

REPORT OF FINDINGS FOR RAHWAY RIVER BASIN (FLUVIAL), NEW JERSEY



September 2025



**US Army Corps
of Engineers®**
New York District

New Jersey Department
of Environmental Protection



Contents

1. INTRODUCTION	1
1.1. Background and Study Purpose	1
1.2. Study Authority	2
1.3. Study Sponsor	3
1.4. Study Area	3
1.5. Previous Studies	5
2. FLOOD RISK ASSESSMENT	8
2.1. Existing Conditions	8
2.1.1. Climate	8
2.1.2. Annual (Daily) and Monthly Precipitation	8
2.1.3. Storm Types	8
2.1.4. Past Storms	9
2.2. Land Use Categories	13
2.2.1. Township of Cranford/Upstream	13
2.2.2. City of Rahway/Robinson's Branch	13
2.3. Regulated Environmental Resources	13
2.3.1. Surface Water Resources	13
2.3.2. Wetlands	15
2.3.3. Vernal Habitat	16
2.4. Riparian Zone	17
2.4.1. Essential Fish Habitat	18
2.4.2. Threatened and Endangered Species	19
2.4.3. New Jersey Green Acres Properties	20
2.5. HTRW	22
2.6. Cultural Resources	23
3. HYDROLOGIC ANALYSIS	27
4. HYDRAULIC ANALYSIS	27
5. PLAN FORMULATION	28
5.1. USACE Planning Process	28

5.2.	Scoping	29
5.2.1.	Period of Analysis	29
5.2.2.	Problems and Opportunities	29
5.2.3.	Planning Objectives	30
5.2.4.	Planning Constraints	30
5.2.5.	Planning Considerations	30
5.3.	Management Measures	31
5.3.1.	Structural Measures	31
5.3.2.	Nonstructural Measures	31
5.3.3.	Natural and Nature-Based Features (NNBF)	32
5.3.4.	Measures Screening	33
5.3.5.	Plan Formulation Strategy	33
5.4.	Description of Alternatives	33
5.4.1.	Alternative 1: No Action	34
5.4.2.	Alternative 2: Upstream Detention	34
5.4.3.	Alternative 3: Combination Plan	37
5.4.4.	Alternative 4: Nonstructural Plan	45
5.4.5.	Alternative 5: Lenape Park Plan	47
5.4.6.	Other Alternatives Considered	49
5.5.	Plan Evaluation	53
5.5.1.	Contributions to the P&G Accounts	54
5.5.2.	Cultural Resource Considerations	67
5.5.3.	HTRW Considerations	68
5.5.4.	Real Estate Considerations	69
5.5.5.	Economic Analysis	73
5.6.	Future Without Project (FWOP) Results	77
5.7.	Comparison with Historical Damage	77
5.8.	Other Social Effects (OSE)	80
5.9.	Future With Project Results	82
5.10.	Alternative Cost Development	82
5.11.	Alternative Results	87
5.12.	Plan Comparison	88
5.12.1.	Contributions to the 1983 Principles & Guidelines (1983 P&G) Criteria	88
5.12.2.	Identification of the Six Plans - (ER-1105-2-103)	90
6.	AGENCY/PUBLIC COORDINATION	92
6.1.	Agency Coordination	92
6.2.	Tribal Consultation	94

7. IMPLEMENTATION/RECOMMENDATIONS	95
7.1. Potential Independent Local Plans	95
7.2. Other Funding Programs	100
7.2.1. USACE Programs	100
7.2.2. Non-USACE Federal Programs	101
7.2.3. New Jersey State Programs	101
8. REFERENCES	103
9. APPENDICES	104
10. LIST OF PREPARERS	104

LIST OF TABLES

TABLE 1: ESSENTIAL FISH HABITAT SPECIES	18
TABLE 2: STATE ENDANGERED, THREATENED AND SPECIAL CONCERN SPECIES POTENTIALLY OCCURRING WITHIN THE STUDY AREA	20
TABLE 3: GREEN ACRES ENCUMBERED PARKS WITHIN STUDY AREA	21
TABLE 4: INITIAL ARRAY OF ALTERNATIVES	33
TABLE 5: MEASURES INCLUDED IN EACH ALTERNATIVE	34
TABLE 6: MEASURES CONSIDERED AS PART OF COMBINATION PLAN	38
TABLE 7: NUMBER OF STRUCTURES IDENTIFIED IN EACH NONSTRUCTURAL ITERATION	45
TABLE 8: PROPOSED NON-STRUCTURAL TREATMENTS BY MUNICIPALITY	45
TABLE 9: BENEFITS AND COSTS FOR ALTERNATIVE 5: 2016 REPORT	49
TABLE 10: UPDATED BENEFITS AND COSTS FOR ALTERNATIVE 5	49
TABLE 11: REGIONAL ECONOMIC DEVELOPMENT IMPACTS ALTERNATIVES 2 AND 3	55
TABLE 12: ALTERNATIVE 4: REGIONAL ECONOMIC DEVELOPMENT IMPACTS	56
TABLE 13: SUMMARY OF EFFECTS OF ALTERNATIVES TO ENVIRONMENTAL RESOURCES	58
TABLE 14: SUMMARY OF EFFECTS TO GREEN ACRES AND CULTURAL RESOURCES	59
TABLE 15: SUMMARY OF CONTRIBUTION OF ALTERNATIVES TO THE EQ ACCOUNT	59
TABLE 16: ALTERNATIVE EFFECTS ON AND MITIGATION REQUIREMENTS FOR SURFACE WATER RESOURCES	61
TABLE 17: ALTERNATIVE EFFECTS ON WETLAND RESOURCES	63
TABLE 18: ALTERNATIVE EFFECTS ON AND MITIGATION REQUIREMENTS FOR VERNAL HABITAT	64
TABLE 19 EFFECTS AND MITIGATION OF REGULATED RIPARIAN ZONE	64
TABLE 20: ALTERNATIVES EFFECTS ON AND MITIGATION FOR ESSENTIAL FISH HABITAT	65
TABLE 21: ALTERNATIVE EFFECTS ON AND MITIGATION FOR FEDERAL AND STATE LISTED SPECIES	65
TABLE 22: ALTERNATIVES EFFECTS ON AND MITIGATION FOR GREEN ACRES ENCUMBERED LANDS	66
TABLE 23: CULTURAL RESOURCE IMPACTS	67
TABLE 24: ALTERNATIVE 2 UPSTREAM DETENTION PLAN REAL ESTATE REQUIREMENTS	69
TABLE 25: ALTERNATIVE 3 COMBINATION PLAN REAL ESTATE REQUIREMENTS	70
TABLE 26: ALTERNATIVE 4 REAL ESTATE NONSTRUCTURAL SUMMARY FOR 10 YEAR STORM	71

TABLE 27: ALTERNATIVE 4 REAL ESTATE NONSTRUCTURAL SUMMARY FOR 100 YEAR STORM	72
TABLE 28: ALTERNATIVE 5 LENAPE PARK PLAN REAL ESTATE SUMMARY	73
TABLE 29: SUMMARY OF DAMAGEABLE ELEMENTS BY MODEL AREA	75
TABLE 30: IDENTIFY SOCIO-ECONOMIC VULNERABLE CENSUS TRACTS	80
TABLE 31: 32ALTERNATIVE 2 UPSTREAM DETENTION TOTAL PROJECT COST SUMMARY	83
TABLE 33: ALTERNATIVE 3 COMBINATION PLAN TOTAL PROJECT COST SUMMARY	84
TABLE 34: ALTERNATIVE 4A,4C,4E NONSTRUCTURAL, 10 YR PLAN TOTAL PROJECT COST SUMMARY	85
TABLE 35: ALTERNATIVE 4B, 4D, 4F NONSTRUCTURAL, 100 YR PLAN TOTAL PROJECT COST SUMMARY	86
TABLE 36: ANNUAL COSTS/BENEFITS, NET BENEFITS, AND BCRS FOR EACH ALTERNATIVE	87
TABLE 37: EFFECTIVENESS OF ALTERNATIVES	89
TABLE 38: IDENTIFICATION OF THE SIX PLANS	91
TABLE 39: CONTRIBUTIONS TO P&G CRITERIA	91
TABLE 40: FINAL ARRAY OF ALTERNATIVES: COMPARISON P&G ACCOUNTS	91
TABLE 41: LIST OF CULTURAL RESOURCES CONSULTING PARTIES	93
TABLE 42: RECOMMENDATIONS SUMMARY FOR TARGET AREAS	96
TABLE 43: ENVIRONMENTAL, CULTURAL RESOURCE AND HTRW CONSIDERATIONS FOR INDEPENDENT LOCAL PLANS	99
TABLE 44: LIST OF REPORT PREPARERS	104

LIST OF FIGURES

FIGURE 1: RAHWAY FLUVIAL STUDY AREA.....	1
FIGURE 2: RAHWAY RIVER BASIN STUDY AREA.....	4
FIGURE 3: IDA HIGH WATER MARK ON STRUCTURE; CITY OF RAHWAY	11
FIGURE 4: VERNAL HABITAT WITHIN THE STUDY AREA	17
FIGURE 5: HISTORIC PROPERTIES IN THE STUDY AREA	25
FIGURE 6: HISTORIC DISTRICTS IN THE RAHWAY RIVER BASIN STUDY AREA	26
FIGURE 7: USACE RISK-INFORMED PLANNING PROCESS (FROM IWR 2017).....	29
FIGURE 8: LOCATION OF ALTERNATIVE 2 – UPSTREAM DETENTION	36
FIGURE 9: DETAILED OUTLINE OF DRY DETENTION BASIN	37
FIGURE 10: LOCATIONS OF EACH COMBINATION PLAN MEASURE.....	39
FIGURE 11: COMBINATION PLAN MEASURES 1 AND 2	40
FIGURE 12: COMBINATION PLAN MEASURES 3 AND 4	41
FIGURE 13: COMBINATION PLAN MEASURE 5.....	42
FIGURE 14: COMBINATION PLAN MEASURE 6.....	43
FIGURE 15: COMBINATION PLAN MEASURES 7, 8, AND 9.....	44
FIGURE 16: ROBINSON'S BRANCH (COMPOUND)	46
FIGURE 17: CRANFORD UPSTREAM	46
FIGURE 18: EAST BRANCH	47
FIGURE 19: ALTERNATIVE #5 - LENAPE PARK DETENTION BASIN & CHANNEL IMPROVEMENTS	48
FIGURE 20: RESIDENT AREA OF CONCERN: GALLOWS HILL BROOK	51
FIGURE 21: LOCATION OF PUMPKIN PATCH BROOK	53
FIGURE 22: RAHWAY FLUVIAL STRUCTURE INVENTORY.....	75
FIGURE 23: AREAS WITH MOST DAMAGE IN FWOP CONDITION.....	77
FIGURE 24: CRANFORD UPSTREAM DAMAGE LOSS OVER TIME.....	78
FIGURE 25: CRANFORD UPSTREAM DAMAGE LOSS OVER TIME BY MUNICIPALITIES.....	79

FIGURE 26: CRANFORD UPSTREAM -TOTAL CLAIM PAYMENT (\$) BY CENSUS TRACTS (1975-2021)..... **ERROR!**
BOOKMARK NOT DEFINED.
FIGURE 27: LOCATION OF SOCIO-ECONOMIC CENSUS TRACTS 81
FIGURE 28: LOCATION OF TARGET AREAS..... 98

LIST OF ACRONYMS

ACM	Asbestos-containing material
AEP	Annual Exceedance Probability
ARA	Alternative Risk Analysis
CAP	Continuing Authorities Program
CDBG-DR	Community Development Block Grant Disaster Recovery
CFS	Cubic Feet per Second
CPI	Consumer Price Index
CRGIS	Cultural Resources GIS
CWA	Clean Water Act
CWCCIS	Civil Works Construction Cost Index System
District	United States Army Corps of Engineers, New York District
EFH	Essential Fish Habitat
EQ	Environmental Quality
ER	Engineer Regulation
FEMA	Federal Emergency Management Agency
FFE	First Floor Elevation
FMA	Flood Mitigation Assistance
FPMS	Floodplain Management Services
FRM	Flood Risk Management
FWP	Future With Project
FWOP	Future Without Project
HMGP	Hazard Mitigation Grant Program
HQUSACE	United States Army Corps of Engineers, Headquarters
HTRW	Hazardous, Toxic and Radioactive Waste
HUD	U.S. Department of Housing and Urban Development
IWR	Institute of Water Resources

LBP	Lead-based paint
PAR	Planning Aid Report
PDT	Project Delivery Team
P&G	1983 Principles & Guidelines
PR&G	2013 Principles, Requirements & Guidelines
MPE	Moderate Positive Effect
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAE	United States Army Corps of Engineers, New England District
NED	National Economic Development
NEPA	National Environmental Policy Act
NFS	Non-federal sponsor
NHPA	National Historic Preservation Act (NHPA)
NJDEP	New Jersey Department of Environmental Protection
NJFHACA	New Jersey Flood Hazard Area Control Act
NJFWWPA	New Jersey Freshwater Wetlands Protection Act
NJOEM	New Jersey Office of Emergency Management
NJSHPO	New Jersey State Historic Preservation Office
N/LTSM	Negligible/Less Than Significant
NNBF	Natural and Nature-Based Features
NPE	Negligible Positive Effect
NPS	National Park Service
NRHP	National Register of Historic Places
NSI	National Structure Inventory
OSE	Other Social Effects
PAR	Planning Aid Report
PAS	Planning Assistance to States
PCB	Polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RED	Regional Economic Development
RMC	Risk Management Center
SPE	Significant Positive Effect
SU	Significant and Unavoidable

TPCS	Total Project Cost Summary
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife
WRDA	Water Resources Development Act

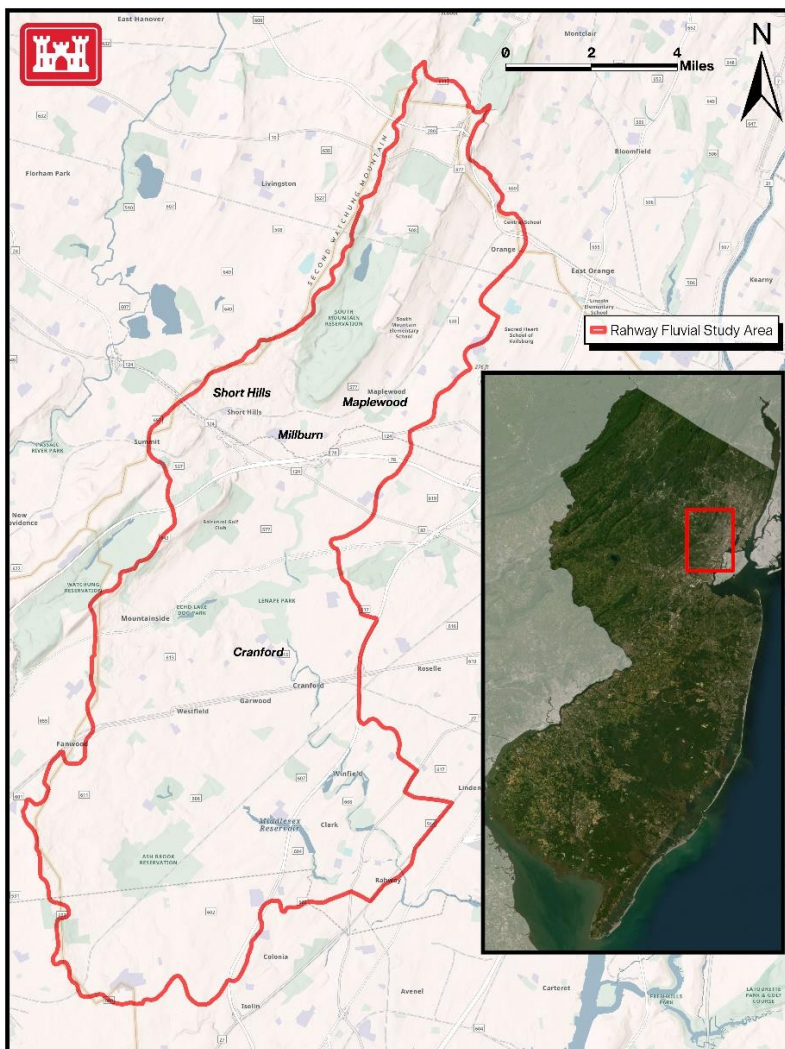
1. INTRODUCTION

1.1. BACKGROUND AND STUDY PURPOSE

This Draft Report of Findings presents the results of the Rahway River Basin, New Jersey, Flood Risk Management Feasibility Study, completed by the United States Army Corps of Engineers, New York District (USACE). The report recommends potential measures and future efforts for areas of the Rahway River Basin that are vulnerable to flooding.

The Rahway River Basin is located in northeastern New Jersey, within the Greater New York City metropolitan area. It encompasses approximately 15 percent of Essex County, 35 percent of Union County, and 10 percent of Middlesex County. The basin is roughly crescent shaped and 83.3 square miles (53,300 acres) in area. The study area includes the portion of the river basin shown in Figure 1: Rahway Fluvial Study area

FIGURE 1: RAHWAY FLUVIAL STUDY AREA



After exploring a range of flood risk management (FRM) alternatives, the feasibility study concluded that a single, large-scale solution implemented by USACE would not best manage flood risk in the Rahway River Basin. A better solution would be to use a variety of federal and state programs to implement a suite of targeted, local solutions in the basin. Ideal locations for the targeted solutions, and federal and state programs that could be used to implement them, are presented in the last chapter of this report.

1.2. STUDY AUTHORITY

USACE prepared this report in response to Section 336 of the Water Resources Development Act of 2020.

USACE previously studied the feasibility of flood risk management in the Rahway River Basin, in response to a House resolution dated 24 March 1998:

“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, AND OTHER PERTINENT REPORTS 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 RELATED PURPOSES.”

The previous study, which began in 2002, released a Draft Report in 2016, which recommended modifying the existing Orange Reservoir dam in the basin as the Tentatively Selected Plan. To address life safety concerns, in 2018 the study was transferred from New York District to New England District, the Dam Safety Production Center for the North Atlantic Division of USACE. Following New England District’s analysis, the study was terminated because none of the alternatives were found to be economically justified or acceptable to the local communities. Section 1.5 of this report provides more detail on the terminated study.

Congress authorized USACE to resume the study in Section 336 of the Water Resources Development Act of 2020:

“THE SECRETARY SHALL:

- (1) NULLIFY THE DETERMINATION OF THE NORTH ATLANTIC DIVISION OF THE CORPS OF ENGINEERS THAT FURTHER ACTIVITIES TO CARRY OUT THE FEASIBILITY STUDY FOR A PROJECT FOR FLOOD RISK MANAGEMENT, RAHWAY, NEW JERSEY, AUTHORIZED BY THE RESOLUTION OF THE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE OF THE HOUSE OF REPRESENTATIVES ADOPTED ON MARCH 24, 1998 (DOCKET NUMBER 2548), IS NOT WARRANTED;*

- (2) IDENTIFY AN ACCEPTABLE ALTERNATIVE TO THE PROJECT DESCRIBED IN PARAGRAPH (1) THAT COULD RECEIVE FEDERAL SUPPORT; AND*
- (3) CARRY OUT, AND EXPEDITE THE COMPLETION OF, A FEASIBILITY STUDY FOR THE ACCEPTABLE ALTERNATIVE IDENTIFIED UNDER PARAGRAPH (2).”*

This report is an interim response to the above authority

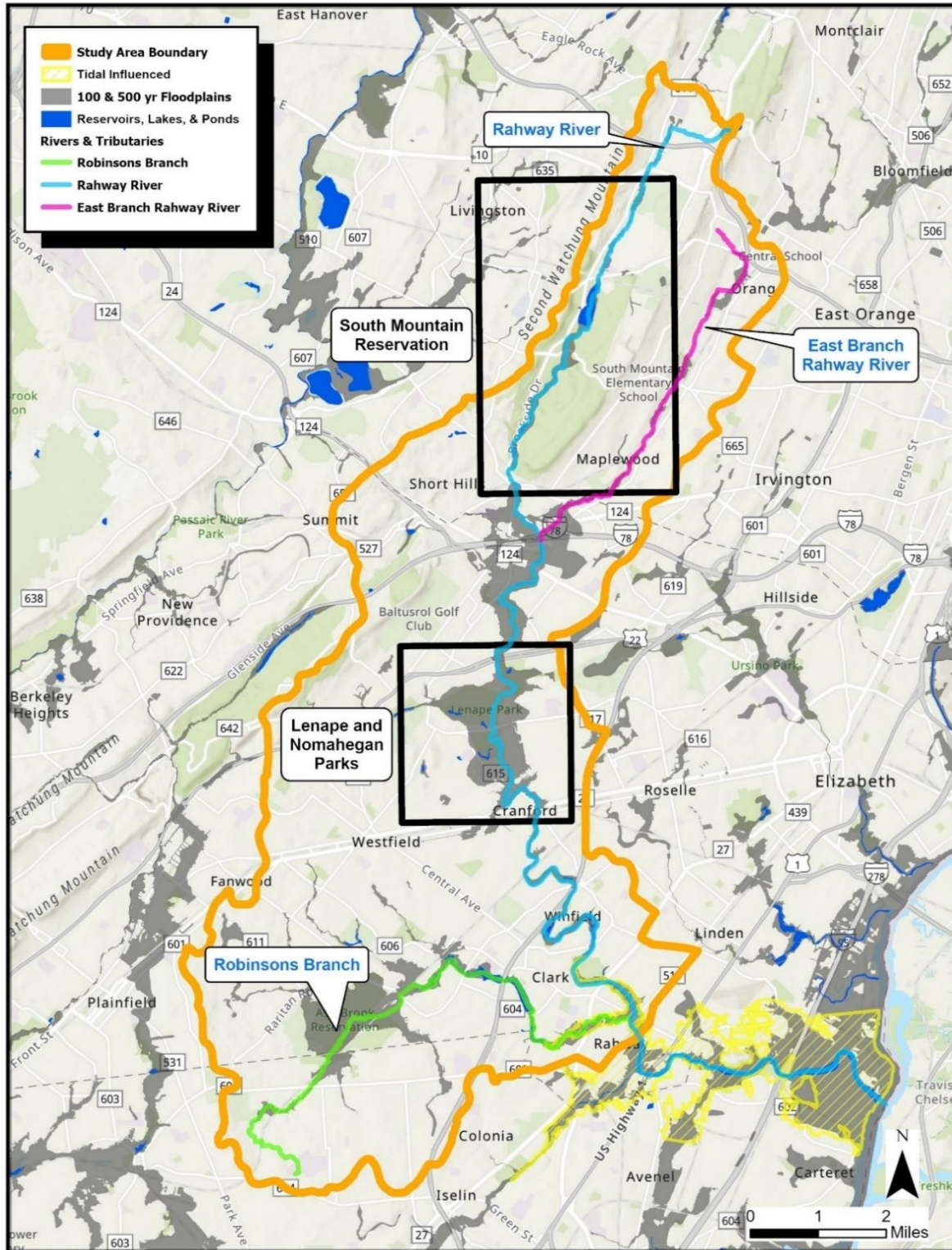
1.3. STUDY SPONSOR

The New Jersey Department of Environmental Protection (NJDEP) is the non-federal sponsor (NFS) for this study.

1.4. STUDY AREA

The study area includes the non-tidally influenced (fluvial) portion of the Rahway River basin. While focused on the fluvial Rahway River basin, because the Rahway River flows into the estuarine Arthur Kill, the study conducts a fluvial-tidal correlation to assess potential backwater elevations due to a tide surge during fluvial events. The study accounts for the interaction of fluvial and tidal conditions within the compound flood zone, assessing how flood dynamics differ across the basin. The Rahway River has four main tributaries, or branches. The river’s headwaters, known as its West and East branches, both originate in West Orange. The West Branch flows south through the South Mountain Reservation and downtown Millburn. The East Branch flows south through South Orange and Maplewood. The West and East branches converge near Route 78 in Springfield to form the Rahway River Main Stem. Rahway River then flows south through the municipalities of Springfield, Union, Cranford, and Clark before reaching the City of Rahway. In Rahway, the river is first joined by Robinson’s Branch, which flows east from above the Ash Brook reservation, and then by the South Branch, which then flows northeast from Menlo Park. Past Rahway, the river flows east through Linden and Carteret before finally reaching the Arthur Kill, a north-south channel that connects Newark Bay to the north with the Raritan and Lower Bays of the New York and New Jersey Harbor to the south. Figure 2 below shows a map of the study area for the Rahway River Project.

FIGURE 2: RAHWAY RIVER BASIN STUDY AREA



1.5. PREVIOUS STUDIES

Many USACE reports have been produced for the Rahway River Basin. The four reports listed below are most significant regarding the evolution of this study and its focus on fluvial flooding.

Robinson's Branch of the Rahway River, Flood Control Study, General Reevaluation Report (GRR), July 1985

This GRR recommended a plan consisting of levees/floodwalls and channel modifications along the Rahway River and Robinson's Branch in the City of Rahway to provide flood risk management for the 1% annual chance of exceedance event. This project did not advance to construction due to lack of funding.

Section 905(b) Reconnaissance Study, Rahway & Woodbridge River Basins, July 1999

The purpose of the 905(b) Reconnaissance Study was to determine if there was a Federal Interest in flood risk management in the Rahway River Basin, beyond the geographic scope evaluated for the Robinson's Branch GRR. The Draft Reconnaissance Report summarized eleven prior reports completed within the basin since 1962 and identified two potential projects with positive net benefits and benefit-cost ratios (BCRs) above one. The first project was a system of levees, floodwalls, channel modifications, and interior drainage improvements along the Robinson's Branch, previously documented in the GRR referenced above. The second project located along the South Branch in the Township of Woodbridge, entailed re-grading the parking lot of a shopping center as an overland flow route. This did not advance to construction due to lack of sufficient damages in the project area necessary for economic justification of the project.

Rahway River Feasibility Study, Initial Screening of Flood Damage Reduction and Restoration Opportunities, September 2006

This report evaluated potential solutions to frequent flooding problems within the Rahway River Basin. The objectives of the report were three-fold:

- To assess flood risk management and environmental restoration needs within the Rahway River Basin;
- To screen flood risk management and environmental restoration opportunities for Federal Interest; and
- To recommend flood risk management and environmental restoration projects for more detailed study, as part of an overall Feasibility Study.

The existing flood risk management and aquatic ecosystem restoration needs were assessed by reviewing prior reports, evaluating flood damage claims filed under the Federal Emergency Management Agency's National Flood Insurance Program, conducting site visits, and discussing flooding concerns with local officials.

The identified flood problem areas were screened to determine which areas should be considered for Federal participation. The criteria for Federal participation included minimum stream discharges, minimum drainage area sizes, and an assessment of previously constructed flood risk management projects within the basin. A preliminary economic analysis was conducted for the flood risk management measures that passed the screening process, to

determine whether a damage area had the potential for economic justification. The without-project damages were estimated using a Hydrologic Engineering Center – Flood Damage Analysis (HEC-FDA) model, and likely economic feasibility was determined by comparing project costs to the without-project damages. It was anticipated during this initial screening that actual benefit-cost ratios would be calculated if the recommended projects were studied in greater detail.

The initial screening of flood risk management opportunities identified one flood risk management project with strong potential for economic feasibility within the Rahway River Basin. The project consisted of levees, floodwalls, and channel modifications along the Robinson's Branch in the City of Rahway and would likely have strong Federal interest. This project is the same as the one discussed above in the 1985 GRR and the 1999 Reconnaissance Study. A second potential flood risk management project was identified along the Rahway River mainstem in the Township of Cranford. Although this community currently has the Lenape Park Regional Stormwater Detention Basin and a series of low-level levees, the level of flood risk management of these projects has been estimated at or below the 2% annual chance of exceedance.

It was recommended that these two potential flood risk management projects be analyzed in greater detail as part of an overall Feasibility Study and that a benefit-cost analysis be performed. The Rahway River Basin, New Jersey feasibility efforts focused analysis on the Township of Cranford and the City of Rahway following the initial screening report.

Rahway River Basin, New Jersey Flood Risk Management Feasibility Study November 2016

Alternatives' analyses were completed in 2016, and a Draft Integrated Report and Environmental Impact Statement was released for public and agency review in November 2016. As part of this effort a set of nine alternatives were formulated and evaluated, including detention basins, channel modifications, dams, and various nonstructural measures. The report identified as the tentatively selected plan (TSP) the modification of the outlet structures of the Orange Reservoir Dam, channel modifications in Cranford and nonstructural measures along the Robinson's Branch in the City of Rahway.

Following the selection of the TSP, concerns were raised by the USACE Headquarters (HQUSACE) Risk Management Center (RMC) regarding life safety due to potential risk of dam failure because the plan included modification of the Orange Reservoir Dam which is over 100 years old. The concern was also due to the forecast-based operation of the dam since the forecast-based operation involves predicting future weather events and could pose challenge if forecasting is inaccurate, and dam does not perform as intended. In March 2018, the study was transferred from New York to New England District (NAE), because NAE is a Dam Safety Production Center qualified to evaluate the risk and policy requirements of dam modifications NAE evaluated five alternatives in addition to the TSP and a summary of these alternatives is provided below. Because none of the alternatives were found to be economically justified or acceptable to the local communities, the study was terminated in December of 2019.

1. Modification of Campbell Mill and Diamond Mill Ponds

In this alternative, both Campbell and Diamond Mill dams were modified to provide

storage in lieu of Orange Reservoir. Neither of these alternatives were determined to be economically justifiable for USACE recommendation ($BCR < 1.0$).

2. Three Dam Alternative

This alternative was suggested by the Mayors Council's consultant and would include three dams with proposed heights of 30, 40, and 40 feet. The protection provided by these dams was proposed in lieu of the Orange Reservoir Dam modification. NAE determined that three dams would not result in greater benefits than the Orange reservoir storage, nor would this alternative result in a $BCR > 1.0$ due to the construction & Operation, Maintenance, Repair and Rehabilitation (OMR&R) costs of three dams.

3. Two Dam Alternative

This alternative included just two of the dams from the second alternative, excluding the upstream most dam. The HEC-RAS model showed that two dams did not result in additional flood benefits and resulted in a BCR of 0.57.

4. (50') Dam Alternative

Intended to optimize the storage goal in alternatives #2 and #3 with one dam while minimizing costs and other impacts (road relocation & mitigation). The BCR for one 50' dam was 0.87 with a rough order of magnitude cost estimate of \$105M.

5. Channel improvements absent upstream storage

The Mayors Council requested modeling of the channel improvement without upstream storage in the event that the local community provided storage in some other capacity. This alternative was ruled out as the model showed minimal (within model error) flood reduction benefits. The model also predicted an increase in downstream water levels. Accordingly, no economic benefits or costs were developed for this alternative.

December 2020 Study Resumption and Current Effort

Following the release of the Water Resources Development Act (WRDA) of 2020, the termination issued by NAE was nullified and the USACE was directed to resume the study. In September 2021 a letter of intent was sent to the New York District by NJDEP to resume the study effort. HQUSACE approved the reactivation in September 2022.

As part of the new effort, a scoping charrette meeting was held on the 23-24 of May 2023 in Cranford, NJ to determine a federal interest and path forward. The first day consisted of a site visit, followed by formal presentations by New York District team members and representatives from the Rahway River Mayors' Council. The second day consisted of a breakout technical/panel discussion on possible alternatives to move forward with the study. The event was attended by representatives from HQUSACE (virtual), USACE North Atlantic Division, New York District, NJDEP, the Rahway River Mayors' Council, and staffers for Senator Booker and Congresswoman Sherrill.

During Day Two breakout sessions, which were held both in-person and online, input received from stakeholders and town officials on a wide variety of measures, including nonstructural, levees/floodwalls, upstream storage, and channel modifications, was documented. The outcomes of this charrette informed the alternatives evaluated in this report.

The current effort includes formulation and analysis of five alternatives, including structural and nonstructural, detailed later in this report. As part of this analysis, both the hydrologic and

hydraulic and economic modeling extents were increased from their footprints in 2016. The details on the current modeling results, economic data, and study recommendations are summarized in the remainder of the report and appendices.

2. FLOOD RISK ASSESSMENT

2.1. EXISTING CONDITIONS

Existing conditions serve as the basis for the characterization of problem identification and projection of future without project conditions.

2.1.1. CLIMATE

The climate of the Rahway River basin is characteristic of the Middle Atlantic Seaboard. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate in both temperature and snowfall. The summers are moderate, with hot sultry weather in mid-summer and frequent thunderstorms. Rainfall is moderate, and well-distributed throughout the year. The relative humidity is high. The most likely scenario for the future without project condition would be the continuation of existing environmental conditions and trends within the study area.

