Hancock County Flood Risk Reduction Program: Updated Benefit Cost Analysis

(STANTEC Project # 174316204)

Prepared for:

Stantec

Submitted by:

Economics
Public Policy
Planning

Jack Faucett Associates

Since 1963

Point of Contact:

Michael F. Lawrence, JFA President

4915 Saint Elmo Avenue, Suite 205

Bethesda, Maryland 20814

Phone: (301) 961-8835 Fax: (301) 469-3001

lawrence@jfaucett.com

DRAFT FINAL REPORT

June 2018

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Executive Summary

The Maumee Watershed Conservancy District (MWCD) engaged the services of Stantec Consulting Services Inc. (Stantec) to analyze the feasibility of alternative structural and non-structural flood control approaches in their watershed and to provide an update to the previously submitted *Hancock County Flood Risk Reduction Program Final Report: Data Review, Gap Analysis, USACE Plan and Alternatives Review, and Program Recommendation*. Following the completion of the 2017 Hancock County Flood Risk Reduction Program report, MWCD and Stantec reviewed feedback from the community, processed additional survey data, and finalized the hydrologic analysis to help refine the study. The additional data collected verified the residual risk of the Program components and allowed the team to update the benefits and impacts of the considered alternatives.

Jack Faucett Associates (JFA) supported Stantec by revising the benefit-cost analysis (BCA) associated with the refinement of the Hancock County Flood Risk Reduction Program. The revised Program and its expected reduction of flood risk and subsequent damages is the subject of this updated BCA report. The BCA presented in this report represents an update and refinement of the previous BCA published March 2017. The project team expended a substantial effort to update and refine the estimates in this report, as well as conduct a complete quality assurance/quality control (QA/QC) analysis of each of the components of the BCA. The BCA addresses the data improvements, changes to the methodology, costs and benefits, and QA/QC efforts that resulted.

The summary of costs and benefits are provided in Exhibit ES- 1. The net present value for The Program with maintenance costs equals **$164.98 million**. The anticipated annual Program costs and benefits are included in Appendix A.

Exhibit ES- 1: Net Present Value of Benefits and Costs of the Hancock County Flood Risk Reduction Program, 2018 Dollars

	Benefits	Costs	Net Benefits	Benefit/ Cost Ratio
The Program	$ 484,341,077	$ 164,981,328	$ 319,359,749	2.94

The individual benefit categories described in the report and in Exhibit ES- 2 provide the present value of each of the individual benefit categories, over the expected 50-year program analysis period.

Exhibit ES- 2 provides the benefits from The Program. Summing all of the present values of these benefits, the total benefits attributable to the Program are approximately **$484.3 million**, achieving a Benefit-Cost Ratio of **2.94**.

Exhibit ES- 2: Present Value Benefits from The Program, Thousands of 2018 Dollars

The Program			
Category	**Costs (Net Present Value)**	**Benefits (Net Present Value)**	**Benefit/ Cost Ratio**
Project Construction	$ 164,981		
Residential Structures		$ 211,234	
Business Structures		$ 81,699	
Vehicles		$ 9,896	
Transport		$ 9,392	
Emergency Response		$ 7,470	
NFIP Admin.		$ 18,223	
Business Loss		$ 3,116	
Business Cleanup		$ 18,876	
Business Emergency Prep		$ 3,576	
Agriculture		$ 574	
Environment		$ 120,286	
Total	$ 164,981	$ 484,341	2.94

Respectfully Submitted,

Michael F. Lawrence, President

Chapter 1 Introduction

The Maumee Watershed Conservancy District (MWCD) engaged the services of Stantec Consulting Services Inc. (Stantec) to analyze the feasibility of alternative structural and non-structural flood control approaches in their watershed and to provide an update to the previously submitted *Hancock County Flood Risk Reduction Program Final Report: Data Review, Gap Analysis, USACE Plan and Alternatives Review, and Program Recommendation*. The U.S. Army Corps of Engineers (USACE), Buffalo District, previously published a report in November 2015 entitled, "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)." Jack Faucett Associates (JFA) supported Stantec by conducting a review of the USACE economics report (*Phase 1 Memorandum: Review and Assessment of the "Blanchard River Management Feasibility Study Appendix B – Economics (Draft)"* – December 2016). In 2017 JFA conducted a benefit-cost analysis (BCA) of the Hydraulic Improvements component of the Hancock County Flood Risk Reduction Program as well as the Final Program recommended by Stantec. This BCA effort is described in detail in a report entitled, "*Hancock County Flood Risk Reduction Program: Benefit Cost Analysis*" (March 2017). Following the completion of the 2017 Hancock County Flood Risk Reduction Program report, MWCD and Stantec reviewed feedback from the community, processed additional survey data, and finalized the hydrologic analysis to help refine the study. The additional data collected verified the residual risk of the Program components and allowed to the team to update the benefits and impacts of the considered alternatives. Stantec revised the hydrologic and hydraulic models for the Hancock County Flood Risk Reduction Program (The Program), generated revised water surface profiles, provided a refined opinion of probable cost for each Program component, and updated the elevations of the structure inventory based on the processed LiDAR data. The revised Program and its expected reduction of flood risk and subsequent damages is the subject of this updated benefit cost analysis report.

1.1 Organization of the Report

This report contains 12 chapters. Chapter 1, the introductory chapter, describes the project background along with a brief history of the areas typically impacted by flooding, impacts of the 2007 flood event and progress on flood mitigation efforts to date. It also provides an overview of the study effort, report organization and project rationale. Chapter 2 describes the methodology used to evaluate the economic efficiency of the proposed Program. It provides an overview of benefit-cost analysis (BCA) and describes the types of benefits included. Chapter 3 describes the Program's opinion of probable costs for the flood mitigation efforts and a projected Program schedule. Chapter 4 reviews the benefit of reduced structural and content damages to residences and businesses as a result of the proposed program alternatives. Chapter 5 covers reduced damages to motor vehicles. Chapter 6 reports the benefits of reduced road closures and transportation impacts. Chapter 7 provides the benefits of reduced costs related to emergency response and debris removal. Chapter 8 looks at the benefit of avoiding administrative costs for the National Flood Insurance Program. Chapter 9 reviews the estimated value of mitigating reduced business sales and wage losses. Chapter 10 reports agricultural losses that the program may mitigate. Chapter 11 outlines increased environmental and land use benefits. Chapter 12 summarizes the key results of the BCA.

1.2 Background and Flood History

The Blanchard River Watershed, a portion of the Maumee River Watershed, is located within the counties of Allen, Hancock, Hardin, Putnam, Seneca, and Wyandot in northwest Ohio. The Blanchard River has a history of flooding with records dating back to January 1846, causing significant damages in the City of Findlay, Hancock County, and the Villages of Ottawa and Glandorf during the 2007 and 2008 floods. According to the stream gage located at Findlay[1] maintained by the U.S. Geological Survey (USGS), the Blanchard River has reached flood stage at least once in 15 of the past 20 years. Between December 2006 and March 2008, Findlay flooded four times with events considered larger than the 10-percent annual chance exceedance (ACE) event flood. Two of the four flooding events are within the top six floods ever recorded in the City.[2]

Three types of flooding occur most often in the Blanchard River Basin – river flooding, flash flooding and urban flooding. Flooding takes place in the urban areas of Findlay and throughout the agricultural land adjacent to the major streams, particularly in the spring when the snows melt and rainfall increases.[3] In the City of Findlay and the Villages of Ottawa and Glandorf, tens of millions of dollars in damage resulted from flooding in 2007 and 2008. Based upon available information, the estimated value of the properties in the potential floodplain within the areas influenced by the recommended Flood Risk Reduction Program exceeds $1 billion. Both businesses and residences experience substantial damage during flood events. Flooding often persists for days during major events, resulting in significant cleanup and restoration expenses to the local, state and federal governments.[4]

In addition to the flood damage to residences and small businesses, flooding damages disrupt the local road and rail systems, as well as regional manufacturing businesses that rely on those facilities. During the periods of major flooding, extensive road closures and delays are typical.

[1] USGS stream gage located in Blanchard River near Findlay, Ohio (04189000)

[2] National Weather Service. https://water.weather.gov/ahps2/hydrograph.php?wfo=cle&gage=fdyo1

[3] USACE, Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT), November 2015

[4] Ibid.

1.3 Benefit-Cost Analysis

The application of a benefit-cost analysis (BCA) has a long-standing history in the region to augment community information and inform local decision-making. Historically, the Ohio Conservancy Law (ORC Chapter 6101), passed in 1914, gave the state authority to establish watershed districts to raise funds for improvements through various funding mechanisms.[5] In the early 20th century, the Miami Conservancy District project brought this approach to fruition with the use of complex simulation and optimization modeling, a detailed cost–benefit analysis, and linking of economics, engineering, science, and law into a far-reaching solution to a complex water resources problem.[6] The Miami Conservancy District is a river management agency operating in Southwest Ohio to control flooding of the Great Miami River and its tributaries. Similarly, the Maumee Watershed Conservancy District, or MWCD, established in December of 1948, provided similar solutions to 15 counties tributary to the Maumee River and western basin of Lake Erie.[7] The upper reaches of the Blanchard River examined within this report are included within the Maumee River watershed.

The benefit-cost ratio (BCR) is determined by dividing the present value of total estimated economic benefits by the present value of estimated costs of the recommended improvements. The BCR indicates which project alternatives produce the most benefits for each dollar of cost. Projects with high BCRs produce the most efficiency per dollar invested. The ratio of benefits to costs must exceed 1.0 for consideration of advancement under Ohio Conservancy Law.

In this BCA study, the research team identified the estimated costs avoided by reducing flooding in and around the City of Findlay and Hancock County. Stantec developed the Hancock County Flood Risk Reduction Program to mitigate the risk of flooding and to increase protection for the community and their assets from periodic flooding events. Stantec provided JFA with Water Surface Profiles (WSP) for the Blanchard River, Eagle Creek, and Lye Creek for eight different return frequencies. By combining the WSP and the floodplain structure inventory, the team determined the expected flood damages avoided over the life of the Program.

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[5] http://www.ohiohistorycentral.org/w/Ohio_Conservancy_Law

[6] Holmes, K. & Wolman, M. Early Development of Systems Analysis in Natural Resources Management from *Man and Nature* to the Miami Conservancy District. Environmental Management (2001) 27: 177

[7] https://www.leagle.com/decision/1960579112ohioapp4671501

1.4 Project Description and Rationale

Representing 15 counties in northwest Ohio and the second largest conservancy district in the state, MWCD is a political subdivision of the State of Ohio that oversees water management, including flood risk reduction, as established under Ohio Revised Code Chapter 6101. The District has the experience assessing these issues and the authority to deal with drainage in the watershed.

In 2016, MWCD contracted Stantec to complete a "Proof of Concept" by reviewing the recommended USACE plan for technically feasible optimizations while at the same time taking a step back to see if there were other feasible and cost-effective solutions that were implementable within the watershed.

After project refinements, Stantec, in March 2017, recommended additional alternative solutions to the base project including dry storage basins on Eagle Creek, the Blanchard River, and Potato Run, removing inline structures on the Blanchard River, and widening the floodplain bench as the Blanchard River flows through the City. Stantec's recommended Final Program increases the level of flood reduction reduces the flooding stage for the 1-percent annual change event by an estimated 3.6 feet below the existing flood elevation on the Blanchard River near Main Street.

JFA evaluated benefits for both the Hydraulic Improvements along the Blanchard River in downtown Findlay and the Final Program. JFA produced a benefit-cost analysis for both the Final Program, as well as the initial Hydraulic Improvements project. That BCA produced a BCR (4.64 – Hydraulic Improvements, 1.60 – Final Program) that demonstrated to the community that the Program benefits outweighed the costs and warranted additional support for moving forward. The BCA demonstrates that the project is highly beneficial to Hancock County community and its residents.

With the additional survey data that was processed, and the finalized hydrologic analysis in hand, Stantec revisited the Final Program at the request of MWCD to refine the study. Stantec verified alternatives that were viable and confirmed the solutions that were not economical based on the enhanced data from the LiDAR survey and projected cost estimates. Stantec completed multiple hydraulic simulations to produce revised WSPs for JFA to utilize in a revised BCA. The following report describes the methodology used in the updated BCA, opinion of probable Program costs and anticipated benefits of the updated Hancock County Flood Risk Reduction Program compared to the existing conditions.

The benefit-cost analysis (BCA) presented in this report represents an update and refinement of the previous BCA published March 2017. The project team expended a substantial effort to update and refine all of the estimates in this report, as well as conduct a complete quality assurance/quality control (QA/QC) analysis of each of the components of the BCA. The last section of Chapter 12, Benefit Cost Analysis Results, highlights major data improvements, changes to the methodology, levels of costs and benefits, and QA/QC efforts.

Chapter 2 Methodology

Chapter 2 describes the methodology used to evaluate the economic efficiency of the proposed *Hancock County Flood Risk Reduction Program: Updated Benefit-Cost Analysis*. It provides background information on conducting a benefit-cost analysis (BCA), explains the construct of "base case" or "no action" condition, expands upon the types of benefits measured and explains the concepts of net present value and of discounting in this type of project.

2.1 Fundamentals of Benefit Cost Analysis

This section provides a brief overview of the essentials of benefit-cost analysis (BCA). Benefit-cost analysis is an economic technique to evaluate what is achieved (benefits) compared to what is invested (costs).[8] BCA analyzes whether the value of benefits exceeds the value of the costs. This allows decision makers to allocate resources in an efficient manner.

BCA can assist decision makers select the best alternative by monetizing both benefits and costs. The first comparison in BCA is to calculate the net benefits by subtracting economic costs from total economic benefits. This allows the analysis to scale a range of alternatives for comparison. The second comparison is to calculate the benefit-cost ratio (BCR) by dividing the present value of total economic benefits by the present value of total economic costs. The ratio of these two values (total benefits/total costs) allows for ranking or comparing different projects by informing which alternative produces the most benefits for every dollar of cost. A BCR of one (1) indicates the total benefits equal the total costs. Therefore, for each dollar of cost, a dollar of benefit accrues. If the ratio of total benefits to total costs is less than one (1), the total costs exceed the total benefits. This indicates a poor investment of resources.

For projects such as flood risk management, decision makers can compare and prioritize projects from across the nation and regionally. Projects with higher BCRs are preferred and the BCR becomes a factor to authorize projects to move from conceptual planning to detailed design and implementation. In an earlier phase of this project, the prior USACE plan used a BCA to compare a range of flood mitigation alternatives from a national perspective. Under the most recent preceding phase of this program, with efforts led by the Maumee Watershed Conservancy District (MWCD), the Program Team utilized a BCA to examine the costs and benefits of the recommended Flood Risk Reduction Program from a regional perspective. This current project is similar in scope. The JFA Team is updating the BCA with new model and cost estimate information provided by Stantec. Exhibit 2-1 provides some useful applications of BCA.

[8] USACE & Institute for Water Resources. Economics Primer. IWR Report 09-R-3, June 2009.

Exhibit 2-1: Useful Applications of Benefit Cost Analyses

Useful Applications of Benefit Cost Analyses (BCAs)

A BCA considers the changes in benefits and costs that a project would produce by a potential improvement to the status quo protection. In flood mitigation, decision makers may use BCA to help determine the following:

- ***Whether or not a project should be undertaken at all*** - (i.e., whether the project's life-cycle benefits will exceed its costs).
- ***When a project should be undertaken -*** A BCA may reveal that the project does not pass economic muster now, but would be worth pursuing 10 years from now due to projected regional growth. If so, it may be prudent to take steps now to preserve the future project's footprint.
- ***Which among many competing alternatives and projects should be funded given a limited budget -*** A BCA can be used to select from among design alternatives that yield different benefits.
- ***After project implementation -*** BCA can evaluate current project performance or evaluate implemented projects to verify BCA ratios for future project performance measurement.

The comparison of benefits to costs over the life of a project is not a simple task of adding up the benefits. The reason is the value of a dollar changes with time. A dollar an entity spends or earns in the future is usually worth less than it is today. To compare multiyear projects, one must account for this changing value of the dollar. Two factors account for the diminishing value of the dollar over time. The two factors are 1) inflation, and 2) the time value of resources. BCA compares projects in real or base year dollars, eliminating the effects of inflation. The process measures the time value of resources by the annual percentage factor known as the discount rate. Through discounting, decision makers can objectively compare different investment alternatives based on their respective current values.

The USACE developed a series of manuals describing how to evaluate urban benefits of water resources implementation projects. The general guidance within these manuals is applicable for both national and regional analyses. JFA followed the guidance of these manuals in reviewing the earlier BCA and, as described below, used these USACE-derived procedures to estimate

Regional Economic Development (RED) benefits and costs of the recommended water resource projects.[9] [10] Exhibit 2-2 provides the major steps in the BCA process.

The objective of the following sections is to discuss in greater detail several methodological issues and procedures applied in this review. These areas include defining the base case condition, project alternatives, Regional Economic Development (RED) benefits, and analysis methodology.

2.2 Base Case Condition ("Without Project Alternative")

An important aspect of benefit-cost analysis is the selection of a base case (i.e. a "without-project condition" or "no action condition") and its comparison with the recommended Flood Risk Reduction Program. According to the USACE's Planning Guidance Notebook, the without-project condition is defined as, *"… the most likely condition expected to exist in the future in the absence of a proposed water resources project. Proper definition and forecast of the future without-project condition are critical to the success of the planning process. The future without-project condition constitutes the benchmark against which plans are evaluated."*[11]

Exhibit 2-2: Major Steps in the Benefit Cost Analysis Process

1. Establish objectives
2. Identify constraints and specify assumptions
3. Define the base case and identify alternatives
4. Set the analysis period
5. Define the level of effort for screening alternatives
6. Develop base case damage estimate
7. Estimate benefits and costs relative to base case
8. Evaluate risks
9. Compare net benefits and rank alternatives
10. Make recommendations

2.3 Definition of NED and RED Benefits

The USACE defines National Economic Development (NED) benefits as benefits that accrue to the nation as a whole: *"Beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan."*[12] The methodology employed by the USACE recognizes NED benefits as only those impacts that would be lost to the nation in the absence of the project.

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[9] USACE, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 1983

[10] Planning Guidance Notebook" (Engineering Record No. 1105-2-100), 2000.

[11] USACE. 2000. "Planning Guidance Notebook." (Engineering Record No. 1105-2-100, Section 2-4.b.(1)). http://www.usace.army.mil/publications/eng-regs/er1105-2-100/

[12] USACE. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." p.8, Section 1.7.1.(b).

In addition, USACE recognizes improvements in efficiency, such as reductions in the nation's overall flood protection bill as NED benefits.

The USACE defines Regional Economic Development (RED) benefits as benefits that accrue at the regional level. According to the USACE Principles and Guidelines, *"The RED account registers changes in the distribution of regional economic activity that result from each alternative plan."* [13]

2.4 Definition of the RED Area

According to the USACE Principles and Guidelines, *"The regions used for RED analysis are those regions with in which the plan will have particularly significant income and employment effects."* [14] For this study, Hancock County is the core of the RED area.

2.5 Benefit-Cost and Net Present Value Analysis

To determine whether an investment is justifiable, the project sponsor performs a Benefit-Cost Analysis (BCA) that quantifies the benefits and costs. The analysis can analyze benefit and cost quantities in many ways, such as total benefits minus total costs (i.e. net present value analysis) or benefits divided by costs (i.e. benefit-cost ratio). In the previous case, the net present value of the costs were based upon estimated costs provided by Stantec for the proposed Hydraulic Improvements components and The Program within the Blanchard River, Eagle Creek and Lye Creek floodplain in and near Findlay, Ohio. The current project again relies on estimated costs updated and provided by Stantec for the Program. However, in order to be meaningful, a BCA must not only express all benefits and costs in monetary terms, it must also account for the change in the value of the dollar over time.

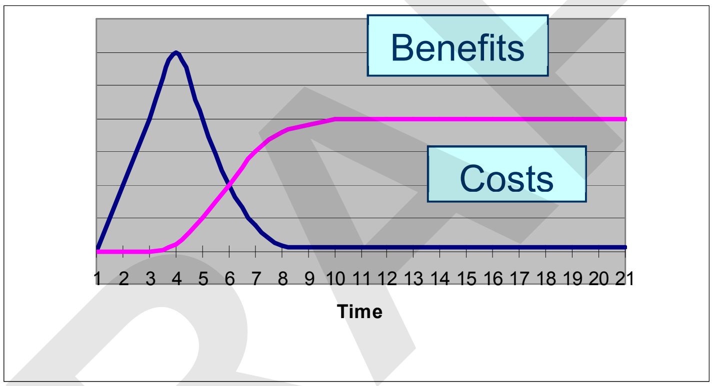
The value of a dollar changes not only with inflation, but also because today's dollar is worth more than a dollar available years from now. For example, a single dollar available today would be worth more than one single dollar in five years because it could be invested and earn interest for five years. An economic concept called "net present value," accounts for the impact of time on the value of money and discounts the future value of a dollar. The analyst selects an appropriate discount rate to calculate the "present value" of any sum of resources or money to be spent or received in the future. The discount rate for costs and benefits applied here is from the annual US Office of Management and Budget (OMB) publication, ***Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses*** which applies to long lived infrastructure investments. The application of the discount rate to future sums to calculate their present value is known as "discounting." Through discounting, different investment alternatives can be objectively compared based on their respective present values, even though

[13] Ibid., p. 11, Section 1.7.4.(a)(1).
[14] USACE. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." p. 11, 1.7.4.(a)(2).

each has a different stream of future benefits and costs. This concept of net present value is important because the timing of costs and benefits of a flood risk reduction program are often different.

A frequent observation in public infrastructure projects is that costs accrue both immediately and over time, while benefits accrue over time after the majority of costs accrue. Exhibit 2-3 provides a sample of typical project benefit and cost flows. Costs, as considered by an engineer for example, inflate over time to reflect generally accepted increases in the costs for goods and services. This provides an estimate of the cash that is going to be necessary to complete a project. However, benefits, as considered in economics, are discounted as they move into the future. Net present value provides the common ground against which the analysis considers costs and benefits.

Exhibit 2-3: Sample Project Costs and Benefit Streams



Most major infrastructure projects use a period of analysis of 50 to 100 years.[15] However there is no specific criterion for selecting a period of analysis. For the purposes of developing this BCA, a period of 50 years has been utilized.

A Benefit-Cost Ratio (BCR) greater than one indicates the anticipated net present value of benefits derived because of the proposed improvements will exceed the estimated net present value of costs and that the investment is anticipated to provide positive value to the community. A ratio of less than one indicates that the anticipated benefits are less than the estimated costs and would require further study or innovative strategies to justify the project.

2.6 Economic Analysis Methodology

There are several steps undertaken to develop a flood risk reduction program BCA. Estimating the program costs and benefits is the initial step in the economic analysis methodology. Once

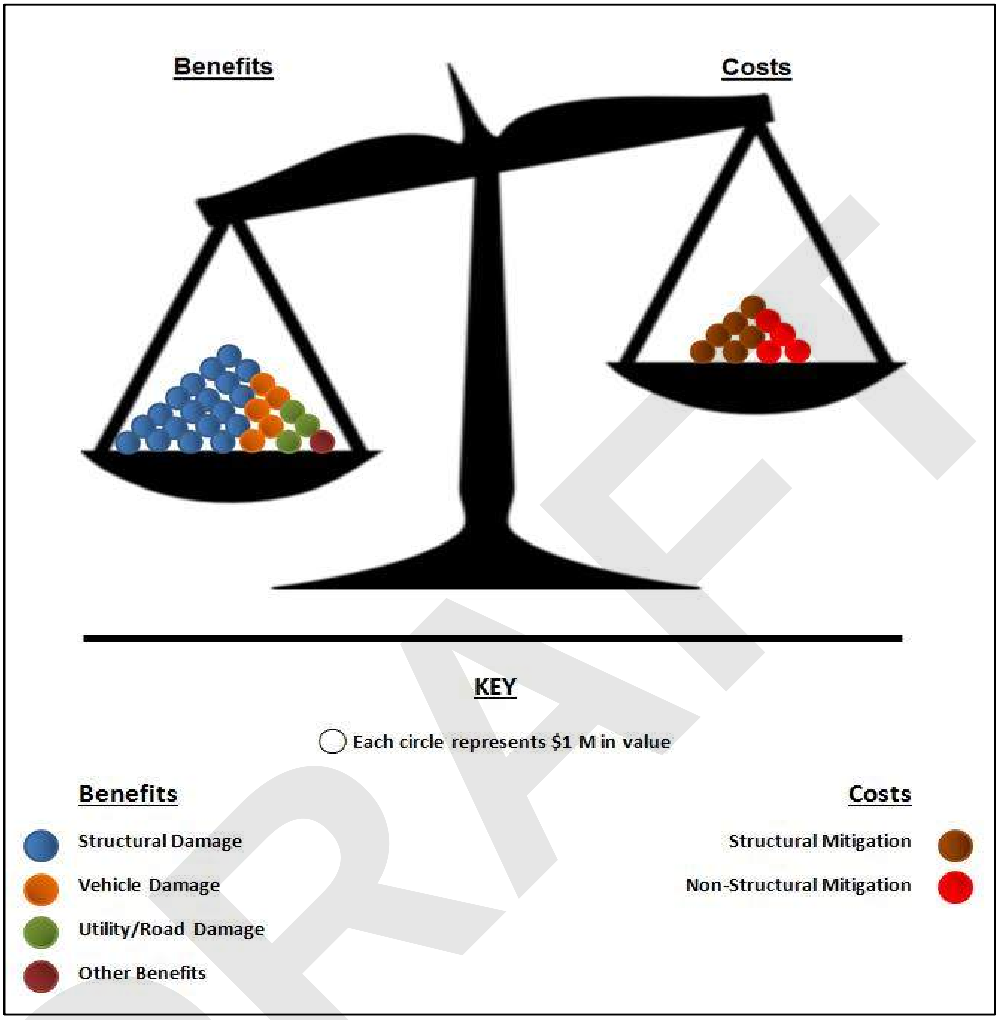
[15] USACE, National Economic Development Procedures Manual, Urban Flood Damage. IWR Report 88-R-2. March 1988

the engineers have analyzed the causes of flooding and developed alternative mitigation strategies, a cost to implement the strategy or strategies is developed. This will include both construction costs and the expenses for on-going maintenance of the program.

Program benefits are changes in value to the output of goods and services expressed in monetary units. Economic benefits are those that accrue in the planning area and the rest of the nation from the selected program. Benefits typically include flood damage reduction avoided in commercial and residential buildings, vehicles, transportation, utilities, equipment, roads, bridges, crops and others. Exhibit 2-4 provides an example of how the BCA weighs benefits and costs against each other.

