US ARMY CORPS
OF ENGINEERS
NEW YORK DISTRICT

NEW JERSEY
DEPARTMENT OF
ENVIRONMENTAL
PROTECTION

WOODBRIDGE RIVER BASIN, NEW JERSEY

FLOOD DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

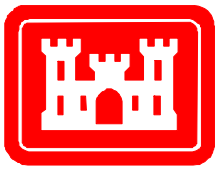
FINAL FEASIBILITY REPORT

AUGUST 2007

Woodbridge River Basin,
New Jersey

Flood Damage Reduction
And
Ecosystem Restoration

Final Feasibility Report



New York District
U.S. Army Corps of Engineers

August 2007

SYLLABUS

This report presents the results of an investigation to determine the feasibility of flood damage reduction and ecosystem restoration in the Woodbridge River Basin, New Jersey. The Woodbridge River Basin Flood Damage Reduction Feasibility Study has been conducted by U.S. Army Corps of Engineers (Corps) with the non-Federal project partner, the New Jersey Department of Environmental Protection (NJDEP).

The study area begins at the headwaters of the Woodbridge River in the northeastern corner of Woodbridge Township near the Carteret/Rahway Township line and ends at the river's confluence with the Arthur Kill. The Study area is approximately five miles in length and 10 square miles in area, and includes Heards Brook, Wedgewood Brook, and Spa Spring. The Corps was authorized by the U.S. House of Representatives Committee on Transportation and Infrastructure resolution dated May 6, 1998, to identify recommendations in the interest of water resources development, including flood control and ecosystem restoration. The Study area has experienced multiple, significant flood events, particularly in the areas between the New Jersey Turnpike (Interstate 95) and Port Reading Avenue, and along the Woodbridge River from the Port Reading railroad north to Crampton Ave. The Rahway and Woodbridge River Basins Reconnaissance Report identified the Crampton Avenue neighborhood and the Rahway Ave Mobile Home Park as the most flood prone communities within the Study area. Flooding in these areas is associated with storm tides. Flood events have resulted in physical damage to residential and public property, as well as a loss of economic activity. For example, the storm event in October 1996 damaged over 170 homes near Crampton Avenue and the Rahway Avenue Mobile Home Park, and totaled approximately $600,000 in damages (Killam 1997). The recurring nature of flood events in the Study area presents a threat to human life and safety for those that reside in the area (USACE 1999). The Corps identified additional floodprone communities in site investigations subsequent to the Rahway and Woodbridge River Basins Reconnaissance Report. Further investigation in these areas indicated that flooding is primarily due to increased rates and volumes of stormwater runoff, which should be addressed by local municipalities.

Analysis indicates that all currently identified flood control scenarios are not practical due to limited cost-effectiveness for the benefits predicted (i.e., a Benefit to Cost Ratio (BCR) less than one).

Intense urbanization and development have also led to the degradation of the environment within the study area. For example, direct development impacts on ecological resources in the study area include increased streambank erosion, loss of wetland acreage, increased sedimentation, nutrient and pollutant loading, and channel siltation. Indirect impacts include increased rates and volumes of stormwater runoff, reduced groundwater recharge, increased stream temperatures, and increased acreage of invasive species. As a result of these direct and indirect impacts, opportunities for ecosystem restoration, including fish and wildlife habitat enhancement, water quality improvement, and restoration of natural floodplain values exist within the Woodbridge River Basin (USACE 1999).

The following are project goals for a separate project effort, the Woodbridge Creek Ecosystem Restoration Project, that would provide ecosystem restoration within the Woodbridge River Basin study area and as discussed in this report:

- Create and restore habitat for native nesting birds, nursery areas for juvenile fisheries
- Remove fill within wetland and re-grade to allow for daily tidal flushing
- Restore hydrology of the site without adversely effecting flood levels
- Re-grade site and create an elevation range that is self sustaining for native salt marsh

The Woodbridge Creek Ecosystem Restoration Project site, located in Woodbridge, New Jersey, has been selected for restoration efforts by the U.S. Army Corps of Engineers (Corps), the Port Authority of New York and New Jersey (Port Authority), the National Oceanic and Atmospheric Administration (NOAA), and the New Jersey Department of Environmental Protection (NJDEP) in cooperation with Woodbridge Township. This project is not designed to address flood control issues and will not influence flooding in the area, but will address ecosystem restoration issues within the Woodbridge River Basin study area and as raised in this report.

The wetland areas selected for mitigation and restoration have historically functioned as a salt marsh with freshwater influences with a diversity of vegetation. In recent years, the invasive form of *Phragmites australis*, or common reed, have overrun the site and, tidal influences have been reduced resulting in a loss of plant and animal diversity.

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GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

CEQ	Council On Environmental Quality
CFR	Code Of Federal Regulations
CMSA	Consolidated Metropolitan Statistical Area
Corps	United States Army Corps Of Engineers
dBA	Decibels
DEP	Department Of Environmental Protection (New Jersey)
EFH	Essential Fish Habitat
EM	Engineering Manual
EPA	United States Environmental Protection Agency
EPW	Evaluation Of Planned Wetlands
ER	Engineering Regulation
FCU	Functional Capacity Units
FEMA	Federal Emergency Management Agency
FR	Feasibility Report
FR/EA	Feasibility Report/Environmental Assessment
FWCA	Fish and Wildlife Coordination Act
HTRW	Hazardous, Toxic, And Radiological Wastes
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NHP	Natural Heritage Program
NHPA	National Historic Preservation Act
NJDEP	New Jersey Department Of Environmental Protection
NJDOT	New Jersey Department Of Transportation
NJHPO	New Jersey Historic Preservation Office
O&M	Operations And Maintenance
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PED	Preconstruction Engineering And Design
PMP	Project Management Plan
S&A	Supervision And Administration
USACE	United States Army Corps Of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish And Wildlife Service
USGS	United States Geological Survey
WES	Waterways Experiment Station
WSEL	Water Surface Elevation

WOODBRIDGE RIVER BASIN
NEW JERSEY

FLOOD DAMAGE REDUCTION AND ECOSYSTEM RESTORATION

FINAL FEASIBILITY REPORT

1. INTRODUCTION

This integrated feasibility report (FR) investigates the feasibility of alternative plans to address problems and opportunities associated with flood damage reduction and ecosystem restoration in the Woodbridge River Basin, New Jersey. This FR has been prepared by the New York District of the U.S. Army Corps of Engineers (Corps) under the General Investigations Program of the Corps. The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal partner for this study.

1.1 Study Authority

The Woodbridge River Basin, New Jersey, Flood Control and Environmental Restoration Feasibility Study was authorized by a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, adopted May 6, 1998. The resolution states that:

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army review the report of the Chief of Engineers on the Rahway River, New Jersey, published as House Document 67, 89th Congress, the report of the Chief of Engineers on Arthur Kill and Kill Van Kull Basin, authorized by Section 206 of the Flood Control Act of 1985, and other pertinent reports, with a view to determine whether any modifications of the recommendations contained therein are advisable at the present time, in the interest of water resources development, including flood control, environmental restoration and protection and other allied purposes, within the Township of Woodbridge and vicinity and the Woodbridge River Basin, New Jersey."*

Under this study authorization, a reconnaissance report was completed in July 1999. The reconnaissance study concluded that there is Federal interest in conducting a feasibility study for addressing problems and opportunities of flood damage reduction and ecosystem restoration in the Woodbridge River Basin. Based on preliminary analysis, the reconnaissance report identified at least two project areas that would be in the Federal interest. Four flood damage reduction alternatives to address flooding in the two projects areas that appeared to have Federal interest were recommended for further investigation: voluntary floodproofing, raising-in-place, floodplain evacuation, and floodplain management measures. In addition, the report identified one potential mitigation/restoration site recommended for further evaluation of Federal interest.

On the basis of these findings, the Corps and the State of New Jersey entered into an agreement to perform a cost-shared feasibility study of the Woodbridge River Basin.

1.2 Study Purpose and Need

The purpose of the Woodbridge River Basin study is to evaluate the feasibility of Federal participation in implementing solutions to problems and opportunities for flood damage reduction and ecosystem restoration along this waterway. More specifically, the study:

- Identifies flooding problems associated with periodic flooding from storms in the Woodbridge River basin, particularly at Woodbridge Township,
- Identifies opportunities for restoration of degraded ecosystems in the Woodbridge River basin,
- Evaluates the technical, economic, environmental, and institutional feasibility of Federal action to address flooding problems and ecosystem restoration opportunities, and
- Determines if there is local support for implementation of the recommended plan.

As part of the plan formulation process, reconnaissance phase plans were evaluated, and other potential flood damage reduction and ecosystem restoration measures were formulated in order to evaluate and select those plans that maximize contributions to National Economic Development (NED) and to the National Ecosystem Restoration (NER) objective. In this document, the NED plan and the NER plan have not been developed to a level of engineering, economic, and environmental detail sufficient to proceed to the Preconstruction Engineering and Design (PED) phase, pending recommendation by the New York District, approval by the North Atlantic Division Commander, support by Corps Headquarters and the Assistant Secretary of the Army (Civil Works), and authorization for construction by Congress. Analysis indicates that all currently identified flood control scenarios are not practical due to limited cost-effectiveness for the benefits predicted (i.e., a Benefit to Cost Ratio (BCR) less than 1).

1.3 Prior Studies, Reports, And Existing Water Projects

The Woodbridge River Basin is subject to frequent flooding. As such, the Corps of Engineers has conducted studies to identify comprehensive solutions to reduce flood damages throughout the basin. Each of the prior studies was reviewed to identify any and all information that could be used in the current feasibility study.

Reconnaissance Study, Rahway & Woodbridge River Basins, New Jersey, Flood Control and Environmental Restoration Study, Section 905(b) (WRDA 86) Preliminary Analysis, July 1999. This report concluded that non-structural flood damage reduction measures appeared to warrant Federal interest in portions of the Woodbridge River Basin. Four alternatives: voluntary floodproofing, raising-in-place, floodplain evacuation and floodplain management measures were recommended for further study in the feasibility phase. Environmental restoration opportunities were also recommended for further study in the feasibility phase.

Scoping Document, Woodbridge River Basin, New Jersey, Flood Control and Ecosystem Restoration Study, September 2003. This report identified structural and non-structural solutions that could alleviate flooding in Woodbridge River Basin. The four structural alternatives identified consist of floodwalls, road raising, levees and storm gates while the three non-structural alternatives identified include property buy-outs, elevating structures and floodproofing buildings. Five flood control scenarios were examined for further study in the feasibility phase but were rejected due to limited cost effectiveness for the benefits predicted. It was concluded that further study during the Feasibility Study may identify additional solutions and yield additional flood control scenarios that may meet the BCR requirement. Environmental restoration opportunities were also recommended for further study in the feasibility phase.

1.4 Study Scope

This FR investigates the feasibility of Federal action to address flooding problems and ecosystem restoration opportunities in the Woodbridge River Basin. It is consistent with Federal water resources policies and practices, including *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G, 1983), the Corps *Planning Guidance Notebook* (ER-1105-2-100, 22 April 2000), and *Procedures for Implementing NEPA* (ER 200-2-2, 4 March 1988). Throughout this investigation, the Corps worked closely with the non-Federal project partner, NJDEP, to (1) describe the range of potential Federal participation in flood damage reduction and ecosystem restoration in the Woodbridge River Basin and (2) explain the roles and responsibilities of the Corps and the non-Federal partner in project planning and implementation.

Had this report identified a flooding solution that warranted Federal interest an Environmental Impact Statement (EIS) would have been created and combined with an expanded FR to form an integrated FR/EIS. The integration of the NEPA documentation with the feasibility report would be consistent with NEPA guidance that allows the combining of required documents with other documents, when practicable.

1.5 National Environmental Policy Act Requirements

Unlike other single-topic environmental laws (e.g., Clean Air Act, or Clean Water Act), NEPA encourages protection of all aspects of the environment. The President's Council on Environmental Quality (CEQ) has pointed out that "NEPA is distinguishable, purposefully so, from other environmental statutes. It targets no specific pollution sources or human health risks for treatment, prescribes formulation of no abatement techniques or remedial actions, and establishes neither milestones nor timetables for achieving its goals" (CEQ, 1990). Instead, NEPA requires that agencies take a systematic, interdisciplinary approach to agency decision making that will ensure the integrated use of the natural sciences, social sciences, and design arts.

The purposes of NEPA are to:

- Provide evidence and analysis sufficient to demonstrate that an EIS is required;
- Aid a federal agency's compliance when no EIS is necessary,

- Facilitate preparation of an EIS when one is necessary, and.
- Serve as the basis to justify a finding of no significant impact (FONSI).

An Environmental Impact Statement (EIS) is a concise public document prepared by the federal agency to determine whether the proposed action has the potential to cause significant environmental effects (40 CFR 1508.9(a)). The CEQ NEPA regulations (40 CFR 1500-1508) do not contain a detailed discussion regarding the format and content of an EA, which is generally prepared when an EIS is not determined to be necessary. However, the EA must discuss:

- The need for the proposed action,
- The proposed action and alternatives,
- The probable environmental impacts of the proposed action and alternatives, and
- The agencies and persons consulted during preparation of the EA.

NEPA requires federal agencies to integrate the environmental review into their planning and decision-making process. Had this report identified a flooding solution that warranted Federal interest an EIS would have been created and combined with an expanded FR to form an integrated FR/EIS. The integration of the NEPA documentation with the feasibility report would be consistent with NEPA guidance to combine required documents with other documents, when practicable.

The report reflects an integrated planning process, which maximizes beneficial impacts on the environment resulting from ecosystem restoration and avoids, minimizes, and mitigates adverse project effects associated with flood damage reduction actions.

1.6 Study Process

The New York District is responsible for conducting the overall feasibility study in cooperation with the non-Federal project partner, NJDEP. Both Woodbridge Township and the NJDEP are committed to working with the Corps to address flooding problems and opportunities for ecosystem restoration along the Woodbridge River.

1.7 Report Organization

This document has been organized in a manner consistent with Corps requirements for feasibility reports. The report reflects an integrated planning process where positive environmental effects associated with proposed restoration action have been maximized and adverse environmental effects associated with flood damage reduction have been avoided, minimized, and mitigated.

Technical appendices, which present details of technical investigations conducted during the feasibility study, are attached. Some section headings are hyphenated to indicate consistency with requirements of feasibility studies.

2. PLAN FORMULATION – FLOOD DAMAGE REDUCTION

Plan formulation for the Woodbridge River Basin feasibility study has been conducted in accordance with the six-step planning process described in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983) and the *Planning Guidance Notebook* (1105-2-100, dated April 2000). The six steps in the iterative plan formulation process are:

1. Specify the water and related land resources problems and opportunities of the study area;
2. Inventory and forecast existing conditions;
3. Formulate alternative plans;
4. Evaluate alternative plans;
5. Compare alternative plans; and
6. Select the recommended plan.

The basis for selection of the recommended plan(s) for the Woodbridge River Basin feasibility study is fully documented below, including the logic used in the plan formulation and selection process.

2.1 Problems And Opportunities

The Study area is located in Middlesex County in northeastern New Jersey (see Figure 2-1). The watershed is approximately five miles in length from its headwaters, or the upper portion of the river, located in the northeastern corner of Woodbridge Township near the Carteret/Rahway Township line to its mouth at the Arthur Kill. The drainage area of the Woodbridge River Basin is approximately 10 square miles and includes Heards Brook, Wedgewood Brook, and Spa Spring.

The Study area has experienced multiple, significant flood events, particularly in the areas between the New Jersey Turnpike (Interstate 95) and Port Reading Avenue, and along the Woodbridge River from the Port Reading railroad north to Crampton Ave. The Rahway and Woodbridge River Basins Reconnaissance Report identified the Crampton Ave neighborhood and the Rahway Ave Mobile Home Park as the most flood prone communities within the Study area. Flooding in these areas is mainly associated with storm tides. Flood events have resulted in physical damage to mainly residential and public property, as well as a loss of economic activity. For example, the storm event in October 1996 damaged over 170 homes near Crampton Avenue and the Ideal Mobile Home Park, and totaled approximately $600,000 in damages (Killam 1997). The recurring nature of flood events in the Study area presents a threat to human life and safety for those that reside in the area (USACE 1999). The District identified additional floodprone communities in site investigations subsequent of the Rahway and Woodbridge River Basins Reconnaissance Report. Further investigation in these areas indicated that flooding is primarily due to increased rates and volumes of stormwater runoff, which should be addressed by local municipalities.