2.1.2. ANNUAL (DAILY) AND MONTHLY PRECIPITATION

The mean annual precipitation in the Rahway River Watershed is approximately 50.94 inches reported by the 1971-2000 Monthly Normals for the Cranford, New Jersey Station. The observed highest daily value at this station was 9.76 inches (17 September 1999). The monthly extremes were 13.96 inches in July 1975 and 0.45 inches in November 1976. The distribution of precipitation throughout the years is fairly uniform with highest amount occurring during the summer months. The mean annual snowfall is 20.00 inches at Cranford, New Jersey.

2.1.3. STORM TYPES

The storms which occur over the northeastern states have their origins in or near the North Atlantic Ocean and may be classified as: extratropical storms - which include thunderstorms, and cyclonic (transcontinental) storms- and tropical storms, which include the West Indies hurricanes. There are also nor'easter storms or extratropical storms, which develop due to rapid convective circulation when a tropical marine air mass is lifted suddenly on contact with hills and mountainous terrain, causing heavy rains, usually in the summer and fall season.

Thunderstorms, resulting from rapid convective circulation, usually in July, are limited in extent and cause local flooding on flash flood prone streams. A cyclonic storm, due to its transcontinental air mass movement with attendant "highs" and "lows," usually occurs in the winter or early spring, and is a potential flood-producer over large areas because of its widespread extent. The West Indies hurricanes of tropical origin proceed northward along the coastal areas, accompanied by extremely violent winds and torrential rains of several days' duration.

A review of storms which have occurred in the northeastern states reveals that the Rahway River basin is located in the center of the North Atlantic storm belt.

2.1.4. PAST STORMS

Some of the notable storms which have caused flood conditions in the basin occurred on or between the following dates: 20-24 September 1882, 30 July 1889, 31 July 1901, 25-26 August 1933, March 1936, 17-25 July 1938, 6-8 August 1938, 17-21 September 1938, 9-16 August 1942, 20 May 1943, 18 September 1945, 28 June 1946, 23-25 July 1946, 8 November 1947, August 1955, October 1955, September 1960, 12-13 March 1962, 21-22 September 1966, 28-29 May 1968, August 1969, 26-28 August 1971, 13 September 1971, 2-3 August 1973, July 1975, November 1977, January 1979, June 1992, October 1996, July 1997, Tropical Storm Floyd in September 1999, 15-16 April 2007, Tropical Storm Irene in 27-28 August 2011, Hurricane Ida in August 2021, and most recently flooding caused by a storm on July 14, 2025.

2.1.4.1. TROPICAL STORM FLOYD (1999)

The eye of Floyd made landfall on September 15th near Cape Fear, North Carolina with Category 2 winds of 105 mph. After crossing eastern North Carolina and Virginia, Floyd weakened to a tropical storm. Its center then moved offshore along the coasts of the Delmarva Peninsula and New Jersey. On September 16th the center of Tropical Storm Floyd moved over Long Island, New York, (making landfall again roughly at the Queens-Nassau counties border) and New England, where it became extratropical.

Precipitation from the storm preceded its center reaching the New York City area on September 15th. Rainfall totals from Floyd were as high as 12 to 16 inches over portions of New Jersey, 4 to 8 inches over southeastern New York, and up to 11 inches over portions of New England. The inland flooding from Floyd was a disaster of immense proportions in the Eastern United States, particularly in North Carolina. The 56 USA direct deaths due to Floyd were the largest hurricane death toll since Agnes caused the deaths of 122 people in 1972. Total USA damage estimates ranged from three to over six billion dollars.

Floyd resulted in new flood peaks of record at sixty or more stream gages within the portions of New Jersey and New York contained by New York District's civil works boundaries. Within the Rahway River basin, the total rainfall at the Township of Cranford was 10.82 inches. Tropical Storm Floyd produced a peak flow at the Springfield USGS gage of 7990 cfs and a peak flow of 5590 cfs at the City of Rahway USGS gage.

2.1.4.2. APRIL 15-16, 2007 NOR'EASTER

The April 15-16, 2007 nor'easter dropped about three to ten inches of rain on the watersheds within the New York – New Jersey metropolitan area between the early morning of Sunday, April 15 2007 and the early afternoon of Monday, April 16th, 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey. This storm produced the worst flooding in the Raritan River basin since Tropical Storm Floyd during September 1999. Bound Brook and Manville were once again inundated as were communities on the other side of the Raritan River in Middlesex County. Lincoln Park in the Passaic Basin also saw flooding from the storm.

The approximate time distribution of the total rainfall of the April 15-16, 2007 nor'easter was an average of 7 to 7 ½ inches between about 2 a.m. on Sunday, April 15 to 2 p.m. on Monday, April 16, 2007, with most within the 24 hours beginning at 2 a.m. on Sunday the 15th. Greatest hourly amounts were from 0.6 to 0.8 inches at about 2 p.m. on Sunday, April 15, 2007.

Unlike Tropical Storm Floyd, which broke the summer 1999 drought and fell on dry ground, the April 2007 nor'easter caused as greater flooding because it was preceded by the smaller March 1-2 and April 12-13, 2007 storms, which created saturated ground conditions.

Within the Rahway River basin, the total rainfall at the Township of Cranford was 6.47 inches. This nor'easter produced a peak flow at the Springfield USGS gage of 5540 cfs and a peak flow of 4910 cfs at the Rahway USGS gage.

2.1.4.3. TROPICAL STORM IRENE (2011)

On 22 August 2011 Tropical Storm Irene made landfall near Punta Santiago, Humacao, Puerto Rico, with estimated sustained winds of 70 mph. Just after its initial landfall, Irene was upgraded to a Category 1 hurricane, the first of the 2011 Atlantic hurricane season.

Moving erratically through the southeast Bahamas over very warm waters, Irene quickly expanded as its outflow aloft became very well established. The cyclone intensified into a Category 3 major hurricane. Early on 27 August, Irene weakened to a Category 1 hurricane as it approached the Outer Banks of North Carolina. At 7:30 am EDT the same day, Irene made landfall near Cape Lookout, on North Carolina's Outer Banks, with winds of 85 mph. Later on 27 August, Irene re-emerged into the Atlantic near the southern end of the Chesapeake Bay in Virginia. Shortly before sunrise, at about 05:35 EDT on 28 August, Irene made a second landfall at the Little Egg Inlet on the New Jersey shore with winds of 75 mph, and soon after moved over water again. Hours later, Irene weakened to a tropical storm with winds of 65 mph near New York City. Following its 28 August New York landfall, Irene moved northeast over New England, becoming post-tropical over the state of Maine at 11:00 pm EDT.

Significant damages occurred in North and Central New Jersey, where flooding was widespread. Severe river flooding took place on the Raritan, Millstone, Rockaway, Rahway, Delaware and Passaic Rivers due to record rainfall. The highest rainfall recorded in New Jersey was in Freehold (11.27 inches), followed by Jefferson (10.54 inches) and Wayne (10 inches). The flooding effected roads, including the heavily used Interstate 287 in Boonton where the northbound shoulder collapsed from the force of the Rockaway River, and the Garden State Parkway (GSP), which flooded in the Township of Cranford from the Rahway River and in Toms River near GSP Exit 98. Along the Hudson River, in parts of Jersey City and Hoboken, flood waters rose as much as five feet and the north tube of the Holland Tunnel was briefly closed. In total, ten deaths within the state are attributable to the storm.

The Rahway River Watershed Mayors' Council, a local stakeholder group, made a statement reporting that Tropical Storm Irene impacted 1,600 structures in Cranford, with 300 structures receiving damage to the main floor, and \$16.5 million in damages to residences, plus \$4 million in damages to two schools. The Mayors' Council statement also indicated that damages totaling \$15 million were incurred to 412 structures in Union Township, and that damages totaling \$8

million were experienced by more than 80 homes in Springfield Township during Tropical Storm Irene.

In addition to major flooding, the combination of already heavily saturated ground from a wet summer and heavy wind gusts made New Jersey especially vulnerable to wind damage. One of the hardest hit areas due to high winds was Union County. Fallen trees, many pushed from the soaked ground with their roots attached, blocked vital roads from being accessed by local emergency services. Numerous homes suffered structural damages from the winds and limbs impacting their roofs. Perhaps the most critical damage, however, due to wind was fallen wires. Around Union County, fallen wires in combination with flooded electrical substations left parts of Union County, including Cranford, Garwood, and Westfield, without power or phone service for nearly a week. In total, approximately 1.46 million customers throughout 21 counties lost power

2.1.4.4. HURRICANE IDA (2021)

In September of 2021, remnants of Hurricane Ida caused severe flooding in the Rahway River Basin (Figure 3). Making landfall in Louisiana in late August 2021, Hurricane Ida made its way northward through the United States, before hitting the northeast in early September. Exacerbated by rainfall that had yet to fully recede from Hurricane Henri two weeks prior, the overtopped banks flooded many homes and businesses in the area. Parts of the study area, including parts of Rahway City, saw upwards of 8-10 inches of rain in a 24-hour period, causing the Rahway River to overflow its banks. Rainfall rates peaked at 2-3 inches per hour in parts of the study area. A total of 30 people lost their lives across New Jersey as a result of the flash flooding caused by Hurricane Ida's rainfall.

Several counties in northern New Jersey were listed as federal disaster areas following Ida, including the three that encompass the Rahway Fluvial study area: Essex, Union, and Middlesex counties. Much of New Jersey Transit infrastructure, including roads, train lines, and parts of Newark Airport, was shut down in the wake of the rainfall.

FIGURE 3: IDA HIGH WATER MARK ON STRUCTURE; CITY OF RAHWAY



2.1.4.5. JULY 14, 2025 STORM

Heavy rainfall during the evening of July 14, 2025, inundated areas across the Rahway River Basin. Several inches of rain over a three-hour period caused flash flooding, closing several roads, causing power outages across the area, and leading to a state of emergency declaration by Governor Phil Murphy. In the town of Plainfield, adjacent to the study area, two individuals lost their lives in the storm, as water in the road washed their car into rising floodwaters.

The New York District team reached out to officials from several municipalities in the study area following the storm to assess flood damages and coordinate a site visit. A team consisting of members of the project delivery team (PDT) traveled to the Townships of Milburn and Cranford to meet with local officials and NJDEP, to tour affected areas and to collect data on high water marks, take pictures, and talk with those affected by flooding.

The Township of Milburn's fire chief escorted the team around to several spots that had poor interior drainage including roads that were often closed as a result of the flash flooding. Additionally highlighted, was an underpass where emergency response teams had rescued stranded individuals during the July 14 storm.

Cranford Local officials including Mayor Terrence Curran, and the Cranford Township Commissioner, Administrator, and Engineer, met with the PDT at two locations that saw significant flash flooding during the storm. A constriction of a tributary to the Rahway River leads to frequent flooding in the area surrounding Burnside Avenue, Elise Street, and County Road 160, leading to inundation of structures and road closures. Several homeowners from the

surrounding neighborhood came out to meet with the team and were able to show high water marks, as well as provide pictures and videos from the event.

The second location visited by the team was along West Holly St. where a county sponsored project is moving forward with widening a culvert that runs under the street and empties into the Rahway River. Several homes are planned to be bought out and the area will be returned to a more natural environment.

2.2. LAND USE CATEGORIES

2.2.1. TOWNSHIP OF CRANFORD/UPSTREAM

Land use within the northern portion of the project area consists predominantly of the South Mountain Reservation, a 2,047-acre park owned by Essex County and located in several municipalities, including Maplewood Township, West Orange Township, and Millburn Township. The park is bounded by Northfield Avenue to the north, the South Mountain Recreational Complex to the northeast, residential land use on the east and west sides, and urban land use consisting of a mix of residential homes, small businesses, and railroad tracks to the south. Land use within the park itself is predominantly recreational, deciduous forests, and wetlands (Amy S. Greene Environmental Consultants, Inc., 2007).

County Road 510 bisects South Mountain, and Cherry Lane/Brookside Drive runs through the park in a northerly/southerly direction. Bear Lane and Crest Drive are located on the eastern side of South Mountain and are part of the park infrastructure. Bear Lane leads to the camping sites, while Crest Drive is closed to vehicular traffic and mainly serves as a walking and bike path.

Land use in the Township of Cranford consists of parks, lands maintained as open space, and predominantly single-family homes. Nomahegan and Lenape Parks, owned and operated by Union County, are the two largest parks within the Township of Cranford portion of the project area. Lenape Park lies directly north of Nomahegan Park and is separated from Nomahegan Park by Kenilworth Boulevard. The majority of Lenape Park is forested and mostly used for passive recreation. Lenape Park also serves as a detention basin for flood risk management purposes; the County constructed a dam and levees in 1983 to reduce flooding within the area. A system of levees was also constructed in Nomahegan Park for flood risk management purposes.

2.2.2. CITY OF RAHWAY/ROBINSON'S BRANCH

Land use within the Robinson's Branch portion of the project area consists of predominantly residential and business land uses, with several open space/parks, including Kiwanis Park, the Union County Arts Center Park, and Milton Lake Park.

2.3. REGULATED ENVIRONMENTAL RESOURCES

2.3.1. SURFACE WATER RESOURCES

Surface waters are regulated by the Clean Water Act. The Clean Water Act (CWA) is the principal law governing pollution control and water quality of the Nations' waterways, including

wetlands. The objective of the CWA is to restore and maintain the chemical, physical and biological integrity of the Nations' waters.

The East Branch, West Branch, Robinson's Branch and the portion of the Rahway River Main Stem from Route 78 to just south of its confluence with Robinson's Branch are designated as FW2-NT: freshwater river not supporting trout spawning (N.J.A.C. 7:9B 2008). By definition, designated uses for FW2 waters include: 1. Maintenance, migration and propagation of the natural and established biota; 2. Primary contact recreation; 3. Industrial and agricultural water supply; 4. Public potable water supply after conventional filtration treatment and disinfection; 5. Any other reasonable uses. Non-trout waters are those "not generally suitable for trout because of their physical, chemical, or biological characteristics but are suitable for a wide variety of other fishes" (NJDEP, 2023).

The majority of the Rahway River Basin is heavily urbanized with the river having experienced modifications associated with water supply, recreation, flood risk management, development of infrastructure, and riverbank stabilization. However, the level of development adjacent to and modification of the Rahway River and the river's major tributaries vary.

The East Branch Rahway River forms in West Orange and flows approximately 5 miles before joining the West Branch to form the Rahway River Main Stem. The average channel width is 20 ft. Average depths range between one to two feet. Development has occurred up to the banks for almost its entire length. Additionally, approximately 40% of the length has had one or both banks converted to concrete retaining walls or modified and stabilized with riprap.

The West Branch Rahway River also forms in West Orange and flows for approximately 6.5 miles before merging with the East Branch to form the Main Stem. The average width of the West Branch is approximately 25 ft. Average depths of the West Branch in this section range from six inches to one foot. The substrate in this segment of the river is typical of a headwater stream; a combination of large rocks, boulders, and cobble. With the exception of the portion that flows through South Mountain Reservation, proximity of development to the riverbanks ranges from immediately adjacent to approximately 25 ft.

Modifications to the West Branch include channel modifications and dams. Within South Mountain Reservation, the Rahway River was dammed in three locations to create a series of impoundments. The largest waterbody, Orange Reservoir, is owned by the City of Orange and until 1999, served as the City's water supply. Orange Reservoir is currently leased from the City by Essex County and is used for recreational purposes only. The remaining two dams are located in the southern portion of South Mountain Reservation and form Campbells Pond and Diamond Mill Pond, respectively. Campbells Mill Pond is also owned by City of Orange. Approximately 0.17 miles of the West Branch have been converted to a concrete flume within the city proper.

The Rahway River Main Stem forms around Route 78 and flows for approximately 17 miles before discharging into the Arthur Kill Channel. The average width of the channel in the upper portion of the Main Stem is 20 ft. The channel widens to an average width of 35 ft in Lenape Park and then to an average width of 70 ft just below Nomahegan Park. Average depths range from six inches to one foot. The substrate in this segment of the Rahway River is predominantly cobble and gravel with finer silts and clay sediment.

Types of modifications that have occurred to the Main Stem within the study area consist of dams that serve different functions in eight locations, bridge crossings and measures to reduce riverbank erosion and riverbank alterations to provide flood risk management. The Sperry and

Droescher's Mill dams in Cranford were originally constructed to server as hydropower for mills. However, they have since been modified by Cranford to include floodgates. The dam at Lenape Park is a non-USACE structure constructed for flood risk management. In addition, approximately 3,500 ft of the left riverbank of the Main Stem from Nomahegan Park to Normandie Place was increased in height to create a small levee to provide flood risk management to the residences on the eastern side of the river. South of Nomahegan Park, portions of the riverbanks have been replaced with concrete, mason rock or timber crib retaining walls in multiple locations. In other locations, riprap has been installed along the riverbanks to prevent erosion. During site visits, boat launches along the riverbanks were observed on several private residences. Within the vicinity of Robinson's Branch's confluence with the Rahway, the Rahway River Dam is used by United Water to withdraw water to supply the City of Rahway.

The average width of Robinson's Branch within the study area ranges between 30-40 ft wide with an average depth of one foot. The substrate is predominantly comprised of sand/gravel. Similar to the Rahway River, Robinson's Branch has experienced manmade modifications in the form of dams to create Clark Reservoir and Milton Lake, the construction of bridge crossings, and the installation of retaining walls and riprap to reduce stream bank erosion. Within the segment of Robinson's Branch below New Church Street, development has occurred right up to the top of the stream banks.

2.3.2. WETLANDS

Federal (33 CFR 328.3(b); EO 11990) and state (N.J.A.C. 7:7A1.4) definitions of wetlands are similar, identifying wetlands as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." As defined above, wetlands generally include swamps, marshes, bogs, and similar areas.

Identification of wetlands within the study area were based on reviews of New Jersey's GIS environmental mapping database (NJ Geoweb) and the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps; formal wetland delineations were not conducted. Based on the review, the study area contains multiple wetland complexes consisting of forested, emergent, scrub-shrub, and disturbed wetlands predominantly along the portions of the Main Stem Rahway River, particularly within the parks and land acquired for open space. The largest wetland complexes within the study area occur in Lenape Park, which consists of approximately 226 acres of deciduous wooded wetlands, and Nomahegan Park, which contains approximately 65 acres of deciduous wooded wetlands. Smaller, sporadic pockets of wetlands occur along the East Branch and West Branch primarily within less developed areas and South Mountain Reservation.

Wetland vegetation species observed within the study area consist of herbaceous, shrub, and tree species. Native herbaceous species include jewelweed (*Impatiens capensis*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmundastrum cinnamomeum*), creeping jenny (*Lysimachia nummularia*), and cattail (*Typha* sp.). Common tree species include sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), dogwood (*Cornus* sp.), and pin oak (*Quercus palustris*). Shrubs include rushes (*Juncus* spp.), sedges (*Carex* spp.), and sweet pepperbush (*Clethra alniflora*). Vegetation within disturbed wetlands in the study area generally consist of lawn and invasive plant species such as reed canary grass (*Phalaris arundinacea*).

2.3.3. VERNAL HABITAT

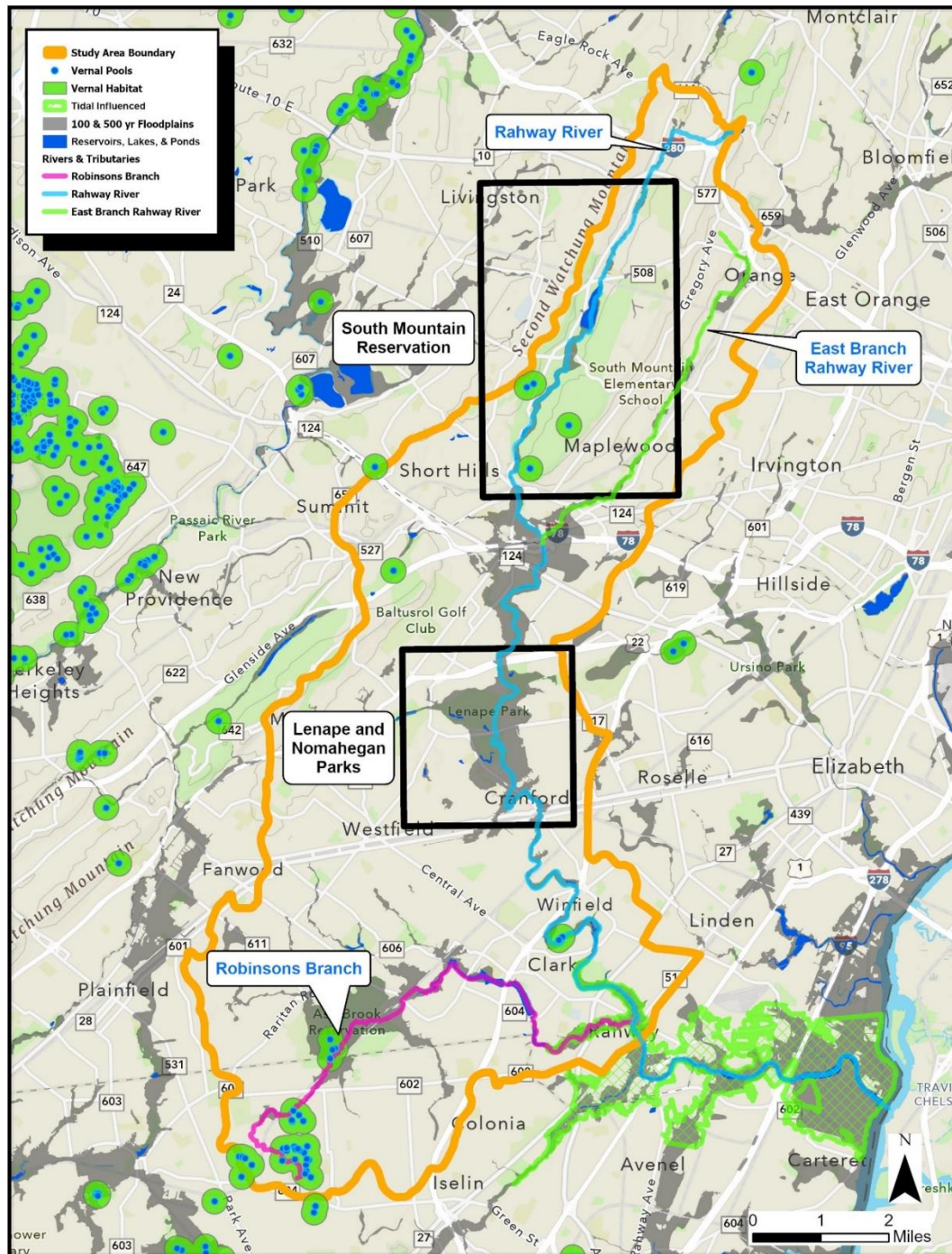
Vernal habitat consists of natural or man-made depressions that maintain water for at least two consecutive months out of the year but are not connected to a waterway (e.g. stream) and do not have breeding fish populations. Vernal habitat is a unique type of ecosystem that supports various species of amphibians, reptiles, plants, and other wildlife.

In New Jersey, vernal habitat is regulated under the Freshwater Wetlands Protection Act which identifies four criteria that must be satisfied for vernal habitat:

- Occurs within a confined depression without a permanent flowing outlet;
- Documentation of obligate or facultative vernal habitat species;
- Maintains ponded water for at least two continuous months between March and September of a normal rainfall year; and
- Area is free of fish populations throughout the year or dries up some time during a normal rainfall year.

A review of NJ Geoweb indicates potential vernal habitat in several locations within the South Mountain Reservation, and in the vicinity of Bloodgoods Pond along the Main Stem Rahway in Clark Township (Figure 3).

FIGURE 4: VERNAL HABITAT WITHIN THE STUDY AREA



2.4. RIPARIAN ZONE

The New Jersey Flood Hazard Area Control Act Rules, N.J.A.C. 13 (FHACAR), establishes and requires the preservation of vegetated riparian zones. The width of the established riparian zone is based on the environmental resources being protected and can range from 50, 150, or 300 ft as measured from the side of surface waters. Given that the Rahway River and Robinson's

Branch are designated FW2-NT and do not have any documented occurrences of federal or state listed species, the riparian zone is 50 ft as described in N.J.A.C. 7:13-4.1. 3.

Within the more urbanized portions of the study area, vegetation within the regulated riparian zone ranges from non-existent to the full 50 ft and consists of a variety of types including native shrub and tree species, maintained lawn, and monocultures of invasive species. Within the larger parks like South Mountain Reservation, Lenape Park, and Nomahegan Park, the riparian zone exceeds 50 ft, with vegetation consisting of native shrubs and tree species and limited stands of invasive species.

Common native tree and shrub species observed within the riparian zone within all portions of the study area during field investigations include American elm (*Ulmus Americana*), red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), sycamore (*Platanus occidentalis*), arrowwood (*Virburnum dentatum*), and dogwood (*Cornus sp.*). Typical invasive species found within the riparian zone include Japanese knotweed (*Reynoutria japonica*), multi-flora rose (*Rosa multiflora*) and tree of heaven (*Ailanthus altissima*).

2.4.1. ESSENTIAL FISH HABITAT

Essential Fish Habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” The MSFCMA requires federal agencies to conduct an assessment to determine whether the proposed action “may adversely affect” designated EFH and to consult with the National Oceanic and Atmospheric Administration – Fisheries (NOAA-Fisheries) on activities that may adversely affect EFH. The objective of an EFH assessment is to determine the potential effects of the proposed action on relevant commercial, federally managed fisheries species within the proposed action area.

Based on a review of the NOAA-Fisheries EFH Mapping System, the portion of the Rahway River from the southern part of Nomahegan Park to its confluence with the Arthur Kill is designated as EFH habitat for the species listed in Table 1.

TABLE 1: ESSENTIAL FISH HABITAT SPECIES

Common Name	Latin Name
Atlantic herring	<i>Clupea harengus</i>
Black sea bass	<i>Centropristis striata</i>
Bluefish	<i>Pomatomus saltatrix</i>
Butterfish	<i>Peprilus triacanthus</i>
Clearnose skate	<i>Raja eglanteria</i>
Cobia	<i>Rachycentron canadum</i>
Little skate	<i>Leucoraja erinacea</i>
Red hake	<i>Urophycis chuss</i>
Windowpane	<i>Scophthalmus aquosus</i>
Winter flounder	<i>Pseudopleuronectes americanus</i>
Winter skate	<i>Leucoraja ocellata</i>

2.4.2. THREATENED AND ENDANGERED SPECIES

Section 7 of the Endangered Species Act (ESA) of 1973 requires a federal agency to ensure that any action authorized, funded, or carried out by the agency does not jeopardize federally listed endangered and threatened species or result in the destruction or adverse modification of designated critical habitat of a federally listed species.

State-listed endangered, threatened, and special concern species are protected under the New Jersey Endangered Species Conservation Act of 1973.

2.4.2.1. FEDERALLY LISTED SPECIES

Identification of listed federal species within the study area is based on a 2023 Planning Aid Report (PAR) prepared by the U.S. Fish and Wildlife Service (USFWS) and an updated List of threatened and endangered species that could occur within the study area obtained in July 2025. Based on the PAR and the List, listed species that could potentially occur within the study area include Indiana bat (*Myotis sodalis*)(Endangered), northern long-eared bat (*Myotis septentrionalis*)(Endangered), and bog turtle (*Glyptemys muhlenbergii*)(USFWS, 2025). New York District also consulted the “New Jersey Municipalities with Hibernation or Maternity Occurrence of Indiana bat or Northern long-eared bat” list (USFWS Bat Municipality List) to supplement the Planning Aid Report. The list indicates known maternity colonies of Indiana bat occurring in Millburn (NJDEP, 2024).

Regarding bog turtle, New York District also referenced the NJDEP “Freshwater Wetlands Attachment D, Known Locations of Bog Turtles in New Jersey”. The list does not include any of the municipalities within the study area as being known to have historical occurrences of bog turtle (NJDEP, 2008).

In addition, the USFWS has proposed listing the tricolored bat (*Perimyotis subflavus*) as endangered and is evaluating little brown bat (*Myotis lucifugus*), wood turtle (*Glyptemys insculpta*), and spotted turtle (*Clemmys guttata*) to determine if listing under ESA is warranted. The monarch butterfly (*Danaus plexippus*) is included in the list of candidate species.

Although the bald eagle (*Haliaeetus leucocephalus*) was removed from the Federal List of Endangered and Threatened Wildlife in 2007, it remains protected through the Bald and Golden Eagle Protection Act of 1940 and the Migratory Bird Treaty Act of 1918. Studies conducted by the NJDEP Division of Fish and Wildlife in 2024 identified one active American bald eagle nest within 4 miles of the study area (Smith and Clark, 2024).

2.4.2.2. STATE LISTED SPECIES

Identification of state endangered, threatened and special concern species occurring within the project area is based on a review of NJ-Geoweb and information presented in the PAR. Species are listed in Table 2.

TABLE 2: STATE ENDANGERED, THREATENED AND SPECIAL CONCERN SPECIES POTENTIALLY OCCURRING WITHIN THE STUDY AREA

Common Name	Latin Name
Listing Status: Endangered	
Northern goshawk	<i>Accipiter gentilis</i>
Short-eared owl	<i>Asio flammeus</i> *
American bald eagle	<i>Haliaeetus leucocephalus</i> *
Indiana bat	<i>Myotis sotoris</i>
Pied-billed grebe	<i>Podilymbus Podiceps</i> *
Red shouldered hawk	<i>Buteo lineatus</i> *
Listing Status: Threatened	
Grasshopper sparrow	<i>Ammodramus savannarum</i> *
Bobolink	<i>Dolichonyx oryzivorus</i> *
Horned lark	<i>Eremophila alpestris</i> *
American kestrel	<i>Falco sparverius</i>
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>
Black-crowned night heron	<i>Nycticorax nycticorax</i> *
Barred owl	<i>Strix varia</i>
Listing Status: Special Concern	
Cooper's hawk	<i>Accipiter cooperii</i>
Sharp-shinned hawk	<i>Accipiter striatus</i>
Great blue heron	<i>Ardea herodias</i>
Cattle egret	<i>Bubulcus ibis</i>
Nighthawk	<i>Chordeiles minor</i>
Little blue heron	<i>Egretta caerulea</i>
Glossy ibis	<i>Plegadis falcinellus</i>
Eastern meadowlark	<i>Sturnella magna</i>
Wood Thrush	<i>Hylocichla mustelina</i>
Silver haired bat	<i>Lasionycteris noctivagans</i>
Snowy egret	<i>Egretta thula</i>
Bald eagle	<i>Haliaeetus leucocephalus</i>

* Listing status is for the breeding life stage only of the listed species, for all other life stages, the species is listed as Special Concern

2.4.3. NEW JERSEY GREEN ACRES PROPERTIES

The Green Acres Program, created in 1961 and administered by the NJDEP, provides funds for state or local municipalities to acquire and maintain lands for the purposes of recreation. A review of the Green Acres Program Open Space Database indicates that most parks and open space areas adjacent to the East Branch, West Branch, and Main Stem Rahway and Robinson's Branch are encumbered by Green Acres rules. Table 3 lists the parks, park features, and their locations within the study area.

The largest parks within the study area are the South Mountain Reservation, Lenape Park, and Nomahegan Park. Recreational components within South Mountain Reservation include passive and active features. The main recreational complex is located in the northern portion of

the park and is comprised of Orange Reservoir, Turtle Back Zoo, Richard J. Cody Arena, and the McLoone’s Boathouse restaurant. Essex County completed major renovations of Orange Reservoir, involving the installation of a picnic pavilion and a floating dock containing paddle boats, in 2013. Additional improvements, involving the installation of a footbridge on the southeastern side of the reservoir, to create a 1.75-mile trail around the reservoir, were completed in 2014.

Additional active recreational elements within the South Mountain Reservation include a dog park and a Girl Scout camping area. Passive recreation features of the park include 19 miles of hiking and walking trails, 27 miles of carriage roads, picnic areas that are interspersed throughout the park, and several camping sites on the eastern side of the park.

Lenape Park contains hiking and biking trails and is frequently used for bird watching and bird counting events. Recreational components of Nomahegan Park include several baseball and soccer fields, two ponds for fishing, a playground, picnic areas, and walking/hiking trails.

Both the Lenape and Nomahegan parks are part of the East Coast Greenway. The East Coast Greenway is an initiative established by the non-profit organization East Coast Greenway Alliance to create a regional bike path along the east coast of Canada and the United States (East Coast Greenway, 2016).

