UPPER PASSAIC RIVER FLOOD CONTROL
LONG HILL TOWNSHIP, NEW JERSEY
N.Y. DISTRICT, U.S. ARMY CORPS OF ENGINEERS

DETAILED PROJECT REPORT
APPENDIX F – DRAFT ECONOMIC ANALYSES

February 2004

Table of Contents

List of Tables

APPENDIX F
ECONOMIC ANALYSES

1. INTRODUCTION

This appendix provides the results of the economic analysis of existing flood damages, evaluation of alternatives, and flood damage reduction benefits for Long Hill Township, New Jersey (conducted as an element of the Upper Passaic River and Tributaries at Long Hill Township Feasibility Study). The economic analysis 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). The Upper Passaic River, New Jersey, Flood Control and Environmental Restoration Feasibility Study is being conducted under the Corps of Engineers General Investigations program.

Long Hill Township is located within the Central Passaic River Basin, a flat, oval 262 square mile depression which is 10 miles wide and 30 miles long. The Central Basin contains 24,485 acres of natural flood storage area, including the Great Swamp National Wildlife Refuge located in the northeastern sector of Long Hill Township. The Passaic River is adjacent to the township and flows south along the western boundary then turns northeast, forming the southern boundary of the Township. The Township is a low density residential community (0.36 housing units per acre) characterized by large tracts of open space and single family residential neighborhoods. Commercial development is well established within the Valley Road business district and four neighborhood business districts: Gillette, Meyersville, Millington, and Stirling. Existing public open space within the Township covers 3,335 acres or 41.1 percent of the total land area. This predominantly undeveloped open space includes Federal (70%), State (3%), County (19%) and Township (8%) lands.

The primary water resources problem within the Long Hill Township portion of the Passaic River basin is persistent, recurring flooding. Flood damages are primarily attributable to backwater flooding from the Passaic River into a series of smaller tributaries which enter damage areas throughout Long Hill Township. Damages from past flood events have included structural damages to buildings and their contents; limitations on the uses of property because of the threat of flooding; impacts of flood-related interruptions in road transport on business and interstate commerce; and threats to public safety. In addition to residential and commercial flooding, many major thoroughfares are impacted by floodwaters, requiring roads to be closed to traffic during flood events. The Long Hill Township Police Station is located within the 100-year floodplain. Emergency flood protection measures in 1996 and 1999 prevented significant damage; however, the police station and related communications centers nearly were evacuated, which would greatly have hampered rescue and recovery efforts. Floodplain properties are primarily residential, though many commercial, industrial and public structures also susceptible to flood damages.

2. SOCIAL AND ECONOMIC SETTING

Long Hill Township is a rural and low density residential community characterized by large tracts of open space, attractive single family residential neighborhoods, tree-lined streets and a

general absence of large non-residential land uses. The Township is one of the least dense and most scenic municipalities in Morris County, and its proximity to New York City allows it to serve as a suburban community.

2.1 Population & Demographics

The population of New Jersey, Morris County, and Long Hill Township has undergone a change in growth over the past decade, as shown in Table 1. The rate of growth in the State, County, and Township currently all outpace the population growth of the nation as a whole. New Jersey Department of Labor projections of population for 2000 to 2010 (see Table 2) continue to be in the double digits for both Morris County and Long Hill Township, whereas projections for the State over the same period are at 6 percent per year.

The age distribution of the State of New Jersey, Morris County, and Long Hill Township are shown in the Table 3. Age distributions and median age for the state, county and township are quite similar, with only minor differences in composition. Given the increase in population and higher portion of persons of age 18 and under and a higher median age, Long Hill Township may be a community in transition.

The median household incomes for New Jersey, Morris County, and Long Hill Township are presented in Table 4. As indicated in this table, Long Hill Township has a significantly higher median household income than either the County or the State.

Employment by economic sector for Long Hill Township is summarized in Table 5. The sectors with the largest shares of employment in the Township are Education, Health, Social Services (18.3 percent); Manufacturing (14.6 percent), and Finance, Insurance, and Real Estate (12.9 percent).

Long Hill Township is well served by a variety of transportation facilities. Interstates 287 and 78 are located adjacent to the Township, providing ready access to the rest of New Jersey, the New York metropolitan area, and other origins/destinations on the eastern seaboard. Local and express bus service is provided from Long Hill Township to New York City and local points. Rail and air transportation are easily accessible from the township.

Table 1
Populations of Study Area Jurisdictions 1980, 1990, 2000

	1980 Population	1990 Population	% Change 1980-1990	2000 Population	% Change 1990-2000
State of New Jersey	7,365,011	7,730,188	5.0%	8,414,350	8.9%
Morris County	407,360	421,353	3.4%	470,212	11.6%
Long Hill Township	7,275	7,826	7.6%	8,777	12.2%

Source: U.S. Bureau of the Census.

Table 2
Population Forecasts for Study Area Jurisdictions 1995 – 2025

	2000	2005	2010	2015	2020	2025
New Jersey*	8,414,350	8,392,000	8,658,000	8,924,000	9,241,000	9,558,000
Morris County*	470,212	500,500	512,500	545,400	564,774	584,148
Long Hill Township***	8,777	9,333	9,556	10,170	10,531	10,892

* Sources: U.S. Bureau of the Census; New Jersey State Data Center
** 2005-2025 Forecasts Estimated Using County Growth Rates

Table 3
Age Distribution of Study Area Populations 2000

Age Distribution	Under 18	18-24	25-44	45-64	65 and Over	Median Age
State of New Jersey	24.8%	8.0%	31.2%	22.7%	13.2%	36.7
Morris County	24.8%	6.4%	31.9%	25.3%	11.6%	37.8
Long Hill Township	26.3%	4.4%	31.2%	25.4%	12.6%	39.2

Source: U.S. Bureau of the Census.