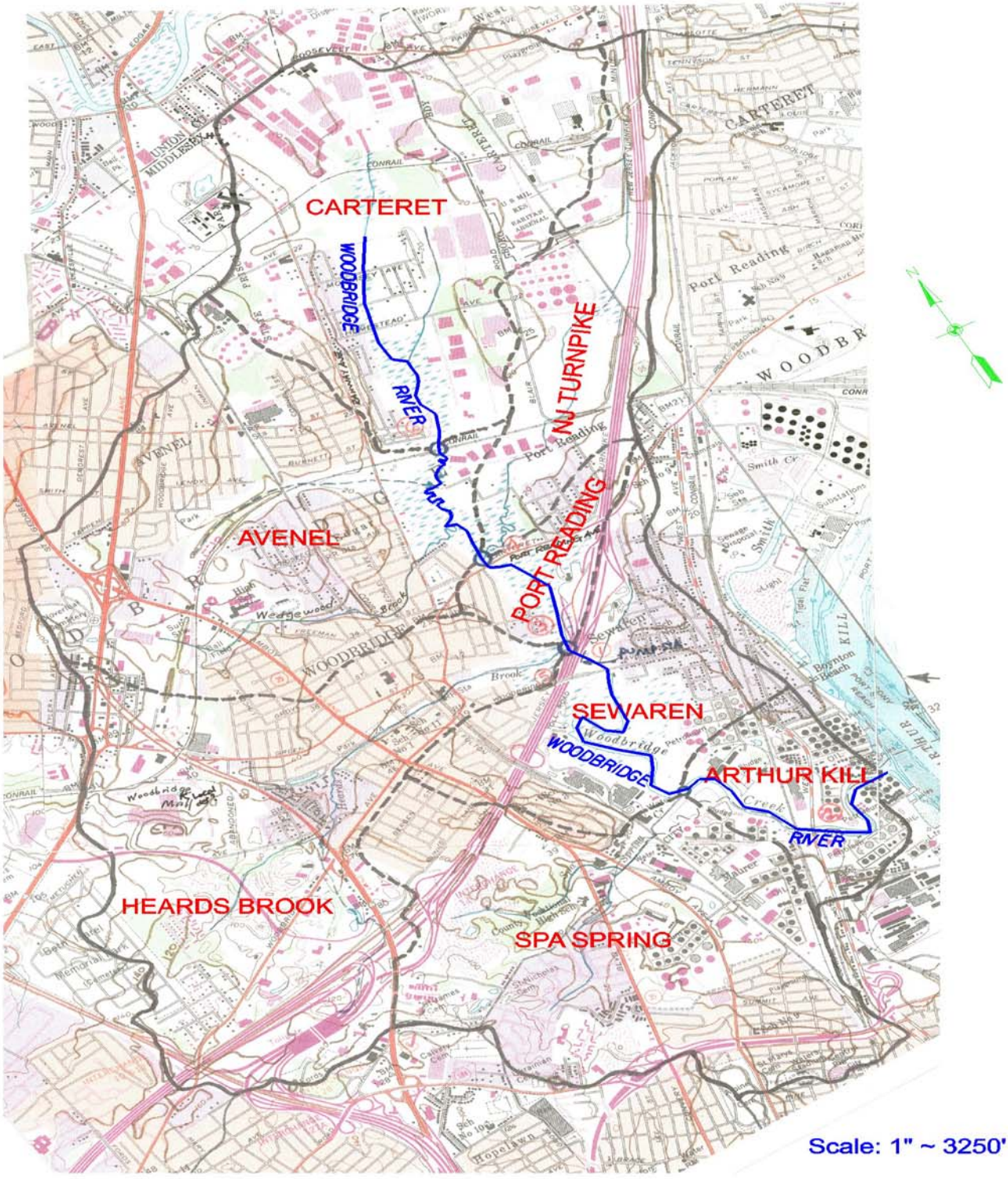

Figure 2-1
Woodbridge River Basin Study Area

Intense urbanization and development have also led to the degradation of the environment within the Study area. For example, direct development impacts on ecological resources in the Study area include increased streambank erosion, loss of wetland acreage, increased sedimentation, nutrient and pollutant loading, and channel siltation. Indirect impacts include increased rates and volumes of stormwater runoff, reduced groundwater recharge, increased stream temperatures, and increased acreage of invasive species. As a result of these direct and indirect impacts, opportunities for ecosystem restoration, including fish and wildlife habitat enhancement, water quality improvement, and restoration of natural floodplain values exist within the Woodbridge River Basin (USACE 1999).

2.1.1 History of Past Flooding

Recent major floods on the Woodbridge River and its tributaries have impacted the Woodbridge River Basin and caused several millions of dollars in damages. The following is a brief listing of the most recent floods that directly affected the Woodbridge River Basin.

October 19, 1996: This storm caused significant damage over a widespread area, including the Woodbridge River Basin. A description of two representative damage areas is provided below.

1. Woodbridge River between New Jersey Turnpike and Port Reading Avenue. During past floods, flooding was known to cover the Crampton Avenue neighborhood to as far as Vesper Avenue. Flooding in this area is characterized as a recurring problem caused by tidal surges in conjunction with stormwater runoff. The flooding has mostly impacted low-lying residential areas and has caused numerous road closings during storm events. The ground surface elevation of the area is 6 to 7 feet NGVD, and the 1 percent chance exceedence event storm surge level is 10.2 feet NGVD (source: FEMA Flood Insurance Study, Township of Woodbridge, March 1, 1983). Approximately 80 Cape-Cod style residential structures are subject to frequent flooding. Damages from the October 1996 flood (1.3 percent chance exceedance / 75 year flood were estimated (via survey) at $360,000.
2. Woodbridge River Tidal Flood Plain at Ideal Mobile Home Community. This area extends along the Woodbridge River from the Port Reading railroad bridge crossing upstream for approximately 1,800 feet. The trailer park consists of approximately 300 units situated within a low-lying area of the Woodbridge River tidal floodplain. This area floods at least once per year and is subject to both tidal and riverine flooding, and the 10 year tide elevation of 7.2 feet NGVD (source: FEMA Flood Insurance Study, Township of Woodbridge, March 1, 1983) would inundate more than half of the roadways at the trailer park. Eighty units of the trailer park incurred total damages of $240,000 during the October 1996 flood (a 75 year / 1.3 percent chance exceedance flood).

Other major floods have been recorded in the Woodbridge River Basin. Based on the magnitudes of the floods and the flood prone areas within the basin, it is believed that the study area would have been impacted.

2.1.2 Principal Flood Damage Reaches

The Woodbridge River Basin study area was not broken into reaches but affected areas. These areas were used to evaluate the costs of structural and nonstructural flood damage reduction

measures and to estimate the benefits of the alternative plans, based on the corresponding reduction in flood damages. The Ideal Mobile Home Park and the Crampton Avenue Neighborhood areas described below are illustrated in Figure 2.2.

Area 1: Ideal Mobile Home Park. Area 1 extends along the Woodbridge River from the Port Reading railroad bridge crossing upstream for approximately 1,800 feet. The trailer park consists of approximately 300 units situated within a low-lying area of the Woodbridge River tidal floodplain. This area floods at least once per year and is subject to both tidal and riverine flooding, damaging residential property.

Area 2: Crampton Ave. Neighborhood. Flooding in Area 2 has mostly impacted low-lying residential areas and has caused numerous road closings during storm events. Approximately 80 Cape-Cod style residential structures are subject to frequent flooding, with flooding being characterized as a recurring problem caused by tidal surges in conjunction with stormwater runoff.

With- and without-project future conditions for the flood-prone reaches assume a stable level of development. Because floodplain regulations restrict new construction in areas that are subject to damage by a 100-year flood event, it was assumed that development of new residential, commercial, and industrial uses in the floodplain is not likely.

2.1.3 Planning Objectives, Constraints, and Key Assumptions

The following discussions identify critical objectives, constraints, and assumptions used during formulation of alternative plans to address problems and opportunities of Federal interest in flood damage reduction in the Woodbridge River Basin.

2.1.4 Planning Goals And Objectives

The Federal objective in making investments in flood damage reduction projects is to contribute to National Economic Development (NED). The pursuit of planning objectives must be consistent with Federal, State and local laws and policies, and technical, economic, environmental, regional, social, and institutional considerations. Recommended plans should avoid, minimize, and then mitigate, if necessary, adverse project impacts to the environment. They should also maximize net economic benefit, avoid adverse social impacts, and meet local preferences to the fullest extent possible.

In pursuit of the goal to reduce flooding damages in the study area, the following objectives for flood damage reduction in the Woodbridge River Basin were established:

- Provide protection from frequent, low-level recurring floods in order to protect and maintain traffic corridors and ensure the operability of emergency and rescue facilities during storm events.
- Reduce the frequency and severity of fluvial and tidal flooding of the Woodbridge River within the study area.
- Provide a plan that is compatible with future flood damage reduction and economic development opportunities.
- Avoid and minimize adverse environmental impacts.

Figure 2-2
Affected Areas - Ideal Mobile Home Community and Crampton Avenue Neighborhood

2.1.5 Planning Constraints

The formulation and evaluation of alternative plans was constrained by a variety of considerations. The planning constraints used to guide the feasibility study are listed below:

- Technical constraints include the need for plans to be: (1) sound, safe, and acceptable solutions, (2) in compliance with sound engineering practice, (3) realistic and state-of-the-art, (4) consistent with existing local plans, and (5) complete and not dependent on future projects.
- Economic constraints include: 1) the need for flood damage reduction features to be efficient (*i.e.*, average annual benefits exceed average annual costs); and 2) the requirement to select the flood damage reduction plan that maximizes net excess benefits (*i.e.*, the NED plan) unless there are overwhelming reasons to select a different plan and an exception is granted by the Assistant Secretary of the Army (Civil Works).
- Environmental constraints affecting the formulation and selection of flood damage reduction features include the need for plans to: (1) avoid unreasonable impact environmental resources, and (2) first consider avoidance followed by minimization, mitigation, and replacement.
- Regional and social constraints include the need for plans to: (1) weigh the interests of State and local public institutions and the public at large, and (2) consider the potential impacts of the project on other areas and groups.
- Institutional constraints include the need for plans to: (1) be consistent with existing Federal, State and local laws, (2) be locally supported, (3) provide public access to the project in accordance with Federal and State laws and regulations, and (4) find overall support in the region and state.

2.1.6 Critical Assumptions Guiding Plan Formulation

Critical assumptions guiding plan formulation for flood damage reduction features include the following:

- Economics of the project will be evaluated using a 50-year period of analysis.
- Prevailing Federal discount rate (5.375 percent) will be utilized in cost and benefit estimates.
- The line of protection and interior drainage features are separately formulated and optimized.

2.2 Screening of Structural Flood Damage Reduction Measures

The screening of flood damage reduction measures includes an assessment of the potential engineering, economic, environmental, institutional, 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 structural flood damage reduction measures were considered for application to flooding problems in the study area: (1) floodwalls, (2) road raising, (3) levees and (4) storm gates. These structural measures and the results of the initial screening are described below.

2.2.1 Floodwalls

Floodwalls are structures composed of steel, concrete, rock, or aluminum, and are used when residential properties directly abut a channel or the shoreline and there is not enough space to construct a levee, or in cases where storm induced floods are too severe for a levee. Interior drainage facilities, located on the landward side of the floodwall, would be needed to collect, control, and disperse water trapped behind the barriers. Otherwise, floodwaters would pond behind the barrier.

2.2.2 Road Raising

Roads that currently experience flooding during storms due to tidal waters or surface runoff would be elevated to heights that would minimize or eliminate the impacts of such events.

2.2.3 Levees

Levees are typically low, wide earthen embankments built to retain floodwater inside a channel. Interior drainage facilities, located on the landward side of the levees, would be needed to collect, control, and disperse water trapped behind the barriers. Otherwise, floodwaters would pond behind the barrier and potentially breach the levee.

2.2.4 Storm Gates

Storm gates are used to alleviate the inundation of landward areas as floodwaters enter canals and creeks. During flood events, storm gates placed across waterways would be closed, and high flows in the creeks would be pumped around the closure.

2.2.5 Dredging

Dredging of blocked or clogged channels and bodies of water can sometimes improve flow and reduce or prevent fluvial flooding. It is important to note that dredging does not reduce or prevent tidal flooding. Figure 2-3 below illustrates why dredging does not affect tidal flooding. We see an undredged channel at left and the same channel dredged at right. It can be observed that when the channel, river, stream, etc. is dredged the level of water still rises to the same level because the large body of water such as the ocean is so relatively large that the water level rises to the same amount. It is this reason that makes dredging a generally ineffective method of affecting flooding causes by tides.

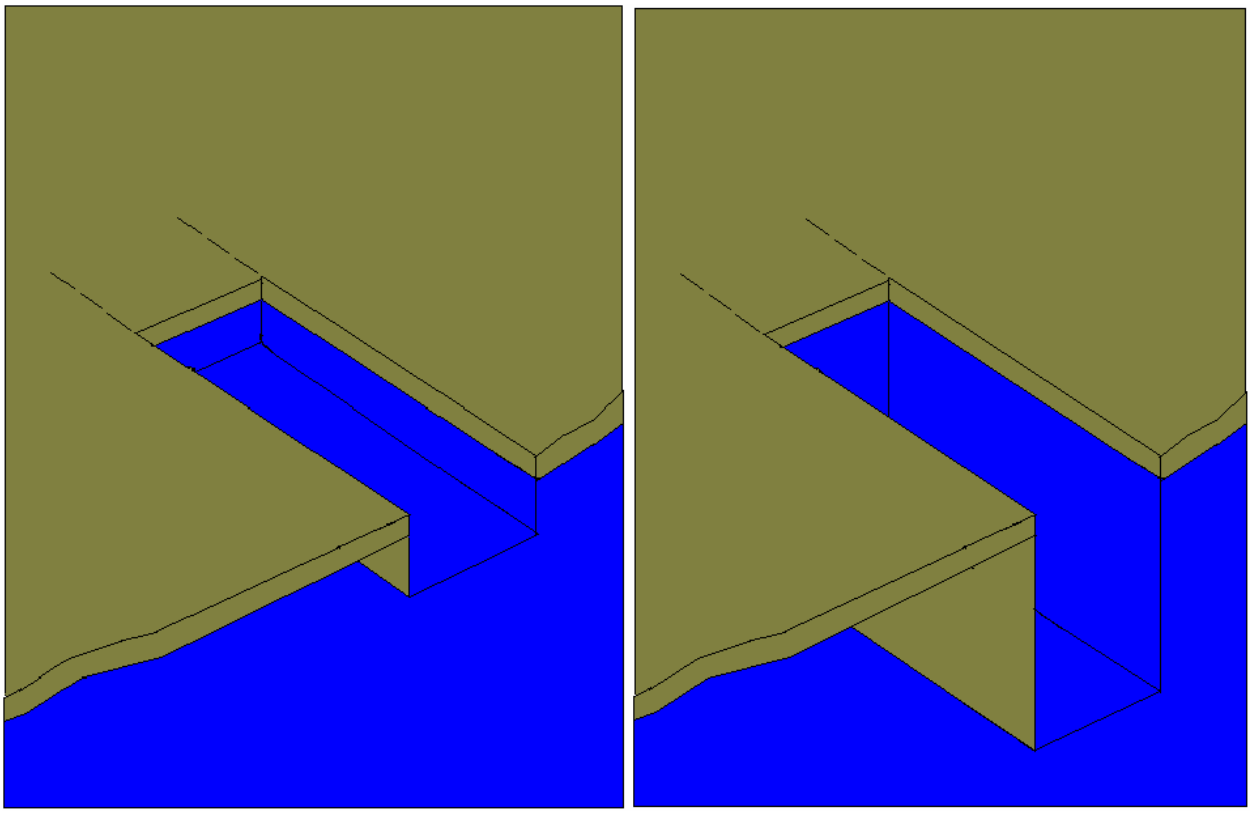

Figure 2-3
Channel undredged at left and dredged at right. Although the channel at right is deeper the water rises to the same level.

As a structural alternative, dredging the Woodbridge River at selected locations was discussed. However, an increase in flood damage reduction along the Woodbridge River is not achievable by dredging the stream channel to a larger cross-section. The Woodbridge River is a tidal estuary, affected by the tides that proceed upstream from the Arthur Kill. The flood damage that is sustained in the identified damage centers along the Woodbridge River is predominately caused by this tidal flooding. As the tide moves upstream from the Atlantic Ocean, through Raritan Bay, Arthur Kill and into the Woodbridge River, it is capable of filling up any channel or area at an elevation lower than the level the particular tide will ultimately reach. Any surge that is added to the astronomical tide, based on a current storm condition, likewise, is of such volume as not to be reduced in elevation by an enlarged channel. Whatever size cross-section is provided will always fill completely to the elevation of the tide for the entire length of the channel system. Any increase in channel size provided to accommodate upland runoff will be filled with the tide prior to the runoff reaching the channel provided that the rainfall event is occurring on a high tide. If the rainfall event occurs on a low tide, then ample channel capacity will already be available and little damage should be realized since flood damage predominately is caused by the high tides.

2.3 Screening of Nonstructural Flood Damage Reduction Measures

Nonstructural measures were fully considered in plan formulation. Some nonstructural measures were identified as potentially applicable to flood damage reduction in the study area, including: (1) acquisition of flood-prone property, (2) elevating structures, and (3) floodproofing. The screening of nonstructural measures is summarized below.

2.3.1 Property Buy-Outs

Buy-outs involve the acquisition of property and its structures and/or the purchase of development rights. A buy-out plan would result in the permanent evacuation of the floodplain in areas of frequent and severe inundation. Development in the areas would cease and structures would be demolished or relocated. A buy-out plan would be successful in re-establishing and maintaining a natural state of the floodplain for purposes that would not be jeopardized by the flood hazard. However, this type of program causes emotional hardship, involves expensive relocation costs, and results in the loss of a community/local tax base.

2.3.2 Elevating Structures

Elevating structures is the process of raising the main living area above the level of the most severe and recurrent floods. Usually, structures are held by hydraulic jacks and temporary supports while a new or extended foundation of piers, posts, columns, or pilings are constructed. After the structure is elevated, only the foundation would remain exposed to flooding.

2.3.3 Floodproofing Buildings

Floodproofing is the process of making adjustments in the design or construction of buildings to reduce potential flood damages. Buildings could be dry or wet floodproofed. Dry floodproofing would protect a building by sealing its exterior walls and providing removable shields at structure openings to prevent the influx of floodwaters. Wet floodproofing would protect a building by allowing floodwaters to enter and exit freely, which reduces the load imposed on the structure.

2.3.4 Flood Warning System

In situations where a structural or non-structural flood damage reduction project is not feasible, a flood warning system may provide some relief to those located within an area subject to flood damages. Even in areas that can claim benefits from a completed project, a flood warning system can afford residents advance warning of what is to come and allow them time to make appropriate preparations. While a flood warning system does not prevent flooding and does not reduce damage to property that is left in the path of floodwaters, it can provide an aid in reducing property loss and increasing the safety of individuals. With the use of a flood warning system, property, such as motor vehicles, can be relocated to higher ground in time to prevent damage from rising waters. In addition, moveable items can be taken to higher floors within structures, where they will not be impacted. Finally, residents will have time to leave the area, if necessary, for their own safety.

Elaborate flood warning systems can be designed and implemented for a particular location. However, this is not being considered for the Woodbridge River basin since other Federal agencies, such as the United States Geological Society and The National Weather Service, already provide satisfactory information sources that can address this situation. By using these available resources, an adequate flood warning system can be provided to the residents of Woodbridge.

2.4 Alternative Flood Damage Reduction Plans

As the next step in the plan formulation process, flood damage reduction measures that survived the initial screening were developed in greater detail. The initial screening of flood damage reduction measures resulted in the following structural and nonstructural measures being carried forward for more detailed investigations:

- No action;
- Tide gate with tidal levee system;
- Levee/floodwall system; and
- Elevation of structures.

Alternative plans were developed incorporating one or more of these flood damage reduction measures to create various flood damage reduction alternative plans. Components of the alternative plans are described below and shown in Table 3-5. Alternatives 1, 2, 3 and 4 provide 100-year level of protection and Alternatives 5 and 6 provide 50-year level of protection.

