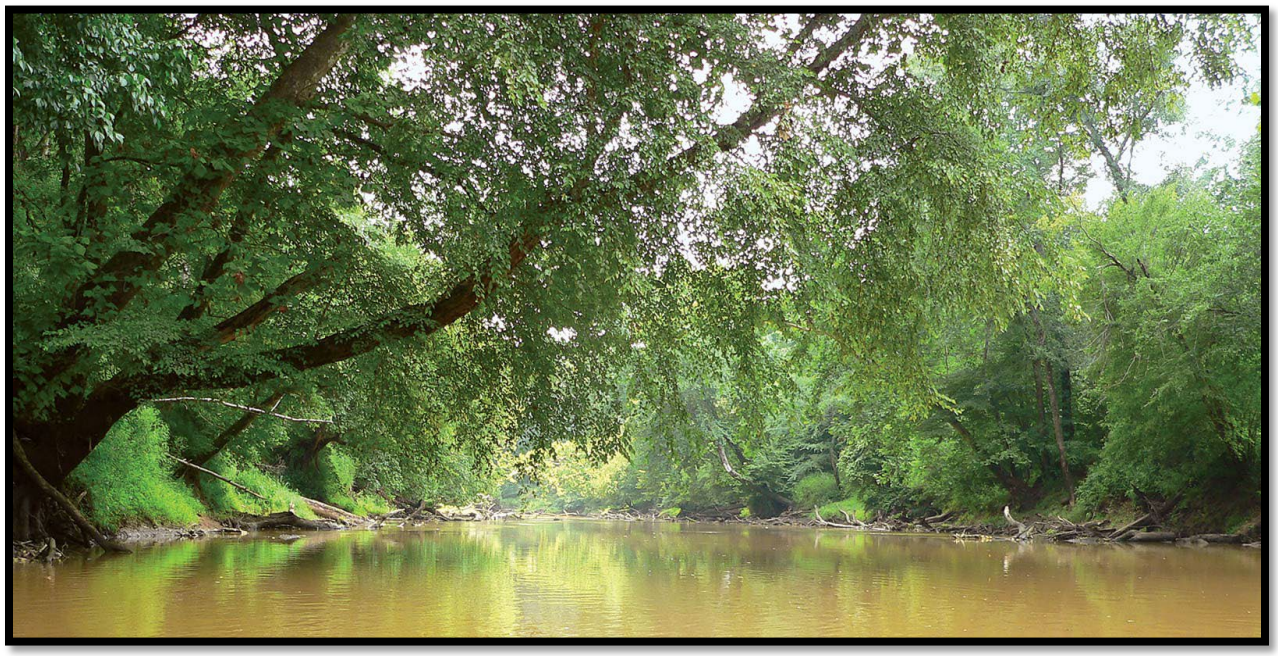
Tar-Pamlico River Basin Flood Risk Management

Integrated Feasibility Report and Environmental Assessment



June 2024

US Army Corps of Engineers
Pittsburgh District

DEQ NORTH CAROLINA

EXECUTIVE SUMMARY

1. Introduction

This Integrated Feasibility Report and Environmental Assessment (IFREA) was prepared by the U.S. Army Corps of Engineers (USACE) and describes alternatives and recommends federal actions to reduce risk and damages caused by flooding within the Tar-Pamlico River Basin in North Carolina.

The current study area is comprised of river reaches along the mainstem of Tar River and its major tributaries in North Carolina, beginning just downstream of Greenville, NC. The study originally included the region of the Tar River near Washington, as well as the area along the Pamlico River immediately downstream of Washington (Figure 1.1). However, through the course of the study, the region near Washington was determined to be affected primarily by coastal flooding. As coastal flooding mitigation was beyond the scope and authority of the current study, the regions affected by coastal flooding were removed from consideration. The remaining study area includes portions of 13 counties.

This IFREA is the result of the feasibility study—officially referred to as the Tar-Pamlico River Basin Flood Risk Management Feasibility Study and subsequently referred to here as the 'feasibility study'—authorized by the House Committee on Transportation and Infrastructure Resolutions adopted April 11, 2000 and May 21, 2003 to assess and recommend actions that reduce flood risk and increase resiliency within the Tar-Pamlico River Basin. The feasibility study was to be executed over a three-year period. The USACE Wilmington District brokered the feasibility study to the USACE Pittsburgh District. This IFREA details the results of the feasibility study and recommends actions that reduce flood risk and increase resiliency within the Tar-Pamlico River Basin. The non-Federal sponsor (NFS) is the North Carolina Department of Environmental Quality (NCDEQ). The Federal Cost Share Agreement (FCSA) was developed and signed at USACE Wilmington District on 8 April 2020.

2. Purpose and Need for Federal Action

Communities within the Tar-Pamlico River Basin have a long history of flooding during major rainfall and hurricane events. There is therefore a need to reduce flood risk in these communities. The purpose of this study is to evaluate plans that will reduce flood risk and increase resiliency within the Tar-Pamlico River Basin. Many communities within the basin have experienced major recurring flood events over the past 25 years associated with Hurricanes Fran (1996), Floyd (1999), Matthew (2016)—each of which ranking among the most destructive storms in state history and representing among the top four floods of record for major population centers within the basin (NCEM and NCDOT, 2018). Recurring flooding within the basin has resulted in considerable economic damages and increased life safety risks.

There is a need for federal involvement to address flooding concerns in the Tar-Pamlico River Basin because of the high level of hydraulic complexity in such a large watershed. The state has engaged in mapping, flood warnings, and other innovative efforts to provide support to stricken communities, and the federal effort will build on that foundation. Other federal and state

agencies have also leveraged programs to reduce flood risk here; however, a considerable amount of flood risk remains. Without federal assistance, the economic, technical, and environmental challenges posed by developing a comprehensive approach to managing flood risk in this dynamic system would have been out of reach.,

3. Plan Formulation

The USACE planning process, which was used in this study, follows the six-step process defined in the USACE Principles, Requirements, and Guidelines (PR&G) (USACE, 2013). This process is a structured approach to problem solving which provides a rational framework for sound decision making. The six-step process is used for all planning studies conducted by the USACE. A two-day virtual planning charrette was held on May 1 and 4, 2020. During the charette, the USACE study team (study team), local sponsor, and various stakeholders identified two main problems, economic damages resulting from riverine flood inundation and elevated risks to life safety associated with riverine flood inundation, that encompass numerous sub-problems. Discussions during the planning charrette resulted in the identification of numerous opportunities and the development of the following objectives: improved quality of life for individuals living within the floodplain; improved aquatic, riparian, and floodplain habitat quality within the study area; reduced water pollution inputs to the Pamlico River and Sound ecosystems; increased awareness of and preparedness for flood risk; increased resilience of communities throughout the study area; reduced life and safety risk for underrepresented and underserved communities; and enhanced recreational opportunities throughout the study area.

Constraints, or restrictions that limit the extent of the planning process, were identified during the planning charrette. The following study-specific constraint was identified: the Princeville, NC Flood Risk Management study and associated Chief's Report. That report recommended modifications to the existing levee system to further reduce flood risk within the Town of Princeville (USACE Wilmington District, 2016). That report's recommended plan was subsequently authorized for construction in the Water Resources Development Act (WRDA) of 2016. Given this ongoing effort, no additional measures specific to Princeville were assessed in the current study. This study must also adhere to general planning constraints that affect all USACE studies, including restrictions established by USACE policy and legal authority. The study team identified the following general policy constraints and planning considerations: induced development, existing flood risk management projects, transferred risk, environmental resources, and cultural resources.

During the planning charette, the study team, local sponsor, and relevant stakeholders developed a list of 11 general management measures that could potentially address the identified problems and realize the identified opportunities. Management measures are classified as either structural, nonstructural, or natural and nature-based measures. Structural measures reduce or avoid damages by modifying the nature and/or extent of the flood hazard. Potential locations for structural measures were identified using two separate strategies. Potential storage areas were considered throughout the study area to achieve local and downstream benefits, and specific locations for these measures were identified using aerial imagery and topography. Potential areas for implementing floodwalls and levees, channel improvements, and diversion channels were limited to the five major population centers, as these areas were the only areas with concentrated

damages to warrant location-specific structural measures. Nonstructural measures reduce or avoid damages by modifying the consequences of the flood hazard. Potential locations for nonstructural measures were identified using existing structure data and inundation grids for standard flood events (i.e., 10-, 25-, 50-, 100-, 200-, and 500-year events). Natural and nature-based measures alter, restore, use, or mimic natural landscape features or processes to manage flood risk. Natural measures were considered throughout the study area as appropriate.

The study team then identified a total of 81 specific and individual management measures that underwent a screening evaluation to determine whether they would be incorporated into the development of flood risk management alternatives. A summary of these measures is provided in Table 3.3. A detailed description of each measure can be found in Appendix A (Plan Formulation Appendix). During the screening process, management measures were evaluated based on completeness, effectiveness, efficiency, and acceptability, as outlined in the PR&G (USACE, 2013). Additional considerations for screening included environmental effects, environmental justice, and technical feasibility (Table 3.1).

Management measure screening was conducted iteratively in order to maximize efficiency. The first iteration of screening was conducted using existing data for the Tar-Pamlico River basin and existing models while the integrated, basin-wide hydrologic and hydraulic models were being developed for the current study. The secondary iteration was based on results of the basin-wide hydrologic and hydraulic model, and the application of those results to analysis of economic and life safety benefits.

Seventy-six (76) of the 81 measures were screened from further consideration. Structural measures retained for incorporation into plan formulation included two dry dams—one on Stony Creek and one on the Tar River. Nonstructural measures retained include structure elevation, floodproofing, and acquisition and relocation.

Alternatives were formulated using the cornerstone, or first added, formulation strategy. The initial array of alternatives consisted of three alternatives. For each alternative, one or more measures were identified as the cornerstone—or the single most important measures(s). Additional measures were then added to meet objectives not served by the cornerstone.

The initial array of alternatives was evaluated using the criteria shown in Table 3.4 to determine whether they should be screened, reformulated, or passed to the final array of alternatives.

Despite fewer environmental impacts as compared to reservoirs, dry dams would still have permanent impacts to critical aquatic habitats and associated threatened and endangered species along the Tar River and, thus, would require extensive environmental coordination and mitigation. Nonstructural measures, such as structure elevation and dry floodproofing, were also assessed as alternatives. Structure elevation consists of elevating a structure's habitable area above a specified flood elevation. Structure elevation could effectively reduce economic damages and life risk for structures impacted by flooding throughout the Tar River Basin. Dry floodproofing consists of waterproofing the entire structure or portions of the structure. Structures can generally be dry flood-proofed up to between 3 to 4 feet on the exterior walls. Dry floodproofing could effectively reduce economic damages and life risk for structures

impacted by flooding throughout the Tar River Basin. Ultimately, dry dams were screened out due to the significant environmental impacts and Alternative 3, which focuses on nonstructural measures, was reformulated into Alternative 3A and 3B.

Prior to reformulation of Alternative 3 (Nonstructural), the 716 structures originally included in Alternative 3 were reassessed with existing data and through visual surveys to remove structures with first floor elevations above the target elevation (i.e., 1% annual exceedance probability (AEP) elevation plus two feet) and those with existing nonstructural features. Structures were then aggregated based on river reach and hydraulic floodplain [i.e., 10%, 4%, 2%, and 1% AEP]. River reaches were further separated based on census tract to enable comparison of socioeconomic data and incorporation of socioeconomic and environmental justice considerations.

A total of 13 reaches and 155 structures were identified as either likely to have positive net economic benefits or as being among the most socially vulnerable communities within the basin (i.e., EJScreen demographic index above 70%).

The cost of acquisition and relocation across all structures was more approximately two times (approximately $200M) that of elevation and floodproofing (approximately $100M). Additionally, dry floodproofing and structure elevation was more efficient (higher net economic benefits) than acquisition and relocation across all reaches with positive net benefits (see Appendix B Economic Analysis for a detailed description of results and analysis). Therefore, the final array consisted entirely of dry floodproofing and structure elevation.

In accordance with USACE Policy Directive, Comprehensive Documentation of Benefits in Decision Document, dated January 5, 2021, Alternative 3 (Nonstructural) was reformulated such that the final array included both a plan that maximizes net national economic development (NED) benefits and a plan that maximizes net total benefits across all benefits categories [i.e., NED, regional economic development (RED), other social effects (OSE), and environmental quality (EQ)]. A summary of the final array of alternatives is provided below.

The final array of alternatives includes the following:

Alternative 1 - No Action:
The No Action Alternative assumes no measures would be implemented by the federal government to achieve the planning objectives.

Alternative 3A - Maximum Net Economic Benefits / NED Plan:
Alternative 3A includes elevation of 2 residential structures, elevation and flood venting of 1 residential structure, and dry floodproofing of 34 structures (Figure 3.9). Floodplain aggregation varied across the 7 reaches, ranging from the 10% to the 1% AEP floodplains (Table 3.6). Regardless of floodplain aggregation, structures would be elevated to the 1% AEP flood elevation plus 2 feet. Structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet but limited to a maximum height of 4 feet.

Alternative 3B - Comprehensive Benefits Plan:

Alternative 3B includes all 155 structures identified as being at-risk within the 1% AEP floodplain across 13 reaches. Alternative 3B includes elevation of 35 structures; flood venting of 8 structures; elevation and flood venting of 18 structures; and dry floodproofing of 94 structures (Figure 1.1; Table 3.7). Structures to be elevated would be elevated to the 1% AEP flood elevation plus 2 feet. Structures to be dry floodproofed would be dry floodproofed to the 1% AEP floodplain plus 2 feet but limited to a maximum height of 4 feet.

Both Alternative 3A and 3B meet federal objectives; however, contribution to objectives and avoidance of constraints for these were also evaluated. Additionally, alternatives were evaluated based on completeness, effectiveness, efficiency, acceptability, environmental justice (resilience), environmental justice (community cohesion), and environmental effects. Alternatives were also evaluated with respect to the Principles and Guidelines four accounts (i.e., NED, RED, OSE, EQ).

Alternative 3A has the greatest net economic benefits ($661,000) and BCR (1.48) and, thus, represents the NED Plan. Although Alternative 3A represents the NED plan, Alternative 3B represents the plan that reasonably maximizes benefits across all four accounts (i.e., NED, RED, OSE, and EQ). Therefore, Alternative 3B was selected as the recommended plan. The additional increment in study cost between Alternative 3A and 3B is primarily justified based on the OSE account due to the benefits associated with environmental justice. Alternative 3B incorporates an additional 118 structures—all of which are within communities that are identified as socially vulnerable, and therefore less resilient; or disadvantaged as defined by the EJScreen and/or the Climate and Economic Justice Screening Tool (CEJST) (Table 5.2). The identified communities have substantial expected annual damages under the "future without-project" (FWOP) condition. Taken together, these conditions emphasize the increased burden that flood risk places on disadvantaged communities, whereby the reaches are generally characterized by historically underserved populations with low income that also have increased vulnerabilities in the face of climate change. Thus, these represent among the least resilient communities within the basin. Alternatives 3B would improve community cohesion in the face of continued flood risk by helping to ensure that communities remain intact by providing equal assistance to all individuals, including those individuals that represent socially vulnerable and historically underserved populations. In doing so, Alternative 3B would promote and preserve diversity and equal opportunity within communities benefited by Alternative 3B.

4. Recommended Plan

As noted above, Alternative 3B is the recommended plan. The recommended plan maximizes benefits within the RED and OSE accounts. The recommended plan also maximizes, to the extent practicable, flood risk reduction benefits within vulnerable populations, including individuals living in poverty and minority populations. The recommended plan is the most equitable in terms of flood risk reduction by ensuring rural, socially vulnerable communities experiencing recurring and frequent flooding receive the same flood risk reduction opportunities as communities within the adjacent urban areas of Rocky Mount and Greenville, which have positive net economic benefits.

The recommended plan will have minimal environmental impacts and is an acceptable plan from an environmental standpoint. Specifically, the recommended plan will not significantly impact federally listed species, designated critical habitat, water quality, riparian habitat, essential fish habitat, or other sensitive aquatic and terrestrial species in the study area. The recommended plan can be implemented in compliance with all applicable environmental laws and regulations. The recommended plan will constitute an undertaking under Section 106 of the National Historic Preservation Act (NHPA) and has a potential to affect historic properties listed on, or determined eligible for, the National Register of Historic Places under 36 C.F.R. § 800.3. All compliance and mitigation requirements under Section 106 will be satisfied prior to project implementation.

The recommended plan includes all 155 structures identified as being at-risk within the 1% AEP floodplain across 13 reaches. Alternative 3B includes elevation of 35 structures; flood venting of 8 structures; elevation and flood venting of 18 structures; and dry floodproofing of 94 structures (Figure 6.1; Table 6.1). All structures would be elevated to the 1% AEP flood elevation plus 2 feet. Structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet, or a maximum height of 4 feet.

The project first cost for the recommended plan is $98,701,000, including $5,495,000 in lands, easements, rights of way, relocations, and disposal costs (LERRDs), $64,280,000 in construction costs associated with structure elevation and floodproofing, $19,605,000 in the Pre-construction, Engineering, and Design (PED) phase, and $9,321,000 in construction management. No mitigation will be required and, as such, there will be no mitigation costs associated with Alternative 3B.

Eminent domain authority will not be used to require landowners in this category to participate in the program; however, tenants who reside in structures to be elevated may be eligible for certain benefits in the accordance with Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs of 1970. Landowner participation in the recommended plan will be voluntary.

The Federal government is responsible for preparing and providing an Operations, Maintenance, Repair, Replacement & Rehabilitation (OMRR&R) manual to the sponsor as the final recommended plan is being implemented. OMRR&R costs associated with this recommended plan are considered ‘de-minimis’ (requiring only periodic surveillance by the NFS). Each individual property owner is ultimately responsible for maintenance of their elevated or floodproofed structure/home.

Residual risk represents existing, future, or historical risk that remains or might remain after an alternative has been implemented. The recommended plan would have residual risk of inundation and associated life safety risk for the remainder of the 3,042 structures within the 0.2% AEP floodplain that are not included in the plan. Furthermore, the recommended plan does not incorporate structures within smaller tributaries and headwaters to the Tar River and its major tributaries. The recommended plan would also have residual economic damages (i.e., traffic delays or detours) and associated life safety risks (i.e., community isolation and loss of access and egress) associated with inundation of transportation infrastructure throughout the watershed.

The recommended plan would also have residual risk associated with climate change over the next 100 years. Increases in the frequency and intensity of extreme rainfall events throughout the watershed could result in reduced performance of each alternative.

Identifying and managing risk is critical to making informed planning decisions in the face of uncertainty. However, some level of uncertainty will remain following any decision. Understanding and characterizing this remaining uncertainty is also critical as it can affect the outcome of any decision.

The recommended plan consists entirely of management measures with voluntary participation. Participation rates could affect the overall benefits achieved by each alternative and the amount of residual risk following implementation. Analyses undertaken to identify the recommended plan were based on visual surveys and existing data, including first floor elevations. Additional information and data obtained during subsequent projects phases could result in additional structures being incorporated or current structures being removed from each alternative.

All estimates are at the 2024 price level and may change due to inflation prior to construction. The NFS must provide self-certification of financial capability as required by USACE policy. Use of funds from other federal programs, including any non-federal contribution required as a matching share, to meet financial obligations of the NFS is not permitted unless USACE authorizes use of those funds in writing.

Project design and implementation costs are shared 80 percent federal and 20 percent nonfederal, in accordance with the results of an Ability to Pay analysis. The NFS is required to provide all LERRDs. Based on these requirements as outlined in Section 6.7, the estimated nonfederal contribution for the recommended plan is $19,704,000 which includes $3,921,000 for PED, $5,495,000 in LERRD costs, and $10,324,000 for construction and construction management.

5. Environmental Effects and Compliance

The recommended plan is environmentally acceptable. Coordination with resource agency representatives was initiated early in the study and there are not expected to be any impacts to threatened and endangered species and associated critical habitat. The recommended plan includes only nonstructural measures to structures located within the floodplain.

This IFREA complies with the National Environmental Policy Act (NEPA). A separate Environmental Assessment (EA) is not required because the IFREA is a fully integrated report that complies with both NEPA requirements and those of the USACE water resources planning process. All coordination required for compliance with Section 7 of the Endangered Species Act (ESA) has been completed for the recommended plan .

The recommended plan will have no effect on threatened or endangered species and critical habitat, and the USFWS has agreed that formal consultation is not necessary for this action. A Clean Water Act Section 401 Water Quality Certification will not be required for the proposed project. Additionally, any Hazardous, Toxic, and Radioactive Waste (HTRW) Phase 1

assessments that may be needed prior to structural elevation and floodproofing of individual structures as part of the recommended plan will be completed during the PED phase. During PED, if it's determined that an area of 1 acre or more would be disturbed, a Sediment and Erosion Control Permit and potentially a Storm Water Management Plan Permit would be obtained prior to start of construction. Erosion and sedimentation best management practices (BMPs) will be obtained by the NFS during construction to minimize sediment runoff. A summary of environmental compliance activities completed to-date is presented in Table 7.1. Tribal consultation was conducted with the following Federally-recognized tribes with ancestral ties in the Tar Pamlico study area: Catawba Indian Nation, Eastern Band of Cherokee Indians, Cherokee Nation, United Keetoowah Band of Cherokee Indians, and Monacan Indian Nation. Tribal consultation was also conducted with the following State recognized tribes: Haliwa-Saponi Indian Tribe, and Meherrin Indians. Additionally, the study team reached out to the North Carolina Commission of Indian Affairs. The Monacan Indian Nation and the Cherokee Nation responded to the invitation to consult but declined to enter formal consultation with the study team.

A Programmatic Agreement (PA) has been executed in accordance with 36 CFR 800.14(b)(3) that outlines the process to identify and evaluate historic properties and avoid, minimize, and where possible, mitigate for any adverse impacts in accordance with Section 106 of the National Historic Preservation Act (NHPA) and implementing regulations 36 CFR 800. The PA will allow the USACE to complete the necessary historic and archaeological surveys during the follow-on PED phase of the project, once the nonstructural measures and identified properties have been confirmed.

6. Public Involvement

The public and external agencies were involved throughout the study process, and were engaged through NEPA scoping notifications, public meetings, and public comment periods. Notable concerns expressed by the public/external agencies during the alternative plan evaluation included: 1) potential degradation of aquatic habitat resulting from implementation of structural measures in the basin, as the Tar-Pamlico River Basin exhibits extraordinary habitat and biodiversity; and 2) economic hardships that could be imposed on municipalities due to required implementation of stormwater and/or other infrastructure regulations. These concerns were considered in the selection of a recommended plan. The recommended plan was released for public comment on 2 November 2023. A virtual public meeting was held 16 November 2023. Comments received during the public comment period included comments from Pitt County, NC, the National Oceanic and Atmospheric Administration, and a citizen of NC. Generally, concerns expressed during the public comment period included: 1) That non-structural measures are insufficient to reduce flooding, and that structural measures are necessary, and 2) Using tax-payer dollars to elevate existing structures does not maintain the cohesiveness of the community, but rather increases the costs and risks associated with rescue operations that occur during flooding events and makes continued residence in these locations more difficult for residents; buyouts and relocations were recommended as the preferred solution.

7. Recommendation

The study team recommends Alternative 3B, the Comprehensive Benefits Plan. Federal implementation of the recommended plan would also be subject to NFS compliance with applicable federal laws and policies.

This study and the associated recommended plan maintain the USACE commitment to environmental stewardship by conforming to USACE Environmental Operating Principles.

The NFS, represented by the North Carolina Department of Environmental Quality, has expressed support of the recommended plan. A letter of intent acknowledging the NFS's intent to support implementation of the recommended plan is included with the final report.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

ACRONYMS	DEFINITIONS
ACS	American Community Survey
AEP	Annual Exceedance Probability
APE	Area of Potential Effect
BBF	Benefits-based Floor
BCR	Benefit Cost Ratio
BMP	Best Management Practice
CEJST	Climate and Economic Justice Screening Tool
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHAT	Climate Hydrology Assessment Tool
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
EA	Environmental Assessment
EAD	Expected Annual Damages
EF	Eligibility Factor
EJ	Environmental Justice
EOP	Environmental Operating Principles
EPA	Environmental Protection Agency
EQ	Environmental Quality
ER	Engineering Regulation
ESA	Endangered Species Act
FCSA	Federal Cost Share Agreement
FEMA	Federal Emergency Management Agency
FWCA	Fish and Wildlife Coordination Act
FWOP	Future Without Project
FY24	Fiscal Year 24
GIS	Geographic Information Systems
HEC-F4DA	Hydrologic Engineering Center's Flood Damage Reduction Analysis
HTRW	Hazardous, Toxic, and Radioactive Wastes
IFR	Integrated Feasibility Report
LERRD	Land, Easements, Rights-of-Way, Relocation, and Disposal
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
NAAQS	National Ambient Air Quality Standards
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation

NCDWR	North Carolina Division of Water Resources
NCEM	North Carolina Emergency Management
NED	National Economic Development
NEPA	National Environmental Policy Act
NFS	Non-Federal Sponsor
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
OMRR&R	Operations, Maintenance, Repair, Replacement and Rehabilitation
OSE	Other Social Effects
PDT	Project Delivery Team
PED	Pre-construction Engineering and Design
PM	Particulate Matter
RED	Regional Economic Development
SHPO	State Historic Preservation Office
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VAT	Vulnerability Assessment Tool
WRDA	Water Resources Development Act

This page has been intentionally left blank

1. INTRODUCTION

In response to recent flooding associated with Hurricanes Matthew (2016) and Florence (2018), the U.S. Army Corps of Engineers (USACE) received $3M through the 2019 Additional Supplemental Appropriations for Disaster Relief Act (Actions - HR2157 - 116th Congress (2019-2020), 2019) for the feasibility study detailed in this integrated feasibility report and environmental assessment (IFREA), subsequently referred to here as the 'feasibility study'—to assess and recommend actions that reduce flood risk and increase resiliency within the Tar-Pamlico River Basin. The feasibility study was to be executed over a three-year period. The USACE Wilmington District brokered the feasibility study to the USACE Pittsburgh District. This IFREA details the results of the feasibility study.

The local sponsor is the North Carolina Department of Environmental Quality (NCDEQ). The Federal Cost Share Agreement (FCSA) was developed and signed at USACE Wilmington District on 8 April 2020, and USACE Pittsburgh District subsequently began the feasibility study.

1.1. USACE Planning Process

The USACE planning process, which was used in this study, follows the six-step process defined in the USACE Principles, Requirements, and Guidelines (PR&G) (USACE, 2013). This process is a structured approach to problem solving which provides a rational framework for sound decision making. The six-step process is used for all planning studies conducted by the USACE. The six steps are:

- Step 1 - Identifying Problems and Opportunities
- Step 2 - Inventorying and Forecasting Conditions
- Step 3 - Formulating Alternative Plans
- Step 4 - Evaluating Alternative Plans
- Step 5 - Comparing Alternative Plans
- Step 6 - Selecting Recommended Plan

USACE decision making is generally based on the accomplishment and documentation of all these steps. It is important to stress the iterative nature of this process. As more information is acquired and developed, it may be necessary to reiterate some of the previous steps. The six steps, though presented and discussed in a sequential manner for ease of understanding, usually occur iteratively and sometimes concurrently. Iterations of steps are conducted as necessary to formulate efficient, effective, complete, and acceptable plans.

The structure of this report generally follows these six steps. This IFREA includes an integrated Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA).

1.2. Study Authority

The feasibility study was authorized by the House Committee on Transportation and Infrastructure Resolution adopted April 11, 2000 and the House Committee on Transportation and Infrastructure Resolution adopted May 21, 2003, which respectively state:

"Resolved by the Committee on Transportation and Infrastructure of the United States of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Tar River, North Carolina, transmitted to Congress on January 29, 1947, 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 and related purposes for the Tar River basin, North Carolina."

"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Division Engineer dated January 29, 1947, and the report of the Chief of Engineers on Eastern North Carolina above Cape Lookout, North Carolina dated February 10, 1992, and other pertinent reports to determine whether modifications to the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, environmental restoration and protection, and related purposes for the Tar Basin and its estuarine areas including Pamlico Sound."

The feasibility study conforms to USACE Policy Guidance on Implementation of Supplemental Appropriations in the Bipartisan Budget Act of 2018, dated 9 August 2018 (James, 2018). The feasibility study also follows guidance provided in Planning Bulletin 2018-01(S) Feasibility Study Milestones Supplemental Guidance, dated 20 June 2019 (Bush, 2019), which supplements Planning Bulletin 2018-01 and applies to all feasibility studies resulting in a Chief's or Director's Report recommending project authorization.

1.3. Study Area (Planning Area)

The Tar-Pamlico River Basin drains approximately 5,570 square miles and originates in Person and Granville counties, flowing from the Piedmont to the outer Coastal Plain of the Atlantic Ocean. The Tar River is a freshwater river from its headwaters to Washington, NC. East of Washington, the river name changes to the Pamlico River and becomes a coastally influenced estuary that empties into the Pamlico Sound. Major tributaries of the Tar River include Fishing Creek, Swift Creek, Little Fishing Creek, Town Creek, Conetoe Creek, Chicod Creek, Tranters Creek and the Pungo River. There are several major population centers within the basin that include (from upstream to downstream) Rocky Mount, Tarboro, and Greenville. These communities, along with rural areas throughout the basin, have experienced major flooding events over the past 25 years associated with widespread heavy rains resulting from hurricanes.

The current study area is comprised of river reaches along the mainstem of Tar River and its major tributaries in North Carolina, beginning just downstream of Greenville, NC. The study originally included the region of the Tar River near Washington, as well as the area along the Pamlico River immediately downstream of Washington (Figure 1.1). However, through the course of the study, the region near Washington was determined to be affected primarily by coastal flooding. As coastal flooding mitigation was beyond the scope and authority of the current study, the regions affected by coastal flooding were removed from consideration. The remaining study area includes portions of 13 counties.

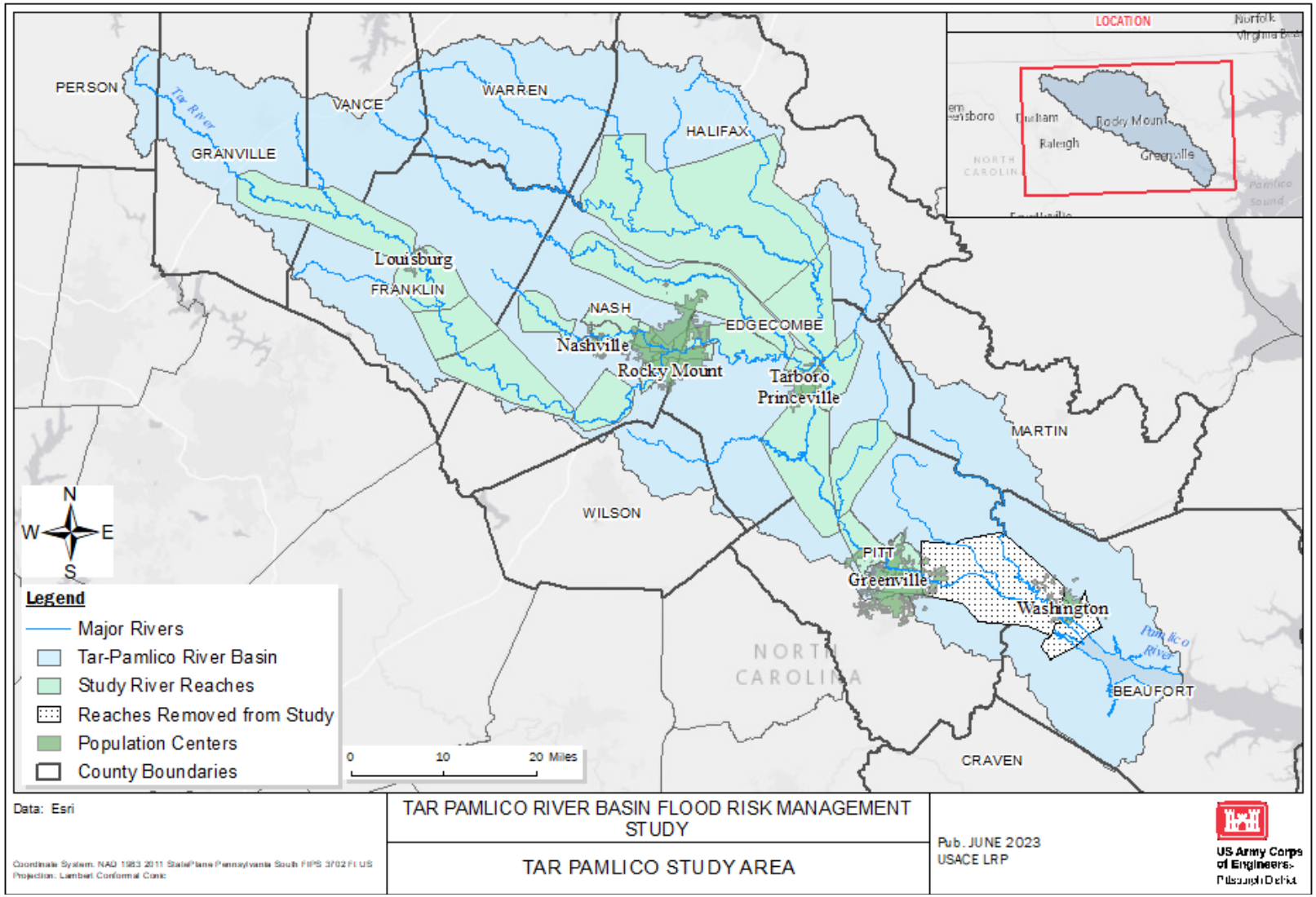


Figure 1.1. Location of the study area within North Carolina. The study area is comprised of river reaches along the mainstem of Tar River and its major tributaries, beginning just downstream of Greenville, NC. Counties, major population centers, rivers, and study "reaches", (delineated based on similar hydromorphology, hydraulic characteristics, and economic considerations) are shown. Regions affected by coastal flooding (stippled areas on map) were removed from consideration.

1.4. Background and History

This section describes the flood history of the study area. In addition, this section provides information about relevant prior efforts to examine and mitigate flood risk.

1.4.1. Flood History

Throughout the past 25 years, several communities along the Tar, Neuse, Lumber, and Cashie Rivers have experienced significant flooding impacts due to Hurricane Fran (1996), Floyd (1999), and Matthew (2016). The riverine flooding associated with these hurricanes resulted in severe damage to properties and infrastructure, as well as loss of life. The most impactful hurricane was Hurricane Matthew. In North Carolina, an estimated 100,000 structures incurred damages, 800,000 homes were without power, and at least 25 people lost their lives.

Flooding within the study area results from major rainfall events associated with hurricanes and non-hurricane storm systems. Past flood events within the Tar River Basin have impacted thousands of structures and caused over $100,000,000 in associated damages (NCEM and NCDOT, 2018). Flooding throughout North Carolina, including within the Tar River basin, also has important socioeconomic consequences through impacts to regional industry (e.g., agriculture) and commerce (The State of North Carolina, 2018).

