

# FTA

Federal Transit Administration

## **How to Use the FTA Hazard Mitigation Cost Effectiveness (HMCE) Tool**

### **USER GUIDE**

March 2017



U.S. Department of Transportation  
Federal Transit Administration

# How to Use the FTA HMCE Tool – USER GUIDE

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# INTRODUCTION

## Background Information

### Disclaimer

This document is intended as a technical assistance product. It is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government and the Contractor, PMO Partnership JV, LLC, assume no liability for the contents or use thereof. The United States Government does not endorse product of manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

This User Guide is intended to be a general reference document for use by public transportation agencies responsible for the financial analysis and management of capital projects involving a transit facility or system. The Hazard Mitigation Cost-Effectiveness (HMCE) Tool for which this User Guide is developed (Version 2.2 dated 3/10/2017) is intended as a planning tool only and is not intended to be used as the basis for grant award determination unless specified in a Notice of Funding Availability (NOFA) or other FTA Guidance.

### HMCE Tool Version 2.2 – Featured Updates

The original FTA HMCE Tool (Version 1.0 dated 1/16/2014) was developed to assess the cost-effectiveness of Competitive Resilience projects submitted under the FTA Public Transportation Emergency Relief (ER) Program and focused only on eastern states impacted by Hurricane Sandy. The current FTA HMCE Tool (Version 2.2 dated 3/10/2017) is intended to be for more generic assessments of cost-effectiveness (not applicable to any specific grant programs) and features the following key updates:

- Expanded inputs to address multiple hazards impacting all states and U.S. territories.
- Coastal Flood Recurrence Interval Estimator integrated into tool with expanded flood gauges covering all U.S. coastal states and territories.
- Option for automatic calculation of post-resilience project damages and losses using simplified approach.
- Additional input guidance data and notes that directly reference this User Guide.
- Revised inflation calculator based on the latest Engineering News Record (ENR) construction index data and projections to allow for project analyses in 2017 or 2018.
- Revised default cost of loss of transit services and expanded list of values for 15 major U.S. metropolitan areas based on latest available data from the U.S. Bureau of Labor Statistics (BLS).

These key updates will be discussed in greater detail throughout this User Guide.

## Purpose

The Hazard Mitigation Cost Effectiveness (HMCE) Tool was developed as a planning tool for the Federal Transit Administration (FTA) to make available to agencies responsible for transit facilities or systems (transit agencies). It is intended to allow transit agencies to evaluate the benefits and costs associated with undertaking the design, construction, and operations and maintenance of capital planning projects that incorporate resilience so that decision makers have additional data to make informed choices regarding their use of limited financial resources. The analysis that is conducted using the tool is dependent upon the quality of the information put into the tool. The results are not conclusive evidence that a resilience project is or is not cost-effective.

This tool is NOT intended for consideration as part of FTA grant applications, however, transit agencies could decide to use it as part of their documentation submitted with a grant application. Unless otherwise specified in a NOFA, transit agencies applying to FTA for grant funding requiring benefit-cost analyses may use any benefit-cost tool they believe meets the requirements of the grant application process.

## Background

### What is resilience?

Many definitions of resilience have been developed in recent years. The FTA defines resilience as “the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions such as significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.” A “resilience project” is “a project designed and built to address existing and future vulnerabilities to a public transportation facility or system due to a probable occurrence or recurrence of an emergency or major disaster in the geographic area in which the public transportation system is located, and which may include the consideration of projected changes in development patterns, demographics, or climate change or extreme weather patterns.”

### What is benefit-cost analysis and why is it used?

**Benefit-cost analysis (BCA)** is a process that quantifies in equivalent money value the benefits and costs of a project or projects to evaluate if they meet financial criteria for project implementation. BCA is completed by first compiling a list of all of the benefits and costs associated with a project. Then a monetary value is assigned to each benefit and cost. The values of the benefits are aggregated, as are the costs, and the aggregated values are compared to determine if the benefits outweigh the costs. This comparison is typically done using a **benefit-cost ratio (BCR)** as shown in Equation 1 on the next page.

**Equation 1. Benefit-Cost Ratio (BCR) formula.**

$$BCR = \frac{BENEFITS}{COSTS}$$

**Where:**        *BCR = Benefit-Cost Ratio*  
                  *BENEFITS = Total project benefits*  
                  *COSTS = Total project costs*

If the BCR is greater than 1.0, then the project is considered cost-effective.

For hazard mitigation and/or resilience projects, **benefits are avoided damages and losses**, as shown in Equation 2 below.

**Equation 2. Determining project benefits.**

$$BENEFITS = \Sigma(\text{Pre} - \text{PROJECT EVENT DAMAGES AND LOSSES}) \\ - \Sigma(\text{Post} - \text{PROJECT EVENT DAMAGES AND LOSSES})$$

Avoided damages and losses are physical damages and/or service losses that would occur as the result of a hazard or incident if the project is not undertaken. For example, if a 100-year flood event will cause \$1 million in damages, a resilience project that will protect against the 100-year flood event with no residual damages has losses avoided valued at \$1 million, which is considered a project benefit.

Project benefits occur over a future period of time, while most project costs are incurred up front and in the present. For this reason, benefits are more difficult to estimate than costs. The Office of Management and Budget (OMB) Circular A-94 states that BCAs should be prepared on a **net present value** basis, meaning the present value of benefits gained from the project are compared to the total project cost to establish the BCR. Since the value of money changes over time, it is useful to calculate the monetary values of costs and benefits of a proposed project in today's dollars (or dollars of a particular date) so that they can be more easily and accurately compared. This is done using a discount rate, which is the rate of return for the project. For public mitigation or resilience projects that use federal funds, the current discount rate prescribed by the Office of Management and Budget (OMB) Circular A-94 for federally funded mitigation/resilience projects is 7.00 percent. Private corporate investments can use the OMB A-94 rates, or they might use a weighted average cost of capital, which is calculated based on the sources of financing for the project. The higher the discount rate, the lower the present value of future benefits and costs.

Because project benefits accumulate over time, project benefits are calculated on an average annual basis ("annualized") and then multiplied by a Present Value Coefficient (PVC) to

determine the present value of the benefits. As shown in Equation 3 below, the PVC is a product of the estimated useful life of the project and the discount rate.

**Equation 3.** *Present Value Coefficient (PVC) formula.*

$$PVC = \frac{[1 - (1 + r)^{-T}]}{r}$$

**Where:** *PVC = Present Value Coefficient*

*r = Discount rate (7.00%)*

*T = Project useful life (years)*

This present value of the benefits is divided by the present value of the costs to determine the BCR.

BCA typically is used when trying to decide if the advantages of a particular action or project outweigh the drawbacks. It provides a quantitative basis on which to make a decision as well as to compare different alternatives. BCA differs from return on investment (ROI) analysis in that ROI is calculated using the most tangible costs and benefits, whereas BCA is more detailed than ROI and includes intangibles such as the value of a person's time or state of health. These intangibles are valued based on "willingness to pay", which is a measure of what individuals are willing to forego to obtain a particular benefit. Some of these willingness to pay values have been preprogrammed into the HMCE Tool.

## Tool Process and Assumptions

The HMCE Tool computes some common financial measures used for decision-making, including annualized damages, the present value of these damages, present value of total project benefits, present value of total project costs, net present value of the project, and the benefit-cost ratio. The user inputs data into cells in an Excel workbook, which are then used to calculate these various financial measures.

There are three basic analysis tabs in the Excel workbook that are always visible:

- 1) The **Project Information (Project Info)** tab is where users input information on the proposed resilience project.
- 2) The **Damage Information (Damage Info)** tab is where users input information about the historic or expected pre-resilience damages and losses.
- 3) The **BCA Results (Analysis Results)** tab provides a summary of the analysis results and allows users to note any qualitative benefits associated with the proposed resilience project.

These three basic analysis tabs include the minimum required information, denoted by a red asterisk (\*), to complete a basic analysis; which assumes that the resilience project will protect against all pre-project damages that would occur for a specified recurrence interval if the project were not undertaken.

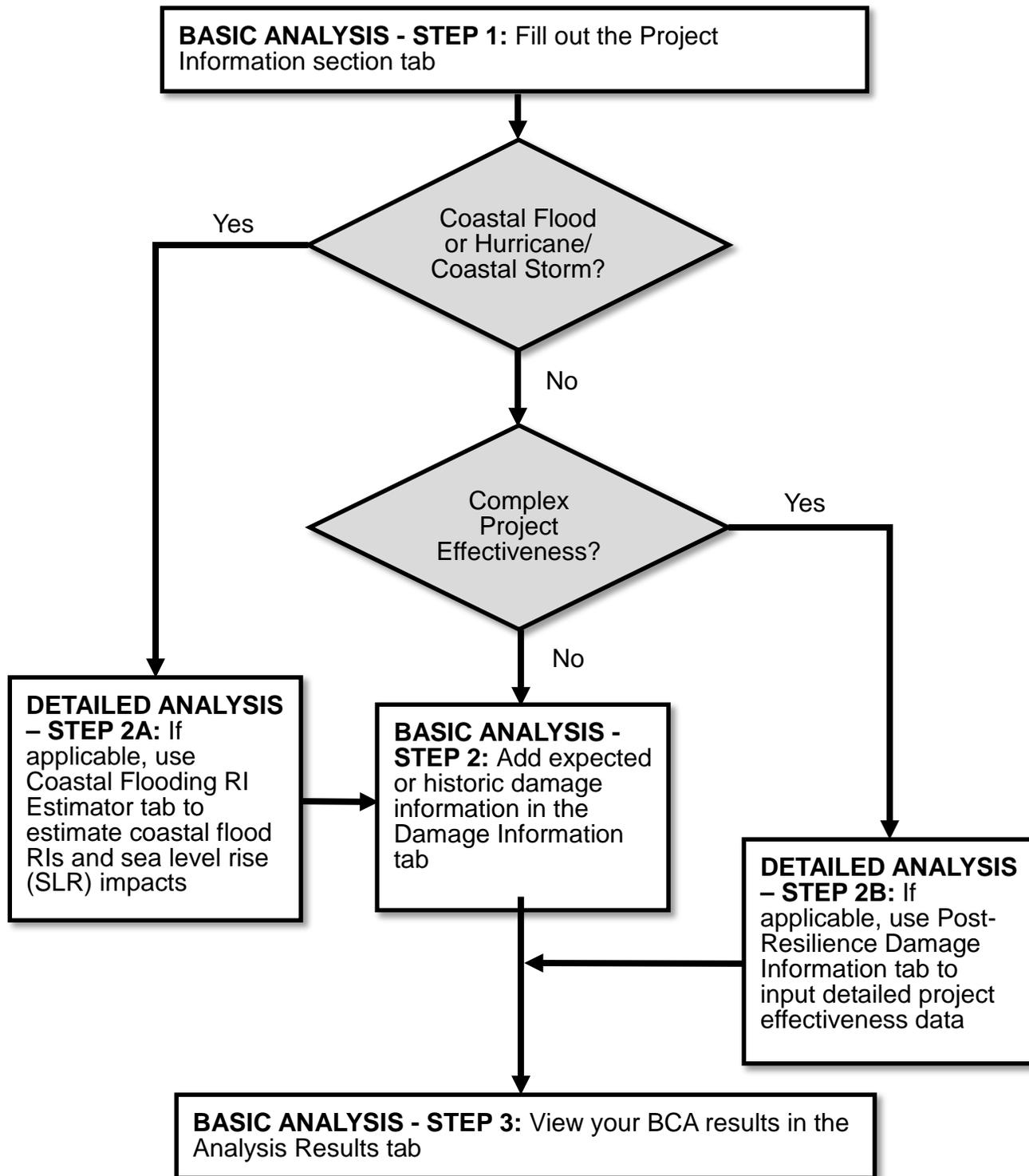
In addition to the basic analysis primary tabs, there are two hidden tabs that appear if the user selects certain options on the Project Info tab. These two detailed analysis tabs are described below:

**NOTE: Recurrence Interval (RI)**

A **recurrence interval (RI)** is the expected frequency of an event based on the annual probability of occurrence (exceedance probability). For example, a flood or other event with a 1-percent chance of being equaled or exceeded in any given year has a probability of 0.01 and a recurrence interval of  $(1/0.01) = 100$  years.

- **Coastal Flood Recurrence Interval (RI) Estimator (RI Estimator):** If the user selects Flood or Hurricane/Coastal Storm as the primary hazard protected by the project, a RI Estimator tab appears. This tab, which is optional to complete, allows the user to adjust the recurrence interval of the hazard to account for sea level rise. Accounting for sea level rise has the effect of reducing the recurrence interval (i.e., the event will occur more frequently), which generally increases the benefit-cost ratio of the proposed project. Refer to Appendix B of the user guide for additional details on coastal flood hazard guidance.
- **Post-Resilience Damage Information (Post Resil Damages):** If the user selects the option to evaluate post-resilience damage on the basis of user-entered data, a Post Resil Damages tab appears. This tab allows the user to enter post-resilience data that assumes that the resilience project might not completely protect against the selected hazard; some residual damages are still likely to occur. This assumption generally decreases the benefit-cost ratio of the project under consideration.

The general process for completing an analysis using the HMCE Tool is summarized in Figure 1 on the next page.



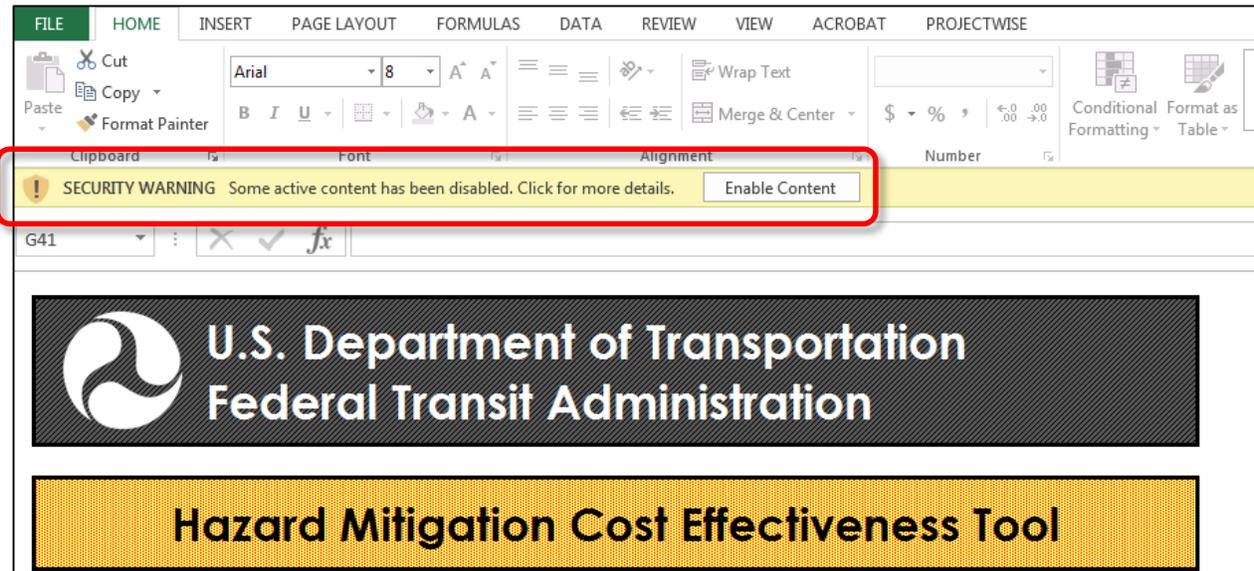
**Figure 1.** Process flow diagram for completing an HMCE Tool analysis.

This User Guide provides details for completing each of these primary and secondary tabs in the sections that follow.

## Before You Start – Opening the Tool

### Actions/Inputs

- When you open the tool in Microsoft Excel® 2013, an error bar might appear like the one shown below informing you that **macros have been disabled**.



- If this error bar appears, or the macros are disabled automatically, take the following steps to enable the macros:
  - 1) Click on **Options**.
  - 2) Select the radio button next to **Enable Content**.
  - 3) Click **OK**.

### Notes and Tips

- Although not needed for calculations, this tool relies on macros to facilitate navigation, saving and printing. Although macros from unknown sources may be dangerous, the macros embedded in the HMCE tool are perfectly safe.
- If you like, you may choose to turn off the feature in Excel that automatically disables macros. You can find instructions on how to do so at [microsoft.com](http://microsoft.com).

# PROJECT INFORMATION

## Basic Analysis Step 1

### General Information



**U.S. Department of Transportation  
Federal Transit Administration**

**Hazard Mitigation Cost Effectiveness Tool**

3/10/2017 – version 2.2

**Disclaimer:**

The results produced by this tool are not conclusive evidence that a project proposal is or is not cost-effective. The analysis conducted is dependent upon the quality of the information input into the tool. It is intended for use as a planning tool only.

**Description:**

Many transit agencies are considering including resilience elements in capital improvement projects during the planning and design phases. This tool may be used for benefit-cost analysis (BCA) of resilience projects being considered for funding as part of a transit agency's asset management program to enable them to make informed decisions about implementing resilience projects.

Resilience projects are those natural hazard mitigation projects designed and built to address vulnerabilities to a public transportation facility or system due to future occurrence of emergencies or major disasters that are likely to occur in the geographic area in which the public transportation system is located; or projected changes in development patterns, demographics, or extreme weather or other climate patterns. Cost-effectiveness evaluations for proposed projects that include a benefit-cost ratio (BCR) can provide important information to decision-makers regarding the project's ability to reduce an asset's and the public transportation system's vulnerabilities to future disasters in a cost-effective way. In general, a BCR of one or greater indicates a project is cost-effective. However, additional considerations may result in some projects with a BCR of less than one being considered cost-effective.

The tool provides a framework for transit agencies to input quantitative information about a project and its cost-effectiveness. Quantitative information to be input into the tool includes the estimated damages and losses from specifically identified hazards (i.e., recorded historical or expected theoretical events) and the reduction in the anticipated damages and losses after such an event as a result of implementing the proposed project.

### Actions/Inputs

- The top left portion of the Project Info tab includes general information about the software including the tool version, build date, disclaimer and description.
- Read this information before using the software for the first time.
- Click on any tab button to proceed directly to that tab.

### Notes and Tips

- It's worthwhile to read this information and the disclaimer - and you only have to do it once.

## Tool Information - Inputs, Saving and Printing

### Tool Information

Project and related information may be inputted only into the white cells on the tabs of this tool. All other cells are protected in order to prevent accidental erasure or overwriting. Attempts to modify a protected cell will display an error. Cells marked with a red asterisk (\*) represent required inputs.

Hover your cursor over cells with red triangles in the top-right corner to show guidance notes for that cell. Guidance notes provide additional information about values that should be entered into cells.

Save As New Project	Click the "Save As New Project" button to start a new project file. You will be prompted to enter a file name.
Save Current Project	Click the "Save Current Project" button to save the current project file.
Print This Tab	Click the "Print This Tab" button to print the current tab. You will be prompted to choose a printer.
Print All	Click the "Print All" button to print all the sheets. You will be prompted to choose a printer.

### Actions/Inputs

- The top right portion of the Project Info tab includes information about data input requirements, guidance notes, saving and printing.
- All input cells are white, but only the white cells marked with a red asterisk (\*) are required inputs.
- Click the **Save as New Project** button to create a new project.
- Click the **Save Current Project** button to save your work.
- Click the **Print this Tab** button to print all inputs on the current tab.
- Click the **Print All** button to print all inputs and outputs on all tabs.

### Notes and Tips

- The **Save As New Project** button only appears on the Project Information tab.
  - Clicking this button should be your first action when you start a new analysis to ensure that you have an electronic copy of your work.
  - Recommend saving each analysis as a separate file
- The **Print All** button only appears on the Project Information tab. Click this button when you complete an analysis to ensure that you have a hard copy record of your work.

## Tool Navigation

**U.S. Department of Transportation  
Federal Transit Administration**

### Hazard Mitigation Cost Effectiveness Tool

3/10/2017 – version 2.2

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The tool provides a framework for transit agencies to input quantitative information about a project and its cost-effectiveness. Quantitative information to be input into the tool includes the estimated damages and losses from specifically identified hazards (i.e., recorded historical or expected theoretical events) and the reduction in the anticipated damages and losses after such an event as a result of implementing the proposed project.

**Instructions:**

**Step 1:** Fill out the Project Information section on this tab.  
**Step 2:** Add expected or historic damage information on the next tab.

Project Info | Damage Info | Analysis Results

**Tool Information**

Project and related information may be inputted only into the white cells on the tabs of this tool. All other cells are protected in order to prevent accidental erasure or overwriting. Attempts to modify a protected cell will display an error. Cells marked with a red asterisk (\*) represent required inputs.

Hover your cursor over cells with red triangles in the top-right corner to show guidance notes for that cell. Guidance notes provide additional information about values that should be entered into cells.

**Save As New Project** Click the "Save As New Project" button to start a new project file. You will be prompted to enter a file name.