Table 2- 1 Features of Alternative Plans

Plan Features	1	2	3	4	5	6	7
Tide / Storm Gate				✓	✓	✓	
Tidal Levee System				✓	✓	✓	
Levee/Floodwall System			✓				
Elevation of Structures	✓	✓	✓				
Road Raising		✓	✓				
No Action							✓

Alternative 1: Ideal Mobile Home Park and Crampton Avenue Neighborhood Nonstructural Protection

This alternative would involve non-structural protection for approximately 189 homes in the Ideal Mobile Home Park, and 110 homes in the Crampton Avenue neighborhood. The nonstructural measure analyzed was to raise the mobile homes in Ideal Mobile Home Park and the homes in the Crampton Avenue neighborhood for structures located within the 100-year

floodplain. The mobile homes would be jacked up and set on new concrete block foundations. New stairs or ramps would be constructed for access to each mobile home. The elevations would range up to several feet dependent on the depth of the flooding at the mobile home location. The mobile home's external utilities (air conditioning compressor, etc.) would also be elevated. For the homes in the Crampton Avenue neighborhood, the elevation would involve jacking up the structure and constructing a new higher foundation wall. Basements would be filled to grade and utilities would be raised or placed in newly constructed utility rooms added to the elevated structure.

Alternative 2: Ideal Mobile Home Park Nonstructural Protection and Crampton Avenue Neighborhood Floodwall System

Approximately 110 homes in the Ideal Mobile Home Community would have non-structural measures applied to them. The nonstructural measure analyzed was to raise the mobile homes in Ideal Mobile Home Park for structures located within the 100-year floodplain. The elevation would involve jacking up the structures and constructing a new higher foundation wall. Basements would be filled to grade and utilities would be raised or placed in newly constructed utility rooms added to the elevated structure.

The other part of this alternative consists of an approximately 4,200 foot-long floodwall placed around the Crampton Avenue neighborhood with an elevation of 12 feet NGVD above existing. The floodwall would require a 100 cubic feet per second submersible pump and outfalls as necessary to remove excess runoff that would accumulate on the landward side of the floodwall. The alternative would also include the raising of Port Reading Avenue. This alternative could be constructed as outlined above or each segment could be constructed independently.

See Figure 2-4 for an illustration of the Crampton Avenue neighborhood floodwall system.

Alternative 3: Crampton Avenue Neighborhood and Ideal Mobile Home Park Floodwall Systems – 100- Year Level of Protection

One part of this alternative consists of an approximately 4,200 foot-long floodwall placed around the Crampton Avenue neighborhood with an elevation of 12 feet NGVD above ground. The floodwall would require a 100 cubic feet per second submersible and outfalls as necessary to remove excess runoff that would accumulate on the landward side of the floodwall. The alternative would also include the raising of Port Reading Avenue.

See Figure 2-4 for an illustration of the Crampton Avenue neighborhood floodwall system.

The other part of this potential flood control scenario would include placing a 12 foot NGVD above ground floodwall around the Ideal Mobile Home Park. This floodwall would extend approximately 1,850 feet and would require a 40 cubic feet per second submersible pump and outfalls as necessary to remove excess runoff that would accumulate on the landward side of the floodwall. Both of these floodwall systems could be constructed as outlined above or could be constructed independently.

See Figure 2-5 for an illustration of the Ideal Mobile Home Park floodwall/levee system.

Alternative 4: Tide Gate with Tidal Levee System - 100-Year Level of Protection (Upstream of the NJ Turnpike Bridge)

Tide Gate Structure Description. The proposed tide gate is a pile supported, stand-alone structure that does not need the New Jersey Turnpike Bridge for stability or support. The design calls for ten openings with ten 5-foot by 5-foot slide gates and stop logs. The total width of the considered tide gate structure ranges between 50 to 60 feet. The top elevation of the tide gate is at 13 feet NGVD (height between 5 to 9 feet). To meet environmental and hydraulic concerns the tidal flow that passes beneath the bridge under present conditions would be maintained by the plan of improvement.

Tidal Levee System Description. In addition to the tide gate structure, a levee system must be included to prevent the tide from circumventing the tide gate and flooding developed areas. The levee system would be approximately 4,140 linear feet in length. The footprint of the levee system would be approximately 80 feet in width. The endpoints of the levee system would be connected to higher ground at an elevation of 13 feet NGVD. One endpoint would be in the vicinity of the NJ Transit Bridge & NJ Turnpike and the other endpoint would be in the vicinity of the intersection of Austin and Summit Streets.

See Figure 2-7 for an illustration of Alternative 4.

Alternative 5: Tide Gate with Tidal Levee System - 50-Year Level of Protection (Downstream of the NJ Turnpike Bridge)

Tide Gate Structure Description. The proposed tide gate is a pile supported, stand-alone structure that does not require the New Jersey Turnpike Bridge for stability or support. The design calls for ten openings with ten 5-foot by 5-foot slide gates and stop logs. The total width of the considered tide gate structure ranges between 50 to 60 feet. The top elevation of the tide gate is at 12 feet NGVD (height between 4 to 8 feet). To meet environmental and hydraulic concerns the tidal flow that passes beneath the bridge under present conditions would be maintained by the plan of improvement.

Tidal Levee System Description. In addition to the tide gate structure, a levee system must be included to prevent the tide from circumventing the tide gate and flooding developed areas. The levee system would be approximately 1,074 linear feet in length. The footprint of the levee system would be approximately 70 feet in width. The endpoints of the levee system would be connected to higher ground at an elevation of 12 feet NGVD. One endpoint would be in the vicinity of Woodbridge Avenue & NJ Turnpike and the other endpoint in the vicinity of the intersection of NJ Turnpike rest area.

See Figure 2-8 for an illustration of Alternative 5.

Alternative 6: Tide Gate with Tidal Levee System - 50-Year Level of Protection (Upstream of the Woodbridge Avenue Bridge)

Tide Gate Structure Description. The proposed tide gate would be a pile supported, stand-alone structure. The design calls for ten openings with ten 5-foot by 5-foot slide gates and stop logs. The total width of the considered tide gate structure ranges between 50 to 60 feet. The top

elevation of the tide gate would be at 12 feet NGVD (height between 4 to 8 feet). To meet environmental and hydraulic concerns the tidal flow that passes beneath the bridge under present conditions would be maintained by the plan of improvement.

Tidal Levee System Description. In addition to the tide gate structure, a levee system must be included to prevent the tide from circumventing the tide gate and flooding developed areas. The levee system would be approximately 924 linear feet in length. The footprint of the levee system would be approximately 70 feet in width. The endpoints of the levee system would be connected to higher ground at an elevation of 12 feet NGVD. One endpoint would be in the vicinity of Woodbridge Avenue & NJ Turnpike and the other endpoint in the vicinity of the intersection of Austin and Summit Streets.

See Figure 2-9 for an illustration of Alternative 6.

Alternative 6A: Tide Gate with Tidal Levee System – 25 -Year Level of Protection (Upstream of the Woodbridge Avenue Bridge)

Alternative 6A was developed by Najarian Associates for Woodbridge Township. This plan is a modified version of Alternative 6. The plan consists of a levee system approximately 300 linear feet in length in conjunction with a tide gate, both at an elevation of 11 feet NGVD. This plan is presented in its entirety in Section 9 of this report. This alternative is analyzed in greater detail in Section 2.5 of this report.

Alternative 7: No Action.
This alternative plan means no additional Federal actions would be taken to provide for Flood Damage Reduction protection. This plan fails to meet any of the objectives or needs for the project, but provides the base against which the project benefits are measured. Additionally, this alternative would be implemented if project costs exceed project benefits thus indicating that protection measures are not in the Federal interest under current NED guidelines.

Figure 2-4
Crampton Avenue Neighborhood Floodwall System – 100- Year Level of Protection

Figure 2-5
Ideal Mobile Home Community Floodwall System – 100 Year Level of Protection

Figure 2-6
Alternative 4: Tide Gate with Tidal Levee System – 100-Year Level of Protection
(Upstream of the NJ Turnpike Bridge)

Figure 2-7
Alternative 5: Tide Gate with Tidal Levee System – 50-Year Level of Protection
(Downstream of the NJ Turnpike Bridge)

Figure 2-8
Alternative 6: Tide Gate with Tidal Levee System – 50-Year Level of Protection
(Upstream of the Woodbridge Avenue Bridge)

2.5 Evaluation of Alternatives

The six alternative plans (Plans 1-6) are evaluated and compared in this section of the report. The comparison of alternatives focuses on the differences between each plan in terms of their beneficial and adverse impacts and contributions to the planning objectives.

2.5.1 Alternative Evaluation Economics

This section of the report presents the results of the economic and engineering studies that were conducted to quantify the benefits and costs of the alternatives developed to reduce flood damages in the Woodbridge River Basin. An Economics Appendix is included with this report. Benefits and costs are expressed as average annual values at the current Federal discount rate of 5-3/8% and a project life of 50 years. After this report was written the October 2005 price level of 5-1/8% was made available. As updating the price level from 5-3/8% to 5-1/8% would only increase the BCR about 4%, a negligible amount, the price level was not updated. Benefits and costs are expressed at October 2004 price levels (P.L.) during the process of alternatives screening.

2.5.2 Flood Damage Reduction Benefits

Corps procedures calculate benefits based on the difference between the expected annual damages with and without alternative flood protection plans. The implicit assumption incorporated into this procedure is that the reduction in flood damages is directly translatable into increased net income to floodplain land uses. Benefits from Flood Damage Reduction measures in the Woodbridge River Basin focused on inundation reduction benefits resulting from reduction of physical damages to structures and contents, emergency services cost savings, and traffic delay savings.

Average annual benefits of the alternatives, which are equal to the difference between residual damages under each alternative and damages under the without project condition are shown in Tables 2-2 through 2-5, which summarize the benefits for the 50-year and 100-year levels of protection. A complete structural inventory of the study area was not performed. It is assumed that all manufactured homes situated in the Ideal Mobile Home Park have their main floor elevation at 2.5 feet. Damage levels for the cape cod structures in the Crampton Avenue neighborhood were calculated under four scenarios: all structures with a main floor at 2 feet, 3 feet, 4 feet, and 5 feet. Residual damages that exceed the level-of-protection are not shown since they are identical in both without and with-project conditions. The net benefits remain the same.

Table 2-2. Annual Benefits - Crampton Avenue (Oct. 2004 P.L.)

100yr Design **Main Floor Elevations**

	2ft.	3ft.	4ft.	5ft.
Without-Project Damages	$ 264,086	$ 182,955	$ 124,560	$ 83,638
With-Project Damages	$ 94,532	$ 72,856	$ 54,564	$ 38,497
With-Project Benefits	$ 169,554	$ 110,099	$ 69,996	$ 45,141

Table 2-3. Annual Benefits - Crampton Avenue (Oct. 2004 P.L.)

50yr Design **Main Floor Elevations**

	2ft.	3ft.	4ft.	5ft.
Without-Project Damages	$ 264,086	$ 182,955	$ 124,560	$ 83,638
With-Project Damages	$ 136,995	$ 101,947	$ 72,971	$ 47,904
With-Project Benefits	$ 127,091	$ 81,008	$ 51,589	$ 35,734

Table 2-4. Annual Benefits - Crampton Avenue (Oct. 2004 P.L.)

25yr Design **Main Floor Elevations**

	2ft.	3ft.	4ft.	5ft.
Without-Project Damages	$ 264,086	$ 182,955	$ 124,560	$ 83,638
With-Project Damages	$ 184,782	$ 132,544	$ 92,363	$ 62,645
With-Project Benefits	$ 79,304	$ 50,411	$ 32,197	$ 20,993

Table 2-5. Annual Benefits - Ideal Mobile Home Park (Oct. 2004 P.L.)

	100yr Design	50yr Design	25yr Design
Without-Project Damages	$ 120,577	$ 120,577	$ 120,577
With-Project Damages	$ 52,569	$ 82,871	$ 111,017
With-Project Benefits	$ 68,008	$ 37,706	$ 9,560

2.5.3 Preliminary Costs of the Alternative Plans

Preliminary costs of the alternative plans, which include construction costs, real estate acquisition, engineering and design, environmental mitigation, and interest during construction are shown in Table 3-8. Interest during construction was calculated assuming a 24 month construction period for all alternatives. Cost estimates for flood damage reduction alternatives were based on calculated quantities and unit prices. Operations and maintenance (O&M) costs were estimated based on the anticipated conditions over a 50-year project life. Annualized costs of the alternatives range from $199,484 (Alternative 6 – Tide Gate with Tidal Levee System - 50-Year Level of Protection – Upstream of the Woodbridge Avenue Bridge) to $1,332,800 (Alternative 1 – Ideal Mobile Home Park and Crampton Avenue Neighborhood Nonstructural Protection).

Alternatives 1 through 4 provide protection against a 100-year storm event and their associated costs are provided in Table 2-6.

Table 2-6 Costs of Alternative Plans (Oct. 2004 P.L.)

100yr Design	**Alternatives Plans**			
	1	2	3	4
Construction Cost	$ 21,997,700	$ 10,050,500	$ 10,250,500	$ 5,070,100
Interest During Construction	$ 989,010	$ 451,867	$ 460,859	$ 227,950
Annual Construction Cost	$ 1,332,800	$ 608,900	$ 621,100	$ 307,200
Annual O&M Costs	$ -	$ 43,100	$ 53,275	$ 2,000
Total Annual Costs	$ 1,332,800	$ 652,000	$ 674,375	$ 309,200

Alternatives 5 and 6 provide protection against a 50-year storm event and their associated costs are provided in Table 2-7.

Table 2-7. Costs of Alternative Plans (Oct. 2004 P.L.)

50yr Design	**Alternatives Plans**	
	5	6
Construction Cost	$ 3,262,800	$ 3,745,800
Interest During Construction	$ 101,783	$ 85,655
Annual Construction Cost	$ 195,100	$ 164,200
Annual O&M Costs	$ 22,000	$ 35,284
Total Annual Costs	$ 217,100	$ 199,484

The construction cost for Alternative 6A was taken from the Najarian Associates report and was amortized to an annual cost of $150,000.

2.5.4 Flood Damage Reduction Benefit Cost Analysis

A preliminary economic comparison of the annual costs, annual benefits, benefit-to-cost ratios, and net benefits of the alternatives are shown in Table 2-8 through Table 2-14. Based on the results of the preliminary analysis, none of the alternatives meet the necessary Net Economic Development (NED) criteria needed to justify Federal interest.
Residual damages were subtracted from the residential structure damage categories. Average annual benefits were calculated by amortizing the expected damages through the 50-year project life at a discount rate of 5-3/8%. After this report was written the October 2005 price level of 5-1/8% was made available. As updating the price level from 5-3/8% to 5-1/8% would only increase the BCR about 4%, a negligible amount, the price level was not updated.

100-year level-of-protection

Table 2-8. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 1 **Main Floor Elevation**

	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 237,562	$ 178,107	$ 138,004	$ 113,149
Annual Costs	$ 1,332,800	$ 1,332,800	$ 1,332,800	$ 1,332,800
Net Benefits	$ (1,095,238)	$ (1,154,693)	$ (1,194,796)	$ (1,219,651)
Benefit-Cost-Ratio	0.2	0.1	0.1	0.1

Table 2-9. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 2 **Main Floor Elevation**

	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 237,562	$ 178,107	$ 138,004	$ 113,149
Annual Costs	$ 652,000	$ 652,000	$ 652,000	$ 652,000
Net Benefits	$ (414,438)	$ (473,893)	$ (513,996)	$ (538,851)
Benefit-Cost-Ratio	0.4	0.3	0.2	0.2

Table 2-10. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 3 **Main Floor Elevation**

	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 237,562	$ 178,107	$ 138,004	$ 113,149
Annual Costs	$ 674,375	$ 674,375	$ 674,375	$ 674,375
Net Benefits	$ (436,813)	$ (496,268)	$ (536,371)	$ (561,226)
Benefit-Cost-Ratio	0.4	0.3	0.2	0.2

Table 2-11. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 4	**Main Floor Elevation**			
	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 237,562	$ 178,107	$ 138,004	$ 113,149
Annual Costs	$ 309,200	$ 309,200	$ 309,200	$ 309,200
Net Benefits	$ (71,638)	$ (131,093)	$ (171,196)	$ (196,051)
Benefit-Cost-Ratio	0.8	0.6	0.4	0.4

50-year level-of-protection

Table 2-12. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 5	**Main Floor Elevation**			
	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 164,797	$ 118,714	$ 89,295	$ 73,440
Annual Costs	$ 217,100	$ 217,100	$ 217,100	$ 217,100
Net Benefits	$ (52,303)	$ (98,386)	$ (127,805)	$ (143,660)
Benefit-Cost-Ratio	0.8	0.5	0.4	0.3

Table 2-13. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 6	**Main Floor Elevation**			
	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 164,797	$ 118,714	$ 89,295	$ 73,440
Annual Costs	$ 199,484	$ 199,484	$ 199,484	$ 199,484
Net Benefits	$ (34,687)	$ (80,770)	$ (110,189)	$ (126,044)
Benefit-Cost-Ratio	0.8	0.6	0.4	0.4

25-year level-of-protection

Table 2-14. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

Alternative 6A	**Main Floor Elevation**			
	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$ 88,864	$ 59,971	$ 41,757	$ 30,553
Annual Costs	$ 150,000	$ 150,000	$ 150,000	$ 150,000
Net Benefits	$ (61,136)	$ (90,029)	$ (108,243)	$ (119,447)
Benefit-Cost-Ratio	0.6	0.4	0.3	0.2

A Benefit-Cost Analysis was not developed for Alternative 7 as it is the No-Action Alternative.

2.5.5 Selected Plan

None of the alternatives have a net benefit greater than zero; therefore there is no Federal interest in this study.

As previously stated, a complete structural inventory of the study area was not performed. It is assumed that all manufactured homes situated in the Ideal Mobile Home Park have their main floor elevation at 2.5 feet. Damage levels for the Cape Cod structures in the Crampton Avenue neighborhood were calculated under four scenarios: all structures with a main floor at 2 feet, 3 feet, 4 feet, and 5 feet as it was noted in the field that main floor elevations of the cape cod structures in the Crampton Avenue neighborhood range from 2ft. to 5ft.

If the best case scenario is assumed then all the structures would have main floor elevations of 2 ft., yielding the lowest main floor elevation and the most damages during flooding which provides the highest Benefit-Cost Ratio as the project would provide the most benefits in that case. Alternatives 4, 5 and 6 yield BCRs of 0.8 at main floor elevations of 2 ft., which is the highest BCR for any of the alternatives. In reality, some of the Crampton Avenue structures have main floor elevations higher than 2 ft. so the highest actual BCR is less than 0.8, and providing no Federal interest as none of the alternatives offer a net benefit greater than zero.

Following the July 2006 draft report, the Township of Woodbridge submitted a proposed Alternative Plan, which has been labeled Alternative 6A. The following section discusses the Corps' review of that plan.

