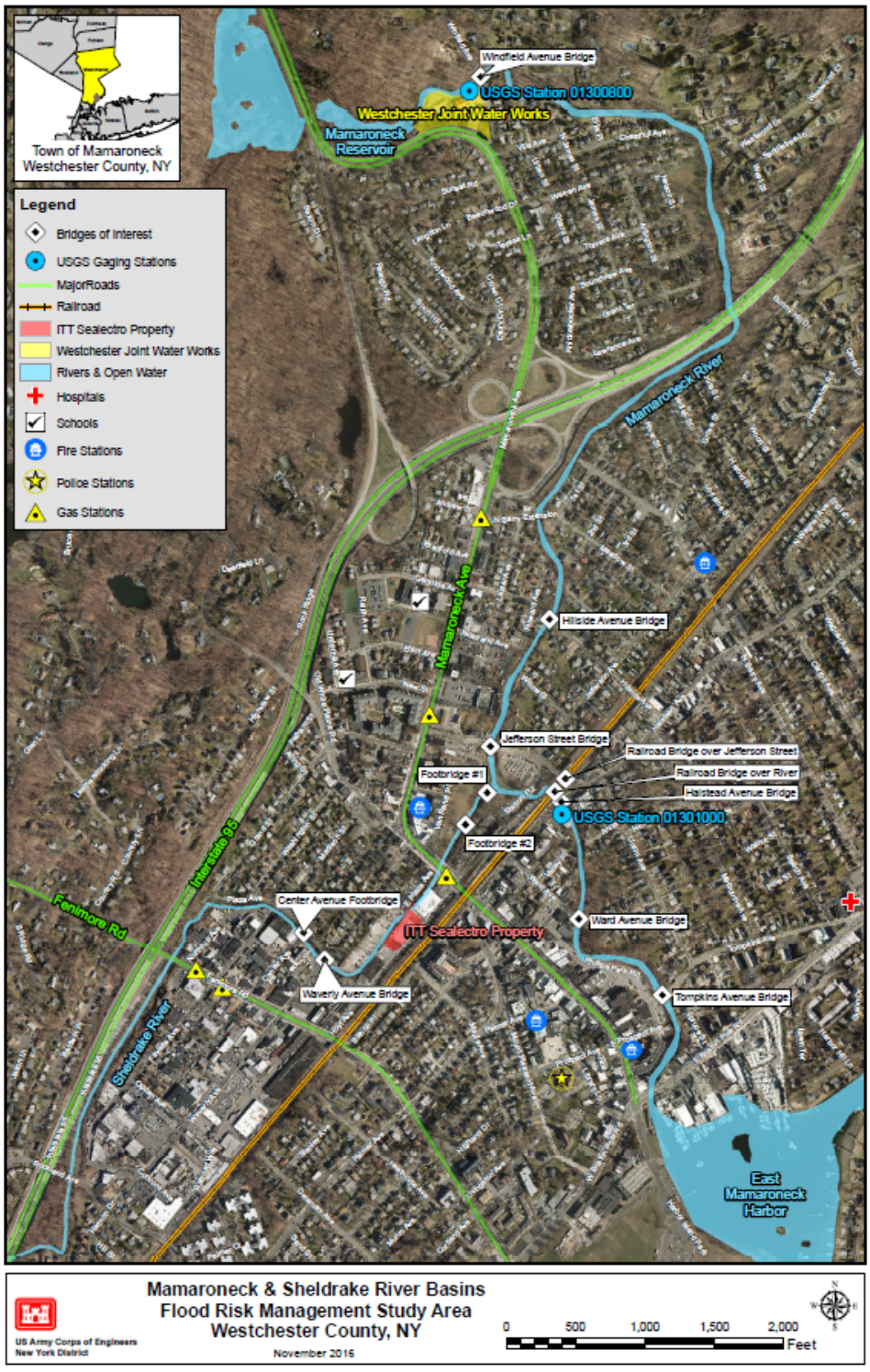

Figure 2 - Study Area

The Mamaroneck River portion of the study area Figure 2 - Study Area begins in a valley between hills that exceed 100 ft amsl at approximately 45 ft amsl southeast of the WJWW dam (USGS 1975). The Sheldrake River portion of the study area starts at the I-95 underpass at approximately 30 ft amsl. The confluence of the two streams is at approximately 15 ft amsl. Specifically, the study area is defined by the flood damage areas located in the Village of Mamaroneck and the Town of Harrison. On the Mamaroneck River, the damage area extends from below Tompkins Avenue upstream to the Westchester Joint Water Works Dam. On the Sheldrake River damages occur from the confluence with the Mamaroneck River upstream to the Village of Mamaroneck line at the New England Thruway (I-95) Bridge.

1.2 Study Purpose

The purpose of this reevaluation is to reanalyze a previously completed study, using current planning criteria and policies, which is required due to changed conditions and/or assumptions. The results may affirm the previous plan; reformulate and modify it, as appropriate; or find that no plan is currently justified. The results of the study are documented in a General Reevaluation Report (GRR). A Reevaluation Justification Report, dated February 2008 was approved by the Major Subordinate Command (MSC) in June of 2008. This reevaluation is being developed in accordance with ER 1105-2-100 §4.1 (b) dated 22 April 2000. In the approximately 27 years that have passed since completion of the 1989 GDM for this project, changes are evident and therefore reanalysis, using current planning criteria and policies, is required due to changed conditions and/or assumptions.

This reevaluation is also being conducted in accordance with the executed Design Agreement, dated March 1, 2010. The cost of the reevaluation and pre-Project Partnership Agreement (PPA) engineering and design activities is being cost shared by the non-federal sponsor, the NYSDEC with funds contributed by Westchester County, NY.

Twenty-seven years of flood history have accumulated in the Mamaroneck River Basin since the completion of the 1989 GDM hydrology (through water year 1982). Large flood-producing storms, such as Tropical Storm Floyd (mid-September 1999) and the April 2007 flood have occurred. The latter storm produced the new flood of record in the basin, surpassing the prior flood of record of September 1975 by 44.6 % in terms of gaged peak discharge. Four other floods occurred for which claims were made by the Village of Mamaroneck residents to the FEMA National Flood Insurance Program (NFIP). An updated gaged peak discharge vs. frequency analysis has shown significant increases in the smaller specific-frequency hypothetical peak flows, ranging from a 31.7% increase for the 100% peak flow to a 4.3% increase for the 4% peak flow. This would indicate that flood damages may be experienced more often and would impact the current economic analysis and benefits. New hydrologic data, i.e. rainfall data and frequency distribution curves have been developed in order to more accurately define the flood plain and identify areas in need of flood risk management efforts. In addition, the changes in construction techniques may have a positive impact on the overall cost of the project.

Major changes that have occurred since 1986 project authorization are changes to the USACE Principles and Guidelines, engineering requirements, environmental compliance and plan formulation guidance, which would have a significant impact on the economic analysis for this reevaluation.

The Village of Mamaroneck was significantly impacted by the April 2007 flooding. In addition to the devastation the residents and owners of flood-damaged property experienced, people who were not directly affected by the flood were also impacted. There were considerable transportation delays as a result of flooded roadways (including I-95), one death occurred during the flood, and residents and businesses not

directly flooded were closed for more than four days after the flood event because of damaged electric transmission lines from flooding. There was no power to a significant portion of the Village of Mamaroneck, especially the downtown area, as a result of the floods.

1.3 Study Scope

This report focuses on the flood risk management problems in the Mamaroneck and Sheldrake River Basins within the Village of Mamaroneck. It offers a recommendation on the cooperative actions that should be taken by the federal government and the non-federal sponsor of the project. The recommendation is based on the following considerations, all of which are documented in this report.

a. Identification of the flood risk management problems;
b. Relationship of flood risk management problems to the environmental and socioeconomic needs and desires of the people living and working in the study area;
c. Refinement of solutions in the 1977 Feasibility Report for protecting the flood prone areas and reducing flood risk and re-examining the National Economic Development (NED) plan in the 1989 GDM;
d. Determination of the costs and benefits as well as the environmental, social and economic impacts associated with implementing these measures;
e. Selection of the plan that would greatly reduce the flood risk in the Village of Mamaroneck consistent with planning objectives;
f. Provision for protection to emergency response and other critical lifeline facilities impacting the general health and welfare of the region, as well as facilities of public congregation such as schools, municipal buildings, etc.; and
g. Identification of the shared responsibilities of the federal government and non-federal sponsor.

h. The feasibility of flood risk management measures in the Basin will be examined by:

- Re-defining the problems, needs and opportunities for improvements associated with periodic flooding from storms within the Mamaroneck and Sheldrake River Basins New York;
- Re-evaluating the technical, economic, environmental, and institutional feasibility for federal interest in addressing flooding issues; identifying and re-evaluating potential solutions to flooding issues;
- Resolving any significant concerns and issues related to biological, ecological, and cultural resources and Hazardous, Toxic and Radioactive Waste (HTRW); and
- Determining if there is local support for implementation of the GRR tentatively selected plan.

The formulation process used in this reevaluation is consistent with the national objectives as stated in the *Principles & Guidelines (P&G)*. In flood risk management, plans must contribute to the National Economic Development (NED) account consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other federal planning requirements. Plans to address the needs in the study area must be formulated to provide a complete, effective, efficient, and acceptable plan of flood risk management. These objectives impose general planning constraints within any study area.

- **Completeness** is defined as *"the extent to which a given alternative plan provides and accounts for all necessary investments of other actions to ensure the realization of the planned effects.*

This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions of the objective."

- **Effectiveness** is defined as *"the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities."*
- **Efficiency** is defined as *"the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment."*
- **Acceptability** is defined as *"the workability and viability of the alternative plan with respect to acceptance by State and local entities, and the public, and compatibility with existing laws, regulations, and public policies."*

1.4 USACE Planning Process

The USACE Planning Process consists of six (6) steps as follows:

1) The first step of the planning process defines study area problems and opportunities, as well as study constraints, goals, and objectives. Because this is a flood risk management study, problems and opportunities are developed to address the federal objective of National Economic Development (NED). Goals, objectives, and constraints are developed to provide potential solutions to reduce flood risk and achieve the opportunities within the confines of legislative authority, policies, and other restrictions.
2) The second step in the planning process consists of the inventory and forecast of resources within the study area. This evaluation, or inventory step, accounts for the level or amount of a particular resource that currently exists within the study area, i.e., identification of existing conditions. This step also involves forecasting to predict what changes will occur to resources throughout the 50-year period of analysis, assuming no actions are taken to address the problems in the study area. Comparison of the existing and forecast conditions of the study area measures the problems resulting from the change in resources over time. Study area problems are quantified based on this predicted change in resources. This second step also results in the delineation of opportunities that fully or partially address the problems in the study area. An opportunity is a resource, action, or policy that, if acted upon, may alter the conditions related to an identified problem.
3) The third step in the planning process is to generate alternative solutions. Alternative plans are formulated across a range of potential scales to demonstrate the relative effectiveness of various approaches at varying scales.
4) In the fourth step in the planning process, alternative plans are evaluated for their potential results in addressing the specific problems, needs, and objectives of the study. The evaluation will be conducted by assessing or measuring the differences between each with- and without-project condition and by appraising or weighting those differences. This difference is referred to as the benefits of the action alternative. Criteria to evaluate the alternative plans include all significant resources, outputs and plan effects. They also include contributions to the federal objective, the study planning objectives, compliance with environmental protection requirements, the P&G's four evaluation criteria (completeness, effectiveness, efficiency and acceptability). Evaluation of the beneficial and adverse effects of the alternatives will provide a basis to determine which plans should be considered further, dropped or reformulated.
5) In the fifth step of the planning process, plans (including the no action plan) are compared against each other, with emphasis on the outputs and effects that will have the most influence in the decision making process. Beneficial and adverse effects of each plan must be compared. These include monetary and non-monetary benefits and costs. Identification and documentation of tradeoffs will

be required to support the final recommendation. The effects include those identified during the evaluation phase and any other significant effects identified in step 5. The output of the comparison step shall be a ranking of plans.

6) The sixth and final step in the planning process is the selection of the plan that best meets the study objectives and the four criteria in the Principles and Guidelines: completeness, effectiveness, efficiency, and acceptability.

Using the six-step planning process, a Tentatively Selected plan (TSP) is identified.

1.5 Non-Federal Partner & Local Stakeholders

The non-federal sponsor for this reevaluation is the NYSDEC, with the Westchester County Department of Planning serving as the local cost-sharing partner. Other municipalities involved in the development of this reevaluation include the Village of Mamaroneck and the Town of Mamaroneck. Other agencies involved in the coordination of this reevaluation include the New York Department of State (NYDOS), New York State Historic Preservation Office (NYSHPO), U.S. Geologic Society (USGS), NYSDEC, FEMA, the New York State Emergency Management Administration, the Federal Railroad Authority, as well as the U.S. Fish and Wildlife Service (USFWS).

2. PRIOR STUDIES AND PROJECTS

A feasibility report was completed in October 1977 and recommended a plan (National Economic Development plan or NED plan) of protection on the Mamaroneck and Sheldrake Rivers in the Village and Town of Mamaroneck consisting of channel modifications, levees, retaining walls and a diversion tunnel. This plan consisted of the total diversion of the Sheldrake River at Fenimore Road that would reduce the flood risk in the worst damage area, near the confluence of the Mamaroneck and Sheldrake Rivers. Additionally, the plan included a reduction in channel width on the Mamaroneck River from 70 feet to 60 feet and a deeper bottom cut. Furthermore, the plan included the construction of levees for 300 feet along the Sheldrake River near the Thruway. The feasibility report also included a plan for the Town of Mamaroneck on the Sheldrake River and also the Byram River in Connecticut. The Board of Engineers for Rivers and Harbors (BERH) transmitted the feasibility report to the Chief of Engineers on July 12, 1978. The Chief of Engineers supported the plan for the Village of Mamaroneck and for the Byram River but the Board recommended deletion of the plan for the Town of Mamaroneck due to Corps policy which deemed the problem area as local drainage and therefore a local responsibility. The Byram River plan was not authorized. The project recommended in the feasibility report was authorized for construction by Section 401(a) of WRDA 1986. As authorized, this project had an estimated cost of $68,500,000 (approximately $160,000,000 at October 2016 price level).

The 1989 GDM detailed design provided for modifying approximately 10,400 feet of river channel, constructing about 7,200 feet of retaining walls, replacing six bridges, and the removal of one bridge on the Mamaroneck River. On the Sheldrake River, modifications include a diversion tunnel 3,550 feet in length from its inlet at Fenimore Road to the west basin of Mamaroneck Harbor, channel modification along approximately 4,200 feet, and a retaining wall for approximately 900 feet (Figure 3). The 1989 GDM documented the plan as providing approximately a 0.5% long-term risk along the Mamaroneck River and the lower Sheldrake River and a Standard Protection Flood (SPF) level along the middle of the Sheldrake River. The developed project in the 1989 GDM had an estimated first cost of $67,100,000 (approximately $156,000,000 at October 2016 price level). However, this project was not constructed due to concerns relating to costs, separable element justification and concerns of the non-federal sponsor and other local stakeholders.

Previous reports on all or part of the Mamaroneck and Sheldrake River Basins are described below. Several of the reports investigated flood risk management improvements along the same reaches of the Mamaroneck and Sheldrake Rivers which are considered in this report. All of these reports were reviewed as part of this reevaluation. Please refer to Appendix A for a chronology of events that also includes a synopsis of prior studies and reports.

2.1 Prior Studies and Reports

A *Preliminary Examination Report on the Mamaroneck and Sheldrake Rivers and Bridges in the Village and Town of Mamaroneck and Town of Harrison* was completed by the New York District on August 14, 1942. This report was marginally favorable and recommended further study in the form of a survey report. However, the Survey Report, which was subsequently completed and submitted to Congress on December 9, 1948, was unfavorable.

A *Survey Report for Streams in Westchester County* completed by the New York District in May 1968 considered local protection works at the Village of Mamaroneck consisting of channel modifications with

walls and levees along the Mamaroneck and Sheldrake Rivers. The study was favorable; however, the Board of Engineers for Rivers and Harbors returned the report to the District for reconsideration. Restudy indicated the considered project was not economically feasible.

A reconnaissance report was completed in April 1973 that considered channel improvements along the Sheldrake River in the Town of Mamaroneck consisting of a reinforced concrete flume. The report was

Figure 3 – 1989 GDM Plan of Improvement

favorable, however, the cost apportioned to federal interests was in excess of the small project authority limitation, and further study was recommended under the Westchester County Streams Survey authority.

2.1.1 Other Corps of Engineers Reports

A Navigation Survey Report for the East Basin of Mamaroneck Harbor at the lower estuary of the Mamaroneck River was developed. This report resulted in the authorized federal navigation project. The first phase of the project completed in 1933 was for an entrance channel and anchorage area in the east basin of the Mamaroneck Harbor to 10 feet below mean low water. In 1939 the project was extended to the west basin including an entrance channel and an anchorage area to a depth of six (6) feet. An additional six (6) foot deep anchorage area was completed for the East Basin in 1966.

An *Interim Survey Report on Hurricane Study of Westchester County, New York along Long Island Sound*, was submitted to Congress on November 29, 1967. This report recommended that no improvements designed to protect the shoreline areas of Westchester County, New York along Long Island Sound against tidal inundation be authorized at that time. Additionally, Part Two, Chapter XXXIX (unpublished) of the report *Land and Water Resources of the New England - New York Region*, (Senate Document No. 14, 85th Congress, 1st Session), prepared by the New England-New York Inter-Agency Committee, includes a brief history of hurricane occurrences in this region, a description of the effects of coastal storm events, and a general discussion of methods of reducing damages.

2.1.2 Reports by other agencies

A report on flood conditions on the streams in Westchester County, including the Mamaroneck and Sheldrake Rivers, was submitted to the Westchester County Board of Supervisors on Storm Water Control on November 27, 1945. Major flood relief measures considered in this report included: (a) channel improvements along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, (b) the diversion of flood flows from the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, and (c) flood detention along the Mamaroneck River at the Westchester Joint Water Works (WJWW) Reservoir, along the Sheldrake River at Larchmont Reservoir #2 and on the East Branch of the Sheldrake River. This report recommended that a project consisting of channel improvement in the Village of Mamaroneck in combination with upstream flood detention be adopted to control floods along the Mamaroneck and Sheldrake Rivers.

A Reconnaissance Report, entitled *Mamaroneck and Sheldrake River Basins - Analyses of Flood Control studies*, was prepared by Dolph Rotfeld Associates and submitted to the Westchester County Department of Planning in April 1968. This report recommended (subject to further detailed studies) the use of the WCJWW Reservoir, Silver Lake, Larchmont Reservoir, Forest Lake and Spring Lake as flood risk management facilities in the Mamaroneck and Sheldrake River Basins.

A May 27, 1983 report entitled *Washingtonville Flood Control Project* was prepared by Clarke and Rapuano Inc., consulting engineers to the Village of Mamaroneck. The report recommended a series of staged channel modifications and bridge alterations to reduce flooding along the lower Mamaroneck and lower Sheldrake Rivers. The recommendations were aimed at providing some immediate flood risk management solutions at a much reduced cost when compared to the federal plan, and was also viewed by the Village of Mamaroneck as a possible non-federal contribution toward the larger plan recommended in the USACE's feasibility report.

No locally constructed project has been implemented as a result of these reports and investigations.

2.3 Existing Projects

No flood risk management projects exist in the Village of Mamaroneck or in the study area.

2.3.1 Improvements by Other Federal Agencies

No flood risk management improvements have been constructed by other federal agencies within the study basin. However, the Village of Mamaroneck has on two (2) occasions received federal funds for implementing locally-conceived flood management improvements on the Mamaroneck and Sheldrake Rivers. In 1933, using federal work relief funds, the Village of Mamaroneck cleared the channels of these streams within its corporate limits. In 1937, using Works Progress Administration (WPA) funds, the channel of the Mamaroneck River was widened to 30 feet and masonry walls were constructed from North Barry Avenue to Jefferson Avenue, a distance of approximately 2,400 feet. The WPA also funded the construction of Hillside Avenue Bridge. Only the middle 1,000 feet of this project centered on Hillside Avenue remained during the period that the 1977 feasibility report was being developed, the upper reach having been replaced by a channel relocation required for the construction of the New England Thruway and the lower reach, by channel work conducted by the Village of Mamaroneck in 1953 and 1954.

2.3.2 Improvements by Non-Federal Agencies

Numerous improvements for flood risk management, including considerable channel modification, have been made throughout the basin. In 1953-1954 the Village of Mamaroneck straightened the Mamaroneck River between Nostrand and Jefferson Avenues and deepened it between Halstead Avenue and a point downstream of the U.S.G.S gaging station weir. The 1977 feasibility report noted that this straightening and deepening of the Mamaroneck River resulted in lower stages than would otherwise have prevailed during the substantial floods which have occurred since the completion of this referenced work.

In connection with the construction of the New England Thruway in the early 1950's, the Mamaroneck River channel was improved within the reach of stream extending from the vicinity of the south end of First Street to the Town of Harrison boundary line for a total of 1,800 feet. Wider channels on better alignments were provided and the old low, short-span bridge at North Barry Avenue was replaced with a higher, longer triple-span structure on a new alignment several hundred feet downstream of the old bridge. Also, in connection with the construction of the Thruway, two reaches of channel of the Sheldrake River totaling nearly 3,000 feet in length within the reach of stream extending from the vicinity of Larchmont Gardens Lake to a point 600 feet below Fenimore Road were replaced with wider reaches on better alignments. Additionally, old, low, short-span bridges at Rockland Avenue and Fenimore Road were replaced with higher, longer twin-span structures.

3. EXISTING CONDITIONS

The Planning process requires an inventory of existing conditions in the study area and serve as the basis for the characterization of problem identification and projection of future without project conditions. This section details the existing conditions within the study area.

3.1 Socioeconomics

The 2010 U.S. Census data indicates that the population of the Village of Mamaroneck is 18,929, the number of households is 7,693, and the population density is 5,971 people per square mile (Table 1). The Census data also indicates that the population for the state of New York has increased by 2.1% since year 2000, and Westchester County increased by 2.78%, while the population of the Village of Mamaroneck increased nearly 1%. Table 1 compares the Village of Mamaroneck demographics to Westchester County and those of New York State.

Table 1: 2010 Demographics

	New York State	Westchester County	Village of Mamaroneck
Population (2010 census)	19,487,053	949,113	**18,929**
Population *	19,651,127	968,802	**19,237**
Area (mi^2)**	54,555	500	**6.7**
Density (ppl/sq-mi)	411	2,205	**5971**
Housing Units*	8,113,270	369,996	**7,693**
Median Value of Housing Units*	**$288,200**	**$518,400**	**$582,800**

**2013 American Community Survey Estimates*
***USGS, Total Area including water area*

3.2 Land Use & Cover

Community planners have categorized the Village of Mamaroneck into 11 land use zones, including waterbodies (Figure 4; Village of Mamaroneck 2012b). The combined Mamaroneck-Sheldrake river system crosses nine of these land use categories, five of which are predominant within the study area. The land use categories within the study area excluding *Waterbodies* are:

Residential – Residential land use is the dominant land use in the study area and also accounts for the majority of the Village of Mamaroneck's land area. Residential use includes single-, two-, and multi-family residences, apartments, townhouse complexes, and condominiums in a mix of low-, medium- and high-density residential neighborhoods. Residential uses account for the vast majority of the Village of Mamaroneck's land area. Residential characteristics vary from waterfront estates, suburban developments, apartment houses, townhouse complexes, condominiums, apartments above storefronts, and single- and two-family houses. Older residences were not constructed to minimize flood impacts. Recent housing developments concentrate many dwellings within smaller footprints and have been constructed to comply

with flood elevation standard. However, these structures are still threatened with emergency service access issues and damage to vehicles and utility services during flood events.

Manufacturing/Industrial – The Sheldrake River flows along and through the Manufacturing/Industrial zone, which is located on the west side of the Village of Mamaroneck. This zone includes commercial and light manufacturing, auto-repair shops, wholesale and trucking operations, and warehouses, as well as a few residences. Much of this area lies within the 1% floodplain. The largest community and institutional uses within the Village of Mamaroneck include the water-treatment plant, the Village Hall, Mamaroneck Avenue School, and Mamaroneck High School.

The industrial area of the Village of Mamaroneck is located in the northwest, bounded by the railway to the south, Fenimore Road to the west, the New England Thruway to the north and Rockland Avenue to the east. This area is located in the M-1 (Industrial) zoning district, and since 1968, residences have been a non-conforming use. Several residential uses remain interspersed among the industrial businesses.

Commercial/Office – The Village of Mamaroneck has several concentrations of commercial retail and office space (along Mamaroneck Avenue, East and West Boston Post Road, and Halstead Avenue). The Mamaroneck River flows through or alongside a large portion of the central business district. Many of these businesses are in the floodplain. The traditional commercial and service core of Mamaroneck was centered along Mamaroneck Avenue between the Boston Post Road and Halstead Avenue. Recent growth has brought commercial uses, such as service and retail to the entire length of Mamaroneck Avenue and the Boston Post Road.

Transportation/Utilities- Both rivers run along the two major transportation corridors that cross the Village of Mamaroneck: I-95 and the Metro-North Railroad, operated by the Metropolitan Transportation Authority (MTA). I-95, also known as the "New England Thruway," is the major highway between New York City and Boston and is the busiest transportation corridor in the Northeast (Village of Mamaroneck 2012a). Regional access is provided by Metro-North Railroad commuter rail service (the New Haven Line) that operates between New York City and New Haven, Connecticut with branches to Waterbury, Danbury, and New Canaan, Connecticut (MTA 2013 and Metro-North Railroad 2013a). The New Haven Line is a major commuter rail line that offers a 40-minute train ride to Midtown Manhattan and has a busy station (i.e., Mamaroneck), which is located near the confluence and adjacent to Columbus Park. This line is known as the busiest commuter line in the nation. Due to the heavily urbanized and developed nature of the Mamaroneck and Sheldrake River Basins, 2 inches of rainfall in 24 hours or 4 inches in 48 hours can cause the rivers to flood, and residential roadways can retain as much as 3 ft of water for several days after heavy rains have subsided (USACE New York District 2011a). Access to the train station is cut-off during storm events.

Open Space – The study area includes several recreational areas which are impacted during flood events. Columbus Park, located at the confluence of the Mamaroneck and Sheldrake rivers is the largest Village of Mamaroneck park within the study area (6 acres). This popular park, which contains a playground, basketball courts, benches, walking paths and footbridges across the rivers, is unique because it offers one of the few areas along the Sheldrake River where development does not encroach up to the river's edge. Columbus Park experiences substantial flooding problems during high flow periods following storm events. The park is adjacent to the train station and commercial areas. During flood events, the park is inaccessible and vehicles within the park are susceptible to damage. There is currently very limited public access to the Mamaroneck and Sheldrake rivers. Much of the property abutting the Mamaroneck

and Sheldrake rivers is privately owned (mostly residential) and is therefore unavailable for public open space and recreational use.

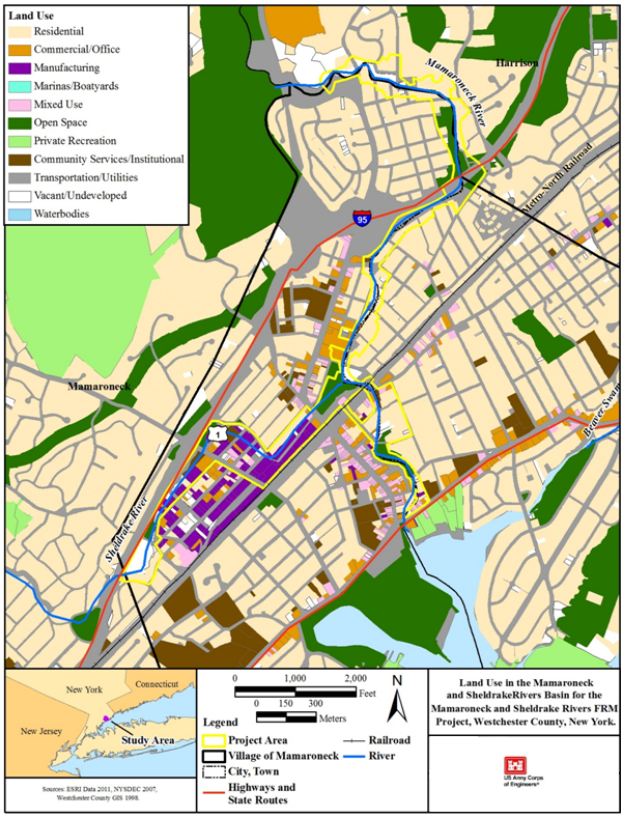

Figure 4 - Land Use in the Mamaroneck & Sheldrake River Basins

3.3 Hydrological Existing Conditions

While excessive rainfall does contribute to flooding, flooding events are caused by a number of variables, only one of which is rainfall. Conditions such as the amount of impervious cover in the watershed, the degree to which soils are already saturated at the time of the storm, whether there is snow on the ground or whether the ground is frozen, all play a role in flooding. For these reasons, a 1% storm event, 24-hour rainfall may not necessarily cause a 1% flood event.

The 1% rainfall event is calculated largely using regional data sources and predictive modeling programs and is presented as the total inches of rainfall in a variety of time periods such as 1-hour, 6-hour, 12-hour, 24-hour (the 24-hour period is often used as the default). The hydrologic analysis conducted for this reevaluation was based on observations at existing river gauges within the study area during storm events, providing a much higher data resolution and level of accuracy. While this may differ from methodologies used by other federal agencies, this yields more accurate results than similar analyses prepared using only rainfall data. The data and model used in this reevaluation may be used by non-federal partners for purposes such as submission of a request to FEMA for revisions to the Flood Insurance Rate Maps for the study area.

The hydrologic analysis for existing conditions included data gathered from peak discharge records, average discharge, storm types, and the storms of water years 1990 through 2010. The storms for water years 1990-2010 are of concern, because these storms occurred after the gage at Halstead Avenue (the Mamaroneck gage) was discontinued at the end of water year 1989, downstream of Halstead Avenue, the major calibration point of the hydrology of this reevaluation. Analysis indicated that the seven most important storms of these water years are those of May 17, 1990; April 16, 1996; October 19, 1996; September 15-16, 1999 (Tropical Storm Floyd); September 8, 2004; October 7-16, 2005; and the April 2007 storm. This last important storm resulted in the current largest historic flood to date in the Mamaroneck and Sheldrake River Basins.

The hydrologic modeling procedure of the current effort is both a continuation and an update of the hydrologic modeling that was completed for the 1989 GDM. The update included an uploading of the HEC-1 model used for the 1989 GDM to the current hydrologic computer program HEC-HMS. Other updates include percent impervious area values, storage-discharge data, flood frequency analysis of the USGS gage on the Mamaroneck River downstream of Halstead Avenue. Additionally, the hydraulic model was calibrated to the high water marks of the largest historic flood. The quality and accuracy of the hydrologic model from the 1989 GDM was verified by using it to accurately reproduce two historic floods that had occurred since the completion of the hydrology of the 1989 GDM; those of July 1984 and May 1989. The April 2007 flood was also reproduced and confirmed by the hydraulic model's calibration to its high water marks.

The flood frequency analysis of the USGS gage on the Mamaroneck River downstream of Halstead Avenue had to be updated from the 1989 GDM. The methodology for this update is included in detail in Appendix C1-Hydrology. The result was a homogeneous sample of annual peak discharges, representing current hydrologic conditions, from which an accurate and valid existing conditions peak discharge vs. frequency calculation was made.

The existing conditions peak discharge vs. frequency curve for water years 1938, and 1944 through 2010, for the long term USGS gauge Mamaroneck River at Mamaroneck at Halsted Avenue was computed. The hydrologic model of the Mamaroneck and Sheldrake River Basins was calibrated to this peak discharge vs. frequency curve. This was performed to compute existing conditions specific-frequency hypothetical peak discharges throughout the basin, including the locations at which flood risk management measures are proposed.

Floods modeled included the historic April 2007 flood, and the hypothetical 100%, 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.45 and 0.2% flood events[5]. A comparison was made between the current existing conditions peak discharge vs. frequency curve at the Mamaroneck gage and the frequency curve in the 1989 GDM (Table 2). The differences between the two curves are documented and explained, as provided in Appendix C1 along with the reasons why the current frequency curve is an improvement over, and more accurate than, the frequency curve in the 1989 GDM.

Table 2: Comparison of Peak Discharges (1989 GDM vs. 2017 GRR)

Frequency[5]	Peak Discharge from 1989 GDM (cfs)	Peak Discharge from current GRR (cfs)
100%	1,230	1,620
50%	1,680	2,140
20%	2,300	2,870
10%	3,000	3,370
4%	3,980	4,150
2%	4,950	4,740
1%	6,000	5,350
0.5%	7,100	5,990
0.4%	7,500	6,200
0.2%	9,050	6,860

3.4 Existing Conditions Hydraulics

The combined watershed of the Mamaroneck and Sheldrake rivers drains into Long Island Sound at the East Basin of Mamaroneck Harbor. The watershed is roughly elliptical shaped, with a maximum length of nine miles in a north-south direction and a west to east width that varies from two to three miles (total of 24 square miles). Ground elevations range from near sea level at the mouth of the Mamaroneck River to about 500 feet above mean sea level in the northwest corner of the basin. As with most urban rivers, extensive development in the basin, right up to the riverbanks, has resulted in changes in the hydrologic regime and morphology of the rivers.

The Mamaroneck River is a natural stream with perennial flow that runs from north to south within the study area. The Mamaroneck River enters the northern portion of the study area southeast of the dam at WJWW. The river continues east and then south under several road crossings and pedestrian bridges before it empties into the East Basin of Mamaroneck Harbor to the Long Island Sound. The river has moderate meander and is confined by rock retaining walls for much of its length. Within the study area, the Mamaroneck River ranges in width from 30 to 50 ft (water and bank), and in depth less than 5 ft.

The Sheldrake River is a natural, perennial stream that flows generally south-southeast for a distance of about 7.0 miles and joins the Mamaroneck River at a point about 0.6 miles above its mouth. The Sheldrake

[5]

1-year (100% flood event)
2-year (50% flood event)
5-year (20 % flood event)
10-year (10% flood event)
25-year (4% flood event)
50-year (2% flood event)
100-year (1% flood event)
200-year (0.5% flood event)
250-year (0.4 % flood event)
500-year (0.2% flood event)

River enters the southwest portion of the study area at the I-95 underpass. The river continues under several road crossings and pedestrian bridges before it empties into the Mamaroneck River at Columbus Park. The river has moderate meander and is confined by rock retaining walls for much of its length. Within the study area, the Sheldrake River ranges in width from 5-15 ft (water and bank), and in depth from approximately 10 inches to more than 36 inches in pools. The river has been confined with hardened shores along most of its length in the Village of Mamaroneck. The complete discussion of the hydrology and hydraulics existing conditions of the Mamaroneck and Sheldrake River Basins may be found in Appendix C. A summary is presented below.

The hydraulic reevaluation extends a distance of 2.5 miles from the mouth of Mamaroneck River upstream to the WJWW Dam. The study area also extends a distance of 1.0 mile along the Sheldrake River from its confluence with the Mamaroneck River upstream for to the I-95 Bridge. The hydraulic model limits are defined by flood damage areas located in the Village of Mamaroneck and the Town of Harrison, NY. Along the Mamaroneck River, the model area extends from below the Rt. 1 Bridge to above the WJWW Dam. On the Sheldrake River, the model extends from the confluence with the Mamaroneck River to the Village of Mamaroneck boundary at the New England Thruway (I-95) Bridge.

The hydraulic analysis of the Mamaroneck and Sheldrake Rivers is based on a steady state numeric model using the Hydraulic Engineering Center, River Analysis System (HEC-RAS). The existing conditions HEC-RAS model of the study area was divided into three hydraulic reaches: Mamaroneck Upstream, Mamaroneck Downstream, and Sheldrake. A total of 176 channel cross-sections, 21 bridges, and two dam structures were surveyed and used in the HEC-RAS hydraulic model. The existing conditions hydraulic profiles for the Mamaroneck River are shown in Figure 8 and Figure 9 and Figure 10 for the Sheldrake River. Note that the reach of the Mamaroneck River downstream of the confluence is characterized by water surface elevation (WSEL) in a step-like pattern caused by the bridges and channel contraction, a major source of flooding. The calibrated HEC-RAS model of the Mamaroneck and Sheldrake Rivers was used to determine the WSEL for the 100%, 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.45 and 0.2% events. Figure 5 illustrates the 1% floodplain versus the 0.1% floodplain. Figure 6 illustrates the location of the Village of Mamaroneck bridges.

The Mamaroneck River flows into Long Island Sound, therefore a tidal-fluvial correlation was performed to analyze the harbor elevations that may occur due to tide and surge during a typical fluvial event. Based on the tidal-fluvial correlation and hydraulic analysis, a weak correlation between the low frequency tidal and fluvial events was found. Also, the influence of high tides during fluvial events on the Mamaroneck River does not extend beyond Tompkins Avenue Bridge.

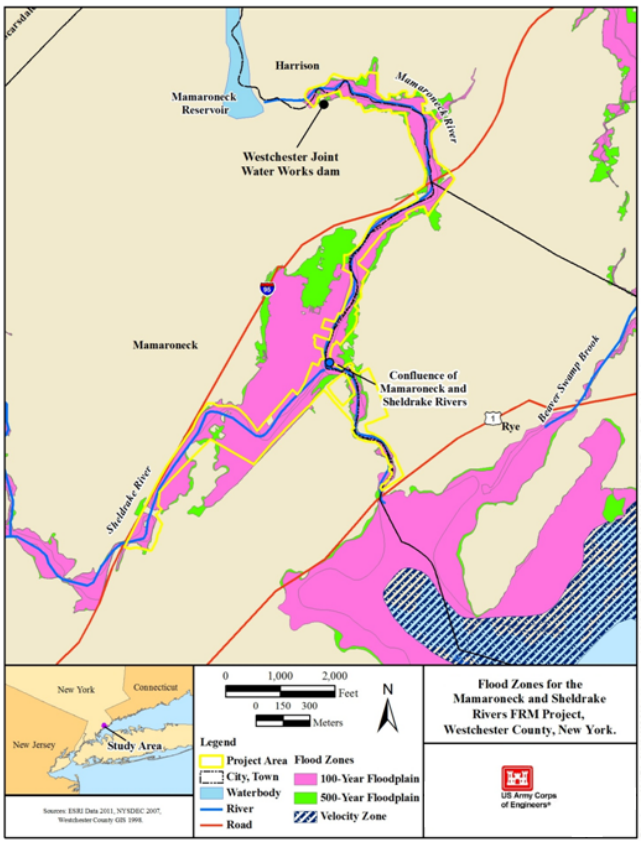

Figure 5 - Village of Mamaroneck– 1% and 0.5% Floodplain Map

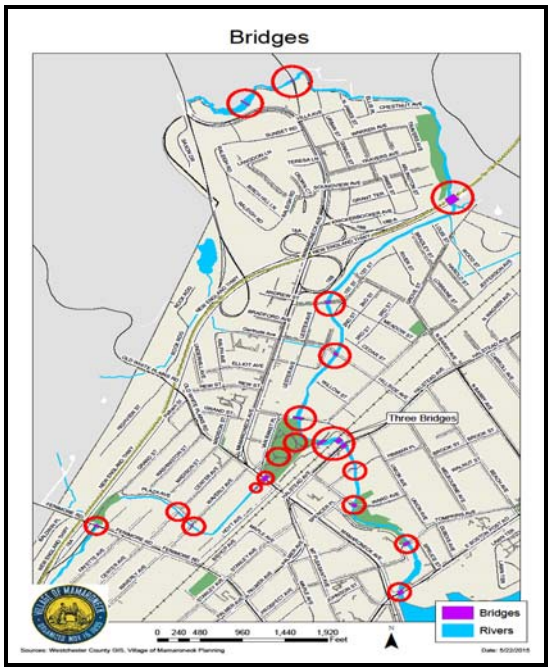

Figure 6 - Watershed Bridge Locations

3.4.1 Economic Reaches

In order to conduct economic benefit analyses, the study area has been divided into three streams containing 13 economic reaches; five along the Mamaroneck River downstream of its confluence with the Sheldrake River, four along the Sheldrake River, and four along the Mamaroneck River upstream of the confluence. The upstream and downstream limits of the reaches were selected to be consistent with the hydrologic/hydraulic modeling. A summary of the economic reaches is presented in Table 3 and Figure 7.