TABLE 3: GREEN ACRES ENCUMBERED PARKS WITHIN STUDY AREA

Park Name	Park Features	Municipality	Waterway
Meadowland / Cameron Park	Walking paths, baseball fields, tennis courts, duck pond	South Orange Village	East Branch Rahway
Memorial Park	Baseball fields, walking paths, amphitheater	Maplewood Township	East Branch Rahway
Kearse Park	Open field	Union Township	West Branch Rahway
South Mountain Reservation	Hiking/biking trails, zoo, fishing ponds, paddle boats, picnic tables, archery range, dog park	South Orange, Maplewood, Millburn	West Branch Rahway
Taylor Park	Tennis courts, baseball fields, pond, walking path	Millburn Township	West Branch Rahway
Lenape Park	Walking trails	Cranford, Westfield, Springfield, and Kenilworth townships	Main Stem Rahway
Nomahegan Park	Walking trails, soccer fields, baseball fields, playground	Cranford Township	Main Stem Rahway
Hampton Park	Walking path, benches	Cranford Township	Main Stem Rahway
Hanson Park	Walking path, picnic tables, gazebo, small outdoor theater	Cranford Township	Main Stem Rahway

Park Name	Park Features	Municipality	Waterway
Sperry Park	Walking paths, benches, fishing access	Cranford Township	Main Stem Rahway
Crane's Park	September 11 th memorial, benches, walking path	Cranford Township	Main Stem Rahway
McConnell Park	Picnic tables	Cranford Township	Main Stem Rahway
Droescher's Mill Park	Maintained as open space	Cranford Township	Main Stem Rahway
Rahway River Park	Walking paths, benches, fishing ponds	Cranford Township	Main Stem Rahway
Milton Lake Park	Walking paths, pond	Rahway City	Robinson's Branch
Veteran's Memorial Field	Baseball fields	Rahway City	Robinson's Branch

2.5. HTRW

Hazardous, Toxic, and Radioactive Waste (HTRW) is defined by Engineering Regulation (ER) 1165-2-132 as: "Except for dredged material and sediments beneath navigable waters proposed for dredging... HTRW includes any material listed as a "hazardous substance" under Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq (CERCLA)..."

An HTRW assessment was prepared by: 1) reviewing existing and readily available federal and state records of contaminated sites within or near the study area; 2) identifying contaminated sites that are collocated within or near the areas of the alternative features; and 3) determining if collocated or nearby contaminated sites may affect or be affected by the alternatives. Below is a summary of HTRW sites within the vicinity of alternative features. Refer to HTRW Appendix G for additional details.

The study area exists in a portion of New Jersey that has been subject to a history of anthropogenic activity and other uses with the potential to affect the subsurface or otherwise impact the project. Through the evaluations contained within this HTRW Assessment, several relevant collocated environmental listings or other environmental concerns have been documented, including:

- NJDEP defined historical fill, deed notice, and groundwater contamination areas within or near the study area. There exists the potential that certain alternative features would necessitate excavation through these areas.
- Documented Resource Conservation and Recovery Act (RCRA) Large Quantity Generator (LQG) listings within the vicinity of the study area, most notably:
 - The Millburn Middle School Site (ID# NJR000079293)
 - Home Depot Inc #0915 Site (ID# NJD064329436)
 - Tru-Form Nails Site (ID# NJR000079814)
 - NJ American Water Springfield Water Treat PI Site (ID# NJR986659274)

- Documented active NJDEP preferred ID listings within or in the immediate vicinity of the study area, most notably:
 - Exxon R/S 37496 Former (ID# 008979)
 - Maplewood Garage (ID# 026379)
 - Fire Department Headquarters (ID# 030050)
 - Former Exxonmobil Station #30559 (ID# 008137)
 - J&C General Excavating Inc (ID# 023867)
 - Cranford Fire Department (ID# 000911)
 - Swan Customer Cleaners (ID# 001944)
 - A & G Exxon (ID# 007499)
 - Lenape Park Trap & Skeet (ID# G000022693)
- The potential presence of asbestos-containing material (ACM), lead-based paint (LBP), and polychlorinated biphenyls (PCBs) that could impact the implementation of nonstructural measures.

These collocated environmental listings and concerns are typical of this area of New Jersey, particularly considering its history of development.

2.6. CULTURAL RESOURCES

“Cultural resources” is an umbrella term for many heritage-related resources, including prehistoric and historic archaeological sites, buildings, structures, districts, or certain objects. Cultural resources are discussed in terms of archaeological resources, architectural resources, or resources of traditional cultural significance. Several federal laws and regulations have been established to manage cultural resources, including the National Historic Preservation Act (NHPA) of 1966, the National Environmental Policy Act of 1969, the Archeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archeological Resource Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1990. In addition, DoDI 4710.02, Department of Defense Interactions with Federally Recognized Tribes (2006), governs DoD interactions with federally recognized tribes and EO 13175, Consultation and Coordination with Indian Governments (2000), charges federal departments and agencies with regular and meaningful consultation with Native American tribal officials in the development of policies that have tribal implications (USACE Tribal Policy Principles).

The National Register of Historic Places (NRHP) is administered by the National Park Service (NPS) and is the official list of the properties in the United States that are significant in terms of prehistory, history, architecture, or engineering. Generally, resources must be more than 50 years old to be considered eligible for the NRHP. To meet the evaluation criteria for NRHP eligibility, a property needs to be significant under one or more NRHP evaluation criteria (36 CFR Part 60.4) and retain historic integrity expressive of the significance. More recent structures might be NRHP-eligible if they are of exceptional importance or if they have the potential to gain significance in the future per special NRHP considerations (USACE 2019).

As a federal agency, USACE has certain responsibilities for the identification, protection, and preservation of cultural resources that may be located within the Area of Potential Effect (APE) associated with any proposed undertaking. Current statutes and regulations governing the identification, protection, and preservation of these resources include the NHPA, NEPA,

Executive Order 11593, and the regulations implementing Section 106 of the NHPA (36 CFR Part 800, Protection of Historic Properties, August 2004). The NHPA and its implementing regulations requires federal decision makers to consider historic properties in their evaluation of effects associated with an undertaking. Under the NHPA, historic property means any prehistoric or historic district, site, building, structure, or object included in or eligible for inclusion in the NRHP maintained by the Secretary of the Interior (NPS).

According to the New Jersey State Historic Preservation Office (NJSHPO) Cultural Resources GIS (CRGIS) database, several historic properties, districts, and archaeological sites have been identified in the study area (NJSHPO 2025). A Phase IA cultural resources investigation was completed for this study and identified more than 5,000 previously recorded aboveground historic properties, 28 recorded historic districts, and 25 archaeological sites within the study area. Of the 5,000 historic properties, 32 are individually NRHP-listed, 45 are individually NRHP-eligible, and 7 are designated Local Landmarks. Several other previously evaluated historic properties contribute to recorded historic districts in the study area, the majority of which are located along the Rahway River in the Borough of Cranford and are within the Cranford Historic District and the Rahway River Parkway Historic District. The Lenape and Nomahegan parks also contain a significant number of cultural resources. A map of all historic properties in the study area is provided in Figure 5.

Two previously recorded archaeological sites in the study area, the Smith Farm Site and the Frazee House Site, are NRHP-listed. Another two sites, the Morris Avenue Rahway River Bridge Site and the First New Jersey State Mint Site, are NRHP-eligible. The other 21 archaeological sites in the study area have not yet been evaluated for NRHP eligibility. Specific site locations and reports are currently unavailable but will need to be consulted once plans are established to determine the level of impact and potential for adverse effects. Due to the sensitive nature of archaeological sites, no locational data is reproduced here.

Three historic districts located in the study area – the Maplewood Village Historic District (HD), the Montrose Park HD, and the Wyoming HD – are NRHP-listed. Seventeen districts, including the Lower Rahway/Main Street HD, the North Cranford HD, and the South Mountain Reservation, are NRHP-eligible. A map of all historic districts in the study area is provided in Figure 6. More information on known or recorded cultural resources in the study area is provided in Appendix A.

FIGURE 5: HISTORIC PROPERTIES IN THE STUDY AREA

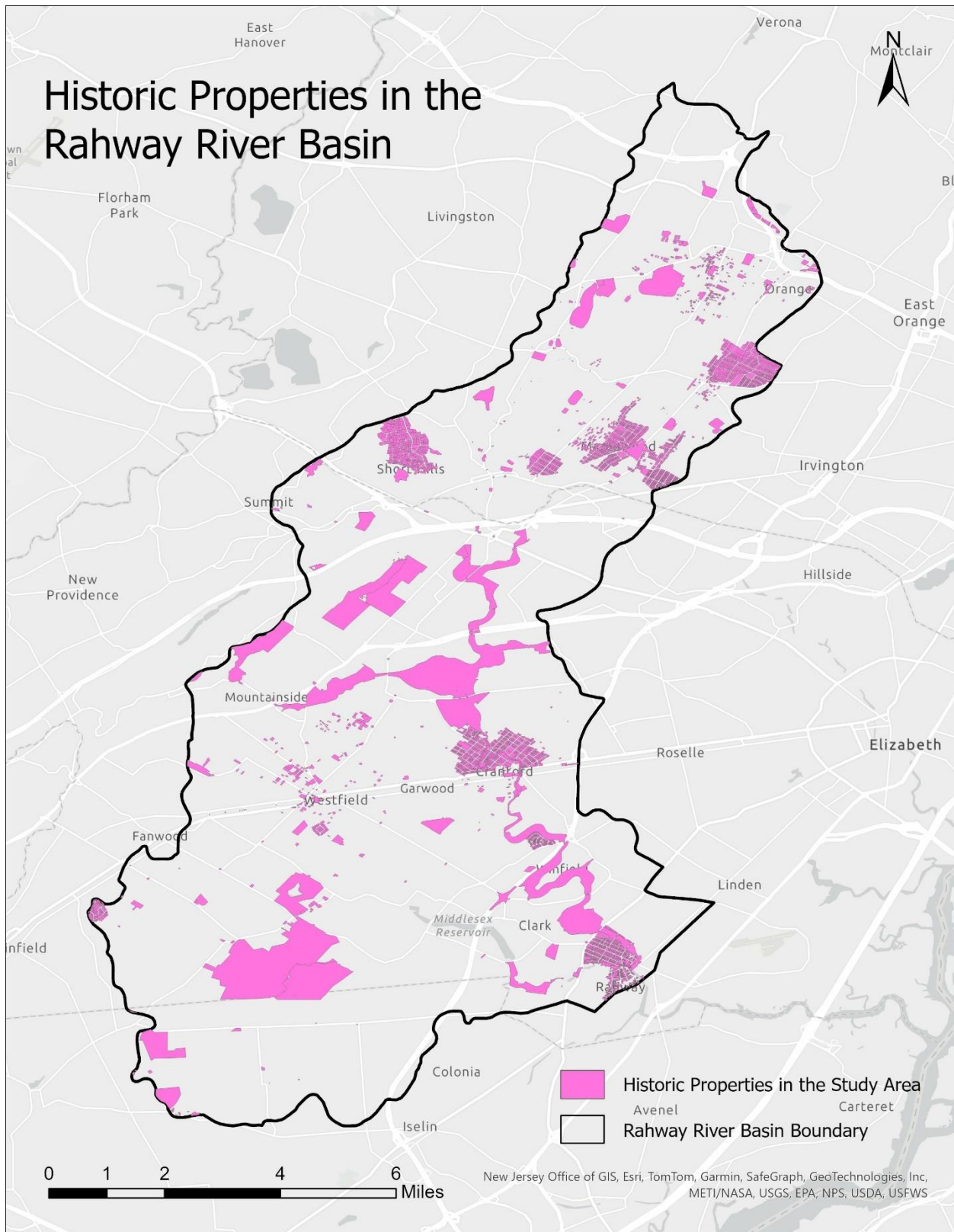
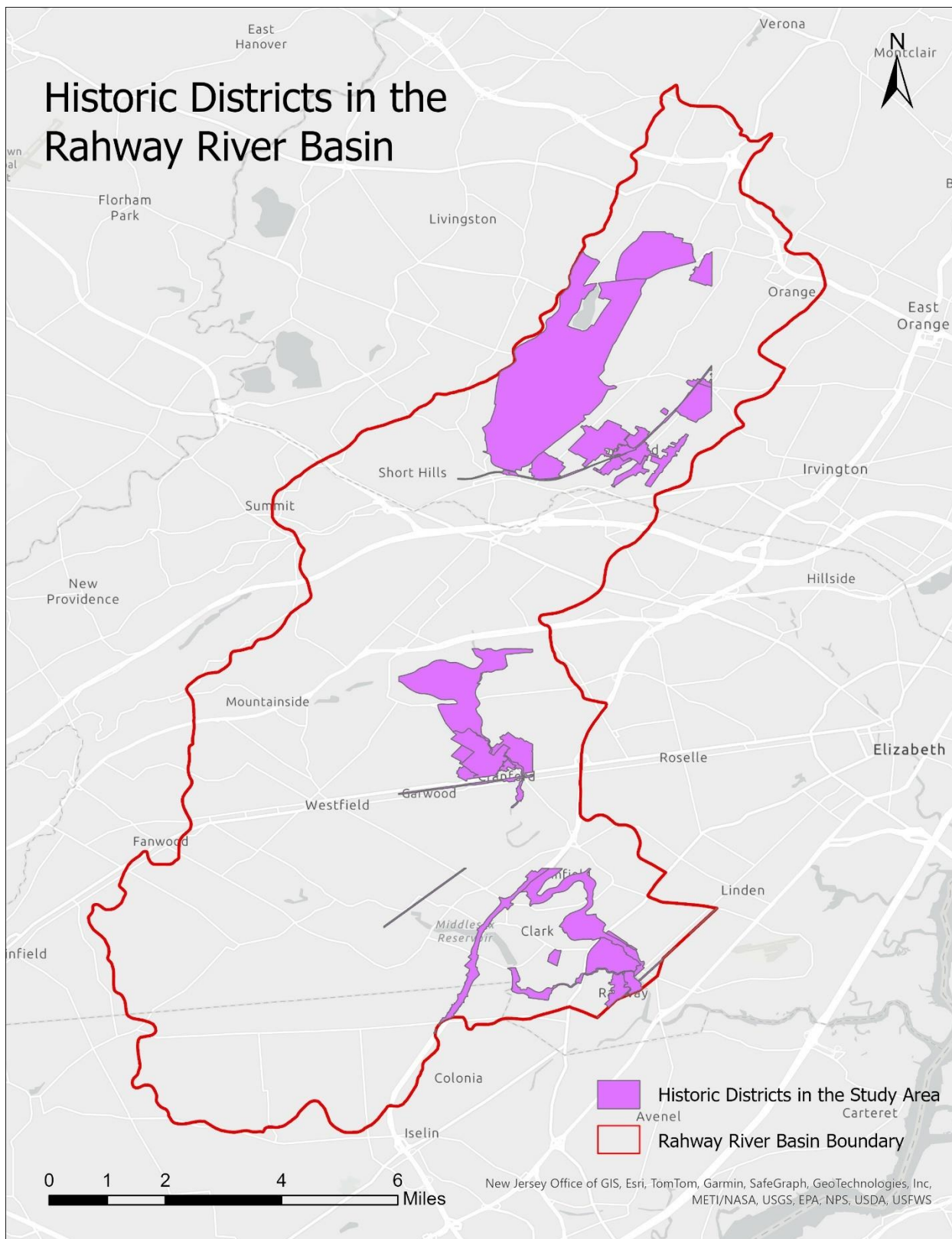


FIGURE 6: HISTORIC DISTRICTS IN THE RAHWAY RIVER BASIN STUDY AREA



3. HYDROLOGIC ANALYSIS

Hydrologic analysis for this feasibility study included updating hydrologic models, analyzing stage-frequency curves, conducting detailed analyses, and developing conceptual plans. An existing Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) model for the Rahway River Basin was updated with a new reach, terrain extending to the project limits, meteorological data for the current water year, and dam and spillway analysis methods.

The HEC-HMS model was calibrated to the Tropical Cyclone Irene in August 2011 (Section 4.5.3: Tropical Cyclone Irene) and Hurricane Ida in September 2021 (Section 4.5.5: Hurricane Ida). The Rahway River at Springfield (USGS 01394500), Rahway River at Rahway (USGS 01395000), and Robinson Branch at Rahway (USGS 01396000) gages were used for the calibration.

A Probable Maximum Precipitation (PMP) model was run in HEC-HMS to optimize the proposed dams on West Branch. After running the model and optimization trial, the maximum PMP at the location of the proposed dams on the West Branch was 14,000 acre-feet.

A detailed description of the hydrologic analysis, including model development, calibration and validation results, and PMP runs within the project area, is included in Appendix C (Hydrologic Analysis).

4. HYDRAULIC ANALYSIS

The objective of the hydraulic analysis was to recognize a feasible means of managing the risk of flooding in the most affected areas of the Rahway River in the most cost-effective manner in an environmentally and culturally acceptable way. The Rahway River in the townships of Millburn and Cranford and Robinson's Branch at Rahway begin to experience fluvial flooding at and above the 10% chance of annual exceedance (10-yr) event. The headwaters of the Rahway River start at the East and West Branch of the Rahway River. The headwaters of the East Branch are located in the vicinity of the City of Orange, and the East Branch flows downstream through South Orange and Maplewood townships. The headwaters of the West Branch are located in the vicinity of West Orange, and the West Branch flows downstream through the South Mountain Reservation into the Township of Millburn. Robinson's Branch is impounded at Middlesex Reservoir and Milton Lake and runs through Clark and Rahway.

The alternatives were focused on reducing flood risk in the townships of Millburn and Cranford and the City of Rahway on Robinson's Branch. The alternatives evaluated can be classified as No Action (same as Future without Project Conditions), structural, and nonstructural alternatives. The flood risk management measures considered were channel modification, bridge replacement, dams, floodwalls, levees, pump stations, reservoirs, detention, nonstructural measures, and a combination of the above.

Hydraulic analysis for this feasibility study included updating models, analyzing stage frequency curves, conducting detailed analyses, and developing conceptual plans. An existing Hydrologic Engineering Center - River Analysis System (HEC-RAS) model was updated and calibrated to produce stage-frequency data and water surface profiles for existing and future conditions.

USACE developed the previous, unsteady state numerical model in HEC-RAS version 5.0, for the 2020 Feasibility Study. The upstream boundary of that model was Orange Reservoir in West Orange, and the downstream boundary was Arthur Kill. Both Robinson's Branch and the South Branch were included. The model was updated for this study to add the East Branch of the Rahway River. The analysis of the boundary between tidal/storm surge dominated areas and the fluvial dominated flood areas was evaluated using a compound flooding assessment. Statistical analysis was conducted to cover the full-range probabilities of all possible coincidental combinations. This model was used to develop the without project and with project conditions for the fluvial and coastal area. The models were updated with the latest hydrology and hydraulic data available and calibrated to Hurricane Irene and Tropical Storm Ida. The models were calibrated to multiple points within the specified peak events (Irene and Ida). A full description of the hydraulic analysis, including model development, calibration and validation, hydraulic profiles, and alternative results within the project area are included in Appendix CII (Hydraulics).

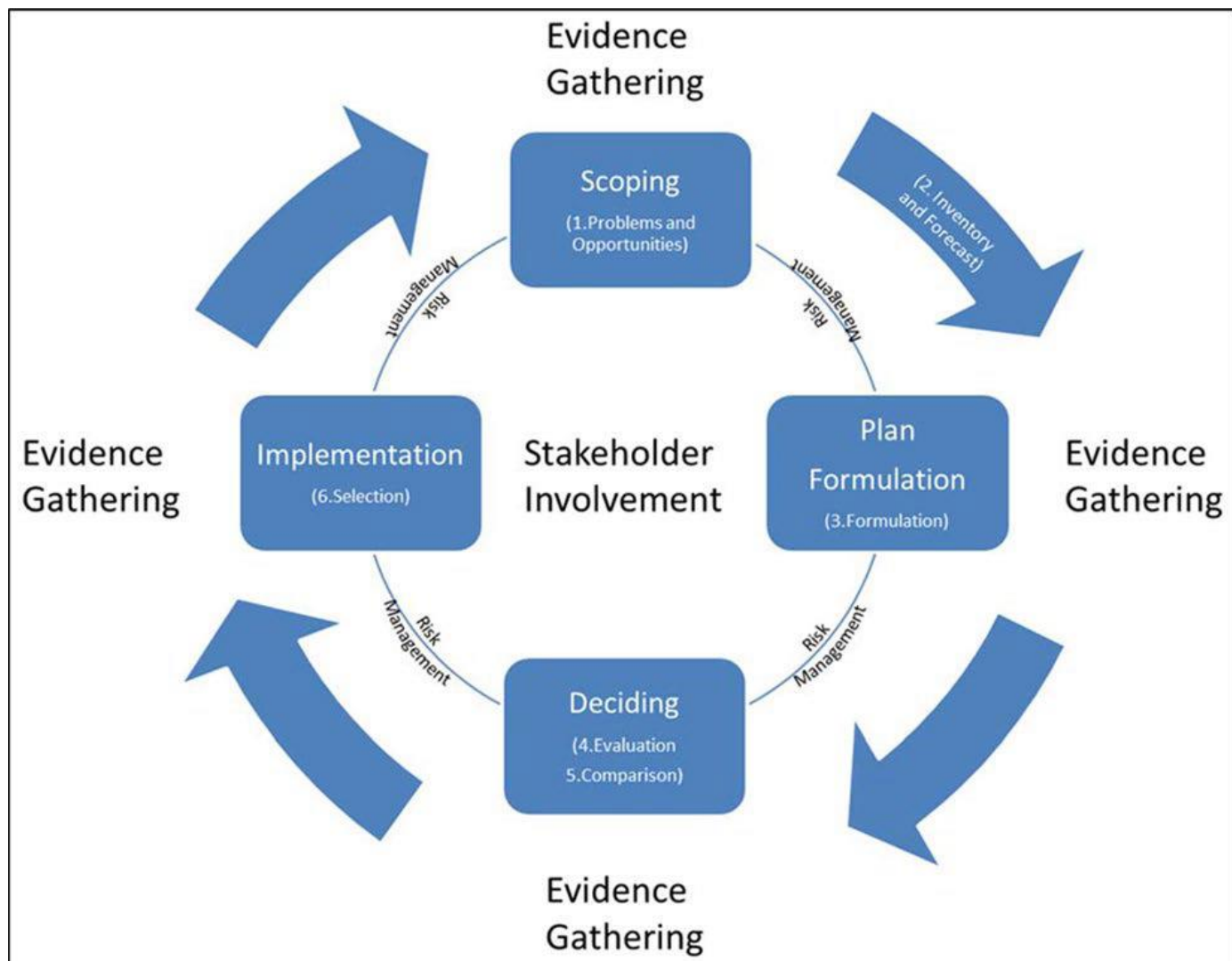
5. PLAN FORMULATION

5.1. USACE PLANNING PROCESS

The USACE Civil Works planning process follows a standard approach to identifying and evaluating potential water resource solutions to ensure that potential federal projects comply with applicable laws and guidance. The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (Principles and Guidelines, or P&G) provide guiding principles for the USACE planning process. The 2013 PR&G (Principles, Requirements & Guidelines) supersedes the 1983 P&G, though both are currently used to guide the planning process. On December 19, 2024, USACE issued the final rule for implementing the 2013 PR&G via its Agency Specific Procedures (ASPs). As there is no current implementation guidance for the ASPs, both are being utilized to guide the planning process. ER 1105-2-103 Policy for Conducting Civil Works Planning Studies and the Planning Manual Part II: Risk-Informed Planning lays out an iterative planning process used for all USACE Civil Works studies in developing and evaluating alternative plans (IWR 2017).

The six steps of the iterative planning process are denoted in Figure 7 and include identifying water resource problems and opportunities (Step 1), inventory and forecast of existing and future conditions (Step 2), plan formulation (Step 3), plan evaluation (Step 4) and comparison (Step 5), and finally plan selection (Step 6), with evidence gathering, risk management, and stakeholder involvement taking place throughout the process.

FIGURE 7: USACE RISK-INFORMED PLANNING PROCESS (FROM IWR 2017)



5.2. SCOPING

5.2.1. PERIOD OF ANALYSIS

A 50-year period of analysis from 2030 to 2079 was used to analyze the future without project conditions and the alternatives in the future with project condition for the Rahway Fluvial Study.

5.2.2. PROBLEMS AND OPPORTUNITIES

The problem this study addresses is fluvial flooding within the Rahway River Basin, which is caused principally by rainfall during storm events. The problem is exacerbated by impervious surface coverage caused by development in the area, resulting in a large increase of stormwater runoff into the Rahway River and its tributaries. The increased runoff coupled with inadequate channel capacities and bridge openings account for most of the flooding problems. Flooding causes negative impacts to life safety and critical infrastructure. Flooded local routes

have the potential to block or delay emergency response teams in the area as well as impacting critical infrastructure and facilities.

Problems within the study area include:

- Damages to residential, commercial, and industrial properties
- Risk to life safety resulting from flood impacts

Opportunities exist in the study area to:

- Restore natural systems in ways that provide FRM benefits
- Contribute to community resilience
- Contribute to resilience of infrastructure and the economy
- Reduce communities' vulnerability of flooding
- Passive recreation or trails

5.2.3. PLANNING OBJECTIVES

Alternative plans were evaluated on their ability to make significant contributions to the planning objectives and sufficiently avoid planning constraints; some alternatives do so more effectively and efficiently than others. The study objectives over the 50-year period of analysis from 2030 to 2079 are:

- Provide flood risk management for business and residential structures
- Improve public health and safety, reduce traffic delays, and improve emergency access for the fire department, medical personnel, and police protection
- Enhance the resources of the existing natural and social environment in the project area
- Reduce vulnerability to flood impacts of at-risk communities in the study area

5.2.4. PLANNING CONSTRAINTS

Planning constraints over the 50-year period of analysis from 2030 to 2079 considered during the planning process include:

- Space constraints related to existing structures and built infrastructure that may limit the ability to implement levees/floodwalls

5.2.5. PLANNING CONSIDERATIONS

Planning considerations include:

- Upstream v. Downstream: Construction of Cranford/Upstream features may result in minimal reductions of water surface elevation levels downstream in the Robinson's Branch area
- Minimize negative effects to plants, animals, or critical habitat of species that are listed under the Federal Endangered Species Act or a New Jersey Endangered Species Act
- Minimize/avoid adverse effects to Green Acres and historic properties
- Avoid impacts to Hazardous, Toxic, and Radioactive Waste (HTRW) sites
- Minimize impacts to ongoing recovery and risk management efforts by others
- Minimize induced flooding in areas not currently vulnerable to flooding and minimize induced additional flooding in flood-prone areas
- Minimize impacts to community access and egress during emergencies

- Sea-level rise is a key factor considered in the study. The project area's proximity to the Atlantic coastline means that rising sea levels directly influence water levels in the Rahway River, which can exacerbate flood risk. The proposed flood risk reduction features, including levees, floodwalls, and non-structural measures, have been designed to account for USACE intermediate sea-level rise through 2073, using a joint probability method to account for a range of potential river flow conditions. This approach is expected to provide robust flood risk reduction throughout the project's design life. The assessment for sea-level rise can be found in the Hydraulics Appendix CII.

5.3. MANAGEMENT MEASURES

The sections below outline the management measures considered during the study.

5.3.1. STRUCTURAL MEASURES

Structural FRM measures are man-made, constructed measures that counteract a flood event in order to reduce the hazard or to influence the course or probability of occurrence of the event.

Structural FRM measures evaluated in this study include:

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. To prevent floodwaters from ponding behind these barriers, interior drainage facilities, located on the landward side of the floodwall, would need to be constructed to collect, control, and disperse water trapped behind the barriers.

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.

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.

Channel Modification: Deepening or widening of the cross-section of a channel of water along a length or lengths of that channel can sometimes improve flow and reduce or prevent fluvial flooding by increasing the flow capacity of the river.

Barriers (aka. Ringwalls): Ringwalls are localized barriers that reduce the severity and frequency of flooding for the buildings they surround, but not for the general floodplain. Because of their localized benefit, ringwalls have historically been considered nonstructural measures (see Section 5.2.2). However, ringwalls now have to meet USACE design requirements for floodwalls, and as such are classified here as structural.

5.3.2. NONSTRUCTURAL MEASURES

Nonstructural FRM measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural

measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding. Nonstructural FRM measures evaluated in this study include:

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.

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.

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 provide flood risk management to a building by sealing its exterior walls and providing removable shields at structure openings to prevent the influx of floodwaters. Wet floodproofing would provide flood risk management to a building by allowing floodwaters to enter and exit freely, which reduces the load imposed on the structure.

Flood Warning System: In situations where a structural or nonstructural 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 of flooding.

5.3.3. NATURAL AND NATURE-BASED FEATURES (NNBF)

NNBF include “the use of landscape features to produce FRM benefits. NNBF projects may also produce other economic, environmental, and social benefits known as NNBF co-benefits.” NNBF features in fluvial systems include measures that reduce flood risk by integrating hydrology, hydraulic, morphological, and ecological principles (USACE 2021). NNBF measures considered in the Rahway River Basin include:

- Small Detention Ponds
- Restoration after nonstructural measures

5.3.4. MEASURES SCREENING

During the initial study phase, a charette was held to discuss potential measures for managing flood risk. During this process, input from locals, stakeholders, the NFS, and members of the PDT was used to screen measures to just those that would be compatible with the study area and the study objectives. The identified measures were carried through to the initial array to be combined into the five alternatives.

5.3.5. PLAN FORMULATION STRATEGY

After suitable measures were identified for the study area, they were combined into different alternatives which are described in the following sections. The measures were combined to maximize flood risk management and minimize disturbance to the surrounding environment and communities. Measures were also combined to complement one another and to address several key plan formulation strategies.

First, measures were combined leveraging existing information including previous studies and existing flood risk management infrastructure ensuring the study effort would not repeat the work completed by earlier efforts. This was a first step that was universally taken across all formulated alternatives.

The second plan formulation strategy was to use a comprehensive approach and look throughout the basin at measures to reduce water surface elevations. The study area encompasses several municipalities and a wide variety of measures are needed to address the unique conditions across the basin. This strategy is the driver of the combination plan, which includes a mix of measures proposed across the study area.

Finally, measures were combined across the basin to address the flooding at a localized level. While measures were considered across the study area, a targeted approach to alternative formulation, that would address flood risk at a local level was used when combining the measures into alternatives. This strategy was mutually exclusive with the comprehensive approach and resulted in alternatives designed to lower water surface elevations in specific areas, such as the dry dam. The below sections go into more details on the formulated and modeled alternatives.

5.4. DESCRIPTION OF ALTERNATIVES

This section summarizes the alternatives that the PDT formulated. Table 4 shows the initial array of alternatives considered. Table 5 shows a matrix of the various measures included in the alternative plans.

TABLE 4: INITIAL ARRAY OF ALTERNATIVES

Alternative	Alternative Description	Name
Alternative 1	No Action	No Action
Alternative 2	Upstream Detention	Upstream Detention Plan

Alternative 3	Combination Plan – targeted channel modification, localized storage, and targeted levees and floodwalls, road raisings, and dam and bridge modifications	Combination Plan
Alternative 4	Nonstructural Plan consisting of acquisition, relocation, elevation, and floodproofing	Nonstructural Plan
Alternative 5	Lenape Park Detention Basin & Channel Modifications	Lenape Park Plan

TABLE 5: MEASURES INCLUDED IN EACH ALTERNATIVE

Measure	Alt 1: No Action	Alt 2: Upstream Detention	Alt 3: Combination	Alt 4: Nonstructural	Alt 5: Lenape Park
Levees/Floodwalls			✓		✓
Dams		✓			✓
Channel Modification			✓		✓
Road Raising/Relocation		✓	✓		✓
Ringwall				✓	
Dam Modification			✓		
Localized Storage			✓		
Pump Station			✓		
Elevation				✓	
Acquisition					
Floodproofing					
Relocation					

5.4.1. ALTERNATIVE 1: NO ACTION

In Alternative 1, no additional federal actions would be taken to provide for flood risk management. The No Action alternative provides the baseline against which the performance of alternatives is measured.

5.4.2. ALTERNATIVE 2: UPSTREAM DETENTION

Alternative 2 draws from two alternatives considered in the 2016 study, which consisted of a dry detention basin in the South Mountain Reservation Area and the relocation of Brookside Drive. The previous alternatives (numbered 5 and 6, in the 2016 study) included a detention basin that was larger than the detention basin being considered in this study, and one of the alternatives (5) also included approximately 15,500 ft of channel modification work. The previous alternatives had BCRs of 0.8 and 1.1 respectively. Despite a BCR above one, the alternative was met with opposition from the public, and another alternative, the Orange Reservoir, had higher net benefits and was selected as the TSP in 2016.