2.5.6 Determining Water Surface Elevations Along the Woodbridge River

The Corps has reviewed the report prepared by Najarian Associates for the Township of Woodbridge dated February 2006, entitled: "Review of Advance Draft Feasibility Report: 'Woodbridge River Basin, New Jersey Flood Damage Reduction and Ecosystem Restoration', New York District, U.S. Army Corps of Engineers (November 2005)". The report prepared by Najarian Associates was submitted to the Corps in September 2006, following the release of the July 2006 Draft Feasibility Report. The Najarian Report is located in the Main Report in Section 9 – "Pertinent Correspondence.

One of the preliminary recommendations in this report was to enhance the Corps Alternative Plan 6 to come up with a more cost-effective levee design and to increase the level of protection up to the 100-year storm event. It is the judgment of the Corps that the Najarian Associates enhanced Alternative Plan 6A with an elevation of 11 feet NGVD for the levee/tide gate structure would only protects up to the 25-year storm event (Corps stage frequency curve). In the following paragraph, a brief summary of the discussion from the Najarian Associates report explains their conclusion on the elevation of the 100-year storm. The latter paragraphs provide the basis for the Corps conclusion concerning the 100-year water surface elevation.

The Corps of Engineers determination of return period of protection includes stage elevation from storms of a given return period at a time 50-years into the future plus some level of risk and uncertainty. For instance, the design elevation for a 25-yr return period event would not be less than the 25-yr stage of 9.3 ft. NGVD, plus 0.7 ft to account for 50 years of sea level rise at a rate of 0.014 ft/year, plus 1.0 ft (at a MINIMUM) to account for uncertainties in the stage and sea level rise: or 11.0 ft. NGVD.

Using the elevation developed by Najarian Associates and the stage-frequency curve developed by the Corps, the revised tide gate/levee system would protect the Woodbridge area from a 25-year storm event (9.3 feet NGVD), with some allowance for future sea level rise. In conclusion, it is the Corps judgment that the data presented in the Najarian Associates discussion is too low a representation of the actual water surface elevation at Woodbridge, and construction of the revised plan as presented would result in a lower level of protection than is expected based on Najarian's discussion.

SENSITIVITY ANALYSIS

Separate stage frequency curves were developed based on the hydrology and hydraulics data provided by Najarian Associates. An assumption was made that the proposed design is for a 100-year non-exceedance event, refer to Tables 2-15 and 2-16.

TABLE 2-15.
Stage Frequency Curve (Revised)

Existing Conditions

Storm Event	Water Surface Elevation in feet (NGVD)
2 Yr.	6.1
5 Yr.	6.9
10 Yr.	7.4
25 Yr.	8.1
50 Yr.	8.9
100 Yr.	9.7
200 Yr.	10.4
500 Yr.	11.5

TABLE 2-16.
Stage Frequency Curve (Revised)

With-Project Conditions - 100 Yr. Design

Storm Event	Water Surface Elevation In feet (NGVD)
2 Yr.	5.19
5 Yr.	5.87
10 Yr.	6.27
25 Yr.	6.67
50 Yr.	6.9
100 Yr.	7.24
200 Yr.	10.4
500 Yr.	11.5

The average annual damages were calculated for structures with main floor elevations of 2 feet, 3 feet, 4 feet, and 5 feet.

The Najarian Associates study raised concerns that automobile damages were too low. Although automobile damages are included in the “other” category under depth damage functions in Table 4 of the Economics Appendix, additional automobile damage assessments were analyzed for the Ideal Mobile Home Park vicinity. An assumption was made that automobiles will be susceptible to flood damages for eight hours each night. Each home was assigned one vehicle with a depreciated replacement value of $17,000.

Benefits were calculated for the Crampton Avenue area and summarized in Table 2-18 below. The benefits for Ideal Mobile Home Park structures and additional automobile damage benefits are summarized in Table 2-19 below.

Table 2-18. Annual Benefits - Crampton Avenue (Oct. 2004 P.L.)

100yr Design	**Main Floor Elevations**			
	2ft.	3ft.	4ft.	5ft.
Without-Project Damages	$115,609	$72,975	$46,165	$30,613
With-Project Damages	$37,793	$24,224	$15,491	$10,029
With-Project Benefits	$77,816	$48,751	$30,674	$20,584

Table 2-19. Annual Benefits - Ideal Mobile Home Park (Oct. 2004 P.L.)

	100yr Design
Without-Project Damages	$47,848
With-Project Damages	$26,514
With-Project Benefits	$21,334

Table 2-20. Benefit Cost Analysis of Alternative Plans (Oct. 2004 P.L.)

100yr Design	**Main Floor Elevation**			
	2 ft.	3 ft.	4 ft.	5 ft.
Annual Benefits	$99,150	$70,085	$52,008	$41,918
Annual Costs	$150,000	$150,000	$150,000	$150,000
Net Benefits	($50,850)	($79,915)	($97,992)	($108,082)
Benefit-Cost-Ratio	0.7	0.5	0.3	0.3

The cost figure for the 100-year non-exceedance design was obtained from Najarian Associates. Net benefits and benefit-cost-ratio are summarized in Table 2-20 above. There is no Federal interest in this study since the costs exceeds the benefits.

3. PLAN FORMULATION – ECOSYSTEM RESTORATION

Restoration plan formulation was performed in accordance with the six-step planning process of the P&G, as well as other Corps policies and planning guidance. The below discussions of restoration plan formulation describe the results of each step in the planning process. Discussions begin with specification of problems and opportunities for ecosystem restoration in the Woodbridge River Basin.

3.1 Problems and Opportunities-Ecosystem Degradation/Restoration

The Woodbridge River Basin was once rich in ecological resources, including extensive tidal and freshwater wetlands. The three major habitat groupings are waterbird foraging areas, freshwater marshes and woody swamps, and upland forests. Development within the basin has degraded these natural systems. Direct development impacts include the loss of wetland acreage, floodplain encroachment, stream bank erosion, increased sedimentation, nutrient and pollutant loading, and channel siltation. Indirect impacts have resulted from development-induced modifications in the hydrology of the basins and the loss of natural cover. Such impacts include increased rates and volumes of runoff, reduced base flows and groundwater recharge, increased stream temperatures, and increased acreage containing invasive species.

3.2 Planning Objectives and Constraints and Key Assumptions

The following discussions identify critical objectives, constraints, and assumptions that are used during plan formulation for ecosystem restoration in the Woodbridge River Basin.

3.2.1 Planning Goals And Objectives

The Federal objective in ecosystem restoration activities is to contribute to National Ecosystem Restoration (NER) goals. The restoration of habitats to less-degraded, more-natural conditions must be consistent with Federal, State and local laws and policies, and technical, economic, environmental, regional, social, and institutional considerations. Recommended plans should maximize the efficiency and effectiveness of restoration expenditures, avoid adverse social impacts, and meet local preferences to the fullest extent possible. In pursuit of the goal to restore degraded ecosystems in the Woodbridge River Basin, the following restoration objectives were established:

- Restore ecosystem structure and function;
- Expand and improve habitat;
- Restore natural vegetation;
- Connect or enlarge wetlands and critical habitat areas; and
- Improve public access and recreational opportunities.

3.2.2 Planning Constraints

Plan formulation for ecosystem restoration must recognize the following constraints:

- Technical Constraints: including the need for restoration options to be: (1) sound, safe, and acceptable solutions, (2) based on sound engineering practice, (3) realistic and state-of-the-art, (4) consistent with existing local plans, and (5) complete and not dependent on future projects.
- Economic Constraints: including the need to the requirement to conduct a cost effectiveness and incremental cost analysis to identify the plans which are the most efficient means to achieve various levels of restoration outputs (i.e., the "best buy" plans).
- Environmental Constraints: including the need to maximize the positive outcomes of restoration action and should avoid the need for mitigation. Environmental constraints also include the need for plans to: 1) be evaluated in a systems context in order to improve the ability of the features to function as self-sustaining systems; 2) be formulated in consideration of intended and unintended effects, both on and off of the project site; and 3) be formulated recognizing the attainable restoration state, given the influences of human activities and culturally induced changes in the landscape which are likely to persist and influence system conditions after project completion.
- Regional and Social Constraints: including the need for plans to: (1) weigh the interests of State and local public institutions and the public at large, and (2) consider the potential impacts of the project on other areas and groups.
- Institutional Constraints: including the need for plans to: (1) be consistent with existing Federal, State and local laws, (2) be locally supported, (3) provide public access to the project in accordance with Federal and State laws and regulations, and (4) find overall support in the region and state.

3.3 Potential Restoration Sites

Four potential restoration sites were identified during the reconnaissance phase of this study. These sites were carried forward into this feasibility study. The sites were identified based on a thorough review of previous studies, maps, and restoration proposals, as well as site visits and several meetings and interviews with stakeholders, local organizations, individuals, and with the non-Federal project partner (NJDEP). This coordination confirmed that these four sites represent the sites of greatest restoration potential within the study area. These sites are profiled below, and their locations are shown in Figure 3-1.

Site 1: Edgerton Boulevard Area. Edgerton Boulevard, off of Rahway Avenue, runs adjacent to the Woodbridge River south of its headwaters above Omar Avenue. Formerly crossing the River, the road is now an unused, dirt path with an undersized culvert connecting upstream and downstream flows. Modification or removal of the culvert would enable a more naturalized flow of water downstream, and may enhance fish movement between habitats. Additionally, stream corridor improvements may provide additional fish and wildlife habitat and enhance water

quality through the reduction and filtration of stormwater runoff associated with the nearby residential development.

Site 2: Coddington Avenue Area. Adjacent to the Ideal Mobile Home Park is a series of utility right-of-ways and an established colony of an opportunistic, non-native, invasive plant species. Overgrown vegetation is partly the cause of increased sedimentation of the River channel through this area, and the restoration of a more natural plant community and streambank/channel may assist in improving water quality, enhancing fish and wildlife habitat, and restoring natural water flows. Reestablishing a freshwater wetland in this area may be accomplished by fill removal and grading, followed by planting of native vegetation.

Site 3: Port Reading Avenue . Divided by Port Reading Ave is an approximately 70 acre degraded tidal wetland. Factors contributing to the deterioration of the site include past filling and diking activities and the predominance of the invasive species *Phragmites australis*. As part of mitigating for wetland impacts related to the deepening of the Port of New York and New Jersey, the Corps and the Port Authority will be restoring approximately 23 acres of tidal wetlands with an additional 27 acres being set aside for state preservation. The construction contract for the restoration work was awarded in February 2006.

Separately, the National Oceanic and Atmospheric Administration, in partnership with New Jersey Department of Environmental Protection awarded a construction contract in the summer of 2006 to restore approximately 17 acres of tidal wetlands in the northern portion of the tract. This effort serves as compensatory restoration from the 1991 Exxon Bayway Oil spill in the Arthur Kill channel.

Further restoration opportunities within this area that would compliment the Corps/Port Authority and NJDEP/NOAA restoration projects at the site, include the removal of fill material and restoration of more acres of tidal marsh and removing a partially exposed dam sill located near the Port Reading Avenue bridge to improve tidal exchange and flushing between the upstream and downstream reaches.

Site 4: Watson Avenue Area. Interpretation of aerial photography and site visits by the District has identified a large fill site within the wetlands located behind Watson Avenue. The removal of fill and regarding of the site to appropriate contours would restore the tidal marsh below the Port Reading Avenue bridge, and provide an increase in the acreage and diversity of fish habitat, which may promote increased anadromous and catadromous fish movement. Restoration of the site would also improve habitat for birds and other wildlife, and may additionally reduce nuisance mosquito populations.

3.4 Alternative Restoration Measures

There are a variety of restoration measures that could be employed at the potential sites to restore degraded ecosystems. As specified in *Ecosystem Restoration in the Civil Works Program* (ER 1105-2-210), Corps restoration planning should place emphasis on engineering measures to achieve restoration objectives, and hydrologic control rather than land acquisition. Restoration measures that are often employed in combination at Corps restoration projects include the following:

- **Stream Corridor and Water Quality Improvements**: This restoration action would include projects that use vegetation and/or approved bioengineering techniques to stabilize the streambank and reduce erosion and sedimentation. Additionally, debris and invasive or opportunistic vegetation would be removed to restore natural stream depths, and flows in the waterway.

- **Restoration of Riparian Wetlands**: This restoration action would target projects that restore degraded or altered wetlands. Fill material would be removed to restore natural water regimes, and vegetation would be planted to reduce sedimentation and pollution, and to increase fish and wildlife habitat.

- **Culvert Replacement and/or Modification**: This restoration action would include the removal and replacement of undersized or inappropriate culverts and drains, which currently reduce natural water flow or tidal exchange. Undersized culverts and drains also limit the movement of fish species between downstream and upstream habitats. Also, some culverts deemed to be unnecessary may be removed to restore the natural stream channel and course.

- **Bridge and Dam Restoration and/or Removal**: This restoration action would include projects that use vegetation to stabilize streambanks around bridges. In addition, some minor water control structures may be removed and/or modified to improve water flow and fish habitat.

3.5 Formulation and Evaluation of Alternative Plans

Had this study been economically warranted to proceed further, the full spectrum of ecosystem restoration measures would be evaluated for their applicability to potential restoration sites identified in the Woodbridge River Basin. Preliminary restoration options wouldl be developed for each site, consisting of combinations of restoration measures that appear to be most appropriate to the existing conditions and restoration potential of each site. Evaluation of the alternatives would use the following parameters: potential ecological benefits, potential costs, methods of implementation, requirements for success, real estate considerations, and support of local stakeholders and the non-Federal project partner (NJDEP). Alternative formulation and evaluation will be conducted in accordance with ER 11105-2-100 *Planning Guidance Notebook,* ER 1165-2-501 *Civil works Ecosystem Restoration Policy* and ER 1165-2-502 *Ecosystem Restoration - Supporting Policy Information*.

A wetland assessment procedure (e.g. Evaluation of Planned Wetlands, Habitat Evaluation Procedure) would be used to characterize the functional value of the existing habitat and would serve as the non-monetary output unit when conducting the incremental cost analysis. The assessment procedure chosen should focus more on overall ecosystem function rather than the specific habitat needs of a particular species.

The USACE Institute for Water Resources (IWR) has developed decision support software known as the IWR-PLAN for use in formulating and comparing alternative restoration and/or mitigation plans. This software was developed based on the methodology presented in "Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps" (USACE 1994). Cost-

effectiveness and incremental cost analyses (CE/ICA) allow the comparison of monetary costs with non-monetary outputs, or benefits. These analyses are conducted in a stepwise process, comparing alternative plans with successive levels of output, identifying those plans that meet the CE/ICA criteria, and eliminating those plans that do not. Although CE/ICA do not result in identification of one "best" plan, they provide the user with a series of cost-effective and "best buy" plans that are the least expensive for different levels of output (cost-effective plans) and provide the greatest increases in output for the least increases in cost ("best buy" plans). CE/ICA provides the user with the information necessary to make more informed decisions regarding ecosystem restoration (USACE 1995). This approach will be used to analyze the alternatives for the project.

4. THE RECOMMENDED PLAN

At this time no recommended plan has been identified due to analysis indicating that all currently identified flood control scenarios are not practical due to limited cost-effectiveness for the benefits predicted (i.e., a BCR less than 1).

Intense urbanization and development have also led to the degradation of the environment within the Study area. For example, direct development impacts on ecological resources in the Study area include increased streambank erosion, loss of wetland acreage, increased sedimentation, nutrient and pollutant loading, and channel siltation. Indirect impacts include increased rates and volumes of stormwater runoff, reduced groundwater recharge, increased stream temperatures, and increased acreage of invasive species. As a result of these direct and indirect impacts, opportunities for ecosystem restoration, including fish and wildlife habitat enhancement, water quality improvement, and restoration of natural floodplain values exist within the Woodbridge River Basin (USACE 1999). Implementation of ecosystem restoration is contingent on selection of a recommended plan.

A separate project effort, the Woodbridge Creek Ecosystem Restoration Project site, located in Woodbridge, New Jersey, has been selected for restoration efforts by the U.S. Army Corps of Engineers (Corps), the Port Authority of New York and New Jersey (Port Authority), the National Oceanic and Atmospheric Administration (NOAA), and the New Jersey Department of Environmental Protection (NJDEP) in cooperation with Woodbridge Township. This project is not designed to address flood control issues and will not influence flooding in the area, but will address ecosystem restoration issues within the Woodbridge River Basin study area and as raised in this report.

This Corps and Port Authority mitigation work is restoration being performed to offset any potential, unavoidable wetland impacts related to the deepening of channels in the Port of New York and New Jersey. Currently, the Corps along with the cost sharing sponsor, the Port Authority, is deepening key shipping channels throughout the Port of New York and New Jersey to accommodate the safe and efficient navigation of ships calling at the Port. The Port of New York and New Jersey, which supports more than 230,000 jobs in the area, is the third largest port in the nation and the largest port on the East coast.

As part of the overall deepening program, and to balance the needs of the New York and New Jersey Harbor Estuary, the Corps and the Port Authority is restoring approximately 23 acres of wetland and upland area at the Woodbridge site. Construction of the mitigation project began in the Fall of 2006 and was substantially completed.

The NOAA/DEP restoration is being conducted to provide compensatory restoration for the 1991 Exxon Bayway Oil Spill. The goal is to restore approximately 17 acres of tidal wetlands at the Woodbridge site. It is essentially completed and is considered to be a success.

The wetland areas selected for mitigation and restoration have historically functioned as a salt marsh with freshwater influences with a diversity of vegetation. In recent years, the invasive form of *Phragmites australis*, or common reed, have overrun the site and, tidal influences have been reduced resulting in a loss of plant and animal diversity.

The following are project goals for the Woodbridge Creek Ecosystem Restoration Project that would provide ecosystem restoration within the Woodbridge River Basin study area and as discussed in this report:

- Create and restore habitat for native nesting birds, nursing areas for juvenile fisheries
- Remove fill within wetland and re-grade to allow for daily tidal flushing
- Restore hydrology of the site without adversely effecting flood levels
- Re-grade site and create an elevation range that is self sustaining for native salt marsh

The selection of recommended flood damage reduction measures and ecosystem restoration opportunities includes an assessment of the potential engineering, economic, environmental, institutional, public, financial, and institutional feasibility of implementing each measure.