Table 3 Summary of Economic Reaches

Stream	Reach	Description
Mamaroneck Downstream	MD1	Harbor to Tompkins Ave Bridge
	MD2	Tompkins Ave Bridge to Ward Ave Bridge
	MD3	Ward Ave Bridge to Valley Place Bridge
	MD4	Valley Place Bridge to Halstead Ave Bridge
	MD5	Halstead Ave Bridge to confluence
Sheldrake	S1	Confluence to Mamaroneck Ave Bridge
	S2	Mamaroneck Ave Bridge to Fenimore Ave Bridge
	S3	Fenimore Ave Bridge to Rockland Ave Bridge
	S4	Rockland Ave Bridge to upstream of I-95 Bridge
Mamaroneck Upstream	MU1	Confluence to Hillside Ave Bridge
	MU2	Hillside Ave Bridge to I-95 Bridge
	MU3	I-95 Bridge to Winfield Ave Bridge
	MU4	Winfield Ave Bridge to Mamaroneck Reservoir Dam

3.4.2 Stream Channel Erosion and Streambed Scour

Lateral streambank erosion (channel widening) and/or streambed downcutting (scour) are typically associated with flood events and impact slope stability and pose a hazard to nearby structures and utilities. Channel widening is defined as the erosion and subsequent recession of one or both streambanks that widens the channel without changing the channel location. Streambed scour is erosion of the streambed resulting in the development of deep pools and/or the systematic lowering of the channel floor elevation. Streambed scour also may result from the passage of debris flows and debris torrents. The Mamaroneck and Sheldrake rivers have an extensive history of flooding, as well as channel erosion and streambed scour.

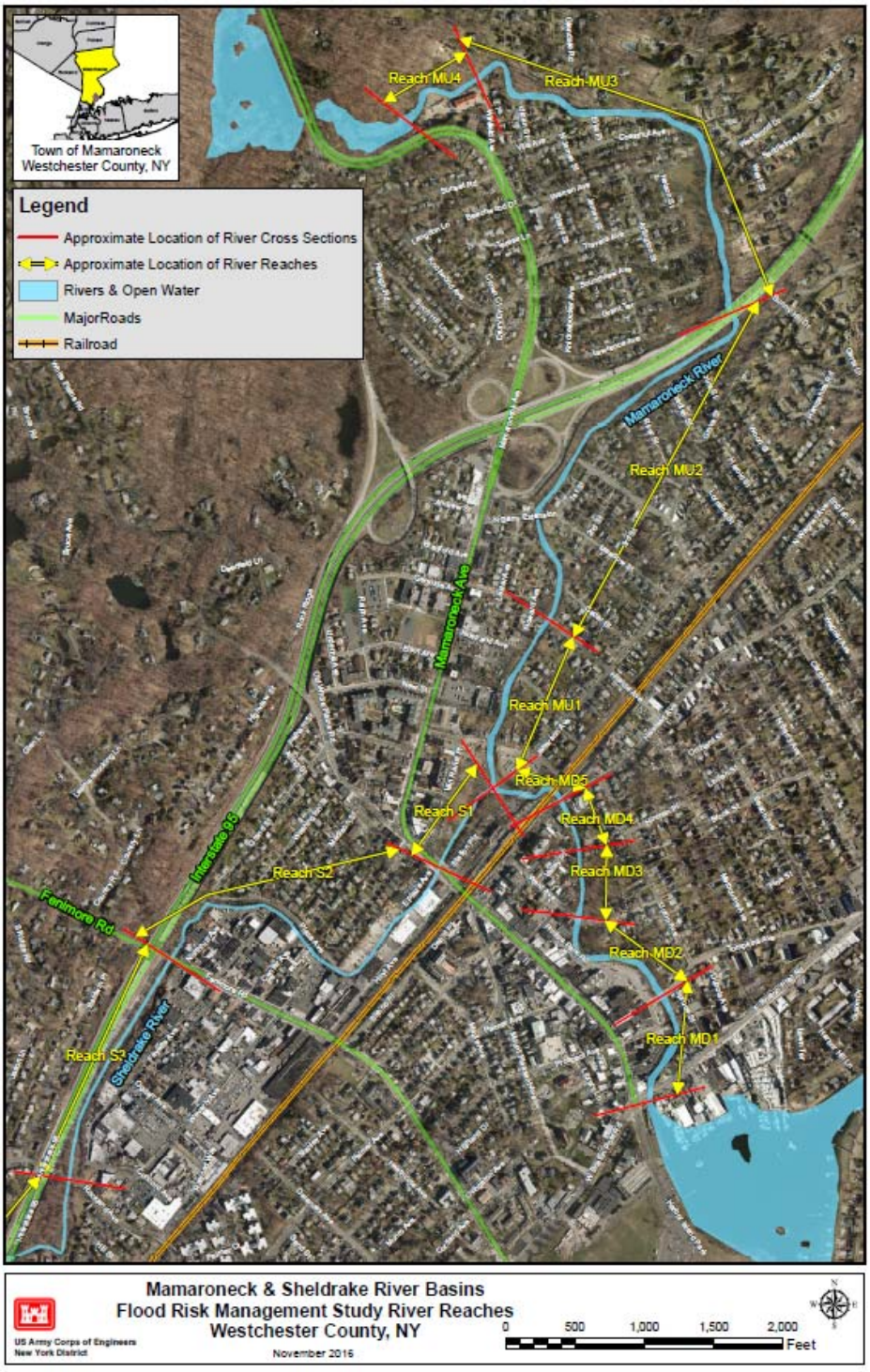

Figure 7 - Study Area Hydraulic and Economic Reaches

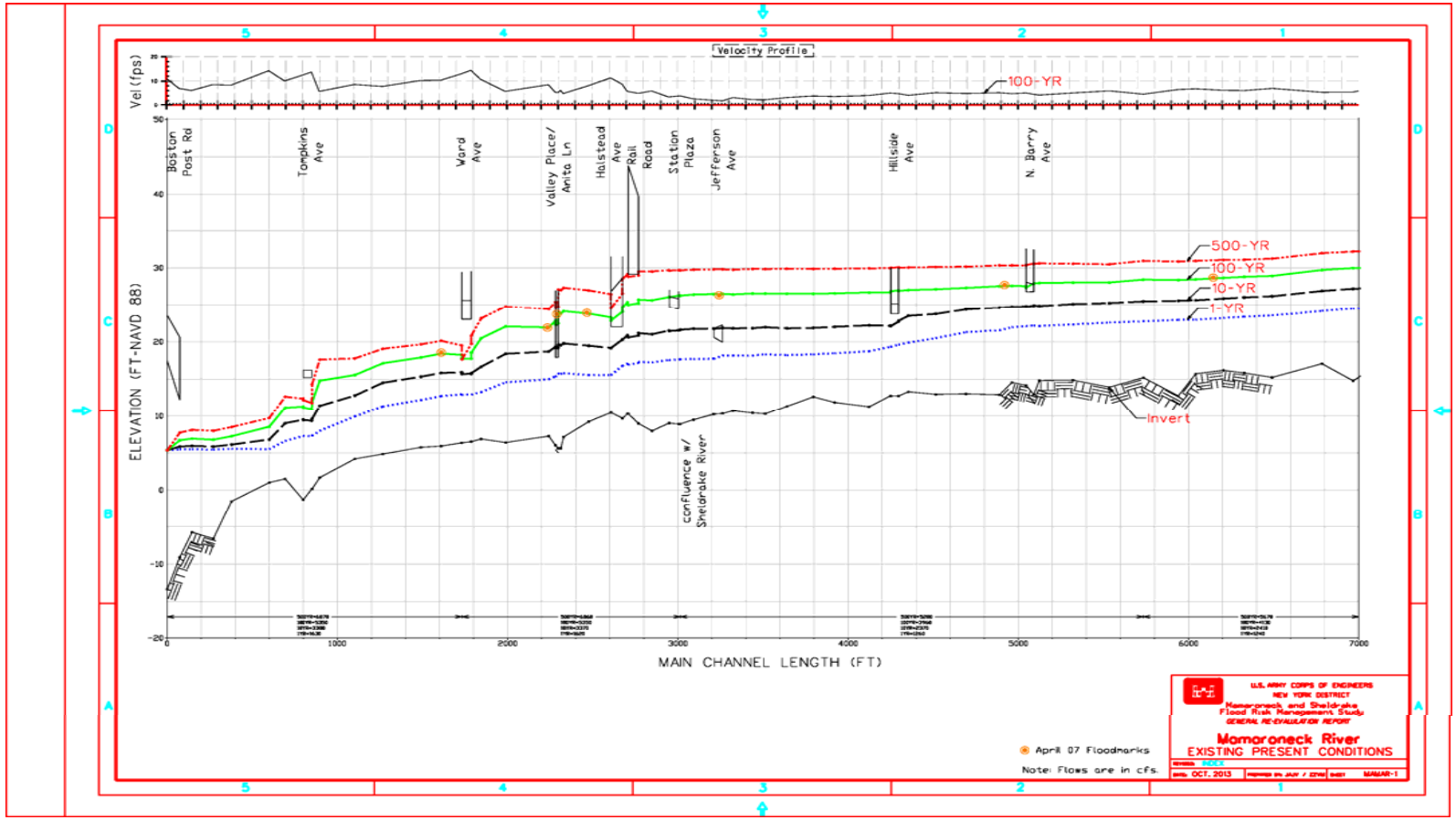

Figure 8 - Mamaroneck River Existing Conditions Hypothetical Event Profiles - ExistingCond_Mamaroneck

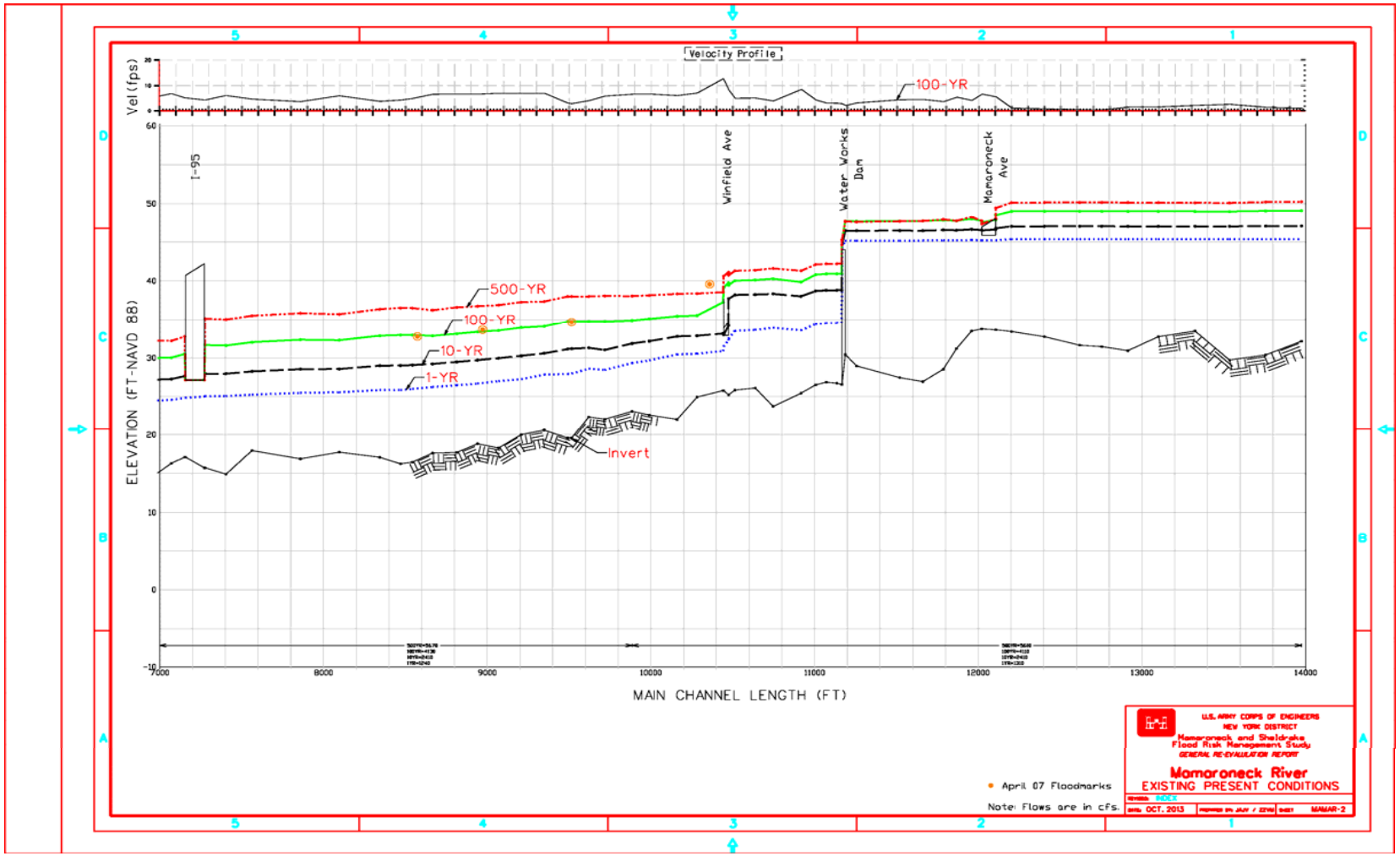

Figure 9 - Mamaroneck River Existing Conditions Hypothetical Event Profiles- ExistingCond_Mamaroneck2

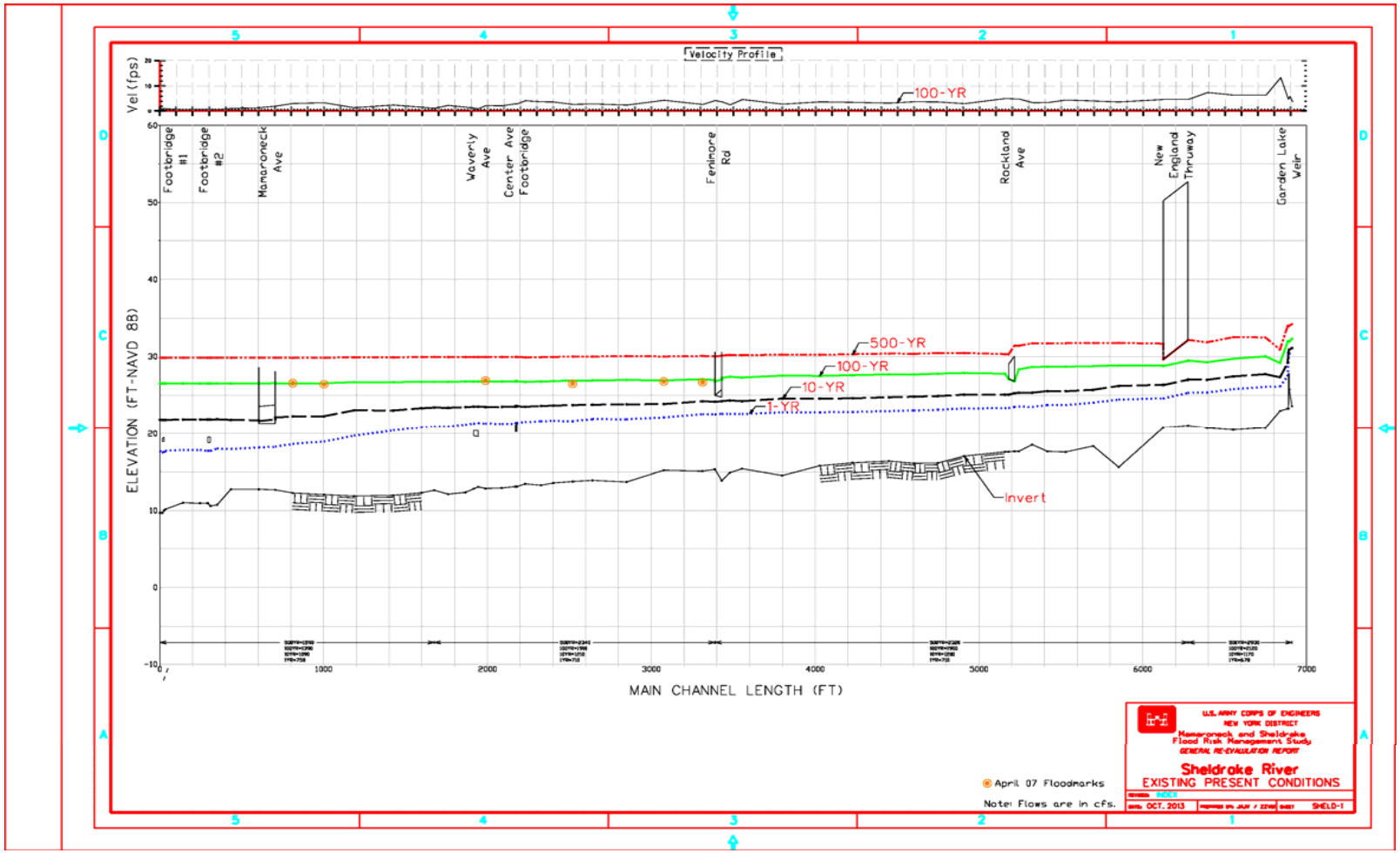

Figure 10 - Sheldrake River Existing Conditions Hypothetical Event Profiles- ExistingCond_Sheldrake1

3.5 Environmental Resources

3.5.1 Water Quality

The Lower Mamaroneck River and the Sheldrake River from Columbus Park to the Larchmont Reservoir, are listed on the New York State 2010 Section 303(d) List of Impaired Waters and are impaired for fish consumption, aquatic life and recreation. A 2008 biological assessment of the Mamaroneck River in the vicinity of Ward Avenue determined this segment had poor water quality and was not fully supportive of aquatic life. Fish consumption in the waterways is impaired due to pesticide levels in contaminated sediment. Aquatic and recreational uses are considered impaired by nutrients as well as silt and sediment loads associated with urban stormwater runoff and other non-point sources (NYSDEC 2010).

3.5.2 Wetlands

Wetland communities are relatively uncommon within the study area due in large part to development in the surrounding area as well as the rock retaining walls and riprap that line much of the Mamaroneck and Sheldrake rivers (Figure 11). It is estimated that nearly 60% of wetlands that occurred within the Mamaroneck River Watershed have been destroyed (Westchester County 2001). The NYSDEC (1974) Tidal Wetlands Inventory Maps indicate tidal wetlands within the study area boundary (Figure 12). The NYSDEC (2011a) Freshwater Wetland Map does not indicate any wetlands within the study area boundary.

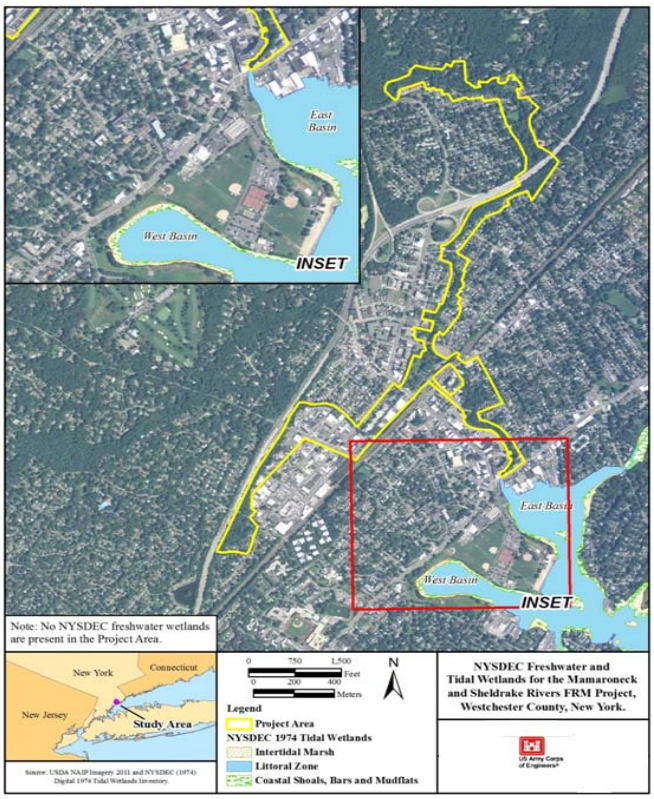

Figure 11 - NYSDEC Freshwater and Tidal Wetlands for the Mamaroneck and Sheldrake Rivers

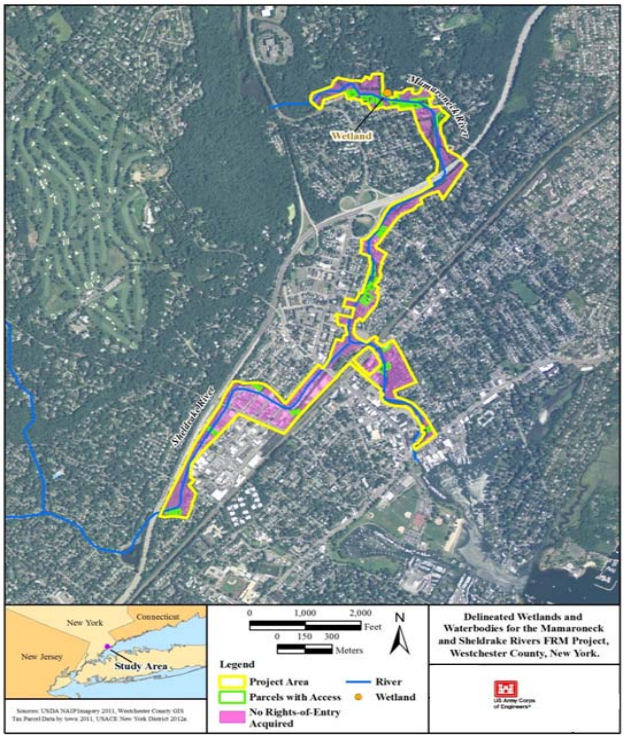

Figure 12 - Delineated Wetlands and Waterbodies for the Mamaroneck and Sheldrake Rivers

3.5.3 Vegetation

The majority of upland within the study area is commercial, residential, or transportation development. Vegetated uplands are mostly maintained lawns dominated by a variety of common native and non-native grass species with narrow bands of small trees and shrubs lining both rivers. Native vegetation is outcompeted by non-native species. A geographic information system analysis of mature trees located within the study area footprint identified less than six non-contiguous, linear acres.

3.5.4 Rare, Threatened, Endangered and Special Concern Species

Approximately 150 New York State special status species are known to or have the potential to occur in Westchester County (Young 2010; see Attachment A of the EIS). Review of the federal threatened and endangered species lists available for Westchester County did not identify any federally-listed plant species with the potential to occur in the study area (USFWS 2015). The study area also was analyzed using the NYSDEC Environmental Resource Mapper, which displays the location of all State listed species in New York (NYSDEC n.d.). This desktop review did not identify any known occurrences or observations of rare plants within the study area. Due to the highly developed nature of the study area, and the limited amount of quality, suitable habitat to support rare plant species, state or federal rare, threatened, and endangered species are not likely to occur.

In accordance with the Fish and Wildlife Coordination Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 *et seq*.) USFWS has prepared a Fish and Wildlife Coordination Act Report (FWCAR) for the Project (see Attachment C of the EIS). Review of the federal threatened and endangered species lists available for Westchester County identified three federally listed species that have the potential to occur in the county:

the federally endangered Indiana bat (*Myotis sodalis*) and the federally threatened bog turtle (*Clemmys muhlenbergii*), and the northern long-eared bat (*Myotis septentrionalis*) (also known as northern myotis and eastern long-eared bat) (USFWS 2012). Two additional species with the potential to occur in Westchester County are New England cottontail (*Sylvilagus transitionalis*), a federal candidate species for listing; and the bald eagle (*Haliaeetus leucocephalus*). Although the bald eagle has been federally delisted, it is still protected by the Bald and Golden Eagle Protection Act (16 USC 668–668c) and the MBTA. Habitat to support New England cottontail, bald eagle, and bog turtle are not present in the study area. Although the study area may contain suitable roosting and foraging habitat for the Indiana bat and the northern long-eared bat (NYSDEC 2013f), the developed and urbanized nature of the study area (e.g., high ambient light levels; lack of large, contiguous forested blocks) substantially lower the likelihood for the Indiana bat and the northern long-eared bat to be present. A review of the study area using the NYSDEC Environmental Resource Mapper tool did not identify any state listed wildlife species (NYSDEC n.d.).

3.5.5 Birds

Nearly all migratory bird species that have the potential to occur in the study area are protected by the Migratory Bird Treaty Act (MBTA) (16 USC 703–712). Under the MBTA, federal project proponents are required to comply with the provisions of the MBTA that do not allow intentional or unintentional take of migratory birds.

3.5.6 Fish

A fish survey conducted within the study area of the Mamaroneck and Sheldrake rivers in 2011 identified American eel, bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), redbreast sunfish, pumpkinseed, brown bullhead (*Ameiurus nebulosus*), largemouth bass (*Micropterus salmoides*), tessellated darter (*Etheostoma olmstedi*), and white sucker (USACE New York District 2011e). The most abundant species collected within the Mamaroneck River just upstream from Columbus Park were American eel, redbreast sunfish, and white sucker. The most abundant species collected within the Sheldrake River at Columbus Park were tessellated darter, white sucker, American eel, and pumpkinseed.

Based on the analysis of fish species collected during the 2011 fish survey within the study area, water quality within the Mamaroneck and Sheldrake Rivers is marginal as it pertains to aquatic resource habitat. Based on the 2011 fish data collected, both of the reaches sampled in the study area had an Index Biological Integrity of poor. Rivers and streams in the "poor" category have low species richness and are dominated by generalists and tolerant species, with no piscivores (excluding eels). None of the fish collected in the 2011 survey exhibited signs of disease or parasites, or had any observed deformities, erosion, lesions, or tumor anomalies.

3.5.7 Benthic Resources

Benthic resources are described as the community of plants and animals that reside on or in the bottom sediments of oceans, streams, and wetlands. In general, water quality in the Mamaroneck River is considered to be poor and aquatic life is not fully supported in the river. A stream bioassessment of the Mamaroneck River conducted by NYSDEC in 2000 determined that macroinvertebrate communities are moderately impacted by poor water quality caused by urban stormwater runoff (USACE New York District 2011a).

3.5.8 Mammals

Mammalian species have been documented at the nearby Greenburgh Nature Center in southern Westchester County and also likely occur within the study area where suitable habitat exists. These species may include common species such as the little brown bat (*Myotis lucifugus*) (Greenburgh Nature Center 2003).

3.5.9 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA [PL 94-265]), as amended, is the primary law governing the conservation and management of fisheries in federal waters of the United States. Review of EFH designations available on NOAA Fisheries Service's EFH-mapper website did not identify any EFH or Habitat Areas of Particular Concern within the study area (NOAA Fisheries Service Habitat Conservation Division n.d. a). However, the EFH summary for the area that includes Mamaroneck Harbor identifies 16 fish species with designated EFH (NOAA Fisheries Service Habitat Conservation Division n.d. b).

3.6 Environmental Justice

The Village of Mamaroneck, itself, neither in percentage of minorities nor the percentage of incomes below the federal poverty level meets the state or federal Environmental Justice criteria. However, within the Village, there are two census block groups, one along the Sheldrake River and one along the Mamaroneck River, within the project area that meet federal and state minority and poverty level Environmental Justice criteria

3.7 Cultural Resources

The Area of Potential Effect (APE) coincides with the project boundaries along the Sheldrake and Mamaroneck Rivers. There is one National Register of Historic Places (NRHP) listed property, the Mamaroneck Railroad Station at Station Plaza, within the APE. A survey undertaken in 2011 identified additional properties that have the potential to be eligible for the State and National Registers (Blair, Wheeler and Kirk 2012). Those within the APE include the Ward Avenue Bridge, built by the Works Progress Administration (WPA) and a portion of the WPA stone retaining walls built along the Mamaroneck River and earlier stone retaining walls built along the Sheldrake River.

3.8 Coastal Zone Management

The entire Village of Mamaroneck, including the study area, is entirely located within the New York-designated coastal zone management area that is associated with Long Island Sound (New York State Department of State [NYSDOS] Coastal Management Program [CMP] 1999). Pursuant to 15 CFR Part 930.34(b) of the federal Coastal Zone Management Act, USACE New York District must evaluate the Preferred Alternatives and consult with the CMP to ensure that the Preferred Alternatives are consistent with the 44 NYSDOS CMP Coastal Policies as refined in the Village of Mamaroneck's Local Waterfront Revitalization Program (LWRP), and that neither would have undue adverse impacts on New York coastal zone resources (NYSDOS CMP 2001). The 44 New York State Coastal Policies are grouped together to address issues related to development, fish and wildlife resources, flooding and erosion hazards, general issues, public access, recreation, historic and scenic resources, agricultural lands, energy and ice management, and water and air resources in New York-designated coastal zone areas. To ensure that the

Preferred Alternatives are consistent with NYSDOS' Coastal Policies (and associated LWRP Policies) and would have no undue adverse impacts on New York coastal zone resources, the District must coordinate and consult with the NYSDOS CMP and other agencies.

3.9 Hazardous, Toxic and Radioactive Waste (HTRW)

The Resource Conservation and Recovery Information System (RCRIS) database identified one site within the area of the proposed project. This site, located at 160 Jefferson Avenue, is situated directly on the Mamaroneck River, just above the confluence with the Sheldrake River. An above ground storage tank with toluene was removed from the site, but the site has remained on the list.

The ITT Sealectro Site is located along the Sheldrake River within the study area and is a designated NY State Superfund site. The site is located on the Sheldrake River at 139 Hoyt Avenue in Mamaroneck. The site, which is .092 acres, consists of a single story building built on a concrete slab. The building is now occupied by the Half-Time Beverage Distributors. From 1960 to 1990, ITT Sealectro manufactured electronic parts and jewelry at the Site and the company used machine oils and cleaning solvents in its manufacturing operations. Spent solvents, electroplating waste and fuel leaked from underground storage tanks. From 1991 to 1992, ITT Sealectro conducted interim remedial measures including the removal of contaminated soil, the removal of underground storage tanks and the installation and operation of two groundwater recovery treatment systems (one for halogenated solvents and one for petroleum-related product floating on top of groundwater). The groundwater quality is continually monitored and the water treatment system was rebuilt in 2008 after it was damaged in the April 2007 flood.

4. FUTURE WITHOUT-PROJECT CONDITIONS

The future without project condition serves as the base condition for all the alternative analyses. The future without project conditions in the Village of Mamaroneck within the period of analysis are identified as continued flooding from future storm episodes, and continued maintenance and reconstruction following storm events.

The future without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis. The period of analysis is determined to be from 2021, the year that construction is implemented and construction is complete for a period of 50 years. In the absence of federal action, flooding problems associated with rainfall events in the study area are expected to continue. These problems may be exacerbated by increased damage potential in the floodplain of the Village of Mamaroneck within the Mamaroneck and Sheldrake River Basins, based upon increases in the values of structures and contents, and by climate change, leading to an increase in intensity and frequency of storm events. Given federal, state, county and local regulations, it is expected that there will be limited additional development within the basin in the future period of analysis.

In general, review of historical trends have illustrated that there has been negligible change in the floodplain because it has been fully built out for decades. Therefore, it is reasonable (and supported by the local floodplain management plan and hazard mitigation plan) that no appreciable changes to the floodplain would be realized in the FWOP condition.

4.1 Socioeconomics

Analysis of population trends from the Census indicate that population increase from 2000 to 2010 was only 1%. Because the Village of Mamaroneck is fully developed, future population increase is expected to be negligible.

4.2 Future Land Use

Westchester County planning officials, and representatives of the Village of Mamaroneck, and other communities within the basin, were consulted about possible future development of the undeveloped land areas. The results included the development of six (6) golf courses within the watershed municipalities as the most likely future development. Increases from existing conditions peak discharges were small, 30 cfs at most for the 1% flood event.

Examining the land use patterns within the Mamaroneck and Sheldrake River Basins, it is clear that this will continue to be a very urbanized watershed. Following the river from its headwaters in the Town of Harrison, to the mouth at the Village of Mamaroneck, most of the watershed has been developed and is characterized as residential, commercial or industrial development. Many of these have been constructed to the edge of the river banks. Within the state of New York, if applicants for new construction can show that their facilities will not increase the 1% flood elevation, they are generally permitted to build flood proofed structures where the lowest floor including any basement, must be at or above the base flood elevation plus two feet beginning in 2007. Refer to the Economics Appendix (Appendix D) of this report for additional future land use and development details for municipalities within the 24 square miles river basin.

4.3 Future Without Project Hydrologic Conditions

Future values of sub-basin percent impervious area were estimated from this input, and input to the hydrologic model of the basin. The model was then run to compute future unimproved conditions peak discharges throughout the basin. Increases from existing conditions peak discharges were small, ranging from zero to 2.3%. The existing conditions and FWOP conditions are, therefore, expected to be the same in that the floodplain is completely built out and intensification is not expected. Further, review of historical trends have illustrated that there has been negligible change in the floodplain because it has been fully built out for decades. Therefore, it is reasonable (and supported by the local floodplain management plan and hazard mitigation plan) that no appreciable changes to the floodplain would be realized in the FWOP condition.

4.4 Future Without Project Hydraulic Conditions

The hydraulic analysis of the Mamaroneck and Sheldrake Rivers is based on a steady state numeric model using the Hydrologic Engineering Center, River Analysis System (HEC-RAS). The technical approach of the numerical modeling involves two phases prior to providing the improvement alternatives. The first phase, the existing condition hydraulics, is described above and in greater detail in Appendix C. Phase two addresses the future without project conditions including an evaluation of future conditions considering the effect of the land use changes over the period of analysis on the hydrologic and hydraulic characteristics of the Mamaroneck and Sheldrake River Basins. Future unimproved WSEL for the 100%, 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.45 and 0.2% flood events were computed in the existing conditions hydraulic model. Because there was only a small increase in the flows between existing conditions and the future unimproved conditions, there is no increase in damages expected for the future unimproved conditions due to the change in flows.

4.5 Sea Level Change

Department of the Army Engineering Circular EC 1165-2-212 requires that each civil works project take into consideration the effects of potential sea level change (SLC) over a 50-year period. Additionally, the Department of the Army Engineering Technical Letter, ETL 1100-2-1 provides procedures to evaluate sea level change: Impacts, responses, and adaptation. Department of the Army Engineering Manual, EM1100-2-8162 requires the use of three scenarios, at a minimum, to estimate future sea levels. These scenarios are a low rate that shall be based on an extrapolation of the historical tide gauge rate and intermediate and high rates that include future acceleration of global mean sea level (GMSL). The effects of vertical land movement (VLM) must also be considered as a component of relative sea-level rise. The low rate of future sea-level change is based upon the historic rate of SLR in the vicinity of the study area ("regional" sea-level rise). Forty-three years of data from the National Oceanic and Atmospheric Administration (NOAA) tide gauge at Bridgeport, Connecticut were used. These data indicate an upward trend of 2.56 mm/year (+/-0.10 in/yr) with a 95% confidence limit of +/- 0.58 mm/year (+/-0.02 in/yr).

In consideration of VLM, it is assumed that the regional mean sea level trend is equal to the global, or "eustatic," mean sea level trend, which has been determined by the International Panel on Climate Change (IPCC 2007a) to be 1.7 mm/year (+/-0.07 in/yr), +/- 0.5 mm/year (+/-0.02 in/yr). Removing the eustatic SLR component from the regional sea level rise would isolate the regional rate of VLM. The result obtained is 0.86 mm/year (0.03 in/yr), or a total of 0.12 ft of VLM subsidence over the 50-year period. The low, intermediate and high rates of future SLR (i.e.; Type I, II and III) are determined from the modified National Research Council (NRC -1987) eustatic sea-level change scenarios and the IPCC (2007).

Relative Sea Level Rise (RSLR)* was computed for the period of 50 years from 2015 with an increment of every 5 years and included the VLM. Changes in RSLR and VLM can be seen in Table 4. Isolating just SLR by removing the effects of local VLM (subsidence) over the 50-year period yields 0.30, 0.7 and 2.06 ft for the low, intermediate and high rates modified National Rate Council (NRC) respectively. These results are in accordance with NYSDEC as projections based in IPCC were adopted by the New York City of Panel of Climate Change (NYCPCC). Results indicate that fluvial flooding in the existing channel is not impacted by the Sea Level Rise (SLR) and therefore, flood damage estimates would not be impacted by SLR.

Table 4: Estimates of Sea Level Change (SLC) and Vertical Land Movement (VLM) 2% Storm Event

Year	Type I	Type II	Type III	VLM (ft)
2015	0.0	0.0	0.0	0.0
2020	0.05	0.08	0.16	-0.01
2025	0.09	0.14	0.31	-0.02
2030	0.13	0.21	0.49	-0.03
2035	0.17	0.29	0.68	-0.04
2040	0.21	0.37	0.88	-0.06
2045	0.25	0.46	1.11	-0.07
2050	0.29	0.55	1.36	-0.08
2055	0.33	0.64	1.62	-0.09
2060	0.37	0.74	1.91	-0.11
2065	0.42	0.82	2.18	-0.12

** Based on NRC -1987 and the IPCC (2007). Required by ER-1100-2-8162*

Higher downstream water levels resulting from future sea level change would not have an effect on the study area. The projected rise in sea level would only extend as far upstream as the Tompkins Avenue Bridge. The main damage areas are approximately 2,000 feet upstream and 10 feet higher than the Tompkins Ave area. The first significant damage elevations in the study area are at about elevation 20 ft (NAVD 88) which is well above the elevation of any recent coastal storm. The lowest significant damage elevation in the study area is 20 ft. NAVD'88, which is about a 2,000-yr. coastal event. Sea level change is expected to have major impacts on direct coastal flooding and wind-wave erosion along the Mamaroneck Bay shoreline, including impacts to properties and critical infrastructure; however reevaluation does not conduct an analysis of conditions associated with coastal flooding. It is limited to river flow related events and is not impacted by sea level rise projections.

4.5.1 Climate Change

NOAA Technical Report NESDIS 142-1 states that the historic annual increase in precipitation is statistically significant. This report also states that there is a "substantial decadal-scale variability" associated with extreme precipitation. Therefore estimates of the 2% and 1% events are very sensitive to the 10 to 30-year period of record used to compute these estimates. Finally the report states that there is great uncertainty associated with model simulation predictions of future precipitation increases. Preliminary results presented by Geoff Bonnin of the National Weather Service at a National Dam Safety

Technical Seminar in Feb 2014 indicate that climate change appears to be impacting frequent events like the 1% to 10% event but there is little to no significant impact on large major events like the 2% and greater. Therefore, it is more probable in the future that the Village of Mamaroneck, without any flood risk management implementation, will experience an increase in flood damages due to frequent storm events. However, larger flood events may not be affected based on climate change estimates.

4.6 Risk & Uncertainty Analysis for Unimproved Conditions

The uncertainty associated with the computed water surface elevations (WSELs) or stage was evaluated by conducting a sensitivity analysis. The goal or overall approach was to develop realistic upper and lower bounds on the computed stage for a given discharge. The hydraulic characteristics considered in developing the upper and lower bounds were the Manning's n-value, debris jams at bridges, channel bed changes and changes in the Mamaroneck Harbor sea level, which is the downstream boundary condition in the HEC-RAS model. To account for the debris during a storm and to develop the upper uncertainty boundary, most bridge parapets were considered to be blocked.

In addition, select bridge low cords were lowered by a foot and all bridge pier sizes were increased by a foot to model debris accumulation. To account for the lack of debris and to develop the lower uncertainty boundary, selected bridge parapets that were blocked in the calibration or base model were opened and the expansion and contraction coefficients of all bridges were lowered by a maximum value of 0.1. A channel bed slope change analysis was based on an invert comparison between the cross-sections surveyed for the 1989 GDM and the cross-sections surveyed for this GRR. The comparison indicated that there was a small but general scouring trend for the Mamaroneck River. The results of the last 20 years were extrapolated 50 years into the future and only the future unimproved model was modified to reflect the scour and help develop the lower uncertainty boundary. Sediment was a negligible issue and was not included in the upper boundary computations. To help develop the degree of uncertainty related to the Mamaroneck Harbor boundary condition, different combinations of tide, surge and sea level rise were developed. This combination can be observed in Table 5. All future conditions were run with the maximum and minimum projected SLR. The minimum SLR was calculated using the regional trends at Bridgeport, Willets Point & Kings Point, and the highest SLR by using the NRC Type III curve.

Hydraulic runs that represented the lower and upper uncertainty stage were modeled at a range of tidal water surface elevations. As explained previously, high tides with additional storm surge values superimposed were used to develop the upper limit and best estimate model for existing conditions. Also as previously stated, low or mid tide elevations without superimposed storm surge values were used to develop the lower limit model for existing conditions. Future conditions were modeled by adding high and low sea level rise estimates to the upper and lower limit models respectively.