**Save Current Project** Click the "Save Current Project" button to save the current project file.

**Print This Tab** Click the "Print This Tab" button to print the current tab. You will be prompted to choose a printer.

**Print All** Click the "Print All" button to print all the sheets. You will be prompted to choose a printer.

## Actions/Inputs

- Navigate through the tool using the three tabs shown at the bottom of the screen.
- Click on any tab to proceed directly to that tab.

## Notes and Tips

- The tool initially shows the basic analysis tabs. The other detailed analysis tabs remain hidden until you select them based on inputs chosen on the Project Information tab.

## Basic Tool Instructions

Instructions:
<p><b>Step 1:</b> Fill out the Project Information section on this tab.</p> <p><b>Step 2:</b> Add expected or historic damage information on the next tab.</p> <p><b>Step 3:</b> View your BCA results in the Analysis Results tab.</p> <p><b>Note:</b> For each damage event in the 'Damage Info' tab, fill in all cells requiring a number.</p> <p><b>Note:</b> For all sheets, cells marked with a red asterisk (*) represent required inputs.</p>

### Actions/Inputs

- Basic Instructions for completing the tool are at near the top of the tab just below the Description.
- The instructions list the three basic analysis steps:
  - 1) Start by filling out the required project information in Project Information tab.
  - 2) Next, fill out the required damage information in the Damage Information tab
  - 3) View results in the Analysis Results tab
- The instructions include notes with additional details on filling in historic or expected damage events, and remind users that all **white cells marked with a red asterisk (\*) represent required inputs.**
  - White cells that are not marked with an asterisk represent optional inputs.
  - Cells shaded in yellow represent values calculated and/or carried over from input cells.

### Notes and Tips

- A process flow diagram of the basic analysis steps and detailed analysis steps is shown in Figure 1 on page 6 of this User Guide.
- Some cells in the tool have red triangles in the upper right corner (▼), indicating there is an explanation attached to the cell than can be viewed by rolling over the triangle.

## Section I – Agency Information

Project Information			
Section I - Agency Information			
Agency*:			
Address:			
City:		State:	Zip:

### Actions/Inputs

- Section I – Agency Information - is located in the middle of the tab just below the Instructions.
- Enter the name of the transit agency in the **Agency** box.
- User have the option of inputting the following optional transit agency information in the appropriate boxes:
  - Address
  - City
  - State
  - Zip

### Notes and Tips

- The **State** input box includes a drop-down menu listing all states and U.S. territories.
- The required input and some optional inputs in Section I will auto-populate to subsequent tabs in the HMCE tool.

## Section II – Project Information: Project Name, Analysis Details, and Transit Mode(s)

Section II - Project Information			
Project Name*:			
Analysis Year*:	<input type="text" value="2017"/>	Analysis Date*:	<input type="text"/>
Analyst*:	<input type="text" value="Select Year"/>	Analyst Phone:	<input type="text"/>
Transit Mode(s) Protected by Project*:	<input type="checkbox"/> Subway/Inner City Rail <input type="checkbox"/> Bus <input type="checkbox"/> Light/Commuter Rail <input type="checkbox"/> Ferry <input type="checkbox"/> Intercity Passenger Rail		
Primary Hazard Protected by Project*:	<input type="radio"/> Flood <input type="radio"/> Hurricane/Coastal Storm <input type="radio"/> Wind <input type="radio"/> Snow/Ice Storm <input type="radio"/> Earthquake <input type="radio"/> Other	If Primary Hazard is "Other," please specify:	
Secondary Hazard(s) Protected by Project:	<input type="checkbox"/> Flood <input type="checkbox"/> Hurricane/Coastal Storm <input type="checkbox"/> Wind <input type="checkbox"/> Snow/Ice Storm <input type="checkbox"/> Earthquake <input type="checkbox"/> Other	If Secondary Hazard is "Other," please specify:	
Brief Project Description*:	<input type="text"/>		
Select Basis to Evaluate Post-Resilience Damage*:	<input type="radio"/> "Project Effectiveness" as entered below <input type="radio"/> "User-Entered Data" (New tab opens)		
Proposed Project Effectiveness (Years)*:	<input type="text"/>	Source/Documentation of Project Effectiveness:	<input type="text"/>

### Actions/Inputs

- Section II – Project Information - is located in the middle of the tab just below Section I.
- Enter the **Project Name**.
- Select an **Analysis Year** from the drop-down menu. Users may select 2017 or 2018, depending on what year is appropriate for the project.
- Enter the name of the **Analyst** and the **Analysis Date** in the appropriate boxes.
- Users have the option of inputting the Analyst Phone to provide contact information for the project.
- Check the **Transit Mode(s) Protected by Project** that the resilience project is designed to mitigate. Note that multiple boxes can be checked.

### Notes and Tips

- The Project Name and other required inputs in this part of Section II will auto-populate to subsequent tabs in the HMCE tool.
- You can select as many transit modes as apply to your project.

## Section II – Project Information: Primary and Secondary Hazards

Section II - Project Information			
Project Name*:			
Analysis Year*:		Analysis Date*:	
Analyst*:			Analyst Phone:
Transit Mode(s) Protected by Project*:	<input type="checkbox"/> Subway/Inner City Rail <input type="checkbox"/> Bus <input type="checkbox"/> Light/Commuter Rail <input type="checkbox"/> Ferry <input type="checkbox"/> Intercity Passenger Rail		
Primary Hazard Protected by Project*:	<input type="radio"/> Flood <input type="radio"/> Hurricane/Coastal Storm <input type="radio"/> Wind <input type="radio"/> Snow/Ice Storm <input type="radio"/> Earthquake <input type="radio"/> Other	If Primary Hazard is "Other," please specify:	
Secondary Hazard(s) Protected by Project:	<input type="checkbox"/> Flood <input type="checkbox"/> Hurricane/Coastal Storm <input type="checkbox"/> Wind <input type="checkbox"/> Snow/Ice Storm <input type="checkbox"/> Earthquake <input type="checkbox"/> Other	If Secondary Hazard is "Other," please specify:	
Brief Project Description*:			
Select Basis to Evaluate Post-Resilience Damage*:	<input type="radio"/> "Project Effectiveness" as entered below <input type="radio"/> "User-Entered Data" (New tab opens)		
Proposed Project Effectiveness (Years)*:		Source/Documentation of Project Effectiveness:	

### Actions/Inputs

- Select the **Primary Hazard Protected by the Project** by clicking on the radio button representing the primary hazard that the resilience project is designed to mitigate.
  - Note that only one radio button can be selected.
  - **When "Flood" or "Hurricane/Coastal Storm" is selected, another tab called "RI Estimator" appears in the workbook** to assist the user in estimating coastal storm recurrence intervals (RI). **Refer to the Coastal Flooding RI Estimator (Detailed Analysis – Step 2A) section for details.**
- Users have the option to check the Secondary Hazard(s) Protected by Project that the project is designed to mitigate. Note that no box or multiple boxes can be checked.

### Notes and Tips

- If the Primary Hazard or Secondary Hazard is not listed, you can select "Other" and describe the mode in the given box next to the input cell.

## Section II – Project Information: Project Description

Section II - Project Information			
Project Name*:			
Analysis Year*:		Analysis Date*:	
Analyst*:			Analyst Phone:
Transit Mode(s) Protected by Project*:	<input type="checkbox"/> Subway/Inner City Rail <input type="checkbox"/> Bus <input type="checkbox"/> Light/Commuter Rail <input type="checkbox"/> Ferry <input type="checkbox"/> Intercity Passenger Rail		
Primary Hazard Protected by Project*:	<input type="radio"/> Flood <input type="radio"/> Hurricane/Coastal Storm <input type="radio"/> Wind <input type="radio"/> Snow/Ice Storm <input type="radio"/> Earthquake <input type="radio"/> Other		If Primary Hazard is "Other," please specify:
Secondary Hazard(s) Protected by Project:	<input type="checkbox"/> Flood <input type="checkbox"/> Hurricane/Coastal Storm <input type="checkbox"/> Wind <input type="checkbox"/> Snow/Ice Storm <input type="checkbox"/> Earthquake <input type="checkbox"/> Other		If Secondary Hazard is "Other," please specify:
Brief Project Description*:			
Select Basis to Evaluate Post-Resilience Damage*:	<input type="radio"/> "Project Effectiveness" as entered below <input type="radio"/> "User-Entered Data" (New tab opens)		
Proposed Project Effectiveness (Years)*:		Source/Documentation of Project Effectiveness:	

### Actions/Inputs

- Enter a **Brief Project Description** to provide a one to three sentence summary of the proposed resilience project.
- Users can copy and paste the description from a grant proposal form or similar document.

### Notes and Tips

- When you briefly describe your project, try to answer the following questions:
  - **What** does the project entail?
  - **Why** is it important to complete this project?
  - **Where** will the project take place?
  - **How** will the project be implemented?

## Section II – Project Information: Project Effectiveness

Section II - Project Information			
Project Name*:			
Analysis Year*:		Analysis Date*:	
Analyst*:			
Analyst Phone:			
Transit Mode(s) Protected by Project*:	<input type="checkbox"/> Subway/Inner City Rail <input type="checkbox"/> Bus <input type="checkbox"/> Light/Commuter Rail <input type="checkbox"/> Ferry <input type="checkbox"/> Intercity Passenger Rail		
Primary Hazard Protected by Project*:	<input type="radio"/> Flood <input type="radio"/> Hurricane/Coastal Storm <input type="radio"/> Wind <input type="radio"/> Snow/Ice Storm <input type="radio"/> Earthquake <input type="radio"/> Other	If Primary Hazard is "Other," please specify:	
Secondary Hazard(s) Protected by Project:	<input type="checkbox"/> Flood <input type="checkbox"/> Hurricane/Coastal Storm <input type="checkbox"/> Wind <input type="checkbox"/> Snow/Ice Storm <input type="checkbox"/> Earthquake <input type="checkbox"/> Other	If Secondary Hazard is "Other," please specify:	
Brief Project Description*:			
Select Basis to Evaluate Post-Resilience Damage*:	<input type="radio"/> "Project Effectiveness" as entered below <input type="radio"/> "User-Entered Data" (New tab opens)		
Proposed Project Effectiveness (Years)*:		Source/Documentation of Project Effectiveness:	

### Actions/Inputs

- **Select Basis to Evaluate Post-Resilience Damage** by clicking on the radio button representing the approach for determining the resilience project effectiveness.
  - When "Project Effectiveness" is selected, a simplified approach is used to measure project effectiveness (residual risk).
  - **When "User-Entered Data" is selected, another tab called "Post Resil Damages" appears in the workbook** to assist the user in a more detailed evaluation of project effectiveness. **Refer to the Post-Resilience Damage Information (Detailed Analysis – Step 2B) section for details.**
- Enter the **Proposed Project Effectiveness** representing the Recurrence Interval (RI) that the proposed resilience project is designed to mitigate. For example, if the proposed project is a flood barrier built to the 100-year flood elevation, then input 100 years.
- Users have the option to select a Source/Documentation of Project Effectiveness from a drop-down menu listing three common types of documentation.

### Notes/Tips

- The simplified approach using "Project Effectiveness" assumes the project is 100% effective for hazard events up to the Proposed Project Effectiveness level, and 0% effective for any hazard events greater than that level. This simplified approach is considered acceptable for a most basic resilience projects, but may not reflect the actual effectiveness of more complex projects with variable levels of residual risk.
- The approach using "User-Entered Data" lets you provide a more detailed estimate of project effectiveness by inputting post-resilience damages and losses for one or more Recurrence Intervals (RIs).

## Section III – Cost Information: Total Initial Project Cost

Section III - Cost Information		
Total Project Initial Cost*:		
Source/Documentation of Total Cost Estimate:		
Project Useful Life (Years):		Select Source
Annual Project Operation & Maintenance (O&M) Cost*:		
Source/Documentation of Annual O&M Cost:		
Discount Rate (%):	7.00	
Present Value of Annual O&M Costs:		
Total Project Cost including O&M:		

### Actions/Inputs

- Enter **Total Initial Project Cost**, including the initial cost of project study and design, and contractual and construction costs.
- Users have the option to select a Source/Documentation of Total Cost Estimate from a drop-down menu listing three common sources of documented costs:
  - Local historic cost data
  - Current contractor bids
  - Published unit costs

### Notes/Tips

- Your Total Initial Project Cost should include:
  - Pre-Construction Costs of study and design;
  - Construction Costs; and
  - Ancillary Costs of contractual costs and associated mark-ups.
- The Total Initial Project Cost entered would match the total cost on any grant proposal form submitted for funding.

## Section III – Cost Information: Project Useful Life

Section III - Cost Information		
Total Project Initial Cost*:		
Source/Documentation of Total Cost Estimate:		
Project Useful Life (Years)*:		
Annual Project Operation & Maintenance (O&M) Cost*:		
Source/Documentation of Annual O&M Cost:		
Discount Rate (%):	7.00	
Present Value of Annual O&M Costs:		
Total Project Cost including O&M:		

### Actions/Inputs

- Enter the **Project Useful Life**, defined as the duration, in years, over which the proposed project will protect the asset(s).

### Notes/Tips

- **Standard Project Useful Life (PUL) Summary Guidance** is given in **Appendix A** of this **User Guide**.
- HMCE Tool analysis is conducted based on Project Useful Life.

## Section III – Cost Information: Annual Project Operation & Maintenance (O&M) Cost

Section III - Cost Information		
Total Project Initial Cost*:		
Source/Documentation of Total Cost Estimate:		
Project Useful Life (Years)*:		
Annual Project Operation & Maintenance (O&M) Cost*:		
Source/Documentation of Annual O&M Cost:		
Discount Rate (%):	7.00	
Present Value of Annual O&M Costs:		
Total Project Cost including O&M:		

### Actions/Inputs

- Enter the **Annual Project Operation & Maintenance (O&M) Cost**, defined as the difference between the average annual operation and maintenance (O&M) costs associated with the proposed project and the current average annual O&M costs for the asset to be protected by the project, as shown in Equation 4 below.

**Equation 4.** Determining project benefits.

$$\text{Annual Project O\&M Cost} = (\text{Average Annual O\&M Costs for Proposed Project}) - (\text{Current Average Annual O\&M Costs for Asset})$$

- Users have the option to briefly describe the Source/Documentation of Annual O&M Cost. If possible, identify a file or reference containing these calculations.

### Notes/Tips

- You may enter any numerical value for Annual Project O&M Cost:
  - A **positive** value indicates that O&M costs will be higher after the proposed project is complete.
  - **Zero** indicates that O&M costs will not change.
  - A **negative** value indicates that the proposed project will actually reduce annual O&M costs.

## Section III – Cost Information: Discount Rate

Section III - Cost Information		
Total Project Initial Cost*:		
Source/Documentation of Total Cost Estimate:		
Project Useful Life (Years)*:		
Annual Project Operation & Maintenance (O&M) Cost*:		
Source/Documentation of Annual O&M Cost:		
Discount Rate (%):	7.00	
Present Value of Annual O&M Costs:		
Total Project Cost including O&M:		

### Actions/Inputs

- No input is required for the Discount Rate. For this FTA HMCE tool, the discount rate is pre-populated at 7 percent (7.00%).

### Notes/Tips

- Office of Management and Budget (OMB) Circular A-94 has established the standard discount rate of 7 percent for benefit-cost analysis of federally funded mitigation projects.
- Users may override the default value of 7 percent for projects where federal funds are not used, but this is not recommended without strong supporting documentation.
- The discount rate accounts for the time value of money.

## Section IV – Interruption of Service Cost and Federal Mileage Rate

Section IV - Cost Associated with Interruption in Transit Services during Project Construction/Implementation		
Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)*:	Default	\$ 17.08
Current Federal Mileage Rate (\$/Mile)*:	\$ 0.535	
Will there be a losses or delays in transit service during project construction?*	No	

### Actions/Inputs

- Select **Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)** by clicking on the radio button and selecting from the following options.
  - 1) Keep the “Default” national average value of \$17.08/Passenger/Hour
  - 2) Scroll down to select average values from one of fifteen U.S. metropolitan areas.
  - 3) Scroll down to the bottom of the list to select “User-Entered”, and type in the customized value in the adjacent input cell.
- Input the **Current Federal Mileage Rate (\$/Mile)** based on data from the U.S. General Services Administration (GSA).
- Select **Will there be losses or delays in transit service during project construction?**
  - Keep the default value of “No” if there will not be a reduction in services for the associated transit mode during project construction, and the section is complete (proceed to User Guide page 26).
  - Select “Yes”, and the section will expand as shown on the pages that follow (see User Guide pages 22-25).

### Notes/Tips

- The default Cost of Loss of Services for Transit Passengers using rail, bus, and/or ferry is \$17.08/passenger/hour based on the current national average hourly wage rate data from the U.S. Bureau of Labor Statistics (BLS) and U.S. Department of Transportation (DOT) guidance.
- Costs of Loss of Services for Transit Passengers for various metropolitan areas is based on the current regional average hourly wage rate data from the BLS and DOT guidance.
- User-entered values for Loss of Services for Transit Passengers must be supported by appropriate documentation from a credible source(s).
- The default Federal mileage rate of \$0.535/mile for passenger vehicles is determined by the GSA for 2017.

## Section IV – Interruption of Service Costs: Duration of Loss or Reduction of Service

Section IV - Cost Associated with Interruption in Transit Services during Project Construction/Implementation			
Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)*:	Default		\$ 17.08
Current Federal Mileage Rate (\$/Mile)*:	\$ 0.535		
Will there be a losses or delays in transit service during project construction?*	Yes		
Duration of Loss or Reduction of Services (Days)*:			
Impacts Due to Delay and/or Extra Travel Time for Transit Mode Under Project Construction			
Delay or Extra Travel Time (Hours):			
Average Daily Number of Passengers:			
Loss of Transit Services Cost:			
Impacts Due to Delay and/or Extra Travel Time and Miles for Alternate Transit Modes			
Additional Time per One-way Trip (Hours):			
Additional Travel Miles:			
Alternate Transit Mode (Rail, Ferry, Buses)		Other Alternate Transit Mode (Vehicles)	
Number of One-way Traffic Trips per Day (Rail/Ferry/Buses):		Number of One-way Traffic Trips per Day (Vehicles):	
Average Number of Passengers per Trip:		Average Number of Passengers per Vehicle:	1.67
Loss of Services Cost (Rail/Ferry/Buses):		Loss of Services Cost (Vehicles):	
Totals			
Total Cost due to Interruption of Services:			
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			

### Actions/Inputs

- Enter the **Duration of Loss or Reduction of Services (Days)** in days associated with construction or implementation of the proposed project.
- Enter "0.00" if there will not be a reduction in services for the associated transit mode during project construction.

### Notes/Tips

- The Duration of Loss or Reduction of Services is the time period (in days) during project construction or implementation that passenger travel will be impacted.

## Section IV – Interruption of Service Costs: Impacts on Transit Mode Under Construction

Section IV - Cost Associated with Interruption in Transit Services during Project Construction/Implementation		
Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)*:	Default	\$ 17.08
Current Federal Mileage Rate (\$/Mile)*:	\$ 0.535	
Will there be a losses or delays in transit service during project construction?*	Yes	
Duration of Loss or Reduction of Services (Days)*:		
Impacts Due to Delay and/or Extra Travel Time for Transit Mode Under Project Construction		
Delay or Extra Travel Time (Hours):		
Average Daily Number of Passengers:		
Loss of Transit Services Cost:		

### Actions/Inputs

- Enter the indicated values if your project has service interruptions involving the same transit mode or reduced transit speeds during construction.
  - Enter the estimated **Delay or Extra Travel Time (Hours)** in hours.
  - Enter the **Average Daily Number of Passengers** using the transit line during the construction period(s).
- If no service interruptions will occur, enter 0 for either or both values.

### Notes/Tips

- The estimated delay is how much longer it will take passengers to get to their destination using the same transit mode due to project construction.
- If no service is available to take passengers to their destination, then Delay of Extra Travel Time should be one-half day (12 hours) to reflect loss of one-way trip.
- The Loss of Transit Services Cost will populate automatically.
- You should maintain documentation to support the number of passengers impacted by the delays.

## Section IV – Interruption of Service Costs: Impacts on Alternate Transit Modes

Impacts Due to Delay and/or Extra Travel Time and Miles for Alternate Transit Modes			
Additional Time per One-way Trip (Hours):			
Additional Travel Miles:			
Alternate Transit Mode (Rail, Ferry, Buses)		Other Alternate Transit Mode (Vehicles)	
Number of One-way Traffic Trips per Day (Rail/Ferry/Buses):		Number of One-way Traffic Trips per Day (Vehicles):	
Average Number of Passengers per Trip:		Average Number of Passengers per Vehicle:	1.67
Loss of Services Cost (Rail/Ferry/Buses):		Loss of Services Cost (Vehicles):	
Totals			
Total Cost due to Interruption of Services:			
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			

### Actions/Inputs

- Enter the indicated values if your project will impact an alternative mode of transit including passenger vehicle traffic.
  - Enter the **Additional Time per One-Way Trip (Hours)** in hours for the alternative transit mode.
  - Enter the **Additional Travel Miles** per one way trip in miles for the alternate
- If no service interruptions will occur, enter 0 for both values.