Flood damages to property, injury and the loss of human life has identified flood risk as the largest single category of loss from natural disasters. Many of these losses can be reduced or prevented with proper planning and engineered solutions. A flood damage reduction plan includes one or more of the measures identified by the engineers. Each one of these measures has some effect on one or more of the three input relationships to the hydro-economic model used to estimate expected annual damages (EAD). The effects of damage reduction measures on the various EAD relationships are what provide the monetized benefits of flood risk reduction.

Exhibit 2-4: Example of Benefits Versus Costs in Flood Mitigation BCA



A stage-damage function (i.e., depth-damage or damage function) shows the relationship between the depth of water and the amount of damages sustained at that depth. Damages may be separated by contents, structure, business loss, transportation losses and other categories of physical and economic damage. The effectiveness of any plan in reducing these various categories of damages will vary from measure-to-measure and plan-to-plan. It is generally the economist's job to estimate a damage function without and with a plan in place and then to estimate a new damage function for every plan that may alter the damage function.

A stage-discharge function (i.e., the rating curve) shows the relationship between the amount of water (discharge or flow) and the stage or depth it reaches in the floodplain reach. Some flood damage reduction measures will alter the stage-discharge relationship. A levee or floodwall, for example, may actually cause a given amount of water to attain a greater depth, causing the rating curve or a part of it to shift upward.

The discharge-exceedance frequency function (i.e., the flow-frequency or frequency curve) shows the relationship between a flow of water (discharge) and the frequency with which a flow of that amount or a greater amount will occur in any given year. Some flood damage measures alter this relationship. Ordinarily, a given flow or discharge will become less frequent, thereby reducing damages. It is generally the engineer's job to estimate discharge-exceedance frequency relationships without a plan in place and then to estimate new functions for every plan that may alter the discharge-exceedance frequency function.

Channel modifications can affect the discharge-exceedance frequency function as well as the rating curve. In many cases, the modifications will increase velocity in the improved section but downstream, where no improvements have been made, there may be a greater discharge and an increase in its frequency. For more detailed discussion of these relationships, refer to Stantec’s *Hancock County Flood Risk Reduction Program Final Report*.

The analysis proceeds with an inventory of all structures and land use within the identified floodplain. Structural damage costs for the without program and with the program were estimated using the USACE Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Economic model, Version 1.4.2 (July 2017). The analysis follows the framework and methodology as directed by the *HEC-FDA Flood Damage Reduction Analysis User’s Manual (*April 2016*).* The content damage, including motor vehicles, is also estimated by applying the HEC-FDA model to the structure inventory and the water surface profiles without The Program and with The Program implemented. The difference between the without and with program damages are the damages avoided for the major categories of benefits. Other benefit categories included in this report include:

- Transportation
- Emergency Response
- NFIP Administrative Cost
- Business Losses (Income)
- Business Losses (Cleanup)
- Business Losses (Emergency-Plan)
- Agricultural
- Environmental & Land Use

For each of these benefit categories the study team utilized existing data and tools or developed new data and tools to estimate the EAD as was done with the HEC-FDA model. The team conducted surveys and interviews with key leaders of the local business, agricultural, and educational communities. Information was collected on how their organizations were impacted by the 2007 flood or other flooding events to determine how a reduction in the flood water depths would reduce flooding damages and disruptions. Each chapter of this report discusses these loss reductions and how they were estimated.

The team employed data and tools from Federal Emergency Management Agency (FEMA), USACE, the IMPLAN Group, Inc. and the Office of Management and Budget (OMB). From FEMA, we utilized the portion of the HAZUS-Flood model dealing with motor vehicle damages. FEMA databases also provided estimates of the annual environmental benefits from the conversion of land use to reduced flood damage risk. Data acquired by the USACE in the original efforts related to Hancock County and Blanchard River provided a detailed crop damage model that was calibrated to Hancock County. The OMB provided a discount rate for long lived infrastructure projects. IMPLAN is a supplier of detailed economic models designed to measure how the Hancock County economy would be impacted due to the loss of business activity during and after the flood event. The various data sources are cited in the individual chapters of this report.

Chapter 3 Project Costs and Schedule

This chapter presents the estimates for both one-time capital and ongoing maintenance costs associated with the *Hancock County Flood Risk Reduction Program: Updated Benefit-Cost Analysis*. The first section describes what project costs are used in a Benefit Cost Analysis. The next section provides the details on 1) one-time construction, planning, engineering and design costs 2) maintenance and associated costs, and 3) program timeline of costs and the start of benefit accrual. The third and final section of this chapter presents the discounted value of the costs.

3.1 Definition of Project Costs

All of the expenditures required for implementation of the project define the costs of the program. The benefit-cost analysis (BCA) weighs the costs of the project against the project benefits. In this program, the cost includes preparatory work, engineering, construction and other elements described below, plus operations and maintenance (O&M) costs to maintain performance of the proposed improvements program. Costs are based on professional judgement based upon past experience, prior bid prices received from previous analogous projects, estimated material costs and other anecdotal information provided by the local communities. Contingencies and administrative expenses factor into project cost estimates. For this Program, project costs are based on costs local to the City of Findlay and Hancock County.

3.2 Hancock County Flood Risk Reduction Program Cost Estimates

This BCA estimates the anticipated costs and benefits of the proposed Flood Risk Reduction Program against a baseline (also called the “base case” or “no build” case). The baseline represents an assessment of the way the world would look if this project is not undertaken. This section covers the estimated construction and maintenance costs.

3.2.1 Construction Costs

Stantec developed estimates for the opinion of probable costs for The Program reported in the revised Final Report (*Hancock County Flood Risk Reduction Program – Final Report Update*). Exhibit 3-1 to Exhibit 3-5 summarize the opinion of probable costs for various phases and elements of The Program. Each exhibit lists the description of each of ten areas of work tasks. These elements include:

- Mobilization, Demobilization and Preparatory Work
- Lands and Damages
- Relocations
- Fish and Wildlife

- Road, Railroads & Bridges
- Channels and Canals
- Floodway Control & Diversion
- Cultural Resources
- Engineering & Design
- Construction Management

The remaining four columns of Exhibits 3-2 to 3-5 detail the anticipated direct cost, contingency percent (25.0% or 30.0% depending on the case), contingency amount, and the total cost. The work phases shown in the five exhibits are:

- Exhibit 3-1: Hydraulic Improvements – Phase 1
- Exhibit 3-2: Hydraulic Improvements – Phase 2: Railroad Bridge Modifications
- Exhibit 3-3: Eagle Creek Dry Storage Basin (Option EC-2C)
- Exhibit 3-4: Potato Run Dry Storage Basin (Option PR-1)
- Exhibit 3-5: Blanchard River Dry Storage Basin (Option BR-3)

Exhibit 3-1 and Exhibit 3-2 together represent the opinion of probable cost for Phase 1 and Phase 2 Hydraulic Improvements component of the Program. Phase 1 total costs are rounded to the nearest thousand dollars. Phase 2 of the Hydraulic Improvements cover the Blanchard River Railroad Bridge Modifications. The Program includes the costs of the Hydraulic Improvements (Phase 1 and Phase 2), plus the costs of the recommended dry storage basins shown in Exhibits 3-3, 3-4 and 3-5.

Exhibit 3-1: Hydraulic Improvements - Phase 1: Opinion of Probable Costs

Description	Amount
Construction Costs	
In-Stream Improvements	$1,638,000
Floodplain Bench Widening Improvements	$7,099,200
Utility and Bike Path Improvements	$1,347,900
Utility Coordination	$768,800
Construction Subtotal	$10,853,900
Contingency (10%)	$1,085,390
Construction Total	$11,939,290
Other Costs	
Tree Removal (Including Debris Removal)	$105,000
Stream Wetland and T&E Mitigation	$77,250
Construction Administration	$675,000
Other Subtotal	**$857,250**
Total Project Costs	**$ 12,797,000**

Exhibit 3-2: Hydraulic Improvements – Phase 2: Railroad Bridge Modifications

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$100,000	30.0%	$30,000	$130,000
01 - Lands and Damages	$6,000	30.0%	$1,800	$7,800
02 - Relocations	$0	30.0%	$0	$0
06 - Fish and Wildlife	$0	30.0%	$0	$0
08 - Road, Railroads & Bridges	$2,500,000	30.0%	$750,000	$3,250,000
09 - Channels and Canals	$5,000	30.0%	$1,500	$6,500
15 - Floodway Control & Diversion	$3,000	30.0%	$900	$3,900
18 - Cultural Resources	$16,000	30.0%	$4,800	$20,800
30 - Engineering & Design	$400,000	30.0%	$120,000	$520,000
31 - Construction Management	$400,000	30.0%	$120,000	$520,000
Total	**$3,430,000**		**$1,029,000**	**$4,459,000**

Exhibit 3-3: Eagle Creek Dry Storage Basin (EC-2C)

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$1,400,000	25.0%	$350,000	$1,750,000
01 - Lands and Damages	$13,800,000	25.0%	$3,450,000	$17,250,000
02 - Relocations	$100,000	25.0%	$25,000	$125,000
06 - Fish and Wildlife	$500,000	25.0%	$125,000	$625,000
08 - Road, Railroads & Bridges	$2,100,000	25.0%	$525,000	$2,625,000
09 - Channels and Canals	$12,700,000	25.0%	$3,175,000	$15,875,000
15 - Floodway Control & Diversion	$11,900,000	25.0%	$2,975,000	$14,875,000
18 - Cultural Resources	$300,000	25.0%	$75,000	$375,000
30 - Engineering & Design	$6,400,000	25.0%	$1,600,000	$8,000,000
31 - Construction Management	$3,100,000	25.0%	$775,000	$3,875,000
Total	**$52,300,000**		**$13,075,000**	**$65,375,000**

Exhibit 3-4: Potato Run Dry Storage Basin (PR-1)

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$500,000	25.0%	$125,000	$625,000
01 - Lands and Damages	$9,000,000	25.0%	$2,250,000	$11,250,000
02 - Relocations	$0	25.0%	$0	$0
06 - Fish and Wildlife	$200,000	25.0%	$50,000	$250,000
08 - Road, Railroads & Bridges	$1,400,000	25.0%	$350,000	$1,750,000
09 - Channels and Canals	$2,200,000	25.0%	$550,000	$2,750,000
15 - Floodway Control & Diversion	$4,500,000	25.0%	$1,125,000	$5,625,000
18 - Cultural Resources	$100,000	25.0%	$25,000	$125,000
30 - Engineering & Design	$2,700,000	25.0%	$675,000	$3,375,000
31 - Construction Management	$1,300,000	25.0%	$325,000	$1,625,000
Total	**$21,900,000**		**$5,475,000**	**$27,375,000**

Exhibit 3-5: Blanchard River Dry Storage Basin (BR-3)

Description	Amount	Contingency %	Contingency $	Total
Mob., Demob., & Preparatory Work	$900,000	25.0%	$225,000	$1,125,000
01 - Lands and Damages	$9,600,000	25.0%	$2,400,000	$12,000,000
02 - Relocations	$100,000	25.0%	$25,000	$125,000
06 - Fish and Wildlife	$2,500,000	25.0%	$625,000	$3,125,000
08 - Road, Railroads & Bridges	$1,600,000	25.0%	$400,000	$2,000,000
09 - Channels and Canals	$3,300,000	25.0%	$825,000	$4,125,000
15 - Floodway Control & Diversion	$11,100,000	25.0%	$2,775,000	$13,875,000
18 - Cultural Resources	$200,000	25.0%	$50,000	$250,000
30 - Engineering & Design	$4,400,000	25.0%	$1,100,000	$5,500,000
31 - Construction Management	$2,100,000	25.0%	$525,000	$2,625,000
Total	**$35,800,000**		**$8,950,000**	**$44,750,000**

The costs for the Hydraulic Improvements in Phase 1 include construction costs for in-stream improvements, floodplain bench widening, utility and bike path improvements, utility coordination, and other costs for tree and debris removal, stream, wetland and threatened and endangered species (T&E) mitigation, and construction administration. Phase 2 Hydraulic Improvements are for Blanchard River Railroad Bridge Modifications (Exhibit 3-2). The Program costs include the Hydraulic Improvements plus the costs of the remaining three phases including the Eagle Creek Dry Storage Basin, Blanchard River Dry Storage Basin and the Potato Run Dry Storage Basin. The estimated total Program costs are $154,756,000.

3.2.2 Maintenance Costs

This section outlines the maintenance costs of the program. Stantec provided estimated values of the Operations, Maintenance and Replacement (OM&R) costs for the project.

Operations and maintenance for the benching area in the Hydraulic Improvements component are estimated at $17,700 annually for mowing and occasional debris removal following flooding events. No additional OM&R costs are applied. The following calculations inform the costs:

- Mowing: 8 hours/mowing x ($25/hour (fully loaded labor rate) + $25/hour mower cost) x 1 mowing/week x 36 weeks/year = $14,400.00
- Debris Removal: 2 staff x $25/hour x 8 hours x 2 times/year + $1,000 per day for equipment x 2 days + $500 disposal = $3,300.00
- Mowing plus Debris Removal = $14,400 + $3,300 = $17,700.00

The Norfolk Southern railroad bridge OM&R costs assume annual inspections and replacement in approximately 75 years. However, the bridge is owned and maintained by the railroad with yearly inspections and minor upkeep in the range of $10,000 to $12,000 annually. The cost analysis assumes inspections and replacement will occur regardless of this Program and thus are not factored into these calculations.

The total annual OM&R costs are $172,700 for the Program starting in 2029, based upon the $17,700 for the Hydraulic Improvements component above, plus the sum of the estimated O&M for the recommended dry storage basins, as follows:

- $75,000 for Eagle Creek Storage Basin
- $40,000 for Blanchard River Storage Basin
- $40,000 for Potato Run Storage Basin

Exhibit 3.8 provides the annual schedule of all construction and OM&R costs.

3.3 Timeline of Costs and Benefits

This section provides the timeline of costs and benefits for the phases of The Program. The analysis assumes costs are divided equally over the span of the timeline for each phase. Benefits occur incrementally after the early stages of The Program are completed. The benefits of The Program occur at terminus of construction. Exhibit 3-6 provides the starting and ending years for costs incurred at each phase of The Program. Construction for Phase 1 of the Hydraulic Improvements project is anticipated to begin in the summer of 2018 pending the permitting process. Initial benefits derived from the completion of the Hydraulic Improvement are expected to begin at the end of 2018.

Exhibit 3-6: Program Schedule by Phase of Project

Project	Phase 1 - Hydraulic Improvements	Phase 2 - Hydraulic Improvements	Phase 3 - Eagle Creek Dry Storage Basin	Phase 4a - Potato Run Dry Storage Basin	Phase 4b - Blanchard River Dry Storage Basin
Timeline (year)	**2018-2019**	**2020-2021**	**2020-2025**	**2022-2029**	**2023-2029**

Exhibit 3-7 shows the timeline when the percentage of annual Program benefits start to accrue as The Program implementation progresses. The left column shows when benefits associated with the improvements would commence. The right column shows the percent of benefits provided through that year.

Exhibit 3-7: Percent of Program Benefits Provided by Year

Year	Benefits (%)
2018	10
2019	25
2020	25
2021	33
2022	33
2023	33
2024	33
2025	67
2026	67
2027	67
2028	67
2029	100
2030	100

3.4 Present Value of Program Construction and OM&R Cost

This section and Exhibit 3-8 provide the total construction costs, including OM&R and present value of total costs by year, for The Program. Costs for Phase 1 and Phase 2 of the Hydraulic Improvements span the first four construction years, from 2018 to 2021 and are shown in column three of Exhibit 3-8. Maintenance costs of $17,700 per year commence following construction and are shown in the fourth column of the exhibit. Construction costs for the Hydraulic Improvements total $17,256,000 for the life of the Project. Maintenance costs total $867,300 over the life of the Project.

The next three columns of Exhibit 3-8 show the construction costs for the three storage basins: Eagle Creek, Potato Run and the Blanchard River. Construction of the Eagle Creek storage basin is estimated to take six years at a cost of $10,896,000 per year. Construction of the storage basin for Potato Run was estimated to cost $3,422,000 per year for eight years. The storage basin for the Blanchard River is estimated to cost $6,393,000 per year for seven years. Total costs for each of the three storage basins are Eagle Creek $65,375,000; Potato Run $27,375,000; Blanchard River $44,750,000.

Maintenance costs for each storage basin begins in the year following its construction. Maintenance costs for the Eagle Creek storage basin begin in 2026 when its construction concludes. As shown above, it is estimated at $75,000 per annum shown in column eight. Maintenance costs for the Potato Run and Blanchard River storage basins begin following their construction in 2030. Those costs, as shown above, are estimated at $40,000 per year for each. These maintenance costs are added to the Eagle Creek maintenance costs beginning in 2030 ($75,000 + $40,000 + $40,000 = $155,000). The costs are assumed constant for the remaining life of The Program.

The final two columns of Exhibit 3-8 show the total costs per year and the net present value of the costs per year. The column showing total costs are the sum of all construction and maintenance costs by year for The Program. Total Program costs are $171,961,000.

Net present value accounts for the time value of money. Economists assume that a dollar earned today is worth more than that dollar in the future, due to inflation. Future sums must be reduced to account for this delay. All future costs are converted to their present values (or discounted values) by using a discount rate. This BCA used a discount rate of 0.6 percent. It allows for comparison of the buying power of one future dollar to the purchasing power of one dollar today. The net present value of the costs each year is shown in the final column of the exhibit. The total net present value of The Program is $164,981,000. The total costs and net present value total costs serve as denominators in the subsequent BCR calculations presented within this report.

Exhibit 3-8: Discounted Construction Project Costs by Year (Present Value, Thousand $)

	Hydraulic Improvements Phases I and 2		Storage Basins				Program	
Year	Construct	Maint.	Construct: Eagle Creek	Construct: Potato Run	Construct: Blanchard River	Maint.	Total Costs in 2018 Dollars	Net Present Value
2018	6,399						6,399	6,399
2019	6,399						6,399	6,360
2020	6,254	17.7	10,896				17,167	16,963
2021	6,254	17.7	10,896				17,167	16,862
2022		17.7	10,896	3,422			14,335	13,996
2023		17.7	10,896	3,422	6,393		20,728	20,117
2024		17.7	10,896	3,422	6,393		20,728	19,997
2025		17.7	10,896	3,422	6,393		20,728	19,878
2026		17.7		3,422	6,393	75	9,907	9,444
2027		17.7		3,422	6,393	75	9,907	9,388
2028		17.7		3,422	6,393	75	9,907	9,332
2029		17.7		3,422	6,393	75	9,907	9,276
2030		17.7				155	173	161
2031		17.7				155	173	160
2032		17.7				155	173	159
2033		17.7				155	173	158
2034		17.7				155	173	157
2035		17.7				155	173	156
2036		17.7				155	173	155
2037		17.7				155	173	154
2038		17.7				155	173	153
2039		17.7				155	173	152
2040		17.7				155	173	151
2041		17.7				155	173	151
2042		17.7				155	173	150
2043		17.7				155	173	149
2044		17.7				155	173	148
2045		17.7				155	173	147
2046		17.7				155	173	146
2047		17.7				155	173	145
2048		17.7				155	173	144
2049		17.7				155	173	143
2050		17.7				155	173	143
2051		17.7				155	173	142
2052		17.7				155	173	141
2053		17.7				155	173	140
2054		17.7				155	173	139
2055		17.7				155	173	138
2056		17.7				155	173	138
2057		17.7				155	173	137
2058		17.7				155	173	136
2059		17.7				155	173	135
2060		17.7				155	173	134
2061		17.7				155	173	134
2062		17.7				155	173	133
2063		17.7				155	173	132
2064		17.7				155	173	131
2065		17.7				155	173	130
2066		17.7				155	173	130
2067		17.7				155	173	129
2068		17.7				155	173	128
2069		17.7				155	173	127
2070		17.7				155	173	127
2071		17.7				155	173	126
2072		17.7				155	173	125
2073		17.7				155	173	124
2074		17.7				155	173	124
2075		17.7				155	173	123
2076		17.7				155	173	122
2077		17.7				155	173	121
2078		17.7				155	173	121
2079		17.7				155	173	120
Total	**25,304**	**1,062**	**65,375**	**27,375**	**44,750**	**8,050**	**171,916**	**164,981**

Chapter 4 Structure/Content Damages

Damages to structure, contents, and automobiles account for the majority of damages that result from a flood event. These categories provide the foundation for the economic evaluation of the alternatives. Flood risk reduction projects are developed with these damages in mind; the goal of plan formulation is to minimize these flood impacts in a way that is consistent with protecting the environment and quality of life in our communities. The USACE Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software was used in this BCA to estimate damages to structures, contents, and automobiles for without-project and with-project alternatives of the updated Hancock County Flood Risk Reduction Program.

The structure inventory developed for the HEC-FDA analysis comprises all residential and nonresidential structures within the planning model's 0.2% Annual Chance Exceedance (ACE) (500-year) event floodplain and additional structures located in areas that could potentially experience induced flooding identified by project engineers. The structure inventory used for this May 2018 analysis was updated based on the 2015 inventory with modifications as described in the following sections.

4.1 Rationale and Justification for Inclusion

Among the physical damage categories identified by the USACE are the savings of structure and contents from flood damage. According to the Corps, most benefits from flood damage reduction projects come from the reduction of inundation damages.[16] The loss of contents may include furnishings and equipment, decorations, raw materials, processed material, among others. The damages are calculated individually for residential, commercial, industrial and public properties. Outside property damage can also be significant, including sheds, garages and other small buildings – structures that may be particularly vulnerable to collapse or being washed away in a flood. Guidance from the Corps states that the value of electrical or mechanical equipment in residential garages damaged by flooding should also be recorded. Damages play a significant role in studies designed for flood mitigation decisions. Regardless of the scope of the study at hand, the Corps states:

> "..accurate estimates of damages to residential and commercial structures and their contents are essential in establishing the feasibility and optimal choice of engineering plans designed to alleviate the effects of flooding. The relationship between the depth of flooding and the severity of damage to structures and their

[16] Institute for Water Resource, USACE. National Economic Development Procedures Manual – Urban Flood Damage. IWR Report 88-R-2, March 1988.

contents is an integral part of the methodology used to estimate the economic benefits associated with floodplain modifications."[17]

This project follows the guidance stated by the Corps in determining benefits derived by removing structures from the floodplain. These benefits are then used in the benefit-cost analysis according to accepted Corps practice. Modern depth damage curves such as those incorporated in the CORP HEC/FDA model include in a single curve the structure and content damage based on the level of inundation.

4.2 Structure Inventory Overview

The structure inventory developed and refined for the analysis contains 4,483 structures: 3,891 residential (86.8%), 453 commercial (10.1%), 129 public (2.9%) and 10 industrial (0.2%). Exhibit 4-1 shows this structure breakdown.

Exhibit 4-1: Hancock County Structure Inventory

Structure Type	Damage Category	Structure Count	Percent of Total
Residential	RES	3,891	86.8
Commercial	COM	453	10.1
Public/Other	P&O	129	2.9
Industrial	IND	10	0.2
Total		**4,483**	**100.0**

Residential structures comprise a majority of the structures in the inventory. Exhibit 4-2 provides a summary of the type of residential structures which exist in the study area. Of the 3,893 residential structures included in the analysis: 1,800 are one-story without basements (46.3%), 886 are one-story with basements (22.8%), 793 are two-plus stories with basements (20.4%), 309 are two-plus stories without basements (7.9%), 56 are split levels without basements (1.4%), and 46 are split levels (1.2%) with basements.

[17] USACE. Final Report: Depth-Damage Relationships For Structures, Contents, And Vehicles And Content-To-Structure Value Ratios (CSVR) In Support Of The Donaldsonville To The Gulf, Louisiana, Feasibility Study. March 2006.

Exhibit 4-2: Residential Structures by Type

Residence Type	Number	Percent of Total
1ST-NB	1,800	46.3
1ST-B	886	22.8
2ST-B	793	20.4
2ST-NB	309	7.9
SL-NB	56	1.4
SL-B	46	1.2
Total	**3,893**	**100.0**

The structure inventory includes specific building attributes for each structure, including a unique structure name, parcel ID, latitude/longitude, structure type, structure/content value, stream and bank side on which the structure is located, approximate stream station location, depth damage function (DDF), first floor elevation (FFE), ground elevation and begin damage elevation.

Following the 2007 flood event, Hancock County purchased multiple structures for flood mitigation via grants funded by the City of Findlay, Hancock County, and Northwest Ohio Flood Mitigation Partnership. Hancock County provided a list of 166 structures that the County purchased inside the 1% ACE floodplain. Six additional structures have been removed since the 2017 study. These 172 structures were removed from the inventory used in the analysis since they no longer exist in the floodplain.

4.3 Structure Location

Project engineers determined structure locations using Geographic Information System (GIS) dwelling footprint and address shapefiles. Each structure with an address was represented by a point file generally at the lowest point of the dwelling footprint. If a dwelling footprint was not available, an address point file generally near the mailbox of the structure was used. This location was assumed to be generally representative of the location of the structure. Structures within the planning model's 0.2% ACE floodplain were selected for analysis. The shapefiles were joined to their respective parcel shapefile obtained from Hancock County tax assessor. This file contained parcel boundaries and parcel numbers that could be cross referenced with the Hancock County tax assessor information.

Project engineers assigned structures to a stream based on their location in the study area. The stream that was adjacent to the structure was typically assigned. In cases where it was not clear which stream to assign (e.g., structure located at the confluence of two streams), professional judgment was used to assign the stream based on which stream was most representative of the flood characteristics for that structure. The structures in Hancock County were assigned to one of three streams: Blanchard River, Eagle Creek, or Lye Creek.

Stream stations which correspond to those used in the hydraulic model were imported into ArcGIS software and used to match each structure to a stream station. The assigned station was the closest point where the structure was perpendicular to the stream.

4.4 Structure Elevation

Project engineers determined the First Floor Elevation (FFE) for each structure by using a Digital Elevation Model (DEM) created by Kucera International with the data obtain from the aerial survey. The DEM was derived from Light Detection and Ranging (LiDAR) collected in 2016 by Kucera.

Based on the structure locations (denoted as points), the DEM was used to extract an elevation of the adjacent grade to the structure point file (ground elevation). Since the study area is very flat, the analysis assumes the ground elevation surrounding a structure was a consistent height. Therefore, grade at each structure was used to represent the adjacent ground elevation. The ground elevation was then adjusted and increased by 1.0 feet to estimate the height of the first floor relative to the ground (FFE).

Since most structures in the study area are damaged by overland flooding, the begin damage point for each structure was assumed to be the elevation of the adjacent grade. HEC-FDA uses the begin damage point to estimate the water elevation that could start to impact a structure. If the begin damage point is not entered, HEC-FDA would begin to estimate damages beginning from the bottom of the depth-damage function assigned to a structure. For overland flooding, flood water would not be anticipated to impact a structure until water reached the structure.