Table 5: Downstream Boundary Conditions, Mamaroneck Harbor WSEL

		Value (feet)			Elevation (feet NAVD 88)		
	Downstream Boundary	Low	Mean	High	Low	Mean	High
Existing	Tide (NAVD 88)	-3.93	3.24	3.24	-2.93	5.34	7.01
	High Surge (April 07)	0.00	1.10	2.77			
	Sea Level Rise	0.00	0.00	0.00			
	Gage translation	1.00	1.00	1.00			
Future With and Without Project	Tide (NAVD 88)	-3.93	3.24	3.24	-2.51	6.16	9.19
	Surge	0.00	1.10	2.77			
	Sea Level Rise	0.42	0.82	2.18			
	Gage translation	1.00	1.00	1.00			

4.7 Damages

USACE's Hydrologic Engineering Center developed the Flood Damage Reduction Analysis (HEC-FDA) software which integrates hydrologic engineering and economic analysis to evaluate and computes equivalent annual damages (EAD), and implements the risk analysis procedures described in EM 1110-2-1619. The economic model which combines the WSE and the structures to generate damages includes uncertainty parameters in the H&H. The disparity between the curves falls within the uncertainty band assigned by the model.

The damage categories consist of primary tangible damages, including (1) physical damages to property, such as damages to buildings and other structures, and loss of contents, including furnishings, inventory and equipment and autos; (2) emergency costs, such as additional expenses due to evacuation and reoccupation, personnel and equipment expenses incurred in floodfighting; and (3) extra costs due to traffic interruptions and delays, and (4) advanced bridge replacement costs.

4.7.1 Physical Damages to Property

Average annual damages to property and contents were calculated for each reach by combining water surface elevations with structure inventory data and damage functions specific to the type of structure using HEC-FDA.

4.7.2 Structure Inventory

The structure inventory for the study area included 225 non-residential structures, 466 single family residential structures, and 12 apartment buildings. Development of the structure inventory is described in greater detail in the Economics Appendix (Appendix D).

A structure inventory for the study area was compiled in stages for use in the HEC FDA model. USACE conducted a 100% survey of structures and generated a database confirming existing structures and their defining characteristics, and adding new developments to the inventory. Commercial, industrial, and

residential properties were described by building type, number of stories, use, and condition for valuation purposes. Characteristics such as low opening, main floor elevation and building material were recorded to determine the percent damage to the structures resulting from inundation levels. Additional information on the structure inventory is included in the Economics Appendix (Appendix D).

4.7.3 Inundation Damage Functions

The computation of annual flood damages in this analysis is based on the application of depth-damage functions to the structures in the study area to compute damage incurred by structures and contents during flood events of different probability of occurrence. The primary source of depth-damage functions for this reevaluation were the generic depth-damage functions for residential structures developed by the U.S. Army Corps of Engineers and the damage functions for non-residential structures that were developed following an expert opinion elicitation exercise carried out by FEMA and USACE/Institute for Water Resources:

Based on the type, usage and size of each structure inventoried, damage was calculated relative to the main floor elevation of the structure. Using structure and ground elevation data, these depths vs. damage relationships were converted to corresponding stage (NAVD 1988) vs. damage relationships. Damages for individual structures at various stages were aggregated according to structure type (residential, apartment, commercial, etc.) and location (reach). Generalized Depth-Percent Damage functions were applied to structures for calculation of inundation damage.

Emergency Costs

Emergency costs include expenses that result from a flood. Emergency costs include expenses for emergency evacuation, flood fighting, administrative costs of disaster relief, public clean-up costs, and increased costs of police, fire, and military patrol. Emergency costs were derived from actual emergency costs incurred by the Village of Mamaroneck during significant flood events and interpreted for and applied to different frequency events.

Bridge/Wall Replacement

Any plan of risk reduction along the Mamaroneck and Sheldrake Rivers may require the replacement of several existing bridges. The replacement of an existing bridge extends the life of the structure with a reduction of maintenance costs. These net reductions may be considered as benefits accruing to flood risk management plans.

Transportation Disruptions

The transportation routes within the study area experience significant disruption in service during flood events. Major access routes which wind through the study area and larger routes which have access and exit ramps in the Village of Mamaroneck are inaccessible under flood conditions. Quantification of transportation disruptions is precise and comprehensive, and for this study area may not generate appreciable benefits (because the duration of flooding is not extensive – although highly disruptive). However, the reevaluation of monetized transportation disruptions in the benefit calculation beyond the costs of emergency personnel responding to dangerous and inaccessible roadways has been analyzed.

4.7.4 Without-Project Damages Summary

Using HEC-FDA, Average Annual Damages (AAD) were calculated for the without-project base year and future condition, and Equivalent Annual Damages (EAD) were calculated for the 50-year period of analysis, using the 2012 fiscal year (FY) USACE project evaluation and federal plan formulation discount rate of 4.0%. A summary of equivalent annual damages for the without-project condition is presented in Table 6.

Table 6: Summary of Equivalent Annual Damages for the Without-Project Condition

	Damage Categories						
Reach	Residential	Apartment	Commercial	Industrial	Public	Vehicles	Reach Total
MD1	$20	$1,720	$1,820	$0	$0	$6,790	$10,350
MD2	$130	$0	$980	$0	$0	$0	$1,110
MD3	$12,770	$0	$230	$0	$0	$440	$13,440
MD4	$470	$0	$10,360	$0	$0	$20	$10,850
MD5	$70	$0	$0	$0	$0	$0	$70
Stream Total	*$13,460*	*$1,720*	*$13,390*	*$0*	*$0*	*$7,250*	*$35,820*
S1	$109,430	$7,470	$124,610	$0	$7,620	$28,830	$277,960
S2	$590,530	$7,610	$660,520	$396,730	$0	$36,420	$1,691,810
S3	$9,580	$0	$48,880	$26,650	$0	$360	$85,470
S4	$3,870	$0	$0	$0	$0	$110	$3,980
Stream Total	*$713,410*	*$15,080*	*$834,010*	*$423,380*	*$7,620*	*$65,720*	*$2,059,220*
MU1	$268,200	$880	$236,390	$0	$104,020	$14,510	$624,000
MU2	$397,380	$0	$1,580	$0	$1,040	$22,720	$422,720
MU3	$256,730	$0	$0	$0	$0	$4,940	$261,670
MU4	$0	$0	$6,900	$0	$0	$0	$6,900
Stream Total	*$922,310*	*$880*	*$244,870*	*$0*	*$105,060*	*$42,170*	*$1,315,290*
Project Total	**$1,649,180**	**$17,680**	**$1,092,270**	**$423,380**	**$112,680**	**$115,140**	**$3,410,330**

Price level: Analysis was conducted at October 2012 price level at this point in the analysis. October 2012[6], 4.0% Discount rate. As analysis progresses, the price level and discount rate was updated to the then current price level.

Results of this analysis indicate that 60% of the without-project condition damages are being incurred by structures considered to be primarily flooded by the Sheldrake River, and 50% of the total damages are being incurred in just one reach (S2). While significant damages (almost 40% of the total) are being incurred by flooding on the Mamaroneck River upstream of the confluence, flooding on the Mamaroneck downstream of the confluence accounts for approximately 1% of the total damages.

[6] The cost and benefits of the initial screening process have not been updated to October 2016 price levels or current discount rate, because the comparisons would not be affected by the updates. Subsequent comparisons of the revised alternatives are presented in current price level and discount rates to ensure that all impacts are evaluated in current terms.

4.8 Natural Resources

4.8.1 Water Quality

The Lower Mamaroneck River and the Sheldrake River are expected to remain listed on the New York State 2010 Section 303(d) List of Impaired Waters. Fish consumption in the waterways will continue to be impaired due to pesticide levels in contaminated sediment as no action is expected to dredge the rivers. Aquatic and recreational uses will also continue to be impaired by nutrients as well as silt and sediment loads associated with urban stormwater runoff and other non-point sources (NYSDEC 2010).

4.8.2 Wetlands

A general decrease in wetland communities is expected within the study area due in large part to development in the surrounding area and continue to be destroyed.

4.8.3 Vegetation

Native vegetation is expected to be outcompeted by non-native species.

4.8.4 Rare, Threatened, Endangered and Special Concern Species

Due to the highly developed nature of the study area, and the limited amount of quality, suitable habitat to support rare plant species, state or federal rare, threatened, and endangered species are not likely to occur.

4.8.5 Birds

Nearly all migratory bird species are expected to continue to have the potential to occur in the study area and remain protected by the Migratory Bird Treaty Act (MBTA) (16 USC 703–712).

4.8.6 Fish

Based on the analysis of fish species collected during the 2011 fish survey within the study area, water quality within the Mamaroneck and Sheldrake Rivers is marginal as it pertains to aquatic resource habitat and water quality based on an Index of Biological Integrity of poor. This Index of Biological Integrity is not expected to change as water quality is also not expected to change.

4.8.7 Benthic Resources

Water quality in the Mamaroneck River will continue to be considered to be poor and aquatic life will not fully supported in the river and macroinvertebrate communities will remain moderately impacted by poor water quality caused by urban stormwater runoff (USACE New York District 2011a).

4.8.8 Mammals

Documented mammalian species are expected to remain likely to occur within the study area where suitable habitat exists.

4.8.9 Essential Fish Habitat

It is expected that the identification of any EFH or Habitat Areas of Particular Concern within the study area will persist based on the existing water quality.

4.9 Environmental Justice

No change to environmental justice, based on historical trends, is expected and will remain relatively constant.

4.10 Cultural Resources

There is a potential for additional cultural resources to be identified in the future.

4.11 Coastal Zone Management

The entire Village of Mamaroneck, including the Project Area, is expected to remain within the New York-designated coastal zone management area that is associated with Long Island Sound (New York State Department of State [NYSDOS] Coastal Management Program [CMP] 1999).

4.12 Hazardous, Toxic and Radioactive Waste (HTRW)

The ITT Sealectro Site is expected to continue the operation of the groundwater recovery treatment systems (one for halogenated solvents and one for petroleum-related product floating on top of groundwater). The groundwater quality will continue to be monitored.

5. PLAN FORMULATION

5.1 Problems and Opportunities

Problem definition is the detailed description of a problem. It begins with a problem statement, a simple assertion of the basic problem.

Problem statement: *The Village of Mamaroneck experiences damages from out of bank flooding from the Mamaroneck and Sheldrake rivers because of storms including tropical storms, hurricanes, and nor'easters.*

The primary problem encountered in the study area is fluvial flooding associated with elevated water levels. Although nuisance flooding can occur during minor storms, severe flooding damage results from tropical storms, hurricanes, and nor'easters. Due to the geographic setting known as the New York Bight and the offshore topography in the NY and NJ region among other meteorological factors, the surge potential is very high in Highlands during extreme coastal storms.

A severe flood risk remains in the Village of Mamaroneck based on the recurrence of flood events and the damages sustained. Until the "Tax Day" Storm of April 2007, the most damaging flood of record resulted from the storms of 15-16 October 1955, 18-19 June 1972, and 26-27 September 1975. The September 1975 flood was the flood of record prior to the April 2007 flood. Other floods occurred in October 1877, September 1882, July 1889, October 1903, March 1936, July 1938, September 1938, July 1942, August 1942, September 1944, May 1946, March 1953, August 1955, August 1960, April 1961, Ash Wednesday nor'easter of March 1962, August 1971, September 1974, April 1983 and September 1999 (Tropical Storm Floyd). Floods of record include the June 1972, September 1975 and April 2007.

Damages within the Mamaroneck and Sheldrake River Basins for the June 18-19 1972 and September 26-27 1975 floods amounted to approximately $20,000,000 and $90,000,000, respectively, based on conditions of development at the time and October 2016 price level. The flood waters from these storms inundated large areas of industrial, commercial and residential property at the Village and Town of Mamaroneck. Because the April 2007 storm produced the flood of record, it is summarized in the following paragraphs. Additional details of flood events are included in Appendix A.

The April 2007 storm dropped about three to ten inches of rain on the watersheds within the New York District's civil works boundaries between the early morning of Sunday April 15th, 2007 and the early afternoon of Monday April 16th, 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey, and, in New York, at the USGS gages Saw Mill River at Yonkers and, most importantly for this reevaluation, Mamaroneck River at Mamaroneck (Halstead Avenue) New York. A peak flow of 5,340 cfs on April 15, 2007 was estimated at the Mamaroneck gage by hydrologic modeling, and subsequently confirmed by hydraulic calibration to recorded high water marks on the Mamaroneck and Sheldrake Rivers. This is a 1% flood peak on the current existing conditions peak discharge vs. frequency curve at the Halstead Avenue gage. Total rainfall over the study basin was estimated at 7.9 inches using data from the Westchester County Airport rain gage, and local observations of total storm rainfall at East White Plains and New Rochelle, New York.

Damage estimates for the April 2007 storm are well over $50,000,000. Unlike Tropical Storm Floyd, which broke the summer 1999 drought and fell on dry ground, the April 2007 storm caused as much flooding as it did because it was preceded by the smaller March 1-2 and April 12-13 2007 storms, and, as such, and for other reasons of antecedent soil moisture conditions, fell on saturated ground (Figure 13 through Figure 22).

The April 2007 flood (the flood of record) damaged over 300 residential and 100 commercial structures and disrupted the lives of thousands of people through transportation delays and loss of income. Because of the devastating flooding caused by out of bank flooding of the Mamaroneck and Sheldrake rivers, four hundred fifteen (415) repetitive FEMA Flood Insurance Claims in the Village of Mamaroneck were recorded prior to the April 2007 storm.

Floodwaters peak on the Mamaroneck River in approximately 4 hours and in approximately 6 hours on the Sheldrake River during the 1% flood event. The resident's evacuation time is severely restricted leading to high risk to life safety. During the September 1992 flood, one person drowned when the car he was traveling in was swept away in a flow of water. Additionally, during the April 2007 flood, a person died in a house fire because flood waters prohibited emergency vehicles from responding to the person's home to provide emergency and medical care. People have been continually evacuated from homes, businesses and vehicles during these damaging floods along both the Mamaroneck and Sheldrake Rivers. No records appear to exist that indicate the number of people evacuated for each flood event or the length of time they were required to stay away from their homes, businesses or jobs. However, Red Cross estimates indicated that more than 200 people were evacuated in the Village of Mamaroneck during the September 1975 flood.

The small flow capacity of the channel bends/contractions through the bridges are key reasons for the frequent flooding in the Village of Mamaroneck. Because the channels are so narrow and/or shallow, the amount of water they can hold above normal flow is minimal. As the channels fill to capacity, they overflow out of bank and those water surface elevations outside of the channel rise and cause the devastating and swift flooding that the Village of Mamaroneck continually experiences. The area just downstream of the confluence between the Mamaroneck and the Sheldrake River, which includes the Station Avenue Bridge, Metro North Railroad Bridge and the Halsted Avenue Bridge, is causing considerable head losses and therefore high water surface elevations. The constriction caused by these three bridges and the "S" shaped channel is causing the most extensive flood "pool" leading to significant flood damages and creating back water upstream of the confluence and into the Sheldrake River. Flood "pools" upstream of Tompkins Avenue Bridge, Ward Avenue Bridge and Valley Place Bridge are caused by backwater due to the bridges small size openings and utility pipes under the low cords. Poorly designed wing walls and ineffective transitions from the channel to the constrictions of the bridges are also a cause for floods in this area. At the Valley Place Bridge, the upstream left side wing wall was constructed towards the center of the channel about 10ft upstream the face of the bridge, thereby obstructing the flow and causing a jump in WSEL of approximately 0.25 ft for the 1% flood event. High velocities downstream of Tompkins Avenue Bridge exist due to a steep channel bed slope and channel bends; possible scouring is expected during low tides and significant fluvial events.

The effect on the Sheldrake River extends upstream to the Rockland Avenue Bridge for large flood events. Floods in the upstream section of the Mamaroneck River are caused mostly by poor channel capacity, channel bends and thick vegetation in the overbanks. The Glendale Avenue and the Winfield Avenue Bridges obstructions also cause upstream flooding in this reach of the Mamaroneck River.

Figure 13 - End of Winfield Avenue

Figure 14 - Church Building Corner of Ralph Ave and Elliot Ave

Figure 15 - River Flooding Harbor Heights

Figure 16 - 2007 Flood Evacuations

Figure 17 - River Flooding Harbor Heights

Figure 18 - Flooding from the Mamaroneck River at New Street

Figure 19 - 2007 Flood Evacuations

Figure 20 - Fenimore Avenue – 2007

Figure 21 - Mamaroneck Sheldrake Confluence-Columbus Park

Figure 22 - Mamaroneck Harbor – April 2007 Aftermath

Opportunities to solve problems in the study area include:

- Manage flood risk to residents, property, and infrastructure associated fluvial flood events.
- Support the resiliency of the community that without flood risk management has negative safety and economic consequences to the region and to the nation.

Project opportunities were developed to comply with the Project authority and to respond to study area problems. The primary goal of this reevaluation is to manage the flood risk from repetitive flooding caused by the Mamaroneck and Sheldrake rivers (USACE New York District 2011a).

However, because the feasibility report and 1989 GDM have already been completed, this GRR focuses on review of measures which were the most feasible, based on prior information and updated information where necessary.

5.2 Planning Objectives

Planning objectives were identified based on the needs and opportunities, as well as existing physical and environmental conditions in the study area:

Specific Objectives

- Manage the risk of damages from fluvial flooding in the Village of Mamaroneck over a 50-year period of analysis.
- Manage the risk to Village of Mamaroneck residents' life and safety for a 50-year period of analysis.
- Minimize environmental impacts within the Village of Mamaroneck over the 50-year period of analysis to the maximum degree practicable.

5.3 Planning Constraints

The formulation and evaluation of alternative plans are constrained by technical, environmental, economic, regional, social and institutional considerations. For plans analyzed in this reevaluation, the following constraints should be taken into account:

5.3.1 Planning Constraints Specific to the Study

Three planning constraints had to be considered when planning this study:

- Metro North Bridge – New Haven Railroad Bridge: There are 4 heavily utilized commuter tracks on the bridge. The cost to maintain service and replace the bridge would far out-weigh the benefits. Additionally, a duplicate bridge constructed with zero deflection and an exact bend radius would need to be erected to divert train traffic. Further, The Metro North Bridge is listed on the National Register of Historic Places. Any modification to this bridge would not be approved by Metro North regardless of the high cost.
- New England Thruway – the cost for any improvement, modification, relocation, traffic maintenance, etc. would largely outweigh any benefit that may be accrued.
- Lack of real estate or open space – the Village of Mamaroneck is highly urbanized and highly developed. There is little to no opportunity to preserve or create open space.

General, physical/technical, economic, environmental, regional/social and institutional considerations must also be taken into account during alternative screening:

5.3.2 General:

The plan must:

1. Meet the needs and concerns of the public within the study area;
2. Be flexible to accommodate changing economic, social and environmental patterns and changing technologies;
3. Integrate with and be complementary to other related programs in the study area;
4. Be able to be implemented with respect to financial and institutional capabilities and public consensus;
5. Comply with USACE environmental operating procedures.

Physical/Technical:

1. Plans shall represent sound, safe, and acceptable engineering solutions;
2. Plans shall be designed to be low-maintenance;
3. Plans shall be sustainable, resilient and adaptable;
4. Plans shall be in compliance with USACE regulations;
5. Plans shall be realistic and state-of-the-art while not relying on future research or development.

Economic:

1. Plans must be efficient, make optimal use of resources, and not adversely affect other economic systems;
2. Average annual benefits must exceed the average annual costs.

Environmental:

1. Plans must avoid and minimize environmental impacts to the maximum degree practicable.

Regional and Social:

1. All reasonable opportunities for development within the project scope must be weighed, with consideration of state and local interests;
2. The needs of other regions must be considered, and one area cannot be favored to the detriment of another;
3. Plans must maintain existing cultural resources to the maximum degree possible and produce the least possible disturbance to the community.

Institutional:

1. Plans must be consistent with existing federal laws and USACE regulations;
2. Plans must be locally supported and signed by local authorities in the form of a Project Partnership Agreement and guarantee for all items of local cooperation including possible cost sharing

6. ALTERNATIVE ANALYSIS

6.1 Management Measures

Plans to manage the risk of flood damage are composed of measures. A measure can be nonstructural (actions to reduce flood damages without significantly alternating the nature of extent of flooding) or structural (a physical modification designed to reduce the frequency of damaging levels of flood inundation). They can be used individually or combined with other management measures to form alternative plans. Measures were developed to address problems and to capitalize upon opportunities. They were derived from a variety of sources including prior studies, the public scoping process, and the study team's experience.

The following nonstructural and structural measures were considered to provide coastal storm risk management and maximize project benefits. All measures were screened for their capability to meet objectives and avoid constraints, for engineering and economic feasibility. Measures that warranted consideration were assembled into alternative plans. Below are the nonstructural and structural measures that were considered.

Flood risk management measures that were examined in this reevaluation report include nonstructural measures, structural measures as well as a combination of the previous solutions. This included, but was not limited to; variations of the recommended plan's components: e.g. channel modification, diversion tunnel, levees and floodwalls. More specifically, the tunnel's alignment and desired long-term risk was reevaluated. Nonstructural measures such as buyouts, floodproofing and preservation and/or creation of open space in the floodplain was also reconsidered in light of changes to existing conditions and changes to environmental policy.

Opportunities with potential for addressing flood risk management that meet USACE policy requirements were developed and are discussed in the following section. A variety of structural and nonstructural measures were evaluated to satisfy the study objectives and constraints.

6.1.1 Nonstructural

In accordance with the USACE National Nonstructural Flood Proofing Committee, nonstructural measures and flood proofing alternatives can be used to mitigate flood hazards and damages. Nonstructural measures typically provide risk reduction to individual structures. Techniques may include:

a. Elevation: Elevation is the process of raising a structure so that the main living area (main floor) will be above design flood elevation.

b. Buy-Out or Acquisition: Buyout or acquisition results in the permanent removal or evacuation of the structure from the floodplain and is typically applied when other nonstructural measures are too costly. Following acquisition, the structure and associated property development is either demolished or relocated. Acquired lands are typically restored to a natural condition and used for recreation or other purposes that would not be jeopardized by the flood hazard.

c. Flood Warning System: Flood warning systems may be utilized to warn property owners of impending floods, and therefore allow time to evacuate and relocate property subject to flood damage. Currently, the Village of Mamaroneck activates their local Flood Warning System for the Mamaroneck and Sheldrake River Basins, to warn residents of the area subject to flooding.

d. Floodproofing: Floodproofing is the process of making any combination of structural or nonstructural changes or adjustments incorporated in the design, construction, or alteration of individual buildings or properties in order to reduce flood damages. There are two categories of floodproofing: wet floodproofing and dry floodproofing.

Wet floodproofing refers to the reduction of risk of a building in a manner that allows floodwaters to enter and exit freely, in such a way that internal and external hydrostatic pressures are equalized. This equalization of pressures reduces the loads imposed on a structure and reduces the probability of structural damage or failure. Additionally, basement utilities subjected to flooding may be relocated to an above-grade utility room, where space permits, otherwise, the basement utilities may be surrounded by a watertight barrier.

Dry floodproofing is the process of reducing the risk to a building by sealing its exterior walls and by providing removable flood shields at structure openings to prevent the entry of floodwaters. Dry floodproofing is practical only for buildings with structurally sound walls and only where flood depths are low: no more than 2 to 3 feet for wood frame structures, or 3 to 4 feet for brick with masonry foundation walls.

e. Surface Periphery Floodwalls or Ringwalls: For structures that are too large to elevate (generally in excess of a 2,000 SF footprint), a concrete wall or levee (ringwall) may be considered around the structure's property, where space and aesthetics permit.

f. Rebuilding: If the estimated cost of any other nonstructural alternative exceeds the estimated cost to demolish a structure and rebuild an equivalent structure, rebuilding the structure above the design flood elevation may be an economically viable nonstructural alternative.

6.1.2 Structural

Structural alternatives typically consist of constructed barriers that reduce the risk to areas of development, and may include levees, walls, and detention basins. Structural alternatives may also include increasing the size of existing floodwater conveyances, such as channel-widening and deepening, or diverting floodwaters through other channels, pipes, and culverts.

a. Diversions: An underground culvert may be used to divert river overflow from upstream of a developed area. Flood flows contained within the culvert would bypass the developed area and re-enter the river downstream. Under normal conditions, base flow would continue to flow within the river channel. An intake structure would allow flood flows to be diverted into the culvert. This type of alternative can also minimize environmental impacts to the stream by avoiding alterations within the river channel.

b. Channel Modifications: Channel modifications may be used to help reduce risk to communities against riverine flooding and stream blockages. Channel modifications can include dredging, deepening and widening, dam modifications, and elevating or widening bridges. Channel modifications can

be an effective means to reduce flooding, however, environmental impacts may be significant. Channel modifications are typically only cost effective for small to medium sized waterways.

c. Detention Basins: Detention basins may be used to reduce the peak flood flows by temporarily storing (detaining) floodwater, then releasing it at a substantially reduced flow to reduce peak flood flows. This reduces peak water surface elevations and helps to minimize flood damages downstream.

d. Levees/Floodwalls: Floodwalls and levees are intended to provide risk management against flooding to homes, commercial buildings, municipal buildings, roadways, and bridges by prohibiting floodwaters from reaching these structures. While levees and floodwalls can provide a cost-effective means to prevent flooding of low-lying areas, interior drainage facilities are required to handle run-off trapped behind them to prevent interior residual flooding.

6.2 Screening of Management Measures

The screening of flood risk management measures includes an assessment of the potential engineering, economic, environmental, public, financial, and institutional feasibility of implementing each measure. Those measures that are not entirely screened out are carried forward for more detailed analysis as alternative plan components. Based on the physical layout of the study area, the flood hydrology, and the profiles of structures at risk, the following flood risk management measures were considered for application to flooding problems in the study area. These measures and the results of the initial screening are described below and in Table 7.

6.2.1 Structural Measures:

The Diversion Culvert Plan (i.e.: the Tunnel Plan): The "Tunnel" plan was the NED plan identified during the 1977 feasibility report and was the authorized plan. Therefore in accordance with ER 1105-2-100, the Tunnel/NED plan cannot be eliminated for reevaluation.

Channel Modification: Channel modification is a highly implementable measure. The opportunity to widen and deepen the channels along both the Mamaroneck and Sheldrake rivers is a more "flexible" option to space constraints than levees and floodwalls. Channel modification also does not require the high acquisition requirements of structures and land that levees and floodwalls require. Based on this assessment, channel modification is retained for detailed analysis.

Detention: There are several upstream sites within the Mamaroneck and Sheldrake River Basins at which flood detention reservoirs are possible. These sites include two areas which are currently occupied, in part, by existing reservoirs which were formerly used for water supply purposes. These facilities, which were used until the 1970s as standby reserves to the supplies obtained from the New York City water supply system, are Larchmont Reservoir #2 along the Sheldrake River, and the Westchester Joint Water Works Reservoir on the Mamaroneck River. Additional sites exist along the Mamaroneck River at Maple Moor Golf Course, and at Silver Lake. However, the development of a flood storage reservoir at each of these sites is not particularly attractive because of excessive costs and/or limited regulation and effectiveness at the downstream areas. The development of flood detention at each of the possible sites is discussed in the following paragraphs.

Larchmont Reservoir #2. Larchmont Reservoir #2 lies along the Sheldrake River, upstream of the damage areas in the Village of Mamaroneck, and upstream of the Sheldrake River's confluence with its East Branch. A reservoir at this site would control a drainage area of 2.63 square miles, constituting 42.7 percent of the entire Sheldrake River watershed. Various schemes for flood risk management at this site were investigated, the most viable of which considered the modification and utilization of the existing dam. As part of this plan, the dam's existing non-overflow section would be increased in elevation, the existing reservoir dewatered, and regulating works constructed. The resulting reservoir would reduce the 1% discharges along the Sheldrake River at the damage area in the Town of Mamaroneck from Lansdowne Drive upstream to Bonnie Briar Lane by approximately 40 and 7 percent, respectively. However, this improved 1% discharge is in excess of the bankfull capacity for this reach of stream, and local risk reduction works would still be necessary at this area for protection against a 1% flood event, or greater.

Furthermore, the effect of the reservoir diminishes progressively at downstream areas, and would provide minimal benefits to the Village of Mamaroneck. The costs of modifying the existing dam, including regulating works, would be approximately 25 million dollars (1977 price level) alone, and combined with the costs of the upstream levees required around the reservoir, relocations and easements and local risk reduction works in the Village of Mamaroneck, the plan would be highly cost prohibitive. Additionally, to increase the storage capacity for the reservoir at this site, a new dam would have to be constructed and more extensive levees constructed around the reservoir. Although such a detention reservoir would provide a lower long-term risk at the Town of Mamaroneck, benefits to the areas below the Sheldrake River's confluence with the East Branch would be limited, and the resulting plan also highly cost prohibitive. No other practical reservoir sites exist in the Sheldrake River watershed.

Westchester County Joint Water Works Reservoir. The Westchester County Joint Water Works Reservoir lies on the Mamaroneck River, upstream of the damage areas in the Village of Mamaroneck. A reservoir at this site would control a drainage area of 15.35 square miles, constituting 65 percent of the entire Mamaroneck River watershed. The existing dam at the site was investigated to determine its potential for flood risk management. This evaluation indicated that, even with significant modifications, the existing structure provided no significant reduction in the peak flows.

A number of alternatives were then considered which included a new dam at this site. The most viable of these schemes considered a new dam with a 200-foot long spillway, averaging 35 feet in height, and an 800-foot long earthen non-overflow section averaging 26 feet in height. Such a reservoir would reduce the 1% flood discharges by approximately 50 and 25 percent, respectively, along the Mamaroneck River at its confluence with the Sheldrake River. However, the improved 1% discharge is in excess of the bankfull capacity for the Mamaroneck River in the Village of Mamaroneck, and local risk reduction works would be necessary to manager the risk against a 1% or greater storm event.

Furthermore, the cost of the structural works required to provide the flood storage discussed above, far exceeds the flood risk management benefits derived. In addition to the new dam and regulating works, several roads and highways would be elevated substantial heights. For example, Mamaroneck Avenue would be elevated to heights up to 21 feet, with the length of roadway affected in excess of 8,009 feet. Other roads to be elevated would include Union Avenue, portions

of the Hutchinson River Parkway, New England Thruway access ramp, and local streets lying from Winfield Avenue to Teresa Lane.

The real estate requirements for such a reservoir at this site would total more than 200 acres, while the total cost, including new dam, road relocations and raising, real estate and local risk reduction works would be in excess of $150 million dollars (1977 price level). Reservoir schemes which consider lower storage capacities would be less costly at the detention site itself; however, the associated cost of the local risk reduction works that would be required downstream to provide at least a level of long-term risk against the 1% flood, would escalate the overall cost and the resulting plan would be highly uneconomical.

Flood Detention at Maple Moor Golf Course. The utilization of the Maple Moor Golf Course and the surrounding area was considered as a possible flood storage site along the Mamaroneck River in response to requests by local interests. The Maple Moor Golf Course lies upstream of the Village of Mamaroneck and the Westchester Joint Water Works Reservoir. A flood risk management reservoir at this site would control a drainage area of 9.4 square miles, constituting 39.8 percent of the entire Mamaroneck River watershed. An analysis of possible reservoir schemes revealed that even if a reservoir at this site stored the total existing 1% peak discharge, the incremental flows generated below the Maple Moor Golf Course from local runoff would far exceed bankfull capacity of the Mamaroneck River at downstream areas and severe flooding would still result in the Village of Mamaroneck during a 1% event. Thus, for such a level of long-term risk against the 1% flood, or greater, extensive local risk reduction works would be necessary even if such a reservoir were constructed at Maple Moor. The construction of a reservoir at the Maple Moor site to provide substantial flood storage would affect the Hutchinson River Parkway, and Interchanges 22 and 23 of the Cross Westchester Expressway. The cost of such a dam and reservoir would far exceed the limited flood management benefits it would provide in the Village of Mamaroneck.

In addition to considering the Maple Moor site individually as a detention reservoir, further consideration was given to a system of storage reservoirs at the Maple Moor Golf Course and the Westchester Joint Water Works site to function in tandem. However, even with such a system, the incremental runoff flows generated below the Westchester Joint Water Works site for a 1% or greater event would cause flooding at the Village of Mamaroneck. The flood risk management benefits which can be attributed to such a reservoir system clearly cannot support the excessive costs required for construction of the two dams and reservoirs, and downstream local risk reduction works.

Flood Detention at Silver Lake. The use of Silver Lake along the Mamaroneck River was considered as a possible flood detention site in response to requests by local interests. However, a reservoir at this site would control a drainage area of 1.1 square miles, constituting only 4.7 percent of the entire Mamaroneck River watershed. Even if the entire existing 1% peak discharge at Silver Lake could be retained, the resulting 1% flow for the Mamaroneck River in the Village of Mamaroneck would be reduced by less than 5 percent. Silver Lake site lies too far upstream from the damage areas to be effective for flood risk management purposes.

Levees & Floodwalls: Levees and floodwalls could be utilized along the bank for the entire length of both the Mamaroneck and Sheldrake rivers. Preliminary screening activities precluded and eliminated levees

and floodwalls due to the high land acquisition costs that would be incurred. Further, levees and floodwalls were not economically justified in the 1977 feasibility report and were also eliminated as an alternative.

Levees and floodwalls would also result in socio-economic impacts due to the higher and wider levees which require substantial portions of residential, commercial and industrial property and the extensive raising of bridges and roadways which would severely disrupt the business community during construction. The high levees and floodwalls, which average approximately 7 and 11 feet in height along the Mamaroneck and Sheldrake Rivers as identified in the 1977 feasibility report, respectively, would also have an adverse aesthetic impact on the community. As noted in Table 7, levees and floodwalls were screened out because of the adverse effect of environmental impacts and that no space to implement these measures are available along long reaches of these rivers. Factories, homes, and businesses along portions of the river are located directly on the river bank.

6.2.2 Nonstructural Measures

Except for the "Preservation and/or Creation of Open Space in the Floodplain" and acquisition (floodplain buyouts) and "flood warning" no nonstructural measure has been eliminated at this time. Further, nonstructural measures would also be evaluated in combination with structural alternative measures. Nonstructural measures could be implemented virtually throughout the study area.

Preservation and/or Creation of Open Space in the Floodplain There is no opportunity for preservation or creation of open space within the damage area of the Village of Mamaroneck. The Village of Mamaroneck is entirely urbanized and no open space is available nor did future land use investigations reveal any possibility of creation of open space.

Acquisition The 50% and 10% floodplain was considered for the acquisition of structures immediately adjacent to the rivers that are subjected to repetitive and substantial flooding. There are approximately 79 structures within the 50% floodplain (43 are residential structures and 36 are commercial/industrial/institutional) and approximately 210 structures in the 10% floodplain (145 are residential structures and 65 are commercial/industrial/institutional).

The average cost of structure elevation is estimated to be $250,000 - $300,000 per structure. In comparison, the residential properties located on both the Mamaroneck River & Sheldrake River have a median value of $668,900 (up from $582,800 based on the 2010 census data). Additionally, adjacent to the Sheldrake River, the majority of structures within the 50% and 10% floodplain are fully operational industrial businesses. Acquisition of the 79 structures within the50% floodplain (assuming all structures were residential) would cost over $55,000,000 and over $145,000,000 for structures within the 10% floodplain. However, they are not all residential structures and include approximately 50% industrial structures on the Sheldrake River and 30% industrial structures on the Mamaroneck River. Acquisition of these structures were cost prohibitive not only for the land and structure but also for the loss of business (and tax base) for the Village and associated relocation expenses.

Damages do not accrue significantly until the 10% event. For example, the without project damages of the 10% storm event is 16 times larger than the 50% storm event damage. The 4% storm event damage is 62 times the damage of the 50% storm event. Therefore, a benefit-to-cost ratio for a watershed solution above unity is not feasible.

Flood Warning Review of the Village's existing flood warning system was also analyzed. The Village of Mamaroneck has already implemented an extensive Flood Warning System. The Village of Mamaroneck tracks major storm forecasts on a regular basis, if predictions of rainfall in excess of three inches (3") are forecast in a 24-hour time frame. Heightened monitoring is applied in instances when there are forecasts for tropical storms, nor'easters and hurricanes and initiates monitoring as much as a week in advance, based on available information and data from regional weather agencies and organizations.

Once a major event is forecast, the Village would begin coordinating with the Town of Mamaroneck typically five to seven days in advance of a storm, so that the Town can drain down the Larchmont Reservoir behind the Larchmont Dam that they operate.

The Village also coordinates with all internal departments and external public safety agencies, and issues advance warnings and notifications community-wide to the residents and businesses so that they may be notified and take appropriate actions in advance of a storm. The Village notifies residents by Reverse 911 telephone calls, e-mail, website posts, Facebook posts and postings on other social media. The clearance time that we try to accomplish is declare an emergency approximately 24-hours in advance of a storm, so that people are not trying to evacuate when it is too late and they are unable to, but rather leave and find other shelter beforehand.

For areas of the rivers in the Village of Mamaroneck, the Public Works and Parks Department employees are deployed in advance to examine and clear all known areas that are known to be trouble-spots to be checked and cleared of debris in heavy rainfall events, including the following:

- Catch-basins
- Culverts
- Mamaroneck Dam outlets
- All bridges with center abutments that are known to catch waterborne debris that create debris dams that block the rivers

Because the Village of Mamaroneck's flood warning system was already extensive, USACE determined that any additional flood warning measures would be redundant but also would not provide for a reduction in the risk of flood damage to property that is quantified for the evaluation of with-project benefits. Therefore, no further consideration was applied to modifying the existing flood warning system.

A nonstructural alternative does not decrease flood water surface elevations but does elevate life and personal property from the rising flood waters. However, the area remains flooded and emergency access remains the same as the "no-action" condition. Still, a nonstructural alternative would reduce the risk of loss of life versus no action. Two people lost their lives during prior flood events in the Village of Mamaroneck. Therefore a nonstructural alternative was evaluated as a measure, when compared with a no action plan, is still a viable means of reducing risk to life.

Table 7: Initial Screening of Measures for Flood Risk Management

Opportunity	Objective	Constraint	Retained for Further Study?
No Action (means that no additional federal action would be taken to provide for flood risk management)	NA	NA	• Yes, as per NEPA and ER 1105-2-100, the No Action alternative provides the base against which project benefits are measured.
Channel Modification	Reduce risk to life and property by widening or deepening the channel to increase conveyance capacity of stream to reduce water surface elevations and flood damages throughout the basin during flood events	• lack of available real estate	• Yes, only minimal real estate would be required for channelization, this measure would meet the planning objectives.
Diversion Culvert	Reduce risk to life and property by increasing conveyance capacity of the stream to reduce water surface elevations and flood damages throughout the study area during flood events.	• Costs for substantial amount of real estate interests may be high.	• Yes, this measure would meet the planning objectives to reduce flood impacts in the basin. Real estate interests could mostly be underground.
Levee / Floodwall	Reduce risk to life and property by reducing flood damages throughout the basin by protecting areas traditionally sustaining flood damages from overbank flooding.	• May not minimize impacts to historical/cultural resources to the maximum degree practicable. • May not minimize environmental impacts to the	• No, land acquisition would be extremely high for the installation of floodwalls and levees. There is not the available space to construct levees

		maximum degree practicable. • Substantial requirement for real estate interests	and floodwalls in the study area.
Creation of temporary detention basins	• Reduce risk to life and property by reducing water surface elevations and flood damages by temporarily detaining waters upstream of areas traditionally sustaining flood damages.	• May not minimize environmental impacts to the maximum degree practicable.	• Yes, reevaluation requested by non-federal partner for further evaluation.
Floodproofing/Elevation of flood prone residences, businesses and public facilities subject to frequent flooding	• Reduce risk to life and property by moving the public out of flood damage • Minimize environmental impacts.	• May not effectively reduce the risk to life as floodplain would still be impacted by floodwaters thereby prohibiting the emergency vehicles access to residents or evacuations. • Access routes would not remain open during flood event (New England Thruway) • Continued potential for loss of life and physical, as well as environmental, damage to study area communities in	• Retained for further study. As per ER 1105-2-100, a nonstructural flood risk management measure must be examined to compare against structural flood risk management plans.

		the occurrence of significant flooding.	
Acquisition	• Reduce risk to life and property by moving the public out of flood damage • Minimize environmental impacts.	• May not effectively reduce the risk to life as floodplain would still be impacted by floodwaters thereby prohibiting the emergency vehicles access to residents or evacuations. • Access routes would not remain open during flood event (New England Thruway) • Continued potential for loss of life and physical, as well as environmental, damage to study area communities in the occurrence of significant flooding	• Not retained for further study. It is an unimplementable measure and cost prohibitive. • Ongoing significant flooding to remaining structures in the floodplain would result in municipal infrastructure damage, loss of jobs, and closure of businesses in addition to loss of personal property and life.
Flood Warning	• Reduce risk to life and property by moving the public out of flood damage • Minimize environmental impacts.	• May not effectively reduce the risk to life as floodplain would still be impacted by floodwaters thereby prohibiting the emergency vehicles access to residents or evacuations. • Access routes would not remain open during flood event (New	• Not retained for further study. The Village of Mamaroneck already has a comprehensive flood warning system. Implementing an additional or supplementing the existing flood warning system would not reduce the life safety risk.