4.1 Mitigation

Mitigation alternatives would be evaluated in accordance with the NJ Freshwater Wetlands Protection Act rules and guidelines regarding compensatory wetland mitigation. The NJDEP mandates on-site mitigation as the preferred option where feasible and practical. On-site mitigation is performed on or adjacent to the project impact location or if not possible on the same waterbody within the same watershed as the impact location. If a suitable on-site opportunity exists for restoration, enhancement or creation then the applicant is normally encouraged or directed, by the NJDEP, to satisfy their compensatory mitigation requirements in this manner. On-site opportunities for wetland enhancement, restoration and creation do exist within the project corridor, though most of these opportunities exist on private property. Permanent easements would need to be obtained or these areas would need to be purchased from the property owner. If property owners are not willing to sell their land, on-site mitigation options may not be viable mitigation alternatives. The NJDEP may permit off-site mitigation if on-site mitigation opportunities do not exist or are not viable.

5. ENVIRONMENTAL AND CULTURAL RESOURCE STUDIES AND REQUIRED AGENCY COORDINATION

In depth literature research and field investigations have not been conducted for this project. Therefore, this section discusses the required research and site sampling necessary to assess beneficial and adverse impacts to natural resources should flood damage reduction and ecosystem restoration opportunities be implemented. Environmental studies will be performed in accordance with the National Environmental Policy Act (NEPA), ER 1105-2-100, and ER 200-2-2. As this project is not economically justified the research and sampling described below are what would likely have happened in the future should the study have identified an economically justifiable plan.

5.1 Soils

Characterization of soils within the areas of the proposed ecosystem restoration and flood damage reduction measures will require a review of County Soil Surveys along with geotechnical samples. The geotechnical borings would be performed to quantify soil and groundwater conditions and would include analyzing physical properties, and soil infiltration/permeability rates. The tide gate, if chosen as the preferred plan, can affect the moisture content of the soil. Therefore, special consideration of the impacts it may have to wetlands and potential ecosystem restoration sites located upstream of the tide gate will have to be considered.

5.2 Water Resources

The assessment on water resources would include an evaluation of beneficial and adverse impacts to water resources including surface and groundwater along with the tidal influences of the River. Hydrologic and hydraulic modeling would be required to determine the effect of any flood damage reduction structures would have on the morphology of the river, estimating the extent and duration of flood events, evaluating water budgets for restoration sites, and developing planting schemes. The modeling should also consider the effect the structures may have on channel velocity, and exchange between freshwater and saltwater. USGS tide and streamflow gauges have not been installed in the Woodbridge River, therefore, gauges would need to be set up by the Corps.

Structures located within the channel or along the channel banks can also alter water temperatures, sediment transport and salinity. The entire length of the Woodbridge River and its associated tributaries are classified as freshwater 2 – non-trout, saline estuarine – 3 (FW2-NT/SE3) waters (NJDEP 2002). The NJDEP (2002) defines FW2 waters as those freshwaters not originating in or wholly contained within federal or state parks, forests, fish and wildlife lands, and other special holdings; not maintained in their natural state of quality; and, possibly subjected to man-made wastewater discharges. Non-trout (NT) waters are those freshwaters generally not considered suitable for trout because of physical, chemical, or biological characteristics, but are suitable for a wide range of other fish species. Saline estuarine (SE3) is a "general surface water classification applied to saline waters of estuaries". In order to obtain a water quality certification from NJDEP, the Corps would have to implement temporary and longterm measures to prevent contravention of the above water quality standards.

5.3 Vegetation

Sampling of upland and wetland areas within the flood damage reduction and the ecosystem restoration areas would be required in order to characterize baseline conditions. Other tasks involved in the characterization include reviewing USFW National Wetland Inventory maps, aerial photos, wetland delineations, and preparing a vegetative community map for the ecosystem restoration, mitigation and reference areas.

5.4 Fish and Wildlife

Literature searches and coordination with USFWS, NJDEP and any special interest organizations would be required to identify the types of fish, mammalian, avian and benthic species occurring within the project area. Depending on the availability of existing information, field investigations may be necessary to supplement the literature research and coordination efforts. Specific sampling methods would be determined in a later phase had the study proved economically justified.

5.5 Threatened and Endangered Species

The investigation would include coordination with the U.S. Fish and Wildlife Service pursuant to the Fish and Wildlife Coordination Act and Section 7 of the Endangered Species Act. The District would also coordinate with the New Jersey Natural Heritage Program, the New Jersey Division of Fish and Wildlife, Endangered and Non-game Species Program to ascertain the presence of any state-listed rare, threatened, or endangered species within the project area.

5.6 Essential Fish Habitat

Essential Fish Habitat (EFH) are areas identified as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" under the Magnuson Stevens Fisheries Conservation and Management Act (MSFCMA) as amended by the Sustainable Fisheries Act (SFA) of 1996. Although the Woodbridge River is not specifically designated as EFH, certain EFH species and EFH prey species have been documented within the river. In accordance to the MSFCMA an assessment identifying the potential impacts resulting from the proposed project on these species will be required. Coordination with the National Oceanic and Atmospheric Association (NOAA-Fisheries) will be initiated to determine the level of assessment necessary to satisfy the requirements promulgated by the MSFCMA.

5.7 Coastal Zone Management

Pursuant to the Coastal Zone Management Act of 1972 and the Coastal Zone Reauthorization Act Amendments of 1990, New Jersey has defined its coastal zone boundaries and developed policies to evaluate and issue permits for projects located within the designated coastal zone. These policies are set forth in the New Jersey Administrative Code (N.J.A.C.) Rules on Coastal Zone Management (N.J.A.C. 7:7, 7:7E, dated July 18, 1996 and addenda to 7:7E-5 and 7:7E-8.7, dated August 19, 1996). The NJDEP administers the coastal permit program through the Coastal Area Facility Review Act (CAFRA) (New Jersey State Act [N.J.S.A.] 13:19-1 *et seq*.), the Wetlands Act of 1970 (N.J.S.A. 13:9A-1 *et seq*.), and the Waterfront Development Law

(N.J.S.A. 12:5-3). Each of these acts provides a slightly different definition of the coastal zone; therefore, the designated coastal zone consists of the cumulative total of these three definitions.

The Woodbridge River Project Area is located outside the CAFRA coastal zone boundary. However, the Wetlands Act of 1970 defines the coastal zone as all tidally influenced wetlands and the Waterfront Development Law designates the coastal zone as any tidal waterway within the coastal area up to and including the high water line. Based on these definitions, the entire Project Area is located within the designated coastal zone. A coastal zone determination will be required and coordination with NJDEP will be necessary to ensure the project conforms with the policies establish in the NJ Administrative Code Rules.

5.8 Cultural Resources

A cultural resources baseline report was prepared to preliminarily determine the potential of significant cultural resource. Based on the preliminary investigation, the currently proposed project is not anticipated to affect any prehistoric or historic cultural resources in the project area. Had the study proved economically justified and the project moved forward, the District would conduct a full inventory of cultural and historic resources within the project area in accordance with the National Historic Preservation Act of 1966 as amended, and the New Jersey State Historic Preservation Act, and would coordinate the findings with the New Jersey Historic Preservation Office. The Baseline Report is located in Appendix G of the report.

5.9 Hazardous, Toxic and Radioactive Waste (HTRW)

HTRW are defined as any "hazardous substance" regulated under Comprehensive, Environmental Response, Compensation, Liability Act (CERCLA), 42 U.S.C. 9601 et seq, including "hazardous wastes" under Section 3001 of the Resource Conservation and Recovery Act (RCRA), 42 U. S. C. 6921 et seq. Hazardous materials may be present within the Study area as a result of past land uses. A wire plating/pickling plan was reportedly located near the headwaters to Woodbridge River and may have discharged wastes until 1960. The Town of Woodbridge hired a consultant in 1991 to conduct sediment sampling in various locations of the river as part of their investigation into the feasibility of dredging the river. The findings indicated potentially high amounts petroleum hydrocarbons/oil and grease that create a disposal problem. Additional wastes from both industrial and commercial sources may be located throughout the Study area.

A complete Phase 1 assessment of the project area and any potential mitigation sites would be required to determine the presence of any HTRW. The Phase 1 assessment consists of a review of regulatory databases, on-site inspection of the properties comprising the project area. A Phase II assessment, which includes taking and analyzing samples, may be initiated contingent upon the results of the Phase 1 investigation. All HTRW investigations would be conducted in accordance with ER 1165-2-132 (Hazardous, Toxic and Radioactive Waste Guidance for Civil Works, 26 June 1992)

5.10 Air Quality

As required by the Clean Air Act of 1970 (CAA), National Ambient Air Quality Standards (NAAQS) have been established by the U.S. Environmental Protection Agency (USEPA) for

carbon monoxide (CO), nitrogen oxides (NOx), ozone, particulates (PM10 and PM2.5), sulfur oxides and lead, outlining maximum levels of pollutants and exposure periods that pose no significant threat to human health or welfare. Primary standards are intended to protect public health, while secondary standards are intended to protect public welfare (physical damage to structures, ecological damage). Areas are designated as "attainment" or "non-attainment" for a given pollutant, based on whether levels comply (attainment) or not (non-attainment) with NAAQS.

Section 176(c) of the Federal Clean Air Act (CAA) prohibits Federal entities from taking actions in non-attainment or maintenance areas that would jeopardize the attainment of NAAQS or otherwise do not conform to the State Implementation Plan (SIP) for the attainment and maintenance of NAAQS. The CAA delegates the responsibility to each state to achieve and maintain the NAAQS. Projects under the Corps' Civil Works Program are governed by the General Conformity regulations (49 CFR Parts 6, 51, and 93) of the CAA and are described in *Determining Conformity of Federal Actions to State or Federal Implementation Plans (40 CFR Part 93).*

Middlesex County is located in the New York–Northern New Jersey–Connecticut Air Quality Control Region. Based on the National Ambient Air Quality Standards (NAAQS) six primary pollutants, Middlesex is designated as a moderate non-attainment area for ozone and non-attainment for PM2.5 and an attainment area for carbon monoxide, sulfur dioxide, respirable particulate matter (PM10), lead, and nitrogen dioxide (USEPA 1997).

A preliminary air quality analysis will be performed in the Feasibility Phase to determine conformity with the Clean Air Act. Since the analysis is dependent upon having a detailed breakdown of equipment type, size and quantity, a more comprehensive analysis will be required during the Plans and Specifications Phase. Depending if the preliminary total direct and indirect projectemissions are below or above the de minimis levels established for NOx and PM2.5, a Draft Record of Non-Applicability or Statement of Conformity will be prepared. Total direct and indirect emissions exceeding the established de minimis levels require the preparation of a Draft Statement of Conformity and an Emissions Reduction Strategy Report that outlines mitigation alternatives, such as emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions.

5.11 Socioeconomics

How the project impacts socioeconomic conditions such as employment distribution, population distribution and quality of community life would be assessed during plan evaluation for both the flood damage reduction and ecosystem restoration components of the project. Included in the evaluation would be environmental justice, which prevents adverse significant impacts from occurring in a disproportionate manner to minority or low-income groups.

5.12 Cumulative Impacts

Cumulative impacts refer to one or more individual impacts which, when considered together, are considerable or which compound or increase the other's impacts. The cumulative impact from several projects is the change in the environment that results from the incremental impact of the selected plan when added to other closely related past, present, or reasonably foreseeable

future projects. An investigation of other Corps or non-Corps projects occurring within the project area would need to be conducted to assess cumulative impacts.

5.13 Clean Water Act Section 404(b)(1) Guidelines Evaluation

Section 404(r) of the Clean Water Act requires Federal agencies proposing to discharge dredge or fill material as part of a construction project to include consideration of the guidelines outlined in 404(b)(1) in the NEPA document. These guidelines were developed by the Environmental Protection Agency to ensure such activities would not cause adverse impacts to water quality and ecosystem parameters. Should the project move forward, a Section 404(b)(1) Evaluation will be developed and appended to the report.

6. COORDINATION

NEPA requires coordination with the public, local, state and Federal agencies throughout the study process. In accordance with NEPA, the District has performed initial outreach to Federal and state agencies and the public by publishing a Notice of Intent to Prepare an Environmental Impact Statement in the Federal Register in June 2003 and by holding a Scoping Meeting in September 2003. As part of the Scoping Meeting, the District prepared a Scoping Document that underwent a 30-day public review period. Subsequent of the Scoping Meeting, a Response to Comments Document summarizing questions and comments that were given at the meeting were received during the public review period was prepared and made available to the public.

Further coordination was conducted with resource agencies and local interests through preparation of this report. This included the public review of the Draft Feasibility Report in August 2006. If at a future date a project were to move forward, coordination with the appropriate regulatory agencies and interested individuals and organization would be reinitiated.

7. PERMITS, APPROVALS AND REGULATORY REQUIREMENTS

The following is a list of potential Federal and State environmental quality statutes where compliance must be achieved should the project move forward.

Permits and Approvals	Agency	Action
Federal		
Clean Water Act of 1977, as amended	NJDEP,	Water Quality Certificate under Section 401
Coastal Zone Management Act of 1972, as amended	NOAA, NJDEP	Provide a Coastal Consistency Certification for the Project.
Endangered Species Act of 1973, as amended	USFWS, NMFS	Consult on Federal listed threatened and endangered species (letter to USFWS).
Marine Mammal Protection Act of 1972, as amended	USFWS, NMFS	Review of, and comments on, the Project to determine impacts to marine mammals (letter to NMFS).
Fish and Wildlife Coordination Act, as amended	USFWS, NMFS, USACE	Consult on wildlife resources and conservation practices (request PAL and 2(b) report.
National Historic Preservation Act of 1966, as amended	NJHPO (NJDEP)	Per Section 106, review of, and comment on, the Project to determine effects on cultural resources that are listed in, or eligible for listing in, the NRHP (letter to NJHPO).
Executive Order 11988, Floodplain Management	USACE	Evaluate the potential effects of the Project with regard to floodplains.
Executive Order 11990, Protection of Wetlands	USACE	Evaluate the potential effects of the Project with regard to wetlands.
Farmland Protection Policy Act of 1981, as amended	NRCS	Analysis of impacts of the Project on prime and unique farmland.
Water Resources Planning Act of 1965, as amended	USACE	Assessment of impacts of the Project on water resources, and related land resources.

Wild and Scenic Rivers Act, as amended	USDI (NPS), USDA (USFS)	Analysis to determine impacts of the Project on specific river reaches or areas that are classified as "wild, scenic, or recreational."
Estuary Protection Act, as amended	USEPA, NMFS	Evaluate the impacts of the Project on estuarine areas.
Archeological and Historic Preservation Act of 1974, as amended	NJHPO (NJDEP)	Evaluation of the impacts of the Project on archaeological and historical resources.
Rivers and Harbors Appropriation Act of 1899, as amended	USACE	Evaluate the impacts of the Project on navigable waters.
National Environmental Policy Act of 1969, as amended	USACE (Lead Agency)	Evaluation of the impacts of the Project on a broad range of environmental resources.
Hazardous, Toxic and Radioactive Waste Guidance	USACE	Guidelines for managing hazardous wastes associated with the Project.
Magnuson-Stevens Fishery Conservation and Management Act of 1990	NMFS	Evaluate the impacts of the Project on anadromous fish species or fishery resources (letter to NMFS).
Safe Drinking Water Act	USEPA	Evaluate compliance of the Project on public drinking water supplies, including surface waters and groundwater.
State and Local		
New Jersey Department of Environmental Protection Rules and Regulations – RTE	NJDEP	Consult on state and Federal listed threatened and endangered species.
New Jersey Department of Environmental Protection Rules and Regulations – Stream Encroachment		Evaluation of the effects of the Project on streams.
New Jersey Department of Environmental Protection Rules and Regulations – Freshwater Wetlands Permit		Evaluation of the effects of the Project on freshwater wetlands.

New Jersey Department of Environmental Protection Rules and Regulations – Tidal Wetlands Permit		Evaluation of the effects of the Project on tidal wetlands
New Jersey Department of Environmental Protection Rules and Regulations – Waterfront Development Permit		Evaluation of the effects of the Project on waterfront areas.
Review under State Historic Preservation Act (SHPA)	NJHPO (NJDEP)	Review to determine effects on properties listed in, or eligible for listing in, the NRHP (letter to NRHP).
Permit under the State Pollutant Discharge Elimination System (SPDES)	NJDEP	Evaluation of the effects of the Project on discharges to water bodies.
Permit for Coastal Erosion Hazard Areas	NJDEP	Evaluation of the effects of the Project on coastal erosion hazard areas.
Water Quality Certification	NJDEP	Evaluation of the effects of the Project on water quality.
Soil Erosion and Sediment Control Plan	Union County	Plan for the control of soil erosion and sediments.

8. PLAN IMPLEMENTATION

This section, Section 8 – Plan Implementation, should not be construed as an intent to study further or design / construct a project as this report identified no economically justified plan and does not recommend moving forward. It is included for informative purposes pertaining to design / construction phases.

Had this study recommended an economically justified plan and funds were appropriated for the design, as the non-Federal project partner, NJDEP would have to sign a Design Agreement that would carry the project through the Project Engineering and Design (PED) phase, which includes development of Plans and Specifications (P&S). The PED phase would be followed by project construction. Funds must be budgeted by the Federal Government and the non-Federal partner to support these activities. A Project Management Plan (PMP) would be prepared to identify tasks, responsibilities, and financial requirements of the Federal Government and the non-Federal partner during PED. A project schedule would be established based on reasonable assumptions for the design and construction schedules.

8.1 General

Following Congressional authorization, the project would be eligible for construction appropriation funding. The project would be considered for inclusion in the president's budget on the basis of national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal partner to fund its share of the project cost, and budgetary constraints that may exist at the time of funding.

8.2 Local Cooperation

In accordance with Section 105 (a)(l) of WRDA 1986, the Woodbridge River Basin Feasibility Study was cost shared 50 percent between the Federal Government and the State of New Jersey. The fact that funds were contributed by the non-Federal project partner, NJDEP, indicates their intent to support a study for flood damage reduction in the Woodbridge River Basin, New Jersey.

A fully coordinated Design Agreement (DA) package, which would include the non-Federal partner's financing plan, would have to be prepared subsequent to the approval of the feasibility phase. It would reflect the recommendations of the Feasibility Study. The non-Federal partner, NJDEP, has indicated it does not support construction of a project due to lack of a justified NED plan.

Should the project be authorized for design and construction in the future, as the non-Federal project partner, NJDEP must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

- Provide all lands, easements, rights-of-way, and relocations and disposal/borrow areas (LERRD) uncontaminated with hazardous and toxic wastes.