For structures with basements, it would be anticipated that floodwater would enter the structure and fill the basement through a window or other low-level opening. Therefore, the begin damage point was set at the adjacent grade to avoid overestimating damages, especially to structures with basements.

4.5 Depreciated Replacement Value

Hancock County tax assessors provided value data for residential and non-residential structures in the study area. The tax assessor data listed multiple valuation components (e.g., land, improvement) for each parcel that could be used to represent the value of structures in the study area. To ensure compliance with USACE guidance requiring the use of depreciated replacement values for structures, a random sample of the structures were valued using

RSMeans[18], a commercially available valuation method for comparison to the tax assessor valuations.

A field inventory of 10% of the structures in the study area was conducted to collect characteristics of the structures, such as size, condition, quality, roofing material, etc. The characteristics are input variables used to estimate the replacement value using RSMeans. The replacement values were adjusted for depreciation using ratios developed by the Institute for Water Resources (IWR). The depreciated replacement values calculated for the sample of inventoried structures were compared to tax assessor values to determine if a relationship between the data sets could be identified. However, there was great variance between the data sets and a relationship could not be identified. Because of the impact that nonresidential structures can have on the results of a flood risk management study and because there were relatively few nonresidential structures in the study area, a second field inventory was conducted to inventory the remaining nonresidential structures. The remaining nonresidential structures were also valued using RSMeans and depreciated. These values were used for the economic analysis of nonresidential structures.

The 2015 USACE inventory further refined structure value using a random sample of records in the inventory. From the random sample, an average dollar per square foot value was estimated based on the structure type (e.g., one-story, two-story). The average dollar per square foot value was then applied to each residential structure in the study area based on the size and characteristics from the tax assessor database. While individual structures may not be as accurate using this method, USACE determined it should provide a reasonable overall estimate of the study area.

The 2015 USACE inventory developed depreciated replacement values from October 2012 prices. These values were updated to November 2014 prices for the current analysis using the Civil Works Construction Cost Index System (CWCCIS – EM 111-2-1304) composite index. The 2015 USACE inventory yielded a 4% increase in structure inventory values. These values were indexed using a 1.0267 percent to account for property value increases to the base year of 2018.

Besides the structures identified by the USACE in 2015, project engineers identified an additional 992 structures located in the 0.2% ACE (500-year) floodplain for the May 2018 analysis. The values used for these structures were based on the Hancock County tax assessor records. The remaining 3,491 records kept the beginning damage depths, structure values and structure types developed by the USACE in 2015.

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[18] Replacement costs were estimated using the model approach provided in the RSMeans Square Foot Costs book (2012). The replacement values were adjusted for depreciation using ratios developed for the USACE Institute for Water Resources.

4.6 Depth-Damage Functions

Each structure was assigned a Depth Damage Function (DDF) that estimates an economic loss as a percentage of the value of the structure or contents based on the depth of flooding. The DDFs used in the May 2018 analysis were based on the USACE analysis completed in 2015. The 2015 analysis used four sources: Economic Guidance Memorandum (EGM) 04-01 Generic Depth-Damage Relationships for Residential Structures, EGM 09-04 Generic Depth-Damage Relationships for Vehicles, building specific commercial damage surveys and generic curves obtained from USACE Galveston District.

4.6.1 Residential Structures

All structure and content DDFs assigned to residential structures were developed by IWR as referenced in EGM 04-01. These DDFs are considered generic and are appropriate for use throughout the United States. The DDFs are divided into multiple categories based on the type of structure (e.g., one-story, two-story, foundation type), with separate DDFs to represent damages to the structure and the contents. The DDFs were assigned to each structure based on information contained in the tax assessor databases (e.g., number of floors, presence of basement). A content-to-structural value (CSVR) of 55 percent was used for residential structures.

4.6.2 Non-Residential Structures

All structure DDFs assigned to non-residential structures were obtained from the 2015 USACE analysis (based on the USACE Galveston District values). These DDFs were selected for use because structures in both locations are built using similar techniques and materials, and they represent fresh water flood damages. The appropriate DDFs were selected from available USACE Galveston District based on the type and the use of the structure. A portion of the DDFs assigned to nonresidential structures were developed based on personal interviews with business owners and operators.

4.6.3 Residential and Non-Residential Structure

In cases where multiple structures were located on a single parcel, the data on the individual structures from the interviews (completed by the USACE in 2015) were combined to form a single DDF. Therefore, each entry in the structural inventory is representative of the damages that would occur for that parcel - not necessarily each structure on the parcel. The content-to-structure-value ratios (CSVRs) for all of the structures were incorporated into the analysis based on the assigned DDF and interview data.

4.7 HEC-FDA Methodology

Structural damage costs were estimated using the USACE Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Economic model. The analysis follows the framework and methodology as directed by the *HEC-FDA Flood Damage Reduction Analysis User's Manual*

(April 2016). Project analysts used Revision 1.4.2 of the HEC-FDA model to assess floodplain damage and develop Equivalent Annual Damage (EAD) estimates for the base case ("without") and program scenario:

- Without Scenario (Base Case). The Without scenario evaluated damage to structures in the base case and none of the proposed improvements were constructed.
- Program Scenario. The Program scenario estimated structural damage for assuming all the proposed improvements are constructed.

The time value of resources is measured by an annual percentage factor known as the discount rate. An appropriate discount rate can be used to calculate the "present value" of any sum of resources or money to be spent or received in the future. The analysis used a discount rate of 0.6 percent for the present value calculation. This discount rate was obtained from the annual Office of Management and Budget publication, *Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses*[19] which applies to long-lived infrastructure investments. The application of the discount rate to future sums to calculate their present value is known as "discounting." Through discounting, different investment alternatives can be objectively compared based on their respective present values, even though each has a different stream of future benefits and costs.

Costs and benefits are expressed in 2018 prices and for each phase of the project a 50-year benefit period is assumed for each phase of the project, beginning in the year after that phase of the project construction is completed. No uncertainty factors were used to develop the analysis nor were Monte Carlo simulations employed to evaluate risk and uncertainty in the analysis. The analyses of without-project and with-project damages include damages or costs incurred from a range of categories. Categories considered in the economic analysis are: damages to structures and contents, damages to automobiles, increased emergency response expenditures, evacuation and subsistence expenditures, reoccupation costs, and costs for commercial cleanup and restoration. These categories are intended to capture a substantial portion of the financial burden incurred by a flood event; however, they are not comprehensive enough to capture every cost or damage that could result from flooding in the area.

Generally, flood damages increase as flood frequency decreases; they are typically higher for the 0.01% Annual Chance Exceedance (ACE) flood compared to the 50% ACE flood. Damages by flood frequency are paramount from the economic perspective since flood damages are reduced to annualized averages based upon the annual chance probability of flood occurrence.

[19] https://www.federalregister.gov/documents/2018/02/08/2018-02520/discount-rates-for-cost-effectiveness-analysis-of-federal-programs

To estimate expected annual damages (EADs) from flooding, eight flooding event frequencies were modeled, representing a range of recurrence probabilities from a 50% ACE (2-year) flood event to 0.2% ACE (500-year) flood event.

4.8 Hydrologic and Hydraulic Modeling

Refer to Stantec's Hancock County Flood Risk Reduction Program Revised Final Report for additional details.

4.8.1 Damage Reaches

The streams in the study area were divided into reaches based on existing features (e.g., bridges) and the extent of proposed alternatives. Dividing the streams into reaches provided the ability to more accurately assess the impacts of proposed alternatives and to focus the analysis on specific areas.

Project engineers assigned reach index locations as a point of reference in development of the stream profiles. The project engineers assigned index locations to locations that were considered to be most closely representative of the actual field conditions when compared to the model results. Exhibit 4-3 summarizes the streams, reaches, and index locations for this HEC-FDA study.

Using HEC-RAS, project engineers developed water surface profiles for each stream and damage reach in the Without and With-Program scenarios. These water surface profiles are read into the HEC-FDA model in order to estimate damage for the eight return frequencies.

Exhibit 4-3: Findlay Streams, Reaches, and Index Locations

Stream Name	Reach Name	Beginning Station	Ending Station	Index Station
Blanchard	Above Potato	394284.7	439732.5	394284.7
	Above Findlay	299534	393578.9	299534
	Eagle-Lye	298205	298802	298205
	Findlay	291423	297726	291423
	Below Findlay	268028	290955	268028
	Gilboa	118486.4	265870	118486.4
Eagle Creek	Full Length	207	49960	207
Lye Creek	Full Length	21515.59	63760	21515.59
	y	72	15758.7	72

4.8.2 Flood Stage Damage Estimation

HEC-FDA uses modeled flooding events to estimate damages to affected structures based on data associated with each structure. HEC-FDA was used to estimate the damages for structures, contents, and automobiles. The HEC-FDA program compiles data generated from the hydraulic analyses, as well as the structure inventory and associated data described above. The hydraulic components used in this analysis included the water surface profiles for every stream for each of the eight analyzed exceedance probability flood events: 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year) and 0.2% (500-year) ACE flood events.

These compiled data are a series of probabilistic curves defining relationships between flood stage and frequency of occurrence, and flood stage and damages. These relationships are used to generate a curve relating probability of occurrence and total damages; the integration of which provides the EAD.

With-project and without-project damages are estimated for both the initial baseline conditions and future conditions, which account for any growth in development and runoff in the study area. As the hydrologic condition of the study area is not anticipated to increase over the period of analysis, the HEC-FDA model was run only for the initial baseline condition, with the resulting annual damages expected to prevail over the 50-year period of analysis.

4.8.3 Damage Categories

Project analysts assigned each structure or vehicle record to one of five damage categories defined for the analysis consistent with USACE guidance:

- **RES.** Residential structure damage category which includes one story, two story homes with and without basements
- **COM.** Commercial structure damage category which includes activities such as offices and restaurants.
- **IND.** Industrial structures damage category which includes activities such as warehouses.
- **P&O.** Public and other structure damage category which includes municipal buildings, public schools, colleges/universities and hospitals.
- **AUTO.** Vehicle damage category including private automobiles, light trucks and heavy trucks.

These damage categories were used to calculate the stage-damage functions and to calculate the Equivalent Annual Damage (EAD) described in the next section.

4.9 Results: Equivalent Annual Damage (EAD)

The results of the HEC-FDA analysis are expressed as an Equivalent Annual Damage (EAD) for each scenario. The USACE defines EAD as the damage value associated with the without- or with-project condition over the analysis period (project life) considering changes in hydrology, hydraulics, and flood damage conditions over the life of the project. HEC-FDA calculates expected annual damage for each analysis year and discounts the value to present worth, then annualizes it to obtain the EAD. Rather than compute the expected annual damage for each year, HEC-FDA computes EAD for the base year and most likely future years and interpolates it for subsequent years. The expected annual damage for years beyond the most likely future conditions year is assumed equal to that year.

Expected annual damage represents the mean amount of damage that would occur in **any given year**, if **that year** were repeated infinitely many times over. The mean value is based on the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage flow, and flow-frequency relationships.

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions. Throughout the period of analysis, EAD can vary if there are changes in hydraulic, hydrologic, or economic conditions. If each year is taken in sequence from the beginning of the period of analysis to the end, the result is a series or “stream” of EAD values.

Calculated EAD for each scenario, stream and damage category is presented in Exhibit 4-4 and Exhibit 4-5. These values are reported in 2017 dollars.

Exhibit 4-4: Equivalent Annual Damage by Stream, Scenario and Damage Category ($1,000s)

	Without (Base Case)	Program
Blanchard		
AUTO	195.28	30.55
RES	2352.1	482.81
COM	1288.38	119.78
IND	6.95	0.37
P&O	535.89	74.41
Subtotal	**4378.6**	**707.92**
Lye		
AUTO	7.63	1.55
RES	354.82	92.57
COM	10.48	2.73
IND	0	0
P&O	8.07	0.69
Subtotal	**381.0**	**97.54**
Eagle		
AUTO	63.99	4.03
RES	3029.57	235.15
COM	254.12	18.97
IND	1.77	0.08
P&O	19.53	2.95
Subtotal	**3368.98**	**261.18**
Total	**8128.58**	**1066.64**

Exhibit 4-5: Equivalent Annual Damage by Damage Category ($1,000s)

	Without (Base Case)	Program
AUTO	266.9	36.13
RES	5736.49	810.53
COM	1552.98	141.48
IND	8.72	0.45
P&O	563.49	78.05
Total	**8,128.58**	**1066.64**

Chapter 5 Motor Vehicles

Damages to structure, contents, and automobiles account for the majority of damages that result from a flood event. These categories provide the foundation for the economic evaluation of the alternatives. This chapter presents the benefits that the project provides by reducing the risk of damages to motor vehicles related to flood events. It includes the rationale and justification for including these benefits and the methodology the study team used to calculate the benefits.

5.1 Rationale and Justification for Inclusion

This section provides the rationale and justification for inclusion of the benefit of reduced flooding of motor vehicles in the BCA. The USACE notes that for many cases, a major share of flood damage occurs to vehicles. Vehicle damage often occurs when warning lead times for flooding events are relatively short. Other factors that may influence the amount of damage to vehicles include the availability of individuals to move vehicles out of the floodplain and the degree of congestion expected on evacuation routes. Relatively low levels of flooding can nonetheless result in significant damage to vehicles. The USACE includes depth damage to vehicles among the four relationships necessary to estimate flood damages (along with depth-damage for structures, depth-damage for contents, and content-to-structure value ratio (CSVR)). [20]

Vehicle flood damage is among of the most frequent varieties of flood damage. Cars are the most often damaged, though they are also the first and most prone item for owners to relocate to safety. If owners are unaware of impending flooding, they may not move their vehicles from locations near a flooding river in time to avert damage. Drivers sometimes get themselves ensnared on flooding roads while attempting to escape flooding areas. Many motorists are largely uninformed of the water depths that will disable a vehicle and may attempt to drive through flooded areas only to become breakdown victims. Relatively shallow bodies of water can cause significant damage to vehicles. The ability to move vehicles makes it difficult for researchers to gauge damage sustained, which is dependent on the day and time of day of flooding and when the flood warning was provided.[21]

[20] US Army Corps of Engineers, New Orleans District, Final Report: Depth-damage relationships for structures, contents and vehicles and content-to-structure value ratios (CSVR) in support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. March 2006.

[21] Richardson, et. al, 2005. Interview with David Richardson, Kevin Andrews from DEFRA and Bill Watts from Environmental Agency in London, March 17, 2005. Cited in: Volker Meyer and Frank Messner, UFZ-Discussion Papers, National Flood-Damage Evaluation Methods: A Review of Applied Methods In England, the Netherlands, the Czech Republic and Germany.

Flood damage to vehicles falls into the direct damage category. These damages occur because of physical contact with floodwaters. The damage is also tangible, which means the damages are assessable in monetary terms.[22]

This project follows the guidance stated by the Corps in determining benefits derived by removing vehicles from the floodplain. The benefit-cost analysis counts these benefits in according to accepted Corps practice.

5.2 Estimation Methodology

This section describes the methodology used to estimate the benefit of reduced flooding of motor vehicles. There are no primary data on the number of vehicles subject to flood damage during individual flood events. As a result, the analysis combined data on:

- The value of individual vehicle types
- The number of vehicles typically owned by households or parked at commercial structures
- The percent of vehicles typically evacuated during flooding events
- Depth-damage curves that predict the percent damage to vehicles caused by different water depths
- The water depths resulting from floods of varying probabilities

The following sections describe the estimation of each of these values. The final section provides the results of the calculations and discusses those results.

5.2.1 Vehicle Values

The project team estimated the average vehicle value by vehicle type by dividing data on the total value of vehicles by the number of vehicles. The Federal Highway Administration provides data on the number of vehicles in the publication Highway Statistics. The Bureau of Economic Analysis (BEA) provides data on the value of all vehicles in U.S. Economic Accounts, Fixed Assets Tables.

The Bureau of Economic Analysis (BEA) provides data on the value of all consumer and business vehicles. The BEA provides 2016 data for Consumer Durable Goods and Private Fixed Assets Nonresidential Equipment. The data represent yearend estimates of current-cost net stock and BEA updated them on August 23, 2017. BEA provides separate data for business and consumer automobiles, light trucks, and heavy trucks. The analysis assumes that the value of consumer owned heavy trucks is 50 percent of the BEA value of Recreational Vehicles (RVs). The BEA did not have data on the value of the vehicles stocks held by governments.

The Federal Highway Administration's (FHWA) "Highway Statistics," provides data on the number of vehicles. FHWA provides the data for 2016 in two tables. State Motor-Vehicle

[22] Smith, K. and Ward, R.: Floods: Physical processes and human impacts. John Wiley & Sons, Chichester, 1998.

Registrations (Table MV-1) provides the number of private and commercial automobiles, buses, trucks, and motorcycles. Truck and Truck -Tractor Registrations (Table MV-9) has a set of columns that provide a Classification of Private and Commercial Trucks Registered. These columns provide data for truck tractors, pickups, vans, sport utilities, and other light trucks. Table MV-1 was the direct source of the number of automobiles. The number of light trucks is a sum of Table MV-9 data on the number of pickups, vans, sport utilities, and other light trucks. The number of heavy trucks is calculated based on the Table MV-1 data on the number of trucks, less the sum of the Table MV-9 figures of the number of pickups, vans, sport utilities, and other light trucks.

Using these sources, the average automobile was valued at $6,984, the average light truck was valued at $10,279, and average heavy truck was valued at $20,455. The analysis then updated the data from 2016 values to 2018 values using the U.S. Bureau of Labor Statistics (BLS) Consumer Price Index (CPI) Inflation Calculator. [23] The CPI inflation calculator uses the All Urban Consumers (CPI-U) U.S. city average series for all items, not seasonally adjusted. This data represents changes in the prices of all goods and services purchased for consumption by urban households. The analysis used the CPI change from February 2016 to February 2018 of 5.01 percent. After accounting for inflation, the average automobile was valued at $7,334, the average light truck was valued at $10,794, and the average heavy truck was valued at $21,480. Exhibit 5-1 provides the above calculation and final average values of vehicles by vehicle type.

Exhibit 5-1: Average Value of Vehicles by Vehicle Type

Vehicle Type	Number of Private and Commercial Vehicles (2016)	Highway Statistics Table Number	Consumer Durable Goods Current Cost ($, 2016, Million)	Non-Residential Fixed Assets Current Cost Net Stocks ($, 2016, Million)	Total Vehicle Value ($, 2016, Million)	Value per Vehicle ($, 2016)	CPI (Feburary 2018/ February 2016)	Value per Vehicle ($, 2018)
Automobiles	111,490,611	TABLE MV-1						
Buses	567,573	TABLE MV-1						
Trucks	143,913,338	TABLE MV-1						
Motorcycles	8,649,613	TABLE MV-1						
Truck Tractor	2,582,751	TABLE MV-9						
Pickups	46,941,851	TABLE MV-9						
Vans	16,577,778	TABLE MV-9						
Sport Utilities	69,112,824	TABLE MV-9						
Other Light	83,218	TABLE MV-9						
Automobiles	111,490,611		568,242	210,400	778,642	6,984	1.0501	7,334
Light Trucks	132,715,671		972,292	391,900	1,364,192	10,279	1.0501	10,794
Heavy Trucks	11,197,667		7,748	221,300	229,048	20,455	1.0501	21,480

[23] U.S. Bureau of Labor Statistics, https://www.bls.gov/data/inflation_calculator.htm

5.2.2 Vehicle Inventory

Project analysts used the structure inventory and Hancock County tax assessor records to determine the location and value of vehicles in the study area. For residential structures, the analysis used data on the average number of vehicles owned by households. For commercial, industrial, and public/exempt structures, project analysts used estimates of vehicles per square foot by structure type and data on the square footage of each structure.

Two sources provided estimates of the number of vehicles per household. The Department of Transportation (2009) estimated an average of 1.9 vehicles per household for the United States. The American Factfinder (U.S. Census Bureau, 2014) estimated 1.8 vehicles per household for Hancock County, and 2.1 vehicles per household for Putnam County. Based on the findings, this study used an estimate of two vehicles per residential household. According to the Southeast Louisiana Evacuation Behavioral Report (2006) following Hurricanes Katrina and Rita, residents used approximately 70 percent of privately owned vehicles for evacuation during storm events. Residents left the remaining 30 percent of vehicles parked at residences and were subject to flooding. This study assumed a similar evacuation pattern for Findlay, with 30 percent of the automobiles remaining at households. Local officials confirmed this estimate as a reasonable approximation. One auto and one light truck record was generated for each structure record. The value was set equal to 30 percent of the value of an average auto or light truck.

In order to estimate flood damage of motor vehicles for non-residential structures, project analysts conducted an estimation procedure using the following steps:

1. Identification of square footage and structure use for each structure
2. Identification of vehicles per square foot based on structure use
3. Multiply square footage by vehicles per square foot, vehicle values and the evacuation factor

Project analysts obtained the square footage for each structure record using Hancock County tax assessment data.

The analysis used square footage conversion factors to estimate the total number of automobiles, light trucks and heavy trucks at each non-residential structure. A report in support of the Federal Emergency Management Agency (FEMA) HAZUS model contains these conversion factors.[24] Exhibit 5-2 provides the conversion factors.

[24] HAZUS Vehicle Flood Damage Data and Analysis, Prepared For ABS Consulting by Jack Faucett Associates, June, 2008.

Exhibit 5-2: HAZUS Conversion Factors

HAZUS ID	HAZUS Building Code	HAZUS Building Category	Automobiles per 1,000 Sq. Feet	Light Trucks per 1,000 Sq. Feet	Heavy Trucks per 1,000 Sq. Feet
1	RES1	Single Family Dwelling	0.433963581	0.318221882	0.012114262
2	RES2	Mobile Home	0.995114383	0.729712148	0.012114262
3	RES3A	Multi Family Dwelling (2)	0.371494481	0.272413472	0.012114262
4	RES3B	Multi Family Dwelling (3-4)	0.637763410	0.467667709	0.012114262
5	RES3C	Multi Family Dwelling (5-9)	0.864554076	0.633972651	0.012114262
6	RES3D	Multi Family Dwelling (10-19)	0.864554076	0.633972651	0.012114262
7	RES3E	Multi Family Dwelling (20-49)	0.864554076	0.633972651	0.012114262
8	RES3F	Multi Family Dwelling (50+)	0.988022505	0.724511694	0.012114262
9	RES4	Temporary Lodging	1.705562886	1.251201290	0.012114262
10	RES5	Institutional Dormitory	0.376217121	0.276167215	0.012114262
11	RES6	Nursing Home	0.376217121	0.276167215	0.012114262
12	COM1	Retail Trade	1.261496553	0.926023763	0.308363031
13	COM2	Wholesale Trade	0.099306308	0.072925726	0.148675033
14	COM3	Personal and Repair Services	1.275829259	0.936660392	0.022025931
15	COM4	Professional/Technical Services	0.808172817	0.593623900	0.022025931
16	COM5	Banks	0.963020482	0.707189087	0.022025931
17	COM6	Hospital	1.152703116	0.846410007	0.022025931
18	COM7	Medical Office/Clinic	1.360449937	0.999090593	0.022025931
19	COM8	Entertainment & Recreation	3.588709699	2.634551062	0.022025931
20	COM9	Theaters	1.075357971	0.789343319	0.022025931
21	COM10	Parking			
22	IND1	Heavy	0.318307367	0.233768977	0.249994314
23	IND2	Light	0.195878311	0.143885211	0.249994314
24	IND3	Food/Drugs/Chemicals	0.318307367	0.233768977	0.249994314
25	IND4	Metals/Minerals Processing	0.318307367	0.233768977	0.249994314
26	IND5	High Technology	0.431667604	0.316994686	0.249994314
27	IND6	Construction	0.431667604	0.316994686	0.249994314
28	AGR	Agriculture	0.431667604	0.316994686	0.249994314
29	REL	Church/Non Profit	0.578117035	0.424301047	0.022025931
30	GOV1	General Services	1.182910329	0.868840761	0.022025931
31	GOV2	Emergency Services	1.476090593	1.083956859	0.022025931
32	EDU1	Schools/Libraries	0.600851617	0.441152292	0.022025931
33	EDU2	Colleges/Universities	0.390941783	0.287079052	0.022025931
Dollar Value			**$6,932.22**	**$9,841.89**	**$16,625.21**

The HAZUS conversion factor report relied upon a number of data sources. The primary source for automobiles and light trucks was the International Transportation Engineers (ITE) report, Parking Generation. [25] The primary data source for heavy trucks was a report from the National

[25] International Transportation Engineers, Parking Generation, 3rd Edition, 2004.

Cooperative Highway Research Program.[26] The analysis to develop the data from these reports into conversion factors was extensive. The authors assigned building types from both reports to the HAZUS categories, estimated missing hourly data, converted hourly estimates to daytime and nighttime rates, converted data reported on a basis other than square footage, and scaled results to reflect nationwide vehicle inventories.

5.2.3 Vehicle Evacuation Factor

No primary data are available on the extent to which Findlay area residents successfully evacuate their vehicles during flood events. As a result, this study relies on secondary data from other locations. According to the Southeast Louisiana Evacuation Behavioral Report (2006) following Hurricanes Katrina and Rita, residents reported using approximately 70 percent of privately owned vehicles for evacuation during storm events. Residents left the remaining 30 percent of the vehicles parked at residences and subject to flooding. The study assumed that a similar evacuation pattern would be applicable for Findlay, with 30 percent of the automobiles remaining at the household when evacuating.

5.2.4 Depth-Damage Functions

Project analysts developed estimates of the value of flood damage to vehicles using data from an unpublished U.S. Army Corps of Engineers (USACE) document entitled, "Estimating Flood Damage to Vehicles" by Stuart A. Davis, Institute for Water Resources. The USACE document used data from a survey of 640 vehicles. The USACE analysis employed statistical regression to estimate the percent of damage sustained by various vehicles types relative to the depth of flooding. These USACE estimates represent a significant improvement in data quality compared to previous estimates. Data in the earlier version of the HAZUS provided data for only three general levels of waters and utilized rough estimates of damages collected from industry experts.

The USACE vehicle types included sedans, pickups, SUVs, sports cars, and minivans. Exhibit 5-3 provides the percent damage to vehicles by floodwater depth. Project staff assigned sedans and sport cars as proxies for automobiles. The analysis calculates auto damage by depth by weighting sedans at 90 percent and sports cars at 10 percent. These weights use the numbers of these vehicles surveyed in the Institute for Water Resources draft, where there were 37 sports cars and 369 sedans.