### Notes/Tips

- The Additional Time per One-Way Trip is how much longer one trip will take on the alternate transit mode during project construction.
- The Additional Travel Miles accounts for delays or detours on alternative transit modes caused by project construction. If there are no delays or detours, enter 0 or leave this field blank.

## Section IV – Interruption of Service Costs: Impacts on Alternate Transit Modes (continued)

Impacts Due to Delay and/or Extra Travel Time and Miles for Alternate Transit Modes			
Additional Time per One-way Trip (Hours):			
Additional Travel Miles:			
Alternate Transit Mode (Rail, Ferry, Buses)		Other Alternate Transit Mode (Vehicles)	
Number of One-way Traffic Trips per Day (Rail/Ferry/Buses):		Number of One-way Traffic Trips per Day (Vehicles):	
Average Number of Passengers per Trip:		Average Number of Passengers per Vehicle:	1.67
Loss of Services Cost (Rail/Ferry/Buses):		Loss of Services Cost (Vehicles):	
Totals			
Total Cost due to Interruption of Services:			
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			

### Actions/Inputs

- Enter the indicated values if your project will impact an alternative mode of transit including passenger vehicle traffic.
  - If alternative transit modes (rail, ferry, bus) will be impacted, enter the **Number of One-way Traffic Trips per Day (Rail/Ferry/Buses)** and the **Average Number of Passengers per Trip**.
  - If passenger vehicles will be impacted, enter the **Number of One-way Traffic Trips per Day (Vehicles)** made by passenger vehicles.
- If there will not be impacts on rail, ferry, bus, or vehicle travel, enter 0.
- If no service interruptions will occur, enter 0 for both values.

### Notes/Tips

- You can enter trip information for rail, ferries, buses and passenger vehicles.
- The default value for Average Number of Passenger per Vehicle (1.67) is based on the latest available DOT traffic studies and should not be changed without supporting documentation.
- You should maintain documentation to support your estimates of the number of trips and average number of bus passengers.

## Section IV – Interruption of Service Costs: Totals

Section IV - Cost Associated with Interruption in Transit Services during Project Construction/Implementation			
Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)*:	Default		\$ 17.08
Current Federal Mileage Rate (\$/Mile)*:	\$ 0.535		
Will there be a losses or delays in transit service during project construction?*	Yes		
Duration of Loss or Reduction of Services (Days)*:			
Impacts Due to Delay and/or Extra Travel Time for Transit Mode Under Project Construction			
Delay or Extra Travel Time (Hours):			
Average Daily Number of Passengers:			
Loss of Transit Services Cost:			
Impacts Due to Delay and/or Extra Travel Time and Miles for Alternate Transit Modes			
Additional Time per One-way Trip (Hours):			
Additional Travel Miles:			
Alternate Transit Mode (Rail, Ferry, Buses)		Other Alternate Transit Mode (Vehicles)	
Number of One-way Traffic Trips per Day (Rail/Ferry/Buses):		Number of One-way Traffic Trips per Day (Vehicles):	
Average Number of Passengers per Trip:		Average Number of Passengers per Vehicle:	1.67
Loss of Services Cost (Rail/Ferry/Buses):		Loss of Services Cost (Vehicles):	
Totals			
Total Cost due to Interruption of Services:			
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			
Totals			
Total Cost due to Interruption of Services:			
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			

### Actions/Inputs

- The Total BCA Project Costs will be displayed at the bottom of the Project Information tab. This number will be used in the evaluation of the benefit-cost ratio (BCR).
- No additional inputs are required for the Project Information tab.
- Remember to **Save As New Project** if you have not done so already or **Save Current Project** (see top right portion of tab) if you have saved as a new project already.
- Please proceed to the Damage Information tab 3.

### Notes/Tips

- The total interruption costs and total project costs will populate in the Total BCA Project Costs based on your inputs to this point.

# GENERAL NOTES ON ENTERING DAMAGE INFORMATION

## General Notes - Entering Damage Information

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### DAMAGE INFORMATION Tab - Basic Analysis Step 2: The current (as-is) situation

- There are two basic options for inputting pre-resilience damage in this tab:
  - 1) Expected Damages, based on damages predicted from a theoretical model or engineering analysis: Need a minimum of one known RI event
  - 2) Historic Damages, based on records from actual past disaster events: Need a minimum of one known RI event or three unknown RI events occurring in different years

### POST-RESILIENCE DAMAGE INFORMATION Tab - Detailed Analysis Step 2B: Residual damage (project effectiveness)

- Input damages based on Expected Damages only

### DAMAGE INFORMATION and POST-RESILIENCE DAMAGE INFORMATION Tab both share the following features:

- The **BCR Summary** and **Tools** boxes remain visible at the top while the user is completing the tab information so that they can see how their entries affect calculations and can always save and print their work.

Hazard Mitigation Cost Effectiveness Tool	
<b>BCR Summary</b>	
Proposed Project Effectiveness (Years):	0
Total Project Benefits:	
Total BCA Project Costs:	\$ -
Benefit-Cost Ratio (BCR):	

Tools
Save Current Project
Print This Tab

- The Agency, Project Name and Analysis Year cells at the top of the Damage Information section auto-populate based on inputs from the previous Project Information tab.
- The Damage Information tab allows input of the following damage categories:
  - Physical Damages Costs - permanent repair/replacement of Fixed Structures (stations, tracks, facilities, substations) and Rolling Stock (rail cars, buses, ferries)
  - Response and Recovery Costs - emergency repairs, other temporary measures
  - Other Damage Costs - miscellaneous costs (lost revenue, debris, cleanup)
  - Economic Impacts of Lost Transit Service (Non-Physical Damages) - service losses/delays, alternate transit, additional mileage

## General Notes – Expected vs. Historic Damages

Section I - General Information	
Agency:	
Project Name:	
Analysis Year:	
Select Damage Analysis Type:	Select Damage Type
	Select Damage Type

***General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab***

### Actions/Inputs

- At the bottom of Damage Information Tab, Section I – General Information, begin with **Select Damage Type** by clicking on the radio button and selecting from the following options.
  - Historic Damages
  - Expected Damages
- The input screens that follow will change based on the selected damage type.

### Notes and Tips

- You must have damage data from at least one event regardless of your selection.
- Use Expected Damages if you are using damages predicted by a model.
  - You must know the recurrence interval (RI) associated with each expected damage event.
  - Post-Resilience Damages = Expected Damages
- Use Historic Damages if you are using records of damages from past disasters.
  - You do not need to know any recurrence intervals for historic damages, but you can enter up to 2 recurrence intervals.
- As a reminder, the RI is the expected return period of an event based on the annual probability of occurrence. (For example, a 100-year recurrence interval has a 1 in 100 probability or 1% chance of occurrence or exceedance in any given year.)

## General Notes – Entering Damages

Expected Damages Part A					
	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Total Part A Damages
	(includes permanent repairs to damaged fixed structures and rolling stock)		(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)		
Recurrence Interval (Years)	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	Response and Recovery Costs (\$)	Other Damage Costs (\$)	

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- Use one row for each damage event. If there are more rows in the table than you have damage events, leave the extra rows blank.
  - Expected Damage events require input of the event **Recurrence Interval (Years)**.
  - Historic Damage events require input of the **Event Year (4-digit Year)** in addition to the RI, if known.

### Notes and Tips

- If you enter a value in the first cell of a row (recurrence interval or year), you must enter a value in every other white cell in that row, even if the value is "0".

#### Additional Guidance on Recurrence Intervals

- You cannot repeat a RI, for instance you cannot enter two 25-year RI events.
  - If you have two 25-year events, enter "25" as the RI for the lower dollar-value event and "26" as the RI for the higher dollar-value event.
- Be sure that your damages increase with increasing RIs; for example, you cannot have a 500-year event with lower damages than a 100-year event.
- **Event Recurrence Interval Guidance is included as part of Appendix C of this User Guide.**

## General Notes – Analysis Year for Damage Estimates

Historic Damages Part A (Unknown Recurrence Interval)							
Event Year* (4-digit Year)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part A Damages (\$)	Are Damages in Current Dollars?	Total Part A Damages (Inflated to Analysis Year) (\$)
	Physical Damage Costs for Fixed Structures* (\$)	Physical Damage Costs for Rolling Stock* (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)				
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- All damage estimates must be estimated for, or inflated to, the Analysis Year selected on the Project Information Screen (i.e., 2017 or 2018).
  - If damage values are adjusted to a certain year's dollars prior to entry in the tool, the Analysis Year should be that year. For example, if a model was run in 2017 such that all estimates are in 2017 dollars, the Analysis Year should be 2017.
  - For Expected Damages, the damage values must be input to match the Analysis Year selected on the Project Information Screen.
  - For Historic Damages, the damage values usually match the Event Year for which the damage was estimated, not necessarily the Analysis Year. In which case, the tool will inflate the historic damage event to the Analysis Year.
- If Historic Damages entered into the tool have already been inflated to the Analysis Year, go to the **Are Damages in Current Dollars?** column and check the **Current Dollars** box for that event.

### Notes and Tips

- Event dollar values are inflated to the Analysis Year based on the latest available Engineering News Record (ENR) Construction Cost Index data.

## General Notes – Physical Damages

Historic Damages Part A (Unknown Recurrence Interval)							
Event Year (4-digit Year)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part A Damages (\$)	Are Damages in Current Dollars?*	Total Part A Damages (Inflated to Analysis Year) (\$)
	Physical Damage Costs for Fixed Structures* (\$)	Physical Damage Costs for Rolling Stock* (\$)	(includes permanent repairs to damaged fixed structures and rolling stock)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)			
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- Enter the **Physical Damage Costs for Fixed Structures (\$)** for each event.
- Enter the **Physical Damage Costs for Rolling Stock (\$)** for each event.
  - For Historic Damages, go to the **Are Damages in Current Dollars?** column and check the **Current Dollars** box for any event that has already been inflated to the Analysis Year.

### Notes and Tips

- Physical Damages can be approximated as the cost to repair the element to pre-disaster condition.
  - This type of damage may be shown on a FTA report, a damage report from transit agency, or as Permanent Work (Categories C-G) on a FEMA *Project Worksheet(s)*.
- If you don't have other damage categories, be sure to enter 0 in the white cells for all rows in which you have damage data.

## General Notes – Response and Recovery Costs

Historic Damages Part A (Unknown Recurrence Interval)							
Event Year* (4-digit Year)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part A Damages (\$)	Are Damages in Current Dollars?*	Total Part A Damages (Inflated to Analysis Year) (\$)
	Physical Damage Costs for Fixed Structures* (\$)	Physical Damage Costs for Rolling Stock* (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)				
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- Enter the **Response and Recovery Costs (\$)** for each event.
  - For Historic Damages, go to the **Are Damages in Current Dollars?** column and check the **Current Dollars** box for any event that has already been inflated to the Analysis Year.

### Notes and Tips

- Response and Recovery (R&R) Costs can include the costs of emergency protective measures (such as sandbags) and temporary repairs or measures that can be avoided by the proposed project.
  - This type of damage may be shown on a FTA report, a damage report from the transit agency, or as Emergency Work (Categories A and B) on a FEMA *Project Worksheet(s)*.
- If you don't have other damage categories, be sure to enter 0 in the white cells for all rows in which you have damage data.

## General Notes – Other Damage/Loss

Historic Damages Part A (Unknown Recurrence Interval)							
Event Year* (4-digit Year)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part A Damages (\$)	Are Damages in Current Dollars?*	Total Part A Damages (Inflated to Analysis Year) (\$)
	Physical Damage Costs for Fixed Structures* (\$)	Physical Damage Costs for Rolling Stock* (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)				
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- Enter a brief Description of **Other Damage/Loss** you are claiming.
- Enter the **Other Damage or Loss (\$)** for each event (i.e., damage costs not captured by Physical Damage Costs and/or Response and Recovery Costs).
  - For Historic Damages, go to the **Are Damages in Current Dollars?** column and check the **Current Dollars** box for any event that has already been inflated to the Analysis Year.

### Notes and Tips

- Examples of Other Damage or Loss may include:
  - Debris removal and disposal
  - Emergency management
  - Environmental cleanup
  - Equipment cleaning
  - Lost transit revenue – Note that lost transit revenue may not be considered an eligible project benefit for a grant submittal.
- If you don't have other damage categories, be sure to enter 0 in the white cells for all rows in which you have damage data.

## General Notes – Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services

Historic Damages Part B (Unknown Recurrence Interval)											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$ 16.79									
Current Federal Mileage Rate (\$/Mile):		\$ 0.540									
Event Year (4-digit Year)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services				Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses						Total Part B Damages
	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)	

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- Enter the **Delay or Extra Travel Time (Hours)** in hours caused by each event.
- Enter the **Average Daily Number of Passengers** for each event.
- Enter the **Duration of Loss or Reduction of Rail or Ferry Services (Days)** in days for each event.

### Notes and Tips

- **Be sure to enter the average daily passengers for the Analysis Year (for Expected Damages) or the year in which the damage occurred (for Historic Damages).**
- As stated previously in the Project Information tab guidance, if no service is available to take passengers to their destination, then Delay Time should be one-half day (12 hours) to reflect loss of one-way trip.
- If you don't have other damage categories, be sure to enter 0 in the white cells for all rows in which you have damage data.
- Damages due to delay and/or extra travel time are measured based on current values of lost transit service.

## General Notes – Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses

Historic Damages Part B (Unknown Recurrence Interval)												
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$ 16.79										
Current Federal Mileage Rate (\$/Mile):		\$ 0.540										
Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services					Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses							Total Part B Damages
Event Year (4-digit Year)	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)		

**General Notes apply to Expected Damages and Historic Damages in Damage Information Tab and Post-Resilience Damage Information Tab**

### Actions/Inputs

- Enter the **Additional Time per One-way Trip (Hours)** in hours.
- Enter the **Additional Travel Miles** in miles.
- Enter the **Duration of Loss or Reduction of Services (Days)** in days for each event.
- Enter the **Number of One-way Traffic Trips per Day (Buses)** made by buses.
- Enter the **Average Number of Passengers per Bus** for each event.

### Notes and Tips

- **Be sure to enter the average daily passengers for the Analysis Year (for Expected Damages) or the year in which the damage occurred (for Historic Damages).**
- As stated previously in the Project Information tab guidance, if no service is available to take passengers to their destination, then Delay Time should be one-half day (12 hours) to reflect loss of one-way trip.
- If you don't have other damage categories, be sure to enter 0 in the white cells for all rows in which you have damage data.
- Damages due to delay and/or extra travel time are measured based on current values of lost transit service.

# DAMAGE INFORMATION

## Basic Analysis Step 2

### Section II - Expected Damages: Questionnaire – Number of Events

Select Damage Analysis Type:	Expected Damages		
<b>Section II - Expected Damages</b>			
<b>Expected Damages Questionnaire</b>			
How many documented expected damage events do you have?	3	For how many of these expected damage events do you know the Recurrence Intervals (RIs)?	0
Errors: (must be corrected to proceed with analysis)	Insufficient number of expected damage events of known RIs to conduct a valid analysis!		
Warnings: (must be addressed to conduct a valid analysis)			
Conclusions: (provide directions on analysis approach based on completed questionnaire)	A valid analysis cannot be conducted without at least one or more damage events of known RIs.		
Source/Documentation of Expected Damages:			

#### Actions/Inputs

- Once Expected Damages is selected in Section I, Section II on Expected Damages begins with an optional Expected Damages Questionnaire to determine if the user has sufficient damage data to conduct an analysis.
- First, enter a number for “How many documented damage events do you have?” This may include one or more catastrophic events of known recurrence intervals.
- Next, enter a number for “For how many of these expected damage events do you know the Recurrence Intervals (RIs)?”
- Analyses based on one event of known RI are of limited accuracy and not recommended for detailed analysis.
- Analyses based on two or more events of known RIs are preferred, especially if one or more are based a recent, well-documented disaster event.

#### Notes and Tips

- You must have between 1 and 5 expected damage events, and you must know the recurrence intervals for each event to be included in your analysis.
- If your entries do not meet the criteria, then Errors, Warnings and/or Conclusions (such as those shown above) will appear.
  - Errors must be corrected to proceed with analysis
  - Warnings must be addressed to conduct a valid analysis
  - Conclusions provide directions on analysis approach

## Section II - Expected Damages: Questionnaire – Source of Expected Events

Select Damage Analysis Type:	Expected Damages		
<b>Section II - Expected Damages</b>			
<b>Expected Damages Questionnaire</b>			
How many documented expected damage events do you have?	3	For how many of these expected damage events do you know the Recurrence Intervals (RIs)?	0
Errors: (must be corrected to proceed with analysis)	Insufficient number of expected damage events of known RIs to conduct a valid analysis!		
Warnings: (must be addressed to conduct a valid analysis)			
Conclusions: (provide directions on analysis approach based on completed questionnaire)	A valid analysis cannot be conducted without at least one or more damage events of known RIs.		
Source/Documentation of Expected Damages:			

### Actions/Inputs

- Once Expected Damages is selected in Section I, Section II on Expected Damages begins with an optional Expected Damages Questionnaire to determine if the user has sufficient damage data to conduct an analysis.
- Users may list or describe the Source/Documentation of Expected Damages.

### Notes and Tips

- Include a link or a reference to the document with the Source/Documentation of Expected Damages.
- Attach a copy of an engineering report or similar document with the source and methodology used to determine the expected damages separately.

## Section II - Expected Damages: Part A and Part B – Entering Expected Damages and Losses

Expected Damages Part A											
Recurrence Interval (Years)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Total Part A Damages						
	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)								
Expected Damages Part B											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$	16.79								
Current Federal Mileage Rate (\$/Mile):		\$	0.540								
Recurrence Interval (Years)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services					Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses					Total Part B Damages
	Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Number of One-way Traffic Trips Per Day (Buses)	Average Number of Passengers per Bus	Loss of Services Damages (Buses)	

### Actions/Inputs

- Follow the General Notes on Entering Damages to complete Expected Damages Part A (damages) and Expected Damages Part B (service losses).
- Once you have entered the information for Expected Damages Parts A and B and any Post-Resilience Damages and Losses (if needed), please proceed to page 58 of this guide.

### Notes and Tips

- You must have between 1 and 5 Expected Damage events in Parts A and B.
- For Expected Damages, all event Recurrence Intervals must be known and input under Expected Damages Part A.
- All Expected Damage events should be estimated based on the Analysis Year selected in the Project Information tab.
- Remember that if you start a row, you must enter a value in every white cell in that row in Parts A and B, even if the value is 0.

## Section II - Historic Damages: Analysis Year and Analysis Duration

Select Damage Analysis Type:	Historic Damages		
<b>Section II - Historic Damages</b>			
Analysis Year:	2017		
Year Built (4-digit Year):			
Analysis Duration (Years):			
User Input Analysis Duration (Years):		Documentation/Justification:	
Selected Analysis Duration (Years):			
<b>Historic Damages Questionnaire</b>			
How many documented historic damage events do you have?*		For how many of these historic damage events do you know the Recurrence Intervals (RIs)?*	
Errors: (must be corrected to proceed with analysis)	Insufficient number of historic damage events of known RIs to conduct a valid analysis!		
Warnings: (must be addressed to conduct a valid analysis)			
Conclusions: (provide directions on analysis approach based on completed questionnaire)	A minimum of one historic event of known RI or three historic events of unknown RI are needed to conduct a valid analysis.		
Source/Documentation of Historic Damages:			

### Actions/Inputs

- Once Historic Damages is selected in Section I, Section II on Historic notes the Analysis Year from the Project Information tab and addresses the Analysis Duration.
- Enter the **Year Built (4-digit Year)** of the system or asset being protected.
- If you choose to use an alternative analysis period, you may enter a User Input Analysis Duration (Years). The minimum allowable User Input Analysis Duration is 10 years.
- You may also type in a brief description of Documentation/Justification used to support your User Input Analysis Duration.
- User Input Analysis Duration may be used with supporting documentation for the following situations: 1) Discontinuities in damage records, 2) Replacement of facility, 3) Change in local flow conditions, 4) Structure age is old or hard to determine (use 50 years).

### Notes and Tips

- When the Year Built is unclear, enter the earliest year built of the largest component of the system being protected.
- If hazard data is not available or there are discontinuities in records for part of the Analysis Duration since the Year Built, you may input a User Input Analysis Duration based on the total number of years for which hazard data is available.
- Significant documentation requirements apply for User Input Analysis Durations of less than 30 years.

