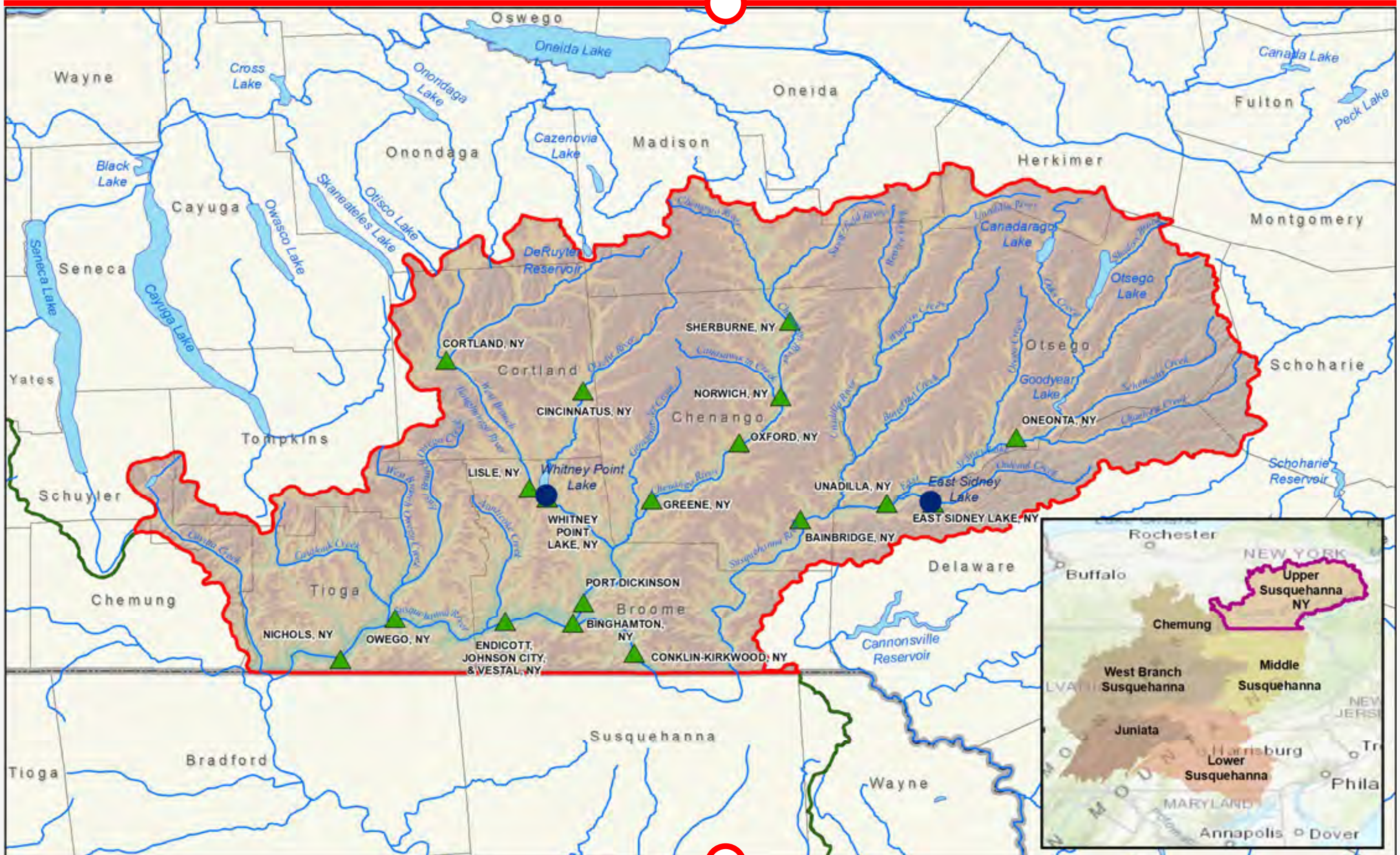
UPPER SUSQUEHANNA RIVER BASIN, NEW YORK COMPREHENSIVE FLOOD DAMAGE REDUCTION FEASIBILITY STUDY COMPLETION REPORT



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DISCLAIMER

This draft feasibility report documents findings of the Upper Susquehanna River Basin (USRB) Comprehensive Flood Damage Reduction Feasibility Study conducted jointly by the U.S. Army Corps of Engineers (USACE) and New York State Department of Environmental Conservation (NYSDEC). The study was conducted from 2016 through 2019 The draft feasibility report is incomplete since it makes no recommendation for construction authorization and has not been reviewed by USACE Headquarters. The report details all work completed for the USRB study leading up to the conclusion of no recommendation under the study authority

This draft report includes some documentation toward meeting the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended, had a viable project been identified. This draft report was prepared intermittently over the study period from 2016-2019, but is not complete. This Completion Report is, therefore, a compendium of the information, analyses, and results that led to the termination of the study effort with no recommendation for construction. Engineer Regulation 1105-2-100, Appendix G, states that if a study results in no implementable plan, a short letter report stating the reasons for termination is sufficient. However, due to the large amount of data collected and analyses performed, it was decided that a Completion Report should be prepared.

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EXECUTIVE SUMMARY

This Completion Report is for the Upper Susquehanna River Basin, Comprehensive Flood Damage Reduction (FDR), New York - Feasibility Study.

The Upper Susquehanna River Basin (USRB) is a flood-prone area with numerous communities at risk. The U.S. Army Corps of Engineers (USACE) has had a long history of working with New York State and local governments in flood risk management (FRM) in the USRB, building 20 FRM projects in the basin since 1938. A small portion of the USRB is in Pennsylvania, but it was not considered in this study effort. Flooding in 2006 and again in 2011 during Tropical Storm Lee have highlighted a need for continued FRM actions by all stakeholders in the basin.

The USRB Study uses a comprehensive watershed planning approach to evaluate flood risk and investigate the feasibility of structural and non-structural FRM measures in identified areas. The USRB Study examined flood risk in order to identify high flood risk areas for the implementation of a potential Federal project, regardless of whether these areas already had a FRM project in place. Preliminary analyses included determining areas of greatest potential benefits and screening of project alternatives to determine areas with the highest potential for construction of a Federal FRM project, or modifications to an existing project. After the preliminary analysis and discussions with the USRB stakeholders, the Project Delivery Team (PDT) determined that a potential Federal project may be feasible for Binghamton. This was based on benefits associated with reducing residual flood damages from the existing FRM project. Binghamton was also initially scoped in the Project Management Plan (PMP) based on information about the project and reconnaissance-level analysis. In addition to Binghamton, the PDT conducted preliminary economics analysis for the Endicott-Johnson City-Vestal (EJV) FRM project and proposed project alternatives in Oneonta and Owego to determine if Federal interest in an FRM project was justified in those areas.

The PDT updated hydrologic modeling, completed concept designs and cost estimates, and applied economic models to evaluate benefits associated with proposed FRM solutions in Binghamton. Benefits estimation for project modifications are based on the incremental benefits associated with reducing residual flood damages beyond the protection afforded by the existing FRM projects. the Binghamton FRM project, the PDT examined two proposed structural alternatives including (2A) levee and floodwall raising and (2B) levee and floodwall raising while replacing some floodwalls with levees. The estimated costs of each alternative are (2A) $115,955,000 and (2B) $118,783,000 in 2017 dollars. Using the 2018 federal discount rate of 2.875% and a 50-year capital recovery factor of 0.037948, the total cost of the project was annualized. The average annual costs for these alternatives are (2A) $4,425,000 and (2B) $4,501,000. The project benefits were estimated by comparing the with-project and without-project future conditions using the Hydrologic Engineering Center’s Flood Damage Analysis (HEC-FDA) modeling tool. The average annual benefits for these alternatives are (2A) $3,169,000 and (2B) $3,163,000 in 2017 dollars. The benefit-cost ratio (BCR) is calculated by dividing annualized benefits by annualized costs. Net benefits are estimated by subtracting the annualized benefits from the costs. The BCR for the proposed structural alternatives for Binghamton are (2A) 0.72 and (2B) 0.70. Both structural alternatives result in negative net benefits, because the costs are greater than the benefits. A BCR less than 1 indicates a negative finding for the National Economic Development (NED) evaluation. The proposed structural alternatives for raising the Binghamton FRM project are not economically justifiable. Each levee system in the Binghamton FRM project was also evaluated independently using HEC-FDA modeling. From an engineering perspective, independent raising of one Binghamton levee system could result in induced flooding impacts in other systems due to the close proximity of the systems. The economic evaluation for each system also resulted in BCRs less than 1 indicating a negative finding for independently raising each Binghamton system.

The economic benefits of a project were determined by calculating the damages reduced due to the proposed project raising (i.e. total damages of the existing condition minus the residual damages in the with-project condition). While the alternatives were not deemed economically justifiable, it should be kept in mind that benefits were calculated according to federal regulations and include only these incremental benefits of additional raising. In Binghamton, proposed project costs included replacing approximately 75 percent of floodwalls to meet the proposed 0.5 to 4 feet of required raising. Replacement, versus raising of the existing structures, is necessary to meet USACE engineering requirements for floodwalls. Replacement results in significant increases in costs. Given this information, the estimated incremental benefits outweigh the estimated project costs.

Economic analysis for EJV used a lesser level of detail due to preliminary information showing lower benefits resulting from residual risk damages from the FRM project. For the EJV project, a structural alternative for raising of all three of the levee systems was examined using parametric cost estimates. Average annual damages (AAD) for EJV were estimated using HEC-FDA. The analysis determined the maximum project costs that could be supported if 100 percent of these AAD were prevented by a proposed project alternative. This is an unrealistic, but conservative assumption. The parametric costs estimates exceed the supported project costs. Preliminary economic analysis for EJV indicates that levee and floodwall raising is not likely to yield a favorable BCR at EJV due to these lower damages and potential for higher costs after concept designs account for contingencies related to mitigation of induced flooding impacts, operation and maintenance costs, cost escalation, and other factors.

In Oneonta, a structural alternative was preliminarily examined for raising of the existing, non-Federal Mill Race levee. An examination of existing documentation and levee elevations against modeled water surface elevations for the 1 percent annual chance flood with 3 feet of freeboard indicated that the levee already reduces risk to National Flood Insurance Program (NFIP) levee accreditation standards. However, the levee ties-into the Interstate-88 highway embankment, which may not meet NFIP standards due its pervious foundation. A closure is also needed on Main Street at the location of the Interstate-88 overpass to prevent flooding from Main Street. HEC-FDA modeling has been updated and run for Oneonta and compared against parametric costs, and the flood damage reductions benefits do not support levee raising. USACE is recommending that the closure structure on Main Street be investigated under USACE technical assistance programs to include (1) surveying Main Street, (2) comparing water surface elevations versus needed design elevations at Main Street, and (3) comparing design alternatives for a closure on Main Street. If this analysis show that design and construction of a closure is appropriate, then it could potentially be pursued under the USACE Continuing Authorities Program (CAP) or Federal Emergency Management Agency's (FEMA) grant assistance programs.

In addition to these structural alternatives, the PDT examined non-structural measures for Binghamton, EJV, and 14 other areas with identified risk of flooding. Economic analyses involved using HEC-FDA modeling for each of these areas. Two sets of preliminary analyses were conducted using this model: an evaluation of elevating the first floor of residential structures and floodproofing non-residential structures up to the 1-percent annual exceedance probability (AEP) plus one foot, and an examination of buyouts of these same properties using the market value and a unit cost for structure removal. The preliminary analysis indicates potentially favorable BCRs associated with non-structural measures in some riverine reaches and jurisdictions in the USRB.Further work is needed to reduce the level of uncertainty and improve confidence in these results including conducting field surveys of the first floor elevations of structures, developing detailed cost estimates, and determining the most suitable non-structural measure for individual structures in each reach. Such analyses were beyond the scope and funding of this study. Also, the Congressionally-authorized General Investigations process is likely not appropriate for these small-scale efforts.

Based on the analysis in this report and associated appendices, the USRB PDT has concluded that construction of a federal FRM project by USACE is not recommended under this study authority at this time. Despite the negative finding in the various structural alternatives examined, the preliminary analysis of non-structural measures results in a possible avenue for federal involvement through existing programs and authorities including the FEMA Hazard Mitigation Grant Program. The effort to implement non-structural flood risk management projects in the USRB is already being led by state and local stakeholders as part of the New York Rising Community Reconstruction Program. USACE is dedicated to support these efforts through technical assistance programs. Should more detailed analysis show areas where non-structural projects are warranted, the CAP may be provide an avenue for implementation. Additional recommendations for technical assistance or CAP projects are provided in Chapter 9.

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CHAPTER 1 INTRODUCTION

The Upper Susquehanna River Basin, Comprehensive Flood Damage Reduction (FDR), New York - Feasibility Study (USRB study) investigated the feasibility of structural and non-structural flood risk management (FRM) measures to reduce damages in areas with high relative flood risk. The USRB study involved evaluation of FRM alternatives that address flood risk to populations, infrastructure, and property with the end goal of identifying one or more areas for the implementation a potential Federal project by the US Army Corps of Engineers (USACE).

USACE has completed this feasibility report with no recommendation under this study authority based on the evaluation of the array of project alternatives developed for, and presented in this report. The evaluation of the alternatives included economic analysis, concept designs, and cost estimation of structural and non-structural alternatives in Binghamton, Endicott-Johnson City-Vestal (EJV), Owego, Oneonta, and non-structural measures in the other communities with identified flood risk. USACE has provided recommendations for technical assistance and other federal involvement through existing programs and authorities to address flood damage reduction needs in communities with high levels of flood risk and vulnerability identified in this study. This report details all work completed for the USRB study leading up to the conclusion of no recommendation for construction under the study authority and includes information on proposed work by USACE and other Federal and non-Federal actors, including NYSDEC, under existing programs or authorities.

1.1 NON-FEDERAL SPONSOR

The New York State Department of Environmental Conservation (NYSDEC) was the non-Federal sponsor for this study and provided 50 percent of the feasibility study costs.

1.2 STUDY AREA

The study area is defined by the Upper Susquehanna River Basin boundary in Southern Tier New York, ending at the Pennsylvania state border (Figure 1). Within New York, the USRB drains approximately 4,520 square miles in the south central part of the state. This drainage area includes Broome, Chenango, Cortland, Otsego and Tioga Counties and parts of Delaware, Madison, Chemung, Schuyler, Tompkins, Onondaga, Oneida, Herkimer and Schoharie Counties.

The USRB includes the northern-most extent of the Susquehanna River, which is part of the larger Chesapeake Bay Watershed. The USRB includes the Chenango subwatershed, which includes the Tioughnioga River and the Otselic River, the Upper Susquehanna subwatershed, which includes the Susquehanna River (Upper) and the Unadilla River, and the Owego-Wappasening subwatershed, which includes Owego Creek, Wappasening Creek, Cayuga Creek, and Nanticoke Creek. Otsego Lake is the largest lake and accounts for approximately 3 percent of water surface area in the basin. The next largest lakes are Canadarago Lake and Whitney Point Reservoir.

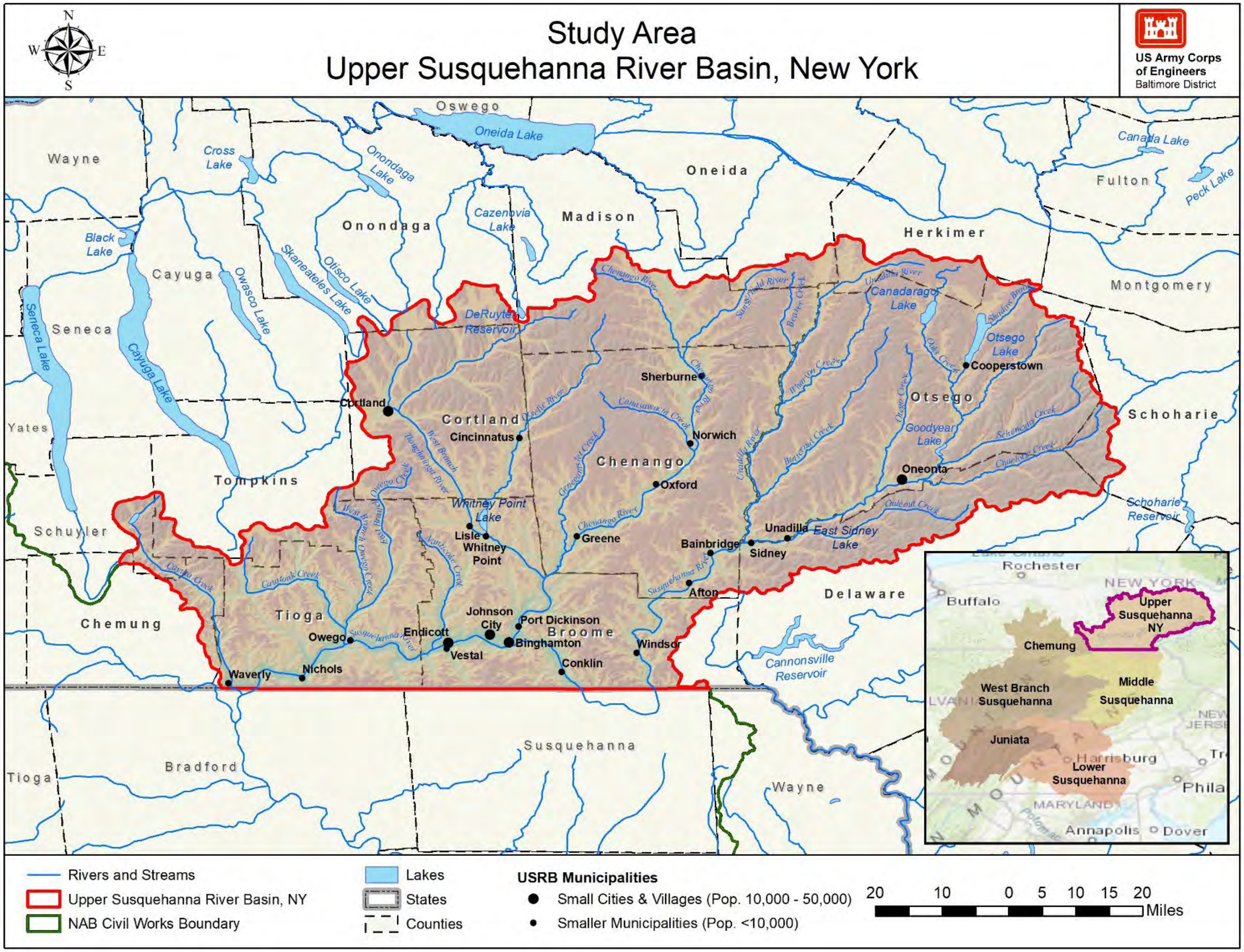

Figure 1: Upper Susquehanna River Basin Study Area

The region is characterized by low rolling hills covered by hardwood forests and large wide valleys scattered with agricultural activity. Seventy percent of the basin is forested and agricultural land uses account for about 25 percent of the drainage area. Most of the basin population is rural or located in smaller villages and hamlets. The City of Binghamton is the largest population center in the study area.

1.3 STUDY AUTHORIZATION

USACE was originally given the authority to conduct a reconnaissance study and any ensuing feasibility-level investigations by a resolution of the Committee on Transportation and Infrastructure of the United States House of Representatives, adopted September 24, 2008, for the Upper Susquehanna River Basin, New York. The authorization that follows was sponsored by Congressman Michael Arcuri, 24th District-New York:

> *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 Susquehanna River, New York, Pennsylvania, and Maryland, published as House Document 702, 77th 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 flood damage reduction, including an evaluation of the effectiveness of the existing flood control system in light of current and projected future conditions, and in the interest of comprehensive watershed management, including environmental restoration, structural and non-structural flood damage reduction, and related purposes for the Upper Susquehanna River Basin, within Tioga, Broome, Chenango, Cortland, Otsego, Delaware, Schoharie, Herkimer, Oneida, Madison, Onondaga, Tompkins, Schuyler, and Chemung Counties, New York.*

The 905(b) report that was prepared in response to the study resolution, dated June 2008, establishing Federal interest, was approved by USACE North Atlantic Division on 14 December 2011.

1.4 PURPOSE OF THE STUDY

The purpose of the USRB study was to evaluate the effectiveness of existing systems of FRM infrastructure, as well as unprotected areas, and to recommend structural and non-structural solutions to flood risk reduction in the USRB. The feasibility study was intended to inform decision-makers about flooding problems and feasible FRM actions that could be considered at the Federal, state or local level. The study was completed in accordance with Engineer Regulation (ER) 1105-2-100, Planning Guidance Notebook (PGN), and informed by Planning Bulletin (PB) 2016-03, Watershed Studies (superceded by PB 2019-01).

The Upper Susquehanna River Basin is a primarily rural basin with urbanized communities located along the rolling hills and steep floodplains of the Susquehanna and Chenango Rivers, the major riverine systems of the basin. The City of Binghamton and nearby urban areas are communities of known historic flooding risk with extensive areas of Binghamton and the adjacent villages of Endicott, Johnson City, and Town of Vestal currently protected by FRM projects. Communities in the USRB remain at high residual risk for flooding as indicated by damages sustained from riverine flooding in the June 2006 storm event. In 2011, flooding from Tropical Storm Lee overwhelmed many of the FRM projects in the watershed including Binghamton, Endicott, Johnson City, and Vestal resulting in over $500 million in property damage in Broome County alone.

1.4.1 COMPREHENSIVE WATERSHED PLANNING

The USRB study used a comprehensive watershed planning approach by evaluating flood risk and residual risk to populated areas in the watershed. The watershed planning approach examined flood risk for communities with and without existing FRM projects in the USRB to recommend strategies for flood damage reduction. This watershed planning approach included computer modeling of flood risk and economic damages using information on structures and critical infrastructure assets with flood inundation data for the entire watershed. Information generated from the watershed screening was used with other existing information to inform the formulation of flood damage reduction measures for communities in the USRB. The feasibility study included recommendations for comprehensive flood damage reduction in communities with the highest risk of flooding impacts including actions that could be implemented by federal, state, or local agencies with FRM roles.

CHAPTER 2 PLANNING PROCESS

The USRB study was conducted using a risk-informed planning process. Risk informed planning is an approach to planning in which decisions are made given that there is uncertainty (see E.R. 1105-2-101). This approach is iterative and involves generating information and analyses to reduce uncertainty and support decision-making. By managing risks and reducing uncertainty in planning decisions, the project team can work towards supportable decisions without complete information. For example, uncertainty may be attributed to unknown future conditions or incomplete information resulting from not having the right stakeholders involved in the planning process. This planning approach is a response to increasing complexity and uncertainty inherent in a changing planning context as a result of climate change and a drive across the Federal government to reduce the duration and costs of plans and studies. The USRB study team used this planning process to formulate potential alternative FRM plans for the watershed. The planning steps are iterated to reduce the level of uncertainty of decisions related to plan formulation as the process moves from selection of FRM measures, to an initial array of alternatives, to a focused array of alternatives, and a final array of alternatives. This chapter describes the planning process, considerations, and formulation strategy. A description of the USACE risk-informed planning process is described in Appendix A Plan Formulation.

2.1 PUBLIC AND STAKEHOLDER COORDINATION

The USRB study PMP was developed by USACE in cooperation with the non-Federal sponsor, NYSDEC, and was approved in October 2015 by USACE North Atlantic Division. The study was funded and initiated in the summer of 2016 with USACE commencing initial coordination with stakeholders in early September. The PDT has participated in various coordination efforts as part of the study including meetings, webinars, conference calls, and correspondence with Federal, state, and local stakeholders.

USACE and NYSDEC increased funding to the U.S. Fish and Wildlife Service (USFWS) so that they could expand the scope of their Fish and Wildlife Coordination Act (FWCA) Report to seek and coordinate input from the Upper Susquehanna Conservation Alliance (USCA). The USCA is an alliance of 50 agencies, organizations, academic institutions, and individuals who work collaboratively to conduct green infrastructure planning, implement restoration and maintenance of high quality watersheds and habitats, protect and restore species of greatest conservation need, reduce impacts of flooding, and promote sustainable working landscapes for the people of the watershed.

Public coordination was initiated with public scoping meetings held on November 21, 22, and 30 of 2016 at various locations in the watershed. Public and stakeholder coordination was a valuable part of the planning process by providing important information and feedback throughout the planning process. All public and stakeholder coordination is summarized in Table 1 below.

Table 1: Public and Stakeholder Coordination in USRB study

SESSION	DATE	DESCRIPTION	STAKEHOLDERS
Living with Water Resiliency Summit, Binghamton, New York	September 13, 2016	Academic/Civic Meeting focused on disaster preparedness and flooding. USACE introduced the USRB Study to stakeholders	FEMA Region II Staff, NOAA National Weather Service, NYSDEC, NYS Department of State and other Agencies, County and Municipal Governments, Academic Representatives
Study Kick-Off Meeting, Kirkwood, New York	September 13, 2016	USACE introduced study to Broome County staff and Congressional staffers	NYSDEC, Broome County, Senator Charles Schumer's staff
Study Stakeholder Meeting, Webinar	October 14, 2016	Overview of the USRB Study, discussed proposed H&H modeling.	NYSDEC SRBC, USGS, FEMA, NOAA
NEPA Public Scoping Meetings – Chenango, Owego, Sidney	November 21-22 and 30, 2016	USACE held meetings to obtain input on flooding concerns, considerations, and impacts to the human environment	Public, Local officials, Representatives from County, State, and Federal Government/Agencies
USRB Progress Webinar #1	April 19, 2017	Presentation of study progress including FRM measures under consideration, H&H modeling, and watershed flood risk screening preliminary results	NYSDEC, NYSHPO, FEMA, SRBC, USFWS
Upper Susquehanna Conservation Alliance (USCA) Meeting # 1	July 20, 2017	USFWS-led webinar where USACE and NYSDEC presented the study and how USCA can play a role in the study	USFWS, NYSDEC, USCA
FEMA-USACE Coordination Meeting #1	August 28, 2017	USACE and FEMA Region II staff coordinated to get a common understanding of the study goals and how the products would benefit communities in Broome County during the Levee Analysis Mapping Procedures (LAMP) process	FEMA Region II Staff, FEMA Consultants
Upper Susquehanna Conservation Alliance (USCA) Meeting # 2	November 8, 2017	NYSDEC staff gave an overview of the study to date. USCA provided information on green mitigation and FRM information needs and actions	USACE, USFWS, NYSDEC
Upper Susquehanna Watershed Screening Stakeholder Meeting	March 28, 2018	USACE presented the results of the watershed screening and formulation process for communities in the watershed. The purpose of the meeting is to give the communities an opportunity to review analysis and provide feedback on the study. Stakeholders provided feedback on modeling work, project alternatives,	NYSDEC, FEMA, USFWS, TNC, Southern Tier East Planning Board Staff, Congressional Staffers, SRBC, Officials from 21 local municipalities and 5 county governments

SESSION	DATE	DESCRIPTION	STAKEHOLDERS
		and the feasibility of presented alternatives.	
Upper Susquehanna Conservation Alliance (USCA) Meeting # 3	April 12, 2018	NYSDEC staff presented the watershed screening process, FRM measures, and how the formulation will lead to selection of candidate areas. USFWS presented the Draft Planning Aid Report for the study. USCA asked questions about evaluation of environmental impacts and potential for more environmentally sensitive FRM measures	NYSDEC, USFWS, SRBC, FEMA, USCA, local Soil and Water Conservation Districts, Consultants
FEMA-USACE Coordination Meeting #2	May 14, 2018	USACE coordinated with FEMA staff and contractors to discuss H&H modeling and to coordinate needed changes to ensure model outputs meet FEMA requirements	FEMA Region II Staff, FEMA Consultants
Upper Susquehanna Study Update Stakeholder Meeting and Workshop	May 7, 2019	USACE presented the results of the evaluation of the focused array of alternatives including process for evaluation by discipline (H&H, civil engineering, structural engineering, cost engineering, economics). The PDT discussed concept design, cost estimation, and economic analysis assumptions and discussed a path forward for recommendations for technical assistance.	Broome County, Village of Johnson City, National Weather Service – Binghamton, USFWS – Cortland, City of Binghamton, Town of Vestal, Town of Union, Congressional Representatives, Village of Port Dickinson, City of Oneonta, SRBC, Tioga County, Village of Endicott

2.2 PREVIOUS STUDIES AND REPORTS

The USRB has been extensively studied for the purposes of FRM by USACE with investigations stretching back as early as 1935. Table 2 lists FRM studies carried out by USACE in the USRB. Since the last round of comprehensive studies in 1981, the FRM projects at Binghamton and EJV have been impacted by storm damages in 2006 and in 2011 resulting in rehabilitation actions to FRM projects by USACE on both occasions.

Table 2: USACE Flood Risk Management Studies in the Upper Susquehanna River Basin

Study	Year	Description
Survey of Streams in New York and Pennsylvania Affected by the Disastrous Flood of 6-7 July 1935	1935	Study examined the Susquehanna River Basin to recommend flood control solutions to flooding that occurred in 1935 and later in 1936.
US Army Corps of Engineers Susquehanna River Basin	1936	Authorized by the Flood Control Act of 1936, as amended by the Flood Control Act of 1938,

Study	Year	Description
Construction Authorization in House Document No. 702, 77th Congress, Second Session		for the construction of detention reservoirs and related flood control works in southern New York. Resulted in construction of Binghamton Levee System
Definite Project Report for the Upper Susquehanna Basin	1939	Recommended projects for upstream detention reservoirs to manage flood risk in the USRB.
Report on Flood Control Project at Endicott, Johnson City, and Vestal, New York, authorized in House Document 500, 81st Congress, Second Session	1949	Recommended local flood control project to reduce damages and residual risk in Endicott, Johnson City, and Vestal, NY. Project was authorized for construction in 1954.
Storage Potential in the Susquehanna River Basin	1966	Examined flood storage locations throughout the Susquehanna River Basin including upstream and downstream of Binghamton, NY.
Susquehanna River Basin Flood Control Study	1970	Study examined FRM projects in the Susquehanna River Basin to provide recommendations for flood risk reduction.
Susquehanna River Basin Flood Control Review Study: Susquehanna River Reconnaissance Report for the Structural Local Flood Protection Project in Endicott, New York	1978	Study examined the raising of the Endicott FRM system. At the time, raising was not economically justified.
Report on the Review of the Endicott, Johnson City, and Vestal, New York Project	1979	USACE reviewed the operation and performance of the EJV project to determine if the project provides adequate protection under current conditions and to examine modifications as needed. Seepage and interior drainage were addressed in a rehabilitation, but raising was not deemed economically justifiable at the time.
Susquehanna River Basin Flood Control Review Study	1981	USACE reviewed existing reports and recommendations to determine if plans for modifying FRM projects within the Susquehanna River Basin are feasible. This study evaluated the feasibility of raising in EJV and found no economic justification for raising at the time. The review also included an examination of nonstructural measures in communities in the USRB.
Increasing the Level of the Local Flood Protection Project in Binghamton, New York	1981	Study to determine the feasibility of structural and nonstructural flood damage reduction alternatives including increasing levels of protection in Binghamton, New York. At the time, only Front Street (Ward 1) project was recommended for raising.
Flood Risk Management Analysis for the Village of Sidney, Delaware County, New York	2010	USACE evaluated structural and non-structural FRM measures for damage reduction in the Village of Sidney, New York under the technical assistance programs. Study found limited Federal interest related to proposed alternatives.

In addition to USACE studies, the NYSDEC, the Susquehanna River Basin Commission (SRBC), and local stakeholders have been extensively involved in FRM actions. After Hurricane Irene and Tropical Storm Lee in 2011 and Hurricane Sandy in 2012, the State of New York paved the way for recovery by leading community initiatives for reconstruction and improved community resilience to extreme weather events that will occur at increased frequency and magnitude as a result of climate change. Several of these studies along with county efforts to update Hazard Mitigation Plans and flood hazard maps were examined to inform formulation for the USRB study. Table 3 lists a handful of the various state and community reports where flood hazard are specifically addressed by state or local actions. The New York Rising Community Reconstruction Plans for Broome County, Tioga County, and Town of Chenango provided baseline conditions for many of the populated areas in the USRB. Additionally, the Hazard Mitigation Plans for Broome, Chenango, Tioga, Delaware, Oneida, Onondaga, Otsego, Schoharie, Schuyler, and Tompkins Counties were available to supplement other existing information on flood hazards and local activities for risk reductions.

Table 3: Recent Water Resource Reports in the USRB

Study	Year	Report Source
Susquehanna-Chemung Action Plan	2012	Southern Tier Central Regional Planning and Development Board, Southern Tier East Planning Development Board
Comprehensive Plan for the Water Resources of the Susquehanna River Basin	2013	Susquehanna River Basin Commission
Blueprint Binghamton (Binghamton, NY Comprehensive Plan)	2014	City of Binghamton
New York Rising Community Reconstruction Plan - Broome County	2014	Broome County
New York Rising Community Reconstruction Plan - Town of Chenango	2014	Town of Chenango
New York Rising Community Reconstruction Plan - Tioga County	2014	Tioga County
Broome County Watershed Flood Hazard Mitigation Plan	2016	Broome County
Building Resiliency Progress Report	2016	Broome County

2.3 EXISTING FLOOD RISK MANAGEMENT PROJECTS

The USRB has 20 federally-authorized, USACE-constructed projects including 2 large reservoirs, 7 levee/floodwall projects, 5 snagging and clearing[1] projects in streams, 5 channel improvement projects, and 1 combination channel improvement with snagging/clearing, see Figure 2.

[1] "Removal of vegetation along the bank (clearing) and/or selective removal of snags, drifts, or other obstructions (snagging) from natural or improved channels and streams." (NRCS, 2010)

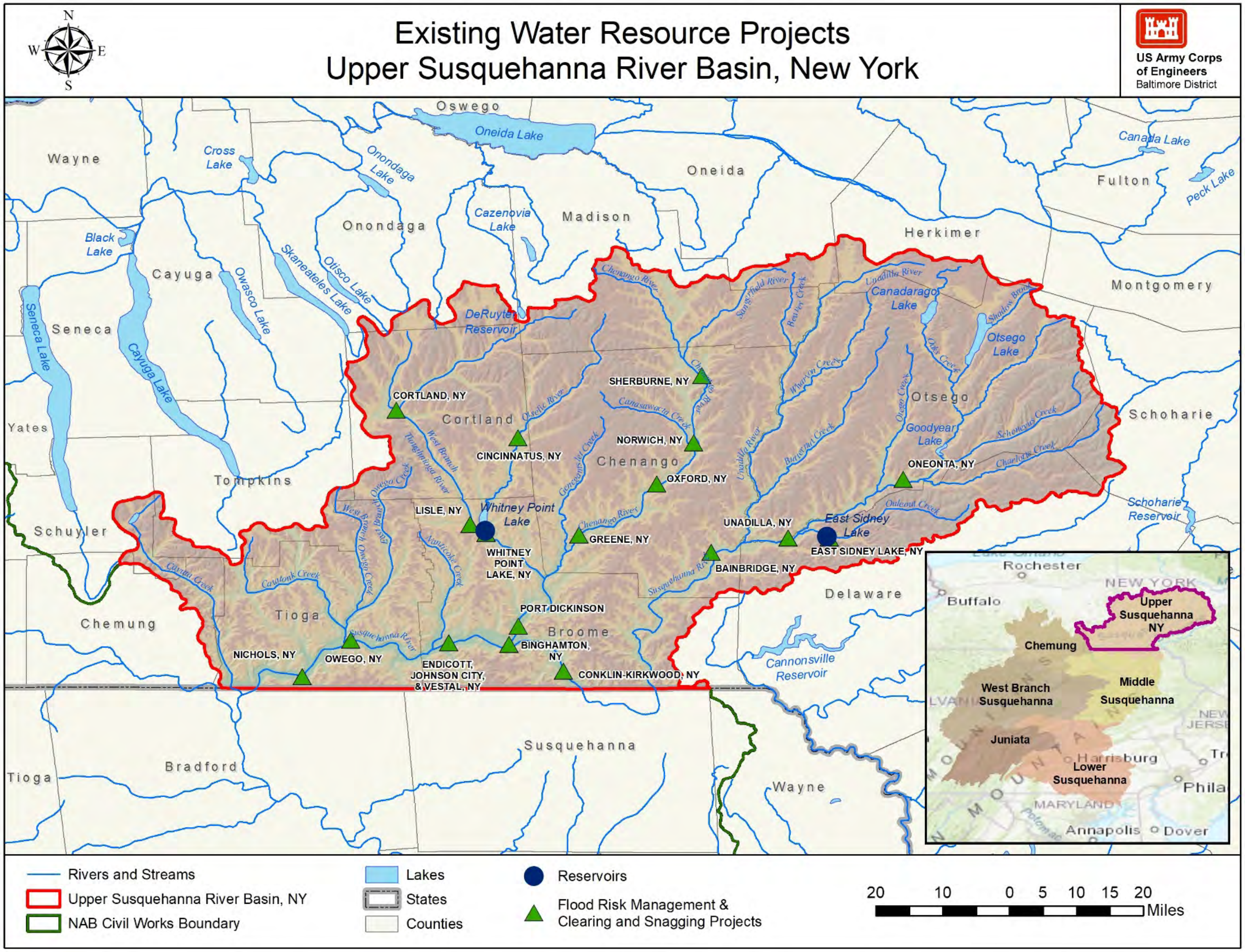

Figure 2: Upper Susquehanna River Basin Existing Water Resource Projects

The Whitney Point Reservoir and Binghamton FRM Project – Levee/Floodwall were the first projects in the USRB, and were authorized by the Flood Control Act of 1936 as amended by the Flood Control Act of 1938. All USACE-constructed projects are listed in Table 4 with a project description included in Appendix A Plan Formulation. Other projects have been historically considered including multiple reservoirs on the Chenango River; the Genegantslet and South Plymouth Reservoirs, which were authorized in the Flood Control Act of 1944 but never constructed; the Fabius Reservoir, which lacked economic justification at the time; and the Charlotte Creek Development Reservoir, which lacked support for implementation.

Table 4: Flood Risk Management Projects in the USRB

Project (Year of Completion)	Type
Bainbridge, Chenango County, NY (1959)	Channel Improvement
Binghamton, Broome County, NY (1943)	Levee/Floodwall
Binghamton, Broome County, NY (1950)	Snagging/Clearing
Cincinnatus, Cortland County, NY (1956)	Snagging/Clearing
Conklin-Kirkwood, Broome County, NY (1955)	Channel Improvement
Cortland, Cortland County, NY (1963)	Channel Improvement
East Sidney Lake, Delaware County, NY (1950)	Reservoir
Endicott, Johnson City, and Vestal, Broome Co, NY (1961)	Levee/Floodwall and Channel Improvement
Greene, Chenango County, NY (1951)	Levee and Channel Improvement
Lisle, Broome County, NY (1948)	Levee/Floodwall and Channel Improvement
Nichols, Tioga County, NY (1971)	Levee/Floodwall and Channel Improvement
Norwich, Chenango County, NY (1950)	Channel Improvement
Oneonta, Otsego County, NY (1963)	Snagging/Clearing
Owego, Tioga County, NY (1952)	Channel Improvement and Snagging/Clearing
Oxford, Chenango County, NY (1938)	Levee/Floodwall and Channel Improvement
Port Dickinson, Broome County, NY (1949)	Snagging/Clearing
Sherburne, Chenango Co., NY (1955)	Snagging/Clearing
Unadilla, Otsego County, NY (1969)	Channel Improvement
Whitney Point Village, Broome County, NY (1948)	Levee/Floodwall and Channel Improvement
Whitney Point Lake, Cortland/Broome Co., NY (1953)	Reservoir

.3.1 PROJECTS IMPLEMENTED BY OTHERS

There are several FRM projects built by local governments or private entities throughout the USRB. These include levee and floodwall projects and elevation of buildings including:

- West Corners Levee, Town of Union, Broome County, NY
- Fairmont Park Levee, Town of Union, Broome County, NY
- Mill Race Levee, City of Oneonta, Otsego County, NY
- Owego Creek Levee, Village of Owego, Tioga County, NY
- Lourdes Hospital - Floodwall, City of Binghamton, Broome County, NY
- Union-Endicott High School - Floodwall, Village of Endicott, Broome County, NY
- Perry Browne Intermediate School - Levee, City of Norwich, Chenango County, NY
- MacArthur Elementary School – Elevation, City of Binghamton, Broome County, NY

- Owego Elementary School - Elevation, Village of Owego, Tioga County, NY

2.4 PLANNING CONSIDERATIONS

.4.1 PROBLEM STATEMENT

The USRB in New York represents a flood prone area that repeatedly experiences flooding damages. Flooding damages are concentrated in floodplains that were developed prior to modern understanding of the risk inherent to these sites. To reduce flood damages, numerous FRM projects have been constructed by the USACE and other agencies, including U.S. Department of Agriculture Natural Resource Conservation Service, the State of New York, and local governments. Additionally, many streams have been channelized and stabilized by landowners to promote drainage and reduce damages to property and structures.

The problem is that the USRB, which includes the Susquehanna River main stem and its tributaries, continues to experience extreme flood events - notably the events of 2006 and 2011 - that have caused loss of life, extensive property damage, and disruptions to critical services supporting communities.

.4.2 OPPORTUNITIES

Opportunities are the desirable future outcomes that address the water resources problems and improve conditions in the study area. The opportunities considered in this study include:

- To reduce flood risk to residential, commercial/industrial and critical infrastructure assets.
- To improve risk communication within the watershed.
- To increase resilience by reducing the time that critical services are disrupted following direct flood damage.
- Ancillary: When implementing a FRM project, to enhance habitat to the degree possible.

.4.3 PLANNING GOAL AND OBJECTIVES

The goal of the feasibility study is to recommend actions to manage and/or reduce flood risk in the USRB in New York. The feasibility study PMP for the purposes of developing a scope of work assumed Federal interest would be established leading to one or more recommended actions by USACE in the form of a Chief's Report. The feasibility study report also documents actions that others could take to manage flood risk and reduce damages in the form of recommendations for a floodplain management plan, which would present the need for shared responsibility to manage flood risk across multiple levels of government and individual property owners.

The feasibility study objectives for the USRB in New York State include the following:

1. Reduce economic damages from riverine flooding to residences and businesses.
2. Reduce riverine flood inundation that disrupts critical infrastructure assets, services, and interdependent systems in communities throughout the study area.
3. Reduce loss of life from riverine flooding to communities with and without existing FRM projects.

.4.4 PLANNING CONSTRAINTS AND CONSIDERATIONS

Constraints are conditions to be avoided or things that cannot be changed that limit the development and selection of alternative plans. No study specific constraints were identified for this study, however, the following general constraints were considered:

- Avoid or minimize induced flooding damages as a result of any structural or non-structural FRM recommendation (USACE policy)
- Comply with all Federal, State, and local regulations, including environmental regulations
- Comply with USACE Environmental Operating Principles

Other planning considerations for this study, several of which are also criteria in plan selection, include:

Regional and social considerations…

- Weigh the interests of state and local public institutions and the public at large

Institutional considerations…

- Include local support
- Demonstrate overall support in the region and state.

.4.5 CONSIDERATIONS FOR RESILIENCY

USACE defines resilience as the *ability to anticipate, prepare for and adapt to changing conditions and withstand and recover from disruptions*. USACE missions have historically supported community resilience through FRM, aquatic ecosystem restoration, natural resource management, critical infrastructure protection, planning technical assistance, and environmental stewardship, but the conceptual link to resilience theory is a relatively novel idea. Resilience can operate in a variety of scales and can include the resilience of a project (i.e. a levee's ability to withstand and recover from a flood event), the resilience of a system, which can include the natural and built environment in a town or geographic area, and of a community, that is made up of many systems (social, institutional/organizational, inter-organizational). Resilience considerations for USACE projects are guided by four principles: Prepare, Absorb, Recover, and Adapt. Resilience principles are outlined in Engineer Pamphlet (EP) 1100-1-2 (2017). These principles roughly correspond to;

- ***Prepare*** - activities done to plan and act during a disturbance or disruption.
- ***Absorb*** – the ability to withstand the disturbance or disruption with minimal change.
- ***Recover*** - the ability to return to a previous functional state.
- ***Adapt*** - ability to anticipate and respond to a changing environment.

In this study, considerations of resilience include those required by Engineering and Construction Bulletin (ECB 2018-14). ECB 2018-14 requires that USACE studies consider climate change impacts in the planning and implementation of projects including considerations for hydrologic and hydraulic modeling (changed flows, precipitation, and storm frequency), engineering design, and the potential for increased economic damages as a result of the changing environment. These considerations are detailed in the future without project conditions of each respective engineering and economic component of this study. FRM measures are also considered in the context of resilience using the three strategies for climate adaptation used in the North Atlantic Coast Comprehensive Study (NACCS), which are more broadly used by communities in the United States and internationally; Preserve, Accommodate, and Avoid. The USRB study develops comprehensive approach to FRM that considers resilience by evaluating structural and non-structural measures for risk reduction in the watershed, even in areas where a USACE or a Federal action is not recommended as this information can support actions by state and local stakeholders.

.4.6 CRITICAL ASSUMPTIONS IN THE PLANNING PROCESS

USACE staff made certain assumptions during the study to facilitate the decision making process. These assumptions were made to match the level of detail in the analysis with the uncertainty associated with decisions in the study, since many of the problems and opportunities in the watershed are well understood and have relatively low uncertainty, while others are poorly understood and have relatively high uncertainty. USACE staff has communicated these assumptions with USACE decision makers in the form of a decision management plan and risk register. The risk register documents areas of risk, assesses the risk as being high, medium or low, and describes how they were addressed or mitigated in proposed actions by the PDT. A few of these assumptions are listed for relevant disciplines in Table 5 below.

Table 5: Critical Assumptions in the Planning Process

Discipline	Critical Assumption
Plan Formulation	Screening using economic benefits as a guide would reduce the number of feasible alternatives in the USRB to develop alternative plan for one area for detailed analysis
Economics	Economic benefits/consequences will be determined for all existing levees/floodwalls in the study area using HEC-FDA modeling
Geotechnical Engineering	Geotechnical evaluations will use existing soils and foundation information including existing borings.
Hydrology and Hydraulics Engineering	A watershed model (HEC-HMS) will be acquired for the entire USRB upstream of Waverly, NY. Forecasted future hydrological conditions will be completed using the HEC-HMS model.
Hydrology and Hydraulics Engineering	Hydraulic modeling (HEC-RAS) (existing and forecasted future conditions) of water surface elevations will be conducted using updated hydrology from HEC-HMS model for each of the FRM projects that include levees and/or floodwalls, along with appropriate mapping.
Civil Engineering	Levels of protection will be defined at each of the existing levee/floodwall projects (Binghamton, Endicott, Johnson City, Vestal, Greene, Lisle, Nichols, Oxford, and Whitney Point) within the study area in terms of the recurrence level for the watercourse discharge that results in incipient overtopping.

2.5 PLAN FORMULATION STRATEGY

The USRB plan formulation strategy was modelled on a comprehensive watershed planning approach. The formulation started with a broad analysis with the watershed-scale flood risk screening and subsequently examined the more specific flooding context of each community identified as having higher relative flood risk. The watershed screening analysis, presented in Chapter 3, identified 17 flood risk areas, which comprise the highest 10th percentile of flood risk areas in the USRB and account for 78 percent of estimated damages (for the 1 percent event[2]) in the watershed. Following the watershed screening, the PDT, including the non-Federal sponsor, formulated measures and alternatives for these 17 flood risk areas in multi-day planning charettes, described in Section 2.6.1. The charettes also resulted in agreement on the screening criteria and planning considerations for evaluating measures and alternatives in the formulation process.

The plan formulation strategy consisted of an iterative process of analysis, evaluation and deliberation, detailed in Figure 3. The intent of this strategy was to determine Federal interest in the proposed alternatives for all 17 areas and screen the best candidate projects for possible implementation. Implementation could come as a recommendation of the feasibility study or as a programmatic recommendation for the Continuing Authorities Program (CAP), or other Federal or State implementation authorities. This formulation process involved considering the consequences of flooding, probability of flooding impacts (associated with flood mapping), and the extent to which there would be impacts to critical infrastructure assets that remain vulnerable to flooding. The alternatives evaluation consisted of iterations of analysis followed by formulation and deliberation in charettes. More detailed analyses followed in areas

[2] A 1-percent annual chance flood (100-year flood) is a flood that has a 1 percent chance of happening in any given year.

where uncertainty was high about the nature of the flooding problem and the feasibility of proposed solutions based on a review of available engineering information or existing hydraulic modeling results.

The formulation process can roughly be summarized in three phases: (1) development and screening of FRM measures, (2) formulation and evaluation of the initial array of alternatives for the flood risk areas, and (3) refinement and evaluation of the focused array of alternatives. Each of these phases is described in subsequent sections, while alternatives formulated and evaluation/comparison of alternatives is described in Chapter 6. In terms of programmatic recommendations, the focused array of alternatives (i.e. meet preliminary Federal interest evaluation criteria) were subdivided into two categories; those that will be included in the final array of alternatives for evaluation and design in the feasibility study (i.e. cost and scope too large that it can only be accomplished in a general investigation) and those alternatives with sufficient information available to be categorized into CAP Section 205 (maximum cost of $10 million) or other programmatic authority in USACE, FEMA, NYSDEC or other Federal, state, or local authority based on the type of recommendation and the scope of the proposed work.