The new Upstream Detention alternative considered in this report was modeled with three variations, two of which had permanent (wet) pools and one of which had a dry detention basin. The wet variations were screened out after early economic modeling showed they would be substantially less effective than the dry variation. Additionally, the wet variations would require

additional infrastructure to manage water levels and remove debris and pollutants, and would require permanent conversion of the land, all of which would increase the cost of the alternative as compared to the dry variation.

The Upstream Detention alternative would include:

- Designed to the 100-year (1% AEP) flood event
- 60-ft high, 300-ft wide earthen dam
- 5' x 5' outlet
- Brookside Road realignment (approx. 3,000ft)
- Inundation duration (from WSE 210' to 210') is 28 hours. This represents the time it takes for the dam to fill and drain from an empty state. An elevation of 210' indicates that the dam is retaining no water.
- Time from peak stage to drain (from WSE 243' to 210') is 23 hours

Preliminary quantities include:

- Embankment fill required: 37,500 cubic yards (cy)
- Spillway area: 122,000 square feet (sq-ft)
- Retaining Walls: 1,900 linear feet (ft)

The figures below show the location and plan outline for the Upstream Detention alternative.

FIGURE 8: LOCATION OF ALTERNATIVE 2 – UPSTREAM DETENTION

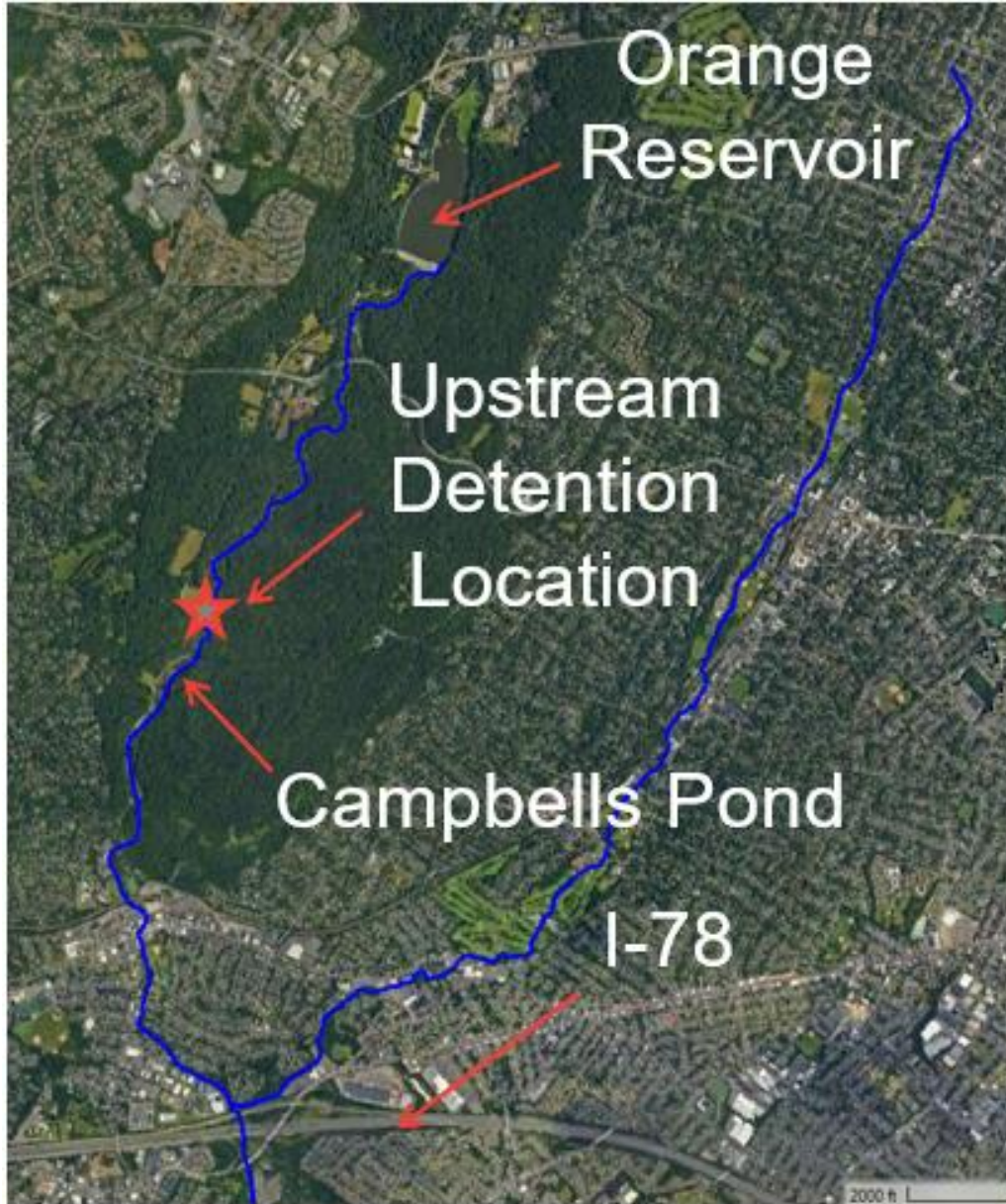
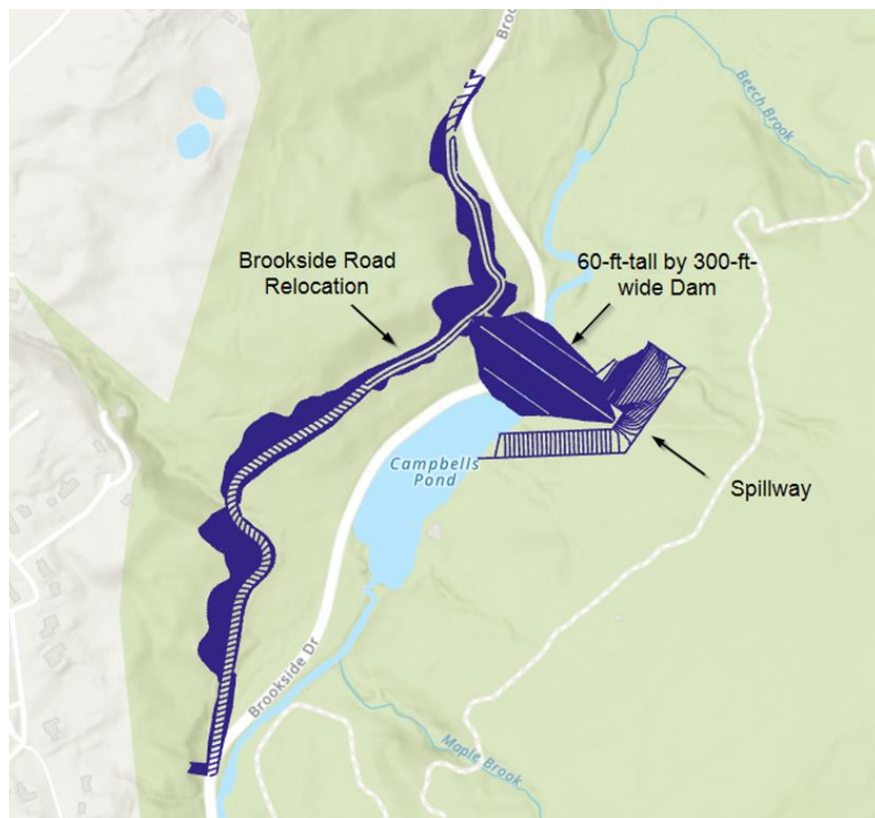


FIGURE 9: DETAILED OUTLINE OF DRY DETENTION BASIN



5.4.3. ALTERNATIVE 3: COMBINATION PLAN

One of the primary outcomes of the scoping charrette held before the resumption of the study was the idea for a combination plan, new to this study effort, that would address vulnerable areas in the study area with a variety of localized structural and nonstructural measures. Building off completed work, both from previous studies and this one, this plan was formulated to provide flood risk management in areas that would benefit the most, rather than focusing on an all-encompassing basin-wide solution. The resulting alternative, Alternative 3, is made up of a variety of FRM measures across the study area. Table 6 below shows measures considered, with those in red being dropped from consideration in the plan after Hydrologic and Hydraulic (H&H) analyses showed they were ineffective at managing the flood risk to structures.

TABLE 6: MEASURES CONSIDERED AS PART OF COMBINATION PLAN

River Modeling Area	Plan Feature	Comment
Milburn-Clark (West Branch)	Raise/ Widen Bridges	Glen Ave (+2 ft raise, +10ft widening) - Ineffective Essex St (+1 ft raise) - Keep Structure over Millburn Ave - Ineffective Footbridge at Taylor Pond - Ineffective Ridgewood Rd - Ineffective
	Improve Channel	2,470 feet of replacing concrete channel with natural, deepen channel
East Branch	Raise/ Widen Bridges	Parker Ave (+1 ft raise, +10ft widening) - Ineffective Oakland Road (+1 ft raise) - Keep Oakview St (+1 ft raise) - Ineffective Pierson Rd (+2 ft elev +10ft open width + channel adj) - Ineffective
	Improve Channel	Deepen channel
Milburn-Clark2	Add Offline Storage	Storage between EB-WB I-78 embankment
	Add Levees/ Floodwalls	Location of Levees/ Floodwalls - from Lenape Park Dam to South Ave East Assume pump stations for interior drainage
	Remove Dams/ Weir	Droescher's Dam modification to a saw-tooth weir, maintain crest elevation Sperry Dam removal/ modification Jackson Dam removal/ modification
Robinsons Branch	Raise/ Widen Bridges	Irving Street (+1 ft raise) - Ineffective
	Add Offline Storage	Storage area at Veterans Memorial Field in Rahway; create levee with weir to attenuate the peak flow -Ineffective

After the screening of the above measures, the retained features were modeled as part of the future with project (FWP) condition for the combination plan. The figures below show the modeled measures included as part of the FWP condition.

As the Combination Plan is a conglomeration of multiple FRM measures, spread throughout the Rahway River Basin, it is ideally suited to be broken up in future study efforts to better serve individual municipalities with more targeted measures. Section 9 of this report, the Implementations/Recommendations section, includes areas that could be targeted for future study efforts and lists any applicable proposed measure of the Combination Plan.

While these measures can be broken out separately in future analysis, and benefits are presented in the proposed municipalities and target areas, they were not modeled independently as part of this current study effort. Therefore, while it can be useful to see how damages are reduced at the proposed site, actual damages reduced may vary based on how the various measures would interact across the basin. Additionally, each measure would include a variety of environmental and cultural impacts that are also discussed in Section 9.

FIGURE 10: LOCATIONS OF EACH COMBINATION PLAN MEASURE

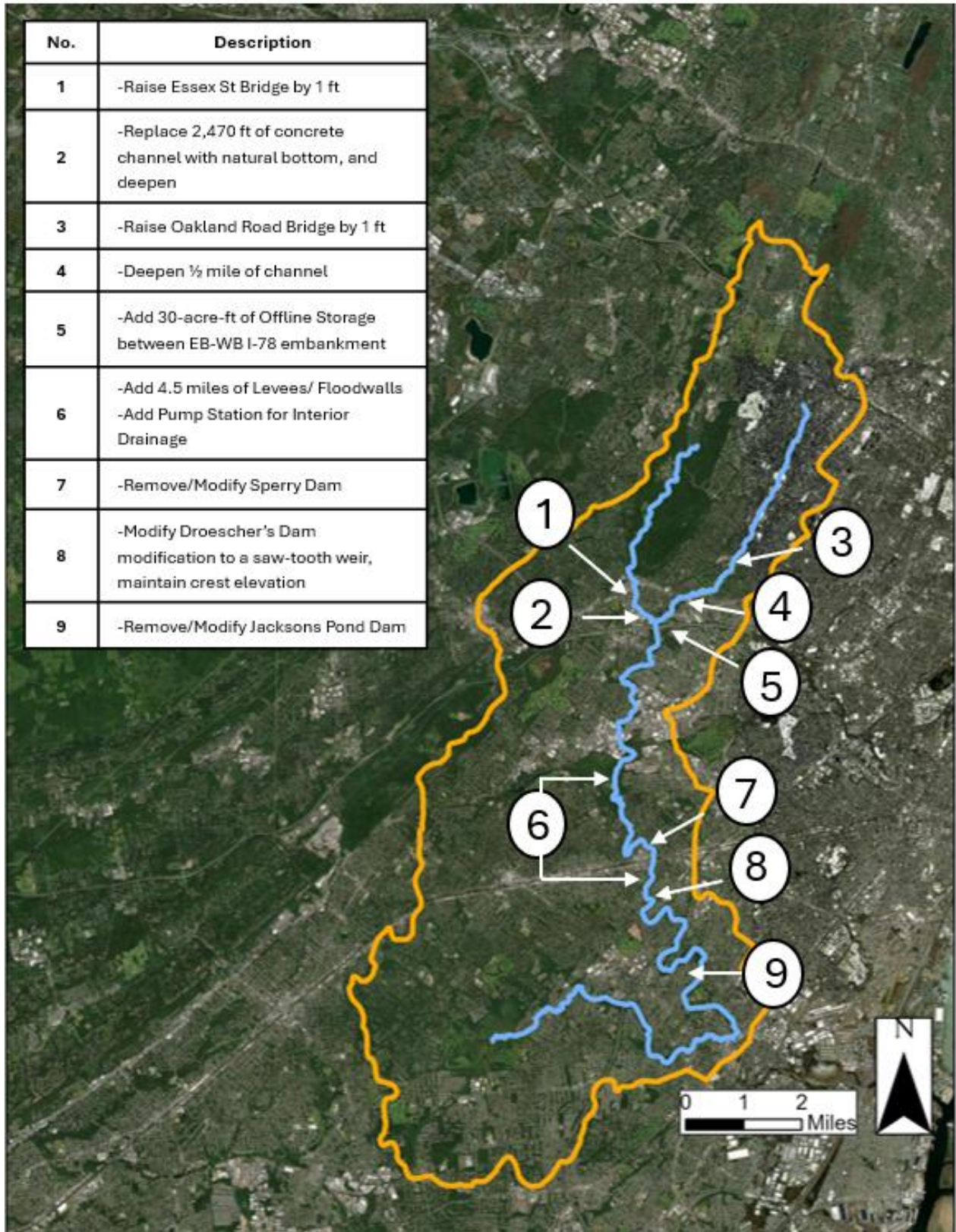


FIGURE 11: COMBINATION PLAN MEASURES 1 AND 2



Measure 1: Raising of Essex Street Bridge

Measure 1 of the Combination Plan is the proposed raising of the Essex Street Bridge in Milburn Township. Located in downtown Milburn, the bridge was identified as a constriction point in the H&H models, limiting the flow of the Rahway River through the township. Raising the bridge by the proposed foot would increase the flow capacity of the river.

Measure 2: Channel Modification and Naturalization

Measure 2 of the Combination Plan proposes 2,470 ft of modification along the concrete channel present in Milburn Township from the Morris & Essex Railroad to the pond at Taylor Park. As part of this modification, the concrete channel would be returned to a natural stream bottom, as well as deepened to increase capacity.

FIGURE 12: COMBINATION PLAN MEASURES 3 AND 4



Measure 3: Raising of Oakland Road Bridge

Measure 3 of the Combination Plan is the proposed raising of the Oakland Road Bridge in Maplewood Township. Similar to Measure 1, the Oakland Road Bridge was identified as a constriction point along the East Branch of the Rahway River and raising the bridge allows for increased river capacity and reduces potential backups during flood events.

Measure 4: Deepening of Channel along East Branch

Measure 4 includes the deepening of roughly half a mile of the East Branch of the Rahway River, from the border of Maplewood to the confluence of the East and West branches in Milburn. Deepening the channel provides increased capacity during storm events.

FIGURE 13: COMBINATION PLAN MEASURE 5



Measure 5: Offline Storage

Measure 5 includes 30 acre-ft of storage at the confluence of the East and West branches near Interstate 78. This proposed measure is located, at least in part, within the municipalities of Milburn, Union, and Springfield townships.

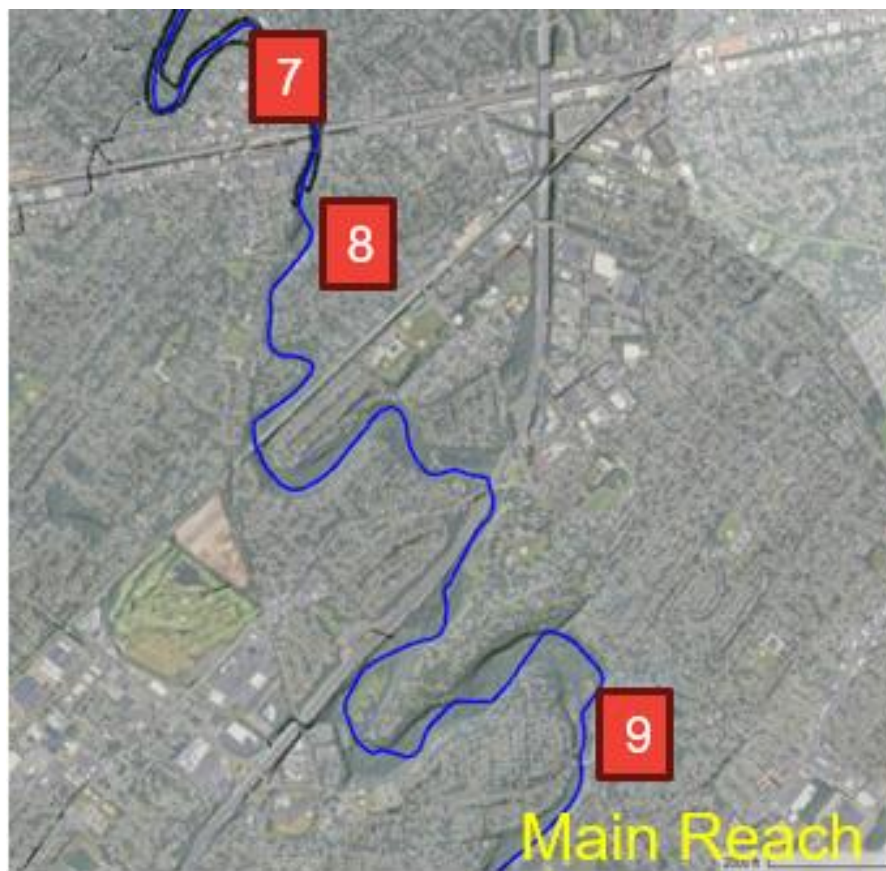
FIGURE 14: COMBINATION PLAN MEASURE 6



Measure 6: Levees/Floodwalls and Pumpstation

Measure 6 of the Combination Plan proposes nearly 4.5 miles of levee and floodwall improvements along the Rahway River, which would include increasing the height of existing structures and new construction. Additionally, to help mitigate potential issues with interior drainage, a pumpstation was modeled to work in conjunction with the levees and floodwalls. The proposed extent of Measure 6 runs from Nomahegan Park through Cranford to Droescher's Park.

FIGURE 15: COMBINATION PLAN MEASURES 7, 8, AND 9



Measure 7: Removal of Sperry Dam

Measure 7 of the Combination Plan includes the removal of Sperry Dam, a low head dam located in the City of Cranford. This measure would aim to achieve more efficient flow of water, reducing the risk of localized flooding during heavy rain events. Refer to the Hydraulic Appendix, Section 4.3, for further information regarding the proposed work on the dam.

Measure 8: Modifications of Droescher’s Dam

Measure 8 of the Combination Plan proposes modifications to Droescher’s Dam in Cranford Township. This measure would modify the dam into a saw tooth weir while maintaining the crest elevation, or the elevation flows would overtop the structure. Refer to the Hydraulic Appendix, Section 4.3, for further information regarding the proposed work on the dam.

Measure 9: Modifications of Jackson’s Pond Dam

Measure 9 proposes the modification of Jackson’s Pond Dam along the main stem of the Rahway River in the town of Clark. This measure would modify the dam into a saw tooth weir and lower crest elevation by 0.6 feet. Refer to the Hydraulic Appendix, Section 4.3, for further information regarding the proposed work on the dam.

5.4.4. ALTERNATIVE 4: NONSTRUCTURAL PLAN

Several iterations of the Nonstructural Plan were formulated and modeled as part of Alternative 4. For each of the model areas: Cranford Upstream (4a and 4b), East Branch (4c and 4d), and Robinson’s Branch (4e and 4f), plans were formulated to include structures in the 10-year (10% AEP) and 100-year (1%AEP) floodplains. More information on the delineation of the model areas is detailed in Section 5.5.5 of this report. Further refinement reduced the number of structures in the 100-year plans to only include structures that see more than 1% (2% for Cranford Upstream) of the depreciated replacement value in damage at the 100-year (1% AEP) event. Table 77 shows the structure count for each of the plans.

TABLE 7: NUMBER OF STRUCTURES IDENTIFIED IN EACH NONSTRUCTURAL ITERATION

Model Area	10-year	100-year and 1% Damage
East Branch	19	51
Cranford Upstream	119	175
Robinson's Branch	23	32

In this study, nonstructural plans were aggregated by reaches that span multiple municipalities, but that does not prevent nonstructural projects from being implemented at the municipal level. Table 88 shows the number of identified structures in the Nonstructural Plan, broken out by municipality. Despite not being chosen as a treatment, buyouts were considered for structures in the study area. Condition criteria for buyouts dictate the 100-water year elevation level at least 12 feet above ground at the structure point. As there were no structures that met this criterion, buyouts were not selected as a treatment.

TABLE 8: PROPOSED NON-STRUCTURAL TREATMENTS BY MUNICIPALITY

Municipality	Elevations	Ringwalls	Total
Cranford Township	36	3	39
Kenilworth Borough	5	2	7
Maplewood Township	1	6	7
Millburn Township	78	35	113
City of Orange	1	-	1
City of Rahway	16	16	32
South Orange	-	1	1
Springfield Township	29	16	45
Union Township	7	6	13
Grand Total	173	85	258

FIGURE 16: ROBINSON'S BRANCH (COMPOUND)

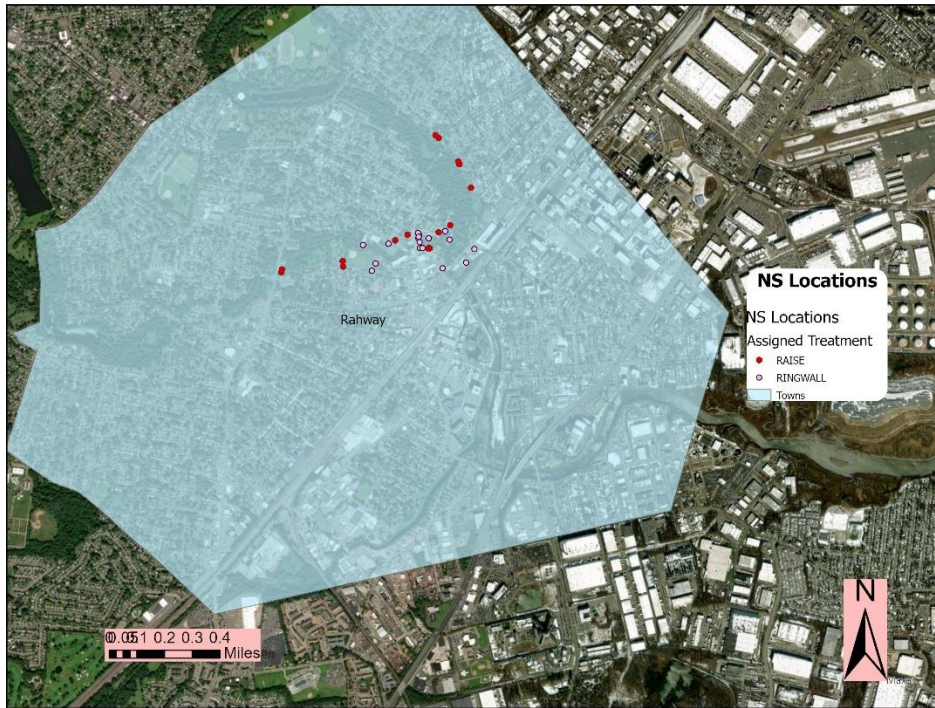


FIGURE 17: CRANFORD UPSTREAM

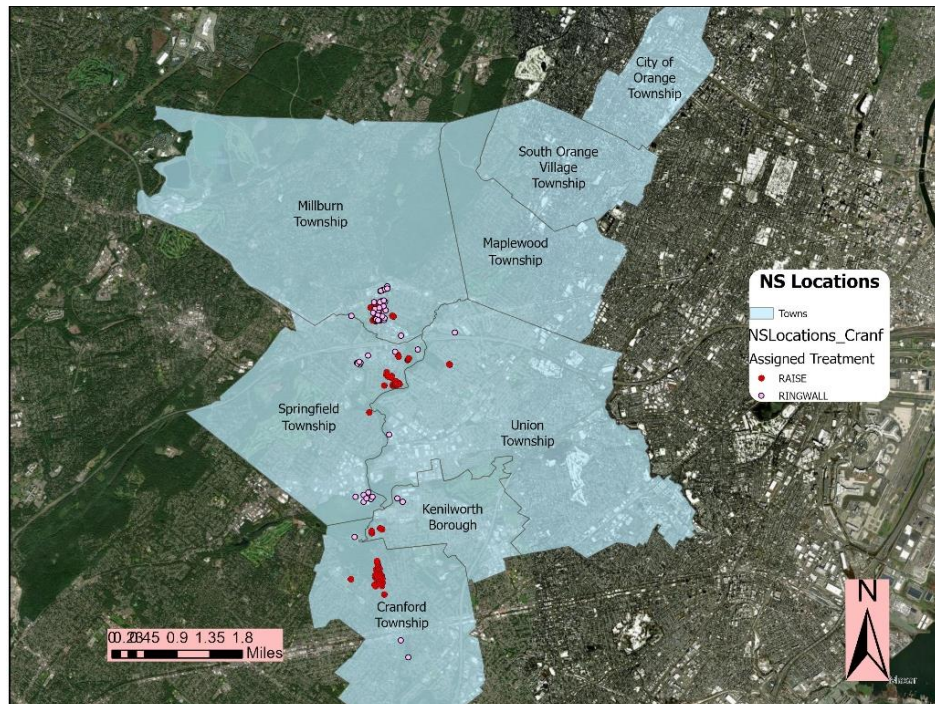
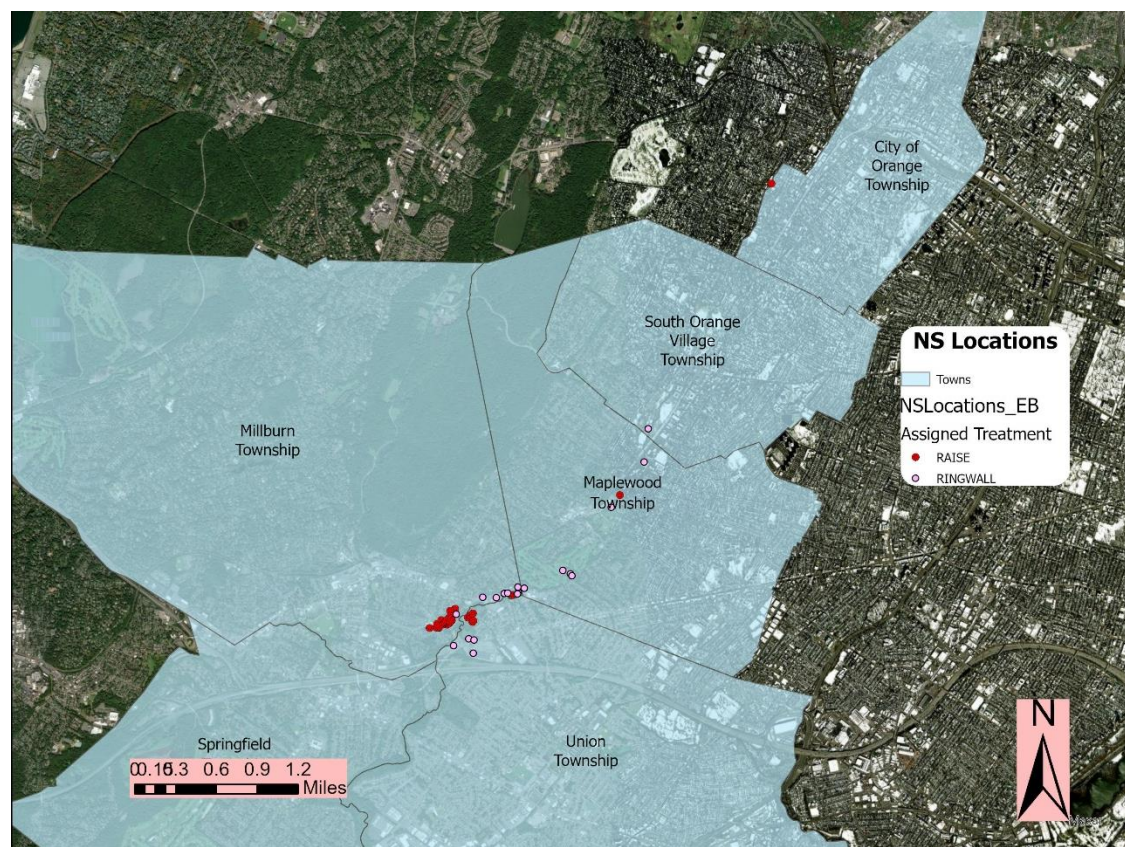


FIGURE 18: EAST BRANCH



5.4.5. ALTERNATIVE 5: LENAPE PARK PLAN

Prior to the resumption of the study, the non-federal sponsor asked New York District to revisit the Lenape Park alternative that was screened out in the 2016 study. That alternative included major channel modifications to the Rahway River in Cranford and modifications to Lenape Park Detention Basin (Figure 19). This alternative is likely to reduce risk for up to the 1% annual chance of exceedance flood (100-yr event) in the Township of Cranford.

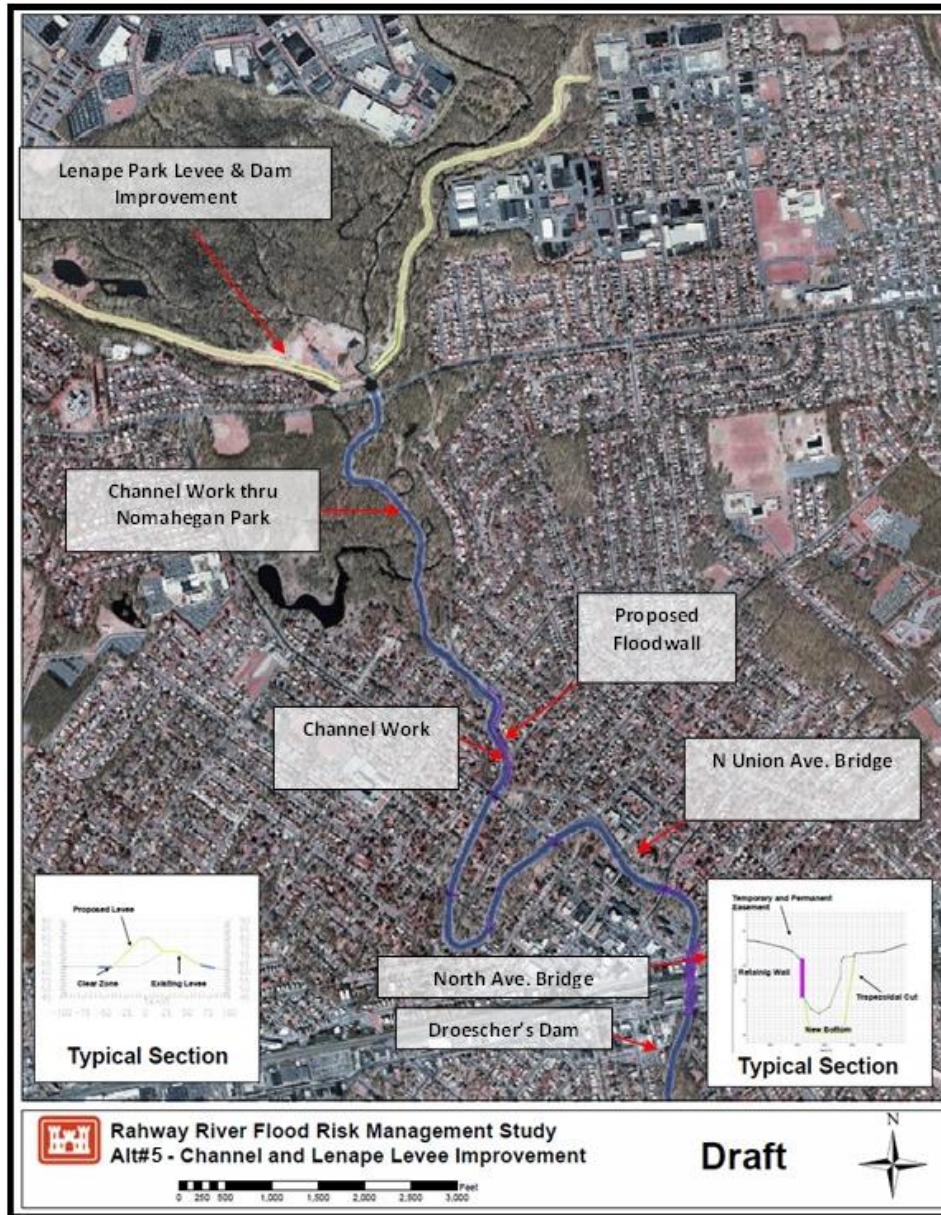
The Lenape Dam modifications would include:

- Replacing the spillway and raising by 6 ft.
- Widening the spillway by 100 ft.
- Widening the opening to 40 ft and lowering by 0.5 ft.
- Raising 10,000 ft of the embankment by 6 ft.
- Widening the auxiliary spillway to 400 ft.
- Adding 6 ft of floodwalls to the existing embankment in the northern area of Lenape Park near Fadem Rd at Springfield Township.