Hurricanes Fran (1996), Floyd (1999) and Matthew (2016) resulted in floods that exceeded the 1% annual exceedance probability (AEP), or having a 1% percent chance of occurrence in any given year, within Louisburg, Rocky Mount, Tarboro, and Greenville, with 0.2% AEP flows also being exceeded in certain locations throughout the watershed. A tropical depression occurring in June 2020—after the start of this study—resulted in the third highest recorded discharge within portions of the Tar River.

Flood characteristics throughout the Tar River basin vary depending on location within the watershed. Smaller tributaries and the headwaters of the major tributaries experience flash flooding that is characterized by a rapid rise of flood waters, which persist for a relatively short time (i.e., hours). Flooding further downstream along the Tar River and its major tributaries, as well as along the backwater areas of smaller adjoining tributaries, is characterized by a much slower rise of flood waters that persist for longer periods of time (i.e., several days).

The state of North Carolina actively works to mitigate flood risk for residents. Several tools and warning systems exist to help residents access flood mitigation preparedness / warning services. Resources available include the NC Flood Risk Information System, which provides a simple mapping interface to help residents identify their flood risk; the Flood Inundation Mapping and Alert Network, that provides rain and stage gage data, flood inundation maps, and alerts in real-time; and the NC Emergency Management Advisory Flood Mitigation Application to provide non-regulatory flood hazard mapping for previously unmapped portions of the state.

1.4.2. Prior Studies and Reports

Tar River Basin Flood Analysis and Mitigation Strategies Study: This planning-level conceptual document was developed by North Carolina Emergency Management and the North Carolina Department of Transportation (NCEM and NCDOT, 2018) (2018 Study). The 2018 Study utilized a granular Hydrology and Hydraulic model to evaluate the effect of 12 different

Mitigation Strategies to reduce flood damage. The 2018 Study determined that the "Elevation, Acquisition, and Relocation" strategy was the most effective based on the timeframe needed to implement, funding, ability to target vulnerable structures and communities, Benefit/Cost ratio, and the positive environmental impact. The 2018 Study found that the construction of new detention facilities would provide varying levels of benefit for different communities, depending on the specific dam, however the timelines required to implement new detention were determined to be between 7-15 years.

Hurricane Florence Recovery Recommendations; Building Communities Stronger and Smarter: This report was released by the State of North Carolina on October 26, 2018 (The State of North Carolina, 2018). The report summarized the financial impact of Hurricane Florence (September 2018) on the Business and Non-profit, Housing, and Agriculture sectors in North Carolina, estimated aid from Federal and Private sources, and provided conceptual level cost estimates for feasibility studies to examine flood mitigation measures for specific basins. For the Tar River Basin, a feasibility study and Design Build for mitigation reservoirs at three proposed locations: Stony Creek Dry Reservoir; Swift Creek Dry Reservoir; and Little Fishing Creek Dry Reservoir; was projected to cost $20.7M.

1.5. Purpose and Need for Action

Communities within the Tar-Pamlico River Basin, North Carolina have a long history of flooding during major rainfall and hurricane events. Many communities within the basin have experienced major recurring flood events over the past 25 years associated with Hurricanes Fran (1996), Floyd (1999), and Matthew (2016)—each of which rank among the most destructive storms in state history and represent among the top three floods of record for major population centers within the basin (NCEM and NCDOT, 2018). Recurring flooding within the basin has resulted in considerable economic damages and increased life safety risks. Due to repeated flood effects businesses and residents have relocated, threating community cohesion. This IFREA assesses and recommends actions that reduce flood risk and increase resiliency within the Tar-Pamlico River Basin.

1.6. Problems and Opportunities

1.6.1. Problems

A two-day virtual planning charrette was held on May 1 and 4, 2020. During the charette, the study team, local sponsor, and various stakeholders identified two main problems that encompass numerous sub-problems:

Problem 1. Economic damages resulting from riverine flood inundation. Recurring flooding has caused extensive economic damage throughout the study area as described by the following sub-problems.

Problem 1.1. Damage to residential and commercial structures. There are an estimated 3,042 structures within the 0.2% AEP (500-year) floodplain throughout the study area, which have historically experienced flood damage.

Problem 1.2. Impacts to industry and commerce throughout the basin. Agriculture represents a significant land use throughout the basin (28%) (North Carolina Department of Water

Quality, 2010). Flooding-related crop and livestock losses can result in increased unemployment and loss of income and tax revenue. For example, direct damages from flooding during Hurricane Matthew to communities in the Tar River Basin were estimated at $112 billion dollars (NCEM and NCDOT, 2018). Flooding can also impact other important sectors of the economy, including manufacturing, professional and business services, and leisure and hospitality, through direct (e.g., inundation) and indirect (e.g., decreased access due to flooding and lost revenue due to increased regional recovery spending) effects.

Problem 1.3. Damage to public infrastructure. Previous flood events have resulted in significant damage to public infrastructure throughout the study basin, including numerous major and minor roads and bridges, as well as infrastructure associated with utilities (e.g., water, wastewater, and power substations).

Problem 1.4. Traffic delays associated with road closures. Road closures associated with inundation of and damage to transportation infrastructure result in transportation delays and/or detours that can have a significant economic impact on affected individuals (e.g., increased drive time, distance traveled, and vehicle wear and tear).

Problem 2. Elevated risks to life safety associated with riverine flood inundation. Inundation of structures and infrastructure increases life safety risk throughout the study area as described by the following sub-problems:

Problem 2.1. Isolation of communities as a result of inundated roadways. Inundation of and associated damage to roadways and bridges increases life safety risk by: 1- impacting critical evacuation routes for at-risk individuals and communities; 2- reducing or preventing access to impacted areas following the recession of flood waters; and 3- reducing or preventing access to population centers and associated critical facilities. In some instances, individuals and/or communities can become completely isolated both during and after flood events.

Problem 2.2. Loss of life due to inundated occupied vehicles on roadways. A large proportion of flooding-related fatalities, including those within the state of North Carolina, have occurred due to inundation or submergence of occupied vehicles (Kellar & Schmidlin, 2012).

Problem 2.3. Potential inundation of critical infrastructure and structures in the floodplain. Inundation of critical infrastructure located within the floodplain, including infrastructure associated with emergency medical services and/or other first responders, as well as infrastructure associated with critical utilities (e.g., power) can also result in increased life safety risk throughout the study area.

Problem 2.4. Elevated life safety risk to vulnerable populations. There is considerable life safety risk associated with direct inundation of structures within the floodplain. Risk tends to be greatest for underserved and underrepresented populations, including elderly residents and residents without vehicles.

1.6.2. Opportunities

Successful completion of this feasibility study and identification of a federally justified project would enable USACE to realize the following identified opportunities (i.e., chance to create a future condition that is desirable through project implementation):

Improved quality of life for individuals living within the floodplain. Realizing the below opportunities, including decreased economic damages and improved life safety, environmental condition, and recreational opportunities, could increase the quality of life for individuals living throughout the study area. Reducing the extent and impact of flooding within the study area could decrease the associated damages and required recovery spending. Reduced recovery spending could increase revenue within other sectors of the local and regional economies.

Improved aquatic, riparian, and floodplain habitat quality within the study area. Implementation of certain flood risk management measures can result in greater floodplain connectivity and associated restoration of natural aquatic, riparian, and floodplain habitats.

Reduced water pollution inputs to the Pamlico River and Sound ecosystems. Reducing inundation of developed/urbanized and agricultural areas could decrease the input of various pollutants into the Tar River and its tributaries, preventing their transport to the Pamlico River and Sound ecosystems.

Increased awareness of and preparedness for flood risk. Community outreach and engagement throughout the study and resulting project could improve community awareness of and preparedness for flood risk, empowering individuals and communities to take actions that reduce their flood risks.

Increased resilience of communities throughout the study area. Reducing flood risk throughout the study area could result in increased resilience—the capacity to recover quickly and completely following hardship—throughout the study area.

Reduced life and safety risk for underrepresented and underserved communities. Reducing risks associated with inundation would also improve life safety for residents currently located within the floodplain and floodway. Reducing transportation stoppages and delays will improve life safety by helping to secure sustained: 1- evacuation routes for at-risk families; 2- access to impacted areas following the recession of flood waters; and 3- access to population centers and associated critical facilities both during and following future flood events. Reductions in life safety risk would be greatest for underserved and underrepresented populations present throughout the study area.

Enhanced recreational opportunities throughout the study area. Implementation of certain flood risk management measures and/or improvements to existing aquatic and riparian habitats could result in improved recreational opportunities for residents of the study area and surrounding areas.

1.7. Objectives and Constraints

Discussions during the planning charrette also resulted in the development of the following objectives and identification of the following constraints.

1.7.1. Objectives

Three main types of objectives were identified:

1.7.1.1. Federal Objectives

Federal Planning Objective. The federal planning objective is to contribute to national economic development (NED) consistent with protecting the nation's environmental resources, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Contributions to NED are reflected monetarily as increases in the net value of the national output of goods and services and are the result of direct net economic benefits that accrue in the study and the rest of the nation following project implementation.

Federal Environmental Objective. USACE strives to balance the environmental and development needs of the nation in compliance with the NEPA and authorities provided by Congress and the Executive Branch. Public participation is encouraged early in the study to help define problems and environmental concerns, as well as to identify environmental resources that would likely be favorably or adversely affected by a project alternative. Alternative plans are formulated to minimize and/or avoid adverse impacts to the greatest extent possible. Significant adverse impacts that cannot be avoided are mitigated as required by Section 906(d) of WRDA 1986.

1.7.1.2. Study Objectives

The following study objectives have been developed to provide a means of determining whether project alternatives can address identified problems while simultaneously maximizing identified opportunities:

Objective 1. Life Safety. Reduce life safety risk associated with inundation of structures (residential, non-residential, critical facilities) resulting from flash flooding along the tributaries and prolonged flooding along the Tar River and associated tributary backwaters throughout the study area for the 50-year period of analysis.

Objective 2. Economic Damages. Reduce damage to structures (residential, non-residential, critical facilities) and public infrastructure resulting from flash flooding along the tributaries and prolonged flooding along the Tar River and associated tributary backwaters throughout the study area for the 50-year period of analysis.

Objective 3. Industry & Commerce. Reduce economic damage to industries (e.g., agriculture) and commerce resulting from flash flooding along the tributaries and prolonged flooding along the Tar River and associated tributary backwaters throughout the study area for the 50-year period of analysis.

1.7.2. Constraints and Considerations

A constraint is a restriction that limits the extent of the planning process. Successful identification of study constraints helps to avoid undesirable outcomes. The following study-specific constraint was identified.

Princeville, NC. In 2016, the Princeville, NC Flood Risk Management study and associated Chief's Report recommended modifications to the existing levee system to further reduce flood risk within the Town of Princeville (USACE Wilmington District, 2016). The recommended plan was subsequently authorized for construction in the Water Resources Development Act (WRDA) of 2016. The proposed project for Princeville will repair and extend existing levees, repair and install flapgates on ungated culverts, increase elevations of roadways, and updating flood warning and evacuation plans. These proposed measures are not expected to impact flows or

hydraulics of the area. Construction has not begun yet. Given this ongoing effort, no additional measures specific to Princeville were assessed in the current study.

This study must also adhere to general planning constraints that affect all USACE studies, including restrictions established by USACE policy and legal authority. The study team identified the following general policy constraints and planning considerations:

Existing Flood Risk Management Projects. Alternatives should not reduce performance of existing flood risk projects in the study area.

Transferred Risk. Alternatives should evaluate the potential to transfer flood risk to other areas and determine appropriate mitigation if necessary.

Environmental Resources. The Tar-Pamlico River Basin is characterized by extensive environmental resources, including a number of threatened and endangered species and associated critical habitats. Alternatives should seek to avoid impacts to endangered species and other protected environmental resources.

Cultural Resources. Alternatives should seek to avoid impacts to existing cultural and archeological resources.

1.8. Study Scope

This feasibility study analyzes a series of alternatives designed to reduce the ongoing flood risks throughout the Tar River basin, including a No Action plan, as well as various combinations of structural and non-structural measures. Plans were evaluated and compared based on a set of criteria that included efficiency, effectiveness, acceptability, environmental effects, environmental justice, and engineering feasibility; resulting in the identification of a recommended plan.

Resources and schedule constraints resulted in a focus on riverine flooding along the Tar River. This precluded detailed consideration of flood risks along the Pamlico River and its direct tributaries, as well as detailed examination of the region of the basin impacted by coincidental riverine and coastal flooding. Similarly, the modeling domain established in this study focused on areas along the Tar River and major tributaries. Regions outside of these domains were not considered due to time and resource constraints.

2. EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

This chapter describes both the existing condition as well as a forecast of the "future without-project" (FWOP) condition. Existing conditions include the general setting, as well as the relevant climate, flooding conditions, and socioeconomic conditions that may affect or be affected by the project alternatives if implemented. The FWOP condition reflects the expected condition in absence of federal action (the "No Action Alternative"). The information provided in this chapter serves as the baseline for alternative evaluation. Because the final array of alternatives includes only those non-structural measures that consist of the modification of a

structure to increase its flood resiliency, some environmental resources that are typically evaluated in an EA are not relevant to alternative evaluation for this study. Additionally, due to the location of the evaluated alternatives, some resources will not be relevant. An in-depth evaluation of these resources is not included in Sections 2 and 4 of this EA because they are not relevant to the evaluation and therefore will not factor into the final decision to recommend a plan. These resources include: Wild and Scenic Rivers, mineral & energy resources, Tribal Trust Resources, invasive species, navigation, effects on designated prime farmland, and public infrastructure.

2.1. Period of Analysis

The planning horizon encompasses the planning study period, project implementation, period of economic analysis, and the effective life of the project (Figure 2-1). The planning study period for the current feasibility study started on April 8, 2020. The project was initially scoped to be completed within 3 years and $3M. However, technical delays and associated cost increases necessitated an increase in study duration to 54 months and an increase in funding to $3.3M. The timeline and budget increase were approved by the Assistant Secretary of the Army (Civil Works) on May 23, 2023.

Design is anticipated to start in 2026 and take approximately 3 years. Construction is expected to take approximately 9 years, with 3 years of additional contingency to account for risks and uncertainties. The period of economic analysis represents the time frame used when forecasting and quantifying benefits associated with the future with- and without-project conditions. The period of economic analysis for flood risk management projects is 50 years. The assumed project life for flood risk management projects is 100 years. For this project, benefits will begin being accrued as soon as the first structures is modified, so the period of economic analysis begins at the beginning of implementation and the project life ends 100 years after the last structure is modified.

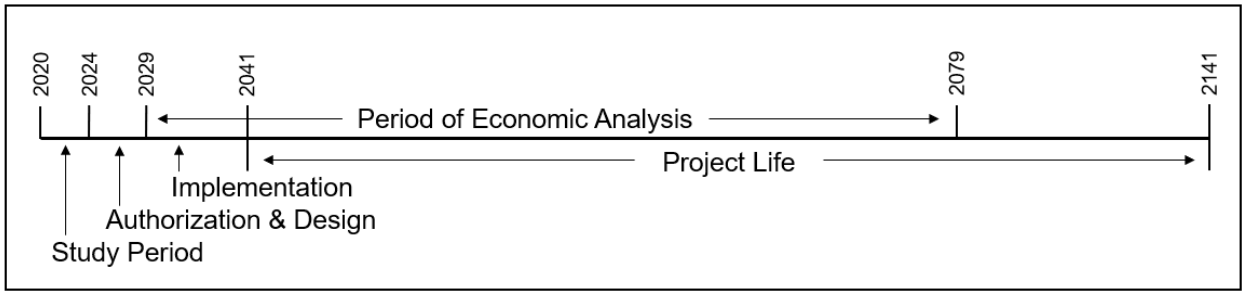


Figure 2.1. Planning horizon for the Tar Pamlico River Basin Flood Risk Management Feasibility Study.

2.2. General Setting

The Tar River begins in the piedmont of North Carolina and extends 215 miles southeast through the Coastal Plain and flows to the Pamlico Sound estuary. The basin covers about 6,100 square miles. Major population centers in the Tar River Basin include the cities of Greenville and Rocky Mount, and the towns of Tarboro, Princeville, Nashville, and Louisburg, NC (Figure 1.1).

2.3. Natural Environment

2.3.1. Wetlands

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (33 C.F.R. § 328.3). Various types of wetlands are present within the study area. Some of the more common wetland types found in the basin include: bottomland hardwood swamp, pocosin, freshwater marsh, riverine forested swamp, forested/shrub, and brackish marsh (North Carolina Division of Water Resources, Water Sciences Section, 2018-2023). Wetlands within the study area will remain as they are in a FWOP scenario.

2.3.2. Threatened & Endangered Species and Critical Habitat

Through coordination with US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), USACE identified threatened and endangered species and areas of designated and proposed critical habitat that may be present in the vicinity of the study area. Most in-stream habitat within the study area is designated as critical habitat, indicating the sensitivity of this habitat to disturbance. Critical habitat is designated in the study area for the following aquatic species: Neuse River waterdog, Carolina madtom, Atlantic pigtoe, and the yellow lance. Additionally, there are 21 federally-listed threatened, endangered, or candidate species that may potentially occur within the study area, including several species of mammals, birds, reptiles, amphibians, fishes, clams, plants, and insects (Table 2.1). Threatened species, endangered species, and critical habitat are projected to remain threatened, endangered, and critical (respectively) in the FWOP scenario; however, the USFWS and NMFS may list new species in the future and/or de-list currently listed species. If the tricolored bat becomes listed in the future (it is currently proposed for listing), the USACE will coordinate with the USFWS on potential impacts related to this species.

Table 2.1. Federally-listed threatened and endangered species in study area.

Common Name	**Scientific Name**	**Status**
Northern long-eared bat	*Myotis septentrionalis*	Endangered
Red wolf	*Canis rufus*	Endangered
Tricolored bat	*Perimyotis subflavus*	Proposed Endangered
West Indian manatee	*Trichechus manatus*	Threatened
Red knot	*Calidris canutus rufa*	Threatened
Red-cockaded woodpecker	*Picoides borealis*	Endangered
American alligator	*Alligator mississippiensis*	Similarity of Appearance (threatened)
Green sea turtle	*Chelonia mydas*	Threatened
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Neuse River waterdog	*Necturus lewisi*	Threatened
Carolina madtom	*Noturus furiosus*	Endangered
Atlantic pigtoe	*Fusconaia masoni*	Threatened
Dwarf wedgemussel	*Alasmidonta heterodon*	Endangered

Tar River spinymussel	*Parvaspina steinstansana*	Endangered
Yellow lance	*Elliptio lanceolata*	Threatened
Monarch butterfly	*Danaus plexippus*	Candidate
Harperella	*Ptilimnium nodosum*	Endangered
Michaux's sumac	*Rhus michauxii*	Endangered
Rough-leaved loosestrife	*Lysimachia asperulaefolia*	Endangered
Sensitive joint-vetch	*Aeschynomene virginica*	Threatened
Smooth coneflower	*Echinacea laevigata*	Threatened

2.3.3. Aquatic Ecology and Riparian Habitat

The North Carolina Natural Heritage Program designated the Tar River, Swift Creek, and Fishing Creek (all encompassed by the study area) as 'exceptional' aquatic habitat, representing the highest rating for biodiversity in North Carolina. In addition to those species mentioned in Section 2.3.2 which are federally-listed, many others are present in the study area which are considered vulnerable and listed by the state agency as a Species of Greatest Conservation Need, emphasizing the high quality of streams within the study area. A few notable ongoing threats to such sensitive species within the study area include competition with invasive species, sedimentation, nutrient loading, and increased isolation caused by reduced tree canopy cover (NCEM and NCDOT, 2018). These threats are expected to persist into the future in a FWOP scenario.

2.4. Physical Environment

This section examines the environmental or human-related factors that contribute to the study area.

2.4.1. Climate

2.4.1.1. Current Climate Conditions

North Carolina has a humid subtropical climate, characterized by very warm summers and moderately cold winters. Climate across the state exhibits substantial regional variation influenced by geographic features. Climate within the study area is influenced by the Piedmont Plateau in the central region and the Coastal Plain in the eastern region.

Recent literature suggests a mild increase in the annual temperature of the South Atlantic-Gulf Region has occurred over the past century, most significantly over the past 40 years. Annual precipitation totals have become more variable in recent years compared to earlier in the 20th century.

Like much of the Atlantic Coast, the study area is vulnerable to tropical storms and hurricanes. Hurricane season extends from 1 June through 30 November. Tropical storms and hurricanes contribute up to 15% of rainfall during the hurricane season in coastal portions of North and South Carolina (Knight & Davis, 2007). The late 1990s and early 2000s were a notably active period for storms reaching North Carolina at hurricane intensity. These storms brought damaging winds and storm surges that caused coastal flooding, and extreme precipitation associated with these events posed a significant flood hazard in the study area.

2.4.1.2. FWOP Climate Projections

Climate change is predicted to affect the temperature, precipitation, and hydrology of the study area. FWOP conditions with respect to climate change were assessed using a combination of qualitative literature review, observed and projected trends of surface water in the Climate Hydrology Assessment Tool (CHAT), and degree of hydrologic consistency in the Nonstationary Detection Tool. No significant trends were observed across the eight stream gauges across the study area with sufficient data for analysis. Nonstationary, indicating a change from "normal" streamflow, were only observed at one gauge, indicating that the region has a high degree of hydrologic consistency.

Based on the observed literature review, there is a strong consensus that air temperatures will increase in the study area over the next century. The studies reviewed generally agree on an increase in mean annual temperature of approximately 2ºC to 4ºC for the South Atlantic-Gulf Region by the latter half of the 21st century. Currently, there is no consensus on trends in the magnitude of annual and seasonal precipitation for the study area. However, existing literature does suggest that the study area has also observed an increase in extreme precipitation events—a trend that is expected to continue into the future. In general, there is consensus that annual streamflow has decreased within the study area; however, there is no consensus regarding future streamflow conditions (i.e., increased or decreased) in the study area.

The USACE Vulnerability Assessment Tool (VAT) indicated that the study area is not within the top 20% of vulnerable watersheds nationally. The VAT indicates that the change in flood runoff (cumulative), combined with the acres of urban area within the floodplain, are driving vulnerability to flooding within the study area. Given the lack of consensus regarding future changes in streamflow, along with the lack of trends and nonstationarities in observed river data, this study assumed no change in future streamflow under the FWOP condition. However, potential future changes in streamflow were qualitatively considered within the plan formulation process with respect to future risk and uncertainty. A detailed description of future climate and hydrologic analyses and assessments described above can be found in Appendix F, Hydraulics and Hydrology Report.

2.4.2. Hydrology and Hydraulics

The Tar River and its tributaries have a history of flooding. National Weather Service gauges at Louisburg, Rocky Mount, Tarboro, and Greenville were used to assess flood characteristics and frequency. The Tar River has reached flood stage a total of 18 times at Louisburg, 8 times at Rocky Mount, 39 times at Tarboro, and 32 times at Greenville over the period of record for each gauge (Figure 2.2). Major flooding has occurred five times at Louisburg and Rocky Mount, four times at Tarboro, and 13 times at Greenville over each gauge's period of record. (Table 1). The flood of record for all four gauges was associated with Hurricane Floyd (1999), with other major flood events being associated with Hurricanes Fran (1996; Louisburg) and Matthew (2016; Louisburg, Rocky Mount, Tarboro, and Greenville) (Figure 2.2). Within the past decade, the Tar River has reached flood stage 5 times at Louisburg, 6 times at Rocky Mount, 9 times at Tarboro, and 5 times at Greenville, with each gauge reaching major flood stage at least once during the same time period.

Louisburg

Flood categories	Stage (ft)
Major flood	23.0
Moderate flood	22.0
Flood	20.0

Stage (ft)	Date	Food Stage
26.1	9/17/1999	Major
25.3	9/7/1996	Major
24.4	4/28/1978	Major
23.3	10/10/2016	Major
23.0	7/16/1975	Major
22.9	4/26/2017	Moderate
22.0	11/14/2018	Moderate
21.8	10/13/2002	Flood
21.7	5/17/2014	Flood
21.6	1/5/1992	Flood
21.2	3/2/1987	Flood
21.2	11/23/1985	Flood
21.1	11/13/1980	Flood
21.0	9/19/2018	Flood
20.8	3/31/2001	Flood
20.7	3/7/1984	Flood
20.6	2/23/1989	Flood
20.6	12/26/2020	Flood

Rocky Mount

Flood categories	Stage (ft)
Major flood	25.0
Moderate flood	23.0
Flood	21.0

Stage (ft)	Date	Food Stage
31.7	9/17/1999	Major
28.7	10/10/2016	Major
27.3	6/18/2020	Major
25.9	9/12/1996	Major
25.8	4/26/2017	Major
21.0	2/20/2021	Flood
21.0	2/20/2021	Flood
21.0	2/20/2021	Flood

Tarboro

Flood categories	Stage (ft)
Major flood	32.0
Moderate flood	24.0
Flood	19.0

Stage (ft)	Date	Food Stage
41.5	9/19/1999	Major
36.3	10/13/2016	Major
34.0	7/27/1919	Major
33.5	10/4/1924	Major
31.8	8/20/1940	Moderate
30.2	9/24/1928	Moderate
29.4	9/1/1908	Moderate
29.2	5/12/1958	Moderate
28.4	4/22/1987	Moderate
28.1	9/23/1945	Moderate
28.0	6/19/2006	Moderate
27.8	10/7/1929	Moderate
27.7	5/1/2017	Moderate
27.5	2/21/2021	Moderate
27.4	1/27/1954	Moderate
27.4	12/6/1934	Moderate
27.3	4/23/1910	Moderate
27.0	9/3/1939	Moderate
26.6	9/15/1996	Moderate
26.4	6/4/1984	Moderate
26.4	3/9/1922	Moderate
26.3	4/15/2003	Moderate
26.2	2/2/1937	Moderate
25.9	10/9/1964	Moderate
25.7	3/11/1993	Moderate
25.6	2/12/2020	Moderate
24.5	1/10/1992	Moderate
24.2	5/6/1989	Moderate
23.4	11/28/1985	Flood
23.0	2/11/2010	Flood
22.2	4/2/2010	Flood
22.1	1/8/2021	Flood
21.7	3/13/1995	Flood
21.7	4/5/1990	Flood
20.9	2/22/1995	Flood
20.1	12/29/2020	Flood
20.0	2/4/2021	Flood
20.0	11/20/2018	Flood
19.2	12/21/2020	Flood

Greenville

Flood categories	Stage (ft)
Major flood	19.0
Moderate flood	17.0
Flood	13.0

Stage (ft)	Date	Food Stage
29.7	9/21/1999	Major
24.5	7/28/1919	Major
24.5	10/14/2016	Major
23.5	10/6/1928	Major
22.3	11/7/1887	Major
22.1	8/22/1940	Major
21.9	9/25/1928	Major
19.9	11/17/2020	Major
19.7	3/14/1958	Major
19.7	10/8/1929	Major
19.4	9/2/1908	Major
19.2	9/25/1945	Major
19.1	3/11/1922	Major
18.8	3/23/1975	Moderate
18.8	12/8/1934	Moderate
18.8	1/29/1954	Moderate
18.7	2/3/1937	Moderate
18.6	9/5/1939	Moderate
18.6	3/9/1929	Moderate
18.5	10/10/1964	Moderate
18.5	8/24/1967	Moderate
18.5	6/19/1910	Moderate
18.3	5/3/2017	Moderate
18.2	9/17/1996	Moderate
18.1	4/14/1936	Moderate
17.8	2/19/1948	Moderate
16.3	3/10/1994	Flood
14.6	3/15/1995	Flood
14.5	8/20/2004	Flood
13.6	11/21/2018	Flood
13.4	7/8/2013	Flood
13.2	3/14/2014	Flood

Figure 2.2. National Weather Service historic peak stages at gauges along the Tar River, including at Louisburg, Rocky Mount, Tarboro, and Greenville.

Flooding in the upstream areas of Louisburg and Rocky Mount tends to be characterized by more rapid rises and decreases of the river. Downstream of Rocky Mount, including the towns of Tarboro and Greenville, the flood events tend to be characterized by more attenuated hydrographs and flooding that can persist for extended periods of time. Figure 2.3 demonstrates these patterns using hydrographs from Hurricane Matthew, which struck North Carolina October 8-9 2016 and caused widespread flooding. In Louisburg, the river remained in a "minor" flood stage for approximately 3 days. In Greenville, the river rose over a period of five days and remained in a "minor" flood stage through October 21st.

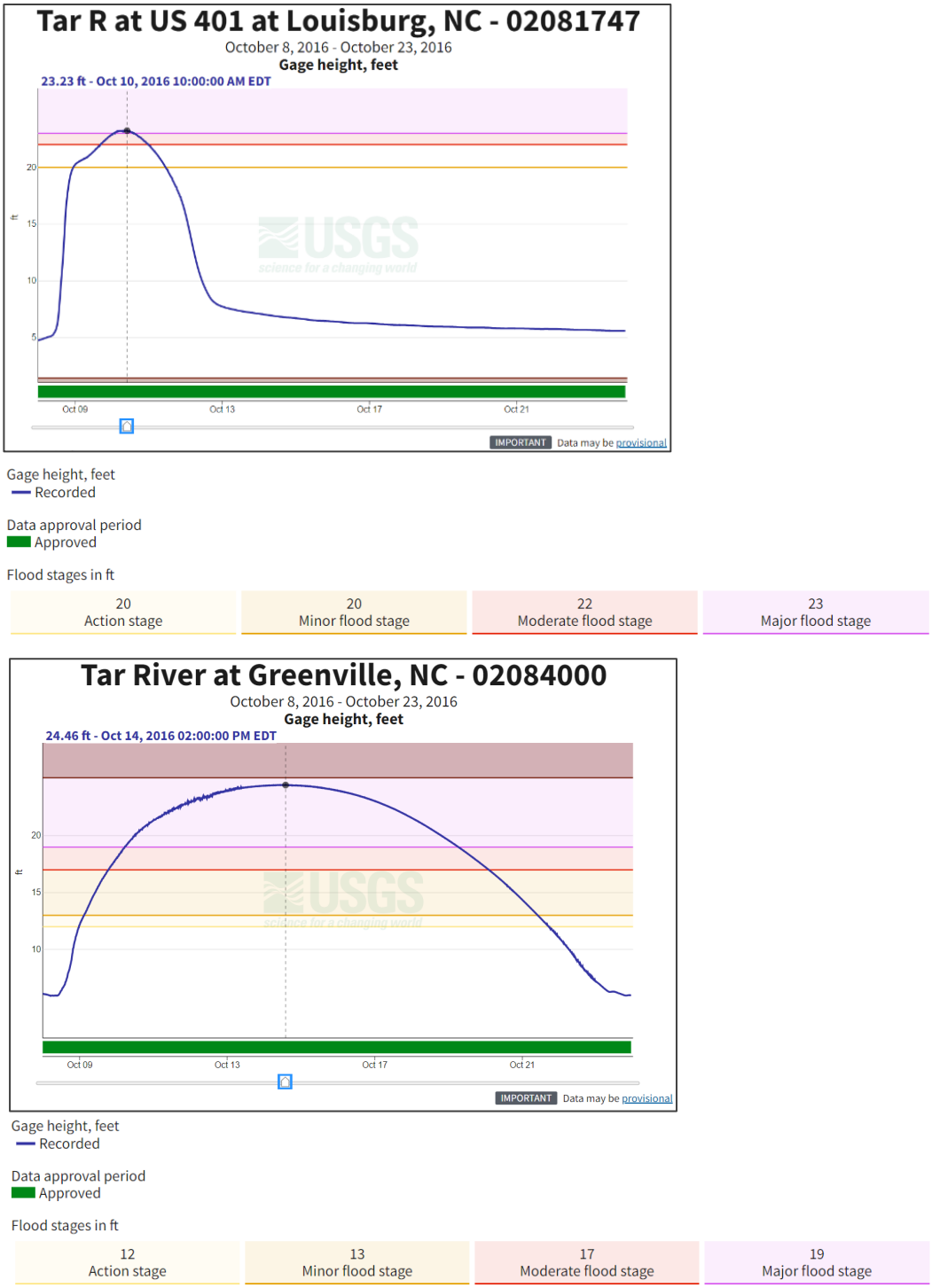


Figure 2.3. USGS flood elevation hydrographs for the Tar River at Louisburg (top) and Greenville (bottom) for the period of October 8-23, 2016.

2.4.3. Land Cover and Use

Flood risk in the Tar-Pamlico River Basin is related to the variety of land use and land cover patterns. Figure 2.4 shows the land cover within the Tar Pamlico Basin (National Land Cover Database, 2016). As shown in the figure, the communities of Greenville and Rocky Mount are the most developed areas within the study area. There are other smaller developed areas throughout the study area, such as Louisburg and Tarboro. Additionally, the figure shows that the majority of the land use west of Rocky Mount is classified as Pasture/Hay, which indicates crop farming, livestock farming, or other agriculture activities occur in this part of the study area. The Tar River corridor generally shows the densest development, including in the floodplains adjacent to the river. This development pattern means that the river communities of Washington, Rocky Mount, and Greenville are most significantly impacted by flood risk. Rural, unincorporated areas outside of the population centers are also significantly impacted by flooding, which includes the potential damage to structures and contents, as well as crops and livestock. It is expected that land cover and use in a FWOP scenario will remain similar to today; however, populations and development may decrease in areas where extreme precipitation events are expected to increase.

Relevant planning documents for communities in the study area are listed below. The flood mitigation plan recommended here is in accordance with these local development and land use plans.

- Horizons 2026, Greenville's Community Plan; 23 August 2016; Adopted by Greenville City Council on 8 September 2016.
- Together Tomorrow, Smart Growth Comprehensive Plan for the City of Rocky Mount. June 2003.
- Tarboro Land Development Plan, Developed by the Tarboro Planning Department, Adopted August 11, 2008.