- If the value of the sponsor's LERRD contributions, plus the 5 percent minimum cash contribution, do not equal at least 35 percent of the total project cost, then the sponsor is required to provide an additional cash contribution necessary to equal a total of 35

percent. The sponsor is required to pay the additional cash contributions during construction at a rate proportional to Federal expenditures. If the value of the sponsor's LERRD contributions, plus the 5 percent minimum cash contribution, exceeds 35 percent of the total project cost, then the Federal contribution is reduced accordingly. If the value of the sponsor's LERRD contributions, plus the 5 percent minimum cash contribution, exceeds 50 percent of the total project cost, the project is cost shared at 50 percent Federal, 50 percent non-Federal cost.

- Provide of all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project.

- For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

- Provide of the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the Project for the purpose of inspection, and, if necessary after failure to perform by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal project partner of responsibility to meet the non-Federal project partner 's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

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

- Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project 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 Codes of Federal regulations (CFR) Section 33.20.

- Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject

to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government; provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.

- Assume complete financial responsibility, as between the Federal Government and the non-Federal project partner for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

- As between the Federal Government and the non-Federal project partner, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA.

- Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and Unifom1 Relocation Assistance Act of 1987 (Public Law 100-17),and the Unifom1 Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

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

- Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement.

- Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with the requirements in Section 402 of the Water Resources Development Act of 1986, as amended.

- Not less than once each year inform affected interests of the extent of protection afforded by the Project.

- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to

prevent unwise future development and to ensure compatibility with the protection provided by the project.

- Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

- Enter into an agreement, which provides, prior to construction, 35 percent of preconstruction, engineering and design costs for flood damage reduction features.

- Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

- Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the non-Federal project partner owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing or rehabilitating the project.

- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.

- Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project.

- Perform, or cause to be performed, 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 necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

- Participate in and comply with applicable Federal floodplain management and flood insurance programs.

- Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

9. PERTINENT CORRESPONDENCE & PUBLIC INVOLVEMENT

Public involvement and citizen participation are an integral part of this feasibility study. Coordination by the Army Corps of Engineers and the New Jersey Department of Environmental Protection with the local sponsor, municipalities adjacent to the study area, other agencies, and interested parties has occurred on a regular basis since the beginning of the study.

Meetings with officials and residents of Woodbridge Township and other interested parties were conducted in groups and on an individual basis. The purpose of carrying out coordination with officials, citizens and other interested parties is to ensure that the study addresses all pertinent questions from the public, is of the highest quality, and ultimately meets the needs of the people it will serve. The table below summarizes the significant meetings where a municipality, group, or agency was briefed on the study.

Numerous meetings and coordination activities were conducted to gather data, conduct field studies, and notify property owners in the study area of the work being conducted. The contacts and meetings for data gathering and coordination are too numerous to mention herein, but are summarized in the next paragraphs.

Coordination with environmental and cultural resource agencies is also documented in environmental sections in the Main Report.

Coordination relating to the real estate activities that has been conducted is presented in the Real Estate Appendix.

Besides the coordination with Woodbridge Township and municipalities adjacent to the study area, contacts with various Federal, State, and local agencies were also made. They include the New Jersey Geological Survey, the United States Geological Survey, the New Jersey Turnpike Authority, Middlesex County and others. Coordination with elected representatives at the Federal, State, and local level has also been integral to the process.

Correspondence relating to general requests for information, questions, letters of invitation, technical, environmental, cultural, real estate rights-of-entry, permits and other matters are too numerous to be present here.

During the public review of this draft feasibility report the public, agencies, and all interested parties were asked to comment on the report. The sole received comment, the "Najarian Report", is included in this final feasibility report as a part of the public record. Responses have been provided where appropriate.

Following is the NJDEP letter of concurrence with the recommendation of no economically justifiable plan by Corps authorities, dated March 3, 2006, and a follow up letter dated December 29, 2006.

Table 9-1
Briefing/Coordination Meetings with Study Area Municipalities, Public, and Interested Parties

DATE	AGENCY (S) / GROUP (S) / ORGANIZATION (S)	PURPOSE	LOCATION
24-Jan-2003	USACE	Site Visit to project areas for observation and insight	Woodbridge Township
4-March-2003	NJDEP USACE Woodbridge Township Woodbridge Township Mayor	P-6 Initial Feasibility Coordination Meeting Project briefing, status and schedule	Woodbridge Township Town Hall
14-May-2003	NJDEP USACE Woodbridge Township Woodbridge Township Mayor	Update on project, discussion of issues and clarification of deliverables	Woodbridge Township Town Hall
14-Aug-2003	NJDEP USACE Woodbridge Township Woodbridge Township Mayor	Pre-Scoping Meeting Discussion of study plan details including progress, planning, environmental, schedule and budget	Woodbridge Township Town Hall
14-Aug-2003	NEA NJDEP USACE USFWS Woodbridge Township	Site Visit to project areas for observation and insight	Woodbridge Township
23-Sept-2003	NJDEP USACE Woodbridge Township Woodbridge Township Mayor	Scoping Meeting	Woodbridge Township Town Hall

Table 9-1
Briefing/Coordination Meetings with Study Area Municipalities, Public, and Interested Parties

DATE	AGENCY (S) / GROUP (S) / ORGANIZATION (S)	PURPOSE	LOCATION
3-Feb-2004	NJDEP USACE Woodbridge Township Mayor Woodbridge Township	Discussion of study plan details including engineering, costs and feasibility of design	Woodbridge Township Town Hall
4-August-2004	NJDEP Office of Congressman Menendez USACE Woodbridge Township Mayor Woodbridge Township	Discussion of study plan details including engineering, environmental, costs, schedule and feasibility of design	Woodbridge Township Town Hall
9-Jan-2006	Congressman Ferguson Office of Congressman Ferguson State Senator Smith Office of State Senator Smith NJDEP USACE Woodbridge Township Mayor Woodbridge Township The Public	Present results of Feasibility Study to officials and public and discuss future options for Woodbridge Township. Note that report identifies no economically justifiable plan	The Cameo
5-Jul-2007	NJDEP USACE Woodbridge Township Mayor Woodbridge Township Najarian Associates	Present results of Feasibility Study to officials of Woodbridge Township. Note that report identifies no economically justifiable plan. Discuss plan submitted by Woodbridge Township	Woodbridge Township Town Hall

CORRESPONDENCE

CENAN-PL-F 23 August 2007

MEMORANDUM FOR THE RECORD

SUBJECT: Woodbridge New Jersey, Flood Control and Ecosystem Restoration Study

1. On 9 July 2007, a draft copy of the economic appendix for Woodbridge New Jersey, Flood Control and Ecosystem Restoration Study was submitted to Mr. Joe DiLorenzo of Najarian Associates for review.

2. On 25 July 2007, Mr. Joe DiLorenzo responded by e-mail to Mr. Johnny Chan to indicate that the economic analysis shown in the appendix addressed his major concerns specifically that additional automobile damages and lower levee heights should be examined in the cost benefit analysis.

3. On 30 July 2007, Mr. Chan telephoned Mr. DiLorenzo to inquire if he had any additional comments and he indicated that he had no further comments, but would like to see the Corps determination for levee heights in the report.

4. On 17 August, Mr. Chan e-mailed Mr. Dilorenzo the following explanation for the Corps reasoning for the levee design height, which will be shown in the final report:

For Alternative 6A, the elevation of 11 feet NGVD for the levee/tide gate structure would only protect up to a 25-year storm event (Corps stage frequency curve). This was the reason behind this conclusion:

The Corps of Engineers determination of return period of protection includes stage elevation from storms of a given return period at a time 50-years into the future plus some level of risk and uncertainty. The Corps of Engineers determination of return period of protection includes stage elevation from storms of a given return period plus some level of risk and uncertainty. For instance, the design elevation for a 25-yr return period event would not be less than the 25-yr stage of 9.3 ft. NGVD, plus 1.7 ft to account for statistical uncertainties in the stage, wind, wave effects, and errors in modeling: or 11.0 ft. NGVD.

Prepared by:

Johnny Chan
Project Economist

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION

JON S. CORZINE
Governor

Natural and Historic Resources
Office of Engineering & Construction

LISA P. JACKSON
Commissioner

AUG 15 2007

Mr. Paul Tumminello
Department of the Army
New York District, Corps of Engineers
Jacob K. Javits Federal Building
26 Federal Plaza
New York, NY 10278

The Department of Environmental Protection has completed our review of the U.S. Army Corps of Engineers Woodbridge River Flood Protection and Environmental Restoration Feasibility Study.

The Department does recognize that flooding along the Woodbridge River is a recurring problem. We also agree with the conclusion as presented in the Feasibility Study that there is no economically viable structural or non-structural solution. This includes the conceptual design for a downsized Woodbridge River tidal dam as proposed by the Township's engineering consultant.

Subsequent to our July 5, 2007 meeting in Woodbridge, it our understanding that the Corps has completed follow-up coordination with the Township's engineering consultant and they are satisfied with the results. Since there is no Federal interest in flood damage reduction along the Woodbridge River, we recommend that the final report be released and the study be closed.

If you have any questions or concerns pertaining to this Feasibility Study please call Charles Defendorf, P.E. at 609-292-2296.

Sincerely,

John H. Moyle, P.E.
Manager
Bureau of Dam Safety and Flood Control

c: Mayor John McCormac , Woodbridge Twp.

E-Mail Address: DamSafety@dep.state.nj.us
Internet Address: www.state.nj.us/dep/damsafety
Mailing Address: 501 East State Street, P.O. Box 419, Trenton, NJ 08625
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State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Natural and Historic Resources
Office of Engineering & Construction

JON S. CORZINE
Governor

LISA P. JACKSON
Commissioner

DEC 2 9 2006

Mr. Paul Tumminello, P.E.
Department of the Army
Corps of Engineers, New York District
Jacob K. Javits Federal Building
26 Federal Plaza
New York, N. Y. 10278

Dear Mr. Tumminello:

This letter addresses our review comments on the conceptual design for a downsized Woodbridge River tidal dam as proposed by Nagarian Associates. As you know Nagarian Associates was retained by the Township to review the Corps of Engineers draft feasibility report for the Woodbridge River Flood Protection and Environmental Restoration.

The proposed downsized structure clearly lowers the cost of the structure but will also effect the benefit component of the Benefit Cost analysis. We recommend that this additional alternative warrants an internal Corps of Engineers review.

It should also be noted that dams in the State of New Jersey are regulated by this Bureau and must meet all appropriate State standards.

If you wish to discuss this further, please contact me or Charles Defendorf of my staff.

Sincerely,

John H. Moyle

John H. Moyle, P.E.
Manager
Bureau of Dam Safety and Flood Control

E-Mail Address: DamSafety@dep.state.nj.us
Internet Address: www.state.nj.us/dep/damsafety
Mailing Address: 501 East State Street, P.O. Box 419, Trenton, NJ 08625

Najarian Associates

Engineers • Planners • Scientists • Surveyors

VIA FEDERAL EXPRESS

October 19, 2006
Job No. 6391

Mr. Paul Tumminello, P.E.
U.S. Army Corps of Engineers, New York District
26 Federal Plaza, Room 2127
New York, NY 10278-0090

Re: Woodbridge River Basin, NJ
Flood Protection and Ecosystem Restoration Study
Benefit/Cost Analysis for Modified Alternative Plan 6

Dear Mr. Tumminello:

Najarian Associates was retained by Woodbridge Township to review the flood-reduction alternatives provided in the "*Woodbridge River Basin, New Jersey, Flood Damage Reduction and Ecosystem Restoration Draft Feasibility Report*" prepared by your office. Our review was completed in February, 2006 and documented in a report entitled "*Review of Draft Feasibility Report: Woodbridge River Basin, New Jersey, Flood Damage Reduction and Ecosystem Restoration*" *New York District, U.S. Army Corps of Engineers (November 2005).*" Our review states that Alternative Plan 6 is the most attractive alternative offered by the Army Corps – but that this alternative may be enhanced with a more cost-efficient levee design. The levee proposed by the USACE would be 924 feet long and would connect to ground at elevation 12 feet NGVD-1929. Based on available information, we proposed a much shorter levee system (approximately 280 feet long) that would tie into ground at elevation 11 feet NGVD-1929. A concept plan for such a levee system, and a copy of our report, was forwarded to your office on September 8, 2006 (additional copies enclosed). As described on page 14 of our report, a levee system designed to elevation 11 feet NGVD-1929 would provide adequate flood protection -- about one foot of additional freeboard above the 100-year design storm elevation documented in referenced flood study reports prepared for both FEMA and New York City. Moreover, the modified levee system would be designed to traverse primarily Township-owned property and would minimize interference with adjacent properties, infrastructure and water resources.

One Industrial Way West, Eatontown, New Jersey
(732) 389-0220 ⋆ Facsimile No. (732) 389-8546

The proposed reduction in the scale of the levee system would reduce construction costs for the project. Using the same unit costs provided in your spreadsheet analysis for Alternative Plan 6 (i.e., Table 6 of the Technical Appendix to the Feasibility Report), we estimate that the total project first cost would be reduced from approximately 2.74 million dollars to 2.05 million dollars (about a 25% reduction). We also estimate that this translates to a reduction in the total annual cost for Alternative Plan 6 from $199,484 to approximately $150,000. If one assumes the same annual benefits ($164,619 for 2-ft main floor elevations), *then the proposed modified alternative would increase the benefit-to-cost ratio to 1.1 which exceeds the Corps' minimum threshold value (1.0)*. Note that this is a reasonable assumption since both the original Alternative Plan 6, and our modified Plan 6, would protect to the documented 100-year FEMA flood elevation (9.7 ft NGVD-1929) and provide additional freeboard.

In addition, it appears that the benefit-to-cost ratios calculated in the Corps' feasibility report do not adequately consider the potentially high replacement costs for flood-damaged automobiles. Such damages may be unavoidable when storms intensify during the night -- as was the case for the December-1992 nor'easter. The Army Corps' present assessment includes an "other" category to account for outdoor flood damages to lawns, outbuildings, automobiles, flood flight, evacuation/reoccupation, lost income, extra housing, clean-up costs, etc. For a flood that reaches the main floor elevation, the total "other" costs are estimated as 7.2% of the replacement value for the Crampton Avenue neighborhood homes, and only 11.9% ($2,616) of the assumed replacement value for the manufactured homes ($21,900) (Table 4, Appendix E of USACE 2005b). Our analyses suggest that about half of the Ideal Mobile Home Park was inundated during this storm, causing damages that likely exceeded the estimated "other" costs.

We discussed such issues with Mr. John Chan from your office, and I requested that the Army Corps evaluate costs associated with the proposed modified alternative. Mr. Chan recommended that I write to you in this regard. Also, Mr. Chan suggested that we obtain data regarding flood damage to automobiles during the 1992 nor'easter. Presently, we are working with the Township to obtain such data, and we are fine-tuning our design for the modified alternative plan. Accordingly, we request that you re-evaluate the benefit-to-cost ratio for our present modified Plan 6, and as such information (and fine tuning) becomes available.

Mr. Paul Tumminello, P.E.
October 19, 2006
Page 3

If you have any questions regarding our assessment, please call me at your earliest convenience. Thank you again for your interest in this project.

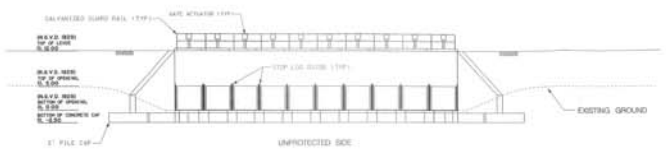
Very truly yours,
NAJARIAN ASSOCIATES

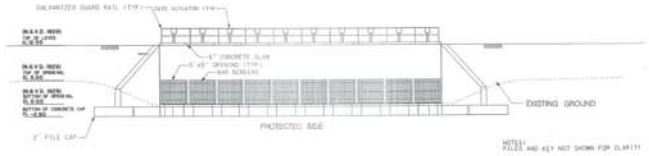
Joseph L. DiLorenzo, Ph.D.
Senior Scientist

w/enclosures
cc: Mr. John Chan, (USACE)
Mr. Robert Kuhne, P.E.
Mr. Robert Landolfi (Woodbridge Township)
Ms. Donna Jago (Woodbridge Township)
Mr. Scott Thompson, P.E. (Woodbridge Township)
Interim Mayor Joseph F. Vitale
Congressman Michael Ferguson (District NJ#7)
Mr. John Moyle (NJDEP)

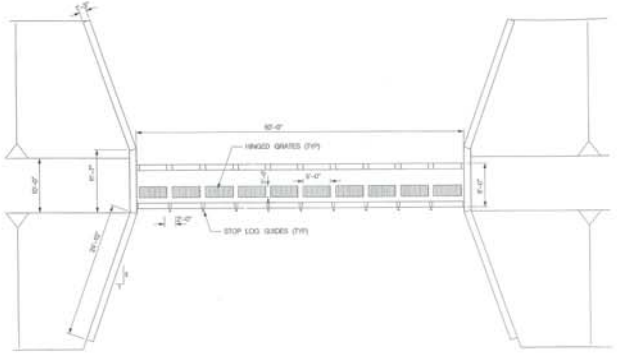
10/19/2006 10:45:00 AM--Y:\6391\letter\Paul Tumminello letter.doc


NEW JERSEY TURNPIKE
WOODBRIDGE RIVER
BLOCK 704 LOT 100
BLOCK 697 B
EAST SUMMIT AVENUE
BLOCK 703
SCOTT PLACE
BLOCK 709 A
BLOCK 709
AUSTIN STREET
BRIDGE STREET
WOODBRIDGE AVENUE
NOTES:
ELEVATIONS REFERENCED TO NAVD-1988 (ADD 1.0' TO CONVERT TO NGVD - 1929)
AERIAL PHOTOGRAPH TAKEN FROM NJDEP OFFICE OF GEOGRAPHIC INFORMATION SYSTEMS, 2002 ORTHOPHOTO FILES.
TOPOGRAPHIC MAP PREPARED BY ATLANTIS SURVEY CO., INC. AND DATED 5-25-95.
EXISTING GROUND ELEVATIONS, UTILITY LOCATIONS AND PROPERTY LIMITS MUST BE FIELD VERIFIED BY SURVEY CREW PRIOR TO FINAL PLAN.
REVISIONS
CONCEPT PLAN
WOODBRIDGE RIVER FLOOD CONTROL FEASIBILITY STUDY
WOODBRIDGE TOWNSHIP
MIDDLESEX COUNTY, NEW JERSEY
ROBERT B. KUHNE
Najarian Associates

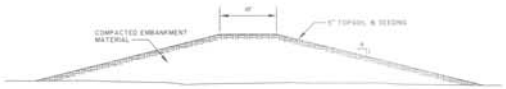




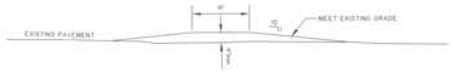
TIDE GATE ELEVATION



TIDE GATE PLAN



TYPICAL SECTION - LEVEE



TYPICAL SECTION - HMA PAVEMENT HUMP

NOTE:

TIDE GATE PLAN/ELEVATION SHOWN HEREON TAKEN FROM "WOODBRIDGE RIVER BASIN, NEW JERSEY FLOOD DAMAGE REDUCTION AND ECOSYSTEM RESTORATION - DRAFT FEASIBILITY REPORT" DATED: NOVEMBER 2005, PREPARED BY U.S.ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT.