This plan also includes approximately 15,500 ft of channel work throughout the extent of the Rahway River in the Township of Cranford, from Kenilworth Blvd, just downstream of Lenape Dam, to a point approximately 1,500 ft downstream of the Lincoln Ave Bridge. Approximately 1,400 ft of the channel work is expected in Nomahegan Park. The downstream slope is approximately 2.6 ft/mile with a maximum deepening of about 3.7 ft near Hansel Dam. The new trapezoidal channel will consist of a combination of a natural channel bed or riprap material and

a 60 ft bottom width. The side slopes will range from one vertical on two horizontals (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft of new and removed/replaced retaining walls. Also, the Union Ave and North Ave Bridges will be removed and replaced. Figure 19 below shows the plan for Alternative 5.

FIGURE 19: ALTERNATIVE #5 - LENAPE PARK DETENTION BASIN & CHANNEL IMPROVEMENTS



5.4.5.1. SCREENING OF ALTERNATIVE 5

Following the resumption of the study, and the request to reanalyze the Lenape Park alternative that was considered in the 2016 effort, USACE decided to perform a planning level analysis, through a sensitivity analysis on escalated benefits and costs, to assess the viability of Alternative 5. The benefits and costs from the 2016 report, shown in the table below, were used as the basis for the updated analysis.

TABLE 9: BENEFITS AND COSTS FOR ALTERNATIVE 5: 2016 REPORT

Alternative	Without Project	With-Project	Annual Benefits	Annual Cost	Net Benefits	BCR
Lenape Park Plan	\$9,773,600	\$7,499,200	\$2,274,400	\$4,096,300	-\$1,821,900	0.6

The Bureau of Labor Statistics Consumer Price Index (CPI) calculator was used to escalate the benefits from Fiscal Year (FY) 2016 to 2024. The CPI calculator is used to determine the present value of a figure based on changes in inflation between two time periods. Similarly, costs were escalated to the current FY using the Civil Works Construction Cost Index System (CWCCIS) after receiving updated contingency inputs from the cost team. Finally, to test the sensitivity of the benefit cost ratio, the average annual benefits were increased by both 10% and 20%, while holding the costs constant. Table 10 shows the results of these escalations.

TABLE 10: UPDATED BENEFITS AND COSTS FOR ALTERNATIVE 5

FY16 Benefits	FY24 Escalated Benefits (CPI)	10% Benefit Increase	20% Benefit Increase	FY24 Escalated Costs	10% BCR	20% BCR
\$2,274,400	\$3,019,600	\$3,321,500	\$3,623,500	\$4,885,700	0.7	0.7

As a result of this analysis, Alternative 5 was removed from further consideration. While its possible benefits could have increased beyond the 10 and 20 percent estimations used in this analysis, its likely costs would have increased by an equal, or more likely greater, amount than the benefits.

5.4.6. OTHER ALTERNATIVES CONSIDERED

During the planning process the PDT received several requests from interested parties including townships, locals, and the non-federal sponsor to consider formulating alternatives consisting of several other potential FRM measures in the study area. These requests are summarized in sections 5.4.6.1 through 5.4.6.3.

5.4.6.1. MULTIPLE DRY BASIN OPTION

The Multiple Dry Basin Option, proposed by the Flood Mitigation Advisory Committee of Millburn Township, was evaluated and determined to be infeasible based on limitations of its proposed design. For further information, refer to the Hydraulic Appendix, Section 4.3.1.3.

During the engineering review, several critical factors were identified, reducing the practicality of the Multiple Dry Basin Option.

- **Safety Requirements (Spillways):** To ensure public safety and comply with dam safety regulations, each of the four proposed sites would necessitate the construction of a robust spillway system capable of safely conveying the Probable Maximum Flood (PMF). This requirement would involve the substantial financial outlay and engineering complexity of replicating high-cost spillway and energy dissipation structures at all four distinct locations.
- **Reduced Effective Storage Depth:** To accommodate the required length and footprint of the necessary spillway at each site, the effective operational storage depth of the basins would be reduced by an estimated 17.5 feet.
- **Significant Capacity Impairment:** The reduction in effective pool depth, coupled with other inherent limitations on the available length and width for storage, drastically diminishes the overall flood storage capacity. The theoretical storage capacity of 4,619 acre-feet, as initially presumed, would be reduced to a practical effective capacity of only 537 acre-feet. This substantial reduction renders the option ineffective for achieving the intended flood mitigation goals.

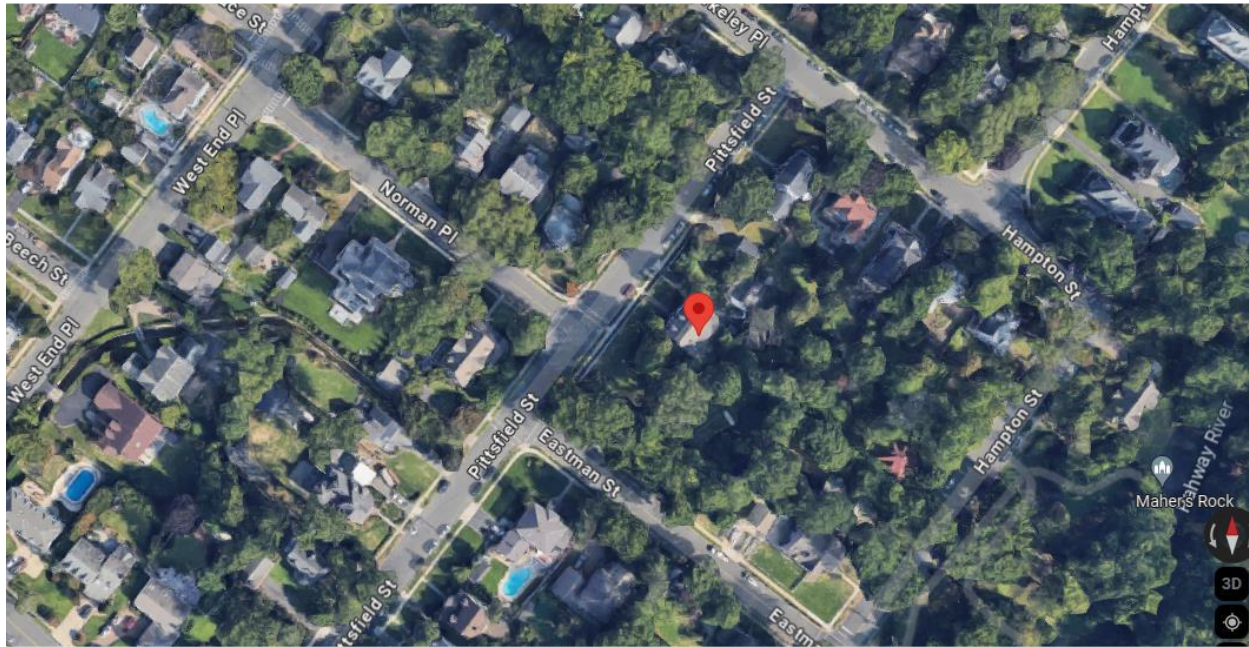
5.4.6.2. GALLOWS HILL BROOK

During the flood analysis, a review was conducted for an area of concern along the Gallows Hill Brook, a tributary to the Rahway River, based on information provided by a local resident on Pittsfield Street in Cranford, NJ 07016 who had reached out to New York District via email with their concerns. The specific area under review is situated near the intersection of Pittsfield Street and Eastman Street in Cranford, NJ (Figure 20). However, the inclusion of this area within the study scope was deemed unfeasible for the following reasons:

Federal Participation Criteria: Gallows Hill Brook is characterized as a small-scale stream, with a calculated discharge of less than 800 cubic feet per second (cfs) during a 10-year storm event. This discharge rate does not meet the established criteria for federal participation in flood risk management projects as laid out in Engineering Regulation 1165-2-21, paragraph 7.a. This criterion also limits the inclusion of the Pumpkin Patch Brook as explained below. The relevant paragraph is included below:

“Urban Flood Control . (1) Urban water damage problems associated with a natural stream or modified natural waterway may be addressed under the flood control authorities downstream from the point where the flood discharge of such a stream or waterway within an urban area is greater than 800 cubic feet per second for the 10-percent flood (one chance in ten of being equalled or exceeded in any given year) under conditions expected to prevail during the period of analysis....”

FIGURE 20: RESIDENT AREA OF CONCERN: GALLOWS HILL BROOK



The primary objective of this review was to assess the potential impacts of a proposed regional flood risk management project for the Rahway River on this specific site and to evaluate whether existing local flood concerns could be mitigated through its implementation. The assessment included a general evaluation of site conditions, an appraisal of the tributary's suitability for federal participation, and an analysis of how the area might be influenced by various project alternatives.

General Site Conditions

The subject area is located near the fringe of the Rahway River floodplain. Elevations at the intersection of Pittsfield Street and Eastman Street are approximately 70 ft NAVD88. Preliminary hydraulic modeling of the Rahway River indicates that properties immediately downstream of this intersection, at approximately 68 ft NAVD88, would experience minor inundation (1 foot or less) during a 1% Annual Exceedance Probability (AEP) flood event (commonly referred to as a 100-year flood) on the Rahway River. These preliminary findings suggest that backwater effects from the Rahway River have a limited impact on this specific site, even during extreme flood events. This indicates that the primary source of local flooding is likely Gallows Hill Brook itself.

Resident-Provided Information

Background information provided by the resident regarding local flooding issues is summarized below:

- A wall failure at 20 Pittsfield Street, approximately 200 meters from the Rahway River, involves a roughly 40-foot section.
- Gallows Hill Brook was subject to a flood control project completed in 1981, with no subsequent modifications.
 - Gallows Hill Brook drains an area encompassing Westfield, Garwood, Mountainside, and Cranford.

- Significant silt accumulation has been observed at the downstream end of the brook and within the Rahway River near their confluence.
- Reported silt accumulation occupies nearly half of the brook's cross-sectional height (unverified by current assessment).
- The brook's channel dimensions are approximately 10 feet wide with 5.5-foot-high walls.
- Peak flows have been observed to overtop the channel walls.

The flood control project referenced by the resident appears to be a municipal endeavor rather than a federally sponsored design.

Gallows Hill Brook Characteristics and Hydrology

Gallows Hill Brook, at its confluence with the Rahway River, has a drainage area of 1.2 square miles. Based on StreamStats, an online stream flow regression tool developed by the U.S. Geological Survey (USGS), the estimated flow for a 10% AEP event is 323 cubic feet per second (cfs), and for a 1% AEP event, it is 578 cfs. The brook generally consists of a rectangular channel with vertical concrete or stone walls, interspersed with relatively long culverts at street crossings.

The project survey did not include detailed cross-sections or bridge/culvert surveys for Gallows Hill Brook, and the brook is not incorporated into the existing Rahway River hydraulic model.

Preliminary Observations and Data Gaps

Without comprehensive hydraulic model outputs for Gallows Hill Brook, the precise details of local flooding cannot be definitively verified. However, the following general observations can be made:

- Peak flows in such a small drainage basin are likely associated with shorter-duration, high-intensity storm events, which may not coincide with the storms that generate peak flows and stages on the Rahway River.
- High velocities within the brook are probably linked to its own high flows and lower stages in the Rahway River, rather than backwater effects from the Rahway River itself.
- Flooding in similar urban stream environments is often attributable to limited culvert capacity. However, this potential cause remains unverified due to the absence of specific hydraulic modeling for Gallows Hill Brook's culverts and channel.

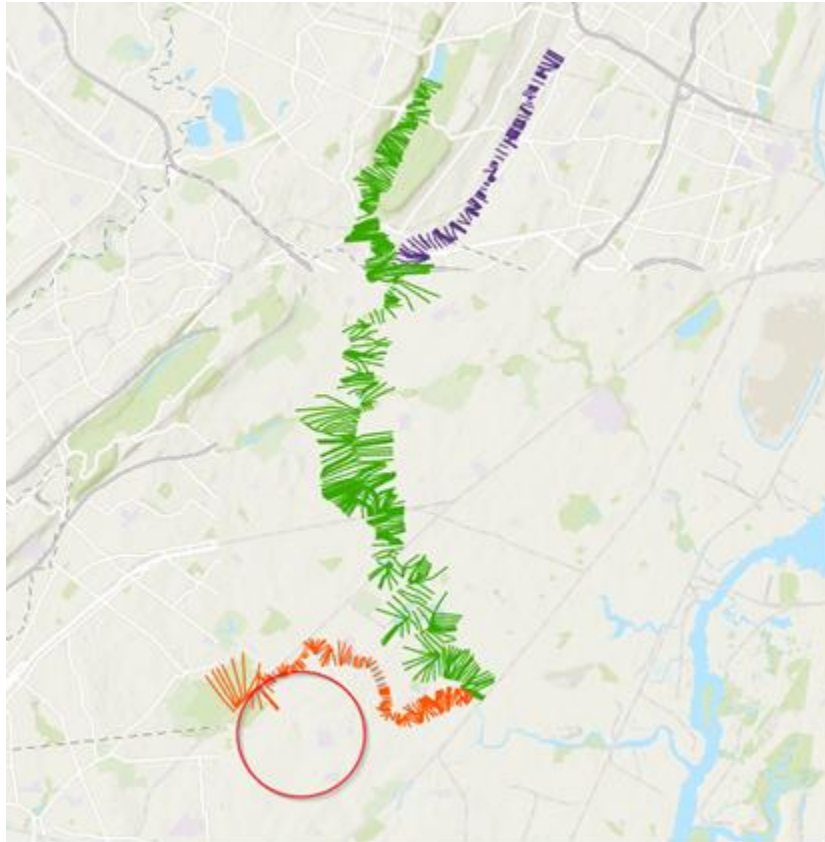
5.4.6.3. PUMPKIN PATCH BROOK

During the flood analysis, the PDT considered incorporating the Pumpkin Patch Brook area into Alternative 3, the Combination Plan. However, the inclusion of this area within the study scope was deemed unfeasible for the following reasons:

- **Federal Participation Criteria:** Pumpkin Patch Brook is characterized as a small-scale stream, with a calculated discharge of less than 800 cubic feet per second (cfs) during a 10-year storm event. This discharge rate does not meet the established criteria for federal participation in flood risk management projects.

- **Modeling Extent:** While Pumpkin Patch Brook is a tributary to Robinson's Branch, and their confluence at Oak Ridge Park falls within the project's defined modeling extent, most of the brook's length and drainage area are situated outside the boundaries of the hydraulic model developed for this study. Figure 21 shows the brook's location (red circle) relative to the modeled area (orange, green, and purple lines).

FIGURE 21: LOCATION OF PUMPKIN PATCH BROOK



5.5. PLAN EVALUATION

The alternative plans were evaluated through several criteria, including their contributions to the planning objectives and constraints, the four planning criteria (completeness, effectiveness, efficiency, and acceptability), and the four P&G benefit accounts (NED, RED, EQ, and OSE). Alternative plans were evaluated for their contributions to these criteria within a 50-year period of analysis, which begins when project construction is anticipated to be complete and project benefits are realized (2030 through 2079). The four selection criteria are briefly described below but are further expanded upon in section 5.12 below.

Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planned efforts, including actions by other federal and non-federal entities. Effectiveness is the extent to which alternative plans contribute to achieving the planning objectives. Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives. Acceptability is the extent to

which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies.

5.5.1. CONTRIBUTIONS TO THE P&G ACCOUNTS

USACE also considers the four accounts established in the Principles & Guidelines (P&G 1983) in the evaluation of alternative plans:

- **NED (National Economic Development):** changes in the economic value of the national output of goods and services
- **EQ (Environmental Quality):** non-monetary effects on significant natural and cultural resources
- **RED (Regional Economic Development):** changes in the distribution of regional economic activity that result from each alternative plan
- **OSE (Other Social Effects):** effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts

This section summarizes the contributions of the alternative plans to each P&G account. USACE is required to identify the plan with the highest net NED benefits, and the plan that maximizes benefits across all four accounts, known as the Comprehensive Benefits plan. They may or may not be the same plan.

For this effort, the primary economic benefit associated with a flood risk management project is the reduction in inundation damages to structures, structure contents (furniture, equipment, inventory, etc.) and infrastructure. All categories of economic benefits considered in this study involve reduction of potential physical flood damages to structures and contents as well as infrastructure. These categories are unquestionably the most significant drivers of National Economic Development (NED) benefits. However, these are not the only benefits that can be counted, as will be discussed in the following sections the report.

5.5.1.1. NATIONAL ECONOMIC DEVELOPMENT

National Economic Development benefits were calculated through version 1.4.3 of Hydrologic Engineering Center - Flood Damage Analysis (HEC-FDA). HEC-FDA is a USACE-certified software tool which performs integrated hydrologic and economic evaluations of flood risk management plans using a structure inventory and stage-frequency and depth damage relationships. More details on the model are discussed in Section 5.5.7 of this report.

The NED benefit is defined as the difference between the without and with-project equivalent annual damage from structure and content values of buildings and vehicles. Benefits and costs are calculated for a 50-year period of analysis from 2030 to 2079 using the Fiscal Year 2025 (FY25) price level and discount rate of 3% to annualize benefits and costs. For each plan, the annual benefit amount is divided by the annual cost to determine a benefit-to-cost ratio. This ratio must be equal to or greater than one (1.0) for federal participation in water resource improvement projects. The plan with the greatest difference between annual benefit and annual cost (net benefit) will be identified. This plan usually defines the extent of federal interest in a project and is considered the National Economic Development (NED) Plan. Section 5.5.7 of this report details the inputs, and the modeling completed as part of the economic analysis for this study effort.

5.5.1.2. REGIONAL ECONOMIC DEVELOPMENT

Per IWR 2011-RPT-01 Regional Economic Development (RED) Procedures Handbook (March 2011), RED impacts are defined as the transfers of economic activity within a region or between regions in the FWOP and for each alternative plan. Reducing flood risk in an area can spur economic activity, making an area more attractive to businesses and workers, leading to increases in employment, income, and output of the regional economy, while chronic or catastrophic flooding can lead to regional losses of employment and income. This analysis uses the USACE RECONS 2.0 input/output model, developed by the Institute for Water Resources (IWR), to estimate the regional economic impacts of proposed construction work activities.

RECONS uses inputs of an impact area, closely defined by your project area, and the total project costs of each of the alternatives in order to provide an estimate of the regional economic impact implementation would have. Of total expenditures, a portion will be captured within the local impact area and the remainder of the expenditures will be captured within the state and the nation. Direct expenditures capture direct impacts on the area's employment and income based on the goods and services necessary to complete the construction of the alternative.

Construction will also generate secondary economic activity often called multiplier effects. This would be realized through companies that supply materials or services to companies engaged in construction. Local restaurateurs, for example, will have higher disposable income because of an increase in clientele, and as a result, they will spend their dollars to purchase appliances, do home repairs, and otherwise put money back into the economy. The extent of the multiplier effect is dependent upon how consumers respond to the additional income; in today's climate consumers might be inclined to save for an emergency rather than spend.

Summarized in the following tables are the impacts of each alternative measured in output, jobs, labor income, and gross regional (value added) product. Only regional economic effects are shown for the local impact area.

TABLE 11: REGIONAL ECONOMIC DEVELOPMENT IMPACTS ALTERNATIVES 2 AND 3

Alternative 2: Upstream Detention Plan

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$191,261,578,095	1,322,858.0	\$149,672,922,272	\$134,897,970,269
<i>Secondary Impact</i>		\$194,153,757,900	836,681.0	\$75,782,397,078	\$125,495,676,061
<i>Total Impact</i>	\$191,261,578,095	\$385,415,335,995	2,159,539.0	\$225,455,319,350	\$260,393,646,330

Alternative 3: Combination Plan

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$304,880,560	2,108.7	\$238,586,154	\$215,034,139
<i>Secondary Impact</i>		\$309,490,840	1,333.7	\$120,800,947	\$200,046,410
<i>Total Impact</i>	\$304,880,560	\$614,371,400	3,442.4	\$359,387,101	\$415,080,549

TABLE 12: ALTERNATIVE 4: REGIONAL ECONOMIC DEVELOPMENT IMPACTS

Alternative 4a: Cranford 10-Year

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$134,400,887	929.6	\$105,176,239	\$94,793,774
<i>Secondary Impact</i>		\$136,433,243	587.9	\$53,252,836	\$88,186,714
<i>Total Impact</i>	\$134,400,887	\$270,834,130	1,517.5	\$158,429,075	\$182,980,489

Alternative 4b: Cranford 100 Year

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$213,982,133	1,480.0	\$167,453,032	\$150,922,918
<i>Secondary Impact</i>		\$217,217,884	936.1	\$84,784,823	\$140,403,696
<i>Total Impact</i>	\$213,982,133	\$431,200,017	2,416.1	\$252,237,855	\$291,326,614

Alternative 4c: East Branch 10-Year

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$21,348,086	147.7	\$16,706,076	\$15,056,937
<i>Secondary Impact</i>		\$21,670,903	93.4	\$8,458,621	\$14,007,479
<i>Total Impact</i>	\$21,348,086	\$43,018,990	241.0	\$25,164,697	\$29,064,416

Alternative 4d: East Branch 100-Year

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$61,066,593	422.4	\$47,788,037	\$43,070,644
<i>Secondary Impact</i>		\$61,990,017	267.1	\$24,196,040	\$40,068,651
<i>Total Impact</i>	\$61,066,593	\$123,056,610	689.5	\$71,984,077	\$83,139,295

Alternative 4e: Robinsons Branch 10-Year

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$30,830,432	213.2	\$24,126,544	\$21,744,894
<i>Secondary Impact</i>		\$31,296,638	134.9	\$12,215,752	\$20,229,290
<i>Total Impact</i>	\$30,830,432	\$62,127,070	348.1	\$36,342,297	\$41,974,184

Alternative 4f: Robinsons Branch 100-Year

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
<i>Direct Impact</i>		\$43,644,329	301.9	\$34,154,137	\$30,782,614
<i>Secondary Impact</i>		\$44,304,300	190.9	\$17,292,923	\$28,637,087
<i>Total Impact</i>	\$43,644,329	\$87,948,629	492.8	\$51,447,061	\$59,419,701

5.5.1.3. ENVIRONMENTAL QUALITY (EQ)

The EQ account measures contributions to significant environmental and cultural resources in, typically, non-monetary means. Effects can be either beneficial or detrimental in terms of the ecological aesthetic and cultural resources influenced by the various alternatives as measured against the conditions that would occur in the no action – future without project – condition. Environmental quality can include factors such as ecosystem restoration, habitat creation, and endangered species protection. Cultural resources are also included in this account such as historic buildings and preservation sites.

A two-step qualitative analysis was conducted to rank how the alternatives contribute to or adversely effect to the EQ Account. The first step involved a preliminary evaluation on the environmental effects. For the purposes of the preliminary screening, the magnitude of impacts are categorized by the following:

- No Effect: No noticeable adverse effect on the environment would occur.
- Negligible/Less Than Significant (N/LTS): The effects of the project do not reach or exceed the defined threshold/criteria of significance as outlined in federal

and/or state laws specific to the resource or are not adverse. No mitigation measures are required for the LTS impact.

- Negligible Positive Effect (NPE): Applies to an action when the potential beneficial effects of the project are small enough to where a minor noticeable positive change to a resource and/or environment may be observed within the project area, but not to such a degree as to have a meaningful, positive change for the system or region as a whole.
- Moderate/Less than Significant with Mitigation (M/LTSM): Mitigation measures in the form of avoidance, minimization, reduction of the impact over time, and/or compensation are identified to reduce the potentially significant effect to a less than significant level.
- Moderate Positive Effect (MPE): MPE applies to actions that result in noticeable and quantifiable positive changes to any physical condition within the project area and a distance beyond the project area, but the effects are not observed throughout the region.
- Significant and Unavoidable (SU): SU is applied to actions that cause substantial permanent adverse changes to any of the physical conditions within the area affected by the proposed action. Although implementation of mitigation measures may reduce the significance of the effects, they will not reduce the impact to a less than significant level. Unavoidable is defined as the impact is necessary in order for the proposed action to achieve its stated goal, in this case flood risk management.
- Significant Positive Effect (SPE): SPE applies to actions that result in a substantial positive change to any physical conditions within the area affected by the proposed action and to the region in which the proposed action is located.

TABLE 13: SUMMARY OF EFFECTS OF ALTERNATIVES TO ENVIRONMENTAL RESOURCES

Alternative	Surface Water Resources	Wetlands	Vegetation	Fish & Wildlife
Alternative 1 No Action	No Effect	No Effect	No Effect	No Effect
Alternative 2 Upstream Detention Plan	M/LTSM	M/LTSM	SU	M/LTSM
Alternative 3 Combination Plan	M/LTSM	SU	SU	M/LTSM
Alternative 4 Nonstructural Plan	No Effect	No Effect	No Effect	No Effect
Alternative 5 Lenape Park Plan	SU	SU	SU	SU

TABLE 14: SUMMARY OF EFFECTS TO GREEN ACRES AND CULTURAL RESOURCES

Alternative	Green Acres Properties	Cultural Resources
Alternative 1 No Action	No Effect	No Effect
Alternative 2 Upstream Detention Plan	SU	M/LTSM
Alternative 3 Combination Plan	SU	M/LTSM
Alternative 4 Nonstructural Plan	No Effect	M/LTSM
Alternative 5 Lenape Park Plan	SU	M/LTSM

The second step involves scoring the alternatives contribution to the EQ account based on the preliminary effects determinations by ranking them low, medium and high. Any alternative that had a majority Significant and Unavoidable or Negligible Positive effects across resource categories was ranked as “low”. Alternatives where the effects were Moderate/Less Than Significant with Mitigation and/or Moderate Positive for a majority for resource categories were marked as “medium”. Alternatives where there were No Effects, Less Than Significant, and/or Significant Positive effects were ranked as “high”.

TABLE 15: SUMMARY OF CONTRIBUTION OF ALTERNATIVES TO THE EQ ACCOUNT

Alternative	Rating
Alternative 1 No Action	High
Alternative 2 Upstream Detention Plan	Medium
Alternative 3 Combination Plan	Medium
Alternative 4 Nonstructural Plan	High
Alternative 5 Lenape Park Plan	Low

5.5.1.4. OTHER SOCIAL EFFECTS

USACE policy, specifically the Principles and Guidelines (P&G) requires consideration of “Other Social Effects,” such as life, health, and safety, social vulnerability and resilience, economic vitality, social connectedness, identity and participation, and leisure and recreation to guide identification and development of water resource projects which are considered to be effective, acceptable, and fair.

Life Safety

Life safety risk assessments are a systematic approach for describing the nature of riverine flood risk, including the likelihood and severity of occurrence, while explicitly acknowledging the uncertainty in the analysis. Life loss consequences are the determination of the population at risk and the estimated statistical life loss in a given area. An assessment of the various types of risk, including residual risk, transferred risk, transformed risk, and incremental risk, can help inform whether an alternative provides a tolerable level of safety for the study area in the future with-project condition.

Residual risk is the riverine flood risk that remains in the floodplain even after a proposed flood risk management project is constructed and implemented. Physical damages, as well as potential life loss consequences, can remain even after the project is implemented due to a variety of causes.

5.5.1.5. SUMMARY OF ENVIRONMENTAL EFFECTS

The offset of adverse effects flood risk management alternatives may have on regulated resources are included in the cost development both as a specific account (Account 06 Fish and Wildlife Facilities) and as part of general construction costs. The applicable federal laws, state laws and USACE policies used to inform the development of Account 06 costs include the following:

- National Environmental Policy Act (NEPA): Defines mitigation as a) avoiding the impact by not taking certain actions or parts of an action; b) minimizing the impact by limiting the degree of the action and its implementation; c) rectifying the impact by repairing, rehabilitating, or restoring the effected environment; d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; e) compensating for the impact by replacing or providing substitute resources or environments.
- Clean Water Act/New Jersey Freshwater Wetlands Protection Act: Sections of the CWA applicable to work within waterways includes Section 401 (Water Quality Certification) and 404 (discharge of fill into the U.S. waters). The state of New Jersey has assumed both the Section 401 and 404 authorities under the New Jersey Freshwater Wetlands Protection Act with the New Jersey Department of Environmental Protection serving as the responsible administering agency.
- The New Jersey Freshwater Wetlands Protection Act (NJFWWPA) Rules require compensatory mitigation for fill to open water and wetland resources in the form of: a) On-site restoration, creation, or enhancement; b) Purchase of in-kind credits from a mitigation bank with a service that includes the area of disturbance; and c) Off-site restoration, creation or enhancement in the same watershed as disturbance. The Freshwater Wetlands Protection Rules further require a five-year post construction monitoring period on-site or off-site mitigation.
- Magnuson-Stevens Act: Requires federal agencies to minimize adverse effects to federally managed fish species and their habitat and to consult with the National Oceanic and Atmospheric Administration – Fisheries (NOAA-Fisheries). Mitigation measures may include: a) Modification of project to minimize impacts on EFH; b) Implementation of Best Management Practices; and c) Habitat restoration.
- Endangered Species Act: Mandates that federal agencies ensure their actions do not jeopardize listed species or their critical habitats, and that agencies consult with either the USFWS or the NOAA – Fisheries depending on the species. Mitigation measures are similar as to those for EFH Habitat.
- New Jersey Flood Hazard Area Control Act (NJFHACA): Requires mitigation for actions that remove vegetation within the riparian zone. Per the Rules, the compensatory mitigation can consist of: a) Removal of any impervious surface within 100 feet of streambank; herbicide application for invasive species management; b)

Clearing/grubbing of invasive plant species; c) Planting natives trees and shrubs within 100 ft of streambank; and 4. Purchase of credits from a state approved mitigation bank.

- New Jersey Green Acres: Under the Green Acres Program Rules, lands subject to the rules of the program cannot be disposed of or diverted unless it can be demonstrated to the state that the modification will protect or enhance the use of the area. By definition, land that is used for purposes other than recreation, open space, and conservation is considered a “diversion” while a disposal is the selling, donating, or some other form of permanent transfer of possession of parkland. Additionally, the Rules mandates compensation for tree removal on parkland when a proposal involves a major diversion and a two-year monitoring period to ensure survivability of the mitigation plantings.
- USACE Engineering Regulation 1105-2-100 Planning Guidance Notebook, Appendix C. Outlines requirements consultation with USFWS and NOAA-Fisheries and for ensuring that wetland resources are fully mitigated through no net loss of wetlands as determined by a habitat functional assessment.

Tables 16 through 22 briefly summarize the effects on the specific regulated resources discussed in Section 2.4 and the potential mitigation measures to minimize or compensate for the loss of or adverse effect to that specific resource. The level of analysis conducted is based on: 1. conceptual plans; 2. documented and established typical effects the proposed flood risk management features of each alternative may have on the various of resources; 3. Federal and state environmental resource databases; and 4. information received during agency coordination for this current report and past reports. Site specific surveys were not conducted and detailed analyses utilizing USACE approved ecological models were not performed.