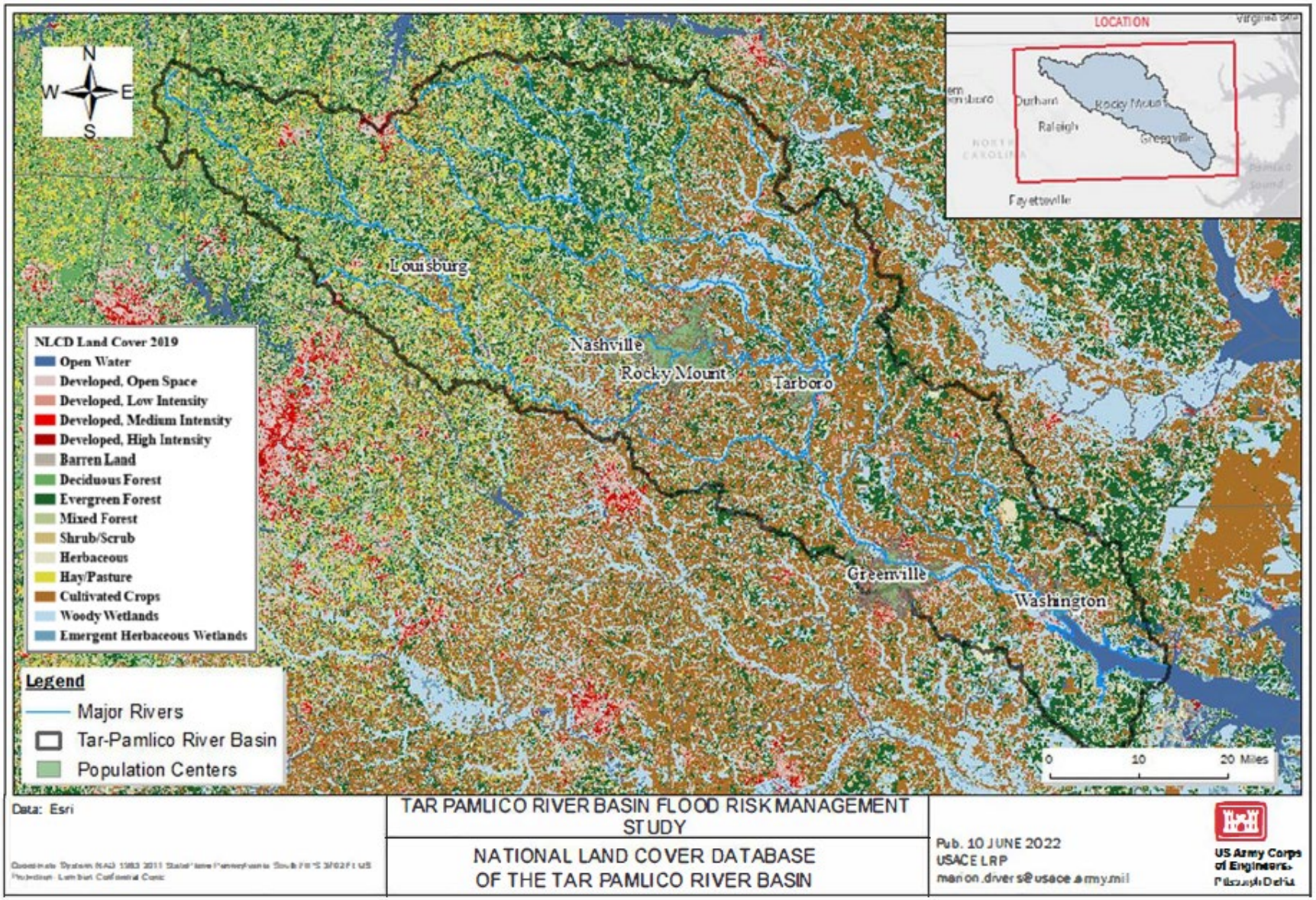


Figure 2.4 National Land Cover Database (2019) of the Tar-Pamlico River Basin.

2.4.4. Cultural and Historical Resources

Initial consultation with the NC State Historic Preservation Office (SHPO) indicates that there are 2,384 archaeological sites recorded within the study area. Of these, two are listed in the National Register of Historic Places (NRHP), while 17 have been determined eligible for listing in the NRHP. An additional four sites have been placed on the NC state study list, an internal listing process that occurs before being nominated to the National Register. There are 919 sites that have been determined not eligible, while the remaining 1,442 sites are either unassessed or do not have their eligibility status recorded in the NC SHPO GIS database.

In addition, a total of 8,354 historic structures have been identified within the study area. Of these, 174 are listed in the NRHP, while 73 have been determined eligible for listing in the NRHP. An additional, 290 have been placed in the NC state study list. There are also 7,817 historic structures that are either unassessed or do not have their eligibility status recorded in the SHPO database.

A total of 73 historic districts have been identified within the study area. Of these 30 are listed in the NRHP, 11 have been eligible for listing in the NRHP, and 32 historic districts have been placed in the NC state list. It is expected that in a FWOP-scenario as structures and districts age, additional structures and districts will be listed in the NRHP.

2.4.5. Hazardous, Toxic, and/or Radioactive Wastes

As the study area encompasses a large geographic area in both industrial and residential zones, there are many hazardous waste, brownfields, superfund, and contaminant remediation sites in the vicinity in various stages of assessment and remediation. This list of contaminated sites is too extensive for this report, but a comprehensive list with details of each facility can be generated at https://www.epa.gov/cleanups/cleanups-my-community, and can be tailored to a specific geographic area of interest. Additional factors relevant to this study include the presence of lead paint and/or asbestos within older structures and homes, although the specific conditions of each and every structure in the study area is outside the scope of this study during the feasibility phase. In a FWOP scenario, it is expected that sites currently undergoing remediation will eventually be fully remediated, but also that additional sites will become contaminated due to ongoing industrial activities. Lead-based paint and asbestos concerns are expected to decrease over time, as these materials are no longer used in construction.

2.4.6. Water Quality

Significant water quality problems known in the Tar-Pamlico River Basin include persistent nutrient pollution in the Pamlico River Estuary. The Pamlico River Estuary is listed as impaired for chlorophyll *a* due to elevated nutrient concentrations across the watershed. Projected increases in runoff, flood magnitude and frequency, and sedimentation and erosion have the potential to exacerbate nutrient pollution in the watershed. Additionally, erosion and sedimentation associated with flood events may degrade water quality in the larger Tar-Pamlico River Basin through increased turbidity and nutrient concentrations. It is expected that these conditions will persist under a FWOP scenario.

2.4.7. Air Quality

The Clean Air Act requires the United States Environmental Protection Agency (USEPA) to set national ambient air quality standards (NAAQS) for six common air pollutants, known as criteria air pollutants. These pollutants include lead, sulfur dioxide, particulate matter (PM-2.5 and PM-10), ozone, carbon monoxide, and nitrogen dioxide. Areas that persistently exceed the standards are designated as nonattainment areas. Federal actions must not cause or contribute to new violations, worsen existing violations, or delay attainment of NAAQS. The study area includes a large geographic area, the entirety of which is in attainment for all NAAQS (EPA Green Book, 30 April 2021). The study area includes both urban and rural environments and is subject to *de minimis* emissions resulting from vehicle traffic, lawn care equipment, and construction equipment on a regular basis. The study area also has other more significant sources of air emissions that contribute to air quality degradation which are regulated by NCDEQ and include various manufacturing facilities and power generation operations. These conditions are expected to persist under a FWOP scenario.

2.4.8. Floodplains

Floodplains exist along the Tar River throughout the basin, as well as along all incoming tributaries to the Tar River. In urban centers such as Nashville, Rocky Mount, and Greenville, floodplains are residentially and industrially developed. It is expected that under a FWOP scenario as extreme precipitation events increase and flooding along these streams increases, that structures will eventually be destroyed and/or abandoned, and additional development will cease.

2.4.9. Greenhouse Gas Emissions

Greenhouse gases (GHG) are constantly emitted throughout the study area from industrial activities, vehicular traffic, motorized boats, routine residential activities such as heating and cooking, and many others. Additional GHG's may be emitted in response to large flooding events which destroy property. These could include the costs to demolish a structure destroyed in a flood, and the costs associated with manufacturing and transport of new items to replace those lost or destroyed in a flood. In a FWOP scenario, GHG's will continue to be emitted by these sources, but may ultimately decrease as global efforts to reduce GHG emissions facilitate the incorporation of more fuel-efficient processes and materials into every-day life.

2.4.10. Aesthetics

The Tar River Basin ranges from rural undeveloped areas to heavily developed industrial and/or residential areas, creating a range of aesthetic conditions in the study area. The Tar River and its tributaries provide appealing riverfront and forested riparian viewsheds in the study area, and many public parks exist within the study area. In a FWOP scenario, such viewsheds will continue to exist, and no significant changes to aesthetic resources is likely to occur.

2.4.11. Noise

Noise levels within the study area are likely typical of other similar communities throughout the US. The study area includes residential areas, industrial areas, airports, roads and highways, and commercial areas, each with varying noise levels. In a FWOP scenario, noise levels will continue to be as they are currently.

2.4.12. Transportation

Public roadways exist in the study area, including rural roads to larger highway thoroughfares and interstate highways. Some public roadways and bridges are impassable during large floods (see Section 1.6.1.). Larger populations centers, such as Rocky Mount and Greenville, have public transportation for residents. In a FWOP scenario, public roadways and transportation are likely to continue to operate as they do currently, with ongoing routine maintenance of roadways and bridges to ensure safe travel. Flooding events will continue to inundate roadways and bridges in some locations in a FWOP scenario.

2.5. Economic Environment

The economic environment discussion below examines existing economic conditions, including population trends.

2.5.1. Population Trends

The total estimated population count in the Tar-Pamlico River Basin is approximately 570,000 as of 2020. Figure 2.5 displays population count by census tract within the study area. More densely populated census tracts include those near Rocky Mount, Greenville, and Princeville. Table 2.2 depicts the change in population for the five largest population centers within the study area from 2010 to 2020. Greenville and Nashville are experiencing some population growth, indicating populations could continue to expand to the surrounding rural areas. However, population growth within Greenville and Nashville is not as high as growth across North Carolina or the United States. The population decline in the other key population centers indicates a significant increase in development in these areas is unlikely over the 50-year period of analysis.

Table 2.2. Population change within the five largest population centers within the study area, as well as across North Carolina and the United States (2010 to 2020). Data from census.gov/quickfacts.

Area	Population (2010)	Population (2020)	Population Change
Greenville	84,554	87,521	3.5%
Rocky Mount	57,477	54,341	-5.5%
Tarboro	11,415	10,721	-6.1%
Nashville	5,352	5,632	5.2%
Franklin County*	3,359	3,064	-8.8%
North Carolina	9,535,486	10,439,388	9%
United States	308,745,538	331,449,281	7%
*census.gov/quickfacts only provides data for communities with populations >5,000. Franklin County reported as a proxy for Louisburg, NC.			

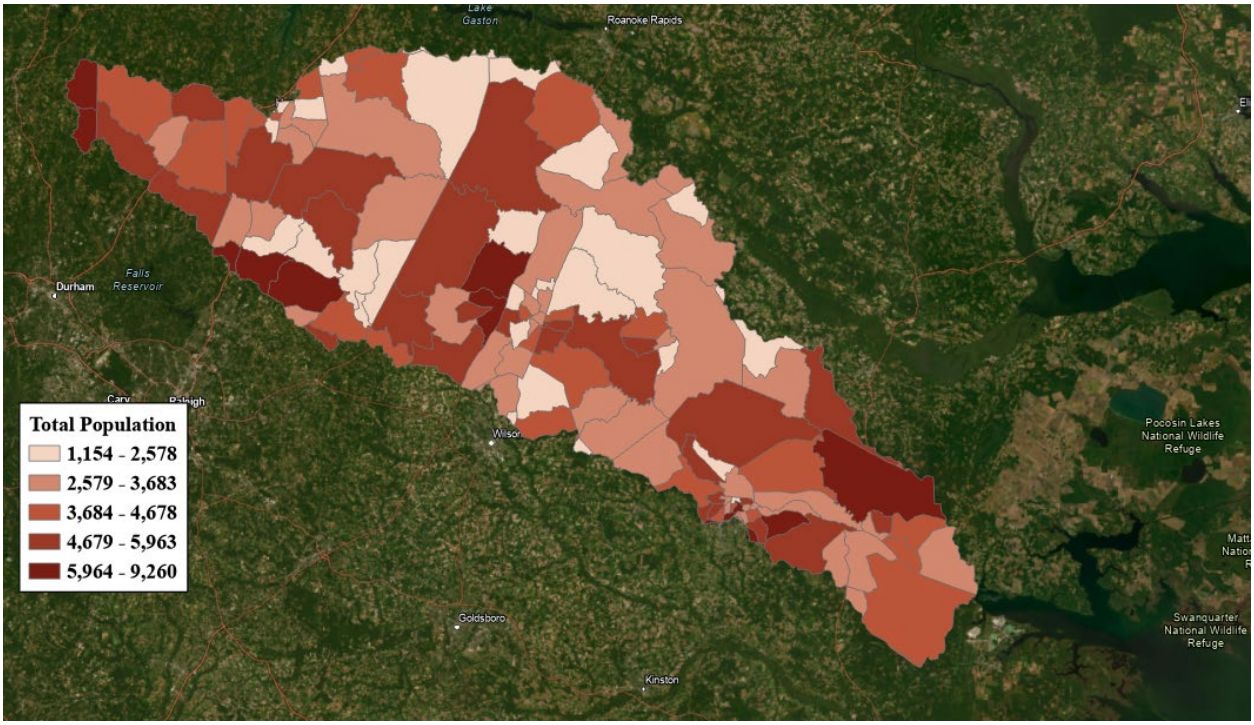


Figure 2.5. Population Count by Census Tract, ACS 2020 5-year Estimates.

2.5.2. Economic Considerations

The average median household income by census tract is $48,000 annually, while the lowest is $17,900 and the highest is $112,600 (Figure 2.6). The basin wide average poverty rate is 19.5%, which is higher than the 2020 national average of 11.4 percent (Figure 2.7). Poverty rate ranges from 1.1% to 60.5% across all census tracts within the study area. Table 2.3 displays key economic indicators for the five major population centers in the study area, as well as the state of North Carolina and the United States for comparison. All population centers within the study area have median home values and household incomes below the national median and percentages of persons in poverty that exceed the national average. All population centers within the study area have median household incomes below the national median, and only Franklin County, a surrogate for Louisburg, has median household incomes above that of North Carolina.

Table 2.3. Economic indicators for the five largest population centers within the study area, as well as across North Carolina and the United States. Data from census.gov/quickfacts. Median home value and median household income reported in 2022 dollars.

Community	Economic Indicators		
	Median Home Value	Median Household Income	Persons in Poverty
Greenville	$192,900	$47,485	25.2%
Rocky Mount	$137,800	$50,092	19.6%
Tarboro	$145,600	$43,523	24.0%

Community	Economic Indicators		
	Median Home Value	Median Household Income	Persons in Poverty
Nashville	$179,500	$61,513	21.9%
Franklin County*	$209,500	$70,493	10.9%
North Carolina	$234,900	$66,186	12.8%
United States	$281,900	$75,149	11.5%
*census.gov/quickfacts only provides data for communities with populations >5,000. Franklin County reported as a proxy for Louisburg, NC.			

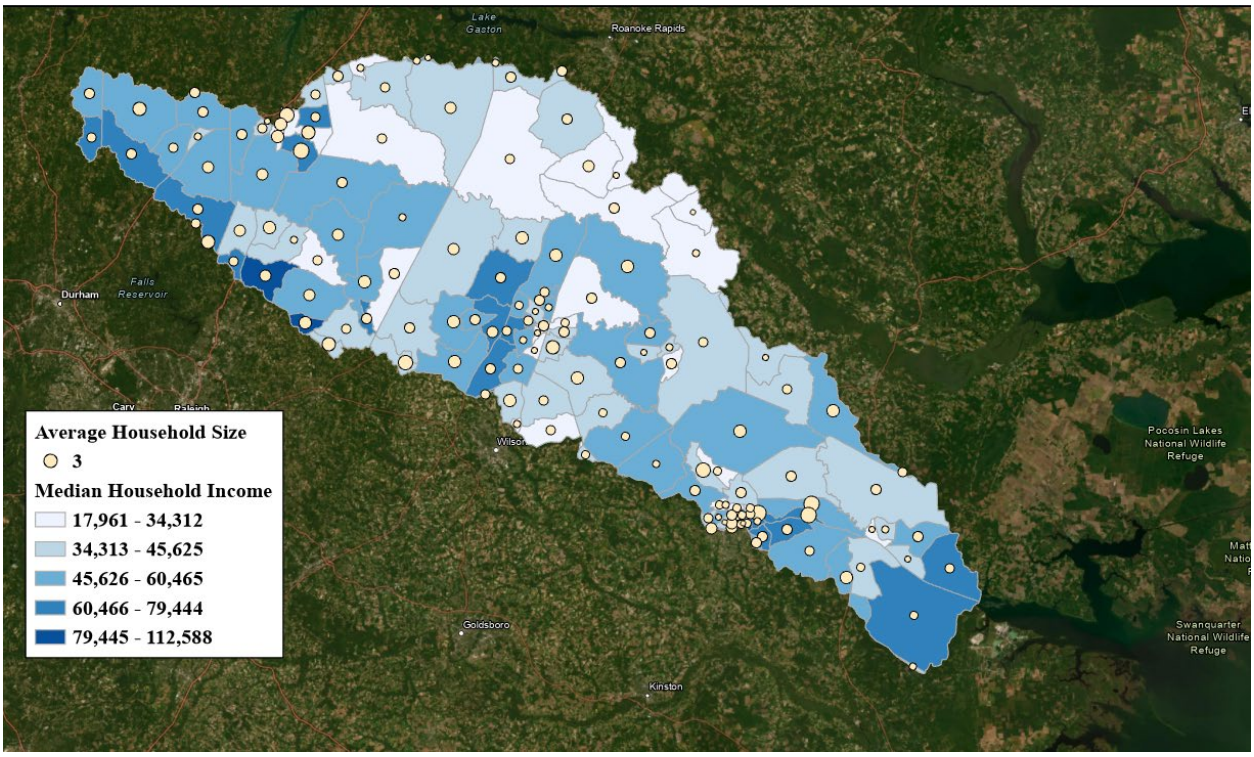


Figure 2.6. Median household income in 2020 inflation adjusted dollars vs household size. Dot size correlates to average household size, with the average value of 3 in the legend for comparison.

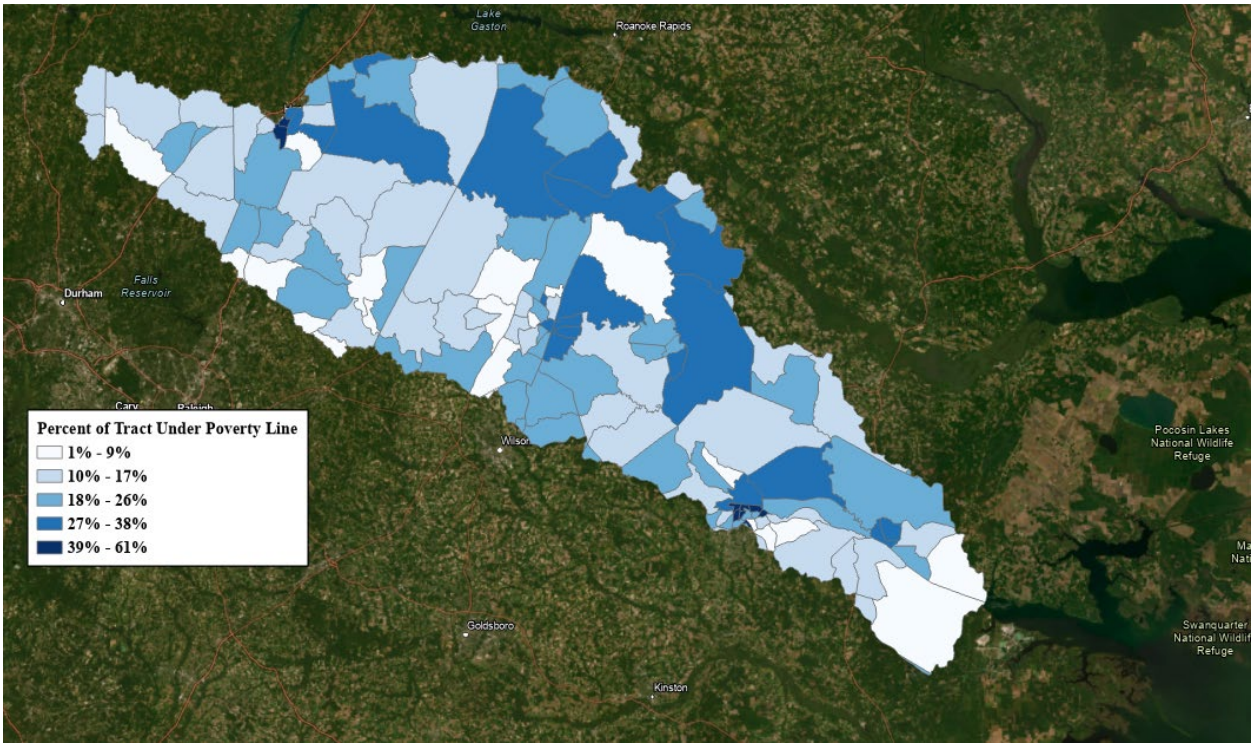


Figure 2.7. Percent of population under poverty line by census tract, 2015 ACS 5-year estimates.

2.5.3. Demographic Considerations

The proportion of non-white individuals within each census tract ranged from 2% to 95%, with census tracts in the northern part of the basin and adjacent to Rocky Mount, Tarboro, and Greenville having the highest non-white populations (Figure 2.8). The proportion of individuals 65 years of age and older—a population with increased risks associated with flooding—ranged from 2% to 44% across census tracts (Figure 2.9).

Table 2.4. Demographic indicators for the five largest population centers within the study area, as well as across North Carolina and the United States. Data from census.gov/quickfacts.

Community	Demographic Indicators					
	White Alone	Black/African American Alone	Asian Alone	Two or More Races	Hispanic or Latino	Persons over 65
Greenville	50.3%	40.1%	2.6%	4.3%	4.2%	10.0%
Rocky Mount	29.7%	62.1%	1.3%	3.7%	4.3%	19.1%
Tarboro	46.2%	49.7%	0.1%	2.3%	6.1%	26.5%
Nashville	35.7%	61.7%	0.7%	2.0%	0.0%	19.5%
Franklin County*	69.8%	25.9%	0.9%	2.3%	10.3%	17.5%
North Carolina	69.9%	22.2%	3.6%	2.6%	10.5%	17.4%
United States	75.5%	13.6%	6.3%	3.0%	19.1%	17.3%
*census.gov/quickfacts only provides data for communities with populations >5,000. Franklin County reported as a proxy for Louisburg, NC.						

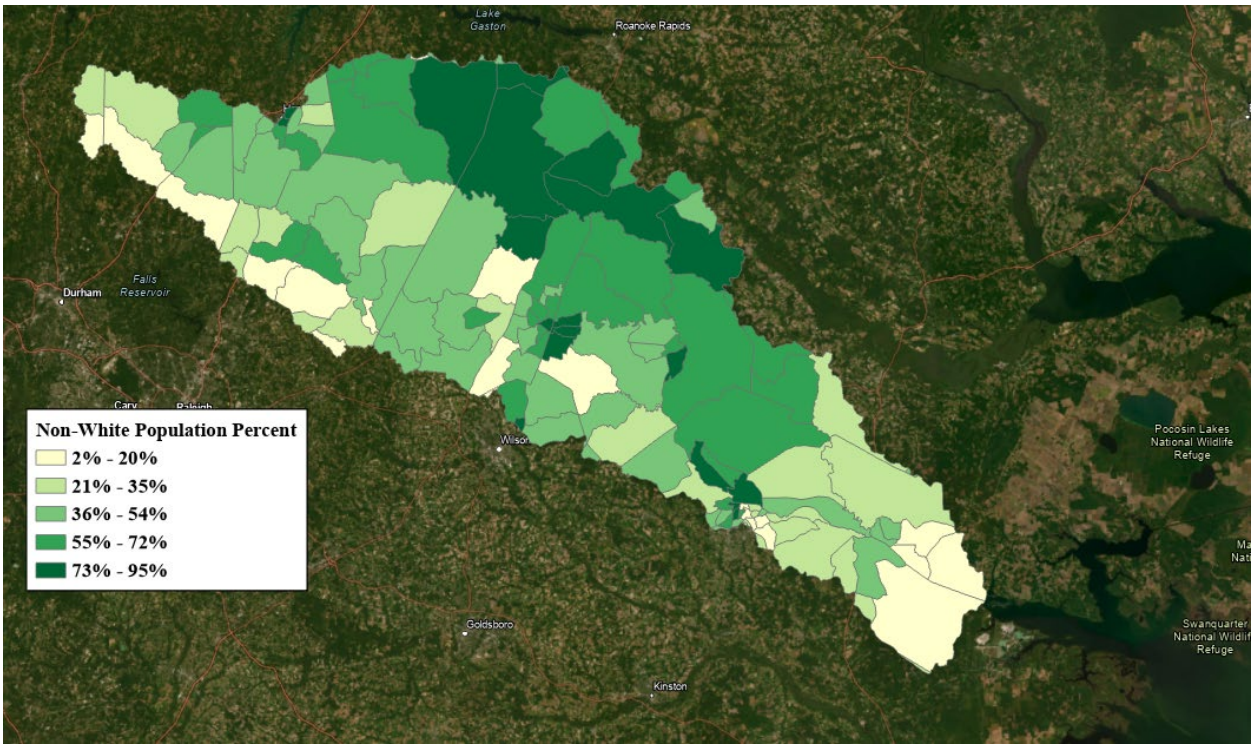


Figure 2.8. Non-white population count by census tract, ACS 2020 5-year estimates.

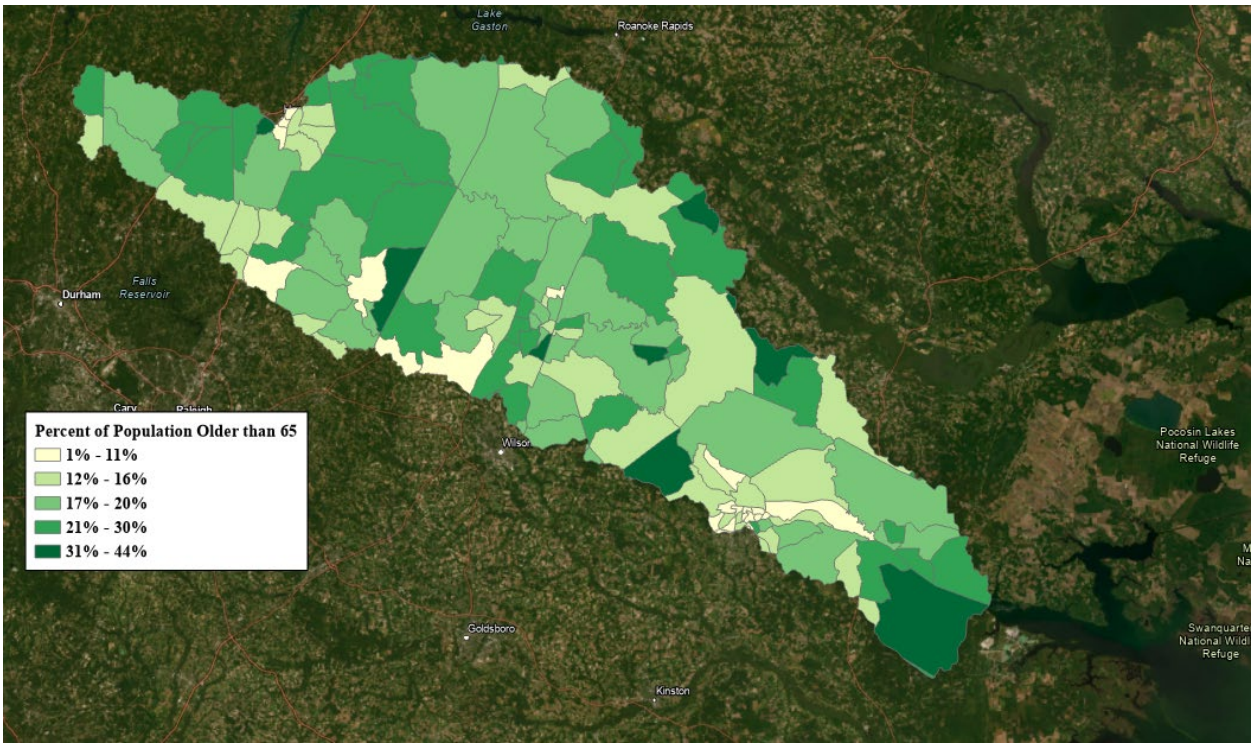


Figure 2.9. Percent of population age 65 or older by census tract, ACS 2019 5-year estimates.

2.5.4. Economic Damages

For the 1% AEP event, a total of 724 structures are impacted throughout the study area, with damages estimated at just over $102M (Appendix G). There are 3,042 structures within the 0.2% AEP floodplain, with estimated damages during a 0.2% AEP event of nearly $400M. Table 2.5 below shows the damages that may occur for a range of events within the study area; damages are displayed for the Tar River and its major tributaries. These damage values include structures and contents.

Table 2.5. Structures impacted and amount of damages projected for Tar River and tributaries during a range of flooding events.

	10% AEP		2% AEP		1% AEP		0.2% AEP	
Stream	**Str**	**Damage ($000s)**	**Str**	**Damage ($000s)**	**Str**	**Damage ($000s)**	**Str**	**Damage ($000s)**
Conetoe Creek	0	$0	2	$29	2	$128	21	$1,042
Fishing Creek	0	$0	10	$49	16	$222	28	$1,310
Stony Creek	8	$116	20	$3,071	43	$7,089	111	$20,854
Swift Creek	0	$0	7	$172	16	$621	60	$7,888
Tar Pamlico	13	$1,300	256	$41,057	643	$93,888	2800	$364,304
Total	21	$1,416	297	$44,397	724	$102,079	3,042	$397,415

The expected annual damages (EAD) under the FWOP condition were calculated by the Hydrologic Engineering Centers-Flood Damage Assessment model and are summarized below in Table 2.6. Total EAD for the study area is estimated at just over $8.9M, including damages to commercial, industrial, public, and residential facilities/infrastructure.

Table 2.6. Expected annual damages under the FWOP condition. EAD calculated using the FY24 price level.

Category	**Expected Annual Damages ($000s)**
Commercial	$4,523
Industrial	$2,592
Public	$364
Residential	$1,470
Total	$8,949

2.5.5. Environmental Justice

In January of 2021, President Biden issued Executive Order 14008 directing the Council on Environmental Quality (CEQ) to develop a new tool that characterizes environmental justice considerations. This tool—the Climate and Economic Justice Screening Tool (CEJST) — provides indicators of burdens in eight categories: climate change, energy, health, housing,

legacy pollution, transportation, water and wastewater, and workforce development. A community is highlighted as disadvantaged on the CEJST map if it is in a census tract that is (1) at or above the threshold for one or more environmental, climate, or other burdens, and (2) at or above the threshold for an associated socioeconomic burden.

Table 2.7. Categories and threshold criteria to determine the status of communities according to the CEJST criteria. The environmental, climate or other burden are indicated in each associated category below. The associated socioeconomic burden for each category is the last entry in each category column and is indicated by an asterisk.

	Categories							
	Climate Change	**Energy**	**Health**	**Housing**	**Legacy Pollution**	**Transpor-tation**	**Water & Waste-water**	**Work-force Dev.**
Total Threshold Criteria	Expected agriculture loss rate	Energy Costs	Asthma	Housing Cost	Abandoned mine land	Diesel particulate matter exposure	Underground storage tanks and releases	Linguistic isolation
	Expected building loss rate	PM 2.5 in the Air (Air Quality)	Diabetes	Lack of Green Space	Formerly Used Defense Sites	Transport barriers	Wastewater discharge	Low median income
	Expected population loss rate	***AND Low Income**	Heart Disease	Lack of Indoor Plumbing	Proximity to hazardous waste facilities	Traffic proximity and volume	***AND Low Income**	Poverty
	Projected flood risk		Low Life Expect	Lead Paint	Proximity to Risk Management Plan facilities	***AND Low Income**		Unemployment
	Projected wildfire risk		***AND Low Income**	***AND Low Income**	Proximity to Superfund sites			***High School education <10%**
	***AND Low Income**				***AND Low Income**			

The tool uses this information to identify communities that are experiencing these burdens and are thus disadvantaged because they are overburdened and underserved. There are numerous tracts within the study area that are considered disadvantaged by one or more of the burden categories (Figure 2.10)

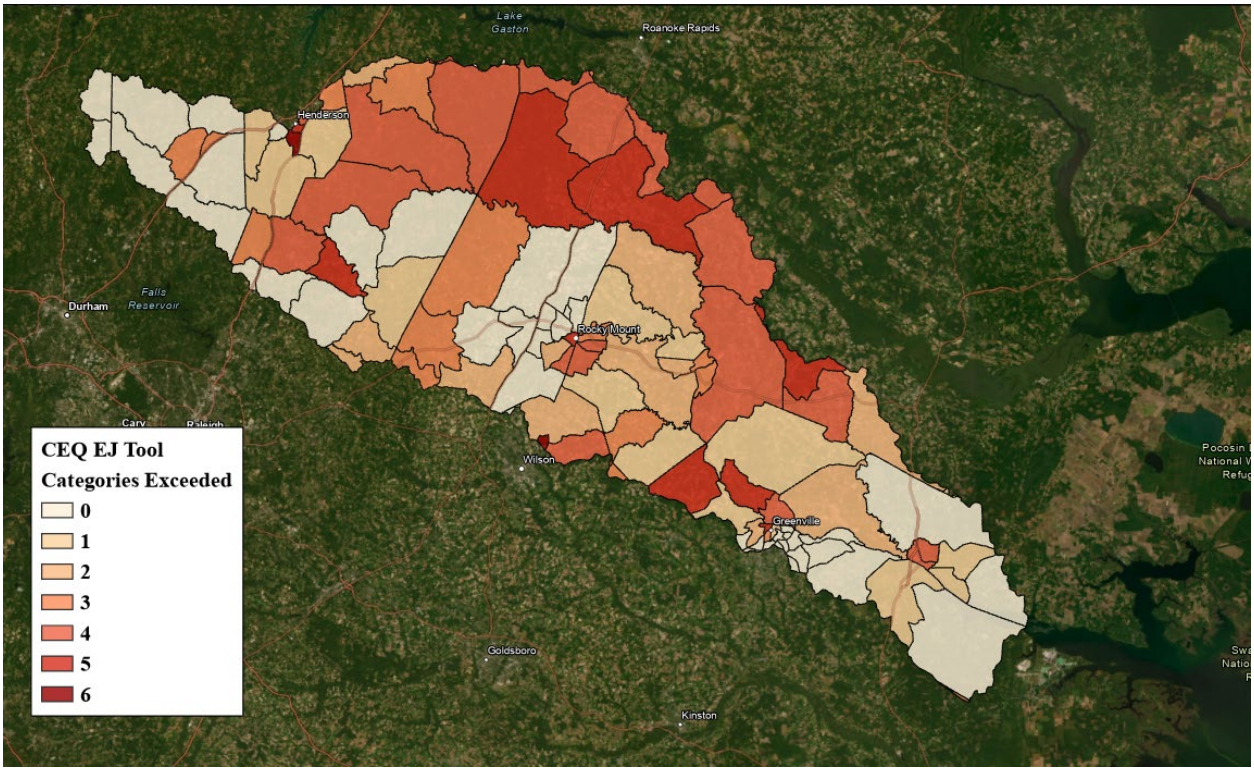


Figure 2.10. Census tracts with a greater number of indicators of burdens are darker in color.