.5.1 USACE-NYSDEC PLANNING CHARETTES

The USRB formulation included several planning charettes between USACE and NYSDEC staff to brainstorm flooding problems and possible solutions in the flood risk areas, summarized in Table 6. These charettes used maps highlighting the flooded areas for various storm events including the 5 percent, 2 percent, 1 percent, and 0.2 percent flood events and served as the foundation of the formulation process by laying out all possible measures and alternatives for flood risk reduction in the seventeen flood risk areas. This process was captured in detailed spreadsheets for each flood risk area which are detailed in the Planning Appendix.

Table 6: Summary of USACE-NYSDEC Planning Charettes

Session	Date	Description
Problem Identification Charette	February 15, 2017	Discuss problem statement, opportunities, goals, objectives, constraints, and considerations
Risk Register Charette	February 23, 2017	Document study risks and decisions in the planning process
Screening Criteria and Measures Charette	March 17, 2017	Discuss FRM measures and screening criteria and considerations for evaluating measures
Measures Screening Charette	June 13 and 14, 2017	Evaluate and screen FRM measures for the 17 risk areas to determine suitable solutions to flooding problems
Alternative Development Charettes #1 and #2	June 27 and 29, 2017	Develop initial array of alternatives based on available information for Binghamton and Johnson City
Alternative Development Charettes #3, #4, and #5	July 5, 6 and 7, 2017	Develop initial array of alternatives based on available information for Endicott, Vestal, Owego, Sidney, Cortland, and other risk areas

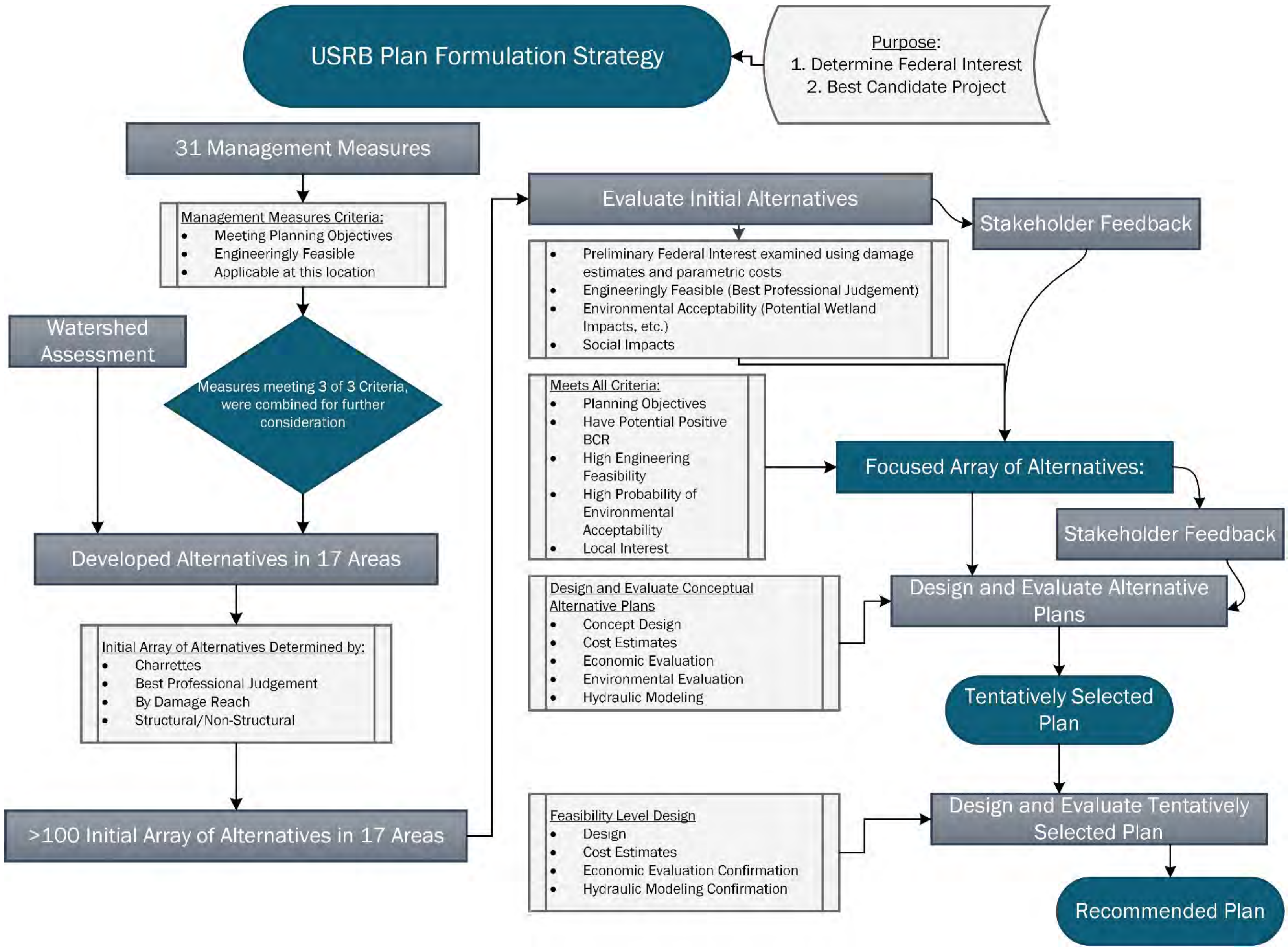

Figure 3: USRB Study Plan Formulation Strategy

2.5.2 FLOOD RISK MANAGEMENT MEASURES

The USRB study started formulation with a comprehensive list of FRM measures including structural and non-structural measures to reduce flood risk that can be implemented by USACE, FEMA, NYSDEC, or other Federal, state, or local authorities. The list is intended to broadly capture possible solutions to FRM. FRM measures are organized in the context of resilience using the three strategies for climate adaptation of Preserve, Accommodate, and Avoid.

- ***Preserve*** - measures that help preserve existing development in communities by reducing flooding risk to development.
- **Accommodate -** measures that accommodate the flooding hazard, for instance by allowing inundation but reducing the impact to existing structures.
- ***Avoid*** - measures that avoid the flooding hazard, for example, by moving development out of the floodplain.

Structural measures are actions that modify the floodplain by physically preventing the movement of water across the natural floodplain. Structural measures are categorized into the Preserve strategy for climate adaption. Non-structural measures, actions that can be applied to a structure and/or its contents to reduce or avoid the consequences from flooding, fall into the Accommodate or the Avoid strategies. USACE is required to evaluate at least one primarily non-structural plan in FRM studies, in which benefits and costs must be calculated in a way that gives equal weight to this plan (WRDA 1974, S73; WRDA 2007 S2031). FRM measures considered in the USRB study are listed in Table 7. Dam modifications were eliminated from consideration prior to the development of the PMP by USACE and NYSDEC because of the magnitude of costs for dam modifications was considered too high and unlikely to result in implementation based on available information. No dam modifications were examined in this study.

Table 7: Flood Risk Management Measures Considered in USRB

Structural Measures (Preserve)	Non Structural Measures (Accommodate/Avoid)	Measures Screened Out
Dredging Channels	Relocation	Floodable Development
Clearing/Snagging/Shoal Removal	Buyout/Acquisition/Razing	Diversions
Channel Modifications	Strategic Acquisition	Ice Jam Structures (most areas)
Levee/Floodwalls (new structure)	Land Use Regulations	Revetment/Retaining Wall
Levee/Floodwall Modifications	Zoning	
Diversions	Building/Housing Codes	
Pump Stations	Flood Insurance	
Conduit for Interior Drainage	Wet/Dry Flood Proofing	
Bridges & Culverts	Elevating Structures	
Revetment/Retaining Wall	Elevating Major Roads for Evacuation	
Storm Water Management Features/Retrofits	Evacuation Plan	
Dams (new structure only)	Emergency Preparedness Plans	
Debris Control Structures	Temporary Flood Barriers	
Ice Jam Structures	Flood Warning Systems	
	Floodable Development	
	Floodplain Regulations	
	Modify/Remove Structures for Better Channel Function	

FRM measures were evaluated during planning charettes to determine the most suitable solutions to flooding concerns in flood risk areas. The evaluation of FRM measures consisted of three primary screening criteria and secondary planning considerations that were qualitatively evaluated using available information. Measures that were carried forward were considered for alternative plans to address flood risk in areas where they were identified as suitable for managing flood risk drivers.

The three screening criteria for management measures include:

1. Meets planning objective – whether the management measure meets one or more planning objectives
2. Applicable at this location – whether the measure is an applicable solution to address the identified flooding concern given the local context
3. Feasible from an engineering perspective/best professional judgment – whether the measure is feasible from an engineering perspective and appropriately supported by best professional judgment

Additionally secondary planning considerations were used to inform but not necessarily eliminate FRM measures from consideration, including:

- Flood conveyance impacts
- Socioeconomic impacts
- Environmental impacts
- Mitigation needed
- Residual risk remaining
- Cost
- Recreation opportunity
- Regional benefits
- Management measure already in place

The measures screening process is documented in tables included in the Planning Appendix. The screening process for FRM measures only eliminated four measures from consideration, shown in Table 8.

Table 8: Flood Risk Management Measures Eliminated from Consideration

FRM Measure	Discussion
Diversions	Unsuitable solution to address flood risk drivers in most risk areas due to the size and flow of rivers, generally unsuitable in urban contexts due to impacts to existing development and difficult to justify in rural contexts (Criteria 1 and 2). Additionally, diversions result in high environmental impacts and high compensatory mitigation costs (Criteria 3). Flooding in most areas is generally associated with major rivers where diversion alternatives would be unsuitable. The PDT only formulated for diversion in one tributary in Cortland, but determined that hydrologic modeling is not currently available to evaluate the tributary as this area is outside of the original modeling scope in the PMP.
Ice Jam Structures (most risk areas)	Ice jams were not identified as a documented problem in most risk areas (Criteria 2). Some tributaries were identified as resulting in ice jam flooding, but USACE determined that solutions are not well understood and tools are not yet available for evaluating alternatives for ice jam flooding at this time (Criteria 3).
Revetment/Retaining Wall	Identified as not meet planning objectives for flood risk reduction (Criteria 2).
Floodable Development	Primarily applicable to new development, unlikely to reduce flood risk to existing development without significant investment. More suitable solutions available.

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CHAPTER 3 WATERSHED SCREENING

3.1 WATERSHED SCREENING PURPOSE

The USRB study watershed screening was an analysis that broadly examined risk and impacts from riverine flooding to existing buildings and critical infrastructure in the USRB. The USRB watershed screening used readily available geospatial data to develop a preliminary assessment of flooding risk in the 4,500 square mile watershed. The primary purpose of the USRB watershed screening was to rapidly identify communities of high relative flooding risk in the watershed to inform formulation of FRM strategies that reduce flood risk to people, property, and critical infrastructure assets in these communities. This chapter will detail the watershed screening process and findings. The watershed screening methods are detailed in Appendix A Plan Formulation. Feedback provided by local stakeholders in these communities and by the non-Federal sponsor (NYSDEC) is also included in this report to document the decision-making processes that informed development of the watershed screening.

3.2 WATERSHED SCREENING RESULTS

The watershed screening analysis was updated with feedback from the PDT. The PDT contributed to assigning asset values for critical infrastructure assets, selected the scale and display of figures to highlight flood risk, and examined total damage values to confirm the areas of higher relative risk shown in generated figures. In the end, two major analyses were generated in the watershed screening: the critical infrastructure analysis and the flood risk analysis for structures. The critical infrastructure analysis was implemented using a framework previously used in the North Atlantic Coast Comprehensive Study (NACCS) for evaluating critical infrastructure using the Homeland Security Infrastructure Program (HSIP) data. Subsequent analysis using a structure inventory, generated from parcel centroids, provided a more comprehensive view of flood risk in the USRB. This analysis also includes critical infrastructure assets that are located in flood hazard areas since these are also included in parcel records. This section documents the results of the watershed screening using maps, tables, and narratives.

3.2.1 CRITICAL INFRASTRUCTURE RISK RESULTS

In the watershed screening, critical infrastructure refers to the physical infrastructure and assets that provide essential services and are important aspects of the operation of the built infrastructure and daily life for communities in the USRB. The USRB critical infrastructure database includes assets that range from roads, rail, transit, to electrical, water and wastewater infrastructure, but also includes important assets related to the delivery of essential services during a disaster including hospitals and health care clinics, fire and emergency medical service facilities, emergency shelters, and nursing homes. Many of these critical infrastructure assets are co-located with urban development in hazardous locations in the USRB. Historic flooding has impacted critical infrastructure assets. In 2006, flooding in the USRB resulted in extensive damages to Lourdes Hospital. Lourdes Hospital has since constructed a floodwall to protect the structure from future storm events. Tropical Storm Lee in 2011 resulted in flooding causing catastrophic damages to the BAE plant, a manufacturer and major employer in Johnson City, the Binghamton – Johnson City Joint Sewage Treatment Plant, which provides sewage treatment to 120,000 residents in the metropolitan area, and damage to two power generating facilities in Johnson City and Bainbridge. At least one of these power plants was no longer operational.

A total of 9,295 assets were included in the critical infrastructure database for this analysis. From this total, 1,256 critical infrastructure assets are located in the area inundated by the 1 percent chance flood event, while 1,475 assets are located in the area inundated by the 0.2 percent chance flood. A summary of infrastructure impacted by the 1 percent and 0.2 percent chance flood events are listed Appendix A Plan Formulation. Given the aggregate nature of this analysis and security concerns associated with data aggregation, detailed information on critical infrastructure from the source data has been omitted.

The critical infrastructure analysis component of the watershed screening was intended to assess the flooding risk to critical infrastructure assets in the USRB. This analysis was implemented by generating a critical infrastructure risk index for all critical infrastructure assets in the USRB including flood risk associated with the 1 percent and 0.2 percent chance flood events. The critical infrastructure risk index used the highest probability from a flood event that impacts each asset. The flood damage risk analysis that was completed after the critical infrastructure analysis used a more nuanced tiered approach, where risk is estimated for each of the four flood events previously discussed. The critical infrastructure risk index was used to generate graphical representations of flood risk to critical infrastructure assets in the USRB. Maps were generated using two different neighborhood scales to account for sensitivity in these areal analysis tools (described in Appendix A). These maps are used to illustrate flood risk to critical infrastructure in Figure 4 and 5. The scales of analysis result in different levels of aggregation, which in the end influences the magnitude of values for each of the “neighborhood” circles generated from each point. Both scales were used for interpretive purposes, and notably, they show significant convergence for higher risk areas.

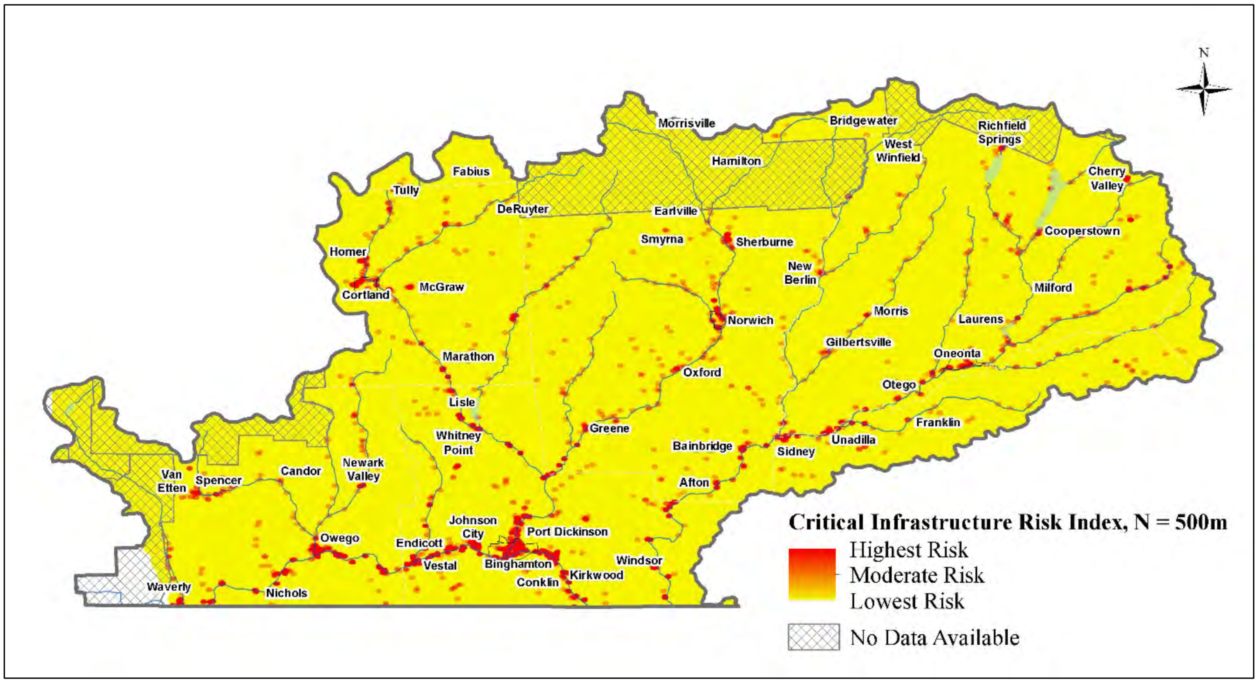

Figure 4: Critical Infrastructure Flooding Risk in the USRB, Neighborhood Scale of 500 meters

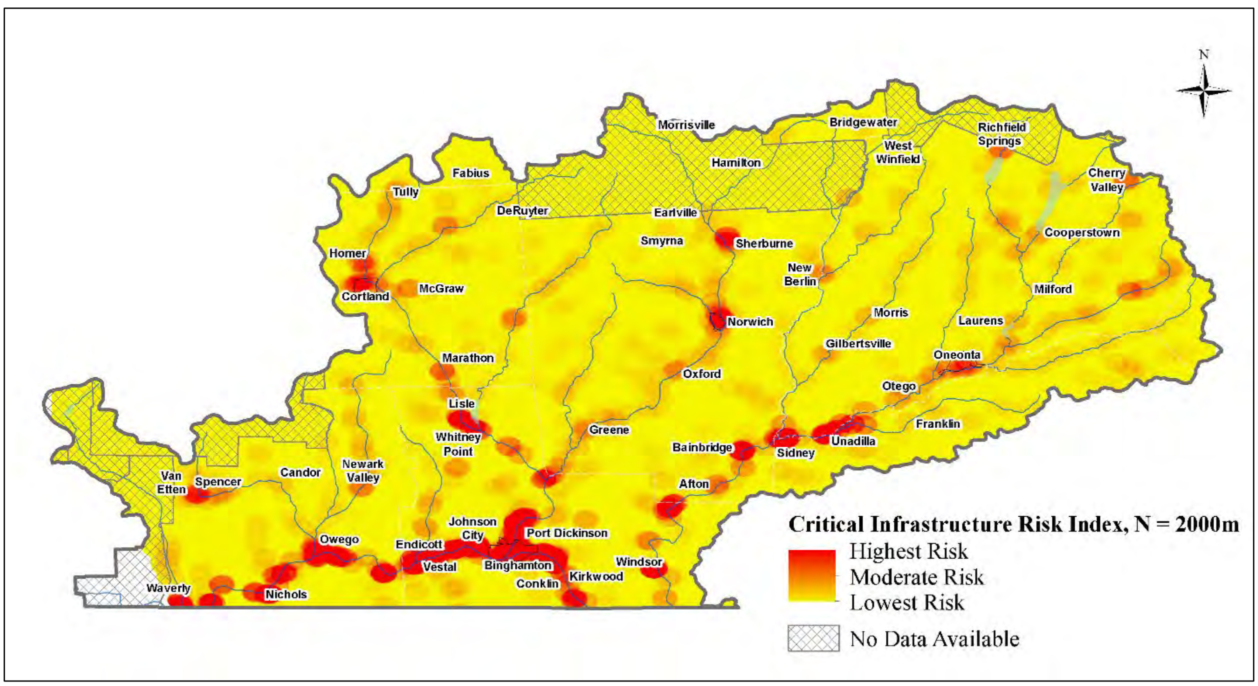

Figure 5: Critical Infrastructure Flooding Risk in the USRB, Neighborhood Scale of 2,000 meters

The critical infrastructure component of the watershed screening presented significant challenges for interpretation and analysis. Many of these challenges related to the number of critical infrastructure assets present in the USRB critical infrastructure database. Another challenge related to the aggregate ranking of asset value based on the relation of each asset category to its function in FRM, which was used as a dummy for consequence, including economic data, missing from the source data. From the 9,295 points and 112 layers representing critical infrastructure assets in the database, a handful of layers with many assets that intersect flood hazard areas were the primary drivers of critical infrastructure risk in this analysis. For instance, highway (National Bridge Inventory) and railroad bridges comprise 81 percent and 74 percent of all assets intersecting the 1 percent and 0.2 percent flood respectively. These assets were also ranked relatively high based on their role as evacuation routes for communities in the USRB. Additionally, the drinking water facilities data points (drinking water sources and treatment plants) published by the Environmental Protection Agency (EPA) were ranked as essential (asset value of 10) for community (public) water systems and non-transient, non-community water systems, which is influenced by the colocation of these facilities with flood hazard areas, resulting in a significant skew in the critical infrastructure risk index. However, these results were not discounted entirely. They were used to inform and compare with subsequent analysis included in the flood damage risk analysis. Many of the communities highlighted in the critical infrastructure analysis were also highlighted by the flood damage risk analysis.

3.2.2 FLOOD DAMAGE RISK RESULTS

A more detailed analysis of the watershed screening than the previously presented critical infrastructure analysis was required to fulfill the goal of highlighting risk areas with the highest flood risk in the watershed. The flood damage risk analysis was developed to fulfill this gap. This analysis creates a watershed scale metric for flood risk using the economic value of structural improvements from parcel-level property tax rolls and flood inundation grids for the USRB. The resulting flood damage risk index is illustrated in maps for each of the four flood events, the 5 percent, 2 percent, 1 percent, and 0.2 percent chance floods, for the USRB. Results were then validated using the total damages for each of the four events and aggregated by municipalities for the entire watershed.

The flood damage risk analysis was completed using a structure inventory containing 16,744 structures in 10 counties in the USRB. This analysis was implemented using flood depths from 4 events including the 5 percent, 2 percent, 1 percent, and 0.2 percent floods. Table 9 lists the number of structures inundated by each of the four flood events by land use type in the USRB. A majority of structures inundated are residential with flooding affecting structures to varying extents. The average depths of flood inundation for affected residential structures are 3.8 feet for the 5 percent flood, 4.4 feet for the 2 percent flood, 4.9 feet for the 1 percent flood, and 7.2 feet for the 0.2 percent flood.

Table 9: USRB Structures Inundated by Flooding, Organized by Type

Structure by Type	Number of Structures Inundated by the 5% Flood	Number of Structures Inundated by the 2% Flood	Number of Structures Inundated by the 1% Flood	Number of Structures Inundated by the 0.2% Flood
Residential	1166	1745	9986	13784
Commercial	134	227	1411	2213
Recreation and Entertainment	24	28	105	124
Industrial	22	25	119	161
Community Services	27	40	217	323
Public Services	15	21	130	139
Total Structures	1388	2086	11968	16744

The results for the flood risk analysis for the 5 percent flood is shown at two neighborhood scales in Figures 6 and 7. These maps illustrate areas with higher relative flood risk based on economic damages of structures in those areas resulting from the 5 percent flood event. At the time of analysis, the Corps Water Management System (CWMS)modeling was not available in areas of Chenango, Otsego, and Cortland Counties so this analysis only provides one part of the picture of flood risk for the 5 percent flood. However, a majority of the population and development in the watershed is concentrated in the CWMS modeling areas. The analysis for the 5 percent flood event illustrates a high concentration of risk in unprotected areas in the watershed including the Towns of Conklin, Kirkwood, Chenango, and Union, and the Villages of Unadilla, Sidney, Owego, Bainbridge, and Afton. In the 5 percent and 2 percent analysis, the larger neighborhood size (n = 2000m) has a tendency to show a larger risk area of high risk than expected for many risk areas.

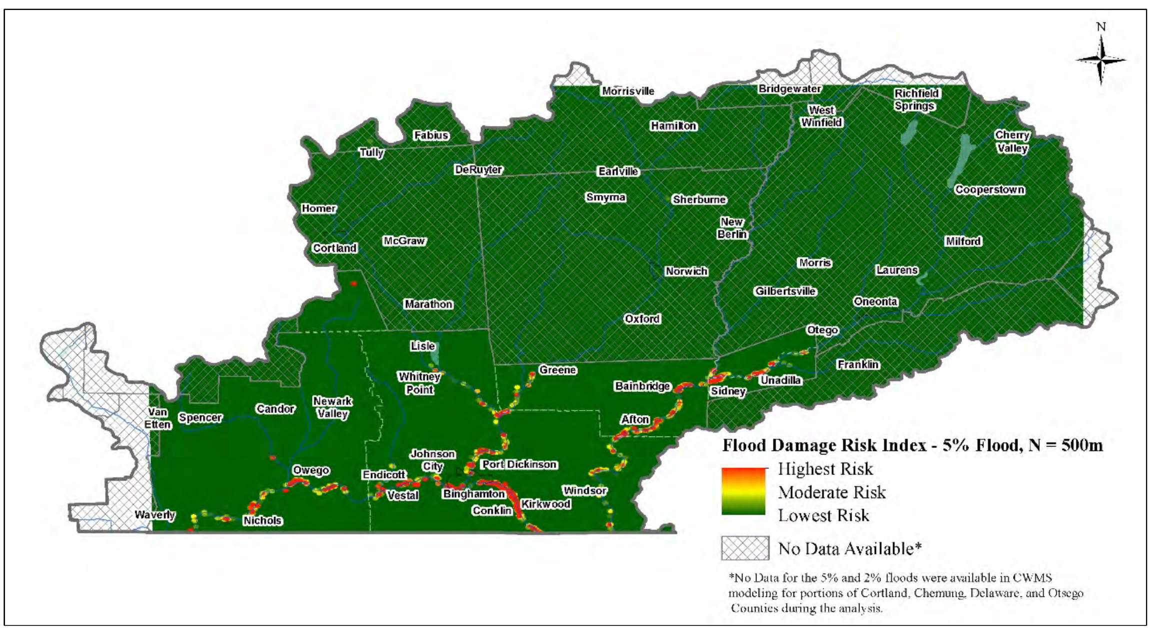

Figure 6: 5% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 500 meters

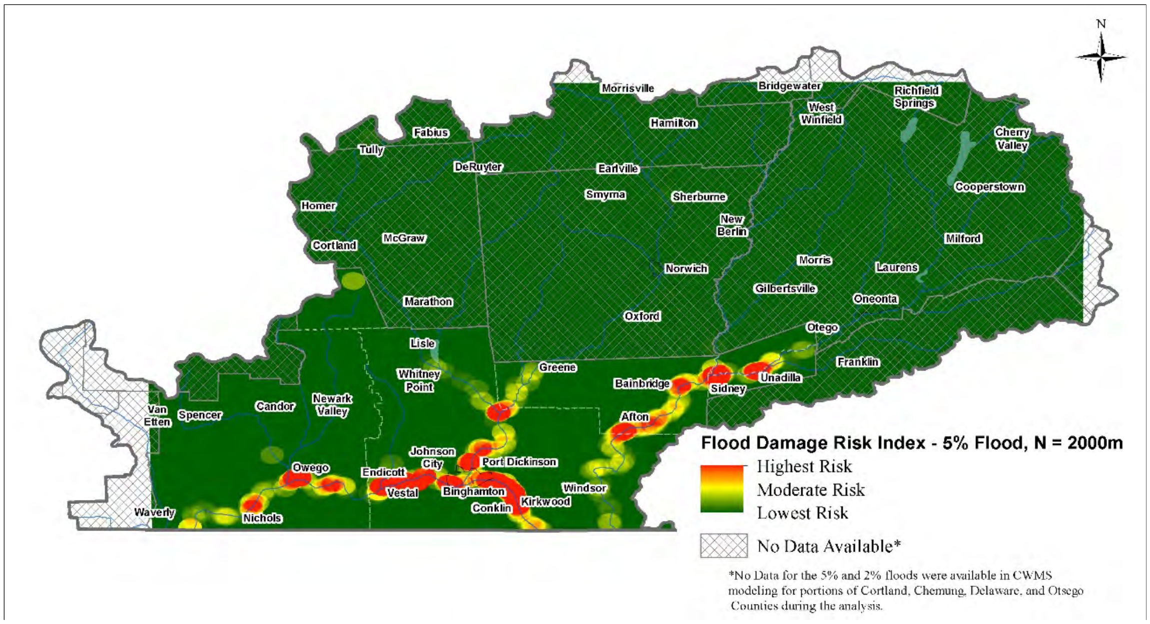

Figure 7: 5% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 2,000 meters

The flood risk analysis for the 2 percent flood are shown in Figures 8 and 9. These maps illustrate areas with higher relative flood risk based on economic damages of structures in those areas resulting from the 2 percent flood event. At the time of analysis, the CWMS modeling was not available in areas of Chenango, Otsego, and Cortland Counties so this analysis only provides one part of the picture of flood risk for the 2 percent flood. The analysis for the 2 percent flood event indicates higher relative flood risk in the same areas as the 5 percent flood - Towns of Conklin, Kirkwood, Chenango, and Union, and the Villages of Unadilla, Sidney, Owego, Bainbridge, and Afton.

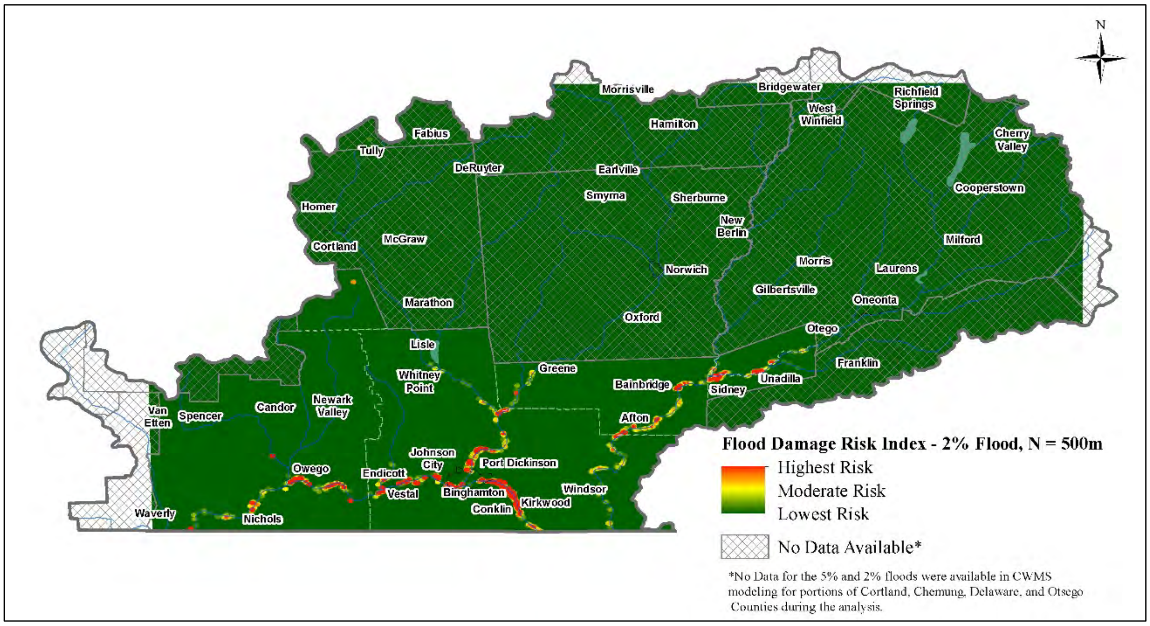

Figure 8: 2% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 500 meters

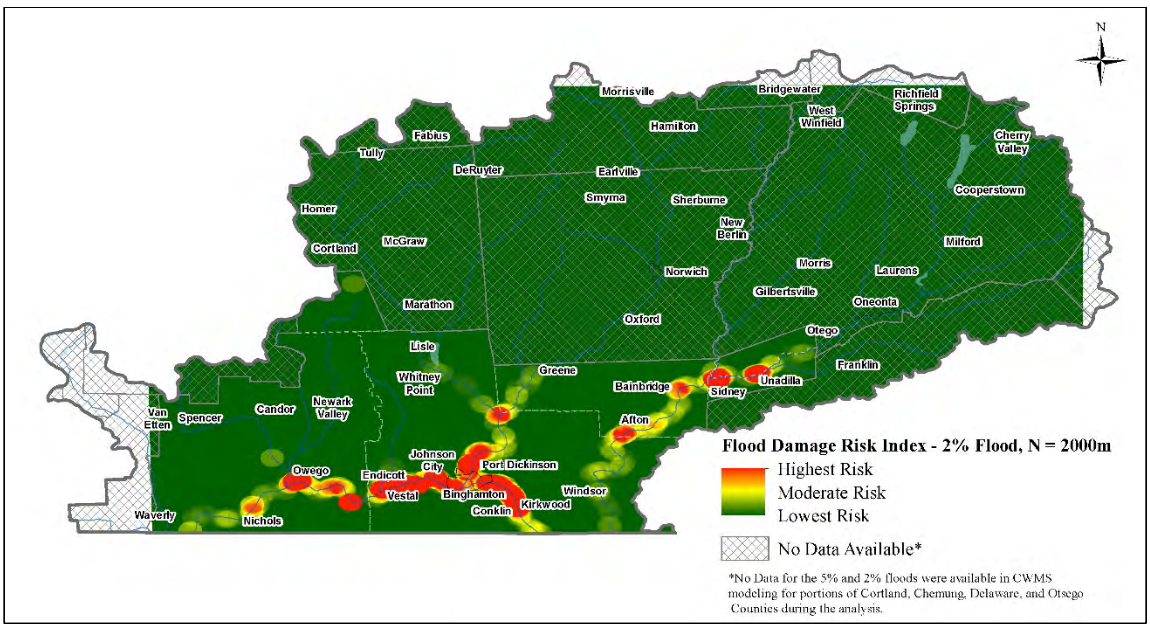

Figure 9: 2% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 2,000 meters

These flood risk maps for the 5 percent and 2 percent flood were validated using spreadsheets of the combined damage estimates, which include structures and content damages estimates for all municipalities in the reduced study area. The top 10 percentile of flood risk, based on estimated damages, were examined in municipalities in the USRB, shown in Table 10. Annualized values are presented using the annualized loss expectancy calculated by multiplying the estimated total damages multiplied by the annual probability of the respective flood hazards. Municipalities without existing FRM projects continue to show as the higher risk areas for more frequent storm events including areas in the City of Binghamton, Towns of Vestal, Conklin, Union, Kirkwood, Chenango, and the Villages of Owego, Sidney, Endicott, and Unadilla. It is important to note that Towns in New York are sub-county jurisdictions that cover a large area so the total damages presented are distributed over a large geographic area and may be overstating the flood risk to structures for the jurisdiction, which in reality might be diffuse throughout the jurisdiction.

Table 10: Total Damage Estimates and Annualized Loss Expectancy for the 5% and 2% Chance Flood in the USRB

Municipality	Estimated Total Damages 5% Flood	Annualized Loss Expectancy 5% Flood	Municipality	Estimated Total Damages 2% Flood	Annualized Loss Expectancy 2% Flood
Conklin, Town	$19,265,777	$963,289	Conklin, Town	$26,994,855	$539,897
Vestal, Town	$8,877,087	$443,854	Vestal, Town	$21,006,016	$420,120
Endicott, Village	$7,200,619	$360,031	Owego, Town	$12,009,345	$240,187
Owego, Village	$4,244,309	$212,215	Union, Town	$11,889,396	$237,788
Sidney, Village	$4,114,442	$205,722	Endicott, Village	$9,288,294	$185,766
Afton, Town	$3,784,812	$189,241	Sidney, Village	$8,989,887	$179,798
Binghamton, City	$3,507,661	$175,383	Owego, Village	$8,213,396	$164,268
Unadilla, Town	$2,669,884	$133,494	Binghamton, City	$5,814,413	$116,288
Owego, Town	$2,375,412	$118,771	Chenango, Town	$5,543,409	$110,868
Unadilla, Village	$2,360,852	$118,043	Unadilla, Village	$4,757,384	$95,148
Nichols, Town	$2,274,308	$113,715	Kirkwood, Town	$4,659,658	$93,193
Kirkwood, Town	$2,190,026	$109,501	Afton, Town	$4,613,246	$92,265
Barker, Town	$2,048,174	$102,409	Unadilla, Town	$3,494,145	$69,883
Colesville, Town	$1,887,333	$94,367	Dickinson, Town	$3,334,346	$66,687
Union, Town	$1,736,086	$86,804	Nichols, Town	$2,791,981	$55,840

The flood damage risk for the 1 percent chance flood is illustrated in Figures 10 and 11 and for the 0.2 percent chance flood in Figures 12 and 13. This analysis includes a majority of the study area, excluding parts the watershed with no available flood hazard data. In areas without CWMS modeling, the National Flood Hazard Layers (NFHL) were used and values were extrapolated based on the mean damage proportion for each flood event, organized by structure type.

The 1 percent chance flood risk is concentrated in areas with and without existing FRM infrastructure. Specifically, flood risk is concentrated in the City of Binghamton, portions of Endicott and Johnson City, and areas of Vestal (Town) without FRM structures, the City of Cortland, City of Norwich, City of Oneonta, and the Villages of Owego and Sidney. Generally, communities highlighted in the 5 percent and 2 percent chance flood risk analysis are not categorized as higher risk areas in the 1 percent chance flood risk analysis. This is a result of the magnitudes of difference in damage estimates between the higher frequency events (5 percent and 2 percent floods) and lower frequency, higher magnitude events (1 percent and 0.2 percent floods), particularly in heavily developed communities flooded more infrequently via overtopping of existing FRM projects.

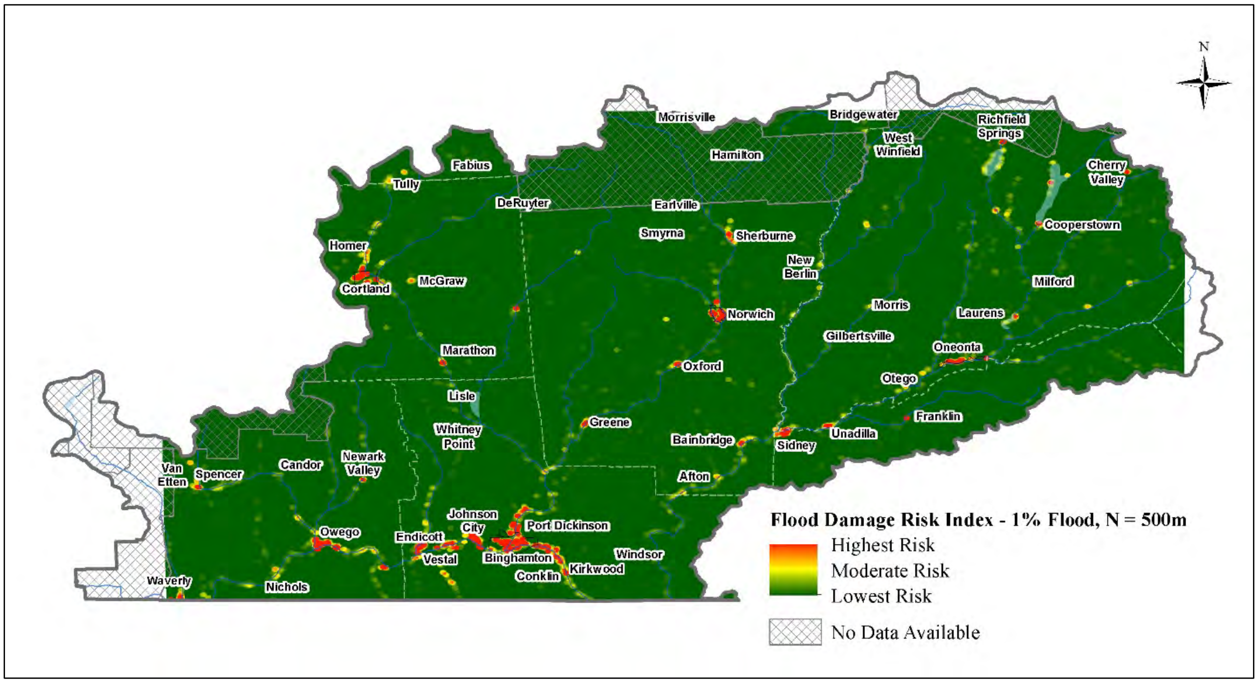

Figure 10: 1% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 500 meters

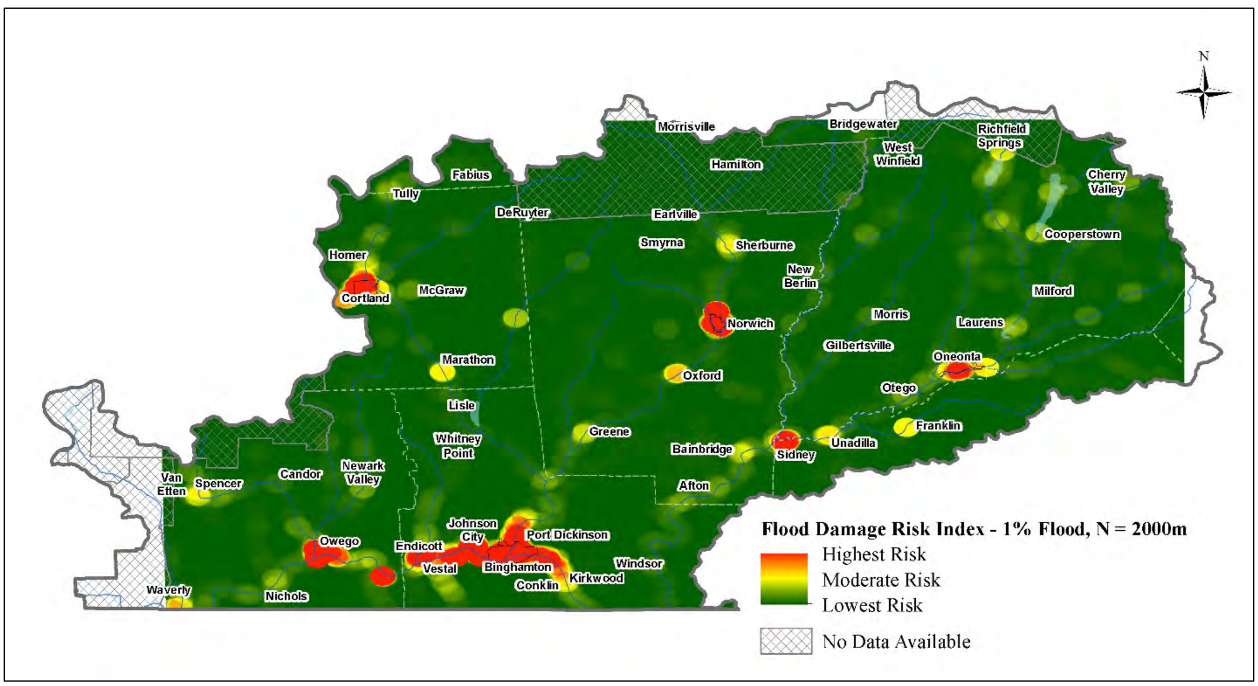

Figure 11: 1% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 2,000 meters

The 0.2 percent chance flood risk, like the 1 percent flood risk, is similarly concentrated in the City of Binghamton, portions of Endicott and Johnson City, and areas of Vestal (Town) without FRM structures, the City of Cortland, City of Norwich, City of Oneonta, and the Villages of Owego and Sidney.

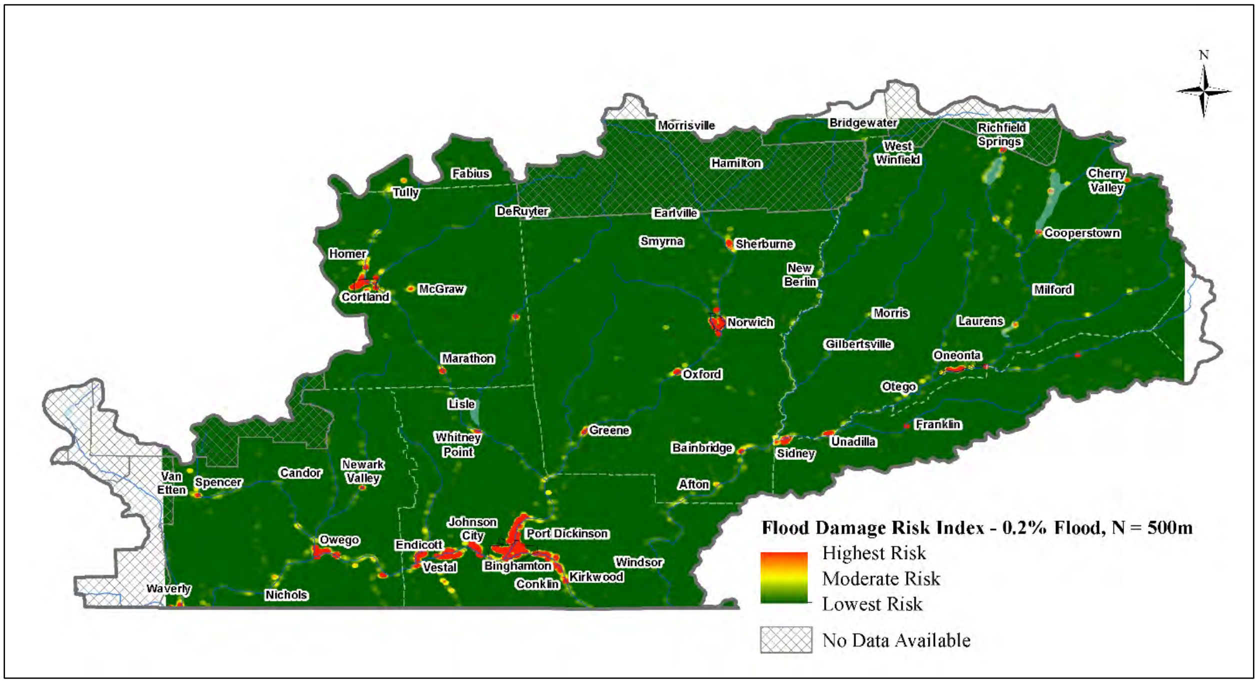

Figure 12: 0.2% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 500 meters

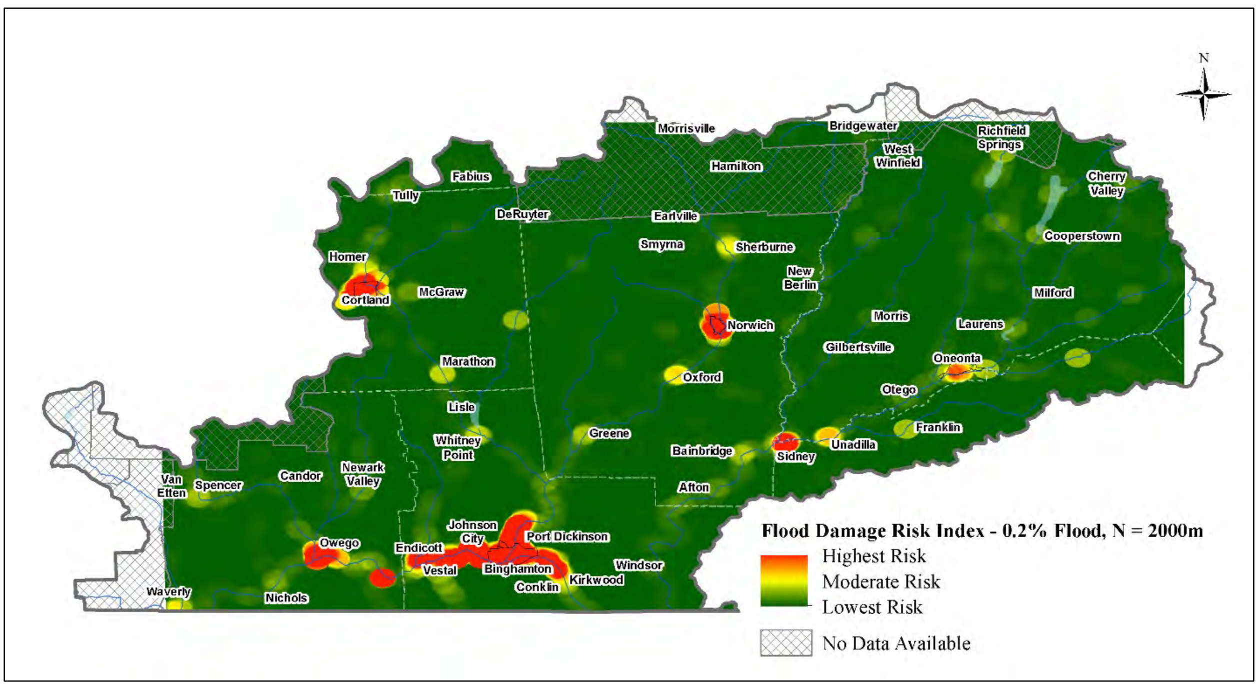

Figure 13: 0.2% Chance Flood Risk to Structures in the USRB, Neighborhood Scale of 2,000 meters

These flood risk maps for the 1 percent and 0.2 percent chance flood were validated using spreadsheets of the combined damage estimates for the entire USRB with available data. The top 10 percentile of flood risk jurisdictions were examined, shown in Table 11. The City of Binghamton has by far the highest concentration of flood risk of any communities in the watershed. The developed areas in the floodplain in Vestal (Town), Union (Town), Owego (Village and Town), Cortland, Sidney (Village), Norwich (City and Town), Johnson City (Village), Chenango (Town), Conklin (Town), Kirkwood (Town), Port Dickinson (Village), and Oneonta (City and Town) have notable concentrations of flood risk for the 1 percent and 0.2 percent chance flood events.