		England Thruway) • Continued potential for loss of life and physical, as well as environmental, damage to study area communities in the occurrence of significant flooding.	

Reduced potential for loss of life was considered as part of the analysis. While the study considers life safety and environmental impacts of the analyses, the NED plan must be identified. The life safety impacts do not change the NED analysis. However, without a project in place, the without project condition of life safety risk is significantly increased because of how rapid the rivers achieve peak flow (generally 4-6 hours). The window to evacuate is extremely narrow and life safety issues are further exacerbated by the decreased access of emergency services during flood events without project.

6.3 Alternative Plan Description & Evaluation

Alternative plans are combinations of management measures that collectively meet study goals and objectives within the defined study constraints. Alternative plans are assembled and compared against one another using performance outputs and costs. Alternative plans and their component management measures will be assessed relative to the objective of National Economic Development (NED). Preliminary costs, benefits, and impacts of each potential alternative were developed to determine which flood risk management plans should be considered for more detailed design and economic analysis. Preliminary alternatives were analyzed as listed below:

1. Authorized (1989 GDM) plan (channel modification and diversion tunnel);
2. Channel modification only;
    i. Mamaroneck below confluence
    ii. Mamaroneck River only
    iii. Mamaroneck and Sheldrake Rivers
3. Channel modification with new tunnel alignment (along Mamaroneck Avenue or another route with an outlet into the East Basin of Mamaroneck Harbor);
4. Nonstructural plan alone.
5. Nonstructural plan in combination with any of the plans mentioned above.
6. No Action plan.

Alternatives 1, 2 and 3 are successively larger versions of each other by adding an increment (reach) to each successive plan. Alternative 1 looks at the confluence of the Mamaroneck and Sheldrake Rivers being the leading cause of obstruction to flow. Once the floodwaters reach the confluence, the constriction of the bridges in the area essentially block the water from draining. Thereby, the floodwaters back up the Mamaroneck and Sheldrake Rivers, accordingly. Alternative 2 added channel work on the Mamaroneck River to the confluence work in Alternative 1. The majority of the floodplain on the Mamaroneck River is

inhabited by private residences and therefore must be addressed to respond to the life safety issue for that area. As noted, the flow on the Mamaroneck River peaks (for the1% event) in approximately 4-6 hours leaving only a short time period for people to evacuate their houses and also the public school located within the Mamaroneck floodplain. Alternative 3 added the Sheldrake River to Alternative 2 as an additional increment to address flood damages in the mostly industrial 1% Sheldrake River floodplain.

Please note that a "Sheldrake River Only" channel modification alternative was not analyzed and screened from consideration for further analysis. A Sheldrake only alternative would do nothing to fix the drainage issues associated with the Mamaroneck downstream of its confluence with the Sheldrake draining through the Metro North embankment and openings and the Halstead Avenue Bridge a short distance downstream. Hydrologically, most of the flooding in the Village of Mamaroneck is due to the Mamaroneck watershed upstream of the Sheldrake River. For the existing conditions 1% flood event, the peak flow of the Sheldrake River at its mouth, drainage area 6.16 sq mi, 1,390 cfs, is only 26 % of the 5,350 cfs 1% peak flow of the Mamaroneck downstream of the Sheldrake. The other 74 % comes from the Mamaroneck watershed upstream of the Sheldrake River, 17.30 sq mi, 1% existing peak flow of 3,960 cfs. Further, the Sheldrake-only alternative would not fully comply with the Planning Objective of life safety.

Under the No Action alternative, no additional federal actions would be taken to provide for flood risk management along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck. Under this scenario, all natural forces and manmade conditions currently in effect would continue. Periodic storm-related flooding would continue to affect low-lying areas within the Village of Mamaroneck. No flood risk management improvements would be implemented through federal actions to reduce flooding problems. As a result of the No Action alternative, flood damage would continue to occur to homes and properties in the Village of Mamaroneck area.

As discussed previously, the objective for the development of improvements is to manage the risk of recurrent flooding in the study area, along the Mamaroneck and Sheldrake Rivers. The following sections present a preliminary list of improvements to be considered in the reevaluation. As part of the GRR a set of alternatives have been considered, including the reevaluation of improvements proposed in the 1989 GDM, to evaluate the possible solution to the flooding problems in the Mamaroneck and Sheldrake River Basins.

The nonstructural alternatives identified for the study area incorporate flood proofing measures and the raising of buildings within the floodplain. The existing floodplain zones would be maintained, with flood risks reduced through modifications of existing structures. Two nonstructural alternatives were identified. These nonstructural alternatives are generally reserved to reduce damages in frequently flooded properties (i.e., less than 4% flood event) due to their associated high costs.

Six structural alternatives were also identified. As a contrast to the nonstructural alternatives, all of the structural alternatives identified for the study area would at least meet FRM requirements for a 1% flood event.

6.3.1 No-Action

The No Action Alternative describes the study area's future if there is no federal action taken to solve the existing flooding problem (i.e., the FWOP condition) -- which reflects the continuation of existing economic, social, and environmental conditions and trends within the affected area. Failure to provide the

Mamaroneck and Sheldrake River Basins study area with the implementation of flood risk management measures could continue to contribute to the potential loss of life and physical, as well as environmental, damage to study area communities in the occurrence of significant flooding. Significant flooding can result in municipal infrastructure damage, loss of jobs, and closure of businesses in addition to loss of personal property and life.

6.3.2 Alternative 1 – Lower Mamaroneck River and Confluence Area

This plan includes channel deepening and widening along both the Mamaroneck and Sheldrake Rivers from a little above the confluence to the Tomkins Avenue Bridge (tidal limit) as seen in Figure 23. Five bridges would be removed and/or replaced including the two Columbus Park pedestrian bridges, Station Plaza, Halstead Avenue and Ward Avenue. Along the Mamaroneck River, channel work extends from the Tompkins Ave. Bridge to 400 ft above the Hillside Avenue Bridge, for an approximate length of 4,200 ft. Along the Sheldrake River, channel work extends from the confluence to 700 ft above the Mamaroneck Avenue Bridge, for an approximate length of 1,400 ft. The river would be significantly realigned at the confluence and below the Ward Ave Bridge. Trapezoidal channel improvements would consist of a natural bed channel with a 30 to 50 ft width and side slopes of one vertical on two and a half horizontal (1:2.5). Concrete retaining walls would be used where space is limited. The existing channel side slopes range from one vertical on one horizontal (1:1), to one vertical on three horizontal (1:3). The width of the existing channel varies from 30 to 50 ft for the Mamaroneck River and from 5 to 15 ft in the Sheldrake River. The channel bottom would be lowered from two (2) to four (4) ft. The channel bottom has a moderate slope, approximately 12 ft per mile. Columbus Park would be used as the staging area during construction.

Figure 23 - Alternative 1

6.3.3 Alternative 2 – Mamaroneck River and Confluence Area

This plan includes Alternative 1 and additional work along the Mamaroneck River up to the Winfield Avenue Bridge as seen in Figure 24. Six bridges would be removed and/or replaced including Hillside Avenue the two Columbus Park pedestrian bridges, Station Plaza, Halstead Avenue and Ward Avenue. Along the Mamaroneck River, channel work extends from the Tompkins Avenue Bridge to 270 ft above Winfield Avenue Bridge, for an approximate length of 6,700 ft. Along the Sheldrake River, channel work extends from the confluence to 750ft above the Mamaroneck Avenue Bridge, for an approximate length of 1,500ft. The river would be significantly realigned at the confluence and just below the Ward Avenue Bridge. Trapezoidal channel improvements would consist of a natural bed channel with side slopes of one vertical on two and a half horizontal (1:2.5), with retaining walls where space is limited. Articulated concrete mats block may be used throughout and just downstream of the Winfield Avenue Bridge due to the high stream velocities.

Figure 24 - Alternative 2

6.3.4 Alternative 3 – Mamaroneck and Sheldrake Rivers

This plan includes Alternative 2 with additional channel deepening along the Sheldrake River as seen in Figure 25. Eight (8) bridges would be removed and/or replaced including Center Avenue, the two (2) Columbus Park pedestrian bridges, Hillside Avenue, Station Plaza, Halstead Avenue, Valley Place (Anita Lane Sewer Bridge); and Ward Avenue. Along the Mamaroneck River, channel work extends from Tompkins Avenue Bridge to 270 ft above Winfield Avenue Bridge, an approximate length of 6,700ft. The Sheldrake River channel work extends from the confluence to 450ft above the Rockland Avenue Bridge, for an approximate length of 6,700ft; a significant amount of retaining walls would be used for this alternative. The river would be significantly realigned throughout the confluence and just below the Ward Avenue Bridge. Trapezoidal channel modification would consist of a natural bed channel with side slopes of one vertical on two and a half horizontal (1:2.5), and concrete retaining walls would be used where space is limited. Articulated concrete mats would be used throughout and just downstream of Winfield Avenue Bridge due to the high stream velocities. A rectangular channel with concrete retaining walls and channel bottom is needed from the Railroad Bridge to the Halstead Avenue Bridge.

Figure 25 - Alternative 3

6.3.5 Alternative 4 – and Fenimore Road Tunnel (From the 1989 GDM)

The 1989 GDM river diversion and channel improvements plan consists of a tunnel system running beneath Fenimore Rd. from the Sheldrake River to the West Basin of Mamaroneck Harbor as seen in Figure 26. This 16 ft wide by 16 ft high tunnel system which was approximately 3,550 in length, is comprised of an inlet structure, the tunnel works and the outlet structure. Channel work in the Mamaroneck River includes a trapezoidal channel modification consisting of a natural bed channel, 45 to 60 ft wide. Side slopes of one vertical on three horizontal (1:3) with concrete retaining walls where space is limited. Sheldrake improvements extend from the Mamaroneck Avenue to I-95 with a trapezoidal channel with a natural bed channel 30 ft wide. The 1989 GDM improvements on the Mamaroneck and Sheldrake Rivers were expected to contain the 0.5% flood event.

Figure 26 - Alternative 4

6.3.6 Alternative 5 – Ward Avenue Tunnel

Alternative 5 (Figure 27) would include channel works throughout the Mamaroneck and Sheldrake rivers. Along the Mamaroneck River, channel work would extend from Tompkins Avenue Bridge to 270 ft above Winfield Avenue Bridge for approximately 6,700 ft. In the Sheldrake River, channel work would extend from the confluence to 450 ft above the Rockland Avenue Bridge for approximately 5,700 ft. Trapezoidal channel improvements would consist of a natural bed channel 30–50 ft wide along the Mamaroneck and 20–40 ft wide along the Sheldrake and vertical concrete walls in areas limited by structures and private properties. A diversion tunnel with an ogee spillway approximately 5.3 ft high and 40 ft long would be constructed just downstream of the confluence between the Mamaroneck and Sheldrake rivers. The diversion tunnel, of approximately 1,050 ft in length and 13 ft in diameter, would start at the confluence and run underneath the railroad and Ward Avenue, discharging back into the Mamaroneck River just downstream of a new Ward Avenue Bridge. Five bridges would be removed and replaced: Ward Avenue, Hillside Avenue, Center Avenue, and the two Columbus Park pedestrian bridges. The Ward Avenue Bridge would be relocated approximately 20 ft upstream of its current location to allow the proposed tunnel to discharge downstream of the bridge.

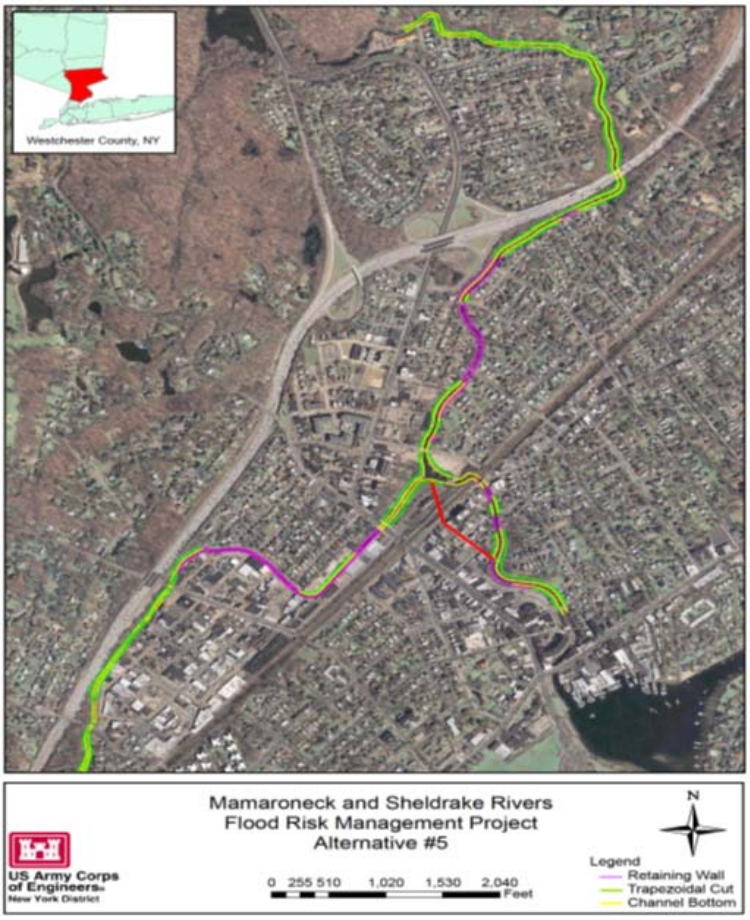

Figure 27 - Alternative 5

6.3.7 Alternative 6 – Nonstructural Alternative

Nonstructural flood risk management techniques consist of measures such as relocation, acquisition, and/or flood proofing. Nonstructural measures were identified and evaluated for structures in the Mamaroneck Sheldrake Area. Measures evaluated included raising buildings (elevation), wet flood proofing, dry flood proofing (sealants and closures), and ring walls/ring levees.

6.3.8 Alternative 7: Combination Plan

This plan was originally intended to combine nonstructural features with structural features. The non-federal sponsor requested that an additional alternative be analyzed (Alternative 8). Therefore, Alternative 7 was deleted from analysis.[7]

Alternative 7 was scoped as a "combination" plan that may include structural and nonstructural flood risk management features. However, during preliminary alternative analysis, the non-federal sponsor requested that an alternative that looked at reservoir and bridge modification be conducted. Although reservoir and bridge modification analysis was conducted in the 1977 feasibility report and was determined to have significant negative annual net benefits, the alternative was revisited for analysis under current conditions.

Optimization plan was intended to combine nonstructural features with structural features. It was determined that Alternative 7 could be removed from consideration because during the optimization phase of any alternative, nonstructural features would be considered regardless. It was determined that Alternative 7 would duplicate efforts that would be conducted during the optimization phase of the study anyway. Therefore, it was acceptable to remove Alternative 7 from preliminary alternative analysis and conduct the "reservoir/bridge modification-only" analysis, Alternative 8.

6.3.9 Alternative 8 – Reservoir and Bridge Plan

This alternative was proposed by NYSDEC and Westchester County (WC). It consists of a combination of detention areas, the realignment of the confluence and bridge removal and/or replacement. The plan was designed to limit the improvements or changes to public lands and thereby avoiding the Real Estate costs associated with purchasing private property. The two primary areas identified for possible detention were the Mamaroneck Reservoir and Sheldrake Lake/Larchmont Reservoir.

Alternative 8a would consist of enlarging Mamaroneck Reservoir with modifications to the WCJWW dam including removal of sediment accumulation near Mamaroneck Avenue Bridge. Alternative 8b would consist of enlarging the Sheldrake Lake/Larchmont Reservoir with modifications to the dam and would include dredging and sediment removal. Alternative 8c would consist of relocation of bridges and Alternative 8d would be a combination plan. Alternative 8e was developed to be all inclusive.

6.4 Alternative Analysis & Evaluation

To provide a basis for selection of the final plan and design, the District evaluated eight (8) alternatives for their potential results in addressing the specific problems, needs, and objectives. The evaluation assesses

[7] A combination plan of structural/nonstructural elements was eventually developed during the optimization of the TSP.

the with- and without-project condition for each alternative. These differences are referred to as the benefits of the action alternative. Criteria to evaluate the alternative plans include all significant resources, outputs, and plan effects. They also include contributions to the federal objective, the planning objectives, compliance with environmental protection requirements, and four evaluation criteria (completeness, effectiveness, efficiency and acceptability).

Evaluation of the beneficial and adverse effects (including both monetary and non-monetary benefits and costs) of the alternatives provided a basis for determining which plans should be considered further, eliminated or reformulated. As required by ER 1105-2-100, alternatives were evaluated by comparing conditions expected under with- and without-project scenarios. Alternatives were compared against the No Action alternative and against each other, with emphasis on the outputs and effects that would have the most influence in the decision-making process which was based on the objective of life safety.

A range of nonstructural and structural alternatives were considered and evaluated. A total of eight alternatives (six structural, one nonstructural, and one combination of structural and nonstructural) were analyzed. They are explained in more detail in Appendix C2-Hydraulics. A summary of initial actions that were modelled for the alternatives is provided in Table 8.

Table 8: Summary of Actions for the Initial Alternatives.

Actions	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 8e
Bridge Removal / Replacement							
Ward Avenue	Remove/ replace	Remove/ replace	Remove /replace		Remove/ replace[1]		Remove
Station Plaza	Relocate	Relocate	Relocate				Relocate
Waverly Place	No action	Remove/ replace	No action		No action		No action
Halstead Avenue	Remove /replace	Remove/ replace	Remove/ replace				Modify
Hillside Avenue		Remove/ replace	Remove /replace		Remove /replace		Modify
Valley Place (Anita Lane)			Remove/ replace	No action		No action	Modify
Winfield Avenue	No action	No action	No action		No action		Remove
Jefferson Avenue			No action				Modify
Center Avenue Footbridge			Remove/ replace		Remove/ replace		
Footbridge #1 (near confluence)	Remove/ replace	Remove/ replace	Remove/ replace		Remove/ replace		No action

Actions	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 8e
Footbridge #2	Remove/ replace	Remove/ replace	Remove/ replace		Remove/ replace		
Tunnel/Culvert & Spillway Construction							
Tunnel length / diameter (ft)	No action	No action	No action	4,010.00 / 16.00	1,050.00 / 13.00	No action	No action
Tunnel construction details				Beneath Fenimore Rd. from the Sheldrake River south to the West Basin of the Mamaroneck Harbor	Beneath the railroad and Ward Ave. from the confluence to the Mamaroneck River, downstream of new Ward Ave. Bridge	No action	No action
Ogee spillway construction details	No action	No action	No action	No action	From just downstream of the confluence between the two rivers	No action	No action
Channel Work Length (ft)							
Mamaroneck	4,200 (Tomkins Ave. Bridge to 400 ft above Hillside Ave. Bridge)	6,700 (Tomkins Ave. Bridge to 270 ft above Winfield Ave. Bridge)	6,700 (Tomkins Ave. Bridge to 270 ft above Winfield Ave. Bridge)	10,420	6,700 (Tomkins Ave. Bridge to 270 ft above Winfield Ave. Bridge)	No action	No action
Sheldrake	1,400 (confluence to 700 ft. above Mamaroneck Ave. Bridge)	1,500 (confluence to 750 ft. above Mamaroneck Ave. Bridge)	5,700 (confluence to 450 ft. above Rockland Ave. Bridge)	5,740 (Mamaroneck Avenue to I-95)	5,700 (confluence to 450 ft. above Rockland Ave.)	No action	No action

Actions	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 8e
Channel Width Size (ft)							
Mamaroneck	30-50	30-50	30-50	45–60	30–50	No action	No action
Sheldrake	20–40	20–40	20–40	30	20–40	No action	No action
Channel Slope							
	1:2.5	1:2.5	1:2.5	1:3	1:2.5	No action	No action
Nonstructural	No action	No action	No action	No action	No action	363 structures evaluated for structure raising, wet/dry floodproofing, ringwalls/ring levees, etc.	No action

All channel improvements proposed (*Alternatives 1, 2 and 3*) would result in loss of natural flood plain storage, and the flood peak reductions associated with it. That is, peak flows would increase downstream of proposed channel improvements, and would occur sooner, under improved conditions, as compared to existing conditions. The channel improvements would increase the capacity of the rivers by deepening and/or widening to allow the reduction of water surface elevations during flood flow, thereby reducing damages and minimizing life safety impacts.

The diversion tunnels (*Alternatives 4 and 5*) proposed would result in a decrease in peak flows downstream. The diversion tunnel proposed at Fenimore Road (Alternative 4) for the Sheldrake River would bring the flood hydrographs of the Sheldrake River from Fenimore Road into the West Basin of Mamaroneck Harbor where floodwaters currently do not discharge. These diverted flood hydrographs do not return to either the Mamaroneck or the Sheldrake River. The Ward Avenue diversion tunnel (Alternative 5) diverts flood hydrographs from the Mamaroneck River downstream of the Sheldrake River. The diverted flood hydrographs re-enter the Mamaroneck River further downstream. Under Alternative 5 the Ward Avenue Bridge would be relocated approximately 20 ft upstream of its current location to allow the proposed tunnel to discharge downstream of the bridge. Discharge would be to the East Basin of the Mamaroneck Harbor where the river currently discharges.

Table 9: Structure and Treatment Type as Identified in the Screening Process of the Nonstructural Alternatives for the 50%, 10% and 1% events.

Nonstructural Flood Proofing Measure	50% Annual Exceedance Floodplain			10% Annual Exceedance Floodplain			1% Annual Exceedance Floodplain		
	Residential	Non-Residential	Sub Total	Residential	Non-Residential	Sub Total	Residential	Non-Residential	Sub Total
Dry Flood proofing	0	2	2	0	4	4	9	19	28
Wet Flood proofing	7	0	7	29	0	29	100	1	101
Barriers	1	34	35	11	61	72	16	73	89
Elevate	35	0	35	105	0	105	145	0	145
Total of Structures	43	36	79	145	65	210	270	93	363

Nonstructural measures are required to be evaluated in all feasibility studies. Under this alternative, the most cost effective treatment for each structure was determined through an assessment of the flood levels at that location, in conjunction with the ground elevation, the main floor elevation, type of construction, and structure condition, details which were obtained from the economic structure inventory or through engineering field surveys. This information was used to consult the flood damage reduction matrix developed by the USACE National Nonstructural Floodproofing Committee.[8] As an example, a structure that experiences flooding which does not reach the main floor may be recommended for wet or dry floodproofing. Dry floodproofing is appropriate for inundation depths shallower than 3 feet, while wet floodproofing techniques may be used for inundation depths up to 6 feet. If it experiences some main floor flooding, it would be recommended for elevation. And if floodwaters totally submerge the structure, it would be a likely candidate for buyout or acquisition.

For the nonstructural alternative (*Alternative 6*), floodplains corresponding to 50%, 10% and 1% flood events were evaluated. The nonstructural measures to be considered includes acquisition or purchasing and removing low lying at risk structures (relocation), dry flood proof measures, wet flood proofing, flood warning and raising buildings (elevation).

Nonstructural Flood Proofing measures considered in this project were dry and wet floodproofing, elevation (aka. elevate).

> *Screening Level Results.* Results of the screening levels analysis by structure type for three floodplains (50%, 10% and 1% flood events) are shown in Table 9 and identifies the number of residential and non-residential structures targeted for treatment within the 50%, 10%and the 1% floodplains. Table 9 also identifies the number of structures identified for each of the different types of nonstructural treatments. All structures would be treated to the same elevation (1% flood elevation plus 1 foot) regardless of the size of the nonstructural plan. Therefore while the number of structures treated under each plan changes, the design water level of treatment for each structure does not vary by plan.

[8] http://cdm16021.contentdm.oclc.org/cdm/ref/collection/p16021coll11/id/363 (August 2015)

Alternative 7 was conceived as a combination of structural and nonstructural alternatives. However, this plan has been omitted from this table due to the local partners' request to add *Alternative 8* to the analysis.

For the Mamaroneck Reservoir, the plan includes the removal of sediment accumulation near Mamaroneck Avenue Bridge, which is a major cause of ineffective or dead storage within Mamaroneck Reservoir. The new slope in this area is 0.0015ft/ft. In order to maximize storage, which would allow low flow to go through without filling Water Works Dam and Mamaroneck Reservoir, a new lower level outlet design is required.

For the existing Sheldrake Lake/Larchmont Reservoir, the plan includes dredging and sediment removal. This adds approximately 85.4 MGa of volume capacity approximately a 50% increase in the reservoir volume. The dam would require an additional 30in diameter pipe below the existing outlet and 5ft above the reservoir is lowest bottom elevation.

The last component of the alternative is bridge Modification and/or Removal. The Ward and Winfield Avenue Bridges were completely removed as well as the Glendale Avenue abutments (Road to No-where). The Halstead Avenue Valley Place (Anita Lane), Hillside Avenue and Jefferson Avenue Bridges were modified. The confluence was re-aligned and Station Plaza Bridge was aligned with the Rail Road and Halstead Avenue Bridges.

This alternative was subdivided into five parts: Alternative 8A (a larger Mamaroneck Reservoir with modifications to the WCJWW Dam), Alternative 8B (a larger Sheldrake Lake/Larchmont Reservoir with modification to the dam), Alternative 8C (Bridge Modifications and/or Removal plan), Alternative 8D (Combination Plan), Alternative 8E (All Inclusive Plan). Refer to Appendix C2 for additional information regarding the details of Alternatives 8A, 8B, 8C, 8D and 8E.

Table 10 provides the detailed analysis of the alternatives. A detailed cost analysis was conducted in developing the cost estimates for the alternative analysis. Additionally, the economic performance of all analyzed alternatives has been computed by HEC-FDA and summarized in Table 11.

The results indicate that only Alternative 1 and 2 show positive annual net benefits. Based on having the highest annual net benefits ($567,500), Alternative 1 is the Tentatively Selected Plan (TSP). This alternative consists of channel modification, bridge removals and retaining walls. Beyond being the most efficient and effective plan, Alternative 1 also best meets the P&G criteria by being the most sustainable and resilient plan, as it requires minimal human intervention to be operational during storm events.

Descriptions of the applicable economic benefit categories cited in Table 10 are presented in greater detail in the Economics Appendix. There are no non-standard benefits. Advanced bridge replacement can be claimed if a bridge is replaced as the result of a flood control project. Pre Base Year benefits reflect avoided damage to structure and contents which accrue from completed segments during construction. Emergency costs avoided through reduced flooding are also shown as a benefit.

Table 10: Summary of Damages, Benefits, and BCRs

Alternative	Stream/Benefit Source	Without Project Annual Flood Damages	With Project Annual Flood Damages	Annual Benefits	First Cost	Total Annual Cost	Annual Net Benefits	BCR
Alt 1	Mamaroneck D/S	$35,820	$12,210	$23,610				
	Sheldrake	$2,059,220	$325,890	$1,733,330				
	Mamaroneck U/S	$1,315,290	$397,620	$917,670				
	Pre Base Year[9]	N/A	N/A	$0				
	Bridge Replacement[10]	N/A	N/A	$553,300				
	Emergency	$94,190	$30,320	$63,870				
	Total	*$3,410,330*	*$735,720*	*$3,291,780*	*$54,434,000*	*$2,724,300*	*$567,500*	***1.2***
Alt 2	Mamaroneck D/S	$35,820	$13,030	$22,790				
	Sheldrake	$2,059,220	$367,720	$1,691,500				
	Mamaroneck U/S	$1,315,290	$89,350	$1,225,940				
	Pre Base Year	N/A	N/A	$153,230				
	Bridge Replacement	N/A	N/A	$675,000				
	Emergency	$94,190	$22,980	$71,210				
	Total	*$3,410,330*	*$470,100*	*$3,839,670*	*$72,705,000*	*$3,625,400*	*$214,300*	***1.1***
Alt 3	Mamaroneck D/S	$35,820	$13,280	$22,540				
	Sheldrake	$2,059,220	$37,680	$2,021,540				
	Mamaroneck U/S	$1,315,290	$33,480	$1,281,810				
	Pre Base Year	N/A	N/A	$312,590				
	Bridge Replacement	N/A	N/A	$683,600				
	Emergency	$94,190	$12,330	$81,860				
	Total	*$3,410,330*	*$84,440*	*$4,403,940*	*$95,961,000*	*$4,772,100*	*-$368,200*	***0.9***
Alt 4	Mamaroneck D/S	$35,820	$8,030	$27,790				

[9] Without Project Flood Damages are N/A (not applicable) because the "Pre-Base Year" benefit source is presented as an annual benefit in the with project condition, not an annual damage.
[10] The Bridge Replacement Benefit is a benefit in the with project condition due to the timing of the replacement of the bridge and therefore NA (not applicable) in the without project condition.

	Sheldrake	$2,059,220	$12,700	$2,046,520				
Alt 4 (Cont.)	Mamaroneck U/S	$1,315,290	$56,340	$1,258,950				
	Pre Base Year	N/A	N/A	$478,330				
	Bridge Replacement	N/A	N/A	$684,800				
	Emergency	$94,190	$12,130	$82,060				
	Total	*$3,410,330*	*$77,070*	*$4,578,450*	*$154,481,000*	*$7,715,400*	*-$3,137,000*	***0.6***
Alt 5	Mamaroneck D/S	$35,820	$7,600	$28,220				
	Sheldrake	$2,059,220	$93,730	$1,965,490				
	Mamaroneck U/S	$1,315,290	$58,260	$1,257,030				
	Pre Base Year	N/A	N/A	$153,230				
	Bridge Replacement	N/A	N/A	$266,600				
	Emergency	$94,190	$14,410	$79,780				
	Total	*$3,410,330*	*$159,590*	*$3,750,350*	*$91,151,000*	*$4,529,300*	*-$779,000*	***0.8***
Alt 6	Mamaroneck D/S	$35,820	$18,690	$17,130				
Nonstructural	Sheldrake	$2,059,220	$442,440	$1,616,780				
	Mamaroneck U/S	$1,315,290	$243,510	$1,071,780				
	Total	*$3,410,330*	*$704,640*	*$2,705,690*	*$86,082,000*	*$4,007,100*	*-$1,301,400*	***0.7***
Alt 8	Mamaroneck D/S	$35,820	$8,220	$27,600				
	Sheldrake	$2,059,220	$583,740	$1,475,480				
	Mamaroneck U/S	$1,315,290	$544,070	$771,220				
	Pre Base Year	N/A	N/A	$68,340				
	Bridge Replacement	N/A	N/A	$530,100				
	Emergency	$94,190	$41,380	$52,810				
	Total	*$3,410,330*	*$1,136,030*	*$2,925,550*	*$79,178,000*	*$3,979,300*	*-$1,053,800*	***0.7***

Price level: Analysis was conducted at October 2014 price level at this point in the analysis. As analysis progresses, the price level and discount rate was updated to the then current price level. The selection of the TSP does not change. Price level: October 2014, 4.0% Discount rate

7. NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Following evaluation of the initial array of alternatives as discussed in Section 6, the TSP was identified as Alternative 1. During consultation with the non-federal sponsor and local partners, USACE evaluated optimization of the TSP to ensure the scale addressed the greatest possible portion of the study area. This optimization generated four scales of Alternative 1, Small (1S), Medium (1M), Large (1L), and Final (1F) identified as 1S, 1M, 1L, and 1F. These scales were developed to include varying lengths of channel work.

7.1 Optimization of Alternative 1

The process of optimization is to determine the project size that would maximize net benefits. The plan exhibiting the highest net benefits is identified as the National Economic Development (NED) plan. The width, depth and extent of the initial Alternative 1 channel improvements were varied along with the number of bridge replacements to develop iterative plans of size. Harbor Heights is included in the study area for all alternatives and without project damage estimates. During alternative analysis, it was determined that downstream solutions were not having a significant effect on the Harbor Heights area. Therefore, the Harbor Heights area was further analyzed and incrementally justified during the optimization process.

The optimization process also included a progression of increasing depths, widths and/or lengths of channelization to incorporate and maximize the effects the alternatives would have on lowering the water surface elevation during a flood event. The extent of the channel modification of Alternative #1 (and the optimization iterations) was determined based on the hydraulic characteristics confirmed by the resulting benefits. During optimization, an in-depth hydraulic investigation of Alternative #1 presented the opportunity of maximizing benefits with a slight variation on the extent of channel modification for both the Mamaroneck and Sheldrake Rivers. The focus of optimizing the channel modification effort after determining the channel extent was the deep and width. The base scenario for the channel deepening and widening was the selected Alternative #1. A "smaller" version of the channel deepening and widening along the Mamaroneck and Sheldrake Rivers produces a smaller flood risk reduction, a reduction in benefits but also a reduction in cost of the alternative. In turn a "larger" version produces an increase in flood risk reduction, and an increase in economic benefits and cost of the alternative. The final alternative presents the channel modification extent, deep and width that maximize net benefits. Variations of Alternative 1 were completed as noted below:

- The small alternative (Alt. 1S) would not include flood risk management features in Harbor Heights.
- The medium alternative (Alt. 1M) would have some channel work in the Harbor Heights area and the removal of Glendale Avenue.
- Alternative 1F is similar (albeit slightly smaller than Alt 1M) would have a nonstructural component in the Harbor Heights area instead of channel work. Nonstructural component includes proposed raisings or elevated structures in the Harbor Heights residential area. In Sheldrake River, there is a proposed barrier or ringwall around the commercial building located near Fenimore Road; while in Mamaroneck River.
- The large alternative (Alt. 1L) would have the same nonstructural component in both the Mamaroneck and Sheldrake Rivers for structures with estimated BCRs above one as Alt. 1F.

Table 11 provides the design details that were evaluated during the optimization of Alternative 1. Optimization consisted on successive variations of the widening, deepening and lengthening of channel sections along the Mamaroneck and Sheldrake Rivers, and bridge removal/modifications. Channel deepening and widening

would be implemented at one on two and a half side slopes and varying bottom widths. Utility removal and replacement may be necessary in certain locations. Where space allow, a trapezoidal channel is proposed.

Table 11: Channel Modification in Alternative 1 S, 1M, 1F and 1L

River Reach	Channel Modification (ft) 1S	Channel Modification (ft) 1M	Channel Modification (ft) 1L	Channel Modification (ft) 1F
Mamaroneck Upstream	2,400	3,470	2,400	2,400
Mamaroneck Downstream	2,400	2,400	2,400	2,400
Mamaroneck Width	30-45	25-45	45	30-45
Sheldrake	3,470	3,470	3,470	3,470
Sheldrake Width	20-30	20-30	30	20-33

Table 12 Hydraulic Optimization of Alternative 1[11]

River Reach	Alternative 1S	Alternative 1M	Alternative 1L	Alternative 1F
Mamaroneck Upstream	Channel bottom width from the confluence to Hillside Ave. 40ft (distance 1,050ft) and 30 ft from Hillside Ave. to just upstream of Barry Ext. (approx. distance 1,350ft).	Channel bottom width variable; 25ft wide from 200ft upstream of the "road to nowhere" and 35ft wide for the next 650 downstream of "road to nowhere". Upstream the confluence 45ft wide for approx. 2400ft.	Channel deepening and widening, upstream the confluence 45ft or approx. 2400ft.	Channel bottom width from the confluence to Hillside Ave. 40ft (distance 1050ft) and 30 ft from Hillside Ave. to just upstream of Barry Ext. (approx. distance 1350ft).
Mamaroneck Downstream	Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge with retaining walls	Channel bottom width 45ft from the confluence to just downstream of Tompkins Avenue bridge.	Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge.	Channel bottom width 45ft from the confluence to just downstream of Tompkins Ave. bridge.

[11] Design dimensions will vary during design refinement

Sheldrake	Channel deepening and widening and rectangular channel where needed (upstream of Mamaroneck Ave. Bridge). Channel bottom width 20ft from the confluence to Mamaroneck Ave. Bridge and 30ft from Mamaroneck Ave. Bridge to Fenimore Ave. Bridge.	Rectangular channel (upstream of Mamaroneck Ave. Bridge). Channel bottom width 20ft from the confluence to Mamaroneck Ave. Bridge, 33ft from Mamaroneck Ave. Bridge to 1,000ft downstream and 30 ft rectangular and semi trapezoidal to Fenimore Ave. Bridge.	Channel deepening and widening and rectangular channel where needed (upstream of Mamaroneck Ave. Bridge). Channel bottom width 30ft.	Rectangular channel (upstream of Mamaroneck Ave. Bridge). Channel bottom width 20ft from the confluence to Mamaroneck Ave. Bridge, 33ft from Mamaroneck Ave. Bridge to 1,000ft downstream and 25ft rectangular and semi trapezoidal channel to Fenimore Ave.

The benefits of each scale were initially compared to the costs. During this comparison, Alternative 1F was initially demonstrated to provide the highest net benefits at this phase of the formulation. The cost summary of these scales is presented in Table 13. The comparison of these costs and benefits are presented in Table 14. A summary of actions for each plan is provided in Table 15.