The Environmental Justice Screen (EJScreen) tool, developed by the US Environmental Protection Agency, is another mapping and screening tool that provides a nationally consistent dataset and approach for combining environmental and demographic socioeconomic indicators into indices that provide an assessment of environmental justice. One of these indices is the demographic index, which is based on the average of the percentage of people with low-income (i.e., less than or equal to twice the federal 'poverty level') and people of color (i.e., racial status other than white alone and/or ethnicity as Hispanic or Latino). The higher the demographic index score, the greater the combined proportion of people of color and people with low income—a group that is historically underserved. Demographic index values for census tracts within the study area are shown in Figure 2.11.

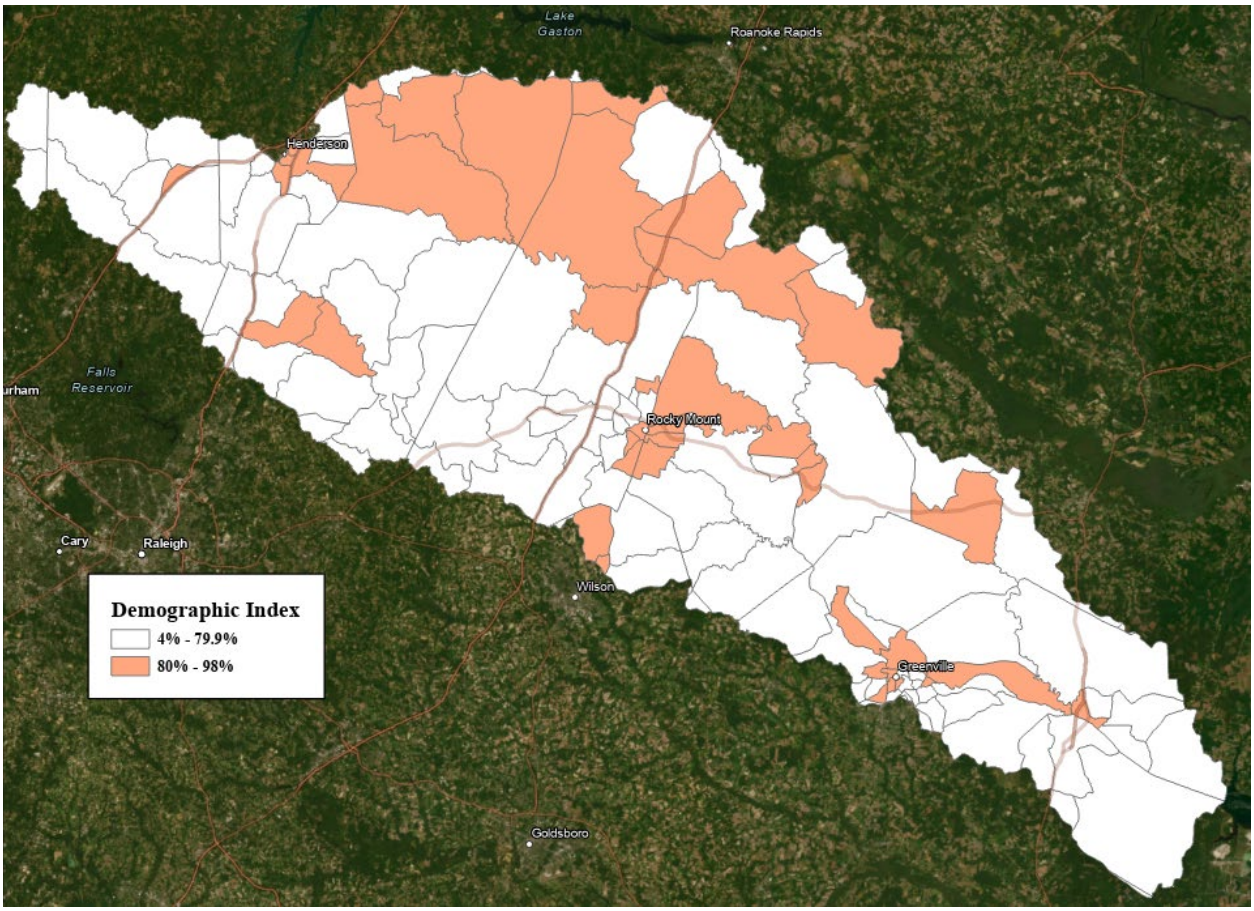


Figure 2.11. Demographic index values for census tracts in the study area. The higher the demographic index score, the greater the combined proportion of people of color and people with low income.

Table 2.8 summarizes the demographic index range, whether a given region is identified as disadvantaged, and whether a region is considered vulnerable to climate change for identified "reaches" in the study area. These reaches were delineated based on similar hydromorphology, hydraulic characteristics, and economic considerations (such as land use and socioeconomic characteristics). In more densely populated areas the reaches were sub-divided by census blocks (Figure 2.12) This table highlights the burden that flood risk places on disadvantaged communities, whereby the reaches are generally characterized by historically underserved populations with low income that also have increased vulnerability in the face of climate change. The Tar-Pamlico basin contains numerous reaches where economic and social burdens significantly reduce the resiliency of residents to the impacts of repeated flooding events, both current and under the FWOP scenarios.

Table 2.8 Comparison of total expected annual damages (EAD) and demographic index values and climate vulnerability as defined by the EJScreen and CEJST tools, respectively, across study reaches. A range of demographic index values indicates that the reach contains a number of census tracts with varying values. For the CEJST metrics, a value of "Y&N" (Y = yes; N = no) indicates a reach that contains multiple census tracts, with one or more being identified as

disadvantaged or vulnerable to climate change and one or more being identified as not disadvantaged or vulnerable to climate change.

Reach	Demographic Index Range (EJScreenEJScreen)	Identified as Disadvantaged (CEJST)	Climate Change Vulnerability (CEJST)
CC	64-70%	Y	Y
FC1	75-92%	Y	Y
FC2	75-96%	Y&N	Y&N
GM	41-98%	Y&N	Y&N
STC1A	55%	N	N
STC1B	72%	N	N
STC1C	67%	N	N
STC1D	12%	N	N
STC1E	51%	N	N
STC1F	71%	N	N
STC2	62-78%	Y&N	Y&N
SWC	12-86%	Y&N	Y&N
TP10A	86%	Y	Y
TP10B	62%	Y	Y
TP10C	84%	Y	Y
TP10D	67%	N	N
TP11	12-64%	Y&N	Y&N
TP12	24-75%	Y	Y
TP13	24-75%	Y&N	Y&N
TP14	53-82%	Y&N	Y&N
TP15	34-82%	Y&N	Y&N
TP3A	73%	Y	N
TP3B	50%	Y	Y
TP3C	64-93%	Y	Y
TP3D	72%	Y	N
TP3E	92%	Y	N
TP3F	92%	Y	Y
TP4	55-93%	Y	Y&N
TP5	77-93%	Y	Y
TP6	66-81%	Y	Y
TP7	77-93%	Y	Y
TP8	75-81%	Y	Y
TP9A	84%	Y	Y
TP9B	76%	N	N
TP9C	92%	Y	Y
TP9D	86%	Y	Y&N

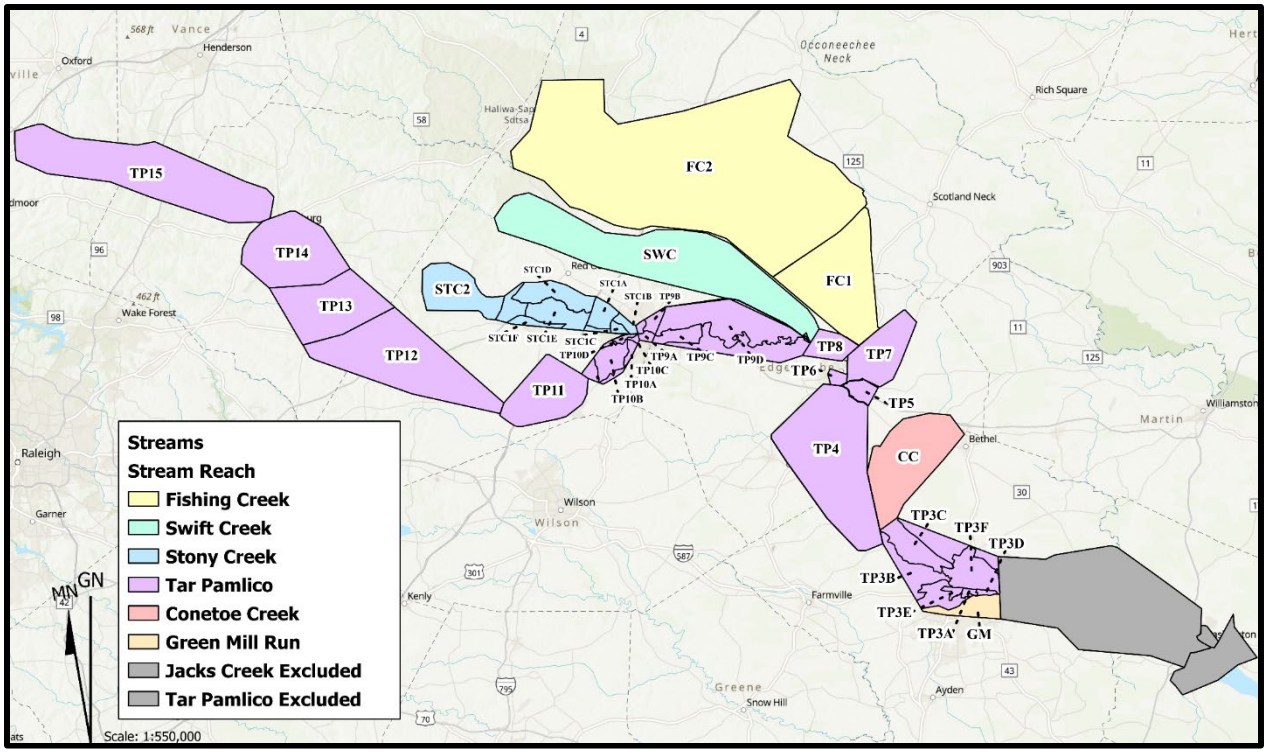


Figure 2.12. Reaches identified in the Tar Pamlico study. In urbanized areas, reaches were sub-divided by census blocks.

2.5.6. Life Safety

The Federal Emergency Management Agency's (FEMA) National Risk Index (NRI) was used as a preliminary assessment of current and potential future life safety risk. The NRI is an online tool that illustrates the risk communities face for a range of natural hazards, including flooding. The NRI provides estimates of population at risk (PAR) and expected annual life loss (EALL) per census tract due to flooding. Due to the robust nature of the tool, it was determined that it would be an adequate proxy for the baseline life safety risk experienced within study area. Further qualitative and semi-quantitative assessment of life risk based on Hydrologic Engineering Center-Life Simulation (HEC-LifeSim) methodologies was undertaken to evaluate and compare the initial and final array of alternatives.

The total population at risk of riverine flooding is estimated to be 9,716 people with an EALL of 0.224 (Table 2.9). The largest EALL is in tract 37065020400 with an EALL of 0.042. This tract is only in reach TP9C.

Table 2.9. Population at risk (PAR) and expected annual life loss (EALL) per census tract as quantified by the NRI. Intersecting reaches and associated county for each census tract are shown. See Figure 2.12 for location of specific reaches.

Census Tract	Intersecting Reaches	County	PAR	EALL
37065020400	TP9C	Edgecombe	964	0.0424
37065020600	SWC, TP9D	Edgecombe	537	0.0236
37065020700	FC1, FC2, SWC	Edgecombe	137	0.0060

Census Tract	Intersecting Reaches	County	PAR	EALL
37065020800	CC, FC1, TP4, TP7	Edgecombe	302	0.0133
37065020900	TP4, TP5, TP7	Edgecombe	176	0.0077
37065021000	TP6, TP7	Edgecombe	189	0.0083
37065021100	SWC, TP7, TP8	Edgecombe	178	0.0078
37065021200	TP6	Edgecombe	72	0.0032
37065021300	TP4, TP9D	Edgecombe	21	0.0009
37065021600	TP4	Edgecombe	13	0.0006
37069060301	TP14, TP15	Franklin	56	0.0014
37069060302	TP14	Franklin	6	0.0002
37069060401	TP15	Franklin	9	0.0002
37069060703	TP12	Franklin	51	0.0013
37069060801	TP12, TP13	Franklin	23	0.0006
37083930800	FC2	Halifax	64	0.0029
37083930902	FC2	Halifax	40	0.0018
37127010200	TP10B	Nash	383	0.0138
37127010301	TP10A	Nash	87	0.0031
37127010302	TP10B	Nash	380	0.0137
37127010400	TP10C, TP9A	Nash	169	0.0061
37127010503	STC1A	Nash	74	0.0027
37127010505	STC1B, TP10D	Nash	164	0.0059
37127010506	STC1C, TP10D	Nash	360	0.0129
37127010604	TP9B	Nash	193	0.0069
37127010700	FC2, SWC	Nash	15	0.0005
37127010801	FC2, SWC	Nash	6	0.0002
37127010802	STC1D, SWC	Nash	161	0.0058
37127010900	SWC	Nash	21	0.0007
37127011000	TP12	Nash	12	0.0004
37127011101	STC1E	Nash	143	0.0051
37127011103	STC1F	Nash	30	0.0011
37127011104	STC2	Nash	2	0.0001
37127011201	TP10B, TP11	Nash	52	0.0019
37127011202	TP11	Nash	80	0.0029
37127011300	TP11	Nash	8	0.0003
37127011502	TP12	Nash	8	0.0003
37147000101	TP3A	Pitt	90	0.0003
37147000102	GM	Pitt	312	0.0012
37147000201	GM, TP3D	Pitt	964	0.0037
37147000400	GM	Pitt	227	0.0009
37147000604	GM	Pitt	213	0.0008
37147000701	TP3E	Pitt	52	0.0002
37147000800	TP3F	Pitt	849	0.0032
37147000901	TP3F	Pitt	608	0.0023
37147001700	TP3B, TP4	Pitt	42	0.0002

Census Tract	Intersecting Reaches	County	PAR	EALL
37147001900	TP4	Pitt	36	0.0001
37147002002	CC, TP4	Pitt	147	0.0006
37147002003	CC, TP3C	Pitt	919	0.0035
37147002004	TP3C	Pitt	70	0.0003
Total			**9,716**	**0.2240**

Source: https://www.fema.gov/flood-maps/products-tools/national-risk-index

2.6. Existing and FWOP Summary Table

Table 2.10. Summary of existing and FWOP conditions that affect the formulation and evaluation of alternative plans.

Consideration	Current Conditions	FWOP Conditions
Natural Environment	The study area contains multiple types of wetlands and critical habitats that are sensitive to disturbance. There are 21 federally-listed threatened, endangered, and/or candidate species. The Tar River and many of its tributaries are considered high quality streams.	The natural environment remains at-risk due to increasing development pressures, as well as potential alterations resulting from flooding events (e.g., streambank erosion).
Physical Environment	A mild increase in the annual temperature of the South Atlantic-Gulf Region has occurred over the past century, most significantly over the past 40 years. Annual precipitation totals have become more variable in recent years compared to earlier in the 20th century. The study area is vulnerable to tropical storms and hurricanes, which pose a significant flood hazard. There are several known cultural resource sites within or adjacent to the study area and some of the structures within the study area are potentially eligible for listing in the NRHP.	Mean annual air temperatures will increase by approximately 2ºC to 4ºC for the South Atlantic-Gulf region by the latter half of the 21st century. No consensus has been identified in the literature regarding future streamflow conditions (i.e., increased or decreased) in the study area. Changes in flood runoff (cumulative), combined with the acres of urban area within the 500-year floodplain, drive flood risk reduction vulnerability. Projected increases in runoff, flood magnitude and frequency, and sedimentation and erosion have the potential to exacerbate water quality problems. Inundation would continue to damage properties currently listed or eligible for the NRHP.
Economic Environment	The more densely populated census tracts include Rocky Mount, Greenville, and Princeville. Population centers in the study area have median home values and household incomes below the national average. Total EAD for the study area is estimated at just over $7.8M, including damages to commercial, industrial, public, and residential facilities/infrastructure. Many communities in the study area are considered disadvantaged and lack economic resiliency.	Generally decreasing population suggest that increasing development is unlikely over the period of analysis. The EAD is estimated at over $8.9 M for the FWOP scenario. EAD for the study area is expected to rise with increased flooding due to climate change. Similarly, economic and social burdens significantly reduce the resiliency of residents to the impacts of repeated flooding events, both current and in expected FWOP scenarios.

3. PLAN FORMULATION AND EVALUATION

This chapter describes the development, evaluation, and selection of alternative plans that address the study objectives. Alternative plans are made up of individual or combinations of management measures. Management measures help prevent or reduce flood risk by using either structural or non-structural means or a combination of the two.

3.1. Planning Framework

The Study Strategy consisted of multi-phased approach. (Figure 3.1).

1. Management Measure Identification: Potential management measures were identified through meetings with the project stakeholders and the study team. The study area was generally broken up into focal areas that included the five major population centers (Greenville, Tarboro/Princeville, Rocky Mount, Nashville, and Louisburg), with the remaining rural areas representing a sixth focal area. The study team assessed the potential for each management measure to meet study objectives within each focal area.

2. Management Measure Screening: Screening determined which management measures should be included in the focused array based on their completeness, effectiveness, efficiency, and acceptability, as outlined in the PR&G (USACE, 2013). Additional considerations for screening included technical feasibility, study authority, and other social and environmental considerations.

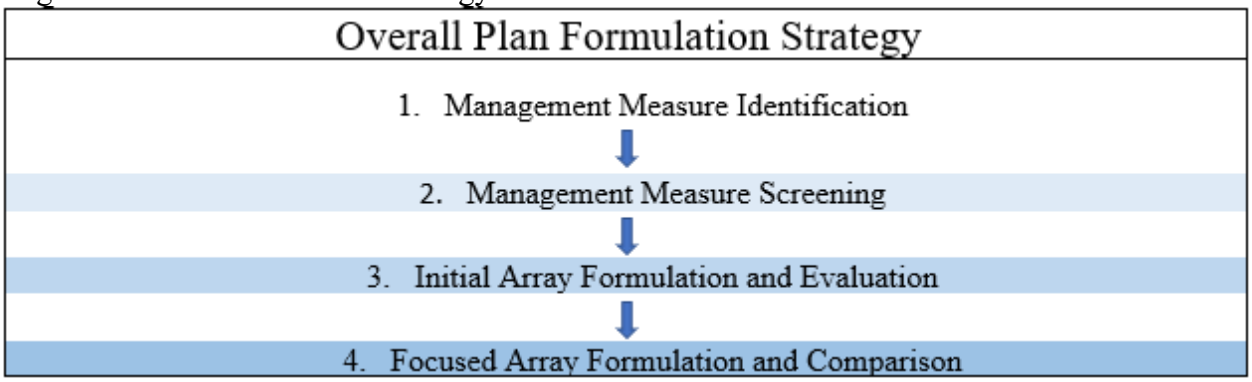
3. Initial Array Formulation and Evaluation: The remaining measures were combined into an initial array of alternatives—combinations of management measures that aim to reduce risk throughout the study area. The initial array was evaluated based on the following evaluation criteria: effectiveness, efficiency, completeness, acceptability, environmental effects, and social considerations. Alternatives were also evaluated with respect to the four accounts as outlined in the PR&G. The four accounts are NED (See section 1.7.1), Regional Economic Development (RED), Other Social Effects (OSE) and Environmental Quality (EQ). . Alternatives in the initial array were either retained for further consideration/reformulation in the final array or screened from further consideration.

4. Final Array Formulation and Comparison: Alternatives retained for further consideration were reformulated into the final array of alternatives. Alternatives within the final array were then evaluated and compared using the same criteria and accounts as discussed above under step 3. The final array was also evaluated and compared with respect to the extent to which they met the planning objectives, as well as remaining risk and uncertainty.

5. Management Measure Screening: A multi-phased screening process was used to determine which management measures should be included in the formulation of alternatives. Screening criteria included effectiveness, efficiency, and acceptability (including whether the project was technically feasible, or within the study authority) as outlined in the PR&G (USACE, 2013). Additional criteria included environmental

effects and social considerations. Definitions and descriptions of each criterion and account are provided in subsequent sections.

Figure 3.1. Plan formulation strategy.



3.2. Screening Criteria

Management measure screening was conducted iteratively in order to maximize efficiency. The first iteration of screening was conducted using existing data for the Tar-Pamlico River basin and existing models while the integrated hydrologic and hydraulic models of the entire Tar River were being developed. Given the additional uncertainty associated with using existing data and models, all measures with the possibility of having positive net economic development benefits and/or substantial benefits to life safety were retained for further analysis utilizing the final models. The secondary iteration was based on results of the basin-wide hydrologic and hydraulic model, and the application of those results to analysis of economic and life safety benefits.

During the screening process, management measures were evaluated based on completeness, effectiveness, efficiency, and acceptability, as outlined in the PR&G (USACE, 2013). Additional considerations for screening included environmental effects, environmental justice, and technical feasibility (Table 3.1).

Table 3.1. Criteria used to screen the initial list of management measures. Description and associated metrics used to assess each criterion are provided.

Criteria	**Description**	**Metric(s)**
Efficiency	Cost effectiveness. Comparison of economic benefits and costs	Quantitative – Comparison of preliminary costs and expected benefits.
Effectiveness – Damages Reduced	Damages to buildings, related contents, and vehicles	Semi-Quantitative – Expected benefits based on preliminary cost benefits analysis and hydrologic and hydraulic modeling.
Effectiveness – Industry and Commercial	Degree to which flood risk is reduced in commercialized reaches	Qualitative – expected benefits in targeted reaches

Effectiveness – Life Safety	Changes in life safety risk expected with alternative implementation.	Qualitative–population at risk, qualitative assessment of reductions in life loss due to expected changes in flooding characteristics (e.g., depth, velocity)
Acceptability	The viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies.	Qualitative – narrative description of acceptability.
Environmental Effects	Effects to aquatic (stream, wetland) and terrestrial (riparian, upland, critical) habitats, water quality, and threatened/endangered species.	Qualitative – positive effect, neutral (no) effect, negative effect based on footprint and effect of each alternative
Environmental Justice	Changes in flood risk or consequences within areas identified as traditionally disadvantaged with respect to environmental concerns per the CEQ's Climate and Economic Justice Screening tool and EPA's EJScreen tool were used to characterize potential benefits to socially vulnerable communities.	Qualitative – Qualitative assessment of potential benefits in areas identified as socially vulnerable based on initial hydrologic and hydraulic modeling results.
Engineering Feasibility	As to whether the measure is engineering feasible and constructable.	Best professional judgement based on engineering practices and standards.

3.3. Assumptions

The following assumptions informed the plan formulation and evaluation process.

- The study area will experience minimal change in river hydrology as per the climate change analysis presented in Section 0 of this report.
- The study area is not projected to experience changes in land use as per the economic trends detailed in Section 2.5 of this report.
- The flood risk management project in Princeville is moving forward and therefore no additional features in / around Princeville were examined / considered.

3.4. Management Measures

During the planning charette, the study team, local sponsor, and relevant stakeholders developed a list of 11 general management measures that could potentially address the identified problems

and realize the identified opportunities (Table 3.2). Management measures are classified as either structural, nonstructural, or natural and nature-based measures.

Structural measures reduce or avoid damages by modifying the nature and/or extent of the flood hazard. Potential locations for structural measures were identified using two separate strategies. Potential storage areas were considered throughout the study area to achieve local and downstream benefits, and specific locations for these measures were identified using aerial imagery and topography. Potential areas for implementing floodwalls and levees, channel improvements, and diversion channels were limited to the five major population centers, as these areas were the only areas with concentrated damages to warrant location-specific structural measures.

Nonstructural measures reduce or avoid damages by modifying the consequences of the flood hazard. Potential locations for nonstructural measures were identified using existing structure data and inundation grids for standard flood events (i.e., 10-, 25-, 50-, 100-, 200-, and 500-year events).

Natural and nature-based measures alter, restore, use, or mimic natural landscape features or processes to manage flood risk. Natural measures were considered throughout the study area as appropriate.

Table 3.2. General management measure types evaluated to manage flood risk within the Tar-Pamlico River study area.

Measure	**Description**
Structural Measures	
Floodwater Storage	Measures designed to capture and store floodwaters to reduce flood stages downstream. Storage measures can either be offline or online. Online storage measures are placed along the channel and attenuate flooding by ponding water during a flood event. Online storage includes reservoirs, which maintain a permanent pool, and online detention areas such as dry dams, which store water only during high flow events and allow unimpeded flow during normal flows. Offline storage refers to the diversion of streamflow to a storage site (e.g., auxiliary channels and detention areas) during a flood event. Water is then returned to the river via pumping or gravity once floodwaters recede.
Floodwall/Earthen Levee	Construction of a concrete wall (floodwall) and/or earthen embankment (levee) along the watercourse or around critical infrastructure to temporarily exclude flood waters from protected areas.
Channel Improvements	Channel improvements result in increased channel capacity and/or expedited water movement through the system. Channel improvements include channel modifications such as widening, deepening, and/or straightening, as well as channel lining to maintain the desired geometry and decrease roughness.
Transportation Modifications	Bridge modifications designed to reduce constrictions and associated upstream water surface profiles.

Diversion Channel	Construction of a secondary channel designed to divert flows from an upstream location to an engineered channel, lowering the flood stages. The engineered channel discharges at a downstream location, bypassing potential damage areas.
Existing Water Resource Project Modifications	This measure would involve updating, improving, or removing existing water resources infrastructure, including existing flood risk management projects or dams and associated reservoirs. This measure could include structural modifications to increase storage capacity and modifications to operations.
Debris Management	Implement measures designed to remove debris from the channel, prevent debris from entering the channel, and/or prevent debris buildup to reduce risk of direct damage and altered hydraulics during high-water water events.
Nonstructural Measures	
Physical Non-structural Measures	Physical nonstructural measures include efforts to reduce flood damage to individual structures and their contents and include floodproofing, elevation, and acquisition and relocation. Floodproofing limits the potential damage to the structure and its contents and includes both wet and dry floodproofing. Wet floodproofing measures allow flood waters to enter the structure to equalize hydrostatic forces and reduce the risk of structural damage, while vulnerable items and utilities are relocated to higher locations and/or waterproofed. Dry floodproofing involves sealing building walls and openings to prevent the entry of flood waters and is most applicable in areas of shallow, low velocity flooding. Structure elevation involves raising structures in place so that the structure sees a reduction in frequency and/or depth of flooding during high-water events. Elevation can be done on fill, foundation walls, piers, piles, posts, or columns, depending on flood characteristics. Structure relocation is the process of physically moving a structure away from the flood hazard or risk. Acquisition and relocation, also called buyouts, includes acquisition and demolition of flood prone structures. Residents would be relocated outside of the floodplain. Participation in the relocation would be mandatory. The floodplain would be planted with native vegetation. The local sponsor would retain ownership of the acquired property and must ensure no future development or fill would occur.
Non-physical Nonstructural Measures	Non-physical nonstructural measures improve the ability to respond to a flood event and prevent future actions that could increase flood risk and include flood warning systems, flood preparedness planning, and land use regulations to prevent development in flood zones.

Natural and Nature-Based Measures	
Watershed Restoration and Conservation	Actions taken to protect, preserve, manage, and restore natural resources at the watershed scale, such as reforestation, that improve natural process and reduce downstream flooding.
Dispersed Water Management	Dispersed water management is a more natural form of off-channel storage. Off-channel areas, which may be part of the floodplain and include wetlands, marshes, and agricultural fields, would be used to temporarily store water diverted from the river channel. Lands used to store water could be public or private. Dispersed water management could involve restoration of floodplains (e.g., planting native vegetation) and wetlands (i.e., plugging surface drains and regulating storage). When agricultural lands are used for off-channel detention, this practice is often referred to as 'water farming'.

The study team identified a total of 81 individual management measures that underwent a screening evaluation to determine whether they would be incorporated into the development of flood risk management alternatives. A summary of these measures is provided in Table 3.3 below. A detailed description of each measure can be found in Appendix A (Plan Formulation Appendix).

Table 3.3. Management measures screened during iterations 1 and 2 of screening. See Appendix A (Plan Formulation Appendix) for detailed descriptions of locations where measures were considered, and the reason screened.

Measure	No. Evaluated	No. Retained	Reason Screened
Structural Measures			
Floodwater Storage	3	2	Environmental Effects, Efficiency
Floodwall / Levee	6	0	Effectiveness, Efficiency
Diversion Channel	13	0	Technical Feasibility, Efficiency
Channel Improvement	2	0	Effectiveness, Efficiency, Environmental Effects
Transportation Modification	17	0	Effectiveness, Efficiency
Debris management	24	0	Effectiveness, Efficiency
Existing Water Resource Project Modifications	3	0	Effectiveness, Efficiency
Nonstructural Measures			
Physical Nonstructural Measures	4	3	Efficiency

Non-Physical Nonstructural Measures	3	0	Effectiveness
Natural and Nature-Based Measures			
Dispersed Water Management	5	0	Effectiveness
Watershed Restoration and Conservation	1	0	Effectiveness, Efficiency
Total	81	5	NA

A summary of screening results is presented in Table 3.3. A more detailed description of management measure screening for each measure is provided in Appendix A Planning Appendix. Seventy-six (76) of the 81 measures were screened from further consideration.

Structural measures retained for incorporation into plan formulation included two dry dams—one on Stony Creek and one on the Tar River. These two dry dams were retained after evaluation of their effectiveness and completeness as well as site-specific characteristics such as the proposed size, cost, feasibility, and real estate considerations. Nonstructural measures retained include structure elevation, floodproofing, and acquisition and relocation. Non-structural measures were retained for all study reaches after high-level screening analysis due to their perceived effectiveness, high-level assessment of potential cost effectiveness, acceptability, and minimal environmental impacts. A description of each of these measures is provided in the subsequent sections.

3.4.1. Management Measures Retained

Structural measures retained for incorporation into plan formulation included two dry dams—one on Stony Creek and one on the Tar River. Nonstructural measures retained include structure elevation, floodproofing, and acquisition and relocation (Table 3.3). A description of each of these measures is provided in the subsequent sections.

3.4.1.1. Dry Dams

Dry dams are in-stream detention basins that are designed to hold back excess water during periods of intense rainfall and subsequent high stream flow, releasing stored water at a controlled rate and reducing downstream peak flows. Dry dams allow the channel to flow freely during normal flow conditions. Dry dams were pursued within the Tar River basin over retention via reservoirs, which hold a permeant pool, due to the permanent loss of in-stream habitat and connectivity, as well as impacts to downstream aquatic resources associated with reservoirs—some of which can be minimized or avoided through the use of dry dams.

Two potential dry dams were retained for further analysis, including one on Stony Creek and one on the Upper Tar River (Figure 3.2). These dry dams would reduce peak flows along the entire length of the Tar River and Stony Creek, including within major population centers (i.e., Nashville, Rocky Mount, Tarboro/Princeville, and Greenville). Construction of one or both dry dams within the Tar River watershed could efficiently and effectively reduce riverine flooding

throughout the study area where the dry dams would be located, reducing both economic damages and life safety risk (Appendix E & F). Despite fewer environmental impacts as compared to reservoirs, dry dams would still have permanent impacts to critical aquatic habitats and associated threatened and endangered species along the Tar River and, thus, would require extensive environmental coordination and mitigation. Additional information regarding the dry dams can be found in Appendix E, Civil & Structural Engineering.

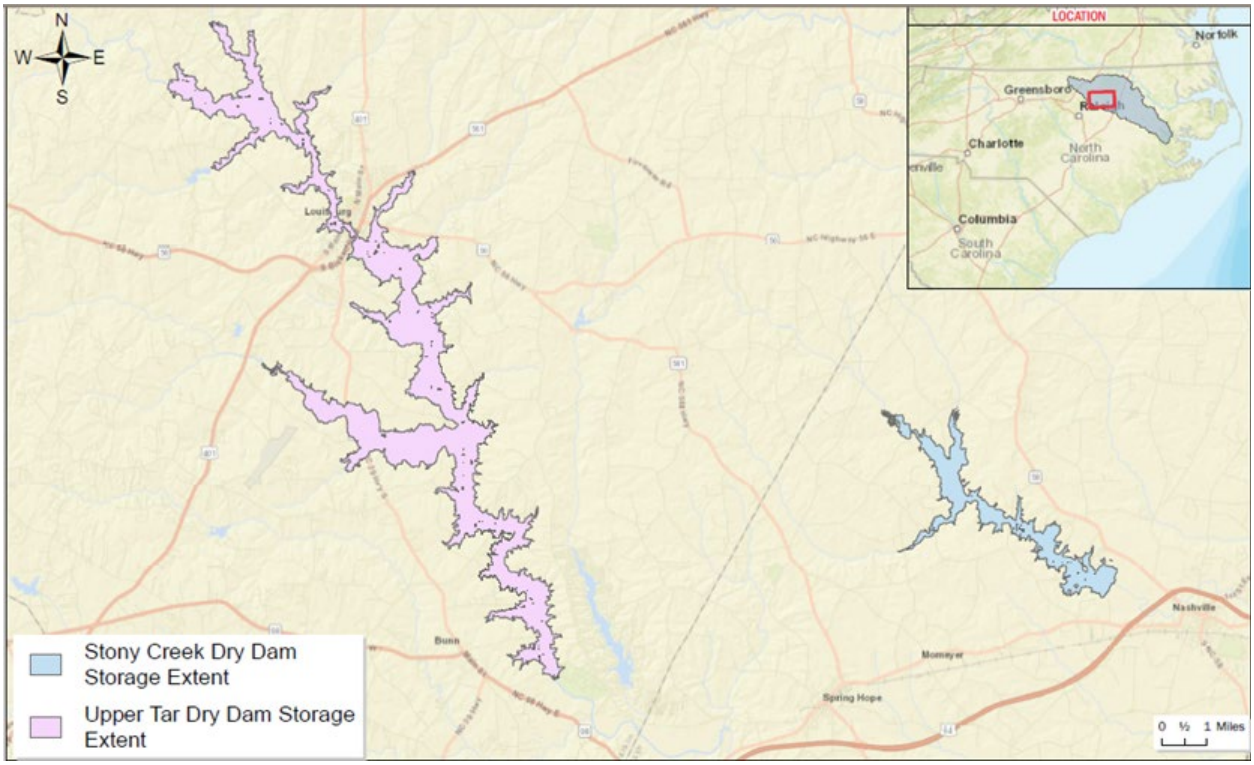


Figure 3.2 Location of potential dry dams on the Tar River and Stony Creek. Colored areas show maximum inundation extents associated with each storage area.

3.4.1.2. Structure Elevation

Structure elevation consists of elevating a structure's habitable area above a specified flood elevation. The target elevation used for this study was the 1% AEP elevation plus two feet. Structures can be elevated on piers or on an extended foundation—the latter also requires installation of flood vents. If a basement exists, it should be abandoned and filled (Figure 3.3).