## Section II - Historic Damages: Questionnaire – Number of Events

Select Damage Analysis Type:	Historic Damages		
<b>Section II - Historic Damages</b>			
Analysis Year :	2017		
Year Built (4-digit Year):			
Analysis Duration (Years):			
User Input Analysis Duration (Years):		Documentation/Justification:	
Selected Analysis Duration (Years):			
<b>Historic Damages Questionnaire</b>			
How many documented historic damage events do you have?*			For how many of these historic damage events do you know the Recurrence Intervals (RIs)?*
Errors: (must be corrected to proceed with analysis)	Insufficient number of historic damage events of known RIs to conduct a valid analysis!		
Warnings: (must be addressed to conduct a valid analysis)			
Conclusions: (provide directions on analysis approach based on completed questionnaire)	A minimum of one historic event of known RI or three historic events of unknown RI are needed to conduct a valid analysis.		
Source/Documentation of Historic Damages:			

### Actions/Inputs

- Once Historic Damages is selected in Section I, Section II on Historic Damages addresses the Analysis Duration and continues with an optional Historic Damages Questionnaire to determine if the user has sufficient damage data to conduct an analysis.
- First, enter a number for “How many documented damage events do you have?” This may include one or more catastrophic events of known recurrence intervals.
- Next, enter a number for “For how many of these expected damage events do you know the Recurrence Intervals (RIs)?”
- If your entries do not meet the criteria, then Errors, Warnings and/or Conclusions (such as those shown above) will appear.
  - Errors must be corrected to proceed with analysis
  - Warnings must be addressed to conduct a valid analysis
  - Conclusions provide directions on analysis approach

### Notes and Tips

- You must have between 1 and 7 historic damage events that meet one of the following situations.
  - 1) At least 3 historic events with unknown RIs occurring in different years
  - 2) At least 1 (no more than 2) historic events with known RIs
  - 3) A combination of historic events with known and unknown RIs as described in situations 1) and 2), where the total number of known RI events exceeds the number of all unknown RI events.

## Section II - Historic Damages: Questionnaire – Source of Historic Damages

Select Damage Analysis Type:	Historic Damages		
<b>Section II - Historic Damages</b>			
Analysis Year :	2017		
Year Built (4-digit Year):			
Analysis Duration (Years):			
User Input Analysis Duration (Years):		Documentation/Justification:	
Selected Analysis Duration (Years):			
<b>Historic Damages Questionnaire</b>			
How many documented historic damage events do you have?*		For how many of these historic damage events do you know the Recurrence Intervals (RIs)?*	
Errors: (must be corrected to proceed with analysis)	Insufficient number of historic damage events of known RIs to conduct a valid analysis!		
Warnings: (must be addressed to conduct a valid analysis)			
Conclusions: (provide directions on analysis approach based on completed questionnaire)	A minimum of one historic event of known RI or three historic events of unknown RI are needed to conduct a valid analysis.		
Source/Documentation of Historic Damages:			

### Actions/Inputs

- Once Historic Damages is selected in Section I, Section II on Historic Damages addresses the Analysis Duration and continues with an optional Historic Damages Questionnaire to determine if the user has sufficient damage data to conduct an analysis.
- Users may list or describe the Source/Documentation of Historic Damages.

### Notes and Tips

- If possible, include a link or a reference to the document with the Source/Documentation of Historic Damages.
- Attach copy of reference document(s) – such as damage reports, FEMA *Project Worksheets*, transit agency records, newspaper articles or transit agency newsletters – separately.

### Additional Notes on Historic Damages Questionnaire – Preferred Approaches

- As with Expected Damages, analyses based on one Historic Damage event of known RI are of limited accuracy and are not recommended.
- Analyses based on two historic events of known RIs are better, especially if one of the known historic event RIs is for Hurricane Sandy (or some other large event) and the other known historic event RI is based on a more frequently occurring event.
- Analyses based on three or more historic events with a combination of up to two known RIs are preferred, especially if one or more of the known historic event RIs is for a large, well-documented catastrophic event, and the other historic event RIs are based on more recent and/or frequently occurring events.

## Section II - Historic Damages: Part A and Part B – Entering Events with Unknown Recurrence Intervals

Historic Damages Part A (Unknown Recurrence Interval)											
Event Year* (4-digit Year)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part A Damages (\$)	Are Damages in Current Dollars?*		Total Part A Damages (Inflated to Analysis Year) (\$)			
	Physical Damage Costs for Fixed Structures* (\$)	Physical Damage Costs for Rolling Stock* (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)			<input type="checkbox"/> Current Dollars	<input type="checkbox"/> Current Dollars				
						<input type="checkbox"/> Current Dollars	<input type="checkbox"/> Current Dollars				
						<input type="checkbox"/> Current Dollars	<input type="checkbox"/> Current Dollars				
						<input type="checkbox"/> Current Dollars	<input type="checkbox"/> Current Dollars				
						<input type="checkbox"/> Current Dollars	<input type="checkbox"/> Current Dollars				
						<input type="checkbox"/> Current Dollars	<input type="checkbox"/> Current Dollars				
Historic Damages Part B (Unknown Recurrence Interval)											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$	16.79								
Current Federal Mileage Rate (\$/Mile):		\$	0.540								
Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services						Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses					
Event Year (4-digit Year)	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)	Total Part B Damages

### Actions/Inputs

- Follow the General Notes on Entering Damages to complete Historic Damages Part A (damages) and Historic Damages Part B (service losses).

### Notes and Tips

- For Historic Damages with unknown recurrence intervals, all Event Years must be known and input under Historic Damages Part A.
- You can have between 1 and 5 Historic Damage events in Parts A and B.
- Historic Damage events are assumed to be estimated based on the Event Year and are inflated to the Analysis Year selected in the Project Information tab.
  - For Historic Damages, go to the **Are Damages in Current Dollars?** column and check the **Current Dollars** box for any event that has already been inflated to the Analysis Year.
- Remember that if you start a row, you must enter a value in every white cell in that row in Parts A and B, even if the value is 0.

## Section II - Historic Damages: Part C and Part D – Entering Events with Known Recurrence Intervals

Historic Damages Part C (Known Recurrence Interval)											
		Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)						
		(includes permanent repairs to damaged fixed structures and rolling stock)		(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)							
Damage Year (4-digit Year)*	Known Recurrence Interval (Years)*	Physical Damage Costs for Fixed Structures (\$)*	Physical Damage Costs for Rolling Stock (\$)*	Response and recovery Costs that can be Avoided by proposed Measures (\$)*	Other Damage or Loss (\$)	Sum of Part C Damages (\$)	Are Damages in Current Dollars?*		Total Part C Damages (Inflated to Analysis Year) (\$)		
							<input type="checkbox"/> Current Dollars <input type="checkbox"/> Current Dollars				
Historic Damages Part D (Known Recurrence Interval)											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$	16.79								
Current Federal Mileage Rate (\$/Mile):		\$	0.540								
Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services					Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses						
Damage Year (4-digit Year)	Known Recurrence Interval (Years)	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)

### Actions/Inputs

- Follow the General Notes on Entering Damages to complete Historic Damages Part C (damages) and Historic Damages Part D (service losses).
- Once you have entered the information for Historic Damages Parts A through D (as appropriate) and any Post-Resilience Damages and Losses (if needed), please proceed to page 58 of this guide.

### Notes and Tips

- For Historic Damages with known recurrence intervals, all Event Year and Recurrence Intervals (RIs) must be known and input under Historic Damages Part C.
- You can have between 1 and 2 Historic Damage events in Parts C and D.
- If you know the RIs of more than 2 events, then input the two largest events as known RI events and enter the additional events as unknown recurrence intervals, or you can input as expected damages if all RIs are unknown.
- You can run multiple versions of an analysis, using known RIs in one case and running known RI events as unknown events in another, to see which yields better results.
- Historic Damage events are assumed to be estimated based on the Event Year and are inflated to the Analysis Year selected in the Project Information tab.

- For Historic Damages, go to the **Are Damages in Current Dollars?** column and check the **Current Dollars** box for any event that has already been inflated to the Analysis Year.
- Remember that if you start a row, you must enter a value in every white cell in that row in Parts C and D, even if the value is 0.

# COASTAL FLOODING RI ESTIMATOR

## Detailed Analysis Step 2A

### General Notes – Intended Use

Hazard Mitigation Cost Effectiveness Tool

Coastal Flooding Recurrence Interval (R.I.) Estimator  
for Hazard Mitigation Cost Effectiveness Tool

Note: Hover your cursor over cells with red triangles in the top-right corner to show guidance notes for that cell. Guidance notes provide additional information about values that should be entered into cells. For general information about this tool and references please hover over the title box above.

Section I - Agency and Project Information				
Agency:				
Project Name:				
Analysis Date:				
Section II - Coastal Flood Recurrence Interval-Elevations Input				
BFE, (ft):				
Recurrence Interval (years)	Stillwater Elevation (ft)*	Default Flood Elevation Including Waveheight (ft)	User-Entered Flood Elevation Including Waveheight (ft)	Flood Elevation Including Waveheight (ft)
10.0				
50.0				
100.0				
500.0				
Source/Documentation				

Tools

Save As New

Save Current Project

Print This Tab

Project Info
Damage Info
Analysis Results
RI Estimator
+

### Actions/Inputs

- If “Flood” or “Hurricane/Coastal Storm” are selected as the Primary Hazard on the Project Information tab, then the RI Estimator tab will appear as shown above.
- Section I of this tab (Agency and Project Information) carries over the Agency, Project Name and Analysis Date input in Section I of the Project Information tab.
- The **Tools** box at the top right of the tab allows users to save and print their work at any time.

### Notes and Tips

- **Coastal Flood Hazard Guidance is given in Appendix B of this User Guide.**
- The RI Estimator tab is intended to be an optional resource to assist HMCE Tool users with determining the Recurrence Intervals of coastal flood events and potential associated Sea Level Rise (SLR) impacts.
- Completion of this this tab is not required to conduct a transit resilience project BCA.
- If you want the option to use the RI Estimator tab to determine SLR impacts, then you must complete the Project Information tab first.

## Section II – Coastal Flood Recurrence Interval- Elevations Input

Section II - Coastal Flood Recurrence Interval-Elevations Input				
BFE, (ft):				
Recurrence Interval (years)	Stillwater Elevation (ft)*	Default Flood Elevation Including Waveheight (ft)	User-Entered Flood Elevation Including Waveheight (ft)	Flood Elevation Including Waveheight (ft)
10.0				
50.0				
100.0				
500.0				
Source/ Documentation of Input Data:				

### Actions/Inputs

- Section II – Coastal Flood Recurrence Interval-Elevations Input cells can be used to determine coastal flood elevations for a range of flood events using one of two approaches.
- The default approach is to input the BFE (ft) and Stillwater Elevations (ft) associated with the Recurrence Intervals of 10 years (10% annual chance), 50 years (2% annual chance), 100 years (1% annual chance) and 500 years (0.2% annual chance).
  - The BFE can be found on a community’s Flood Insurance Rate Map (FIRM) by reading the elevation at the project location.
  - The default 10-, 50-, 100- and 500-year Stillwater Elevations can be found in the community’s Flood Insurance Study (FIS). The Stillwater Elevations are mapped using a series of transects (cross-sections) taken along the community’s coastline. Input the Stillwater Elevations from the transect(s) that are closest to the project location.
- The alternate approach is to input the User-Entered Flood Elevations Including Wave Height (ft) for the 10-, 50-, 100- and 500-year Recurrence Intervals.
  - User-Entered Flood Elevations may be determined as part of a hydraulics and hydrology (H&H) study. H&H studies are prepared in communities where the FIRM and/or FIS are unavailable or the information is out of date.

### Notes and Tips

- Coastal flood elevations are listed in feet and are typically referenced from either the National Geodetic Vertical Datum of 1929 (NGVD 29) or the North American Vertical Datum of 1988 (NAVD 88).
- If needed, elevation data from one reference datum can be converted to another using online resources such as [https://www.ngs.noaa.gov/cgi-bin/VERTCON/vert\\_con.prl](https://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl).

## Section II – Source/Documentation of Coastal Flood Recurrence Interval-Elevations Input Data

Section II - Coastal Flood Recurrence Interval-Elevations Input				
BFE, (ft):				
Recurrence Interval (years)	Stillwater Elevation (ft)*	Default Flood Elevation Including Waveheight (ft)	User-Entered Flood Elevation Including Waveheight (ft)	Flood Elevation Including Waveheight (ft)
10.0				
50.0				
100.0				
500.0				
Source/ Documentation of Input Data:				

### Actions/Inputs

- Users may type a brief description of the Source/Documentation of Input Data used to determine the coastal flood elevations for 10-, 50-, 100- and 500-year Recurrence Intervals.
  - For the default data approach, list the Flood Insurance Rate Map (FIRM) used to determine the BFE and the Flood Insurance Study (FIS) used to determine the Stillwater Elevations.
  - For the User-Entered Approach, note the hydraulics and hydrology (H&H) study used to determine the User-Entered Flood Elevations Including Wave Height (ft).

### Notes and Tips

- If the default approach is used to determine coastal flood elevations, then remember to include copies of the FIRM and FIS transect data used to support the BFE and Stillwater Elevation inputs.
- If User-Entered Flood Elevations Including Wave Heights are used to determine coastal flood elevations, then remember to include a copy of the H&H study used to support the inputs.

## Section III (Optional) – Adjustment of Flood Elevations for Sea Level Rise (SLR)

Section III (Optional) – Adjustment of Flood Elevations for Sea Level Rise (SLR)					
Project Useful Life (Years):		Analysis Year:		Last SLR Year:	
Automatic Evaluation of SLR (Select nearby NOAA Gauge and SLR Trend)					
Click to Select nearby NOAA Gauge:	This Option Not Used		Sea Level Rise is not considered for this analysis		
Recurrence Interval (years)	Equivalent SLR to Add (ft)	Equivalent Flood Elevation Including Wave Height & SLR (ft)			
10.0					
50.0					
100.0					
500.0					

### Actions/Inputs

- Based on the Project Useful Life (Years) and Analysis Year input in the Project Information tab, users may use Section III to adjust coastal flood elevations input in Section II of this tab for Sea Level Rise (SLR).
- Use the drop-down menu in the Click to Select nearby NOAA Gauge cell to select the National Oceanographic and Atmospheric Administration (NOAA) tide gauge closest to the project location.
  - NOAA has tide gauges for approximately 100 locations along the Atlantic, Gulf and Pacific coasts of the continental United States, Alaska, Hawaii, and U.S. Caribbean and Pacific territories.
  - Once the gauge location is selected, the tool estimates projected linear SLR increases for the 10-, 50-, 100- and 500-year flood events at the NOAA tide gauge locations for the projected Project Useful Life of the project beginning at the Analysis year.

### Notes and Tips

- If you want to use the RI Estimator tab to determine SLR impacts, then you must complete the Project Information tab and Section II of this tab first.

## Section IV – Recorded Flood Elevations and Estimated RIs with and without SLR

Section IV - Recorded Flood Elevations and Estimated RIs without and with SLR					
Input Recorded Elevation(s) to see R.I.(s)			R.I.s of Current Flood Elevations Considering SLR		
Recorded Flood Elevation (ft)*	Estimated R.I. Without SLR (Year)	Estimated Equivalent R.I. With SLR (Year)	Flood Elevation Including Wave Height (ft)	RI Without SLR (Year)	Estimated Equivalent R.I. With SLR (Year)
				10.00	
				50.00	
				100.00	
				500.00	

### Actions/Inputs

- In Section IV, you input the **Recorded Flood Elevation (ft)** for 1 to 5 flood events based on tide gauge readings taken during recorded flood events.
- For each Recorded Flood Elevation are input, the tool calculates the Estimated Event RI Without SLR and Estimated Equivalent RI With SLR in years.
- These event RIs can then be input into the Damage Information tab for Historic Damages or Expected Damages:
  - Use Estimated RIs Without SLR for projects that do not include SLR into the design flood elevation.
  - Use Estimated Equivalent RIs With SLR for projects that incorporate SLR projections into the design flood elevation.

### Notes and Tips

- Use Estimated RIs Without SLR for projects that do not include SLR into the design flood elevation.
- Use Estimated Equivalent RIs With SLR for projects that incorporate SLR projections into the design flood elevation.

# POST-RESILIENCE DAMAGE INFORMATION

## Detailed Analysis Step 2B

### General Notes – Post-Resilience Damage Information

**Post-Resilience Damages:** Damages expected to occur after the resilience project has been constructed.

In BCA, the total post-resilience damages for a project (the proposed design) is subtracted from the total pre-resilience damages (the as-is condition) to determine the project benefits.

Post-resilience damages are estimated damages based on three factors:

- 1) Project type
- 2) Project effectiveness, defined as the engineering design level - expressed as an event RI – where post-resilience damages begin to occur.
- 3) Pre-resilience damages

### Guidance on Estimating Post-Resilience Damages

The following general and specific guidance assumptions may be used to estimate post-resilience damages based on the type of project, the engineering design level of effectiveness, and the pre-resilience damages:

- **Generic projects:** For most projects, a simple, conservative approach is to use no post-resilience damages until design level of effectiveness is reached, assume the maximum pre-resilience damages once the design level of effectiveness is reached or incrementally increase pre-resilience damages as RIs increase.
- **Acquisition/Relocation projects:** Zero post-resilience damages are acceptable since the facility will be removed from the floodplain.
- **Elevation projects:** No post-resilience damages until design level of effectiveness is reached, then use minimum pre-resilience damages beginning at the design level of effectiveness.
- **Flood barriers/dry floodproofing:** No post-resilience damages until design level of effectiveness is reached, then apply the maximum pre-resilience damages that would occur for that flood level after that.
- **Wet floodproofing:** Use reduced pre-resilience damages (say 50%) to reflect reduced clean up or down time costs until design level of effectiveness is reached, then apply the maximum pre-resilience damages that would occur for that flood level after that.
- **Drainage improvements:** No post-resilience damages until design level of effectiveness is reached, then incrementally increase pre-resilience damages as RIs increase.

Note for some project types, the project effectiveness represents a single, definitive RI where post-resilience damages jump from zero to 100% of pre-resilience damages once the RI is reached. For other project types, the project effectiveness more accurately represents a range of RIs values where post-resilience damages increase gradually to match pre-resilience damages.

Post-resilience damages are closely linked to project effectiveness and to measure residual risk, as illustrated below:

- When post-resilience damages are low and project effectiveness is high (RI = 500 years or larger), the proposed project is considered to have a low residual risk.
- When post-resilience damages are high and project effectiveness is low (RIs = 50 years or smaller), the project is considered to have a high residual risk.

## General Notes - Post-Resilience Damage Options

BCR Summary	
Proposed Project Effectiveness (Years):	100
Total Project Benefits:	
Total BCA Project Costs:	\$ -
Benefit-Cost Ratio (BCR):	

**Tools**

Save Current Project

Print This Tab

Post-Resilience Damage Information				
<b>Section I - General Information</b>				
Agency:				
Project Name:				
Analysis Year:	2017			
<b>Section II - Expected Damages</b>				
Source/Documentation of Expected Damages:				
<b>Expected Damages Part A</b>				
	Physical Damages Costs  (includes permanent repairs to damaged fixed structures and rolling stock)	Response and Recovery Costs  (includes costs of emergency protective measures and temporary repairs or measures that can be avoided)	Other Damage/Loss (describe below)	

Project Info Damage Info Post Resil Damages Analysis Results RI Estimator

### Actions/Inputs

- Options for Post-Resilience Damage are established on the Project Information tab using the **Select Basis to Evaluate Post-Resilience Damage** radio button and selecting one of two approaches to determine the resilience project effectiveness.
  - When “Project Effectiveness” is selected, the simplified approach for Generic projects is used to measure project effectiveness automatically.
  - When “User-Entered Data” is selected, the Post-Resilience Damage Information tab appears as shown above to assist the user in a more detailed evaluation of project effectiveness.
- Section I of this tab (Agency and Project Information) carries over the Agency, Project Name and Analysis Date input in Section I of the Project Information tab.
- The **Tools** box at the top right of the tab allows users to save and print their work at any time.

### Notes and Tips

- If you want the option to use Post Resil Damages tab to determine SLR impacts, then you must complete the Project Information tab first.

## Section II - Expected Damages: Source/Documentation

Hazard Mitigation Cost Effectiveness Tool											
<table border="1"> <thead> <tr> <th colspan="2">BCR Summary</th> </tr> </thead> <tbody> <tr> <td>Proposed Project Effectiveness (Years):</td> <td>0</td> </tr> <tr> <td>Total Project Benefits:</td> <td></td> </tr> <tr> <td>Total BCA Project Costs:</td> <td>\$ -</td> </tr> <tr> <td>Benefit-Cost Ratio (BCR):</td> <td></td> </tr> </tbody> </table>		BCR Summary		Proposed Project Effectiveness (Years):	0	Total Project Benefits:		Total BCA Project Costs:	\$ -	Benefit-Cost Ratio (BCR):	
BCR Summary											
Proposed Project Effectiveness (Years):	0										
Total Project Benefits:											
Total BCA Project Costs:	\$ -										
Benefit-Cost Ratio (BCR):											
<table border="1"> <thead> <tr> <th colspan="2">Tools</th> </tr> </thead> <tbody> <tr> <td colspan="2">Save Current Project</td> </tr> <tr> <td colspan="2">Print This Tab</td> </tr> </tbody> </table>		Tools		Save Current Project		Print This Tab					
Tools											
Save Current Project											
Print This Tab											
Post-Resilience Damage Information											
Section I - General Information											
Agency:											
Project Name:											
Analysis Year:											
Section II - Expected Damages											
Source/Documentation of Expected Damages:											

### Actions/Inputs

- Once the Post-Resilience Damage Information tab appears as shown, Section II on Expected Damages begins by letting users list or describe the Source/Documentation of Expected Damages.
- Refer to the General Notes in this section on guidance and assumptions for estimating post-resilience damages for various project types.