[26] National Cooperative Highway Research Program, NCHRP SYNTHESIS 298, Truck Trip Generation Data: A Synthesis of Highway Practice, Michael J. Fischer Cambridge Systematics, Inc. and Myong Han Jack Faucett Associates, Transportation Research Board — National Research Council, National Academy Press,

Washington, D.C., 2001.

Exhibit 5-3: Percent Damage to Vehicles by Water Depth and Vehicle Type

Depth Above Ground	Survey Data*					Calculated Data**		
	Sedans	Pickups	SUVs	Sports	Mini Vans	Autos	Light Trucks	Heavy Trucks
0.5	7.6%	5.2%	0.0%	1.4%	0.0%	7.0%	1.8%	0.0%
1	28.0%	20.3%	13.8%	29.2%	17.8%	28.1%	16.6%	0.0%
2	46.2%	34.4%	30.6%	52.8%	38.3%	46.9%	32.9%	1.8%
3	62.2%	47.5%	45.8%	72.2%	56.8%	63.2%	47.8%	16.6%
4	76.0%	59.6%	59.4%	87.4%	73.3%	77.1%	61.2%	32.9%
5	87.6%	70.7%	71.4%	98.4%	87.8%	88.7%	73.2%	47.8%
6	97.0%	80.8%	81.8%	100.0%	100.0%	97.3%	83.7%	61.2%
7	100.0%	89.9%	90.6%	100.0%	100.0%	100.0%	91.5%	73.2%
8	100.0%	98.0%	97.8%	100.0%	100.0%	100.0%	98.1%	83.7%
9	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	91.5%
10	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	98.1%
11	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Project staff assigned pickups, SUVs, and minivans as proxies for light trucks. The analysis uses the relative number of these vehicles to derive an average damage for each depth of flooding. The number of vehicles of each type in 2016 is reported in Table MV-9 from the Federal Highway Administration's Highway Statistics. The table reports 46,941,851 pickups, 69,112,824 sport utilities and 16,577,778 vans. Heavy truck damage percentages were estimated assuming that these vehicles have an additional two feet of clearance relative to light trucks based on data from the previous HAZUS model. Therefore, heavy trucks sustain the same degree of damage as light trucks, but at higher levels of flooding.

The study assumed that the elevation of the vehicles was equal to be the elevation of each structure's adjacent grade, which the study estimated using digital elevation models and GIS.

5.2.5 Water Depths by Return Frequency

Project analysts derived vehicle location from the location of the associated structure and its assignment to the stream, stream bank, and damage reach used for the analysis in a similar manner as the structure inventory.

Project engineers assigned structures to a stream based on their location in the study area, typically assigning the stream that was adjacent to the structure. In cases where it was not clear which stream to assign (e.g., structure located at the confluence of two streams), professional judgment was used to assign the stream based on which stream was most representative of the flood characteristics for that structure. The analysis assigned the structures in Hancock County to one of three streams: Blanchard River, Eagle Creek, or Lye Creek.

The analysis imported stream stations, which correspond to those used in hydraulic model, into ArcGIS software to match each structure to a stream station. The assigned station was the closest point where the structure was perpendicular to the stream.

5.3 Results

The values of vehicles present at each structure along with the depth-damage curves for vehicles are an input into the HEC-FDA model. The model then processes the data in the same manner as for structures. The HEC-FDA model expresses results in terms of an Equivalent Annual Damage (EAD) for each scenario. The US Army Corps of Engineers defines EAD as the damage value associated with the without-or-with project condition over the analysis period (project life) considering changes in hydrology, hydraulics, and flood damage conditions that may occur over the useful life of the program. HEC-FDA calculates expected annual damage for each analysis year and discounts the value to present worth, then annualizes it to obtain the EAD. Rather than compute the expected annual damage for each year, HEC-FDA computes EAD for the base year and most likely future years and interpolates it for subsequent years. The expected annual damage for years beyond the most likely future conditions year is equal to that year.

The EAD represents the mean amount of damage that may occur in any given year, if that year repeated infinitely many times over. The mean value assumes the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage-flow, and flow-frequency relationships.

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions. Throughout the period of analysis, EAD can vary if there are changes in hydraulic, hydrologic, or economic conditions. If each year occurs in sequence from the beginning of the period of analysis to the end, the result is a series or "stream" of EAD values.

Exhibit 5-4 presents the calculated EAD for each scenario, stream and damage category. The exhibit reports these values in 2018 dollars.

Exhibit 5-4: Equivalent Annual Damages for Motor Vehicles ($1,000s)

Reach	Without The Program (Base Case)	With The Program	Reduction in Damages
Blanchard	213.94	33.14	180.80
Lye	7.64	1.52	6.12
Eagle	69.48	4.06	65.42
Total	**291.06**	**38.72**	**252.34**

Chapter 6 Transportation Benefits

A flood event can have significant impacts on a regional transportation network. These impacts include road closures, and impediment to traffic flow between the origin and destination both resulting in increased travel times due to detours. This chapter presents the benefits provided by reducing the risk of potential impacts related to flood events. It includes the rationale and justification for including these benefits and the methodology the study team used to calculate the benefits.

6.1 Rationale and Justification for Inclusion

This section provides the rationale and justification for inclusion of transportation benefits in the BCA. The analysis of the benefits of flood mitigation projects commonly assess the benefits of reduced flooding on the transportation network. For example, the USACE National Economic Development Procedures Manual for Urban Flood Damage (NED Manual) states:

> *"Flooding can temporarily impede traffic by covering roads and bridges. Even the threat of flooding and concern for public safety may make it necessary to close roads and detour traffic. Bridge and road damage may cause detours for several months until repairs can be made. The costs of traffic disruption include 1) the additional operating cost for each vehicle, including depreciation, maintenance, and gasoline per mile of detour; and, 2) the traffic delay costs per passenger."*[27]

In the November 2015 USACE Economics Report (Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT), the authors acknowledge the consequence of road flooding noting that:

> "*The Blanchard River Watershed is located in the center of an extensive transportation network of road and rail systems. The level of accessibility afforded by this network has contributed significantly to both local and regional economic growth. Although Hancock County is largely rural, it is also home to many businesses, (including Cooper Tire, Hearthside Foods, Marathon Petroleum, and Whirlpool Corporation) that are able to quickly and easily export manufactured goods using the area's many convenient State routes and interstates.*
>
> *During flood events, transportation infrastructure in the study area (including, but not limited to, I-75) is significantly impacted. Closure times range from short to relatively long to account for inundation, debris clearance, and safety assessments which vary by storm and particular*

[27] U.S. Army Corps of Engineers, National Economic Development Procedures Manual - Urban Flood Damage. IWR Report 88-R-2, March 1988. pp. VII-6 – VII-11.

transportation route. During major flood events, a majority of the Blanchard River crossings are closed. Major flooding has also resulted in the closure of several Blanchard River rail crossings."[28]

6.2 Estimation Methodology

This section describes the methodology used to estimate the transportation related benefits. The USACE describes in its NED Manual the recommended method for estimating the costs of rerouting traffic. The costs of traffic disruption include:

- The additional operating cost for each vehicle, including depreciation, maintenance, and gasoline per mile of detour
- The traffic delay costs per passenger

The USACE NED Manual notes, "To determine traffic operating cost, it is first necessary to determine the frequency, depth, and duration of flooding along major stretches of road that are subject to flooding. In order to concentrate on areas where the most significant benefits might occur, it is necessary to focus on portions of roads where there would be considerable traffic rerouting for long periods of time."

The manual notes that beyond the inundation mapping, there are several tasks necessary to determine the operating costs of traffic rerouting:[29]

Step 1: Determine the amount of time that particular stretches of road would be impassable.

Step 2: Determine the number of miles for the original route.

Step 3: Determine the number of miles for the best alternative route.

Step 4: Determine the additional miles per vehicle.

Step 5: Determine the total additional mileage by multiplying the additional miles per vehicle by the average daily travel and period that the roads are impassable.

Step 6: Estimate the average vehicle operating expense.

Step 7: Multiply average operating cost by total mileage to obtain additional operating cost.

The second portion of traffic rerouting is traffic delay costs. This cost accounts for the additional time spent by individuals forced to take the detours due to road closures. Since time is usually more valuable than the average vehicle operating costs in the same period, traffic delay costs are often higher than traffic operating costs. The procedures for calculating traffic delay costs are as follows:

---

[28] Ibid, Section 1.3, p. 2.

[29] The steps described roughly parallel those that USACE provides in the National Economic Development Procedures Manual for Urban Flood Damage. However, the discussion both edited the steps to simplify the descriptions and enhanced them to include steps that the manual did not specifically discuss.

Step 1: Determine the amount of time that particular stretches of road would be impassable.

Step 2: Determine the number of miles for the original route.

Step 3: Determine the number of miles for the best alternative route.

Step 4: Determine the additional miles per vehicle.

Step 5: Determine the amount of time required on the original route.

Step 6: Determine the amount of time required on the alternative route.

Step 7: Subtract the original from the rerouted travel time to compute additional travel time.

Step 8: Determine the approximate average number of passengers per vehicle.

Step 9: Determine the total additional time by multiplying the additional time per vehicle by the number of passengers per vehicle and the average daily travel and the period that the roads are impassable.

Step 10: Determine the value-of-time for passengers using area wage rates.

Step 11: Multiply the additional travel time by the value-of-time.

During the 2007 floods, numerous routes became impassable. Based upon that anecdotal information from local records and interviews, the methodology calculates the results for each route separately and sums the results. In addition, the number of route closures has a significant impact on travel delays. According to local officials, traffic during the 2007 flood caused significant traffic delays on the alternative routes. As a result, the analysis assumes that the travel times on the alternate routes would be double the travel times with no delay.

The following sections detail the calculations that the analysis study team undertook to calculate the transportation benefits of reduced flooding that the proposed program alternatives would provide.

6.3 Inundated Routes

Steve Wilson, the former Hancock County Engineer and current Project Manager for the MWCD, provided a list of road closures and the estimated duration of those closures during the 2007 flood event. Exhibit 6-1 lists those road closures, along with the Average Daily Travel (ADT) traffic volume on sample segments for each of the roads. The exhibit also provides the estimates of closure durations during the 2007 event and an approximated detour, or in one case, alternative detours. The Ohio Department of Transportation (ODOT) was the source of ADT traffic volumes.

Exhibit 6-1: Inundated Travel Routes, Average Daily Travel and Detours

Name	Average Daily Travel	Duration of Closure During 2007 Event	Approximated Detour
US 224 - CR 140 to I-75	11,000	24	Local Traffic Westbound on 224 -- (West on Trenton Ave. (US 224), Turn right on Northridge Rd., Turn left on TR 94, Turn Left CR140) Non-Local Traffic Wanting to travel West -- (North on I-75, West on State Route 613, South on Local Road and destination)
Main St - Center St to Sandusky St	18,000	72	Southbound Main Street at Center Street -- Travel North to Trenton Ave. (224), turn left to I-75, travel south to SR 12 (exit 157), turn left to head east on Main Cross St. to Western Ave., to Hardin Street.
Main St - Olive Street to SR 15	8,000	48	Southbound Main Street -- Turn right at Orchard Lane, Right on Western Avenue to Lima Avenue, Left on Lima Avenue to CR 9, Left (south on CR 9 to CR 37) to US 68.
Main Cross St - Western Ave To Bright Rd 5 (West St)	12,000	72	Eastbound on SR 12 (Main Cross St.) -- Get onto northbound I-75, Take exit 159 to East 224, Travel east onto 224 back to the City.
Main Cross St - Western Ave To Bright Rd 4 (East St)	12,000	72	
Main Cross St - Western Ave To Bright Rd 3 (Blanchard St)	12,000	72	
Main Cross St - Western Ave To Bright Rd 2 (Warrington)	12,000	72	
Main Cross St - Western Ave To Bright Rd 1 (West of Bright)	12,000	72	
SR 37 - Main St to TR 205	5,000	72	Eastbound on SR 37 at Main St and Lincoln --Travel South on Main Street to Lima Avenue to CR 9, travel South on CR 9 to CR 37, continue on CR 37 to SR 37 south of SR 15.
SR 37 - CR 8 to TR 234	4,000	48	Southeast bound on SR 37 -- South on TR 180 to SR 15 to SR 37
Sandusky St (SR568) - Main St to TR 237 (TR 236)	12,000	72	Regionally closed to TR 245 - West on 568 from Main Street, Backtrack to I-75, go north to 224, follow 224 east to CR 330 (4 miles east of Findlay) follow CR 330 south to 568.
Sandusky St (SR568) - Main St to TR 237 (Lye Creek Bridge)	12,000	72	
Sandusky St (SR568) - Main St to TR 237 (Blanchard St)	12,000	72	
Sandusky St (SR568) - Main St to TR 237 (RR)	12,000	72	
SR 568 - TR 237 to TR 245 (twp hwy 241)	6,000	48	
SR 568 - TR 237 to TR 245 (TR 245)	6,000	48	
US 68 / SR 15 @ Eagle Creek (SR 15)	20,000	48	Westbound on SR 15, go south to Village of Vanlue SR 330. Get off at interchange, turn left through village, changes into CR 330. Follow north to US 224, West to I-75. Southbound on SR 15 from I-75, backtrack toward I-75 to Lima Avenue. Lima Ave west to CR 9, south on CR 9 to CR 37, east on CR 37 to SR 37, back north to SR 15.
US 68 / SR 15 @ Eagle Creek (US 68)	20,000	48	From South to North, (to west side of Findlay) get off of US 68 at CR 37 to CR 9 to Lima Ave into Findlay. From South to North, (to east side of Findlay) TWP 168 to Twp Rd 180. turn left on 180 to SR 15. East on SR 15 to Village of Vanlue and SR 330.

6.4 Time and Distance Values

The research team selected ten road segments and their expected detour routes for analysis. Exhibit 6-2 lists each of the road segments, the ADT, the change in distance in miles due to detour, the change in time in minutes due to detour, the mileage rate the analysis used, and the value of time in dollars per minute that the analysis used. The analysis calculated distances and times using standard travel route mapping software. The Internal Revenue Service was the source for the mileage rate for 2018 of $0.545.[30] The value of time per vehicle per minute of $0.322 is a weighted average of personal and commercial wage rates multiplied by average vehicle occupancy. The weighting, 95.4 percent for personal purposes and 4.6 percent for business, is from the US DOT. The US Bureau of Labor Statistics, State Occupational Employment and Wage Estimates, was the source of the 2015 mean hourly wage rate for Ohio of $22.08. The assumption was that the personal value of time was half the wage rate. The source of the vehicle occupancy rate of 1.67 was the 2017 National Household Travel Survey, which is the latest version of that survey.

Exhibit 6-2: Time, Distance, and Rate Variables:

Name	ADT	Est. Duration Closed 1% ACE	Change in Distance (miles)	Change in Time (minutes)	Mileage Rate ($)	Value of Time ($/minute)
US 224 - CR 140 to I-75	11,000	24	1.1	9	0.545	$ 0.322
Main St - Center St to Sandusky St	18,000	72	4.2	23	0.545	$ 0.322
Main St - Olive Street to SR 15	8,000	48	7.8	28	0.545	$ 0.322
Main Cross St - Western Ave To Bright Rd 3	12,000	72	3.1	26	0.545	$ 0.322
SR 37 - Main St to TR 205	5,000	72	5.5	34	0.545	$ 0.322
SR 37 - CR 8 to TR 234	4,000	48	1.9	11	0.545	$ 0.322
Sandusky St (SR568) - Main St to TR 237	12,000	72	15.8	58	0.545	$ 0.322
SR 568 - TR 237 to TR 245 (TR 245)	6,000	48	15.8	58	0.545	$ 0.322
US 68 / SR 15 @ Eagle Creek (SR 15)	20,000	48	8.2	38	0.545	$ 0.322
US 68 / SR 15 @ Eagle Creek (US 68)	20,000	48	2.7	20	0.545	$ 0.322

6.5 Road Closure Durations

The research team estimated durations of road closures using water surface profiles and time-varied inundation mapping from the planning level hydraulic modeling. Stantec calculated the closure durations using HEC-RAS for each scenario and eight flood frequencies. Stantec assumed that for roads with inundation depths less than 0.5 feet the segment did not close. If the inundation depth was between 0.5 and 0.9 feet, Stantec assumed the closure was a

[30] https://www.irs.gov/newsroom/standard-mileage-rates-for-2018-up-from-rates-for-2017

minimum of 12 hours, or longer in 2-hour increments if the inundation was greater than 12 hours. If the inundation depth was greater than 1.0 foot, Stantec assumed the closure was a minimum of 24 hours, or longer in 2-hour increments if the inundation was greater than 24 hours. The ADTs from Exhibit 6-2 were used for this analysis. Exhibit 6-3 provides road closure durations for the without project conditions, for The Program and the difference between the two conditions.

Exhibit 6-3: Road Closure Durations for Without and With Program Conditions

	Existing Conditions - Road Closed (Flooding > 6 inches (Hours))							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	0	0	0	24	34	42	48	54
Main St - Center St to Sandusky St	0	0	24	40	46	52	56	62
Main St - Olive Street to SR 15	0	0	0	12	16	24	24	28
Main Cross St - Western Ave To Bright Rd 3 (Blanchard St)	62	70	76	80	86	90	94	108
SR 37 - Main St to TR 205	0	0	24	24	38	44	48	54
SR 37 - CR 8 to TR 234	0	0	0	0	0	0	0	12
Sandusky St (SR568) - Main St to TR 237 (Lye Creek Bridge)	0	26	40	50	54	60	64	72
SR 568 - TR 237 to TR 245 (TR 245)	0	0	0	16	24	32	38	46
US 68 / SR 15 @ Eagle Creek (SR 15)	0	0	0	0	0	12	24	24
US 68 / SR 15 @ Eagle Creek (US 68)	0	0	0	12	24	24	24	26

	Program Road Closed (Flooding > 6 inches (Hours))							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	0	0	0	0	0	34	44	54
Main St - Center St to Sandusky St	0	0	0	0	0	34	46	52
Main St - Olive Street to SR 15	0	0	0	0	0	0	0	12
Main Cross St - Western Ave To Bright Rd 3	48	60	66	74	80	84	88	94
SR 37 - Main St to TR 205	0	0	0	0	0	0	24	40
SR 37 - CR 8 to TR 234	0	0	0	0	0	0	0	0
Sandusky St (SR568) - Main St to TR 237	0	0	0	36	48	56	60	64
SR 568 - TR 237 to TR 245 (TR 245)	0	0	0	0	0	0	38	46
US 68 / SR 15 @ Eagle Creek (SR 15)	0	0	0	0	0	0	0	0
US 68 / SR 15 @ Eagle Creek (US 68)	0	0	0	0	0	0	0	24

	Difference in Duration of Road Closure (Hours)							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	0	0	0	24	34	8	4	0
Main St - Center St to Sandusky St	0	0	24	40	46	18	10	10
Main St - Olive Street to SR 15	0	0	0	12	16	24	24	16
Main Cross St - Western Ave To Bright Rd 3	14	10	10	6	6	6	6	14
SR 37 - Main St to TR 205	0	0	24	24	38	44	24	14
SR 37 - CR 8 to TR 234	0	0	0	0	0	0	0	12
Sandusky St (SR568) - Main St to TR 237	0	26	40	14	6	4	4	8
SR 568 - TR 237 to TR 245 (TR 245)	0	0	0	16	24	32	0	0
US 68 / SR 15 @ Eagle Creek (SR 15)	0	0	0	0	0	12	24	24
US 68 / SR 15 @ Eagle Creek (US 68)	0	0	0	12	24	24	24	2

6.6 Change in Distance Traveled

Exhibit 6-4 estimates the number of vehicles impacted and changes in distance traveled due to detours. The exhibit calculates the number of vehicles impacted by multiplying the ADT by the duration of flooding in hours and dividing the result by 24 hours per day. It also displays the calculated changes in distance traveled. These values were developed by multiplying the number of vehicles impacted by the change in distance caused by the detour. Exhibit 6-4 provides results by flood frequency and road segment.

Exhibit 6-4: Number of Vehicles Impacted and Change in Distance Traveled

	Number of Vehicles Impacted							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	11,000	15,583	3,667	1,833	-
Main St - Center St to Sandusky St	-	-	18,000	30,000	34,500	13,500	7,500	7,500
Main St - Olive Street to SR 15	-	-	-	4,000	5,333	8,000	8,000	5,333
Main Cross St - Western Ave To Bright Rd 3	7,000	5,000	5,000	3,000	3,000	3,000	3,000	7,000
SR 37 - Main St to TR 205	-	-	5,000	5,000	7,917	9,167	5,000	2,917
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	2,000
Sandusky St (SR568) - Main St to TR 237	-	13,000	20,000	7,000	3,000	2,000	2,000	4,000
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	4,000	6,000	8,000	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	10,000	20,000	20,000
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	10,000	20,000	20,000	20,000	1,667

Name	Change in Distance Traveled (miles) 2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	12,100	17,142	4,033	2,017	-
Main St - Center St to Sandusky St	-	-	75,600	126,000	144,900	56,700	31,500	31,500
Main St - Olive Street to SR 15	-	-	-	31,200	41,600	62,400	62,400	41,600
Main Cross St - Western Ave To Bright Rd 3	21,700	15,500	15,500	9,300	9,300	9,300	9,300	21,700
SR 37 - Main St to TR 205	-	-	27,500	27,500	43,542	50,417	27,500	16,042
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	3,800
Sandusky St (SR568) - Main St to TR 237	-	205,400	316,000	110,600	47,400	31,600	31,600	63,200
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	63,200	94,800	126,400	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	82,000	164,000	164,000
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	27,000	54,000	54,000	54,000	4,500

6.7 Change in Vehicle Operating Cost

Exhibit 6-5 estimates the change in vehicle operating cost. The exhibit calculates change in vehicle operating cost by multiplying the changes in distance traveled by the IRS mileage rate. The exhibit provides results by flood frequency and road segment.

Exhibit 6-5: Change in Vehicle Operating Cost

Name	Change in Vehicle Operating Cost ($) 2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	6,474	9,171	2,158	1,079	-
Main St - Center St to Sandusky St	-	-	40,446	67,410	77,522	30,335	16,853	16,853
Main St - Olive Street to SR 15	-	-	-	16,692	22,256	33,384	33,384	22,256
Main Cross St - Western Ave To Bright Rd 3	11,610	8,293	8,293	4,976	4,976	4,976	4,976	11,610
SR 37 - Main St to TR 205	-	-	14,713	14,713	23,295	26,973	14,713	8,582
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	2,033
Sandusky St (SR568) - Main St to TR 237	-	109,889	169,060	59,171	25,359	16,906	16,906	33,812
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	33,812	50,718	67,624	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	43,870	87,740	87,740
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	14,445	28,890	28,890	28,890	2,408

6.8 Change in Time Traveled and Value of Time

Exhibit 6-6 estimates the change in time traveled due to detour and change in value of time. The exhibit shows the calculated change in time traveled. These values were developed by multiplying the number of vehicles impacted by the change in time the detour causes. The exhibit also shows the changes in value of time calculated by multiplying the change in time traveled by the value of time per hour. The exhibit provides results by flood frequency and road segment.

Exhibit 6-6: Change in Time Traveled

	Change in Time Traveled (minutes)							
Name	**2-Yr (50%)**	**5-Yr (20%)**	**10-Yr (10%)**	**25-Yr (4%)**	**50-Yr (2%)**	**100-Yr (1%)**	**200-Yr (.5%)**	**500-Yr (.2%)**
US 224 - CR 140 to I-75	-	-	-	99,000	140,250	33,000	16,500	-
Main St - Center St to Sandusky St	-	-	414,000	690,000	793,500	310,500	172,500	172,500
Main St - Olive Street to SR 15	-	-	-	112,000	149,333	224,000	224,000	149,333
Main Cross St - Western Ave To Bright Rd 3	182,000	130,000	130,000	78,000	78,000	78,000	78,000	182,000
SR 37 - Main St to TR 205	-	-	170,000	170,000	269,167	311,667	170,000	99,167
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	22,000
Sandusky St (SR568) - Main St to TR 237	-	754,000	1,160,000	406,000	174,000	116,000	116,000	232,000
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	232,000	348,000	464,000	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	380,000	760,000	760,000
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	200,000	400,000	400,000	400,000	33,333

Exhibit 6-7: Change in Value of Time

	Change in Value of Time ($)							
Name	**2-Yr (50%)**	**5-Yr (20%)**	**10-Yr (10%)**	**25-Yr (4%)**	**50-Yr (2%)**	**100-Yr (1%)**	**200-Yr (.5%)**	**500-Yr (.2%)**
US 224 - CR 140 to I-75	-	-	-	31,850	45,122	10,617	5,308	-
Main St - Center St to Sandusky St	-	-	133,193	221,988	255,287	99,895	55,497	55,497
Main St - Olive Street to SR 15	-	-	-	36,033	48,044	72,066	72,066	48,044
Main Cross St - Western Ave To Bright Rd 3	58,553	41,824	41,824	25,094	25,094	25,094	25,094	58,553
SR 37 - Main St to TR 205	-	-	54,693	54,693	86,597	100,270	54,693	31,904
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	7,078
Sandusky St (SR568) - Main St to TR 237	-	242,579	373,198	130,619	55,980	37,320	37,320	74,640
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	74,640	111,959	149,279	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	122,254	244,509	244,509
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	64,344	128,689	128,689	128,689	10,724

6.9 Change in Transportation Cost

Exhibit 6-7 estimates the change in transportation cost. The exhibit shows the change in transportation cost calculated by summing the change in vehicle operating cost and the change in value of time. The exhibit provides results by flood frequency and road segment.

Exhibit 6-7: Change in Transportation Cost

	Change in Transportation Cost ($)							
Name	2-Yr (50%)	5-Yr (20%)	10-Yr (10%)	25-Yr (4%)	50-Yr (2%)	100-Yr (1%)	200-Yr (.5%)	500-Yr (.2%)
US 224 - CR 140 to I-75	-	-	-	38,324	54,292	12,775	6,387	-
Main St - Center St to Sandusky St	-	-	173,639	289,398	332,808	130,229	72,350	72,350
Main St - Olive Street to SR 15	-	-	-	52,725	70,300	105,450	105,450	70,300
Main Cross St - Western Ave To Bright Rd 3	70,163	50,116	50,116	30,070	30,070	30,070	30,070	70,163
SR 37 - Main St to TR 205	-	-	69,405	69,405	109,892	127,243	69,405	40,486
SR 37 - CR 8 to TR 234	-	-	-	-	-	-	-	9,111
Sandusky St (SR568) - Main St to TR 237	-	352,468	542,258	189,790	81,339	54,226	54,226	108,452
SR 568 - TR 237 to TR 245 (TR 245)	-	-	-	108,452	162,677	216,903	-	-
US 68 / SR 15 @ Eagle Creek (SR 15)	-	-	-	-	-	166,124	332,249	332,249
US 68 / SR 15 @ Eagle Creek (US 68)	-	-	-	78,789	157,579	157,579	157,579	13,132

6.10 Results

Exhibit 6-8 estimates the average annual benefit (the change in transportation cost). The first column of the exhibit lists the flood frequencies. The second column lists the sum of the change in transportation costs from Exhibit 6-8. The final stage of the analysis (columns three through six) involves constructing a frequency-damage curve from the results of the change in transportation cost for each frequency. This involves the calculation of the average change in transportation cost, the probability of occurrence, the incremental occurrence and the average annual change in transportation cost. The sum of the average annual change over the eight frequencies provides the incremental average annual change in transportation cost, which is the estimate of the benefit. The annual average benefit of reducing flood related transportation detours is $219,027.