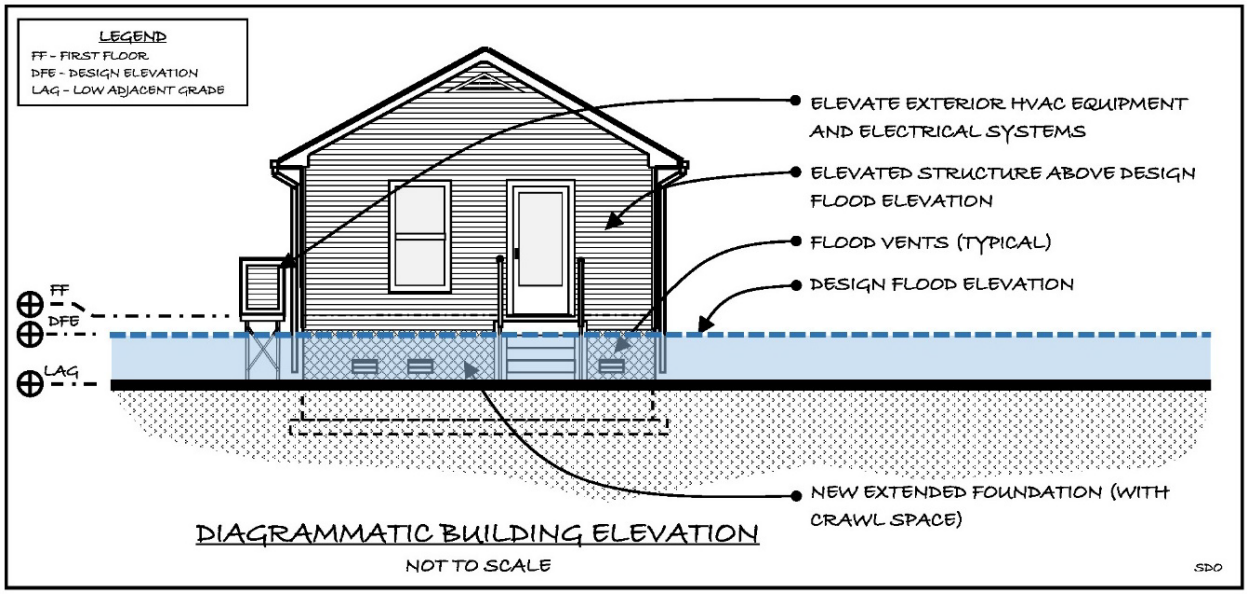


Figure 3.3 Diagrammatic building elevation (top) and example of an elevated house with flood vents (bottom).

Structure elevation could effectively reduce economic damages and life risk for structures impacted by flooding throughout the study area. Structure elevation would be voluntary.

3.4.1.3. Dry Floodproofing

Dry floodproofing consists of waterproofing the entire structure or portions of the structure. Structures can generally be dry flood-proofed up to between 3 to 4 feet on the exterior walls. For this study, the PDT assumed that dry floodproofing would be to the 1% AEP flood elevation plus two feet or a maximum of four feet. Exterior walls would be floodproofed using waterproof membranes and protective veneer wall. A sump pump and drain system may be required as part of the project to remove seepage or interior drainage. Closure panels are required for all openings (Figure 3.4).

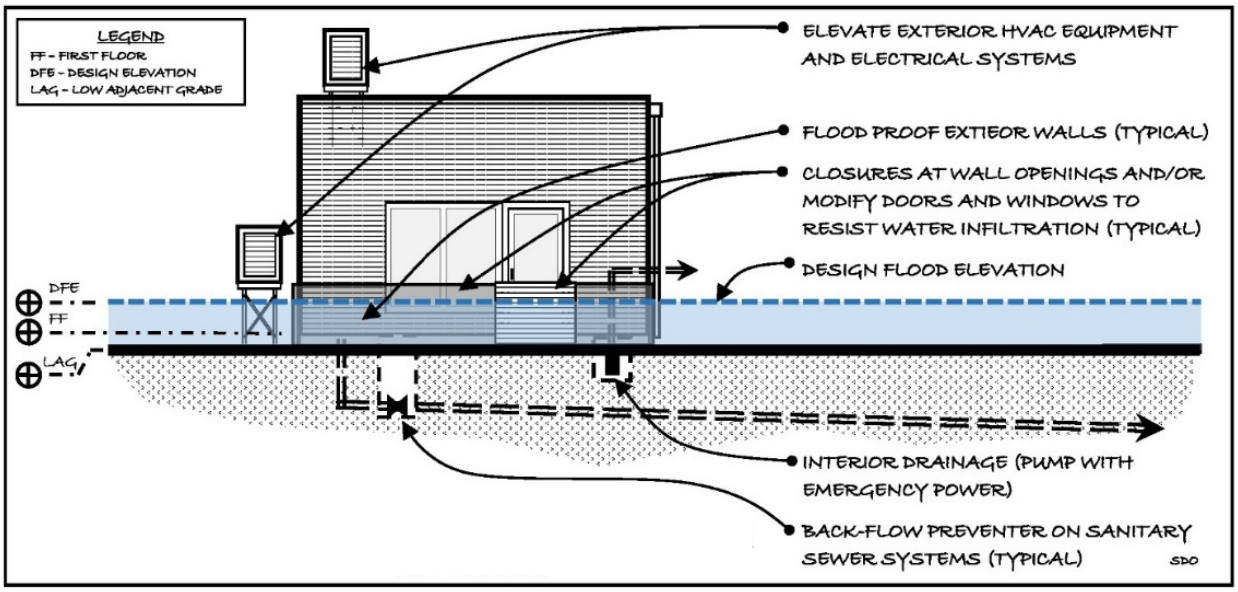


Figure 3.4 Dry floodproofing diagrammatic drawing (top) and example (bottom).

Dry floodproofing could effectively reduce economic damages for structures impacted by flooding throughout the study area. Dry floodproofing is only applicable to non-residential structures. Dry floodproofing would be voluntary.

3.4.1.4. Wet Floodproofing

Wet floodproofing allows flood water to enter all or part of a structure. Construction materials and finishes are to be water/flood resistant, and all utilities elevated to the 1% AEP flood elevation plus two feet (Figure 3.5, Figure 3.6). Flood vents are installed in the walls to allow floodwaters into the building and equalize the hydrostatic forces. Since wet floodproofing allows floodwaters into a building, it is not recommended for finished floors of residential buildings.

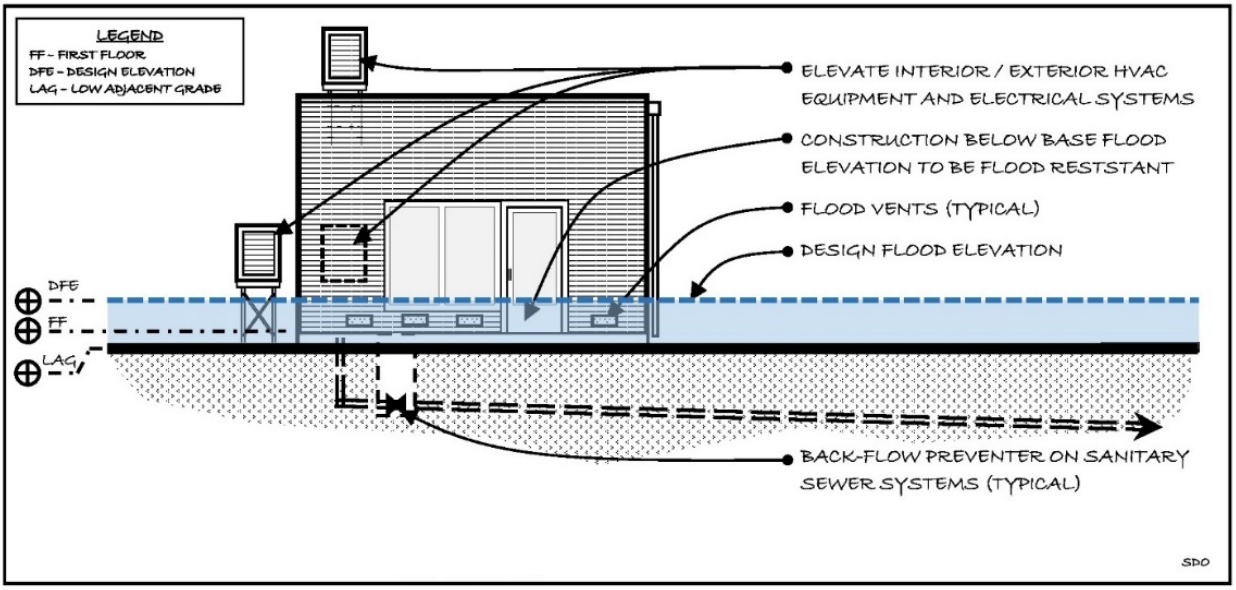


Figure 3.5. Diagram depicting specific actions associated with wet floodproofing measures. Diagram not to scale.

Figure 3.6. Example of exterior (left) and interior (right) wet flood-proofing of a fire station.

3.4.1.5. Acquisition and Relocation

Acquisition and relocation, also called buyouts, includes acquisition and demolition of flood prone structures (Figure 3.7). Residents would be relocated outside of the floodplain to comparable properties that are deemed to be decent, safe, and sanitary. The floodplain would be re-planted with native vegetation. The local sponsor would retain ownership of the acquired property and must ensure no future development or fill would occur. Acquisition and relocation could effectively reduce economic damages and life risk for structures impacted by flooding across the study area. Participation would be mandatory.

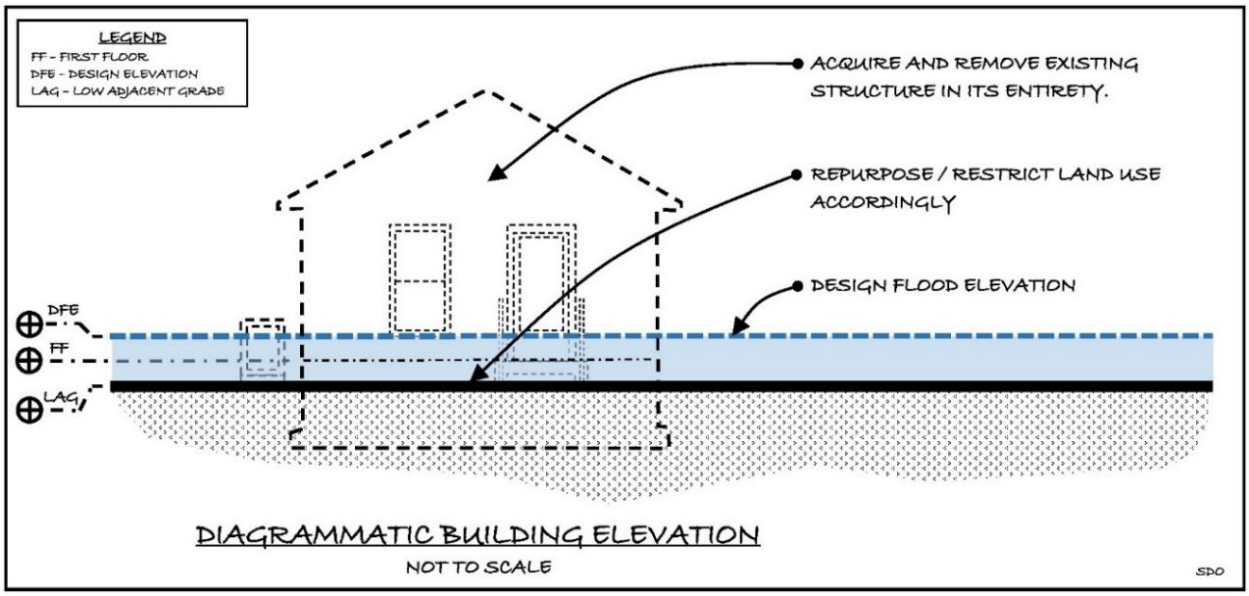


Figure 3.7 Diagrammatic illustration of acquisition and relocation of structures.

3.5. Array of Alternatives

3.5.1. Initial Array of Alternatives

3.5.1.1. Alternative Formulation

Alternatives were formulated by combining the remaining measures into logical combinations that achieved the planning objectives. The initial array of alternatives consisted of three distinct alternatives. A summary of the initial array of alternatives is provided below.

Alternative 1. No Action: USACE planning policy (Engineering Regulation 1105-2-103) and NEPA require consideration of a 'No Action' Alternative. The No Action Alternative assumes no measures would be implemented by the federal government to achieve the planning objectives. The FWOP condition as described under Section 2 is the consequence of taking no action.

Alternative 2. Dry Dams & Nonstructural: Alternative 2 consisted of two dry dams located along Stony Creek and the upper Tar River (Figure 3.2). The dry dams would work together to detain floodwaters and decrease flood risk to downstream rural and urban areas, including Rocky Mount, Tarboro, and Greenville. Physical (i.e., elevation, floodproofing, acquisition/relocation) and non-physical (i.e., flood warning) nonstructural measures would be incorporated to reduce residual risk to the greatest extent possible.

Alternative 3. Nonstructural: Alternative 3 consists of physical nonstructural measures, including elevation and acquisition/relocation of residential structures and dry floodproofing or acquisition and relocation of commercial structures throughout the study area. Through existing data and surveys, total of 716 structures were identified within the 1% AEP (i.e., 100-year) floodplain.

3.5.1.2. Alternative Evaluation

The initial array of alternatives was evaluated using the criteria shown below in Table 3.4 to determine whether they should be screened, reformulated, or passed to the final array of alternatives.

Table 3.4. Criteria used to evaluate the initial and final array of alternatives. Description and associated metrics used to assess each criterion are provided.

Criteria	Description	Metric(s)
Efficiency	Cost effectiveness. Comparison of economic benefits and costs	Quantitative – BCR and net economic benefits as assessed by the Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA) software.
Effectiveness – Damages Reduced	Damages to buildings, related contents, and vehicles	Quantitative – Expected benefits based on output from HEC-FDA.
Effectiveness – Industry and Commercial	Degree to which flood risk is reduced in commercialized reaches	Qualitative – expected benefits in targeted reaches
Effectiveness – Life Safety	Changes in life safety risk expected with alternative implementation.	Qualitative/Semi-Quantitative – Life loss was qualitatively assessed for the initial array of alternatives based on expected changes in flood characteristics (i.e., depth and velocity). Life loss was semi-quantitatively assessed for the final array of alternatives for the future without and future with project conditions based on HEC-LifeSim methodologies. A detailed description of the life safety analysis can be found in Appendix B, Economics Analysis.
Completeness	Extent to which each plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects	Qualitative – Narrative description of completeness.
Acceptability	Workability and viability with respect to acceptance by the nonfederal sponsor, local entities, the public, and compatibility with existing laws, regulations and policies.	Qualitative – Narrative description of acceptability.

Environmental Justice – Resilience	Extent to which each alternative improves the ability of communities to withstand and recover quickly after future flood events.	Semi-Quantitative – Assessment of expected annual damages and EJ metrics related to social vulnerability and future climate risk. Based on EJ metrics as described by EJScreen and CEJST.
Environmental Justice – Community Cohesion	The extent to which each alternative maintains social relationships within a community by promoting and preserving diversity and equal opportunity.	Semi-Quantitative – Assessment of the extent to which each alternative promotes equity in terms of benefits to socially vulnerable and diverse populations. Based on EJ metrics as described by EJScreen and CEJST.
Environmental Effects	Effects on aquatic (stream, wetland) and terrestrial (riparian, upland, critical) habitats, water quality, and threatened/endangered species.	Qualitative – positive effect, neutral (no) effect, negative effect based on footprint and effect of each alternative

A summary of the evaluation of the initial array is presented below in Table 3.5. A detailed narrative of the evaluation of each alternative within the initial array is also provided.

Table 3.5. Evaluation results for the initial array of alternatives. Green indicates a positive determination for each criterion; amber indicates a neutral determination or a metric that would require further quantitative evaluation; and red indicates a negative determination.

	Alt. 1. No Action	**Alt. 2. Dry Dams & Nonstructural**	**Alt 3. Nonstructural**
Efficiency	No effect	Negative effect	Positive effect
Effectiveness (Damage)	No effect	Positive effect	Positive effect
Effectiveness (Commercial/Industry)	No effect	Positive effect	Positive effect
Effectiveness (Life Safety)	No effect	Positive effect	Positive effect
Acceptability	No effect	Positive effect	Positive effect
Completeness	Positive effect	Positive effect	Positive effect
Regional Economic Impact	No effect	Positive effect	Positive effect
Environmental Justice (Resilience)	No effect	Positive effect	Positive effect
Environmental Justice (Community Cohesion)	No effect	Positive effect	Positive effect
Environmental Effects	No effect	Negative effect	No significant effect

Alternative 1. No Action: The no action plan would not reduce ongoing flood risk within the study area, including economic damages associated with inundation of structures and impacts to industry and commerce, as well as risks to life safety. No action would result in no change in community resilience, and repetitive inundation within socially vulnerable communities would result in continued exodus as individuals are able, resulting in a loss of community cohesion. There would be no change in RED as a result of the no action plan. Environmental resources

would continue to be degraded due to flooding, including impacts to water quality. The no action plan was retained for further consideration.

Alternative 2. Dry Dams & Nonstructural: Dry dams would be effective at reducing downstream flood risk, including economic damages associated with inundation of structures and impacts to industry and commerce, including in agricultural areas and many areas identified as socially vulnerable. Reduction in inundation of socially vulnerable communities would increase resilience and improve community cohesion as underserved and overburdened individuals would be less affected and able to stay in place. However, preliminary costs and benefits analysis indicated the alternative would not result in positive net benefits. Essentially eliminating damages at all events to structures in the existing conditions would still result in a Benefit Cost Ratio (BCR) of around 0.3 with the total cost being $642M (average annual costs of around $24M) and potential benefits of around $7.8M. Dry dams would reduce life safety risk by reducing inundation depths and extents; however, construction of dry dams would introduce new incremental risks, including risk of dam failure. Dry dams would have significant, permanent impacts to environmental resources, including federally-listed critical habitat for threatened & endangered species, would disturb ecologically-important riparian areas and wetlands along streams, and would disrupt the natural hydrology and sediment transport processes of the watershed—impacts that could affect the acceptability of this alternative by partnering state and federal resource agencies. Due to the lack of efficiency and significant environmental impacts, dry dams were screened from further consideration.

Alternative 3. Nonstructural: Nonstructural measures would be effective at reducing downstream flood risk by reducing the consequences of flooding, including reducing economic damages and life safety risk associated with inundation of structures. The nonstructural measures that were evaluated included elevation and flood venting (residential structures), wet floodproofing (commercial structures) and dry floodproofing (commercial structures). Several reaches, including several socially vulnerable areas, were identified where application of nonstructural measures could potentially be economically justified with positive BCR's. Preliminary cost and benefits analysis indicated a positive BCR when calculated for 21 structures in the 10% AEP (10-year) floodplain. In the 4% AEP (25-year) floodplain, 184 structures were identified for nonstructural measures in 17 reaches. This scenario had a calculated BCR of 0.9. The 2% AEP (50-year) floodplain and had a calculated BCR of 0.71 for 296 structures identified for potential nonstructural measures. The 1% AEP (100-year) floodplain included 582 structures and a calculated BCR of 0.48.

Reduction in inundation of socially vulnerable communities would increase resilience and improve community cohesion as underserved and overburdened individuals would be less affected and able to stay in place. Nonstructural measures could be implemented in commercial areas, resulting in reductions in risk to commerce. Participation in elevation and floodproofing would not be mandatory and, thus, participation rates could affect the overall efficiency and benefits of the plan. Alternative 3 was moved forward for further analysis and optimization.

3.5.2. Final Array Formulation

The No Action Alternative and Alternative 3 were the two alternatives that were retained for further consideration.

3.5.2.1. Visual Structural Survey and Aggregation

Prior to further analysis of Alternative 3 (Nonstructural), the 716 structures originally included in Alternative 3 were reassessed with existing data and through visual surveys to remove structures with first floor elevations above the target elevation (i.e., 1% AEP elevation plus two feet) and those with existing nonstructural features. Structures were then aggregated based on river reach and hydraulic floodplain [i.e., 10%, 4%, 2%, and 1% AEP]. River reaches were further separated based on census tract to enable comparison of socioeconomic data and incorporation of socioeconomic and environmental justice considerations. See Appendix B (Economic Analysis) for detailed description of nonstructural aggregation methodology.

HEC-FDA was used to identify reaches and hydraulic floodplain combinations where physical nonstructural measures would have positive net benefits. The study team additionally examined environmental justice indicators to identify river reaches where application of nonstructural measures could benefit socially vulnerable communities. A total of 13 reaches and 155 structures were identified as either likely having positive net economic benefits or as being among the most socially vulnerable communities within the basin (i.e., EJScreen demographic index above 70%).

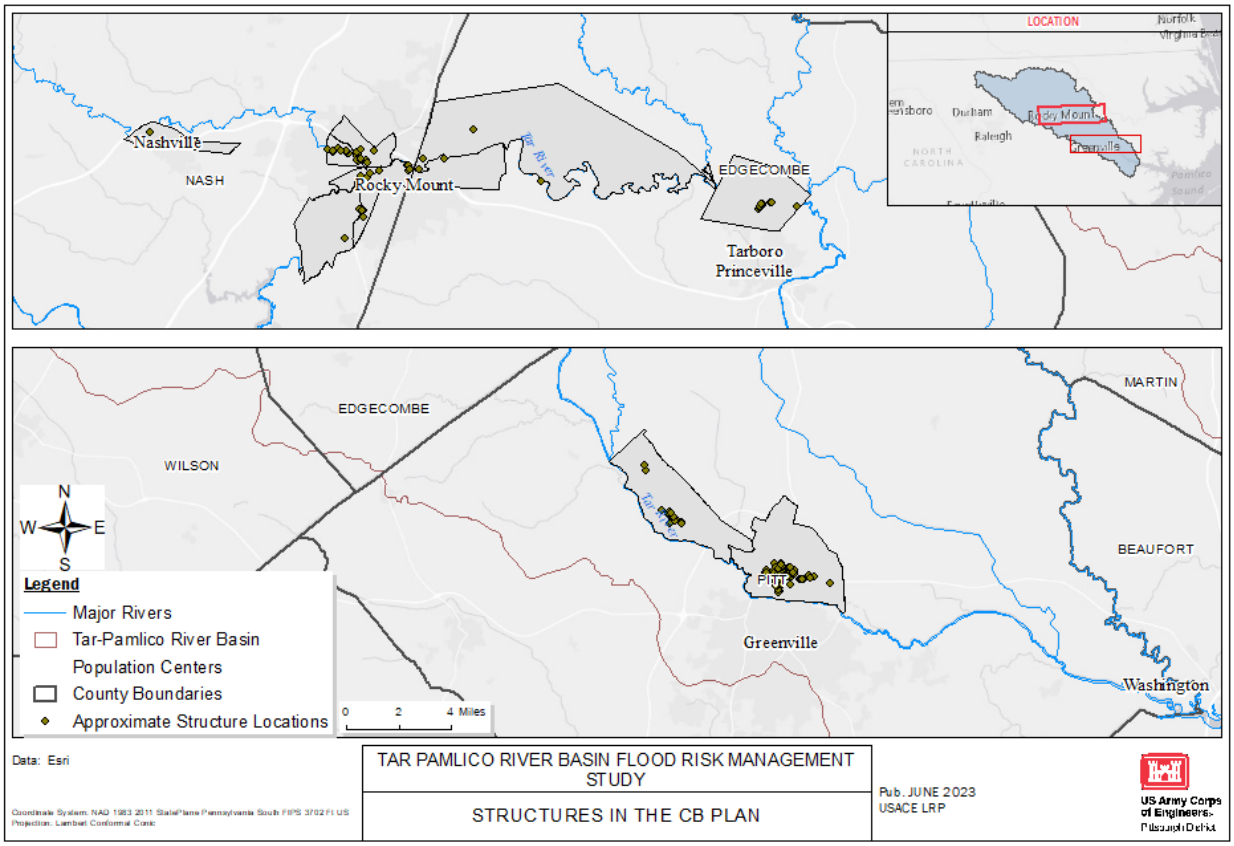


Figure 3.8. Approximate locations of 155 structures evaluated in formulation of the final array.

3.5.2.2. Nonstructural Measure Application

Initial analyses focused on elevation and floodproofing based on a preliminary review and previous studies, including the Neuse River Flood Risk Management Feasibility Study, which identified elevation and floodproofing as being more efficient than acquisition and relocation. Real estate conducted a rough order of magnitude appraisal of the 155 properties, enabling a

more detailed comparison of elevation and floodproofing with acquisition and relocation. The study team chose to aggregate based on river reach and, therefore, the nature of flooding was similar for all structures within each reach. As a result, the team determined that it would be most appropriate for the same type of measure (i.e., elevation and floodproofing or acquisition and relocation) to be applied within each study reach, also ensuring community cohesion. When floodproofing and elevation was compared with the cost of acquisition and relocation across all structures, acquisition and relocation was approximately two times (approximately $200M) that of elevation and floodproofing (approximately $100M). Additionally, dry floodproofing and structure elevation was more efficient (higher net economic benefits) than acquisition and relocation across all reaches with positive net benefits [see Appendix B (Economic Analysis) for a detailed description of results and analysis)]. Therefore, the final array consisted entirely of dry floodproofing and structure elevation.

In accordance with USACE Policy Directive, Comprehensive Documentation of Benefits in Decision Document, dated January 5, 2021, the remaining alternative was further refined. This refinement identified the plan that maximizes net NED benefits and a Comprehensive Benefits (CB) plan that maximizes total benefits across all benefits categories (i.e., NED, RED OSE, and EQ). A summary of the final array of alternatives is provided below.

Alternative 1. No Action: USACE planning policy (Engineering Regulation 1105-2-100) and NEPA require consideration of a 'No Action' Alternative. The No Action Alternative is the basis for the 'FWOP Condition' and assumes no measures would be implemented by the federal government to achieve the planning objectives.

Alternative 3A. Maximum Net Economic Benefits / NED Plan: Alternative 3A includes elevation or floodproofing of 37 structures across 7 reaches (Table 3.6**;** Figure 3.9). Alternative 3A includes elevation of 2 residential structures, elevation and flood venting of 1 residential structure, and dry floodproofing of 34 commercial structures (Table 3.6). Floodplain aggregation varied across the 7 reaches, ranging from the 10% to the 1% AEP floodplains (Table 3.6). Regardless of floodplain aggregation, structures would be elevated to the 1% AEP flood elevation plus 2 feet. Structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet, or a maximum height of 4 feet.

Table 3.6. Reach, aggregation floodplain, and number of structures for each reach in Alternative 3A, Maximum Net Economic Benefits / NED Plan.

Reach	Aggregation Floodplain	Elevate	Elevate Flood Vent	Dry Floodproof	Total
STC1B	0.01 AEP Floodplain	1	0	14	15
TP10A	0.10 AEP Floodplain	0	0	2	2
TP10C	0.10 AEP Floodplain	0	1	1	2
TP10D	0.01 AEP Floodplain	0	0	1	1
TP3F	0.04 AEP Floodplain	1	0	15	16
TP8	0.02 AEP Floodplain	0	0	0	0
TP9A	0.02 AEP Floodplain	0	0	1	1
NED Plan		**2**	**1**	**34**	**37**

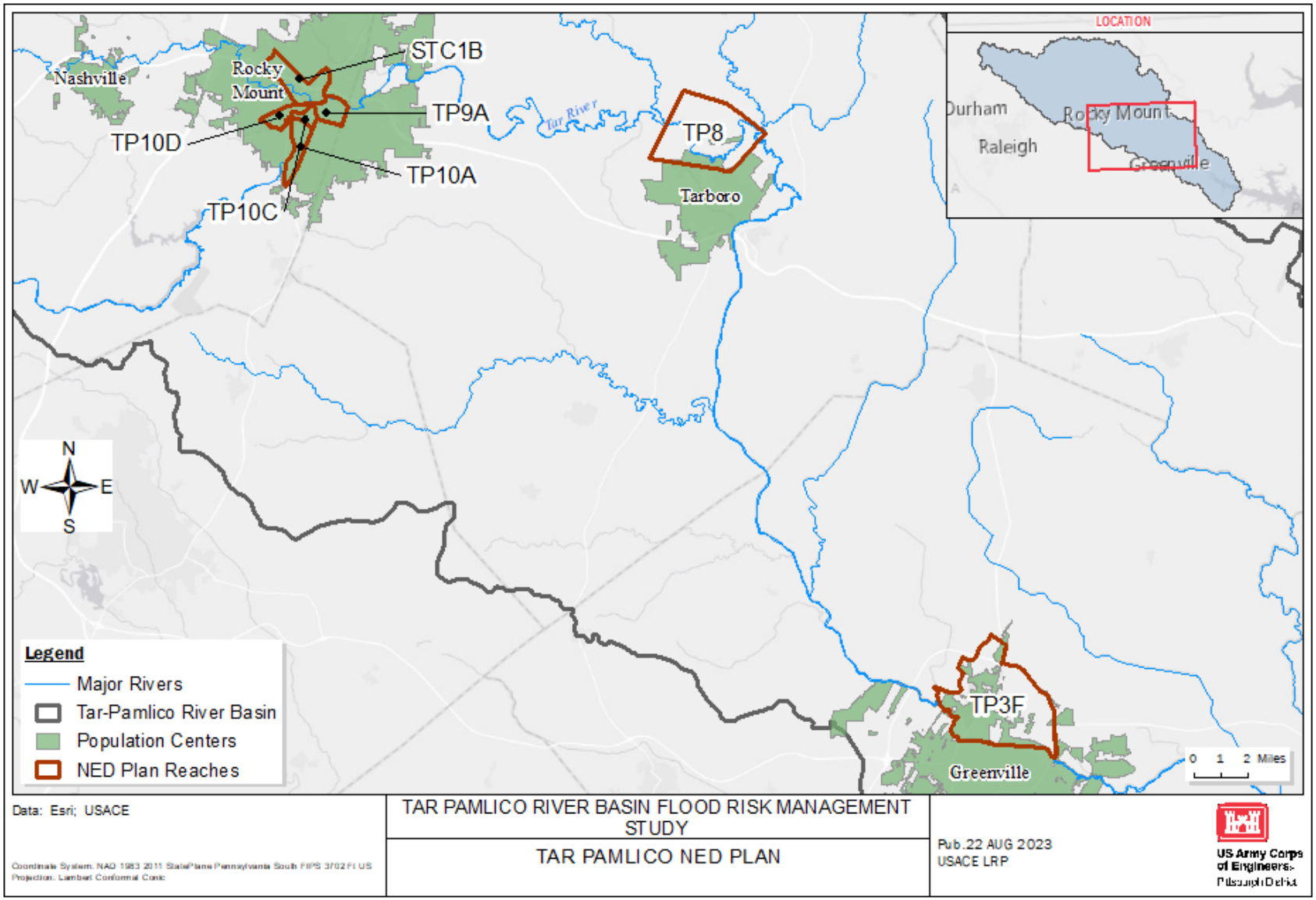


Figure 3.9. Reaches in Alternative 3A, the Maximum Net Benefits / NED plan.

Alternative 3B. Comprehensive Benefits Plan: Alternative 3B includes all 155 structures identified as being at-risk within the 1% AEP floodplain across 13 reaches. Alternative 3B includes elevation of 35 residential structures; elevation and flood venting of 18 residential structures; flood venting of 8 residential structures; and dry floodproofing of 94 commercial structures (Figure 3.10; Table 3.7). All structures would be elevated to the 1% AEP flood elevation plus 2 feet. Structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet, or a maximum height of 4 feet.

Table 3.7. Reach, aggregation floodplain, and number of structures for each reach in Alternative 3B, Comprehensive Benefits Plan.

Reach	Aggregation Floodplain	Elevate	Elevate Flood Vent	Flood Vent	Dry Floodproof	Total
STC1B	0.01 AEP Floodplain	1	0	0	14	15
STC1C	0.01 AEP Floodplain	1	7	4	7	19
STC1F	0.01 AEP Floodplain	0	0	0	1	1
TP10A	0.01 AEP Floodplain	0	1	1	2	4
TP10B	0.01 AEP Floodplain	1	0	0	1	2
TP10C	0.01 AEP Floodplain	0	3	1	1	5
TP10D	0.01 AEP Floodplain	0	0	0	1	1
TP3C	0.01 AEP Floodplain	22	0	0	0	22
TP3F	0.01 AEP Floodplain	10	5	0	52	67
TP8	0.01 AEP Floodplain	0	1	0	9	10
TP9A	0.01 AEP Floodplain	0	0	2	2	4
TP9C	0.01 AEP Floodplain	0	0	0	1	1
TP9D	0.01 AEP Floodplain	0	1	0	3	4
Comp Benefits		**35**	**18**	**8**	**94**	**155**

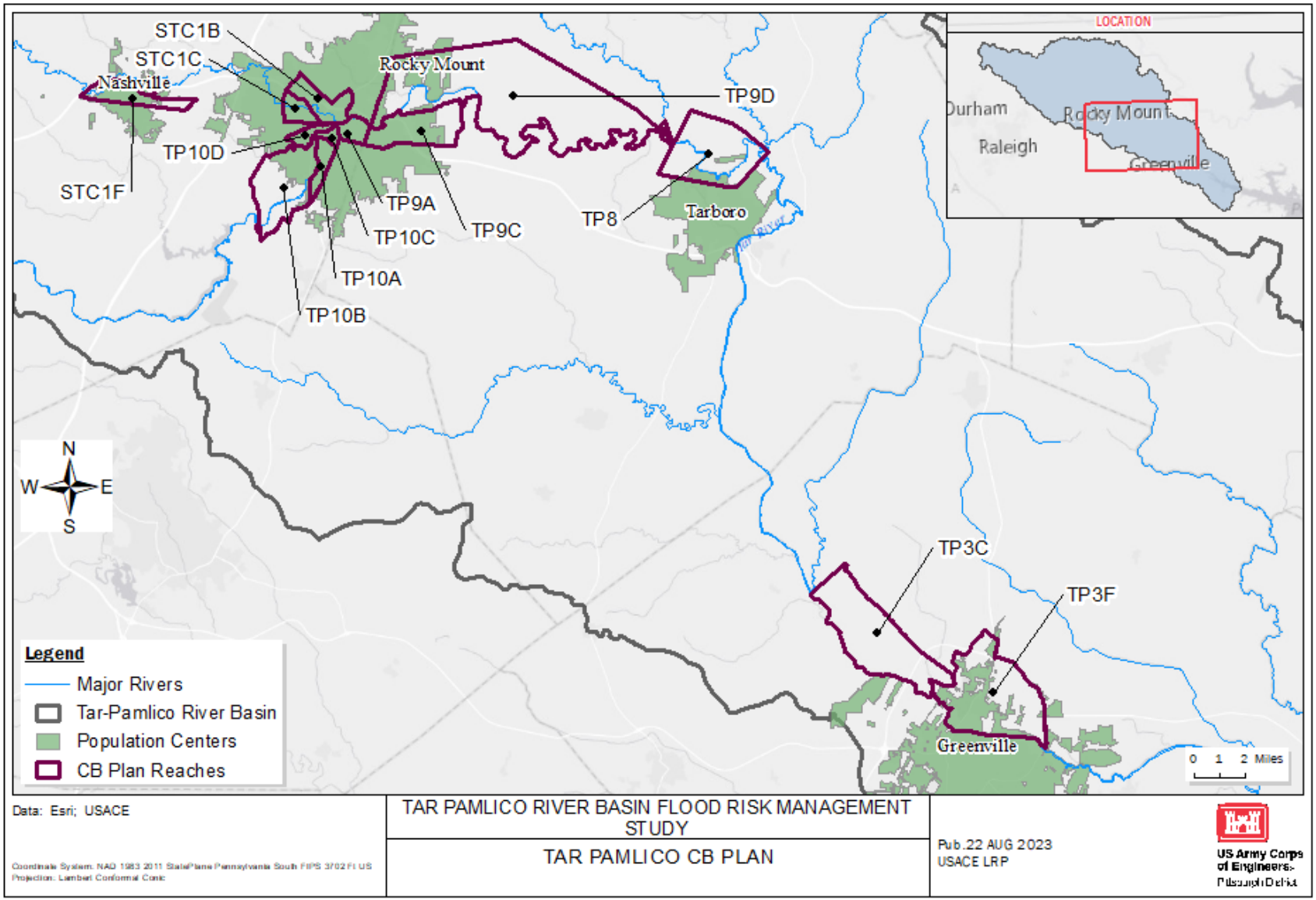


Figure 3.10. Reaches included in Alternative 3B, Comprehensive Benefits Plan.