### Notes and Tips

- If possible, include a link or a reference to the document with the Source/Documentation of Expected Damages.
- Attach copy of reference document(s) – such as engineering design reports, damage functions or fragility curves.

## Section III - Expected Damages: Part A and Part B – Entering Expected Damages and Losses

Expected Damages Part A											
Recurrence Interval (Years)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)							
	(includes permanent repairs to damaged fixed structures and rolling stock)		(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)								
Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	Response and Recovery Costs (\$)	Other Damage Costs (\$)	Total Part A Damages							
Expected Damages Part B											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$	16.79								
Current Federal Mileage Rate (\$/Mile):		\$	0.540								
Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services					Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses					Total Part B Damages	
Recurrence Interval (Years)	Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Number of One-way Traffic Trips Per Day (Buses)	Average Number of Passengers per Bus		Loss of Services Damages (Buses)

### Actions/Inputs

- Follow the General Notes on Entering Damages to complete Expected Damages Part A (damages) and Expected Damages Part B (service losses).

### Notes and Tips

- You must have between 1 and 5 Expected Damage events in Parts A and B.
- For Expected Damages, all event Recurrence Intervals must be known and input under Expected Damages Part A and tied to the design level of effectiveness.
- As with expected pre-resilience events, post-resilience Expected Damage events should be estimated based on the Analysis Year selected in the Project Information tab.
- Remember that if you start a row, you must enter a value in every white cell in that row in Parts A and B, even if the value is 0.



## Section IV – Final Results of the BCA (Benefit-Cost Ratio)

Section IV - Final Results of BCA		
Reduction in Annual Damages:		
Total Project Benefits:		
Total BCA Project Costs:	\$ -	
Benefits Minus Costs:		
Benefit-Cost Ratio (BCR):		BCR is not evaluated.

### Actions/Inputs

- Review the Reduction in Annual Damages, Total Project Benefits, and Total BCA Project Costs calculated by the tool.
- The Benefit-Cost Ratio (BCR) is the final output.
- Results are also be expressed in terms of Benefits Minus Costs
- You have now completed the quantitative analysis portion - you're essentially done with the tool.

### Notes and Tips

- Different BCA results have different meanings:
  - A BCR greater than 1.0 (Benefits Minus Costs greater than \$0) indicates a cost-effective project.
  - A BCR less than 1.0 (Benefits Minus Costs less than \$0) indicates that although the project is not considered cost-effective based on the quantitative information provided, it may be cost-effective based on a review of the qualitative information provided.
  - A negative BCR indicates the project is not effective at reducing damages and losses.

## Section V – Qualitative Benefits

Section V - Qualitative Benefits	
Description of Qualitative Benefits of the Proposed Project:	

### Actions/Inputs

- Users may input Description of Qualitative Benefits of the Proposed Project that are not reflected in the quantitative analysis portions of the HMCE Tool.
- Users can also use this space to include a link or a reference to a document with the source of qualitative benefits.
- This input can be used to account for lost revenue to the transit line and associated businesses due to a transit line shutdown.
- Congratulations – you’re done!

### Notes and Tips

- Qualitative Benefits are other direct or indirect benefits of this project that cannot or have not been quantified in dollar value in other parts of this BCA, but would contribute to the general goal of resilience of the facility or transit system to be protected.
- You can describe how the project may protect against any of the secondary hazards listed in the Project Information tab, and explain factors that are not directly accounted for in the BCA in this space.
- As indicated in the discussion of Other Damage/Loss for the Damage Information tab, lost transit revenue may not be considered an eligible project benefit for a grant submittal. Therefore, it may be more appropriate to input the lost revenue as a qualitative benefit if the tool is being used to conduct analyses for a grant application.
- Attach copy of reference document(s) – such as transit agency records or impact studies – separately.

## EXAMPLES

This section provides two examples of transit resilience projects analyzed using the tool that can be used to get a better understanding of required, analysis calculations and results. The first example is for a relatively basic project with expected damages; while the second example is for a more complex project with historic damages that uses the Coastal Flood RI Estimator. Note that for the sake of clarity, the examples will focus on required input cells rather than optional inputs.

### Example 1: Project with Expected Damages

#### Project Information

**Agency:** Windy City Transit Authority (WCTA)

**Address:** 1 Cook County Plaza, Chicago, IL 60606

**Project Name:** WCTA Electrical System Resilience Enhancement

**Analysis Year:** 2017

**Analysis Date:** March 17, 2017

**Analyst:** John Doe

**Transit Mode(s) Protected by Project:** Subway/Inner City Rail

**Primary Hazard Protected by Project:** Wind

**Secondary Hazard(s) Protected by Project:** Snow/Ice

**Brief Project Description:** Replace overhead electrical line and feeder system used to power WCTA trains with an underground system fed to the trains using a third rail. This critical long-term improvement would reduce service losses from high wind events up to a 100-year storm event as well as snow and ice events that damage poles and disrupt service to overhead electrical lines.

**Select Basis to Evaluate Post-Resilience Damage:** "Project Effectiveness" as entered below

**Proposed Project Effectiveness (Years):** 100

**Total Project Initial Cost:** \$700 million

**Source/Documentation of Total Cost Estimate:** Local historic cost data

**Project Useful Life (Years):** 50

**Annual Project Operation & Maintenance (O&M) Cost:** \$3.5 million

**Discount Rate (%):** 7.00

**Cost of Loss of Services for Transit**

**Passengers (\$/Passenger/Hour):** Chicago-Naperville-Michigan City (IL-IN-WI) = \$18.24

**Current Federal Mileage Rate (\$/Mile):** \$0.535

**Will there be losses or delays in transit service during project construction?** No

## Example 1: Project with Expected Damages (continued)

### Damage Information

Select Damage Analysis Type: Expected Damages

How many documented expected damage events do you have? 5

For how many of these expected damage events do you know the RIs? 5

Expected Damages Part A								
	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss				
				Debris removal				
Recurrence Interval (Years)	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	Response and Recovery Costs (\$)	Other Damage Costs (\$)				
10	\$50,000,000	\$10,000,000	\$25,000,000	\$10,000,000				
25	\$100,000,000	\$20,000,000	\$50,000,000	\$20,000,000				
50	\$250,000,000	\$50,000,000	\$125,000,000	\$50,000,000				
100	\$400,000,000	\$80,000,000	\$200,000,000	\$80,000,000				
150	\$500,000,000	\$100,000,000	\$250,000,000	\$100,000,000				
Expected Damages Part B								
RI (Yrs)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services			Damages Due to Delay and/or Extra Travel Time for Passengers in Buses				
	Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Average Number of One-way Traffic Trips Per Day (Buses)	Average Number of Passengers per Bus
25	12.00	750,000	1.00	0.50	10.00	1.00	15,000	50
50	12.00	750,000	3.00	1.00	10.00	3.00	15,000	50
75	12.00	750,000	5.00	1.50	10.00	5.00	15,000	50
100	12.00	750,000	10.00	2.00	10.00	10.00	15,000	50
150	12.00	750,000	12.00	2.00	10.00	12.00	15,000	50

## Example 1: Project with Expected Damages (continued)

### HMCE Tool Inputs: Project Information tab – Sections I and II

Section I - Agency Information				
Agency*:	Windy City Transit Authority (WCTA)			
Address:	1 Cook County Plaza			
City:	Chicago	State:	Illinois	Zip: 60606
Section II - Project Information				
Project Name*:	WCTA Electrical System Resilience Enhancement			
Analysis Year*:	2017	Analysis Date*:	3/17/2017	
Analyst*:	John Doe	Analyst Phone:		
Transit Mode(s) Protected by Project*:	<input checked="" type="checkbox"/> Subway/Inner City Rail <input type="checkbox"/> Bus <input type="checkbox"/> Light/Commuter Rail <input type="checkbox"/> Ferry <input type="checkbox"/> Intercity Passenger Rail			
Primary Hazard Protected by Project*:	<input type="radio"/> Flood <input type="radio"/> Hurricane/Coastal Storm <input checked="" type="radio"/> Wind <input type="radio"/> Snow/Ice Storm <input type="radio"/> Earthquake <input type="radio"/> Other		If Primary Hazard is "Other," please specify:	
Secondary Hazard(s) Protected by Project*:	<input type="checkbox"/> Flood <input type="checkbox"/> Hurricane/Coastal Storm <input type="checkbox"/> Wind <input checked="" type="checkbox"/> Snow/Ice Storm <input type="checkbox"/> Earthquake <input type="checkbox"/> Other		If Secondary Hazard is "Other," please specify:	
Brief Project Description*:	Replace overhead electrical line and feeder system used to power WCTA trains with an underground system fed to the trains using a third rail. This critical long-term improvement would reduce service losses from high wind events up to a 100-year storm event as well as snow and ice events that damage poles and disrupt service to overhead electrical lines.			
Select Basis to Evaluate Post-Resilience Damage*:	<input checked="" type="radio"/> "Project Effectiveness" as entered below <input type="radio"/> "User-Entered Data" (New tab opens)			
Proposed Project Effectiveness (Years)*:	100	Source/Documentation of Project Effectiveness:		

## Example 1: Project with Expected Damages (continued)

### HMCE Tool Inputs and Outputs: Project Information tab – Sections III and IV with Totals

Section III - Cost Information			
Total Project Initial Cost*:	\$	700,000,000	
Source/Documentation of Total Cost Estimate:	Local historic cost data		
Project Useful Life (Years)*:		50	
Annual Project Operation & Maintenance (O&M) Cost*:	\$	3,500,000	
Source/Documentation of Annual O&M Cost:			
Discount Rate (%):		7.00	
Present Value of Annual O&M Costs:	\$	48,302,612	
Total Project Cost including O&M:	\$	748,302,612	
Section IV - Cost Associated with Interruption in Transit Services during Project Construction/Implementation			
Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)*:	Chicago-Naperville-Michigan City (IL-IN-W		\$ 18.24
Current Federal Mileage Rate (\$/Mile)*:	\$	0.535	
Will there be a losses or delays in transit service during project construction?*	No		
Totals			
Total Cost due to Interruption of Services:	\$	-	
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			\$ 748,302,612

## Example 1: Project with Expected Damages (continued)

### HMCE Tool Inputs and Output: Damage Information tab – Sections I and II (Questionnaire)

Damage Information			
Section I - General Information			
Agency:	Windy City Transit Authority (WCTA)		
Project Name:	WCTA Electrical System Resilience Enhancement		
Analysis Year:	2017		
Select Damage Analysis Type:	Expected Damages		
Section II - Expected Damages			
Expected Damages Questionnaire			
How many documented expected damage events do you have?		4	For how many of these expected damage events do you know the Recurrence Intervals (RIs)?
		4	
Errors: (must be corrected to proceed with analysis)			
Warnings: (must be addressed to conduct a valid analysis)			
Conclusions: (provide directions on analysis approach based on completed questionnaire)	A valid analysis may be conducted using two or more damage events of known RIs.		
Source/Documentation of Expected Damages:			

## Example 1: Project with Expected Damages (continued)

### HMCE Tool Inputs and Output: Damage Information tab – Section II (Part A)

Expected Damages Part A					
Recurrence Interval (Years)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Total Part A Damages
	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)	Debris removal	
10.00	\$ 50,000,000	\$ 10,000,000	\$ 25,000,000	\$ 10,000,000	\$ 95,000,000
25.00	\$ 100,000,000	\$ 20,000,000	\$ 50,000,000	\$ 20,000,000	\$ 190,000,000
50.00	\$ 250,000,000	\$ 50,000,000	\$ 125,000,000	\$ 50,000,000	\$ 475,000,000
100.00	\$ 400,000,000	\$ 80,000,000	\$ 200,000,000	\$ 80,000,000	\$ 760,000,000
150.00	\$ 500,000,000	\$ 100,000,000	\$ 250,000,000	\$ 100,000,000	\$ 950,000,000

### HMCE Tool Inputs and Output: Damage Information tab – Section II (Part B) with Total Expected Damages

Expected Damages Part B											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$ 18.24									
Current Federal Mileage Rate (\$/Mile):		\$ 0.535									
Recurrence Interval (Years)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services				Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses						Total Part B Damages
	Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Number of One-way Traffic Trips Per Day (Buses)	Average Number of Passengers per Bus	Loss of Services Damages (Buses)	
10.00	12.00	750,000	1.00	\$ 164,148,203	0.50	10.00	1.00	15,000	50	\$ 6,919,758	\$ 171,067,961
25.00	12.00	750,000	3.00	\$ 492,444,608	1.00	10.00	3.00	15,000	50	\$ 41,277,801	\$ 533,722,409
50.00	12.00	750,000	5.00	\$ 820,741,014	1.50	10.00	5.00	15,000	50	\$ 102,993,877	\$ 923,734,890
100.00	12.00	750,000	10.00	\$ 1,641,482,027	2.00	10.00	10.00	15,000	50	\$ 274,382,838	\$ 1,915,864,865
150.00	12.00	750,000	12.00	\$ 1,969,778,432	12.00	10.00	12.00	15,000	50	\$ 1,970,741,432	\$ 3,940,519,865
Overall Expected Damages to be Used in BCR Calculation											
Recurrence Interval (Years)	Total Expected Damages	Error Check:									
10.00	\$ 266,067,961										
25.00	\$ 723,722,409										
50.00	\$ 1,398,734,890										
100.00	\$ 2,675,864,865										
150.00	\$ 4,690,519,865										

## Example 1: Project with Expected Damages (continued)

### HMCE Tool Output: Analysis Results tab – Sections III and IV

Section III - Resilience Damages					
Pre-Resilience Damages*			Post-Resilience Damages		
Recurrence Interval (Years)	Total Damages	Annualized Damages	Recurrence Interval (Years)	Total Damages	Annualized Damages
10.00	\$ 266,067,961	\$ 26,328,951	10.00	\$ -	\$ -
25.00	\$ 723,722,409	\$ 20,122,582	25.00	\$ -	\$ -
50.00	\$ 1,398,734,890	\$ 19,346,384	50.00	\$ -	\$ -
100.00	\$ 2,675,864,865	\$ 12,058,363	100.00	\$ -	\$ -
150.00	\$ 4,890,519,865	\$ 32,603,466	150.00	\$ 4,890,519,865	\$ 32,603,466
Sum of Annualized Damages:		\$ 110,459,745	Sum of Annualized Damages:		\$ 32,603,466
Present Value of Annual Damages:		\$ 1,524,426,916	Present Value of Annual Damages:		\$ 449,952,159
*Pre-Resilience Damages are based on Expected Damages.					
Section IV - Final Results of BCA					
Reduction in Annual Damages:		\$ 77,856,279			
Total Project Benefits:		\$ 1,074,474,757			
Total BCA Project Costs:		\$ 748,302,612			
Benefits Minus Costs:		\$ 326,172,145			
Benefit-Cost Ratio (BCR):		1.44	BCR is greater than 1.0; the project is cost-effective based on the quantitative information provided.		

## Example 2: Project with Historic Damages using RI Estimator

### Project Information

**Agency:** New York Railroad (NYRR)

**Address:** 555 Broadway, New York, NY 10001

**Project Name:** NYRR Montauk Line Flood Mitigation

**Analysis Year:** 2017

**Analysis Date:** March 17, 2017

**Analyst:** Bob Smith

**Transit Mode(s) Protected by Project:** Subway/Inner City Rail

**Primary Hazard Protected by Project:** Flood

**Secondary Hazard(s) Protected by Project:** Hurricane/Coastal Storm

**Brief Project Description:** Realignment and reconstruction of vulnerable sections of the Montauk Line to the 500-year flood level to reduce future flood damage and sea level rise impacts throughout the system.

**Select Basis to Evaluate Post-Resilience Damage:** "User Entered Data"

**Proposed Project Effectiveness (Years):**

**Total Project Initial Cost:** \$100 million

**Source/Documentation of Total Cost Estimate:** Current contractor bids

**Project Useful Life (Years):** 50

**Annual Project Operation & Maintenance (O&M) Cost:** \$750,000

**Discount Rate (%):** 7.00

**Cost of Loss of Services for Transit**

**Passengers (\$/Passenger/Hour):** New York-Newark-Bridgeport (NY-NJ-CT-PA) = \$22.08

**Current Federal Mileage Rate (\$/Mile):** \$0.535

**Will there be losses or delays in transit service during project construction?** Yes

**Duration of Loss or reduction of Services (Days):** 180

**Impacts Due to Delay and/or Extra Travel Time for Transit Mode Under Project Construction:**

**Delay of Extra Travel Time (Hours):** 0.167

**Average Daily Number of Passengers:** 250,000

**Impacts Due to Delay and/or Extra Travel Time for Alternate Transit Modes:** None

## Example 2: Project with Historic Damages using RI Estimator (continued)

### Damage Information

Select Damage Analysis Type: Historic Damages

Year Built (4-digit Year): 1895

User Input Analysis Duration (Years): 35 Documentation/Justification: System rebuilt 1980s

How many documented historic damage events do you have? 3

For how many of these historic damage events do you know the RIs? 1

Historic Damages Part A (Unknown Recurrence Interval)								
	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss				
	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)		Debris removal				
Event Year (4-digit Year)	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	Response and Recovery Costs (\$)	Other Damage Costs (\$)	Are Damages in Current Dollars?			
1995	\$10,000,000	\$5,000,000	\$2,500,000	\$4,000,000	No			
2011	\$30,000,000	\$15,000,000	\$7,500,000	\$12,000,000	No			
Historic Damages Part B (Unknown Recurrence Interval)								
	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services			Damages Due to Delay and/or Extra Travel Time for Passengers in Buses				
	Event Year (4-digit Year)	Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Average Number of One-way Traffic Trips Per Day (Buses)
1995	1.00	225,000	5.00	0.50	5.00	5.00	4,500	50
2011	2.00	240,000	10.00	1.00	5.00	10.00	4,800	50

## Example 2: Project with Historic Damages using RI Estimator (continued)

### Damage Information (continued)

Historic Damages Part C (Known Recurrence Interval)									
Event Year (4-digit Year)	Known Recurrence Interval (Years)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss	Are Damages in Current Dollars?			
		Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)		Debris removal				
2012	See Coastal Flood RI Estimator	\$50,000,000	\$25,000,000	\$10,000,000	\$4,000,000	No			
Historic Damages Part D (Known Recurrence Interval)									
Event Year (4-digit Year)	Known RI (Years)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services			Damages Due to Delay and/or Extra Travel Time for Passengers in Buses				
		Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Average Number of One-way Traffic Trips Per Day (Buses)	Average Number of Passengers per Bus
2012	See Coastal Flood RI Estimator	12.00	250,000	15.00	2.00	5.00	15.00	4,500	50

## Example 2: Project with Historic Damages using RI Estimator (continued)

### Coastal Flood Recurrence Interval Estimator

Section II – Coastal Flood RI Elevations Input	
BFE (ft)	10.00
Recurrence Interval (years)	Stillwater Elevation (ft)
10.0	5.20
50.0	6.20
100.0	6.70
500.0	6.80

Click to Select nearby NOAA Gauge: Montauk, NY

Section IV – Recorded Flood Elevations and Estimated RIs without and with SLR		
Input Recorded Elevation(s) to see R.I.(s)		
Recorded Flood Elevation (ft)	Estimated R.I. Without SLR (Year)	Estimated Equivalent R.I. With SLR (Year)
11.0		<b>Use for the 2012 event</b>

## Example 2: Project with Historic Damages using RI Estimator (continued)

### Post-Resilience Damage Information

Expected Damages Part A								
		Physical Damages Costs		Response and Recovery Costs		Other Damage/Loss		
						Debris removal		
Recurrence Interval (Years)	Physical Damage Costs for Fixed Structures (\$)	Physical Damage Costs for Rolling Stock (\$)	Response and Recovery Costs (\$)	Other Damage Costs (\$)				
500	\$30,000,000	\$15,000,000	\$7,500,000	\$12,000,000				
Expected Damages Part B								
		Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services		Damages Due to Delay and/or Extra Travel Time for Passengers in Buses				
RI (Yrs)	Delay or Extra Travel Time (Hours)	Average Daily Number of Passengers	Duration of Loss or Reduction of Rail or Ferry Services (Days)	Additional Time per One-way Trip (Hours)	Additional Travel Miles	Duration of Loss or Reduction of Services (Days)	Average Number of One-way Traffic Trips Per Day (Buses)	Average Number of Passengers per Bus
500	2.00	250,000	5.00	1.00	5.00	5.00	5,000	50