NO.	DATE	DESCRIPTION	BY

REVISIONS

DETAILS

WOODBRIDGE RIVER FLOOD CONTROL
FEASIBILITY STUDY
WOODBRIDGE TOWNSHIP
MIDDLESEX COUNTY, NEW JERSEY

ROBERT B. KUHNE
N.J. PROFESSIONAL ENGINEER No. 41367

Najarian Associates

DESIGNED	DRAWN BY	SCALE	DATE	DRAWING NO.	SHEET NO.
	JT	N.T.S.	8/2/06	6391	2 of 2

Township of Woodbridge Joseph F. Vitale, Interim Mayor

Department of Public Works
Division of Engineering

One Main Street
Woodbridge, New Jersey 07095
www.twp.woodbridge.nj.us
Tel: (732) 602-6047
Fax: (732) 602-6048

September 13, 2006

Najarian Associates
One Industrial Way West
Eatontown, New Jersey 07724

Re: Draft Concept Plan
Woodbridge River Flood-Control Structures
Township of Woodbridge, New Jersey
(Your job number 6391)

Attn: Joseph L. DiLorenzo, Ph.D.
Senior Scientist

Dear Mr. DiLorenzo:

I am writing in response to your letter to Gayle Marchetti dated September 8, 2006 on the referenced project. I have reviewed the two-sheet Concept Plan prepared by your office on August 2, 2006. Based upon my review, the plan appears to offer an acceptable, more cost effective alternative to the plan identified as Alternative 6 in the Army Corps of Engineer's Flood Damage Reduction and Ecosystem Restoration Draft Feasibility Report dated July, 2006.

If you have any questions or if you would like to discuss this matter at greater length, please do not hesitate to contact me.

Very truly yours,

Scott Lee Thompson, PE
Municipal Engineer

C: Interim Mayor Joseph F. Vitale
Robert Landolfi, Business Administrator
Donna Jago, Chief of Staff
Dennis Henry, Director of Public Works
Paul Tumminello, U.S. Army Corps of Engineers, New York District, 26 Federal Plaza, Room 2127, New York, NY 10278

Woodbridge - A Township United

Najarian Associates

Engineers • Planners • Scientists • Surveyors

September 8, 2006

VIA FEDERAL EXPRESS

Ms. Gayle Marchettti
Township of Woodbridge
One Main Street
Woodbridge, New Jersey 07095

Re: Draft Concept Plan
Woodbridge River Flood-Control Structures
Township of Woodbridge, New Jersey
Our Job No. 6391

Dear Ms. Marchetti:

In accordance with his instructions, please forward immediately the enclosed set of draft engineering concept plans to Mr. Robert Landolfi. These plans describe our alternative conceptual design for flood-control structures along the Woodbridge River. As described on page 14 of our report (dated February 2006), the proposed alternative structures would tie into the ground at elevation 10 ft NAVD-1988 (11 ft NGVD-1929) and provide about one foot of freeboard above the documented 100-year storm elevation.

Our proposed flood-control structures include essentially the same tide gate designed by the U.S. Army Corps of Engineers. However, our modified design includes levees that extend approximately 280 linear feet -- considerably shorter than the 924-foot-long levees proposed by the Army Corps in their Alternative 6 design. Thus, our design would reduce project costs. We are in the process of estimating a benefit-to-cost ratio for the proposed modified design based on unit costs provided in the Army Corps' report. However, are we waiting for the Army Corps to inform us whether *flood damage to automobiles* was incorporated into their previous estimate.

If you have any questions regarding these plans, please call me or Mr. Robert Kuhne at your earliest convenience. Thank you again for your interest in our services.

Very truly yours,

Joseph L. DiLorenzo, Ph.D.
Senior Scientist

c.c. Mr. Robert Landolfi (Woodbridge Township)
Mr. Paul Tumminello, P.E. (U.S. Army Corps) w/ encl.
Ms. Donna Jago (Woodbridge Township)
Mr. Robert Kuhne, P.E.

9/8/2006 1:35:00 PM--Y:\6391\DOC\REV Concept Plan letter-Landolfi.doc

One Industrial Way West, Eatontown, New Jersey
*(732) 389-0220 * Facsimile No. (732) 389-8546*

Township of Woodbridge

One Main Street
Woodbridge, New Jersey 07095
www.twp.woodbridge.nj.us
Tel: (732) 634-4500

MEMO

TO: Paul Tumminello, USACE

FROM: Donna Jago, Chief of Staff

DATE: September 6, 2006

RE: Woodbridge River Basin Feasibility Study

Paul:

As per our conversation yesterday, enclosed please find the "Review" of the Draft Feasibility Report for the Woodbridge River Basin, New Jersey, Flood Control and Ecosystem Restoration Study. This review was compiled by our consultants, Najarian Associates.

Please incorporate this review as Woodbridge Township's comments and address them in your Final Feasibility Report.

If you have any questions, please feel free to contact me at (732) 602-6039.

I look forward to hearing from you.

With best wishes,

Donna Jago
Chief of Staff

encl

cy: Interim Mayor Joseph Vitale
Robert Landolfi, Business Administrator
Scott Thompson, Engineer
Joe DiLorenzo, Najarian Associates

Woodbridge—A Township United

Review of Draft Feasibility Report:

"*Woodbridge River Basin, New Jersey Flood Damage Reduction and Ecosystem Restoration*"
New York District, U.S. Army Corps of Engineers (November 2005)

Reviewed by:
Najarian Associates
1 Industrial Way West
Eatontown, New Jersey 07724

February, 2006

Najarian Associates

Engineers • Planners • Scientists • Surveyors

TABLE OF CONTENTS

LIST OF FIGURES

Page

1.0 INTRODUCTION

1.1 Background

On May 6, 1998, the U.S. Congress authorized the U.S. Army Corps of Engineers' (USACE) Woodbridge River Basin, New Jersey, Flood Control and Environmental Restoration Feasibility Study. Subsequently, The USACE conducted a reconnaissance study of the Woodbridge River Basin (the "Basin"), and identified at least two project areas that would be in the federal interest (i.e., the Crampton Avenue neighborhood and Ideal Mobile Home Park). Also, they recommended investigating four flood damage reduction alternatives: voluntary flood-proofing, raising-in-place, floodplain evacuation and floodplain management measures. Based on these recommendations, the USACE and the New Jersey Department of Environmental Protection (NJDEP) agreed to conduct a cost-shared feasibility study of the Basin. Recently, a draft feasibility report of this study (USACE 2005a), and Technical Appendices (USACE, 2005b), were released to Woodbridge Township for their review. The draft report concluded that none of the flood-damage-reduction alternatives considered in the feasibility study have a net benefit, and that there is no federal interest in pursuing such plans.

On November 29, 2005, the Township retained Najarian Associates to: (1) review the flood-reduction alternatives proposed in the USACE report; and (2) to investigate alternate funding sources for flood mitigation projects. This report summarizes our review of the USACE's report; we will submit a separate letter report to review potential funding sources.

Previously, Najarian Associates conducted a field and model study of tides and salt intrusion in the Woodbridge River system (Najarian Associates, 2001). The goal of this study was to provide tidal information needed to restore the River's Cove Creek marsh located between the Crampton Avenue Neighborhood and the Ideal Mobile Home Park (Figure 1). While this study did not focus on flooding issues, it provides valuable background information for reviewing the USACE's feasibility study. Accordingly, a brief summary of this background information is provided in sections 1.2, 1.3 and 1.4. A review of the USACE's proposed flood-reduction alternatives follows in chapter 2. Chapter 3 provides recommendations for flood mitigation projects.

1.2 Topographic Survey Data

One of the limitations of the USACE's report is that many analyses are based on old topographic survey data collected primarily in March 1962 (e.g., page 14 and page 18 of USACE 2005b), and supplemented by recent (2002) aerial photography. Figures 2-4 display portions of a more recent (1995) aerial topographic survey of the study area used in the Cove Creek restoration project. These plans provide elevation contours in two-foot increments.

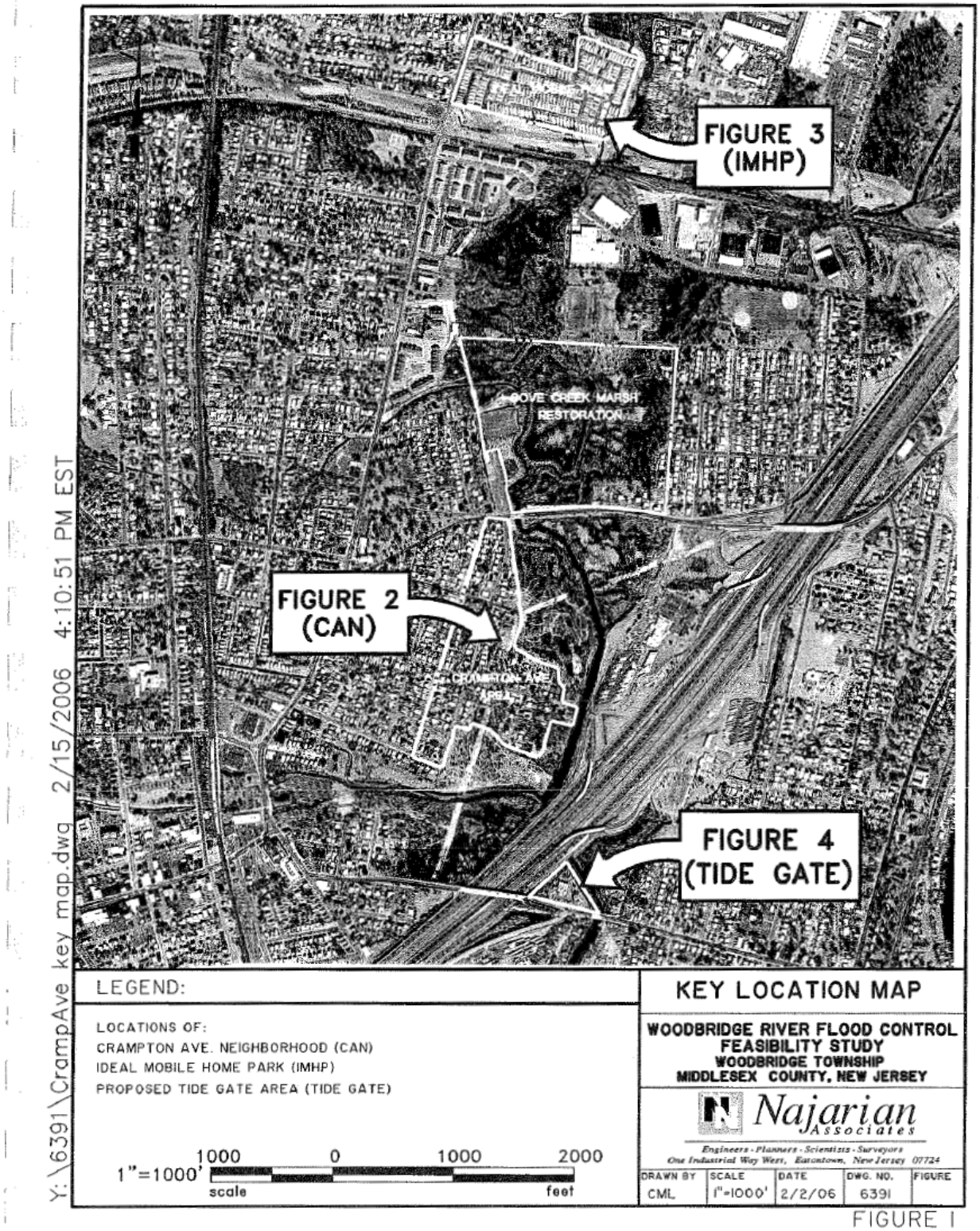


FIGURE 3
(IMHP)
FIGURE 2
(CAN)
FIGURE 4
(TIDE GATE)
COVE CREEK MARSH
RESTORATION
CRAMPTON AVE.
AREA
Y:\6391\CrampAve key map.dwg 2/15/2006 4:10:51 PM EST
LEGEND:
LOCATIONS OF:
CRAMPTON AVE. NEIGHBORHOOD (CAN)
IDEAL MOBILE HOME PARK (IMHP)
PROPOSED TIDE GATE AREA (TIDE GATE)
1"=1000'
1000 0 1000 2000
scale feet
KEY LOCATION MAP
WOODBRIDGE RIVER FLOOD CONTROL
FEASIBILITY STUDY
WOODBRIDGE TOWNSHIP
MIDDLESEX COUNTY, NEW JERSEY
Najarian Associates
Engineers - Planners - Scientists - Surveyors
One Industrial Way West, Eatontown, New Jersey 07724
DRAWN BY CML
SCALE 1"=1000'
DATE 2/2/06
DWG. NO. 6391
FIGURE

FIGURE 1

Note that ground elevations shown in Figures 2-4 are referenced to the modern NAVD-1988 vertical datum which lies approximately one foot above the former NGVD-1929 datum used in all of the USACE analyses. Thus, one foot must be added to the NAVD-1988 elevations shown in Figures 2-5 to convert these elevations to the NGVD-1929 elevations used by the USACE.

1.3 Tidal Observations

Another limitation of the USACE's report is that it provides limited information regarding actual (i.e., measured) flood elevations in the Woodbridge River. Figure 5a provides time histories of tidal elevations measured at four stations in the tidal Woodbridge River, as compiled in our previous study (Najarian Associates, 2001). Also shown are tidal elevations at Sandy Hook, New Jersey, as obtained from the National Oceanic and Atmospheric Administration (NOAA). Figure 6 displays corresponding River station locations. Figure 5a highlights the salient features of Woodbridge River tides, and captures effects of a storm event which occurred on January 3, 1999.

Woodbridge River tides are predominantly semi-diurnal, with two high tides and two low tides per lunar day (24.84 hrs). Tidal elevations at Sandy Hook (dashed line) are a good indicator of water levels at the mouth of the Woodbridge River (magenta line). As reported in the *NOAA Tide Tables*, the tidal height (amplitude) at the River entrance is approximately 1.11 times the height at Sandy Hook, and low tide at the River entrance lags low tide at the Hook by only 21 minutes.

The tidal bulge propagates rapidly through the Woodbridge River system, as evidenced by the nearly coincident high water elevations at stations 1, 2 and 3 (Figure 5a). While the observed high water elevations are nearly uniform throughout the River, the low water elevations increase progressively upstream. Falling tides at stations 2, 3 and 4 are truncated, as indicated by the flat troughs displayed in Figure 5a. This tidal asymmetry is due to upstream sills, pipe crossings and shoals in the river bed (Najarian Associates, 2001).

Effects of a storm event on Woodbridge River tides are seen by comparing tide (Figure 5a) and precipitation (Figure 5b) records. Note that a 3-inch rainfall event occurred (at Newark Airport) on January 3, 1999, and coastal sea levels rose approximately 2 feet in response to a coastal storm. As illustrated, peak flood elevations were nearly the same at all stations following this storm event. Nearly three days elapsed before water levels at stations 3 (just upstream of the Crampton Avenue Neighborhood) and station 4 (near the Ideal Mobile Home Park) returned to their pre-storm levels. These observations suggest that the *duration* of flooding impacts is an important consideration at these up-river stations. Upstream sills, pipe crossings and other constrictions likely delay falling tides following storm events.

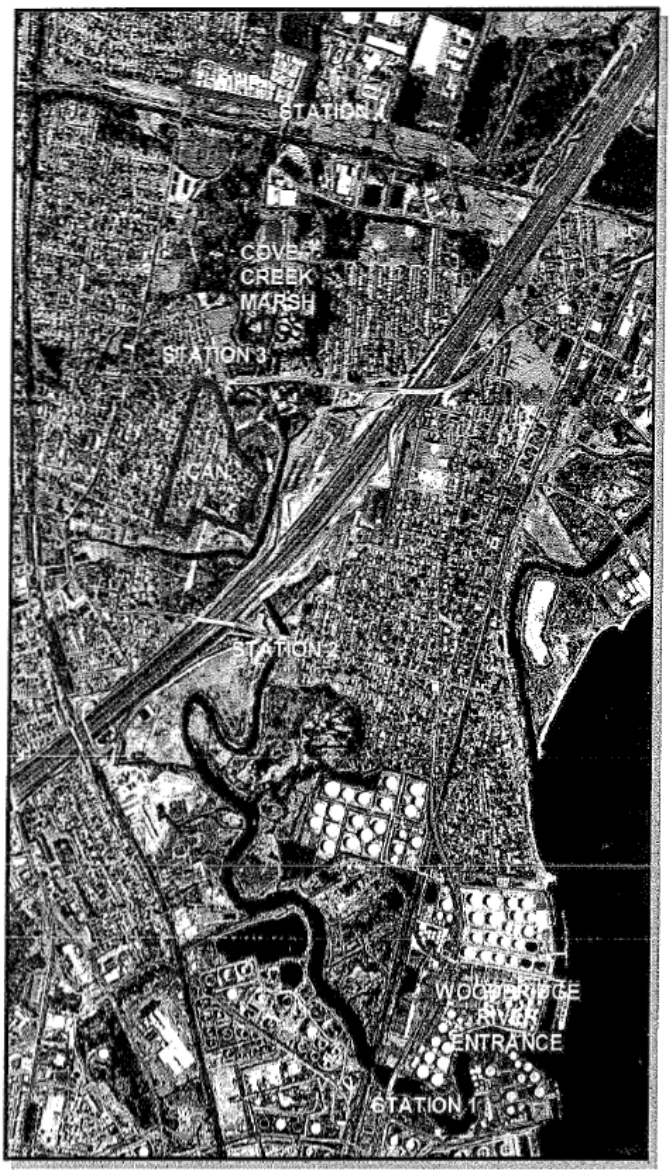


Figure 6: Woodbridge River Tide Gauge Locations

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Available NOAA tidal data indicate that the mean high water elevation in the lower Woodbridge River is 3.4 feet NGVD-1929 (2.4 feet NAVD-1988). Departures of +1 to +3 feet above mean levels occur frequently during coastal storm events, causing tidal inundations at the foot of low-lying roads, and inhibiting drainage of these roads. For example, minimum road surface elevations approach 5 feet NGVD-1929 (4 feet NAVD-1988) at the southern foot of both Heidelberg Avenue and Vesper Avenue (Figure 2). Also, road surface elevations are about 6 feet NGVD-1929 (5 feet NAVD-1988) at the southern end Watson Avenue and near the eastern end of Crampton Avenue.