3.6. Plan Evaluation

3.6.1. Federal Planning and Environmental Objectives

Alternative 3A has positive net annual benefits and, thus, would meet the Federal Planning Objective of contributing to the net value of the national output of goods and services and would provide direct net economic benefits that accrue in the study area and the rest of the nation following project implementation (Table 3.8. Costs and benefits for Alternatives 3A and 3B. Costs were calculated using FY24 price levels.). Although Alternative 3B has negative net annual economic benefits, it would provide greater benefit to socially vulnerable communities, having a greater benefit to community cohesion, social equity, vulnerability, and resiliency. Alternative 1, No Action, was considered throughout the plan evaluation process as well, but as it would not contribute to the Federal Planning and Environmental Objectives as discussed, it is not included in the below discussion.

Table 3.8. Costs and benefits for Alternatives 3A and 3B. Costs were calculated using FY24 price levels.

	Costs ($000s)	
Construction Item	**Alt. 3A. Maximum Net Economic Benefits**	**Alt. 3B. Comprehensive Benefits**
Investment Cost		
Total Project First Cost	$37,193	$98,701
Interest During Construction	$115	$305
Total Investment Cost	$37,308	$99,006
Annual Cost		
Annualized First Cost	$1,382	$3,667
Estimated OMRR&R	$0	$0
Total Average Annual Cost	$1,382	$3,667
Average Annual Benefits	$2,043	$2,944
Net Annual Benefits	$661	($723)
Benefit-Cost Ratio	1.48	0.80

Interest during construction for both alternatives was calculated at 2.75% over a 3-month construction period per structure. Costs were annualized over a 50-year period of analysis. BCR assumes a 100% participation rate.

Definitions:

- Total project first costs: Costs associated with construction, project management, engineering & design, construction management, real estate, and contingency.
- Interest during construction: Opportunity cost of capital incurred during the construction period.
- Total investment cost: Cost of interest during construction plus total project first costs.
- Annualized first costs: Total investment costs annualized over 50 years using the fiscal year 2024 interest rate of 2.75%
- OMRR&R: Operations, maintenance, repair, replacement, and rehabilitation costs
- Average annual benefits: Without-project expected annual damages minus with-project expected annual damages.

- Net annual benefits: Annualized benefits minus annualized costs

Both Alternatives 3A and 3B would meet the Federal Environmental Objective. The nonstructural plans would not adversely affect environmental resources and would not require mitigation as required by Section 906(d) of WRDA 1986.

3.6.2. Contribution to Objectives and Avoidance of Constraints

3.6.2.1. Contribution to Objectives:

Objective 1. Reduce life safety risk associated with inundation of structures (residential, non-residential, critical facilities) resulting from flash flooding along the tributaries and prolonged flooding along the Tar River and associated tributary backwaters throughout the study area: Both Alternatives 3A and 3B would reduce life safety risk associated with inundation of structures by elevating residential structures and floodproofing of commercial structures such that their risk of inundation is reduced. Reductions in inundation are associated with reduced life safety risk, particularly within more vulnerable communities. Of the two alternatives, Alternative 3B would reduce life safety risk to a greater extent due to the greater number of structures that would be included in the proposed plan. Alternatives 3A and 3B would reduce life safety risk associated with direct inundation, neither would reduce risks associated with inundation of roadways and associated loss of access and egress. The No Action alternative would not contribute to meeting the objective.

Objective 2. Reduce damage to structures (residential, non-residential, critical facilities) and public infrastructure resulting from flash flooding along the tributaries and prolonged flooding along the Tar River and associated tributary backwaters throughout the study area: Both Alternatives 3A and 3B would reduce flood damages by elevating residential structures and floodproofing of commercial structures such that their risk of inundation is reduced. Both alternatives would reduce damages within socially vulnerable and historically underserved populations, increasing their resiliency and capacity to recover following future flood events. Of the two action alternatives, the Alternative 3B would reduce damages to a greater number of structures, including to socially vulnerable communities, as this plan includes more structures. The No Action alternative would not contribute to meeting the objective.

Objective 3. Reduce economic damage to industries (e.g., agriculture) and commerce resulting from flash flooding along the tributaries and prolonged flooding along the Tar River and associated tributary backwaters throughout the study area: Both Alternatives 3A and 3B would reduce economic damage to industries and commerce resulting from flooding. Both alternatives would decrease economic damages by floodproofing commercial and industrial structures. Floodproofing of commercial and industrial facilities would increase their ability to reopen following flood events, improving service to the community and decreasing overall economic impact to commerce and industry. Of the two action alternatives, Alternative 3B would have a greater benefit to commerce and industry due to the greater number of commercial and industrial structures included in this plan as compared to Alternative 3A. The No Action alternative would not contribute to the meeting the objective.

3.6.2.2. Avoidance of Constraints

Alternatives 3A and 3B each avoid the only study-specific constraint by not affecting the ongoing flood risk management effort in the Town of Princeville, NC. Both action alternatives also would have no significant impacts to environmental or cultural resources.

3.6.3. Principles, Requirements, and Guidelines Criteria

Alternatives were also evaluated based on the four evaluation criteria outlined in the PR&G (USACE, 2013) and defined and described below:

Completeness: The extent to which the alternative provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. Both Alternatives 3A and 3B represent complete alternatives in that they account for all necessary investments and actions required to ensure realization of the planned effects. However, floodproofing and structure elevation are voluntary and participation rate could affect overall benefit accrued by each action alternative. No Action would be considered a complete alternative.

Effectiveness: The extent to which each alternative contributes to achieving the planning objectives. Both Alternatives 3A and 3B are effective at addressing the identified problems and realizing the below identified opportunities.

Problem 1: Economic Damages. Both Alternatives 3A and 3B reduce economic damages, providing $2,043,000 and $2,944,000 in average annual benefits, respectively. These benefits are associated with both residential and commercial/industrial facilities and, thus, each alternative would benefit both private residences and industry and commerce (i.e., Problem 1.1 and 1.2, respectively; see Section 1.6.1). Neither action alternative would reduce economic damages associated with inundation of roadways and associated traffic detours and delays (Problem 1.4). The No Action alternative would not address the problem of reduction in economic damages.

Problem 2. Life Safety. Both Alternatives 3A and 3B would reduce life safety risk associated with direct inundation of occupied residential and commercial and industrial structures, particularly within socially vulnerable communities and communities identified as overburdened due to environmental justice considerations [see Appendix B (Economic Analysis) for a detailed description of social vulnerability] (Problems 2.3 and 2.4). Neither action alternative would reduce life safety risk associated with inundation of roadways (i.e., access and egress or community isolation; Problem 2.1) or direct inundation of vehicles on roadways (Problem 2.2). The No Action alternative would not address the problem of reduction of life safety.

Opportunities Realized.

Improved quality of life for individuals living within the floodplain. Both 3A and 3B would achieve opportunities associated with improving quality of life by decreased economic damages and improved life safety. Reducing the impact of flooding within the study area will decrease the associated damages and required recovery spending. Reduced recovery spending could increase revenue within other sectors of the local and regional economies. The No Action alternative would not achieve any of the opportunities associated with improving quality of life for individuals living within the floodplain.

Increased awareness of and preparedness for flood risk. Both 3A and 3B would achieve opportunities associated with increasing community awareness and preparedness for flood risk. Community outreach and engagement throughout the study and resulting project could improve community awareness of and preparedness for flood risk, empowering individuals and communities to take actions that reduce their flood risks. The No Action alternative would not achieve any of the opportunities associated with increasing awareness of and preparedness for flood risk.

Increased resilience of communities throughout the study area. Both 3A and 3B would result in increased resilience—the capacity to recover quickly and completely following hardship—throughout the study area. The No Action alternative would not realize this opportunity.

Reduced life and safety risk Both Alternatives 3A and 3B would improve life safety for residents currently located within the floodplain and floodway by reducing inundation in structures. The No Action alternative will not realize this opportunity.

Opportunities Unrealized

Improved aquatic, riparian, and floodplain habitat quality within the study area. The alternatives evaluated would not result in improved aquatic, riparian, or floodplain habitat.

Reduced water pollution inputs to the Pamlico River and Sound ecosystems. The alternatives evaluated would not result in reduced inundation or reduced pollution inputs.

Enhanced recreational opportunities throughout the study area. The alternatives evaluated would not improve recreational opportunities for residents of the study area and surrounding areas.

Efficiency: The extent to which each alternative is a cost-effective means of alleviating the specified problems and achieving the objectives, consistent with protecting the Nation's environment. The net annual economic benefits and BCRs for Alternatives 3A and 3B are $661,000 and -$723,000 and 1.48 and 0.80, respectively. Both Alternatives 3A and 3B would have no significant impact on the Nation's environment. The environmental effects of each alternative are presented in detail in Section 4 of this report. The No Action alternative would not be efficient, while no federal dollars would be spent, the problem would not be solved.

Acceptability: The workability and viability of the measure with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies. Both Alternatives 3A and 3B would be acceptable to the state and are compatible with existing laws, regulations, and policies. Structure elevation and floodproofing measures comprising each plan are voluntary and, therefore, it is unlikely that there would be significant public dislike for either plan. The No Action alternative would be considered acceptable.

In addition to the four criteria outlined in the PR&G (USACE, 2013), the study team identified three additional evaluation criteria, including Environmental Justice (Resilience), Environmental Justice (Community Cohesion), and Environmental Effects (see Table 3.9). An evaluation of each alternative with respect to these criteria is provided below:

Environmental Justice (Resilience): Extent to which each alternatives improves the ability of communities to withstand and recover quickly after future flood events. Both Alternatives 3A and 3B would increase the resilience of socially vulnerable, underserved, and underrepresented communities within the study area. Both Alternatives 3A and 3B include structure elevation and floodproofing measures in communities identified as socially vulnerable as defined by the EJScreen and CEJST tools. Specifically, both action alternatives reduce risk in communities with high minority populations and low incomes, which also have high projected community and economic losses due to climate change. These represent the communities with the least capacity to recover following future flood events. Although both alternatives would increase resilience in socially-vulnerable communities, Alternative 3B would have the greatest benefit by reducing risk to an additional 118 structures located within vulnerable communities. The No Action plan would have no significant effect on resiliency of communities throughout the study area.

Environmental Justice (Community Cohesion): The extent to which each alternative maintains social relationships within a community by promoting and preserving diversity and equal opportunity. Both Alternatives 3A and 3B would improve community cohesion in the face of continued flood risk by helping to ensure that communities remain intact by providing equal assistance to all individuals, including those individuals that represent socially vulnerable and historically underserved populations, promoting and preserving diversity and equal opportunity. Both Alternatives 3A and 3B incorporate structure elevation and floodproofing measures in areas identified as socially vulnerable as defined by the EJScreen and CEJST tools. Although both action alternatives would benefit community cohesion, Alternative 3B would have the greatest benefit on community cohesion by increasing the resiliency and decreasing the vulnerability of an additional 118 structures within at-risk communities throughout the study area. The No Action alternative would have no significant effect on community cohesion.

Environmental Effects. Effects on aquatic (stream, wetland) and terrestrial (riparian, upland, critical) habitats, water quality, and threatened/endangered species. Environmental effects of each alternative are presented in detail in Section 4 of this report. Neither Alternative 3A nor 3B have significant impacts to aquatic or terrestrial habitats, water quality, or threatened and endangered species. Any environmental impacts would be minor and temporary. The No Action alternative would not have significant effects on this criterion.

A summary of the evaluation of the final array of alternatives is presented below in Table 3.9.

Table 3.9. Summary of the evaluation of the final array of alternatives.

Evaluation Criteria	**Alt. 1. No action**	**Alt. 3A. Max Net Economic Benefits/NED**	**Alt 3B. Comprehensive Benefits**
Completeness	No significant effect	Positive effect	Positive effect
Effectiveness (Damage)	No significant effect	Positive effect	Positive effect
Effectiveness (Commercial/Industry)	No significant effect	Positive effect	Positive effect
Effectiveness (Life Safety)	No significant effect	Positive effect	Positive effect

Efficiency	No significant effect	Positive effect $661,000 in net benefits 1.48 BCR	Negative effect -$723,000 in net benefits 0.8 BCR
Acceptability	No significant effect	Positive effect	Positive effect
Environmental Justice (Resilience)	No significant effect	Positive effect on 37 structures	Positive effect on 155 structures
Environmental Justice (Community Cohesion)	No significant effect	Positive effect on 37 structures	Positive effect on 155 structures
Environmental Effects	No significant effect	No significant effect	No significant effect

3.6.4. System of Accounts

This section summarizes and compares alternatives with respect to the four accounts. Alternatives were assessed and compared using the four accounts established in the PR&G (USACE, 2013), which are described below in Table 3.10.

Table 3.10. Definition and analyses and associated metrics used to quantify benefits across the four accounts described in the PR&G (USACE, 2013).

Account	**Definition**	**Analysis/Metrics**
National Economic Development (NED)	The NED account represents the change in the economic value of the national output of goods and services that result from each alternative.	The NED account was assessed using the Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA) software. Metrics include net annual economic benefits and BCR.
Regional Economic Development (RED)	The RED account characterizes changes in the distribution of regional economic activity that result from each alternative.	The USACE Regional Economic System (RECONS) was used to estimate regional economic impacts and contributions associated with the various alternatives. Metrics include increases in employment and labor income.
Other Social Effects (OSE)	The OSE account characterizes effects that are relevant to the planning process but not reflected in the other three accounts.	Qualitative/semi-quantitative assessment of effects on life safety risk. Semi-quantitative assessment of benefits to resiliency and community cohesion within reaches identified as socially vulnerable using the EJScreen and CEJST Tools.
Environmental Quality (EQ)	The EQ account characterizes non-monetary effects (positive	Qualitative analysis that considers benefits to aquatic and riparian

	or negative) on significant natural and cultural resources that result from each alternative.	habitats and downstream water quality.

A summary of how each alternative contributes to the four accounts is provided in the following sections and is summarized in Table 3.11.

NED. Alternative 3A would contribute to the national economy, having positive net economic benefits and a positive BCR. Specifically, the net annual economic benefits and BCR for Alternative 3A are $661,000 and 1.48, respectively. Although Alternative 3B has negative net economic benefits (i.e., $-723,000), it does have the greatest benefits across all 4 accounts, as discussed in the subsequent sections. The No Action alternative would have significant negative effects on the national economy as continued and repetitive flooding would continue to require recovery expenditures at the local, state, and federal levels.

RED. Both Alternatives 3A and 3B would contribute to the regional economy through increases in both regional employment and labor income. Alternative 3A would create 661.5 full time equivalent jobs and a total of $42,611,000 in labor income. Alternative 3B would create 1,755.5 full time equivalent jobs and $118,385,000 in labor income. The No Action alternative would have significant negative effects on the regional economy as continued and repetitive flooding would continue to require recovery expenditures that would otherwise contribute to the local and regional economies.

EQ. Environmental effects of each alternative are presented in detail in Section 4 of this report. In general, neither Alternative 3A nor 3B have significant impacts to aquatic or terrestrial habitats, water quality, or threatened and endangered species. Any impacts would be minor and temporary. The No Action alternative would have no significant effect on environmental resources.

OSE.

Life Safety: Both Alternatives 3A and 3B would reduce life safety risk associated with direct inundation of occupied residential and commercial and industrial structures, particularly within socially vulnerable communities and communities identified as overburdened due to environmental justice considerations [see Appendix B Economic Analysis for a detailed description of life safety and social vulnerability] (Problems 2.3 and 2.4). The No Action alternative would have no significant effect on life safety, with risk continuing to remain the same or slightly worsen due to climate change.

Environmental Justice. Both Alternatives 3A and 3B would increase the resilience of socially vulnerable, underserved, and underrepresented communities within the study area by including structure elevation and floodproofing measures in communities identified as socially vulnerable as defined by the EJScreen and CEJST Tools. These represent the communities with the least capacity to recover following future flood events. Both Alternatives 3A and 3B would improve community cohesion in the face of continued flood risk by helping to ensure that communities remain in-tact by providing equal assistance to all

individuals, including those individuals that represent socially vulnerable and historically underserved populations, promoting and preserving diversity and equal opportunity.

Although both Alternative 3A and 3B would have positive effects on environmental justice, Alternative 3B includes application of nonstructural measures to an additional 118 structures beyond those included in Alternative 3A—structures located within disadvantaged and socially vulnerable communities (e.g., minority and/or elderly populations or populations with high poverty and/or unemployment, as defined by EJScreen and the CEJST) that are characterized by repetitive historic flooding and low resilience in the face of future flood risk. Thus, Alternative 3B provides benefit to nearly four times as many structures, having a much greater positive effect on resilience and community cohesion within the most socially vulnerable and disadvantaged communities across the study area. The No Action alternative would have no significant effect on environmental justice, with risk continuing to remain the same or slightly worsen due to climate change.

Table 3.11. Summary table comparison of alternatives with respect to the four accounts established in the PR&G (USACE, 2013).

Account	Alternative 1: No Action	Alternative 3A: Max Net Economic Benefits/NED	Alternative 3B: Comprehensive Benefits
NED	Negative change	Positive change	Negative change
RED	Negative change	Positive change	Positive change
OSE	No significant effect	Positive change (37 structures)	Positive change (155 structures)
EQ	No significant effect	No significant effect	No significant effect

3.6.5. Risk and Uncertainty

Alternatives were also evaluated with respect to remaining risk and uncertainty. The following sections detailed residual risk and uncertainty associated with each alternative.

3.6.5.1. Residual Risk

Residual risk represents existing, future, or historical risk that remains or might remain after an alternative has been implemented. Both Alternatives 3A and 3B would have residual risk of inundation and associated life safety risk for the remainder of the 3,042 structures within the 0.2% AEP floodplain within the study area that are not incorporated into each alternative. Residual risk would be less for Alternative 3B, which incorporates 22% of the 716 structures within the 1% AEP floodplain initially considered for inclusion within the final array of alternatives, as compared to Alternative 3A, which includes only 5%. Furthermore, the current study did not assess or seek to reduce risk to structures within smaller tributaries and headwaters to the Tar River and its major tributaries. Both Alternative 3A and 3B would also have residual economic damages (i.e., traffic delays or detours) and associated life safety risks (i.e., community isolation and loss of access and egress) associated with inundation of transportation infrastructure throughout the watershed.

Although nonstructural measures included in both Alternative 3A and 3B would reduce economic damages and life safety risks associated with direct inundation, structures could be inaccessible during flood events, isolating residents of they choose not to evacuate. Isolation

could impact the ability of residents to access critical facilities (e.g., medical facilities) and necessary goods and services (e.g., food and clean water), as well as receive support, during flood events. Isolation would be longer (i.e., up to several days) for residents in the lower portions of the watershed, including Greenville and Tarboro, as compared to residents further up in the watershed, including areas along Stony Creek and the upper Tar River. Furthermore, structures elevated and floodproofed under both Alternatives 3A and 3B would have residual risk during events with flood elevations exceeding the 1% AEP flood elevation plus 2 feet. Communities throughout the study area have experienced floods exceeding the 1% AEP event, including during hurricanes Fran (1996), Floyd (1999) and Matthew (2016). The 0.2% AEP event was also exceeded in certain locations throughout the watershed. Structures identified for floodproofing that cannot achieve the 1% AEP event plus 2 feet target due would have the greatest residual risk during future floods exceeding the 1% AEP event.

Both Alternatives 3A and 3B also have residual risk associated with climate change over the next 100 years. There is considerable uncertainty with respect to future climate change and associated changes in streamflow. Although climate change analyses included in this report led to the FWOP condition assuming no change in streamflow due to climate change (see Appendix F), increases in the frequency and intensity of extreme rainfall events beyond those considered here could result in reduced performance of each alternative. The extent of the 1% AEP floodplain or flood height may change such that the effectiveness of measures within each alternative is decreased and additional structures not incorporated in each alternative have increased risk and/or flood elevations for the 1% AEP increase over time. Alternative 3B would have less residual risk in the face of climate change because all reaches were aggregated at the 1% AEP floodplain, as compared to Alternative 3A, which aggregated across the 1% and 10% floodplain extents. Similarly, the frequency with which roadways become inundated could also increase, increasing associated damages and life safety risk. Finally, accelerated rates of sea level rise beyond those included in the analyses and projections utilized in this report could also impact project performance in the downstream areas of the watershed, particularly those near Greenville. Additional increases in sea level rise beyond those characterized in this study could further increase water surface elevations under the full range of flood events and result in additional residual risk.

3.6.5.2. Uncertainty

Identifying and managing risk is critical to making informed planning decisions in the face of uncertainty. However, some level of uncertainty will remain following any decision. Understanding and characterizing this remaining uncertainty is also critical as it can affect the outcome of any decision. This section characterizes uncertainty associated with each alternative.

Both Alternatives 3A and 3B consist entirely of management measures that participants would have to choose to participate in. Participation rates could affect the overall benefits achieved by each alternative and the amount of residual risk following implementation. Both Alternatives 3A and 3B are based on visual surveys and existing data, including first floor elevations. Additional information and data obtained during subsequent projects phases could result in additional structures being incorporated or current structures being removed from each alternative.

Participation in nonstructural measures is completely voluntary and will vary based on several factors. While the BCR is calculated using a 100% participation rate, it is likely that participation

will be less than 100%, which will impact the economic and non-economic benefits associated with each plan.

4. ENVIRONMENTAL EFFECTS AND CONSEQUENCES

This section describes the expected impacts to relevant environmental resources for each of the three alternatives in the final array of alternatives. In many cases, the expected impacts for each resource for all three alternatives are the same; in these cases, impacts were described in a single statement that accounts for all three alternatives. A description of each of these three final array alternatives from Section 3 is briefly reiterated below:

Alternative 1. No Action. USACE planning policy (Engineering Regulation 1105-2-100) and NEPA require consideration of a 'No Action' Alternative. The No Action Alternative is the basis for the 'FWOP Condition' and assumes no measures would be implemented by the federal government to achieve the planning objectives.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Alternative 3A consists of application of physical nonstructural measures to a total of 37 structures—elevation of 2 residential structures, elevation and flood venting of 1 residential structure, and dry floodproofing of 34 commercial and industrial structures—across seven study reaches. Structures would be elevated to the 1% AEP flood elevation plus 2 feet. Structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet, or a maximum height of 4 feet.

Alternative 3B. Comprehensive Benefits Plan. Alternative 3B includes application of physical nonstructural measures to 155 structures— elevation of 35 structures; flood venting of 8 structures; elevation and flood venting of 18 structures; and dry floodproofing of 94 structures —across 13 study reaches. All residential structures would be elevated to the 1% AEP flood elevation plus 2 feet. Commercial and industrial structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet, or a maximum height of 4 feet.

4.1. Natural Environment

4.1.1. Wetlands

Alternative 1. No Action. No action would result in wetlands continuing to exist in the study area as they are.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Elevating and/or floodproofing homes and structures does not occur within wetlands and will therefore not affect wetlands.

Alternative 3B. Comprehensive Benefits Plan. Elevating and/or floodproofing homes and structures does not occur within wetlands and will therefore not affect wetlands.

4.1.2. Threatened & Endangered Species and Critical Habitat

Alternative 1. No Action. If no action is taken, threatened and endangered species will remain threatened and endangered, and critical habitat will be unchanged.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Elevating and/or floodproofing homes and structures will not occur within the preferred habitat for federally-listed species, and will not occur within critical habitat. Therefore, this alternative will have no effect on threatened or endangered species and will not impact critical habitat.

Alternative 3B. Comprehensive Benefits Plan. Elevating and/or floodproofing homes and structures will not occur within the preferred habitat for federally-listed species, and will not occur within critical habitat. Therefore, this alternative will have no effect on threatened or endangered species and will not impact critical habitat.

4.1.3. Aquatic Ecology and Riparian Habitat

Alternative 1. No Action. If no action is taken, aquatic and riparian habitat will be unaffected.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Elevating and/or floodproofing homes and structures will occur on pre-existing structures which are not located within the river or riparian habitat. This alternative will therefore have no impacts on aquatic ecology or riparian habitat.

Alternative 3B. Comprehensive Benefits Plan. Elevating and/or floodproofing homes and structures will occur on pre-existing structures which are not located within the river or riparian habitat. This alternative will therefore have no impacts on aquatic ecology or riparian habitat.

4.2. Physical Environment

4.2.1. Climate

Implementation of Alternatives 1, 3A, or 3B would have no impact on climate, and climate conditions under each alternative will be the same as those described in Section 2.4.1 Climate. Floodproofing and/or elevating up to 155 structures is not significant enough of an undertaking to affect the climate.

4.2.2. Land Use and Cover

Alternative 1. No Action. If no action is taken, it is expected that land cover and use will remain similar to today; however, populations and development may decrease in areas where extreme precipitation events are expected to increase.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Elevating and/or floodproofing 37 homes and structures will have no effect on land use and cover; it would likely maintain the current use of these properties as they would be less likely to be impacted by flooding. This alternative would generally work alongside relevant community land use planning documents (see Section 2.4.3 for specific plans) in that it reduces flood risk hazards and damages. However, the land use/community planning document for Greenville, NC, discourages development in the floodplain and restricts the use of public investment (i.e., local and state funds) in floodplain development.

Alternative 3B. Comprehensive Benefits Plan. Elevating and/or floodproofing 155 homes and structures will have no effect on land use and cover; it would likely maintain the current use of these properties as they would be less likely to be impacted by flooding. This alternative would

generally work alongside relevant community land use planning documents (see Section 2.4.3. for specific plans) in that it reduces flood risk hazards and damages. However, the land use/community planning document for Greenville, NC, discourages development in the floodplain and restricts the use of public investment (i.e., local and state funds) in floodplain development.

4.2.3. Cultural and Historical Resources

Alternative 1. No Action. No impact. If no action is taken, then no impacts to historical or cultural resources will be realized.

Alternative 3A. Maximum Net Economic Benefits / NED Plan & Alternative 3B. Comprehensive Benefits Plan. Individual NRHP evaluations have not been completed for each of the 37 structures identified for flood proofing/elevation under Alternative 3A, or the 155 structures identified for flood proofing/elevation under Alternative 3B; and thus it is unknown if the proposed alternative would have effects on historic properties. Individual evaluations would need to be completed to determine if any of these structures are eligible for inclusion in the NRHP and if the proposed action would have an effect. Based on a preliminary review of the NC SHPO database is likely that some of these structures may be eligible for inclusion in the NRHP.

The potential impact to these properties would be minimal. Floodproofing, elevation and flood venting structures as proposed in the alternatives are effective treatments to ensure that historic properties located in floodplains are more resilient to flood hazards. Generally, nonstructural measures have the potential to architecturally alter a historic property to the extent that it may no longer qualify for the National Register. If the historical significance of a historic property is based on its ability to convey a specific architectural style, workmanship, design, and/or materials, modifying the property could negatively impact the historic significance and integrity of such property. Thus far, none of the structures selected for non-structural measures have been evaluated for inclusion in the National Register. Pursuant to the draft Memorandum of Agreement USACE will survey and evaluate all structures 45 years or older and determine if any are eligible for the National Register. If any of the structures is deemed eligible, then USACE will evaluate the effect of the measure(s) and determine if any adverse effects can be avoided, minimized or mitigated in consultation with the SHPO and any additional consulting parties.

Furthermore, any activities associated with the implementation of the recommended plan that include any type of ground disturbance have the potential of impacting unknown archaeological resources. These mitigation measures can be applied with minimal effects on the historic character of a property. However, a programmatic agreement (PA) has been drafted with the NC SHPO which will ensure compliance with the NHPA and reduce any potential impacts on cultural resources (Appendix C).

4.2.4. Hazardous, Toxic, and/or Radioactive Wastes (HTRW)

Alternative 1. No Action. No impact.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Individual environmental site inspections have not been made for each of the 37 structures identified for flood proofing/elevation under Alternative 3A, and thus concerns associated with HTRW are not

specifically known for each structure. Individual site inspections would be made as needed for the individual structures during the PED phase of the project to determine whether construction plans for that structure must be modified or if specific precautions must be taken. Based on a preliminary review of federal and state agency databases which track and compile information on contaminated sites, it is unlikely that HTRW would be a serious concern for Alternative 3A.

Alternative 3B. Comprehensive Benefits Plan. Individual environmental site inspections have not been made for each of the 155 structures identified for floodproofing/elevation under Alternative 3B at this stage, and thus concerns associated with HTRW are not specifically known for each structure. Individual site inspections will be made as needed for the individual structures during the PED phase of the project to determine whether construction plans for that structure must be modified or if specific precautions must be taken. Based on a preliminary review of federal and state agency databases which track and compile information on contaminated sites, it is unlikely that HTRW will pose a considerable risk in implementing Alternative 3B. One site listed by the US Environmental Protection Agency (USEPA) in the remediation site database, known as the Mid-South Metal Mercury Site (EPA ID: NCN000410864), overlaps with three of the structures identified under this alternative for floodproofing/elevation. The Mid-South Metals Mercury site is located adjacent to the Pitt-Greenville Airport in Greenville, NC. However, the database does NOT consider the Mid-South Metal Mercury Site a Superfund Site, and this site is not listed on the National Priority List for Superfund cleanup (https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0410864). The database identifies this site as a 'Removal Only Site' and indicates that additional assessment is not needed. Therefore, it is unlikely that the overlap of these structures and the Mid-South Metal Mercury Site will be problematic in the implementation of this alternative. During the PED phase of this project, structures in this heavily industrialized area near the airport will be given special consideration to ensure that no HTRW concerns are encountered during the elevation or floodproofing of these buildings. Potential contaminants of concern in this industrialized area would include heavy metals (e.g. mercury), petroleum-related contaminants, and chlorinated solvents. Additionally, for any building that will be structurally disturbed by elevation, a determination will be made prior to construction regarding the potential presence of lead-based paint or asbestos within the structure to ensure that proper precautions are taken during construction.

4.2.5. Water Quality

Alternative 1. No Action. If no action is taken, water quality will not be impacted.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Any ground-disturbing construction activities related to structure elevation will implement erosion and sediment control BMPs to minimize impacts of excess sedimentation in streams or ongoing erosion issues. As a result of these BMPs, impacts to water quality resulting from structure elevation will be insignificant. Dry floodproofing of non-residential structures is not expected to have significant effects to water quality, as ground disturbing construction activities are not necessary to floodproofing.

Alternative 3B. Comprehensive Benefits Plan. No impacts to water quality are expected in implementing Alternative 3B. Any construction activities associated with structure elevation would include the use of sediment erosional controls to ensure that sediment is not inadvertently

washed into any nearby waterway, thus controlling any potential impacts to water quality. Dry floodproofing of non-residential structures is not expected to have significant effects to water quality, as ground disturbing construction activities are not necessary to floodproofing.

4.2.6. Air Quality

Alternative 1. No Action. No impacts. Not implementing a plan will not change the air quality from what it otherwise would be.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Construction activities associated with structure elevation may temporarily and insignificantly affect air quality within the localized area of the structure. These effects are expected to be minimal.

Alternative 3B. Comprehensive Benefits Plan. Construction activities associated with structure elevation may temporarily and insignificantly affect air quality within the localized area of the structure. These effects are expected to be minimal.

4.2.7. Floodplains

Alternative 1. No Action. If no action is implemented, as extreme precipitation events increase and flooding along these streams increases, structures will eventually be destroyed and/or abandoned, and additional development will cease. This will lead to a more natural less-developed floodplain in urban areas.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Structures selected for floodproofing and/or elevation under this alternative will be more resilient to flooding, and therefore will likely be occupied for a longer duration than if they were not modified to be more flood resilient. This may have the effect of keeping floodplains in the study area occupied with residences and/or businesses, though the small number of structures identified under this alternative is unlikely to significantly affect development/ongoing occupation of the floodplain.

Alternative 3B. Comprehensive Benefits Plan. Structures selected for floodproofing and/or elevation under this alternative will be more resilient to flooding, and therefore will likely be occupied for a longer duration than if they were not modified to be more flood resilient. This may have the effect of keeping floodplains in the study area occupied with residences and/or businesses, though the small number of structures identified under this alternative is unlikely to significantly affect development/ongoing occupation of the floodplain.

4.2.8. Greenhouse Gas Emissions

Alternative 1. No Action. If no action is implemented, then GHG's may be emitted in response to large flooding events which destroy property. These could include the costs to demolish a structure destroyed in a flood, and the costs associated with manufacturing and transport of new items to replace those lost or destroyed in a flood. However, estimating these emissions is difficult and would depend on the severity of the flooding event, but it is expected that these emissions would be minimal and insignificant.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Construction associated with floodproofing and/or elevating structures will emit a small amount of CO_2, a GHG, due to the use

of construction equipment and vehicular travel for personnel performing the work. Additionally, the manufacturing and transport of any construction materials used will consume non-renewable resources and emit GHG. These GHG emissions would be derived from diesel and/or gasoline powered equipment and vehicles. However, due to the small number of structures identified under this alternative, these emissions would be far below current USEPA regulatory reporting thresholds for attainment of air quality standards (25,000 metric tons per year). These emissions would also only be associated with active construction, as this alternative does not require the ongoing operation of any equipment that would continually contribute GHG emissions to the atmosphere. Therefore, this alternative would have only minor insignificant contributions to GHG emissions, with minor impacts expected.

Published USEPA data indicate that approximately 22 pounds of CO_2 are produced for every gallon of diesel fuel burned, and approximately 19 pounds are produced for every gallon of gasoline used (USEPA, Tailpipe Greenhouse Gas Emissions from a Typical Passenger Vehicle., 2023). Construction equipment represents a relatively small fraction of petroleum use, however, compared to road vehicles such as passenger cars. The transportation industry (trucks and cars) uses approximately 77% of diesel fuel in the U.S., while the entire industrial sector (including all factories, commercial uses and construction equipment) uses approximately 13% (USEIA, 2022). In general, construction equipment emissions are a small fraction of GHG emissions.