Table 4
Median Household Income of Study Area Jurisdiction 1999

New Jersey	$55,146
Morris County	$77,340
Long Hill Township	$84,532

Source: U.S. Bureau of the Census

Table 5
Employment by Sector (1997) Study Area Jurisdictions

	Employees	Percent
Agriculture, Forestry, Fishing/Hunting, Mining	19	0.4
Construction	244	5.5
Manufacturing	647	14.6
Wholesale Trade	175	3.9
Retail Trade	378	8.5
Transportation	134	3
Information	338	7.6
Finance, Insurance, and Real Estate	573	12.9
Professional, Scientific, Mgmt	513	11.6
Education, Health, Social Services	810	18.3
Arts, Entertainment, Recreation, Accommodation, Food Service	295	6.7
Other Services (except Public Administration)	165	3.7
Public Administration	140	3.2
Total	4,431	100

2.2 Land Use

Land use in Long Hill Township is primarily suburban. Residential land uses includes older homes clustered in the communities of Gillette, Meyersville, Millington, and Stirling. Commercial and light industrial land uses are primarily located along Valley Road. Most of the undeveloped land is found in the riparian corridor of the Passaic River and in wetland areas associated with tributary streams.

The future development potential of Long Hill Township is based on development of approved projects not yet built and future development of vacant land. It is not anticipated that any radically different land use concepts would dramatically change the character of the community. Owners of the remaining few vacant tracts of land are encouraged by the Township Planning Board to develop them in a manner that will be compatible with the surrounding area, as outlined in the Township Master Plan with input from the Planning Board and from the Environmental Commission.

2.3 Parks and Recreation

The Great Swamp National Wildlife Refuge is located approximately 1.5 miles north of the study area. Morris County Parks Commission owns the majority of the land adjacent to the Passaic River. This land is kept in its nature set and passive recreation (hiking, canoeing, and

fishing) is allowed in these areas. Long Hill Township has several recreational sites located adjacent to the study area. A baseball facility is located at the end of Poplar Drive. A larger recreational facility is located south of Valley Road across from Morristown Road. The facility consists of soccer fields, tennis courts, a small maintenance building, basketball court, and bocce courts.

3. ECONOMIC ANALYSIS METHODOLOGY

Flood damages under future with- and without-project conditions were estimated through: (1) an inventory of floodplain development, (2) estimation of depreciated structure replacement costs and content damages, (3) preparation of generalized stage-damage functions, and (4) combination stage/frequency relationships and stage/damage relationships into frequency/damage relationships.

3.1 Flood Damage Surveys

A structure inventory was compiled by conducting field surveys of structures in the 500-year floodplain during February and March of 2002. There are approximately 175 total structures within the 500-year floodplain, including 2 municipal and 41 non-residential structures. Each structure was assigned a unique structure identification number. First floor and low opening elevations (measured off of known benchmarks using a transit) and street addresses were recorded for all structures. Structure information required to compute depreciated replacement values was collected for residential structures based on Means Residential Square Foot Costs (2003). Data collected included the following categories: structure type, style, construction material, quality, condition, effective age, finished floor area, and other exterior characteristics. Content values were estimated at 50 percent of the structure value.

Interviews were held (spring 2002) with owners/operators of non-residential floodplain properties, including municipal and major industrial facilities. Actual damage information from the 1996 flood was obtained from the township and was used to calibrate depth-damage functions. Public emergency costs were calculated as a percentage of total damages based on local damage reports provided by the Long Hill Township Police Department (which also serves as the Township's Emergency Operations Center).). Damage records from the 1996 and 1998 events showed that emergency services costs averaged 3.1 percent of total damages. Because emergency services costs were available for only these two events, was assumed that emergency services costs would be 3.1 percent of total damages for each return interval analyzed.

3.1.1 Principal Flood Damage Reaches

The Upper Passaic River at Long Hill Township study area was divided into three reaches based on location and flooding pathways. These reaches 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 a reduction in flood damages.

Reach 1: South of Valley Road. Reach 1 is bounded by Valley Road to the north and the Passaic River to the south. Flooding in this reach causes inundation of roadways, public works, commercial and industrial structures, and residential structures. The flood pathway for all damageable property in this reach is via direct inundation by the Passaic River. The reach contains the Shop Rite Shopping Center, which is a multipurpose retail strip mall, a wastewater

treatment plant, several restaurants, and about twenty residential structures. Flooding begins for structures in this reach at elevation +213 NGVD, which corresponds to roughly a 7 year event, though most damages begin to occur between the 10 and 15 year events. With the exception of the Shop Rite Shopping Center, all of the structures located within this reach are inundated between the 25 and 50 year events.

Reach 2: North of Valley Road. Reach 2 includes Valley Road and the area north of Valley road. Similar to Reach 1, flooding in this reach damages residential property, roadways, public buildings, and commercial and industrial property. The Long Hill Township Police Department, the Township's Emergency Operations Center, is located within this reach. Floodwaters first inundate this reach due to backwater flow through the Passaic River tributaries that serve to drain stormwater flow from the reach. As the waters of the Passaic River rise, the flow in the tributaries changes direction and volume of flow increases as floodwaters are conveyed into the reach through culverts that cross beneath Valley Road.

Reach 3: Madison Avenue off of Mountain Road. Reach 3 is an isolated area of flood-prone properties, consisting solely of residential structures. Floodwaters approach this reach through the drainage culvert that joins a Passaic River tributary. As the tributary fills with back flow from the Passaic, the flow in the culvert changes direction and floodwaters enter the reach. This isolated pocket contains less than ten structures at risk from flooding. After an examination of measures and alternatives (discussed later in this section), Reach 3 was combined with Reach 2. The principal reason for combining these reaches was that the measures that would protect Reach 2 also would protect Reach 3.

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.

3.2 Depth-Damage Relationships

Depth-damage functions from Economic Guidance Memorandum 01-03 – Generic Depth-Damage Relationships – augmented with New York District depth-damage curves used in previous Passaic River Basin analyses were applied to the inventory of floodplain properties in order to develop depth-damage relationships.