Exhibit 6-8: Average Annual Transportation Benefits

Flood Event	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Change
500	$ 716,242		0.002		
		$ 771,978		0.003	$ 2,316
200	$ 827,715		0.005		
		$ 914,157		0.005	$ 4,571
100	$ 1,000,599		0.01		
		$ 999,778		0.01	$ 9,998
50	$ 998,957		0.02		
		$ 927,955		0.02	$ 18,559
25	$ 856,953		0.04		
		$ 846,186		0.06	$ 50,771
10	$ 835,418		0.1		
		$ 619,001		0.1	$ 61,900
5	$ 402,584		0.2		
		$ 236,373		0.3	$ 70,912
2	$ 70,163		0.5		
Total average annual change:					**$ 219,027**

Chapter 7 Debris Removal, Relocations & Emergency Response

This chapter presents the rationale, methodology and results of the economic benefit resulting from reduction of Emergency Response expenses. These reductions occur when emergency responders from Hancock County, various Townships and the City of Findlay are able to avoid the expenses brought about by responses and rescues related to significant flood events. The flood damage expenses avoided may include water and flood-related rescues, utility damages, debris removal, costs associated with emergency shelters and temporary relocations for residents, government agencies and businesses, and other disaster related costs. The savings in emergency response expenditures constitutes a benefit of the Hancock County Flood Risk Reduction Program.

7.1 Rationale and Justification for Inclusion

The US Army Corps of Engineers (USACE) classifies emergency costs as nonphysical flood losses.[31] Emergency response costs are incurred by Federal, State, and local government agencies that provide emergency services and debris removal during a flood. Benefits accrue when the community avoids expenses for emergency services brought on by flooding. These may include, for example, costs of rescue, flood fighting and cleanup along with the costs of debris removal, resident evacuation and temporary housing, and first responders including police and fire. As noted by the USACE,

> *"Emergency costs include those expenses resulting from a flood that would not otherwise be incurred. For example, the costs of evacuation and reoccupation, flood fighting, and administrative costs of disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. Emergency costs should be determined by specific survey or research and should not be estimated by applying arbitrary percentages to the physical damage estimates."*[32]

The agency's Flood Risk Management report elaborates:

> *"Clean up and recovery costs include the cost of all labor and materials associated with cleaning up flood debris and damage, repairing damages, replacing evacuated and moved*

[31] Flood Risk Management. Institute for Water Resources Report 2013-R-05, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, June 2013.

[32] Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, Planning Guidance Notebook, ER 1105-2-100, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, 22 April 2000.

property, providing emergency food, water, shelter and medical expenses, policing and securing damaged areas, clearing roads, disposing of debris and other similar expenses."[33]

7.2 Estimation Methodology

This section describes the methodology used to estimate the economic benefit from reduced emergency expenses. The research team received a summary of Disaster Assistance funds distributed by FEMA for the 2007 flood in Findlay (not including Flood Insurance payments to businesses) from the Maumee Watershed Conservancy District Project Manager. The Ohio Emergency Management Agency (EMA) provided the information. [34] There are two sets of data, one covering loans and one covering public assistance.

7.2.1 Loans

Exhibit 7-1 provides the Hancock County loan funding that came from two sources, the Individuals and Households Program (IHP) and the Small Business Administration (SBA). The IHP provides financial help or direct services to those who have necessary expenses and serious needs if they are unable to meet those needs through other means. [35] The SBA provides federal disaster loan assistance to businesses, homeowners, nonprofits and renters.[36] The total loans issued in response to the 2007 flooding event summed to just under $20 million. The IHP funding represented 2,743 registrations of which 1,748 were approved for $7,234,176. The SBA funds covered 211 Home/Personal Property Loans totaling $6,798,400 and 69 Business Loans totaling $5,768,700.

Exhibit 7-1: Hancock County Loan Funding

				Small Business Administration (SBA)			
	Individuals and Households Program (IHP)			Home/Personal Property Loans		Business Loans	
County	Registrations	Approved	Amount				
Hancock	2,743	1,748	$7,234,176	211	$6,798,400	69	$5,768,700

Since the funds were loans and used primarily for structure and content damage, according to the Project Manager for the MWCD, these funds are not included in this part of the analysis. The simulations of the HEC-FDA model produce values for individual and household losses.

[33] Flood Risk Management. Institute for Water Resources Report 2013-R-05, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, June 2013.

[34] http://www.ema.ohio.gov/

[35] https://www.fema.gov/media-library/assets/documents/24945

[36] https://disasterloan.sba.gov/ela/Declarations

7.2.2 Public Assistance

The second funding source, representing $7,652,947.58 in public assistance, provided detail for Hancock County grant awards in response to the 2007 flood event. The data included the fund recipients, such as Blanchard Valley Health System and Findlay City Schools, and the breakdown by funding source, such as Federal, Administrative (federal) State or Local share.

The first column in Exhibit 7-2 provides the total public assistance for each entity. First, the research team assigned these expenses to one of four expense categories. The categories were debris removal and roadway and bridge impacts, emergency services, structure or content damage, and outside of the Flood Risk Reduction Program zone of influence.

Exhibit 7-2: Hancock County Grant Recipients by Jurisdiction and Damage Category

Jurisdiction	Total Grant Award	Debris Removal and Roadway and Bridge Impacts	Emergency Services	Structure and Content Damage	Outside of Program Influence
Amanda Township	$45,051	$45,051	$0	$0	$0
Blanchard Township	$5,471	$5,471	$0	$0	$0
Blanchard Valley Health System	$50,416	$0	$50,416	$0	$0
City of Findlay	$1,592,447	$1,592,447	$0	$0	$0
Delaware Township	$7,342	$7,342	$0	$0	$0
Findlay City Schools	$2,457,104	$0	$0	$2,457,104	$0
Findlay-Hancock Co. Public Library	$2,220,342	$0	$0	$2,220,342	$0
Hancock County Agency on Aging	$6,496	$0	$6,496	$0	$0
Hancock County Board of Elections	$130,431	$0	$0	$130,431	$0
Hancock County Board of MR/DD	$3,566	$0	$0	$3,566	$0
Hancock County Commissioners	$656,513	$0	$0	$656,513	$0
Hancock County Engineer	$195,774	$195,774	$0	$0	$0
Hancock County Fairgrounds	$19,787	$4,947	$0	$14,840	$0
Hancock County Health Dept.	$19,118	$0	$0	$19,118	$0
Hancock County Sheriff	$28,385	$0	$0	$28,385	$0
Hancock Park District	$14,995	$0	$0	$14,995	$0
Liberty Township	$13,590	$13,590	$0	$0	$0
Madison Township	$4,047	$0	$0	$0	$4,047
Marion Township	$18,375	$18,375	$0	$0	$0
Pioneer Club	$7,279	$0	$0	$7,279	$0
The Arts Partnership of Greater Hancock	$26,697	$0	$0	$26,697	$0
Village of Arlington	$78,236	$0	$0	$0	$78,236
Village of Jenera	$3,813	$0	$0	$0	$3,813
Village of Mt. Blanchard	$47,671	$0	$0	$0	$47,671
HANCOCK COUNTY TOTALS	**$7,652,948**	**$1,882,997**	**$56,912**	**$5,579,270**	**$133,768**

Second, the research team determined which of the entities were outside the area of influence of the Flood Risk Reduction Program based on geographic location. As shown in the rightmost column of Exhibit 7-2, expenses expended to jurisdictions outside of The Program influence totaled $133,768.

Third, to assign the remaining funds to the remaining three categories of Debris Removal and Bridge Impacts, Emergency Services and Structure and Content Damage, the research team collected FEMA damage applications as available from the Hancock County Historical Society and reviewed them to determine what the actual funding request was for.

The final total of emergency response costs from 2007 is $1,939,909, the sum of debris removal and emergency services in Exhibit 7-2. The analysis then updated the data from 2007 values to 2018 values using the U.S. Bureau of Labor Statistics (BLS) Consumer Price Index (CPI) Inflation Calculator. [37] The CPI inflation calculator uses the All Urban Consumers (CPI-U) U.S. city average series for all items, not seasonally adjusted. This data represents changes in the prices of all goods and services purchased for consumption by urban households. The analysis used the CPI change from February 2007 to February 2018. After accounting for inflation, the 2018 cost of emergency response is $2,373,574.

7.3 Results

This section provides the results related to the emergency response component of the BCA. In order to estimate the benefits, the research team made several assumptions. First, the research team removed funding for structure and contents damage to avoid double counting. Second, the research team assumed that the estimates included within the funding applications submitted in response to the 2007 flood event approximated these costs during a 1% ACE event. Third, a method was required to scale these estimates to other flood frequencies. Duration of road closures provides a reasonable proxy for debris removal and the research team chose to use hours of road closures as the proxy. Thus, the impacts were scaled to the other flood frequencies using the number of hours of road closures. Exhibit 7-3 provides the results of emergency response avoidance benefits under the existing and program scenarios.

The water surface elevation (WSE) reductions related to the Flood Risk Reduction Program were compared to the existing 1% ACE flood event. The Program improvements scenario saves $174,208 ($387,448 - $213,241) in incremental annual damages.

[37] U.S. Bureau of Labor Statistics, https://www.bls.gov/data/inflation_calculator.htm

Exhibit 7-3: Benefits of Avoidance of Emergency Response Expenses

Flood Event	Duration of Road Closures (hours)	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Annual Damage
Existing Conditions							
500	486	$ 3,035,676		0.002			
			$ 2,829,550		0.003	$ 8,489	
200	420	$ 2,623,424		0.005			
			$ 2,498,499		0.005	$ 12,492	
100	380	$ 2,373,574		0.01			
			$ 2,192,433		0.01	$ 21,924	
50	322	$ 2,011,292		0.02			
			$ 1,811,412		0.02	$ 36,228	
25	258	$ 1,611,532		0.04			
			$ 1,317,958		0.06	$ 79,077	
10	164	$ 1,024,385		0.1			
			$ 812,012		0.1	$ 81,201	
5	96	$ 599,640		0.2			
			$ 493,454		0.3	$ 148,036	
2	62	$ 387,267		0.5			
Total average annual damage:						$ 387,448	
Program							
500	386	$ 2,411,051		0.002			
			$ 2,142,463		0.003	$ 6,427	
200	300	$ 1,873,874		0.005			
			$ 1,586,547		0.005	$ 7,933	
100	208	$ 1,299,219		0.01			
			$ 1,049,370		0.01	$ 10,494	
50	128	$ 799,520		0.02			
			$ 743,303		0.02	$ 14,866	
25	110	$ 687,087		0.04			
			$ 549,670		0.06	$ 32,980	
10	66	$ 412,252		0.1			
			$ 393,514		0.1	$ 39,351	
5	60	$ 374,775		0.2			
			$ 337,297		0.3	$ 101,189	
2	48	$ 299,820		0.5			
Total average annual damage:						$ 213,241	**$ 174,208**

Chapter 8 Reduced NFIP Administrative Costs

This chapter presents the rationale, methodology and results of the economic benefit resulting from reduction of National Flood Insurance Program (NFIP) administrative costs. These reductions occur when structure owners are no longer required to purchase flood insurance or experience fewer flood events. The savings in administrative costs is a benefit of the flood mitigation program.

8.1 Rationale and Justification for Inclusion

The NFIP is a Federal program created by Congress in 1968 to mitigate future flood losses nationwide through sound, community-enforced building and zoning ordinances and to provide access to affordable, federally backed primary flood insurance protection for property owners. The NFIP provides an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.[38] One purpose is to reduce flood risk through the adoption of floodplain management standards.[39]

This section provides the rationale and justification for inclusion of savings in administrative costs for policies in the national flood insurance program. Owners of structures within the 1% Annual Chance Exceedance (ACE) (100-year) floodplain are required to purchase NFIP flood insurance. As with any insurance, the owners pay yearly premiums for the insurance policies regardless of whether they file claims. The NFIP program returns the majority of these premiums to the owners in the form of payments for claims. However, the program includes administrative costs that owners never recover. In essence, these administrative costs are "lost" each year.

The proposed Flood Risk Reduction Program will result in the removal of some of the structures from the 1% ACE (100-year) floodplain. The owners of these parcels will no longer be required to purchase NFIP insurance and therefore would not pay for certain administrative costs such as insurance agent's commissions and general overhead costs. The proposed Flood Risk Reduction Program also reduces the frequency that individual structures are flooded. This

[38] U.S. Department of Homeland Security. FEMA. National Flood Insurance Program. Answers to Questions about the NFIP. FEMA F-084. March 2011.

[39] Congressional Research Service. Introduction to FEMA's National Flood Insurance Program (NFIP). August 16, 2016.

reduces other administrative costs such as the cost of claim adjustment. Flood mitigation projects that eliminate the requirement to carry a flood insurance policy or reduce the claim administration burden provide benefits in the form of reduced NFIP administrative costs.

8.2 Estimation Methodology

This section describes the methodology used to estimate the benefit from reduced NFIP administrative costs. This methodology uses data on NFIP administrative costs and data on flooding of structures.

8.2.1 NFIP Administrative Costs

The USACE publishes guidance on NFIP administrative costs for flood projects.[40] The current updated operating cost per policy is $192. However, USACE has not updated the guidance memorandum since 2006. The research team was able to identify newer data from an actuarial rate review that the Federal Insurance and Mitigation Administration (FIMA) conducted.[41] In addition, recently an analyst at the National Water Management Center (NWMC) calculated the average administrative cost per policy in second quarter 2015 dollar terms.[42] This included the calculation of the 2005-2009 arithmetic mean, of price updated administrative costs, for each year. The NWMC price updated the FEMA data using Implicit Price Deflators for Gross Domestic Product published by the US Bureau of Economic Analysis. Using the same source, the research team further updated the table to fourth quarter 2017 dollar terms. [43]

Exhibit 8-1 provides the estimated cost of national flood insurance based on 2011 actuarial analysis. The top part of the exhibit provides the data that the NWMC extracted from the FEMA Actuarial report, the middle part of the exhibit provides the data the authors used to calculate the average administrative cost per policy, and the lower part of the exhibit provides the conversion to current dollars. Average administrative cost per policy in fourth quarter 2017 dollar terms is $321.69.

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[40] USACE, National Flood Insurance Program Operating Costs, Fiscal Year 2006, Memorandum For Planning Community Of Practice, Economic Guidance Memorandum 06-04, CECW-CP April 6, 2006.

[41] Actuarial Rate Review In Support of the Recommended October 1, 2011, Rate and Rule Changes; Thomas L. Hayes, ACAS, MAAA Actuary and D. Andrew Neal, FSA Actuary Federal Insurance and Mitigation Administration (FIMA).

[42] George Townsley, National Water Management Center, Personal Communication. April 19, 2016.

[43] Table 1.1.9. Implicit Price Deflators for Gross Domestic Product. 2017 Q4. Last revised on April 27, 2018. https://bea.gov/iTable/iTable.cfm?reqid=19&step=3&isuri=1&1921=survey&1903=13#reqid=19&step=3&isuri=1&1921=survey&1903=13

Exhibit 8-1: Estimated Cost of National Flood Insurance based on 2011 Actuarial Analysis

Item	2005	2006	2007	2008	2009	Mean: 2005-09
Actuarial Data						
1) Average Amount of Insurance per Policy	$170,683	$185,090	$196,009	$205,768	$213,659	$194,242
2) Earned Premium (A)	$1,967,567,898	$2,246,009,756	$2,538,508,566	$2,781,296,850	$2,975,306,740	$2,501,737,962
3) Losses Cost Incurred (B)	$17,574,729,866	$632,729,059	$605,120,360	$3,362,868,736	$727,585,902	$4,580,606,785
4A) Allocated Loss Adjustment Expense (ALAE)	$456,472,905	$28,755,619	$27,540,260	$129,548,476	$38,051,385	$136,073,729
4B) Special All. Loss Adjustment Expense (SALAE)	$41,507,953	$3,189,318	$2,935,928	$10,201,394	$1,948,928	$11,956,704
4C) Unallocated Loss Adjustment Expense (ULAE)	$558,464,178	$17,804,122	$16,757,316	$104,041,398	$19,172,477	$143,247,898
5) Loss Cost & LAE per Policy	$18,631,174,902	$682,478,119	$652,353,863	$3,606,660,004	$786,758,692	$4,871,885,116
6) Loss & LAE Ratio	9.469	0.304	0.257	1.297	0.264	$2
7A) Direct Agent Commission	$13,358,493	$13,404,745	$13,949,376	$14,608,696	$14,850,458	$14,034,354
7B) WYO Agent Commission Allowance	$281,776,692	$323,496,719	$366,826,909	$402,585,831	$431,445,553	$361,226,341
8A) Direct & Bureau General Expense	$54,800,000	$58,320,000	$68,753,000	$72,501,000	$81,315,000	$67,137,800
8B) Interest on 2005 Borrowing	$5,232,217	$523,535,548	$730,185,164	$811,515,698	$214,368,255	$456,967,376
8C) WYO Operating Allowance (w/o ULAE)	$326,860,963	$378,491,161	$406,566,491	$407,953,642	$437,198,160	$391,414,083
9) Earned Exposure (C)	4,657,365	5,132,786	5,463,375	5,587,482	5,616,311	$5,291,464
10) Average Premium	$422.46	$437.58	$464.64	$497.77	$529.76	$470
11) Average Operating Expense Other than Agent Commission & Loss Adjustment Expense	$83.07	$187.10	$220.65	$231.23	$130.49	$171
12) Average Agent Commission	$63.37	$65.64	$69.70	$74.67	$79.46	$71
13) Average Loss Cost & LAE per Policy	$4,000.37	$132.96	$119.40	$645.49	$140.08	$1,008
14) Underwriting Profit/(Deficit) per Policy	($3,724.34)	$51.88	$54.89	($453.61)	$179.72	$778
Calculation of Average Administrative Cost Per Policy						
Million Exposures	4.66	5.13	5.46	5.59	5.62	5.29
4) Allocated Loss Adjustment Expenses (ALAE)	$497,980,858	$31,944,937	$30,476,188	$139,749,870	$40,000,313	$148,030,433
4) Allocated Loss Adjustment Expenses (ALAE)/Exposures	$106.92	$6.22	$5.58	$25.01	$7.12	$30.17
10) Average Operating Other than Agent Commission & Loss Adjustsment Expense	$83.07	$187.10	$220.65	$231.23	$130.49	$170.51
11) Average Insurance Agents' Commission	$63.37	$65.64	$69.70	$74.67	$79.46	$70.57
Average Administrative Cost Per Policy	$253.36	$258.96	$295.93	$330.91	$217.07	$271.25
Conversion to Current Dollars						
GDP-IPD	91.543	94.587	97.194	98.995	99.895	114.352
Average Administrative Cost Per Policy (2017 QIV Dollar Terms)	$316.49	$313.08	$348.17	$382.25	$248.49	$321.69

For the period 2005 to 2009, the administrative cost consists of three major expenses:

- Loss Adjustment Expenses (ALAE)/Exposures ($30.17)
- Operating Expense ($170.51)
- Insurance Agents' Commission ($70.57)

Note that only the smallest category depends on whether a structure is flooded, while the bulk of administrative costs depends on whether there is a policy in place. If the structure is out of the 1% ACE (100-year) floodplain, the owner saves the administrative costs of the insurance policy. Therefore, the methodology derives the estimate of benefits by multiplying the number of structures removed from the 1% ACE (100-year) floodplain in each alternative by the NFIP administrative cost. The number of structures includes residences and businesses as stated in guidance provided by FEMA:

> "Flood insurance is available to homeowners for dwellings and contents, to businesses for buildings and contents, and to renters for contents."[44]

8.2.2 Number of Structures

The research team determined the number of structures currently within the 1% ACE (100-year) floodplain "Without Project" base case and the number protected from flooding in The Program case. Exhibit 8-2 provides the number of structures with total damage greater than zero for the 1% ACE (100-year) flood in the base case and Program scenarios. The earlier chapter on structures provides a detailed description of the development of these estimates.

Exhibit 8-2: Number of Structures with Total Damage Greater Than Zero for the 1% ACE Flood Event

Area	Base Case	The Program
Eagle Creek	504	50
Lye Creek	74	8
Blanchard River	947	146
TOTAL	**1,525**	**204**

[44] Now that you know, what are you going to do? FEMA Press Release: 1709-114. November 8, 2009. https://www.fema.gov/news-release/2007/11/08/now-you-know-what-are-you-going-do#. Accessed May 10, 2018.

8.3 Results

Exhibit 8-3 provides the calculation of the annual benefit for each alternative. The methodology multiplies tallies of residential structures no longer flooded in the 1% ACE (100-year) flood event by the average NFIP administrative cost. The average annual benefit for The Program is $424,952.

Exhibit 8-3: Benefits of Reduced NFIP Administrative Costs

Alternative	Structures Flooded in 100-Year Event	Reduced Number of Structures	NFIP Administrative Cost per Structure	Yearly Savings (Benefit)
Without project	1,525			
The Program	204	1,321	$321.69	$424,952

The reduction in average annual damages this chapter describes will occur as the community implements the flood reduction program. The reduction in average annual damages will then continue throughout the 50-year life of the program. The Results chapter at the end of this report describes and provides the calculation of the net present value of that stream of benefits.

Chapter 9 Business Losses

This chapter presents the rationale, methodology and results of the economic benefit resulting from reduction of business losses due to the implementation of flood protection measures contained in the *Hancock County Flood Risk Reduction Program*. These reductions occur when business structure owners are no longer impaired by recurring flooding events and do not have to close their businesses for an extended or temporary period of time. The reduction in business losses generated from flood protection measures is a benefit of the flood mitigation program.

9.1 Rationale and Justification for Inclusion

The USACE report quotes its own guidance informing how lost wages should be included over and above physical flood damages. The guidance goes on to explain the method to derive those estimates. However, lost income or lost wages do not appear to be included in "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)" results. The National Economic Development (NED) Manual classifies income loss under non-physical damage.[45] The manual defines it as *"the loss of wages or net profits to businesses over and above physical flood damages. It results from a disruption of normal activities that cannot be recouped from other businesses or from the same business at another time. Prevention of income loss can be counted as a national benefit only to the extent that such loss cannot be offset by postponement of an activity or transfer of the activity to other establishments."*[46]

Under some conditions, income loss is an NED benefit. The NED Manual states *"Income losses are reductions in the national income when flooding or the threat of flooding halts production or delivery of goods and services. National losses occur 1) when the production or delivery of these goods and services are not recuperated by postponing the activity or transferring it to another location, or, 2) when there are additional costs caused by delay or transfer of the activity. Income losses are incurred by businesses and labor as a result of flood induced shut-down in the production and delivery of goods and services. These losses can occur at any time during three periods: 1) flood warning, when business operations shut down and effort concentrates on damage prevention and evacuation; 2) flood inundation, when flood fighting and evacuation continues; and, 3) cleanup and restoration, when there may be a phasing in of normal activity. Even the threat of flooding can cause shut down of business operations for extended periods along large river basins. Inundation can vary from several hours to over a week, depending on the sources of flooding. Income losses may occur directly to the business or institution being*

[45] USACE. National Economic Development Procedures Manual – Urban Flood Damage. 1988 Section VII-2.

[46] Ibid.

flooded. Losses may occur indirectly when roads are closed and public utilities are cut off. Business losses can also occur from the spoilage of perishable commodities and when their processing or distribution are [sic] interrupted by flooding. Income losses also include any additional transportation or production costs that occur from transferring production from one area to another."[47]

9.2 Estimation Methodology

This section describes the methodology used to estimate the benefit from reduced business losses in Hancock County generated by the Hancock County Flood Risk Reduction Program. It is structured in three main parts: Business Loss Categories, Business Loss Recovery Rate and Final Methodology.

9.2.1 Business Loss Categories

The U.S. Army Corps of Engineers (USACE), Buffalo District, previously published a report in November 2015 entitled "The Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)." The business loss benefit category and methodology uses data on business losses and flooding of business structures captured in a survey called "Commercial and Industrial Flood Damage Survey Findlay, OH", (Survey), which was part of the aforementioned report.[48] The Survey included 431 businesses responses, which the study team used to estimate the business losses for this BCA. In order to generate the business loss results, the research team extracted the following three response categories from the Survey:

1. Loss of Net Income
2. Cost of Cleanup
3. Cost of Emergency Plan

Please note that all the above categories and the respective values represent estimates made by the business owners who responded to the Survey. Furthermore, the research team made several assumptions in order to provide for a conservative estimate of business losses. First, the team considered losses of net income as losses in sales, which is a more conservative approach. This is because sales are much larger than net income, including taxes, fees, cost of goods sold, and other business expenses such as labor and rent. The project team made this assumption because it appeared that some respondents may have reported sales rather than net income. Second, the study team assumed that the responses the Survey collected represent the entirety of all business activities in Hancock County. Since the Survey included 431 responses and there

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[47] Ibid.

[48] Office of Budget and Management (OMB), Commercial and Industrial Flood Damage Survey Findlay, OH, OMB Control Number 0710-0001

are over 1,500 businesses in Hancock County, this approach neglects possible additional business losses that may occur in the case of a flooding event or have occurred during flooding events in the past. Therefore, this approach is more conservative than an extrapolation of business losses to the total of 1,500 businesses. Exhibit 9-1 shows an illustration of the types of responses that were posted on the Survey.[49] It includes the following columns: *Has the facility flooded in the past? (Y/N)*, *Loss of Net Income*, *Cost of Cleanup* and *Estimated Cost of Emergency Plan*.