Table 11: Total Damage Estimates and Annualized Loss Expectancy for the 1% and 0.2% Chance Flood in the USRB

Municipality	Estimated Total Damages 1% Flood	Annualized Loss Expectancy 1% Flood	Municipality	Estimated Total Damages 0.2% Flood	Annualized Loss Expectancy 0.2% Flood
Binghamton, City	$168,635,622	$1,686,356	Binghamton, City	$343,715,579	$687,431
Vestal, Town	$108,964,900	$1,089,649	Vestal, Town	$175,090,060	$350,180
Union, Town	$75,495,432	$754,954	Union, Town	$110,445,469	$220,891
Owego, Village	$65,571,647	$655,716	Owego, Village	$97,778,530	$195,557
Norwich, City	$41,180,656	$411,807	Chenango, Town	$72,264,476	$144,529
Owego, Town	$40,853,223	$408,532	Norwich, City	$65,317,974	$130,636
Cortland, City	$40,295,173	$402,952	Cortland, City	$63,481,589	$126,963
Conklin, Town	$34,170,555	$341,706	Owego, Town	$60,288,943	$120,578
Sidney, Village	$27,131,762	$271,318	Conklin, Town	$53,920,235	$107,840
Cortlandville, Town	$24,469,693	$244,697	Cortlandville, Town	$44,563,902	$89,128
Oneonta, City	$21,685,516	$216,855	Sidney, Village	$39,343,363	$78,687
Johnson City	$19,207,072	$192,071	Johnson City	$31,432,066	$62,864
Norwich, Town	$18,907,840	$189,078	Norwich, Town	$30,657,779	$61,316
Chenango, Town	$17,395,239	$173,952	Dickinson, Town	$30,018,753	$60,038
Otsego, Town	$13,291,791	$132,918	Kirkwood, Town	$26,018,742	$52,037
Endicott, Village	$12,657,634	$126,576	Oneonta, City	$24,924,970	$49,850
Kirkwood, Town	$12,562,923	$125,629	Port Dickinson	$24,123,465	$48,247
Port Dickinson	$12,239,516	$122,395	Endicott, Village	$20,511,263	$41,023

3.3 CONCLUSIONS

The watershed screening analysis used both sets of analysis to inform final selection of focus risk areas. At the time of the initial analysis, the critical infrastructure analysis and the flood risk damage analysis had been completed for the 1 percent and 0.2 percent chance flood with limited information on the higher frequency storm events. The watershed screening information was used with local knowledge and available plans, reports, and other studies to support selection of 17 focus risk areas for alternative formulation. In the end, the critical infrastructure analysis had limited usefulness with the availability of better data in the form of the flood damage risk analysis, but comparison of both mapping products illustrates concurrence at the 1 percent chance flood for areas where flood risk is concentrated in the USRB. Both analyses illustrate areas with population centers and important economic and infrastructure assets.

Based on the analysis, the PDT selected the following focus risk areas: Binghamton and Port Dickinson (City/Village), Endicott-Johnson City-Vestal (Villages/Town), Union (Town), Chenango (Towns, north of Binghamton), Conklin/Kirkwood (Towns), Owego (Village), Cortland (City), Oneonta (City), Unadilla (Village), Sidney (Village), and Norwich (City). These areas represent the top 10 percent of jurisdictions with the highest flood risk in the watershed. For the 1 percent chance flood, these flood risk areas account for nearly two thirds of all damages in the USRB. Additionally, the Villages of Greene, Bainbridge, and Waverly, which were not highlighted in the highest risk category, were included in the analysis based on information in the initial scoping of the study.

Each focus risk area is affected by different flood risk drivers. At the 5 percent and 2 percent chance frequency flood level, the analysis highlighted relatively high flood risk in unprotected areas throughout the watershed including Conklin/Kirkwood, Bainbridge, Sidney, Unadilla, Owego, and unprotected areas in Binghamton, Vestal, and Chenango (north of Binghamton). At the 1 percent and 0.2 percent chance frequency flood level, the analysis indicated high relative flood risk in both protected and unprotected areas. The areas most affected at these flood frequencies include Binghamton, Chenango (north of Binghamton), Dickinson (north of Binghamton), Conklin, Cortland, Norwich, Oneonta, Owego, Sidney, and Vestal.

CHAPTER 4 HYDROLOGY AND HYDRAULIC MODELING

Hydrologic analysis was performed for the majority of the USRB using the Hydraulic Engineering Center's River Analysis System (HEC-RAS) model. This hydrologic modeling was used to determine the probability and extent of flood inundation in the study area and was the basis for evaluating residual risk and economic damages for communities with flood risk in the USRB. The hydrologic modeling provided information used to quantify risk and to inform the definition of the flooding problem in the study area. This section describes the hydrology and hydraulic modeling (H&H) completed for the USRB study including information on basin hydrology, flooding history, stream flow analysis, collection of survey data, information on the HEC-RAS model and its outputs, and a summary of flood risk information in the seven federally-constructed FRM projects in the USRB.

4.1 SUMMARY OF USRB HYDROLOGY

The USRB drains approximately 4,520 square miles in the south central part of New York State. The drainage area includes Broome, Chenango, Cortland, Otsego and Tioga Counties and parts of Delaware, Madison, Chemung, Schuyler, Tompkins, Onondaga, Oneida, Herkimer and Schoharie Counties. The USRB includes the upper Susquehanna River and numerous tributary streams including Charlotte Creek, Ouleout Creek, Unadilla River, Chenango River, Tioughnioga River, Nanticoke Creek, Owego Creek, and Cayuta Creek (USACE, 2016; SRBC, 2017; NYSDEC, 2017). There are two major lakes in the USRB; Otsego Lake and Canadarago Lake, and two major reservoirs, where flow is controlled by USACE-built dams at Whitney Point Lake and East Sidney Lake.

The upper Susquehanna River originates at the outlet of Otsego Lake in Cooperstown, New York, and extends for approximately 170 miles before merging with the Chemung River near Athens, Pennsylvania. The major tributaries are the Chenango River, extending for 90 miles from Morrisville, New York to Binghamton, New York where it convergences with the Susquehanna River, the Tioughnioga River, a tributary of the Chenango River, Unadilla River and Owego Creek, tributaries of the Susquehanna River. The hydrologic analysis extends the length of the Susquehanna River, the Chenango River up to Norwich, New York, and the Tioughnioga River up to Cortland, New York.

4.2 FLOODING HISTORY

The Susquehanna River flooded 48 times between 1789 and July of 2018. Table 12 below shows the 10 most significant floods (by flow) recorded. A history of storm events and flooding that have impacted the USRB specifically in New York State is included in Appendix B Economics.

Table 12: Top Ten Flood Events in the Susquehanna River

Date	Crest (feet)	Stream flow (cubic feet per second)
March 3, 1902	22.94	449,000
September 27, 1975	23.82	529,000
September 19, 2004	24.40	557,000
March 18, 1865	24.60	573,000
January 20, 1996	25.08	568,000
September 9, 2011	25.17	590,000
May 22, 1894	25.70	613,000
June 2, 1889	26.80	654,000
March 19, 1936	29.23	740,000
June 24, 1972	33.27	1,020,000

Source: Hasco, 2018

4.2.1 RECENT MAJOR FLOOD EVENTS

2006 Flood Event

Between June 26 and June 28, sections of the USRB along the Delaware and Chenango River Basins flooded as a result of a combination of tropical moisture and a stalled cold front (National Weather Service, 2006). The 2006 floods were greater than the 1 percent annual chance flood and in some areas exceeded the 0.2 percent annual chance flood (SRBC, 2007). Twelve counties were declared Federal disaster areas in New York and more than 15,500 residents applied for disaster assistance resulting in $227 million in disaster assistance to individuals and businesses impacted by the floods (Suro, Firda, Szabo, 2009).

Source: National Weather Service

2011 Flood Events

The USRB was affected by heavy flooding again between September 7 and 8, 2011 as a result of remnants of Tropical Storm Lee interacting with a frontal system to the west as well as additional moisture being drawn into New York and Pennsylvania from Hurricane Katia. Rainfall of 6 to 12 inches fell over most of the USRB resulting in extensive flooding and overtopping of FRM projects throughout the basin. The flooding claimed 1 life, injured another, and caused nearly $1 billion in damages (National Weather Service, 2011).

Source: National Weather Service

4.3 PRECEDING HYDROLOGIC ANALYSES

The basis of the HEC-RAS model for the USRB was the CWMS developed for reservoir routing of East Sydney and Whitley Point reservoirs. CWMS is an information management system used by USACE to manage and process hydro-meteorological data to inform decisions on water regulation at Corps managed dams. The CWMS model includes critical components of the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), a program used to simulate hydrologic processes in watersheds, and HEC-RAS, a program used to model riverine flow, sediment transport, and water temperature/water quality (USACE, 2018). USACE completed updates to the USRB CWMS models in 2014, which included modeling approximately 220 miles of stream in the main stem of the Upper Susquehanna River and all tributaries downstream of East Sidney Dam and Whitney Point Dam. Critical components of the CWMS were extracted into HEC-RAS for hydrologic modeling as part of this study effort in 2016.

The HEC-RAS model has been calibrated using historic data from eight stream gages along the Susquehanna River and its tributaries, summarized in Table 13. Eight USGS stream gages currently in operation in the upper reach of the Susquehanna River basin within the area covered by this study were analyzed to determine flow frequency relationships and future trends based on historic records. Seven of the 8 stream gages were used to determine peak flow frequency relationships for 8 frequencies; the 0.2, 0.4, 1.0, 2.0, 4.0, 10, 20, and 50 percent annual chance floods[3]. The short period of record for the Owego Creek stream gage were biased by recent large flow events, which increased uncertainty in the analysis, therefore, the Owego Creek gage data was

[3] The percent annual chance exceedance describes the likelihood that a specific magnitude will be exceeded in a given year considering the full range of possible annual floods (USACE, 2015). A 50 percent annual chance flood (commonly known as the 2-year flood) is a flood that has a 50 percent chance of happening in any given year. These percent annual chance frequencies are associated with the following recurrence intervals; 20 percent (5-year flood); 10 percent (10-year flood), 4 percent (20-year flood), 2 percent (50-year flood), 1 percent (100-year flood), 0.4 percent (250- year flood), 0.2 percent (500-year flood). Recurrence intervals terms do not accurately represent flood risk described in these probabilities.

removed from the analysis to control for bias from this shorter flow history. A comparison of flows using these stream gages is detailed in the Appendix C Engineering.

Table 13: Stream Gages in USRB used for Hydrologic Modeling

USGS Gage Number	USGS Gage Name	Drainage Area (miles squared)	Period of Review (POR, in water years)
01515000	Susquehanna River Near Waverly NY	4773	1936-2015
01513500	Susquehanna River at Owego NY	4216	1936, 1988-1996, 1999-2015
01513831	Susquehanna River at Vestal NY	3941	1935-2016
01503000	Susquehanna River at Conklin NY	2232	1913-2015
01500500	Susquehanna River at Unadilla NY	982	1935, 1936, 1938-2015
01512500	Chenango River Near Chenango Forks NY	1483	1913-2016
01507000	Chenango River at Greene NY	593	1937-2016
01511500	Tioughnioga River at Itaska NY	730	1930-1975, 1977-2015

4.4 HYDROLOGY AND HYDRAULIC MODELING

The HEC-RAS model used for the USRB study expanded the CWMS model to include many other FEMA models to capture the sponsor's extended area of interest, including modeling along the Susquehanna River up to Oneonta, New York, along the Chenango River up to Norwich, New York, and along the Tioughnioga River up to Cortland, New York. In some cases, new HEC-RAS modeling was developed using HEC-GeoRAS where modeling was not available in digital format. The final extent of the HEC-RAS model includes a majority of the upper Susquehanna River, Chenango River, Tioughnioga River, and portions of Cayuta Creek, Nanticoke Creek, Little Choconut Creek, Otselic River, Pierce Creek, Unadilla River, Ouleout Creek, and West Branch Tioughnioga River, shown in Figure 14.

The HEC-RAS modeling outputs include information about water surface elevations in the study area for eight flow frequencies including the 0.2, 0.4, 1.0, 2.0, 4.0, 10, 20, and 50 percent chance flood events. This information is used to quantify flood risk and flooding damages throughout the USRB using economic modeling, detailed in Chapter 5.

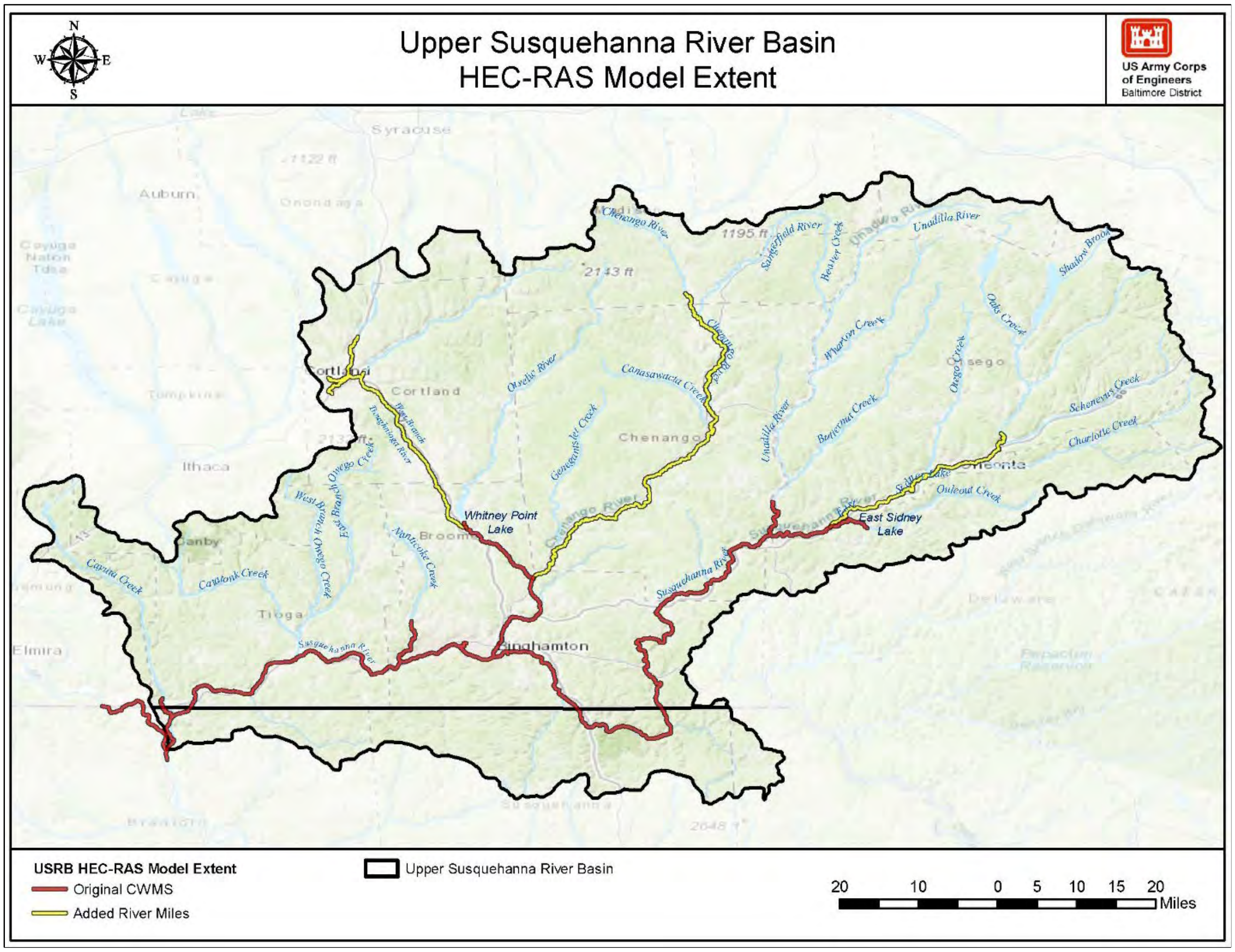

Figure 14: Extent of HEC-RAS Modeling for USRB Study

4.4.1 SURVEY UPDATES

Previous analysis had indicated that low areas that were shown in the National Levee Database's (NLD) levee surveys (completed in 2008), were not observed during field observations. To address these concerns, USACE Philadelphia District surveyed the top of levee elevations for all of the levee systems in the USRB in February and March of 2017. The surveyed top of levee elevations were then compared against the elevations in NLD to identify areas where NLD survey elevations are lower than subsequently observed. The point elevations and profiles generated from this survey were used to update the NLD and for hydrologic modeling. Additionally, new survey information was used to update the NLD where it was deemed appropriate based on a review of the profile comparisons and as-built drawings. Survey profile comparisons and figures are included in Appendix C Engineering.

Bridges and culverts can present a restriction to natural stream flow particularly in areas where legacy infrastructure was built at lower elevations over stream crossings which can constrain the natural flow of the stream. Bridge and culvert data was obtained from the New York Department of Transportation to inform modeling updates. Additional surveys were also conducted at several bridges and culverts in Broome, Chenango, and Cortland Counties to update the HEC-RAS modeling parameters.

4.5 FUTURE CONDITIONS AND CLIMATE CHANGE CONSIDERATIONS

USACE hydrologic analyses must consider the potential impacts of climate change and sea level rise to existing and future hydrologic conditions in accordance with ECB No. 2018-14. ECB No. 2018-14 provides guidance for incorporating climate change information in hydrologic analyses in accordance with the USACE overarching climate change adaption policy. The ECB guidance requires a qualitative analysis for all hydrologic studies to support planning and engineering decisions. The qualitative analysis is intended to identify trends in flows based on past (historical) and future (projected) changes in the existing literature for the study area and the Region. USACE conducted qualitative analysis of historical trends in the literature to determine if changes in streamflows would result from observed climactic and hydrologic trends. This full analysis is detailed in the Appendix C Engineering and summarized below.

Regional trends in precipitation, streamflows, storm frequencies, and sea level rise are detailed in the National Climate Assessment (NCA) for the Mid-Atlantic Region, which includes the USRB. The NCA examines historical records to identify and detect changes in climate trends. The following trends are detailed in the NCA for the Mid-Atlantic Region; increases in the annual temperature in the Mid-Atlantic Region (particularly over the past 40 years), an increase in the number of extreme heat days and a decrease in the number of extreme cold days; increases in precipitation, and an increase in the occurrence of extreme storm events (USACE, 2015). Despite the increased precipitation observed in the Mid-Atlantic Region, evidence is inconclusive of significant increases in base stream flow over the same period. This is potentially attributed to seasonal differences in the timing of the changes in precipitation versus streamflow. Predictions by general circulation models indicate consensus that regional air temperatures will increase sharply upward over the next century. There is less consensus on precipitation and streamflow, although most studies project an increase in both and particularly during extreme storm events. There is moderate consensus that peak flows will increase in the region through the 21st century, although low flows are projected to decrease (USACE, 2015).

Trend analysis of streamflow was completed using the Climate Hydrology Assessment Tool (CHAT) for the Susquehanna River Basin (HUC 0205). The results indicate a statistically significant increase in the average annual maximum monthly peak discharges for the basin. However, an analysis of projected annual maximum monthly stream flows using CHAT indicates a great deal of uncertainty associated with streamflows in the basin. The aggregate scale of this initial watershed analysis is difficult to apply to observed and projected trends in the USRB specifically. Additional analysis was done using stream gages to determine if more definitive evidence on streamflow trends can be ascertain from examining observed and projected trends related to peak stream flow at 13 USGS stream gages in the USRB. Initial analysis was completed using the CHAT to examine peak stream flow at the USGS gages over the available historical record. While several of these stream gages showed an increase in peak flow discharge over time, none of these relationships were statistically significant.

Additional analyses were completed to assess nonstationarity in stream gages in the USRB using the USACE Nonstationarity Detection Tool (NSD) as required by Engineer Technical Letter (ETL) Number 1100-2-3 and ECB 2018-14. Nonstationarities are changes in the statistical properties (mean, variance, etc.) of a variable (ETL 1100-2-3). Nonstationarities in the stream gage record indicate that past conditions may not represent future conditions. No significant trends were detected, however, nonstationarity was observed in several of the USGS gages. An examination of Climate Change Vulnerability was also completed using the USACE Climate Vulnerability Assessment Tool, a screening level watershed assessment tool used to evaluate future risk due to climate change in the future. The Climate Change Vulnerability Assessment Tool indicates that the Susquehanna River Basin (HUC 0205) is not in the top 20th percentile for vulnerability rating, but may still experience changes and increased vulnerability related to climate change.

The interaction between streamflow, precipitation, and temperature illustrates that there is some uncertainty with predicting future stream flows. While precipitation increased during the observed record and may continue to increase in the future, increases in temperature and evapotranspiration may potentially outweigh watershed runoff, which could potentially reduce flood risk. The effects from increases in temperature also have the ability to alter flood risk in the basin. While peak flows appear to increase in the region, particularly as extreme storm events are projected to increase in the future, this has been difficult to quantify based on observed trends. Current evidence does not support any quantifiable increase of streamflows due to climate change in the basin. Since there remains significant uncertainty associated with streamflows in the USRB, the hydrologic modeling has not included changes to future streamflows from existing conditions.

4.6 EVALUATION OF FLOOD RISK MANAGEMENT PROJECTS

The USRB PMP identifies the need to update analyses for the level of FRM provided by existing FRM projects in the USRB. This analysis compares the top of alignment (levee/floodwall) elevations for FRM projects with water surface elevations in HEC-RAS modeling to determine whether flood risk management projects would occur for the modeled 1% and 0.2% annual exceedance chance flood events. The results of this evaluation are presented in Table 14. A positive value indicates that the top of the alignment elevations for the flood risk management project are higher than water surface elevations so no flooding occurs, whereas a negative value represents that water surface elevations are higher by that amount at the lowest point in the flood risk management project.

Table 14: Existing Flood Risk Management Project Status

Flood Risk Management System	Existing Conditions at 0.1 Annual Percent Exceedance Probability	Existing Conditions at 0.2 Annual Percent Exceedance Probability
Binghamton	**Flooded** Range -2.1 ft to +4.2 ft	**Flooded** Range -5.1 ft to 0.7 ft
Endicott	Dry, +4.3 ft	Dry, +0.4 ft
Johnson City	**Dry, not enough freeboard** Range 0.5 ft to 2.8 ft	**Flooded** Range -0.8 ft to -3.1 ft
Vestal	Dry, +3.0 ft	**Flooded**, Range -1.1 to 1.6 ft
Lisle	Dry, +4.7 ft	Dry, +1.6 ft to 7.5 ft
Whitney Point	Dry, +3.3 ft	**Flooded**, -3.6 ft
Nichols	Dry, +4.9 ft	Dry, +2 ft to 9.9 ft

CHAPTER 5 ECONOMIC ANALYSIS

Following a preliminary examination of costs and benefits and feedback by watershed stakeholders, specific urban areas within the USRB were selected as candidates for detailed economic evaluation of FRM alternatives by the PDT. The detailed economic analysis for the USRB study involved examination of economic damages from flooding impacts to residential and nonresidential structures in the watershed using the HEC-FDA tool. FRM alternatives include potential structural and non-structural alternatives in the City of Binghamton, the area of highest concentrated risk, and Endicott-Johnson City-Vestal, which remains at high residual risk of flooding, and non-structural measures in the municipalities of Bainbridge, Cortland, Greene, Norwich, Oneonta, Owego, Sidney, Unadilla, Waverly, Whitney Point, and the Towns of Conklin, Kirkwood, and Union. The preliminary evaluation process is detailed in Chapter 6 and Appendix A Plan Formulation.

The purpose of the USRB study was to evaluate the effectiveness of the existing system of FRM infrastructure and to recommend structural and non-structural solutions for flood damage reduction in the USRB. Additionally, the feasibility study was intended to identify one or more FRM projects that could lead to Federal authorization for construction. A Federal project must be economically justifiable, feasible from an engineering perspective, and whenever possible result in no significant adverse impacts to cultural, historic, social, or environmental resources in the community. A Federal project is considered economically justified if the benefits of the project equal or exceed the costs. The economic benefits of a project are determined by calculating the damages reduced due to the proposed project (i.e. total damages of the existing condition minus the residual damages in the with-project condition). These damages are estimated using HEC-FDA. This chapter details economic modeling procedures and assumptions while results of the economic analyses are presented in Chapter 7 and in Appendix B Economics.

5.1 HYDROLOGIC ENGINEERING CENTER'S FLOOD DAMAGE ANALYSIS (HEC-FDA) TOOL

The USACE flood damage analysis tool, HEC-FDA Version 1.4.2, was used to model all inundation damages. The HEC-FDA analysis incorporated inputs that include: HEC-RAS hydrologic modeling outputs, designated project reaches that breakdown the study area based on similar flooding characteristics, the depreciated replacement costs and content values of structures, and the use of appropriate stage-damage functions.

5.1.1 DELINEATION OF PROJECT REACHES

The study area was divided into three sets of analyses for economic evaluation: Binghamton, Endicott-Johnson City-Vestal (EJV), and a non-structural analysis of other towns in the watershed. Each of these areas was subdivided into economic reaches. The reaches were determined by the presence or absence of existing projects, municipality (to make for an easier review of town or village cost) and are consistent with hydrologic/hydraulic modeling. The USRB reaches are shown in Figure 15.

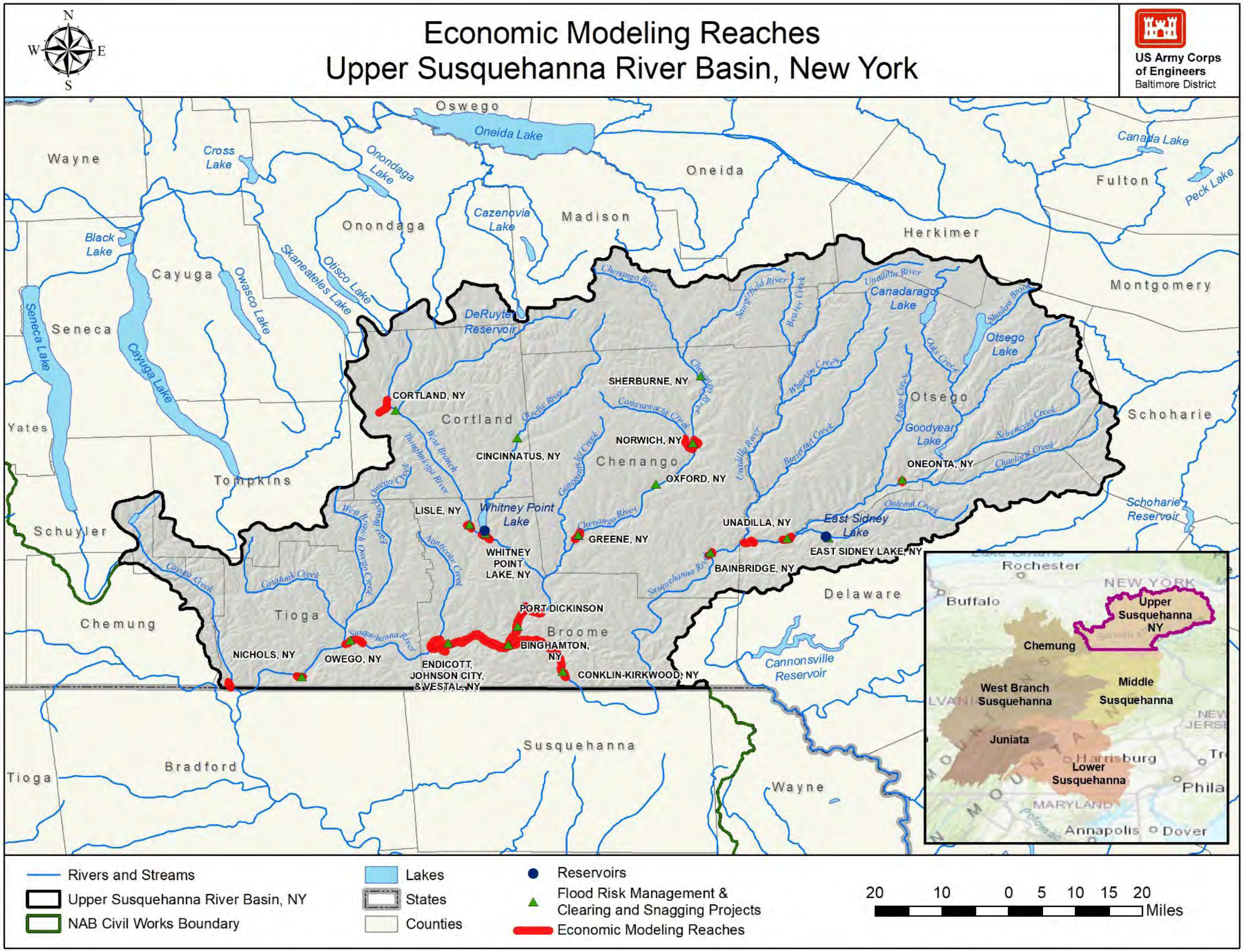

Figure 15: USRB Economic Modeling Project Reaches

5.1.2 DEVELOPMENT OF THE STRUCTURE INVENTORY

Collection of Source Parcel Data

Data for this analysis was collected for 10 counties representing most of the populated areas in the USRB. These counties include Broome, Chemung, Chenango, Cortland, Delaware, Oneida, Onondaga, Otsego, Schoharie, and Tioga. The data used for this analysis includes the 2015 county property appraiser's parcel centroids.

First Floor Elevation

Structures were viewed using Google Earth and Google Street View to estimate the first floor elevation relative to the ground elevation. Due to the large number of structures in the full inventory, assumptions were made for streets and blocks with similar structures following sampling of structures in the study area. During the preliminary nonstructural analysis, general assumptions were made for the first floor elevation starting at 2.5 feet above ground elevation for residential structures and at 0 feet above ground elevation for nonresidential structures.

Depreciated Replacement

The depreciated replacement cost is the cost to replace the existing structure according to structure type, condition, and age. County parcel data provided a wide number of characteristics for the structures including the number of stories, square footage, building usage, year built, and presence of a basement. This data was used to calculate a depreciated replacement value using *"Square Foot Costs with RSMeans Data 2017"* for the Binghamton and Endicott-Johnson City-Vestal.

Using the averages of the depreciated replacement values determined by RSMeans for Binghamton and EJV, the remaining structures in the USRB study area used a calculation of 0.7 times the market value for residential structures and 0.9 times the market value of nonresidential structures.

Summary of Structure Types and Values

A total of 11,276 structures were evaluated for the structure inventory of which 4,629 are in the Binghamton area, 3,518 are in the Endicott-Johnson City-Vestal area, and another 3,129 structures were evaluated for a preliminary analysis of non-structural measures in other areas of the watershed. The structure inventory is 79 percent residential.

5.1.3 INUNDATION DAMAGE FUNCTIONS

The computation of annual flood damages in this analysis is based on the application of depth-damage functions to structures and their contents during flood events of different annual chance exceedance probabilities. The depth-damage functions used for this study were the generic depth-damage functions for residential structures developed for use in USACE in 2000 and 2003, and the depth-damage functions for non-residential structures that were developed by USACE specifically for the Passaic River Basin flood damage reduction study during the 1980s. These functions were deemed appropriate for the analysis since they were developed for structurally-similar buildings in New York and New Jersey, which are anticipated to result in similar flood stage-damage associations.

Damage functions for single-family residential structures (and two- or multi-family structures with similar physical characteristics) without basements were applied in accordance with: *Economic Guidance Memorandum (EGM) 01-03, "Generic Depth-Damage Relationships", December 4, 2000.* Damage functions for single-family residential structures (and two- or multi-family structures with similar physical characteristics) with basements were applied in accordance with: *Economic Guidance Memorandum (EGM) 01-04, "Generic Depth-Damage Relationships for Residential Structures with Basements", October 10, 2003*. Passaic River Basin Damage functions for non-residential structures (plus apartment buildings and large multi-family structures) were applied in accordance with previous experience with similar flood risk reduction projects in northern New Jersey.

Contents of residential structures are valued at 50 percent of the structure value, divided by the number of stories, and is based on insurance industry averages cited in *IWR Report 93-R-7, "Guidelines to Estimating Existing Future Residential Content Values", June 1993*. Nonresidential structure content values are determined using the ratios described in *IWR Report 96-R-12, "Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies", May 1996.* Nonresidential structures are categorized by the type of business or building type and the corresponding content to structure value is utilized in the analysis. The analysis of non-structural measures in other areas of the USRB utilized a simplified method of multiplying the residential structure values by 0.32 to calculate the content value and multiplying the nonresidential structure values by 1.24 to calculate the content value. The ratios were determined by averaging known values in the Binghamton and EJV study areas.

5.1.4 PERIOD OF ANALYSIS

USACE Planning Guidance limits the period of analysis for economic evaluation to 50 years for major civil works projects. This standard period of analysis is used in the USRB study to evaluate existing and future conditions from the base year, 2020, to the end of the period of analysis, 2070.

5.2 EXISTING CONDITIONS

5.2.1 POPULATION TRENDS

The USRB has shown patterns of significant population decline since the 1940's and 1950's, in part resulting from a decline in manufacturing employment in the region. Patterns of population decline continue to this day with the five major counties in the USRB showing consistent decreases in population between 2010 and 2017 and projected decreases through 2030, shown in Table 15. Similarly, a majority of municipalities in the USRB are experiencing similar declines in population, detailed in Appendix B Economics.

Table 15: Total Population, Population Projections, and Percent Change by County

Population						
County	2010	2017	2020	2030	Percent Change 2010-17	Percent Change 2017-30
Broome	200,600	193,639	192,262	186,950	-3.5%	-3.5%
Chenango	50,477	47,863	47,099	44,197	-5.2%	-7.7%
Delaware	47,980	45,001	44,419	42,076	-6.2%	-6.5%
Otsego	62,259	60,094	59,778	59,008	-3.5%	-1.8%
Tioga	51,125	48,578	47,864	45,090	-5.0%	-7.2%

Source: US Census Bureau American Community Survey 2013-2017, 2010 Census, Cornell University (2030) estimates

5.2.2 ECONOMIC TRENDS

The USRB region has experienced significant economic decline as a result of regional and national trends in manufacturing, the historic economic base of the region. These changes have been variously attributed to a shift towards overseas manufacturing for electronic components and decreases in demand for defense and electronics manufacturing, once the region's largest employers, at the end of World War II, and again following the Cold War (City of Binghamton, 2018). The employment base in the USRB has shifted towards a service based industry with significant concentrations in educational, health care and social assistance services, accommodation and food services, professional, scientific and technical services, and retail trade. Employment statistics by county are detailed in Appendix B Economics. Broome County has the largest labor force in the USRB, with 94,186 individuals employed in the County (US Census Bureau, 2013-2017). Binghamton remains the largest city in the USRB. Private sector job growth has increased in the last decade, despite a continued decline in manufacturing employment (City of Binghamton, 2018).

5.3 FUTURE WITHOUT PROJECT CONDITIONS

The future without project conditions serve as the baseline to use as a comparison for evaluation of alternatives. In the absence of a Federal project, homeowners and businesses will continue individual efforts to repair damages after flooding events, using emergency funding or personal resources when available. The future without-project conditions within the period of analysis include continuation of damages to structures and property in the floodplain from future storm events.

No future growth or development in the study area was projected for this analysis, therefore the structure inventory and values were kept the same as those under the existing conditions. With stagnant or declining population in the region, there is likely to be limited additional future development.

Changes in hydrology resulting from climate change are detailed in Chapter 3. Based on the available literature, there remains significant uncertainty about future stream flows and no evidence has been found to support a quantifiable increase to future conditions in hydrologic modeling. For this study, the hydrologic modeling for future conditions and the associated water surface profile used in HEC-FDA modeling will not change from existing conditions. It is assumed that the water surface profiles would remain constant in the future relative to existing conditions and the structure inventory is not anticipated to change during the period of analysis, therefore the existing and future conditions are considered to be the same and annual damages are consistent across years.

CHAPTER 6 PLAN FORMULATION

Alternatives formulation consists of an iterative process of alternative development, evaluation, and deliberation, which can broadly be characterized by two formulation phases and a process to categorize the remaining alternatives based on whether they would be analyzed in Alternative Plans in the feasibility study or provided as programmatic recommendations. This formulation process is shown in Figure 3 in this report. The level of detail was increased in each stage of the analysis to reduce the level of uncertainty with associated decisions.

Alternatives formulation was iterative with a first planning analysis completed in the fall of 2016 and early 2017. This planning analysis was followed by more detailed formulation by USACE and NYSDEC in planning charettes hosted between February and July of 2017. These planning charettes resulted in agreement on screening criteria for evaluating the initial array of alternatives. In these charettes, the PDT also completed screening of measures and formulation of an initial array of alternatives for the 17 flood risk areas identified in the watershed screening. During the screening charettes, environmental acceptability and acceptability of impacts from a social, cultural, and historical perspective were considered together, therefore, they have been included in the same field in screening tables in this section. Additional information on environmental and cultural considerations that were used to support this screening process are described in Annex 1 Environmental Annex, located in Appendix A of this Report. The three criteria for the screening of the initial array of alternatives are described in Table 16.

Alternative plans evaluated in iterations of the planning process described in this report were also informally evaluated by the effectiveness and efficiency criteria defined by the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies (1983; Principles and Guidelines (P&G)). Effectiveness was measured by either assumed or modeled project performance and efficiency was measured by the net benefits produced by an alternative. Completeness was measured by a plan meeting the planning objectives. Acceptability was based on sponsor knowledge, stakeholder input, and PDT experience in the study area and was used implicitly as evaluation criteria. Formal evaluation of alternative plans by P&G Criteria was not conducted because no plans were advanced to a point where this evaluation was practical.

A contextual evaluation of the results of the preliminary analysis was implemented to justify the analysis with narrative support. Alternatives in the initial array that did not meet screening criteria were eliminated from consideration in the focused array of alternatives. At this stage of the analysis, on March 28 2018, a stakeholder meeting was held in Broome County, New York to gather feedback from stakeholders on the initial array of alternatives. This meeting included representatives from Federal and state agencies, non-governmental organizations, and local government representatives. Stakeholders provided statements of support in the forms of letters and forms created by NYSDEC. Local community support was added as a criteria for evaluating the focused array of alternatives based on discussions with the project sponsor since cost-sharing is required for construction of all new FRM projects in New York State.

Table 16: Screening criteria for evaluating the initial array of alternatives

Initial Screening Criteria	Description and Evaluation Considerations
Preliminary Federal interest estimation	The PDT used preliminary analysis to evaluate the potential for Federal interest in proposed project alternatives by comparing the annualized preliminary damage estimates versus the annualized costs of parametric cost estimates. There are two levels of damage reduction that were considered to account for a range of preliminary benefits to be captured in project justification at this stage of the analysis: ♦ Level # 1: Proposed alternative would reduce damages by 50%. The annualized parametric costs were compared with annualized preliminary damages. The alternative would warrant further analysis if the annualized damage reduction exceeded costs at this threshold. This is considered a more conservative estimation level. ♦ Level # 2: Proposed alternative would reduce damaged by 66%. The annualized parametric costs were compared with annualized preliminary damages. The alternative would warrant further analysis if the annualized damage reduction exceeded costs at this threshold. This level is considered more generous since more of these damage reduction benefits could be used to initially justify a project alternative.
Feasible from an engineering perspective	The PDT examined the physical environment of the project area and flood inundation mapping to determine if proposed alternatives are likely to be feasible from an engineering perspective, given the available information. An important consideration related to the potential of proposed alternatives for reducing water surface elevations and modeled damages. The engineering team provides an overall assessment of the feasibility of the proposed array of alternatives based on the risk reduction potential and best professional judgment about the feasibility of proposed designs from an interdisciplinary perspective.
Acceptability of impacts from an environmental, social, cultural, and historical perspective	The PDT examined whether the impacts of the proposed alternatives were acceptable from an environmental perspective. This analysis was completed using various tools to identify potential impacts of FRM measures to natural resources and the environment in all flood risk areas. The PDT looked at impacts to wetlands, threatened and endangered species, regionally rare habitats, hazardous, toxic, and radioactive wastes (HTRW) sites, and prime farmlands. Consideration was also given to evaluations conducted by the USFWS in the Final Planning Aid Report. Additional information on environmental and cultural considerations are detailed in Annex 1 Environmental Annex, located in Appendix A. The PDT also examined whether the impacts of the proposed alternatives were acceptable from a social, cultural, and historical perspective. Two primary considerations were used for evaluating social/cultural acceptability; (1) impacts to cultural and historical resources of proposed alternatives, and (2) impacts to socially vulnerable populations, examined using the Social Vulnerability Index.

During the study alternatives were formulated for 17 flood risk areas initially identified in the watershed screening, detailed in Chapter 3. These flood risk areas include all areas covered by the initial study scope developed by USACE and NYSDEC and areas discussed during scoping meetings in November of 2016, which were also identified as higher flood risk areas in the watershed screening. The flood risk areas are summarized in Table 17. An initial array of alternatives was formulated for each of the 17 flood risk areas. It is important to note that formulation was aggregated for some risk areas based on the existence of an FRM project, which includes multiple systems and flood risk areas included in the authorized FRM project. This chapter details plan formulation for the full initial array of alternatives along with stakeholder feedback that informed the refinement of alternative plans. The refinement of alternative plans and focused array of alternatives are detailed in Chapter 7.

Table 17: USRB Flood Risk Areas, Total Population and Number of Structures

Risk Area	Total Population in Jurisdiction (2017)	Total Number of Structures in Flood Hazard Areas
Areas with existing flood risk management structures (levees/floodwalls)		
Binghamton (City)	45,179	3808
Port Dickinson (Village)	1,909	491
Union (Town)	54,033	1337
Johnson City (City)	14,508	334
Endicott (Village)	12,828	203
Vestal (Town)	28,199	836
Oneonta (City)	14,057	321
Greene (Village)	1,624	329
Areas with channel project, but no levees/floodwalls		
Cortland (City)	18,698	1008
Norwich (City)	6,718	1368
Conklin (Town)	5,215	616
Kirkwood (Town)	5,600	175
Owego (Village)	3,805	1559
Bainbridge (Village)	1,345	247
Unadilla (Village)	1,031	469
Areas with no flood risk management projects		
Sidney	4,160	712
Chenango	10,733	717
Waverly	4,259	161

6.1 SUMMARY OF FORMULATION FOR THE INITIAL ARRAY OF ALTERNATIVES FOR FOCUS RISK AREAS

Formulation of the initial array of alternatives was completed in planning charettes in June and July of 2017. The PDT identified measures that would be appropriate for flood risk reduction in each flood risk area including considering structural and non-structural measures. Each measure that was identified as appropriate for the flood risk area was included in the initial array of alternatives. Initial alternatives were then screened using the preliminary damages analysis data from the watershed screening and using environmental, social, and engineering information. This section presents a summary of the screening for the initial array of alternatives. Results were documented in spreadsheets presented here while detailed narratives are included in Appendix A Plan Formulation.

6.1.1 THE CITY OF BINGHAMTON AND VILLAGE OF PORT DICKINSON

Preliminary analysis for Binghamton yielded one alternative that met all screening criteria with potential for Federal interest; Alternative 2, which included raising all existing levees and floodwalls in the Binghamton system shown in Figure 16. Details of this analysis are included in Chapter 4.1 of Appendix A Plan Formulation. At this preliminary stage, the cost range for this alternative were approximated at $21-26 million in 2018 dollars. This project required more detailed analysis based on the types of existing floodwalls present at the various segments of the system. An important concern is that many of the walls may be I-walls that would need to be replaced to allow for additional raising, which may result in higher costs than anticipated in the preliminary analysis. The environmental impacts of this alternative were expected to be low as a result of the existing levee and floodwall projects at the same locations in Binghamton. Social impacts may result from possible real estate acquisitions, visual and recreational impacts from reduced visibility to the riverfront, and construction impacts to cultural and historical resources in downtown Binghamton. Environmental, social, and cultural impacts from construction and changes to the surrounding area would need to be examined as part of the environmental compliance process.