Given the relatively low number of structures in this analysis, a risk-based spreadsheet model (MS Excel running statistical modeling software) was used to estimate flood damages to non-residential and residential structures and contents. Structure specific information (identification number, structure type, value, first floor elevation, zero damage level, and reach designation) was included in a structure inventory database for input to the model. Residential structures were classified as one of five types: one-story with a basement, one-story without a basement, split-level, two-story with a basement, and two-story without a basement (see Tables 6 and 7). The model used depth-percent damage curves corresponding to the structure type to relate flood depth to percent damage for residential and selected non-residential structures and their contents. Each structure was referenced to two cross sections which were used to determine the water surface elevations for the storm frequency events of 2-, 5-, 10-, 25-, 50-, 100-, 250- and 500-year return intervals.

Table 6
Depth-Damage Functions of
One Story and Split Level Residential Structures

Depth of First Floor Flooding	One Story				Split Level	
	With Basement		Without Basement			
	Structure	Contents	Structure	Contents	Structure	Contents
-4	0.0%	0.0%	0.0%	0.0%	2.0%	3.0%
-3	0.2%	0.2%	0.0%	0.0%	4.0%	5.0%
-2	0.3%	0.4%	0.0%	0.0%	6.0%	10.0%
-1	3.0%	3.5%	2.5%	4.8%	7.0%	15.0%
0	16.1%	18.9%	13.4%	16.2%	8.0%	18.0%
1	28.0%	32.9%	23.3%	26.6%	16.0%	31.0%
2	38.6%	45.3%	32.1%	35.8%	16.0%	44.0%
3	48.2%	56.6%	40.1%	44.0%	19.0%	52.0%
4	56.6%	66.5%	47.1%	51.4%	22.0%	58.0%
5	63.9%	75.1%	53.2%	57.6%	25.0%	61.0%
6	70.4%	82.8%	58.6%	63.0%	26.0%	63.0%
7	76.0%	89.3%	63.2%	67.6%	27.0%	64.0%
8	80.8%	94.9%	67.2%	71.4%	27.0%	66.0%
9	84.7%	99.6%	70.5%	74.4%	30.0%	69.0%

Table 7
Depth-Damage Functions of
Two Story Residential Structures

Depth of First Floor Flooding	Two Story			
	With Basement		Without Basement	
	Structure	Contents	Structure	Contents
-4	0.0%	0.0%	0.0%	0.0%
-3	0.2%	0.3%	0.0%	0.0%
-2	0.3%	0.4%	0.0%	0.0%
-1	4.0%	5.4%	3.0%	2.0%
0	12.5%	16.7%	9.3%	10.0%
1	20.4%	27.3%	15.2%	17.4%
2	28.0%	37.5%	20.9%	24.4%
3	35.2%	41.2%	26.3%	31.0%
4	42.1%	45.3%	31.4%	37.0%
5	48.5%	49.9%	36.2%	42.6%
6	54.5%	54.9%	40.7%	47.8%
7	60.2%	60.3%	44.9%	52.6%
8	65.4%	66.4%	48.8%	56.8%
9	70.2%	73.0%	52.4%	60.6%

3.3 Risk and Uncertainty – Structural Flood Damages

Planning guidance requires that risk and uncertainty be incorporated into flood damage reduction studies. Statistical modeling software and Microsoft Excel were used to incorporate uncertainty from damage input variables into the analysis. The evaluation process used Monte Carlo Simulation to compute the expected value of damages while incorporating the variability associated with each input variable.

Some of the important uncertainties specific to this particular analysis include:

- Hydrologic and Hydraulic uncertainty factors include hydrologic data record lengths that are often short or do not exist, precipitation-runoff computational methods that are not precisely known, and imprecise knowledge of the effectiveness of flow regulation. Additional uncertainty arises from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, material variability, and from errors in estimating slope and roughness factors. Water surface elevations were allowed to vary based on the standard deviations for specific return events taken directly from the hydrologic and hydraulic analyses conducted as part of this feasibility study.
- Economic uncertainty factors include land uses, depth/damage relationships, structure/content values, structure locations, first floor elevations, floodwater velocity, the amount of debris and mud, flood duration, and warning time and response of floodplain inhabitants. Variability in depth-damage curves were incorporated into the model by using standard deviations for specific damage percents taken directly from depth-damage functions provided in Economic Guidance Memorandum 01-03. . Additional variability in first floor survey error (5 percent), and depreciated replacement values (estimated as a percent of the range shown in Means Cost Estimating Guides) were captured in the damage model.

Under the Monte Carlo approach, multiple iterations selected input values from the full range of possible values for each variable identified as a source of uncertainty. Expected values and standard deviations for each key input variable were used to develop distributions from which sample variables were randomly selected in the calculation of flood damages.

In normal distributions, 68 percent of the sampled values of a particular variable are within one standard deviation on either side of the mean, 95 percent within two standard deviations from the mean, and 99.7 percent within three standard deviations from the mean. With each iteration of the model a value is randomly selected from the key hydraulic and economic variable distributions and used in the calculation of structure and contents flood damages for that particular iteration. The sum of all flood damage calculations divided by the number of iterations yields the expected value of flood damages for the model run. Ten thousand iterations were run for each study area reach to ensure that the full range of possible outcomes was represented in the analysis.

Restrictions were imposed on the model in the computation of benefits for alternative flood damage reduction plans. For example, if an alternative was a levee with a design height at the mean 100 year water surface elevation, sampled water surface elevations were not permitted to exceed the design elevation. This type of model restriction helped to ensure that alternative project benefits were not overstated.

3.4 Traffic Delay Costs

Traffic delays on Valley and Morristown Roads are common following floods in excess of the 10 percent chance exceedance event, which require partial or full roadway closures. Closure of Valley Road results in the diversion of east- and west-bound traffic along a route north to Long Hill Road. This additional distance is approximately 4.0 miles, and will add about 10 minutes to the motorists' travel time (25 miles per hour plus an allowance for congestion). Traffic delay damages for each impacted motorist are calculated as the sum of the opportunity cost of the additional time spent driving due to speed reductions or detours. Traffic count data published by Morris County in April of 2002 indicated that an average of 20,364 vehicles travel Valley Road on a daily basis.