Exhibit 9-1: Extract of Business Loss Category Questions

Has the Facility flooded in the past? (Y/N)	Loss of Net Income	Cost of Cleanup	Estimated cost of emergency plan
Y	-	$ -	$ 1,000
Y	-	$ -	$ 200
Y	-	$ 7,000	$ 1,000
No	-	-	-
Y	$ 300,000	$ 30,000	-
Y	-	$ 1,000	$ 5,000
Y	-	$ 5,000	$ 75
Y	-	$ -	$ 200
Y	$ 3,000	$ 4,000	$ 6,000
Y	$ 7,000	$ 4,000	$ 1,000
Y	-	$ -	$ 200
Y	-	$ -	$ 3,000
Y	$ 200,000	$ 300,000	$ 500
Y	-	$ 200	$ 7,000
No	-	-	-
Y	-	$ 500,000	-
Y	-	$ 2,500	-
Y	$ 400	$ 300	$ 30
No	-	-	-
Y	-	$ 22,000	$ 400
Y	$ 35,000	$ 500	$ 500
Y	$ 25,000	$ 15,000	$ 1,010
Y	-	$ 500	$ 50

[49] For illustrative purposes only. Not exact responses from the USACE Survey.

9.2.2 Business Loss Recovery Rate

It is common that businesses are able to recover temporary business losses caused by flooding later on. Therefore, the research team generated an average business loss recovery rate and applied it to the estimated business losses in order to provide for meaningful benefit results in this category.

For this purpose, the team used most recent data from a new on-line business survey that the Program Team conducted in Hancock County to estimate the business loss recovery rate for this benefit category. Based on the current business survey, the JFA team created the following formula to estimate the average business loss recovery rate:

$$Business\ Loss\ Recovery\ Rate = \frac{\left(\left(\frac{100+91}{2}\right)*21\right)+\left(\left(\frac{90+75}{2}\right)*5\right)+\left(\left(\frac{0+74}{2}\right)*16\right)}{42}$$

The numbers highlighted in yellow represent the number of businesses that estimated their business loss recovery rate in one of the following three brackets:

1. 91-100% (21 responses)
2. 75-90% (5 responses)
3. 0-74% (16 responses)

The number that is highlighted in green represents the total amount of responses for business loss recovery rates included in the recent business survey. JFA used these responses because they represent the most recent data on business loss recovery in Hancock County.

This formula results in an average business loss recovery rate of 71.67%. The JFA team used this average in the *Final Methodology* section to generate the final benefit results for this benefit category.

9.2.3 Final Methodology

This section brings together the Business Loss Categories and Business Loss Recovery Rate sections to provide a concise overview of the final methodology the research team utilized to generate the benefits for this category. In order to generate the business loss results, the research team extracted the following three business loss categories from the Survey:

1. Loss of Net Income
2. Cost of Cleanup
3. Cost of Emergency Plan

This section is structured based on these three business loss categories. The *Cost of Cleanup* and *Cost of Emergency Plan* are direct expenses that the respective businesses would not have to incur if there was no flooding event. Therefore, they can be summed up as direct benefits, since they represent a reduction of business expenses. This section describes the methodology for business loss category 2 (Cost of Cleanup) and 3 (Cost of Emergency Plan) first. Exhibit 9-2 shows the totals for both of these business loss categories. Please note that these figures were extracted directly from the Survey and reflect 2007 dollar values. This approach provides a conservative estimate, since the figures would be higher in 2018 dollars.

Exhibit 9-2: Total Costs of Cleanup and Emergency Plan in 2007 Dollars

Data Point	Total
Total Cost of Cleanup	$ 7,316,873
Estimated Cost of Emergency Plan	$ 1,386,061

The team did not apply the Business Loss Recovery Rate to these *Costs of Cleanup and Emergency Plan* since the businesses that incurred expenses for these two categories cannot recoup these expenses through regular business activities.

Next, the project team calculated the Loss Value Added, a measure similar to gross national product (GNP) but at the local level. Exhibit 9-3 shows the total dollar amount for Loss of Sales Income based on the USACE Survey. Since this research effort is only interested in the economic value that was lost due to the flooding event in 2007, the total amount of Loss of Sales requires several adjustments.

Exhibit 9-3: Total Loss of Sales

Data Point	Total
Total Loss of Sales	$ 6,393,892

The first set of adjustments was to run the sales data through the IMPLAN model to calculate changes in the value added that would result from the direct, indirect and induced economic activity generated by those sales. For this purpose, the research team assigned each Loss of Net Income response collected in the survey to an IMPLAN code. IMPLAN is an economic model that estimates the final amount of Value Added for the Business Losses Category “Loss of Net Income.” Exhibit 9-4 shows an example extract of the single survey responses with the according IMPLAN code, business description and Loss of Net Income dollar amount.

Exhibit 9-4: Example Extract of Loss of Net Income Responses Coded to IMPLAN Sectors

All Assigned IMPLAN Codes	IMPLAN Description	Loss of Net Income
399	Retail - Building material and garden equipment and supplies stores	$ 60,000
400	Retail - Food and beverage stores	$ 10,000
509	Personal care services	$ 20,000
509	Personal care services	$ 1,500
509	Personal care services	$ 2,000
499	Hotels and motels, including casino hotels	$ 50,000
406	Retail - Miscellaneous store retailers	$ 400

Finally, the team summed up the dollar amount for each IMPLAN sector and ran it through the IMPLAN Model. Exhibit 9-5 provides an example extract of the records for final IMPLAN concordance.

Exhibit 9-3: Extract of Final IMPLAN Concordance

All Assigned IMPLAN Codes	Sales By IMPLAN Sector
56	$ 10,000
58	$ 20,000
59	$ 10,000
166	$ 60,000
394	$ 3,300
395	$ 4,000
396	$ 76,000
398	$ 10,000
399	$ 138,750
400	$ 185,600
401	$ 47,000
403	$ 14,000
404	$ 10,000
406	$ 164,900
416	$ 55,750

As a last step, the research team applied the business loss recovery rate of 100%-76.67%=28.33% to the IMPLAN results.

9.3 Results

This section provides the benefits or costs avoided from the program improvements. In order to estimate the benefits the research team made several assumptions. First, the research team assumed that the 2007 estimates approximated these costs during a 1% annual chance event (ACE). Second, a method was required to scale these estimates to other flood return frequencies. Duration of road closures provides a reasonable proxy for Loss of Net Income as it measures the inability of customers and employees to travel and conduct commerce. For the other two categories, Costs of Cleanup and Costs of Emergency Plan, the research team utilized the number of flooded commercial and industrial buildings for each return frequency.

Exhibit 9-6 provides the results of avoided business loss benefits (Average Annual Damages – AAD) under The Program scenario for Business Loss Category 1, Loss of Net Income.

Exhibit 9-4: Results for Business Loss Category 1, Loss of Sales

Flood Event	Duration of Road Closures (hours)	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Average Annual Damage
Existing Conditions							
500	486	$ 1,266,224		0.002			
			$ 1,180,246		0.003	$ 3,541	
200	420	$ 1,094,268		0.005			
			$ 1,042,160		0.005	$ 5,211	
100	380	$ 990,052		0.01			
			$ 914,495		0.01	$ 9,145	
50	322	$ 838,939		0.02			
			$ 755,566		0.02	$ 15,111	
25	258	$ 672,193		0.04			
			$ 549,739		0.06	$ 32,984	
10	164	$ 427,286		0.1			
			$ 338,702		0.1	$ 33,870	
5	96	$ 250,118		0.2			
			$ 205,827		0.3	$ 61,748	
2	62	$ 161,535		0.5			
Total average annual damage:						$ 161,610	
The Program							
500	386	$ 1,005,684		0.002			
			$ 893,652		0.003	$ 2,681	
200	300	$ 781,620		0.005			
			$ 661,772		0.005	$ 3,309	
100	208	$ 541,923		0.01			
			$ 437,707		0.01	$ 4,377	
50	128	$ 333,491		0.02			
			$ 310,043		0.02	$ 6,201	
25	110	$ 286,594		0.04			
			$ 229,275		0.06	$ 13,757	
10	66	$ 171,956		0.1			
			$ 164,140		0.1	$ 16,414	
5	60	$ 156,324		0.2			
			$ 140,692		0.3	$ 42,207	
2	48	$ 125,059		0.5			
Total average annual damage:						$ 88,946	**$ 72,665**

Exhibit 9-7 provides the results of avoided business loss benefits under The Program scenario for Business Loss Category 2, Costs of Cleanup.

Exhibit 9-5: Results for Business Loss Category 2, Costs of Cleanup

Flood Event	of Commercial and Industrial Buildings	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Average Annual Damage
Existing Conditions							
500	333	$ 15,421,004		0.002			
			$ 13,267,621		0.003	$ 39,803	
200	240	$ 11,114,237		0.005			
			$ 9,215,555		0.005	$ 46,078	
100	158	$ 7,316,873		0.01			
			$ 5,904,439		0.01	$ 59,044	
50	97	$ 4,492,004		0.02			
			$ 3,450,045		0.02	$ 69,001	
25	52	$ 2,408,085		0.04			
			$ 1,875,528		0.06	$ 112,532	
10	29	$ 1,342,970		0.1			
			$ 926,186		0.1	$ 92,619	
5	11	$ 509,403		0.2			
			$ 324,165		0.3	$ 97,250	
2	3	$ 138,928		0.5			
Total average annual damage:						$ 516,326	
The Program							
500	111	$ 5,140,335		0.002			
			$ 3,727,900		0.003	$ 11,184	
200	50	$ 2,315,466		0.005			
			$ 1,736,600		0.005	$ 8,683	
100	25	$ 1,157,733		0.01			
			$ 856,722		0.01	$ 8,567	
50	12	$ 555,712		0.02			
			$ 463,093		0.02	$ 9,262	
25	8	$ 370,475		0.04			
			$ 254,701		0.06	$ 15,282	
10	3	$ 138,928		0.1			
			$ 92,619		0.1	$ 9,262	
5	1	$ 46,309		0.2			
			$ 46,309		0.3	$ 13,893	
2	1	$ 46,309		0.5			
Total average annual damage:						$ 76,133	**$ 440,193**

Exhibit 9-8 provides the results of avoided business loss benefits under The Program scenario for Business Loss Category 3, Costs of Emergency Plan.

Exhibit 9-6: Results for Business Loss Category 3, Costs of Emergency Plan

Flood Event	of Commercial and Industrial Buildings (Flood	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage	Incremental Average Annual Damage
Existing Conditions							
500	333	$ 2,921,255		0.002			
			$ 2,513,332		0.003	$ 7,540	
200	240	$ 2,105,409		0.005			
			$ 1,745,735		0.005	$ 8,729	
100	158	$ 1,386,061		0.01			
			$ 1,118,499		0.01	$ 11,185	
50	97	$ 850,936		0.02			
			$ 653,554		0.02	$ 13,071	
25	52	$ 456,172		0.04			
			$ 355,288		0.06	$ 21,317	
10	29	$ 254,404		0.1			
			$ 175,451		0.1	$ 17,545	
5	11	$ 96,498		0.2			
			$ 61,408		0.3	$ 18,422	
2	3	$ 26,318		0.5			
Total average annual damage:						$ 97,809	
The Program							
500	111	$ 973,752		0.002			
			$ 706,189		0.003	$ 2,119	
200	50	$ 438,627		0.005			
			$ 328,970		0.005	$ 1,645	
100	25	$ 219,313		0.01			
			$ 162,292		0.01	$ 1,623	
50	12	$ 105,270		0.02			
			$ 87,725		0.02	$ 1,755	
25	8	$ 70,180		0.04			
			$ 48,249		0.06	$ 2,895	
10	3	$ 26,318		0.1			
			$ 17,545		0.1	$ 1,755	
5	1	$ 8,773		0.2			
			$ 8,773		0.3	$ 2,632	
2	1	$ 8,773		0.5			
Total average annual damage:						$ 14,422	**$ 83,387**

Finally, Exhibit 9-9 summarizes the AAD and incremental AAD avoided which represent the benefits of the three Business Loss Categories. Please note that the table contains standard dollar values, as opposed to other tables in this report. The Program improvements scenario reduces annual damages by $596,245 over existing conditions. This is called the incremental annual damages avoided shown in the column labeled IAAD in Exhibit 9-9.

Exhibit 9-7: Business Losses Final Results: AAD and IADA Avoided

Average and Incremental Annual Damages Avoided			
	AAD		IAAD
Category and Scenario	Existing Conditions	The Program	
Loss of Net Income	$ 161,610	$ 88,946	$ 72,665
Cost of Cleanup	$ 516,326	$ 76,133	$ 440,193
Cost of Emergency Plan	$ 97,809	$ 14,422	$ 83,387
Total	**$ 775,745**	**$ 179,501**	**$ 596,245**

In each case, the AAD avoided is the basis for the Net Present Value of damages or costs avoided over the 50-year analysis period of the Hancock County Flood Risk Reduction Program.

Chapter 10 Agricultural Damages Avoided

This chapter presents the agricultural damages avoided by the Hancock County Flood Risk Reduction Program. The first section describes the rationale and justification for inclusion of agricultural damages in a benefit cost analysis. The second section explains the methodology used to calculate the costs and benefits.[50] The third section presents the results of the benefit cost analysis.

10.1 Rationale and Justification for Inclusion

Ponding and flooding can damage crops, but the extent of the damage depends on the type of plant, growth stage, air temperature, and the duration of the flooding.[51] In general:

- Plants with some growth above the water level are more likely to survive.
- A warmer mid-summer flood increases the rate of damage and death to submerged plants, whereas plants can survive longer under water during a colder spring flood.
- Plants that encounter flash-flooding, where the water rises and recedes quickly, are more likely to survive than longer-duration flooding.

The agricultural analysis focuses on Hancock County, where the primary crops grown are soybeans, corn, and wheat.

Soybeans can generally survive for 2 to 4 days when completely submersed. The actual time frame depends on air temperature, cloud cover, soil moisture conditions prior to flooding, and rate of soil drainage. Cool air temperatures and cloudy days increase the survival of a flooded soybean crop; whereas in temperatures of 80 degrees Fahrenheit or above, soybean plants may only survive a few days. Increased soil moisture conditions prior to flooding and a decreased rate of soil drainage contribute to the buildup of toxins and carbon dioxide, which is more damaging to plants than lack of oxygen.

The plant stage of development when ponding occurs, the duration of ponding, and the air temperature determine the extent to which flooding damages corn crops. Prior to the 6-leaf collar stage or when the growing plant is at or below the soil surface, corn can usually survive only 2 to 4 days of flooded conditions. If the air temperature is greater than 77 degrees Fahrenheit during ponding, corn plants may not survive 24 hours, but cooler air temperatures

[50] The research team received detailed spreadsheets, modeling program and a draft write-up of this chapter from the USACE. The research team relied extensively on these materials.

[51] Exhibit 10-2 and the discussion of that exhibit provide the sources this study used to estimate potential reduction in yield from flooding by crop.

(mid-60s or cooler) can prolong survival up to about 4 days. Also, once the growing point is above the water level, the likelihood for survival improves greatly.

The most significant factor affecting wheat during a flooding event is air temperature. During summer conditions, 2 to 3 days of flooding can impact plant growth. If the air temperature is above 65 degrees Fahrenheit and the plants are below water for more than 5 to 7 days, the wheat crops will not survive. There is limited information on the effect of flooding on wheat when temperatures are below 40 degrees Fahrenheit. Under cooler temperatures, the negative effects of flooding take longer to impact plant tissues, so winter wheat can tolerate flooding beyond the limits described above for summer conditions.

10.2 Methodology

Resources published by the USDA National Water Management Center describe the methodology applied to evaluate flood damages to crops. The resources are available online.[52] The agricultural damages estimation used the following basic data:

- The U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS) data sources provided land use, average crop production (bushels per acre), and crop progress and condition by month in Hancock and Putnam Counties.
- The Agricultural Resource Management Survey (ARMS) provided costs of farm operation per acre (crop production costs). ARMS is jointly sponsored by USDA's Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS),
- The USDA Economic Research Service provided the 2016 normalized value of production per acre by county and crop (based on 5-year lagged averages of actual market prices).
- Weather Spark provided air temperature ranges and probabilities by month.
- Floodwater damage percentages indicate the average loss of yield by month compared to flood-free conditions. The percentages vary according to the depth and the duration of the flood event. The Hancock County Soil and Water Conservation District vetted these estimates with USACE.
- The Stantec team estimated the number of acres flooded for the with- and without-project conditions for each of the return frequencies.

The method for calculating agricultural benefits began with the identification of land use and cropping patterns. The study focused on the three primary crops grown in the study area:

[52] USDA, Natural Resources Conservation Service, National Water Management Center. Flood Damage Assessment Tools. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/nwmc/partners/?&cid=nrcs143_009725

soybeans, corn, and wheat. The analysis assumed that the crop distribution remained constant over the period of analysis for each alternative. The analysis used the following crop distribution for Hancock County:

- 54 percent soybeans
- 36 percent corn
- 8 percent wheat

These data come from the 2012 Census of Agriculture.[53]

Stantec provided data sourced from hydraulic modeling in conjunction with GIS to provide the number of acres flooded. The research team distributed the damage by duration (less than one day, 1 to 2 days, 2 to 3 days, and more than 3 days) for each flood recurrence interval using data from the previous USACE study. The research team calculated the areas flooded under exiting conditions and under The Program. Exhibit 10-1 shows, for each flood stage, the area flooded under existing conditions and The Program, as well as the acres removed from flooding.

Exhibit 10-1: Acres Flooded and Protected by Flood Stage

Flood Stage (yr)	Area Flooded (Acres)		
	Existing Conditions	The Program	Reduction in Area Flooded
2	3,116	2,525	591
5	4,090	3,104	986
10	5,015	3,608	1,407
25	6,165	4,252	1,914
50	7,025	4,760	2,265
100	7,906	5,312	2,594
200	8,691	6,408	2,283
500	9,854	7,560	2,294

The analysis identified the acres as soybean, corn or wheat crops according the crop distribution. The damages were valued by analyzing the production function of farm land under the with- and without-project alternatives. Assuming the cropping pattern did not change; the

[53] U.S. Department of Agriculture, 2012 Census Volume 1, Chapter 2: County Level Data (Ohio). Accessed at: http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Ohio/

benefit was determined by using the applicable farm budget and the likelihood of a yield loss and/or need for replanting according to each month of the year.

The reduction in crop yield as a result of flooding was estimated from publications and work on other studies (Butzen, 2010; Elmore and Abendroth, 2008; Nielsen, 2011; Pedersen, 2008; Ransom, 2009; Thomison, 2012), but primarily from the USDA Natural Resources Conservation Service study, *Final Supplementation Watershed Plan No. 1 and Environmental Assessment for Big Slough Watershed.* Exhibit 10-2 presents the anticipated reduction in yield, which accounts for the impacts of air temperature, crop progress by month, and whether there is an opportunity to replant the crop. Flooding durations less than the amount described above would have minimal impacts on the yield.

Exhibit 10-2: Potential Reduction in Yield from Flooding

Month	Soybeans	Winter Wheat	Corn
January	No loss	100% yield loss	No loss
February	No loss	100% yield loss	No loss
March	No loss	100% yield loss	No loss
April	Replanting	100% yield loss	Replanting
May	Replanting	100% yield loss	Replanting & 25% yield loss
June	Replanting & 25% yield loss	10–65% yield loss	50–75% yield loss
July	50–100% yield loss	0% loss	100% yield loss
August	100% yield loss	0% loss	100% yield loss
September	65–100% yield loss	Replanting	60–85% yield loss
October	10–65% yield loss	Replanting	25–50% yield loss
November	0–5% yield loss	25% yield loss	10–30% yield loss
December	No loss	40–100% yield loss	No loss

Exhibit 10-3 provides production values, operating costs, replanting costs and overhead for corn, soybean and wheat production per planted acre in for 2017. Soybeans were the most profitable crop followed by corn and wheat, as valued by calculating production less operating costs. The data are from the U.S. Department of Agriculture, Commodity Costs and Returns.[54]

[54] Commodity Costs and Returns, U.S. Department of Agriculture, Economic Research Service, accessed at: https://www.ers.usda.gov/data-products/commodity-costs-and-returns/

Exhibit 10-3: 2017 Production Values and Returns in the Program Area

Item	Corn	Soybeans	Wheat
Gross value of production			
Primary product	651.24	492.37	345.19
Secondary product	0.84		5.96
Total, gross value of production	652.08	492.37	351.15
Operating costs:			
Seed	103.48	57.22	27.08
Fertilizer	119.64	25.28	72.16
Chemicals	36.12	27.15	9.56
Custom operations	23.33	9.52	12.23
Fuel, lube, and electricity	24.62	11.24	9.40
Repairs	31.22	19.89	15.72
Purchased irrigation water	0.00	0.00	0.52
Interest on operating capital	1.78	0.79	0.77
Total, operating costs	340.19	151.09	147.44
Replanting Cost	282.72	129.25	130.19
Allocated overhead:			
Hired labor	3.21	1.95	1.84
Opportunity cost of unpaid labor	20.27	17.65	19.55
Capital recovery of machinery and equipment	120.25	84.01	73.65
Opportunity cost of land (rental rate)	195.75	177.60	136.88
Taxes and insurance	11.56	11.09	7.73
General farm overhead	17.17	18.74	14.24
Total, allocated overhead	368.21	311.04	253.89
Total, costs listed	708.40	462.13	401.33
Value of production less total costs listed	-56.32	30.24	-50.18
Value of production less operating costs	311.89	341.28	203.71
Supporting information:			
Yield (bushels per planted acre)	201.00	53.00	68.90
Price (dollars per bushel at harvest)	3.24	9.29	5.01
Enterprise size (planted acres)	307.00	268.00	101.00

The analysis calculated replanting costs by summing costs per seed, fertilizer, chemicals, hired labor and opportunity cost of unpaid labor.

The analysis calculated full damages (complete loss of crop) for each month by multiplying the average value of the crop per acre and adding the replanting cost (Exhibit 10-3), if necessary, by the percentage yield loss. The analysis assumes damages would occur in two scenarios, in the case where there was 2 to 3 days of flooding, or in the case where there was more than 3 days of flooding.

To estimate the damages for each of these scenarios and each flood event, the analysis multiplies the full damages for each month by the corresponding probability that each flood event would occur in that particular month. The probability that a flood event would occur in a particular month uses data from the U.S. Geological Survey (USGS). Project analysts obtained gage data (maximum per day) for USGS site 04189000 (Blanchard River near Findlay OH) for 1924 to 2016. The analysts sorted the data and found when flow was higher than 3,000 cfs for unique years. Exhibit 10-4 provides the frequency of occurrence of maximum yearly peak discharge by month for period 1923 to 2011.

Exhibit 10-4: Frequency of Occurrence of Maximum Yearly Peak Discharge by Month 1924-2016

Month	Number of Maximum Events	Percent of Total
January	14	12.8%
February	12	11.0%
March	15	13.8%
April	13	11.9%
May	10	9.2%
June	10	9.2%
July	8	7.3%
August	1	0.9%
September	6	5.5%
October	1	0.9%
November	5	4.6%
December	14	12.8%
Total	**109**	**100.0%**

The analysis then multiplies the damages for each scenario by the corresponding number of acres damaged for each crop and for each flood event. The NED benefit is the net increase in yield attributable to a with-project alternative.

10.3 Results

This section presents the results of the benefit cost analysis in the base case (no action alternative) and the Final Program cases. Exhibit 10-4 shows the average annual damage in the Base Case and The Program scenarios for each modeled ACE flooding event. The average annual damage in the no project or base case was $63,133. With the Final Program in place, the average annual damage fell to $49,758. The incremental average annual damage avoided would then be $13,375, representing the difference between the two averages.

Exhibit 10-5: Flood Damage by Event in Base Case and Full Program Scenarios

Flood Event	Total Damage	Average Damage	Probability of Occurrence	Incremental Occurrence	Average Annual Damage
Without Project					
500	$ 1,228,058		0.002		
		$ 1,040,292		0.003	$ 3,121
200	$ 852,527		0.005		
		$ 739,032		0.005	$ 3,695
100	$ 625,538		0.01		
		$ 564,827		0.01	$ 5,648
50	$ 504,116		0.02		
		$ 469,373		0.02	$ 9,387
25	$ 434,629		0.04		
		$ 347,014		0.06	$ 20,821
10	$ 259,398		0.1		
		$ 144,122		0.1	$ 14,412
5	$ 28,846		0.2		
		$ 20,161		0.3	$ 6,048
2	$ 11,476		0.5		
Total Average Annual Damage:					**$ 63,133**
The Program					
500	$ 948,656		0.002		
		$ 791,335		0.003	$ 2,374
200	$ 634,014		0.005		
		$ 549,340		0.005	$ 2,747
100	$ 464,666		0.01		
		$ 423,895		0.01	$ 4,239
50	$ 383,124		0.02		
		$ 354,769		0.02	$ 7,095
25	$ 326,414		0.04		
		$ 265,577		0.06	$ 15,935
10	$ 204,740		0.1		
		$ 115,497		0.1	$ 11,550
5	$ 26,254		0.2		
		$ 19,396		0.3	$ 5,819
2	$ 12,539		0.5		
Total Average Annual Damage:					**$ 49,758**
Incremental Average Annual Damage Avoided:					**$ 13,375**

Chapter 11 Environmental and Land Use Benefits

This chapter presents the environmental benefits of changes in land use resulting from the purchase and conversion of land and properties to facilitate the implementation of the Flood Risk Reduction Program. It includes the rationale and justification for including these benefits and the methodology used to calculate the economic benefits resulting from the purchases.

11.1 Rationale and Justification for Inclusion

This section provides the rationale and justification for inclusion of environmental land use benefits in the BCA. Environmental benefits are an important component of flood protection benefits. FEMA guidance contends specified types of environmental benefits may be realized when land is returned to open space uses. The purchase of land is a significant cost attributed to the Hancock County Flood Risk Reduction Program. However, new uses of the purchased properties provide economic benefits.

FEMA allows consideration of Environmental Benefits in the Evaluation of Acquisition Projects under its Hazard Mitigation Assistance (HMA) Programs.[55] Therefore, this project, in accordance with the FEMA guidance, includes environmental benefits in the benefit cost analysis (BCA). The objective is to determine the benefits and costs under The Program.

11.2 Estimation Methodology

This section describes the methodology used to estimate the environmental land use benefits from the flood mitigation project. The City of Findlay and Hancock County purchased approximately 150 properties damaged in prior flooding. In addition, the proposed project will include the purchase, use, and conversion of lands among various land use types. Each of these land acquisitions and conversions may provide environmental benefit beyond the avoidance of structure damage. Changes in land value are benefits of newly protected lands from the base case to The Program.

The estimation methodology relies upon environmental values of different land use classes that FEMA developed. The analysis couples these values with data Stantec provided the research

[55] U.S. Department of Homeland Security, "Consideration of Environmental Benefits in the Evaluation of Acquisition Projects under the Hazard Mitigation Assistance (HMA) Programs," FEMA Mitigation Policy – FP-108-024-01, June 18, 2013.

team on the acreage of the converted lands for four types of land use classifications. The four pre-flood and post-flood mitigation land classifications are:

- **Riparian Areas** - Similar to Green Open Space but the lot is located along a water feature such as the stream, creek, or river. These areas serve as a buffer to improve water quality entering the stream, as well as reducing erosion potential
- **Green Open Space** - Defined as land allowed to revert to a natural state or be converted into park-like settings
- **Agricultural Land** - The third type of post-mitigation land use assumes a portion of the acquired land remains agricultural and is either leased or sold back for agricultural purposes
- **Woods/Shrubs -** The projects converts some areas from woods and shrubs to other land use, while leaving some areas in that state. This analysis classifies this land in the forest category.