Tailpipe emissions from passenger vehicles amount to 400 grams of CO2 per mile, and the average vehicle in the US therefore emits approximately 4.6 metric tons of CO2 per year (assumes 11,500 miles per year of driving) (USEPA, Tailpipe Greenhouse Gas Emissions from a Typical Passenger Vehicle., 2023). Thus, this alternative would only exceed the USEPA reporting threshold of 25,000 metric tons per year if it required the equivalent of 5,434 vehicles being used at 11,500 miles each, which is far larger than would be necessary to construct this alternative.

Efforts are on-going for all equipment manufacturers to reduce emissions and increase the fuel efficiency of construction equipment and passenger vehicles. Best management practices (BMPs) can also be used to decrease GHG emissions from diesel engines. Some BMPs that are commonly implemented on construction projects and that would be implemented on this project include:

1. Minimize waiting times and idling times by staging equipment to be present and operating only when needed.

2. Conduct operations in sequence and bundle work to minimize the time needed for any piece of equipment.

The social cost of carbon emissions must also be considered in our overall assessment of GHG emissions for each alternative. The social cost of carbon is an estimate of the cost, in dollars, of the damage done by each additional ton of carbon emissions. The current approximate estimate from the US Government of the social cost of carbon is $120 per metric ton of CO2 emissions. To roughly calculate this cost for this alternative, the following assumptions were made: each structure affected requires 5 laborers, and the duration of work is 4 days per structure; each laborer drives 60 miles per day to and from the work site. For 42 structures (per this

Alternative), 50,400 miles will be driven. If 11,500 miles emits 4.6 metric tons of CO2, then 50,400 miles will emit approximately 20 tons of CO2. At $120/ton (USEPA, 2023), the social cost of carbon emissions under this alternative is approximately $2,400. To account for uncertainty in this calculation and the use of construction equipment, we conservatively double this cost to be $4,800. This cost is a small fraction of the overall cost of implementing this alternative and is considered negligible in the overall benefit/cost analysis.

Alternative 3B. Comprehensive Benefits Plan. Contributions to GHG emissions in the atmosphere for this alternative will be of a similar scale and nature as those described for Alternative 3A. The social costs of GHG emissions will also be of similar scale and nature. GHG emissions for this alternative would be slightly higher than those for Alternative 3A due to the increased number of structures, but only slightly so. This alternative would have only minor insignificant contributions to GHG emissions, with minor impacts expected. Using the same assumptions described above for calculating the social cost of carbon, the total mileage driven for this alternative is 188,400 miles emitting about 75 metric tons of carbon, with the approximate social cost of emissions being $9,000. To account for uncertainty in this calculation and the use of construction equipment, we conservatively double this cost to be $18,000. This cost is a small fraction of the overall cost of implementing this alternative and is considered negligible in the overall benefit/cost analysis.

4.2.9. Aesthetics

Alternative 1. No Action. If no action is implemented, the aesthetics of the study area will not be impacted.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Elevation and/or floodproofing of structures may have a minor effect on aesthetics, by changing the appearance of these structures. However, because the number of structures is small, and they are not located within public spaces, this alternative will not significantly affect aesthetics.

Alternative 3B. Comprehensive Benefits Plan. Elevation and/or floodproofing of structures may have a minor effect on aesthetics, by changing the appearance of these structures. However, because the number of structures is small, and they are not located within public spaces, this alternative will not significantly affect aesthetics.

4.2.10. Noise

Alternative 1: No Action. If no action is implemented, noise levels will not change.

Alternative 3A. Maximum Net Economic Benefits/NED Plan. Elevation and/or floodproofing of structures may very slightly increase noise levels in the immediate vicinity of where the construction activities are occurring resulting from the use of construction equipment and materials. However, these slight increases will be insignificant and only temporary during the actual construction.

Alternative 3B. Comprehensive Benefits Plan. Elevation and/or floodproofing of structures may very slightly increase noise levels in the immediate vicinity of where the construction activities are occurring resulting from the use of construction equipment and materials. However, these slight increases will be insignificant and only temporary during the actual construction.

4.2.11. Transportation

Alternative 1: No Action. If no action is implemented, transportation will be unaffected.

Alternative 3A. Maximum Net Economic Benefits/NED Plan. Elevation and/or floodproofing of structures may very slightly increase traffic in the immediate vicinity of where the construction activities are occurring; however, this is expected to be insignificant due to the nature of the construction activities and that the structures identified under this alternative are spread out within and across communities. In the unlikely event that construction activities may need to temporarily operate or park within a public roadway, it is expected that this will be coordinated with the local government to ensure adequate detour routes and/or safe lane closures. Such events are unlikely to be necessary under this Alternative, and therefore would only affect a few locations where structures may be located in close proximity to a roadway. These potential effects to transportation would be temporary and insignificant.

Alternative 3B. Comprehensive Benefits Plan. Elevation and/or floodproofing of structures may very slightly increase traffic in the immediate vicinity of where the construction activities are occurring; however, this is expected to be insignificant due to the nature of the construction activities and that the structures identified under this alternative are spread out within and across communities. In the unlikely event that construction activities may need to temporarily operate or park within a public roadway, it is expected that this will be coordinated with the local government to ensure adequate detour routes and/or safe lane closures. Such events are unlikely to be necessary under this Alternative, and therefore would only affect a few locations where structures may be located in close proximity to a roadway. These potential effects to transportation would be temporary and insignificant.

4.3. Economic Environment

4.3.1. Economic Damages

Alternative 1- No Action. Lack of federal action would not result in benefits to the economic environment. No reduction in EAD would be expected under the No Action plan, and EAD could increase due to the effects of climate change.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Alternative 3A would add positively to the economic environment by decreasing flood damages experienced by property owners in the affected reaches. Alternative 3A would decrease expected annual damages from $4,484,000 to $2,441,000 and provides overall annual net benefits of $661,000 (Table 4.1.).

Table 4.1. Comparison of EAD under the future without (FWOP) and future with project conditions, as well as the associated annual costs and benefits, BCR, and net benefits for reaches included in Alternative 3A. All costs are presented in $1000s.

Reach	Aggregation Floodplain	No. Struct.	EAD Without	EAD With	Avg. Annual Benefit	Avg. Annual Costs	BCR	Net Benefits
STC1B	0.01 AEP	15	$1,155	$259	$896	$464	2.15	$433
TP10A	10% AEP	2	$176	$69	$108	$55	2.16	$52
TP10C	10% AEP	2	$242	$79	$163	$64	2.89	$100
TP10D	0.01 AEP	1	$118	$80	$39	$31	1.36	$7
TP3F	0.04 AEP	16	$2,718	$1,905	$813	$742	1.22	$70
TP9A	0.02 AEP	1	$76	$51	$25	$25	1.09	$0
Total		**37**	**$4,484**	**$2,441**	**$2,043**	**$1,382**	**1.48**	**$661**

Alternative 3B. Comprehensive Benefits Plan. Alternative 3B would add positively to the economic environment by decreasing flood damages experienced by property owners in the affected reaches. Alternative 3B would decrease expected annual damages from $5,611,000 to $2,667,000 (Table 4.2.).

Table 4.2. Comparison of EAD under the FWOP (without) and future with (with), as well as costs the associated annual costs and benefits, BCR, and net benefits for reaches included in Alternative 3B.

Reach	Aggregation Floodplain	No. Struct.	EAD Without	EAD With	Avg. Annual Benefits	Avg. Annual Costs	BCR	Net Benefits
STC1B	0.01 AEP	15	$1,155	$259	$896	$464	1.93	$433
STC1C	0.01 AEP	19	$446	$177	$270	$388	0.70	($118)
STC1F	0.01 AEP	1	$28	$10	$17	$48	0.36	($31)
TP10A	0.01 AEP	4	$176	$56	$120	$90	1.33	$30
TP10B	0.01 AEP	2	$209	$198	$10	$27	0.39	($17)
TP10C	0.01 AEP	5	$242	$74	$168	$93	1.81	$75
TP10D	0.01 AEP	1	$118	$80	$39	$31	1.23	$7
TP3C	0.01 AEP	22	$75	$66	$9	$325	0.03	($316)
TP3F	0.01 AEP	67	$2,718	$1,482	$1,235	$1,758	0.70	($522)
TP8	0.01 AEP	10	$208	$124	$84	$195	0.43	($111)
TP9A	0.01 AEP	4	$76	$33	$43	$82	0.52	($39)
TP9C	0.01 AEP	1	$13	$12	$1	$9	0.07	($8)
TP9D	0.01 AEP	4	$148	$96	$52	$159	0.33	($106)
Total		**155**	**$5,611**	**$2,667**	**$2,944**	**$3,667**	**0.8**	**($723)**

4.3.2. Environmental Justice

Alternative 1- No Action. Communities throughout the study area have been impacted by high-water events numerous times, hindering the economic viability of the community and creating an ongoing cycle of recovery. As a result of persistent flooding, structures throughout the study area have already been built or retrofitted with non-structural flood mitigation measures, and

numerous federal and state buyout and relocation programs have been undertaken. Despite these efforts, many structures remain at risk—comprised of homes and businesses that were not prioritized as having the greatest risk under previous programs and/or those unable to independently implement flood risk reduction measures. The remaining at-risk structures are largely within underserved and disadvantaged communities that have experienced among the greatest flood-related impacts and are less able to afford preparedness and recovery actions, making their occupants among the most vulnerable within the study area. Lack of federal action would not promote environmental justice for these individuals.

Alternative 3A. Maximum Net Economic Benefits / NED Plan. Alternative 3A would provide assistance to 34 commercial structures and 3 residential structures across 7 reaches with communities identified as disadvantaged in some aspect. However, there would still be considerable flood risk to structures in those reaches where vulnerable peoples live and work—structures that have experienced repetitive flooding and that have been unable to independently implement flood risk reduction measures and/or receive previous federal and state assistance. Occupants of structures not included in Alternative 3A could ultimately be forced to relocate because of continued recurring flooding, impacting community cohesion, diversity, and social equity.

Alternative 3B. Comprehensive Benefits Plan. Alternative 3B would provide assistance to 155 structures identified as being at-risk across 13 study reaches, including 61 residential and 94 non-residential structures. Thus, Alternative 3B includes application of nonstructural measures to an additional 118 structures beyond those included in Alternative 3A—structures located within disadvantaged and socially vulnerable communities (e.g., minority and/or elderly populations or populations with high poverty and/or unemployment, as defined by EJScreen and the CEJST) that are characterized by both high expected annual damages and low resilience in the face of future flood risk.

Alternative 3B would also help ensure community cohesion in the face of continued flood risk—keeping communities intact by providing equal assistance to all individuals affected by the calculated flood risk, including those individuals that represent socially vulnerable and historically underserved populations. In doing so, Alternative 3B would promote and preserve diversity and equal opportunity within affected communities.

4.4. Compliance with Section 106 of the National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966 requires federal agencies to identify and assess the effects of actions on historic buildings when making final project decisions. Based on the present (i.e., feasibility-level) design, uncertainty remains regarding the effects of the Study on historic properties. This uncertainty prevents USACE from conducting the surveys necessary to identify historic properties prior to completing the appropriate NEPA documentation. Given this limitation, USACE has and the NC SHPO have executed a Study-specific PA (Appendix C). NHPA Draft Tar Pamlico Programmatic Agreement) to comply with Section 106 of the NHPA. The PA includes timelines to conduct surveys to identify historic properties within the area of potential effect (APE), review procedures to ensure appropriate participation by each office, and requirements to avoid, minimize, or mitigate adverse effects to historic properties.

4.5. Cumulative Effects

Cumulative effects refer to the environmental consequences that arise when the effects of one action, in combination with the effects of past, present, and reasonably foreseeable future actions add up over time. A single action may seem insignificant, but when considered together with other actions or circumstances it can have a significant overall impact. No significant cumulative effects are expected from implementation of either of the action alternatives, but the following aspects are considered:

- By maintaining structures within a floodplain through elevation and floodproofing, residents will continue to inhabit a floodplain that they may otherwise leave. This could continue to strain to local rescue operations that are tasked with rescuing people during flooding emergencies, as people would remain in these areas and need assistance during these large floods. This strain would be felt financially and could pose a greater safety risk to rescue teams particularly with increasing intensity of storm events due to changing precipitation regimes.
- Both Alternative 3A and 3B will encourage residents and businesses to continue residing in a natural floodplain. This limits the effectiveness of the floodplain in mitigating flood waters downstream and improving water quality and decreases potential future effectiveness. Moving structures out of the floodplain and limiting development in these areas would be beneficial for long-term floodplain management.
- The construction and associated travel for contractors to complete this project will release greenhouse gases and add CO2 to the atmosphere; although this alone is an insignificant impact, it contributes to global problem of climate change. Climate change disproportionately affects low-income and minority populations. If this project were not implemented and these emissions not released, however, it's probable that emissions would otherwise be released in the following ways: homes destroyed by flooding may need to be demolished using construction equipment and/or items damaged in floods would need to be replaced which utilizes resources which create GHG emissions,
- Local traffic congestion could be temporarily exacerbated if other larger construction projects are happening with the region at the same time and/or if nonstructural mitigation measures are implemented on multiple structures at the same time in the same general area. It is unknown whether other construction projects are scheduled to occur during the time that this project would be implemented. This could affect air quality temporarily.

Based on these considerations, the cumulative impacts of either of the action alternatives combined with past, present, and reasonably foreseeable future circumstances are not significant.

4.6. Summary Table of Environmental Effects

Resource	Alternative 1 (No Action)	Alternative 3A (NED)	Alternative 3B (Comprehensive)
Wetlands	No effect.	No effect.	No effect.
Threatened and Endangered Species	No effect.	No effect.	No effect.

Aquatic Ecology and Riparian Habitat	No effect.	No effect.	No effect.
Climate	No effect.	No effect.	No effect.
Land Use and Cover	Minor effect; under a no action scenario where structures are continually inundated with flood waters, it's possible that residents and businesses may move elsewhere changing some land use in the study area.	No effect.	No effect.
Cultural & Historical	No effect.	Potential effect. Some structures proposed for elevation & floodproofing may be eligible for inclusion on the historical registry. A Programmatic Agreement is in place to ensure compliance with the NHPA.	Potential effect. Some structures proposed for elevation/floodproofing may be eligible for inclusion on the historical registry. A Programmatic Agreement is in place to ensure compliance with the NHPA.
HTRW	No effect.	Potential effect, but unlikely. Individual environmental assessments have not been done for each structure, but based on preliminary database searches, it is unlikely that floodproofing and/or elevation will result in the discovery of HTRW.	Potential effect, but unlikely. Individual environmental assessments have not been done for each structure, but based on preliminary database searches, it is unlikely that floodproofing and/or elevation will result in the discovery of HTRW.
Water Quality	No effect.	Minor effect but will be mitigated by the installation of erosion and sediment controls during any earth-	Minor effect but will be mitigated by the installation of erosion and sediment controls during any earth-disturbance

		disturbance during construction activities. The need for water quality permits is not expected.	during construction activities. The need for water quality permits is not expected.
Air Quality	No effect.	Minor, localized effects may be realized during construction from the use of vehicles/equipment, but these will be temporary and insignificant.	Minor, localized effects may be realized during construction from the use of vehicles/equipment, but these will be temporary and insignificant.
Floodplains	Potential minor beneficial effects. If structures are not floodproofed, the floodplain will be a less attractive place to live and do business, leading to decreased development in the floodplain.	Minor impacts. By floodproofing structures and homes, residents and businesses may reside in the floodplain longer than they otherwise would, and the floodplain will remain developed.	Minor impacts. By floodproofing structures and homes, residents and businesses may reside in the floodplain longer than they otherwise would, and the floodplain will remain developed.
Greenhouse Gas Emissions	Potential minor effects resulting from demolition and/or rebuilding if structures are damaged during flood events and are not appropriately flood-proofed.	Minor, insignificant impacts resulting from construction activities and vehicle use.	Minor, insignificant impacts resulting from construction activities and vehicle use.
Aesthetics	No effect.	Minor, insignificant effects resulting from the changed appearance of some structures from floodproofing/elevation.	Minor, insignificant effects resulting from the changed appearance of some structures from floodproofing/elevation.
Noise	No effect.	Insignificant, temporary, localized increases in noise.	Insignificant, temporary, localized increases in noise.

Transportation	No effect.	Insignificant, temporary, localized increases in traffic and very slight potential for temporary road detours.	Insignificant, temporary, localized increases in traffic and very slight potential for temporary road detours.
Economic Environment	No effect.	Positive benefits from the reduction in flood damages.	Positive benefits from the reduction in flood damages.

5. PLAN COMPARISON AND SELECTION

A summary of the comparison of the final array of alternatives is presented below in Table 5.1. A summary of comparison with respect to the four accounts, evaluation criteria, contribution to the planning objectives, and risk and uncertainty are provided in the following sections.

Table 5.1. Summary of comparison of the final array of alternatives with respect to analysis of the four PR&G accounts, alternative evaluation, and risk and uncertainty. Ranks are provided to assist with comparison across alternatives and consideration.

Consideration	**Alt. 1. No Action**	**Alt. 3A. Max Net Economic Benefits/NED**	**Alt. 3B. Comprehensive Benefits**
1. Account Analysis			
A. NED			
(1) Annual Net Benefits (2) BCR (3) Rank	(1) $0 (2) 0.00 (3) 2nd	(1) $661,000 (2) 1.48 (3) 1st	(1) -($723,000) (2) 0.8 (3) 3rd
B. RED			
(1) Employment (2) Labor Income (3) Rank	(1) 0 full time equivalents (2) $0 in labor income (3) 3rd	(1) 641.5 full-time equivalent jobs, (2) $44,610,517 in labor income (3) 2nd	(1) 1,755.5 full-time equivalent jobs, (2) $118,384,737 in labor income (3) 1st
C. OSE			
(1) Life Safety (2) Rank	(1) No reduction in life safety risk. (2) 3rd	(1) Reduction in life safety risk for occupants of 37 structures due to reduction in inundation and increase in flood awareness. (2) 2nd	(1) Reduction in life safety risk for occupants of 155 structures due to reduction in inundation and increase in flood awareness. (2) 1st

Consideration	Alt. 1. No Action	Alt. 3A. Max Net Economic Benefits/NED	Alt. 3B. Comprehensive Benefits
(1) Environmental Justice (Resilience) (2) Rank	(1) No increase in resilience of at-risk communities; potential reduction in resilience due to climate change. (2) 3rd	(1) Increased resilience of communities that benefit; however, minimal benefit to communities identified as socially vulnerable due to focus on maximizing economic benefits. (2) 2nd	(1) Increased resilience of communities that benefit, including 9 reaches identified as socially vulnerable. Benefits to a larger proportion of each community, including socially vulnerable populations, increases overall resilience. (2) 1st
(1) Environmental Justice (Cohesion) (2) Rank	(1) Loss of community cohesion as communities continue to be impacted and fragmented. (2) 3rd	(1) Benefits community cohesion by reducing risk to 37 at-risk structures; however, most at-risk structures—particularly those in socially vulnerable communities—remain at risk with a potential for future impacts that result in a loss of community cohesion. (2) 2nd	(1) Benefits community cohesion by reducing risk to 155 at-risk structures, with a greater focus on socially vulnerable communities. Much less risk remains in benefiting communities that could degrade community cohesion in the future. (2) 1st
Overall Rank for OSE account	3rd	2nd	1st
D. EQ			
(1) Natural Environment (2) Rank	(1) No change in the natural environment, including wetlands, aquatic habitat, riparian habitat, threatened and endangered species or critical habitat. (2) 1st	(1) No significant impacts to the natural environment, including wetlands, aquatic habitats, riparian habitats, threatened and endangered species or critical habitat. (2) 2nd (tie)	(1) No significant impacts to the natural environment, including wetlands, aquatic habitat, riparian habitat, threatened and endangered species or critical habitat. (2) 2nd (tie)
(1) Physical Environment	(1) No change in the physical environment,	(1) No significant impacts to the	(1) No significant impacts to the

Consideration	Alt. 1. No Action	Alt. 3A. Max Net Economic Benefits/NED	Alt. 3B. Comprehensive Benefits
(2) Rank	including climate, land use, cultural resources, air quality, water quality, or HTRW. (2) 1st	physical environment, including climate, land use, cultural resources, air quality, water quality, or HTRW. All impacts would be minor and temporary. (2) 2nd (tie)	physical environment, including climate, land use, cultural resources, air quality, water quality, or HTRW. All impacts would be minor and temporary. (2) 2nd (tie)
Overall Rank for EQ account	1st	2nd (tie)	2nd (tie)
2. Alternative Evaluation			
A. Criteria			
(1) Efficiency (2) Rank	(1) No net economic benefits. (2) 2rd	(1) $661,000 in net benefits. (2) 1st	(1) (-$723,000) in net economic benefits. (2) 3nd
(1) Effectiveness (Damages reduced) (2) Rank	(1) No damages reduced. (2) 3rd	(1) Reduces damages to 37 residential and commercial structures. (2) 2nd	(1) Reduces damages to 155 residential and commercial structures. (2) 1st
(1) Effectiveness (Commercial/Industry) (2) Rank	(1) No benefits to commerce or industry. (2) 3rd	(1) Reduces damages to 34 commercial and industrial facilities. (2) 2nd	(1) Reduces damages to 94 commercial and industrial facilities. (2) 1st
(1) Effectiveness (Life Safety) (2) Rank	(1) No reduction in life safety risk. (2) 3rd	(1) Reduction in life safety risk for occupants of 37 structures due to reduction in inundation. (2) 2nd	(1) Reduction in life safety risk for occupants of 155 structures due to reduction in inundation. (2) 1st
(1) Acceptability (2) Rank	(1) Meets acceptability criteria. (2) 1st (tie)	(1) Meets acceptability criteria. (2) 1st (tie)	(1) Meets acceptability criteria. (2) 1st (tie)
(1) Completeness (2) Rank	(1) Does not meet completeness criteria. (2) 3rd	(1) Meets completeness criteria, benefitting 37 structures in total. (2) 2nd	(1) Meets completeness criteria, benefitting 155 structures in total. (2) 1st

Consideration	Alt. 1. No Action	Alt. 3A. Max Net Economic Benefits/NED	Alt. 3B. Comprehensive Benefits
(1) Environmental Justice (Resilience) (2) Rank	(1) No increase in resilience of at-risk communities. Potential reduction in resilience due to climate change. (2) 3rd	(1) Increased resilience of communities that benefit. However, minimal benefit to communities identified as socially vulnerable due to focus on maximizing economic benefits. (2) 2nd	(1) Increased resilience of communities that benefit, including 9 reaches identified as socially vulnerable. Benefits to a larger proportion of each community, including socially vulnerable populations, increases overall resilience. (2) 1st
(1) Environmental Justice (Community Cohesion) (2) Rank	(1) Loss of community cohesion as communities continue to be impacted and fragmented. (2) 3rd	(1) Benefits community cohesion by reducing risk to 37 at-risk structures; however, most at-risk structures—particularly those in socially vulnerable communities—remain at risk with a potential for future impacts that result in a loss of community cohesion. (2) 2nd	(1) Benefits community cohesion by reducing risk to 155 at-risk structures, with a greater focus on socially vulnerable communities. Much less risk remains in benefiting communities that could degrade community cohesion in the future. (2) 1st
(1) Environmental Effects (2) Rank	(1) No effect on environmental resources. (2) 1st	(1) No significant effects on environmental resources. (2) 2nd (tie)	(1) No significant effects on environmental resources. (2) 2nd (tie)
Overall Rank Criteria	3rd	2nd	1st
B. Contribution to Objectives			
(1) Life Safety (2) Rank	(1) No benefits to life and safety. (2) 3rd	(1) Reduction in life safety risk for occupants of 37 structures due to reduction in inundation. (2) 2nd	(1) Reduction in life safety risk for occupants of 155 structures due to reduction in inundation. (2)1st
(1) Economic damages	(1) No reduction in economic damages.	(1) Expected annual benefits of $2,043,000	(1) Expected annual benefits of

Consideration	Alt. 1. No Action	Alt. 3A. Max Net Economic Benefits/NED	Alt. 3B. Comprehensive Benefits
(2) Rank	(2) 3rd	which equals an approximate 46% reduction in expected annual damages. (2) 2nd	$2,944,000, which equates to an approximate 52% reduction in expected annual damages. (2) 1st
(1) Industry & Commerce (2) Rank	(1) No benefits to industry and commerce. (2) 3rd	(1) Decrease in damages to 34 commercial and industrial structures. (2) 2nd	(1) Decrease in damages to 94 commercial and industrial structures. (2) 1st
Overall Rank Contribution to Objectives	3rd	2nd	1st
C. Risk and Uncertainty			
(1) Residual Risk (2) Rank	(1) No change in flood risk throughout the basin. Greatest residual risk. (2) 3rd	(1) Includes 4% of structures within the 1% AEP floodplain initially considered for inclusion within the final array of alternatives. (2) 2nd	(1) 22% of the 716 structures within the 1% AEP floodplain initially considered for inclusion within the final array of alternatives. Least residual risk due to climate change. (2) 1st
(1) Uncertainty (2) Rank	(1) Relies completely on nonfederal action to reduce flood risk. (2) 2nd	(1) Participation rates could affect benefits. (2) 1st (tie)	(1) Participation rates could affect benefits. (2) 1st (tie)
Overall Rank Risk and Uncertainty	3rd	2nd	1st

System of Accounts. Alternative 3A has the greatest net economic benefits ($661,000) and BCR (1.48). However, Alternative 3B has the greatest benefits to RED and OSE, including increased community resiliency and community cohesion—particularly within and across socially vulnerable communities. Alternative 3B includes application of nonstructural measures to an additional 118 structures beyond those included in Alternative 3A—structures located within disadvantaged and socially vulnerable communities (e.g., minority and/or elderly populations or populations with high poverty and/or unemployment, as defined by EJScreen and the CEJST) that are characterized by both high expected annual damages (EAD) and low resilience in the face of future flood risk (Table 5.2). This plan includes all 155 structures identified as being at-risk within the 0.01 AEP floodplain across 13 study reaches. Thus, the incremental cost

difference between Alternative 3A and Alternative 3B (i.e., approximately three-fold for Alternative 3B) provides benefit to nearly four times as many structures, promoting increased resilience and community cohesion within the most socially vulnerable and disadvantaged communities across the study area.

Table 5.2. Comparison of EAD, average annual benefits, and social vulnerability as described by the EJScreen tool (demographic index, minority population, population over 64, unemployment) and Climate and Economic Justice Screening Tool (CEJST; climate vulnerability).

Reach	**Total EAD ($000s)**	**Average Annual Benefits ($000s)**	**EJScreen**	**Climate Vulnerability (CEJST)**
STC1B*†	$1,155	$896	Minority	-
STC1C	$446	$270	Unemployment	-
STC1F	$28	$17	Unemployment	-
TP10A*†	$176	$120	Demographic Index	Yes
TP10B	$209	$10	Over 64	Yes
TP10C*†	$242	$168	Demographic Index	Yes
TP10D*†	$118	$39	Unemployment	-
TP3C	$75	$9	Demographic Index	Yes
TP3F*	$2,718	$1,235	Demographic Index	Yes
TP8*	$208	$84	Demographic Index	Yes
TP9A*	$76	$43	Demographic Index	Yes
TP9C	$13	$1	Demographic Index	Yes
TP9D	$148	$52	Demographic Index	Yes
TOTAL	**$5,611**	**$2,944**	-	-
* Indicates reaches that are also part of Alternative 3A † Indicates reaches that have positive net economic benefits within Alternative 3B				

Alternative 1 would have the least impact to the EQ account; however, neither Alternative 3A nor 3B have significant environmental impacts.

Alternative Evaluation. Alternative 3A represented the most efficient plan (i.e., highest net economic benefits and BCR); however, Alternative 3B also represents an efficient plan. Alternative 3B ranked highest in all three effectiveness criteria—having the greatest reduction in economic damages, the greatest benefits to commerce and industry, and the greatest benefit to life safety. Alternative 3B also had the greatest effect on improving community resiliency and promoting community cohesion by reducing risk within socially vulnerable communities (i.e., low-income and high minority populations) with significant future flood risk. Alternative 1 had the least impact to environmental resources. Alternative 3B had the greatest contribution to all three planning objectives—providing the greatest reduction in economic damages, the greatest benefit to commerce and industry, and the greatest reduction in life safety risk. Alternatives 3A and 3B have similar levels of residual risk and uncertainty.

5.1. Identification of the NED Plan

Alternative 3A has the greatest net economic benefits ($661,000) and BCR (1.48) and, thus, represents the NED Plan.

5.2. Plan Selection

Although Alternative 3A represents the NED plan, Alternative 3B represents the plan that maximizes benefits across all four accounts (i.e., NED, RED, OSE, and EQ). Thus, Alternative 3B was selected as the recommended plan.

The additional increment in implementation cost between Alternative 3A and 3B is primarily justified based on the OSE account due to the benefits associated with environmental justice. Alternative 3B incorporates an additional 118 structures—all of which are within communities that are identified as socially vulnerable, and therefore less resilient; or disadvantaged as defined by the EJScreen and/or CEJST tools (Table 5.2). The identified communities have substantial expected annual damages under the FWOP condition. Taken together, these conditions emphasize the increased burden that flood risk places on disadvantaged communities, whereby the reaches are generally characterized by historically underserved populations with low income that also have increased vulnerabilities in the face of climate change. Thus, these represent among the least resilient communities within the study area.

Alternative 3B would improve community cohesion in the face of continued flood risk by helping to ensure that communities remain intact by providing equal assistance to all individuals, including those individuals that represent socially vulnerable and historically underserved populations. In doing so, Alternative 3B would promote and preserve diversity and equal opportunity within communities benefited by Alternative 3B.

5.3. Deviations from the NED Plan

The NED Plan (Alternative 3A) includes structure elevation or floodproofing of 37 structures across seven reaches. The NED Plan has a total first costs of $37,193,000, producing $661,000 in net annual benefits and a BCR of 1.48 (Table 5.3, Table 5.4Table 3.8). The recommended plan, Alternative 3B, has a total first cost of $98,701,000, producing (-$723,000) in net annual benefits and a BCR of 0.80 (Table 5.3, Table 5.3).

The incremental cost difference between Alternative 3A and 3B (i.e., approximately three-fold) provides benefit to nearly four times as many structures, promoting resilience and community cohesion within socially vulnerable and disadvantaged communities within the study area. Approval to recommend a plan other than the NED Plan was granted by the Assistant Secretary of the Army on February 2, 2024 (Office of the Assistant Secretary, Civil Works, 2024).

Table 5.3. Comparison of total first costs for the NED plan (Alternative 3A) and the recommended plan (Alternative 3B).

	Costs ($000s)	
Construction Item	**Alt. 3A. Maximum Net Economic Benefits**	**Alt. 3B. Comprehensive Benefits**
LERRDs	$1,311	$5,495

Project Elements		
Elevation and Floodproofing*	$24,745	$64,280
Pre-Construction Engineering and Design (PED)*	$7,547	$19,605
Construction Management*	$3,588	$9,321
Total First Cost	$37,193	$98,701
*Includes 43% contingency as determined by a cost and schedule risk analysis.		

Table 5.4. Comparison of annual costs and benefits for the NED Plan (Alternative 3A) and the recommended plan (Alternative 3B).

	Costs ($000s)	
Construction Item	**Alt. 3A. Maximum Net Economic Benefits**	**Alt. 3B. Comprehensive Benefits**
Investment Cost		
Total Project First Cost	$37,193	$98,701
Interest During Construction	$115	$305
Total Investment Cost	$37,308	$99,006
Annual Cost		
Annualized First Cost	$1,382	$3,667
Estimated OMRR&R	$0	$0
Total Average Annual Cost	$1,382	$3,667
Annual Benefits	$2,043	$2,944
Net Annual Benefits	$661	(-$723)
Benefit-Cost Ratio	1.48	0.80
Interest during construction was calculated at 2.75% over a 3-month construction period per structure. Costs were annualized over a 50-year period of analysis. BCR assumes a 100% participation rate.		

6. RECOMMENDED PLAN

6.1. Plan Accomplishments

Alternative 3B (Nonstructural Comprehensive Benefits Plan) is the recommended plan. Alternative 3B includes elevation of 35 structures; flood venting of 8 structures; elevation and flood venting of 18 structures; and dry floodproofing of 94 structures, for a total of 155 residential and commercial structures throughout the study area (Figure 6.1).

The recommended plan maximizes benefits within the RED and OSE account. The recommended also maximizes, to the extent practicable, flood risk reduction benefits within vulnerable populations, including individuals living in poverty and minority populations. The recommended plan is the most equitable alternative considered in terms of flood risk reduction by ensuring rural, socially vulnerable communities experiencing recurring and frequent flooding receive the same flood risk reduction opportunities as communities within the adjacent urban areas of Rocky Mount and Greenville, which have positive net economic benefits.

The recommended plan would have only minor environmental impacts and is an acceptable plan from an environmental standpoint. Specifically, the recommended plan would not have

significant impacts on the environment under the NEPA and will have no effect on federally-listed species or designated critical habitat under the ESA. The recommended plan can be implemented in compliance with all applicable environmental laws and regulations. The recommended plan would constitute an undertaking under Section 106 of the National Historic Preservation Act (NHPA) and has a potential to affect historic properties listed on, or determined eligible for, the National Register of Historic Places under 36 C.F.R. § 800.3. All compliance and mitigation requirements under Section 106 will be satisfied prior to project implementation.

6.2. Plan Components

The recommended plan includes all 155 structures identified as being at-risk within the 1% AEP floodplain across 13 reaches. Specifically, the recommended plan includes elevation of 35 structures; flood venting of 8 structures; elevation and flood venting of 18 structures; and dry floodproofing of 94 structures (Figure 6.1; Table 6.1). All structures would be elevated to the 1% AEP flood elevation plus 2 feet. Structures would be dry floodproofed to the 1% AEP floodplain plus 2 feet, or up to a maximum height of 4 feet.

Table 6.1. Aggregation floodplain and number of structures included for dry floodproofing and structure elevation and/or flood venting within each of the 13 reaches included in Alternative 3B, Comprehensive Benefits Plan.