Opportunity cost of time estimates are based upon the duration of the delay and the estimated annual wage of the motorist. The hourly wage ($41.57) was calculated from the Bureau of the Census 1999 estimate of median family income for Morris County[1] ($77,340) and adjusted to 2003 dollars using the Bureau of Labor Statistics Inflation Calculator. IWR Report 91-R-12 "Value of Time Saved for Use in Corps Planning Studies" indicates that the hourly opportunity cost for automobile trips delayed less than five minutes should be valued at 6.4% of the motorist's hourly wage. For delays greater than five minutes but less than 15 minutes the opportunity cost is valued at 32.2% of the motorist's hourly wage. Conducting the calculations indicates that the opportunity cost of time partial closure is $13.39 per person per hour delayed ($41.57 * 0.322 = $13.39) for all flood events that close Valley Road. The U.S. Bureau of Transportation Statistics estimates that there are 1.6 persons per vehicle on average. Using this occupancy estimate, the opportunity cost of time for a closure of valley road is $21.42 per vehicle per hour detoured around Valley Road during flood events.

4. WITHOUT PROJECT CONDITIONS DAMAGES

Hydrologic, hydraulic, and statistical analysis required for the development of existing conditions stage-frequency curves and associated uncertainties were conducted as part of the feasibility study (See Hydrology and Hydraulics Appendix for more information). The hydraulic model was updated with adjusted parameters and water surface profiles for 50 HEC-RAS river stations were calculated for all design storm events, using discharge values determined by the HEC-HMS model. Water surface profiles for the eight storm events modeled for this analysis are provided in the Table 8 below for stations in the immediate vicinity of the damage centers.

Damages begin for residential structures at the 20 percent chance exceedance (5-year reoccurrence interval) flood event, impacting twenty residential structures and five nonresidential structures with total estimated damages at cost of approximately $480 thousand. As shown in Tables 9 and 10, the 100-year event affects 132 structures and results in approximately $7.9 million in damages (of which, 3.4 million are damages to residential structures). Average annual damages to property through the 500-year event amount to over $700,000.

[1] Median family income for Long Hill Township was not used because much of the traffic on Valley Road is assumed to be motorists transiting through the township with an alternate destination point.

Table 8
Water Surface Profiles for Eight Modeled Storm Events

Cross Section	Water Surface Elevation (NGVD)							
	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	250-Yr	500-Yr
48	210.4	212.2	213.4	214.5	215.2	216.2	216.9	217.6
49	210.5	212.2	213.5	214.6	215.3	216.2	216.9	217.6
50	210.6	212.3	213.5	214.6	215.3	216.3	217.0	217.6
50a	210.6	212.3	213.5	214.6	215.3	216.3	217.0	217.6
51	210.7	212.4	213.5	214.6	215.3	216.3	217.0	217.6
52	210.7	212.4	213.5	214.6	215.3	216.3	217.0	217.6
52a	210.7	212.4	213.6	214.6	215.3	216.3	217.0	217.6
53	210.7	212.4	213.6	214.7	215.3	216.3	217.0	217.6

Table 9
Damages to Residential Structures and Contents – Without Project Conditions

	Reach 1		Reach 2	
Recurrence Interval	Structures Damaged	Damages ($1,000)	Structures Damaged	Damages ($1,000)
2-year	0	0	0	0
5-year	6	83	14	148
10-year	12	234	29	550
25-year	18	444	38	1,244
50-year	18	591	50	1,734
100-year	20	833	72	2,579
250-year	20	1,011	78	3,326
500-year	20	1,231	94	3,955

Table 10
Damages to Non-Residential Property – Without Project Conditions

	Reach 1		Reach 2	
Recurrence Interval	Structures Damaged	Damages ($1,000)	Structures Damaged	Damages ($1,000)
2-year	0	0	0	0
5-year	0	0	5	249
10-year	10	154	18	736
25-year	10	366	21	1,656
50-year	12	524	23	2,391
100-year	14	802	26	3,670
250-year	16	1,008	30	4,748
500-year	18	1,229	34	5,575

Table 11 provides information on traffic delay costs that result from the closure of Valley Road during times of flooding. As shown in the table, road closures begin between the 5- and 10-year events. Closure times were obtained from data provided in the Hydrology and Hydraulics Appendix, and range from 25 hours for a 10-year event to 130 hours for a 500-year event. While the detour around the flooded areas of Valley Road is brief (expected to take less than ten minutes), the road's typical traffic volume yields total delay costs that range from $72.7 thousand to 378 thousand. Average annual traffic delay costs for the intervals shown on the table amount to $51,650 through the 500-year event, and $48,200 through the 100-year event.

Table 11
Traffic Delay Costs

Return Frequency	Closure Duration	Additional Travel Time	Vehicles Delayed	Delay Time Cost ($)
2	None	None	0	0
5	None	None	0	0
10	25 hrs	9.6 min	21,213	72,700
25	70 hrs	9.6 min	59,395	203,500
50	90 hrs	9.6 min	76,365	261,700
100	110 hrs	9.6 min	93,335	319,900
250	120 hrs	9.6 min	101,820	348,900
500	130 hrs	9.6 min	110,305	378,000

5. COSTS AND BENEFITS OF ALTERNATIVES

The initial screening of flood damage reduction alternatives resulted in the following structural and nonstructural measures being carried forward for more detailed investigations:

- tributary closure structures;
- levee along the Passaic River;
- setback levee/floodwall south of Valley Road;
- raise Valley Road;
- acquisition of flood-prone properties,
- floodproofing, and
- flood warning systems.

Alternative plans were developed incorporating one or more of these plan features. The components of alternative plans are described below.

Alternative 1: No Action.

Alternative 2: Install closure structures on Passaic River tributaries, implement limited nonstructural armoring and structure raisings, and install flood warning system.

Alternative 3: Construct a levee along the Passaic River with tributary closure gates, install a tributary closure structure outside of the levee/floodwall line of protection, implement limited nonstructural armoring and structure raisings, and install flood warning system.