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Inputs: Project Information tab – Sections I thru III

Section I - Agency Information				
Agency*:	New York Railroad (NYRR)			
Address:	555 Broadway			
City:	New York	State:	New York	Zip: 10001
Section II - Project Information				
Project Name*:	NYRR Montauk Line Flood Mitigation			
Analysis Year*:	2017	Analysis Date*:	3/17/2017	
Analyst*:	Bob Smith	Analyst Phone:		
Transit Mode(s) Protected by Project*:	<input checked="" type="checkbox"/> Subway/Inner City Rail <input type="checkbox"/> Bus <input type="checkbox"/> Light/Commuter Rail <input type="checkbox"/> Ferry <input type="checkbox"/> Intercity Passenger Rail			
Primary Hazard Protected by Project*:	<input checked="" type="radio"/> Flood <input type="radio"/> Hurricane/Coastal Storm <input type="radio"/> Wind <input type="radio"/> Snow/Ice Storm <input type="radio"/> Earthquake <input type="radio"/> Other	If Primary Hazard is "Other," please specify:		
Secondary Hazard(s) Protected by Project*:	<input type="checkbox"/> Flood <input checked="" type="checkbox"/> Hurricane/Coastal Storm <input type="checkbox"/> Wind <input type="checkbox"/> Snow/Ice Storm <input type="checkbox"/> Earthquake <input type="checkbox"/> Other	If Secondary Hazard is "Other," please specify:		
Brief Project Description*:	Realignment and reconstruction of vulnerable sections of the Montauk Line to the 500-year flood level to reduce future flood damage and sea level rise impacts throughout the system.			
Select Basis to Evaluate Post-Resilience Damage*:	<input type="radio"/> "Project Effectiveness" as entered below <input checked="" type="radio"/> "User-Entered Data" (New tab opens)			
Proposed Project Effectiveness (Years)*:		Source/Documentation of Project Effectiveness:		
Section III - Cost Information				
Total Project Initial Cost*:	\$ 100,000,000			
Source/Documentation of Total Cost Estimate:	Current contractor bids			
Project Useful Life (Years)*:	50			
Annual Project Operation & Maintenance (O&M) Cost*:	\$ 750,000			
Source/Documentation of Annual O&M Cost:				
Discount Rate (%):	7.00			
Present Value of Annual O&M Costs:	\$ 10,350,560			
Total Project Cost including O&M:	\$ 110,350,560			

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Inputs and Outputs: Project Information tab – Section IV with Totals

Section IV - Cost Associated with Interruption in Transit Services during Project Construction/Implementation			
Cost of Loss of Services for Transit Passengers (\$/Passenger/Hour)*:	New York-Newark-Bridgeport (NY-NJ-CT-P)		\$ 22.08
Current Federal Mileage Rate (\$/Mile)*:	\$ 0.535		
Will there be a losses or delays in transit service during project construction?*	Yes		
Duration of Loss or Reduction of Services (Days)*:	180.00		
Impacts Due to Delay and/or Extra Travel Time for Transit Mode Under Project Construction			
Delay or Extra Travel Time (Hours):	0.17		
Average Daily Number of Passengers:	250,000		
Loss of Transit Services Cost:	\$ 165,953,353		
Impacts Due to Delay and/or Extra Travel Time and Miles for Alternate Transit Modes			
Additional Time per One-way Trip (Hours):			
Additional Travel Miles:			
Alternate Transit Mode (Rail, Ferry, Buses)		Other Alternate Transit Mode (Vehicles)	
Number of One-way Traffic Trips per Day (Rail/Ferry/Buses):		Number of One-way Traffic Trips per Day (Vehicles):	
Average Number of Passengers per Trip:		Average Number of Passengers per Vehicle:	1.67
Loss of Services Cost (Rail/Ferry/Buses):		Loss of Services Cost (Vehicles):	
Totals			
Total Cost due to Interruption of Services:	\$ 165,953,353		
Total BCA Project Costs: Total Project Cost including O&M and Interruption of Services Loss:			\$ 276,303,913

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Inputs and Output: Damage Information tab – Sections I and II (Questionnaire)

Damage Information			
Section I - General Information			
Agency:	New York Railroad (NYRR)		
Project Name:	NYRR Montauk Line Flood Mitigation		
Analysis Year:	2017		
Select Damage Analysis Type*:	Historic Damages		
Section II - Historic Damages			
Analysis Year :	2017		
Year Built (4-digit Year)*:	1895		
Analysis Duration (Years):	110		
User Input Analysis Duration (Years):	35	Documentation/Justification:	System rebuilt 1980s
Selected Analysis Duration (Years):	35		
Historic Damages Questionnaire			
How many documented historic damage events do you have?*	3	For how many of these historic damage events do you know the Recurrence Intervals (RIs)?*	1
Errors: (must be corrected to proceed with analysis)			
Warnings: (must be addressed to conduct a valid analysis)	The known RI event must have the highest Total Historic Damages to conduct a valid analysis!		
Conclusions: (provide directions on analysis approach based on completed questionnaire)	Two historic events of unknown RIs and one historic event of known RI (see WARNING) is sufficient to conduct a valid analysis.		
Source/Documentation of Historic Damages:			

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Inputs and Output: Damage Information tab – Section II (Part A)

Historic Damages Part A (Unknown Recurrence Interval)							
Event Year* (4-digit Year)	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part A Damages (\$)	Are Damages in Current Dollars?*	Total Part A Damages (Inflated to Analysis Year) (\$)
	Physical Damage Costs for Fixed Structures* (\$)	Physical Damage Costs for Rolling Stock* (\$)	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)	Debris removal			
1995	\$ 10,000,000	\$ 5,000,000	\$ 2,500,000	\$ 4,000,000	\$ 21,500,000	<input type="checkbox"/> Current Dollars	\$ 42,866,386
2001	\$ 30,000,000	\$ 15,000,000	\$ 7,500,000	\$ 12,000,000	\$ 64,500,000	<input type="checkbox"/> Current Dollars	\$ 111,077,676
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	
						<input type="checkbox"/> Current Dollars	

### HMCE Tool Inputs and Output: Damage Information tab – Section II (Part B)

Historic Damages Part B (Unknown Recurrence Interval)											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$ 22.08									
Current Federal Mileage Rate (\$/Mile):		\$ 0.535									
Event Year (4-digit Year)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services				Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses						
	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)	Total Part B Damages
1995	1.00	225,000	5.00	\$ 24,843,316	0.50	5.00	5.00	4,500	50	\$ 12,481,846	\$ 37,325,162
2001	2.00	240,000	10.00	\$ 105,998,150	1.00	5.00	10.00	4,800	50	\$ 53,127,475	\$ 159,125,625
Overall Historic Damages to be Used in BCR Calculation (Not Including Catastrophic Events to be Entered in Parts C and D)											
Event Year (4-digit Year)	Total Historic Damages	Error Check:									
1995	\$ 80,191,548										
2001	\$ 270,203,301										

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Inputs and Output: Damage Information tab – Section II (Part C)

Historic Damages Part C (Known Recurrence Interval)								
Damage Year (4-digit Year)*	Known Recurrence Interval (Years)*	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Sum of Part C Damages (\$)	Are Damages in Current Dollars?*	Total Part C Damages (Inflated to Analysis Year) (\$)
		Physical Damage Costs for Fixed Structures (\$)*	Physical Damage Costs for Rolling Stock (\$)*	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)	Debris removal			
2012	156.17	\$ 50,000,000	\$ 25,000,000	\$ 10,000,000	\$ 20,000,000	\$ 105,000,000	<input type="checkbox"/> Current Dollars	\$ 121,686,101
							<input type="checkbox"/> Current Dollars	

**See Coastal Flood Recurrence Interval Estimator Tab for Known Recurrence Interval Estimate of the 2012 Flood Event**

### HMCE Tool Inputs and Output: Damage Information tab – Section II (Part D) with Overall Historic Damages

Historic Damages Part D (Known Recurrence Interval)												
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$ 22.44										
Current Federal Mileage Rate (\$/Mile):		\$ 0.535										
Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services						Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses						
Damage Year (4-digit Year)	Known Recurrence Interval (Years)	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)	
2012	156.17	12.00	250,000	15.00	\$ 1,009,800,000	2.00	5.00	15.00	5000.00	50.00	\$ 168,500,625	
Historic Damages Totals (Known Recurrence Interval)												
Damage Year (4-digit Year)	Known Recurrence Interval (Years)	Total Part C Damages	Total Part D Damages	Total Historic Damages (Inflated to Analysis Year)	Error Check:							
2012	156.17	\$ 112,583,070	\$ 1,178,300,625	\$ 1,290,883,695								
Overall Historic Damages to be Used in BCR Calculation												
Recurrence Interval (Years)	Total Historic Damages	Error Check:										
19.30	\$ 77,587,348											
42.30	\$ 232,666,090											
156.20	\$ 1,290,883,695											

## Example 2: Project with Historic Damages using RI Estimator (continued)

HMCE Tool Inputs and Output: Coastal Flood RI Estimator tab – Sections II thru IV

Hazard Mitigation Cost Effectiveness Tool					
Coastal Flooding Recurrence Interval (R.I.) Estimator for Hazard Mitigation Cost Effectiveness Tool					
Section II - Coastal Flood Recurrence Interval-Elevations Input					
BFE, (ft):	10.00				
Recurrence Interval (years)	Stillwater Elevation (ft)*	Default Flood Elevation Including Waveheight (ft)	User-Entered Flood Elevation Including Waveheight (ft)	Flood Elevation Including Waveheight (ft)	
10.0	5.20	7.76		7.76	
50.0	6.20	9.25		9.25	
100.0	6.70	10.00		10.00	
500.0	8.00	11.94		11.94	
Source/ Documentation of Input Data:					
Section III (Optional) – Adjustment of Flood Elevations for Sea Level Rise (SLR)					
Project Useful Life (Years):	50	Analysis Year:	2017	Last SLR Year:	2067
Automatic Evaluation of SLR (Select nearby NOAA Gauge and SLR Trend)					
Click to Select nearby NOAA Gauge:	Montauk, NY		Linear SLR projected for the next 50 years is 0.48 ft, but the rise by equiv. year in 27 years after project starts is 0.26 ft and the equivalent rise in 100-year flood elev. is 0.5 ft.		
Recurrence Interval (years)	Equivalent SLR to Add (ft)	Equivalent Flood Elevation Including Wave Height & SLR (ft)			
10.0	0.35	8.11			
50.0	0.43	9.68			
100.0	0.50	10.50			
500.0	0.58	12.52			
Section IV - Recorded Flood Elevations and Estimated RIs without and with SLR					
Input Recorded Elevation(s) to see R.I.(s)			R.I.s of Current Flood Elevations Considering SLR		
Recorded Flood Elevation (ft)*	Estimated R.I. Without SLR (Year)	Estimated Equivalent R.I. With SLR (Year)	Flood Elevation Including Wave Height (ft)	RI Without SLR (Year)	Estimated Equivalent R.I. With SLR (Year)
11.00	257.30	156.17	7.76	10.00	7.05
			9.25	50.00	32.54
			10.00	100.00	63.62
			11.94	500.00	297.34

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Output: Post-Resilience Damage Information tab – Section II (Part A)

Expected Damages Part A					
Recurrence Interval (Years)*	Physical Damages Costs		Response and Recovery Costs	Other Damage/Loss (describe below)	Total Part A Damages
	Physical Damage Costs for Fixed Structures (\$)*	Physical Damage Costs for Rolling Stock (\$)*	(includes costs of emergency protective measures and temporary repairs or measures that can be avoided by the proposed project)	Debris removal	
500.00	\$ 30,000,000	\$ 15,000,000	\$ 7,500,000	\$ 12,000,000	\$ 64,500,000

### HMCE Tool Output: Post-Resilience Damage Information tab – Section II (Part B) with Overall Expected Damages

Expected Damages Part B											
Cost of Loss of Transit Services for Passengers (\$/Passenger/Hour):		\$ 22.08									
Current Federal Mileage Rate (\$/Mile):		\$ 0.535									
Recurrence Interval (Years)	Damages Due to Delay and/or Extra Travel Time for Passengers in Rail or Ferry Services				Damages Due to Delay and/or Extra Travel Time and Miles for Passengers in Buses						
	Delay or Extra Travel Time (Hours)*	Average Daily Number of Passengers*	Duration of Loss or Reduction of Rail or Ferry Services (Days)*	Loss of Services Damages (Rail or Ferry)	Additional Time per One-way Trip (Hours)*	Additional Travel Miles*	Duration of Loss or Reduction of Services (Days)*	Number of One-way Traffic Trips Per Day (Buses)*	Average Number of Passengers per Bus*	Loss of Services Damages (Buses)	Total Part B Damages
500.00	2.00	250,000	5.00	\$ 55,207,370	1.00	5.00	5.00	5,000	5	\$ 2,827,243	\$ 58,034,613
Overall Expected Damages to be Used in BCR Calculation											
Recurrence Interval (Years)	Total Expected Damages	Error Check:									
500.00	\$ 122,534,613										

## Example 2: Project with Historic Damages using RI Estimator (continued)

### HMCE Tool Output: Analysis Results tab – Sections III and IV

Section III - Resilience Damages					
Pre-Resilience Damages*			Post-Resilience Damages		
Recurrence Interval (Years)	Total Damages	Annualized Damages	Recurrence Interval (Years)	Total Damages	Annualized Damages
19.30	\$ 80,191,548	\$ 4,147,055	500.00	\$ 122,534,613	\$ 245,069
42.30	\$ 270,203,301	\$ 10,142,923			
156.20	\$ 1,281,241,488	\$ 8,202,570			
Sum of Annualized Damages:		\$ 22,492,549	Sum of Annualized Damages:		\$ 245,069
Present Value of Annual Damages:		\$ 310,413,958	Present Value of Annual Damages:		\$ 3,382,138
*Pre-Resilience Damages are based on Historic Damages.					
Section IV - Final Results of BCA					
Reduction in Annual Damages:		\$ 22,247,479			
Total Project Benefits:		\$ 307,031,820			
Total BCA Project Costs:		\$ 276,303,913			
Benefits Minus Costs:		\$ 30,727,907			
Benefit-Cost Ratio (BCR):		1.11	BCR is greater than 1.0; the project is cost-effective based on the quantitative information provided.		

## APPENDIX A

### Project Useful Life Summary Guidance

Standard project useful life values used by other federal agencies such as FEMA are summarized in Table A-1. Standard project useful life values may be used with minimal documentation. Acceptable Limits may be used in lieu of standard values, but will require additional documentation (such as a manufacturer’s warranty or an engineering report) to support values that exceed the standard project useful life.

**Table A-1.** Project useful life summary table.

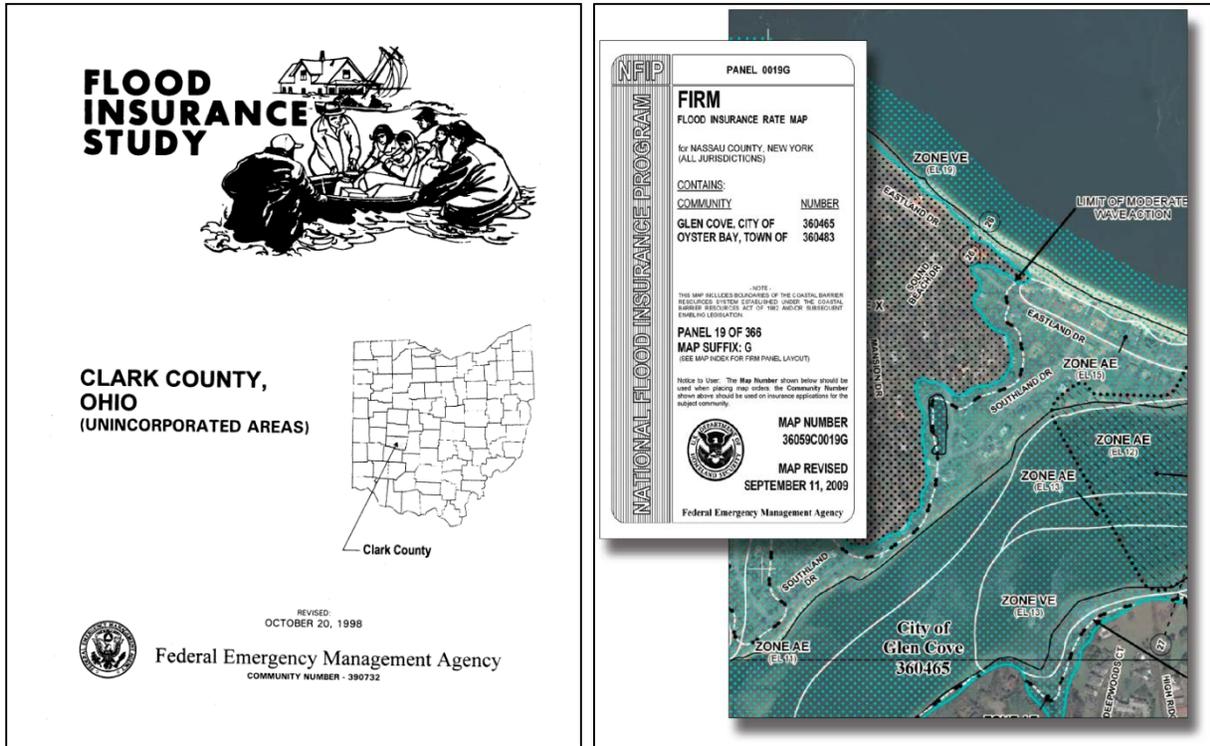
Project Type	Standard Project Useful Life (years)	Acceptable Limits (years)	Comments
Acquisition	100	100	None
Elevation – Non-Residential, Public, and/or Historic Building or Transit Facility	50	50-100	None
Non-Residential Building Retrofit	25	25-50	None
Public and/or Historic Building/Transit Facility Retrofit	50	50-100	None
Roof Diaphragm Retrofit	30	30	Roof hardening and roof clips
Non-Structural Building/Facility Elements	30	30	Ceilings, electrical cabinets, generators, parapets, chimneys
Non-Structural Major Equipment	15	15-30	Elevators, HVAC, sprinklers
Non-Structural Minor Equipment	5	5-20	Generic contents, racks, shelves
Major Infrastructure (minor localized flood reduction projects)	50	35-100	None
Concrete Infrastructure, Flood Walls, Roads, Bridges, Major Drainage Systems	50	35-50	None
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatments	30	25-50	End treatment (wing walls, end sections, head walls, etc.)
Culverts (concrete, PVC, CMP, HDPE, etc.) without end treatments	10	5-20	End treatment (wing walls, end sections, head walls, etc.)
Pump Stations, Substations, Wastewater System Structures	50	50	Structures
Pump Stations, Substations, Wastewater System Equipment, Generators	5	5-30	Equipment. FEMA uses a standard Project Useful Life of 19 years for generators
Hurricane Storm Shutters	15	15-30	Depends on type of storm shutter
Major Utility Mitigation/Resilience Projects	50	50-100	Power lines, cable, hardening gas, water, sewer lines, etc.
Minor Utility Mitigation/Resilience Projects	5	5-30	Backflow valves, downspout disconnect, etc.
Equipment Purchases	2	2-10	Small, portable equipment (e.g., computer)
Equipment Purchases	30	5-30	Heavy equipment

# APPENDIX B

## Coastal Flood Hazard Guidance

### B.1 Identifying Coastal Flood Hazards

Nearly all communities that experience coastal flooding participate in the National Flood Insurance Program (NFIP) and have the flood hazard identification resources illustrated below.



- **Flood Insurance Study (FIS):** Provides a narrative of the community’s flood history and sources of flooding, as well as detailed information on the hydraulics and hydrology in the community
- **Flood Insurance Rate Map (FIRM):** Official map of an NFIP community that delineates the Special Flood Hazard Areas (SFHAs) and the insurance risk premium zones applicable to the community

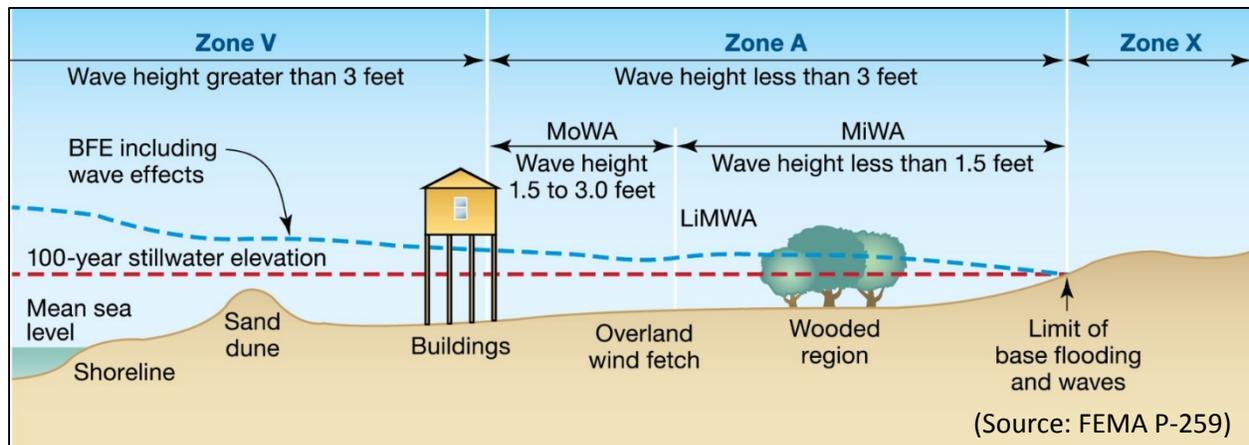
The regulatory basis for flood hazard identification under the NFIP is the 100-year or **Base Flood Elevation (BFE)**, defined as a flood event that has a 1% chance of being equaled or exceeded in any given year.