1.4 Water Surface Elevations for 50-year and 100-year Storm Events

The USACE's proposed flood reduction alternatives are designed to provide a high level of flood protection – up to elevation 12-13 feet NGVD-1929 (11-12 feet NAVD-1988). Given the high cost of such protection, it is instructive to review available information regarding water levels during design flood events. According to the Federal Emergency Management Agency (FEMA) Flood Insurance Study for Woodbridge Township (FEMA, 1983), the 100-year event still-water elevation in Woodbridge River varies from **9.7** feet NGVD-1929 (8.7 feet NAVD-1988) near the Crampton Avenue Neighborhood (at River mile 2.4) to about 9.8 feet, NGVD-1929 (8.8 feet, NAVD-1988) near the Ideal Mobile Home Park (at River mile 3.2). These are water surface elevations that are predicted to be equaled or exceeded once (on average) during any 100-year period. Likewise, the 50-year event water still-water elevations vary from about **8.8** feet NGVD-1929 (7.8 feet NAVD-1988) near the Crampton Avenue Neighborhood (river mile 2.4) to about 9.0 feet NGVD-1929 (8.0 feet NAVD-1988) near the Ideal Mobile Home Park (river mile 3.2).

Very similar 50- and 100-year flood elevations are predicted in the New York City (NYC) Flood Insurance study (CDM 1981) referenced by the USACE. This report estimates that the 100-year still-water elevation in the Arthur Kill (near the Woodbridge River entrance) is **9.7** feet NGVD-1929, and the 50 year still-water elevation is **8.9** feet NGVD-1929.

Such predicted elevations compare well with tidal elevations *observed* during extreme storms. At Sandy Hook (the representative indicator station), the maximum still-water elevation recorded by NOAA is **8.94** feet NGVD-1929 (7.9 feet NAVD-1988), which occurred during a severe nor'easter on December 11, 1992. This is the maximum elevation measured during the station's 73-year record. This observed elevation is comparable to the 50-year still-water elevation predicted in the FEMA and NYC reports cited above (i.e., 8.8-8.9 feet NGVD-1929). Thus, *the USACE's proposed alternatives provide about 3 feet of additional freeboard above the corresponding water-surface elevations reported for the 50- and 100-year design storms.*

2.0 REVIEW OF ALTERNATIVE FLOOD DAMAGE REDUCTION PLANS

The USACE report considers both structural and nonstructural flood damage reduction measures. Structural measures include: constructing floodwalls, levees, storm gates and road-raising. Nonstructural measures include elevating structures, acquiring properties and flood-proofing buildings. All such measures are effective given a proper environmental setting. The key for this feasibility study is determining which, if any, measure(s) provide adequate flood protection and long-term benefits that exceed costs. To this end, the USACE presents the following alternatives:

2.1 Alternative 1: Raising Homes in CAN and IMHP

The first proposed alternative would raise homes in both the Ideal Mobile Home Park (IMHP) and Crampton Avenue neighborhood (CAN) and provide 100-year flood protection. This alternative would include raising foundations, external utilities, staircases, etc., and relocating overhead lines/underground utilities. Such a nonstructural alternative is certainly worth considering, as it would largely eliminate flooding of area homes and minimally impact the environment. However, raising entire neighborhoods is typically an expensive proposition, as is the case here.

The USACE report (USACE 2005b) provides estimated costs for this alternative in Table 1 (Appendix D). This estimate is based on raising 189 mobile homes in the IMHP and 110 fixed homes in the CAN. The USACE draft feasibility report states that these particular homes are all within the 100-year flood plain, but is ambiguous regarding the extent of the 100-year floodplain. On page 10 of the Technical Appendices report (USACE 2005b), it states that the assumed 100-year floodplain elevation is 11.85 feet NGVD-1929. As noted in section 1.3, this assumption would likely overestimate the extent of the actual 100-year floodplain, and slightly inflate the number of homes that need to be raised. Nevertheless, this alternative would not be cost effective even if the number of raised homes were revised in accordance with a lower 100-year floodplain elevation (e.g., 9.7 feet NGVD-1929). This is due to the relatively high unit cost of raising homes (estimated in Table 1 as $109,614 for *each* home in the CAN). Thus, the USACE is justified in rejecting this costly alternative.

2.2 Alternative 2: Raising IMHP Homes and Constructing CAN Floodwall System

The second proposed alternative avoids the costly proposition of raising homes in the CAN. Instead, it considers building a large (4,200-foot-long) floodwall system around the eastern and southern boundaries of the CAN. An advantage of floodwalls is that they may be constructed in a densely developed neighborhood where a wide levee would not fit. The proposed floodwall systems are feasible and would provide a high level of storm protection. However, constructing a 4,200-foot-long floodwall is a costly endeavor and is hardly worth considering given damage estimates for a previous storm event (e.g., only $600,000 for an event in 1996; page 2-1 of USACE 2005a). The costs for this alternative are compounded by the need to raise Port Reading Avenue. Clearly, such large-scale structural alternatives are not appropriate for this situation, and the USACE is justified in not recommending this alternative.

2.3 Alternative 3: Constructing Floodwall Systems for both the CAN and IMHP

The third alternative proposed by the USACE would construct large-scale floodwall systems around both the CAN and IMHP. The proposed floodwall systems are feasible and would provide a high level of storm protection. However, like the previous alternative, constructing two large floodwall systems is a costly endeavor and is hardly worth considering given damage estimates for a previous storm event (e.g., only $600,000 for an event in 1996; page 2-1 of USACE 2005a). The USACE report provides ample cost justification to reject this unlikely alternative.

2.4 Alternative 4: Constructing a Tide Gate and a 4,140-foot-long Levee System

The fourth proposed alternative would provide a high level of protection -- up to elevation 13 feet NGVD-1929. To this end, a tide gate would be constructed across the River, and a 4,140-foot-long by 80-foot-wide levee would extend across the River's floodplain, adjacent to the New Jersey Turnpike. The endpoints of the levee system would be designed to connect to higher ground at elevation 13 feet NGVD-1929.

The advantages of this alternative are numerous. Undoubtedly, this high and expansive line of protection would prevent impacts of severe coastal storms, while allowing normal tidal flows to pass. Also, the tide gate would be located away from the expansive tidal marsh areas and closer to higher ground. Also, the pile-supported design of the tide gate would not need existing roads/structures for support and would minimize interference with major roadways/structures. However, the main drawback of this alternative is its scale and resulting costs.

The design of the proposed 4,140-foot-long levee is predicated on the need to tie into higher ground at elevation 13 feet NGVD-1929. The intent is to provide protection for the 100-year storm and provide some additional freeboard for added safety. While additional height may be beneficial, it comes at great cost given the prevailing ground elevations.

An inspection of the corresponding aerial (1995) topographic survey (Figures 2-4) reveals few contiguous areas exceeding elevation 13 feet NGVD-1929 (12 feet NAVD-1988 in these figures) in the River's floodplain. However, the elevation of the New Jersey Turnpike road surface is about 11 feet NGVD-1929 (10 feet NAVD-1988), along with properties near Woodbridge Avenue. Thus, the proposed stand-alone tide gate structure and a much smaller levee system could provide protection up to 11 feet NGVD-1929. Since the FEMA 100-year still-water elevation is approximately 9.7 feet NGVD-1929 at this location (section 1.3), it follows that a smaller levee system at elevation 11 feet NGVD-1929 should have been offered as a reasonable alternative. In any case, it is not surprising that the estimated cost of alternative 4 exceeds the estimated benefit. Clearly, a smaller and more efficient levee design should be considered.

2.5 Alternative 5: Constructing a Tide Gate and a 1,074-foot-long Levee System

The fifth proposed alternative reduces the elevation of the proposed tide gate and levee to 12 feet NGVD-1929 (11 feet NAVD-1988). This design is intended to provide protection from the "50-year tide elevation plus risk and uncertainty (freeboard)." Since the endpoints of the levee would be connected to higher ground at elevation 12 feet NGVD-1929 (rather than the previous elevation of 13 feet NGVD-1929), a somewhat shorter (1,074-foot-long) and narrower (70-foot-wide) levee was proposed for this alternative.

Like the previous alternative, alternative 5 would provide protection from severe coastal storms, while allowing normal tidal flows to pass. Also, the pile-supported design of the tide gate would not need support from the nearby New Jersey Turnpike. However, the proposed tide gate and levee would be located on property owned by the Turnpike Authority and may interfere with future road repair/expansion operations.

A field inspection conducted by our staff indicated that a berm already exists where a levee extension is proposed – on the northern side of the River adjacent to the elevated exit ramp of the Turnpike. Our updated topographic survey (Figure 4) indicates ground elevations up to 21 feet NGVD-1929 (20 feet NAVD-1988) adjacent to this ramp. Thus, the proposed levee design is still too long and costly.

2.6 Alternative 6: Constructing a Tide Gate and a 924-foot-long Levee System

The proposed alternative 6 is similar in scale and design to alternative 5. However, the tide gate is located in a more desirable location: on Township property, thus avoiding interference with the Turnpike facilities. Unfortunately, the proposed levee is still quite long (i.e., 924 linear feet) and, thus, costly.

The proposed levee was designed to provide protection up to elevation 12 feet NGVD-1929. This design was intended to provide protection from the "50-year tide elevation plus risk and uncertainty (freeboard)." Inspection of the proposed levee location on the topographic aerial survey (Figure 4) indicates that portions of the adjacent floodplain already lie above elevation 11 feet NGVD-1929 (10 feet NAVD-1988). Thus, it is not clear that a 924-foot-long levee system is needed at this location.

Overall, alternative 6 is the most attractive solution offered, and the most cost-efficient of those considered. The USACE reports a maximum benefit-to-cost ratio of 0.8, assuming that all main-floor elevations are only 2 feet above ground level in the CAN. They also report lower possible ratios, assuming that main-floor elevations exceed 2 feet (building surveys were not conducted to resolve this issue). In any case, the actual ratio would be improved somewhat with a more efficient levee design. The proposed levee system comprises approximately 23% of the estimated total construction costs, and 18% of the estimated total project first cost. Thus, a large reduction in the size of the levee would increase the benefit-to-cost ratio somewhat.

2.7 USACE's Assessment of Flood Damages

It should be noted that the USACE's assessment of flood damage for all alternatives includes an "other" category to account for flood damages to lawns, outbuildings, flood flight, evacuation/reoccupation, lost income, extra housing, clean-up costs, etc. For example, for a flood elevation that reaches the main floor elevation, "other" costs are estimated as 7.2 % for the CAN homes and 11.9% for the IMHP mobile homes (Table 4, Appendix E of USACE 2005b). *However, it does not appear that cost for flood damage to cars was properly factored into this assessment.* For example, peak still-water elevations at Sandy Hook were 8.94 NGVD-1929 (7.9 NAVD-1988) during the severe nor'easter of December 11, 1992. Assuming that the same peak water level occurred along the Woodbridge River, this storm would have inundated nearly half of the IMHP area (Figure 3, thick green contour line) and the lower CAN up to about Watson Avenue (Figure 2). Since this storm intensified unexpectedly during the night, there was limited time to move cars and other possessions to high ground. Consequently, many cars were lost here and throughout the New York-New Jersey metropolitan region during this storm, and the value of lost automobiles should be included in damage estimates.

Since the structural value of the mobile homes was assessed at only $21,900, it is unlikely that the above-referenced 11.9% allotted for "other" damages would cover automobile replacement costs. This consideration would increase the estimated benefit-to-cost ratio for alternative 2.6.

3.0 PRELIMINARY RECOMMENDATIONS

Based on this review, the following three recommendations are offered to address the issues of coastal flooding, fluvial flooding and flood duration:

3.1 Modify USACE Alternative 6 to Mitigate Coastal Flooding Impacts

Alternative 6 is the most attractive alternative devised by the USACE in their feasibility study. Based on our review and site visits, we believe that this attractive alternative may be enhanced with a more cost-efficient levee design. The levee proposed by the USACE would be 924 feet long and would connect to higher ground at elevation 12 feet NGVD-1929. We propose a much shorter levee (approximately 300 linear feet) that would tie into ground at elevation 11 feet NGVD-1929. While a levee/tide gate system built to elevation 12 feet NGVD-1929 would provide added benefit, the need for such a high structure has not been demonstrated. As noted in section 1.4, FEMA reports that the 100-year still-water elevation near the CAN is about 9.7 feet NGVD-1929 (8.7 feet NAVD-1988). Moreover, the NYC Flood Insurance study estimates that the 100-year still-water elevation in the Arthur Kill (near the Woodbridge River entrance) is about 9.7 feet NGVD-1929. In addition, the highest historical tidal elevation observed at Sandy Hook is 8.94 feet NGVD-1929. These lines of evidence suggest that a levee/tide gate system designed to elevation 11 feet NGVD-1929 would be adequate -- providing about one foot of additional freeboard above the 100-year design storm elevation, and about two feet above the corresponding 50-year elevation.

The modified levee system would be designed to traverse primarily Township-owned property – mostly at the sites of the existing (and former) sewer pump-station facilities flanking the River. This location would minimize interference with adjacent properties, infrastructure and water resources.

The proposed reduction in the scale of the proposed levee system would increase the benefit to cost ratio -- especially if consideration is given to protection afforded to automobiles in flood-prone areas (section 2.7). Thus, we recommend that a concept plan be developed to explore this enhanced alternative.

3.2 Maintain/Improve Drainage Facilities to Reduce Fluvial Flooding Impacts

While the primary issue is coastal flooding, it appears that street drainage may be improved in some areas during *fluvial* flooding events -- rainfall events that are not associated with coastal storms and the accompanying rise in coastal sea levels. This observation is based on our recent visits to the site. Recommended drainage improvements include locating, inspecting and maintaining existing stormwater inlets and drainage lines. Our staff located some inlets that were nearly filled with sediment and debris.

In some areas, surface runoff is conveyed to swales and drainage ditches that ultimately drain into the main-stem Woodbridge River. In many places, these swales/ditches appear to be partially blocked by weeds/shrubs, silt, litter and other debris. This condition may result in local street ponding during rainfall events. Accordingly, we recommend that such conditions be further investigated, especially *during* these rainfall events. If necessary, swales and ditches may be simply cleaned and maintained. In other areas, existing swales or ditches may be re-graded and enlarged, or new swales/ditches may be incised in areas of poor drainage. However, note that such physical improvements will provide no benefits during coastal flooding events.

Also, some localized street profiling/shimming may provide positive drainage of the street cross-section. Note that topographic surveys and some environmental permits may be required for the above activities.

3.3 Conduct Model Simulations of Dredging to Reduce Duration of Flooding

As noted in section 1.3, the *duration* of flooding impacts is an important consideration along the upper Woodbridge River, especially at the IMHP. Here, flood waters may be retained for several days due to upstream sills, pipe crossings and other constrictions in the river bed (Najarian Associates, 2001). One potential method to address this issue would be to dredge the upper River channel. Note that dredging may reduce the duration of flooding impacts – not eliminate flooding. However, reducing the duration of flooding, from time scales of days to hours, would be beneficial to residents.

In our previous model study of the Woodbridge River system (Najarian Associates 2001), Najarian Associates adapted and calibrated a numerical hydrodynamic model to this system. This model, which has been maintained by our staff, provides a convenient tool for investigating the advantages (and potential disadvantages, if any) of channel dredging. Accordingly, it is recommended that this model be used to simulate various dredging scenarios (i.e., bottom profiles) for the upper River. Such an analysis would quantify potential reductions in the duration of flooding impacts at both the IMHP and CAN sites.

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Camp Dresser & McKee, Inc. (CDM) (1981). "New York City Flood Insurance Study, Report No. 7, Total Stillwater Frequency Elevations Implementation and Results." Prepared for New York Department of Environmental Conservation,

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USACE (2005b). "Woodbridge River Basin, New Jersey, Flood Damage Reduction and Ecosystem Restoration Draft Feasibility Report Technical Appendices (November 200

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Natural and Historic Resources
Office of Engineering & Construction

JON S. CORZINE
Governor

LISA P. JACKSON
Commissioner

MAR 0 3 2006

Mr. Paul Tumminello, P.E.
Department of the Army
Corps of Engineers, New York District
Jacob K. Javits Federal Building
26 Federal Plaza
New York, NY 10278-0090

Dear Mr. Tumminello:

The State of New Jersey Department of Environmental Protection has completed our review of the draft feasibility report for the Woodbridge River Flood Protection and Environmental Restoration Study dated November 2005.

The Corps of Engineers has correctly observed that flooding is today, as is had been historically, a recurring problem in the Woodbridge River flood plain.

We also concur with the Corps of Engineers conclusion that there is no economically viable structural or non-structural solution. The study is very comprehensive and covers a range of alternatives including buyouts, flood proofing and the suggestion made by Woodbridge Township for a downstream tidal barrier.

We therefore concur with your recommendation that no further analysis be conducted and that a draft report be prepared for public release. If you have any questions or concerns pertaining to this feasibility study please call Charles Defendorf, P.E. at (609) 984-0859.

Sincerely,

John H. Moyle, P.E.
Manager
Bureau of Dam Safety and Flood Control

C: David Rosenblatt, Administrator
Joseph Ruggeri, P.E.
Mayor Frank Pelzman, Woodbridge Twp.

V://NHRG//FM//Woodbridge River Study

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10. RECOMMENDATIONS

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental, social and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests.

I recommend no further action for flood damage reduction in the Woodbridge River Basin, New Jersey project, as detailed in this feasibility report, as a Federal project for flood damage reduction due to lack of a plan that meets National Economic Development criteria, and thus Federal interest, subject to such modifications as may be prescribed by the Chief of Engineers.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a 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 Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the non-Federal project partner (the New Jersey Department of Environmental Protection) interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Aniello L. Tortora
Colonel, Corps of Engineers
District Engineer

11. LIST OF STUDY TEAM MEMBERS AND REPORT PREPARERS

The following individuals were primarily responsible for the preparation of this integrated feasibility report and environmental assessment.

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