Alternative 4: Construct a setback levee/floodwall south of Valley road, install tributary closure gates along the levee/floodwall, install a tributary closure structure outside of the levee/floodwall line of protection, implement limited nonstructural armoring and structure raisings, and install flood warning system.

Alternative 5: Raise Valley Road, install closure structures on Passaic River tributaries, implement limited nonstructural armoring and structure raisings, and install flood warning system.

5.1 Alternative Plan 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 on the Passaic River at Long Hill Township focused on inundation reduction benefits resulting from reduction of physical damages to structures and contents, and reduced flood insurance administration costs[2] over the 50-year period of analysis.

Without-project average annual flood damages and with-project average annual residual flood damages are shown in Table 12. Average annual damages under without-project conditions equal $780,500 (February 2003 price levels). Average annual residual damages range from $627,500 (Alternative 2) to $172,900 (Alternative 3). The reduction in average annual damages provided by the alternatives ranges from 20% (Alternative 2) to 78% (Alternative 3).

Average annual benefits of the alternatives are shown in Table 13. The benefits are comprised of:

- the difference between residual damages under each alternative and damages under the without project condition;
- traffic delay cost savings;
- National Floodplain Insurance Program Administrative Cost savings (which equal $133 per residence enrolled in the program that would be protected by the alternative to the 100-year event); and
- emergency services costs savings (discussed in Section 3.1 above).

[2] Reduced flood insurance administration costs were included as benefits only in cases where the alternative under consideration would protect against a 1 percent exceedence event.

Table 12
Average Annual Damages of Alternatives 1 Through 5
($000)

Damage Category and Reach	Alt 1 Without-Project Condition	Alt 2	Alt 3	Alt 4	Alt 5
Reach 1 Residential	94.1	94.1	16.9	47.9	94.1
Reach 1 Non-residential	63.6	63.6	20.7	20.7	63.6
Reach 2 Residential	223.5	206.9	48.6	48.6	48.6
Reach 2 Non-residential	325.7	244.1	78.1	78.1	78.1
Traffic Delay Costs	51.7	51.7	3.5	3.5	19.3
Emergency Svcs Costs	21.9	18.8	5.1	6.0	8.8
Total Damages	780.5	679.2	172.9	204.8	312.5
Reach 1 percent Damage Reduction	N/A	0%	76%	56%	0%
Reach 2 percent Damage Reduction	N/A	18%	77%	77%	77%
Total Percent Damage Reduction	N/A	13%	78%	74%	60%

Table 13
Average Annual Benefits of Alternatives 1 Through 5
($000)

Damage Category and Reach	Alt 1 Without-Project Condition	Alt 2	Alt 3	Alt 4	Alt 5
Reach 1 Residential	0.0	0.0	77.2	46.2	0.0
Reach 1 Non-residential	0.0	0.0	42.9	42.9	0.0
Reach 1 NFIP Admin Savings	0.0	0.0	2.7	1.3	0.0
Reach 2 Residential	0.0	16.6	174.9	174.9	174.9
Reach 2 Non-residential	0.0	81.6	247.6	247.6	247.6
Reach 2 NFIP Admin Savings	0.0	0.0	9.0	9.0	0.0
Transportation Cost Savings	0.0	0.0	48.2	48.2	32.4
Emergency Services Savings	0.0	3.1	16.8	15.9	13.1
Total Benefits	0.0	101.3	619.3	586.0	468.0

5.2 Alternative Plan Costs

Preliminary cost estimates used to screen alternative plans were prepared using February 2003 price levels. Cost estimates for 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. Preliminary estimates of wetland mitigation costs and land acquisition for feature footprints costs were included. Estimated wetland mitigation costs included $100,000 per acre of wetlands directly impacted by plan features.

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 14. Average annual costs were calculated based on the FY04 Federal discount rate of 5.625 percent and an analysis period of 50 years. Interest during construction was calculated assuming an 18 month construction period for all alternatives except Alternative 3, for which a 24 month construction period was assumed. Annualized costs of the alternatives range from $74,000 (Alternative 2 – Tributary Closure Structures Only) to nearly $1.5 million (Alternative 3 – Levee Along the Passaic River with Tributary Closure Structures). Alternatives 4 and 5 have similar annualized costs of $334,700 and $374,300, respectively.

Table 14
Preliminary Costs of Alternative Plans

	Alternative Plans			
	2	**3**	**4**	**5**
Construction Cost, LERRD, PED	940,700	22,330,500	5,019,600	5,651,900
Interest During Construction	39,690	982,700	211,800	238,400
Annual O&M Costs	15,000	65,000	20,000	20,000
Annualized Cost	74,000	1,467,300	334,700	374,300

5.3 Comparison of Alternatives

A preliminary economic comparison of the costs, benefits, residual damages, benefit-to-cost ratios, and net benefits of the alternatives is shown in Table 15. Based on the results of the preliminary analysis, the Net Economic Development (NED) Plan is Alternative 4 (Setback Levee/Floodwall South of Valley Road), as this alternative provides the highest benefit-to-cost ratio and the highest net benefits. Alternatives 2 and 5 also are economically justified, with benefit-to-cost ratios of 1.37 and 1.25, respectively.

Table 15
Preliminary Economics of Alternative Plans

	Alternative Plans				
	1	**2**	**3**	**4**	**5**
Annualized Cost	$ 0	$ 74,000	$ 1,467,300	$ 334,700	$ 374,300
Total Annual Benefits	$ 0	$ 101,300	$ 619,300	$ 586,000	$ 468,000
Total Residual Damages	$ 780,500	$ 679,200	$ 172,900	$ 204,800	$ 312,500
Benefit-to-Cost Ratio	0.00	1.37	0.42	1.75	1.25
Net Benefits	$0	$ 27,300	$(848,000)	$ 251,300	$ 93,700

5.4 Non-structural Features Analysis of Alternative 4

Twelve residential structures and the Township's wastewater treatment plant are not protected by the preliminary NED plan (Alternative 4). Low opening elevations of ten of the twelve residential structures are located below the 100 year floodplain. The combined average annual damages of the ten residential structures amounts to approximately $67,500 at elevation +216.2 (the 100 year water surface elevation). Six of the ten structures would be candidates for floodproofing without raising the structures to a higher elevation. Utilities would be relocated to an attached utility shed placed at an elevation one foot higher than the 100 year water surface elevation (to elevation +217.2 NGVD), and basements (if any) would be filled with concrete. Four of the ten structures would need be raised out of the 100 year floodplain, as the first floor elevations of these structures are lower than +216.2 NGVD. Based on current New York District experience, the cost of these types of non-structural measures amounts to roughly $70,000 per residence for general floodproofing, and $135,000 per residence for floodproofing and raising.