11.2.1 Environmental Land Values

Land values were required for the four types of land affected by this project. The source for land values in this study was FEMA. FEMA guidance provides values for two of the types of land analyzed in the project. The report states:

> "FEMA has identified and quantified environmental benefits for mitigation activities. Incorporating environmental benefits into the overall quantification of benefits for acquisition-related activities supports the Flood Insurance and Mitigation Administration's (FIMA's) mission of risk reduction, environmental compliance, and preservation of the natural and beneficial functions of the floodplain."[56]

In addition, FEMA has developed an excel-based "Environmental Benefits Calculator for Acquisition Projects," and developed a policy statement on the consideration of environmental benefits.[57] Finally, a more detailed report provides detailed environmental benefits for many land use types along with the methodology and data used to estimate the values.[58] Exhibit 11-1 provides these values in monetized benefits per acre per year.

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[56] FEMA, Hazard Mitigation Assistance Guidance, Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program, Federal Emergency Management Agency Department of Homeland Security, Washington, DC, February 27, 2015.

[57] U.S. Department of Homeland Security, "Consideration of Environmental Benefits in the Evaluation of Acquisition Projects under the Hazard Mitigation Assistance (HMA) Programs," FEMA Mitigation Policy – FP-108-024-01, June 18, 2013.

[58] Final Sustainability Benefits Methodology Report, Federal Emergency Management Agency, Department of Homeland Security, Developed under Contract HSFEHQ-10-D-0806, Task Order HSFEHQ-11-J-1408, Washington, D.C., August 23, 2012

Exhibit 11-1: Monetized Environmental Benefits by Type of Land Use and Type of Benefit

Environmental Benefit	Monetary Benefit per Acre per Year ($, 2011)				
	Riparian Area	Wetland	Green Space	Agricultural Lands	Forests
Aesthetic Value	$ 580.87	$ 1,720.99	$ 1,623.00	$ 51.87	
Air Quality	$ 215.06		$ 204.47		$ 225.65
Biological Control	$ 163.68			$ 14.29	
Biodiversity		$ 113.12			
Climate Regulation	$ 204.21	$ 214.48	$ 13.19		$ 395.23
Erosion Control	$ 11,447.30		$ 64.88		$ 62.22
Flood Hazard Reduction	$ 4,007.01				
Hurricane Storm Hazard Risk Reduction		$ 3,982.70			
Water Supply		$ 218.57			
Fiber/Raw Materials		$ 560.72			
Food Provisioning	$ 609.44	$ 1,338.96			
Habitat	$ 835.41	$ 164.07			
Pollination			$ 290.08	$ 900.85	
Recreation/ Tourism	$ 15,178.07	$ 483.57	$ 5,365.26		
Storm Water Retention		$ 5,335.30	$ 293.02		
Nutrient Cycling		$ 527.65			
Water Filtration	$ 4,251.89	$ 731.21			
Soil Erosion				$ 127.14	
Carbon Storage				$ 51.48	
Soil Formation				$ 109.47	
Total	**$ 37,492.94**	**$ 15,391.34**	**$ 7,853.90**	**$ 1,255.10**	**$ 683.10**

The project team adjusted these values for use in this project. First, the analysis updated the data from 2011 values to 2018 values using the U.S. Bureau of Labor Statistics (BLS) Consumer Price Index (CPI) Inflation Calculator. [59] The CPI inflation calculator uses the for All Urban Consumers (CPI-U) U.S. city average series for all items, not seasonally adjusted. This data represents changes in the prices of all goods and services purchased for consumption by urban households. The analysis used the CPI change from February 2011 to February 2018. Next, the analysis eliminated the benefits of Erosion Control and Flood Hazard Reduction from the post-project land use categories Riparian Areas and Green Space. The project team did this to eliminate double counting, as the analysis already accounts the benefits of these items in

[59] U.S. Bureau of Labor Statistics, https://www.bls.gov/data/inflation_calculator.htm

categories such as structural benefits. The project team also eliminated the Recreation/Tourism benefit for the post-project land use categories Riparian Areas and Green Space, as these rural former farmland areas do not provide these types of benefits. The exception is the downtown Riparian Areas, as the project is converting these to park type lands with walkways, benches, and plantings. In addition, the analysis eliminated the wetlands land use classification as none of the lands the project affected fit this land use. Exhibit 11-2 provides the revised monetized environmental benefits by type of land use and type of benefit

Exhibit 11-2: Revised Monetized Environmental Benefits

Environmental Benefit	Monetary Benefit per Acre per Year ($, 2018)				
	Downtown Riparian Area	Riparian Area	Green Space	Agricultural Lands	Forests
Aesthetic Value	$ 656.38	$ 656.38	$ 1,833.99	$ 58.61	
Air Quality	$ 243.02	$ 243.02	$ 231.05		$ 254.98
Biological Control	$ 184.96	$ 184.96		$ 16.15	
Biodiversity					
Climate Regulation	$ 230.76	$ 230.76	$ 14.90		$ 446.61
Erosion Control					$ 70.31
Flood Hazard Reduction					
Hurricane Storm Hazard Risk Reduction					
Water Supply					
Fiber/Raw Materials					
Food Provisioning	$ 688.67	$ 688.67			
Habitat	$ 944.01	$ 944.01			
Pollination			$ 327.79	$ 1,017.96	
Recreation/ Tourism	$ 17,151.22				
Storm Water Retention					
Nutrient Cycling					
Water Filtration	$ 4,804.64	$ 4,804.64			
Soil Erosion				$ 143.67	
Carbon Storage				$ 58.17	
Soil Formation				$ 123.70	
Total	**$ 24,903.65**	**$ 7,752.43**	**$ 2,407.74**	**$ 1,418.26**	**$ 771.90**

11.2.2 Land Acreages

Stantec provided aerial photos containing the approximate acreage for each type of land use area both before and after The Program. Exhibit 11-3 (Blanchard River Hydraulic Improvements), Exhibit 11-4 (Eagle Creek Dry Storage), and Exhibit 11-5 (Potato Run & Blanchard River Dry Storage) provide these photographic images depicting the changes in land uses and associated acreages.

Exhibit 11-3: Locations of Pre-Project Land Uses and Acreages for the Blanchard River Hydraulic Improvements

Exhibit 11-3: Locations of Post-Project Land Uses and Acreages for the Blanchard River Hydraulic Improvements

Exhibit 11-4: Locations of Pre-Project Land Uses and Acreages for the Eagle Creek Dry Storage

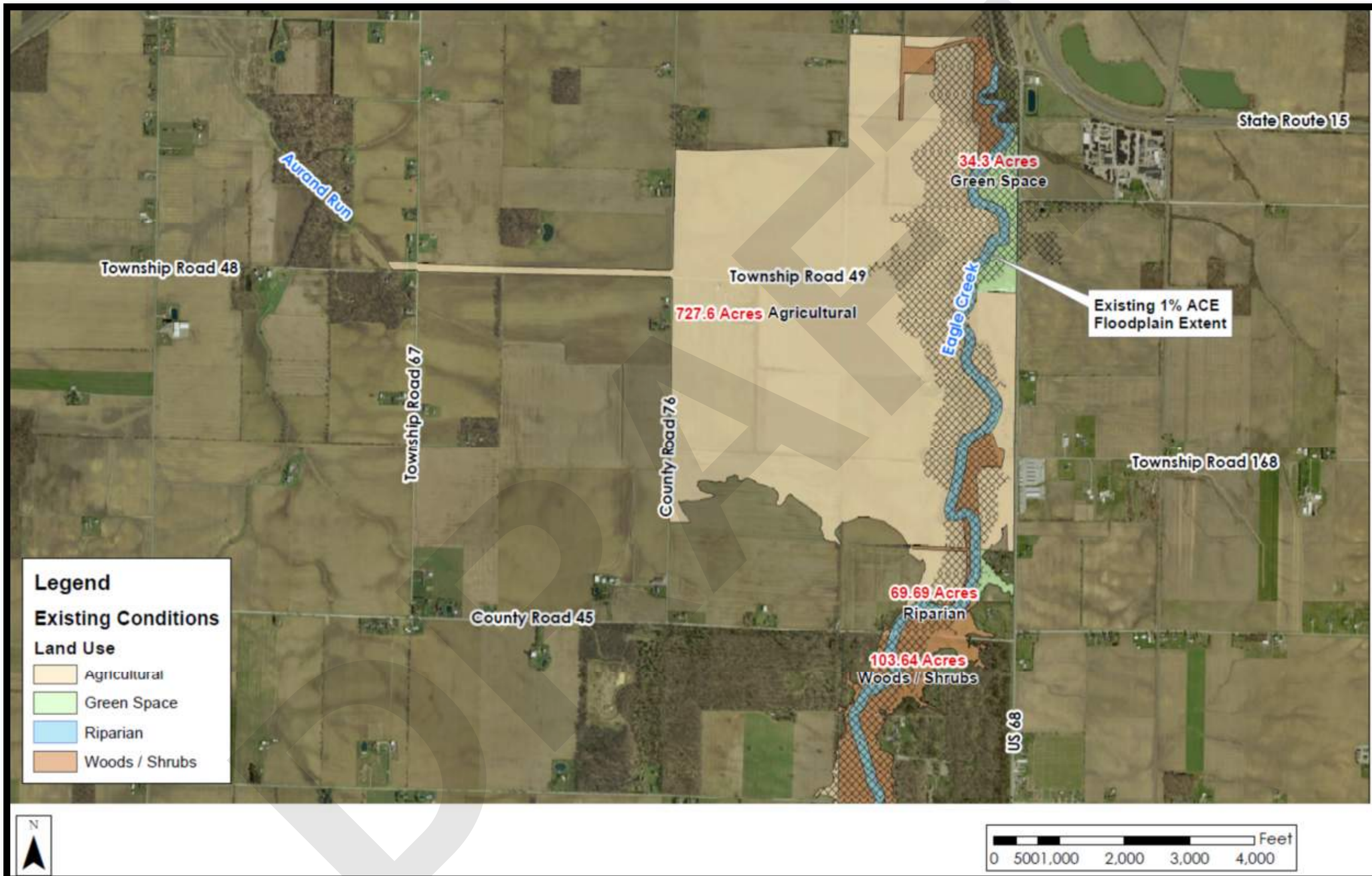


Exhibit 11-4: Locations of Post-Project Land Uses and Acreages for the Eagle Creek Dry Storage

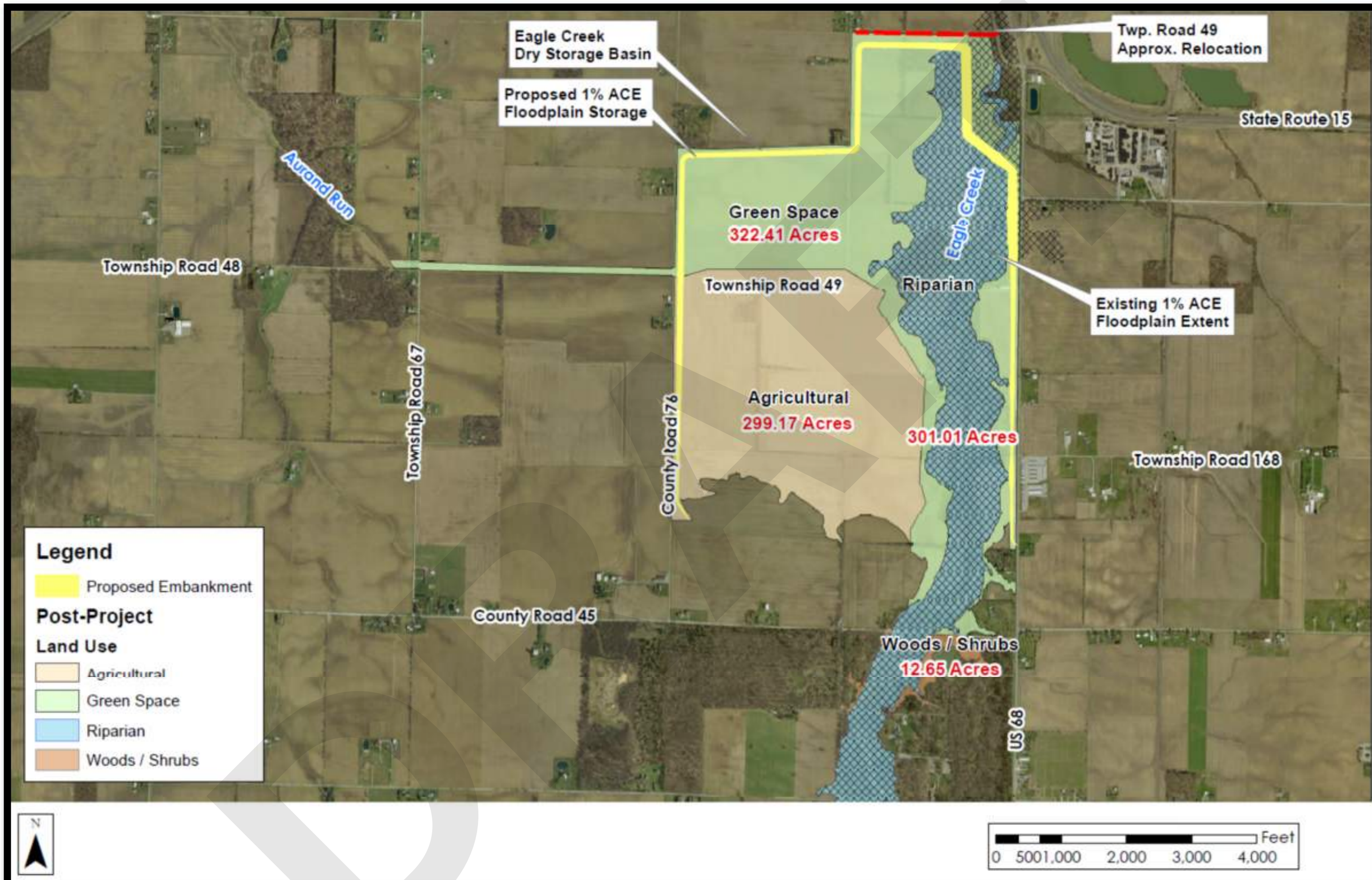


Exhibit 11-5: Locations of Pre-Project Land Uses and Acreages for the Potato Run and Blanchard River Storage

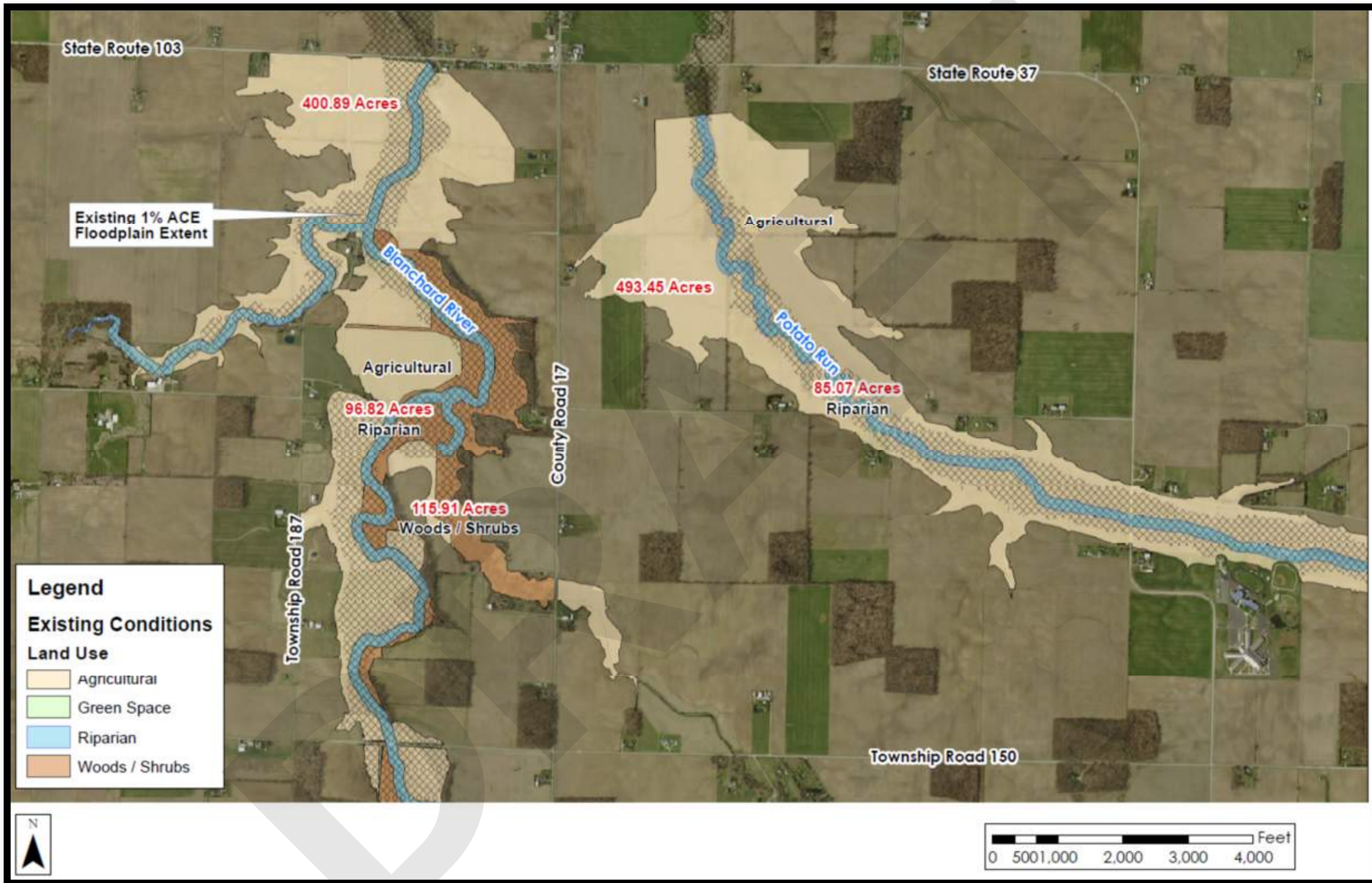
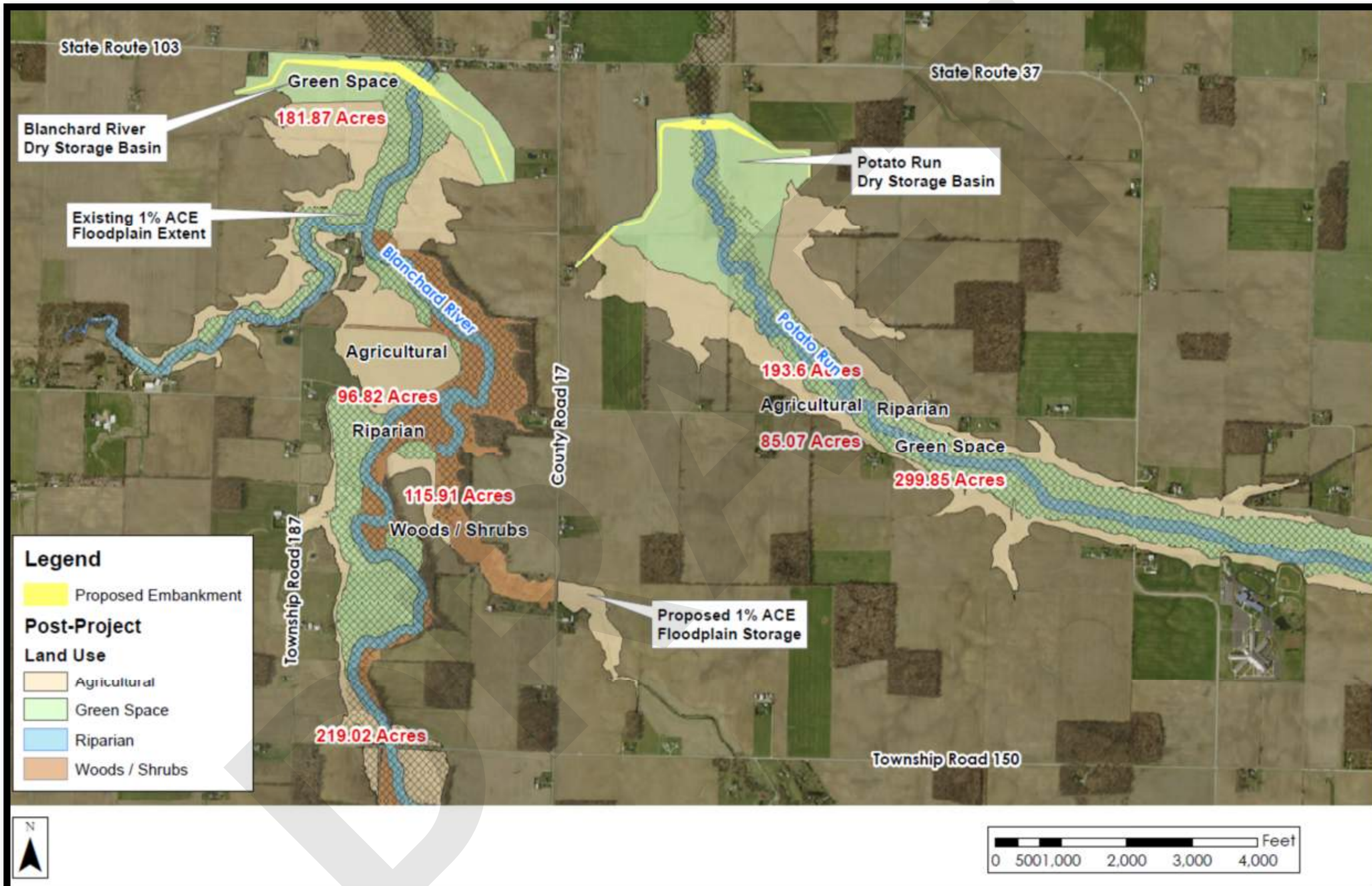


Exhibit 11-5: Locations of Post-Project Land Uses and Acreages for the Potato Run and Blanchard River Storage



11.3 Results

Exhibit 11-6 calculates the environmental benefit value for land use changes. The research team used the property acreages and classifications from the photographic images. The first part of the exhibit provides the existing acres by land use and area, while the second provides the after project acres by land use and area. The third section of the exhibit summaries the annual environmental benefits per acre by land use and area. The forth section calculates the environmental benefits of the current land uses by multiplying the existing acres by the benefits per acre. The fifth section calculates the environmental benefits after the project by multiplying the acres by land use after the project by the benefits per acre. The sixth and final section, subtracts the existing condition benefits from the post program benefits to calculate the increase in environmental benefits, which the methodology estimates at $2,805,050 per year.

Exhibit 11-6: Annual Environmental Benefit of Land Use Changes

Land Use	Hydraulic Improvements	Eagle Creek	Blanchard River	Potato Run	Total
Existing Conditions (Acres)					
Agriculture	-	727.6	400.9	493.4	1,621.9
Green Space	6.2	34.3	-	-	40.5
Riparian	10.4	69.7	96.8	85.1	262.0
Woods / Shrubs	18.4	103.6	115.9	-	237.9
Total	34.9	935.2	613.6	578.5	2,162.3
The Program (Acres)					
Agriculture	-	299.2	219.0	193.6	711.8
Green Space	2.8	322.4	181.9	299.9	806.9
Riparian	32.1	301.0	96.8	85.1	515.0
Woods / Shrubs	-	12.6	115.9	-	128.6
Total	34.9	935.2	613.6	578.5	2,162.3
Benefits (Per Acre)					
Agriculture	$ 1,418.26	$ 1,418.26	$ 1,418.26	$ 1,418.26	
Green Space	$ 2,407.74	$ 2,407.74	$ 2,407.74	$ 2,407.74	
Riparian	$ 24,903.65	$ 7,752.43	$ 7,752.43	$ 7,752.43	
Woods / Shrubs	$ 771.90	$ 771.90	$ 771.90	$ 771.90	
Existing Conditions (Benefits)					
Agriculture	$ -	$ 1,031,923	$ 568,567	$ 699,840	$ 2,300,330
Green Space	$ 14,848	$ 82,595	$ -	$ -	$ 97,443
Riparian	$ 258,011	$ 540,301	$ 750,617	$ 659,524	$ 2,208,453
Woods / Shrubs	$ 14,195	$ 79,999	$ 89,473	$ -	$ 183,668
Total	$ 287,055	$ 1,734,819	$ 1,408,657	$ 1,359,364	$ 4,789,895
The Program (Benefits)					
Agriculture	$ -	$ 424,297	$ 310,627	$ 274,569	$ 1,009,494
Green Space	$ 6,765	$ 776,271	$ 437,903	$ 721,968	$ 1,942,906
Riparian	$ 799,607	$ 2,333,559	$ 750,617	$ 659,524	$ 4,543,306
Woods / Shrubs	$ -	$ 9,765	$ 89,473	$ -	$ 99,237
Total	$ 806,371	$ 3,543,892	$ 1,588,620	$ 1,656,061	$ 7,594,944
Change in Environmental Benefits					
Agriculture	$ -	$ (607,626)	$ (257,940)	$ (425,271)	$ (1,290,836)
Green Space	$ (8,084)	$ 693,676	$ 437,903	$ 721,968	$ 1,845,463
Riparian	$ 541,595	$ 1,793,258	$ -	$ -	$ 2,334,853
Woods / Shrubs	$ (14,195)	$ (70,235)	$ -	$ -	$ (84,430)
Total	$ 519,316	$ 1,809,074	$ 179,963	$ 296,697	$ 2,805,050

Chapter 12 Benefit Cost Analysis Results

This section summarizes and compares the data on benefits and costs developed in the previous sections of this report. The section begins with an overview of Conservancy Court Law, summarizes costs, summarizes benefits, compares costs to benefits, and then concludes with the presentation of benefit-cost ratios.

For the Conservancy Court to approve a reappraisal of benefits, it must determine that the benefits exceed the cost. In Muskingum Watershed Conservancy District vs. Clow, 57 Ohio App. 132 (Fifth District 1937) the syllabus of the court discussed section 6828-33 of the General Code (now R.C. §6101.34) and stated that it was essential "that it be determined as a matter of fact that the estimated cost of the improvement is less than the benefit appraised." The Court also noted that the term "cost," as used in this section means the cost to the District and does not include contribution by the Federal Government, or by the State of Ohio.