Other alternatives have been screened out from further investigation for a variety of reasons. The screening of the initial array of alternatives for Binghamton and Port Dickinson is summarized in Table 18. Alternatives 2.1 through 2.4 proposed independent raising of Binghamton levee segments, which are likely to result in induced flooding impacts in other parts of the hydraulic-linked project. Alternative 3, which proposed raising of all existing levees and replacement of all existing floodwalls, is unlikely to yield sufficient damage reduction benefits to justify its costs due to the high cost of floodwall replacement. However, more detailed analysis may result in a proposed alternative (based on Alternative 2) recommending that some floodwalls be replaced and other floodwalls be raised, resulting in a more manageable project costs. Finally, channel projects were considered as part of this preliminary analysis. A new clearing, snagging, and shoal removal project (Alternative 4) along the Susquehanna and/or Chenango River is unlikely to yield sufficient damage reduction benefits and is likely to be more costly than originally estimated because operation and maintenance costs have not been included. Therefore Alternative 4 was removed from further consideration for risk reduction in this area. Alternative 5, which examined channel dredging for the Chenango and Susquehanna Rivers, is unlikely to yield sufficient damage reduction benefits to justify project costs and it would likely result in very high environmental impacts to ecological resources. Non-structural measures were not examined in detail during the evaluation of the initial array of alternatives, but the PDT evaluated non-structural measures for the focus risk area during the analysis of the focused array of alternatives detailed in Chapter 7.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Binghamton. In summary, the following alternatives were carried forward for further consideration in the focused array of alternatives;

- **Binghamton Alternative 2** - raising all floodwalls and levees, with potential for floodwall replacement as needed
- **Binghamton Alternative 6** – non-structural measures in Binghamton

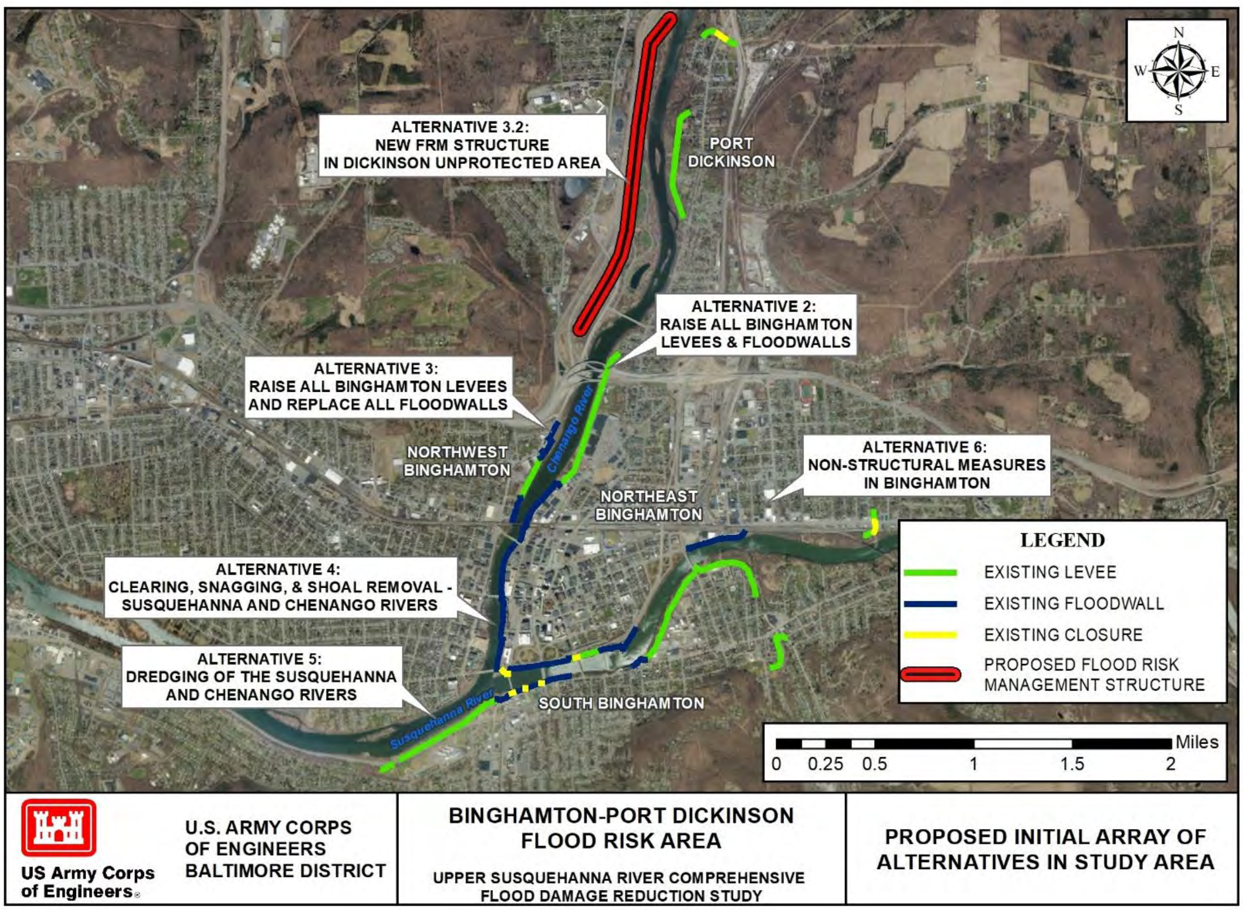

Figure 16: Binghamton Flood Risk Area Initial Array of Alternatives

Table 18: Initial Array of Alternatives for Binghamton/Port Dickinson Flood Risk Area

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: BINGHAMTON AND PORT DICKINSON	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Raise all levees and floodwalls in the Binghamton levee system	Potential	Feasible	Low Impacts Likely; Acceptable	$21 - $26	Yes
Alternative 2.1: Raise Northeast Binghamton levee segment along the left bank of the Chenango River	Potential	Likely Not Feasible	Low Impacts Likely; Acceptable	$8 - $10	No
Alternative 2.2: Raise Northwest Binghamton levee segment along the right bank of the Chenango River	Potential	Likely Not Feasible	Low Impacts Likely; Acceptable	$1.7 - $2	No
Alternative 2.3: Raise South Binghamton levee segment along the left bank of the Susquehanna River	Potential	Likely Not Feasible	Low Impacts Likely; Acceptable	$8.4 - $10.2	No
Alternative 2.4: Raise Northeast Binghamton levee segment along the right bank of the Susquehanna River	Potential	Likely Not Feasible	Low Impacts Likely; Acceptable	$3.0 - $3.7	No
Alternative 3: Raise all levees and rebuild all floodwalls to a higher elevation in the Binghamton System	More Detailed Analysis Required	Feasible	Moderate Impact Likely; More Analysis Needed	$80 - $97	Unknown
Alternative 3.1: Rebuild all floodwalls to a higher elevation in the Binghamton System	No Potential	Feasible	Moderate Impact Likely; More Analysis Needed	$64 - $77	No
Alternative 3.2: New levee segment in Dickinson unprotected area between Dickinson North Boundary and Dickinson Town Court	Potential	More Detailed Analysis Required	Moderate Impact Likely; More Analysis Needed	$4.2 - $5.1	Unknown
Alternative 3.3: New levee segment in Binghamton unprotected area from Front St to Ackley St along the right bank of the Susquehanna River	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$13.5 - $16.3	No
Alternative 3.4: New levee segment in Binghamton unprotected area from Home Avenue to Iva Avenue along the left bank of the Susquehanna River	No Potential	Feasible	Moderate Impact Likely; More Analysis Needed	$5.6 - $6.8	No

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: BINGHAMTON AND PORT DICKINSON	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 3.5: New levee segment in Binghamton unprotected area from Binghamton Eastern Boundary to Northwest Binghamton Levee along the right bank of the Susquehanna River	No Potential	Feasible	Moderate Impact Likely; More Analysis Needed	\$5.6 - \$6.8	No
Alternative 3.6: New levee segment in Binghamton unprotected area from the Binghamton Southeast Boundary to Tributary Stream along the left bank of the Susquehanna River	No Potential	Feasible	Moderate Impact Likely; More Analysis Needed	\$5.6 - \$6.8	No
Alternative 3.7: New levee segment in Binghamton unprotected area from Edgebrook Rd to Service Rd along the right bank of the Susquehanna River	No Potential	Feasible	Moderate Impact Likely; More Analysis Needed	\$13.5 - \$16.3	No
Alternative 4: Clearing, snagging, and shoal removal of Susquehanna and Chenango Rivers in Binghamton	Potential	Maybe Feasible	High Impacts Likely; More Analysis Needed	\$31 - \$38	Yes
Alternative 5: Dredging of Susquehanna and Chenango Rivers in Binghamton	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	\$98 - \$118	No
Alternative 5.1: Dredging of Chenango River in Binghamton only	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	\$50 - \$62	No
Alternative 5.2: Dredging of Susquehanna River in Binghamton only	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	\$47 - \$57	No
Alternative 6: Non-structural measures in Binghamton including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.2 THE TOWN OF UNION AND ENDICOTT-JOHNSON CITY-VESTAL

Preliminary analysis was conducted to evaluate multiple approaches to flood damage reduction in the EJV system. Alternative 2, which includes levee system raising in Endicott and Vestal and Alternative 3, which includes levee system raising in Johnson City, showed some potential, but more detailed analysis of the system hydraulics was needed to determine whether levee raising is necessary throughout the system. As these alternatives would address most of the FRM concerns for this area, these were considered the likeliest feasible alternative for further analysis. At this preliminary stage, the estimated costs for these alternatives were between $38 and $47 million. There are currently no major environmental concerns for these alternatives as FRM systems are already in place at these locations. Environmental impacts are expected to be low. Construction impacts and impacts to real estate would have to be examined if levee raising were proposed as vertical raising would require horizontal extension of systems to high ground tie-ins. Cost estimates are likely to increase if floodwall segments in Endicott are found to be structurally inadequate for raising. Social impacts are expected from real estate acquisitions, visual impacts, and potential construction impacts to cultural and historical resources.

Additional alternatives were considered as part of the alternatives screening process. Alternatives 2.1 to 2.3 proposed segment raising in both the Endicott and Vestal systems, which are likely to result in induced flooding impacts in other parts of the project. Alternative 3.1 and 5.1 proposed a related project that includes levee relocation to the former BAE site (3.1) and a clearing/shoaling removal channel in Little Choconut Creek (5.1), a risk driver for flooding areas adjacent to the existing levee system. The City and local stakeholders currently plan on re-developing the BAE site. Alternative 4 was utilized to estimate the cost of floodwall replacement in Endicott as the aging system floodwalls may need to be replaced if floodwall raising is deemed not feasible from an engineering perspective. Alternative 5 proposed clearing, snagging, and shoal removal for the Susquehanna River to increase stream capacity. This alternative is likely to have high environmental impacts and result in limited damage reduction benefits for catastrophic events (0.01 percent chance exceedance frequency or higher) and is thus considered an unlikely alternative to meet planning objectives. Alternative 6, which proposed channel dredging along the Susquehanna River between Johnson City and Endicott, was removed from further consideration as an alternative due to the magnitude of costs, limited benefits to flood risk reduction, and the high likelihood of significant environmental impact from large-scale river dredging. A preliminary cost estimate for pump stations was also prepared for preliminary analysis in Alternative 7, but no detailed analysis for interior drainage issues, pump capacity/size, pump locations or prospective needs have been examined at this preliminary stage.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for EJV. Additionally, the project sponsor requested that the USACE engineers verify the hydrologic modeling for EJV and re-evaluate the potential for project raising. Therefore, the following alternatives were carried forward for further analysis in the focused array of alternatives;

- **EJV Alternative 2 combined with EJV Alternative 3** - raising all floodwalls and levees in the EJV project
- **EJV Alternative 8** – non-structural measures in EJV and the Town of Union

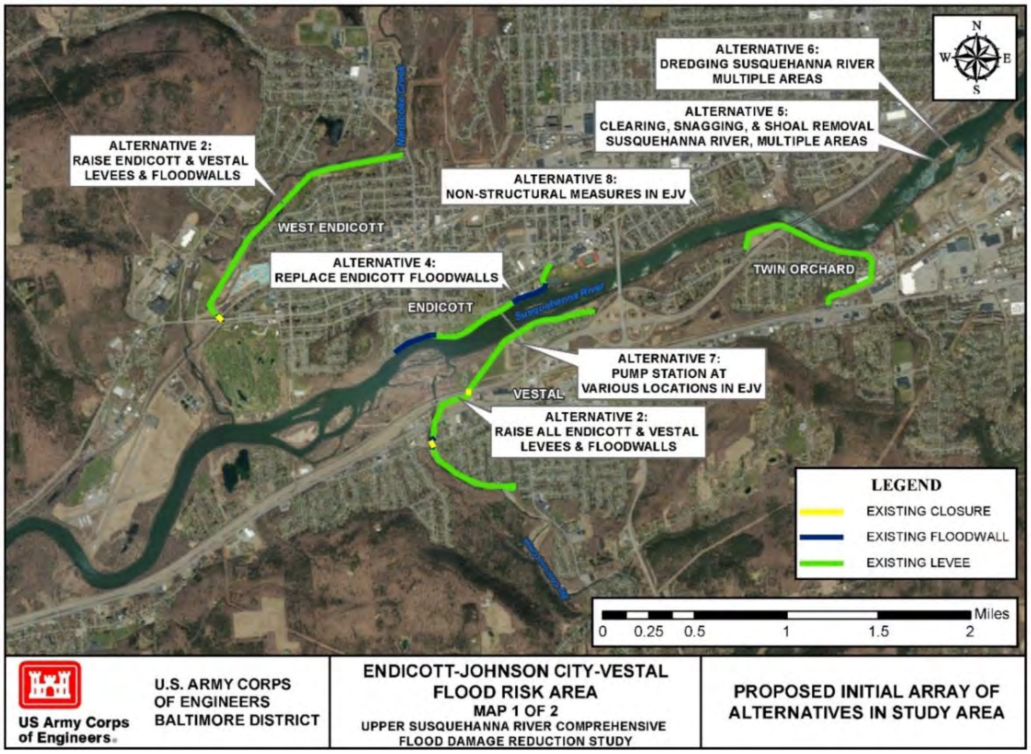

Figure 17: Endicott and Vestal Flood Risk Area Initial Array of Alternatives

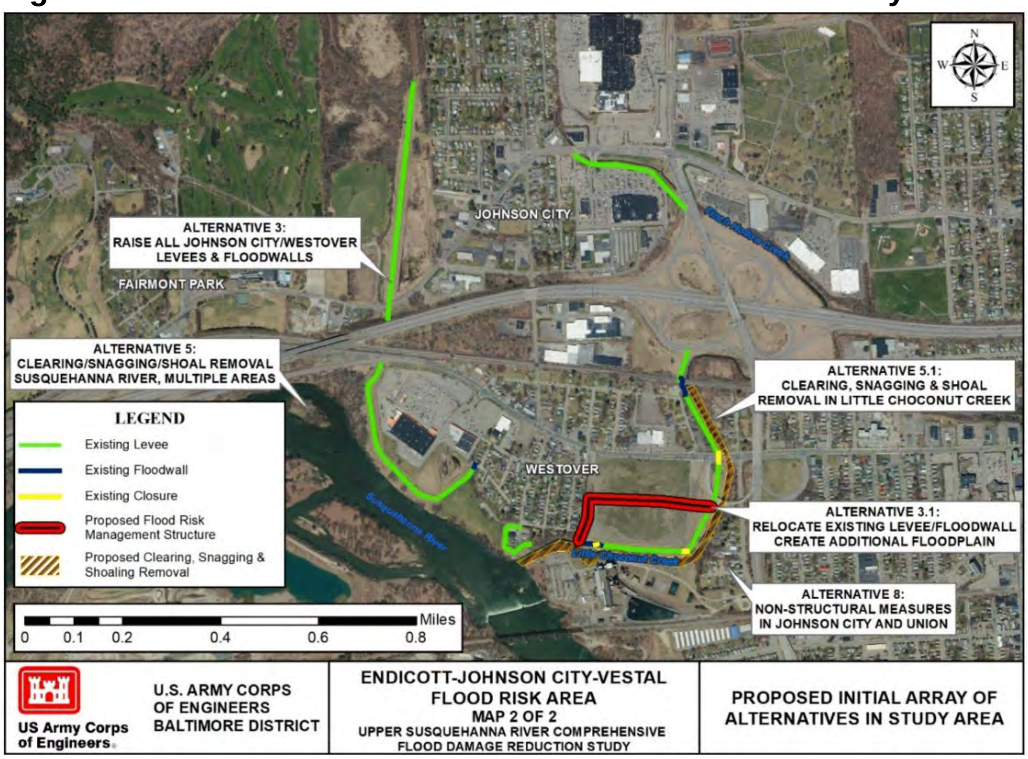

Figure 18: Johnson City Flood Risk Area Initial Array of Alternatives

Table 19: Initial Array of Alternatives for EJV and the Town of Union

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: ENDICOTT JOHNSON CITY VESTAL	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Raise all levees and floodwalls in Endicott and Vestal systems	More Detailed Analysis Required	Feasible	Low Impacts Likely; Acceptable	$29 - $36	Unknown
Alternative 2.1: Raise all levees and floodwalls in the Endicott levee system	More Detailed Analysis Required	Likely Not Feasible	Low Impacts Likely; Acceptable	$11 - 13	Unknown
Alternative 2.2: Raise all levees in the West Vestal levee segment	More Detailed Analysis Required	Likely Not Feasible	Low Impacts Likely; Acceptable	$13 - $16	Unknown
Alternative 2.3: Raise all levees and floodwalls in the East Vestal levee segment	More Detailed Analysis Required	Likely Not Feasible	Low Impacts Likely; Acceptable	$5 - $7	Unknown
Alternative 3: Raise all levees and floodwalls in the Johnson City levee segment	Potential	Feasible	Low Impacts Likely; Acceptable	$9 - $11	Yes
Alternative 3.1: Relocate and replace existing levee segment by former BAE plant site in Johnson City	Potential	Feasible	Low Impacts Likely; Acceptable	$3 - $4	Yes
Alternative 4: Rebuild all existing Endicott system floodwalls to a higher elevation	More Detailed Analysis Required	Feasible	Moderate Impact Likely; More Analysis Needed	$15 - $18	Unknown
Alternative 5: Clearing, snagging, and shoal removal of Susquehanna River between Johnson City and Endicott-Vestal	Potential	Maybe Feasible	High Impacts Likely; More Analysis Needed	$32 - $38	Yes
Alternative 5.1: Clearing, snagging, and shoal removal of Little Choconut Creek (Johnson City)	Potential	Feasible	High Impacts Likely; More Analysis Needed	$1.8 - $2.2	Yes
Alternative 6: Dredging of Susquehanna River between Johnson City and Endicott/Vestal	Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	$93 - $112	No

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: ENDICOTT JOHNSON CITY VESTAL	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 7: Pump Station at various locations in the EJV system	Potential	Feasible	More Detailed Analysis Required	More Detailed Analysis Required	Unknown
Alternative 8: Non-structural measures in Endicott, Johnson City, Vestal, and Town of Union including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.3 THE CITY OF ONEONTA

Initial analysis for Oneonta relied on the use of FEMA flood hazard data due to inadequate hydraulic modeling for preliminary analysis in this area. Based on preliminary analysis, there was potential for a levee project raising (Alternative 2) east of Main Street at the current location of the Mill Race levee. This location was identified as a high flood risk area as a result of the levee overtopping risk at the 1 percent chance flood event indicated by FEMA flood hazard data. Updated modeling completed later in the study indicated that the levee system already manages risk up to the 1 percent change flood event, but other issues were identified with the system, discussed in Chapter 7. Parametric costs were prepared for the alternative using the project length of 1,100 feet, which was estimated at a total cost of between $1.8 and $2.2 million, without including a closure structure or any pump stations if they were deemed necessary for this system. More detailed economic analysis was needed to determine the optimum top of levee elevations for this system. Alternative 2 meets the parameters of a CAP Section 205 project based on the estimated project costs.

This study considered and eliminated other alternatives for preliminary analysis. Alternative 3 was used as a preliminary cost feasibility tool for a pump station at the Mill Race levee location, but more detailed analysis would be needed to determine whether there is a need for a pump station, pump station capacity and costs, and risk reduction benefits of a pump at this location. Alternatives 4 and 5 were used to examine (4) clearing, snagging, and shoal removal and (5) channel dredging along the Susquehanna River. Both of these alternatives are unlikely to yield sufficient damage reduction benefits to justify their cost, given that the previous Federal channel improvements have provided risk reduction at this location. Alternative 6 has been preliminarily examined as a bridge raising for Neahwa Place to provide the needed level of risk reduction at this site. Based on the limited residual risk damages, the costs for a bridge raising are unlikely to be justified at this location, thus levee raising was considered a more likely alternative. Flood risk was also identified from backflow along Interstate 88 culverts in stakeholder discussions.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Oneonta. In summary, the following alternatives were carried forward for further consideration in the focused array of alternatives;

- **Oneonta Alternative 2** - raising of the non-Federal Mill Race levee system
- **Oneonta Alternative 7** – non-structural measures in Oneonta

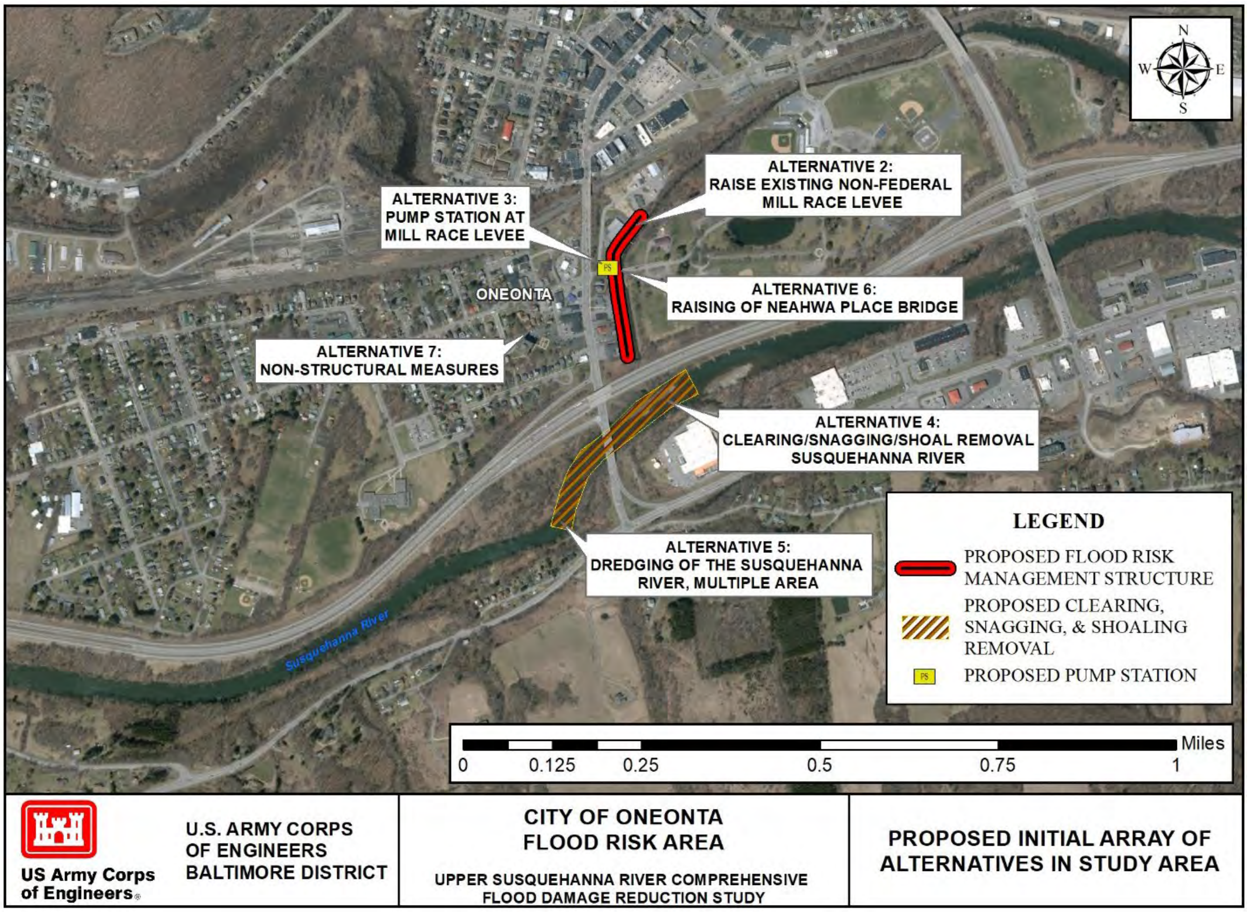

Figure 19: Oneonta Flood Risk Area Initial Array of Alternatives

Table 20: Initial Array of Alternatives for City of Oneonta

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: ONEONTA	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Raise existing non-Federal Mill Race levee at Neahwa Place	Potential	Feasible	Low Impacts Likely; Acceptable	$1.8 - $2.2	Yes
Alternative 3: Pump station at Mill Race levee	More Detailed Analysis Required	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal of Susquehanna River in Oneonta	No Potential	Feasible	High Impacts Likely; More Analysis Needed	$7 - $8	No
Alternative 5: Dredging of Susquehanna River in Oneonta	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	$6 - $8	No
Alternative 6: Raising of Neahwa Place Bridge	No Potential	Not Feasible	Moderate Impact; More Analysis Needed	More Detailed Analysis Required	No
Alternative 7: Non-structural measures for Oneonta including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.4 THE VILLAGE OF GREENE

Initial analysis indicated that flooding is occurring primarily along Birdsall Creek, downstream of the Federal project, and along the banks of the Chenango River. Preliminary analysis for alternatives was completed for the Village of Greene based on residual flooding risk. The proposed alternatives included a new levee along the Chenango River (Alternative 2), clearing/snagging of the Susquehanna River (Alternative 3), a pump station (Alternative 4) – which was examined for cost estimating purposes (i.e. if a levee project is feasible), and non-structural measures (Alternative 5). Preliminary analysis indicated that the proposed alternatives are unlikely to have Federal interest using residual risk damages. A new levee would also have significant environmental impacts and impacts to the floodplain in addition to providing limited risk reduction for the Village. Clearing/snagging would have limited damage reduction benefits and result in significant environmental impacts to stream habitats. Evaluation of non-structural measures (Alternative 5) was included in the analysis of the focused array of alternative in Chapter 7. The area downstream of the Birdsall Creek FRM project was identified as a hotspot for potential non-structural measures. There was also potential for upstream storage areas along Birdsall Creek, northeast of the Village of Greene, where there are open fields and forests.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Greene. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Greene Alternative 5** – non-structural measures in the Village of Greene

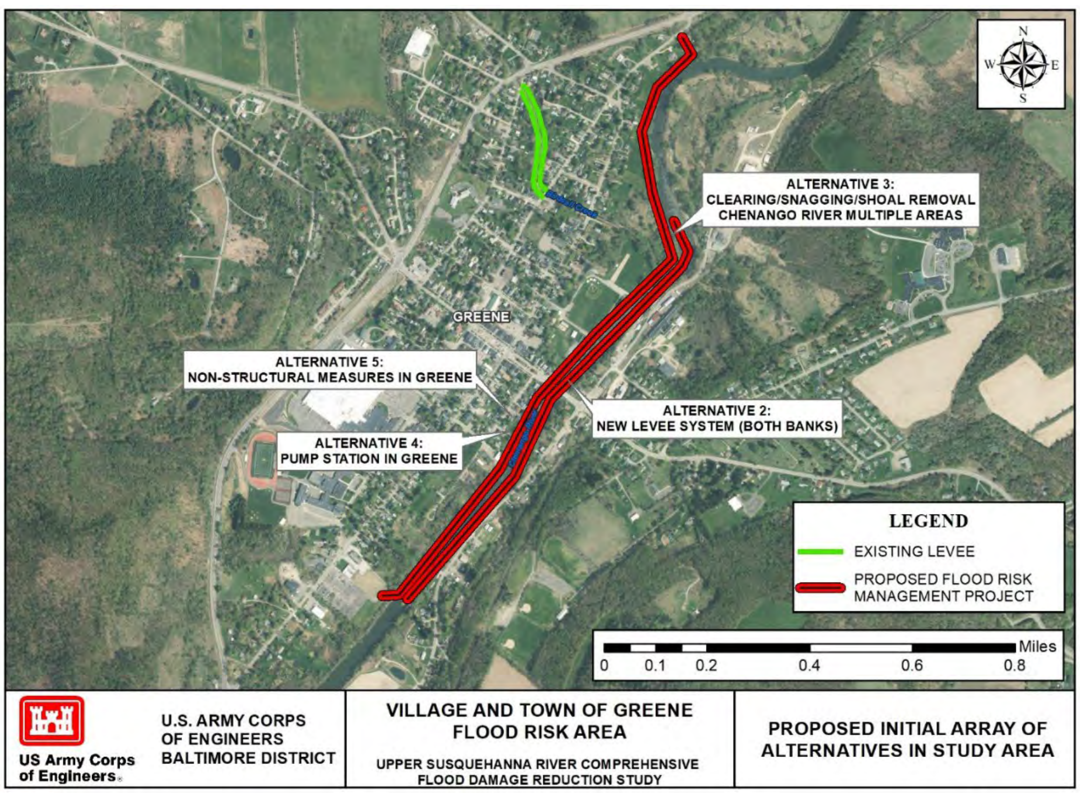

Figure 20: Greene Flood Risk Area Initial Array of Alternatives

Table 21: Initial Array of Alternatives for the Village of Greene

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: GREENE	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Greene along the Chenango River	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$16.5 - $23.9	No
Alternative 2.1: Build a new levee segment in Greene along the Chenango River (left bank)	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$7.7 - $11.3	No
Alternative 2.2: Build a new levee segment in Greene along the Chenango River (right bank)	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$8.7 - $12.6	No
Alternative 3: Clearing, snagging, and shoal removal along Chenango River in Greene	No Potential	Feasible	High Impacts Likely; More Analysis Needed	$11.7 - $17.0	No
Alternative 4: Pump station in Greene	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 5: Non-structural measures in Greene including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.5 THE CITY OF CORTLAND

Formulation for the City of Cortland included consideration of residual flood risk for the 1 percent flood event using FEMA FHA data, including addressing flooding along the banks of the Tioughnioga River and along Dry and Otter Creek. The initial array of alternatives for Cortland are illustrated in Figure 21 and Table 22. Based on the preliminary analysis of residual risk, damages were low and none of the proposed alternatives, where parametric costs were developed, could be justified by damage reduction benefits. While the existing clearing/snagging project on the Tioughnioga River was identified as a risk driver, due to shoaling at various locations, the residual flooding risk from initial modeling did not justify large-scale clearing/snagging removal throughout the channel. Pump stations were not initially evaluated since a levee was deemed not justifiable and no interior drainage issues were identified during formulation. For detailed evaluation, the PDT considered Alternative 6 which proposes non-structural measures as the most appropriate path forward for risk reduction in this flood risk area. Other alternatives were eliminated from consideration based on low damage reduction or deemed unlikely to address identified flooding issues along areas with residual flooding risk including neighborhoods near Dry and Otter Creek, which were outside of the modeling scope. This area is considered a potential area for the evaluation of non-structural measures in subsequent detailed analysis.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Cortland. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

Cortland Alternative 6 – non-structural measures in the City of Cortland

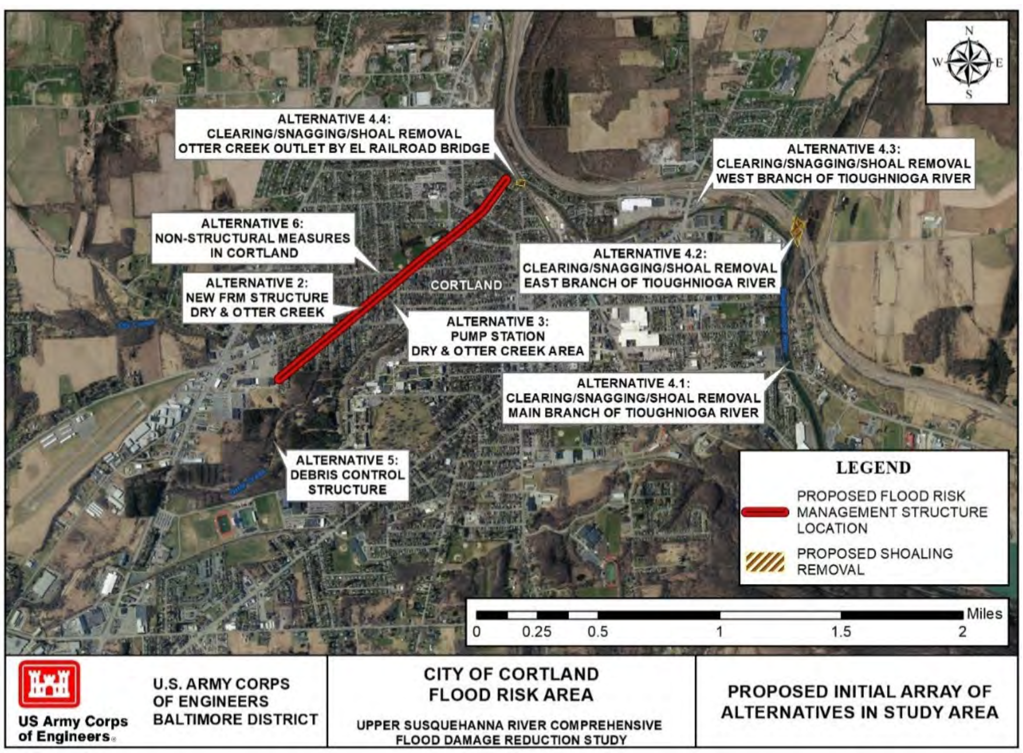

Figure 21: City of Cortland Flood Risk Area Initial Array of Alternatives

Table 22: Initial Array of Alternatives for the City of Cortland

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: CORTLAND	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Cortland along Dry and Otter Creeks	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$13.5 - $19.6	No
Alternative 2.1: Build a new levee segment in Cortland along Dry Creek	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$5.5 - $8.0	No
Alternative 2.2: Build a new levee segment in Cortland along Otter Creek	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$8 - $11.7	No
Alternative 3: Pump station in Cortland at the confluence of Dry and Otter Creeks	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal Federal channel along Tioughnioga River East, West, and Main Branches, Otter Creek Confluence in Cortland	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$10.9 - $15.8	No; Existing Project
Alternative 4.1: Clearing, snagging, and shoal removal Federal channel along Tioughnioga River Main Branch in Cortland	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$6.4 - $9.2	No; Existing Project
Alternative 4.2: Clearing, snagging, and shoal removal Federal channel along Tioughnioga River East Branch in Cortland	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$0.3 - $0.5	No; Existing Project
Alternative 4.3: Clearing, snagging, and shoal removal Federal channel along Tioughnioga River West Branch in Cortland	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$4.1 - $5.9	No; Existing Project
Alternative 4.4: Clearing, snagging, and shoal removal Federal channel at the confluence of Otter Creek and Tioughnioga River in Cortland	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$0.10 - 0.15	No; Existing Project
Alternative 5: Debris removal structure along Dry and Otter Creek in Cortland	N/A	More Detailed Analysis Required	High Impacts Likely; Likely Unacceptable	More Detailed Analysis Required	Unknown

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: CORTLAND	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 6: Non-structural measures in Cortland including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.6 THE CITY OF NORWICH

The City of Norwich experiences overbank flooding from the Chenango River, on the east and south side, and from Canasawacta Creek, on the west side, mainly at infrequent high magnitude events. Formulation was completed using residual flood risk information for the 1 percent annual chance flood event. The initial array of alternatives for Norwich are illustrated in Figure 22 and Table 23. Based on the preliminary analysis of residual risk, no initial alternatives were able to be justified on damage reduction. Alternative 2, which examined construction of a levee system to reduce flooding risk from the Chenango River, was not justifiable and would also result in significant floodplain impacts. Pump stations were not initially evaluated since a levee was deemed not justifiable and no interior drainage issues were identified during formulation. The raising of bridges would reduce flooding resulting from inadequate flow at these locations, but was unlikely to significantly reduce overbank flooding, which is diffuse along three locations in the City, at the 1 percent flood event. While ice jams were identified as an issue along Canasawacta Creek, there was insufficient information available to examine this flooding concern at this time. For detailed analysis, the PDT considered Alternative 7, which proposed non-structural measures as the most appropriate path forward for risk reduction in this flood risk area. Other alternatives were eliminated from consideration because they did not meet all screening criteria or developing additional information was not likely to improve evaluation of the alternative.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Norwich. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Norwich Alternative 7** – non-structural measures in the City of Norwich

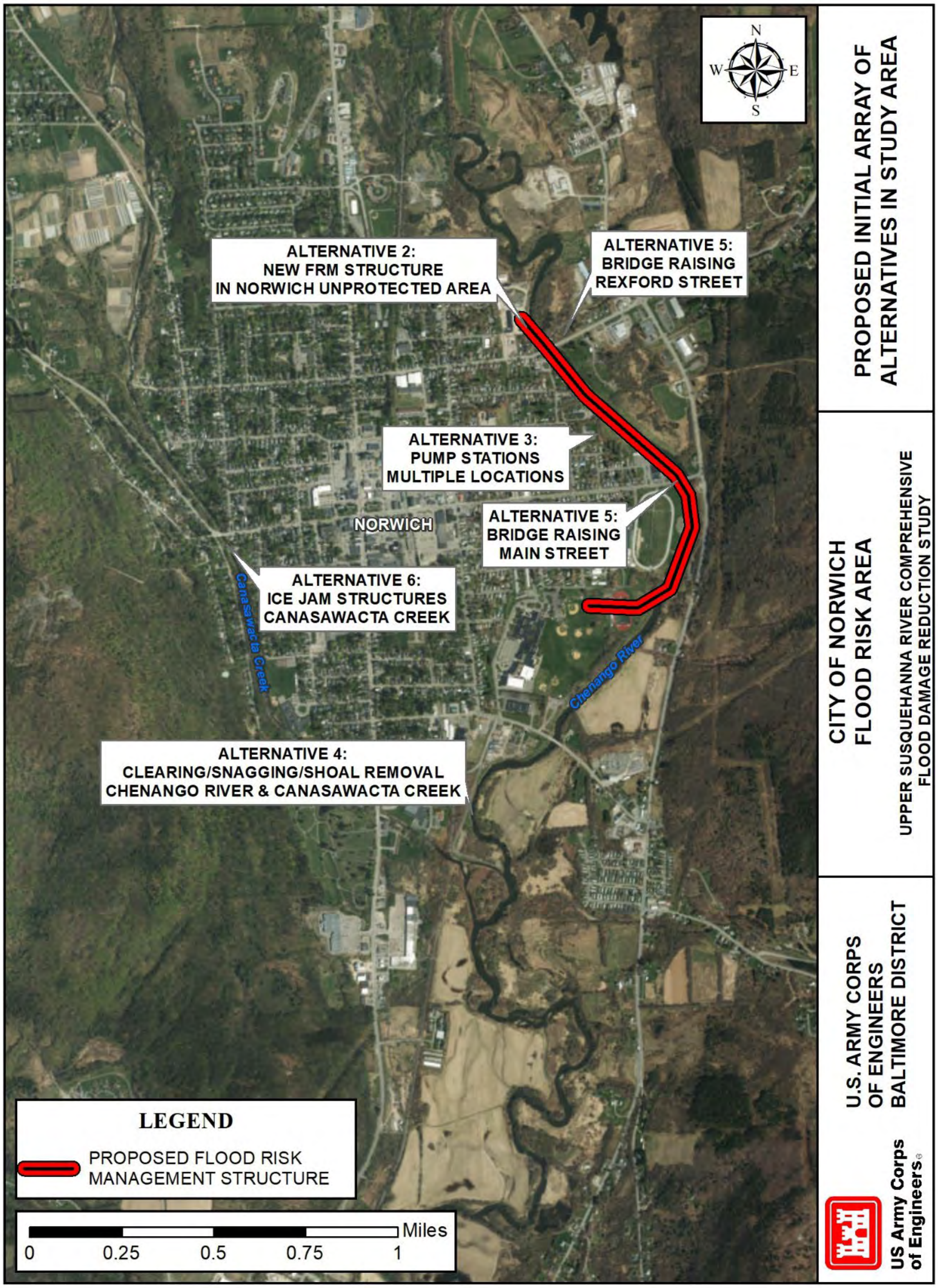

Figure 22: Norwich Flood Risk Area Initial Array of Alternatives

Table 23: Initial Array of Alternatives for the City of Norwich

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: NORWICH	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Norwich from Rexford Street to south of the Fairgrounds along the Chenango River	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$8.2 - $11.9	No
Alternative 3: Pump station in Norwich	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal Federal channel along Chenango River and Canasawacta Creek in Norwich	No Potential	Feasible	High Impacts Likely; More Analysis Needed	$1.7 - $2.5	No; Existing Project
Alternative 5: Bridge Raising for Rexford Street, East Main Street, and Hale Street along the Chenango River in Norwich	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	More Detailed Analysis Required	No
Alternative 6: Ice Jam Structures along Canasawacta Creek in Norwich	N/A	More Detailed Analysis Required	N/A	N/A	Unknown
Alternative 7: Non-structural measures in Norwich including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.7 THE TOWNS OF CONKLIN AND KIRKWOOD

The preliminary analysis indicated that Conklin experiences repeat flooding at high frequency events resulting in high annualized damages for properties near the riverfront. Several project alternatives demonstrated potential for preliminary Federal interest. However, more detailed analysis was required to determine Federal interest, engineering feasibility, and the environmental impacts of conceptual project alternatives. In this analysis, conceptual alignments for FRM structures were used to develop project quantities and costs based on parametric unit costs. Preliminary analysis indicated potential for an FRM project in this area including potential for a new FRM structure (Alternative 2) or an improved channel project (Alternative 3). Any proposed project in this area should also include non-structural measures to leverage existing work in risk reduction from past acquisitions, structure razing, and other non-structural work conducted by Federal, state, and local agencies. Environmental impacts in this area were expected to be high based on the natural floodplain characteristics, wetlands, and prime farmlands in the project area. There is also concern with a superfund site near the project location. Social and cultural impacts are expected from visual changes to the riverfront, construction impacts related to any structural project, and potential impacts to important historic landmarks near project sites. Further analysis of project siting and environmental, cultural, and social impacts is needed.

Conklin is hydraulically linked to downstream levee systems (Binghamton, Endicott-Johnson City-Vestal) therefore any structural projects in this area would require complex hydraulic analysis of possible downstream impacts. Additionally, flooding impacts would have to be examined in Kirkwood, located on the opposite bank of the Susquehanna River, as this area includes significant commercial development in flood risk areas.
.
Additional FRM alternatives were considered in Conklin. Alternative 2.3, a proposed FRM structure alignment in the southern Binghamton area, was unlikely to yield sufficient damage reduction benefits to justify project costs given the limited amount of development affected by flooding in this area. Channel dredging (Alternative 4) would result in limited damage reduction, and it may result in very high environmental impact to ecological resources and therefore was not further investigated.

The PDT combined this preliminary analysis with feedback from local stakeholders (summarized in Table 31) to finalize the screening process for Conklin-Kirkwood. Structural alternatives for Conklin were removed from consideration in the focused array of alternatives due to lack of local support by stakeholders. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Conklin-Kirkwood Alternative 5** – non-structural measures in the Towns of Conklin and Kirkwood

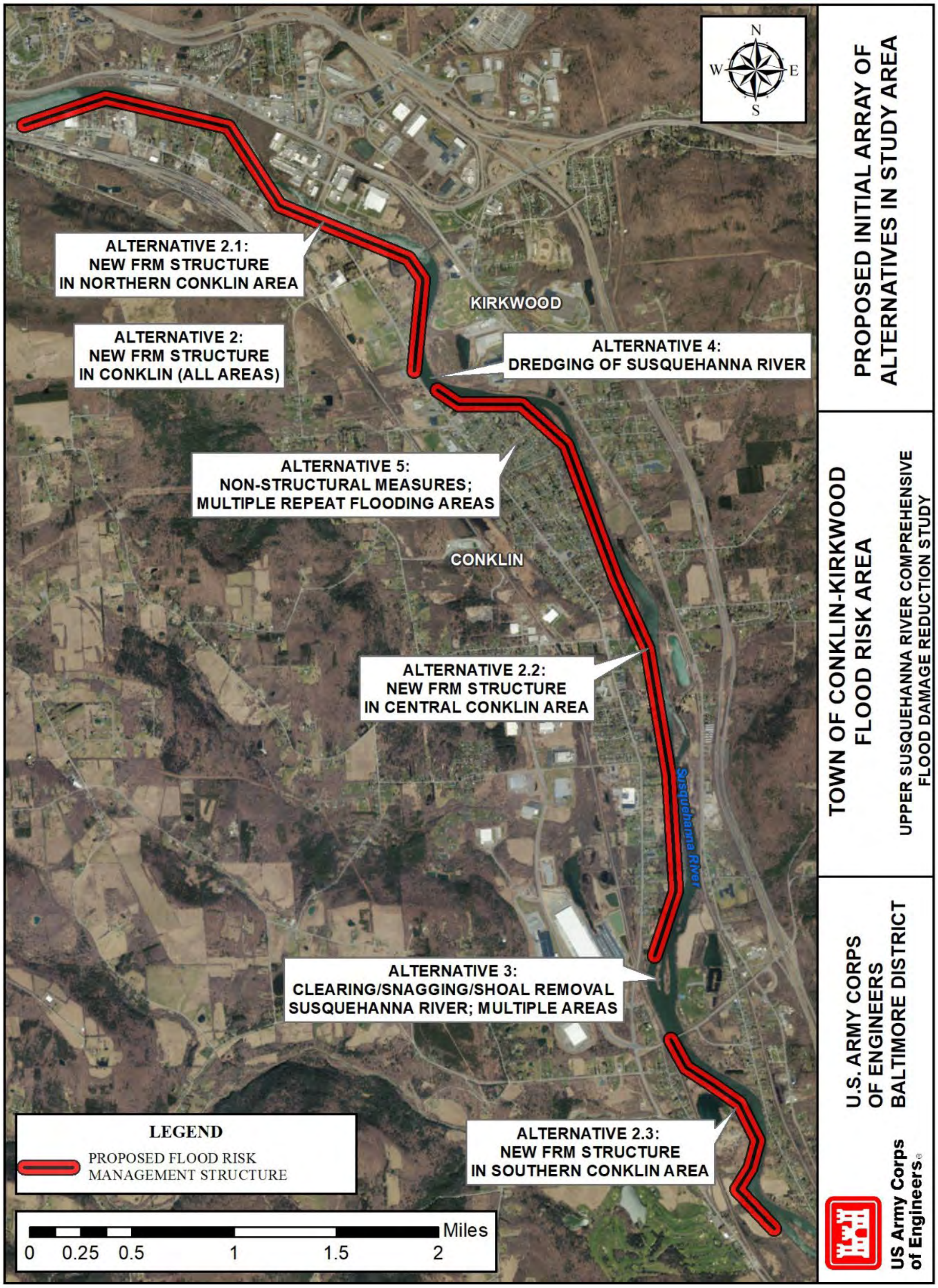

Figure 23: Conklin-Kirkwood Focus Risk Area Initial Array of Alternatives

Table 24: Initial Array of Alternatives for Conklin-Kirkwood

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: CONKLIN KIRKWOOD	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Conklin along all three damage areas	Potential	More Detailed Analysis Required	High Impacts Likely; More Analysis Needed	\$60 - \$72	Unknown
Alternative 2.1: Build new levee in Conklin along the Northern damage area	Potential	More Detailed Analysis Required	High Impacts Likely; More Analysis Needed	\$28 - \$34	Unknown
Alternative 2.2: Build new levee in Conklin along the Central damage area	Potential	More Detailed Analysis Required	High Impacts Likely; More Analysis Needed	\$23 - \$28	Unknown
Alternative 2.3: Build new levee in Conklin along the Southern damage area	No Potential Alone	More Detailed Analysis Required	High Impacts Likely; More Analysis Needed	\$8 - \$10	No
Alternative 3: Clearing, snagging, and shoal removal of Susquehanna River along Conklin-Kirkwood Area	Potential	Feasible	Moderate Impact Likely; More Analysis Needed	\$7 - \$9	Yes; Existing Project
Alternative 4: Dredging of Susquehanna River along Conklin-Kirkwood Area	Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	\$21 - \$26	No
Alternative 5: Non-structural measures in Conklin including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.8 THE VILLAGE OF OWEGO

Preliminary analysis indicated potential for a FRM project in Owego to protect from overbank flooding along Owego Creek and at the confluence of Owego Creek and the Susquehanna River. Alternative 2, modifying the existing non-Federal berm along Owego Creek, and Alternative 3, building a new FRM structure along Downtown Owego and the Brick Pond Park areas both showed some preliminary potential for a project. Both of these alternatives required further detailed analysis to determine the scope and feasibility of an FRM project in this location. Costs for berm modification (Alternative 2) were derived from Owego (village) documents, which evaluated this alternative to cost an estimated $3 million. Costs for Alternative 3 are estimated at $28 - $34 million and are based on a large-scale project estimate. Environmental impacts for Alternatives 2 are expected to be low to moderate as an FRM berm is already existing along Owego Creek. Social and cultural impacts are expected to be high as Alternative 3 would impact the Owego Historic District riverfront. Alternatives 4 explored a clearing, snagging, and shoal removal project along parts of the Susquehanna River and Owego Creek. Alternative 4 also shows some potential for more detailed analysis, however, an existing channel clearing project exists at Owego Creek. Further detailed analysis of all proposed impacts is required for this area.