Total costs of the non-structural measures amount to $960,000, and average annual costs are $87,250. The average annual cost of this project feature was calculated over a 30 year horizon (period adjusted), and includes contingencies and interest during construction. The benefit-to-cost ratio for the non-structural measures is 0.77 to 1, and net benefits are negative at $19,750. Because incremental economic justification will not be achieved, the non-structural element of Alternative 4 was eliminated from further consideration.

5.5 Selected Plan Optimization

Economic analysis was used to optimize the level of protection of the selected plan (Alternative 4). The plan would provide protection all structures in Reach 2, most structures in Reach 1, and would protect Valley Road during flood events. Costs were developed for the selected plan with alternative levee/floodwall heights of +215.2, +216.2, +216.9, and +217.6 NGVD. These levels of protection correspond to the 50-year, 100-year, 250-year, and 500-year recurrence intervals without risk and uncertainty adjustments. Costs for the levee/floodwall at the four levels of protection are shown in Table 16. Average annual costs were calculated based on the FY02 Federal discount rate of 5.625 percent and an analysis period of 50 years. Interest during construction was calculated assuming an 18 month construction period.

In Table 17, the costs and benefits of four levels of protection for the selected plan are compared. As shown in the table, the level of protection with the greatest net benefits was determined to be elevation +217.6 NGVD, which would provide protection from 500-year floods. This NED plan would provide average annual benefits of $685,500 with average annual costs estimated at $396,100. Annual net benefits are estimated to be approximately $289,400, and the benefit-cost ratio is anticipated to be 1.73 to 1.

Table 16
Costs of Alternative Levels of Protection – Selected Plan

	Probability of Exceedance			
	0.02	0.01	0.004	0.002
Levee/Floodwall Height (feet NGVD)	215.2	216.2	216.9	217.6
Construction Cost, LERRD, PED	4,715,700	5,019,600	5,336,400	5,759,800
Interest During Construction	199,000	211,800	225,100	243,000
Annualized First Cost	295,600	314,700	334,500	361,100
Annual O&M Cost	20,000	20,000	20,000	35,000
Total Annual Costs	315,600	334,700	354,500	396,100

Table 17
Benefits and Costs Comparison of Alternative Protection Levels

Exceedance Probability	Average Annual Damages Prevented	Reduced Annual FIA & Emgcy Costs	Reduced Traffic Delay Costs	Total Average Annual Benefits	Average Annual Costs*	Average Annual Net Benefits	BCR
0.02	352,200	13.0	32.4	397,600	315,600	82,000	1.26
0.01	511,600	25.8	48.2	585,600	334,700	250,900	1.75
0.004	562,600	28.0	49.7	640,300	354,500	285,800	1.81
0.002	605,300	28.5	51.7	685,500	396,100	289,400	1.73

Residual risk of the four levels of protection considered for Alternative 4, along with the without-project condition are shown in Table 18. The table shows the expected annual probability of each level of protection being exceeded, and the equivalent long-term risk of exceedance over 10, 20, 30, 40, and 50 years. Examination of equivalent long-term risk for the without-project condition shows that the probability of a damaging flood occurring over the next

10 years is about 89 percent (relative certainty) and increases to 100 percent (absolute certainty) over the next 40 years. These long-term risks are consistent with the flood risk that Long Hill Township currently faces. The table also shows a decrease in long-term risk for all levels of protection being considered for Alternative 4, though none of the levels of protection provide a complete elimination of risk. For example, the table shows that even the 500 year level of protection (protection from a flood with a 0.2 percent chance of occurring in any year) does not eliminate the risk of a damaging flood event. Over a 50 year period of analysis there is still a 9.5 percent chance that a damaging flood will occur with a 500 year level of protection.

Table 18
Residual Risks of Existing Conditions and Alternative Protection Levels

	Expected Annual Probability of Design Being Exceeded	Equivalent Long-Term Risk (Probability of Exceedance Over Time Period)				
		10 Years	20 Years	30 Years	40 Years	50 Years
Without-Project	.20	0.893	0.988	0.999	1.000	1.000
50 Year Levee	.02	0.183	0.332	0.455	0.554	0.636
100 Year Levee	.01	0.096	0.182	0.260	0.331	0.395
250 Year Levee	.004	0.039	0.077	0.113	0.148	0.182
500 Year Levee	.002	0.020	0.039	0.058	0.077	0.095

5.6 Selection of the Recommended Level of Protection

Although the NED plan could potentially be implemented, the NED plan does not have the support of the local sponsor. A change in the FEMA flood hazard mapping will hamper the Township's ability to regulate growth. In addition, the height of the levee/floodwall will be obtrusive at a maximum height above ground of 6.4 feet. The sponsor has identified a preferred level of protection at +216.2 NGVD (100-year level). At this elevation, the levee/floodwall would not block the viewshed (maximum height 5.4 feet), and additional development in the flood plain would not be expected.

Table 19 shows the economic differences between the two plans. Average annual benefits of the LPP are $99,900 lower than the NED plan, attributable to a corresponding reduction in residual damages of $99,900 when moving from the level of protection provided by the LPP to the level of protection provided by the NED Plan. Also shown in the table are differences in costs and average annual costs. The increase in construction costs of $740,200 when moving from the LPP to the NED Plan translates to an increase of $61,400 in average annual costs (discounted at 5.625 percent over 50 years after accounting for interest during construction and O&M costs). Additional net benefits of $38,500 would be attained if the NED Plan were selected over the LPP.