Note that both FIRMs and FIS reports can be downloaded from the Federal Emergency Management Agency (FEMA) Map Service Center: <https://msc.fema.gov/portal>

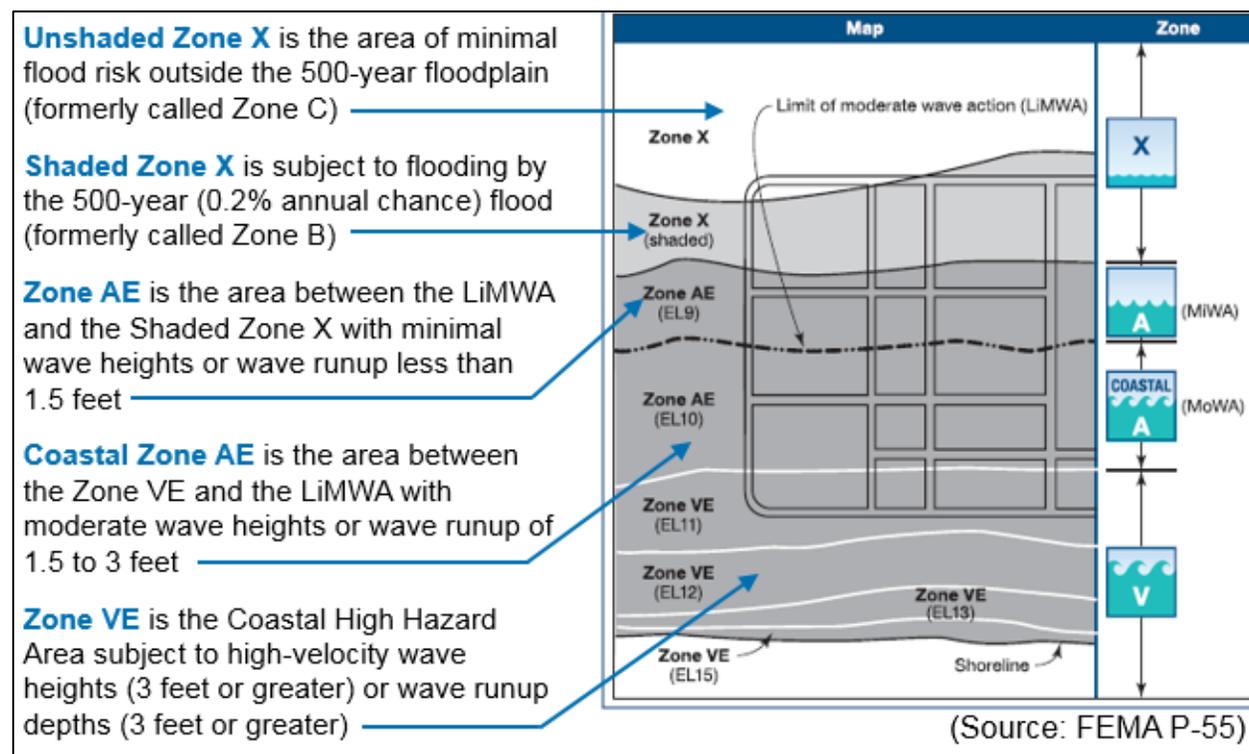
## B.2 Coastal Flood Zones

Coastal FIRMs identify flood hazards based on the wave heights during the base flood:

- **V Zones** are subject to wave heights of 3 feet or greater
- **Coastal A Zones**, identified on newer flood maps using the Limit of Moderate Wave Action (LiMWA) line, are subject to wave heights between 1.5 and 3 feet
- **Non-Coastal A Zones** are subject to wave heights less than 1.5 feet



These flood zones and other coastal flood zones are illustrated on the sample coastal FIRM shown below:



### B.3 Coastal Flood Terminology

The **Base Flood Elevation (BFE)** for coastal flood events represents the top of the wave crest associated with the base, or 100-year flood event, which has a 1% chance of being equaled or exceeded in any given year.

- The BFE can be found on a community's Flood Insurance Rate Map (FIRM).

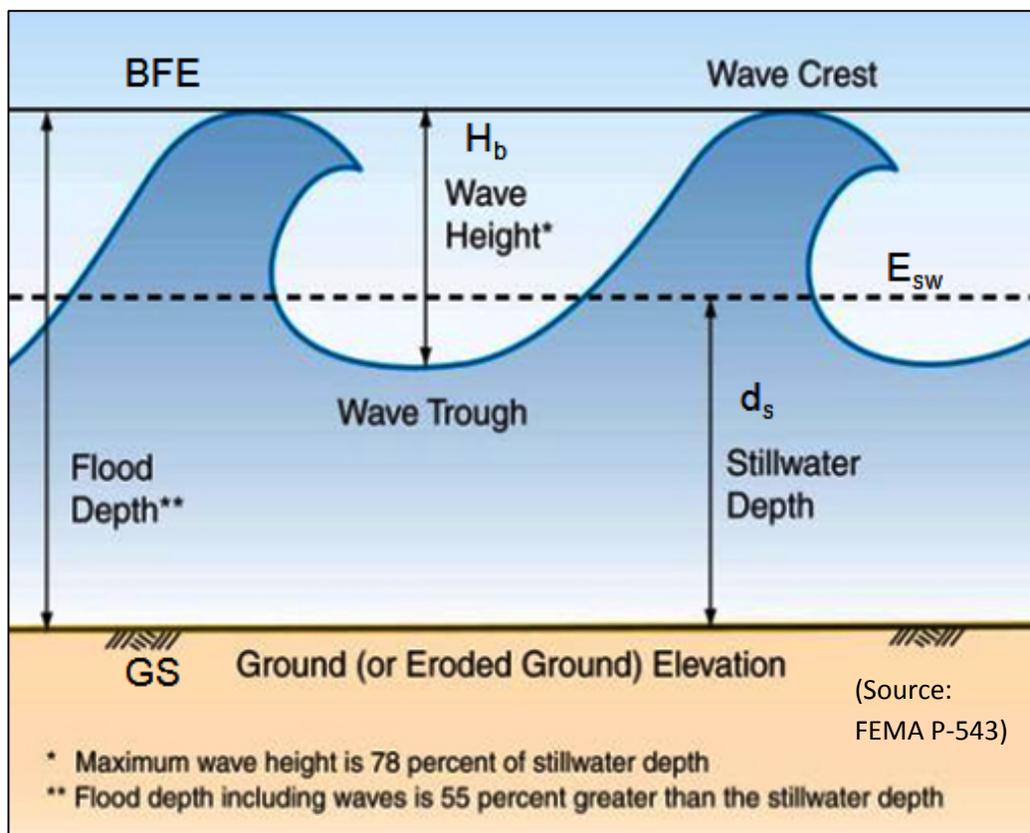
The **Stillwater Elevation ( $E_{sw}$ )** is the coastal flood elevation without wave action.

- $E_{sw}$  can be found in the community's Flood Insurance Study (FIS).

$H_b$  is the **Wave Height** associated with the base flood, and **GS** is the **Ground (or Eroded Ground) Surface Elevation**.

As shown in the figure below, the following relationships can be drawn between the  $H_b$ , BFE, Stillwater depth ( $d_s$ ) and GS:

- $H_b = 0.78 d_s$
- $d_s = 0.65 (BFE - GS)$



## APPENDIX C

### Documentation Requirements for Key Inputs in the HMCE Tool

This appendix contains detailed guidance on documentation for project costs (Section C.1), event damages (Section C.2), event service losses (Section C.3), recurrence intervals (Section C.4), and post-resilience damages (Section C.5).

#### C.1 Project Costs

##### C.1.1 Project Cost Elements

The project cost should include the following elements.

##### **Total Project Initial Cost**

The Total Project Initial Cost should include:

- Pre-construction or non-construction costs: May include right-of-way review, surveying, permitting, site preparation, and engineering design
- Construction costs: The “hard costs”/base cost of the project, developed based on local historic cost data, current bids, or published unit costs
- Ancillary costs: Contractor costs and markups (i.e., mobilization/demobilization, general conditions and requirements, overhead and profit, bid documents, permit fees, project management costs)

##### **Annual Project Operation and Maintenance (O&M) Cost**

Annual Project O&M Cost represent the differential annualized cost of operating and maintaining the proposed resilience project over its useful lifetime vs. the current annualized O&M costs for the existing part of the system that will be impacted by the proposed project. Although not eligible for grant funding, O&M costs must be accounted for in the BCA to ensure the overall investment cost of the project is considered. Remember some “low-cost” projects may have high maintenance costs.

NOTES: In some cases, O&M costs may be negative.

##### **Total Cost due to Interruption of Services**

Total Cost due to Interruption of Services associated with loss or interruption of transit service during project construction/implementation:

- May still take place even when transit agencies work during off-peak hours or weekends to minimize disruptions from resilience project construction or implementation.
- Although not eligible for grant funding, service interruption costs must be accounted for in the BCA to ensure the overall investment cost of the project is considered.

- In some cases, service interruption costs may exceed the total project initial and/or maintenance costs.

## C.1.2 Project Cost Documentation Sources

Project cost documentation sources include:

- **Local historic cost data** – Cost estimates developed based on experience with similar projects
- **Current contractor bids** – Bid documents prepared by qualified contractors
- **Published unit costs** – Published unit cost guidance available from a variety of sources including FTA’s Capital Cost database ([http://www.fta.dot.gov/12305\\_11951.html](http://www.fta.dot.gov/12305_11951.html)), R.S. Means and/or Marshall & Swift

## C.2 Event Damages

### C.2.1 Historic Damages

Historic damages are based on records from actual past disaster events. You need a minimum of one known RI event or three unknown RI events occurring in different years to run the HMCE tool.

Potential sources of documentation include:

#### 1) Disaster Damage Worksheets

- Disaster Damage Worksheets such as FEMA *Project Worksheets* (PWs) are useful for documenting historic damages to public transit facilities from Presidentially-declared disaster events
- PWs may include Response and Recovery costs (Category A or B) as well as Physical Damage repair and restoration work (Categories C – F)
- PWs may include emergency protective measures (Category A for debris removal or Category B for sandbagging or emergency services) as well as permanent repair and restoration work (Categories C – F, depending on the type of facility)
- Make sure PWs apply directly to facility(ies) to be mitigated by the project
- Always include complete copies of all referenced PWs
- Spreadsheets may be helpful to organize data when multiple PWs are attached
- NOTE: FTA and FEMA signed a Memorandum of Understanding (MOA) in March 2013 that outlines the roles and responsibilities of both agencies in providing federal assistance to repair and restore public transportation systems in areas the President has declared a major disaster or emergency. The MOA was required to establish the FTA’s newly authorized Public Transportation

Emergency Relief Program as part of the Moving Ahead for Progress in the 21st Century Act (MAP-21).

**2) FTA's 28-day and 60-day Damage Assessment Reports**

- Following Hurricane Sandy, FTA Prepared 28-day and 60-day supplemental reports on public transit projects.
- Appendix B of the 28-day report includes a cost data table showing an itemized list of damages to various transit agency facilities as a result of Sandy.

**3) Insurance Claims (Flood Events):**

- Useful for documenting Physical Damages to insured properties (Fixed Structures) from various hazard events
- For flood events, grantees may obtain flood insurance claim data on all properties insured under the NFIP through BureauNet (<http://bsa.nfipstat.com>). You can register to obtain information on various properties insured under the NFIP within their community.
- Additional benefits may be estimated from flood claims data when other event information is available. For example, if the flood claim lists only building damage, but the building type, size and the depth of flooding in the building is known, then the FEMA Depth Damage Functions (DDFs) can be used to extrapolate contents damage and even displacement costs for that event.
- Be aware of Severe Repetitive Loss (SRL) Program properties.

**4) Insurance Claims (Other Events):**

- Commercial or public properties may have insurance claims for other (non-flood) events
- Remember that smaller claims from multiple events typically produce greater benefits than a large claim from a single event
- Always include complete copies of insurance claims documented on insurance company letterhead.
- Spreadsheets may be helpful to organize data when multiple claims are attached.

**5) Repair Records:**

- Useful for documenting historic damages to various facilities (including transit facilities) from hazard events
- Repair records for public facilities may include records of expenditures in financial databases, receipts for repairs or equipment rental, force account labor records, and may be supported by other documentation such as news articles or community/agency board meeting minutes
- Repair records must:

- be related to specific hazard events rather than scheduled maintenance or repairs, and
  - apply directly to asset(s) to be mitigated by the project
- Always include complete copies of records organized in a spreadsheet when needed

**6) News Articles Citing Credible Sources:**

- News articles can include nationally or locally published newspapers or newsletters that are printed or posted online
- Credible sources – sources other than individual (homeowner/customer) accounts
- Make sure the articles indicate the specific dates and impacts to facilities to be mitigated by the proposed project

### **C.2.2 Expected Damages**

Expected damages are based on damages predicted from a theoretical model or engineering analysis. You need a minimum of one expected damage event with a known RI.

#### **Building Damages**

Building damages can be tied to FEMA BCA software or HAZUS-MH.

- **Flood Events:**
  - Flood damages to buildings can be estimated using DDFs based on structure information (building type, number of stories, foundation type, size and BRV) as a function of flood depth above the First Floor Elevation (FFE).
  - DDFs can be documented from the FEMA BCA software, HAZUS-MH output, or transcribed into a separate document or spreadsheet (recommended)
  - Structure information can be documented from various sources, including tax records, structure plans with dimensions, site photographs, engineering reports, and building cost data
  - Be sure to establish the correct reference point for the FFE
- **Wind Events:**
  - Wind damages to buildings can be estimated using WDFs based on structure information (building type, construction materials, details, size, BRV) as a function of hurricane wind speed
  - WDFs can be documented from the FEMA BCA software, HAZUS-MH output, or transcribed into a separate document or spreadsheet (recommended)
  - Structure information can be documented from various sources, including engineering reports, tax records, structure plans with dimensions, site photographs, and building cost data

- Be sure to indicate the applicable expected wind speed in 3-second peak gust (mph) to match wind design standards
- **Earthquake Events:**
  - Earthquake damages to buildings can be estimated using fragility curves based on building construction and the type of lateral force resisting system as a function of peak ground acceleration (PGA)
  - Fragility curves can be documented from the FEMA BCA software, HAZUS-MH output or transcribed into a separate document or spreadsheet (recommended)
  - Structure information can be documented from various sources, including engineering reports, tax records, structure plans with dimensions, site photographs, and building cost data
  - Be sure to indicate the type of soil for the site.

## Facility Damages

Engineering studies or reports from qualified experts may be used to estimate damages to various [non-building] transit facilities from various hazards. Documentation sources include:

- **Engineering Reports** – Good documentation source to indicate estimated damages to various types of facilities based on similar historic events or detailed engineering analysis; should include a complete copy of the report prepared by qualified professional
- **Transit Agency Studies** – Good documentation source to indicate estimated damages to transit facilities; should include a complete copy of the study prepared by qualified transit agency engineers or contractors

## C.3 Event Service Losses

### C.3.1 Historic Service Losses

Remember that for each type of service loss, documentation must be provided for:

- Cost of lost transit service – based on value of passenger time (\$/passenger/hour),
- Delay or extra travel time (hours), and
- Actual loss of function (LOF) durations for each historic event (days).

Remember that transit service losses can be combined in a variety of ways: For example, a loss of rail transit could use additional temporary bus service or may increase passenger vehicle traffic. The HMCE Tool was designed to balance flexibility of inputting various complex service loss scenarios with efficiency in entering values for the majority of more simple/basic service loss scenarios.

General Notes:

- The HMCE Tool uses a standard value of \$15.58/passenger/hour for lost transit service based on:
  - Average hourly wage rate of \$31.16 based on latest available data from the Bureau of Labor Statistics (September 2013) report - available online at <http://www.bls.gov/news.release/ecec.nr0.htm>
  - DOT value of commute time at 50% of wage rate taken from latest FEMA Standard Economic Values Methodology report (December 2011).
- The HMCE Tool also uses a standard value of \$15.58/passenger/hour for the Federal mileage rate of personal vehicles based on the latest 2014 rate from the General Services Administration. Available online at - [http://www.gsa.gov/portal/content/100715?utm\\_source=OGP&utm\\_medium=print-radio&utm\\_term=mileage&utm\\_campaign=shortcuts](http://www.gsa.gov/portal/content/100715?utm_source=OGP&utm_medium=print-radio&utm_term=mileage&utm_campaign=shortcuts)
- NOTE: The standard value is based on national average values reflecting loss of regional economic impacts. Therefore, no adjustments to the number of trips are required to account for residential vs. commercial or emergency vehicles
- As discussed in Unit 2, loss of transit revenue is not considered as a quantitative benefit in the HMCE Tool, but is included as a qualitative benefit.

### **Loss of Rail or Ferry Service**

Rail or Ferry Service Loss values must document Delay or Extra Travel Time (hours) and Average Daily Number of Passengers for lines/systems impacted by the event and addressed by the project. Documentation sources include:

- Transit Agency Statistics – Good for documenting delay or extra travel time and the average daily number of passengers; should be provided from transit agency or included with a signed letter from a transit official.
- Transit Maps – Good for documenting delay times; required for documenting no available alternative route when alternate transit routes included; online sources are acceptable
- Other Sources – Commuter surveys, if available, may be suitable for documenting delay times if developed by a credible source

The Duration of Loss or Reduction of Rail or Ferry Services (days) must be documented for lines/systems impacted by each historic event to be addressed by the proposed project.

Documentation sources include:

- Transit Agency Records – Good documentation source to indicate durations of rail/ferry repairs; should be provided from transit agency or included in a signed letter from a transit official

- FEMA *Project Worksheets* (PWs) – Potential documentation source; must include complete/signed copies of PWs
- News Articles Citing Credible Sources – Potential documentation source in locally published newspapers or online newsletters; must include date of article that can be linked to the hazard event and the impacted rail or ferry transit lines/systems.

## Loss of Bus Service

Bus Service Loss values must document Additional Time per One-way trip (hours), Additional Travel Miles, Number of One-way Traffic Trips per Day, and Average Number of Passengers per Bus for lines impacted by the event and addressed by the project. Documentation sources include:

- Transit Agency Statistics – Good for documenting additional trip times, additional travel miles, number of trips and average number of passengers; should be provided from transit agency or included with a signed letter from a transit official.
- Bus Route Maps – Good for documenting delay times and additional travel miles; required for documenting no available alternative route when alternate transit routes included; online sources are acceptable
- Other Sources – Commuter surveys, if available, may be suitable for documenting additional time/mileage if from a credible source

The Duration of Loss or Reduction of Bus Services (days) must be documented for lines impacted by each historic event to be addressed by the proposed project. Documentation sources include:

- Transit Agency Records – Good documentation source to indicate durations of bus repairs or bus service interruptions; should be provided from transit agency or included in a signed letter from a transit official
- FEMA *Project Worksheets* (PWs) – Potential documentation source; must include complete/signed copies of PWs
- News Articles Citing Credible Sources – Potential documentation source in locally published newspapers or online newsletters; must include date of article that can be linked to the hazard event and the impacted bus lines.

## Passenger Vehicle Delays

Passenger vehicle delay values documentation must include the number of one-way trips (vehicles/day), the delay (detour) time, and any additional mileage associated with the delay. Documentation sources include:

- DOT Traffic Counts – Best for documenting one-way trips; should be provided from DOT or included in a signed letter from a local official
- Maps with Detours and Mileages – Good for documenting delay times and additional mileage; required for documenting no available alternative route; online sources are acceptable
- Other Sources – For smaller subdivision roads where traffic counts are unavailable, can estimate one-way trips using the TRB Highway Capacity Manual or other recognized sources

NOTES:

- Although this is typically applied to project costs (TAB 2), HMCE Tool inputs could be adjusted for this as a benefit (TABS 3 and 4) if a transit line loss leads to increased passenger vehicle traffic and associated delays. This would be done by using the inputs for bus transit service delays.
- The HMCE Tool uses a national average value of 1.67 passengers per passenger vehicle based on the latest available National Household Travel Survey (DOT 2009). This default value can be adjusted if more current or local study data is provided from a credible source.