TABLE 16: ALTERNATIVE EFFECTS ON AND MITIGATION REQUIREMENTS FOR SURFACE WATER RESOURCES

Alternative	Effect
Alternative 1 No Action	No Effect
Alternative 2 Upstream Detention Plan	<u>Effect:</u> Fill of approximately 400 linear feet of the West Branch Rahway resulting from dam construction.
	<u>Mitigation Specific to Account 06 Costs:</u> Compensation through the enhancement or restoration of a degraded portion of the West Branch Rahway River and five-year post mitigation construction monitoring or purchase of mitigation credits from a state approved mitigation bank.
	<u>Mitigation Incorporated into Overall Construction Costs:</u> Implementation of erosion and sediment control best management practices during construction to prevent water quality degradation.
Alternative 3 Combination Plan	<u>Effect:</u> Modification of 2,470 ft of the West Branch by converting it from a concrete channel to a natural, deeper channel. Channel modification of approximately 2,640 feet of the West Branch Rahway River through deepening. Removal/modification of Droescher’s dam, Sperry Dam, and Jackson Dam.
	<u>Mitigation Specific to Account 06 Costs:</u> Incorporation of stream enhancement or restoration measures such as streambank stabilization with native vegetation or in-channel features that

Alternative	Effect
	support aquatic wildlife within the portion of the channel being modified. Potential off-site mitigation through the enhancement or restoration of another location within the Rahway River. Five-year post construction monitoring would be performed with either option.
	<u>Mitigation Incorporated into Overall Construction Costs:</u> Implementation of erosion and sediment control best management practices during construction.
Alternative 4 Nonstructural Plan	No Effect
Alternative 5 Lenape Park Plan	<u>Effect:</u> Modification of approximately 15,500 linear feet of the Main Stem Rahway River.
	<u>Mitigation Specific to Account 06 Costs:</u> Incorporation of stream enhancement or restoration measures such as streambank stabilization with native vegetation or in-channel features that support aquatic wildlife within the portion of the channel being modified. Potential off-site mitigation through the enhancement or restoration of another location within the Rahway River. Five-year post construction monitoring would be performed with either option.
	<u>Mitigation Incorporated into Overall Construction Costs:</u> Implementation of erosion and sediment control best management practices during construction.

TABLE 17: ALTERNATIVE EFFECTS ON WETLAND RESOURCES

Alternative	Effect/Mitigation
Alternative 1 No Action	No Effect
Alternative 2 Upstream Detention Plan	<u>Effect</u> : Direct adverse effects to approximately 0.10 acres of forested wetland resulting from construction of the dam and a required 50 ft vegetation free zone as required by USACE Engineering Technical Letter 1110-2-583.
	<u>Mitigation Specific to Account 06 Costs</u> : Compensation through the enhancement, creation, or restoration of wetlands offsite within the watershed and five-year post mitigation construction monitoring, or purchase of mitigation credits from a state approved mitigation bank.
	<u>Mitigation Specific to Overall Construction Costs</u> : Implementation of erosion and sediment control best management practices during construction to prevent water quality degradation.
Alternative 3 Combination Plan	<u>Effect</u> : Direct adverse effects to approximately 2.07 acres of scrub/shrub wetlands and 7 acres of forested wetlands as a result of the construction of the offline retention basin and levees/floodwalls.
	<u>Mitigation Specific to Account 06 Costs</u> : Compensation through the enhancement, creation, or restoration of wetlands offsite within the watershed and five-year post mitigation construction monitoring, or purchase of mitigation credits from a state approved mitigation bank.
	<u>Mitigation Specific to Overall Construction Costs</u> : Implementation of erosion and sediment control best management practices during construction to prevent degradation to wetlands adjacent to or downstream of the project area.
Alternative 4 Nonstructural Plan	No Effect
Alternative 5 Lenape Park Plan	<u>Effects</u> : Fill/conversion of 16 acres of forested wetlands resulting from the construction of the dam and levee improvements, and channel modifications.
	<u>Mitigation Specific to Account 06 Costs</u> : Compensation through the enhancement, creation, or restoration of wetlands offsite within the watershed, or purchase of mitigation credits from a state approved mitigation bank.
	<u>Mitigation Specific to Overall Construction Costs</u> : Implementation of erosion and sediment control best management practices during construction to prevent degradation to wetlands adjacent to or downstream of the project area.

TABLE 18: ALTERNATIVE EFFECTS ON AND MITIGATION REQUIREMENTS FOR VERNAL HABITAT

Alternative	Effect/Mitigation
Alternative 1 No Action	No Effect
Alternative 2 Upstream Detention Plan	No Effect: No vernal habitat within alternative footprint.
Alternative 3 Combination Plan	No Effect: No vernal habitat within alternative footprint.
Alt 4 Nonstructural Plan	No Effect: No vernal habitat within alternative footprint.
Alt 5 Lenape Park Plan	No Effect: No vernal habitat within alternative footprint.

TABLE 19 EFFECTS AND MITIGATION OF REGULATED RIPARIAN ZONE

Alternative	Effect/Mitigation
Alt 1 No Action	No Effect
Alternative 2 Upstream Detention Plan	<u>Effect</u> : Approximately 0.01 acres of riparian vegetation would be removed during the construction of the dam, and approximately 1 acre of riparian vegetation could be indirectly impacted from the change in hydrology within the impoundment area footprint.
	<u>Mitigation Specific to Account 06 Costs</u> : Flood Hazard Area Control Act rules do not apply to dams. However, the removal of the trees would be compensated as required per the Green Acres Regulations. Costs include the required two-year vegetation monitoring period.
	<u>Mitigation Specific to Overall Construction Costs</u> : Implementation of erosion and sediment control best management practices during construction to prevent degradation to wetlands adjacent to or downstream of the project area.
Alternative 3 Combination Plan	<u>Effect</u> : Removal of approximately 20 acres riparian vegetation resulting from construction of the offline retention basins, channel modifications, and levee/floodwalls.
	<u>Mitigation Specific to Account 06 Costs</u> : Compensation through the enhancement, creation, or restoration of the riparian zone offsite within the watershed and five-year post construction mitigation monitoring, or purchase of mitigation credits from a state approved mitigation bank.
	<u>Mitigation Specific to Overall Construction Costs</u> : Implementation of erosion and sediment control best management practices during construction to prevent degradation to wetlands adjacent to or downstream of the project area.
Alternative 4 Nonstructural Plan	No Effect
Alternative 5 Lenape Park Plan	<u>Effect</u> : Removal of 12 acres of riparian vegetation resulting from construction of the flood risk management measures.
	<u>Mitigation Specific to Account 06 Costs</u> : Compensation through the enhancement, creation, or restoration of the riparian zone offsite within the watershed and five-year post mitigation construction

Alternative	Effect/Mitigation
	monitoring, or purchase of mitigation credits from a state approved mitigation bank.
	<u>Mitigation Specific to Overall Construction Costs:</u> Implementation of erosion and sediment control best management practices during construction to prevent degradation to wetlands adjacent to or downstream of the project area.

TABLE 20: ALTERNATIVES EFFECTS ON AND MITIGATION FOR ESSENTIAL FISH HABITAT

Alternative	Effect
Alternative 1 No Action	No Effect
Alternative 2 Upstream Detention Plan	No Effect
Alternative 3 Combination Plan	<u>Effect:</u> Approximately 8,700 linear ft of the Main Stem Rahway River designated as EFH could be indirectly adversely affected through the removal of riparian vegetation.
	<u>Mitigation Specific to Account 06 Costs:</u> Any in-channel habitat restoration or enhancement and any riparian mitigation would be covered under the mitigation requirements by the Freshwater Protection Act and Flood Hazard Area Control Act respectively.
	<u>Mitigation Specific to Overall Construction Costs:</u> In-water timing restrictions if best management practices such as cofferdams are not used; Implementation of erosion and sediment control BMP's to prevent degradation of EFH downstream of the project area.
Alternative 4 Nonstructural Plan	No Effect as there is no work proposed in open water and/or wetlands.
Alternative 5 Lenape Park Plan	<u>Effect:</u> 14,500 linear feet of the Main Stem Rahway designated as EFH would be impacted through the channel modification.
	<u>Mitigation Specific to Account 06 Cost:</u> In-channel habitat restoration and any riparian mitigation would be covered under the mitigation requirements by the Freshwater Protection Act and Flood Hazard Area Control Act respectively.
	<u>Mitigation Specific to Overall Construction Costs:</u> In-water timing restrictions if best management practices such as cofferdams are not used.

TABLE 21: ALTERNATIVE EFFECTS ON AND MITIGATION FOR FEDERAL AND STATE LISTED SPECIES

Alternative	Effect/Mitigation
Alternative 1 No Action	No Effect
Alternative 2 Upstream Detention Plan	<u>Effect:</u> Potential loss of habitat supportive of federally listed bat species through removal of mature trees.
	<u>Mitigation Specific to 06 Account:</u> Due to acreage to be cleared, a presence/ absence survey for listed bat surveys would be required prior to construction.

Alternative	Effect/Mitigation
	<u>Mitigation Incorporated into Overall Construction Costs:</u> Implementation of tree clearing restriction from 1 April through 30 September.
Alternative 3 Combination Plan	<u>Effect:</u> Potential loss of habitat supportive of federally listed bat species through removal of mature trees.
	<u>Mitigation Specific to 06 Account:</u> Due to acreage to be cleared, a presence/ absence survey for listed bat surveys would be required prior to construction.
	<u>Mitigation Incorporated into Overall Construction Costs:</u> Implementation of tree clearing restriction from 1 April through 30 September.
Alternative 4 Nonstructural Plan	No Effect
Alternative 5 Lenape Park Plan	<u>Effect:</u> Potential loss of habitat supportive of federally listed bat species through removal of mature trees.
	<u>Mitigation Specific to 06 Account:</u> Due to acreage to be cleared, a presence/ absence survey for listed bat surveys would be required prior to construction.
	<u>Mitigation Incorporated into Overall Construction Costs:</u> Implementation of tree clearing restriction from 1 April through 30 September.

TABLE 22: ALTERNATIVES EFFECTS ON AND MITIGATION FOR GREEN ACRES ENCUMBERED LANDS

Alternative	Effect/Mitigation
Alternative 1 No Action	<u>Effect:</u> Green Acres encumbered properties subject to flooding under existing conditions would still be subject to flooding.
	<u>Mitigation:</u> Not applicable.
Alternative 2 Upstream Detention Plan	<u>Effect:</u> Direct adverse effects to approximately 37.5 acres of Green Acres encumbered lands through the construction of the dam, road relocation, and impoundment area.
	<u>Mitigation Specific to Account 06:</u> Conduct a tree survey, develop a tree compensation plan, and conduct a 2-year post construction planting monitoring to ensure survivability of vegetation.
	<u>Mitigation Specific to Real Estate Considerations:</u> Potentially acquire lands to compensate for the changed use.
Alternative 3 Combination Plan	<u>Mitigation Specific to Account 06:</u> Conduct a tree survey, develop a tree compensation plan, and conduct a 2-year post construction planting monitoring to ensure survivability of vegetation.
	<u>Mitigation Specific to Real Estate Considerations:</u> Potentially acquire lands to compensate for the changed use.
Alternative 4 Nonstructural Plan	No Effect as no nonstructural measures would be implemented within Green Acres encumbered lands.

Alternative	Effect/Mitigation
	<u>Mitigation</u> : Not applicable.
Alternative 5 Lenape Park Plan	<u>Effect</u> : Direct adverse effects to approximately 16 acres of Green Acres encumbered lands through the enhancement of existing embankments.
	<u>Mitigation Specific to Account 06</u> : Conduct a tree survey, develop a tree compensation plan, and conduct a 2-year post construction planting monitoring to ensure survivability of vegetation.
	<u>Mitigation Specific to Real Estate Considerations</u> : Potentially acquire lands to compensate for the changed use.

5.5.2. CULTURAL RESOURCE CONSIDERATIONS

Current statutes and regulations governing the identification, protection, and preservation of cultural resources include the National Historic Preservation Act (NHPA); NEPA; Executive Order 11593; and the regulations implementing Section 106 of the NHPA (36 CFR Part 800, Protection of Historic Properties, August 2004). These regulations form the basis of the cultural resource mitigation cost component (Account 18) of the overall project cost estimate.

TABLE 23: CULTURAL RESOURCE IMPACTS

Alternative	Effect
Alternative 1 No Action	Potential adverse impacts to cultural resources currently at risk of flooding, including several historic structures within the North Cranford Historic District, as well as archaeological sites located along the Rahway River in Cranford.
Alternative 2 Upstream Detention Plan	Potential adverse impacts to 18 previously recorded cultural resources in the alternative APE, including the South Mountain Reservation and North Cranford Historic Districts, the Rahway River Parkway, Union County Park System (Lenape and Nomahegan Parks), McConnell Park, and the Hanson House and Park, among others (see Appendix A).
Alternative 3 Combination Plan	Potential adverse impacts to 19 previously recorded cultural resources in the alternative APE, including several archaeological sites, the South Mountain Reservation and North Cranford Historic Districts, the Rahway River Parkway, Union County Park System (Lenape and Nomahegan Parks), and the South Orange Avenue and Cherry Lane Bridges, among others (see Appendix A).
Alternative 4 Nonstructural Plan	Potential adverse impacts in the alternative APE, specifically historic structures receiving nonstructural measures under this alternative.
Alternative 5 Lenape Park Plan	Potential adverse impacts to 18 previously recorded cultural resources in the alternative APE, including several archaeological sites, the South Mountain Reservation, North Cranford Historic District, the Rahway River Parkway, Union County Park System (Lenape and Nomahegan Parks), Droscher’s Mill, and Orange Reservoir and Dam, among others (see Appendix A).

In accordance with NEPA and the National Historic Preservation Act (54 USC 306108), federal agencies are required to consider the effect of their projects to historic properties and cultural resources prior to initiating the action and to allow the public and potential consulting parties an opportunity to weigh in on any determination of effect. Federal agencies must consider impacts to cultural and historic resources, which encompass a broader range of resources including but not limited to archaeological collections, sacred sites, and some resources that may not meet the criteria for eligibility to the National Register. Section 106 of the NHPA outlines the steps a federal agency must take to avoid, preserve, protect, minimize, or compensate for impacts to National Register of Historic Places (NRHP) eligible or listed sites where an undertaking will result in adverse effect to such resources. In consultation with NJSHPO, Consulting Tribal Nations, and Consulting Parties, any known or recorded cultural resources within proposed project footprints that may face potential adverse effects resulting from a project would be evaluated if designs are further formulated.

The District carried out an assessment and made the determination that each alternative has the potential to have an adverse effect to historic properties. Table 23 presents an overview of cultural resources located in the Area of Potential Effect (APE) for each action alternative. The Upstream Detention, the Combination Plan, the Nonstructural Plan, and the Lenape Park Plan have the potential to adversely affect several historic properties such as Droescher's Mill, Orange Reservoir and Dam, Nomahegan Park, and Lenape Park, as well as several notable historic districts such as the North Cranford, South Mountain Reservation, and Rahway River Parkway Historic Districts. For a complete list of all cultural resources in the APEs for each action alternative, see Appendix A, Section 6.1.

For each action alternative the District recommended consultation with the NJSHPO, ACHP and other potential consulting parties to develop a Memorandum of Agreement (MOA) or Programmatic Agreement (PA) to develop a process for resolution of adverse effects through mitigation. Cultural resources mitigation costs were developed for each alternative at each site in the final array in accordance with ER 1105-2-100. Survey and mitigation estimates include archaeological investigations, architectural surveys, and data recovery. Estimates were developed using existing information and assumptions about the level of mitigation required at each site depending on the scale of the undertaking proposed in each alternative as well as the presence of historic properties and potential for buried archaeological sites within a given area. For a detailed discussion of potential cultural resources impacts at each site, refer to the Cultural Resources Report and Background Study (Appendix A).

5.5.3. HTRW CONSIDERATIONS

If alternatives were further developed, a subsurface/structural planning investigation would take place to further characterize the subsurface or structural conditions. This investigation would inform any potential HTRW risks associated with construction and implementation of a proposed project.

Should HTRW be identified during any phase of a USACE civil works project, it is USACE policy to avoid it as practicable. However, if HTRW avoidance is not possible it would be the

responsibility of the NFS to provide a clean site for the project, using 100% non-federal non-project funds, in accordance with ER 1165-2-132.

5.5.4. REAL ESTATE CONSIDERATIONS

Five (5) potential alternatives as described under Section 5.3 were evaluated, each with differing real estate requirements and factors to consider. These alternatives have not been optimized, and real estate adjustments may be required as designs progress. The following is a breakout of the real estate considerations associated with each alternative.

Alternative 1 (No Action) – No real estate actions required.

Alternative 2 (Upstream Detention) – Real Estate requirements include a mix of fee simple acquisition, perpetual, & temporary easement acquisitions across five (5) parcels to support this alternative. All five parcels identified for this alternative are publicly owned properties located within the South Mountain Reservation as referenced in Section 5.3.2. No NFS owned properties are included within this alternative.

The South Mountain Reservation is included as part of the New Jersey Department of Environmental Protection’s Green Acres Program, and any real estate acquisition must adhere to the requirements imposed for diversion and/or use of Green Acres property. Since the associated real estate is Green Acres encumbered, mitigation efforts are anticipated to be required for diversion of parkland properties for purposes other than recreation, open space, or conservation.

As directed by ER 405-1-12, Chapter 12-9.b.(1) Fee title is required for dam sites and needed to support this proposed dam construction/alternative. Additionally, placement of the dam is anticipated to create inundation of adjacent properties beyond what is typical under a 50-year storm event and will require at minimum acquisition of flowage easements for perpetual and occasional flooding. Recent policy per CECW Memo dated 28 Jul 25 may dictate the need for additional compensation and/or acquisition in fee of the inundated property based on a physical takings analysis. The anticipated inundated parcels are on publicly owned property.

Perpetual road easements will also be required to support the relocation of a portion of Brookside Drive to include real estate acreage for road grading & drainage.

Below is a summary of the estimated acreage required to support this alternative excluding possible Green Acres mitigation requirements to be assessed at a 2:1 ratio.

TABLE 24: ALTERNATIVE 2 UPSTREAM DETENTION PLAN REAL ESTATE REQUIREMENTS

Alternative 2 Upstream Detention Plan Real Estate Requirements	
Acquisition Type	Acreage
Temporary Work Area Easement	1.02
Road Easement	13.33
Flowage Easement	37.08
Fee Simple Acquisition	7.36
Total	58.79

Alternative 3 (Combination Plan) – Real Estate requirements include a mix of fee simple acquisition, perpetual, & temporary easement acquisitions across two hundred fifty-one (251) parcels to support this alternative. Properties identified for this alternative include 204 private & 47 public properties at various locations along the West Branch, East Branch, Main Reach & Robinson’s Branch of the project extending from Milburn and Maplewood through Clark and Cranford to Rahway as more clearly defined in Section 5.23.3. No NFS owned properties are identified for this alternative.

The required real estate is to support construction of the levees & floodwalls. Full taking fee acquisitions are required for twenty-three (23) residential properties where existing structures reside within the design alignment and require buyouts to support construction.

Perpetual flood protection levee easements & temporary work area easements are also required for the remaining acreage needed to support construction & future maintenance of the levees and floodwalls.

Real Estate includes NJDEP Green Acres properties located within the Rahway River Parkway at Lenape Park, Nomahegan Park, MacConnell Park, Hanson Park, Sperry Park & Droescher’s Mill Park. Real estate acquisition must adhere to the requirements imposed for diversion and/or use of Green Acres property. Since portions of the real estate required is Green Acres encumbered, mitigation efforts are anticipated for diversion of parkland properties for purposes other than recreation, open space, or conservation.

Navigational servitude will also be utilized for channel modifications intended below mean high water line. No channel widening or efforts above mean high water line is anticipated with the channel modifications.

Below is a summary of the estimated acreage for Real Estate required to support this alternative excluding Green Acres mitigation requirements to be assessed at a 2:1 Ratio.

TABLE 25: ALTERNATIVE 3 COMBINATION PLAN REAL ESTATE REQUIREMENTS

Alternative 3 Combination Plan Real Estate Requirements	
Acquisition Type	Acreage
Temporary Work Area Easement	11.49
Flood Protection Levee Easement	42.48
Flowage Easement	13.96
Fee	7.41
Total	75.34

Alternative 4 (Nonstructural) – Although typical real estate land acquisitions are not required for nonstructural plans, perpetual easements will be needed to restrict future modification efforts to the constructed nonstructural elements.

The real estate efforts identified for this alternative includes up to two hundred fifty-eight (258) eligible structures for nonstructural participation. The nonstructural efforts will be for either

raising the structure or constructing ringwalls around the eligible structures as described in Section 5.3.4.

Real estate’s primary role is administrative. Efforts and costs are driven by the number of eligible properties and property owners who choose to participate. Efforts will vary as participation is on a voluntary basis.

Real Estate factors to consider include tenant relocations, participation agreement/right of access, survey/title work, & perpetual easement execution.

Below is a breakdown of the location of eligible properties and associated nonstructural efforts. Included is estimated percentage of tenant-occupied properties within each location broken up between the 10-year (10% AEP) storm event (Table 26) and 100-year (1% AEP) storm event (Table 27). Tenant occupied properties are subject to the Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs which requires tenants to receive relocation assistance while home elevations are under construction.

TABLE 26: ALTERNATIVE 4 REAL ESTATE NONSTRUCTURAL SUMMARY FOR 10 YEAR STORM

Grouping	Tenant %	Elevation		Ringwalls		Total Structures
		Residential	Non-Residential	Residential	Non-Residential	
East Branch		17	0	2	4	23
Maplewood (Essex)	23.10%				3	3
Millburn (Essex)	19.10%	14		1		15
Orange City (Essex)	76.20%	1				1
Union (Union)	26.70%	2			1	3
South Orange Village (Essex)	34.00%			1		1
Robinson’s Branch		6	1	5	7	19
Rahway City (Union)	44.90%	6	1	5	7	19
Cranford		91	2	17	9	119
Cranford (Union)	25.30%	13			1	14
Kenilworth (Union)	17.20%	3				3
Millburn (Essex)	19.10%	49	2	16	4	71
Springfield (Union)	37.70%	26		1	4	31
Treatment Totals		114	3	24	20	161

TABLE 27: ALTERNATIVE 4 REAL ESTATE NONSTRUCTURAL SUMMARY FOR 100 YEAR STORM

Grouping	Tenant %	Elevation		Ringwalls		Total Structures
		Residential	Non-Residential	Residential	Non-Residential	
East Branch		31	1	2	17	51
Maplewood (Essex)	23.10%	1			6	7
Millburn (Essex)	19.10%	25		1	7	33
Orange City (Essex)	76.20%	1				1
Union (Union)	26.70%	4	1		4	9
South Orange Village (Essex)	34%			1		1
Robinson’s Branch		15	1	6	10	32
Rahway City (Union)	44.90%	15	1	6	10	32
Cranford		122	3	16	34	175
Cranford (Union)	25.30%	35	1		3	39
Kenilworth (Union)	17.20%	5			2	7
Millburn (Essex)	19.10%	51	2	15	12	80
Springfield (Union)	37.70%	29		1	15	45
Union (Union)	26.70%	2			2	4
Treatment Totals		168	5	24	61	258

Alternative 5 (Lenape Park Plan) – Real Estate requirements include a mix of perpetual and temporary easement acquisitions across one hundred thirty-three (133) parcels to support this alternative. Properties identified for this alternative include Lenape and Nomahegan Parks and various locations along the Rahway River at the Township of Cranford as more clearly defined in Section 5.4.5.

Modifications of structures at Lenape Park will require perpetual flood protection levee easements and temporary work area easements.

Channel widening efforts are part of this effort and will require acquisition of various properties along Rahway River, including properties within Nomahegan Park. Perpetual channel improvement easements and temporary work area easements are required to support the channel modifications. Navigational servitude cannot be utilized for channel modifications as efforts will include acquisition of properties above mean high water line.

Lenape Park and Nomahegan Park are included within the NJDEP Green Acres Program. Real Estate acquisition must adhere to the requirements imposed for diversion and/or use of Green Acres properties. Since portions of required real estate is Green Acres encumbered, mitigation efforts are anticipated for diversion of parkland properties for purposes other than recreation, open space, or conservation.

Below is a summary of the estimated Real Estate acreage required to support this alternative excluding possible Green Acres mitigation requirements to be assessed at a 2:1 ratio.

TABLE 28: ALTERNATIVE 5 LENAPE PARK PLAN REAL ESTATE SUMMARY

Alternative 5 Lenape Park Plan Real Estate Requirements	
Acquisition Type	Acreage
Temporary Work Area Easement	4.77
Flood Protection Levee Easement	42.45
Channel Improvement Easement	23.17
Total	70.39

Additional alternatives as identified under Section 5.3.6 were evaluated and determined to be unfeasible due to limitations with design and did not require real estate evaluation for determination.

5.5.5. ECONOMIC ANALYSIS

The study area has been divided into three areas for the economic analysis: Cranford Upstream, for the municipalities of Cranford, Kenilworth, Springfield, Union, Milburn; Robinson’s Branch, for the City of Rahway; and East Branch for the Millburn, Maplewood, and South Orange municipalities.

To conduct economic damage analyses for the without-project condition and alternative plans, Cranford Upstream has been divided into two streams containing a total of 74 economic reaches, including left and right banks. Robinsons Branch fluvial and compound contain 32 and 16 reaches, respectively. East Branch has 32 reaches. Streams, reach locations, and the upstream and downstream limits of the reaches in the economic model were selected to be consistent with the hydrologic/hydraulic modeling and were mostly located at bridges, existing levees, and hydraulic structures such as dams, so that the effects of these features could be modeled in detail.

The building survey and structure inventory development are described in the following subsections.

5.5.5.1. STRUCTURE DATA REFINEMENT

The data sources of the inventory data are NJ MODIV¹ shape file and National Structure Inventory (NSI)². The properties are represented as tax lot (polygon) and points in MODIV and NSI, respectively. Since block and lot numbers are not available in NSI, the two datasets were merged by ArcGIS spatial-join function. The data was cross validated by logical tests. For instance, when the building class is 2 (residential house) in MODIV, but the damage category in NSI is not residential, we use Google Maps and other online real estate resources to verify and

¹ <https://nj.gov/njqin/edata/parcels/>

² <https://www.hec.usace.army.mil/confluence/nsi>

correct the occupancy types. Meanwhile, missing structures from NSI are identified by locating non-vacant land tax lots without a point. For instance, when the building class is 2 (residential house) in MODIV but there are no data points from NSI, we would use Google Maps or other online real estate resources to verify and correct the property attributes. Outliers were identified by logical tests. The first cleansing procedure is removing structures with unreasonably large size. We filter single family houses with building size bigger than 5,000 square feet and verify it with the MODIV online database. We also extract parcels with unreasonably small size. The threshold we used is 500 square feet for residential houses. There were about 300 such parcels. We sampled parcels and confirmed that the size was too small. Due to resource limitations, we corrected the size to be 1,200 square feet.

For an unknown reason, NSI tends to assign a 1,000 square feet structure to vacant public property (property class 15C). They were deleted accordingly. Another limitation of this dataset is missing number of stories. MODIV does not provide this data field. It is likely that NSI sampled number of stories in the study area. This clearly has an implication on the accuracy of occupancy types.

First Floor Elevation (FFE) is derived by summing up the ground elevation (in feet) and foundation height. The former is estimated by LiDAR; and the latter are mapped into each foundation type. When foundation type is not available, NSI randomly assigns a foundation type using Federal Emergency Management Agency (FEMA) HAZUS data. These heights were estimated in a 2021 survey completed by USACE economists with each assumed height closely matching the median value from the survey. This process ignores elevated structures in the study area and will over-estimate potential damage. Elevated buildings were identified from the FEMA Flood Mitigation Assistance (FMA) and Hazard Mitigation Grant Program (HMGP) list provided by the New Jersey Office of Emergency Management (NJOEM). We found 16 properties in Cranford Upstream that have received HMGP grants, and the elevation certificates have been issued³.

5.5.5.2. STRUCTURE AND CONTENTS VALUATION

The structure value is based on the RSMMeans 2024 square foot cost manual. For mass appraisal purpose, only observable data can be used for computation⁴. The depreciated replacement cost is determined by occupancy types (41 categories)⁵, construction types (5 categories - wood, masonry, steel, manufactured, and concrete) and size (2 categories) – a total of 410 categories. Size is a dummy variable of large (L) vs small (S) manual, it is classified as L, vice versa for small-sized properties. The table description of the 410 categories is available upon request. Each residential structure is depreciated by 1% per year for the first 20 years (straight line depreciation), after which it is assumed that routine maintenance would keep structure values at 80% of their replacement values. For commercial and public properties, the maximum depreciation is 30%.

³ Fifteen properties are in Cranford and one at Springfield.

⁴ For instance, square foot cost should increase with the number of bathrooms in the structure. However, this piece of information is not available from NSI nor tax assessor data.

The RSMeans square foot cost is an estimate for national average. The RSMeans manual appendix provides location adjustment for residential and commercial properties. There is no adjustment factor for Cranford. We use Long Branch, NJ as a reference. The choice is dictated by location proximity. The adjustment factors are 1.13 and 1.1 for residential and commercial, respectively. The structure-contents value ratio of residential structure is one, according to the *Economic Guidance Memorandum (EGM) 01-03, "Generic Depth-Damage Relationships", December 4, 2000.*

Each structure is assigned to the nearest cross section line (not necessarily the nearest river station) and the associated water surface profile is used for damage calculation.

Figure 22: Rahway Fluvial Structure Inventory shows the spatial distribution of the structure data. In total 7,859 structures in the study area were identified and subjected to the inventory process for the purposes of damage estimation. The Cranford Upstream study area has 4,739 structures; the Robinson's Branch (Compound) study area has 641 structures; the Robinson's Branch (Fluvial) study area has 1,584 structures; and the East Branch has 895 structures

FIGURE 22: RAHWAY FLUVIAL STRUCTURE INVENTORY

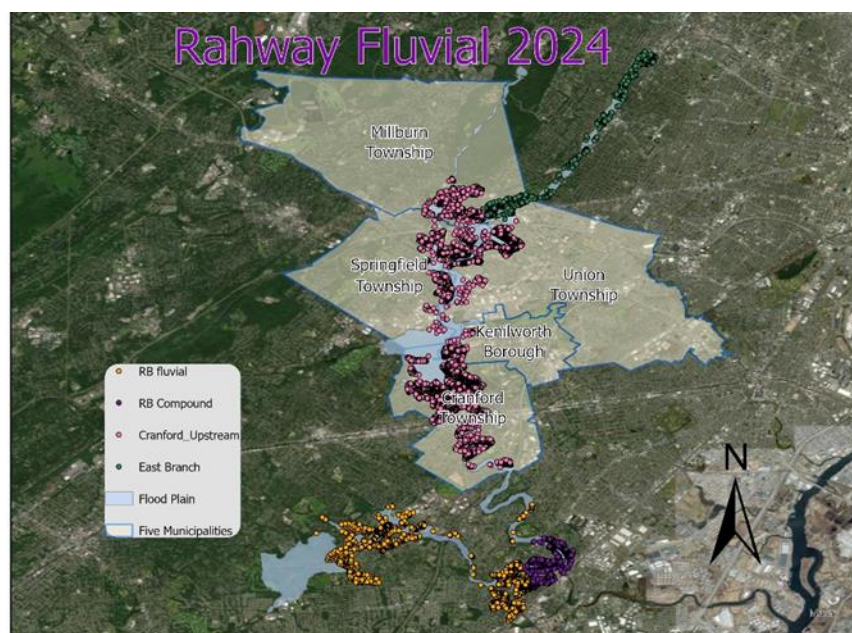


Table 29: Summary of Damageable Elements by Model Area presents a summary of the distribution of building types in the study area and total depreciated structure replacement values at the March 2024 price level by damage categories and model areas. All depreciated structure replacement values are expressed in multiples of \$1,000.

TABLE 29: SUMMARY OF DAMAGEABLE ELEMENTS BY MODEL AREA

	Commercial	Industrial	Public	Residential
Cranford Upstream				
Parcels at Risk (#)	287	75	70	4,307
Damageable Value (\$1,000s)*	\$112,969	\$781,462	\$416,130	\$2,087,836

	Commercial	Industrial	Public	Residential
Average Damageable Value*	\$394	\$10,419	\$5,945	\$485
Robinsons Branch				
Parcels at Risk (#)	149	9	43	2024
Damageable Value (\$1,000s)*	\$399,577	\$39,982	\$273,126	\$1,233,433
Average Damageable Value*	\$2,682	\$4,442	\$6,352	\$609
East Branch				
Parcels at Risk (#)	107	8	34	746
Damageable Value (\$1,000s)*	\$360,230	\$25,110	\$145,294	\$381,148
Average Damageable Value*	\$3,367	\$3,139	\$4,273	\$511

*Price Level March 2024


5.5.5.3. Economic Model Development

The Future Without Project (FWOP) damage is calculated using the stage-frequency distribution, water surface profile, structure data with parcel features and structure values, and damage functions by HEC-FDA 1.4.3. The Future with Project (FWP) damage is calculated in a similar fashion with a different water surface profile. The benefit is defined as reduction in damage, which will be compared to the cost.