Table 13: Cost Summary of Scales of TSP Plan

ACCT#	CWBS FEATURE	Alt 1S	Alt 1M	Alt 1L	Alt 1F
02	RELOCATIONS	$663,151	$710,516	$670,234	$663,151
08	ROADS, RAILROADS AND BRIDGES	$11,450,852	$13,010,363	$29,184,434	$13,010,363
09	CHANNELS AND CANALS	$10,358,374	$12,796,645	$11,976,202	$10,358,374
11	LEVEES AND FLOODWALLS FLOODWAY CONTROL & DIVERSION STRUCTURE	$6,371,782	$7,254,497	$13,586,641	$6,371,782
16	ENVIRONMENTAL MITIGATION	$1,800,000	$2,280,000	$1,800,000	$1,800,000
	TOTAL CONSTRUCTION COST	$30,644,159	$36,052,021	$58,536,865	$33,523,024
01	LANDS & DAMAGES	$9,693,750	$11,787,500	$9,693,750	$9,693,750
30	ENGINEERING & DESIGN	$4,597,269	$5,408,562	$8,781,762	$5,029,159
31	CONSTRUCTION MANAGEMENT	$2,451,533	$2,884,162	$4,682,949	$2,681,842
	TOTAL FIRST COST	**$47,386,711**	**$56,132,245**	**$81,695,326**	**$50,927,775**
	IDC	$2,638,983	$3,126,022	$4,549,638	$2,836,182
	TOTAL PROJECT COST	**$50,025,694**	**$59,258,267**	**$86,244,964**	**$53,763,957**
	ANNUAL COST	$2,328,706	$2,758,484	$4,014,720	$2,502,723
	OMRR&R	$153,300	$180,300	$292,700	$167,700
	MAJOR REHAB/REPLACEMENT	$0	$0	$0	$0
	TOTAL ANNUAL COST	**$2,482,006**	**$2,938,784**	**$4,307,420**	**$2,670,423**

October 2012 Price Level, 4% Interest Rate

Table 14: Economic Summary Table of Alternative 1

October 2012 Price Level, 4% Interest Rate – costs are prior to the Value Engineering study

Plan	Stream	Without Project Damages	With Project Damages	Annual Benefits	Total Annual Cost	Net Excess Benefits	BCR
Alt 1S	Mamaroneck DS	$35,820	$7,750	$28,070			
	Sheldrake	$2,059,220	$339,810	$1,719,410			
	Mamaroneck US	$1,315,290	$420,980	$894,310			
	Pre Base Year	N/A	N/A				
	Bridge Replacement	N/A	N/A	$357,700			
	Emergency	$94,185	$31,225	$62,960			
	Total	*$3,410,330*	*$799,765*	*$3,050,350*	*$2,482,000*	*$568,350*	*1.2*
Alt 1M	Mamaroneck DS	$35,820	$5,620	$30,200			
	Sheldrake	$2,059,220	$173,100	$1,886,120			
	Mamaroneck US	$1,315,290	$246,400	$1,068,890			
	Pre Base Year	N/A	N/A				
	Bridge Replacement	N/A	N/A	$357,700			
	Emergency	$94,185	$21,741	$72,444			
	Total	*$3,410,330*	*$446,861*	*$3,403,254*	*$2,938,800*	*$465,454*	*1.2*
Alt 1L	Mamaroneck DS	$35,820	$5,670	$30,150			
	Sheldrake	$2,059,220	$203,110	$1,856,110			
	Mamaroneck US	$1,315,290	$121,220	$1,194,070			
	Pre Base Year	N/A	N/A				
	Bridge Replacement	N/A	N/A	$874,300			
	Emergency	$94,185	$19,114	$75,071			
	Total	*$3,410,330*	*$349,114*	*$4,000,301*	*$4,307,400*	*(-307,099)*	*.92*
Alt 1F	Mamaroneck DS	$35,820	$5,870	$29,950			
	Sheldrake	$2,059,220	$254,180	$1,805,040			
	Mamaroneck US	$1,315,290	$272,660	$1,042,630			
	Pre Base Year	N/A	N/A				
	Bridge Replacement	N/A	N/A	$357,700			
	Emergency	$94,185	$24,712	$62,960			
	Total	*$3,410,330*	*$557,422*	*$3,298,279*	*$2,670,423*	***$627,856***	*1.2*

Table 15: Summary Action per Alternative

Feature			Alternatives																Units
Bridge Name	**River/Reach**	**Hydraulic River Stationing**	**Alt. 1**		**Alt. 1S - Small**		**Alt. 1M - Medium**		**Alt. 1L - Large**			**Alt. 1F - Final**							
Bridge Modification:																			
Ward Ave.	Mamaroneck /DS	17+86	Remove/replace		No action		Remove		Remove			Remove							-
Halstead Ave.	Mamaroneck /DS	26+75	Remove/replace		No action		No action		Remove/replace			No action							-
Station Plaza	Mamaroneck /DS	29+84	Remove/relocate		Remove/relocate		*(Remove/relocate)**		Remove/relocate			*(Remove/relocate)**							-
Footbridge #1 (near confluence)	Sheldrake/Sheldrake	00+25	Remove		Remove		Remove		Remove			Remove							-
Footbridge #2	Sheldrake/Sheldrake	03+07	Remove		Remove		Remove		Remove			Remove							-
Waverly Ave.	Sheldrake/Sheldrake	19+43	No action		Remove/replace		Remove/replace		Remove/replace			Remove/replace							-
Center Ave. Footbridge	Sheldrake/Sheldrake	21+71	Remove		Remove		Remove		Remove			Remove							-
Channel Work Length:																			
Mamaroneck River at Harbor Heights		93+50 (midpoint)	N/A		N/A		1,340.00		N/A			N/A							ft
Mamaroneck River Upstream of Confluence		42+50 (midpoint)	1,800.00		2,400.00		2,400.00		2,400.00			2,400.00							ft
Mamaroneck River Downstream of Confluence		20+00 (midpoint)	2,400.00		2,400.00		2,400.00		2,400.00			2,400.00							ft
Sheldrake River		17+50 (midpoint)	1,400.00		3,470.00		3,470.00		3,470.00			3,470.00							ft
Channel Width Size:																			
Mamaroneck River at Harbor Heights			N/A		N/A		25.00 - 35.00		N/A			N/A							ft
Mamaroneck River Upstream of Confluence			45		30.00 - 40.00		45		45			30.00 - 40.00							ft
Mamaroneck River Downstream of Confluence			45		45		45		45			45							ft
Sheldrake River			30		20.00 - 30.00		25.00 - 33.00		30			20.00 - 33.00							ft
Channel Cut Volume (Soil/Rock):			47,000	10,000	60,990	11,250	89,210	11,250	87,230	11,250	60,990	11,250							cyd
Walls (average height/Length):			8.5	4,955	8.4	4,085	8.5	4,360	8.7	7,210	8.4	4,085							ft
Nonstructural:																			
Elevate			No action		No action		No action		8 structures			8 structures							-
Ringwall			No action		No action		No action		1 structure			1 structure							-

***** Subsequent design change as a result of the Value Engineering Study resulted in the inclusion of a short diversion culvert instead of replacing the Station Plaza Bridge.

7.2 Refinement & Optimization of the NED Plan

The plan that optimizes the annual net benefits is Alternative 1F. Alternative 1L shows negative annual net benefits and therefore is dropped from further analysis and consideration. However, Alternative 1M provides a higher level of flood risk management than Alternative1F and would be retained for further consideration. Because Alternative 1S includes no elements or features in the Harbor Heights area (Alternative 1F includes the nonstructural solution in the Harbor Heights reach whereas Alternative 1M includes channelization in the Harbor Heights reach), any cost refinement applied to Alternative 1S would decrease the BCR, proportionately. Therefore, further cost refinement is applied to Alternative 1M and 1F only. Regardless, this cost refinement would be applied to Alternative 1S to ensure the appropriate identification of the NED plan. Alternative 1M and Alternative 1F have been retained for further analysis.

7.3 Value Engineering Recommendations

The Value Engineering (VE) analysis is an internal review conducted by a VE team, exclusive of the Project Development Team, who seek, during their review to add value to the project by changing, modifying, or taking a different approach to the solutions proposed. The findings of this study were evaluated by the VE team after the TSP plan was developed.

The most significant recommendation by the team was to retain the Station Plaza Bridge and substitute the replacement of that bridge with an overflow diversion culvert under the commuter parking lot located on the left bank (north side) of the river. The culvert would start just downstream of the Jefferson Ave Bridge and discharge almost directly into the Rail Road Bridge opening (Figure 28).

A hydraulic and an economic analysis of the VE recommendation was performed and the diversion culvert should reduce construction cost by $3 to $5 million, without altering the water surface elevations or reducing the flood risk management benefits of both Alternative 1F and 1M.

The culvert would be about 390 feet long with a slope of 0.36 feet per 100 feet, 25 feet wide, 8 feet high, would be about 3 feet above the proposed bottom of the river and about 3.5 feet under the finish grade of the parking lot. Therefore, the culvert would be dry during normal flows but it would divert flood flows of the Mamaroneck River flows for a 100% flood event or greater. The channel from the Rail Road Bridge to the Jefferson Avenue Bridge would still be deepened to the same depths previously specified but the alignment of the river would remain as it currently is. While the two 90-degree bends would remain, the impact of head losses would be reduced because a portion of the river would now flow “straight” through the culvert (Alternative 1F is shown in Figure 28 through Figure 31 and Alternative 1M is shown in Figure 32 through Figure 35).

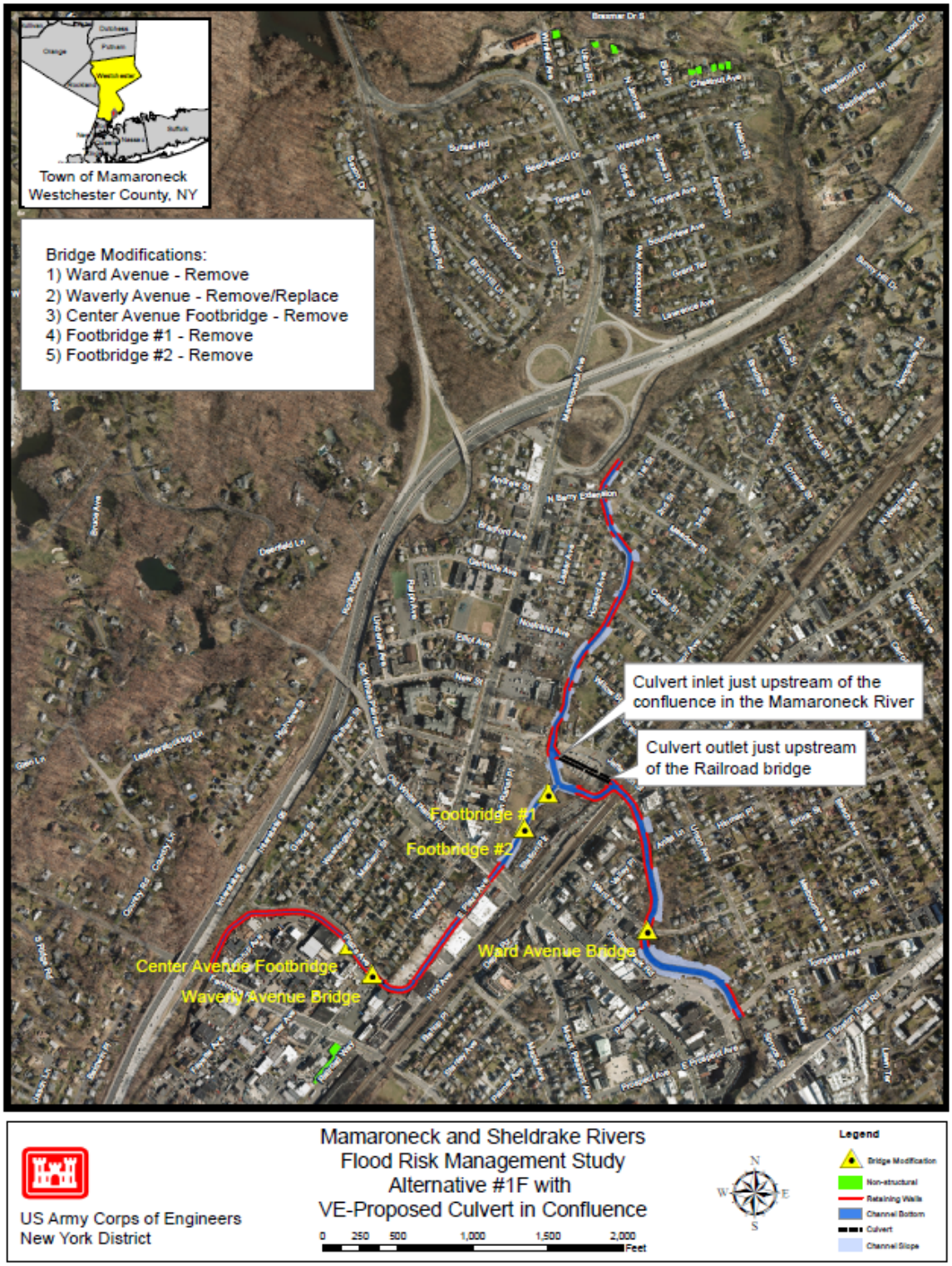

Figure 28 - Alternative 1F | with the VE Proposed Culvert in Confluence Plan View.

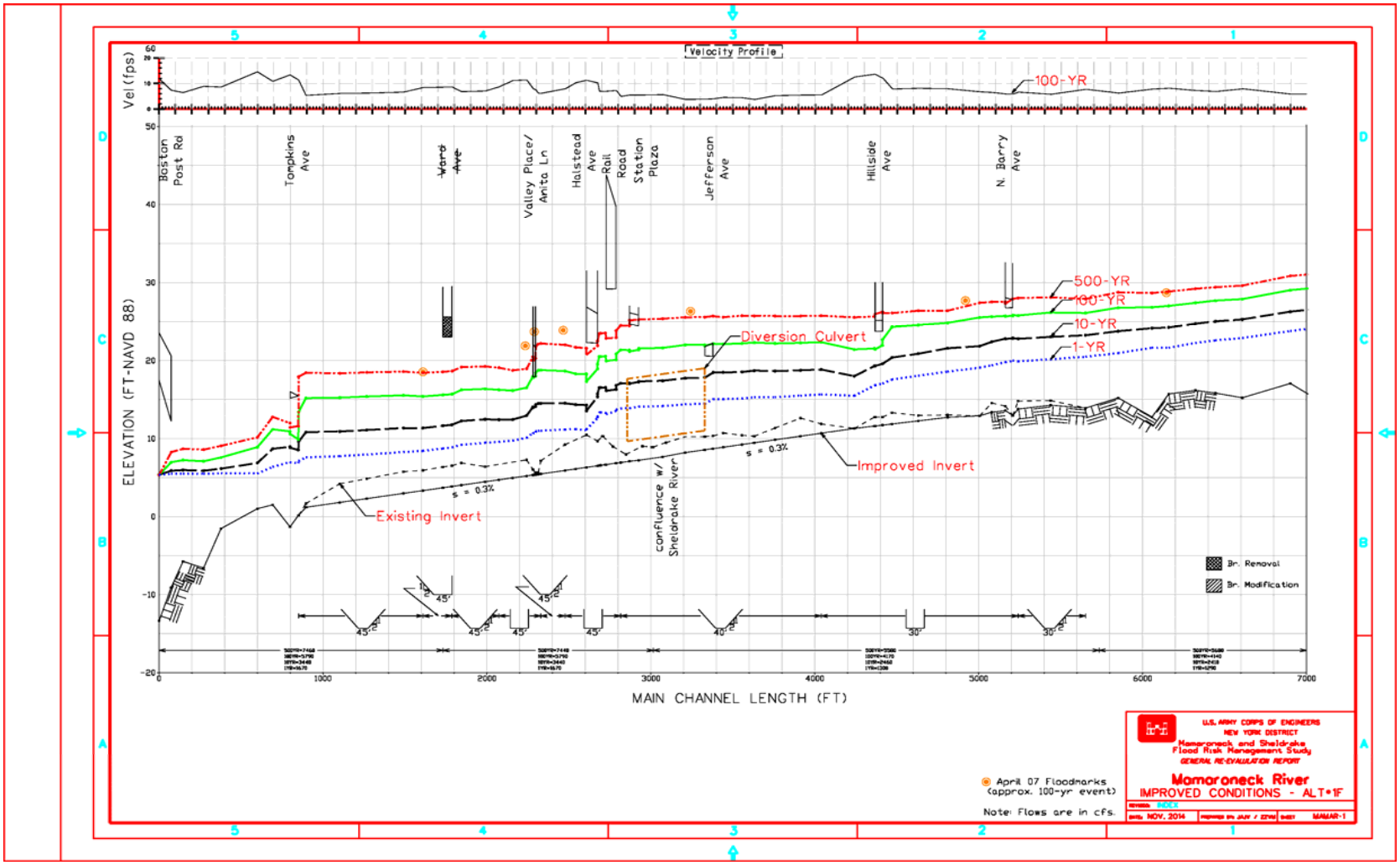

Figure 29 - Alternative 1F | Mamaroneck1 Profile

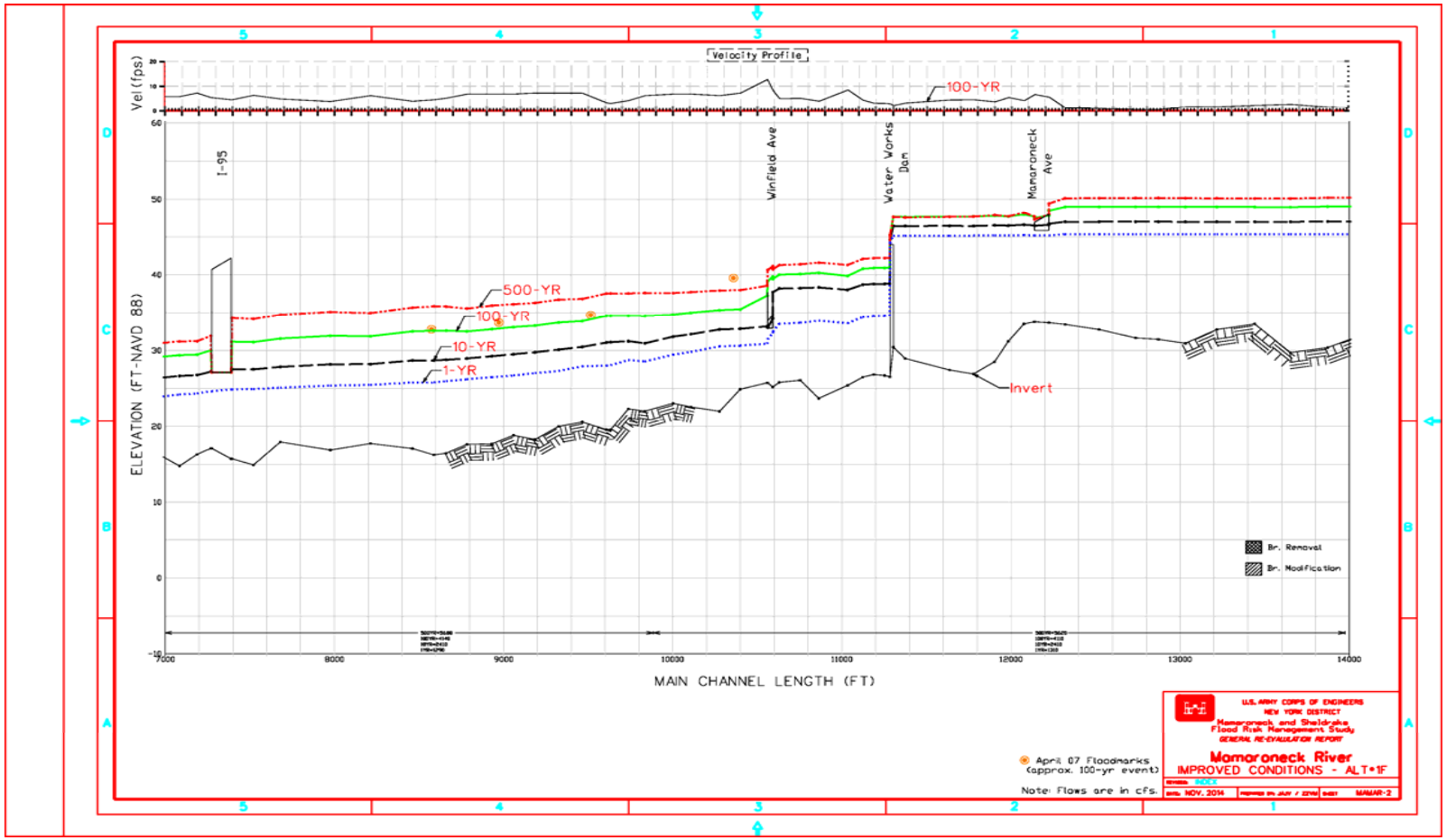

Figure 30 - Alternative 1F | Mamaroneck2 Profile

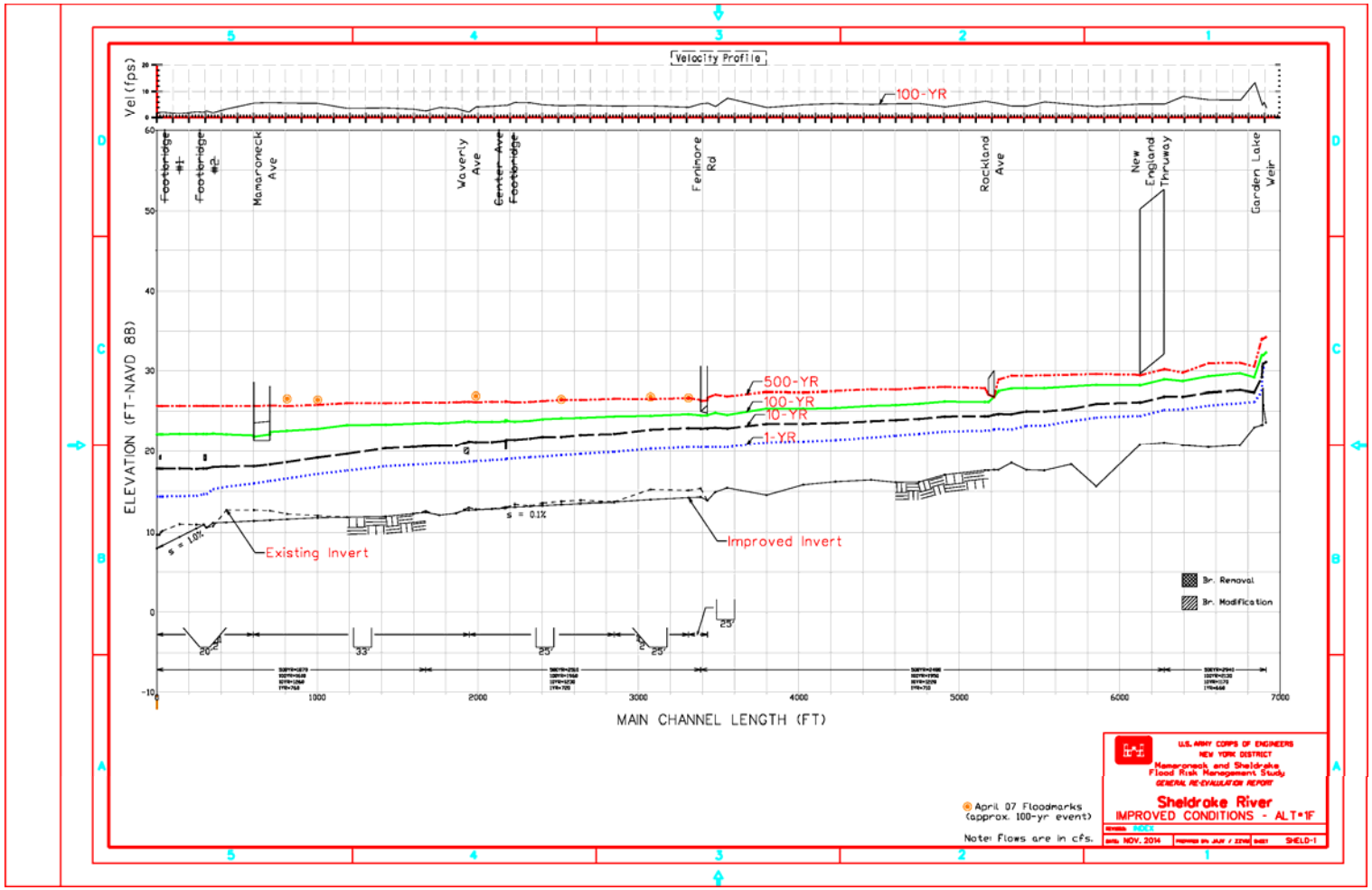

Figure 31 -Alternative 1F | Sheldrake Profile

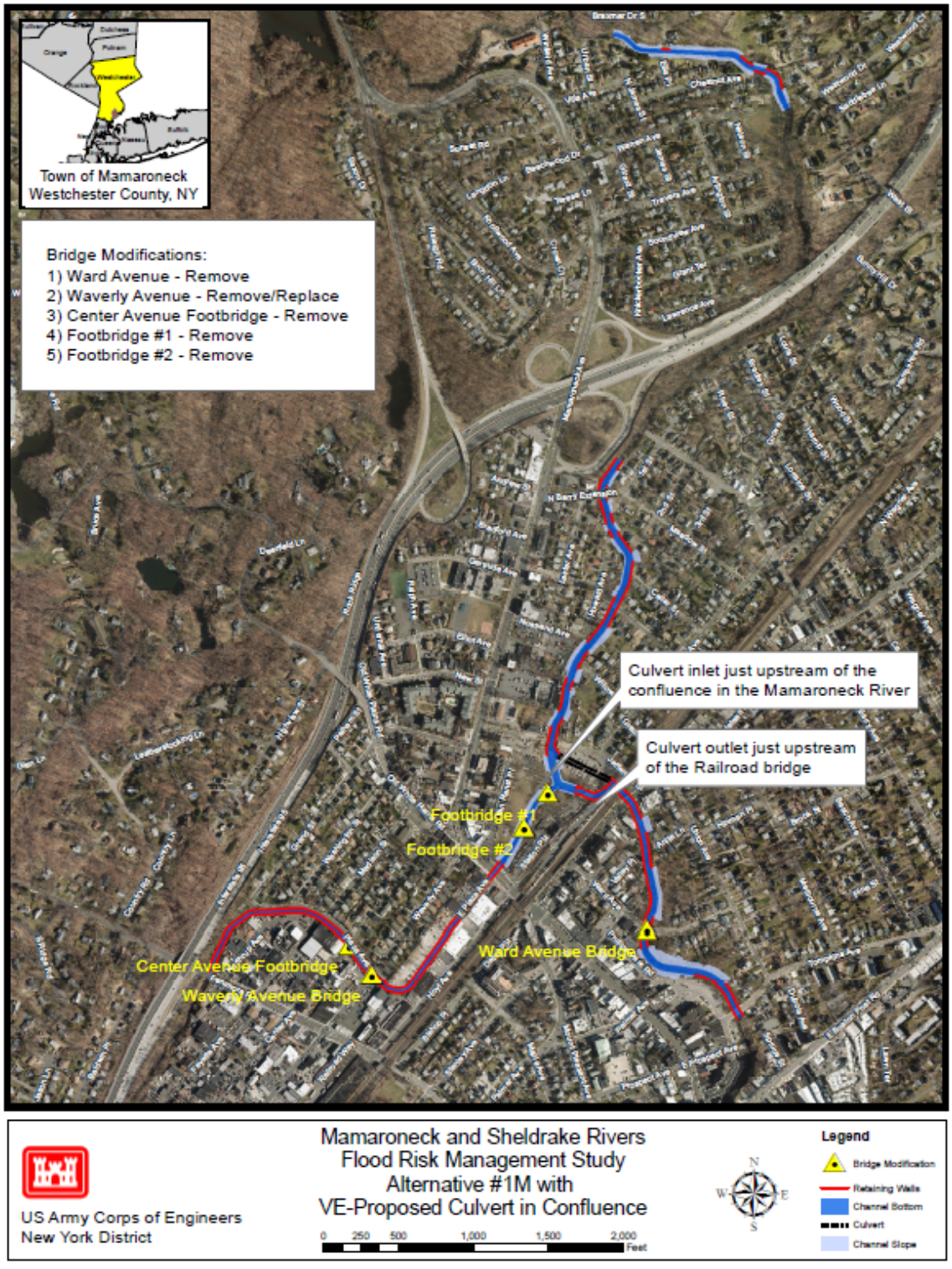

Figure 32 - Alternative 1M | Plan View with the VE Proposed Culvert in Confluence

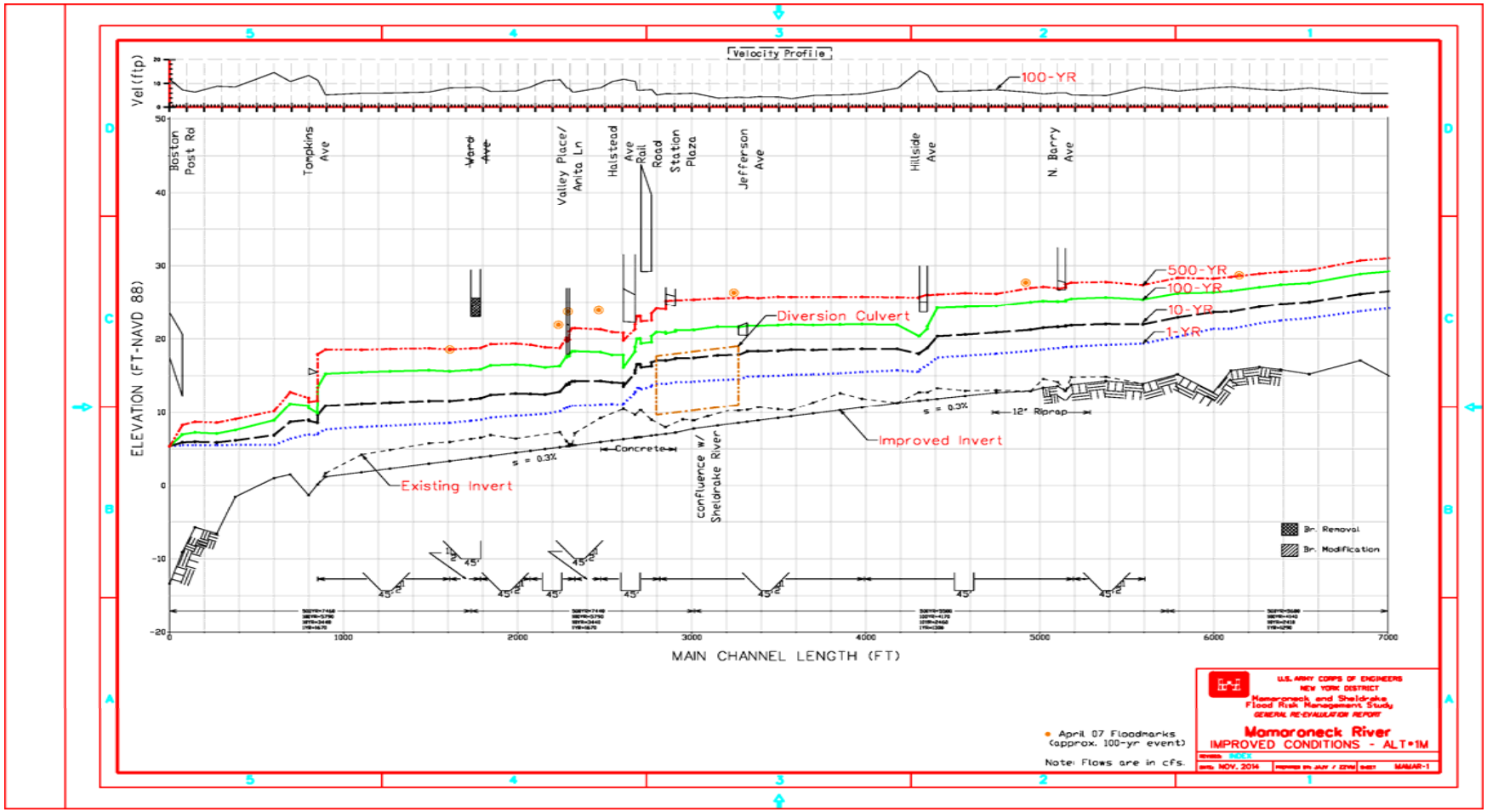

Figure 33 - Alternative 1M | Mamaroneck1 Profile

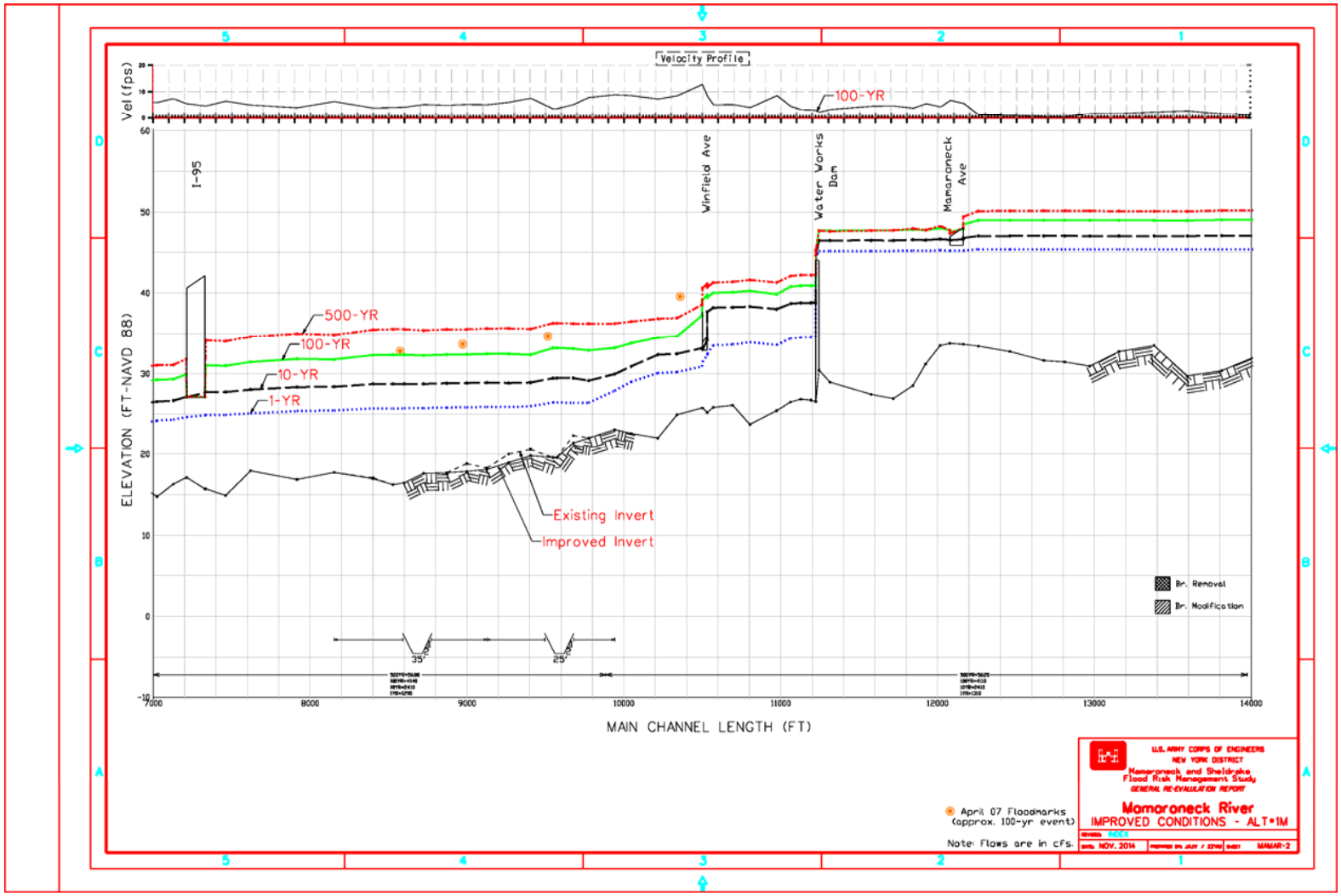

Figure 34 - Alternative 1M | Mamaroneck2 Profile

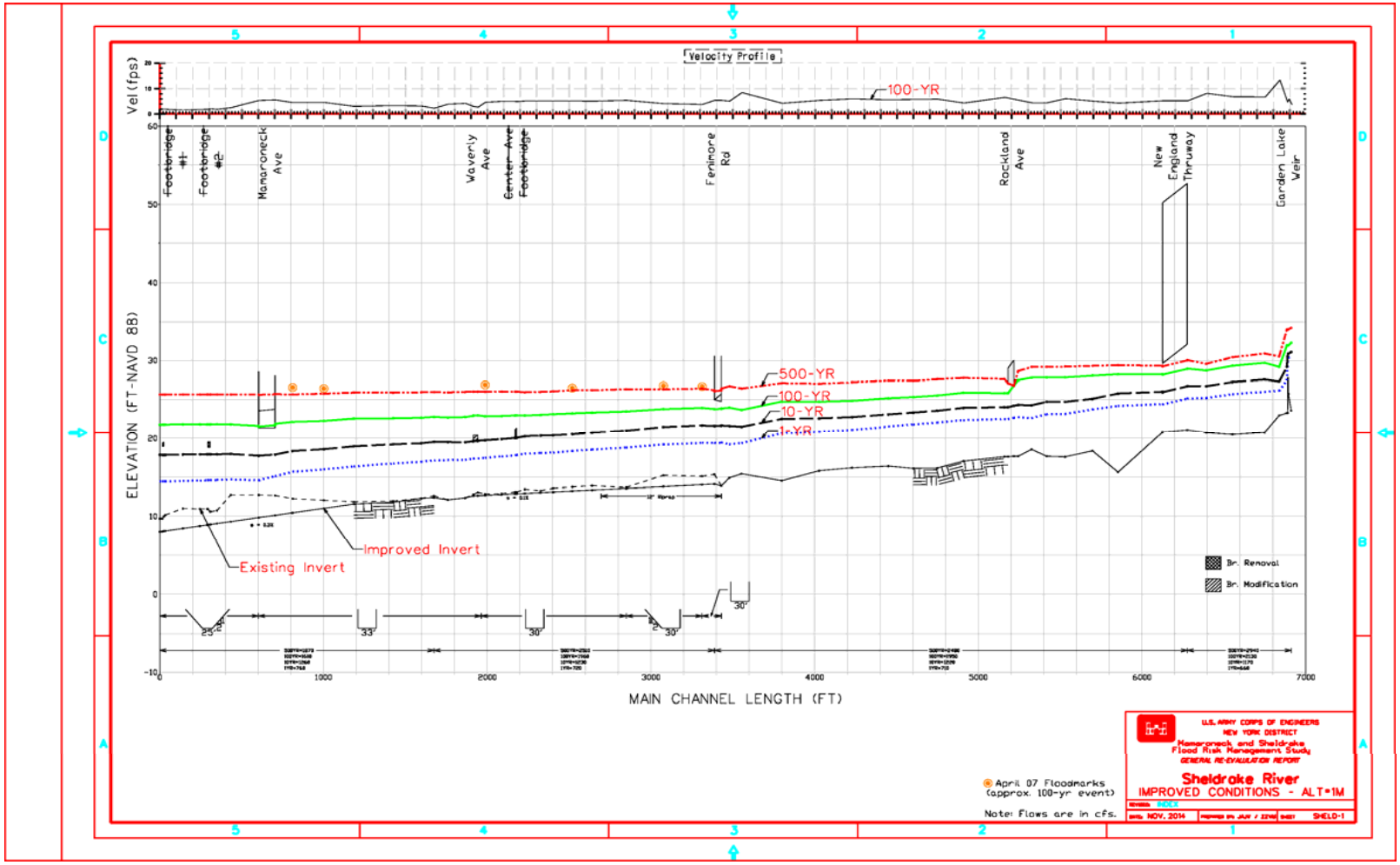

Figure 35 - Alternative 1M | Sheldrake Profile

7.4 Updated Cost and Benefit Summaries

As noted in Section 4 of the Economic Appendix, significant time has elapsed since the initial formulation and cost and benefit calculations. Therefore, prior to refining the design for Alternative 1F and Alternative 1M, the economics for the plans were updated (also the costs were updated to incorporate the Value Engineering design modifications results to Alternative 1F and 1M). The cost summary of the optimized alternatives and the benefits comparisons are presented in October 2015 price level, and at the October 2015 discount rate of 3.375%.

The cost and benefit comparison changed in two ways. The structure inventory was updated to reflect the change in price level and the updated benefits are shown in the final benefit cost comparison table. Structures and content values were adjusted to the current price level with the changed with RSMeans indices, and the bridge benefits were adjusted with the Civil Works Breakdown Structure (CWBS) Indices for Feature Code 08, Roads, Railroads and Bridges. Advanced wall replacement benefits were added to the benefit pool upon final assessment of the design team during the optimization phase. The hydrologic data generated to assess with and without project conditions assumes the stability of the floodwalls is maintained throughout the 50-year period of analysis. The final assessment of the engineering team, and the final cost estimates which resulted, reflect that the existing walls would not withstand the channel work required. The final plan requires replacement of the existing walls, and advanced wall replacement benefits and are calculated as an avoided cost in the near future, because it was determined that the walls would need to be replaced in the without project condition in year 2021. It should be noted that these walls would be replaced earlier in the with-project condition because engineering assessment determined that they would not withstand the channel construction work. This benefit is comparable to the advanced bridge replacement benefits. If a floodwall is replaced as the result of a flood risk management project, a benefit can be claimed to at least partially offset the cost of bridge replacement. Advanced wall replacement benefits are quantified for the period that the useful life of the floodwall is extended by the project.

Based on the economic update, Alternative 1F still provides the maximum annual net benefits with a BCR of 1.21. Alternative 1M was also economically justified with a BCR of 1.17 and indicated higher performance against long term risk. The comparison of these costs and benefits and project actions are presented in Table 16 and Table 17.

Table 16: Comparison of the Benefits and Costs of 1F and 1M

Plan	Stream/Benefit Source	Flood Damages Without Project	Flood Damages With Project	Annual Benefits	Ratio	Updated Benefits	Total Annual Cost[2]	Net Excess Benefits	BCR
1M	Mamaroneck DS	$35,820	$5,620	$30,200	1.07	$32,222			
	Sheldrake	$2,059,220	$173,100	$1,886,120	1.07	$2,012,383			
	Mamaroneck US	$1,315,290	$246,400	$1,068,890	1.07	$1,140,445			
	Pre Base Year	N/A	N/A	$165,494	1.07	$176,573			
	Wall Replacement	N/A	N/A	$160,500	1.00	$160,500			
	Bridge Replacement	N/A	N/A	$119,900	1.06	$127,100			
	Emergency	$94,185	$21,741	$72,444	1.09	$78,891			
	Total	*$3,410,330*	*$446,861*	*$3,503,548*		*$3,728,114*	*$3,181,000*	*547,100*	*1.2*
1F	Mamaroneck DS	$35,820	$5,870	$29,950	1.07	$31,955			
	Sheldrake	$2,059,220	$254,180	$1,805,040	1.07	$1,925,876			
	Mamaroneck US	$1,315,290	$272,660	$1,042,630	1.07	$1,112,427			
	Pre Base Year	N/A	N/A	$165,494	1.07	$176,573			
	Wall Replacement	N/A	N/A	$118,600	1.00	$118,600			
	Bridge Replacement	N/A	N/A	$119,900	1.06	$127,100			
	Emergency	$94,185	$24,712	$62,960	1.09	$68,563			
	Total	*$3,410,330*	*$557,422*	*$3,344,574*		*$3,561,093*	*$2,951,000*	*610,100*	*1.2*

Price level: Analysis was conducted at October 2015 price level at this point in the analysis. As analysis progresses, the price level and discount rate was updated to the then current price level. The selection of the TSP does not change. October 2015 Price Level, 3.375% Interest Rate.