Other alternatives were considered as part of the alternative screening for Owego. Alternative 3.1 proposed building new floodwalls in all damage areas, which is unlikely to yield sufficient damage reduction benefits to justify project costs based on preliminary analysis of damages in this area. Alternative 5 proposed dredging of the Susquehanna River and Owego Creek and various combinations of these two projects. Preliminary analysis based on environmental impact and cost indicated that channel dredging would result in significant impact to ecological resources with limited benefits to flood reduction and would therefore not be further investigated.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Owego. In summary, the following alternatives were carried forward for further consideration in the focused array of alternatives;

- **Owego Alternative 2 combined with Alternative 3** - raising of existing berm and a new levee system in the Village of Owego
- **Owego Alternative 6** – non-structural measures in the Village of Owego

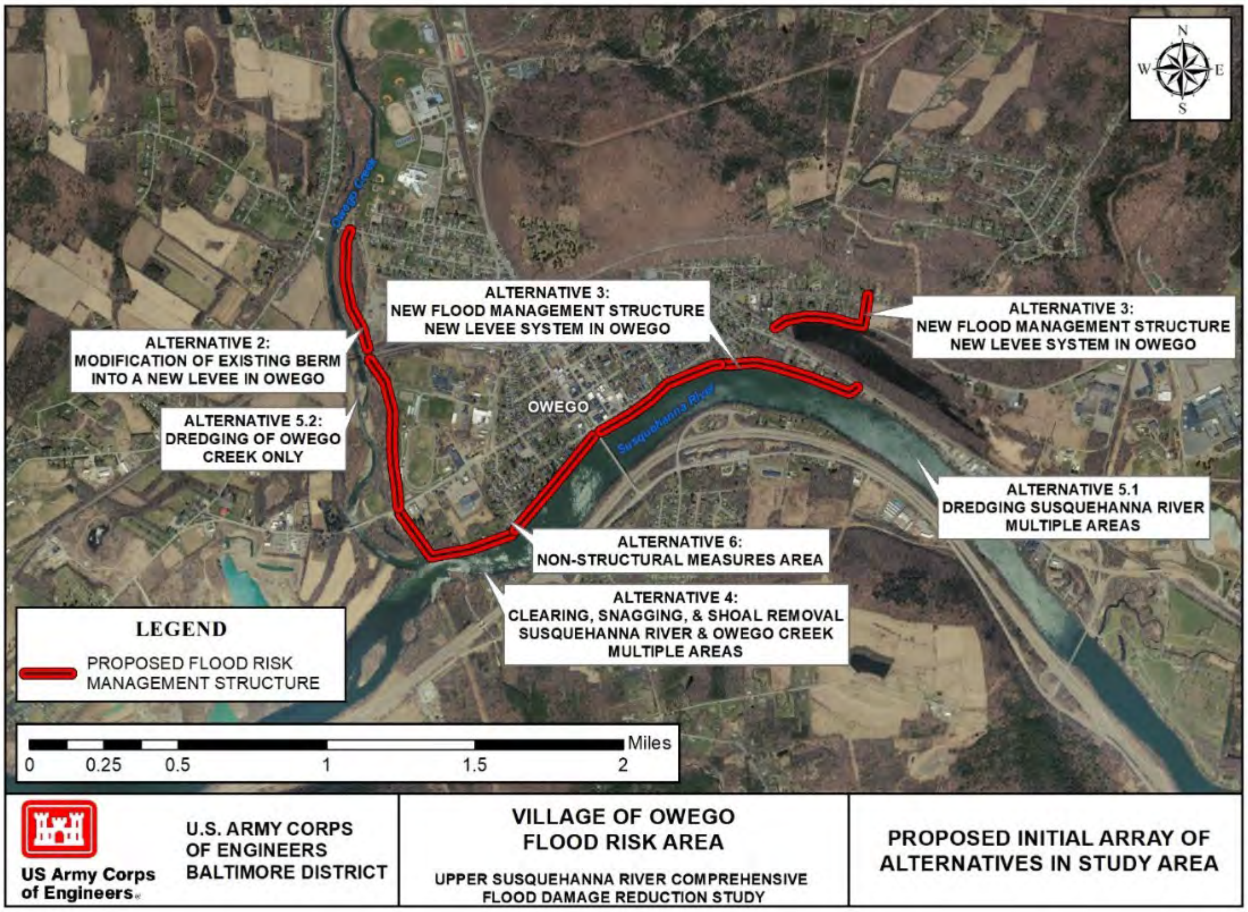

Figure 24: Owego Flood Risk Area Initial Array of Alternatives

Table 25: Initial Array of Alternatives for the Village of Owego

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: OWEGO	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Modification and extension of existing berm along Owego Creek	Potential	Feasible	Low Impacts Likely; Acceptable	$3	Yes
Alternative 3: Build a new levee system in Owego along the Historic District and the Brick Pond area	Potential	Feasible	High Impacts Likely; More Analysis Needed	$28 - $34	Yes
Alternative 3.1: Build new floodwalls in Owego along the Historic District and Brick Pond area	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$57 - $69	No
Alternative 4: Clearing, snagging, and shoal removal of Susquehanna River and Owego Creek	Potential	Likely Not Feasible	High Impacts Likely; More Analysis Needed	$34 - $41	Yes - Existing
Alternative 5: Dredging of Susquehanna River and Owego Creek	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	$70 - $84	No
Alternative 5.1: Dredging of Susquehanna River Only	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	$21 - $26	No
Alternative 5.2: Dredging of Owego Creek Only	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	$48 - $59	No
Alternative 6: Non-structural measures in Owego including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.1.9 THE VILLAGE OF BAINBRIDGE

The Village of Bainbridge experiences overbank flooding along the Susquehanna River and previously experienced flooding along Newton Creek, which has been previously channelized by USACE. USACE used CWMS modeling to develop an initial array of alternatives considering impacts from the 1 percent flood event. The initial array of alternatives for Bainbridge is illustrated in Figure 25 and Table 26. Based on the preliminary analysis of flood risk, annualized damages were low and a new levee project would not be justified. Additionally, the extent of the proposed levee would result in significant environmental impacts with limited damage reduction to a handful of structures spread out along the banks of the Village. While clearing/snagging along the Susquehanna River showed some potential (Alternative 4), the PDT did not include O&M in parametric cost estimates and used a generous consideration for damage reduction (50 percent), so this alternative was not justifiable.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Bainbridge. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Bainbridge Alternative 5** – non-structural measures in the Village of Bainbridge

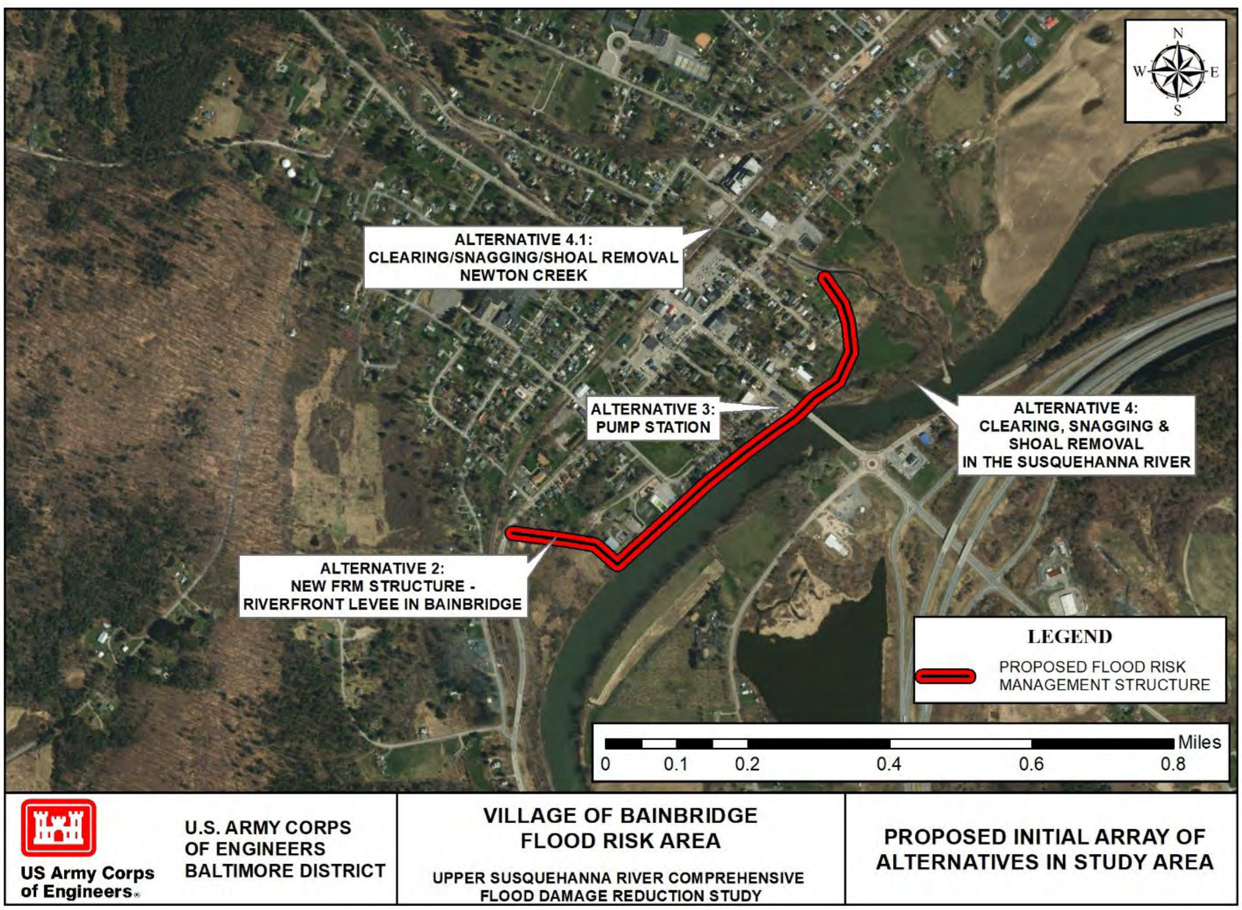

Figure 25: Bainbridge Flood Risk Area Initial Array of Alternatives

Table 26: Initial Array of Alternatives for the Village of Bainbridge

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: BAINBRIDGE	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Bainbridge along the Susquehanna River (right bank)	No Potential	Not Feasible	Moderate Impact Likely; More Analysis Needed	$5.0 - $7.2	No
Alternative 3: Pump station in Bainbridge	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal along Susquehanna River in Bainbridge	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$0.6 - $0.9	No
Alternative 4.1: Clearing, snagging, and shoal removal along Newton Creek in Bainbridge	Potential	Not Feasible	Low Impacts Likely; Acceptable	$0.2 - $0.3	No; Existing Project
Alternative 5: Non-structural measures in Bainbridge including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

.10 THE VILLAGE OF UNADILLA

Preliminary analysis indicated the potential for a FRM project in Unadilla to protect from overbank flooding along the Susquehanna River. Alternative 2.1 proposed a new levee system extending the length of Unadilla along the riverfront. This alternative required more detailed analysis to determine alignment, feasibility, and floodplain impacts. At this preliminary stage, the cost range for this alternative were approximated at $12-14 million in 2018 dollars. The environmental impacts of this alternative were expected to be high based on the natural floodplain characteristics of the area. Other social and cultural impacts would have to be examined as part of the environmental compliance process.

Additional FRM alternatives were considered in Unadilla. Alternative 2 proposed a combination of floodwall and levee along the Unadilla riverfront. Alternative 2 was examined for cost feasibility purposes only. Alternative 3 was similarly used for cost feasibility of a pump station. No detailed analysis of pump location, capacity, or detailed costs have been examined as part of this preliminary analysis. Alternative 4 included clearing, snagging, and shoal removal of the Susquehanna River. This alternative requires more detailed analysis as it has some potential for providing risk reduction benefits in this area. Alternative 5 proposed dredging of the Susquehanna River. Preliminary analysis based on environmental impact and cost indicated that channel dredging would result in significant impact to ecological resources with limited benefits to flood reduction and would therefore not be further investigated.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Unadilla. Structural alternatives for Unadilla were removed from consideration in the focused array of alternatives due to lack of local support by stakeholders. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Unadilla Alternative 6** – non-structural measures in the Village of Unadilla

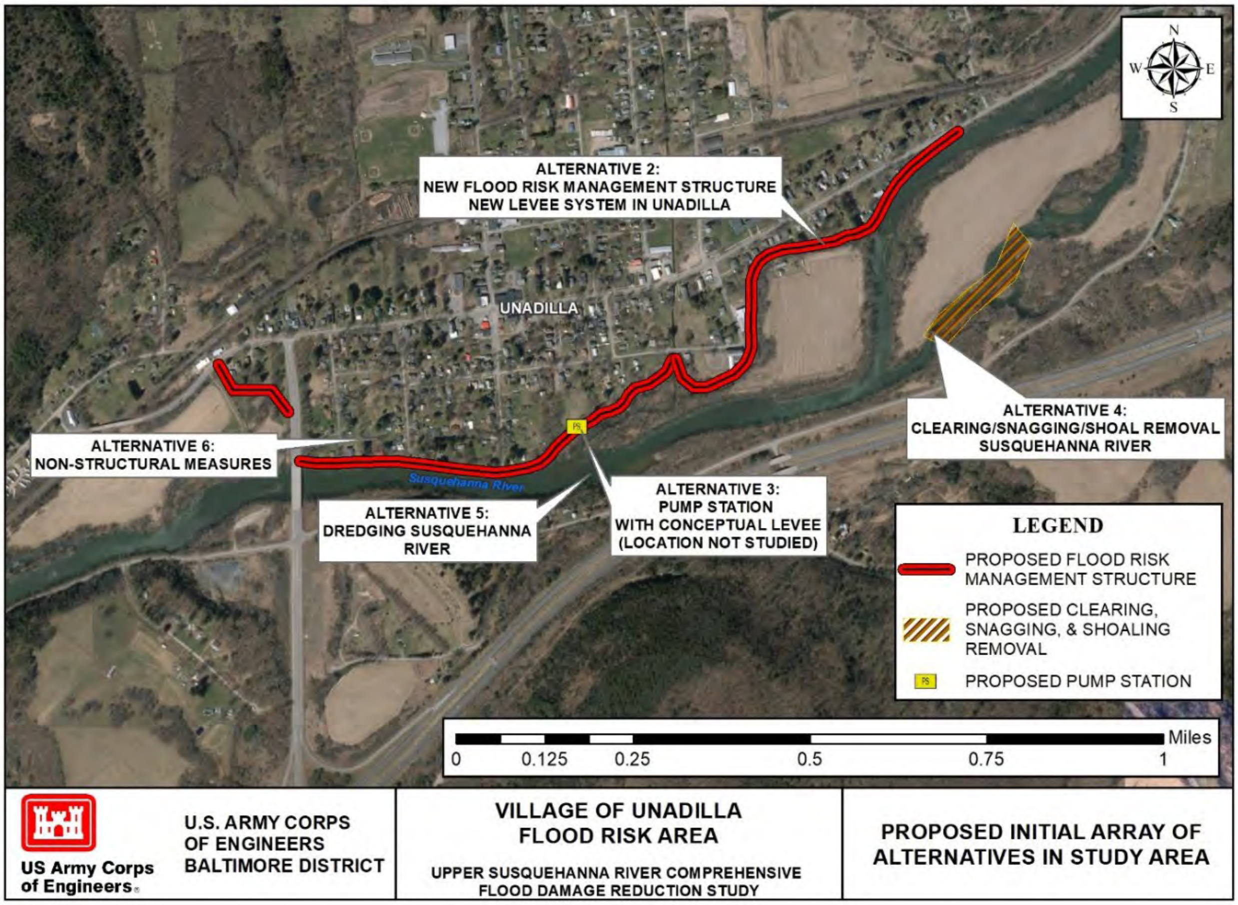

Figure 26: Unadilla Flood Risk Area Initial Array of Alternatives

Table 27: Initial Array of Alternatives for the Village of Unadilla

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: UNADILLA	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	PARAMETRIC COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee and a new floodwall in Unadilla	Potential	More Detailed Analysis Required	High Impacts Likely; More Analysis Needed	$22 - $26	Yes
Alternative 2.1: Build a new levee system in Unadilla	Potential	Feasible	High Impacts Likely; More Analysis Needed	$12 - $14	Yes
Alternative 3: Pump station at conceptual Unadilla levee location	More Detailed Analysis Required	Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal of Susquehanna River upstream and riverfront in Unadilla	Potential	Feasible	High Impacts Likely; More Analysis Needed	$2.5 - $3.1	Yes
Alternative 5: Dredging of Susquehanna River upstream and riverfront near Unadilla	Potential	Likely Not Feasible	High Impacts Likely; Likely Unacceptable	$1.7 - $2.1	No
Alternative 6: Non-structural measures in Unadilla including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

.11 THE VILLAGE OF SIDNEY

USACE completed a previous examination of flood management risk and strategies in Sidney in 2010 (USACE, 2010). In that study, USACE proposed solutions to managing risk in the Village including levee/floodwall solutions, channel improvements, and bridge raising. The PDT used the rough of order of magnitude costs generated from that study and preliminary analysis damages from the watershed screening to screen an initial array of alternatives, presented in Figure 27 and Table 28. Based on the preliminary analysis, none of the structural alternatives appeared to be justified based on damage reduction benefits alone. Non-structural measures are examined in Chapter 7 with the focused array of alternatives.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Sidney. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Sidney Alternative 7** – non-structural measures in the Village of Sidney

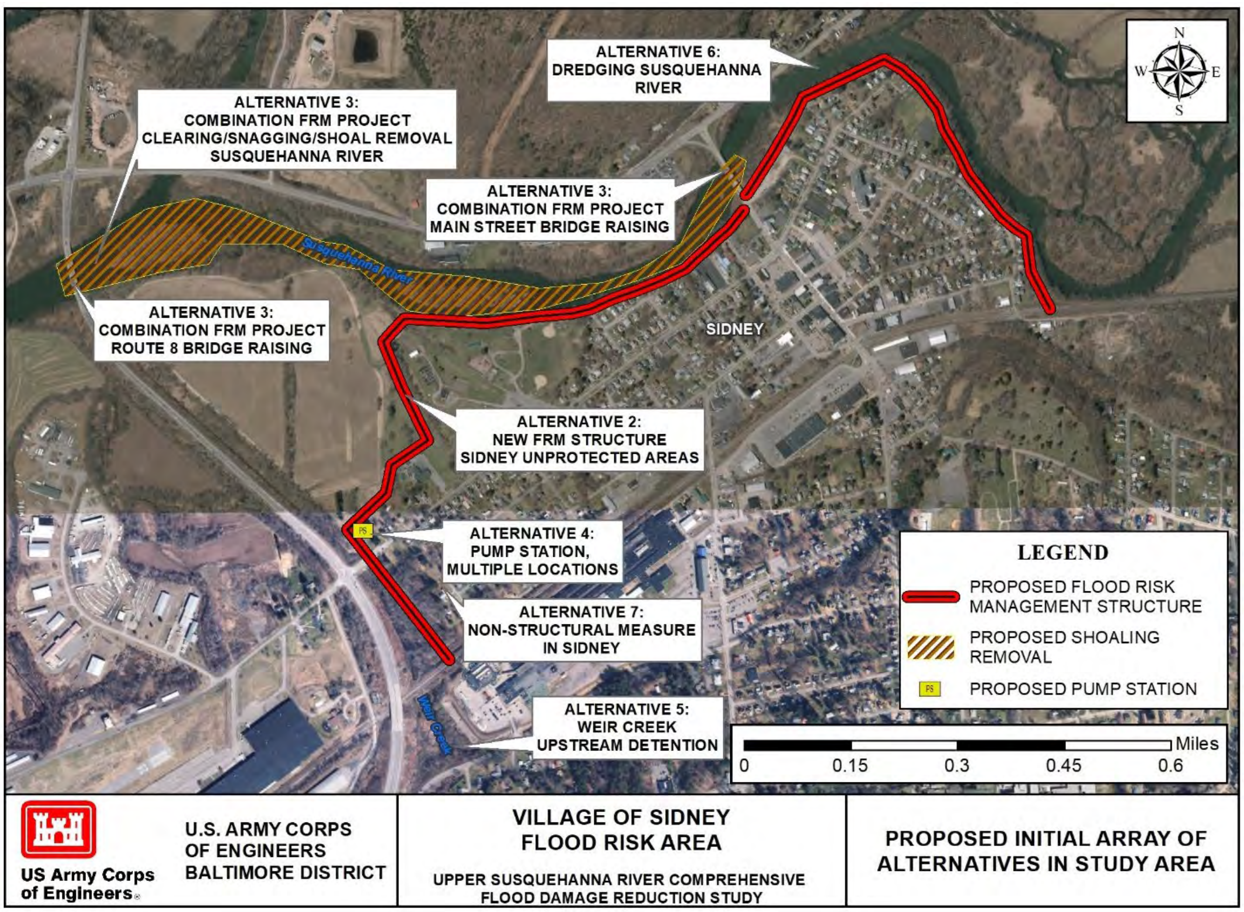

Figure 27: Sidney Flood Risk Area Initial Array of Alternatives

Table 28: Initial Array of Alternatives for the Village of Sidney

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: SIDNEY	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	ESTIMATED COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Sidney along the Susquehanna riverfront	No Potential	Feasible	High Impacts Likely; More Analysis Needed	$50	No
Alternative 2.1: Build a new floodwall in Weir Creek in Sidney	N/A; outside of modeling extent	Feasible	High Impacts Likely; More Analysis Needed	$9	Unknown
Alternative 3: Combination FRM project for Sidney including channel improvement along the Susquehanna River and raising of the Route 8 and Main Street bridges	No Potential	Feasible	High Impacts Likely; More Analysis Needed	$14	No
Alternative 4: Pump station in Sidney	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 5: Upstream detention in Weir Creek in Sidney	N/A; outside of modeling extent	Feasible (Some Alternatives)	High Impacts Likely; More Analysis Needed	$1.5 - $3	Unknown
Alternative 6: Dredging of Susquehanna River in Sidney	No Potential	Not Feasible	High Impacts Likely; Likely Unacceptable	$14	No
Alternative 7: Non-structural measures in Sidney including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

.12 THE TOWN OF CHENANGO

The Town of Chenango experiences overbank flooding from the Chenango River and tributary flooding from Thomas Creek. Overbank flooding along developed areas is diffuse and infrequent with historic impacts resulting from catastrophic storms (1 percent chance flood event of higher). The initial array of alternatives for Chenango are illustrated in in Figure 28 and Table 29. Based on the preliminary analysis of residual risk, annualized damages were low and none of the proposed structural alternatives could be justified by damage reduction benefits.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Chenango. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Chenango Alternative 5** – non-structural measures in Town of Chenango

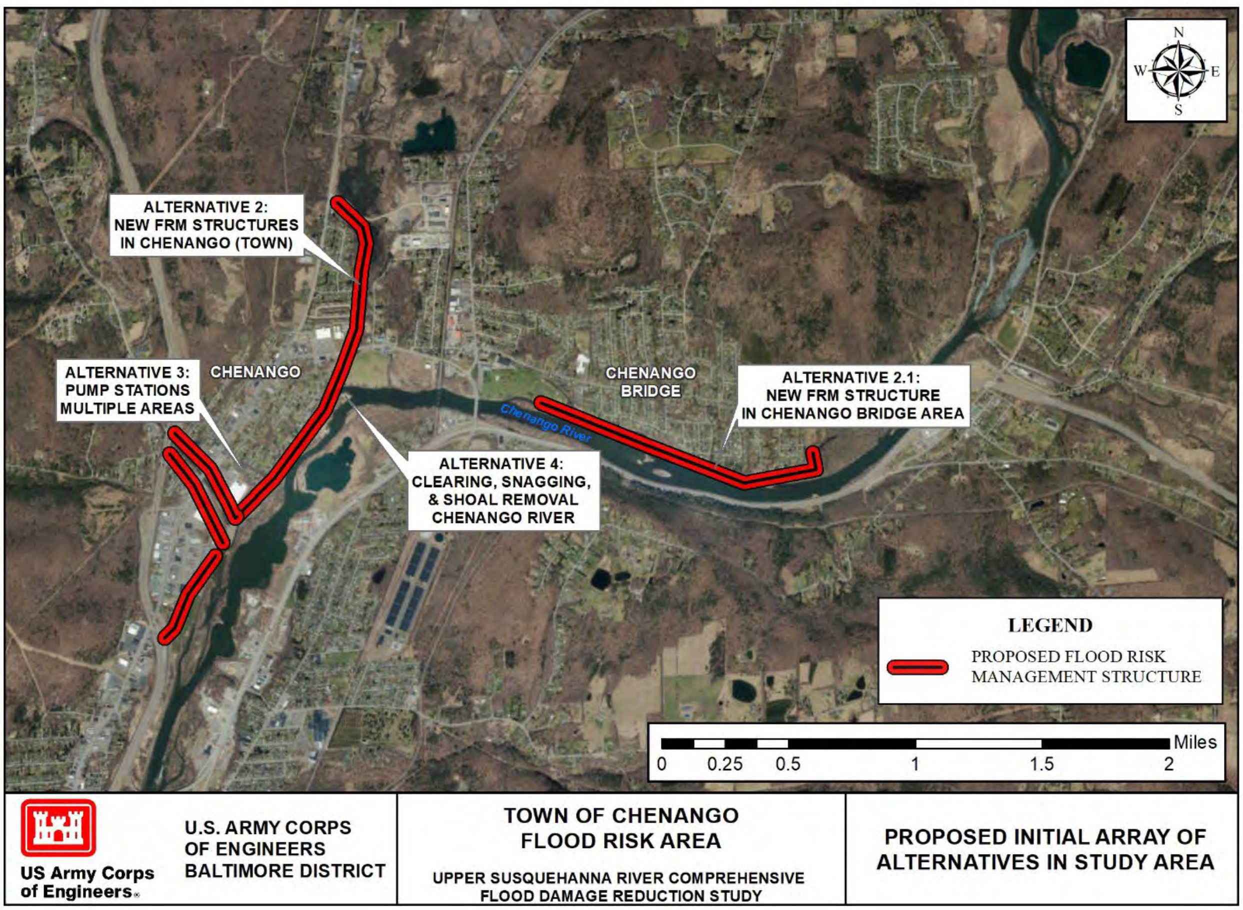

Figure 28: Chenango Flood Risk Area Initial Array of Alternatives

Table 29: Initial Array of Alternatives for Town of Chenango

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: CHENANGO	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	ESTIMATED COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Chenango (Town) along the Chenango River (right bank)	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$21.1 - $30.6	No
Alternative 2.1: Build a new levee segment in Chenango Bridge area along the Chenango River (right bank)	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$4.7 - $6.8	No
Alternative 3: Pump station in Chenango	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal along Chenango River in Chenango	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$0.8 - $1.2	No
Alternative 5: Non-structural measures in Chenango including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

.13 THE VILLAGE OF WAVERLY

The Village of Waverly experiences flooding from Cayuta Creek on the east side and from the Chemung River, which is mostly outside of the modeling extent. Based on existing hydrology, flood risk for the 1 percent chance flood event was examined. The initial array of alternatives for Waverly is illustrated in in Figure 29 and Table 30. Based on the preliminary analysis of residual risk, annualized damages were low and none of the proposed structural alternatives could be justified by damage reduction benefits. Non-structural measures are examined in Chapter 7 with the focused array of alternatives.

The PDT combined this preliminary analysis with feedback from local stakeholders to finalize the screening process for Waverly. In summary, the following alternative was carried forward for further consideration in the focused array of alternatives;

- **Waverly Alternative 5** – non-structural measures in the Village of Waverly

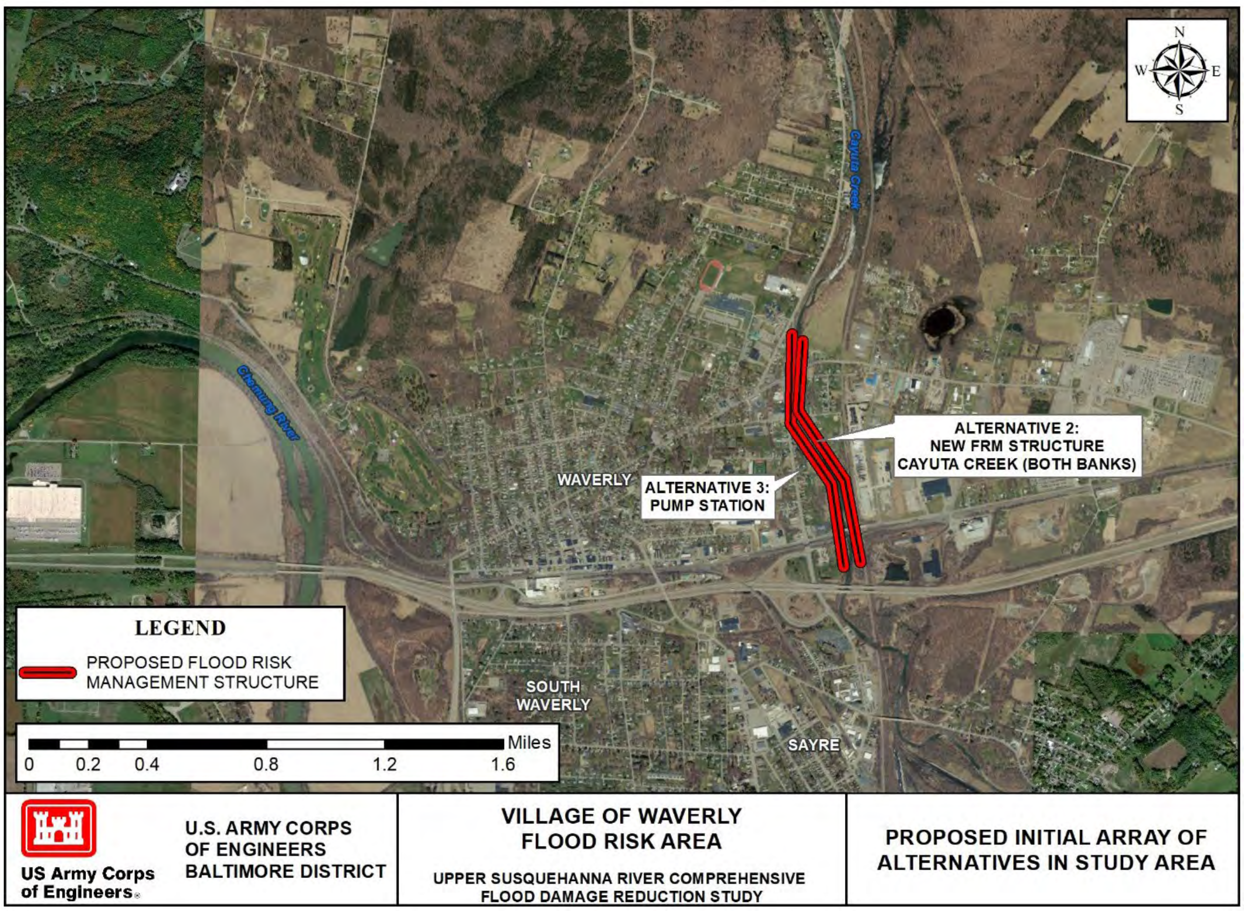

Figure 29: Waverly Flood Risk Area Initial Array of Alternatives

Table 30: Initial Array of Alternatives for the Village of Waverly

ALTERNATIVES CONSIDERED FOR FOCUS RISK AREA: WAVERLY	PRELIMINARY FEDERAL INTEREST	ENGINEERING JUDGMENT	ACCEPTABILITY OF POTENTIAL IMPACTS	ESTIMATED COSTS (IN MILLIONS)	MEETS ALL CRITERIA FOR FURTHER STUDY
Alternative 1: No Action					
Alternative 2: Build a new levee system in Waverly along Cayuta Creek (both banks)	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$6.8 - $9.9	No
Alternative 3: Pump station in Waverly	More Detailed Analysis Required	Not Feasible	Low Impact; Likely Acceptable	More Detailed Analysis Required	Unknown
Alternative 4: Clearing, snagging, and shoal removal along Susquehanna River in Waverly	No Potential	Not Feasible	High Impacts Likely; More Analysis Needed	$0.8 - $1.2	No
Alternative 5: Non-structural measures in Waverly including a combination of elevating structures, acquisitions, and floodproofing of structures	Potential	Feasible	Low Impacts Likely; Acceptable	More Detailed Analysis Required	Yes

6.2 STAKEHOLDER AND AGENCY INVOLVEMENT AND FEEDBACK

Due to the large study area and limited scope, resources, and time for completion of the USRB study, USACE and NYSDEC needed to acquire feedback from the USRB communities to assess local interest in the full array of alternatives, determine gaps in knowledge, and develop a strategy for a study path forward using stakeholder feedback. USACE and NYSDEC hosted a stakeholder involvement meeting on March 28 of 2018 to present the watershed screening results and plan formulation results for the full array of alternatives, which included fact sheets presenting the information included in this Chapter. Officials from all municipalities (counties, towns, villages, and cities) within the study area, along with Federal and state agency representatives, and non-governmental organizations, were invited to attend the meeting and provide feedback. The stakeholders were also given a period of 60 days to review the study documents and factsheets provided and provide feedback to NYSDEC. The stakeholder comments and feedback are provided in this section.

In the March 2018 stakeholder meeting, USACE highlighted six focus risk areas that indicate potential for a structural and/or non-structural alternative for flood damage reduction including Binghamton-Port Dickinson, EJV, Oneonta, Conklin-Kirkwood area, Owego, and Unadilla. These areas either showed favorable damage reduction potential for the initial array of alternatives or had insufficient information, but the PDT had a high level of confidence that alternatives should be explored further.

The stakeholder meeting was held in Broome County, New York, and was attended by 70 officials representing 21 local municipalities, 5 county governments, and 10 agencies including state and Federal partners. This meeting consisted of a presentation followed by breakout sessions where USACE and NYSDEC PDT and senior staff answered questions and discussed proposed projects, programs, and known flooding issues with community stakeholders. An additional meeting was held on April 12, 2018 to solicit feedback from the Upper Susquehanna Conservation Alliance, which is coordinated by the USFWS. USACE received local government, nonprofit, state, and Federal partner feedback for the study effort on May 1, 2018. The comments from this effort are summarized below and included in full in Appendix A Plan Formulation.

In June of 2018, after a review of feedback from local stakeholders, USACE received input from NYSDEC on a proposed strategy for conducting more detailed analysis for structural alternatives in four areas. These four areas include: Binghamton/Port Dickinson, Endicott-Johnson City-Vestal, Owego, and Oneonta. These structural alternatives are organized by project scope into alternatives that fall within the scope of the feasibility study (large scale, scope) or with potential for a USACE CAP project (smaller scope) once Federal interest is verified in the study. Additionally, NYSDEC requested that recommendations for USACE Technical Assistance Program work be made for the following communities: Village of Greene, Town and Village of Bainbridge, and the Village of Endicott. The PDT would also complete analysis for non-structural measures using HEC-FDA modeling for all focus risk areas to inform FRM actions by USACE, NYSDEC, and other basin stakeholders.

.2.1 SUMMARY OF STAKEHOLDER AND AGENCY FEEDBACK

Federal Emergency Management Agency (FEMA) – The FEMA comments include;

1. Ensuring that USACE conducts the adequate level of NEPA documentation based on the complexity and potential impacts of the proposed project alternatives (environmental assessment or environmental impact statement if projects were recommended);
2. Levee and floodwall projects would have the greatest potential environmental impacts and are likely to have the longest review timelines, FEMA guidelines also discourage constructed-hard edges stream bank work (levees/floodwalls);
3. FEMA has funded numerous projects including elevation and buyout of properties in several of the identified communities and floodwall projects in others, but FEMA has to date not funded large-scale projects in New York that implement principles of natural stream and riparian/wetland/floodplain area restoration.

Village of Afton – Requested technical assistance for enlargement of the culvert opening beneath the I-88 embankment exit ramps into Afton and restoration of wetlands upstream and downstream of that location.

City of Binghamton – Expressed support for raising of all levee and floodwalls in Binghamton, and replacing floodwalls if needed.

Town of Dickinson – Expressed support for a new levee segment (Binghamton, Alternative 3.2) as proposed addition to the Binghamton system.

USRB Community Stakeholder Meeting in Broome County, March 2018

Village of Endicott, Village of Johnson City, Town of Vestal, Town of Union – Expressed support raising of all floodwalls and levees (Alternative 2 and 3), including exploring opportunities for levee relocations in Johnson City (Alternative 3.1). The Town of Union and Village of Johnson City expressed support for channel clearing in Little Choconut Creek (Alternative 5.1), while Vestal expressed interest in channel clearing at the confluence of Big Choconut Creek and the Susquehanna River (part of Alternative 5). Vestal expressed support in pump stations in the Town to reduce flooding. All jurisdictions expressed support for non-structural measures.

Village of Endicott – Requested technical assistance for clearing at an identified drainage outfall along the Susquehanna River.

Village of Greene – Requested that the extent of the existing USACE-built project along Birdsall Creek be extended from North Canal Street to the Chenango River to address local O&M and permitting concerns. The Village also requested technical assistance to implement a locally-produced watershed study calling for retention and stream stabilization, along with other options, on the west side (upstream) of the Village.

Village of Owego – Expressed support for modification (raising) of the existing berm (Alternative 2) and building a new levee to protect downtown Owego and the Brick Pond Area (Alternative 3). The Village also expressed support for non-structural measures to reduce flood risk. The Village detailed that there were damages in 2005, 2006, and 2011 flooding particularly in downtown and the Brick Pond area. The Village has also done FEMA buyouts and elevations in the past.

Village of Bainbridge – Expressed support for nonstructural measures. They also requested technical assistance for addressing riverbank erosion along the Susquehanna River that is undermining Chenango County Road #39 and utility poles.

Town of Bainbridge - Requested technical assistance for stream bank erosion control at Clinton Park and shoaling at the confluence of Yaleville Creek along the Susquehanna River.

Village of Unadilla – Expressed support for clearing/snagging shoal removal (Alternative 4) in the Susquehanna River and non-structural measures.

Village of Oneonta – Expressed support for raising of Mill Race levee at Neahwa Place. Requested technical assistance to install an automatic check valve on the I-88 culvert to prevent back-flooding along the channel.

The Nature Conservancy – Recommended more emphasis on nonstructural measures to reduce flood risk and pair flood risk reduction with without impairing the ecological condition of the watershed. TNC also requested additional details on the methodologies used in the analysis and to a clearer accounting of costs to include O&M costs since including O&M costs may result in costs outweighing benefits in these communities.

TNC clarified that alternatives with reduced O&M costs would increase the long-term success of alternatives since rural communities in the basin have low tax bases.

Otsego Land Trust – Provided comments emphasizing that: direct land conservation and removal of land from development is important for flood reduction, particularly in properties in the floodplain; to develop a methodology for assigning monetary value of flood reduction benefits for protecting upland lands; and increasing capacity to conduct stream improvement and land protection to reduce inappropriate development.

U.S. Fish and Wildlife Service – The Draft FWCA Planning Aid Report (PAR) for the USRB study was completed and provided to the PDT for review. This report contains recommendations from both the USFWS and the USCA. The report provides five major recommendations including:

1. Fully develop a regional "watershed restoration flood control alternative". This would include upland retention/detention and would focus on four pilot watersheds.
2. Proposed alternatives should minimize environmental impact.
3. Examine non-structural measures in conjunction with structural alternatives.
4. Quantify ecological benefits to assess the costs and benefits of flood management projects.
5. Alternative evaluation should include impacts to other human-use services (e.g. recreation, fishing, boating, etc.).

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CHAPTER 7 EVALUATION OF THE FOCUSED ARRAY OF ALTERNATIVES

Following the local government stakeholder meeting, the PDT updated the initial array of alternatives and developed a focused array of alternatives from the six focus areas with favorable alternatives in the preliminary analysis after confirming local support. USACE received input from NYSDEC on a proposed strategy for conducting more detailed analysis for structural alternatives in four of these six focus risk areas. These four areas include: Binghamton/Port Dickinson, Endicott-Johnson City-Vestal, Owego, and Oneonta.

The PDT updated the focused array using feedback from stakeholders and updated hydraulic and economic information for the areas with potential structural or non-structural alternatives based on preliminary screening information. Existing pump stations in Binghamton and EJV are locally-owned and maintained; therefore, proposals for new pump stations were not examined in greater detail since interior drainage analysis was not originally scoped in the PMP or completed for all of the initial study areas. Structural alternatives for Unadilla and Conklin were removed from consideration in the focused array of alternatives due to lack of local support by stakeholders. Additionally, updated modeling indicated a lower level of damage reduction for the proposed levee in Unadilla, which would reduce damage reduction benefits of the proposed structural alternative. It is important to note that evaluation of non-structural measures is being conducted for all focus risk areas, detailed in Appendix B Economics.

While some alternatives are suitable for the feasibility study based on the scope of the proposed alternatives, others alternatives may be more suitable for CAP 205 or other authorities. More detailed engineering and economic analysis is completed in this study to assess Federal interest in these alternatives. The focused array of alternatives are highlighted in Table 31.

The level of detail in the analysis was increased in the evaluation of the focused of array of alternatives, particularly for Binghamton, Oneonta, and Owego, where potential projects were considered to be likely more feasible than in other areas based on an examination of economic benefits. In these three areas, the PDT developed concept designs and detailed cost estimates (if appropriate), and ran HEC-FDA models for economic analyses. Economic analysis for EJV used a lesser level of detail due to preliminary information showing lower benefits resulting from residual risk damages at the FRM project.

Table 31: USRB Focused Array of Alternatives with recommendations for implementation authorities *(highlighted alternatives are examined further)*

Flood Risk Area	Proposed Alternative	Meets All Screening Criteria and Planning Objectives	Local Community Support	Recommendation
Binghamton-Port Dickinson	Alternative 2: Raise all levees and floodwalls in the Binghamton System	Yes	Yes	Examine in USRB Study
	Alternative 6: Non-Structural Measures in Binghamton	Yes	Unknown	Recommendations for FEMA HMGP
Endicott-Johnson City-Vestal	Alternative 2 and 3: Raise all levees and floodwalls in Endicott, Vestal and Johnson City Systems	Not Yet Evaluated	Yes	Examine in USRB Study
	Alternative 3.1 and 5.1: Relocate and replace existing levee segment by former BAE plant site and channel clearing in Little Choconut Creek in Johnson City/Union	Yes	Yes	Not carried forward due to existing plans for site.
	Alternative 8: Non-Structural Measures in Endicott, Johnson City, Vestal, and Town of Union	Not Yet Evaluated	Yes	Recommendations for FEMA HMGP
Oneonta	Alternative 2: Raise existing non-Federal Mill Race levee at Neahwa Place	Yes	Yes	Recommendation for CAP 205 or Technical Assistance
Conklin-Kirkwood	Alternative 2: Build a new levee system in Conklin along all three damage areas	No	No	Not carried forward due to no local support
	Alternative 3: Clearing, Snagging, and Shoal Removal of Susquehanna River along Conklin-Kirkwood Area	Yes – Existing Project	-	Recommendation for Operation & Maintenance, CAP 208 if funding becomes available
	Alternative 6: Non-Structural Measures in Conklin-Kirkwood	Not Yet Evaluated	Unknown	Recommendation for FEMA HMGP
Owego	Alternative 2 and 3: Modification and extension of existing berm along Owego Creek and building a new levee system in Owego along the Historic District and the Brick Pond area	Yes	Yes	Likely a recommendation for CAP 205
Owego	Alternative 6: Non-Structural Measures in Owego	Not Yet Evaluated	Yes	Recommendation for FEMA HMGP
Unadilla	Alternative 2: Build a new levee and a new floodwall in Unadilla	Yes	No	Not carried forward due to no local support
	Alternative 6: Non-Structural Measures in Unadilla	Not Yet Evaluated	Yes	Recommendation for FEMA HMGP

The PDT updated cost estimates using concept designs for four structural alternatives in the focused array of alternatives. Additionally, HEC-FDA modeling was used to estimate damages for each of these areas, which are utilized to calculate the flood reduction benefits of proposed project alternatives by comparing the with-project and without-project conditions. The preliminary analysis, presented in Chapter 6, made broad assumptions regarding structures and content values as well as the start of damage. Unlike the preliminary, the final economic analysis using HEC-FDA modeling uses eight flood frequencies from updated hydrologic data and relies on Monte Carlo simulations that improve the accuracy of damage estimates by iterating modeling parameters and averages the results of these iterations. The resulting average annual damages estimate thus captures a range of potential modeling outcomes providing a higher level of confidence in the resulting economic information.

The evaluation of the focused array of alternatives included three previously used screening criteria that were updated with engineering, economic, environmental, social, cultural, and historical information for each of these areas. The evaluation criteria for the focused array of alternatives are summarized in Table 32.

A Federal project must be economically justifiable, feasible from an engineering perspective, and whenever possible result in no significant adverse impacts to cultural, historic, social, or environmental resources in the community. Following evaluation of the focused array of alternatives, alternative plans were developed for Binghamton as the most likely area for a Federal project based on economic benefits. As described in Section 7.2 and 7.6, the engineering and economic evaluation included concept drawings, development of cross sections, and detailed quantities. The PDT also did risk and uncertainty analysis to estimate contingencies for cost estimates generated for Binghamton. Environmental evaluation was also commenced for Binghamton, shown in the Environmental Annex. Section 7.6 describes the economic evaluation and findings from this analysis.

Table 32: Evaluation criteria for the focused array of alternatives

Evaluation Criteria	Description and Evaluation Considerations
Meets Planning Objectives	The PDT evaluated whether alternatives meet planning objectives to reduce flood damages to communities, impacts to critical infrastructure facilities, and reducing life loss from riverine flooding.
National Economic Development (NED) Evaluation	NED is evaluated by estimating the benefit to the nation of proposed project alternatives. The economic benefits of a project are determined by calculating the damages reduced due to the proposed project (i.e. total damages of the existing condition minus the residual damages in the with-project condition). Two measures are used for estimate benefits for NED evaluation; the benefit-cost ratio and net benefits. The benefit-cost ratio (BCR) is calculated by dividing economic benefits by economics costs. Net benefits are estimated by subtracting the economic benefits from the economic costs. A Federal project is considered economically justified if the benefits of the project equal or exceed the costs. This is indicated by a BCR greater than 1 and positive net benefits.
Feasible from an engineering perspective	The PDT examined the physical environment of the project area and flood inundation information to determine if proposed alternatives are likely to be feasible from an engineering perspective, given the available information. The engineering team provides an overall assessment of the feasibility of the proposed array of alternatives based on the risk reduction potential and best professional judgment. The PDT also developed concept designs, quantities, and detailed cost estimates for use in the economic evaluation of alternatives.
Acceptability of impacts from an environmental, social, cultural, and historical perspective	The PDT examined whether the impacts of the proposed alternatives were acceptable from an environmental perspective. This analysis was completed using various tools to identify potential impacts of FRM measures to natural resources and the environment in all flood risk areas. The PDT looked at impacts to wetlands, threatened and endangered species, regionally rare habitats, hazardous, toxic, and radioactive wastes (HTRW) sites, and prime farmlands. Consideration was also given to evaluations conducted by the USFWS in the Draft Planning Aid Report. The PDT also examined whether the impacts of the proposed alternatives were acceptable from a social, cultural, and historical perspective. Two primary considerations were used for evaluating social/cultural acceptability; (1) impacts to cultural and historical resources of proposed alternatives, and (2) impacts to socially vulnerable populations, examined using the Social Vulnerability Index.
Local Support	Local stakeholders have demonstrated support for the proposed alternatives in stakeholder meetings and through project support forms provided to the project sponsor.

7.1 PLANNING ASSUMPTIONS FOR EVALUATING THE FOCUSED ARRAY OF ALTERNATIVES

At this stage of the planning formulation process, the focused array of alternatives consisted of structural alternatives in Binghamton, EJV, Owego, and Oneonta, and non-structural evaluation in all focus risk areas. The PDT had to increase the level of detail in analysis for evaluating the focused array of alternatives to reduce uncertainty of associated decisions. The PDT identified uncertainty with hydrologic modeling, preliminary economic analysis, the condition of existing FRM systems, and the use of parametric cost estimates. To address uncertainty, the team expanded hydrologic modeling to Oneonta and Unadilla to improve evaluation of proposed solutions in those areas, evaluated and corrected coincident peak flows in tributaries in the hydrologic modeling, conducted detailed economic analyses using HEC-FDA modeling for structural and non-structural measures, and improved cost estimates by developing conceptual design for alternatives that appear feasible after re-evaluation of the focused array of alternatives with HEC-FDA results.

The PDT also evaluated and updated planning assumptions for the evaluation of the focused array of alternatives. These planning assumptions for the various disciplines include:

<u>Cost Estimating:</u> Costs will be developed based on concept design quantities. Risk and uncertainty analysis will be completed to the appropriate level of risk at the conceptual design stage. Costs may vary up to award of construction contract. Cost estimating assumptions will be consistent with Engineer Regulation 1110-2-1302.

<u>Geotechnical Engineering:</u> Use existing soils and foundation information, deferring new geotechnical explorations until the Planning Engineering and Design (PED) phase.

<u>Mechanical Engineering:</u> No utility surveys will be completed. Defer surveys of utilities for bridges and utility features until PED phase.

<u>Civil Engineering:</u> Existing LiDAR will be used to develop topographic conditions. Proposed top of levee elevations will be developed based on water surface elevations in HEC-RAS modeling. Levee and floodwall tie-ins will need to be extended in some locations to provide the manage risk to the proposed elevations.

<u>Hydrology and Hydraulics Engineering:</u> Hydraulic modeling (HEC-RAS) (existing conditions) of water surface elevations will be conducted using updated hydrology from HEC-RAS model for each of the FRM projects that include levees and/or floodwalls, along with appropriate mapping. Efforts in HEC-HMS modeling will be reduced to expand the scope of HEC-RAS modeling.

<u>Economics:</u> Use existing parcel data to populate the structure inventory. LiDAR elevations will be used to determine lowest adjacent grade. Assign first floor elevations based on the characteristics of structures following sampling in the study area using

Google Earth. Use existing depth-damage relationships representative of the observed flooding in the study area.

Plan Formulation: Geographic scope of analysis limited to areas where USACE and the sponsor, with local feedback, have agreed based on available information on flood risk and damages.

Environmental: Use interim evaluation based on existing information before NEPA documentation is complete. Annex I of Appendix A provides current information on environmental resources in the areas of interest. Develop level of detail consistent with the scope and significance of impacts of proposed actions. SMART Planning NEPA will be consistent with all applicable Federal and state laws and USACE guidance.

Cultural: Use existing surveys and information for evaluating potential impacts to cultural, historic, and prehistoric resources. Appendix A provides current information on cultural resources in the areas of interest. If necessary, a programmatic agreement with the SHPO will be signed and additional Section 106 evaluation regarding the project's impacts to cultural resources will be deferred to a later stage of the project.

7.2 FOCUSED ARRAY OF ALTERNATIVES FOR THE CITY OF BINGHAMTON AND VILLAGE OF PORT DICKINSON

7.2.1 EXISTING CONDITIONS

The City of Binghamton serves as the urban center of commerce for the USRB in Southern Tier New York. Binghamton is intersected by the Susquehanna River, flowing from the East to the West, and the Chenango River, flowing from North to South where both rivers converge. Binghamton has recently experienced severe flooding in 2006 and again in 2011 during Tropical Storm Lee. In 2011, the FRM project was overtopped by flood waters overwhelming the existing FRM infrastructure. Both flood events resulted in significant damages to buildings and several important critical infrastructure assets that provide city services. State and local knowledge and preliminary analysis of historic information supported formulation of FRM alternatives for the City of Binghamton.

The City of Binghamton and Village of Port Dickinson are currently protected by the existing Binghamton FRM project, originally authorized by the Flood Control Act of 1936, as amended in 1938. The Binghamton FRM project includes three separate levee systems that reduce risk from riverine flooding primarily from the Chenango River and the Susquehanna River. The Binghamton systems include Northeast Binghamton, Northwest Binghamton, and South Binghamton. The flood risk area with the FRM project are shown in Figure 30.