The computation of annual flood damages in this analysis is based on the application of depth-damage functions to the structures in the study area to compute damage incurred by structures, their contents, and other associated features during flood events of different probability of occurrence.

Damage is determined as a percentage of overall structure or content value using a triangle distribution of values: Minimum, Most Likely (ML), and Maximum. For inundation, damage is determined by the storm-surge heights above the first-floor elevation. While depth-percent damage curves do provide the option for quantifying damages at thresholds below the First Floor Elevation, the begin damage point for all occupancy types is set to 0 ft.

The depth-percent damage functions utilized in this study are developed by the North Atlantic Coast Comprehensive Study (NACCS) - Resilient Adaptation to Increasing Risk: Physical Depth Damage Function Summary Report⁶.

While the generic residential damage functions do not include a component for other damages, the study attempted,  to capture damages to motor vehicles using USACE guidance found in *Economic Guidance Memorandum 09-04, "Generic Depth-Damage Relationships for Vehicles", June 22, 2009*. The damageable vehicle values of each occupancy type were extracted from NSI. Vehicle values for each structure are based on the number of housing units for residential structures and the number of employees for commercial structures. These estimates do not vary with vehicle ownership rates or income levels throughout the nation. An adjustment factor is

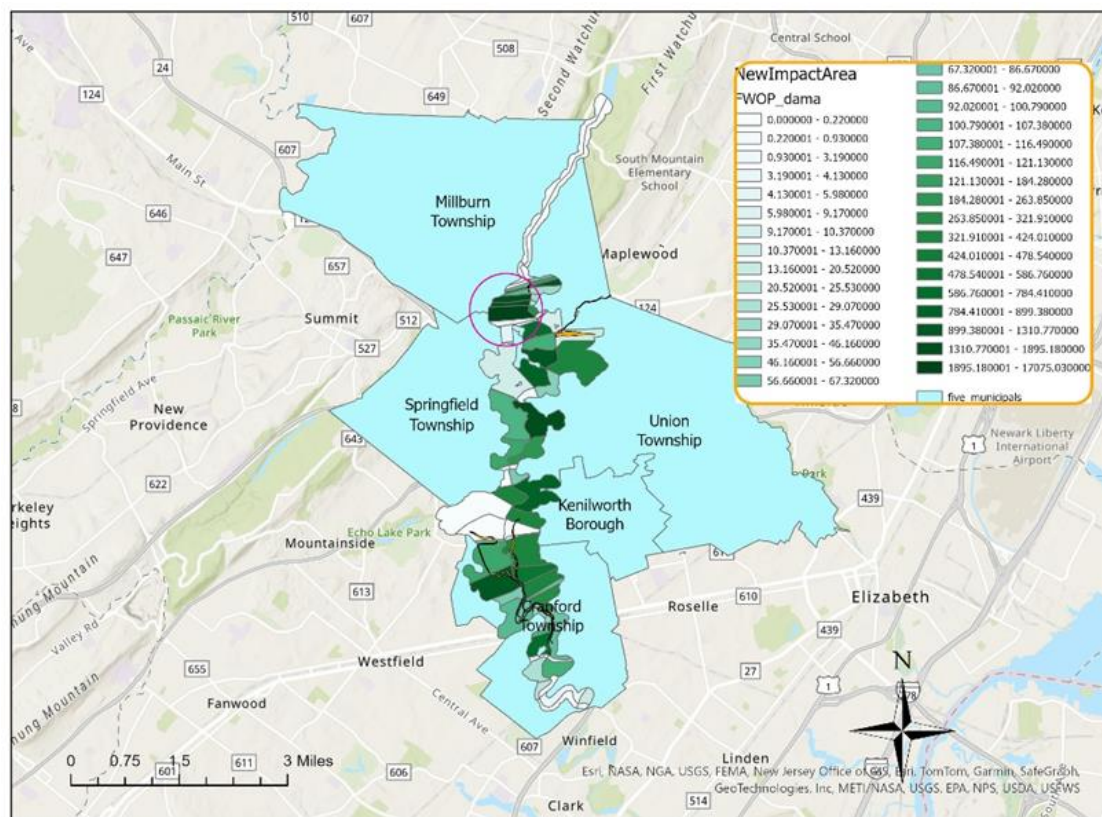
⁶ The damage functions are available upon request.

applied to the FWOP and FWP vehicle damage value because owners are likely to move their cars to higher ground. The probability that vehicle owners would move their vehicles to higher ground before a flood was assumed to be 73%. In the absence of any specific information regarding local warning times in advance of flood events this figure was derived by taking an average of the percentages given in Table 5 of EGM 09-04. Therefore, the adjustment factor is 27%.

5.6. FUTURE WITHOUT PROJECT (FWOP) RESULTS

Using a 3% discount rate, the annual FWOP damage values of Cranford Upstream, East Branch, and Robinson’s Branch (compound) are \$34.11, \$7.57 and \$9.96 million, respectively. Notice that Robinson’s Branch (fluvial) results are not reported because of overlap with the Rahway Tidal study area. The key area of concern is Cranford Upstream. Figure 23 shows the spatial distribution of the FWOP damage by economic reaches. The FWOP damage is highly concentrated in the area circled in pink. More than half of the damage (about 17 million) is recorded in these areas. The location is south of Short Hills – Main Street between Millburn Avenue and I-78 Express.

FIGURE 23: AREAS WITH MOST DAMAGE IN FWOP CONDITION



5.7. COMPARISON WITH HISTORICAL DAMAGE

This section compares the FWOP damage to historical damage using FEMA National Flood Insurance Program (NFIP) claim data. FEMA publishes the NFIP insurance claim data with a

moving window of 46 years⁷. It records redacted individual claim data. Some notable fields are claim paid on building, claim paid on contents and an indicator of post-FIRM. The historical claim payment is only a proxy to past damage. It underestimates actual damage loss for two reasons. 1. Due to adverse selection (hidden types) and moral hazard (hidden action), insurance companies do not compensate damage loss fully, and 2. Residential properties not under mortgage are not required to buy flood insurance. Nonetheless, the spatial and temporal distribution of NFIP can provide useful insights for policy.

We sum up the claim payments over time (temporally) or across census tracts (spatially) to generate a graphs and maps to understand the temporal and spatial distribution of damage. Inflation adjustment is not made because it will only change the scale. To be more specific, inflation adjustment will not alter the ordinal ranking of census tracts by total claim payments.

FIGURE 24: CRANFORD UPSTREAM DAMAGE LOSS OVER TIME

CRANFORD UPSTREAM, RAHWAY RIVER BASIN, NEW JERSEY – ANNUAL TOTAL CLAIM PAYMENT (\$) OVER TIME (1975-2021)

SOURCE: NFIP

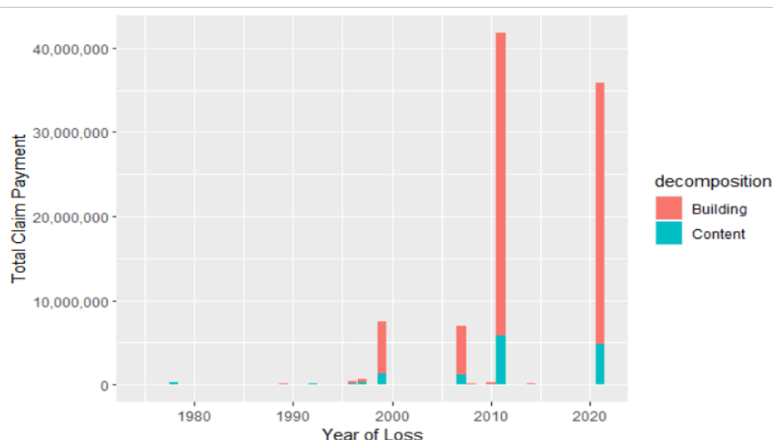


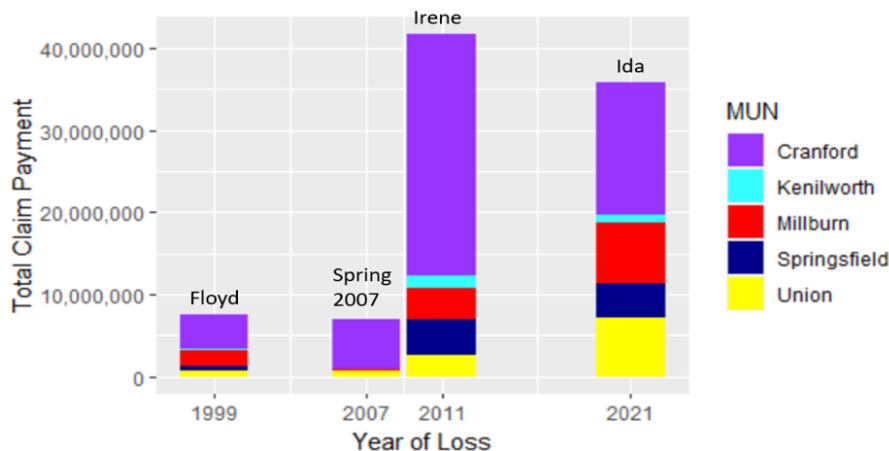
Figure 24 shows the total damage loss from 1975-2021. While the loss distribution is sporadic, the trend is obviously increasing. Building loss is significantly higher than contents loss. Hurricane is the key driving force of damage. The highest loss is about \$42 million in 2011 due to Hurricane Irene. Figure 25 highlights the four years with severe damage by locations. Cranford suffered most loss in all scenarios; Kenilworth experienced the least damage. A prolonged period of rain (1 month) in 2007 contributed to the fourth largest loss in past 46 years.

⁷ <https://www.fema.gov/about/openfema/data-sets>

FIGURE 25: CRANFORD UPSTREAM DAMAGE LOSS OVER TIME BY MUNICIPALITIES

CRANFORD UPSTREAM, RAHWAY RIVER BASIN, NEW JERSEY – ANNUAL TOTAL CLAIM PAYMENT (\$) IN SELECTED HURRICANE YEARS(1975-2021)

SOURCE: NFIP



Error! Reference source not found. Figure 26 illustrates the spatial distribution of loss by census tracts. Darker color means heavier loss. The confluence of east and west branch (Millburn), and Cranford had the highest loss in history, consistent with the FWOP damage distribution.

5.8. OTHER SOCIAL EFFECTS (OSE)

We identify socio-economic vulnerable neighborhoods by eleven environmental, social, and economic factors. The spatial unit is census tract (2023). The sole environmental factor is Parcels at Risk which is the number of structures under the 100-year (1% AEP) floodplain in the census tract⁸. A census tract is deemed more vulnerable when the Parcels at Risk is larger⁹. The data source of the remaining ten social and economic factors is 2022 Census American Community Survey (ACS). The values in Table 30 are 5-year average; they are extracted from a R package known as Tidycensus. U.S Census department authorized an Application Programming Interface (API) developed by Walker and Herman (2021)¹⁰.

Other than population having a degree and median income, a census tract is considered to be more socio-economic vulnerable when the indicator value is higher. Table 31. reports the values of the 11 factors from ACS. The whole study area does not seem to be economically inferior. Only one census tract has median income (census tract # 336) lower than the 2022 national level (\$ 37,585). Two census tracts (#201 and 202) have median income over \$100,000. The percentage of households receiving public assistance is zero in four census tracts.

⁸ The data source of PAR is NSI. This analysis was initially conducted for the charrette.

⁹ Relative area of floodplain to the size of census tract was considered initially. However, it is possible that there is no structure in floodplain, especially along floodway. PAR seems to be a more reliable index of environmental vulnerability.

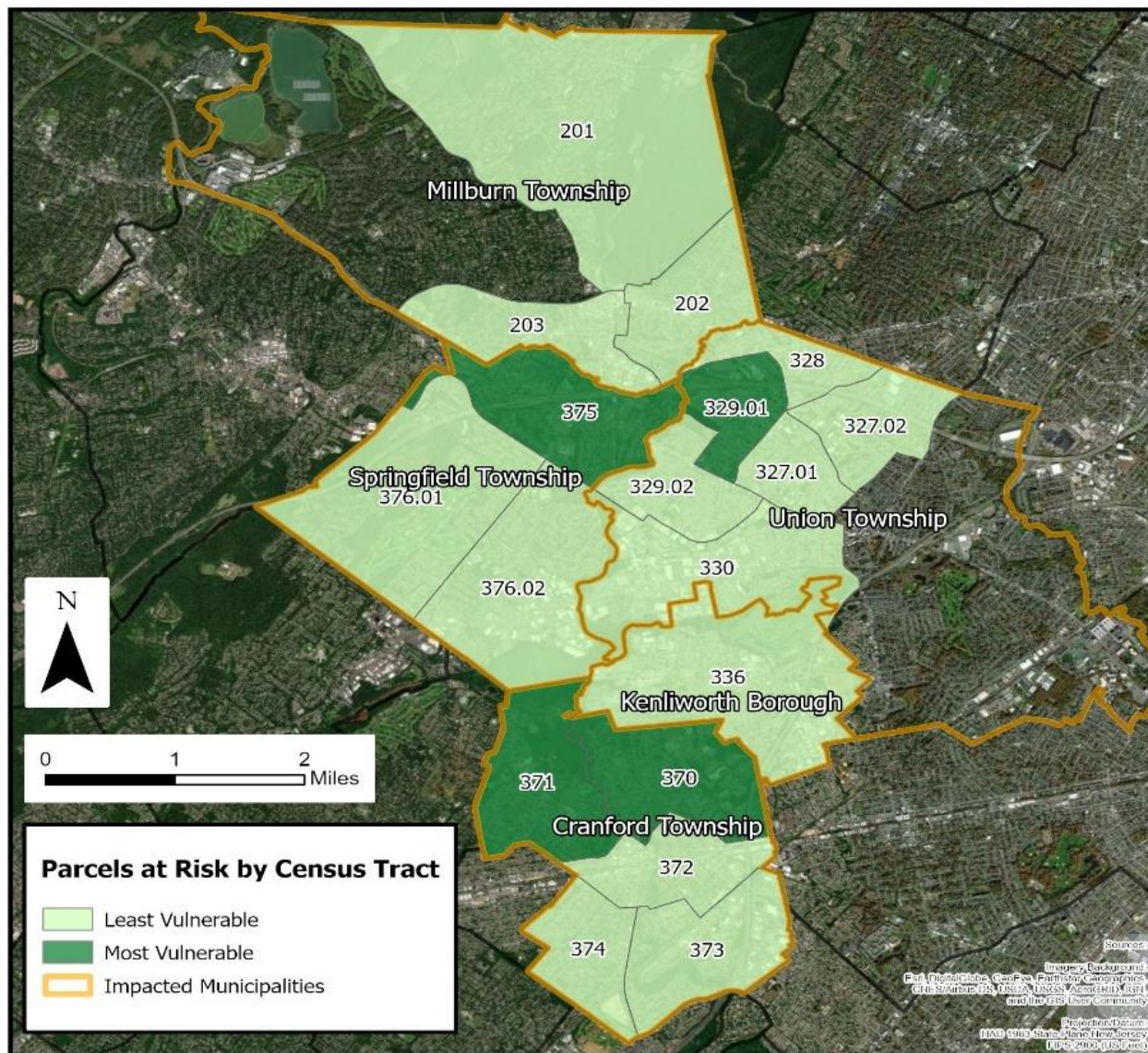
¹⁰ <https://walker-data.com/census-r/an-introduction-to-tidycensus.html#searching-for-variables-in-tidycensus>

TABLE 30: IDENTIFY SOCIO-ECONOMIC VULNERABLE CENSUS TRACTS

Identify Socio-Economic Vulnerable Census Tracts											
Census Tract #	Environmental	Social				Economic					
	Parcels at Risk (PAR)	Population	over65	Population having a degree	Households with at least one member with disability	Median Income	Poverty Rate	Unemployment rate	GINI Index	Households receiving public assistance	Gross rent as percentage of income
201	28	5213	14.4%	32.4%	7.1%	\$ 156,250	1.1%	3.5%	44.9%	0.0%	20.1%
202	367	5139	15.6%	36.1%	12.6%	\$ 116,250	3.7%	3.9%	41.7%	4.4%	31.2%
203	399	5098	8.7%	35.0%	4.2%	\$ 86,573	12.4%	7.6%	48.4%	3.6%	27.4%
327.01	73	3768	19.1%	36.8%	14.1%	\$ 47,906	2.1%	6.5%	48.6%	30.6%	23.5%
327.02	73	5330	18.5%	22.3%	22.3%	\$ 50,518	2.7%	4.8%	39.8%	6.2%	21.5%
328	161	4928	17.9%	21.2%	30.2%	\$ 34,665	13.4%	6.2%	40.4%	36.4%	41.9%
329.01	615	4940	15.4%	23.6%	17.5%	\$ 41,440	2.3%	3.2%	32.6%	4.1%	29.6%
329.02	260	4499	23.3%	24.0%	19.9%	\$ 45,146	8.5%	4.0%	41.9%	15.9%	37.1%
330	254	4032	15.3%	35.2%	12.2%	\$ 68,063	4.1%	9.7%	31.1%	5.3%	22.4%
336	614	8345	14.5%	19.0%	24.1%	\$ 37,089	7.6%	8.4%	50.8%	6.3%	26.5%
370	849	6052	26.7%	34.2%	31.0%	\$ 67,339	2.6%	2.5%	40.6%	0.0%	32.1%
371	854	4458	15.1%	43.3%	13.5%	\$ 94,167	3.1%	4.3%	44.4%	3.7%	22.0%
372	239	4237	22.3%	39.9%	16.4%	\$ 46,373	7.4%	3.1%	50.0%	1.1%	29.7%
373	327	4498	13.7%	35.3%	21.8%	\$ 69,861	2.4%	5.2%	36.4%	4.2%	34.9%
374	138	4593	16.5%	39.6%	15.2%	\$ 73,186	2.3%	3.2%	36.8%	4.0%	22.4%
375	1107	5484	10.4%	46.8%	16.3%	\$ 70,024	3.5%	4.8%	40.1%	0.0%	26.9%
376.01	17	4913	18.2%	39.8%	22.4%	\$ 65,625	5.1%	3.5%	44.3%	20.3%	32.4%
376.02	430	6614	20.1%	37.0%	19.0%	\$ 68,010	8.8%	5.7%	37.7%	0.0%	21.2%

Census tract #375 has highest Parcels at Risk, followed by #370, #371 and #329.01. There is larger variation among the social factors. Census tract #370 has the highest percentage of population over 65 years old and second highest at least one household member having disability. Considering all these, the PDT determined that Census tract #370 is the most socio-economic vulnerable area in the study area. Three areas are classified as moderately socio-economic vulnerable. Census tract #371 and #375 have more Parcels at Risk than #370 although other social factors are better. Although census tract #329.01 has less Parcels at Risk than #371, the median income is one of the lowest in the study area. The location of the four socio-economic vulnerable census tracts is shown in Figure 26. Two are in Cranford, one at Springfield and one at Union.

FIGURE 26: LOCATION OF SOCIO-ECONOMIC CENSUS TRACTS



To sum up, areas with high FWOP damage coincides with areas with high historical damage; and socio-economically vulnerable census tracts.

5.9. FUTURE WITH PROJECT RESULTS

Tables 35 in section 5.11 report the benefits of each plan. The dry dam reduced about 24% of total damage (comparing columns 3 and 4); the Combination Plan reduced damage by about 16%. Section 5.11 will discuss the BCR.

5.10. ALTERNATIVE COST DEVELOPMENT

Three different estimates were developed for alternative analysis by the Architect/Engineer (A/E) and reviewed by USACE. The estimates were developed using the MCACES II (MII) software with RSMMeans Data in the form of the 2024 English Cost Book and 2024 Region 01 Equipment

Book. Labor rates were determined using current Davis-Bacon Wage rates for the counties in which each alternative would be constructed.

The costs for each alternative that were developed in MII were then transferred to the Total Project Cost Summary (TPCS) below. The TPCS details the estimated cost of construction (column 1), the first project cost in present dollars (column 2), and the project fully funded cost at the midpoint of construction (column 3).

The contingencies in the TPCS were developed using an Alternative Risk Analysis (ARA), conducted separately for each alternative. For the ARAs, the PDT and the A/Es congregated and discussed any foreseen risks for each of the alternatives. Each risk was categorized by alternative and given a likeliness and impact rating to determine the cost risk to the project. When the risks were compiled, a Crystal Ball Simulation was run, and the contingencies were developed.

TABLE 31: 32ALTERNATIVE 2 UPSTREAM DETENTION TOTAL PROJECT COST SUMMARY

This Estimate reflects the scope and schedule in report;

Rahway River Alternative 2 - Dry Detention Dam

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST	CNTG	CNTG	TOTAL	ESC	COST	CNTG	TOTAL	Spent Thru: 1-Oct-24 (\$K)	TOTAL FIRST COST (\$K)	INFLATED	COST	CNTG	FULL
		(\$K) C	(\$K) D	(%) E	(\$K) F	(%) G	(\$K) H	(\$K) I	(\$K) J			(%) L	(\$K) M	(\$K) N	(\$K) O
		Program Year (Budget EC): 2025 Effective Price Level Date: 1 OCT 24													
02	RELOCATIONS	\$18,513	\$12,645	68.3%	\$31,158	0.0%	\$18,513	\$12,645	\$31,158	\$0	\$31,158	8.8%	\$20,147	\$13,760	\$33,907
04	DAMS	\$82,378	\$48,373	58.7%	\$130,751	0.0%	\$82,378	\$48,373	\$130,751	\$0	\$130,751	8.8%	\$89,647	\$52,641	\$142,288
06	FISH & WILDLIFE FACILITIES	\$17,596	\$2,715	15.4%	\$20,311	0.0%	\$17,596	\$2,715	\$20,311	\$0	\$20,311	8.8%	\$19,149	\$2,955	\$22,103
11	LEVEES & FLOODWALLS	\$0	\$0		\$0	-	\$0	\$0	\$0	\$0	\$0		\$0	\$0	\$0
13	PUMPING PLANT	\$0	\$0		\$0	-	\$0	\$0	\$0	\$0	\$0		\$0	\$0	\$0
15	FLOODWAY CONTROL & DIVERSION STRUC	\$0	\$0		\$0	-	\$0	\$0	\$0	\$0	\$0		\$0	\$0	\$0
18	CULTURAL RESOURCE PRESERVATION	\$1,150	\$81	7.0%	\$1,231	0.0%	\$1,150	\$81	\$1,231	\$0	\$1,231	8.8%	\$1,251	\$88	\$1,339
19	BUILDINGS, GROUNDS & UTILITIES	\$0	\$0		\$0	-	\$0	\$0	\$0	\$0	\$0		\$0	\$0	\$0
	CONSTRUCTION ESTIMATE TOTALS:	\$119,637	\$63,813		\$183,450	0.0%	\$119,637	\$63,813	\$183,450	\$0	\$183,450	8.8%	\$130,194	\$69,443	\$199,638
01	LANDS AND DAMAGES	\$16,131	\$3,226	20.0%	\$19,357	0.0%	\$16,131	\$3,226	\$19,357	\$0	\$19,357	8.8%	\$17,551	\$3,510	\$21,061
30	PLANNING, ENGINEERING & DESIGN	\$36,489	\$3,649	10.0%	\$40,138	0.0%	\$36,489	\$3,649	\$40,138	\$0	\$40,138	10.4%	\$40,292	\$4,029	\$44,321
31	CONSTRUCTION MANAGEMENT	\$17,347	\$1,735	10.0%	\$19,082	0.0%	\$17,347	\$1,735	\$19,082	\$0	\$19,082	10.4%	\$19,155	\$1,916	\$21,071
	PROJECT COST TOTALS:	\$189,605	\$72,422	38.2%	\$262,027		\$189,605	\$72,422	\$262,027	\$0	\$262,027	9.2%	\$207,193	\$78,898	\$286,091

TABLE 33: ALTERNATIVE 3 COMBINATION PLAN TOTAL PROJECT COST SUMMARY

This Estimate reflects the scope and schedule in report;

Rahway River Alternative 3 - Combination Plan

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J	Program Year (Budget EC): 2025 Effective Price Level Date: 1 OCT 24		TOTAL FIRST COST (\$K) K	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O
										Spent Thru: 1-Oct-24 (\$K)						
06	FISH & WILDLIFE FACILITIES	\$29,000	\$5,490	18.9%	\$34,490	0.0%	\$29,000	\$5,490	\$34,490	\$0	\$34,490	8.8%	\$31,559	\$5,974	\$37,533	
09	CHANNELS & CANALS	\$23,128	\$8,694	37.6%	\$31,822	0.0%	\$23,128	\$8,694	\$31,822	\$0	\$31,822	8.8%	\$25,169	\$9,461	\$34,630	
11	LEVEES & FLOODWALLS	\$129,525	\$89,579	69.2%	\$219,104	0.0%	\$129,525	\$89,579	\$219,104	\$0	\$219,104	8.8%	\$140,954	\$97,484	\$238,438	
15	FLOODWAY CONTROL & DIVERSION STRUC	\$5,331	\$1,258	23.6%	\$6,589	0.0%	\$5,331	\$1,258	\$6,589	\$0	\$6,589	8.8%	\$5,802	\$1,369	\$7,170	
18	CULTURAL RESOURCE PRESERVATION	\$1,200	\$84	7.0%	\$1,284	0.0%	\$1,200	\$84	\$1,284	\$0	\$1,284	8.8%	\$1,306	\$91	\$1,397	
CONSTRUCTION ESTIMATE TOTALS:		\$188,184	\$105,104		\$293,288	0.0%	\$188,184	\$105,104	\$293,288	\$0	\$293,288	8.8%	\$204,790	\$114,379	\$319,169	
01	LANDS AND DAMAGES	\$29,967	\$8,990	30.0%	\$38,957	0.0%	\$29,967	\$8,990	\$38,957	\$0	\$38,957	8.8%	\$32,606	\$9,782	\$42,388	
30	PLANNING, ENGINEERING & DESIGN	\$57,746	\$5,775	10.0%	\$63,521	0.0%	\$57,746	\$5,775	\$63,521	\$0	\$63,521	8.6%	\$62,710	\$6,271	\$68,981	
31	CONSTRUCTION MANAGEMENT	\$27,287	\$2,729	10.0%	\$30,015	0.0%	\$27,287	\$2,729	\$30,015	\$0	\$30,015	10.4%	\$30,130	\$3,013	\$33,143	
PROJECT COST TOTALS:		\$303,183	\$122,598	40.4%	\$425,781		\$303,183	\$122,598	\$425,781	\$0	\$425,781	8.9%	\$330,236	\$133,445	\$463,680	

TABLE 34: ALTERNATIVE 4A,4C,4E NONSTRUCTURAL, 10 YR PLAN TOTAL PROJECT COST SUMMARY

This Estimate reflects the scope and schedule in report;

Rahway River Alternative 4 - Nonstructural Plan

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J	Program Year (Budget EC): Effective Price Level Date: 2025 1 OCT 24		TOTAL FIRST COST (\$K) K	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O
										Spent Thru: 1-Oct-24 (\$K)						
11	LEVEES & FLOODWALLS	\$63,632	\$25,141	39.5%	\$88,772	0.0%	\$63,632	\$25,141	\$88,772	\$0	\$88,772	8.8%	\$69,247	\$27,359	\$96,606	
19	BUILDINGS, GROUNDS & UTILITIES	\$44,460	\$21,017	47.3%	\$65,477	0.0%	\$44,460	\$21,017	\$65,477	\$0	\$65,477	8.8%	\$48,384	\$22,872	\$71,255	
CONSTRUCTION ESTIMATE TOTALS:		\$108,092	\$46,158		\$154,250	0.0%	\$108,092	\$46,158	\$154,250	\$0	\$154,250	8.8%	\$117,631	\$50,231	\$167,861	
01	LANDS AND DAMAGES	\$2,968.180	\$594	20.0%	\$3,562	0.0%	\$2,968	\$594	\$3,562	\$0	\$3,562	8.8%	\$3,230	\$646	\$3,875	
30	PLANNING, ENGINEERING & DESIGN	\$39,982.634	\$4,159	10.4%	\$44,142	0.0%	\$39,983	\$4,159	\$44,142	\$0	\$44,142	9.2%	\$43,656	\$4,543	\$48,199	
31	CONSTRUCTION MANAGEMENT	\$15,122.967	\$1,512	10.0%	\$16,635	0.0%	\$15,123	\$1,512	\$16,635	\$0	\$16,635	10.4%	\$16,699	\$1,670	\$18,369	
PROJECT COST TOTALS:		\$166,166	\$52,423	31.5%	\$218,588		\$166,166	\$52,423	\$218,588	\$0	\$218,588	9.0%	\$181,215	\$57,090	\$238,305	

TABLE 35: ALTERNATIVE 4B, 4D, 4F NONSTRUCTURAL, 100 YR PLAN TOTAL PROJECT COST SUMMARY

This Estimate reflects the scope and schedule in report;

Rahway River Alternative 4 - Nonstructural Plan

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J	Program Year (Budget EC): 2025 Effective Price Level Date: 1 OCT 24		TOTAL FIRST COST (\$K) K	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O
										Spent Thru: 1-Oct-24 (\$K)						
11	LEVEES & FLOODWALLS	\$120,214	\$47,496	39.5%	\$167,710	0.0%	\$120,214	\$47,496	\$167,710		\$0	\$167,710	8.8%	\$130,822	\$51,688	\$182,510
19	BUILDINGS, GROUNDS & UTILITIES	\$64,358	\$30,423	47.3%	\$94,781	0.0%	\$64,358	\$30,423	\$94,781		\$0	\$94,781	8.8%	\$70,037	\$33,107	\$103,145
CONSTRUCTION ESTIMATE TOTALS:		\$184,572	\$77,919		\$262,491	0.0%	\$184,572	\$77,919	\$262,491		\$0	\$262,491	8.8%	\$200,859	\$84,795	\$285,654
01	LANDS AND DAMAGES	\$4,639,940	\$928	20.0%	\$5,568	0.0%	\$4,640	\$928	\$5,568		\$0	\$5,568	8.8%	\$5,049	\$1,010	\$6,058
30	PLANNING, ENGINEERING & DESIGN	\$68,102,983	\$7,068	10.38%	\$75,171	0.0%	\$68,103	\$7,068	\$75,171		\$0	\$75,171	9.2%	\$74,358	\$7,721	\$82,078
31	CONSTRUCTION MANAGEMENT	\$25,159,894	\$2,516	10.0%	\$27,676	0.0%	\$25,160	\$2,516	\$27,676		\$0	\$27,676	10.4%	\$27,782	\$2,778	\$30,560
PROJECT COST TOTALS:		\$282,475	\$88,431	31.3%	\$370,906		\$282,475	\$88,431	\$370,906		\$0	\$370,906	9.0%	\$308,047	\$96,303	\$404,351

5.11. ALTERNATIVE RESULTS

Table 35 summarizes the results of benefit and cost analysis of the alternatives considered. The second column reports the number of structures protected by that measure while the third and fourth present the without and with project expected annual damages (EAD). All cost and benefits have been annualized using the FY25 interest rate of 3% and a period of 50 years. All figures presented are in millions.

Alternative 2, the Upstream Detention plan has an annual cost is \$11.3 M and annual benefits of \$10.11 M. The net benefit is -\$1.18 M and the BCR is 0.9. The Upstream Detention Plan reduces roughly a quarter of the total FWOP damages, primarily benefitting Milburn and Springfield.

Alternative 3, the Combination Plan provides annual benefits of \$6.76 million and when compared to annual costs of \$19 million yields a BCR of 0.35. The costs are primarily driven by the proposed 4.5 miles of levees and floodwalls through the Township of Cranford (Measure 6 in Figure 10) which account for roughly 50% of the total cost for Alternative 3.

Alternative 4, the Nonstructural Plan, is split up into six separate and independent plans to facilitate timely implementation. Five of them (Alt. 4a, 4b, 4d, 4e and 4f) yielded positive net benefits and BCRs of 3.09, 2.13, 1.09, 3.54, and 3.43 respectively. Annual costs vary by number of structures included in the plan and the treatment assigned to those structures. More information on number of structures in each plan and their treatment is found in Tables 7 and 8 above. These nonstructural plans could be implemented through “Section 205” of USACE’s Continuing Authorities Program, for small flood risk management projects. It is assumed that potential nonstructural projects, organized by municipalities in the Cranford area and along Robinson’s Branch, would be the best candidates for these future efforts. Currently, USACE has paused investigations of nonstructural treatments while it reevaluates its methods for implementation. This pause is in effect until further notice. Until then, USACE may identify potential nonstructural treatments, but will have to defer further investigations for nonstructural treatments until the pause is lifted by the agency.