N/A (not applicable) as Pre-Base Year, Wall Replacement and Bridge replacement are benefits, not damages in the without project conditions.

Table 17: Summary of Actions for the Alternatives

Bridge Removal	Alternative 1F	Alternative 1M
Ward Avenue	Remove	Remove
Station Plaza	No action	No action
Waverly Place	Remove/replace	Remove/replace
Center Avenue Footbridge	Remove	Remove
Footbridge #1 (near confluence)	Remove	Remove
Footbridge #2	Remove	Remove
Road Removal		
Glendale Avenue (20-ft section)	No action	Remove
Channel Work Length (ft)		
Harbor Heights	No action	1,378.00
Mamaroneck Upstream	2,368.00	2,368.00
Mamaroneck Downstream	2,408.00	2,408.00
Sheldrake	2,800.00	2,800
Channel Width Size (ft)		
Harbor Heights	No action	25.00–35.00
Mamaroneck Upstream	30.00–40.00	45
Mamaroneck Downstream	45	45
Sheldrake	25.00-33.00	25.00–30.00
Channel Cut Depth (maximum) (ft)		
Harbor Heights	No action	1.1
Mamaroneck Upstream	2.3	2.3
Mamaroneck Downstream	4.2	4.2
Sheldrake	1.8	3.4
Walls (average height/length) (ft)	8.4 8,795	8.5 10,210
Nonstructural	9 structures	No action

7.5 NED Plan Identification

Upon presentation of the plan formulation and optimization tables with Benefit to Cost Ratios (B/C), Net Benefits and Local Cost Sharing Amounts, both the Non-federal sponsor (NYSDEC) and the Local Partners (County of Westchester and the Village of Mamaroneck) jointly requested that the federal Government further analyze the level of long term risk that Harbor Heights Reach was providing for Alternative 1M (channelization) and Alternative 1F (nonstructural component). Based on this request, USACE conducted an incremental economic analysis for the Harbor Heights reach.

As illustrated by Figure 37, Alternative 1M provides, overall, more flood risk management than Alternative 1F based on the reduction in WSELs with the project in place. However, the channelization in the Harbor Heights reach (upstream Mamaroneck Reach) recommended in Alternative 1M (deepening and widening) requires further evaluation and analysis to determine the level of performance and incremental justification it provides.

Alternately, the flood risk management solution for Alternative 1F (Figure 36) in Harbor Heights is a nonstructural feature that includes the elevation of approximately eight structures along the Mamaroneck River (during Plans and Specifications, additional structures may be identified for elevation whiles others identified for elevation may be wet or dry floodproofed). The flood vulnerable homes were evaluated as a whole alternative to a structural solution in the outlying areas of the project. Homes at risk of flooding were individually justified.

As indicated in the figures that illustrate the residual risk for first floor damages of structures for a modeled 1% flood event, Harbor Heights realizes a 1.6-foot reduction in water surface elevation as a result of the proposed channelization for Alternative 1M. Alternative 1M channelization cost estimate is estimated at over $6 million.

Alternative 1F only realizes a 0.4-foot reduction in WSEL in the Harbor Heights reach. However, this 0.4-foot reduction in water surface elevation is a result of downstream channelization and provides only a negligible amount of flood risk management. The proposed flood risk management feature recommended for Harbor Heights for Alternative 1F is a nonstructural solution (elevation of structures out of the 1% floodplain). Alternative 1F nonstructural cost estimate is approximately $2.4 million.

It should be noted at this juncture that the remaining study areas of Alternative 1F and 1M other than Harbor Heights represent almost identical flood risk management features with Alternative 1M providing slightly more flood risk management probability than Alternative 1F as noted in Figure 36 and Figure 37 with wider and/or deeper channel modification along the Sheldrake and Mamaroneck Rivers.

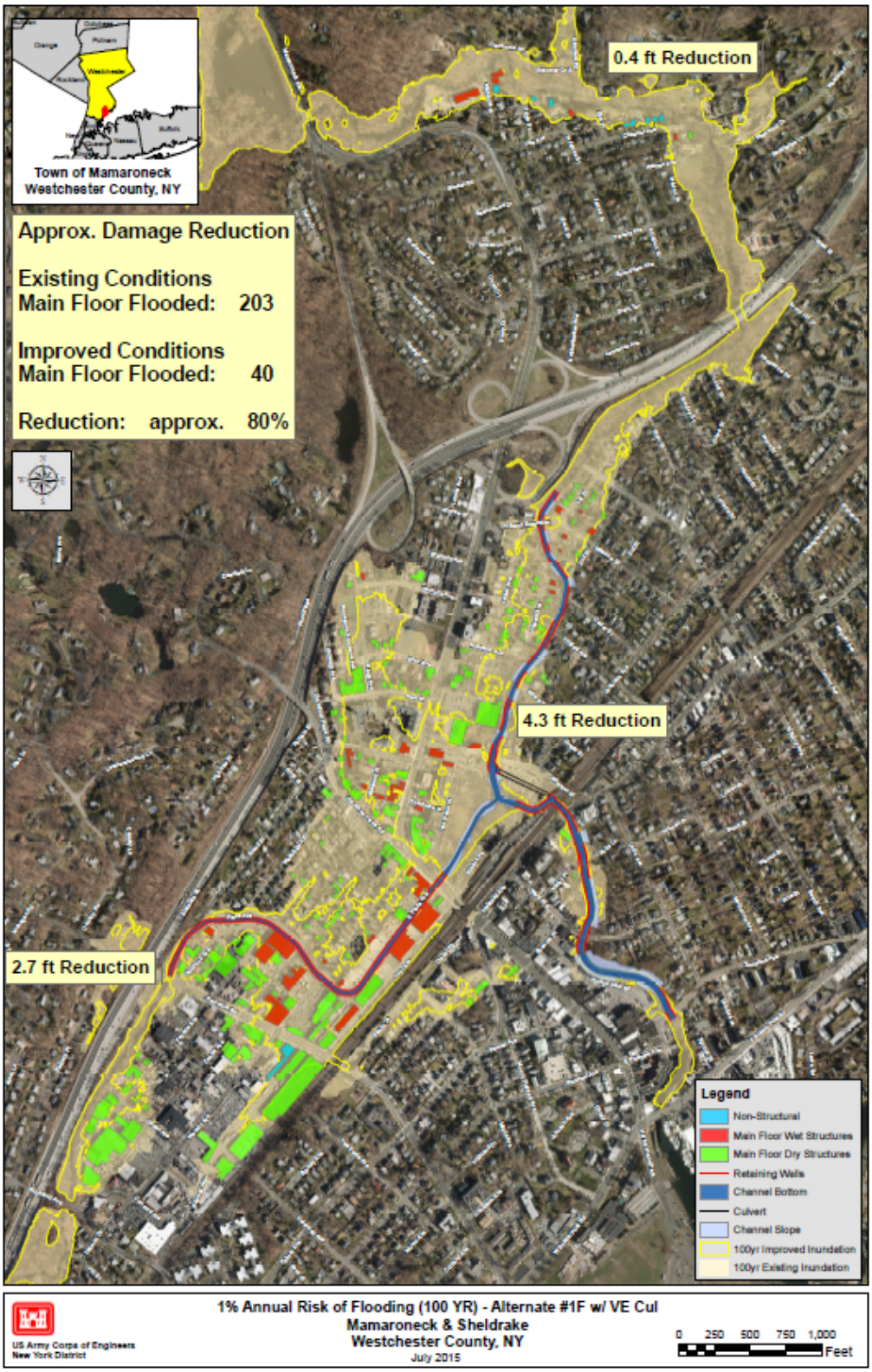

Figure 36: Alternative 1F -1% Annual Probability of Exceedance Residual Risk

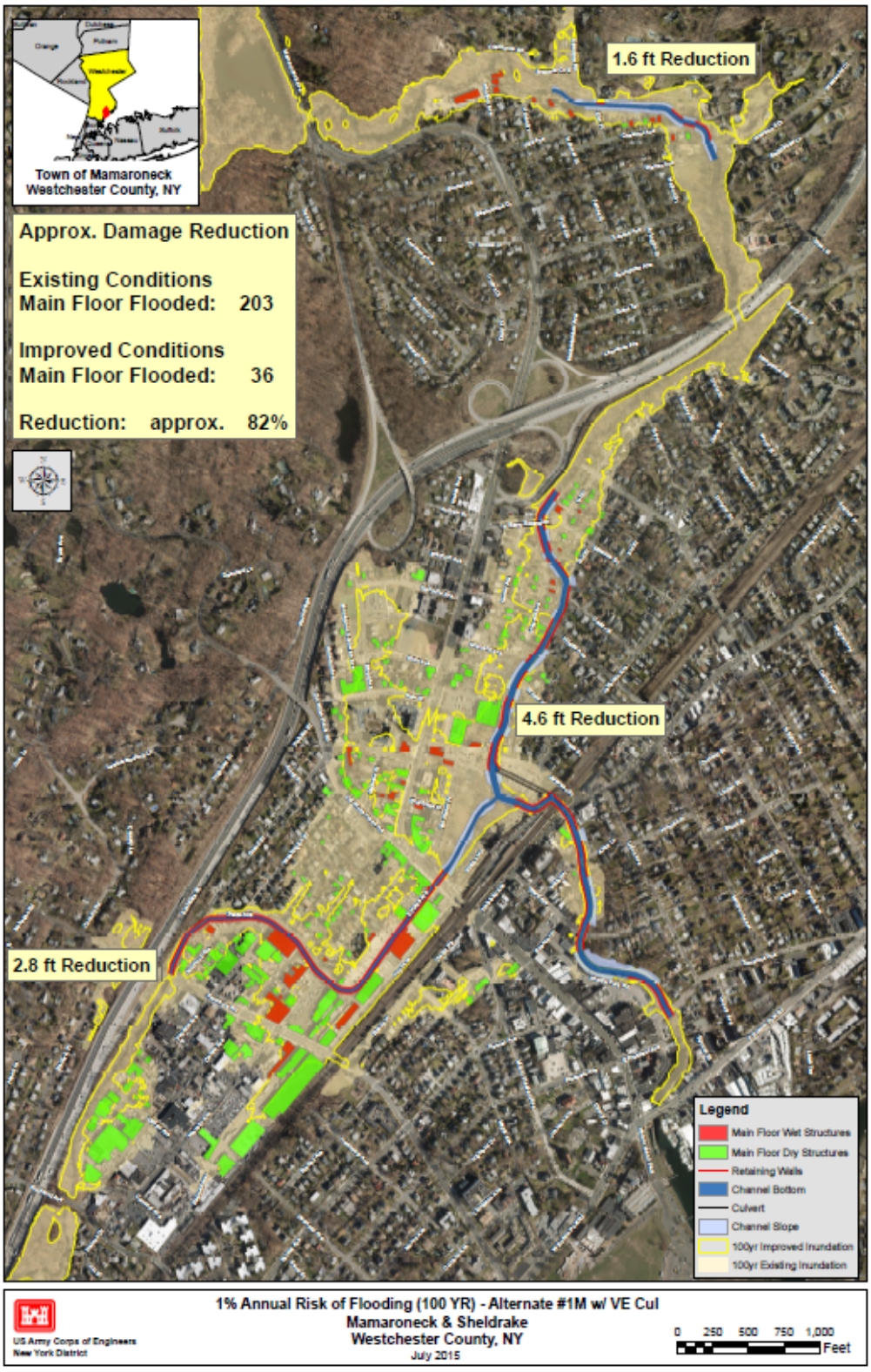

Figure 37: Alternative 1M -1% Annual Probability of Exceedance Residual Risk

7.6 NED Plan Level of Performance Analysis

The following is the step by step analysis for the "level of performance" analysis (Table 18) for each reach for Alternative 1M and 1F and also the "incremental justification" analysis conducted on the Harbor Heights reach (Upper Mamaroneck) for each alternative.

This "Level of Performance Analysis" indicates that the channel modification that is proposed in Alternative 1M, in the Harbor Heights reach of the Upper Mamaroneck River (1,340 feet) would only provide against a 20% annual average exceedance probability whereas the nonstructural elevation of homes would be elevated out of the 1% flood plain. At the initiation of optimization of Alternative 1, it was not expected that a) channelization would have such a minimal effect on water surface elevations and thus, long-term risk output and b) resident participation would be receptive.

Table 18: Level of Performance Analysis (Alternative 1M & 1F)

	Alt 1F	**Alt 1M**
Mamaroneck Reaches	Level of Performance	Level of Performance
Tompkins to Ward	2% flood event (50-yr)	2% flood event (50-yr)
Ward to Valley	>200-yr (0.5%)	>200-yr (0.5%)
Valley to Halstead	>100-yr (1%)	>100-yr (1%)
Halstead to Confluence	65 to 85-yr (1.5% to 1.2%)	75 to 100-yr (1.3% to 1%)
Confluence to Hillside	30-yr (3.3%)	30-yr (3.3%)
Hillside to I-95	**15-yr (6.6%)**	**30-yr (3.3%)**
I 95 to Winfield (Harbor Heights)[1]	**100-yr (1%) (select structures) 1%**	**5-yr (20%)**
Sheldrake Reaches		
Mouth to Mamaroneck Ave	50-yr (2%)	50-yr (2%)
Mamaroneck Ave to Fenimore[2]	**50-yr (2%)**	**65 to 95-yr (1.5% to 1.05%)**
Fenimore to Rockland[2]	**20-yr (5%)**	**40-yr (2.5%)**

1. Channelization determined to be not economically justified in Harbor Heights (see next section)
2. Due to development along Sheldrake, Alternative 1M & 1F would now be identical on the Sheldrake River

7.7 NED Plan Incremental Justification Analysis

Once it was determined that the level of performance in the Harbor Heights reach for channelization in Alternative 1M was only 20% annual exceedance probability, an incremental economic analysis was conducted for the Harbor Heights reach.

The total cost of channel modification in Alternative 1M for the Harbor Heights reach is approximately $6,000,000 with a total annual equivalent cost of approximately $322,000 and annual benefits of only $147,000 for a BCR of 0.46.

Noting that Harbor Heights channelization is not incremental justified (and therefore does not meet NED plan qualifications for federal interest), the nonstructural feature for Harbor Heights as presented in Alternative 1F was incrementally analyzed. The total cost for the nonstructural solution in Alternative 1F for the Harbor Heights reach is approximately $2,400,000 with a total annual equivalent cost of approximately $114,100 and annual benefits of $154,700 for a BCR of 1.36.

Based on the above analysis, Alternative 1M channel modification is not incrementally justified and only provides a 20% "level of performance" in the Harbor Heights reach. Therefore, a new iteration of Alternative 1 was developed during the optimization, Alternative 1Z. Alternative 1Z is the same as alternative 1M below the Harbor Heights reach. In the Harbor Heights reach (upper Mamaroneck) channel modification has been replaced with the nonstructural elevation of structures

Realizing that channel modification did not provide the level of performance expected, USACE also analyzed the removal of Glendale Road (the "Road to Nowhere"). The hydraulic modeling results of the removal of the "Road to Nowhere" indicated only a negligible effect on water surface elevations for the more frequent flood events and even less for the less frequent flood events (i.e. the 1% flood event). Channel modification, bridge removal or modification, dam removal/repair, and/or road removal within the Harbor Heights reach was determined to be not hydraulically effective.

Table 19 provides the updated cost and benefit analysis including Alternative 1Z comparison to Alternative 1M and 1F. Please note that alternative costs have been updated for Alternative 1F and 1M to include post-ATR refinements and preliminary CSRA contingencies. Based on this refined analysis and revision, Alternative 1Z is the NED plan and the recommended plan for implementation. Alternative 1Z cost estimates are further refined in Section 10. Any cost refinements noted in Section 10 of this Report for Alternative 1Z would also apply to Alternative 1M and 1F equally and proportionally and therefore would not change the plan selection results.

Further, please also note that the cost of Alternative 1S would increase proportionately with Alternative 1M and 1F. However, Alternative 1S does not include the Harbor Heights reach at all. Therefore, Alternative 1S would not capture the benefits of the increase of annual net benefits (but would capture the cost increases noted in 1F and 1M) and therefore a total decrease in annual net benefits. Alternative 1S annual net benefits would change relative to Alternative 1F. Alternative 1F is identical to Alternative 1S with the exception of Harbor Heights. Alternative 1S does not include any flood works in Harbor Heights. Therefore, the Annual Net Benefits for Alternative 1S would always remain below those of Alternative 1F and therefore below Alternative 1Z, the NED plan. Therefore, Alternative 1S was removed from further consideration.

Costs and benefits were refined for Alternative 1Z and are presented in Table 20.

Table 19: Comparison of the Benefits and Costs of the 1F, 1M and 1Z

October 2015 Price Level, 3.125% Interest Rate

Project Plan	Total Project Cost	Total First Cost	Harbor Heights	OMRR&R	IDC	Annual Cost	Annual Benefits	Annual Net Benefits	BCR
Alt 1M Channelization in Harbor Heights Reach	$70,021,000	$67,778,000	$6,481,232	$311,846	$2,243,720	$3,230,159	$3,581,438	$351,279	1.1
Alt 1Z nonstructural in Harbor Heights Reach Alt 1F & 1M HYBRID PLAN	$64,212,440	$62,265,040	$2,429,725	$270,663	$1,947,396	2,946,861	$3,403,704	$456,843	1.2
Alt 1F nonstructural in Harbor Heights Reach	$64,772,400	$62,825,000	$2,429,725	$270,663	$1,947,396	$2,970,200	$3,368,217	$398,019	1.1

Table 20: Updated Benefits and Costs of the NED – Alternative 1Z

Plan	Stream/Benefit Source	Flood Damages Without Project	Flood Damages With Project	Annual Benefits	Ratio	Updated Benefits	Total Annual cost	Annual Net Benefits	BCR
1Z	Mamaroneck DS	$35,820	$5,620	$30,200	1.07	$32,222			
	Sheldrake	$2,059,220	$173,100	$1,886,120	1.07	$2,012,383			
	Mamaroneck US	$1,315,290	$246,400	$1,042,630	1.07	$1,147,914			
	Nonstructural			145,000	1.07	154,707			
	Wall Replacement	N/A	N/A	$118,600	1.00	$118,600			
	Bridge Replacement	N/A	N/A	$133,900	1.06	$142,497			
	Emergency			$62,960	1.09	$68,563			
	Total	*$3,410,330*	*$532,710*	*$3,306,380*		*$3,403,704*	*$3,146,900*	*$256,800*	*1.1*

N/A (not applicable) as Pre-Base Year, Wall Replacement and Bridge Replacement are benefits, not damages in the without project conditions.
Post CSRA Cost Estimate and Updated Comparison of the Benefits and Costs of the NED- October 2015 Price Level, 3.125% Interest Rate.

7.8 Updated Economic Damage Assessment

The final benefit analysis of the optimized NED plan reflects several changes as a result of internal and external reviews. The updated benefits are shown in the final benefit analysis table at an October 2016 discount rate of 2.875%. Structures and content values were adjusted to the October 2016 price level and the emergency costs were adjusted with the Consumer Price Index (CPI). Additionally, the benefits were updated based on the final design and associated "advanced replacement" benefits. Transportation benefits were also added to the final benefit calculation.

7.8.1 Transportation Benefits

Flooded roadways pose significant life safety risks by impeding access for emergency vehicles and impeding travel to safety. An allowable NED benefit is the time savings of eliminated detours for residents and travelers in the community when inundation does not impede travel. Time savings were calculated using Appendix D-4 of Appendix D of ER 1105-2-100. Two primary routes require detours during a flood event for a several hour duration. Time cost of business and recreational travelers account for an annual individual savings of $4,200.

7.8.2 Bridge Analysis

It was during the optimization of Alternative 1 that the cost of bridge removals versus channelization against water surface elevations was evaluated. Some existing bridges have to be removed to facilitate a larger channel and/or construction activities (such as the footbridges). Other bridges wouldn't be required to be removed as channel modification provides a reduction in water surface elevations during a flood event. By deepening and widening the channel under the bridges, the flow capacity is increased.

The Halstead Avenue Bridge causes approximately a two (2) foot increase in the 1% flood event water surface elevations. The Halstead Ave bridge would be particularly expensive to replace due to its' proximity to the railroad, heavy traffic, and the utilities in the left abutment. The cost to remove and replace Halstead Avenue Bridge is approximately $16M. Channelization would provide about a 4 foot reduction in the 1% flood event water surface elevation.

Additionally, the Tompkins Avenue Bridge has approximately a 4 foot impact on the existing 1% flood elevation. However, the bridge is not in the vicinity of the main damage areas. In addition the Tompkins Ave Bridge would be very expensive to replace due to the size and high traffic load.

Further, the Valley Place Bridge has approximately a 3-foot impact on the existing 10% flood elevation. The NED plan recommends that the channel under this bridge be widened and deepened to increase flow capacity to reduce water surface elevations during the 1 % flood event. The wing wall would also be corrected as part of the channel improvements.

Ward Avenue Bridge is required to be removed because it acts as a significant impediment to flow. Ward Avenue Bridge causes a five (5) foot increase in the 1% flood event elevations and although is high enough not to impede flow, it is very narrow. Ward Avenue Bridge carries a two-lane roadway, providing access to public transportation, local businesses and the Metro-North station. Removal, without replacement, would severely limit residents' access on Ward Avenue to much of the Village of Mamaroneck that they can easily access now. Further, it was noted that turning Ward Avenue into a cul-de-sac or dead end would have an effect on the ability of emergency vehicles to reach them. An analysis was also conducted to determine the costs associated with the additional land requirements, utility relocation, transportation

analysis, emergency vehicle access, etc. determined that not only is it cost prohibitive in not replacing Ward Avenue Bridge it also would not accrue any replacement benefits. Therefore, to return the residents to pre-construction conditions without negatively impacted them, USACE has determined that the Ward Avenue Bridge would be removed and replaced as part of this project.

A table of the flooding impacts of many key bridges and the estimated costs of replacement for these is noted below (Table 21).

Table 21 Key Bridge Flood Impacts

Feature	Flood Impact (1%)	Cost to remove and replace
Ward Ave Bridge	About 5 ft.	$6.4M
Halstead Ave	About 2 ft.	$16M
Glendale Ave. (road to nowhere)	About 0.25 ft. (Max of 0.7 ft. at Winfield)	No replacement required
Waverly Ave. Bridge	N/A (negligible)	$3.1M
Foot Bridge	About 0.1 ft.	$400k

October 2016 Price Level, 2.875% Interest Rate, 50-year period of analysis

The NED plan was therefore refined to replace three bridges which were not originally proposed to be replaced. The Ward Avenue Bridge and two pedestrian footbridges are included in the revised project costs. Consequently, the benefit stream has been revised to reflect those additional advanced replacement benefits. The sum of the Waverly, Ward, and two pedestrian bridge advanced replacement benefits totals $229,000. The derivation of the benefits is shown in Table 22. The bridge replacement dates in the absence of a federal project were provided by the Village of Mamaroneck and Westchester County, who maintain bridges in accordance with a Memorandum of Understanding which mandates shared responsibilities for maintenance and replacement of the bridges in their overlapping jurisdictions.

Table 22 Bridge Replacement Benefit

	Waverly	Ward	Pedestrian
Cost of new bridge ($)	3,147,900	4,164,149	372,000
Life of new bridge (years)	50	50	50
Remaining life of existing bridge (years)	0	10	38
Extended life of the bridge (years)	50	40	12
Discount Rate	0.02875	0.02875	0.02875
Capital Recovery Rate	0.04	0.04	0.04
Annual Cost of new bridge ($)	119,500	158,000	14,100
PW annuity for extended life (years)	26	24	20
Benefits in year to be replaced ($)	3,149,000	3,727,100	1,414,000
Single payment pw for replacement year	1	.75	.34
Present worth in year one ($)	3,149,000	2,807,200	48,200
Average annual benefit ($)	119,500	106,500	1,800

October 2016 Price Level, 2.875% Interest Rate, 50-year period of analyses

7.8.3 Advanced Wall Replacement Benefits

Advanced wall replacement benefits were added to the benefit pool upon final assessment during the optimization phase. The hydrologic data generated to assess with and without project conditions assumes the stability of the floodwalls is maintained throughout the 50-year period of analysis. The final assessment of the engineering team, and the final cost estimates which resulted, reflect that the existing walls will not withstand the channel work required. The final plans require replacement of the existing walls, and advanced wall replacement benefits are calculated as an avoided cost in the near future. This benefit is comparable to the advanced bridge replacement benefits. Advanced wall replacement benefits are quantified for the period that the useful life of the floodwall is extended by the project. Derivation of the wall replacement benefits is presented in Table 23, in October 2016 price level and prevailing discount rate of 2.875%.

This benefit is calculated for 80% of the entire wall construction cost of $6M, since 20% of the walls constructed do not replace existing walls. More than half of the existing walls were constructed in the 1930's as WPA efforts and have not been repaired. They are constructed of rocks with both dry stack and mortar stack and have already failed in some places. The engineers confirm that without a federal project, the walls would require replacement. It was determined that approximately 70% of these walls would need to be replaced in the without project condition in year 2021. An additional 30% of the walls will replace walls with an estimated 20 years of remaining life.

Table 23 Wall Replacement Benefit

	1st Increment	Delayed 1st Increment*	2nd Increment	TOTAL RANGE
Cost of New Wall ($)	3,361,000	3,361,000	1439,000	
Life of new wall (years)	50	50	50	
Remaining life of existing wall (years)	4	10	20	
Extended life of the wall (years)	46	40	30	
Discount Rate	0.02875	0.02875	0.02875	
Capital Recovery Rate	0.04	0.04	0.04	
Annual Cost of New Wall ($)	127,500	127,500	54,600	
PW annuity for extended life (years)	25	24	20	
Benefits in year to be replaced ($)	3,230,800	3,007,600	1,087,700	
Single payment pw for replacement year	1	1	1	
Present worth in year one ($)	2,884,500	2,265,300	617,000	
Average annual benefit ($)	109,500	86,000	23,400	109,400-132,900

October 2016 Price Level, 2.875% Interest Rate, 50-year period of analysis

The analysis calculates the benefits for the most deteriorated walls that are estimated to have only 4 years of life remaining. Then tallies the benefits if the local sponsor were not able to replace those walls and they survived for ten years instead of four to assess the sensitivity of the project justification based upon the replacement assumptions for the walls. Finally, the analysis generates the benefits which accrue from replacing the less deteriorated walls. The result is a sensitivity analysis that show the high and low range of advanced wall replacement benefits. The low estimate of wall replacement benefit represents a delayed first increment plus the increment which had twenty years of life estimated, or $86,000 plus $23,400, for a total of $109,400. The high estimate of wall replacement benefit represents an earlier first increment plus

the increment which had twenty years of life estimated,$109,500 plus $23,400, for a total of $132,900. Annual benefits (lower range) for the NED plan (Table 24) is estimated at $3,777,749 and $3,821,139 for the high range (Table 25).

Table 24 Updated Benefits of the NED Plan – Lower Range

Stream/Benefit Source	Flood Damages Without Project	Flood Damages With Project	Annual Benefits	2017 Bldg. Cost/CWBS 08/CP Ratio	Updated Benefits	BCR
Mamaroneck DS	$35,820	$5,620	$30,200	1.08	$32,472	
Sheldrake	$2,059,220	$173,100	$1,886,120	1.08	$2,028,044	
Mamaroneck US	$1,315,290	$246,400	$1,068,900	1.08	$1,149,331	
Nonstructural	N/A	N/A	$145,000	1.08	$155,911	
Wall Replacement	N/A	N/A	$109,400	1.00	$109,400	
Bridge Replacement	N/A	N/A	$229,600	1.00	$229,600	
Transportation Disruption	N/A	N/A	$4,200	1.00	$4,200	
Emergency	$94,185	$21,741	$72,444	1.09	$78,891	
Total	*$3,410,330*	*$446,900*	*$3,596,300*		*$3,787,849*	*1.04*

October 2016 Price Level, 2.875% Interest Rate, 50-year period of analysis

Table 25 Updated Benefits of the NED Plan – Higher Range

Stream/Benefit Source	Flood Damages Without Project	Flood Damages With Project	Annual Benefits	2017 Bldg. Cost/CWBS 08/CP Ratio	Updated Benefits	BCR
Mamaroneck DS	$35,820	$5,620	$30,200	1.08	$32,472	
Sheldrake	$2,059,220	$173,100	$1,886,120	1.08	$2,028,044	
Mamaroneck US	$1,315,290	$246,400	$1,068,890	1.08	$1,149,320	
Nonstructural	N/A	N/A	$145,000	1.07	$155,911	
Wall Replacement	N/A	N/A	$234,500	1.00	$132,900	
Bridge Replacement	N/A	N/A	$210,800	1.00	$229,000	
Transportation Disruption	N/A	N/A	$4,200	1.00	$4,200	
Emergency	$94,185	$21,741	$72,444	1.09	$78,891	
Total	*$3,410,330*	*$446,861*	*$3,714,896*		*$3,811,139*	*1.05*

October 2016 Price Level, 2.875% Interest Rate, 50-year period of analysis

7.9 Description of the NED Plan

Based on consideration of benefits from an assessment of damages avoided in accordance with economic and environmental USACE procedures, the NED plan (Alternative 1Z) is the recommended plan with various channel widths, depths and lengths within the Village of Mamaroneck. The NED plan also involves retaining walls, bridge removal and replacement, a culvert under the railroad parking lot, as well as nonstructural measures potentially applied to a maximum of eight residences and one non-residential building. The NED plan includes approximately 1.82 miles of channel work in the Mamaroneck and Sheldrake rivers. The average height of the new channel retaining walls would be 8.5 ft (visible height from bottom of the channel, not above ground surface) and the total combined length of new channel retaining walls in the entire study area would be 8,660 ft, some of which replace the existing retaining walls that are deteriorated.

A 25-foot wide by 8-foot high, 390-foot long culvert would be located under the railroad station parking lot from Jefferson Avenue Bridge to the Railroad Bridge to alleviate the poor channel alignment. Concrete retaining walls are proposed where sloped banks are not possible and are currently proposed from Station Plaza to Halstead Avenue along the Sheldrake River as well as reaches within the upper and lower Mamaroneck River. Retaining walls would be constructed in those areas where the trapezoidal channel cannot be constructed, typically where buildings, roads or other features may be affected. Trapezoidal channel improvements would consist of rip-rap or a natural bed channel with sloped or pitched vegetated banks. The channel bottom would remain natural except in the location of the Station Plaza Bridge, which currently has a concrete bottom where it crosses the Mamaroneck, and the Halstead Avenue Bridge. The details for the location of the concrete and steel cantilever retaining walls would be determined as part of the design phase. Retaining walls would vary in height above the water level, depending on the location of the wall (steep embankment, etc.). From the land side, retaining walls would either be level with or not extend more than six inches above post-construction ground surface. The concrete retaining walls may be textured to resemble stone or similar.

Channel work on the segment of the Mamaroneck River south of I-95 and upstream of the confluence with Sheldrake River would total approximately 2,300 ft, and channel work on the segment stretching from south of the confluence to just downstream of the Tompkins Avenue Bridge also would total approximately 2,400 ft. In both segments, the river channel bottom would be widened to 45 ft. The removal and replacement of retaining walls and utilities would be necessary in certain locations including the removal/replace of the Ward Avenue Bridge as noted above.

Channel work on the Sheldrake River from Fenimore Road to the confluence in Columbus Park would total approximately 2,800 ft. The river channel would be deepened and widened to approximately 25-33 feet wide and 3.4-ft cut. Rectangular channel modification would be executed, upstream of Mamaroneck Avenue Bridge. The removal and replacement of retaining walls and utilities would be necessary in certain locations including the removal/replacement of Waverly Avenue Bridge and the removal of the Center Avenue pedestrian bridge. Two footbridges in Columbus Park (footbridge #1, near the confluence, and footbridge #2, closer to the southern edge of the park across from Station Plaza) also would be removed during construction activities and replaced.

In addition to channel work along both rivers, the NED plan would have a nonstructural component along the Mamaroneck and Sheldrake rivers. A total of nine (9) structures (eight residential structures in the Harbor Heights reach and one (1) non-residential structure located on the bank of the Sheldrake River) were selected based on a benefit-cost evaluation. Eight of residential properties in the Harbor Heights neighborhood just south of the Mamaroneck River, all of which are candidates for structure elevation, or

raising were evaluated. No other flood risk management alternative was determined to be incrementally justified in the Harbor Heights area and therefore, cannot be recommended to be eligible of federal funds. The ninth structure is a non-residential property in the Village of Mamaroneck's industrial area along Fenimore Road and just south of the Sheldrake River, which is a candidate for the construction of a ringwall.

All nonstructural actions are contingent upon owner approval and would adhere to construction standards outlined in Village of Mamaroneck's Code Chapter 186-5 that apply to the improvement of structures located in areas of special flood hazard (Village of Mamaroneck 1987). It should be noted that during the design phase of this project, additional structures may be identified for acquisition, elevation or wet/dry floodproofing. Coordination with property owners would be conducted by the Village of Mamaroneck and USACE Real Estate specialists during the design phase of the project. Determination of the nonstructural measure implemented for structures in Harbor Heights will be based on topographic surveys, structure survey, depth of flooding, velocity of waters and technical feasibility of the nonstructural measure.

During the design phase, a full evaluation of public safety would be addressed with the local sponsor. Appropriate treatments to consider all potential implications to public safety would be applied.

Table 26 provides a summary of features for the NED plan. Additionally, Figure 38 through Figure 41 provides features and profiles of the NED plan, Alternative 1Z.

Table 26: Summary of Actions for the NED Plan

Actions	Alternative 1Z – NED Plan
Bridge Removal	
Ward Avenue	**Remove/Replace**
Station Plaza	**No Action**
Waverly Place	**Remove/Replace**
Center Avenue Footbridge	**Remove**
Footbridge #1 (near confluence)	**Remove/Replace**
Footbridge #2	**Remove/Replace**
Channel Work Length (ft)	
Harbor Heights	**No Action**
Mamaroneck Upstream	**2,300**
Mamaroneck Downstream	**2,408**
Sheldrake	**2,800**
Channel Width Size (ft)	
Harbor Heights	**No Action**
Mamaroneck Upstream	**45**
Mamaroneck Downstream	**45**
Sheldrake	**25-33**
Channel Cut Depth (maximum) (ft)	
Harbor Heights	**No Action**
Mamaroneck Upstream	**2.3**
Mamaroneck Downstream	**4.2**
Sheldrake	**3.4**
Walls (average height/length) (ft)	**8.5/8,660**
Nonstructural	**9 Structures**

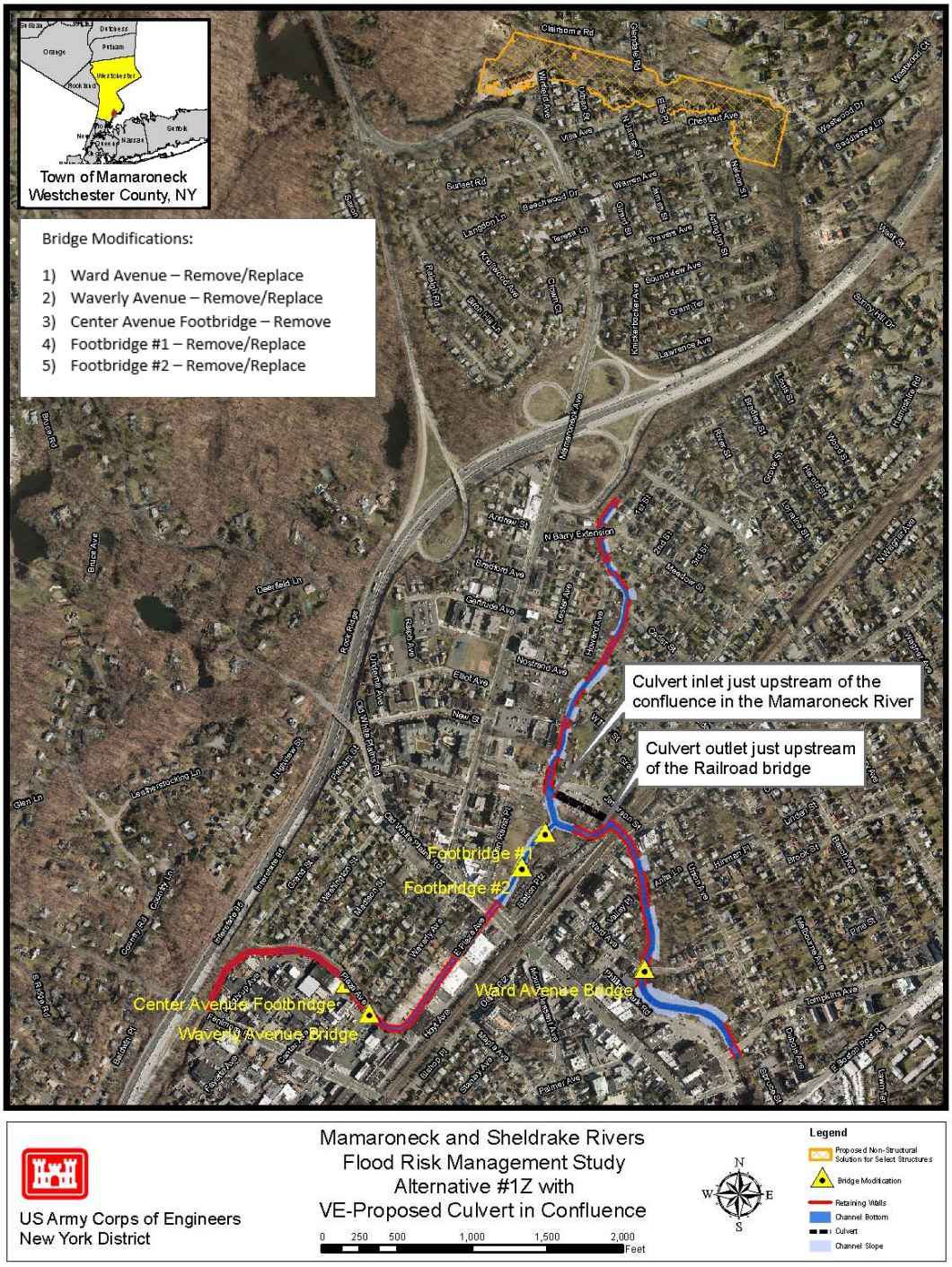

Figure 38: Alternative 1Z | Plan View of Alternative 1Z with the VE Proposed Culvert in Confluence (note: The diversion culvert makes the removal of the Station Avenue Bridge unnecessary.)