Table 19
Benefits and Costs Comparison of the LPP and NED Plan

Plan	Average Annual Benefits	Average Annual Residual Damages	Construction Costs	Average Annual Costs*	Average Annual Net Benefits	BCR
LPP	585,600	194,900	5,019,600	334,700	250,900	1.75
NED	685,500	95,000	5,759,800	396,100	289,400	1.73
Difference:	-99,900	99,900	-740,200	-61,400	-38,500	-0.02

Differences in level of protection and residual risk between the LPP and NED Plan are shown in Table 20. As would be expected, the table shows a reduction in risk when moving from the LPP level of protection to the NED Plan level of protection. For any given 10 year period, the probability of incurring a damaging flood with the NED Plan in place is 2 percent. The residual risk of a damaging event being incurred with the LPP in place increases to 9.6 percent over the same time period. Were the NED Plan constructed, the risk of incurring a damaging flood event over a 50 year period would be 9.5 percent. Residual risks over 50 years increases to 39.5 percent with the LPP in place.

Table 20
Level of Protection and Residual Risk Comparison of the LPP and NED Plan

	Expected Annual Probability of Design Being Exceeded	Equivalent Long-Term Risk (Probability of Exceedance Over Time Period)				
		10 Years	20 Years	30 Years	40 Years	50 Years
LPP	.01	0.096	0.182	0.260	0.331	0.395
NED	.002	0.020	0.039	0.058	0.077	0.095
Decrease in Residual Risk from LPP to NED Plan		0.076	0.143	0.202	0.254	0.300

The sponsor's selection of a locally preferred plan (LPP) over the NED plan is permitted under guidance stated in *Planning Guidance Notebook* (ER-1105-2-100, 22 April 2000). The residual risk of the LPP is acceptable to the Sponsor, and the LPP provides greater net benefits than the smaller scale, 50-year level of protection plan.

6. THE RECOMMENDED PLAN

The recommended plan will provide flood damage reduction up to elevation +216.2 for events with an exceedance probability of approximately 1 percent (100-year event). The plan consists of one levee/floodwall construction with two sluice gate closure structures on the western side of the Township and a sluice gate closure structure and a limited road raising on the eastern side of Township. The alignment of the line of protection was refined based on physical, environmental, and economic criteria. The optimal alignment was identified by:

- Avoiding and minimizing adverse effects on study area wetlands,
- Following high ground to the extent possible to minimize floodwall/levee costs, and
- Protecting flood-prone structures, which are located in high-density concentrations.

6.1 Economics of the Recommended Plan

A detailed cost estimate was developed for the selected plan using the Microcomputer Aided Cost Engineering System (MCAES) program. Project implementation costs include: pre-construction engineering and design (PED); real estate acquisition; project construction; construction management / supervision and administration (S&A); wetlands mitigation; cultural mitigation; escalation; and contingencies. A summary of the cost estimate for the selected plan is provided in Table 21. The change in costs for Plan 4 from those shown in the evaluation of alternatives reflect the final feasibility level design and MCACES cost estimate prepared for the selected plan (the detailed MCACES cost estimate is included in the Cost Engineering Appendix). The costs of the selected flood damage reduction plan and mitigation plan are summarized below.

Table 21
MCACES Cost Estimate – Locally Preferred Plan

Item	Cost	Contingencies	Total Cost
01 Lands & Damages	324,400	81,100	405,500[3]
02 Roadway Relocations	163,700	40,900	204,600
03 Mobilization & Site Prep	234,000	58,400	292,400
06 Wetlands Mitigation	325,600	81,400	407,000[4]
11 Levees and Floodwalls	1,579,300	394,900	1,974,200
15 Tributary Closures	437,600	109,400	547,000
30 Engineering and Design	750,000	187,500	937,500
31 Construction Management	300,000	75,000	375,000
Total Cost of LPP	4,114,600	1,028,600	5,143,200

6.1.1 Interest During Construction

Interest during construction (IDC) was calculated to account for the cost of capital during the construction period prior to the realization of project benefits. Construction costs were separated into two categories for the IDC analysis: initial costs and other construction costs. Initial costs included PED, which was assumed to be incurred at the inception (prior cost) of the 18-month

[3] Includes $119,700 for NJDEP compensatory mitigation real estate requirements, which are not considered part of Total Project Costs.
[4] Includes $203,250 for NJDEP compensatory mitigation construction costs, which are not considered part of Total Project Costs.

construction period. Real Estate costs were assumed to be incurred over the first six months of the 18 month period (see implementation schedule in the Feasibility Report). Construction costs, which includes tributary closure structures, floodwall / levee construction, road closure structures and S&A, were assumed to be distributed evenly across the 12 month construction period (again, see implementation schedule). Project costs were amortized over the expected period of project construction (12 months) at an interest rate of 5.625 percent. It was assumed that all payments were incurred mid-month. Table 22 shows the IDC calculations for the recommended plan.

Table 22
Interest During Construction Calculation

Implementation Period	Funds Spent in Period	Months to Completion	Compound Interest Factor	Interest Amount
1	99,717	17.5	8.3%	8,284
2	99,717	16.5	7.8%	7,793
3	99,717	15.5	7.3%	7,304
4	99,717	14.5	6.8%	6,817
5	99,717	13.5	6.4%	6,332
6	99,717	12.5	5.9%	5,850
7	351,829	11.5	5.4%	18,944
8	351,829	10.5	4.9%	17,257
9	351,829	9.5	4.4%	15,578
10	351,829	8.5	4.0%	13,906
11	351,829	7.5	3.5%	12,242
12	351,829	6.5	3.0%	10,585
13	351,829	5.5	2.5%	8,936
14	351,829	4.5	2.1%	7,295
15	351,829	3.5	1.6%	5,661
16	351,829	2.5	1.1%	4,034
17	351,829	1.5	0.7%	2,415
18	351,829	0.5	0.2%	803

6.1.2 Annual Operation and Maintenance

Annual O&M costs include regular inspection of the floodwall, levee, and closure structures and levee. Maintenance costs include levee mowing and vegetation control, floodwall fence maintenance, and closure structure lubrication and cleaning. A conservative estimate of these costs was made by assuming that Long Hill Township would assign a general public works employee to inspection and maintenance tasks for one full day each week. At a competitive salary of $40,000 per year and an overhead cost of 150 percent, annual O&M costs would amount to approximately $20,000.