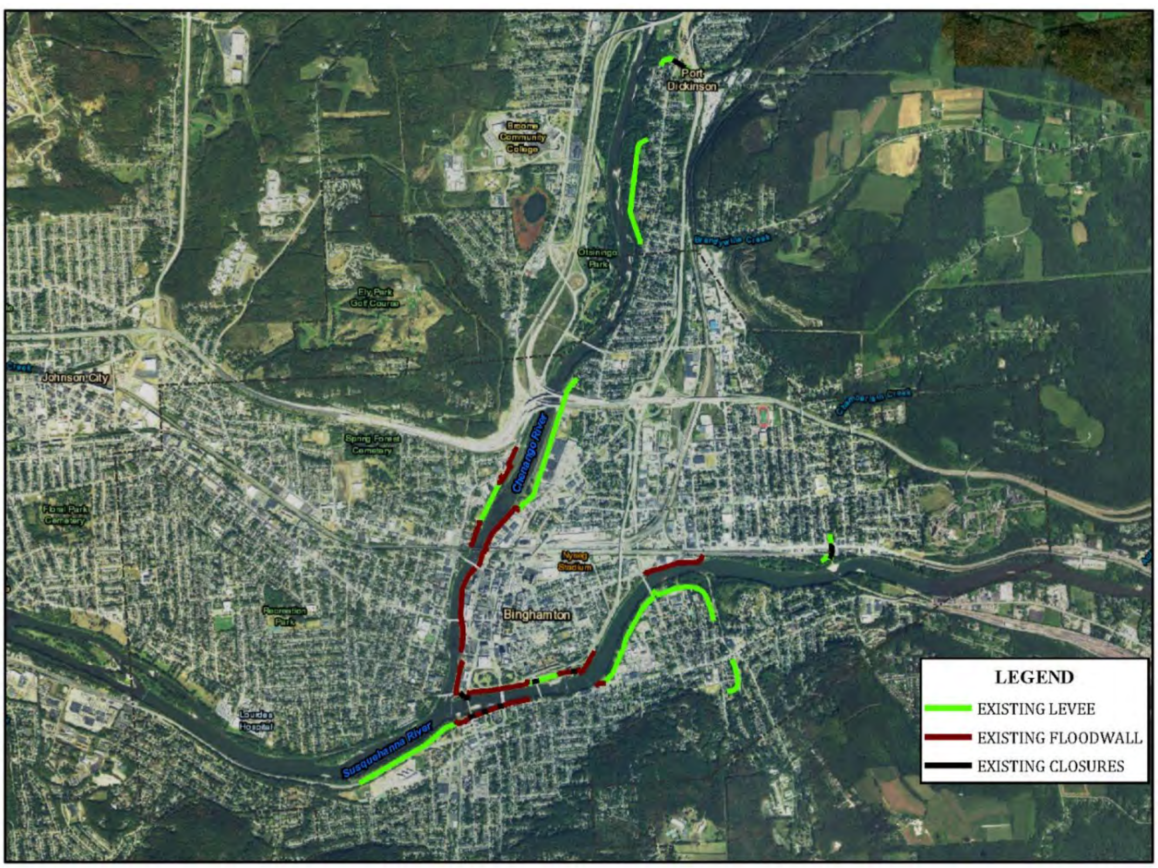

Figure 30: Binghamton Flood Risk Management Project

The Northeast Binghamton system includes approximately 1.7 miles of levee, 1.9 miles of floodwall, 34 drainage structures, and 7 closures. The Northwest Binghamton system consists of approximately 0.2 miles of levee and 0.3 miles of floodwall along the right bank of the Chenango River. The South Binghamton system consists of approximately 1.0 miles of levee and 0.4 miles of floodwall along the left bank of Pierce Creek, and along the left bank of the Susquehanna River. The FRM project has been modified several times during its project life including to address tributary flooding, to improve interior drainage, and to repair storm damages to the project. The NYSDEC operates and maintains the FRM project except at Pierce Creek and Park Creek in South Binghamton, which are federally maintained by USACE. Several pump stations maintained by the City of Binghamton also help alleviate interior drainage flooding.

The City of Binghamton is the largest city in the watershed. Binghamton has historically been a manufacturing center for the region but has seen steady declines in manufacturing employment and population. The City of Binghamton's population in 2017 was 45,179 and has declined by 44.3 percent since 1950. Like many cities in the Southern Tier, Binghamton's population decline can be attributed to the decline in manufacturing employment in the region. At the same time, the city's economic base has slowly transitioned into services and healthcare. Our Lady of Lourdes Memorial Hospital is the largest employer in the city (City of Binghamton, 2018). Development in the City of Binghamton is composed of a mix of residential, commercial, and industrial land uses with dense commercial development in Downtown Binghamton. Binghamton University has a downtown campus in the city, although many facilities are now located in main campus in the Town of Vestal. The Village of Port Dickinson is a suburb of Binghamton, contiguous with residential development in the City's northeastern boundary. The population of Port Dickinson in 2017 was 1,909.

Table 33: Binghamton and Port Dickinson Demographic and Socioeconomic Characteristics, 2017

	Binghamton	Port Dickinson
Total Population	45,179	1,909
Percent Change in Population since 1950	-44.3%	-21.6%
Percent Age Under 18	19.3%	23.7%
Percent Age Over 65	17.0%	12.1%
Minority Population	27.7%	7.8%
Percent Below Poverty	33.3%	11.9%
Median Household Income	$31,103	$58,190
Unemployment Rate	11.7%	6.5%
Percent Service Employment	59.3%	56.8%
Percent Educational Services Employment	13.8%	9.6%
Percent Healthcare and Social Assistance Employment	18.1%	21.8%
Percent Manufacturing Employment	8.1%	7.3%
Decline in Manufacturing Employment since from 1990 to 2011 (Broome County, 2013)	47.7%	

Source: American Community Survey, Economic Census, and U.S. Census 2017

Binghamton and Port Dickinson are both located in inherently flood prone areas with a significant portions of the city's development located below 848 feet (NAVD88), the average top of levee elevation. Binghamton has been recently impacted by flooding in 2006 and again in 2011 by Hurricane Irene followed by Tropical Storm Lee, which saw water overtopping the levee/floodwall project at and near the confluence of the Chenango River and Susquehanna River. Flooding from Hurricane Irene and Tropical Storm Lee resulted in significant damages in Broome County, where Binghamton is located. The New York Rising Community Reconstruction Plan estimated that flooding from these storms resulted in $502.8 million in property damages and impacted over 9,000 homes in the county (Broome County, 2014). The city's critical infrastructure has been severely crippled by flooding in past events including catastrophic damages to the Binghamton-Johnson City Joint Sewage Treatment Plant in 2011 and damages to Lourdes Hospital in 2006, both of which have since constructed floodwalls to reduce future storm damages. The communities immediately upstream and downstream of Binghamton are also characterized by floodplain development with historic damages resulting from recurring flooding in those areas.

DESCRIPTION OF FLOODING RISK

The Binghamton and Port Dickinson area are primarily affected by residual flood risk from infrequent, high intensity events which can result in overtopping of levees and floodwalls and overwhelming of interior drainage pumps. Some of the levee and floodwall segments in the Binghamton FRM project have been tentatively identified by FEMA as freeboard deficient since FEMA's draft hydrology and hydraulics modeling shows that they do not meet current freeboard requirements for levee accreditation. FEMA has not finalized these determinations and plans to update their modeling at a future data. One likely point of overtopping in this system is at the confluence of the Chenango River and Susquehanna River, where higher water surface elevations could result in flooding of areas behind the levee.

FRM ALTERNATIVES FOR BINGHAMTON AND PORT DICKINSON

7.2.2 ALTERNATIVE 1: NO ACTION

Under the no action alternative, USACE would not propose raising of levee or floodwalls and would not propose non-structural measures for risk reduction in Binghamton and Port Dickinson as a Federal action. The existing FRM project will continue to be operated and maintained by NYSDEC and the systems would continue to provide risk reduction benefits to these communities. The Binghamton-Port Dickinson FRM project would still continue to be inspected by USACE and areas of Federal responsibility will remain the responsibility of USACE for operation and maintenance. The FRM project would also qualify for PL84-99 Federal emergency rehabilitation assistance for as long as the project meets criteria for rehabilitation assistance under the Rehabilitation and Inspection Program (RIP).

Under the no action alternative:

- Population is anticipated to continue patterns of decline due to economic stagnation.
- Re-development of downtown commercial districts is likely to continue.
- Downtown areas are not anticipated to change significantly in land use or economic growth.
- Precipitation and the occurrence of extreme storm events will increase in the USRB in the future.
- Variability in climatic factors is likely to increase including temperature variation and monthly streamflows.
- FEMA HMGP will continue to target grants in residential areas with significant recurring damages from flooding.
- New York State and local jurisdictions will continue to implement risk reduction actions identified in the NY Rising Community Reconstruction Plan.

7.2.3 ALTERNATIVE 2-A: LEVEE AND FLOODWALL RAISING IN THE BINGHAMTON FRM PROJECT

CONCEPT DESIGNS

The PDT developed conceptual designs for the raising of levees and floodwalls in the Binghamton FRM Project to address flood risk reduction needs in the project. The engineering team conducted a field visit of the Binghamton project in July of 2018 to assess the existing conditions of the levees and floodwalls in the FRM project. Following the field visit, engineers modeled the 1 percent chance flood with three feet of freeboard for levees and floodwalls and four feet of freeboard at bridges, using FEMA NFIP levee accreditation criteria as a starting point for developing conceptual designs, as outlined in the feasibility study PMP. The top of levee and floodwall elevations were used to develop conceptual designs that identify areas throughout the project that need to be raised to meet the proposed level of risk reduction. The resulting conceptual designs are shown in Figures 31 to 33. These conceptual designs were used to develop quantities for cost estimation of the proposed alternative. Based on the needed level of raising, several segments of floodwall would need to be replaced in each of the systems, while the FRM project would also need to be extended in other areas to tie-in with high ground. Detailed engineering information is included in Appendix C Engineering.

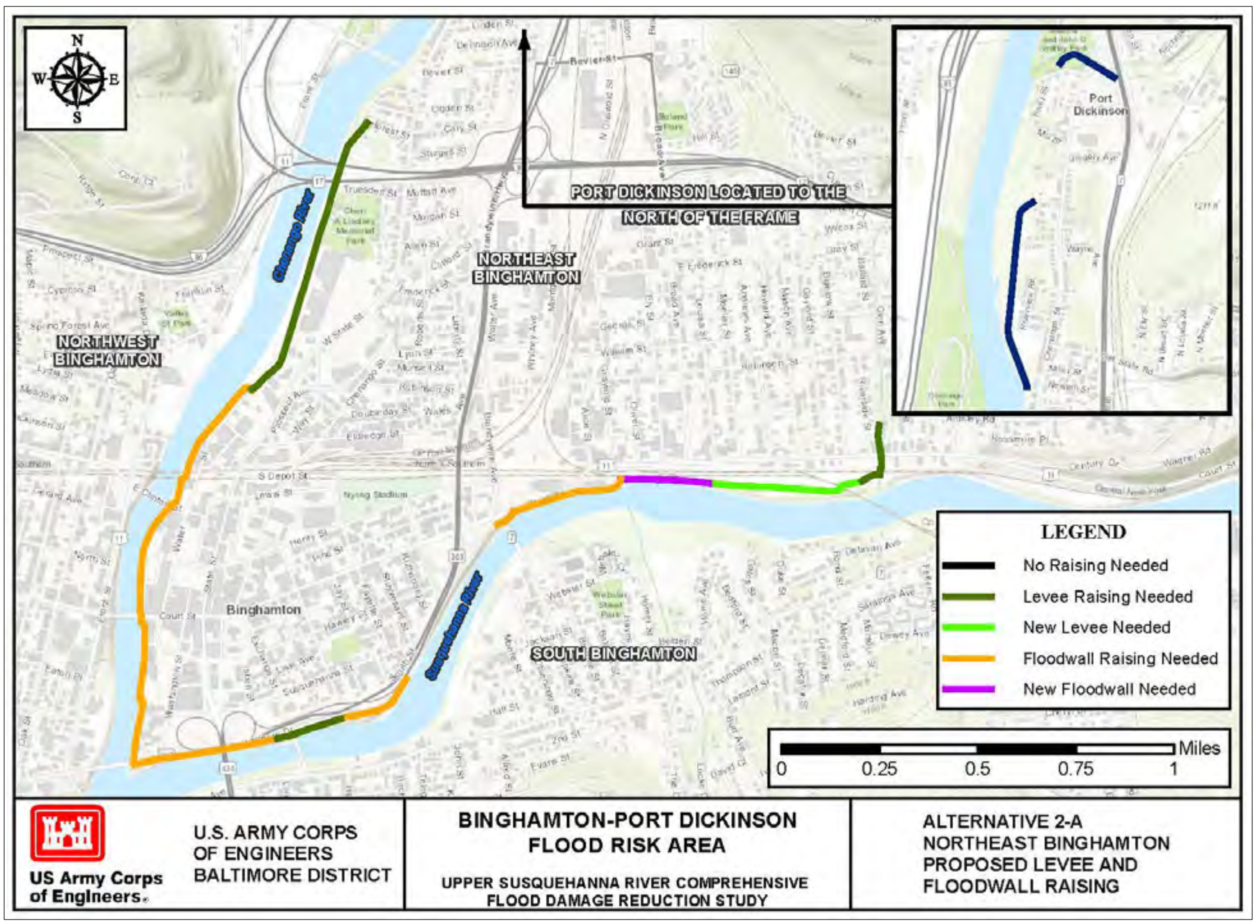

Figure 31: Northeast Binghamton Proposed Raising Concept Design

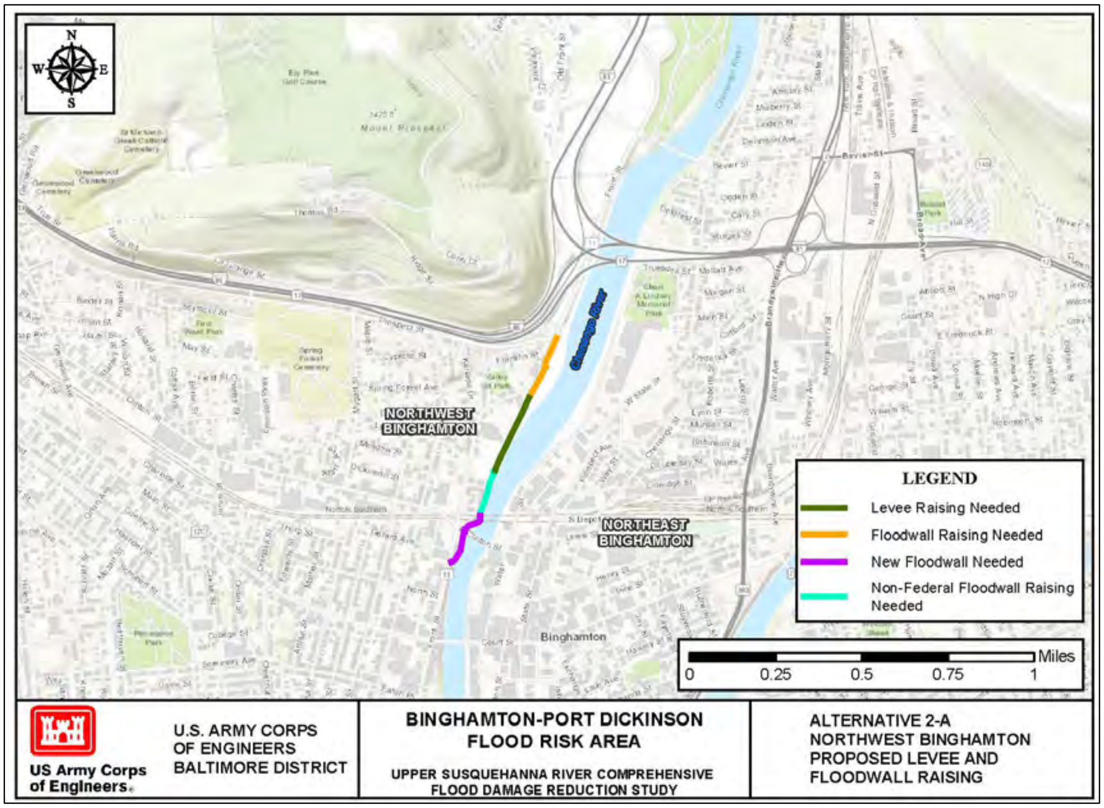

Figure 32: Northwest Binghamton Proposed Raising Concept Design

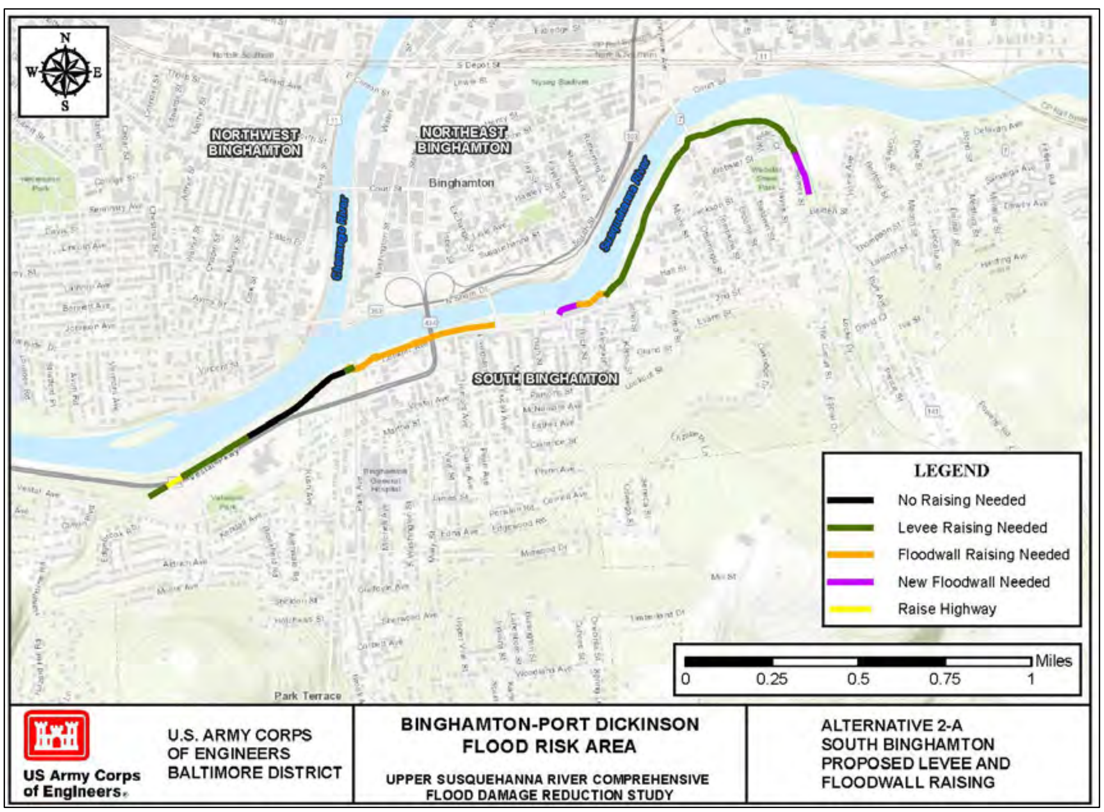

Figure 33: South Binghamton Proposed Raising Concept Design

7.2.4 ALTERNATIVE 2-B: LEVEE AND FLOODWALL RAISING IN THE BINGHAMTON FRM PROJECT, WITH REPLACEMENT OF SOME FLOODWALLS WITH LEVEES

CONCEPT DESIGNS

Following the initial concept designs in Alternative 2-A, NYSDEC provided additional information indicating that existing floodwalls at some locations of the Northwest, Northeast, and South Binghamton systems where system raisings are proposed could be replaced with levees instead of floodwalls in the future. The replacement of floodwalls with levees is likely feasible due to changes in land use, removal of structures previously present adjacent to the floodwalls, and proposed re-alignment of roads at the various locations, which permits for the acquisition of additional real estate by the state for implementation of this alternative. The PDT developed conceptual designs, quantities, and cost estimates for this proposed alternative. The resulting concept designs are shown in Figures 34 through 36. While the replacement of floodwalls with levees may be feasible, the costs are not expected to decrease substantially from outright floodwall replacement. This is due to two reasons: the proposed design for floodwall replacement includes shallow foundation floodwalls which generally have lower costs than anticipated, and levees would require high volumes of select fill material and riprap that would need to be acquired for construction of a levee at the proposed locations.

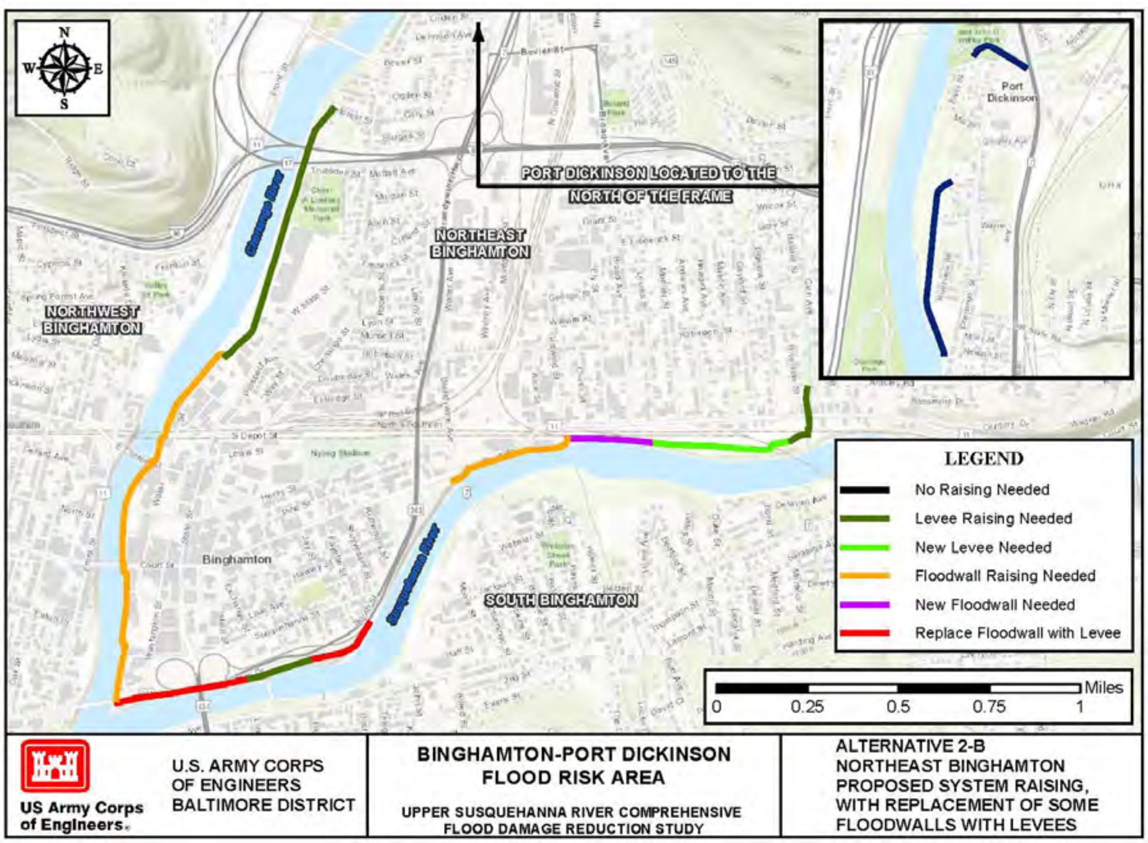

Figure 34: Northeast Binghamton Proposed Raising Concept Design with Replacement of some Floodwalls with Levees

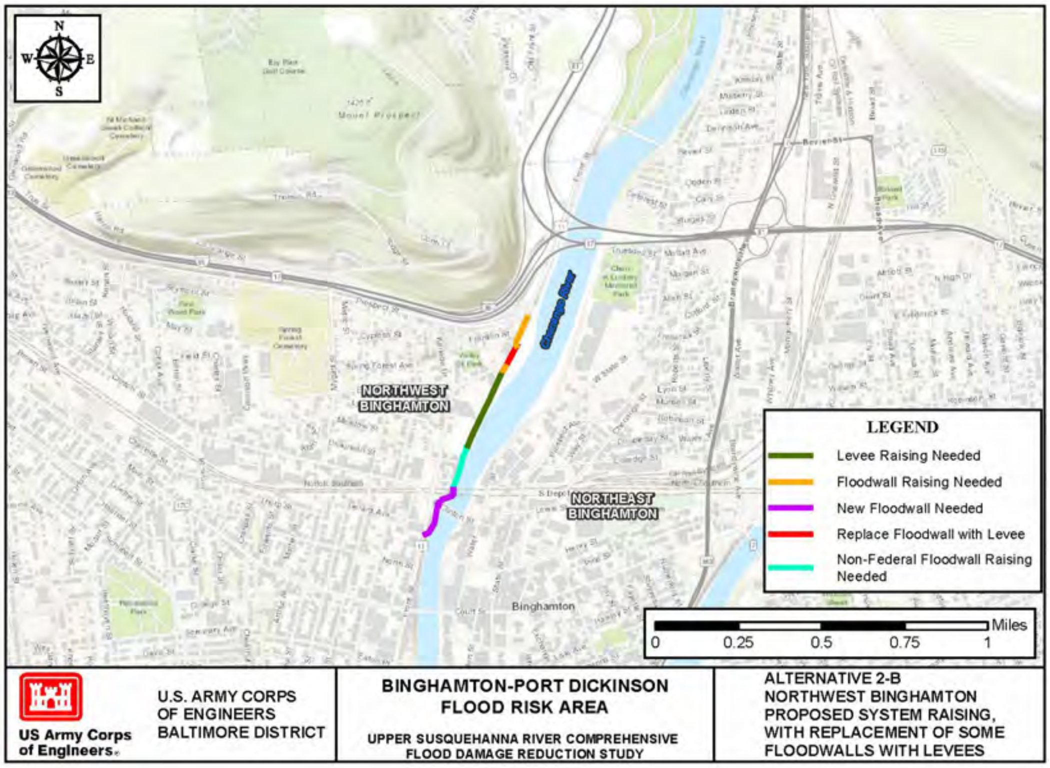

Figure 35: Northwest Binghamton Proposed Raising Concept Design with Replacement of some Floodwalls with Levees

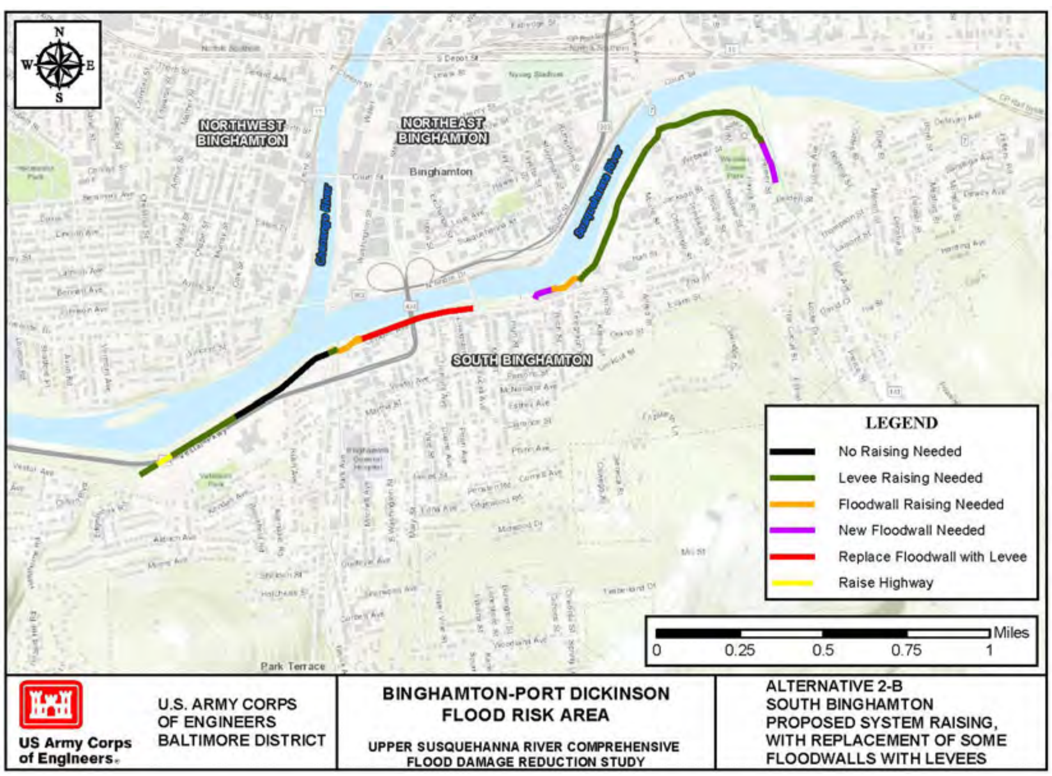

Figure 36: South Binghamton Proposed Raising Concept Design with Replacement of some Floodwalls with Levees

7.2.5 ALTERNATIVE 3X: NON-STRUCTURAL MEASURES IN BINGHAMTON AND PORT DICKINSON

The Binghamton and Port Dickinson structures were evaluated using HEC-FDA modeling to determine the feasibility of non-structural measures in this area. The Binghamton-Port Dickinson non-structural analysis includes 25 reaches that include of 4,629 structures in Binghamton, Port Dickinson, and the upstream communities of Chenango, Dickinson, Conklin, and Kirkwood. Two sets of preliminary analysis were conducted using this model: an evaluation of elevating the first floor elevation of residential structures and floodproofing non-residential structures up to the 1 percent annual exceedance probability (AEP) plus one foot, and an examination of buyouts of these same properties using the market value and a unit cost for structure removal. The full structure inventory used in this analysis is illustrated in Figure 37.

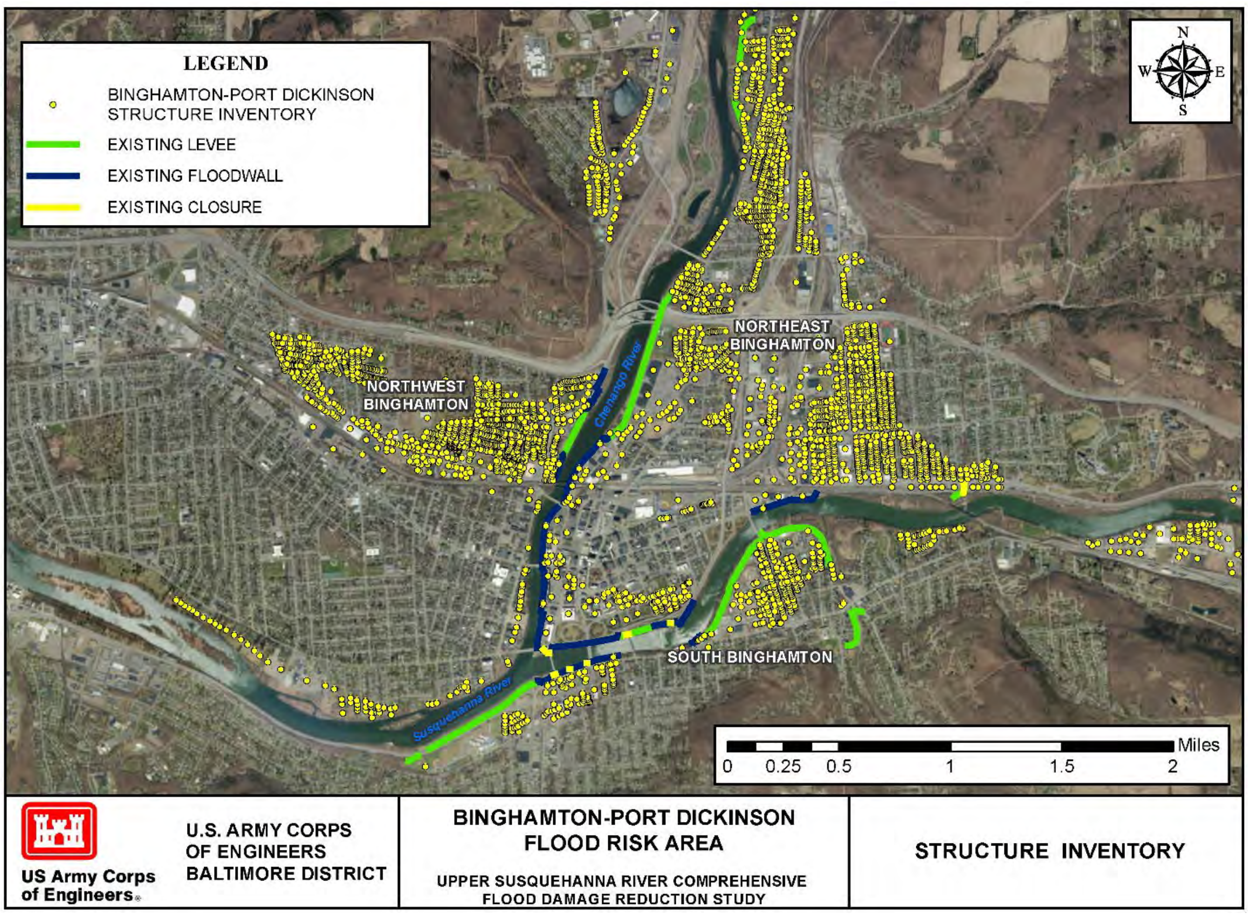

Figure 37: Binghamton-Port Dickinson structure inventory for non-structural analysis

7.3 FOCUSED ARRAY OF ALTERNATIVES FOR ENDICOTT-JOHNSON CITY-VESTAL

7.3.1 EXISTING CONDITIONS

Endicott, Johnson City, and the Town of Union are located on the right bank of the Susquehanna River. The tributaries of Little Choconut Creek, Finch Hollow Creek, and Nanticoke Creek cross developed areas in the Town of Union. The Town of Vestal is located on the left bank of the Susquehanna River, on the opposite bank of the Town of Union, and is located immediately downstream of the City and Town of Binghamton. The tributaries of Willow Run and Big Choconut Creek traverse the Town of Vestal, emptying into the Susquehanna River.

The Endicott-Johnson City-Vestal FRM project provides FRM benefits to the Towns of Union and Vestal including a majority of the Village of Endicott and flood-prone areas of the Village of Johnson City. The EJV project was authorized by the Flood Control Act of 3 September 1954. EJV consists of three separate levee systems that reduce risk from riverine flooding from the Susquehanna River and its tributaries; the Endicott levee system, the Johnson City levee system, and the Vestal levee system. In addition to the EJV project, the non-Federally constructed Fairmont Park and West Corners FRM projects are located in the Town of Union. The FRM projects in the area are shown in Figure 38.

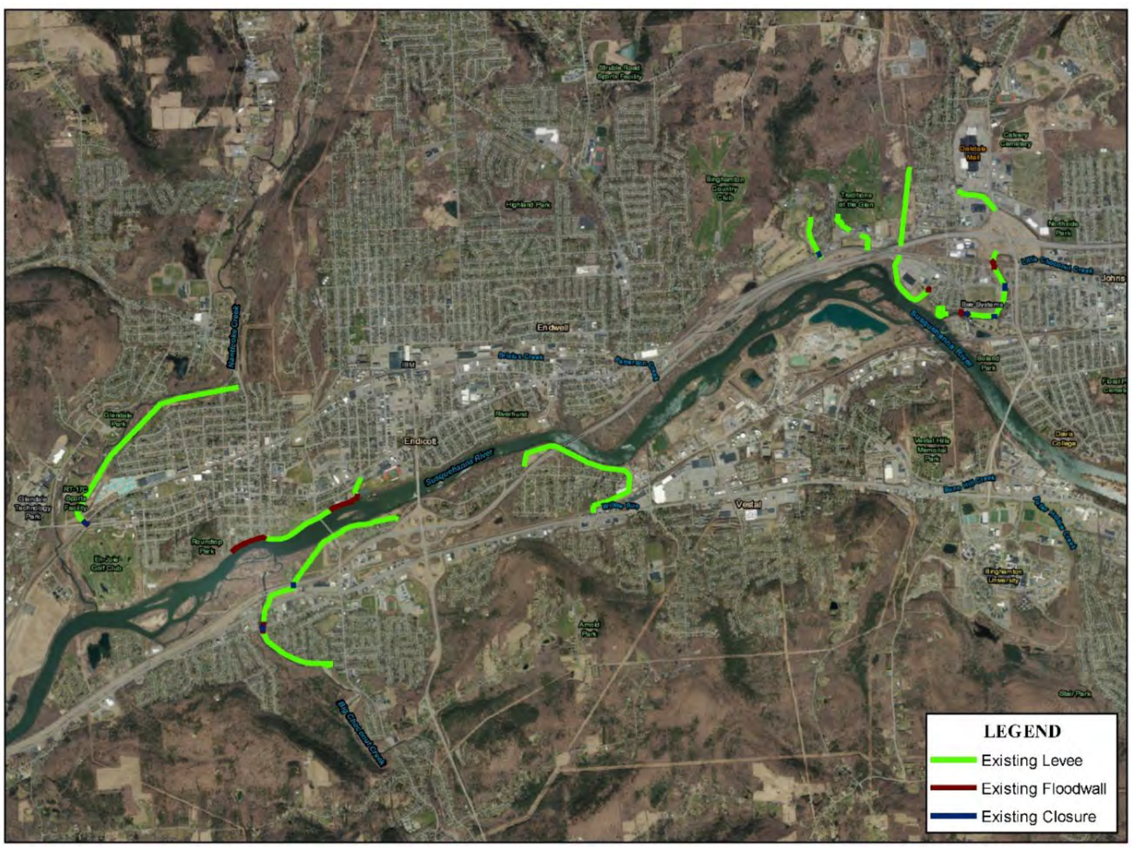

Figure 38: EJV Flood Risk Management Project, with Fairmont Park Non-Federal Levee

The authorized EJV project consisted of a combined length of 7.5 miles of earthen levee and 0.5 miles of floodwall. The EJV project was originally constructed between 1957 and 1961 and was designed for a flood of 126,000 cfs on the Susquehanna River and the backwater effects on Nanticoke Creek, Willow Run, and Big and Little Choconut Creeks. Construction of New York State Route 17 also resulted in a few modifications to the project, the most significant along the Little Choconut Creek section, where the levee now extends underneath the Route 17 and Route 201 highway cloverleaf ramps. The original elevations have been maintained. The FRM project was modified to reduce interior drainage issues in the 1970s and 15 ponding areas were created behind the levee project to reduce interior flooding. The NYSDEC is responsible for operation and maintenance of the FRM project. Several pump stations maintained by local jurisdictions also help alleviate interior drainage flooding.

The Towns of Union and Vestal were affected by severe flooding in 2011, which resulted in flood waters overtopping the EJV FRM project resulting in the catastrophic loss of the BAE systems plant at Johnson City and damages throughout the region. A significant portion of the USRB's critical infrastructure, educational facilities, and concentration of employment are located in EJV, therefore a disruption of services caused by a major storm would have significant regional impacts.

Table 34: Critical Infrastructure Assets in Leveed Areas of the EJV Project

Infrastructure Type	Total Number of Structures
Ambulance Providers	2
EMS	3
Fire Stations	4
Law Enforcement	1
Schools	3
Water Treatment	1
Museums	1
Oil Gas Pipelines	3

The Endicott system is divided into two segments; Endicott, located along the Susquehanna River and West Endicott, located along Nanticoke Creek. The Endicott system includes a total of 2.1 miles of earthen levee, 0.4 miles of concrete floodwall, one closure, 3 pump stations (locally managed), and 30 drainage structures. The Vestal system is divided into two segments; the Twin Orchards segment (Vestal East), located at the intersections of Willow Run and the Susquehanna River, and Vestal (Vestal West), located along the Susquehanna River and tying in at Big Choconut Creek. The Vestal system includes a total of 2.95 miles of earthen levee, 0.04 miles of floodwall, 1 closure, 26 drainage structures, and 16 relief wells. The Johnson City system only includes one segment consist of a total of 2.0 miles of earthen levee, 0.1 miles of floodwall, 3 closures, and 21 drainage structures.

The Village of Endicott has historically been a manufacturing center with roots in shoe manufacturing and is best known as the birthplace of IBM. The Village of Johnson City has been primarily a residential area with important industrial, commercial, and institutional areas including a satellite campus of Binghamton University. The Towns of

Vestal and Union have been primarily residential suburbs to Endicott, Johnson City, and Binghamton. Vestal also has a significant population of university students as the main campus of Binghamton University is located on the eastside of the town. The population and demographic characteristics of EJV and Union are summarized in Table 35. Endicott, Johnson City, and Town of Union have experienced population declines, likely as a result of decline in employment opportunities resulting from decreases in manufacturing employment in the region. The Town of Vestal has a relatively stable population likely influenced by the presence of Binghamton University.

Table 35: EJV and Union Demographic and Socioeconomic Characteristics, 2017

	Village of Endicott	Village of Johnson City	Town of Union	Town of Vestal
Total Population	12,828	14,508	54,033	28,199
Percent Change in Population since 1950	-36.4%	-25.8%		
Percent Age Under 18	20.2%	22.3%	20.0%	15.9%
Percent Age Over 65	18.2%	16.2%	19.7%	16.1%
Minority Population	20.0%	23.3%	15.6%	23.7%
Percent Below Poverty	19.6%	18.6%	13.4%	13.4%
Median Household Income	$35,371	$39,992	$47,824	$61,993
Unemployment Rate	10.2%	6.3%	6.6%	3.5%

Source: American Community Survey, Economic Census, and U.S. Census 2017

DESCRIPTION OF FLOODING RISK

The EJV project is primarily affected by residual flood risk from infrequent, high intensity events, which can result in overtopping of levees and floodwalls and overwhelming of interior drainage pumps. Flooding from Tropical Storm Lee in 2011 resulted in overtopping of all three systems in the EJV project resulting in significant damages in affected communities. Additionally, flood risk may be affected by limited flood storage capacity in tributaries of the Susquehanna River, which can result in back-flooding, particularly along Little Choconut Creek, which can affect areas on the opposite bank of the existing levee. A final risk driver in Endicott includes driveways that are cutting into the levee crown just south of NYS Highway 17c where the levee ties in to high ground.

FRM ALTERNATIVES FOR EJV

7.3.2 ALTERNATIVE 1: NO ACTION

Under the no action alternative, USACE would not propose raising of levee or floodwalls and would not propose non-structural measures for risk reduction in EJV and Union as a Federal action. The existing FRM project will continue to be operated and maintained by NYSDEC and the systems would continue to provide risk reduction benefits to these communities. The EJV FRM project would still continue to be inspected by USACE. The FRM project would also qualify for PL84-99 Federal emergency rehabilitation assistance for as long as the project meets criteria for rehabilitation assistance under the Rehabilitation and Inspection Program (RIP).

Under the no action alternative:

- Population is anticipated to continue to decrease or stagnate based on historic patterns.
- Developed areas are not anticipated to change significantly in land use or economic growth.
- Precipitation and the occurrence of extreme storm events will increase in the USRB in the future.
- Variability in climatic factors is likely to increase including temperature variation and monthly streamflows.
- FEMA HMGP will continue to target grants in residential areas with significant recurring damages from flooding.
- New York State and local jurisdictions will continue to implement risk reduction actions identified in the NY Rising Community Reconstruction Plan.

7.3.3 ALTERNATIVE 2X: LEVEE AND FLOODWALL RAISING IN ENDICOTT, JOHNSON CITY, AND VESTAL

The PDT developed parametric cost estimates for the conceptual raising of levees and floodwalls in the EJV, assuming an average of two feet of raising is needed throughout the system, which is based on escalated unit costs from the Value Engineering Study for Lackawanna River FRM Project dated September 2011. The total lengths used includes 11,110 feet of levee and 2,200 feet of floodwall raising at Endicott, 21,700 feet of levee and 174 feet of floodwall in Vestal, and 9,950 of levee and 450 feet of floodwall at Johnson City. Preliminary cost estimates did not include estimated costs for raising or replacement of closure structures, nor do they include operation and maintenance costs, any needed mitigation costs, or real estate costs, therefore, these estimates likely underestimate the construction costs of the proposed alternative. The cost estimates were used for the purposes of screening since initial analysis indicated that levee raising is unlikely to be economically justifiable. HEC-FDA modeling was used to estimate damages at each of the levee systems and used to compare benefits assuming two levels of damage reduction, 50 percent and 100 percent (although no FRM project is likely to reduce damages by 100 percent), with annualized parametric costs. No detailed engineering concept designs were completed because the initial HEC-FDA damages were unlikely to be higher than total project costs. Evaluations are summarized in Section 7.6 and in Appendix B Economics.

7.3.4 ALTERNATIVE 3X: NON-STRUCTURAL MEASURES IN ENDICOTT, JOHNSON CITY, VESTAL, AND TOWN OF UNION

Buildings in EJV, including the Town of Union, were evaluated using HEC-FDA modeling to determine the feasibility of non-structural measures in this area. The EJV non-structural analysis includes 38 reaches that include of 3,518 structures in Endicott, Johnson City, Vestal, Union, and upstream/downstream communities. Two sets of preliminary analysis were conducted using this model: an evaluation of elevating the first floor elevation of residential structures and floodproofing non-residential structures up to the 1 percent AEP plus one foot, and an examination of buyouts of these same properties using the market value and a unit cost for structure removal. The full structure inventory used in this analysis is illustrated in Figure 39.

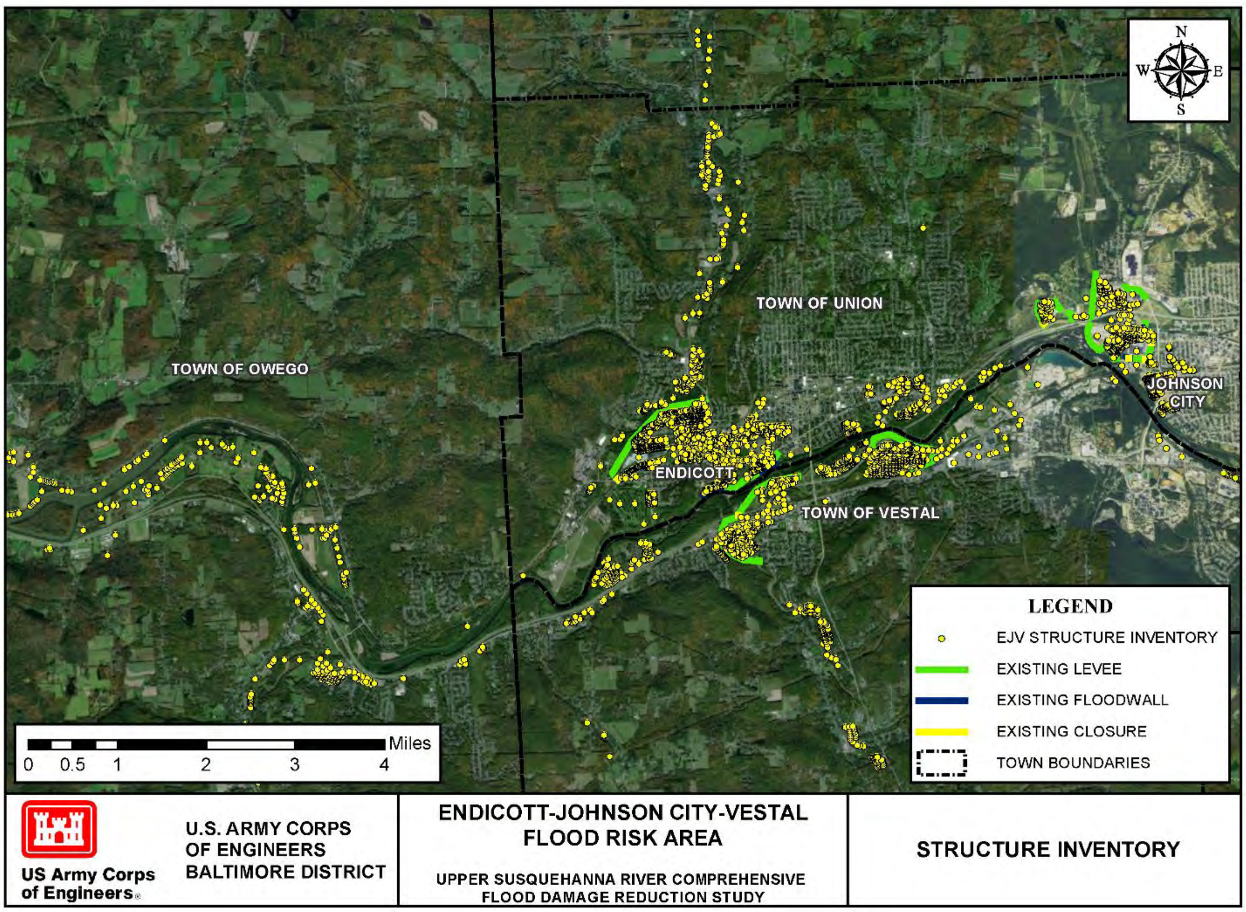

Figure 39: EJV structure inventory for non-structural analysis

7.4 FOCUSED ARRAY OF ALTERNATIVES FOR THE VILLAGE OF OWEGO

7.4.1 EXISTING CONDITIONS

The Village of Owego is located in the Town of Owego in Tioga County at the confluence of the Susquehanna River and Owego Creek. The Village of Owego has been identified as an area of high residual flood risk in the USRB with a majority of the Village being situated in the floodplain (NY Rising Tioga County, 2011). In 1952, USACE completed a channel improvement/clearing and snagging project along Owego Creek, which included building a berm from dredged spoils along the left bank of Owego Creek to reduce flooding risk to the community. Owego experienced significant flash flooding during the 2011 floods, which lasted for three days and resulted in flood damages to "85% of the homes, businesses, and municipal structures within the Village" (NY Rising Tioga County, 2011). Following the 2011 floods, FEMA acquired 34 properties in the Village of Owego through the Hazard Mitigation Grant Program.