The primary purpose of this report is to evaluate the benefits and costs of the Hancock County Flood Risk Reduction Program, including the proposed activities in the Program Plan. From a legal perspective, it is important to consider the benefits and costs of the entire program from its inception. The timing of the construction activities and costs, maintenance, and the period where partial and full benefits begin to accrue for the community determine the present value of benefits and costs. The analysis assumes the stream of project costs and benefits continues for 50 years after the completion of all phases of the project.

Exhibit 12-1 provides a summary of costs and benefits. The net present value of costs of The Program with maintenance equals **$164.98 million**. Appendix A provides the anticipated annual program costs by component and year, both undiscounted and discounted. The net present value of benefits of The Program with maintenance equals **$484.3 million**. Appendix A also includes benefits by component and year, both undiscounted and discounted.

Exhibit 12-1: Costs of the Hancock County Flood Risk Reduction Program (2018$, Millions)

	Benefits	Costs
The Program	$484.3	$ 164.98

Exhibit 12-2 summarizes the individual benefits described in the previous chapters and provides the present values of each of the individual benefits over the expected 50-year program analysis period. Benefits from the reduced flooding of structures constitute the largest share of benefits, followed by environmental benefits. Overall, the project achieves a Benefit-Cost Ratio of 2.94.

Exhibit 12-2: Present Value Benefits and Costs for The Program (2018$, Thousands)

The Program			
Category	Costs (Net Present Value)	Benefits (Net Present Value)	Benefit/ Cost Ratio
Project Construction	$ 164,981		
Residential Structures		$ 211,234	
Business Structures		$ 81,699	
Vehicles		$ 9,896	
Transport		$ 9,392	
Emergency Response		$ 7,470	
NFIP Admin.		$ 18,223	
Business Loss		$ 3,116	
Business Cleanup		$ 18,876	
Business Emergency Prep		$ 3,576	
Agriculture		$ 574	
Environment		$ 120,286	
Total	$ 164,981	$ 484,341	2.94

Exhibit 12-3 summarizes the individual benefits described in graphical form. Benefits from the reduced flooding of residential structures constitute the largest share of benefits, followed by environmental benefits and reduced flooding of business and government structures.

Exhibit 12-3: Present Value Benefits for The Program (2018$, Thousands)

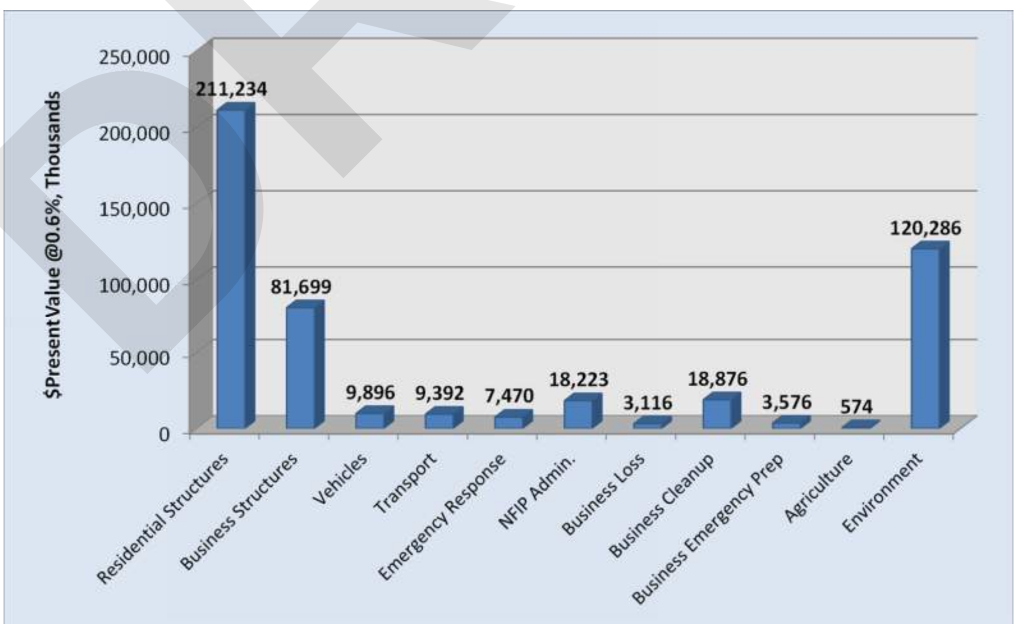
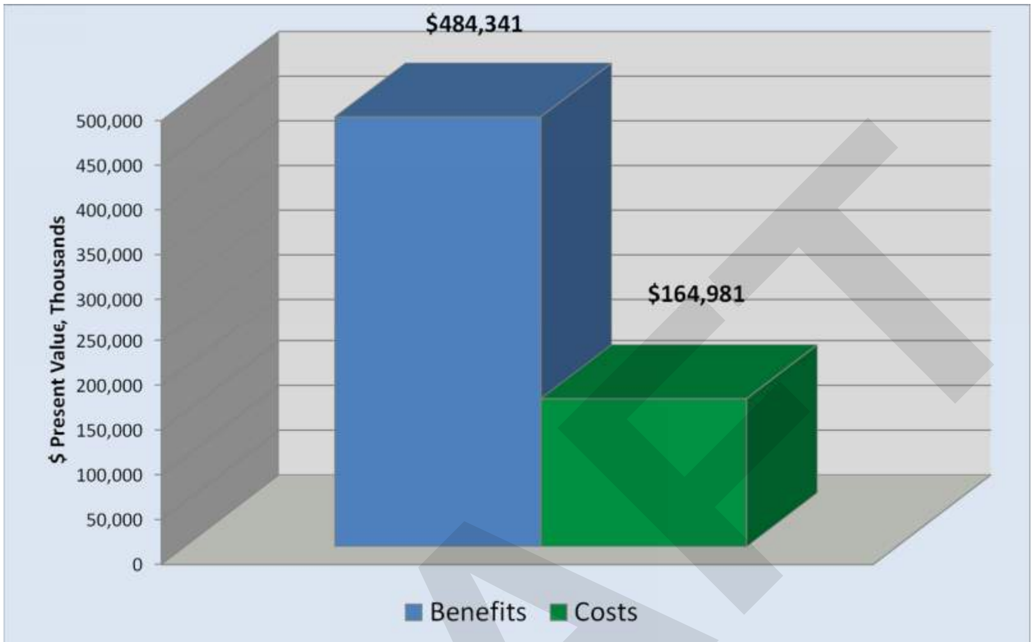


Exhibit 12-4 compares the benefits and costs of The Program graphically for a side-by-side comparison. The exhibit shows that the estimated benefits of the Hancock County Flood Risk Reduction Program are larger than the opinion of probable cost by a large margin.

Exhibit 12-4: Summary of Hancock County Flood Risk Reduction Program (2018$, Thousands)



Economists typically compare the present values of benefits and costs in two ways. One is to calculate the difference between the benefits and the costs. Economists referred to this as the net present value (NPV). If this value is larger than zero, benefits exceed costs and the project is economically justified. The second method is to calculate the ratio of benefits to costs. In this case, if the benefit-cost ratio (B/C Ratio) exceeds one, the project is economically justified.[60] Exhibit 12-5 presents the results of the benefit cost analysis, in terms of both net present value and benefit-cost ratio.

12-5: Summary of Results of the Benefit Cost Analysis, NPV and B/C Ratio

	Benefits	Costs	Net Benefits	Benefit/ Cost Ratio
The Program	$ 484,341,077	$ 164,981,328	$ 319,359,749	2.94

This Benefit Cost Analysis of the Hancock County Flood Risk Reduction Program demonstrates that the recommended Flood Risk Reduction Program is cost effective. The Net Present Value

[60] These two methods are mathematically equivalent. Consider the following illustration:

A > B is equivalent to A – B > 0 (subtract B from both sides) and A/B > 1 (divide B from both sides).

of $319.4 million substantially exceeds the cost, indicating that it is an efficient infrastructure investment. In addition, the Benefit Cost Ratios of 2.94 reveals a substantial benefit margin over costs. This indicates that for each dollar of investment in The Program, the communities will receive $2.94 in estimated benefits.

Enhancements and Quality Assurance and Control

The Benefit-Cost Ratio increased from 1.6 in 2017 to 2.9 in the current study, due the many modifications made to methods and procedures which are discussed for each benefit category below. The benefit-cost analysis (BCA) presented in this report represents an update and refinement of the previous BCA published March 2017. The project team expended a substantial effort to update and refine all of the estimates in this report, as well as conduct a complete quality assurance/quality control (QA/QC) analysis of each of the components of the BCA. The following paragraphs highlight some of the major data improvements, changes to the methodology, levels of costs and benefits, and QA/QC efforts that resulted.

On the cost side, the project team incorporated new cost estimates and a revised project schedule. This included a revised time schedule that affected the level of both benefits and costs. In addition, a 50-year benefit period specific to each phase of the project now follows each of the five main phases of the project (hydraulic improvements, railroad bridge modifications, Eagle Creek storage basin, Potato Run storage basin, and Blanchard River storage basin). This change affects the present value of both benefits and costs, but increases benefits more than costs, as they are larger in the out years of the project.

In addition, the analysis uses an updated discount rate.[61] The White House Office of Management and Budget publishes an annual update of "A forecast of real interest rates from which the inflation premium has been removed and based on the economic assumptions from the 2018 Budget… These real rates are to be used for discounting constant-dollar flows, as is often required in cost-effectiveness analysis." This study uses the 30-Year rate of 0.6 percent, which is down from the previous rate of 0.7 percent. Note that the circular states "Programs with durations longer than 30 years may use the 30-year interest rate." This updated discount rate increases benefits and the BCA ratio as future benefits have relatively higher value.

Structure benefits have also undergone changes. The project team has used new aerial laser LIDAR imaging to improve the accuracy of structure elevations. The project team also revised the water surface profiles (WSP) using the last National Oceanic and Atmospheric Administration (NOAA) data. The team also reduced first floor elevations by a half foot relative to the ground elevation to provide a more accurate reflection of actual conditions. In addition, the project team is now employing the recently released and improved U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center (HEC) Flood Damage Reduction Analysis (FDA)

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[61] OMB Circular No. A–94, Appendix C, Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Office of Management and Budget, Revised November 2017. Accessed at https://www.whitehouse.gov/wp-content/uploads/2017/1 l/Appendix-C.pdf.

software version 1.4.2. The overall effect of these changes is an increase in the benefits associated with reductions in structure damages. The project team conducted detailed QA/QC of the HEC-FDA model runs including processing the previous and current elevations and WSPs through both the current and previous versions of HEC-FDA. The team performed these runs with both current and previous assumptions on first floor elevations and structure inventories. Finally, the team compared results for high damage structures between the various runs. This process verified that the new model was functioning correctly and verified that changes in damages accurately reflected changes in input data and assumptions.

Estimates of damages to motor vehicles have also changed. For this update, the project team fully deployed an improved methodology that the Federal Emergency Management Agency (FEMA) uses in their HAZUS model. The previous USACE methodology valued vehicles using new car prices and assumed that vehicles were only located at residences with no vehicles located at non-residential structures. The enhanced methodology uses data from the Bureau of Economic Analysis on the value of vehicle stocks by vehicle type, Federal Highway Administration data on the number of vehicles by type, International Transportation Engineers (ITE) data on parking generation by type of vehicle and structure, and USACE data on depth-damage curves by vehicle type. The overall effect of these changes is an increase in the benefits associated with reductions in vehicle damages.

The methodologies for transportation, emergency response, NFIP administrative costs, and business losses are largely unchanged. Transportation benefits have increased slightly due to increase in IRS mileage rates, increases in local wage rates, changes in flood depths, and slightly longer benefit horizons. Emergency response benefits increased as the project team enhanced the methodology to update 2007 costs using a Consumer Price Index (CPI) inflator and slightly longer benefit horizons. The benefit of reduced NFIP administrative costs increased primarily due to slightly longer benefit horizons. While the methodology for the three business loss categories was largely unchanged, the estimates for business cleanup costs and business emergency preparation both increased due to QA/QC enhancements while business sales losses remained virtually unchanged.

Estimates or reductions in agricultural losses changed, albeit from a small base. This change resulted from updates in crop production and replanting costs, as well as incorporation of new U.S. Geological Survey (USGS) data on flood history by month, which expanded estimates of flood likelihood during the peak growing season.

Environmental benefits also expanded. This is the result of major improvements in the methodology. In the previous BCA, the project team was working from Federal Emergency Management Agency (FEMA) summary guidance on environmental benefits. However, for this update, the project team was able to work back to the detailed research that underpinned the FEMA summary guidance. Using this detailed source data, the team was able to update the benefit period and discount rate to make them more compatible with this study, incorporate better data on the environmental benefits of agricultural and forested lands, and include estimates of the recreational value of the riparian waterfront parks and trails.

Appendix A:

50 Year Calculation of the Benefits and Costs of the Hancock County Flood Risk Reduction Program

A-1: Hancock County Flood Risk Reduction Program Costs, Present Value ($2018, Thousands)

	Hydraulic Improvements Phases I and 2		Storage Basins				Program	
Year	Construct	Maint.	Construct: Eagle Creek	Construct: Potato Run	Construct: Blanchard River	Maint.	Total Costs in 2018 Dollars	Net Present Value
2018	6,399						6,399	6,399
2019	6,399						6,399	6,360
2020	6,254	17.7	10,896				17,167	16,963
2021	6,254	17.7	10,896				17,167	16,862
2022		17.7	10,896	3,422			14,335	13,996
2023		17.7	10,896	3,422	6,393		20,728	20,117
2024		17.7	10,896	3,422	6,393		20,728	19,997
2025		17.7	10,896	3,422	6,393		20,728	19,878
2026		17.7		3,422	6,393	75	9,907	9,444
2027		17.7		3,422	6,393	75	9,907	9,388
2028		17.7		3,422	6,393	75	9,907	9,332
2029		17.7		3,422	6,393	75	9,907	9,276
2030		17.7				155	173	161
2031		17.7				155	173	160
2032		17.7				155	173	159
2033		17.7				155	173	158
2034		17.7				155	173	157
2035		17.7				155	173	156
2036		17.7				155	173	155
2037		17.7				155	173	154
2038		17.7				155	173	153
2039		17.7				155	173	152
2040		17.7				155	173	151
2041		17.7				155	173	151
2042		17.7				155	173	150
2043		17.7				155	173	149
2044		17.7				155	173	148
2045		17.7				155	173	147
2046		17.7				155	173	146
2047		17.7				155	173	145
2048		17.7				155	173	144
2049		17.7				155	173	143
2050		17.7				155	173	143
2051		17.7				155	173	142
2052		17.7				155	173	141
2053		17.7				155	173	140
2054		17.7				155	173	139
2055		17.7				155	173	138
2056		17.7				155	173	138
2057		17.7				155	173	137
2058		17.7				155	173	136
2059		17.7				155	173	135
2060		17.7				155	173	134
2061		17.7				155	173	134
2062		17.7				155	173	133
2063		17.7				155	173	132
2064		17.7				155	173	131
2065		17.7				155	173	130
2066		17.7				155	173	130
2067		17.7				155	173	129
2068		17.7				155	173	128
2069		17.7				155	173	127
2070		17.7				155	173	127
2071		17.7				155	173	126
2072		17.7				155	173	125
2073		17.7				155	173	124
2074		17.7				155	173	124
2075		17.7				155	173	123
2076		17.7				155	173	122
2077		17.7				155	173	121
2078		17.7				155	173	121
2079		17.7				155	173	120
Total	**25,304**	**1,062**	**65,375**	**27,375**	**44,750**	**8,050**	**171,916**	**164,981**

A-2: Hancock County Flood Risk Reduction Program Anticipated Benefits, ($2018, Thousands)

Year	Residential Structures	Business Structures	Vehicles	Transport	Emergency Response	NFIP Admin.	Business Loss	Business Cleanup	Business Emergency Prep	Agriculture	Environment	Total
2017	492.6	190.5	23.1	21.9	17.4	42.5	7.3	44.0	8.3	1.3	280.5	1,129.5
2018	1,231.5	476.3	57.7	54.8	43.6	106.2	18.2	110.0	20.8	3.3	701.3	2,823.7
2019	1,231.5	476.3	57.7	54.8	43.6	106.2	18.2	110.0	20.8	3.3	701.3	2,823.7
2020	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2021	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2022	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2023	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2024	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2025	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2026	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2027	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2028	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2029	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2030	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2031	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2032	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2033	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2034	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2035	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2036	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2037	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2038	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2039	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2040	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2041	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2042	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2043	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2044	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2045	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2046	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2047	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2048	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2049	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2050	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2051	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2052	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2053	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2054	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2055	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2056	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2057	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2058	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2059	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2060	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2061	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2062	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2063	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2064	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2065	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2066	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2067	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2068	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2069	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2070	4,926.0	1,905.2	230.8	219.0	174.2	425.0	72.7	440.2	83.4	13.4	2,805.1	11,294.8
2071	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2072	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2073	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2074	3,300.4	1,276.5	154.6	146.7	116.7	284.7	48.7	294.9	55.9	9.0	1,879.4	7,567.5
2075	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2076	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2077	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
2078	1,625.6	628.7	76.2	72.3	57.5	140.2	24.0	145.3	27.5	4.4	925.7	3,727.3
	254,179.5	**98,308.8**	**11,907.7**	**11,301.8**	**8,989.1**	**21,927.5**	**3,749.5**	**22,714.0**	**4,302.8**	**690.2**	**144,740.6**	**582,811.5**

A-3: Hancock County Flood Risk Reduction Program Anticipated Benefits Present Value ($2018, Thousands)

Year	ResidentialStructures	Business Structures	Vehicles	Transport	Emergency Response	NFIP Admin.	Business Loss	Business Cleanup	Business Emergency Prep	Agriculture	Environ-mental	Total
2017	492.6	190.5	23.1	21.9	17.4	42.5	7.3	44.0	8.3	1.3	280.5	1,129.5
2018	1,224.1	473.5	57.3	54.4	43.3	105.6	18.1	109.4	20.7	3.3	697.1	2,806.9
2019	1,216.8	470.6	57.0	54.1	43.0	105.0	18.0	108.7	20.6	3.3	692.9	2,790.1
2020	1,596.7	617.5	74.8	71.0	56.5	137.7	23.6	142.7	27.0	4.3	909.2	3,661.0
2021	1,587.1	613.9	74.4	70.6	56.1	136.9	23.4	141.8	26.9	4.3	903.8	3,639.2
2022	1,577.7	610.2	73.9	70.1	55.8	136.1	23.3	141.0	26.7	4.3	898.4	3,617.4
2023	1,568.3	606.6	73.5	69.7	55.5	135.3	23.1	140.1	26.5	4.3	893.0	3,595.9
2024	3,165.0	1,224.1	148.3	140.7	111.9	273.0	46.7	282.8	53.6	8.6	1,802.3	7,257.2
2025	3,146.2	1,216.8	147.4	139.9	111.3	271.4	46.4	281.1	53.3	8.5	1,791.6	7,213.9
2026	3,127.4	1,209.6	146.5	139.1	110.6	269.8	46.1	279.5	52.9	8.5	1,780.9	7,170.9
2027	3,108.8	1,202.4	145.6	138.2	109.9	268.2	45.9	277.8	52.6	8.4	1,770.3	7,128.1
2028	4,612.3	1,783.9	216.1	205.1	163.1	397.9	68.0	412.2	78.1	12.5	2,626.4	10,575.5
2029	4,584.7	1,773.2	214.8	203.9	162.1	395.5	67.6	409.7	77.6	12.4	2,610.7	10,512.4
2030	4,557.4	1,762.7	213.5	202.6	161.2	393.2	67.2	407.3	77.1	12.4	2,595.2	10,449.7
2031	4,530.2	1,752.1	212.2	201.4	160.2	390.8	66.8	404.8	76.7	12.3	2,579.7	10,387.4
2032	4,503.2	1,741.7	211.0	200.2	159.3	388.5	66.4	402.4	76.2	12.2	2,564.3	10,325.4
2033	4,476.3	1,731.3	209.7	199.0	158.3	386.2	66.0	400.0	75.8	12.2	2,549.0	10,263.9
2034	4,449.6	1,721.0	208.5	197.8	157.4	383.9	65.6	397.6	75.3	12.1	2,533.8	10,202.6
2035	4,423.1	1,710.7	207.2	196.7	156.4	381.6	65.2	395.3	74.9	12.0	2,518.7	10,141.8
2036	4,396.7	1,700.5	206.0	195.5	155.5	379.3	64.9	392.9	74.4	11.9	2,503.7	10,081.3
2037	4,370.5	1,690.4	204.7	194.3	154.6	377.0	64.5	390.6	74.0	11.9	2,488.7	10,021.2
2038	4,344.4	1,680.3	203.5	193.2	153.6	374.8	64.1	388.2	73.5	11.8	2,473.9	9,961.4
2039	4,318.5	1,670.3	202.3	192.0	152.7	372.5	63.7	385.9	73.1	11.7	2,459.2	9,902.0
2040	4,292.8	1,660.3	201.1	190.9	151.8	370.3	63.3	383.6	72.7	11.7	2,444.5	9,842.9
2041	4,267.2	1,650.4	199.9	189.7	150.9	368.1	62.9	381.3	72.2	11.6	2,429.9	9,784.2
2042	4,241.7	1,640.6	198.7	188.6	150.0	365.9	62.6	379.0	71.8	11.5	2,415.4	9,725.9
2043	4,216.4	1,630.8	197.5	187.5	149.1	363.7	62.2	376.8	71.4	11.4	2,401.0	9,667.9
2044	4,191.3	1,621.1	196.4	186.4	148.2	361.6	61.8	374.5	71.0	11.4	2,386.7	9,610.2
2045	4,166.3	1,611.4	195.2	185.2	147.3	359.4	61.5	372.3	70.5	11.3	2,372.5	9,552.9
2046	4,141.4	1,601.8	194.0	184.1	146.5	357.3	61.1	370.1	70.1	11.2	2,358.3	9,495.9
2047	4,116.7	1,592.2	192.9	183.0	145.6	355.1	60.7	367.9	69.7	11.2	2,344.2	9,439.3
2048	4,092.2	1,582.7	191.7	182.0	144.7	353.0	60.4	365.7	69.3	11.1	2,330.3	9,383.0
2049	4,067.8	1,573.3	190.6	180.9	143.9	350.9	60.0	363.5	68.9	11.0	2,316.4	9,327.0
2050	4,043.5	1,563.9	189.4	179.8	143.0	348.8	59.6	361.3	68.4	11.0	2,302.5	9,271.4
2051	4,019.4	1,554.6	188.3	178.7	142.1	346.7	59.3	359.2	68.0	10.9	2,288.8	9,216.1
2052	3,995.4	1,545.3	187.2	177.7	141.3	344.7	58.9	357.0	67.6	10.8	2,275.2	9,161.1
2053	3,971.6	1,536.1	186.1	176.6	140.5	342.6	58.6	354.9	67.2	10.8	2,261.6	9,106.5
2054	3,947.9	1,526.9	184.9	175.5	139.6	340.6	58.2	352.8	66.8	10.7	2,248.1	9,052.2
2055	3,924.3	1,517.8	183.8	174.5	138.8	338.5	57.9	350.7	66.4	10.7	2,234.7	8,998.2
2056	3,900.9	1,508.8	182.8	173.5	138.0	336.5	57.5	348.6	66.0	10.6	2,221.4	8,944.5
2057	3,877.7	1,499.8	181.7	172.4	137.1	334.5	57.2	346.5	65.6	10.5	2,208.1	8,891.2
2058	3,854.5	1,490.8	180.6	171.4	136.3	332.5	56.9	344.4	65.3	10.5	2,194.9	8,838.1
2059	3,831.6	1,481.9	179.5	170.4	135.5	330.5	56.5	342.4	64.9	10.4	2,181.9	8,785.4
2060	3,808.7	1,473.1	178.4	169.3	134.7	328.6	56.2	340.4	64.5	10.3	2,168.8	8,733.0
2061	3,786.0	1,464.3	177.4	168.3	133.9	326.6	55.8	338.3	64.1	10.3	2,155.9	8,681.0
2062	3,763.4	1,455.6	176.3	167.3	133.1	324.7	55.5	336.3	63.7	10.2	2,143.0	8,629.2
2063	3,741.0	1,446.9	175.3	166.3	132.3	322.7	55.2	334.3	63.3	10.2	2,130.3	8,577.7
2064	3,718.7	1,438.3	174.2	165.3	131.5	320.8	54.9	332.3	62.9	10.1	2,117.6	8,526.5
2065	3,696.5	1,429.7	173.2	164.4	130.7	318.9	54.5	330.3	62.6	10.0	2,104.9	8,475.7
2066	3,674.4	1,421.2	172.1	163.4	129.9	317.0	54.2	328.4	62.2	10.0	2,092.4	8,425.1
2067	3,652.5	1,412.7	171.1	162.4	129.2	315.1	53.9	326.4	61.8	9.9	2,079.9	8,374.9
2068	3,630.7	1,404.3	170.1	161.4	128.4	313.2	53.6	324.4	61.5	9.9	2,067.5	8,324.9
2069	3,609.1	1,395.9	169.1	160.5	127.6	311.3	53.2	322.5	61.1	9.8	2,055.2	8,275.3
2070	3,587.5	1,387.6	168.1	159.5	126.9	309.5	52.9	320.6	60.7	9.7	2,042.9	8,225.9
2071	2,389.3	924.1	111.9	106.2	84.5	206.1	35.2	213.5	40.4	6.5	1,360.6	5,478.5
2072	2,375.1	918.6	111.3	105.6	84.0	204.9	35.0	212.2	40.2	6.4	1,352.5	5,445.8
2073	2,360.9	913.1	110.6	105.0	83.5	203.7	34.8	211.0	40.0	6.4	1,344.4	5,413.4
2074	2,346.8	907.7	109.9	104.3	83.0	202.5	34.6	209.7	39.7	6.4	1,336.4	5,381.1
2075	1,149.0	444.4	53.8	51.1	40.6	99.1	16.9	102.7	19.5	3.1	654.3	2,634.6
2076	1,142.2	441.7	53.5	50.8	40.4	98.5	16.8	102.1	19.3	3.1	650.4	2,618.9
2077	1,135.3	439.1	53.2	50.5	40.2	97.9	16.7	101.5	19.2	3.1	646.5	2,603.2
2078	1,128.6	436.5	52.9	50.2	39.9	97.4	16.6	100.9	19.1	3.1	642.7	2,587.7
Total	**211,234.0**	**81,698.8**	**9,895.8**	**9,392.3**	**7,470.4**	**18,222.7**	**3,116.0**	**18,876.3**	**3,575.8**	**573.5**	**120,285.6**	**484,341.1**