TABLE 36: ANNUAL COSTS/BENEFITS, NET BENEFITS, AND BCRS FOR EACH ALTERNATIVE

Alternative	Structure #	FWOP EAD (Million)	FWP EAD (Million)	Benefits (Million)	Cost (Million)	Net Benefit (Million)	BCR
Alternative 2 Upstream Detention Plan	5634	\$41.68	\$31.57	\$10.11	\$11.30	\$ (1.18)	0.90
Alternative 3 Combination Plan	5634	\$41.68	\$34.92	\$6.76	\$19.077	\$ (12.32)	0.35

Alternative	Structure #	FWOP EAD (Million)	FWP EAD (Million)	Benefits (Million)	Cost (Million)	Net Benefit (Million)	BCR
Alternative 4a: 10-year NS Cranford Upstream	119	\$34.11	\$15.18	\$18.92	\$6.13	\$12.8	3.09
Alternative 4b: 100-year NS Cranford Upstream	175	\$34.11	\$13.29	\$20.81	\$9.75	\$11.06	2.13
Alternative 4c: 10-year NS East Branch	19	\$7.57	\$7.34	\$0.24	\$0.97	\$ (0.73)	0.24
Alternative 4d: 100-year NS East Branch	51	\$7.57	\$4.54	\$3.03	\$2.78	\$2.78	1.09
Alternative 4e: 10-year NS Robinson's Brand (compound)	23	\$9.96	\$4.99	\$4.97	\$1.41	\$3.57	3.54
Alternative 4f: 100-year NS Robinson's Brand (compound)	32	\$9.96	\$3.15	\$6.81	\$1.99	\$4.82	3.43

*FY25 Price Levels and Discount Rate of 3%

5.12. PLAN COMPARISON

5.12.1. CONTRIBUTIONS TO THE 1983 PRINCIPLES & GUIDELINES (1983 P&G) CRITERIA

The 1983 P&G requires that alternative plans are formulated and compared in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability. Plans that require substantial activity by others, that is not likely to be forthcoming, in order to reach a “go” appraisal for critical objectives are not complete. Plans that are not appraised as a “go” for planning objectives are not effective. Plans that achieve contributions to objectives at higher costs, whether objectively or subjectively measured, are not efficient. Plans with effects that result in infeasibility are not acceptable. Minimum standards for these four criteria must be established in order to determine whether a plan is worthy of additional consideration. No action alternative plans were screened out as part of the evaluation for P&G criteria.

Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planned efforts, including actions by other federal and non-federal entities. Project performance of the alternative plans is not dependent upon the completion or function of a project by another government agency or

private investment. All alternative plans are complete in that they do not rely upon actions by other federal and non-federal entities to be implemented. The planning process has factored in projects that would be constructed in the absence of any action, which constitute the No Action Alternative, aka the future without-project condition.

Effectiveness is the extent to which alternative plans contribute to achieving the planning objectives:

- Provide flood risk management for business and residential structures
- Improve public health and safety, reduce traffic delays, and improve emergency access for the fire department, medical personnel, and police protection
- Enhance the resources of the existing natural and social environment in the project area
- Reduce vulnerability to flood impacts of at-risk communities in the study area

Alternative plans were judged upon whether or not they make significant contributions to these opportunities; some do so more efficiently than others. Alternative 4, the Nonstructural Plan, is the most effective plan, providing the most reduction in flood risk, though it does come with residual risk as the modifications are to the structures themselves and it does not alter the floodplain.

Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives. Alternative 4, the Nonstructural Plan, is also the most efficient plan as it is the most cost-effective solution. Alternative 3, the Combination Plan, is the least efficient plan.

Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies. The alternative plans were formulated in accordance with applicable laws, regulations, and policies. The alternative plans are equal in that there are no known issues with laws, regulations, and policies that would preclude their implementation. All alternative plans meet the criterion of acceptability to varying degrees, depending on what the exact footprint for the project will be. Alternatives 3, the Combination Plan, the plan with the greatest geographic reach, poses the highest risk of negatively affecting environmental resources and potentially conflicting with existing federal laws.

Table 37 ranks Alternatives 1 through 5 using the descriptors of Low, Medium, and High to qualitatively assess their ability to meet the study objectives.

TABLE 37: EFFECTIVENESS OF ALTERNATIVES

Objective	Alt 1: No Action	Alt 2: Upstream Detention	Alt 3: Combination	Alt 4: Nonstructural	Alt 5: Lenape Park
Reduce Flood Risk	None	Medium	Low	Medium	Medium

Objective	Alt 1: No Action	Alt 2: Upstream Detention	Alt 3: Combination	Alt 4: Nonstructural	Alt 5: Lenape Park
Improve Public Health and Safety	None	High	Medium	Medium	Medium
Enhance Natural and Social Environment	None	Medium	Low	Low	Medium
Reduce Vulnerability of At-risk Communities	None	Medium	Low	Low	Medium

5.12.2. IDENTIFICATION OF THE SIX PLANS - (ER-1105-2-103)

As mentioned in previous sections, ER 1105-2-103 requires the identification of six alternative plans to evaluate trade-offs among the four P&G accounts: NED, RED, OSE, EQ. The six alternative plans are as follows:

No Action. The “no action” plan, Alternative 1, recommends none of the alternatives for construction authorization.

NED Plan. The NED Plan, Alternative 4a: 10-year Cranford Upstream Nonstructural Plan, has the largest contribution to NED net benefits. Net NED benefits were negative for the two structural alternatives, alternatives 2 and 3. The best performing (highest net benefit) plan was the 10-year Cranford Upstream Nonstructural plan, contributing \$18.92M FY25 price levels in annual benefits and \$12.8M in annual net benefits, respectively, based upon a federal discount rate of 3.0%.

Total Net Benefits Plan. The Total Net Benefits Plan, Alternative 4a: 10-year Cranford Upstream Nonstructural Plan, is the plan that reasonably maximizes total net benefits across all benefit categories. The measures that collectively contribute the most from each element were combined to develop a plan that reasonably maximizes contributions across the four accounts.

Study Purpose Only Net Benefits Plan. The Study Purpose Only Net Benefits Plan, Alternative 4: Nonstructural Plan, is the plan that reasonably maximizes net benefits consistent with the study purpose only. Alternative 4a: 10-year Cranford Upstream Nonstructural Plan maximizes the net benefits consistent with the study purpose of flood risk management.

Least Environmentally Damaging Practicable Alternative (LEDPA). The LEDPA, Alternative 4: Nonstructural Plan, has the largest positive contribution to the EQ account. More information about the alternatives’ contributions to EQ is provided in section 5.4.8.

Locally Preferred Plan. The Locally Preferred Plan is Alternative 5: Lenape Park Plan. The non-federal partner asked New York District to revisit this previously screened alternative.

Table 37 below identifies each of the six plans within the formulated alternatives.

TABLE 38: IDENTIFICATION OF THE SIX PLANS

Required Plan	Alt A: No Action	Alt B: NED Plan	Alt C: Total Net Benefits Plan	Alt D: Study Purpose Only Net Benefits Plan	Alt E: LEDPA	Alt F: Locally Preferred Plan
Corresponding Alternative	Alt 1: No Action	Alt 4a: 10-year Cranford Upstream	Alt 4a: 10-year Cranford Upstream	Alt 4a: 10-year Cranford Upstream	Alt 4: Nonstructural Plan	Alt 5: Lenape Park

Table 38 below shows how each of the formulated plans contribute to the previously explained P&G Criteria of Completeness, Acceptability, Effectiveness, and Efficiency.

TABLE 39: CONTRIBUTIONS TO P&G CRITERIA

Alternative	P&G Criteria			
	Complete?	Acceptable?	Effective?	Efficient?
Alt 1: No Action	High	Low	Low	Low
Alt 2: Upstream Detention	High	High	Medium	Medium
Alt 3: Combination Plan	High	High	Medium	Low
Alt 4: Nonstructural Plan	High	High	High	High
Alt 5: Lenape Park Plan	High	High	Low	Low

Table 39 shows how each of the five alternatives contribute to the four P&G accounts. Alternative 4, the Nonstructural Plan has the highest contribution to the NED account. Alternatives 2 and 3 have the highest contribution to the RED account and Alternative 4 has the highest contribution to the EQ account. All alternatives mildly contribute to the OSE account. More details on how each of the alternatives contribute to the four accounts is found in sections 5.5.1.1 through 5.5.1.4.

TABLE 40: FINAL ARRAY OF ALTERNATIVES: COMPARISON P&G ACCOUNTS

Alternative	P&G Evaluation Accounts			
	NED	RED	EQ	OSE
Alt 1: No Action	High	Low	High	Medium
Alt 2: Upstream Detention	Medium	High	Medium	Medium
Alt 3: Combination Plan	Low	High	Medium	Medium
Alt 4: Nonstructural Plan	High	Medium	High	Medium
Alt 5: Lenape Park Plan	Low	Medium	Low	Medium

6. AGENCY/PUBLIC COORDINATION

6.1. AGENCY COORDINATION

A charrette to discuss the flooding issues occurring within the study area and to brainstorm flood risk management measure plans was held between the District and representatives from the NJDEP, municipalities, and the Rahway River Watershed Association in May 2023.

An interagency meeting attended by representatives of state and federal agencies and tribes was held in August 2023 to introduce meeting participants to the study and alternatives to be evaluated and obtain initial feedback on the alternatives related to any regulatory or resource impact concerns that could affect the feasibility of implementing any of the alternatives.

The District sent letters extending an invitation to the Federal Highways Administration (FHWA), U.S. Environmental Protection Agency (USEPA), FEMA, and the USFWS to serve as cooperating agencies. The USEPA, USFWS, and FHWA accepted the invitation to serve as cooperating agencies; the FEMA requested to serve as a participating agency. Relevant correspondence with the agencies pertaining to serving as a cooperating agency is located in Appendix F.

The District received a Preliminary Endangered Species Act Technical Review letter in September 2023 and a Planning Aid Report from USFWS in September 2023 and February 2024 respectively.

This findings report will be provided to agencies as a courtesy but given that no FRM plan is being recommended, no further coordination is required.

Section 106 consultation was initiated with the New Jersey Historic Preservation Office (NJHPO) in a letter dated 18 July 2023. The NJHPO accepted the District's invitation for consultation in a response dated 17 August 2023. In a letter dated 12 September 2023, the following consulting parties were invited to consult in accordance with Section 106: the Cranford Historic Preservation Advisory Board, Cranford Historical Society, Dr. William Robinson Plantation Museum, Fanwood Historic Preservation Commission, Historic Society of Elizabeth, Maplewood Historic Preservation Commission, Merchants and Drovers Tavern Museum, Milburn Historic Preservation Commission, New Jersey Historical Commission, New Jersey Historical Society, New Jersey Historic Trust, New Jersey State Museum, Rahway River Association, the Land Conservancy of New Jersey, Union County Cultural and Heritage Affairs, Union County Parks and Recreation, Westfield Historic Preservation Commission, West Orange Historic Preservation Commission, and the Woodbridge Historic Preservation Commission. At this time, the Cranford Historic Preservation Advisory Board, New Jersey Historic Trust, New Jersey State Museum, and Union County Parks and Recreation have accepted the District's invitation for consultation (Table 41). Further coordination with the NJHPO, SHPOs, and tribes will be conducted throughout the release of the report.

TABLE 41: LIST OF CULTURAL RESOURCES CONSULTING PARTIES

Consulting Party	Date of Coordination
New Jersey Historic Preservation Office (NJHPO)	Initiated 18 July 2023; Invitation accepted 17 August 2023
Cranford Historic Preservation Advisory Board	Initiated 12 September 2023; accepted on 2 October 2023
Cranford Historical Society	Initiated 12 September 2023; No response received
Dr. William Robinson Plantation Museum	Initiated 12 September 2023; No response received
Fanwood Historic Preservation Commission	Initiated 12 September 2023; No response received
Historic Society of Elizabeth	Initiated 12 September 2023; No response received
Maplewood Historic Preservation Commission	Initiated 12 September 2023; No response received
Merchants and Drovers Tavern Museum	Initiated 12 September 2023; No response received
Millburn Historic Preservation Commission	Initiated 12 September 2023; No response received
New Jersey Historical Commission	Initiated 12 September 2023; No response received
New Jersey Historical Society	Initiated 12 September 2023; No response received
New Jersey Historic Trust	Initiated 12 September 2023; Invitation accepted on 29 September 2023
New Jersey State Museum	Initiated 12 September 2023; Invitation accepted on 14 September 2023
Rahway River Association	Initiated 12 September 2023; No response received
The Land Conservancy of New Jersey	Initiated 12 September 2023; No response received
Union County – Cultural & Heritage Affairs	Initiated 12 September 2023; No response received
Union County – Parks and Recreation	Initiated 12 September 2023; Invitation accepted on 14 September 2023
Westfield Historic Preservation Commission	Initiated 12 September 2023; No response received
West Orange Historic Preservation Commission	Initiated 12 September 2023; No response received
Woodbridge Historic Preservation Commission	Initiated 12 September 2023; No response received

6.2. TRIBAL CONSULTATION

The U.S. Government has a unique legal relationship with Tribal Nations, governed by treaties, statutes, executive orders, court decisions, and the U.S. Constitution. The United States works with Indian Tribes on a Government-to-Government basis to address issues concerning Indian Tribal self-government, trust resources, Indian Tribal treaties, and other rights. As such, USACE will make good faith efforts to engage Tribes to ascertain interest in USACE projects and obtain information relevant to USACE Federal decisions.

The USACE Tribal Consultation Policy is composed of the following six principles: Tribal Sovereignty; Tribal Responsibility; Government to Government Relations; Pre-Decisional and Honest Consultation; Self-Reliance, Capacity Building, and Growth; and Natural and Cultural Resources. Specific to this action, New York District strives to establish relationships that focus on successful communications and a collaborative process that ensures Tribal involvement in project development and implementation.

Section 106 consultation was initiated with the Delaware Nation, the Delaware Tribe of Indians, the Shawnee Tribe of Oklahoma, and the Stockbridge Munsee Community in letters dated 18 July 2023. The Shawnee Tribe responded on 30 August 2023 stating the study area was outside their tribal area of interest. The Delaware Nation, the Delaware Tribe of Indians, and the Stockbridge Munsee Community have yet to accept our invitation for consultation in accordance with Section 106.

7. IMPLEMENTATION/RECOMMENDATIONS

7.1. POTENTIAL INDEPENDENT LOCAL PLANS

While there is no effective basin-wide solution, more effective solutions could be implemented at the local level, either by USACE or otherwise. Specifically, the proposed Combination Plan is able to be broken up into individual, smaller efforts. The section below identifies target areas with high local efficiency. Each target area has the potential to be implemented as an independent, smaller-scale study. Sections 7.2.1 and 7.2.2 below discuss various programs and avenues for the potential spin off studies. While USACE is not recommending a project with this report of findings, the intent is that the data presented, target areas identified, and recommendations made by this report can be used by state or local entities to better inform any future study efforts. Any data or modeling completed by USACE can be made available to further assist future efforts. Future efforts may include small projects under the Continuing Authorities Program, Environmental Infrastructure projects under Section 219 of WRDA 1992, or Technical Assistance Studies under Planning Assistance to States (PAS) or Floodplain Management Services (FPMS) to support local projects or information to pursue grants. More information on these programs is discussed in section 7.2 of this report.

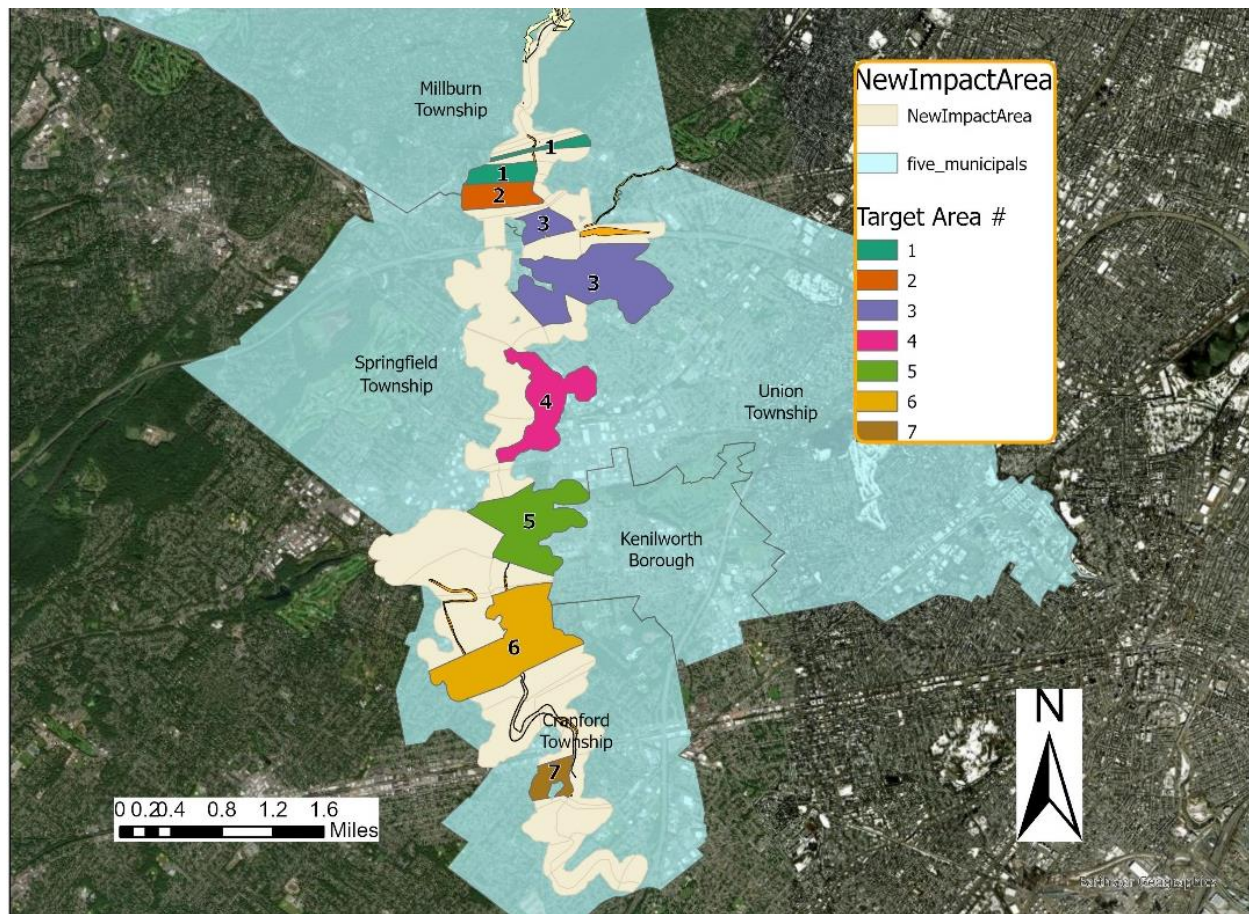
Table 42 presents a breakdown of target areas, which are visually depicted in Figure 25. Each target area encompasses one or more economic reaches, as shown in Figure 23. Columns 1 and 2 identify the target area number and corresponding municipality, respectively. Columns 3 and 4 present the Future Without Project (FWOP) and Future With Project (FWP) damage estimates. The difference between FWOP and FWP damage, representing the anticipated damage reduction, is shown in column 5. Column 7 indicates the corresponding flood control measures, as illustrated in Figure 7. For example, the second row demonstrates that increasing the height of an existing levee and adding a pump station is projected to reduce annual damages by \$1,812.1 thousand, representing an 86% reduction. Target areas 1, 6, and 7 are recommendations based on features developed as part of this report's design. Target areas 2-5 exhibit high damage potential and may warrant smaller-scale studies to further reduce damages and enhance benefits. Local plans may better inform federal interest in a small-scale plan moving forward and would influence the proposed recommendation. For instance, we have limited information for the proposed water detention basins in Van Winke Brook (Cora Hartshorn Arboretum, Millburn) and widening of a culvert at W Holly Street by 20 ft. (between Spring Garden St. and Orchard St, Cranford).

TABLE 42: RECOMMENDATIONS SUMMARY FOR TARGET AREAS

Target Area #	Municipality	Annual FWOP Damage (1,000s)	Annual FWP Damage (1,000s)	Damage Reduction (1,000s)	Damage Reduction (%)	Corresponding Combination plan measures from Figure 10	Potential Flood Mitigation Solutions (Subject to Study)	Potential Authority or Program
1	Millburn	\$5,300	\$4,100	\$1,200	22%	1. Raise Essex St Bridge by 1 ft	Raising the Essex St. Bridge is expected to work in conjunction the proposed offline storage area near Rt-78, as it effectively mitigates increased flows from the channel and bridge improvements in Millburn. However, further hydrological analysis is needed to validate the independent effectiveness of the bridge and offline storage under a range of flood scenarios.	CAP 205
	Millburn					2. Replace 2,470 ft of concrete channel with natural riverbed and deepen channel	Channel improvement is expected to be mitigated by the proposed offline storage area near Rt-78, which reduces the total inflow to the Lenape Park detention area and provides additional storage during peak flood stages. However, detailed hydrological modelling is required to fully assess the performance of the offline storage and confirm its effectiveness under various flood conditions	CAP205, 206 Section 219: Environmental Infrastructure
2	Millburn	\$17,000	\$16,600	\$400	2.3%	Any ongoing local projects would help inform future H&H modeling		
3	Millburn, Union, and Springfield	\$3,200	\$3,100	\$100	3.1%	Any ongoing local projects would help inform future H&H modeling		
4	Union	\$1,900	\$1,900	-	-	Any ongoing local projects would help inform future H&H modeling		

Target Area #	Municipality	Annual FWOP Damage (1,000s)	Annual FWP Damage (1,000s)	Damage Reduction (1,000s)	Damage Reduction (%)	Corresponding Combination plan measures from Figure 10	Potential Flood Mitigation Solutions (Subject to Study)	Potential Authority or Program
5	Kenilworth and Springfield	\$1,700	\$1,600	\$100	5.8%	Any ongoing local projects would help inform future H&H modeling		
6	Springfield and Cranford	\$2,100	\$300	\$1,800	86%	Increase the height of existing levees by 6-9 feet, and add Pump Station for Interior Drainage	Increasing levee height may increase upstream flows, requiring the implementation of detention or flood storage. Furthermore, any levee construction or modification necessitates the development of an adequate interior drainage system. A comprehensive hydraulic analysis is needed to determine the extent of potential flow changes and design appropriate drainage infrastructure.	CAP 205
	Cranford					7. Modify Droescher's Dam to a saw-tooth weir, , maintain crest elevation	The removal or modification of dams has the potential to alter downstream flow patterns. A comprehensive analysis is required to determine the extent of potential changes. A detailed hydrological study is necessary to quantify the potential flow alterations and inform the design of appropriate mitigation strategies.	CAP 205
7	Cranford	\$800	\$30	\$770	96%	9. Remove/Modify Jackson's Pond Dam (downstream at Clark)	The removal or modification of dams has the potential to alter downstream flow patterns. A comprehensive analysis is required to determine the extent of potential changes. A detailed hydrological study is necessary to quantify the potential flow alterations and inform the design of appropriate mitigation strategies.	CAP 205

FIGURE 27: LOCATION OF TARGET AREAS



Target Area 1 focuses on flood mitigation immediately upstream of the Essex St Bridge, resulting in significant water surface elevation reductions during the 50-year flood event in Millburn. Hydraulic modeling (Figure 61 in the Hydraulic Appendix) indicates a reduction of 2 to 8 feet, demonstrating the effectiveness of the proposed measures in this area. Target Area 6 focuses on flood mitigation within a protected reach. Due to the lack of independent modeling, no estimated ranges of flood reduction are available. Target Area 7 focuses on the removal or modification of the Jackson Dam. The dam removal was not modeled independently, and no estimated ranges of flood reduction are available.

While these measures can be analyzed individually in future studies, and benefits are presented for specific municipalities, the current study did not model them independently. Therefore, the presented damage reduction estimates are subject to uncertainty, as interactions between measures across the basin may influence actual outcomes. Table 44 identifies the general potential effects and regulatory considerations related to environmental resources, cultural resources and HTRW assessment for the specific combination measures identified for Target Areas #1, #6 and #7. Although no specific measures were identified for Target Areas #2 through #5, any future proposed flood risk management measures would have to be assessed for compliance under the Federal and state laws cited in Sections 5.5 through 5.7 of this report.

TABLE 43: ENVIRONMENTAL, CULTURAL RESOURCE AND HTRW CONSIDERATIONS FOR INDEPENDENT LOCAL PLANS

Target Area #	Corresponding Combination Plan Measure from Figure 7	Environmental, Cultural Resource and HTRW Considerations
1	Raise Essex St. Bridge	Environmental: Work would require permitting under the NJFWWPA and NJFHACA, however given the urbanized nature of the project area, compensatory mitigation would not be expected.
		Cultural: Since the bridge is eligible for the National Register of Historic Places (NRHP), work would require Section 106 consultation and a determination of effect. Mitigation measures may be required and would be developed in coordination with the State Historic Preservation Office (SHPO) and relevant consulting parties.
		HTRW: Bridge materials would be surveyed for potential asbestos-containing materials prior to disturbance.
	Conversion of 2,470 ft of concrete channel with natural riverbed and deepen channel	Environmental: Work would require permitting under the NJFWWPA and NJFHACA, however conversion of the existing concrete chute to a more natural channel would not require compensatory mitigation and would overall result as an ecological enhancement.
		Cultural: Work would require Section 106 review, determination of effect, and consultation with consulting parties as appropriate.
		HTRW: Sediment and subsurface materials proposed to be disturbed would be appropriately characterized prior to project implementation.
6	Increase height of existing levees, add pump station	Environmental: Work would require permitting under the NJFWWPA and NJFHACA. The increase in levee height and addition of a pump station would result in increased wetland and riparian zone impacts which would require compensatory mitigation.
		Cultural: Work would require Section 106 review, determination of effect, and consultation with consulting parties as appropriate.
		HTRW: Subsurface conditions proposed for disturbance would be considered and potentially characterized prior to project implementation.
	Droescher's Dam modification	Environmental: Work would require permitting under the NJFWWPA, the Dam Safety Act and potentially under NJFHACA depending on scope of modification. As part of modifications, a fish ladder to provide fish passage may be required as mitigation.
		Cultural: Since Droescher's Mill Dam is listed on the National Register of Historic Places (NRHP), work would require Section 106 consultation and a determination of effect. Mitigation measures may be required and would be developed in coordination with the State Historic Preservation Office (SHPO) and relevant consulting parties.
		HTRW: Release of any impounded sediment behind the dam would be analyzed and the sediment would be characterized to ensure project implementation is permissible.
7	Remove/modify Jackson Dam	Environmental: Work would require permitting under the NJFWWPA, the Dam Safety Act and potentially under NJFHACA depending on scope of removal or modification. Removal would be considered an overall ecological enhancement and compensatory mitigation would not be expected. If modifications were opted versus removal a fish ladder to provide fish passage may be required as mitigation. The portion of the Main Stem where the dam is located is designated as EFH. Therefore, coordination with NOAA-Fisheries and the preparation of an EFH Assessment would be required. Mitigation

Target Area #	Corresponding Combination Plan Measure from Figure 7	Environmental, Cultural Resource and HTRW Considerations
		<p>related to EFH could include time of year in-water restrictions beyond what may be placed as a condition as part of the NJFWWPA permit.</p> <p>Cultural: Work would require Section 106 review, determination of effect, and consultation with consulting parties as appropriate.</p> <p>HTRW: Release of any impounded sediment behind the dam would be analyzed and the sediment would be characterized to ensure project implementation is permissible.</p>

Ultimately, this report identifies key areas at risk of flooding and lays the groundwork for future efforts to minimize the impacts of flood events across the basin. As indicated in Table 40, the study team is relying on local officials to provide the most up to date information on ongoing local projects that would help avoid duplication of effort and inform development of the appropriate flood risk management measures.

7.2. OTHER FUNDING PROGRAMS

While this report is not recommending one of the investigated alternatives to move forward into the design phase, there are many other programs through USACE, FEMA, and non-federal entities and agencies, that can help mitigate the risk posed by the flooding issues experienced within the Rahway River Basin.

7.2.1. USACE PROGRAMS

In addition to the congressionally authorized feasibility study effort such as this one, USACE offers a variety of other programs and authorities capable of managing flooding issues. The Continuing Authorities Program (CAP) is a group of nine legislative authorities under which USACE can plan, design, and implement certain types of water resources projects without additional project specific congressional authorization. The purpose of the CAP is to plan and implement projects of limited size, cost, scope and complexity and these would provide more targeted, independent solutions for the Rahway River Basin. The CAP authorities that may be most applicable to the study area are small flood risk management (Section 205), Emergency Streambank Restoration (Section 14), or Clearing and Snagging (Section 208). The CAP efforts, while smaller in scope than the current effort, would be able to provide an expedited study phase, focused on a more targeted area of the basin.

Planning Assistance to States (PAS) is another USACE offered program that can provide states, local governments, other non-Federal entities, and eligible Native American Indian tribes assistance in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. With a PAS effort, USACE, rather than providing a design for project construction, would provide a comprehensive snapshot of the area’s water resources, including the provision and integration of hydrologic, economic, or environmental data and analysis in support of the basin’s water resources management and related land resources development.

Through Floodplain Management Services (FPMS), USACE can offer both technical and planning level support on properly managing the Rahway River Basin. General technical assistance efforts under this program includes determining site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural flood plain resources; and flood loss potentials before and after the use of flood plain management measures. Types of studies have been conducted under the FPMS program include flood plain delineation/hazard, dam failure analyses, hurricane evacuation, flood warning, floodway, flood damage reduction, storm water management, floodproofing, and inventories of flood prone structures. FPMS efforts are fully federally funded unless completed on behalf of another federal agency or a private entity.

Section 219 of the Water Resources Development Act (WRDA) authorizes and provides funding to USACE to assist nonfederal interests in carrying out water-related environmental infrastructure and resource protection and development projects. Assistance may be in the form of technical, planning, design and/or construction assistance for wastewater and wastewater treatment systems including treatment plants treatment and related facilities and water supply, storage, treatment and distribution facilities.

7.2.2. NON-USACE FEDERAL PROGRAMS

The Federal Emergency Management Agency (FEMA) offers a grant program to states, territories, local governments, and recognized Tribal Nations that help fund projects that are designed to manage flood risk. The Flood Mitigation Assistance Grant Program requires the applicant to submit a “Hazard Mitigation Plan” which identifies the risks and potential strategies for managing those risks. If selected, the grant money can be applied to the construction costs of raising residential properties and reducing their flood risk.

Additionally, the United States Department of Housing and Urban Development (HUD) offers a grant program that can help fund rebuild efforts after a flood related disaster event. The Community Development Block Grant Disaster Recovery (CDBG-DR) funds, appropriated by Congress, can be authorized to provide cities, counties, recognized native tribes, and States assistance in the recovery effort from Presidentially declared disasters. Pending grant approval and availability of funding, the CDBG-DR is aimed to help vulnerable communities that otherwise may not have the ability to recover from a disaster event.

7.2.3. NEW JERSEY STATE PROGRAMS

The NJDEP Blue Acres program offers relocation to homeowners whose properties are subject to repetitive inundation, acquiring the property to use as flood storage, or community open space. Buyouts allow the floodplain to be restored to a more natural state which, in turn, increases potential flood storage and can reduce the downstream flow rate of the river. More information on the New Jersey Blue acres program can be found at their website located here: <https://dep.nj.gov/blueacres/>

New Jersey also offers mitigation assistance programs through the New Jersey Department of Community Affairs (DCA), Division of Disaster Recovery and Mitigation. The goal of the program is to help flood affected homeowners cover the expenses related to elevation of their home, as well as the relocation expenses during the duration of construction. Eligible properties, as determined by FEMA, can potentially lower flood insurance premiums if selected for the assistance. The New Jersey “Swift Current” initiative awards money to flood damaged properties that are insured through the Nation Flood Insurance Programs that show a history of repetitive or substantial flood damages. The focus of the Swift Current initiative is to elevate homes to reduce their flood risk. More information on both the mitigation program and Swift Current initiative can be found here: <https://www.nj.gov/dca/ddrm/programs/mitigation.shtml>

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9. APPENDICES

Appendix A: Cultural Resources Phase IA Appendix

Appendix B: Economic Appendix

Appendix C1: Hydrology Appendix

Appendix C2: Hydrologic Appendix

Appendix D: Engineering Plans - Alternative 2 and 3 Appendix

Appendix E: Cost Appendix

Appendix F: Environmental Appendix

Appendix G: HTRW

Appendix H: Geotechnical Appendix

10. LIST OF PREPARERS

TABLE 44: LIST OF REPORT PREPARERS

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