Despite previous flooding, the Village of Owego remains a vibrant rural community and a regional tourist destination due to its historic character. The Village of Owego population of 3,805 is only small portion of the 19,092 residents in the Town of Owego, however, many of the commercial, cultural, and institutional buildings in the town are concentrated in the village. The downtown of the Village of Owego includes many national historical landmarks including the James C. Beecher House, the Tioga County Courthouse, St. Paul's Church, and the United States Postal Service Office in Owego.

The Village of Owego experiences multiple flooding issues along the Susquehanna River and Owego Creek. The primary risk drivers include overbank flooding from the Susquehanna River at catastrophic low frequency events (0.01 percent chance or 100-year or higher) and back-flooding along Owego Creek. Owego Creek also has shoaling and debris accumulation issues resulting which can result in neighborhood flooding in the west side of the village.

A reconnaissance level of analysis was completed to determine if a Federal FRM project in the Village of Owego is feasible and economically justified. The PDT developed a conceptual level of design for a structural and a non-structural alternative for the Village of Owego. The FRM alternatives are detailed in this section.

7.4.2 ALTERNATIVE 1: NO ACTION

Under the no action alternative, USACE would not propose a new FRM project and would also not propose non-structural measures for risk reduction in the Village of Owego as a Federal action. The existing berm and channel will provide some degree of risk reduction, but it is likely that the Village of Owego would continue to experience flooding damages in the future. The flood risk of the Village of Owego is likely to increase in the future as a result of more frequent high severity storms predicted for the region.

Under the no action alternative:

- Population is anticipated to remain constant or slightly decrease over time.
- Development is not anticipated to increase significantly.
- The Historic District is not expected to change significantly in growth or extent.
- Precipitation and the occurrence of extreme storm events will increase in the USRB in the future.
- Variability in climatic factors is likely to increase including temperature variation and monthly streamflows.
- FEMA HMGP will continue to target grants in residential areas with significant recurring damages from flooding.
- New York State and local jurisdictions will continue to implement risk reduction actions identified in the NY Rising Community Reconstruction Plan.

7.4.3 ALTERNATIVE 2X: RAISING OF THE EXISTING BERM ALONG OWEGO CREEK AND A NEW LEVEE AND FLOODWALL PROJECT IN DOWNTOWN OWEGO

CONCEPT DESIGN

The PDT developed conceptual designs for the raising of the existing berm along Owego Creek and a new levee and floodwall project to protect Downtown Owego up to the Brick Pond area. The conceptual level of design includes providing risk reduction to the 1 percent chance flood with three feet of freeboard for floodwalls and levees using HEC-FDA modeling. This structural levee alternative assumes that the Owego Creek berm is inadequate due to poor foundation and would likely need to be rebuilt as a levee. The total length of levee is estimated at 2.3 miles, 1 mile of floodwall to protect areas of downtown and the Brick pond area, three road closures, and two railroad closures. The top of levee alignment elevations vary between 3 feet to 10 feet in some areas. Only one closure would likely need to be greater than 2 feet, the 5th Avenue closure, thus the remaining closures may be addressed by temporary measures such as sandbags. The conceptual design is illustrated in Figure 40.

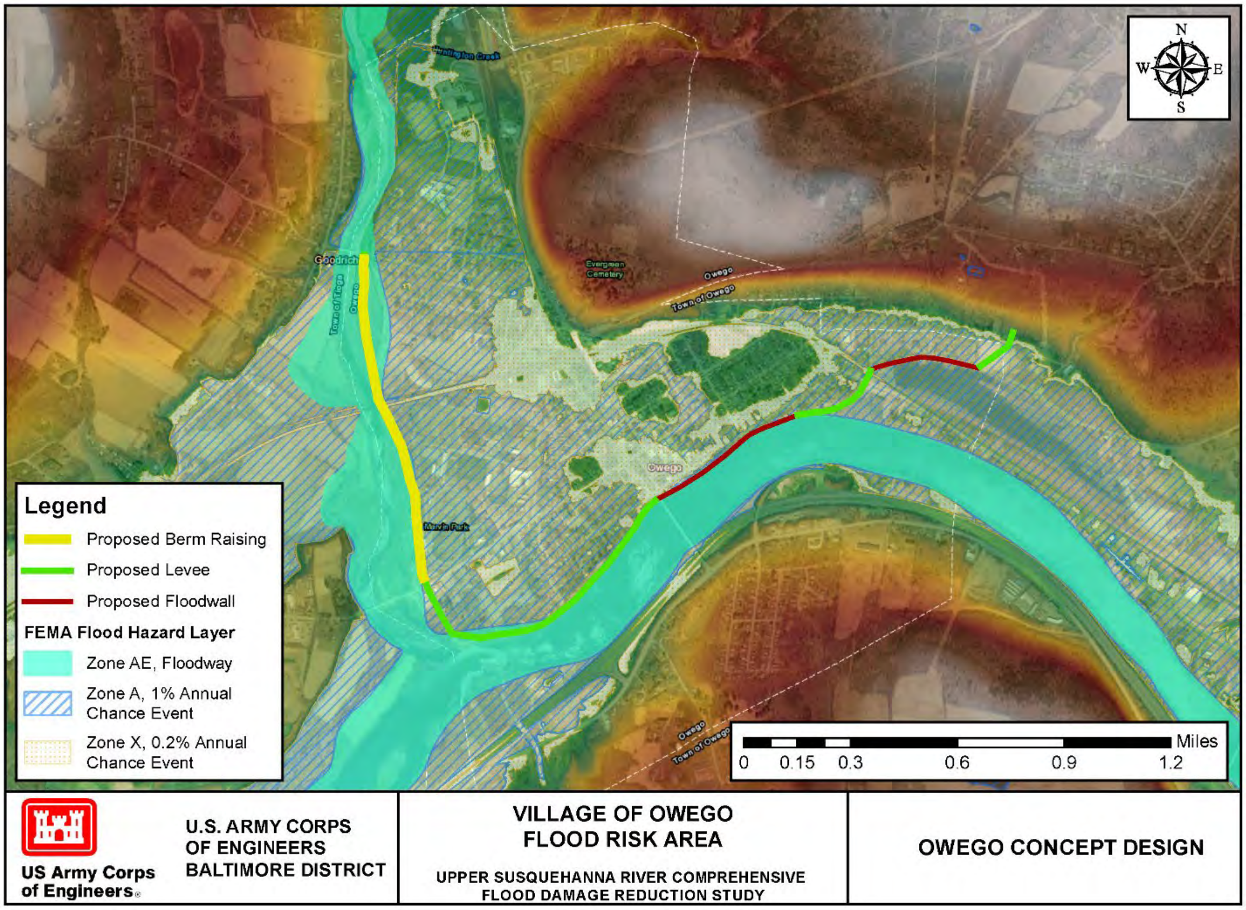

Figure 40: Owego Flood Risk Management Project Concept Design

A combination of structural and non-structural measures is also feasible to reduce overall costs of the project, including non-structural measures at the confluence of Owego Creek and the Susquehanna River and the Brick Pond area, areas where FEMA has acquired a large number of properties with recurring damages to buildings.

7.4.4 ALTERNATIVE 3X: NON-STRUCTURAL MEASURES IN THE VILLAGE AND TOWN OF OWEGO

Structures in the Village and Town of Owego were evaluated using HEC-FDA modeling to determine the feasibility of non-structural measures in this area. The Owego non-structural analysis includes three reaches that include of 1,121 structures in the Village and Town of Owego. Two sets of preliminary analysis were conducted using this model: an evaluation of elevating the first floor elevation of residential structures and floodproofing non-residential structures up to the 1 percent annual exceedance probability (AEP) plus one foot, and an examination of buyouts of these same properties using the market value and a unit cost for structure removal. The full structure inventory used in this analysis is illustrated in Figure 41.

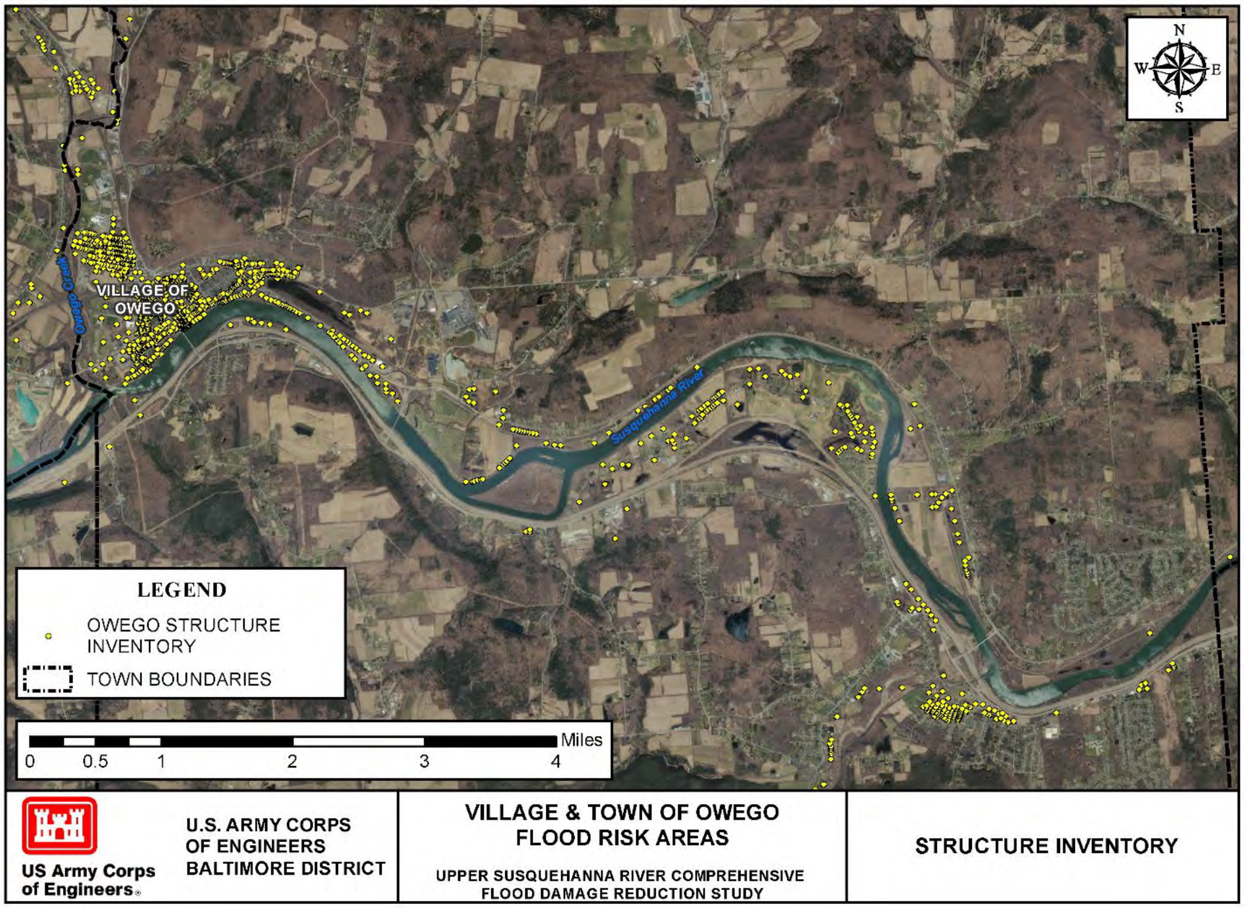

Figure 41: Owego structure inventory for non-structural analysis

7.5 FOCUSED ARRAY OF ALTERNATIVES FOR THE CITY OF ONEONTA

The City of Oneonta is a small city located in the foothills of the Catskill Mountains along the upstream end of the Susquehanna River. Oneonta is a regional commercial center and is also home to two mid-sized colleges and universities: State University of New York (SUNY) College at Oneonta and Hartwick College. The City of Oneonta's total population of 13,932 has been relatively stable with small increased due to increases in enrollment at the higher education institutions in the city. SUNY College at Oneonta is the largest employer in the city. A majority of the development in the city is located in valleys nestled between rolling hills with the Susquehanna River and the river's steep left bank serving as a geologic constraint on urbanization.

The City of Oneonta has extensive FRM infrastructure including two channels improvements along the Susquehanna River, one Federal and one non-Federal, and a non-Federal levee system at Mill Race that ties into Interstate-88 to manage flood risk along the right bank of the Susquehanna River. The Interstate-88 highway embankment may not meet NFIP standards due its pervious foundation so a levee may be needed to tie-in to the Mill Race levee. A closure is also needed on Main Street at the location of the Interstate-88 overpass to prevent flooding from Main Street. The 2006 flooding inundated the Oneonta Wastewater Treatment Plant resulting in raw sewage traveling downstream along the Susquehanna River.

A reconnaissance level of analysis was completed to determine if a Federal FRM project in the City of Oneonta is feasible and economically justified. The PDT developed a conceptual level of design for a structural and a non-structural alternative for the City of Oneonta. The FRM alternatives are detailed in this section.

7.5.1 ALTERNATIVE 1: NO ACTION

Under the no action alternative, USACE would not propose a raising of the existing non-Federal project and would also not propose non-structural measures for risk reduction in the City of Oneonta as a Federal action. The existing non-Federal levee and channel will continue to provide some level of risk reduction and would continue to be operated and by maintained by non-Federal owners of the project. Flooding may still occur at Main Street if no temporary closures are installed prior to a storm event and the highway embankment may still seep water that may affect leveed area and the structural integrity of the embankment.

Under the no action alternative:

- Population is anticipated to remain constant, due to decreases from migration, but continued increase in student enrollment at SUNY Oneonta.
- Development is not anticipated to increase significantly.
- Precipitation and the occurrence of extreme storm events will increase in the USRB in the future.
- Variability in climatic factors is likely to increase including temperature variation and monthly stream flows.

- FEMA HMGP will continue to target grants in residential areas with significant recurring damages from flooding.
- New York State and local jurisdictions will continue to implement risk reduction actions identified in the NY Rising Community Reconstruction Plan.

7.5.2 ALTERNATIVE 2X: RAISING OF THE EXISTING NON-FEDERAL MILL RACE LEVEE IN THE CITY OF ONEONTA

The PDT examined the FRM level currently provided by the Mill Race levee and determined whether additional raising is needed in the system. The FRM project consists of a short levee segment (0.2 miles) and a stoplog closure structure. The engineering team examined hydrologic information and available information about the FRM system. The engineering team determined that the Mill Race Levee appears to provide adequate protection for the 1 percent flood event with the needed freeboard, however, the Interstate-88 highway embankment consists of a pervious foundation, which may not meet NFIP criteria for FRM features. A closure is also needed on Main Street at the location of the Interstate-88 overpass to prevent flooding from Main Street. No further analysis has been carried out to investigate levee raising in this non-Federal system.

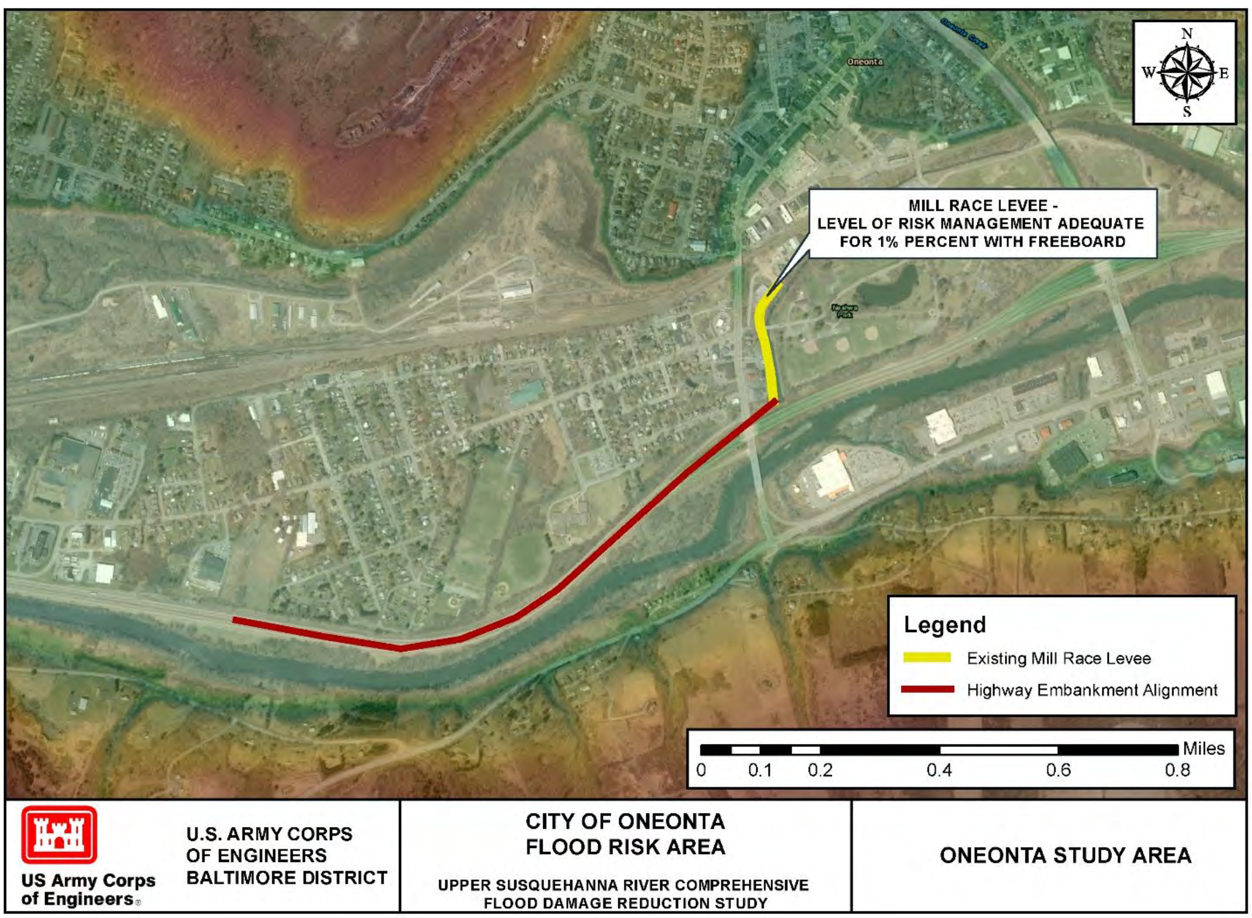

Figure 42: City of Oneonta Existing FRM Infrastructure

7.5.3 ALTERNATIVE 3X: NON-STRUCTURAL MEASURES IN THE CITY OF ONEONTA

Structures in the City of Oneonta were evaluated using HEC-FDA modeling to evaluate non-structural measures in this area. The Oneonta non-structural analysis includes one reach and 187 structures in the City. Since these structures are currently receiving risk reduction benefits from the accredited levee, there would be limited remaining benefits to implement non-structural measures at this location. The USACE PDT evaluated non-structural measures in the City of Oneonta that resulted in a negative benefit-cost ratios (BCR), shown in Appendix B Economics.

7.6 EVALUATION OF THE FOCUSED ARRAY OF ALTERNATIVES

7.6.1 EVALUATION OF STRUCTURAL ALTERNATIVES

The USRB feasibility study considered a range of structural and non-structural measures to reduce the risk of flood damages throughout the basin. Through the planning process, potential FRM alternatives were identified, evaluated, and compared. Following a preliminary analysis and discussions with local stakeholders, the PDT identified a focused array of alternatives detailed in this chapter. Previously, evaluation of the initial array of alternatives established that the proposed focused array of alternatives meet planning objectives, are likely to be feasible from an engineering perspective, and have demonstrated local support, in forms submitted by local government officials (see Table 31).

Plan formulation for the focused array of alternatives has been centered on flood damage reduction and contributing to NED, while considering environmental quality, regional economic impacts, and other social effects. The NED evaluation is completed by evaluating the benefits of the alternative plan based on damage reduction using HEC-FDA modeling. HEC-FDA modeling reduces the level of uncertainty associated with benefit estimation by simulating a range of conditions based on hydrologic and economic data. BCR are calculated using benefits estimated in HEC-FDA against the concept design cost estimates generated for the Binghamton FRM project alternatives, or parametric cost estimates, where concept designs were not developed. Alternative plans that are economically justifiable based on a benefit-cost ratio greater than one and positive annual net benefits may be suitable for further examination.

Alternatives for Binghamton were evaluated using HEC-FDA Modeling based on concept designs presented in Section 7.2. Alternative 2-A, levee and floodwall raising, involves raising a majority of the FRM project in Binghamton 0.5 to 4 feet, excluding the Port Dickinson segment of the project. This would also entail a new levee and floodwall segments along Court Street in Northeast Binghamton, a new floodwall at the USACE-maintained Pierce Creek segment in South Binghamton, extending the city maintained McDonald Avenue floodwall, and replacement of approximately 75 percent of all of the existing floodwalls in the FRM project, based on the needed level of raising to meet accreditation standards (1 percent design event with freeboard). A second alternative, 2-B involves replacing floodwalls with levees at select locations. Benefits were estimated for both alternatives by modeling the without and with- project conditions in HEC-FDA. The economic analysis is summarized in Table 36.

The estimated costs of each alternative are (2A) $115,955,000 and (2B) $118,783,000 in 2017 dollars. Using the 2018 federal discount rate of 2.875% and a 50-year capital recovery factor of 0.037948, the total cost of the project was annualized. The average annual costs for these alternatives are (2A) $4,425,000 and (2B) $4,501,000. The project benefits were estimated by comparing the with-project and without project conditions using the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) modeling tool. The average annual benefits for these alternatives are (2A) $3,169,000 and (2B) $3,163,000 in 2017 dollars. BCR is calculated by dividing economic benefits by economics costs. Net benefits are estimated by subtracting the economic benefits from the economic costs. The BCR for the proposed structural alternatives for Binghamton are (2A) 0.72 and (2B) 0.70. Both structural alternatives result in negative net benefits, because the costs are greater than the benefits. A BCR less than one indicates a negative finding for the National Economic (NED) evaluation. Based on these findings, BCRs less than one and negative net benefits, no structural alternatives are likely to be economically justifiable at the Binghamton FRM project.

Each levee system in the Binghamton FRM project was also evaluated independently using HEC-FDA modeling. From an engineering perspective, independent raising of a Binghamton levee system could result in induced flooding impacts in other systems due to the close proximity of the levee systems in the FRM project. The economic evaluation for each system also resulted in BCRs less than one indicating a negative finding for independently raising each system.

Table 36: Evaluation of the Focused Array of Alternatives for Binghamton

Proposed Alternative	Measure	Total Average Annual Costs ($1,000's)	Total Average Annual Benefits ($1,000's)	Annual Net Benefits ($1,000's)	BCR	Total Project Costs in 2017 Dollars ($1,000's)
Binghamton Alternative 1	No Action	0	0	0	0	0
Binghamton Alternative 2-A	Levee and floodwall raising	$4,425	$3,169	($1,256)	0.72	$115,955
Binghamton Northeast System	Alternative 2-A by system	$616	$203	($413)	0.33	$16,242
Binghamton Northwest System	Alternative 2-A by system	$2,796	$2,567	($229)	0.92	$73,683
Binghamton South System	Alternative 2-A by system	$1,013	$399	($614)	0.39	$26,685
Binghamton Alternative 2-B	Levee and floodwall raising, with replacement of some floodwalls with levees	$4,501	$3,163	($1,338)	0.70	$118,783
Binghamton Northeast System	Alternative 2-B by System	$634	$203	($431)	0.32	$16,744
Binghamton Northwest System	Alternative 2-B by System	$2,906	$2,561	($345)	0.88	$75,962
Binghamton South System	Alternative 2-B by System	$967	$399	($568)	0.41	$27,510

Economic analysis for EJV used a lesser level of detail due to preliminary information showing lower benefits resulting from residual risk damages at the FRM project. The structural alternative (2X) for EJV includes levee raising in all three of the EJV levee systems. This structural alternative was evaluated using HEC-FDA modeling and parametric cost estimates previously generated. Parametric cost estimates were developed using unit costs from the Value Engineering Study for the Lackawanna River FRM Project dated September 2011 escalated to fiscal year 2017. Average annual damages (AAD) for EJV were estimated using HEC-FDA. The capital recovery factor was used to determine the maximum project costs that could be supported if 100 percent of these AAD were prevented by a proposed project alternative. Preliminary economic analysis was completed for EJV using revised HEC-FDA damages to determine the maximum project cost that could be supported that would maintain a BCR of 1 or greater. The parametric cost estimates exceed the supported project costs, which is based on the damage reduction benefits if 100 percent of these damages are used as benefits to economically justify the project. This analysis indicates that levee and floodwall raising is not likely to yield a favorable BCR at EJV due to these lower damages and potential for higher costs after concept designs account for contingencies related to mitigation of induced flooding impacts, operation and maintenance costs, cost escalation, and other factors. A comparison of supportable project costs with parametric costs is shown in Table 37. It is important to note that parametric costs do not account for induced flooding mitigation, real estate costs, or replacement of floodwalls and that no project is likely to reduce damages by 100 percent.

Table 37: Evaluation of the Focused Array of Alternatives for EJV

Proposed Alternative	Measure	Parametric Costs ($000)	Project supported, 100% reduction ($000)	Project supported, 50% reduction ($000)
EJV Alternative 1	No Action	0	0	0
EJV Alternative 2X: Levee and floodwall raising in Endicott, Johnson City, and Vestal	Raise all levees and floodwalls in EJV	$65,214	$43,655	$21,828

The PDT examined the FRM level currently provided by the non-Federal Mill Race levee in Oneonta to determine if additional system raising is needed. An examination of existing documentation and levee elevations against modeled water surface elevations for the 1 percent annual chance flood with 3 feet of freeboard indicated that the levee already reduces risk to National Flood Insurance Program (NFIP) levee accreditation standards. However, the levee ties-into the Interstate-88 highway embankment, which may not meet NFIP standards due its pervious foundation so a levee may be needed to tie-in to the Mill Race levee. A closure is also needed on Main Street at the location of the Interstate-88 overpass to prevent flooding from Main Street. HEC-FDA modeling has also been updated and run for Oneonta resulting in negligible flood damage reductions benefits in this area. USACE is recommending that the closure structure on Main Street be investigated under USACE technical assistance programs to include surveying, hydrologic analysis using existing models, and preliminary design for this closure.

The PDT examined raising the existing berm along Owego creek and building a new levee and floodwall to protect downtown Owego upstream to the Brick Pond area. The estimated length of levee is 2.3 miles with 1 mile of floodwall to be constructed. A permanent closure structure is needed at 5th Avenue. Cost estimates do not include the costs of mitigating induced flood impacts at this stage of analysis, nor does it include real estate easements. Therefore, costs are considered low. The cost of the project is estimated to be $55.1 million. HEC-FDA modeling has been updated and run for

Owego. If 100 percent of damages are used as benefits, the project may be economically supported with a BCR of 1.72. However, at 50 percent of damages the project is not economically supported with a BCR of 0.86. It is important to note that as stated previously parametric costs do not account for induced flooding mitigation, interior drainage concerns, or real estate costs, and that no project is likely to reduce damages by 100 percent. The high project cost is not supportable under the Continuing Authorities Program Section 205. Based on the uncertainties present in this analysis, USACE technical assistant via Floodplain Management Services would be suitable to further analyze the feasibility of the proposed solution.

7.6.2 EVALUATION OF NON-STRUCTURAL MEASURES FOR ALL FOCUS RISK AREAS IN THE USRB

A preliminary evaluation of non-structural measures was completed for Binghamton, EJV, and 14 focus risk areas using HEC-FDA modeling. Two sets of preliminary analysis were conducted using this model: an evaluation of elevating the first floor elevation of residential structures and floodproofing non-residential structures up to the 1 percent AEP plus one foot, and an examination of buyouts of these same properties using the market value and a unit cost for structure removal. Results for this analysis are detailed in Appendix B Economics.

This preliminary economic evaluation of non-structural measures indicate favorable BCRs and net benefits in some of the reaches using both floodproofing/elevation and buyout approaches to flood damage reduction. Favorable reaches in the USRB are detailed in Tables 38 and 39. Further work is needed to reduce the level of uncertainty and improve confidence in these results including conducting field surveys of elevations, developing detailed cost estimates, and determining the most suitable non-structural measure for each structure in the reach. The results presented in these table are intended to inform recommendations for non-structural FRM work by USACE and other Federal and non-Federal actors using existing programs and authorities. Recommendations based on this analysis are detailed in Chapter 9.

Table 38: Reaches with potential for non-structural measures: floodproofing and elevation

Non-Structural Measures by Reach	Percent Damage Reduced	Annual Benefits ($000)	Annual Cost of Flood-proof Nonresidential ($000)	Annual Cost to Elevate Residential Structures ($000)	Total Costs ($000)	Net Benefits ($000)	BCR
Binghamton-1	77%	$146	$40	$34	$74	$72	2
Binghamton-2	35%	$493	$182	$179	$361	$132	1.4
Binghamton-7	92%	$536	$15	$358	$372	$164	1.4
Binghamton-12	83%	$702	$40	$51	$91	$611	7.7
Binghamton-15	93%	$269	$51	$94	$145	$125	1.9
Binghamton-16	98%	$863	$11	-	$11	$852	78.8
Conklin-2	95%	$2,558	$95	$1,507	$1,602	$956	1.6
Conklin-3	98%	$42,597	$212	$783	$995	$41,602	42.8
Kirkwood-1	92%	$7,354	$150	$681	$831	$6,524	8.9
Endicott-1	98%	$253	$7	-	$7	$245	34.6
Endicott-4	98%	$263	$11	-	$11	$253	24.1
Endicott-6	95%	$403	$7	-	$7	$396	55.2
Johnson City-1	48%	$31	$11	$9	$19	$11	1.6
Owego-1	94%	$1,282	$44	$519	$563	$719	2.3
Union-6	95%	$14	-	$9	$9	$6	1.7
Union-8	83%	$1,144	$106	$545	$651	$494	1.8
Union-10	88%	$23	$15	-	$15	$8	1.6
Vestal-6	66%	$1,294	$69	$9	$78	$1,216	16.6
Vestal-7	75%	$48	$11	$9	$19	$28	2.5
Greene-1	99%	$3,156	$40	$136	$176	$2,980	17.9
Greene-2	99%	$5,549	$36	$792	$828	$4,721	6.7
Norwich-1	99%	$18,566	$106	$1,984	$2,090	$16,476	8.9
Norwich-2	76%	$24,474	$66	$1,175	$1,241	$23,234	19.7

Table 39: Reaches with potential for non-structural measures: buyouts

Non-Structural Measures by Reach	Annual Benefits ($000)	Annual Buyout Costs ($000)	Total Buyout Cost ($000)	Net Benefits ($000)	BCR
Binghamton-7	$583	$574	$15,114	$9	1
Binghamton-12	$843	$164	$4,315	$679	5.1
Binghamton-14	$124	$97	$2,544	$27	1.3
Binghamton-15	$289	$178	$4,693	$111	1.6
Binghamton-16	$882	$15	$389	$867	59.8
Conklin-2	$2,676	$1,472	$38,802	$1,204	1.8
Conklin-3	$43,469	$1,086	$28,616	$42,383	40
Kirkwood-1	$7,950	$1,420	$37,410	$6,531	5.6
Endicott-1	$257	$18	$469	$240	14.5
Endicott-4	$268	$131	$3,439	$138	2.1
Endicott-6	$423	$292	$7,682	$131	1.4
Union-6	$15	$6	$153	$9	2.6
Union-8	$1,268	$690	$18,175	$578	1.8
Union-10	$25	$21	$544	$5	1.2
Union-14	$61	$58	$1,534	$3	1.1
Vestal-1	$283	$270	$7,123	$13	1
Vestal-7	$62	$42	$1,109	$20	1.5
Greene-1	$3,189	$221	$5,828	$2,968	14.4
Greene-2	$5,618	$683	$18,009	$4,935	8.2
Norwich-1	$18,566	$1,600	$42,167	$16,966	11.6
Norwich-2	$24,474	$1,386	$36,524	$23,088	17.7

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CHAPTER 8 AFFECTED ENVIRONMENT

The existing conditions of the USRB were examined to establish baseline conditions of the natural and built environments in the watershed. The USRB is characterized by narrow floodplains and rolling hills, with a majority of development in rural communities near rivers or in the metropolitan area of Greater Binghamton, where nearly a third of the watershed's population is concentrated. Almost 70 percent of the watershed is forested and an additional 25 percent of the lands in the watershed are agricultural. The USRB population and economic growth have declined in the last few decades. The USRB population has shrunk by 6 percent between 1970 and 2017 for the 5 county area. This pattern is expected to continue to decrease by an additional 4.7 percent by 2030 (see Appendix B Economics for more information). The USRB has also experienced a significant decline in manufacturing, an important historic industry in the basin. This chapter documents the existing conditions of the physical environment, habitats, plants, animals, communities, and the built environment.

8.1 STUDY AREA

The Upper Susquehanna River Basin covers much of south-central New York State. This drainage area includes parts of fourteen counties (Figure 43). Of these counties, Chenango, Otsego, Broome, Cortland, and Tioga Counties comprise the majority of the study area. The study area contains portions of two loosely-defined geographic regions of New York State. The southernmost counties of the study area lie in the eastern half of the region of southern New York immediately north of the Pennsylvania border classified by the New York Division of Local Government Services as the "Southern Tier". The Southern Tier is bounded on the east by the Catskill Mountains. Several of the northernmost counties in the study area in the Syracuse vicinity lie in what is typically called "Central New York." Definitions vary as to which counties lie in which region. Some counties of the study area lie in both regions.

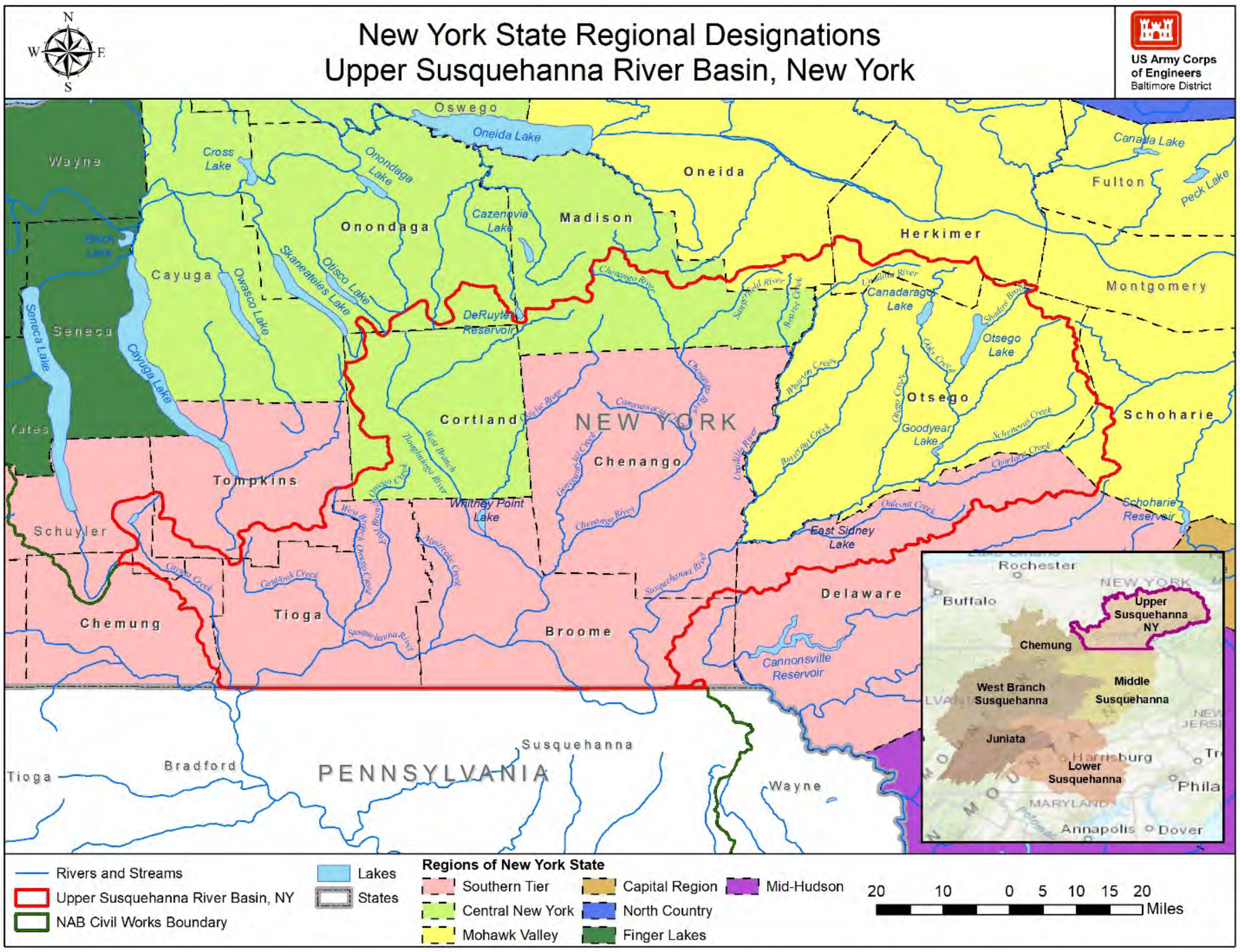


Figure 43: Counties in Study Area and Regional Geographic Affiliation

Because flooding problems for people occur primarily in valleys, and because of the FRM focus of the study, existing conditions information centers on conditions of stream valleys. However, the greater landscape is considered as appropriate to understand stream valley conditions.

8.2 PHYSIOGRAPHY AND TOPOGRAPHY

The majority of the study area is located within the Allegheny Plateau. The southeastern most portion of the study area lies in the Catskill Mountains. Both of these regions are part of the Appalachian Plateau physiographic province that stretches from Alabama to New York on the west side of the Appalachian Mountains (Cline and Marshall, 1977; Isachsen, et al., 2000).

The study area landscape is a plateau dissected by numerous rivers. The dip of rock layers causes low hills that run east-west across the western and central portion of the study area (Isachsen, et al., 2000). The Susquehanna River and major tributary rivers have valleys that are quite broad and commonly nearly level. The valley sides are steep in most areas (Otsego, 2007). The lowest elevation in the study area in NY, about 750 feet above sea level, occurs where the Susquehanna River flows south into Pennsylvania at Waverly, NY. At its confluence with the Chemung River, the Susquehanna River lies at about 730 feet above sea level. The highest parts in the watershed lie in the Catskills in the southeastern part of the watershed where elevations reach approximately 2,700 feet (USACE 2016; USGS, 2017).

The slope of the Upper Susquehanna River is approximately 2.5 feet per mile (ft/mi) with some portions exceeding slopes of 10 ft/mi. Wide and extensive flood plains are located at various reaches along the Upper Susquehanna River. The Susquehanna River makes several large sweeping turns. The Great Bend takes the Susquehanna River into Pennsylvania for approximately 15 miles before crossing back in New York (USACE, 2016).

8.3 GEOLOGY

Ancient sedimentary rocks (Devonian period) consisting principally of mudstone underlie the basin in New York state. Sandstone occurs along the New York-Pennsylvania state line in the southeastern part of the basin, and dominates the southeastern portion of the basin within Pennsylvania. Limestone occurs as the dominant surface rock northeast of Otsego and Canadarago Lakes, as well as at the northern headwaters of the Unadilla River. Limestone dominates at the surface locally also at the headwaters of the Otselic and East Branch Tioughnioga Rivers (SRBC, 2007). Sandstone and limestone also occur locally throughout the basin. Rock layers are typically horizontal, but dip gently southward. The entire study area was impacted by multiple glaciers, and glacial deposits occur throughout the study area. Massive glacial deposits occur in river valleys up to hundreds of feet thick. Moraines extend across the region on the landscape (i.e., not confined to the river valleys) in roughly east-west bands (Isachsen, et al., 2000). Large areas of glacial lake deposits occur in the western portion of the study area (Fullerton, et al., 1992). Where glacial deposits occur in stream valleys, they are typically an important natural source of sediment entering the streams (Nagle, et al., 2007; Williams and Reed, 1972).

Geologic materials extracted economically include gravels, salt, peat, clay (from shale), building stone, and paving stone (the latter both called bluestone) (Isachsen, et al., 2000). Sand and gravel are mined from surficial glacial deposits throughout the study area, while salt, peat, clay, and building stone are mined at select sites (Isachsen, et al., 2000). Natural gas is being mined from Marcellus and Utica black shale (rock) in New York. These rock formations occur in the study area. Although as of 2008, no natural gas wells were located in the study area, it is possible that natural gas wells could be developed in the study area in the future if allowed by state law (NYSDEC, 2010).

8.4 SOILS

The “General Soil Map of New York State” from 1977 depicts two different soil associations as being dominant along the Susquehanna River mainstem and larger tributaries. The Susquehanna River basin major rivers and streams upstream of Big Bend Pennsylvania, other than along the Unadilla River, is depicted as having Chenango and Blasdell soils. These soils formed from glacial outwash and deltaic sand. Otherwise, the river mainstem from the re-entry of the Susquehanna River back into NY State after the big bend down to its second exit from the state in Waverly, as well as along the Unadilla River, is depicted as having Howard Soils, which are Hapludalfs. Uplands (non-river valley areas) are depicted as possessing several soil associations, each of which occupy broad areas with gaps/transitions to other soil associations between.

Chenango-Tioga Association soils are found in valleys of major streams. The soils are deep and mostly well drained, although the flood plains include considerable poorly drained land. In the uplands of the basin bordering the major streams, Lordstown-Mardin Volusia Association Soils occur. These derive from glaciated till, gray shale, and sandstone. Under older terminology, these would be classified as moderate podsols. All have fragipans except Lordstown. Lordstown on the higher slopes is shallow, about 2 feet deep to compact till and 3 feet to bedrock, and is well drained. Mardin, on lower slopes, is about 18 inches deep to the fragipan and moderately well drained. Volusia is on the lower slopes and flats; it is somewhat poorly drained and shallow with a depth of 6 to 12 inches to fragipan. All soils are generally stony and flaggy (Lull Reigner, 1957).

Hydric soils are soils currently or historically wet enough to produce low oxygen conditions. Where not drained or filled, these soils naturally support wetlands vegetation. Hydric soils occur naturally in the study area in valleys along rivers and streams, in depressions formed by glaciers, and in seepage areas. The basin possesses more than 300,000 acres of mapped hydric soils, based on data downloaded from NRCS Soil Survey Geographic Database (SSURGO) in May 2017. Hydric soils constitute about 11 percent of the basin. Among the counties of the study area, Chenango County possesses the greatest portion of hydric soils in the basin at 16 percent while Broome County mapped soils within the basin consist of only 3 percent hydric soils (NRCS, 2017) .

Eroding streamside glacial deposits dominate sediment yield in many watersheds. Past human impacts to streams such as channelization have also resulted in high levels of bank erosion in many watersheds (Nagle, et al., 2007).

Soils mapped to occur in the watershed include a substantial area of soils classified as farmland soils (prime farmland and farmland of state importance) (USDA, 2017). These soils have combined physical and chemical characteristics best for producing crops and are also available for farming. Inclusion of soils on the important farmland list does not constitute a recommendation for a particular land use. The basin contains almost 3,000,000 acres of mapped notable farmland soils, based on data downloaded from NRCS Soil Survey Geographic Database (SSURGO) in May 2017.

Table 40: Mapped hydric soils by county in the Upper Susquehanna River Basin

County	Acres in Basin	Acres Mapped Hydric Soils in Basin	% of Area with Mapped Hydric Soils
Broome	410,953	11,098	3%
Chemung	35,202	1,272	4%
Chenango	574,249	89,102	16%
Cortland	294,791	42,174	14%
Delaware	197,442	11,581	6%
Herkimer	56,847	6,576	12%
Madison	201,180	28,211	14%
Oneida	30,145	3,885	13%
Onondaga	42,319	2,794	7%
Otsego	635,106	66,534	10%
Schoharie	26,253	3,034	12%
Schuyler	27,771	1,482	5%
Tioga	333,037	40,956	12%
Tompkins	64,767	5,209	8%
Entire Basin	2,930,063	313,908	11%

Table 41: Farm soils in study area.

County	Acres in Basin	Mapped acres prime farmland	Mapped acres farmland of statewide importance	Mapped acres prime farmland if drained	Mapped notable farm soils	% of area with mapped notable farm soils
Broome	410,953	23,029	252,579	1,008	276,616	67%
Chemung	35,202	2,497	18,009		20,505	58%
Chenango	574,249	87,339	297,083	6,560	390,982	68%
Cortland	294,791	52,665	150,657	577	203,898	69%
Delaware	197,442	15,532	95,750	309	111,592	57%
Herkimer	56,847	21,851	12,545	4,573	38,969	69%
Madison	201,180	30,867	104,381	1,990	137,238	68%
Oneida	30,145	4,638	12,094	1,603	18,335	61%
Onondaga	42,319	9,316	16,309	1,739	27,364	65%
Otsego	635,106	103,808	258,685	17,795	380,288	60%
Schoharie	26,253	821	10,469	68	11,357	43%
Schuyler	27,771	4,067	10,891	640	15,598	56%
Tioga	333,037	45,259	186,653	1,284	233,196	70%
Tompkins	64,767	2,292	39,548	47	41,888	65%
Total	2,930,063	403,981	1,465,651	38,195	1,907,827	65%

8.5 CLIMATE

The study area has a humid continental climate, with warm summers and long and cold winters. The humid continental climate is marked by variable weather patterns and a large seasonal temperature variance. Summers are often warm and humid with frequent thunderstorms, while winters can be very cold with frequent snow and persistent snow cover on the ground (National Climate Data Center; Wikipedia, 2017). The growing season ranges from as little as 123 days in the Catskill Mountains in the southeastern portion of the study area to as many as 143 days in the Binghamton area (Cline and Marshall, 1977).

Table 42: Normal temperature ranges for the region (Freeman and Nasuti, 2000)

Month	Minimum (°F)	Maximum (°F)
January	10 to 20	30 to 35
July	55 to 60	75 to 85

Precipitation is well distributed throughout the year. Annual precipitation in the subbasin ranges from less than 40 to greater than 50 inches per year, with the greatest annual precipitation occurring in the southeastern portion of the study area in the vicinity of the Catskill Mountains. Annual snowfall is typically 60 to 100 inches (Freeman and Nasuti, 2000).

8.6 AIR QUALITY

In light of the rural character of the basin, minimal urban or industrial pollutants are generated in the study area. Air pollution derived locally would be that arising from agriculture, transportation routes, and the limited urban centers of the study area.

Six criteria pollutants that can injure health, harm the environment and cause property damage are evaluated by the EPA to determine air quality in an area. The EPA calls these pollutants criteria air pollutants because the agency has developed science-based guidelines as the basis for setting permissible levels. There are National Ambient Air Quality Standards (NAAQS) for each of the criteria pollutants. These standards apply to the concentration of a pollutant in outdoor air. If the air quality in a geographic area meets or does better than the national standard, it is called an attainment area; areas that don't meet the national standard are called nonattainment areas and the air is more polluted than acceptable.

Non-attainment and maintenance areas for the six criteria pollutants are summarized in EPA's greenbook: https://www.epa.gov/green-book. A review of the geographic information provided in the greenbook identifies no counties within the Upper Susquehanna River Basin currently in nonattainment or maintenance status. Thus, the area is in attainment for criteria air pollutants.

8.7 HYDROLOGY

The Susquehanna River is the largest river east of the Appalachian Mountains in the USA, and the largest tributary of the Chesapeake Bay. The watershed occupies 4,520 square miles of New York State (excluding the Chemung River watershed) and 430 square miles in Pennsylvania. The study area contains three large subwatersheds (Table 43).