Reach	Aggregation Floodplain	Elevate	Elevate & Flood Vent	Flood Vent	Dry Floodproof	Total
STC1B	0.01 AEP	1	0	0	14	15
STC1C	0.01 AEP	1	7	4	7	19
STC1F	0.01 AEP	0	0	0	1	1
TP10A	0.01 AEP	0	1	1	2	4
TP10B	0.01 AEP	1	0	0	1	2
TP10C	0.01 AEP	0	3	1	1	5
TP10D	0.01 AEP	0	0	0	1	1
TP3C	0.01 AEP	22	0	0	0	22
TP3F	0.01 AEP	10	5	0	52	67
TP8	0.01 AEP	0	1	0	9	10
TP9A	0.01 AEP	0	0	2	2	4
TP9C	0.01 AEP	0	0	0	1	1
TP9D	0.01 AEP	0	1	0	3	4
Total		35	18	8	94	155

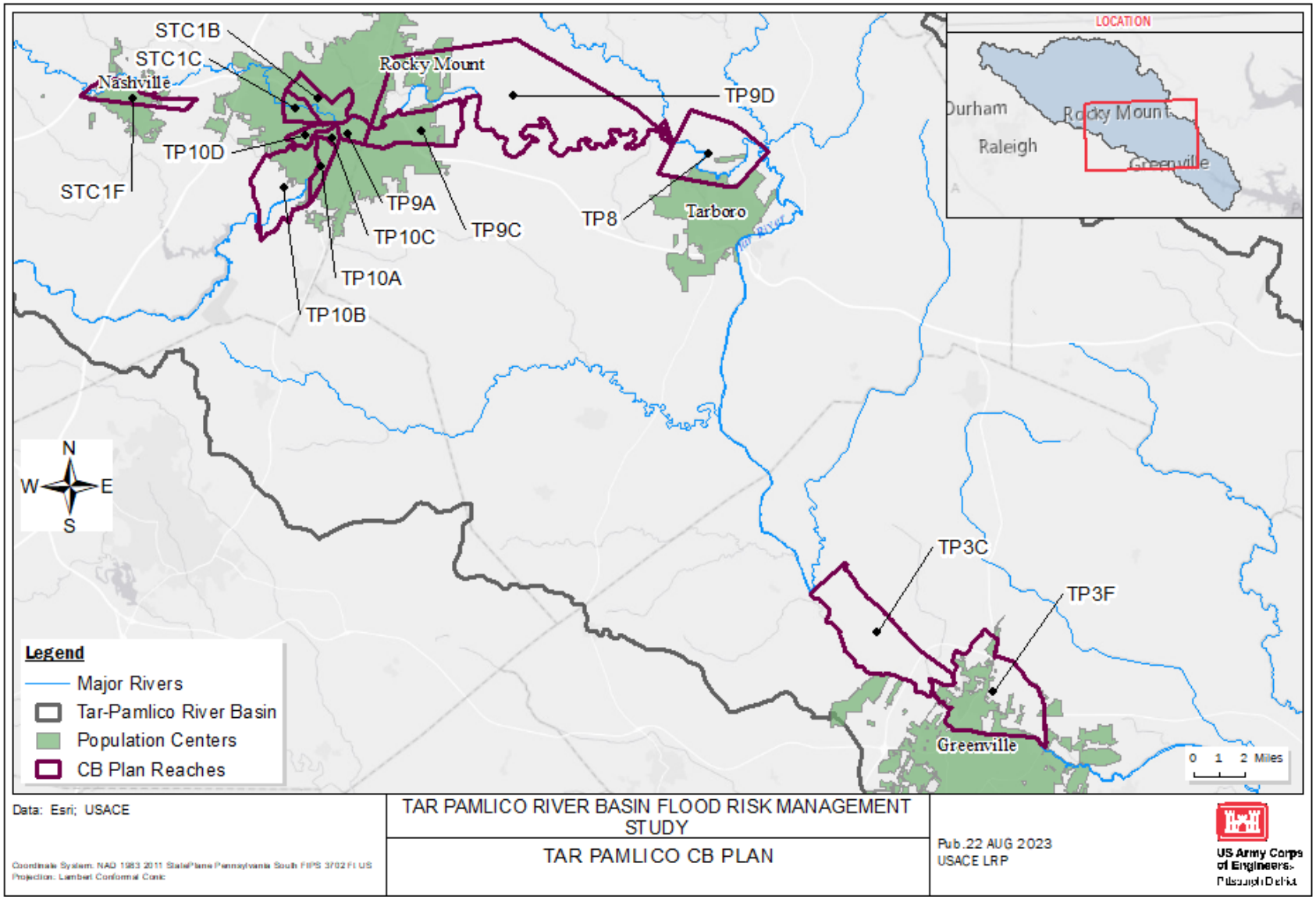


Figure 6.1. Reaches included in the Comprehensive Benefits plan, Alternative 3B.

6.3. Cost Estimate

The project first cost for the recommended plan is $98,701,000, including $5,495,000 in lands, easements, rights of way, relocations, and disposal costs (LERRDs), $64,280,000 in construction costs associated with structure elevation and floodproofing, $19,605,000 in the Pre-construction Engineering and Design phase (PED), and $9,321,000 in construction management (Table 6.2). It is expected that the selected plan will not require mitigation as per section 106 of the NHPA, and, as such, there will be no mitigation costs associated with Alternative 3B.

Table 6.2. Cost summary for the recommended plan calculated using FY24 price levels. Costs shown are annualized using a FY24 discount rate of 2.75%. Values shown are $000s.

	Costs ($000s)
Construction Item	**Alt. 3B. Comprehensive Benefits**
LERRDs	$5,495
Construction Costs*	$64,280
PED*	$19,605
Construction Management*	$9,321
Total First Cost	$98,701
*Includes 43% contingency as determined by a cost and schedule risk analysis.	

Individual costs for each of the 13 reaches included in the recommended plan are shown below in Table 6.3.

Table 6.3. Cost table for individual reaches in Alternative 3B.

Reach	**No. Structures**	**First Cost ($000s)**
STC1B	15	$12,483,631
STC1C	19	$10,438,416
STC1F	1	$1,290,015
TP10A	4	$2,417,488
TP10B	2	$725,962
TP10C	5	$2,498,783
TP10D	1	$846,000
TP3C	22	$8,746,438
TP3F	67	$47,304,937
TP8	10	$5,240,017
TP9A	4	$2,196,348
TP9C	1	$240,528
TP9D	4	$4,272,719
Total	**155**	**$98,701**

6.4. Lands, Easements, Rights-of-Way, Relocations, and Disposal

The non-federal sponsor is required to provide all LERRDs. The total cost for LERRDs associated with Alternative 3B is $5,495,000, which includes all estimated costs of performing all responsibilities described in the implementation plan, as well as any tenant relocation

assistance required by Public Law 91-646. Specifically, these costs include $3,100,000 in tenant temporary relocations, $775,000 in relocation administration, $521,000 in federal reviews, and $1,099,000 in contingency. Real estate costs are detailed in Appendix D Tar Pamlico Real Estate Plan.

In the Preconstruction Engineering and Design Phase, all willing property owners will be asked to grant a standard right-of-entry for survey and exploration to USACE and the nonfederal sponsor to enter upon the property to conduct property and structural investigations deemed necessary to determine final eligibility for participation. These investigations may include structural inspections, surveys, limited environmental testing and site assessments, verifying current structure elevation and determining elevation requirements, and conducting such other activities deemed necessary by USACE and the nonfederal sponsor to make a final determination of a structure's eligibility.

Once the structure has been determined eligible and prior to construction, the landowner will be required to execute a Nonstructural Floodproofing Agreement with the nonfederal sponsor. The agreements will be recorded in the local records and will include a restriction of future construction on the site below a stated elevation as well as holding and saving the nonfederal sponsor and the federal government harmless from any damages or injuries resulting either directly or indirectly from any structure elevation or floodproofing work conducted on the property.

Eminent domain authority will not be used to require landowners in this category to participate in the program; however, tenants who reside in structures to be elevated may be eligible for certain benefits in the accordance with Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs of 1970.

6.5. Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

The Federal government is responsible for preparing and providing an OMRR&R manual to the sponsor as the final recommended plan is being implemented. OMRR&R costs associated with this recommended plan are considered 'de-minimis' (requiring only periodic surveillance by the non-Federal sponsor). Ultimately, each individual property owner will be responsible for maintenance of their elevated or floodproofed structure/home. This may include keeping the vents free of obstructions and ensuring that floodproofing features remain functional.

6.6. Project Risks

6.6.1. Residual Risk

Residual risk represents existing, future, or historical risk that remains or might remain after an alternative has been implemented. The recommended plan will have residual risk of inundation and associated life safety risk for the remainder of the 3,042 structures within the 0.2% AEP floodplain that are not included in the plan. Furthermore, the recommended plan does not incorporate structures within smaller tributaries and headwaters to the Tar River and its major tributaries. The recommended plan will also have residual economic damages (i.e., traffic delays

or detours) and associated life safety risks (i.e., community isolation and loss of access and egress) associated with inundation of transportation infrastructure throughout the watershed.

Although the recommended plan would reduce economic damages and life safety risks associated with direct inundation, structures could be inaccessible during flood events, isolating residents if they choose not to evacuate. Isolation could impact the ability of residents to access critical facilities (e.g., medical facilities) and necessary goods and services (e.g., food and clean water), as well as receive support, during flood events. Isolation would be longer (i.e., up to several days) for residents in the lower portions of the watershed, including Greenville and Tarboro, as compared to residents further up in the watershed, including areas along Stony Creek and the upper Tar River. Furthermore, structures elevated and floodproofed under recommended plan would have residual risk during events with flood elevations exceeding the 1% AEP flood elevation plus 2 feet. Communities throughout the study area have experienced floods exceeding the 1% AEP event, including during hurricanes Fran (1996), Floyd (1999) and Matthew (2016). The 0.2% AEP event was also exceeded in certain locations throughout the watershed. Structures identified for floodproofing that cannot achieve the 1% plus 2 feet target due would have the greatest residual risk during future floods exceeding the 1% AEP event.

The recommended plan will also have residual risk associated with climate change over the next 100 years. Increases in the frequency and intensity of extreme rainfall events throughout the watershed could result in reduced performance of each alternative. The extent of the 1% AEP floodplain or flood height may change such that the effectiveness of measures within each alternative is decreased and additional structures not incorporated in each plan have increased risk. Similarly, the frequency with which roadways become inundated could also increase, increasing associated damages and life safety risk. Finally, accelerated rates of sea level rise could also impact project performance in the downstream areas of the watershed, particularly those near Greenville. Additional increases in sea level rise beyond those characterized in this study could further increase water surface elevations under the full range of flood events and result in additional residual risk.

6.6.2. Uncertainty

Identifying and managing risk is critical to making informed planning decisions in the face of uncertainty. However, some level of uncertainty will remain following any decision. Understanding and characterizing this remaining uncertainty is also critical as it can affect the outcome of any decision. This section characterizes uncertainty associated with each alternative.

The recommended plan consists entirely of management measures with voluntary participation. Participation rates could affect the overall benefits achieved by each alternative and the amount of residual risk following implementation. Additionally, analyses undertaken to identify the recommended plan were based on visual surveys and existing data, including first floor elevations. Visual surveys were conducted remotely using Google Earth ©, which provided detailed views of the exterior of all structures. It is possible that floodproofing measures currently in place for structures within the recommended plan were not visible from the exterior photographs. Additional surveys will be conducted during the PED phase of the project prior to the start of construction to address this uncertainty.

To provide a complete picture to decision makers, a sensitivity analysis was performed based on the participation of the top and bottom 75%, 50%, and 25% of structures in terms of structure specific BCRs.

A total of 155 structures were identified in the comprehensive benefit aggregation. Most of these structures (94) were identified to be dry floodproofed. The top and bottom 117 (75%), 78 (50%), and 39 (25%) structures were used for the sensitivity analysis and were chosen based on the BCR of the individual structure.

Each of these sensitivity aggregations was run through HEC-FDA to attain the corresponding benefits of only those structures. The included structures were assigned the previously identified nonstructural methodology and corresponding structure attribute modifications while the structures not in the aggregation were left with their existing conditions attributes. Costs were provided on a per-structure basis allowing for costs to only be applied for structures in the sensitivity run. An overview of the sensitivity analysis is presented in Table 6.4 and detailed in section 13.2.5 of Appendix B, Economic Analysis.

Table 6.4. Alternative 3B sensitivity analysis overview.

Participation Rate	Annual Benefits	Annual Costs	Net Benefits	BCR
100%	$2,944,280	$3,667.30	($723,.02)	0.80
Top 75%	$2,922.11	$3,105.63	($183.52)	0.94
Top 50%	$2,812.27	$2,476.82	$335.45	1.14
Top 25%	$2,447.25	$1,543.44	$903.81	1.59
Bottom 75%	$511.75	$2,142.07	($1,630.32)	0.24
Bottom 50%	$136.04	$1,193.28	($1,057.24)	0.11
Bottom 25%	$23.57	$572.03	($548.46)	0.04

The participation rate with the highest net benefits is the top 25%. Benefits exceed $900 thousand per year with very minimal loss to overall benefits. However, any lost participation from lower BCR structures tends to move the overall BCR closer to 1. If the bottom 38 structures do not participate in the project the BCR will be positive. The recommended plan is very reliant on the participation of the top structures.

6.7. Cost Sharing

An ability-to-pay analysis was conducted in accordance with EGM 19-04 (USACE, Directorate of Civil Works, 2019). The first step in determining eligibility is to determine the benefits-based floor (BBF). The BBF determines the maximum possible reduction in the level of non-Federal cost-sharing and is calculated by dividing the project's BCR by four and expressing that factor as a percentage. If the factor determined is less than the standard level of cost-sharing, projects may be eligible for either a reduction in the non-Federal share to the BBF, or for a partial reduction to a share between the standard level and the BBF, as determined by the eligibility factor in the second step below. In no case, however, will the non-Federal cost-share be less than five percent. The BBF for Tar Pamlico is 0.8 (project BCR) divided by four which equals 0.20. Expressed as a percentage the BBF is 20%.

For step two, the eligibility factor (EF) is determined as per the method outlined in EM 19-04 (USACE, Directorate of Civil Works, 2019). The EF is calculated using the formula below:

$$EF = a - (b_1 * state\ income\ index) - (b_2 * county\ income\ index)$$

Where:

State income index = the average over three years of the state per-capita income index (state per capita income divided by the national per capita income) for the state in which the project is located

County income index = is the average over three years of the county per-capita income index (county per capita income divided by national per capita income) for the county in which the project is located

a=18.22

b_1=0.079

b_2=0.158

The values of the parameters a, b_1, and b_2 are determined by HQUSACE (USACE, Directorate of Civil Works, 2019).

Using these parameters, the calculation for Tar Pamlico River Basin Flood Risk Management Feasibility Study was determined as follows:

$$EF = 18.22 - (0.079 * 88.09) - (0.158 * 79.20) = 18.03$$

If the EF is one or more, the project is eligible for the full reduction in cost-share to the BBF Using this methodology, the EF for the Tar Pamlico study was determined to be greater than one, therefore, the project was eligible for the full reduction in cost-share to the BBF of 20%.

All estimates are at the 2024 price level and may change due to inflation prior to construction. The non-federal sponsor must provide self-certification of financial capability as required by USACE policy. Use of funds from other federal programs, including any non-federal contribution required as a matching share, to meet financial obligations of the non-federal sponsor is not permitted unless USACE authorizes use of those funds in writing.

Project design and implementation costs are shared. Based on the ability-to-pay analysis, the cost share for this project was determined to 80 percent federal and 20 percent non-federal. The non-federal sponsor is required to provide all LERRDs. Based on these requirements, the estimated non-federal contribution for the recommended plan is $19,740,000, which includes $3,921,000 for PED, $5,495,000 in LERRD costs, and $15,819,000 in construction costs (Table 6.5).

Table 6.5. Federal and non-federal cost share for the recommended plan.

	Costs ($000s)		
Construction Item	**Federal Cost**	**Non-Federal Cost**	**Total Cost**
PED*	$15,684 *(80%)*	$3,921 *(20%)*	$19,605
LERRDs	$0	$5,495	$5,495
Construction Costs*	$63,277	$10,324	$73,601
Subtotal	$63,277 *(80%)*	$15,819 *(20%)*	$79,096
Total Project	**$78,961 *(80%)***	**$19,740 *(20%)***	**$98,701**
*Construction costs include construction and construction management			

6.8. Design and Construction

The following considerations should be observed during design and construction of non-structural measures general considerations from the *FEMA Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (FEMA P-259) when applying nonstructural measures for flood risk management:

- Owner motivation
- Regulatory requirements
- [Proposed measures should] Observe codes, ordinances, and regulations for other restrictions, such as setbacks and wetlands.
- [Proposed measures] Should be designed and constructed by experienced professionals (engineers, architects, or contractors) to ensure effectiveness.
- Implement a scheduled maintenance plan to ensure nonstructural measures adequately reduce flood risk to the structure over time.
- Recommend owners continue flood insurance coverage or consider buying flood insurance coverage as floods may exceed the level of flood risk provided.

6.9. Environmental Commitments

The recommended plan is environmentally acceptable. Coordination with resource agency representatives was initiated early in the study and there will be no effect on threatened and endangered species and associated critical habitat. The recommended plan includes only nonstructural measures to structures located within the floodplain.

This IFREA complies with NEPA. A separate EA is not required because the study document is a fully integrated report that complies with both NEPA requirements and those of the USACE water resources planning process. A Clean Water Act Section 401 Water Quality Certification and Section 404(b)(1) analysis will not be required for the recommended plan as this proposed plan will not discharge dredged or fill material into navigable waters. Additionally, any HTRW Phase 1 assessments that would be needed prior to structural elevation and floodproofing of individual structures as part of the recommended plan will be completed during the PED phase. During PED, if it's determined that an area of 1 acre or more of earth would be disturbed, a National Pollutant Discharge Elimination System (NPDES) Permit and potentially a Storm

Water Management Plan Permit would be obtained prior to start of construction. Erosion and sedimentation BMPs will be implemented as necessary during construction to minimize sediment runoff.

A PA has been executed in accordance with 36 CFR 800.14(b)(3) that outlines the process to identify and evaluate historic properties and avoid, minimize, and where possible, mitigate for any adverse impacts in accordance with Section 106 of the NHPA and implementing regulations 36 CFR 800. The PA will allow the USACE to complete the necessary historic and archaeological surveys during the follow-on PED phase of the project, once the nonstructural measures and identified properties have been confirmed.

The Clean Water Act, Section 404 (40 CFR Part 230), requires that the Least Environmentally Damaging Practicable Alternative be identified. Although Alternative 1, No Action, would be the Least Environmentally Damaging Practicable Alternative (LEDPA) because it has less of an environmental impact than either Alternatives 3A or 3B, Alternative 1 does not meet the project purpose or objectives. Alternative 3B, the recommended plan, is the LEDPA. Alternative 3B more effectively meets the project purpose and objectives than does Alternative 3A, and will result in very similar environmental impacts. The difference in environmentally damaging impacts resulting from Alternatives 3A and 3B are marginal, and therefore these alternatives are considered to be comparable and effectively equal with respect to damaging environmental impacts. Because Alternative 3B (recommended plan) also is most effective at meeting the project purpose and objectives, the recommended plan is the LEDPA.

6.10. Environmental Consequences

The environmental consequences of implementing the recommended plan are considered insignificant based on the analysis provided in Section 4. Minor environmental effects will be realized and are unavoidable if the recommended plan is implemented. These minor effects are described throughout Section 4. The recommended plan will allow for some businesses and residents to continue to reside in the floodplain by reducing damages from flooding, but this is a relatively short-term solution to reducing flood damages. To reduce flood risk over the long-term, development in the floodplain must be minimized. This will enhance the natural functioning of the floodplain in mitigating floodwaters and reducing flood risk. Implementation of the recommended plan would result in the irreversible and irretrievable commitment of the following resources: greenhouse gases will be emitted (Section 4.2.8.), and there is the potential that historical structures may be modified from their original form (Section 4.2.3.).

6.11. Project-specific Considerations

Federal implementation of the recommended plan would also be subject to non-federal sponsor compliance with the following applicable federal laws and policies:

- Inform affected interests of the extent of protection afforded by the project no less than once each year.
- Agree to participate in and comply with applicable federal floodplain management and flood insurance programs.
- Prepare a floodplain management plan already within one year of the signing of the project partnership agreement and implement the plan no later than one year following completion of

project constructions as specified in Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12).

- Prevent obstructions or encroachments on the project, including prescribing and enforcing regulations to prevent obstructions or encroachments, such as new developments on project lands, easements, and rights-of-way or the addition of facilities that may reduce the level of protection the project affords, hinder project OMRR&R, or interfere with project function.
- Publicize floodplain information and provide this information to zoning and other regulatory agencies for use in adopting regulations, taking other actions to prevent unwise future development, and ensuring compatibility with protection levels provided by the project.
- Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24 in acquiring lands, easements, and rights-of-way required for construction and OMRR&R of the project, including those necessary for relocations, borrowing of material, or disposal of dredged or excavated material. Inform all affected persons of applicable benefits, policies, and procedures in connection with these laws and regulations.
- For so long as the project remains authorized, complete OMRR&R requirements on the project at no cost to the federal Government in a manner compatible with the project's authorized purposes and in accordance with applicable federal and commonwealth laws, regulations, and any specific directions prescribed by the federal government.
- Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purposes of completing, inspecting, or conducting OMRR&R on the project.
- Hold and save the U.S. free from all damages arising from the construction or OMRR&R of the project and any betterments, except for damages due to the fault or negligence of the U.S. or its contractors.
- Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project for a minimum of three years after final accounting.
- Comply with all applicable federal and commonwealth laws and regulations, including but not limited to: Section 601 of the Civil Rights Act of 1964 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794) and Army Regulation 6007 issued pursuant thereto; 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (labor standards originally enacted as the Davis-Bacon Act, the Contract Work Hours and Safety Standards Act, and the Copeland Anti-Kickback Act).
- Perform, or ensure performance of, any investigations that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Public Law 96-510, as amended (42 U.S.C. 9601-9665) that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction and completion of OMRR&R of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction.

- Assume, as between the federal government and the nonfederal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction and completion of OMRR&R of the project.
- Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purposes of CERCLA liability, and to the maximum extent practicable, OMRR&R the project in a manner that will not cause liability to arise under CERCLA.
- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project, or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

6.12. Environmental Operating Principles (EOP)

This study and the associated recommended plan maintain the USACE commitment to environmental stewardship by conforming to the following USACE Environmental Operating Principles:

Foster sustainability as a way of life throughout the organization. The recommended plan fosters environmental sustainability by representing the plan with no significant or permanent environmental impacts.

Proactively consider environmental consequences of all USACE activities and act accordingly. The study team coordinated with appropriate environmental agencies to identify all possible environmental impacts and sought avenues to minimize those impacts throughout the development and evaluation/comparison of alternative plans.

Create mutually supporting economic and environmentally sustainable solutions. The recommended plan reduces flood risk to communities throughout the study area through the implementation of measures that have no significant or permanent environmental impacts.

Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments. The study team is engaged in the activities necessary to assess and minimize cumulative impacts to the environment through NEPA via necessary surveys and agency coordination. It is expected that the recommended plan will be compliant with all applicable laws and policies.

Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs. Environmental risks were identified early in the study process and used to inform plan formulation decisions.

Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner. The study team worked with local and regional stakeholders and held multiple scoping meetings with the public to obtain all existing

scientific, economic, and social knowledge regarding environmental context and used this information during the plan formulation process.

Employ an open, transparent process that respects views of individuals and groups interested in USACE activities. The study team was open and transparent regarding the study process and possible outcomes during site visits and the public scoping meetings. All feedback obtained during these outreach activities was incorporated into the planning process. The recommended plan will be reviewed and potentially modified during the PED phase. If changes to the project result in effects that have not been previously evaluated, then pursuant to NEPA, USACE will prepare a separate NEPA document to address the changes and evaluate the associated effects. USACE and its contractors commit to avoiding, minimizing, and mitigating for adverse effects during construction activities.

6.13. Views of the Non-Federal Sponsor

The NFS, represented by the North Carolina Department of Environmental Quality, has expressed support of the recommended plan. A letter of intent acknowledging the NFS's intent to support project implementation is included with this report.

7. ENVIRONMENTAL COMPLIANCE

7.1. Environmental Compliance Table

The PDT has determined that an EA is the appropriate compliance pathway for this study. Given that the recommendation will be purely nonstructural, an Environmental Impact Statement is not warranted. A summary of environmental compliance activities completed to-date is presented in Table 7.1, as well as the compliance status of the recommended plan for each applicable statute.

Table 7.1 Environmental coordination and compliance activities completed.

Statute	Actions	Compliance Status
NEPA	Scoping letters sent: 4 JUN 2020 (Appendix J, includes recipient list); EA has been prepared and is integrated within this report.	Compliant
ESA	Species list initially obtained from USFWS 29 April 2020; Updated species list obtained December 2023 (Appendix I); Scoping letters sent to USFWS 4 JUN 2020. USFWS has reviewed the draft IFREA and indicated that formal consultation is not necessary. No further compliance coordination necessary at this time.	Compliant
Fish and Wildlife Coordination Act (FWCA)	Included as part of NEPA Scoping Letter; Scoping letters sent to USFWS 4 JUN 2020. Recommended plan does not necessitate separate FWCA report/compliance because it does not impact any stream or waterbody.	Compliant

Statute	Actions	Compliance Status
Migratory Bird Treaty Act (MBTA)	Included as part of NEPA Scoping; Scoping letters sent to USFWS on 4 JUN 2020. No further compliance coordination necessary.	Compliant
CWA	Included as part of NEPA Scoping; Scoping letters sent to NCDEQ and EPA Region 4 on 4 JUN 2020. Recommended plan may necessitate a CWA permit under Section 402 (erosion and sediment control permit (E&S) and potentially a stormwater management plan (SWMP) permit), but this will be determined and obtained if necessary during PED.	Compliant
CERCLA	Included as part of NEPA Scoping; Scoping letters sent to NCDEQ and EPA Region 4 on 4 JUN 2020. Recommended plan may warrant a Phase 1 Environmental Site Assessment for a subset of structures, but this will be determined during PED. Further compliance coordination is not necessary.	Compliant
NHPA	Scoping letters sent to NC SHPO and federally recognized Tribes on 4 JUN 2020. Formal NHPA consultation occurred between 27 OCT 2023 through 6 JUN 2024. On 6 JUN 2024 the Corps and the NC SHPO executed a project specific Programmatic Agreement that details the timeline and methods for identifying, avoiding, minimizing, and mitigating effects to historic properties under Section 106 of the NHPA.	Compliant
Coastal Zone Management Act (CZMA)	Included as part of NEPA Scoping; Scoping letters sent to NOAA on 4 JUN 2020. CZMA is not applicable to the recommended plan; no further compliance coordination is necessary.	Compliant
Marine Mammal Protection Act (MMPA)	Included as part of NEPA Scoping; scoping letters sent to NOAA on 4 JUN 2020. NOAA provided comments on the draft IFREA and noted no objections to our determinations. No further compliance coordination is necessary.	Compliant

7.2. Public Involvement

7.2.1. Scoping

Scoping under NEPA was initiated on June 4, 2020. An initial public and stakeholder comment period occurred from June 4 through – July 4, 2020. Comments and concerns were received from several agencies, and are summarized here:

- Many comments pertained to the presence of exceptional aquatic habitat and biodiversity in the study area and the occurrence of rare or protected species; these comments

encouraged the use of non-structural measures to address flood-risk concerns to minimize disturbances or destruction of this exceptional habitat.
- Economic implications for the communities and municipalities resulting from any imposed restrictions or regulations on development or requirements to install additional stormwater control measures were also noted as a concern.

7.2.2. Agency Coordination

The recommended plan does not require further coordination with state, local, or federal agencies *except* the following:

- NC State Historic Preservation Office: Coordination with this office is ongoing with respect to historic structures that may be affected by the recommended plan. A PA that outlines future coordination and obligations has been developed. See Appendix C, Executed Programmatic Agreement, for additional information.
- NCDEQ: If the footprint for construction activities for the recommended plan for any single structure or group of adjacent structures exceeds 1 acre, then a Section 402 Clean Water Act permit may be necessary. This will be determined during the PED phase of the project and will be coordinated with NCDEQ as needed.
- If the tri-colored bat is listed as endangered under the ESA prior to construction (it is currently proposed), USACE will coordinate any consultation requirements with the USFWS. This would be conducted as informal consultation.

7.2.3. Tribal Consultation

Tribal consultation letters were drafted and were sent in conjunction with the release of the draft report for public review. Tribal consultation was conducted with the following Federally-recognized tribes with ancestral ties in the Tar Pamlico study area: Catawba Indian Nation, Eastern Band of Cherokee Indians, Cherokee Nation, United Keetoowah Band of Cherokee Indians, and Monacan Indian Nation. Tribal consultation was also conducted with the following State recognized tribes: Haliwa-Saponi Indian Tribe, and Meherrin Indians. Additionally, the study team reached out to the North Carolina Commission of Indian Affairs. The Monacan Indian Nation and the Cherokee Nation responded to the invitation to consult but declined to enter formal consultation with the study team.

7.2.4. Public Comments Received and Responses

Comments received during the public comment period included comments from Pitt County, NC, NOAA, FWS, and a citizen of NC. Generally, concerns expressed during the public comment period included:

1) A citizen expressed that non-structural measures are insufficient to reduce flooding, and that structural measures are necessary. They also expressed that reservoirs and dry-dams were not given enough consideration during the feasibility study.

USACE RESPONSE: Structural measures, such as dry dams were considered throughout the feasibility study, but were ultimately determined to be not economically justified, and some were additionally determined to be environmentally damaging. USACE recognizes their

potential to reduce downstream flooding impacts, but they were ultimately too expensive and environmentally detrimental to be justified.

2) Pitt County, NC, expressed that using tax-payer dollars to elevate existing structures does not maintain the cohesiveness of the community, but rather increases the costs and risks associated with rescue operations that occur during flooding events and makes continued residence in these locations more difficult for residents; buyouts and relocations were recommended as the preferred solution.

USACE RESPONSE: Buyouts and relocations were considered in this feasibility study, but were not selected as the recommended plan because floodproofing and elevation measures were determined to be more economically feasible, and would maintain community cohesion to some extent.

3) NOAA indicated they had no recommendations under FWCA for the recommended plan.

4) FWS expressed that no formal consultation under ESA is needed, and expressed their support for not recommending structural solutions such as dry-dams.

All written comments and correspondence received from the public and agencies throughout the study are included as Appendix J.

8. District Engineer Recommendations

On the basis of the conclusions of this study, I recommend the implementation of the recommended plan, which consists solely of nonstructural measures. Measures include the structure elevation and floodproofing of an estimated 155 flood-prone structures adjacent to the Tar River in Nashville, Rocky Mount, Tarboro, and Greenville, North Carolina.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authority as proposals for authorization and implementation funding. However, prior to transmittal to higher authority, the sponsor, the states, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

1 July 2024
Date

NICHOLAS O. MELIN
Colonel, Corps of Engineers
District Commander

9. List of Preparers

Name	Project Delivery Team Role
Eric Merriam	Project Manager
Marion Divers	Plan Formulator
Kristi Dobra	Environmental and EA Preparation
Taylor Bolt	Economics
Andrew Branard	Hydraulic & Hydrologic Engineer
Michelle Zulauf	Cultural Resources
Debra Hunter	Cost Engineer
Gregory Pagani	Civil Engineer
Frederick Sheffield	Structural Engineer
Allen Gratzer	Real Estate
James Kelly	Real Estate

Name	District Quality Control Team Role
Kaitlyn Kiehart	Planning
Kristina Schultz	Environmental and EA Preparation
Amber Lanphere	Cost Engineering
Ed Stowasser	Hydraulic and Hydrologic Engineering
Frank Mills	Civil Engineering
Brittany Cranor	Structural Engineering
Jeffrey Horneman	Real Estate
Nakita Smith	Real Estate
Joseph Delucia	Economics
Michael Iagnemma	Office of Counsel
Stephanie Chechak	Geotechnical Engineering

REFERENCES

Actions - HR2157 - 116th Congress (2019-2020). (2019, June 6). Additional Supplemental Approproiations for Diaster Relief Act. Retrieved from Actions - H.R.2157 - 116th Congress (2019-2020): Additional Supplemental Appropriations for Disaster Relief Act,https://www.congress.gov/bill/116th-congress/house-bill/2157/actions

Bush, E. L. (2019). *Planning Bulletin 2018-01 (S) Feasibility Study Milestones Supplemental Guidance* . CECW-P.

James, R. (2018). *Policy Guidance on Implementation of Supplemental Appropriations in the Bipartisan Budget Act of 2018.*

Kellar, D., & Schmidlin, T. W. (2012). Vehicle-related flood deaths in the United States, 1995-2005. *Journal of Flood Risk Management, 5*.

Knight, D., & Davis, R. (2007). Climatology of Tropical Cyclone Rainfall in the Southeastern United States. *Physical Geography, 28:2*, 126-147. doi:10.2747/0272-3646.28.2.126

NCEM and NCDOT. (2018). *Tar River Basin Flood Analysis and Mitigation Strategies Study.*

North Carolina Department of Water Quality. (2010). *Tar-Pamlico RiverBasin Plan - Agriculture & Water Quality in teh Tar-Pamlicon River Basin.* NC Department of Environmental Quality.

North Carolina Division of Water Resources, Water Sciences Section. (2018-2023). *North Carolina Wetlands Information.* Retrieved from NC Wetlands: https://www.ncwetlands.org

Office of the Assistant Secretary, Civil Works. (2024, 02 02). Tar Pamlico Basin Flood Risk Management Feasibility Study, North Carolina, National Economic Development (NED) Plan Policy Exception Request. Washington, DC.

The State of North Carolina. (2018). *Hurricane Florence Recovery Recommendations; Building Communities Stronger and Smarter.*

University of North Carolina Institute for the Environment. (n.d.). *Rocky Mount Case Study, Rocky Mount, NC.*

USACE. (1980). *ER 1165-2-21Flood Damange Reduction Measures in Urban Areas.*

USACE. (2000). *ER1105-2-100 Appendix E Civil Works Missions and Evaluation Procedures.*

USACE. (2000). *Planning Guidance Notebook Regulation 1105-2-100.*

USACE. (2003). *Policy for Implementation and Integrated Application of the U.S. Army Corps of Engineers (USACE) Environmental Operating Principles (EOP) and Doctrine.* Department of the Army. Washington, DC: U.S. Army Corps of Engineers.

USACE. (2013). *ER 1100-2-8162 Incorporating Sea Level Change in Civil Works Programs.*

USACE. (2013). *Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies.*

USACE. (2019). *EP 1100-2-1 Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation.*

USACE. (2021). *Tar-Pamlico & Neuse River Basins, NC - Geomorphic Summary Report* .

USACE Wilmington District. (2016). *Princeville, North Carolina Flood Risk Management Integrated Reasibility Report and Environmental Assessment* .

USACE, Directorate of Civil Works. (2019). *Economic Guidance Memorandum, 19-04, Current State and County Income Index Data, Current Eligibility Factor Formula (Abiltiy to Pay)2019.* Washington, DC.

USEIA. (2022). *Diesel Fuel Explained*. Retrieved from https://www.eia.gov/energyexplained/diesel-fuel/use-of-diesel.php

USEPA. (2023). *EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.*

USEPA. (2023). Tailpipe Greenhouse Gas Emissions from a Typical Passenger Vehicle.