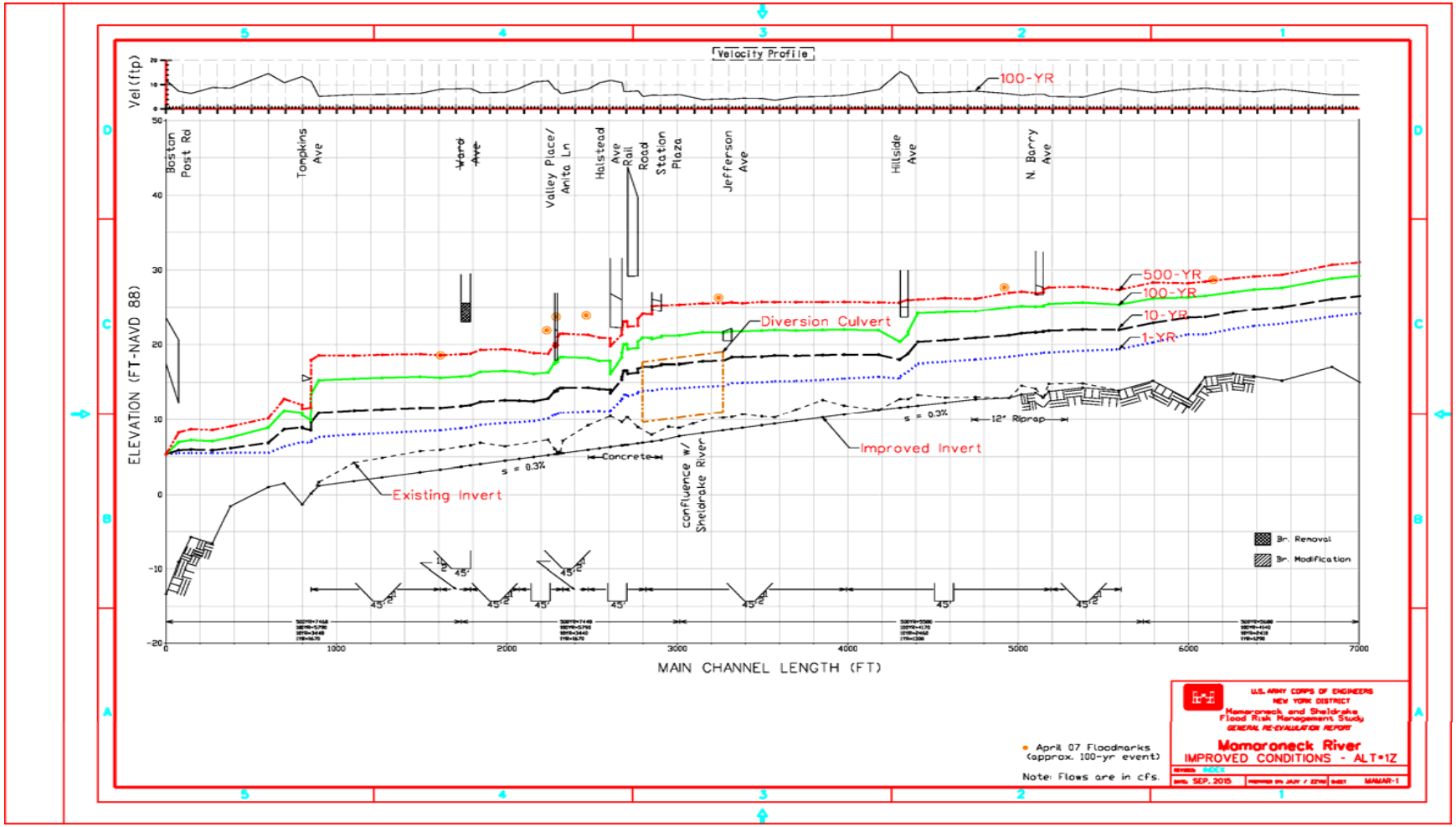

Figure 39: Alternative 1Z | Mamaroneck1 Profile

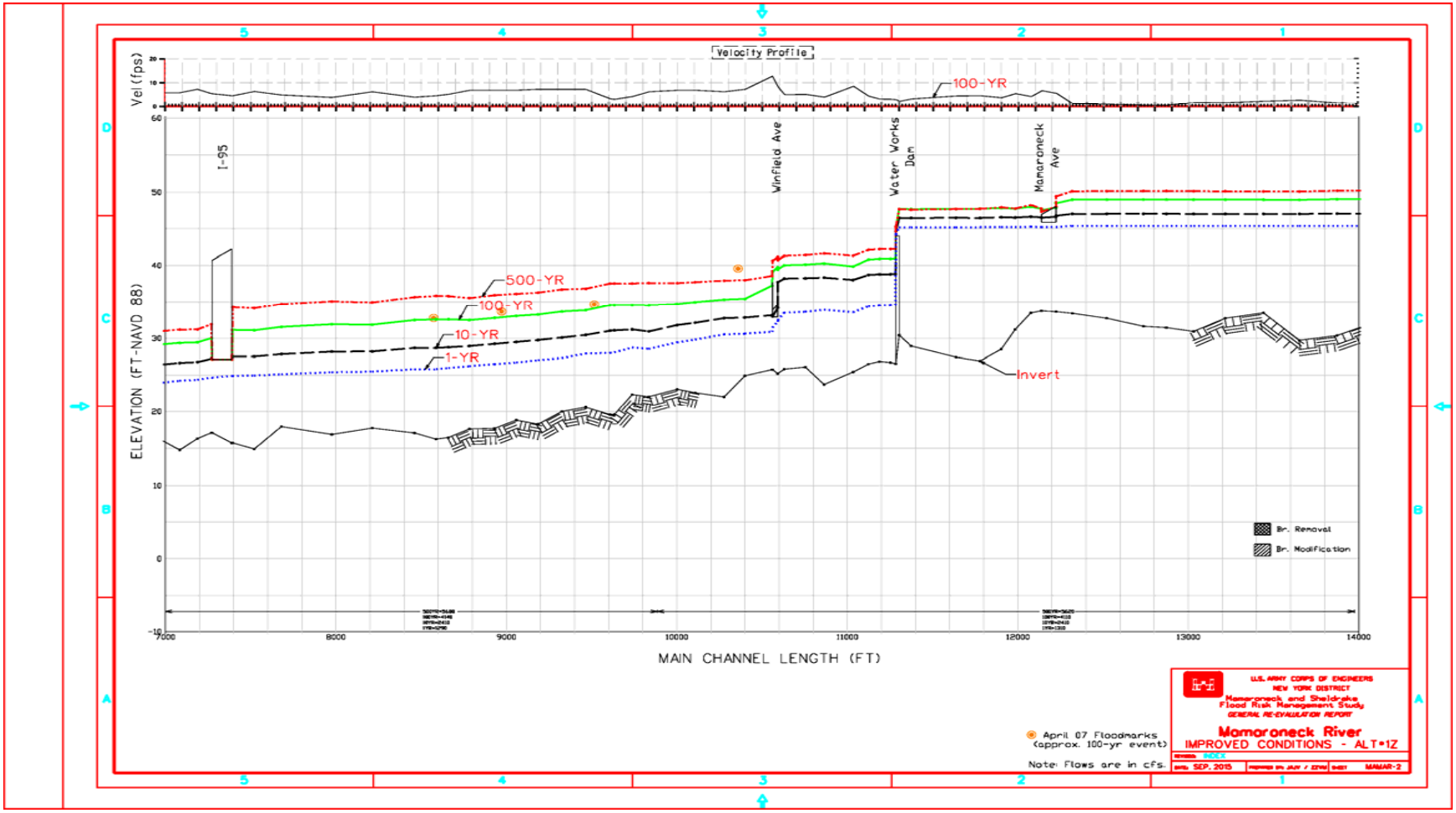

Figure 40: Alternative 1Z | Mamaroneck2 Profile

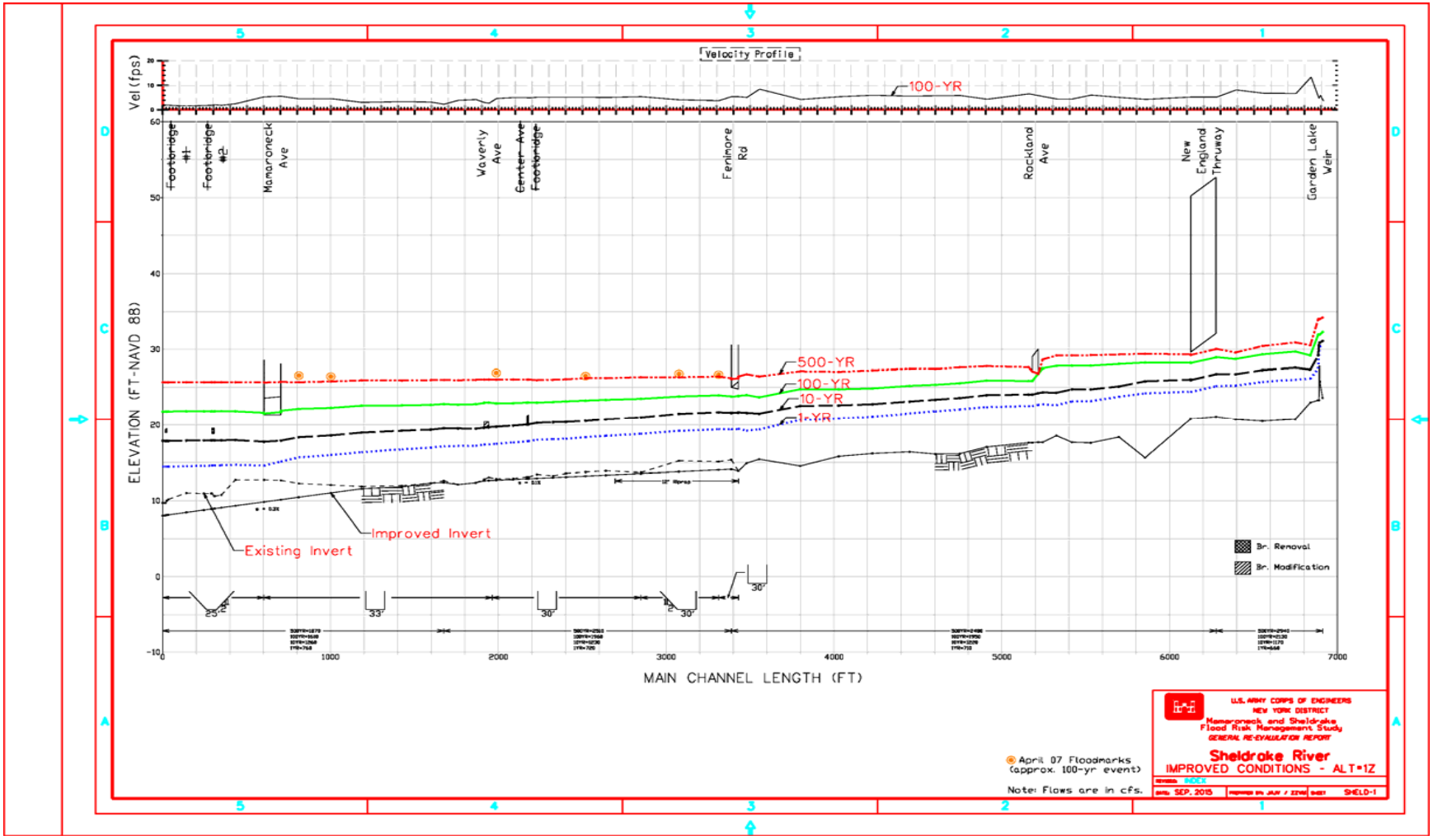

Figure 41: Alternative 1Z | Sheldrake Profile

It should be noted that comparing future conditions to present conditions profiles indicates that increasing the tidal elevations (for Climate Change/Sea Level Rise) does not change the water surface elevations in the main damage areas. For information and sensitivity purposes a 1% flow was run with Hurricane Sandy tide elevations for Alternative 1Z and there was no significant change in the flood elevations in the main damage area. This confirmed expectations that this project design is not impacted by coastal events. The lowest significant damage elevation for the project is 20 ft. NAVD'88, which is about a 2,000-yr. coastal event.

Examples of project features as they have been constructed on existing projects are provided in Figure 42 through Figure 49:

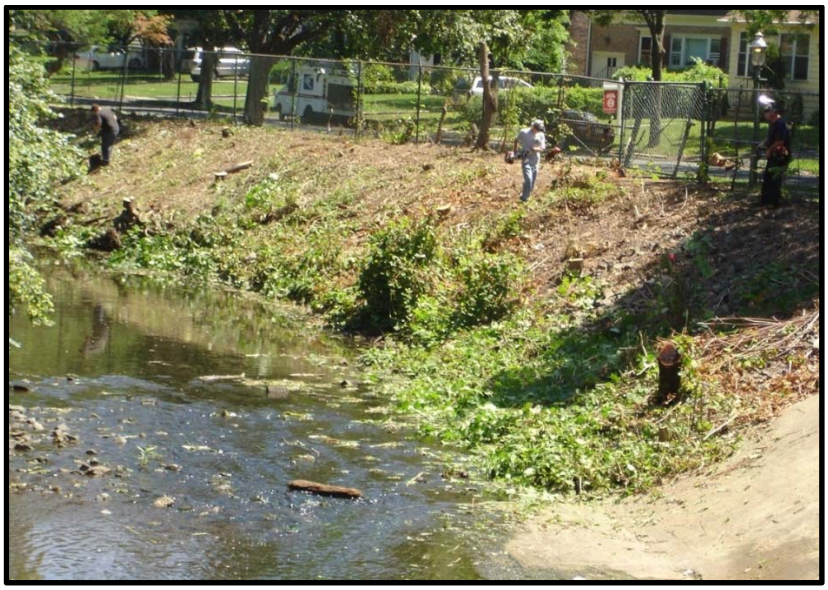

Figure 42: Clearing Activities Before Construction.

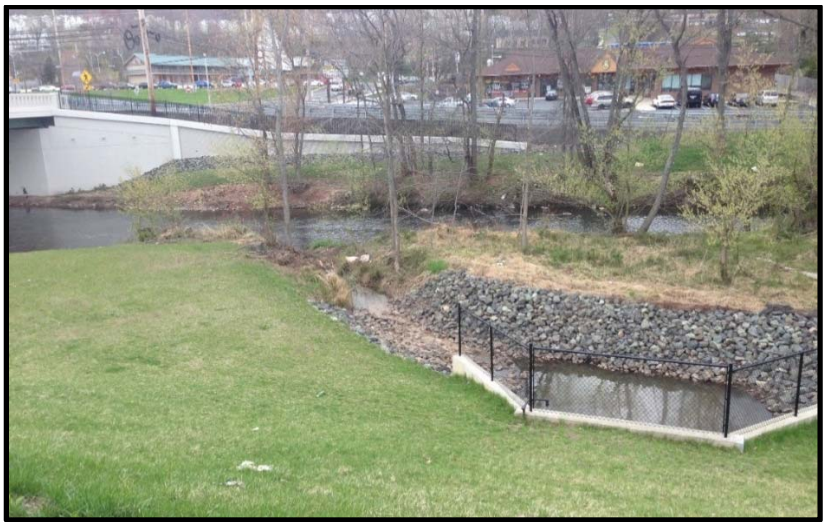

Figure 43: Concrete Retaining Walls and Sloped Grassed Embankments.

Figure 44: Examples of Concrete Retaining Walls

Figure 45: Example of Culvert Structure

Figure 46: Example of Concrete Retaining Walls: Sheldrake River East of Mamaroneck Avenue.

Figure 47: Example of Concrete Retaining Walls: Sheldrake River Near Waverly Avenue.

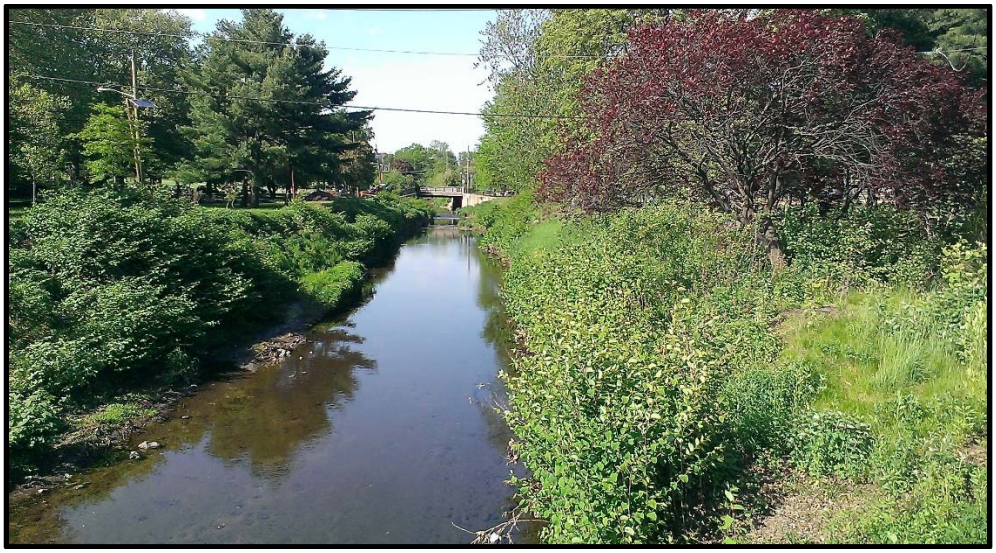

Figure 48: Example of a Sloped Grassed Bank or Trapezoidal Channel.

Figure 49: Example of a Sloped Grassed Bank or Trapezoidal Channel in Winter.

7.10 Residual Risk

The analysis has been conducted in accordance with ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies (USACE, January 3, 2006), which stipulates that the risk analysis for a flood risk management project should quantify the performance of all alternatives and evaluate the residual risk,

including the consequences of the project's capacity exceedance. In addition to the basic economic performance of a project, the guidance stipulates that the engineering performance of the project is to be reported in terms of 1) the annual exceedance probability; 2) the long-term risk of exceedance and; 3) the conditional non-exceedance probability. As part of the continued coordination with the local partners and the public, the following concepts of flood risk management have been presented on several occasions.

- No Flood Risk Management project can eliminate the risk of flooding. Given a long enough period of time, all projects would experience an event exceeding design criteria.
- Flood Risk Management projects can only reduce the frequency and/or severity of flood damages and can provide additional time to respond.
- Communication of accurate and timely information about the risk of living in a flood prone area is critical.
- Physical features are only a single component of a flood risk management approach. (insurance, zoning, Emergency Action Plans)
- Flood safety is a shared responsibility and a collaborative approach is required to effectively manage the risk of flooding and to save lives. (Corps, FEMA, State, County, Local Government Emergency Personnel & Residents)

In addition, "residual risk" inundation maps have been presented to both the local partners and the public as a means of illustrating both the amount of flood risk reduction and the amount of residual risk. This project consists of channel improvements, therefore there would be no significant change in the warning time and the depth of flooding. The improvements would reduce depth of flooding by approximately 2.5 to 3.5 feet for almost all events regardless of whether the channel design capacity is exceeded or not (Figure 50).

The NED plan would have reduced the April 2007 flood elevations by about 4.5 feet in Columbus Park, 3 feet along lower the Sheldrake, about three (3) feet at Barrie Avenue and tapering to no change in all other areas.

Reduced potential for loss of life was considered as part of the economic analysis, and is noted in the economic appendix. The analysis applied HEC FIA to assess life safety before and after project implementation. The model assesses risk to life as a function of warning time and availability of evacuation routes superimposed on the water surface elevations and location of structures in the study area. Without the project in place, the without project condition life safety risk is significantly increased because of how rapid the rivers achieve peak flow (4-6 hours). Additionally, in the no-action condition, the risk to loss of life is increased as the time to evacuate is a very small window.

7.10.1 Residual Risk-Executive Order 11988

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, action shall be taken to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities for the following actions:

- acquiring, managing, and disposing of federal lands and facilities;
- providing federally-undertaken, financed, or assisted construction and improvements;

- water and related land resources planning, regulation, and licensing activities
- conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities.

Residual Risk in accordance with EO 11988 was conducted on the NED plan. Such measures determined by residual flooding information such as rates of rise, depths and velocities, warning times and evacuation routes are included such as emergency action planning advice. The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight step process that agencies should carry out as part of their decision making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below. Recognizing the federal government's commitment to ensure no inducement of development in the floodplain, pursuant to Executive Order 11988, this project would identify in the Project Partnership Agreement, the need for the local partner to develop a Floodplain Management Plan.

1. **Determine if a proposed action is in the base floodplain (that area which has a one percent of greater chance of flooding in any given year).** The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.

2. **If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.** This document presents an analysis of potential alternatives. Practicable measures and alternatives were formulated and evaluated against the Corps of Engineers guidance, including nonstructural measures such as retreat, demolition and land acquisition.

3. **If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.** There has been extensive coordination with pertinent federal, State and local agencies. After the draft report was released, a public hearing was conducted in the study area during the public review period.

4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain would affect the base flood plain, impacts resulting from these actions should also be identified.** The anticipated impacts associated with the recommended plan are summarized in this report. The project would not alter or impact the natural or beneficial flood plain values.

5. **If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.** The project provides benefits solely for existing and previously approved development.

6. **As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.** The project would not induce development in the flood plain and the project would not impact the natural or beneficial flood plain values. This report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.

7. **If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft GRR and Environmental Impact Statement was provided for public review and a public hearing was conducted during the public review period. Each comment received was addressed and, if appropriate, incorporated into the Final Report. A record of all comments received is also included in the Pertinent Correspondence Appendix of the Final EIS.

8. **Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.** The recommended plan is the most responsive to all of the study objectives and the most consistent with the executive order.

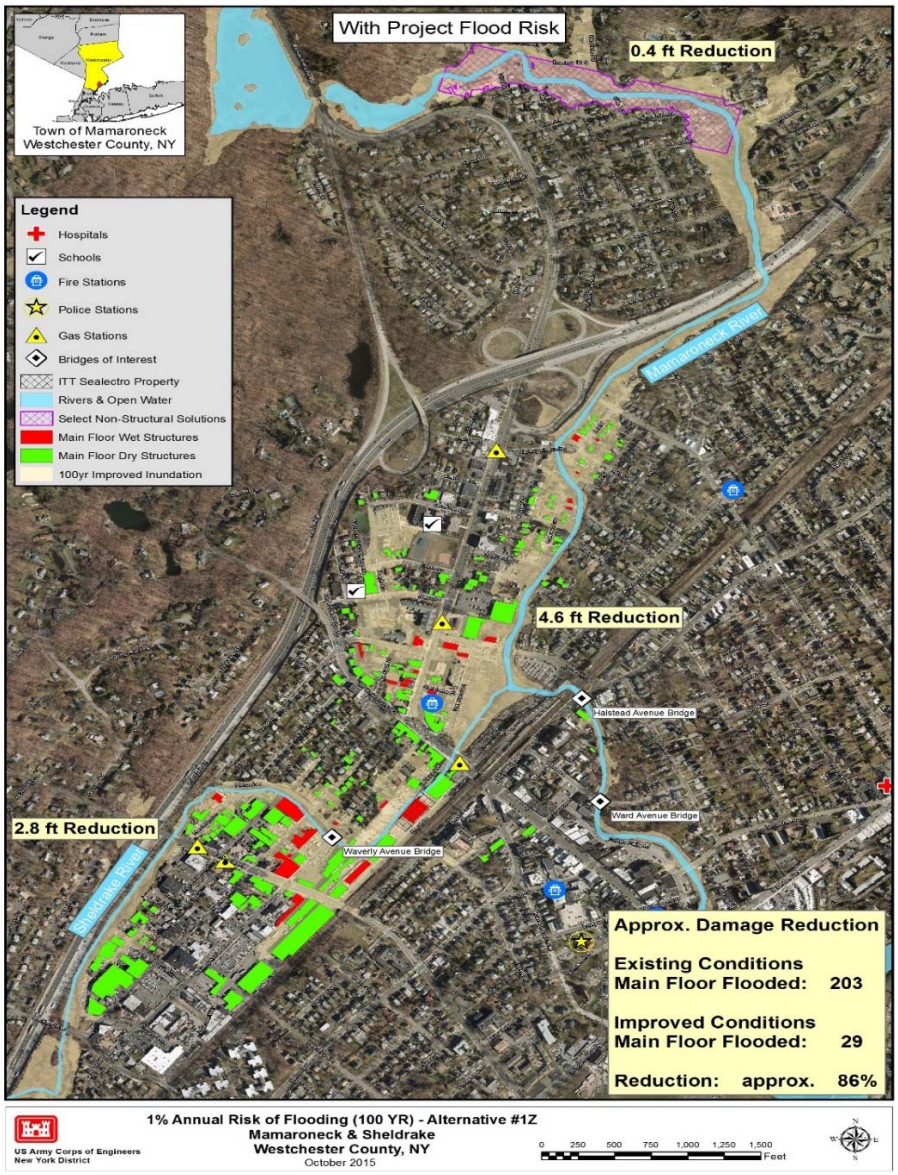

Figure 50 Residual Risk Associated to Alternative 1Z for the 1% Flood Event

The implementation of the NED plan would not eliminate flooding or the potential for loss of life or damage to property. The NED plan would reduce the risk of loss of life and damage to property by reducing the frequency of flooding from overbank flooding which may generate life safety risks in addition to those created by the depth of flooding alone.

The Village of Mamaroneck has a well-established flood warning system, education and outreach program to increase flood evacuation awareness among the residents. To support this objective, the Village of Mamaroneck runs a Web site that provides a broad approach to communicating preparedness and evacuation information. The goal is to inform the public what evacuation procedures to adhere in the event of a storm event. The online mapping tool also shows the locations of the evacuation centers, which are the central nodes for a system of shelters strategically placed throughout the Village of Mamaroneck that would be put in use in the event that an evacuation order was in effect. In the event of a significant storm, official evacuation orders are sent through a wide range of networks including telephone to communicate the level of risk to the public. Because the benefits of a flood warning system in this area are so low, the additional benefits of improving the existing system would be negligible.

Media broadcasts, e-mail, reverse 911 telephone calls, social media alerts, and other Emergency Alerts are all sent to notify residents at risk. Special attention is given to notify those who are homebound or need special assistance. Evacuation orders are issued by the Village of Mamaroneck Manager's office based upon the storm's predicted intensity and direction (bearing), in coordination with County and State emergency services. Evacuation decisions typically must occur before real-time/storm specific probabilistic storm forecasts are made available, usually when a Flood Watch is issued.

As part of the Mamaroneck & Sheldrake Flood Risk Management reevaluation, the Village of Mamaroneck should conduct an analysis of the existing evacuation zones/routes within the study area upon plan implementation to ensure the appropriate level of evacuation safety.

7.11 Critical Infrastructure

The NED plan provides a significant reduction in water surface elevations in the Mamaroneck and Sheldrake Rivers at and above the confluence to manage the risk of:

a) Rapid rate of rise of flood waters
b) Evacuation routes impassable
c) Schools and daycares within floodplain
d) Emergency access

Implementation of the NED plan would reduce the risk associated with flood damages to life and property. Figure 51 and Figure 52 indicate the transportation infrastructure, schools, daycares, hospitals, fire stations and police station that are all vulnerable under the "without project condition".

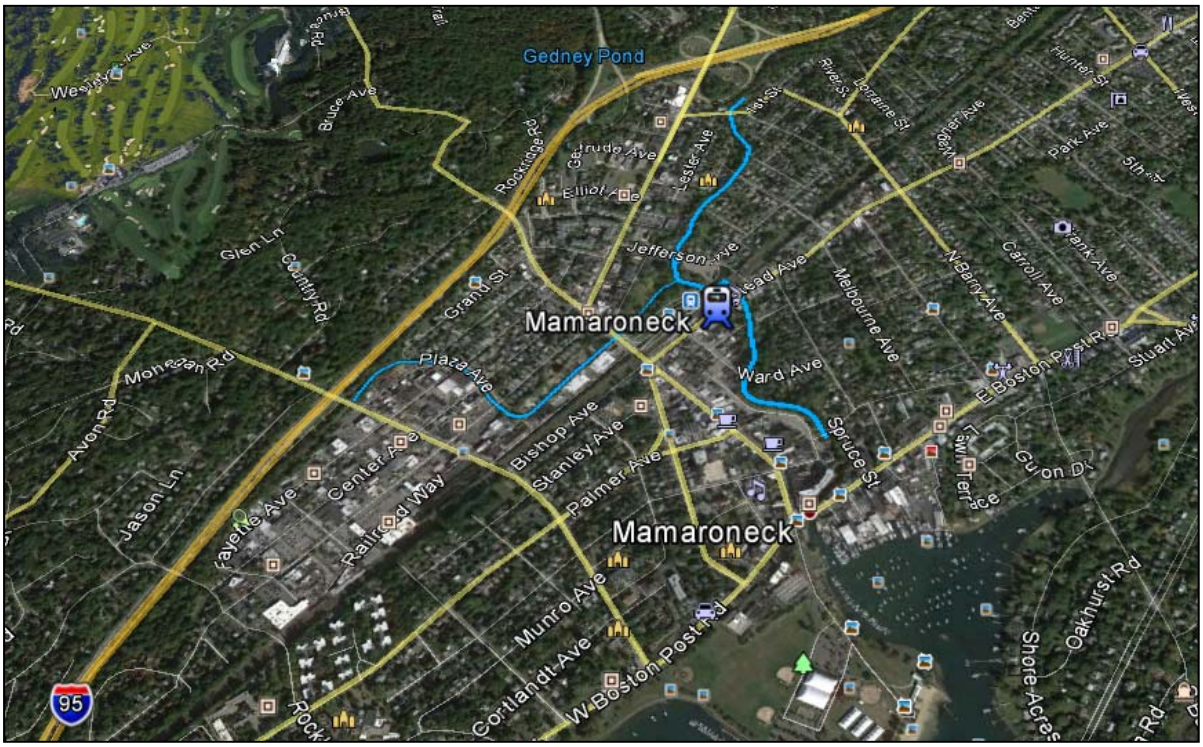

Figure 51: Transportation, Evacuation and Access – Village of Mamaroneck

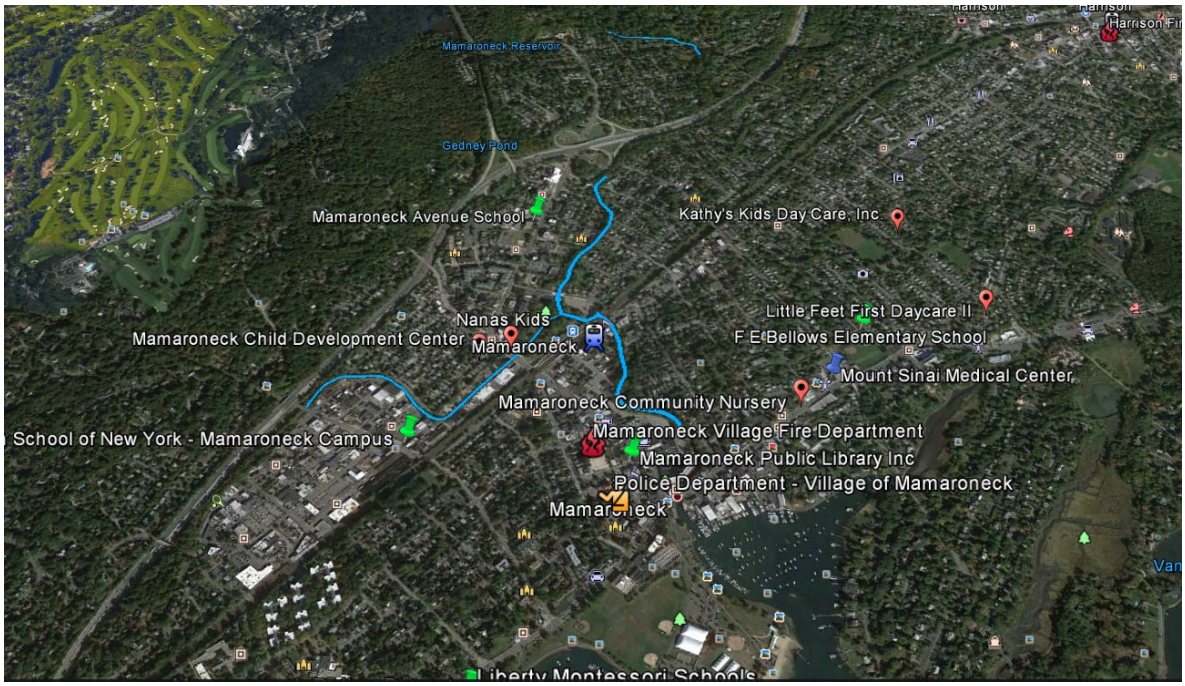

Figure 52: Vulnerable Infrastructure – Village of Mamaroneck

7.12 Environmental Operating Principles

The Environmental Operating Principles is an essential component of the Corps of Engineers' risk management approach in decision making, allowing the organization to offset uncertainty by building flexibility into the management and construction of infrastructure.

The Environmental Operating Principles are:

- Foster sustainability as a way of life throughout the organization.
- Proactively consider environmental consequences of all Corps activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.
- Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.
- Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

Plan selection took into account these principles to ensure the sustainability and resiliency of the NED plan while considering the environmental consequences of implementation. USACE considered the avoidance of existing wetlands and cultural resources within the project area during the value engineering analysis. Additionally, the NED plan employed a risk management and systems approach by reducing the required bridge removals and also incorporating risk management and systems approach to the entire Mamaroneck & Sheldrake river basins with the inclusion of the Harbor Heights nonstructural component. Continual coordination with NYSDEC, Westchester County, the Village of Mamaroneck and the public ensured an open and transparent process that respects views of individuals and groups. Specifically, additional public meetings were incorporated into the process to ensure that the public's interests were addressed as noted in the EIS Appendix H.

8. IMPROVED CONDITIONS & PLAN IMPACTS

8.1 Improved Conditions - Hydraulics

8.1.1 Sedimentation

A sediment trend assessment was conducted. The soils and channel bottom for the study area above the railroad consists of silty sands. Below Halstead Avenue there are large cobbles and bedrock in the channel especially where the channel bottom gets steeper. There are small reservoirs upstream of the study area on both rivers which have been filling in and have historically been cleared of sediment. The local officials noted that shoals have formed under one bay of the North Barry Avenue Bridge on the inside of a bend. They noted that after the April 2007 storm they removed some sediment from under Fenimore Road, the Thruway, North Barry Avenue and the Anita Lane/Valley Place bridges. They also noted that the river banks in Columbus Park tend to erode. An invert comparison between the cross-sections surveyed for the 1989 GDM and the cross-sections surveyed for this GRR was made. The comparison indicated that there was a small but general scouring trend for the Mamaroneck River. The results of the last 20 years were extrapolated 50 years and the future unimproved model inverts were lowered to reflect the small erosion trend. The improved conditions would include channel and bank erosion protection, therefore, none of the improved conditions models were modified to include an erosion trend. It is anticipated that the reservoirs would continue to prevent some sediment from entering the study area. Large events would cause some bank and bottom erosion in or near the study area but much of that sediment would pass through the study area and be deposited in the harbor. Sediment transport is not expected to be a significant concern for this project. However, a sediment analysis would be conducted during the design phase once more detailed information is available. There are bedrock outcrops in several areas along the channel and banks through the proposed alignment.

8.1.2 Erosion Protection and Bank Stabilization

Riprap, Turf Reinforced Mat, and concrete was selected to protect the banks of the Mamaroneck and Sheldrake Rivers from erosion. This solution would stabilize the stream bank using techniques consistent with the requirements of the USACE, NYSDEC, Westchester County and the Village of Mamaroneck. The size and gradation of the riprap was determined following Corps of Engineers' procedures and methodology presented in EM 1110-2-1601, 1 July 1991, revised 30 June, 1994. Approximately 1,200 linear feet of riprap (i.e.; 13,000 square feet, 600 cubic yards) would be used for the Mamaroneck and Sheldrake Rivers. About 500 feet of riprap would be located roughly 200 feet both upstream and downstream of the N. Barry Avenue Extension Bridge over the Mamaroneck River and 700 feet of riprap would be placed at the 90 degree turn in the Sheldrake River located downstream of the Fennimore Road Bridge. Also, due to high velocities and structural considerations along the Mamaroneck River from the Station Plaza Bridge to just downstream of the Halstead Avenue Bridge, 300 LF concrete would be placed along the bottom of the stream prevent scour under and around the footings of these three bridges.

Turf reinforced matting may be used instead of riprap on the upper river banks where bank slopes are available. It should be noted that the much of the existing banks already have retaining walls or hard structure so limited slope opportunity is available.

8.1.3 Groundwater

The channel would be lowered an average of about 2 feet for a minimal section of the Sheldrake River and for about 4,000 feet of the Mamaroneck River. Depending on the soil types, the ground water draw down associated with lower normal river water levels would vary in both height and distance. The impacts are currently anticipated to be negligible and limited to the areas immediately adjacent to the river. Groundwater issues do not impact the plan selection. During the design phase of the project, groundwater would be further analyzed to ensure the appropriate design requirements. Future methods to evaluate the groundwater impacts include reviewing the recent report on groundwater levels and the aquifer performed for the Village of Mamaroneck, the existing USGS ground water gage data, soil types and conditions near the river as well as existing well logs.

8.2 Westchester County Joint Water Works Reservoir

Westchester Joint Water Works Reservoir (WJWW). The WJWW reservoir lies on the Mamaroneck River, upstream of the damage areas in the Village of Mamaroneck. The Village of Mamaroneck is considering the decommissioning of the dam. Construction activities for the removal of the dam would include: 1) demolition of the existing dam and associated structures; 2) channel modifications above the dam; 3) removal of sediment from the existing reservoir; 4) restoration/armoring of the surrounding area; 5) flood risk management measures downstream from the dam; and 6) erosion control measures. The decommissioning of the existing dam was investigated to determine its potential for "with project" impacts. This evaluation indicated that, even with the removal of the dam and other modifications, the decommissioning of the existing structure provides no significant increase in the peak flows and water surface elevations and would not cause adverse environmental impact to the recommended plan. Details the impacts to WSE's on the "with project" condition based on the Village of Mamaroneck decommissioning the WJWW dam.

Table 27: Decommissioning Impacts

Location	Change is WSEs / Chance of Exceedance (ft)		
	100%	10%	1%
Upstream WWD	-8.5	-6.8	-5.6
Harbor Heights	0.0	0.0	+0.1
Confluence	+.4	+.15	+.20

8.3 Environmental Consequences

The Environmental Consequences section in the EIS presents the potential adverse impacts and beneficial effects associated with implementing the NED plan and the No Action alternative.

Following is a summary of the primary environmental effects that will result from plan implementation, most of which will be concentrated in and along the streambed, banks, and floodplain areas of the Mamaroneck and Sheldrake rivers within the study area. Although the No Action Alternative would avoid potential NED plan-related environmental impacts and financial expenditures, it would not fulfill the plan's primary purpose of reducing flood risk and reducing property damage for the Village of Mamaroneck, and it also would fail to produce the associated social, economic, and environmental benefits. The No Action

alternative would therefore result in continued risk to human health, including potential loss of life, local socioeconomics including personal property and housing, and transportation within the study area.

The NED plan will result in an overall long-term benefit to natural resources and inhabitants of the study area and region due to the substantial reduction in flood risk that will be realized.

The impacts, which are expected to have negligible cumulative effects overall, are primarily associated with sedimentation, dust and waste generated by rock excavation, the clearing and grading of construction and staging sites, and other channel modifications. In addition, the channel improvements will have long-term beneficial effects on flood-induced stream channel erosion and streambed scour.

Short-term impacts to native fish and wildlife populations within the area will be limited to the construction period. No rare, threatened, or endangered species or their critical habitat will be adversely affected by the NED plan. Impacts to vegetation resulting will be minimized and mitigated by replanting of the riparian areas to pre-construction conditions, to the maximum extent feasible.

Short- and long-term minor adverse impacts on surficial geologic resources are expected to result from the NED plan implementation, though it is not anticipated to have substantial impacts on bedrock or mineral resources and topography, nor will it affect or increase the risk for any geologic hazards to the community. The impacts, which are expected to have negligible cumulative effects overall, are primarily associated with sedimentation, dust and waste generated by rock excavation, the clearing and grading of construction and staging sites, and other channel modifications. In addition, the channel improvements associated with implementation will have long-term beneficial effects on flood-induced stream channel erosion and streambed scour.

Implementation of the NED plan will have short- and long-term minor adverse impacts, as well as long-term beneficial effects, on land use and cover. Short-term impacts on residential and commercial land uses around temporary workspaces will occur during and immediately after construction, whereas long-term adverse impacts on land cover will result from the removal of mature trees. The District will avoid or minimize the clearing of forested habitat during the breeding period for sensitive wildlife species, including birds, in compliance with the (Migratory Bird Treaty Act (MBTA), and bats. Tree-cutting will be prohibited from 1 April to 1 August to avoid the removal of roost trees. However, implementation of the NED plan also is expected to result in long-term benefits by reducing the flood risk to surrounding properties, which, if left unaddressed, could negatively impact land use in the future.

Short-term minor adverse impacts to soils and vegetation, caused by the movement and operation of construction vehicles and equipment within the study area during the construction period, are expected to temporally impact water quality. In-stream work associated with the NED plan also could adversely affect aquatic and terrestrial wildlife species that inhabit or utilize waters within the study area. Temporary increases in turbidity and suspended sediments near and downstream of in-stream construction activities could cause direct mortality or indirect decreased reproductive success in species over the short-term. In-stream construction activities also could temporarily increase ambient water temperature, although such conditions should dissipate once the construction phase ends. Implementation of sediment and erosion control plans and best management practices (BMPs) to protect water quality will aid in minimizing impacts to water quality and fish and wildlife during construction. No in-stream work will be conducted between 1 June and 1 September.