Table 43: USRB Subwatersheds (USGS HUC08)

Subwatersheds	Hydrologic Unit Code (HUC). U.S. Geological Survey (USGS), 8 digit
Chenango	02050102
Owego-Wappasening	02050103
Upper Susquehanna	02050101

The Susquehanna River originates at the outlet of Otsego Lake in Cooperstown, New York. The north branch of the river runs west-southwest, receiving the Unadilla River at Sidney and the Chenango in downtown Binghamton. Just south of Waverly, New York, in northern Pennsylvania, the Susquehanna River receives the Chemung River from the northwest. The upper Susquehanna River flows for approximately 170 miles before reaching the Chemung River. The Susquehanna River then flows south and southeastward further into Pennsylvania. The Upper Susquehanna River is fed by numerous tributary rivers and streams. Major tributary streams include Charlotte Creek, Ouleout Creek, Unadilla River, Chenango River, Tioughnioga River (being a tributary of the Chenango River), Nanticoke Creek, Owego Creek, and Cayuta Creek (USACE, 2016; SRBC, 2017; NYSDEC, 2017). The watershed contains 130 substantial lakes, ponds, and reservoirs which total 16,521 acres. Notable water bodies are presented in Table 44.

Table 44: Notable water bodies (SRBC, 2017 and NYSDEC, 2017)

Water Body	Size (acres)
Otsego Lake/Reservoir	4,083
Canadarago Lake	1,882
Whitney Point Lake/Reservoir	1,235

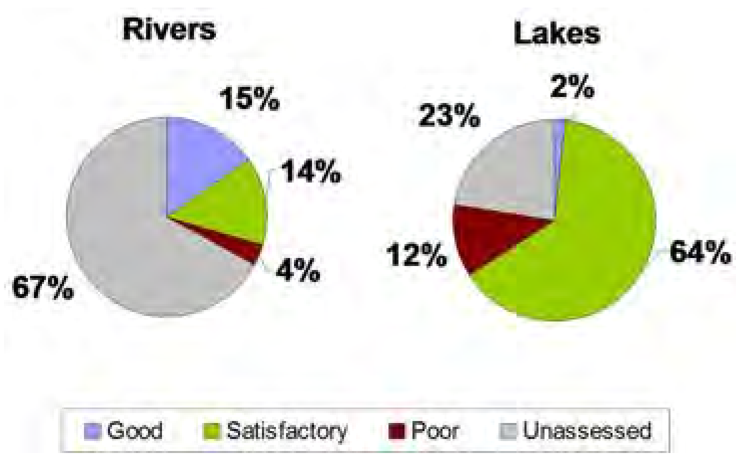
The basin contains 2 USACE major reservoirs and dams (Whitney Point and East Sidney), as well as 27 NRCS flood-control reservoirs on tributaries to the Susquehanna River upstream from the confluence with the Chemung River just south of Sayre, Pennsylvania. 20 of these reservoirs are located in Broome County, New York. Most of these facilities are designed to control runoff from a 1 percent annual chance storm. At flows greater than the design storm, auxiliary spillways pass flows around the dams. These reservoirs store substantial quantities of flood water until their capacity is reached (USGS, 2014). Whitney Point Dam has storage allocated to low-flow augmentation purposes (USACE, 2016).

There are over 250 artificial dams and reservoirs with storage values in excess of 50 acre-feet within the Upper Susquehanna River watershed. These dams were built for a variety of purposes including hydropower, water supply, and recreation, and are owned by local and state governments as well as private entities. The seven largest and most impactful dams (in terms of flows and stages at critical locations) include several structures along the Susquehanna River as well as numerous tributaries. Otsego Lake Dam creates Otsego Lake near Cooperstown, New York. With an approximate area of 4000 acres and a normal storage of over 345,000 acre-ft, Otsego Lake can affect runoff hydrographs to a large extent in the headwaters of the Susquehanna River. Colliersville Dam is located on the Susquehanna River slightly upstream of the Schenevus Creek confluence. Colliersville Dam is operated for run-of-river hydropower production. The Finch Hollow Dams within the Little Choconut Creek watershed were constructed by the National Resources Conservation Service (NRCS) to provide limited flood control to portions of Johnson City, New York. The Site 1 and Site 2 Dams directly impact flows and stages along the Johnson City, Endicott, and Vestal LFP system. Several other dams are operated solely for recreational purposes including Little York Dam and Upper Candor Dam (USACE, 2016).

High vegetation cover and low impermeable land area are characteristics of watersheds that typically reduce flood risk (USGS, 2016). Yet, the USRB is one of the most flood-prone basins in the country from a human perspective. In spite of the basin’s rural conditions with high percent forest and low percent impervious cover, people in the basin are concentrated in flood-prone locations that reflect historic settlement patterns (see Cultural and Historic Resources Section).

8.8 WATER QUALITY

In the Susquehanna Watershed in New York, water quality of about 33% of river/stream miles, and 77% of lake, pond and reservoir acres has been assessed. Waterbody Inventory/Priority Waterbodies List (WI/PWL) water quality assessment information is available online for waters of the USRB.



Good water quality: *Fully supports designated activities and uses.*
Satisfactory: *Fully supports designated activities, but with minor impacts.*
Poor (Impaired): *does not support designated activities and uses.*
Unassessed: *Insufficient data available.*

In the assessed water bodies of the Susquehanna River Watershed, water quality is generally classified as satisfactory (NYSDEC, 2004). The most widespread impacts are the result of agricultural and other nonpoint sources which contribute nutrients and sediment to the waters. Municipal wastewater discharges (including combined sewer overflows) are concerns in and around the Binghamton-Johnson City area. Inadequate wastewater treatment in some rural areas by means of on-site septic or smaller community systems has also been cited as contributing to water quality issues. Impacts from flooding are also a concern in this flood-prone area (NYSDEC, 2017).

Major water quality concerns in the watershed are documented by NYSDEC and include:

- Agricultural and other nonpoint sources of nutrients and various other pollutants
- Municipal wastewater and combined sewer overflow impacts in Binghamton-Johnson City area
- On-site septic and rural community wastewater treatment in areas without sewer systems
- Flooding impacts in the flood-prone Southern Tier of New York

Lakes, ponds, rivers and streams can be classified as either warmwater or coldwater. Waters classified as coldwater usually maintain a temperature below 70 degrees and provide ideal habitat for trout, salmon and other species that prefer lower temperatures. Warmwater lakes, rivers and streams get too warm for trout and salmon, but provide great habitat for fish species such as largemouth bass and chain pickerel. Some waters are deep enough that they have both warmwater habitat at the surface and deeper coldwater habitat that provides suitable conditions for a variety of fish species.

The Susquehanna River is the single largest source of nutrients to the main stem of the Chesapeake Bay. A substantial portion of these nutrient sources come from the USRB (Zhang, et al., 2016).

USE CLASSIFICATION OF WATERS

NYSDEC provides all waters of the state a class and standard designation based on existing or expected best use of each designated water or waterway segment. The Susquehanna River and its tributaries provide water to support a variety of human uses. Users of river water in the USRB include municipal water supply, manufacturing, and electrical generation. As of 2012 there were no natural gas extraction users of water in the basin. The Susquehanna River serves as the water supply for more than 40,000 people in the City of Binghamton (SRBC, 2013).

Table 45: Waters Use Classification

Classification	Waters Assigned
AA or A	source of drinking water
B	swimming and other contact recreation, but not for drinking water
C	supporting fisheries and suitable for non - contact activities
D	lowest classification and standard

Waters with classifications A, B, and C may also have a standard of (T), indicating that it may support a trout population, or (TS), indicating that it may support trout spawning. Special requirements apply to sustain these waters that support these valuable and sensitive fisheries resources. Small ponds and lakes with a surface area of 10 acres or less, located within the course of a stream, are considered to be part of a stream and are subject to regulation under the stream protection category of Protection of Waters. NYSDEC environmental resources mapper provides maps of stream class and standard designation. Table 46 presents stream class and standard designations (Environmental Resources Mapper).

Table 46: Susquehanna River main stem class and standard by segment in NY State (NYSDEC, 2017)

Segment	Class	Standard	Notes
Cooperstown downstream to NY State Line	B	B	Includes Unadilla, Sidney, Bainbridge, Oneonta, Colliersville, Milford. Ends at PA line
NY State Line to downstream of Corbettsville	B	B	
Downstream of Corbettsville to upstream of Appalachin	A	A	Includes Kirkwood, Binghamton, Johnson City, Endicott,
upstream of Appalachin to upstream of Owego	B	B	
upstream of Owego to downstream of Owego	C	C	Owego vicinity
Downstream of Owego to PA line	B	B	Includes Nichols

Table 47: Tioughnioga River Main stem class and standard by segment, Chenango Forks up to Lisle (NYSDEC, 2017)

Segment	Class	Standard	Notes
Entire	B	B	Does not include Whitney Point Reservoir which is C Class and C Standard

Table 48: Chenango River up to Greene class and standard by segment (NYSDEC, 2017)

Segment	Class	Standard	Notes
Greene downstream to Confluence with Susquehanna River main stem	B	B	

Table 49: Unadilla River from South New Berlin to Confluence with Susquehanna River main stem (NYSDEC, 2017)

Segment	Class	Standard	Notes
South New Berlin to Confluence with Susquehanna River main stem	B	B	Includes Mt Upton

Table 50: Ouleout Creek (NYSDEC, 2017)

Segment	Class	Standard	Notes
Downstream of East Sidney Lake to Unadilla	C	C	
East Sidney Lake	B	B(T)	
Franklin downstream to East Sidney Lake	C	C(T)	

8.9 AQUATIC HABITATS

8.9.1 STREAM HABITAT

The majority of the rivers in the USRB are free-flowing along most of their length other than in the vicinity of the dams (see Hydrology section). The free-flowing rivers contain riffle-run-pool-glide habitats. Riffles are shallow, high-gradient channel units with moderate current velocities and are characterized by some partially exposed substrate. Runs and glides are characterized by relatively shallow water that flows over a variety of substrates that lack turbulence. Runs are associated with downstream sections of riffles as they lose velocity. Glides are associated with the downstream section of pools as they gain velocity entering a riffle. Pools are deep, low gradient, low velocity stream units. The rivers possess streambanks and shorelines seasonally or perennially devoid of vegetation where vegetation is prevented from growing by ice and water scour, substrate instability, duration of exposure/inundation, or other factors. Where conditions are suitable, shoreline vegetation becomes established seasonally or perennially as discussed in the vegetation section below (TNC, 2010).

Larger rivers and streams have been channelized by government agencies to provide FRM benefits to riverine communities. Flood walls and levees have been constructed near many cities to confine the larger rivers and reduce flood damage. Additionally, many smaller streams have been channelized and bermed by landowners and government agencies to protect farm fields and structures. The result of these alterations has been a simplification of stream habitat and reduction in the amount of functional flood plain in the basin. Throughout the basin, excess sediment from historic and ongoing human activities degrades stream habitats (NYSDEC, 2005).

8.9.2 WETLANDS

Existing wetlands and open waters habitat mapped by the National Wetlands Inventory (NWI) were used to determine existing wetland and water acres. The results are displayed in Table 51 below. The study area possesses 101,558 acres of mapped wetlands and 33,676 acres of mapped waters. The waters include both natural and manmade water bodies. The wetlands are presumably predominantly natural features, but are often affected by altered hydrologic regime. An additional 643 acres of farmed wetlands and unconsolidated shoreline (largely unvegetated) are known to occur in the study area. Quality control studies of NWI mapping find that wetlands and waters mapped by the NWI generally exist on the landscape. In contrast, quality control studies find that additional wetlands not mapped by the NWI also exist. Thus, generally the NWI can be considered an underestimate of existing. Wetlands occur widely distributed in floodplains in the study area, as well as throughout the landscape in glacial deposits.

Table 51: Wetlands and waters of the study area as mapped by NWI (2010)

Wetland Type	Acres
Freshwater Emergent	28,942
Freshwater Forested/Shrub	72,616
Total	101,558
Water Body Type	**Acres**
Freshwater Pond	11,094
Lake	14,776
Riverine	7,807
Total	33,676

Urban areas located within the active or historic floodplain often have parcels of mapped vegetated wetlands, although larger wetland parcels are typically located upstream and downstream of the urban area rather than in the urban area itself. This pattern presumably occurs because historic wetlands in urban areas were filled in the process of urbanization. Wetlands occur in open space parcels rather than in the built portions of urban areas. Open space corridors often occur along major streams and rivers.

WETLANDS LOSSES

No studies were located in preparation of this reconnaissance report that document specific historic wetlands losses in the study area. Dahl (1990) reported that New York State has lost approximately 60% of the wetlands that were historically present prior to European settlement. Hydric (wetland) soils can retain their wetland character for a substantial period of time after a wetland is destroyed. USFWS NWI data generally provides a minimum estimate of existing wetlands (i.e., more wetlands exist than are captured on NWI maps). A comparison of hydric soil data from the NRCS to wetlands and waters data of the USFWS thus provides a means to roughly estimate maximum wetlands losses that have occurred in the study area since European settlement. The study area now possesses 130,666 acres of hydric (wetland) soils that do not possess wetlands or water bodies mapped by the NWI. Accordingly, at this time it is roughly estimated that a maximum of about 65% of historic wetlands of the study area have been lost since European settlement. About 60,000 of these acres occur in the flood plain, while an additional area of about 60,000 acres occurs in depressions outside of floodplains. In light of the predominant rural character of the study area, these losses have been presumably mostly from ditching and filling of land to improve it for agricultural use. However, losses in settled floodplains have also presumably occurred from urbanization and infrastructure.

8.10 VEGETATION

8.10.1 SUBMERGED AQUATIC VEGETATION (SAV)

SAV can occur within portions of a stream that are permanently inundated during the growing season. SAV requires flows that maintain inundation during the growing season, as growth rates are particularly sensitive to decreases in river stage that expose leaves and stems. One of the Susquehanna River basin’s most abundant SAV species is riverweed. Riverweed is a perennial found in moderate to high velocity riffles. Extensive populations have been documented in many tributaries and mainstem reaches within the Susquehanna basin (TNC 2010).

. . UPLAND VEGETATION

Natural upland vegetation of the region is principally forest, with both conifers (cone-bearing) and deciduous dicots being abundant. Typical tree species include white pine and northern hardwoods. In sites where soils are too wet, dry, or disturbance too frequent or severe, shrubs and grasses may dominate. Forests of the USRB are predominantly maple-beech-maple, with lesser areas of white pine-red pine-jack pine, and oak hickory (Freeman and Nasuti, 2002).

8.11 FISH AND WILDLIFE

8.11.1 AQUATIC ANIMAL LIFE

New York State Department of Environmental Conservation conducts monitoring of macroinvertebrates as an indicator of overall stream biological condition in streams throughout the state of New York. NYSDEC (2004) compiled summary data for macroinvertebrate data collected in the state over the period 1972 and 2002, including 120 stations that had been sampled one or more times in the USRB. Macroinvertebrates in most of the basin show no impacts ("non-impacted") of impairment by degraded water, indicating that water quality in the majority of the basin is good. However, reaches do occur along many waterways where resident macroinvertebrates are slightly to moderately impacted, indicating impaired water quality in those reaches.

According to the 2005 Comprehensive Wildlife Strategy for New York State, the Upper Susquehanna sub-watershed contains a high number of mollusks and insects taxa, and a moderate number of fish taxa. Reports were located that presented finfish of headwater streams and select subwatersheds of the basin (Kraft, 2006; SRBC, 2015).

Information was also located on occurrence of brook trout which live only in cold clean waters of headstreams (Trout Unlimited, 2017). No report was located that presented results of recent sampling from larger streams of the basin. However, Kraft et al 2006 has range occurrence maps for fish species in NY State. These maps were used to generate a list of fish species occurring in the basin, and to identify species typical of the larger rivers.

According to the 2005 Comprehensive Wildlife Strategy for New York State, four species of fish are identified that are on the “Species of Greatest Conservation Need” statewide list: blackchin shiner, heritage-strain brook trout, comely shiner, and swallowtail shiner.

Although stream macroinvertebrates are healthy in much of the Upper Susquehanna River Basin today, the region contributes substantial nutrients that are exported downstream to the detriment of Chesapeake Bay.

Hellbender were apparently never very common in USRB but have declined in numbers. Excess sedimentation is thought to be a principal stressor (Quinn, 2009).

. WILDLIFE

The rural character of the study area supports wildlife typical of the northeastern United States. The NY Department of Environmental Conservation website provides substantial information on wildlife of the state. The Comprehensive Wildlife Conservation Strategy for New York contains a chapter on wildlife of the Susquehanna River Basin. New York Nature Explorer online tool provides a means to identify habitats, plants, and animals in areas of interest throughout NY State. Included in Nature Explorer are the rare plants, rare animals, and significant natural communities (such as forests, wetlands, and other habitat types) documented by the Natural Heritage database; birds documented during the second NYS Breeding Bird Atlas from 2000 to 2005; and reptiles and amphibians documented during the NYS Herp Atlas from 1990 to 1999.

The USRB with its large expanse of rural lands and extensive forest, supports mammals typical of natural habitats of the region, including black bear, coyote, beaver, gray squirrel, red squirrel, northern flying squirrel, striped skunk, red fox, gray fox, raccoon, woodchuck (groundhog), bobcat, river otter, eastern cottontail, chipmunk, porcupine, opossum, muskrat, and raccoon. Urban areas support wildlife associated with urban areas, including starling, house sparrow, pigeon, Norway rat. Urban areas also support wildlife species tolerant of people, including gray squirrel, raccoon, possum, and skunk (Freeman and Nasuti, 2002)

The National Audubon Society has identified areas of particular importance to birds to focus conservation efforts (National Audubon Society, 2007; Nature Serve, 2018). Three important bird areas (IBA) considered state priorities are located in the USRB (Table 52).

Table 52: Audubon NY-State Important Bird Areas

Audubon Important Bird Area	County	Notes
Cannonsville/Steam Mill	Broome, Chenango, Delaware	Minor part of this IBA extends into USRB in Catskills. Primarily in Delaware River Watershed.
Tioughnioga River/Whitney Point Reservoir	Broome/Cortland	Reservoir and adjacent lands to Tioughnioga River, as well as upstream along Otselic River.
Pharsalia Woods	Chenango	High elevation forests and open farmland.

8.12 ENDANGERED AND THREATENED SPECIES

USACE requested a review of endangered and threatened species in the watershed using the USFWS IpaC website in April 19, 2017. The IpaC reports four federally listed species that could be found in the USRB; one mollusc, one reptile, and two bats.

The Northern long-eared bat (*Myotis septentrionalis*) has not been confirmed during the winter or summer in the study area as of 2016 (NYSDEC, 2016). The Indiana bat (*Myotis sodalis*) is confirmed to occur in the study area. Females congregate in nursery colonies, only a handful of which have ever been discovered. These were located along the banks of streams or lakes in forested habitat, under the loose bark of dead trees. Both sexes congregate in winter hibernacula located in caves or old mines (NYSDEC, No Date). Massasauga (*Sistrurus catenatus*), a swamp rattlesnake, could possibly occur in the study area, but none were reported over the period of 1990-2007 during which data was compiled for the state (NYSDEC, No Date).

The Dwarf wedgemussel (*Alasmidonta heterdon*) is mapped to occur in the southeastern part of the USRB in the Catskills vicinity. Typical habitat for this mussel includes running waters of all sizes, from small brooks to large rivers. Bottom substrates include silt, sand and gravel, which may be distributed in relatively small patches behind larger cobbles and boulders. The river velocity is usually slow to moderate. Water pollution, including sediments and chemicals from agriculture and other development projects such as golf courses, have been implicated in the mussel's decline. Also, impoundments and channelization may have eliminated the mussel from former habitat (NYSDEC, No Date). No critical habitat is mapped for any of these species in the watershed (USFWS IPaC, see Annex 1 Environmental Annex).

The USFWS 12/7/2016 coordination letter also lists the plant northeastern bulrush *(Scirpus ancistrochaetus,* Endangered) as occurring in the watershed. The USFWS ECOS website indicates that northern bulrush is present in Steuben County, which is outside of the study area, but doesn't identify any other counties in the state that that plant occurs in.

The New York State Comprehensive Wildlife Conservation Strategy Plan provides a list of species of greatest conservation need in the basin as of 2005, which include endangered/threatened species in the basin, and general overview of rare species and habitat types.

8.13 LAND USE AND LAND COVER

The 2005 Comprehensive Wildlife Conservation Strategy for New York provides a summary of land use and land cover in the basin derived from USEPA and Chesapeake Bay Program data. According to EPA data, the upper Susquehanna River Basin is 70% forest, 27% agricultural lands, and 2.5% developed. The Chesapeake Bay Program estimated impervious surfaces in the watershed to be 0.63% in 2000.

Following European settlement, forest lands were cleared for timber, charcoal, and to create farmland (Stranahan, 1993; Brush, 2009). By the late 19th century, the basin was 90% cleared. Forest cover increased over the 20th century as farmland was abandoned and underwent natural reforestation (NYSDEC, 2005; Meade and Trimble, 1974).

Large population centers and urban land occur in the municipalities of Binghamton, Cortland, Johnson City, Oneonta, and Endicott. However, overall the watershed is rural in character. The rural population is dispersed throughout the basin in small villages. Forest land dominates steeply sloped hills and ridges. Agricultural operations occupy the valleys. (SRBC, 2017; NYSDEC, 2009).

8.14 CULTURAL AND HISTORICAL RESOURCES

8.14.1 CULTURAL RESOURCES

The Chenango Canal was a towpath canal built and operated in the mid-19th century that extended 97 miles along the Chenango River from Binghamton at its southern end to Utica at its northern end. The route it followed roughly aligns with what is today Route 12 N-S. It operated from 1834 to 1878 and provided a significant link in the water transportation system of the northeastern U.S., connecting the Susquehanna River to the Erie Canal. Much of the channel was subsequently filled in, and frequently paved over, particularly within the cities and the more populated areas. In many places the canal path became the roadbed for streets, and its path can be traced by the roads which replaced it. These include Binghamton's State Street and Chenango Street, NY Route 5, NY Route 8, NY Route 12 and NY Route 12B. But some of the more isolated stretches of the canal were simply closed and abandoned (Wikipedia, 2017).

A western extension, commonly known as the Extension Canal, was begun in 1840. The extension continued west along the south side of the Susquehanna River as far as Vestal. (Vestal is on the south border of the county and is west and southwest of Binghamton). In the original plan, the Chenango Canal was supposed to connect the Erie Canal with the Pennsylvania Canal, but the connecting canals in the southern part of the state and in northern Pennsylvania were never fully completed nor totally operational. This canal was begun at the close of the canal era, and the canal era ended before the line could be completed (Wikipedia, 2017).

. HISTORICAL RESOURCES

Following European settlement, extensive movements of Native Americans occurred in response to pressures from European settlers as well as other Native American tribes that were relocating. This area may have been home to more than one tribe in the years following European settlement.

There are no Native American reservations within the study area, although reservations occur immediately outside of the study area to the north in Onandaga and Oneida Counties (Onondaga and Oneida Nations, respectively). The Onondaga Nation website contains maps depicting a large portion of the study area as lying within Onondaga Nation Aboriginal Territory, and claims this land as belonging to the Onondaga People (Onondaga Nation, 2016). This claim was dismissed by the U.S. Supreme Court in 2013. According to New York State Office of Parks and Recreation and Historical Preservation map "Indian Nation Areas of Interest for Tribal Consultation Purposes Only," several Native American Nation Areas of Interest occur in the study area, in north-south oriented bands these are from west to east Seneca, Cayuga, Onondaga, Oneida, and Mohawk.

Concentrated settlement historically occurred in the study area in valleys along rivers as these were natural transportation corridors for people (trails and water-borne initially, followed by roads, canals, and railroads), opportunities for developing water power for milling, and flat easily-settled land suitable for farming or towns. Important regional towns developed in these settings include Binghamton, Cortland, Norwich, and Oneonta.

8.15 TRANSPORTATION AND NAVIGATION

The USRB is crossed by Interstates 81, 86, and 88. These highways follow major valleys along much of their length. Numerous state highways also cross the study area. There is no current passenger railroad service in the basin, although historically many urban areas were connected by passenger rail. The Greater Binghamton Airport is the primary commercial airport lying within the basin. However, people in the basin utilize commercial airports outside of the study area, particularly Ithaca Tompkins Regional Airport and Syracuse Hancock International Airport.

Initially, natural waterways served as means to ship logs down river in log drives in the first half of the 19th century. Rafts on the rivers also provided a means of downstream transportation at that time. The Chenango Canal in 1836 connected the Erie Canal at Utica to Binghamton and caused a business boom in the Chenango River valley. The Chenango and Chemung canals linked the Erie with the Susquehanna River system. The Chemung Canal connected the south end of Seneca Lake to Elmira in 1833, and was an important route for Pennsylvania coal and timber into the canal system. (Wikipedia, 2017). The Chenango Canal was a towpath canal that was built and operated in the mid-19th century in Upstate New York. It was 97 miles long and for much of its course followed the Chenango River, from Binghamton on the south end to Utica on the north end. It operated from 1834 to 1878 and provided a significant link in the water transportation system of the northeastern U.S., connecting the Susquehanna River to the Erie Canal (Wikipedia, 2017).

Railroads reached Binghamton and towns of the study area in the mid-19th century, following the valleys of the Susquehanna and Chenanango Rivers. Binghamton became an important regional transportation hub (Wikipedia, 2017).

8.16 INFRASTRUCTURE

. .1 WATER SUPPLY

Water use from rivers is covered in the stream subsection. Deposits of sand and gravel in the valleys provide productive aquifers. Where sand and gravel deposits are absent, bedrock aquifers throughout most of the basin occur in fractured shale and sandstone. Carbonate bedrock aquifers (limestone and related rocks) occur only in a small area in the northern part of the basin (USGS, 2012).

8.17 WILD AND SCENIC RIVERS/AMERICAN HERITAGE RIVERS

There are no designated rivers of the National Wild and Scenic Rivers System in the USRB (National Wild and Scenic Rivers System, 2017), nor are there designated American Heritage Rivers in the USRB (USEPA, 2017). New York State maintains a state system of designated "Wild, Scenic and Recreational Rivers" (NYSDEC, No Date). However, no river segments listed in the state program are listed as occurring in the USRB.

8.18 RECREATION

Whitney Point Dam and East Sidney Dam maintain conservation pools that provide water-oriented recreation opportunities such as fishing, swimming and boating as well as picnicking and camping (USACE, 2016).

The Susquehanna River flows through a mix of rural and urban communities and has many numerous public river access points with places for cars to park. The Susquehanna River is navigable by non-motorized recreational boats from its origin at Otsego Lake to the final exit from New York 30 miles, west of Binghamton, with much of it being slow-moving (Trails.com, 2017). These access points are mapped on the NYSDEC “places to fish” website, where information on launching opportunities and boat size is provided.

The waters of the study provide recreational fishing opportunities. Depending on water body size and depth, anglers fish from boats, wading, ice, or shore. Numerous smaller streams support cool water species such as trout, while larger rivers support warmwater fish such as smallmouth bass, walleye, northern pike, muskellunge, yellow perch, black crappie, pumpkinseed sunfish, bluegill, rock bass, brown bullhead, channel catfish, common carp, fall fish, and white sucker. NYSDEC stocks many of the lakes and streams of the study area. Information on recreational fishing is presented at the NYSDEC “Central New York Fishing” website (NYSDEC, 2017).

8.19 PUBLIC SAFETY

Flooding is the primary natural hazard in New York State. The area is also vulnerable to severe winter storms (Broome County, DMA 2000 Hazard Mitigation Plan Update – February 2013). There are 20 FRM projects in the basin.

The principal causes of floods in the Eastern United States are hurricanes and storms. Widespread riverine flooding can occur when excessive runoff from long lasting rainstorms and sometimes from melting snow causes a water-level rise over a large area. Floods also can be caused by ice jams on a river. Flash floods occur when runoff from excessive rainfall causes a rapid rise in the stage (water height) of a stream or normally dry channel. Flash floods are more common in areas with a rocky terrain because lack of soil or vegetation allows torrential rains to flow overland rather than infiltrate into the ground. Flash floods generally cause greater loss of life, and widespread river floods generally cause greater loss of property (USGS, 2016).

8.20 SOCIOECONOMIC AND DEMOGRAPHIC INFORMATION

Major population centers include Binghamton, Johnson City, Endicott, Cortland and Oneonta. Population estimates, socioeconomic, and demographic information is summarized in Appendix B Economics.

Broome County has a distinctive development pattern that consists of a densely populated urban core with associated suburban fringe, narrow transportation corridors that follow the river valleys, rural village points, and open spaces found in the rural areas. The development patterns of the county were initially defined by the county's step slopes and fertile river valleys. Native Americans and early European settlers utilized the rivers for navigation and used the valley soils for farming. The urban core of the community first formed around the confluence of the Chenango and Susquehanna Rivers and then spread along the river valleys. As development increased, roads, canals, and railroads were constructed in the river valleys that connected Broome County communities with the remainder of New York State and the contiguous United States. The construction of the Erie Canal, which spanned the northern tier of the State, initiated the building of a canal roughly following the Chenango River's course. The Chenango Canal operated in the mid-19th century and cut shipping times between the Cities of Binghamton and Albany. It also connected the growing manufacturing base with the port of New York City via the Hudson River. By 1848, railroads reached the County. Industrial development in the river valleys flourished due to the rail lines. Today, rail lines remain an important means of transportation for high volume industrial users (Broome County Comprehensive Plans, 2012).

CHAPTER 9 CONCLUSION AND RECOMMENDATIONS

The USRB study investigated the feasibility of FRM measures to reduce damages in communities in the basin. The PDT conducted preliminary analyses and screening of an initial array of alternatives for 17 areas with high relative flood risk, identified during the watershed screening. Following a meeting with local stakeholders in March 2018, the PDT developed a focused array of alternatives for four areas (Binghamton, EJV, Oneonta, and Owego) using initial alternatives that met all screening criteria and had local support. Additionally, the PDT completed preliminary non-structural analyses for all 17 areas identified in the watershed screening.

The focused array of alternatives were evaluated using HEC-FDA modeling and concept design costs, or parametric costs, where concept designs were not available. The economic evaluation, detailed in Section 7.6, resulted in a negative economic justification for the primary structural alternatives examined, including raising of the Binghamton FRM project and the Endicott-Johnson City-Vestal FRM project.

Reconnaissance-level analysis was also completed for Oneonta and Owego. The analysis for Oneonta that evaluated a structural alternative for raising the non-Federal Mill Race levee, indicated that the existing levee elevations meet the 1 percent chance flood event with adequate freeboard. However, the community expressed a need for technical assistance to address issues with backflow along a bridge and a needed closure along Main Street at the location of the Interstate-88 overpass. USACE recommends that the technical analysis needed for the closure and backflow issue in Oneonta be investigated under technical assistance programs. Reconnaissance-level analysis for Owego has not been completed, however further analysis under technical services programs is warranted. The cost of a project would exceed USACE CAP 205 limits and therefore would not be appropriate for that program.

The preliminary analyses of non-structural measures detailed in this report indicate potentially favorable BCRs associated with non-structural measures in some riverine reaches and jurisdictions in the USRB. These potential projects are relatively small in nature and not appropriate for consideration in this effort. The estimated BCRs and net benefits in these areas should be investigated further under USACE technical assistance programs or other existing programs to determine if implementation under CAP Section 205 or by other State or Federal entities is justified.

Based on the findings presented in this report and associated appendices, the USACE PDT has concluded that construction of a Federal FRM project by USACE is not recommended under this study authority at this time. The PDT has compiled a list of recommendations for work by USACE and other Federal or non-Federal stakeholders under existing programs and authorities included in this Chapter.

The PDT provides the following recommendations for potential action by USACE under existing programs or authorities, based on discussions with the project sponsor and local stakeholders;

1. Provide technical assistance via Floodplain Management Services to the City of Owego to further analyze the feasibility and uncertainties of the proposed levee, floodwall, and berm raising, which are cost prohibitive for investigation under the Continuing Authorities Program.
2. Provide technical assistance via Floodplain Management Services to the City of Oneonta to address the need for a closure at Main Street and an automatic check valve on the Interstate 88 culvert to prevent backflow issues
3. Providing technical assistance to the Village of Endicott with issues related to a drainage structure in the Federal FRM system
4. Provide technical assistance to the Village/Town of Bainbridge for streambank erosion issues at Clinton Park along the Susquehanna River and shoaling at the confluence of Yaleville Creek along the Susquehanna River
5. Provide technical assistance to the Village of Afton for culvert evaluation and design
6. Provide technical assistance to the Village of Greene for stream stabilization and issues related to shoaling downstream of the existing Federal FRM project, along the state maintained portion of Birdsall Creek

Additionally, the PDT recommends additional analysis and evaluation of non-structural measures in areas with identified high risk. The preliminary analysis presented in this report indicates that non-structural measures are a possible avenue for Federal involvement in flood damage reduction through existing programs including FEMA's Hazard Mitigation Grant Program. The effort for implementing non-structural measures in the USRB is already being led by state and local stakeholders as part of the New York Rising Community Reconstruction Program. USACE is dedicated to support these flood damage reduction efforts, including through technical assistance programs, CAP, and other existing programs and authorities.

CHAPTER 10 FLOOD RISK MANAGEMENT PROGRAMS AND AUTHORITIES

The USACE is dedicated to working with the State of New York and appropriate local stakeholders in developing and implementing solutions to reducing flood hazards by combining and coordinating agency resources, including funding, programs, and technical expertise. The purpose of this section is to provide an overview of the Federal, state, and interagency FRM programs available to local communities and the public to address flood hazards.

10.1 U.S. ARMY CORPS OF ENGINEERS (USACE) PROGRAMS

Mission: Provide vital public engineering services in peace and war to strengthen our Nation's security, energize the economy, and reduce risks from disasters.

USACE is authorized by Congress to study, plan, and implement FRM projects that benefit the country through the various Flood Control Acts and Water Resources Development Acts. In addition to the various Upper Susquehanna general investigation studies previously authorized by Congress (this study included), USACE can support FRM through the CAP authorities, technical assistance programs, and various planning and engineering services to states and local jurisdictions.

10.1.1 USACE CONTINUING AUTHORITIES PROGRAM (CAP)

https://www.nab.usace.army.mil/Missions/Civil-Works/cap/

The CAP is a group of legislative authorities that allows USACE to plan, design, and implement water resources project without the need to obtain specific Congressional authorization for each project, detailed in Table 53. A sponsoring agency, which may be a state, county, tribe, or other group, must request assistance and agree to cost share in project costs in excess of $100,000 for most authorities.

- **Emergency Stream Bank and Shoreline Protection, Section 14** - Provides for protection of public facilities/services and historic properties in imminent danger of damage by natural stream or shoreline erosion.
- **Flood Damage Reduction, Section 205** - Provides for local FRM by the construction or improvement of flood management projects.
- **Aquatic Ecosystem Restoration, Section 206** - Provides for restoration of degraded aquatic ecosystem structure, function, and dynamic processes to a less degraded, more natural condition
- **Snagging and Clearing for Flood Damage Reduction, Section 208** - Provides for local FRM by channel clearing and excavation, with limited embankment construction by use of materials from the clearing operation only
- **Project Modifications for Improvements to the Environment, Section 1135** - Provides for improving environmental quality through modifications to Corps structures and operations of Corps structures or implementation of measures in affected areas

Table 53: Continuing Authorities Program Authorities applicable to USRB

Program	Authority	Feasibility Cost Share Federal / Non Federal	Implementation Cost Share Federal / Non Federal	Federal Project Limit	Operation and Maintenance Costs
Emergency Stream Bank and Shoreline Protection, Section 14	Section 14, 1946 Flood Control Act, as amended	100% / 0% for initial $100,000; 50% / 50% remaining cost	65% / 35% [1]	$5,000,000	100% Non-Federal
Flood Damage Reduction, Section 205	Section 205, 1948 Flood Control Act, as amended	100% / 0% for initial $100,000; 50% / 50% remaining cost	65% / 35% [1, 2]	$10,000,000	100% Non-Federal
Aquatic Ecosystem Restoration, Section 206	Section 206, 1996 Water Resources Development Act, as amended	100% / 0% for initial $100,000; 50% / 50% remaining cost	65% / 35%	$10,000,000	100% Non-Federal
Snagging and Clearing for Flood Damage Reduction, Section 208	Section 208, 1954 Flood Control Act, as amended	100% / 0% for initial $100,000; 50% / 50% remaining cost	65% / 35% [1]	$500,000	100% Non-Federal
Project Modifications for Improvements to the Environment, Section 1135	Section 1135, 1986 Water Resources Development Act, as amended	100% / 0% for initial $100,000; 50% / 50% remaining cost	75% / 25%	$10,000,000	100% Non-Federal

1 - For structural flood damage reduction purpose, non-Federal share is 35% up to 50% (based on cost of LERRDs), plus 5% must be in cash.

2 - For non-structural flood damage reduction purpose, non-Federal share limited to 35%, with no 5% cash requirement.

10.1.2 USACE PLANNING ASSISTANCE TO STATES (PAS) PROGRAM

https://www.nab.usace.army.mil/technical-services/

Section 22 of the Water Resources Development Act (WRDA) of 1974, as amended, provides authority for USACE to assist the states, local governments, Native American Tribes, and other non-Federal entities in the preparation of comprehensive plans for the development and conservation of water and related land resources. The needed planning assistance is determined by the individual non-Federal sponsors.

Typical studies are for only the planning level of detail; they do not include detailed design for project construction. Examples of projects include water quality studies, water supply and demand studies, and dam safety studies.

The PAS program is funded annually by Congress and each state or tribe is limited to $5,000,000 annually, but typically receives much less. Individual studies are cost shared on a 50 percent Federal/50 percent non-Federal basis (can include work in-kind). WRDA 2014 enables non-Federal contributions to exceed 50 percent Federal/50 percent non-Federal through voluntary contributions to develop comprehensive water resource plans.

10.1.3 USACE FLOOD PLAIN MANAGEMENT SERVICES PROGRAM (FPMS)

https://www.nab.usace.army.mil/technical-services/

Section 206 of the 1960 Flood Control Act (PL 86-645), as amended, provides the authority for USACE to provide assistance and guidance on all aspects of floodplain management planning at full federal expense.

The program allows USACE to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods, and general criteria for guidance in the use of floodplain areas. USACE can provide engineering advice to local interests in planning to reduce the flood hazard. Upon request, program services are provided to the state, regional, and local governments, Native American Tribes, and other non-Federal public agencies without charge. Per Section 202 of WRDA 1999, USACE may accept funds voluntarily contributed by sponsors for the purpose of expanding the scope of the services.

10.1.4 USACE NATIONAL LEVEE SAFETY PROGRAM

https://www.nab.usace.army.mil/Home/Levee-Safety-Program/

The National Levee Safety Program assesses the integrity and viability of levees and recommends actions to assure that levee systems do no present unacceptable risk to the public, property, and the environment. The program aims to achieve three goals:

1) Reduce risk and increase public safety through an informed public
2) Develop a clear national levee safety policy and standards

3) Maintain a sustainable FRM system that meets public safety needs

National Levee Database
https://levees.sec.usace.army.mil/

The National Levee Database (NLD) is a storehouse of information for the nation's levee infrastructure. The NLD contains comprehensive information to facilitate and link activities including flood risk communication, levee system evaluation for the National Flood Insurance Program (NFIP), levee system inspections, flood plain management, and risk assessments.

10.1.5 USACE INSPECTION OF COMPLETED WORKS (ICW) PROGRAM

Section 221 of the Flood Control Act of 1970, as amended, requires that a written agreement be executed between the Secretary of the Army and the non-Federal sponsor to identify the "items of local cooperation" for USACE projects, including operation and maintenance of FRM projects (levees, floodwalls, etc.). ICW eligible projects are federally authorized and locally maintained. To determine whether the non-Federal sponsor is performing as it has agreed, (i.e. doing required maintenance), USACE undertakes an inspection of the completed projects. Projects that meet inspection criteria are eligible for Federal rehabilitation funds if damaged in a flood event.

This program helps to ensure USACE's familiarity with the projects through inspections and monitoring to address any future project modifications, repairs, or rehabilitation. The ICW program is authorized by Engineer Regulation (ER) 1130-2-530, dated Oct 30, 1996, Flood Control Operations and Maintenance Policies.

10.1.6 USACE REHABILITATION AND INSPECTION PROGRAM (RIP)

https://www.nab.usace.army.mil/Missions/Emergency-Operations/

The USACE Rehabilitation and Inspection Program provides for inspection of flood control projects, the rehabilitation of damaged flood control projects, and the rehabilitation of federally authorized and constructed hurricane or shore protection projects.

Inspections of non-Federal Flood Control Works (FCWs) are accomplished under provisions of Public Law 84-99 (PL 84-99). The RIP assures sponsor compliance with existing agreements that the structures and facilities constructed by the United States, or eligible projects constructed by non-Federal governmental entities, for flood protection and/or hurricane and shore protection will be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits. Failure of local government to properly maintain such projects may result in a determination of ineligibility for Federal assistance to rehabilitate a storm-damaged project.

Projects initially constructed by the Corps, including hurricane and shore protection projects, and turned over to the local sponsor for maintenance are inspected under authority of the Inspection of Completed Works (ICW) program. Should an eligible project require rehabilitation as a result of damage from a significant flood or storm event, project rehabilitation would be accomplished under PL 84-99 provisions.

There are two ways for a flood control/protection project to be included in the RIP:
1) Non-federally constructed flood control works
2) Federally constructed/locally maintained flood control works

Flood control and Hurricane/Shore Protection projects in an active status at the time of a flood or storm event may receive Rehabilitation Assistance under the authority of PL 84-99. An active status is maintained by proper project maintenance and the correction of deficiencies identified during periodic inspections.

Rehabilitation Assistance can be provided on a cost shared bases for non-federally constructed projects (currently 80% Federal/20% non-Federal). Projects initially constructed by USACE and properly maintained are eligible for 100% Federal funding for repairing the project to its pre-storm condition. Local sponsors will be required to assume any rehabilitation cost of a damaged active project attributable to deferred maintenance.

10.1.7 USACE GENERAL INVESTIGATION (GI)

These are congressionally authorized studies under USACE's Civil Works program. Congress can authorize USACE to study, design and construct major FRM projects. The feasibility study is cost shared 50/50 and construction is cost shared 65/35 between the Federal government and non-Federal sponsor. These are generally large scale projects that cost more than $10 million. Congress can also authorize USACE to conduct other water-related studies/projects such as watershed assessments, ecosystem restoration and navigation improvements.

10.2 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) PROGRAMS

Mission: FEMA's mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.

10.2.1 FEMA FLOOD MITIGATION ASSISTANCE (FMA)

https://www.fema.gov/flood-mitigation-assistance-grant-program

The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NRIP. FMA is a pre-disaster grant program that is a State-administered, cost-shared program. FEMA provides FMA funds to assist states and communities in implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program. Three types of grants are available:

1) Planning grants to states and communities to develop or update flood mitigation plans
2) Project grants to states and communities to implement measures to reduce flood losses
3) Management cost grants for the state to help administer the FMA program and activities. Up to ten percent (10%) of project grants may be awarded to states for management cost grants.

Communities that have flood mitigation plans can request approval of their plans from their FMA state point of contact (POC) and FEMA. Approved plans make a community eligible to apply for FMA project grants. Plans must assess flood risk and identify actions to reduce that risk. Any state agency, participating NFIP community, or local organization is eligible to participate in FMA. Communities that are suspended or on probation from the NFIP are not eligible for FMA.

FEMA may contribute up to 75% of the total eligible costs. At least 25% of the total eligible costs must be provided by a non-Federal source. There is a $20 million limit to the amount of assistance that any one state can receive from FMA in a 5-year period; however, in the event that a disaster is declared as a result of flooding, FEMA has the authority to waive the assistance limits.

For severe repetitive loss (SRL) homes, FEMA will pay 100% of eligible costs; for repetitive loss (RL) properties, FEMA will pay up to 90% of eligible costs but as in years past, NFIP increased cost of compliance (ICC) funds cannot be used to make up the local 10% match.

10.2.2 FEMA NATIONAL FLOOD INSURANCE PROGRAM (NFIP)

https://www.fema.gov/national-flood-insurance-program

Since standard homeowners insurance does not cover flooding, in 1968 Congress created the NFIP to help provide a means for property owners to financially protect themselves. There are three components of the NFIP:

1) Flood insurance
2) Floodplain management
3) Flood hazard mapping

The NFIP offers flood insurance to homeowners, renters, and business owners if their community participates in the NFIP. Flood insurance protects two types of insurable property – building and contents.

NFIP is a Federal program and the rates are set so there is no difference from company to company or agent to agent. Mortgage lends for all Federal and Federally-backed loans require flood insurance if the property is in a Special Flood Hazard Area (SFHA). SFHA is land within the floodplain of a community subject to a 1 percent or greater chance of flooding in any given year, otherwise known as the 100-year flood. These rates do depend on many factors, which include the date and type of construction of your home, along with your building's level of risk. In order to qualify for flood insurance, a community must join the NFIP and agree to enforce sound floodplain management standards.

Floodplain management is the operation of a community program of corrective and preventative measures for reducing future flood damage, such as zoning, and rules for building in floodplains. Flood hazard mapping provides information to communities about risks involved in building in a flood hazard area and provides data to actuarially rate new construction for flood insurance. Claims and expenses of the NFIP are funded by insurance premiums, not tax dollars.

10.2.3 FEMA COMMUNITY RATING SYSTEM (CRS)

https://www.fema.gov/national-flood-insurance-program-community-rating-system

The NFIP Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

1) Reduce flood losses
2) Facilitate accurate insurance rating
3) Promote the awareness of flood insurance

The CRS classes for local communities are based on 18 creditable activities, organized under four categories:

1) Public information
2) Mapping and regulations
3) Flood damage reduction
4) Flood preparedness

Each participating community receives a designated point value based on each creditable activity. Class ranking is assigned by credit points and flood insurance premium rates are then discounted based on rank. Premiums are discounted in increments of 5%; i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount (a Class 10 is not participating in the CRS and receives no discount).

10.2.4 FEMA HAZARD MITIGATION GRANT PROGRAM (HMGP)

https://www.fema.gov/hazard-mitigation-grant-program

The Hazard Mitigation Grant Program (HMGP) provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster.

The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Funds may be used to protect either public or private property or to purchase property that has been subjected to, or is in danger of, repetitive damage. Examples of projects include, but are not limited to, acquisition of real property for willing sellers and demolition or relocation of buildings to convert the property to open space use (otherwise known as a FEMA Buy-Out); retrofitting structures and facilities to minimize damages from high winds, earthquake, flood, wildfire, or other natural hazards; and elevating of flood prone structures.

Hazard Mitigation Grant Program funding is only available to applicants that reside within a presidentially declared disaster area. FEMA funds up to 75% of the eligible costs of approved projects and the remainder must come from the non-Federal sponsor.

10.2.5 FEMA PRE-DISASTER MITIGATION (PDM) PROGRAM

https://www.fema.gov/pre-disaster-mitigation-grant-program

The Pre-Disaster Mitigation (PDM) program provides funds to states, territories, Native American tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these hazard mitigation plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations.

A FEMA-approved hazard mitigation plan, whether new or upgrade of an existing plan, is required for the grant. Ineligible projects include major flood control projects, studies that do not result in a project (i.e. feasibility studies), flood studies, and warning and alert notification systems. PDM grants are to be awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds. Generally the cost share is divided 25% non-Federal, 75% Federal; small, impoverished communities may be eligible for up to 90% Federal cost share.

10.2.6 FEMA PUBLIC ASSISTANCE (PA) GRANT PROGRAM

https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit

The purpose of the Public Assistance (PA) Grant Program is to provide assistance to state, tribal and local governments, and certain types of private nonprofit organizations so that communities can quickly respond to and recover from major disasters or emergencies declared by the President. Through the PA Program, FEMA provides supplemental Federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations.

The PA Program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process. All projects are reviewed for Section 406 Hazard Mitigation fund eligibility. The Federal share of assistance is not less than 75% of the eligible cost for emergency measures and permanent restoration. The grantee (usually the State) determines how the non-Federal share (up to 25%) is split with the sub-grantees (eligible applicants).

Additional programs through FEMA can be found at the links below;

- **Individual Disaster Assistance Programs**: https://www.fema.gov/individual-disaster-assistance
- **Grant Programs**: https://www.fema.gov/grants
- **Community Service Programs**: https://www.fema.gov/community-services-programs

10.3 NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

NYSDEC interacts with USACE and serves as the non-Federal sponsor for federally-constructed FRM projects in the state. To initiate a project, a local municipality (and/or other governmental entity) must enter into a "local cooperation agreement" with NYSDEC. The non-Federal share of FRM design costs for an approved project can be funded up to 100% by NYSDEC. The non-Federal share of construction costs are generally divided equally between NYSDEC and the local municipality.

Both NYSDEC and the New York State Department of Homeland Security interact with FEMA and can provide assistance to local municipalities seeking to utilize FEMA programs.

In New York State the Department of Environmental Conservation is required by law (Article 16 Flood Control) to be the non-Federal sponsor in Federal FRM programs. For implementation the non-Federal cost of between 35% and 50% is split between the State and the local municipality. A minimum of 5% of the non-Federal share must be in cash with all remaining costs provided through in-kind contributions. The O&M costs are the responsibility by the municipality.

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