6.1.3 Project Economic Summary

Table 23 shows the project economic summary for the LPP. The plan has total average annual costs of $ 319,560, total average annual benefits of $576,600, a benefit-cost ratio of 1.8 to 1, and annual net benefits of $ 257,040.

Table 23
Project Economic Summary for the LPP
April 2003 Price Level, 5.625% Discount Rate
50 Year Period of Analysis

Costs	
Total Costs	$ 5,143,200
Less: NJDEP Compensatory Mitigation[5]	$ 322,950
Total Project Costs	$ 4,820,250
Interest During Construction[6]	$ 160,030
Total Investment Costs	**$ 4,980,280**
Annualized Investment Costs	$ 299,560
Annual Operations & Maintenance Costs	$ 20,000
Total Average Annual Costs	**$ 319,560**
Benefits	
Residential Damage Reduction	221,100
Non-Residential Damage Reduction	290,500
Emergency Savings	16,800
Transportation Cost Savings	48,200
Total Average Annual Benefits	**576,600**
Benefit to Cost Ratio	**1.80**
Net Benefits	**257,040**

6.2 Cost Sharing

The fully funded cost of the Project, escalated to the base year of 2007 is shown in Table 24. Table 25 displays the apportionment of cost sharing responsibilities between the Federal government and the non-Federal sponsor, NJDEP. The table includes costs associated with flood damage reduction features and environmental mitigation features. The total project first costs - including Lands, Easements, Rights-of-way, Relocations, and Disposal areas (LERRD) - are shared on a 65 percent basis by the Federal government and a 35 percent basis by the non-Federal partner. As indicated in Table 25, the Federal share of the entire project's total first cost

[5] See Section 6.15.1 of the DPR/EA for a discussion of mitigation requirements.
[6] Calculated on Total Project Costs, which are equal to Total Costs minus NJDEP compensatory mitigation costs.

is $3,534,213; the non-Federal share is $1,903,037. The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-Federal partner.

The non-Federal partner is responsible for all LERRD costs, mitigation costs for the State's required compensatory mitigation, which are not considered total project costs; and all O&M costs. The LERRD costs are applicable to the non-Federal share of the initial project costs. For example, the total project LERRD costs of $542,700 (total of Accounts 01 and 02 minus escalated real estate costs from the NJDEP Compensatory mitigation: $674,700 – $132,000) borne by the non-Federal partner are applicable to the $1,903,037 share of total initial non-Federal project costs.

Table 24
Fully Funded Cost Estimate – Selected Plan

Item	Cost	Contingencies	Escalation	Fully Funded Cost
01 Lands & Damages	324,400	81,100	41,500	447,000
02 Roadway Relocations	163,700	40,900	23,100	227,700
03 Mobilization & Site Prep	234,000	58,400	32,800	325,200
06 Wetlands Mitigation	325,600	81,400	47,400	454,400
11 Levees and Floodwalls	1,579,300	394,900	222,000	2,196,200
15 Tributary Closures	437,600	109,400	61,500	608,500
30 Engineering and Design	750,000	187,500	155,000	1,092,500
31 Construction Management	300,000	75,000	69,700	444,700
Total Cost of Selected plan	4,114,600	1,028,600	653,000	5,796,200
Less NJDEP Compensatory Mitigation Costs	258,360	64,590	36,000	358,950
Total Project Cost of Selected Plan	**3,856,240**	**964,010**	**617,000**	**5,437,250**

Table 25
Cost Apportionment: Federal and Non-Federal Responsibilities

Federal Project Cost (65%)	**$ 3,534,213**
Non-Federal Project Cost (35%)	
5% Cash	$ 271,863
LERRD	$ 674,661
Cash Balance	$ 956,513
Non-Federal Project Cost Total (35%)	**$ 1,903,037**
Total Project Cost (100%)	**$ 5,437,250**
Non-Federal Compensatory Mitigation Cost	$ 358,950
Total Cost	**$ 5,796,200**

6.2.1 Application of Passaic River Wetlands Bank Credit

The New Jersey Department of Environmental Protection (NJDEP), as non-Federal sponsor has indicated via a letter dated 16 April 2003 (presented in Section 9 of this Feasibility Report) that it intends to use credits available in the Passaic River Wetlands Bank for the Upper Passaic River and Tributaries, Long Hill, New Jersey project. The credit is applicable to this project as per Section 101 (a)(18)(C) of the Water Resources Development Act of 1990 (Public Law 101-640) as amended by Section 102(p) of the Water Resources Development Act of 1992 (Public Law 102-580).

The NJDEP currently has sufficient approved credit in the Passaic River Wetlands Bank to apply to the Upper Passaic River and Tributaries, Long Hill, New Jersey project. It should be noted that the costs presented are estimated and that actual costs and credits will be determined based upon financial accounting as stipulated in the construction Project Cooperation Agreement that will be executed with the NJDEP prior to actual construction of the recommended plan. The cost apportionment for the project including this credit is shown in Table 26 below.

Table 26
Cost Apportionment Federal and Non-Federal Responsibilities
Including Wetlands Bank Credit

Federal Project Cost (65% plus credit)	**$ 4,490,726**
Non-Federal Cost (35% less credit)	
5% Cash	$ 271,863
LERRD	$ 674,661
Cash Balance	$0
Non-Federal Project Cost Total (35% Less Credit)	**$ 946,254**
Total Project Cost	**$ 5,437,250**
Non-Federal Compensatory Mitigation Cost	$ 358,950
Total Cost	**$ 5,796,200**