Short-term minor and long-term minor and moderate adverse impacts to wetland resources and riparian areas are expected to result from the implementation of the NED plan. Short-term effects include temporary

impacts outside the footprint of the expanded channel but within construction workspaces where heavy equipment will access construction sites, soil compaction, trampling and removal of vegetation, and tree removal. BMPs will minimize construction impacts and restoration of the riparian areas will occur after work is completed. Long-term impacts to riparian areas will occur from the permanent loss of these habitats. The removal of mature trees, required for the access of construction equipment to workspaces and as part of channel work, will produce long-term adverse impacts because it will take many decades for trees to reach their original size. However, the post-construction restoration of riparian habitat (i.e., revegetation, tree planting) will produce some long-term beneficial effects to natural resources that may outweigh many of these adverse impacts. Where practicable, larger trees will be replanted. Any invasive species removed during implementation of the NED plan will be replaced with native species, and the channel improvements are expected to reduce sediment loads within the rivers and minimize transportation of these sediment loads during flood events, thereby improving habitat for fish and wildlife resources and water quality. Short-term impacts to native fish and wildlife populations within the study area will be limited to the construction period. No rare, threatened, or endangered species or their critical habitat will be adversely affected by the NED plan.

The NED plan is expected to have a long-term benefit to economy, income, housing and other structures, and environmental justice communities due to the reduction in flood risk and the various costs associated with flood damages. Short-term minor and long-term minor and moderate adverse impacts to aesthetic and scenic resources are expected to result from the implementation of the NED plan. Short- and long-term impacts to aesthetics and scenic resources resulting from construction activities will be mitigated using various measures.

Implementation of the NED plan will produce short-term minor adverse impacts to recreation from construction activities and the use of Columbus Park as a staging area, as well as temporary impacts to recreation resulting from the construction activities associated with the removal and replacement of the Columbus Park footbridges. Short-term impacts to recreation will be minor due to the availability of alternative recreation opportunities in the region, and temporary impacts will be reduced by the availability of other pedestrian access routes within and around the park area during construction. Long-term recreational benefits will occur in the study area due to a reduction in the flooding of Village of Mamaroneck parks, a reduction in increased sediment loads delivered to Mamaroneck Harbor during flooding events that affect water quality and water-related recreation (e.g., swimming and fishing), and the minimization of other disruptions of recreational activities due to flooding.

Short-term minor and long-term moderate adverse impacts to transportation are expected. Worker commutes and traffic may be temporarily affected by construction traffic (e.g., the delivery of equipment and materials) on haul routes and roadways leading to and from construction sites and the Columbus Park staging area, as well as temporary road and bridge closures requiring the use of alternative routes. Temporary moderate adverse impacts will result from the closure of the Ward Avenue Bridge during the removal and replacement of the bridge. The removal and replacement of the Waverly Place Bridge will produce long-term benefits to transportation infrastructure, and the implementation of the NED plan will have no effect on air, rail, or public transportation. The NED plan will create short-term minor adverse impacts on air quality and noise resulting from construction activities and increased construction-related vehicle and equipment use in the study area. However, it may also introduce long-term incremental beneficial effects to air quality by reducing emissions associated with flood related traffic congestion and heavy construction activities during post-flooding reconstruction efforts.

New York State Department of State concurred with the Consistency Determination for the activity under the enforceable coastal policies of the New York State Coastal Management Plan (CMP) as refined in the Village of Mamaroneck Local Waterfront Revitalization Program (LWRP).

Impacts to vegetation resulting from the implementation of the proposed plan will be minimized and mitigated by replanting of the riparian areas to pre-construction conditions, to the maximum extent feasible.

During plans and specifications, as well as construction, the District will work, where practicable, to retain or replace trees and other vegetation in shaded areas along the rivers. A contract requirement will be that the contractor will guarantee the post-construction tree plantings.

Mitigation for adverse effects to historic properties, the Ward Avenue Bridge, Metro-North Railroad Bridge, and the stone retaining walls thematic district, will include consideration of incorporation of these elements into the NED Plan and the documentation of these resources.

No areas were identified as containing potential environmental contamination or were considered to have a great risk to human health for most of the study area.

Table 28 provides a summary of the anticipated adverse impacts and/or beneficial effects for each resource area under the NED plan and No Action alternative scenarios. This section also summarizes the impact minimization and mitigation measures that would be carried out if the NED plan is implemented. Based on the results of the environmental consequences analysis and the proposed minimization and mitigation measures provided below, the NED plan is expected to result in an overall long-term benefit to natural resources and inhabitants of the study area due to the substantial reduction in flood risk that would be realized. Some short- and long-term minor and moderate adverse impacts would result from implementation of the NED plan, but these are expected to be outweighed by the long-term beneficial effects the Project would provide. No significant adverse impacts are associated with the NED plan.

8.3.1 Cumulative Effects

This section provides a summary of the anticipated adverse impacts and/or beneficial effects for each resource area under the NED plan and No Action alternative scenarios of the Project (Table 28). This section also summarizes the impact minimization (e.g., BMPs) and mitigation measures that would be carried out if the proposed action (i.e., the NED plan) is implemented (Table 29). These measures have been selected and designed to help avoid and minimize the adverse environmental impacts that are expected from implementing the NED plan, and to mitigate for those impacts that cannot be avoided.

Based on the results of the environmental consequences analysis and the proposed minimization and mitigation measures provided below, the NED plan is expected to result in an overall long-term benefit to natural resources and inhabitants of the study area due to the substantial reduction in flood risk that would be realized. Some short- and long-term minor and moderate adverse impacts would result from implementation of the implementation of NED plan, but these are expected to be outweighed by the long-term beneficial effects it would provide. No significant adverse impacts are associated with the NED plan. The majority of the long-term impacts would be attributed to the removal and loss of vegetation required. More specifically, long-term impacts would result from the permanent removal and loss of vegetation and riparian areas within the footprint of the newly expanded river channels, which serve as habitat for amphibians, reptiles, and small mammals. The removal of mature trees and other vegetation during construction activities and channel modifications would likely permanently impact aesthetic and scenic resources as well as land cover; although vegetation would be replanted and replaced, it may take decades

for new trees to reach the height and character of trees found in the existing riparian habitat. Where practicable, larger, older trees would be planted.

Short-term impacts would primarily be the result of temporary construction activities including impacts to land use, vegetation, water resources, recreation, and aesthetic and scenic resources resulting from the presence of construction equipment; the disturbance of sediments during channel modifications, which has the potential to affect water quality, and temporary disruptions to transportation (e.g., traffic), air quality, and noise.

Table 28: Summary of Potential Environmental Consequences for the Mamaroneck and Sheldrake River Basins

Resources	NED Plan	No Action Alternative
Topography and Geology	Short-term minor adverse impacts Long-term minor adverse impacts Long-term beneficial effects	No impacts
HTRW	No impacts	No impacts
Land Use, Cover, and Zoning	Short-term minor adverse impacts Long-term minor adverse impacts Long-term beneficial effects	Long-term adverse impacts
Water Resources	Short-term minor adverse impacts Long-term minor and moderate adverse impacts Long-term beneficial effects	Long-term adverse impacts
Vegetation	Short-term minor adverse impacts Long-term moderate adverse impacts	No impacts
Fish and Wildlife	Short-term minor to moderate adverse impacts Long-term minor adverse impacts Long-term beneficial effects	Long-term adverse impacts
Socioeconomics	Long-term beneficial effects	Long-term adverse impacts
Cultural Resources	Adverse effects to historic properties	Long-term adverse impacts
Coastal Zone Management	Short-term minor adverse impacts Long-term minor adverse impacts	Long-term adverse impacts
Aesthetics and Scenic Resources	Short-term minor adverse impacts Long-term moderate adverse impacts	Long-term adverse impacts
Recreation	Short-term minor adverse impacts Long-term moderate adverse impacts Long-term beneficial effects	Long-term adverse impacts
Transportation	Short-term minor adverse impacts Long-term moderate adverse impacts Long-term beneficial effects	Long-term adverse impacts

Air Quality	Short-term minor adverse impacts Long-term beneficial effects	No impacts
Noise	Short-term minor adverse impacts	No impacts

Table 29 Summary of Impact Minimization and Mitigation Measures for the Mamaroneck and Sheldrake Rivers FRM Project, Westchester County, New York.

Topography and Geology • Current applicable USACE design criteria would be met, taking into account site conditions, physical constraints, and design flood requirements. • Excavated material would be handled, removed, utilized, and/or disposed of in accordance with applicable construction standards and regulations. • USACE would coordinate with local authorities and make public announcements to help ensure public safety, acquire a Dig Safe permit to locate and identify utilities, and properly handle and dispose of waste material. • Proposed improvements would be designed and built to meet USACE and other applicable codes and standards, including seismic standards. • OSHA guidelines and standard construction practices (e.g., shoring-up of channel slopes) would be followed during construction. • Monitoring equipment would be used, as necessary, to ensure construction activities that cause ground vibrations do not exceed state and federal thresholds to avoid damages to nearby structures. Pre-construction inspections of buildings may be required as part of the efforts to monitor effects of vibrations
HTRW • Based on current project designs, there should be no impacts to HTRW
Land Use, Cover, and Zoning • Most of the construction activity would occur within the existing channel, which would help minimize impacts to adjacent land uses. Temporary workspaces along the top of the channel would generally be limited to a 15 ft (4.5 m) clearance from the channel bank edge along portions of the study area. • Channel construction (and related impacts) would not be concentrated in any one location for extended periods of time; construction would be moved from area to area as it progresses. • Disturbed areas would be restored and their use returned to pre-construction land uses. • Vegetation, including trees, would be replanted using native species. Where practicable, larger trees would be planted.

Water Resources

- Standard industry BMPs to protect water quality and wetlands during in-stream work would be implemented to reduce the potential for impacts during construction.
- An ESCP and site-specific SWPPP would be developed and implemented in accordance with the SPDES General Permit for Stormwater Discharges from Construction Activity. Upon completion, a Notice of Termination would be filed to verify that BMPs were implemented and that disturbed areas were restored and stabilized.
- Water quality and water resources protection measures would be implemented in accordance with local, county, NYSDEC permitting requirements and regulations, CWA Sections 401 and 404, RHA Section 10, Article 15, and Village Code Chapter 192-5.
- Study area would be restored to pre-construction conditions: temporary workspaces would be stabilized and revegetated by planting native trees and shrubs. Native seed mix applied to exposed soils to maximize the rate of revegetation and reduce the likelihood that invasive species would take over disturbed areas.
- In-stream activities would be avoided from 1 June through 1 September.
- Pools, riffles and a low-flow channel would be included as part of the channel modification.

Vegetation

- Impacts to vegetation would be minimized and mitigated by restoring riparian areas to pre-construction conditions. Following construction activities temporary workspaces would be stabilized and revegetated as recommended by the Village of Mamaroneck Department of Public Works and Tree Committee by planting trees where mature trees were removed, the top layer of soil would be removed and replaced with clean topsoil that is seeded with a native upland or wetland seed mix in order to maximize the rate of revegetation and reduce the likelihood that invasive species would take over disturbed areas, and native trees and shrubs would be planted in areas where mature trees and shrubs were removed during construction. Where practicable, larger trees would be planted.

Fish and Wildlife

- Standard industry BMPs to protect water quality during in-stream work and activities that would disturb or remove soils would be implemented in accordance with NYSDEC and USACE CWA permitting requirements.
- Streamside wildlife habitat that is removed or disturbed would be revegetated using native plant species, with immediate results expected for grasses and other herbaceous species and long-term restoration needed for establishment of larger shrub and tree species.
- No tree cutting would occur from 1 April to 1 August. If trees greater than three inches density breast height (dbh) would be removed from 1 January through 31 March, a survey for breeding raptors would be conducted.
- No in-stream work would be conducted from 1 June through 1 September.
- Pools, riffles and a low-flow channel would be included as part of the channel modification.

Cultural Resources

- Adverse effects to the Ward Avenue Bridge, Metro-North Railroad Bridge, and the stone retaining walls thematic district.
- Mitigation, at a minimum, would include consideration of incorporation of these elements into the NED plan and the documentation of these resources
- A Memorandum of Agreement (MOA) has been executed with the NYSHPO. The Village of Mamaroneck Historian, the Village Historical Society and the Westchester County Historical Society will be consulting parties throughout the implementation of the MOA.

Coastal Zone Management • Mitigation measures required based on the determination issued by NYSDOS includes implementation of standard industry BMPs to protect water quality during construction of the NED plan (e.g., development of a SWPPP and ESCP). • See impact mitigation and minimization measures for Water Resources, Vegetation, Fish and Wildlife, Aesthetics and Scenic Resources, and Recreation.
Aesthetic and Scenic Resources • Measures that could be implemented to reduce the short-term effects of construction activities include: adhering to the Project's ESCP to minimize the transport of suspended solids downstream, and erecting temporary fences in Columbus Park to screen the construction staging area. • Various measures would be implemented to reduce the Project's long-term adverse visual impacts and restore the study area to pre-construction conditions including: riparian habitat restoration activities such as tree replanting, and revegetation; and the use of a trapezoidal channel with grassy sloped banks where possible.
Recreation • Both footbridges in Columbus Park would be removed and replaced to accommodate channel modifications. • Upon Project completion, parks and surrounding areas would be restored to pre-construction conditions and access to other riverine areas and affected parks would be restored. • Additional specific measures that could be implemented to reduce the limited short-term effects of construction activities include: adhering to the Project's ESCP to minimize the transport of suspended solids downstream, restricting construction primarily to normal weekday business hours in residential areas, erecting temporary fences and other physical barriers around construction areas, temporarily reducing vehicular speed limits, and hanging signage that informs people of the Project's purpose, duration, and expected outcomes. • USACE would work with the Village of Mamaroneck regarding the Village's proposed plan to develop riverwalks and other areas to improve public access.
Transportation • No mitigation measures would be required, but USACE is currently evaluating additional measures to be implemented for construction activities to further minimize these already limited effects. Traffic control and operations strategies may include measures like preparing a Construction Traffic Management Plan, establishing detours and alternate routes when/where needed, or temporarily reducing speed limits.
Air Quality • Construction would be performed in full compliance with current NYSDEC Chapter III-Air Quality Regulations requirements, with compliant practices and/or products. No mitigation measures would be required outside of these and other applicable air pollution control regulations. A RONA is provided in Appendix E of the EIS.
Noise • No mitigation measures would be required, but USACE is currently evaluating additional noise risk management measures to be implemented for construction activities to further minimize these already limited effects. • In accordance with the local noise ordinance, heavy equipment generating sounds would be required to close down after 6:00 p.m. from Monday through Friday, and all day on Saturdays, Sundays and holidays • Special variances to the local noise ordinance may be obtained; however, additional noise reduction measures (e.g., enclosure of construction power units and generator sets, use of noise barriers) could be required.

8.3.2 Hazardous, Toxic, Radioactive Waste

The site lies outside and adjacent to the project alignment, to the east (landward) of the existing retaining wall. The existing building is situated on top of the existing retaining wall. Along this portion of the Sheldrake River, a steel-sheet pile retaining wall transitioning to a concrete retaining wall will be built in the channel waterside of the existing retaining wall. Fill will be placed between the existing and project retaining wall. Based on the plans, the project alignment will not impact the ITT Sealectro state superfund site. If project plans change such that the alignment would be redesigned to require removal of portion of the streambank within the affected property, the District will coordinate with the NYSDEC to determine how the project will proceed in that area. The NYSDEC will conduct those remedial activities necessary to remove contaminated materials in accordance with ER 1165-2-132.

9. PROJECT COSTS & COST SHARE

9.1 Project First Costs

For the detailed cost estimate, project quantities were developed using On Screen Take-Off (OST), Microsoft Excel calculations, and manual calculations, where applicable. The cost estimate was compiled using the Micro-Computer Aided Cost Estimating System, Second Generation (MII).

The detailed cost estimate for the NED plan is based on combination of MII's 2012 English Cost Book, estimator-created site specific cost items, local subcontractor quotations, and local material suppliers' quotations. For the purposes of updating the Cost Book to present day pricing, a current, area-specific labor library was used to reflect market labor conditions. Major material costs were verified. For cost book material items that did not reflect current commodities pricing, vendor quotes were obtained and estimator judgment applied where warranted.

The specific components in the cost basis are outlined in the Cost Appendix (Appendix C). Cost contingencies were developed through a standard Cost and Schedule Risk Analysis (CSRA). The Project first cost for the NED plan is approximately $82,252,000. Project first costs for the NED plan by line item are presented in Table 30.

Table 30: Cost Summary of the NED Plan

Cost Code Account	Cost Code Description	Cost ($)
02	RELOCATIONS	14,144,000
08	ROADS, RAILROADS AND BRIDGES	48,000
09	CHANNELS AND CANALS	44,050,000
12	FLOODWAY CONTROL & DIV STR	3,018,800
18	CULTURAL RESOURCE PRESERVATION	558,000
19	BUILDINGS, GROUNDS & UTILITIES	2,736,000
	TOTAL CONSTRUCTION COST	**64,608,000**
01	LANDS & DAMAGES	5,001,000
30	ENGINEERING & DESIGN	8,226,000
31	CONSTRUCTION MANAGEMENT	4,417,000
	TOTAL FIRST COST	**82,252,000**
	IDC	4,428,000
	TOTAL PROJECT COST	**$86,682,000**
	ANNUAL COST	$3,289,400
	OMRR&R	$357,100
	TOTAL NED ANNUAL COST	**$3,646,500**

October 2016 Price Level, 2.875% Interest Rate

9.2 Operation and Maintenance Considerations of the NED plan

The channel and culvert must be maintained to ensure that the hydraulic capacity of the project is preserved. Also, access to the project must be maintained for inspection and maintenance purposes. The project and areas immediately upstream and downstream should be inspected annually. Channel improvements provide passive flood risk management assistance and do not require any operation. However, removal of debris, particularly from bridges before and after a storm event, should be performed. To maintain the hydraulic capacity of this project, shoals, debris, encroachments and heavy vegetation should be removed from the channel. Shoaling and debris accumulation can be expected after a significant flood especially under and around bridges, the inside of bends (North Barry Ave) and at the confluence of the Mamaroneck and Sheldrake Rivers. The channel cross-section should be maintained to the original design invert and bottom width as shown in the contract plans. The amount of sediment removal required should be slightly less than the historic volumes of sediment removed because the riprap and other erosion protection measures would reduce the amount of erosion experienced in the study area. Vegetation along the side slopes of the channel should be cut annually in late spring. There should be no woody vegetation on the low half of the slope. Small bushes and shrubs should only be permitted above mid-slope and trees should only be permitted at the top of slope. Vegetation along the access and maintenance paths should be cleared several times a year. Riprap erosion protection should be inspected and any broken or displaced stones should be repaired or replaced. Dumping of snow or grass clippings into the channel should not be permitted.

The culvert under the Station Plaza parking lot should be inspected yearly for cracks, movement and sediment accumulation. Large sized sediment or significant volumes of sediment should be removed. Channel retaining walls and the culvert should be inspected yearly for cracks and movement such as sliding, rotation and tilting. Vegetation should be removed from the walls and drainage openings. No improvements or changes shall be made over, under or through this project without prior determination by the District Engineer that the requested improvements or changes would not adversely affect the function of the improved channel and culvert. The OMRR&R cost basis is outlined in the Cost Appendix (Appendix C).

9.3 Real Estate Requirements

The NED plan, Alternative 1Z, only requires easements. It is not expected that any structures will need to be acquired. Alternative 1Z requires a total of 22 acres of easements that includes 14.3 acres in permanent easements which would require approximately 73 channel improvement easements (53 private parcels and 20 public parcels). Additionally, the NED requires acquisition of approximately 7.8 acres in Temporary Work Area Easements impacting a total of 55 easements (47 private easements and 8 public easements). This alternative impacts a total of 110 parcels, 88 privately-owned and 22 publicly-owned.

The details regarding the location of all permanent and temporary easements would be determined once the surveys of the river are completed and project details are plotted. The non-federal sponsor, the New York State Department of Environmental Conservation, would work with each affected property owner and would conduct appraisals for the property needed. Affected property owners would be compensated for the fair market value of the property for both temporary and permanent easements and property owners would still own their property. Detailed discussion regarding the real estate requirements for the NED is outlined in the Real Estate Appendix, Appendix E. The NED real estate maps are included as Exhibit A to the Appendix.

9.3.1 Appraisal Information:

An appraisal cost estimate was prepared identifying the land values for the NED plan – Alternative 1Z. The land values for this plan are as follows in Table 31:

Table 31: Appraisal Cost Estimate for NED Plan

Easement Type	Value
Channel Improvement Easements	$483,826
Temporary Work Area Easements	$2, 655,602
Contingency (10%)	$313,943
Total NED Plan:	**$3,453,371**

October 2016 Price Level, 2.875% Interest Rate

Baseline Cost Estimates for Real Estate: Table 32 details the total 01-Lands and Damages costs for both the NED plan: To avoid double accounting, a 20% contingency was only applied to the Incidental Cost because a contingency is already embedded in the Acquisition Costs through the appraisal cost estimate.

Table 32: Total 01-Lands and Damages Costs for NED Plan

Real Estate Cost	Total
Incidental Cost	$1,216,800
Acquisition Cost	$3,453,371
20 % Contingency (less Land Payments)	$330,829
Total Lands and Damages (01- Account)	**$5,001,000**

October 2016 Price Level, 2.875% Interest Rate

Facility and/or Utility Relocations There are existing sanitary sewer and water pipelines that would be required to be relocated for implementation of the selected alternative. The precise location of the pipelines and whether the owners have a compensable real property interest is still being determined. The Real Estate Plan would be updated accordingly upon the conclusion of the forgoing. The NED plan requires the removal of three public pedestrian bridges, included Center Avenue Bridge and 2 footbridges in Columbus Park, both of which would be replaced. A fourth bridge, the Waverly Avenue Bridge would be removed and replaced as would the Ward Avenue Bridge. The removal and replacement of Waverly Avenue and Ward Avenue bridges (as well as the Columbus Park footbridges) is considered a "relocation and costs and are included in the Cost Code Account 02-Relocation costs (Table 33):

Table 33 Total 02-Relocation costs for NED Plan

Real Estate Cost	Total
Relocation Cost	$9,006,715
57 % Contingency	$5,137,285
Total Relocations (02- Account)	**$14,144,000**

October 2016 Price Level, 2.875% Interest Rate

10. PLAN IMPLEMENTATION

The completion of this GRR/EIS and Recommendation by the District Engineer are the first steps toward implementing the design and construction of the flood risk management project along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, Westchester County, New York. Upon approval by USACE's North Atlantic Division, the project would be considered for design and construction upon Congressional authorization and appropriation.

10.1 Non-Federal Sponsor's and Local Partners' Responsibilities

The non-federal sponsor, New York State Department of Environmental Conservation (NYSDEC), in cooperation with Westchester County and the Village of Mamaroneck, must comply with all applicable federal laws and policies and other requirements, including but not limited to:

1. In coordination with the federal Government, who shall provide 65% of the initial project cost,
   a. Provide 35 percent of the total nonstructural flood damage reductions costs and a minimum of 35 percent, but not to exceed 50 percent, of the total structural flood damage reduction costs and, as further specified below:
      1. Provide, during design, 35 percent of design costs allocated to nonstructural flood damage reduction and 35 percent of design costs allocated to structural flood damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
      2. Pay, during construction, a contribution of funds equal to 5 percent of total structural flood damage reduction costs;
      3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the federal government to be required or to be necessary for the construction, operation, and maintenance of the project;
      4. Pay, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total nonstructural flood damage reduction costs and at least 35 percent of total structural flood damage reduction costs;

   b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

   c. Inform affected interests, at least annually, of the extent of protection afforded by the structural flood damage reduction features;

   d. Participate in and comply with applicable floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12);

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood damage reduction features;

g. Operate, maintain, repair, rehabilitate, and replace the project at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government;

h. Give the federal 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 for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

i. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

j. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, 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 CFR, Section 33.20;

k. Perform, or ensure performance of, any investigations for hazardous substances that 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 federal government determines to be necessary for the construction or operation and maintenance of the project;

l. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way required for construction, operation, maintenance, repair, rehabilitation, or replacement of the project;

m. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C.

2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. 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; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)); and

q. Not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal sponsor's obligations for the project unless the federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

10.2 Implementation Schedule

Release of the draft General Reevaluation Report and Environmental Impact Statement was approved by HQUSACE at the TSP Briefing held on 10 September 2015. Public release was conducted in January 2016. Public review was completed within 60 days with an extension is requested to extend the public review period by 2 weeks. Public review was conducted concurrently with MSC and HQUSACE review of the draft report. Agency Technical Review and Independent External Peer Review has been completed and certified.

- CWRB…….. 23 Mar 17
- Initiate State & Agency Review ……..... 10 Apr 17
- Complete S&A review……..... 22 May 17
- Chief's Report & Draft ROD Submitted to ASA ……... 16 Jun 17
- Chief's Report & Final ROD Signed…….…… 28 Jul 17

10.3 Financial Analysis

Typical cost share for Flood Risk Management projects is 65% federal and 35% non-federal. The District conducted a cost share analysis to determine the cost share ratio for the initial construction costs of the NED plan. The Lands, Easements, Relocations, Right-of-Ways and Disposal (non-federal responsibility) cost share analysis was completed in accordance with ER 1165-2-161(12)(c)(5) that states:

Where the value of LERRD in a structural flood control project is greater than 45 percent of the total project cost, the LCA should be prepared to reflect that agreement has been reached on the most efficient and practical means for acquisition of the LERRD over 45 percent. If there is no Government acquisition, the District Commander should budget for the value of the LERRD exceeding 45 percent. The LCA should then provide a mechanism for the Government to reimburse the local partner this difference upon completion of construction. (See paragraph d. of ARTICLE II - OBLIGATIONS OF PARTIES and explanatory note in paragraph b.3. of Option II, ARTICLE VI - METHOD OF PAYMENT of the model Flood Control LCA, Appendix A).

The analysis indicated that the total LERRD is less than 45% and also concluded that the value of the LERRD (that is a non-federal sponsor responsibility) is less than the 35% cost share required for federal construction projects (Table 34). The estimated federal cost for both the NED plan is 65% of the Project first Cost. The non-federal cost share is 35% of the Project first cost of the NED plan. Therefore, 100% of LERRD may be applied towards the non-federal sponsor's 35% cost share.

Table 34: LERRD Requirement

Cost Account	Account Description	NED
01	**LANDS & DAMAGES**	**$5,001,000**
02	**RELOCATIONS**	**$14,144,000**
Total LERRD		**$19,145,000**

October 2016 Price Level, 2.875% Interest Rate

Table 35 displays the apportionment of cost sharing responsibilities between the federal government and the non-federal sponsor and the fully funded cost which is escalated to the midpoint of construction (March 2023) and is the basis for the construction cost-sharing agreement. The table includes costs associated with flood risk management features and environmental mitigation features. The total project costs are shared on a 65% basis by the federal government and a 35% basis by the non-federal sponsors. Cost share responsibilities do not include Interest During Construction (used for the annualization of project costs for economic purposes) and OMRR&R costs. OMRR&R is a 100% non-federal responsibility and the calculation of which is used for the annualization of project costs for economic purposes). As indicated in Table 35, the federal share of the project's total first cost is **$53,464,000** the non-federal share is **$28,788,000.** However, the fully funded cost is the basis of the cost share for the PPA.

The federal Government would design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-federal sponsor. The non-federal sponsor is responsible for all lands, easements, Right-of-ways, and relocations (LERRD) costs and all operation, maintenance, replacement, repair and rehabilitation (OMRR&R) costs. The LERRD costs are applicable to the non-federal share of the initial project costs. For example, the approximate total project LERRD costs of **$19,145,000** borne by the non-federal sponsor are applicable to the **$28,788,000** share of non-federal project costs.

Table 35: Cost Apportionment

Federal Project Cost (65%)	**$53,464,000**
Non-Federal Project Cost (35%)	**$28,788,000**
Lands & Damages	$5,001,000
Relocations	$14,144,000

5% Cash Requirement	$3,976,000[12]
Cash or In-Kind Service balance	$5,667,000
Project First Cost*	**$82,252,000**
***Does not include OMRR&R and IDC**	

October 2016 Price Level, 2.875% Interest Rate

The October 2016 first cost as noted above is $82,252,000. Annual costs are approximately $3,646,500 (which includes the annualized costs of OMRR&R of $357,000 and IDC of $4,428,000) and annual benefits are $3,820,500 with a BCR of approximately 1.05 which yields annual net benefits of about $174,000 for the NED plan.

10.4 Agency, Public Review and Coordination

10.4.1 Independent External Peer Review (IEPR)

The review resulted in 29 final panel comments – (2) comments were rated as having high significance, (5) comments was rated as medium/high, (10) were rated medium, and (12) were rated medium/low. The District provided 12 responses of "concur" and 17 responses of "non-concur". The IEPR panel provided a "non-concur" to 11 of the District responses. The District and IEPR panel developed paths to resolution for all non-concur responses during the IEPR teleconference held 16 June 2016. The Panel's most significant finding was that stream flows were not systematically recorded, but rather estimated using various correlation techniques. A Sensitivity Analysis was conducted and the Panel "concurred" with the approach. The Panel also had a concern that quantities for excavation, length of channel work, and retaining walls were inconsistent. All quantities and costs were reevaluated by the District and confirmed plan selection. The Panel "concurred" with the reevaluation. The final IEPR Report was received on 1 July 2016. All 29 responses were concurred to by the IEPR Panel.

10.4.2 Technical Reviews

Comments received from Agency Technical Review (ATR), HQUSACE, and NAD were all resolved prior to submittal of the Final Report.

i. Agency Technical Review (ATR)

A total of 105 comments were submitted in Dr. Checks by the reviewers. Comment discipline breakdown for these comments is as follows: Civil Engineering (4); Cost Engineering (71); Economics (7); Environmental (5); General (2); Geotechnical Engineering (2); Hydrology (5); Hydraulics (2); Plan Formulation (1); Real Estate (1); Risk Assessment (1); Structural Engineering (4). No comments were identified as critical and all comments have since been resolved. ATR Certification was provided October 2015. ATR certification of the FINAL report (November 2016) includes Cost Certification.

ii. Major Subordinate Command (MSC) Planning & Policy Review

A total of 32 comments were submitted

- 3 Formulation comments
- 10 Environmental comments

[12] 5% cash requirement is calculated from structural costs only

- 3 Economic comments
- 9 Real Estate comments
- 7 Legal comments

All responses were pre-coordinated. No critical or significant comments were identified. All comments were addressed for final report submission.

iii. Office of Water Project Review (OWPR) Policy Review

A total of 30 comments were received. All responses were pre-coordinated. No critical comments were identified. All comments were addressed for final report submission. The two comments of high significance were in regard to the State Superfund site and compliance with ER 1165-2-132.

iv. Public Review

On January 29, 2016, the US Army Corps of Engineers, New York District (District) released the Draft Mamaroneck and Sheldrake Rivers, Flood Risk Management, General Reevaluation Report and associated Draft Environmental Impact Statement (DEIS) which initiated a 45-day public comment period, scheduled to end March 15, 2016. A public meeting, consisting of a presentation and poster session, at which the public was encouraged to ask questions of the District's project team, was held on February 25, 2016. USACE extended the comment period until March 31, 2016 at the request of the Village of Mamaroneck. USACE requested public comments via mail, e-mail, and facsimile. Attachment C of the EIS contains all of the comments received, as well as USACE's responses. During this EIS process, USACE coordinated closely with other federal, state, and local agencies, and the public. In addition to the public information meetings, USACE has met with federal, state, and local agencies on many occasions. These meetings have provided the parties an opportunity to better understand the Project, discuss issues of interest, and develop proposed improvements to the Project that contributed to the identification of the proposed NED plan. Details related to the correspondence between the USACE and federal, state, and local agencies can be found in Attachment C of the EIS [Project Correspondence]).

The District received approximately 270 comments from the public regarding the selected alternative and its associated impacts. The comments received centered around seven topics

- The removal of the Ward Avenue Bridge
- Compliance with New York State Department of State (NYSDOS) and Village of Mamaroneck coastal zone management regulations.
- The Halstead Avenue Bridge
- The project elements in the Harbor Heights area, including the proposed nonstructural plan, the Glendale Road (Harrison, NY) also known as the Road-to-Nowhere, and the removal of the Westchester Joint Water Works Dam
- Real Estate requirements
- The removal of the footbridges in Columbus Park
- Aesthetics – what would the project look like?

Resolution of comments/concerns were addressed with the public during a meeting on 25 May 2016 and 20 July 2016. Responses to all public comment were incorporated into the FINAL report in coordination with the non-federal sponsor and local stakeholders, accordingly.

11. VIEWS OF NON-FEDERAL PARTNERS AND OTHER AGENCIES

The New York State Department of Environmental Conservation, Westchester County and the Village of Mamaroneck are fully supportive of the NED plan. The flooding and damages within the Village of Mamaroneck have a long history. It is the concern of the above non-federal sponsor and local stakeholders that if this reevaluation is not approved and construction funds are not appropriated expeditiously, there may not be another opportunity to provide a comprehensive flood risk management to this area that has been repetitively plagued by floods over the past century. There is significant motivation to implement the recommended plan. Letters of Support, including the non-federal sponsor's Self Certification of Financial Capability is included in Appendix F.

11.1 Areas of Concern

Flood risk management studies in highly urban area within the New York District boundaries have generally exhibited BCRs between 1.0 and 1.3. The reason for this relatively low benefit to cost ratio is the regional expense of construction costs and high contingency factors that are applied to the already high costs for projects in the region. However, the benefit categories are not afforded the same escalation or contingency factors that the costs are for this expensive region. The concern of the non-federal partners is that the BCR for the recommended plan relative to the rest of the nation for flood risk management projects would minimize the importance and need for the project. The residents and businesses in the Village of Mamaroneck have been continually subjected to flood damages that are swift and highly damaging to personal property, safety, business losses, emergency costs, transportation, recreation and the environmental.

Additional areas of concern include:

a. Schedule of real estate acquisition. The plan requires the acquisition of 110 parcels for easements of which 88 are privately-owned. The timing of construction is dependent upon the timely acquisition of the real estate requirements for this project for which the residents are reluctant to provide.

b. On-going remediation at a State Superfund site. The construction schedule assumes that either construction would only be performed in areas where no contamination exists or known contamination has been remediated by the responsible party in accordance with ER 1165-2-132 and the appropriate "No Further Action" requirements have been met in accordance with federal and state laws.

11.2 Major Conclusions and Findings

In such a populous area, finding and implementing a feasible Flood Risk Management Plan solution is critical for ability for continued functionality and livelihood of the local residents. The implementation of the NED plan would be the difference between saving lives and businesses in the event of another storm event like the April 2007 flood. A quantitative review of the economic analysis used for the NED plan finds that the basis for the implementation of the project is sound. The estimated total project cost to achieve these benefits is $86,600,000 and a fully funded cost of $93,739,000 (escalated to an estimated midpoint of construction – March 2023) is the basis for the PPA.

Through the cycles of iterations involved in the planning process the project plan has grown in physical size, shape and monetary cost—all with the aim of producing a robust and resilient Flood Risk Management solution that provides a high level of Net Excess Benefits.

11.3 Public Involvement

The first public meetings were held during the NEPA scoping process during 2010 (June 22, 2010). Additional public meetings to present the Alternative Analysis and Tentative Selected Plan were held in 2014 (May 22, 2014). Public release of the draft Report and EIS was conducted in January 2016 with public meetings held in the Village of Mamaroneck in February 2016.

11.4 Environmental Compliance

Table 36 provides a summary of the major permits, approvals, concurrences, and consultations required for the project under applicable environmental statutes and regulations. The NED Plan will have unavoidable impacts to cultural resources, vegetation, trees, and some wildlife habitats. With Best Management Practices, such as native vegetation planting, tree replacements, tree removal windows, Stormwater Pollution Prevention Plan, seasonal windows for river channel work, and historic property documentation in place, no significant adverse impacts to trees, vegetation, or wildlife would be expected as a result of construction.

Estimated air emissions generated by construction activities are not expected to exceed the General Conformity thresholds set for the New York City metropolitan area, which includes Westchester County during the project construction phase. A General Conformity analysis based on the anticipated NED Plan emissions resulted in a Record of Non-Applicability (RONA). In addition, the State of New York has stated to USACE that construction equipment (non-road) associated with these types of projects is included in the State Implementation Plan (SIP).

A Clean Water Act Section 404(b)(1) Guidelines analysis has been prepared and is included in Appendix F of the Final EIS. USACE will be requesting a water quality certificate from the New York State Department of Environmental Conservation under Section 401 of the Clean Water Act.

A consistency determination was prepared (Appendix D of the Final EIS) pursuant to the federal Coastal Zone Management Act. New York State Department of State has concurred with USACE's determination that the Plan is consistent with the State's and Village of Mamaroneck's policy statements.

A Memorandum of Agreement to account for adverse effects to historic properties has been executed with the New York State Office of Parks, Recreation and Historic Preservation, which serves at the New York State Historic Preservation Office. The effected historic properties include the Works Progress Administration-constructed retaining walls and Ward Avenue Bridge, which will be removed and replaced as part of this project. Mitigation of this adverse effect includes the preparation of documentation of the retaining walls and bridge. The Village of Mamaroneck Historian and the Village of Mamaroneck Historical Society will be participating in this effort as consulting parties.

Federal Statutes	Compliance Status
Clean Air Act, as amended	In Compliance
Clean Water Act of 1977, as amended	In Compliance
Coastal Zone Management Act of 1972, as amended	In Compliance
Endangered Species Act of 1973, as amended	In Compliance
Fish and Wildlife Coordination Act, as amended	In Compliance
National Historic Preservation Act of 1966, as amended	In Compliance
National Environmental Policy Act of 1969, as amended	In Compliance
Rivers and Harbors Appropriation Act of 1899, as amended	In Compliance
Executive Orders, Memorandum, etc.	
Executive Order 11988, Floodplain Management	In Compliance
Executive Order 11990, Protection of Wetlands	In Compliance
Executive Order 12989, Environmental Justice in Minority and Low-Income Populations	In Compliance
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	In Compliance
Executive Order 11593, Cultural Resources	In Compliance
State and Local Statutes and Requirements	
NYSDEC permits for activities in wetlands and adjacent areas as per Article 24 6NYCRR Part 663 Freshwater Wetlands Permits	on-going/design phase
NYSDEC State Pollution Discharge Elimination System (SPDES) permits for surface water outlets and discharges in accordance with Article 17 6NYCRR Part 750-757	on-going/design phase
Licenses and agreements with New York State Department of Transportation (NYSDOT) and Westchester County for activities that may impact state roadways	on-going/design phase
Permits, licenses and agreements with Village of Mamaroneck for activities on Village land and with Westchester County for tree clearing/restitution	on-going/design phase
NYSDOS and the Village of Mamaroneck for coastal zone consistency review	In compliance
License agreements or other forms of approvals with private landowners for any temporary work on private lands and sewer easements for any permanent infrastructure that would be on private lands and also require maintenance access	on-going/design phase

Table 36 Environmental Compliance

12. RECOMMENDATIONS

Prefatory Statement

In making the following recommendations, I have given consideration to all significant aspects of this reevaluation, as well as the overall public interest in flood risk management within the Village of Mamaroneck study area. The aspects considered include engineering feasibility, economic effects, environmental impacts, social concerns, and compatibility of the project with the policies, desires, and the capabilities of the local government, state, federal government, and other interested parties.

Recommendations

A number of alternatives have been examined as part of the ongoing general reevaluation and the National Economic Development plan has been identified. That plan may be further refined during the design phase once this report has been approved and the project has been authorized. However, in accordance with the current analysis and the guidance outlined in ER 1105-2-100, the Mamaroneck & Sheldrake River Basins Project described in this report is acceptable to the non-federal partners, agencies, and stakeholders as a flood risk management project for immediate implementation.

I make this recommendation based on findings that the National Economic Development Plan constitutes engineering feasibility, economic justification, and environmental acceptability. These recommendations are made for the implementation of this Project, at a first cost of **$82,250,000** (at October 2016 price levels) and a fully funded cost of **$93,740,000** (based on an estimated midpoint of construction – December 2019), provided that non-federal interests comply with all the requirements substantially in accordance with a Project Partnership Agreement which would be executed upon approval of this report. It is understood that it is in the discretion of the Assistant Secretary of the Army (Civil Works) to recommend modification of project elements as the Secretary deems required.

Disclaimer

The recommendations contained herein reflect the information available at this time and the current Department policies governing formulation of individual projects. The recommendations 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 transmitted to higher authority as proposals for authorization and/or implementation funding.

David Caldwell
Colonel, U.S. Army Corps of Engineers
District Engineer

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