Passenger vehicle delay duration documentation must include the Duration of Loss or Reduction of Services that triggered the delay. Documentation sources include:

- DOT/Transit Agency Records – Good documentation source to indicate durations of service losses/reductions; should be provided from DOT/transit agency or included in a signed letter from a local official
- FEMA PWs – Potential documentation source; must include complete/signed copies of PWs
- News Articles Citing Credible Sources – Potential documentation source in locally published newspapers or online newsletters; must include date of article that can be linked to the hazard event and loss or reduction of service

NOTE: Although this is typically applied to project costs (TAB 2), HMCE Tool inputs could be adjusted for this as a benefit (TABS 3 and 4) if a transit line loss leads to increased passenger vehicle traffic and associated delays. This would be done by using the inputs for bus transit service delays.

### C.3.2 Expected Service Losses

As with historic losses, the following documentation must be provided for each type of service loss:

- cost of lost transit service – based on value of passenger time (\$/passenger/hour),

- delay or extra travel time (hours), and
- actual loss of function (LOF) durations for each historic event (days).

Remember that transit service losses can be combined in a variety of ways: For example, a loss of rail transit could use additional temporary bus service or may increase passenger vehicle traffic. The HMCE Tool was designed to balance flexibility of inputting various complex service loss scenarios with efficiency in entering values for the majority of more simple/basic service loss scenarios.

### **Loss of Rail or Ferry Services**

Rail or Ferry Service Loss values and durations must document Delay or Extra Travel Time (hours) and Average Daily Number of Passengers for lines/systems impacted by the event and addressed by the project. Documentation sources include:

- Transit Agency Studies – Good documentation source to indicate estimated durations of service losses to rail/ferry transit facilities, lines and/or systems; should include a complete copy of the study prepared by qualified transit agency engineers or contractors
- Engineering Reports – Good documentation source to indicate estimated durations of service losses to various types of transit facilities based on similar historic events or detailed engineering analysis; should include a complete copy of the report prepared by qualified professional

### **Loss of Bus Service**

Bus Service Loss values and durations must document Additional Time per One-way trip (hours), Additional Travel Miles, Number of One-way Traffic Trips per Day, and Average Number of Passengers per Bus for lines impacted by the event and addressed by the project.

Documentation sources include:

- Transit Agency Studies – Good documentation source to indicate estimated durations of service losses to bus facilities, lines and/or systems; should include a complete copy of the study prepared by qualified transit agency engineers or contractors
- Engineering Reports – Good documentation source to indicate estimated durations of service losses to various types of transit facilities based on similar historic events or detailed engineering analysis; should include a complete copy of the report prepared by qualified professional

## Loss of Passenger Vehicle Service

Passenger vehicle delay values and durations documentation must include the number of one-way trips (vehicles/day), the delay (detour) time, and any additional mileage associated with the delay. Documentation sources include:

- DOT/Transit Agency Traffic Studies – Good documentation source to indicate estimated durations of passenger vehicle delays; should include a complete copy of the study prepared by DOT/transit agency officials
- Engineering Reports – Good documentation source to indicate estimated durations of passenger vehicle delays based on similar historic events or detailed engineering analysis; should include a complete copy of the report prepared by qualified professionals

## Alternative Approach for Historic or Expected Service Losses

For damaged buildings or facilities that experience a loss of function but do not impact transit service, an alternative approach to estimate historic or expected service losses is to look at service losses based on the annual operating budget and loss of function duration for the damaged building or facility:

$$\text{Service Loss} = \frac{\text{Annual Operating Budget, \$}}{365 \text{ days}} \times [\text{Service Loss Duration, days}]$$

Input alternate approach results as “Other Damages” in the HMCE Tool, and include calculations and supporting documentation as attachments.

NOTE: Since buildings or facilities using the alternative approach do not impact overall transit service, experience with similar projects has shown that they yield benefits are significantly lower than facilities that directly impact transit service.

If you use the alternative approach, you must document the annual operating budget value. Annual reports are best for documenting annual operating budgets for public facilities or net income for commercial buildings; they must indicate breakdown for the individual structure(s) to be addressed by the proposed resilience project; copies of reports from online sources are acceptable.

Service loss duration documentation must include the duration of the building service loss for each historic or expected hazard event. Documentation sources include:

- **Historic Events:**

- Facility Records – Good documentation source to indicate durations of building service losses and repairs; should be provided from public/transit agency representative or included in a signed letter from a transit agency official
- Other Potential Sources: FEMA PWs (complete/signed copies); Insurance Claims (complete copies on insurance company letterhead); News Articles Citing Credible Sources
- **Expected Events:**
  - FEMA/HAZUS-MH Damage Functions for Flood or Hurricane Wind – Good documentation source to estimate service loss durations; should include a copy of the Damage Function for applicable the building type
  - Engineering Reports – Good documentation source to indicate estimated service loss durations based on similar historic events or detailed engineering analysis; should include a complete copy of the report prepared by qualified professionals

## C.4 Event Recurrence Intervals

### C.4.1 Historic Events with Known Recurrence Intervals (RIs)

The HMCE Tool requires:

1. Minimum of three hazard events occurring in different years where either:
  - a. The RIs of all events are unknown, **or**
  - b. The RIs of up to two events are known **and** have total damage values that exceed the total damage values of all the other unknown RI events
2. Analysis Duration based on the age of the structure or a minimum of 10 years; whichever is greater

NOTE: If you have one historic event of known RI that has damages less than events of unknown RIs, then you can still use the event of known RI but treat it like an unknown RI.

The following approaches may be used to estimate known recurrent intervals of historic events.

#### Flood Elevations or Discharges Tied to Identified Flood RIs

Documentation must include flood elevations and/or discharges from historic events as well as identified flood RIs that are used to determine the historic event RIs.

- Both stream and tide gauge data can be obtained from the **U.S. Geological Survey (USGS)** website (<http://waterdata.usgs.gov/nwis/sw>).
  - Make sure to use the gauge data closest to the project site.
- **The USGS PeakFQ Program**, which can be downloaded from the USGS website (<http://water.usgs.gov/software/PeakFQ>), provides identified flood RI data.

- Refer to Section 2.1.2 of FEMA's *Supplement to the Benefit-Cost Analysis Reference Guide* for step-by-step instructions and a detailed example of estimating RIs using the USGS PeakFQ approach: the guide is available from the FEMA website ([http://www.fema.gov/media-library-data/20130726-1807-25045-6430/bca\\_guide\\_supplement\\_508\\_final.pdf](http://www.fema.gov/media-library-data/20130726-1807-25045-6430/bca_guide_supplement_508_final.pdf))
- **FEMA Flood Insurance Study (FIS) Profiles and Discharge Tables or Transects** provide flood elevations and discharges for the 10-, 50-, 100-, and 500-year flood events. FIS data is available from the FEMA Map Service Center website (<http://msc.fema.gov>), then select Product Catalog from the top menu bar and search for the Effective FIS.
  - As indicated in the NOFA, FTA will consider best available flood hazard information released by FEMA as of February 1, 2014.
  - Following Hurricane Sandy, FEMA produced Advisory Base Flood Elevation (ABFE) and Preliminary Flood Insurance Rate Maps (FIRMs) for coastal counties in New Jersey and New York. These advisory maps can be found online at <http://184.72.33.183/best>.
  - In other cases, Hydraulics and Hydrology (H&H) Studies may be used where FIS data may be incomplete or out-of-date; must include complete copies of studies

### Hydrologic Analysis

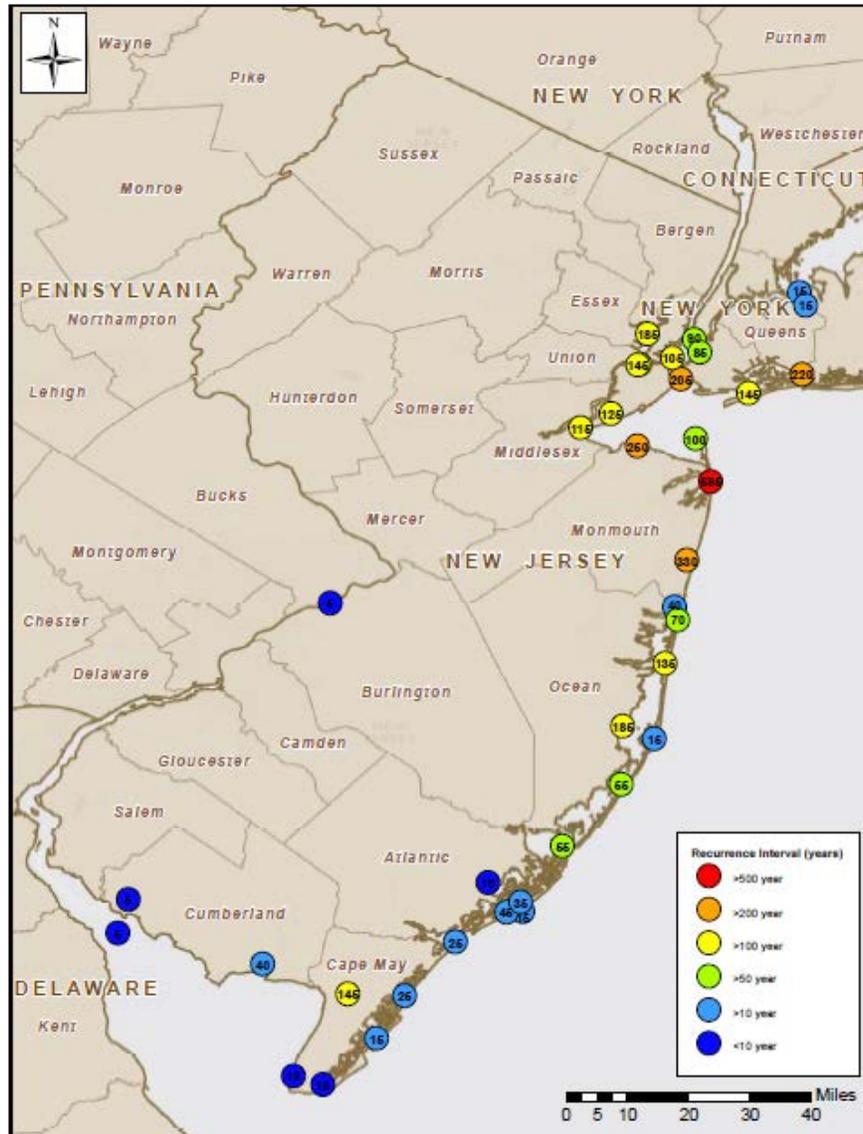
RI determinations made by a hydrologist or other qualified expert may be limited for use in a specific geographic location, especially for large events such as Hurricane Katrina (2005) or Hurricane Sandy (2012). Documentation sources include:

- Post-event studies prepared by the U.S. Army Corps of Engineers (USACE) or the U.S. Geological Survey (USGS); must include complete copies of studies
- Estimates prepared by a hydrologist; must include background data and/or calculations used to estimate RIs.

However, it's important to remember that the recurrence intervals of major storm events can vary significantly depending on the location. This is illustrated in Figure C-1 shown on the next page. Figure C-1 shows the results of a January 2013 analysis report prepared by a FEMA contractor (CDM PA TAC Recovery Services) intended to provide guidance for estimating the storm surge flood recurrence intervals of Hurricane Sandy in New York and New Jersey.

### Climatological or Rain Gauge Data

Since a 100-year rainfall event does not usually equate to a 100-year flood, rain gauge data for historic damage events must be tied to flood RIs by a hydrologist or other qualified professional. Sources include:



**Figure C-1.** Estimated coastal flood recurrence intervals for Hurricane Sandy in New Jersey and New York (shared with permission from the Federal Emergency Management Agency).

- The National Climatic Data Center (NCDC) records daily rainfall and other climactic data recorded by thousands of weather stations nationwide and is available online (<http://www7.ncdc.noaa.gov/IPSCoop/coop.html>); must include copies of all applicable data
- NCDC also has U.S. Hourly Precipitation Data (HPS) data records available online (<http://www.climate.gov/hourly-precipitation-data>)
- Analysis of rain gauge data prepared by a hydrologist; must include background data and/or calculations used to estimate flood RIs

## Other Approaches for Non-Flood Events

Other approaches are available to calculate recurrence intervals for hurricane and other wind events. These include:

- **Interpolated wind RIs from FEMA BCA Software Modules:**
  - Hurricane event RIs tied to wind speed data by zip code in BCA Hurricane Wind Module
  - Tornado event RIs tied to tornado frequency data by county in Tornado Safe Room Module.
  - Documentation sources include:
    - Hurricane wind speeds from NCDC records or copies of published weather data; must indicate wind speed in 3-second peak gust (mph) to match BCA data
    - Tornado event types from NCDC records or copies of published weather data; must indicate wind speed in 3-second peak gust (mph) using Enhanced Fujuta (EF) scale to match BCA data
    - Location by zip code or county can be documented using maps available online
- **Interpolated Wind RIs from ASCE 7 Data:**
  - Wind event RIs tied to ASCE 7 wind speed data by latitude/longitude
  - Documentation sources include:
    - NCDC records wind speed and other climactic data recorded by thousands of weather stations nationwide and is available online (<http://www7.ncdc.noaa.gov/IPSCoop/coop.html>); must indicate wind speed in 3-second peak gust (mph) to match ASCE 7 data
    - Latitude/longitude data available from various map sites online (e.g., Microsoft's terra server, mapquest.com)
    - ASCE 7 wind speed data can be obtained directly from the following ATC website (<http://www.atcouncil.org/windspeed/>); listed in 3-second peak gust wind speeds (mph)
- **Earthquake Events from Peak Ground Acceleration (PGA) data:**
  - Earthquake Peak Ground Acceleration (PGA) data is available by location (latitude/longitude) and soil type from the U.S. Geological Survey (USGS) records or published technical reports.
  - Documentation sources include:
    - PGA data from USGS records available online (<http://www.usgs.gov>)
    - Latitude/longitude data available from various map sites online (e.g., Microsoft's terra server, mapquest.com)

- Soil type can be documented using geotechnical report data for the site or nearby development; use Site Class D as default if no data available.

### **C.4.2 Historic Events With Unknown Recurrence Intervals (RIs)**

Documentation of historic events with unknown RIs must include the historic event damages and the year built for the facility to be mitigated. Sources include:

- Historic hazard event damages/losses can be documented using approaches and sources listed previously for other historic damage events
- Year Built can be documented using tax records or facility records provided from public/transit agency representative or included in a signed letter from a transit agency official

NOTE: For facilities with multiple structures of different construction dates, the construction date of the oldest structure in the group must be used for the Year Built.

#### Important Reminders:

- The HMCE Tool uses a minimum Analysis Duration of 10 years
- Significant documentation requirements apply for User Input Analysis Durations less than 30 years
- No historic events that occur before the start of the adjusted Analysis Duration may be included in the analysis
- Inflation calculations do not go back before a Year Built of 1908.

The analysis duration is a key component to determine RIs for unknown RI events, and can present difficulties for facility(ies) that are older or where the Year Built is unknown. A user-input analysis duration may be used when one of the following situations apply:

- 1) Discontinuities in Damage Records
- 2) Replacement of Facility
- 3) Change in Local Flow Conditions
- 4) Use 50-year Project Useful Life

#### **Discontinuities in Damage Records**

If hazard data is not available for part of the Analysis Duration since the Year Built, you may input the total number of years for which hazard data is available. Where there are discontinuities in damage records, enter the sum of periods when records were kept in the User Input Analysis Duration.

Documentation sources include transit agency damage records, which are the best documentation source to indicate available hazard data; they should include complete copies of records and indicate reasons why records were not kept over selected periods.

## Replacement of a Facility

When a facility or facilities to be mitigated are replaced or completely rebuilt, it may be appropriate to adjust the Analysis Duration. Documentation sources include:

- Letter from a city engineer or transit official on appropriate letterhead that includes dates, site photographs, and all details of the facility(ies) replacement/rebuild
- An engineering report with photographs that addresses the date and all details of the facility(ies) replacement/rebuild
- Current and old tax records with photographs that indicate the replacement of the facility(ies)

NOTE: Partial rebuilding/replacement of a facility(ies) is not acceptable documentation to adjust the Analysis Duration.

## Change in Local Flow Conditions

When local flow conditions have changed significantly over the life of a structure, it may be appropriate to adjust Analysis Duration. Documentation sources include:

- Current and old FIS showing the before and after changes
- Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR)
- Hydraulics and hydrology (H&H) study that accounts for the change
- Letter from city engineer or floodplain manager on community letterhead that addresses the changes in local flow conditions
- Aerial photographs of the project area before and after the change in the watershed, or other photographs with dates showing increased development

Refer to Section 2.1.3 of the *Supplement to the Benefit-Cost Analysis Reference Guide* for step-by-step instructions and a detailed example of adjusting the Analysis Duration using this approach.

## Use a 50-Year Project Useful Life

For public infrastructure such as roads or rail lines where the date of construction (Year Built) is old or cannot be accurately determined, it may be permissible to adjust the Analysis Duration to 50 years based on the standard Project Useful Life for such assets. Documentation sources include a letter from a city engineer, DPW official, or transit agency representative on appropriate letterhead that explains why the date of construction cannot be accurately determined.

NOTE: That fact that infrastructure is greater than 50 years old alone is not acceptable documentation to adjust the Analysis Duration.

### **C.4.3 Expected Damage Events**

Only expected damage events with known recurrence intervals may be used in the HMCE tool. Approaches for estimating recurrence intervals are discussed below.

#### **Estimated Event RIs from Engineering Studies**

Engineering studies or reports from qualified experts may be used to estimate RIs of various hazard events. Documentation sources include:

- Engineering Reports – Good documentation source to indicate estimated various event RIs to various facilities based on similar historic events or detailed engineering analysis; should include a complete copy of the report prepared by qualified professional
- Transit Agency Studies – Good documentation source to indicate estimated event RIs impacting transit facilities; should include a complete copy of the study prepared by qualified transit agency officials or contractors

#### **Estimated Flood Event RIs based on FEMA BCA Flood Module**

Flood event RIs are estimated in the Flood Module as a function of flood depth based on the FEMA Flood Insurance Study (FIS) or equivalent Hydraulics and Hydrology (H&H) data.

Documentation sources include:

- FIS Profiles and Discharge Tables or Transect data is available from the FEMA Map Service Center website (<http://msc.fema.gov>), then select Product Catalog from the top menu bar and search for the Effective FIS
- When available, Preliminary FIS or H&H Studies may be used where Effective FIS data may be incomplete or out-of-date; must include complete copies of studies

#### **Other Approaches for Estimated Wind Event RIs**

Hurricane Wind Event RIs are estimated in the Hurricane Wind Module as a function of wind speed based on zip code location. Documentation sources include hurricane wind speeds that indicate 3-second peak gust (mph) to match BCA data; location by zip code can be documented using maps available online.

Wind event RIs can be tied to ASCE 7 wind speed data by latitude/longitude location. ASCE 7 wind speed data can be obtained directly from the following ATC website

(<http://www.atcouncil.org/windspeed/>); listed in 3-second peak gust wind speeds (mph).

Latitude/longitude location data available from various map sites online.

#### C.4.4 Impact of Sea Level Rise (SLR) on Event Recurrence Intervals

The NOFA indicates that grant applicants may consider transit resilience projects that address the impacts of sea level rise (SLR). FTA has gone on to clarify that SLR data may come from government- produced or academic/peer-reviewed sources.

In December 2013, FEMA released information on incorporating SLR into BCA on the FEMA website (<http://www.fema.gov/media-library/assets/documents/89659>) which can be applied to HMCE analysis of FTA transit resilience projects and provides several reference to SLR data that meets FTA requirements

SLR impacts reduce coastal flood/surge RIs for Historic or Expected Damage Events, thereby increasing pre-resilience damages and losses for the same event(s); For example, the coastal flood/storm surge RI for Hurricane Sandy may be estimated based on a comparison of the recorded tide gauge levels with the 10-, 50-, 100- and 50-year RI flood events found in the FEMA flood map and flood study data (FIRM and FIS). So if the 10-, 50-, 100- and 500-year RI events are increased to account for sea level rise, then the estimated coastal flood RI for Hurricane Sandy will be reduced and the corresponding damages and losses would be increased.

FTA has indicated that SLR data may come from government- produced or academic/peer-reviewed sources. The FEMA SLR FAQ memo provides the following acceptable sources of SLR data:

- NOAA Center for Operational Oceanographic Products and Services' Mean Annual SLR Trend Data (<http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml>);
- USACE Climate Change Adaptation Sea Level Change Curves (<http://corpsclimate.us/ccaceslcurves.cfm>); and
- Globalchange.gov provides more information specific to New Jersey and New York (<http://www.globalchange.gov/what-we-do/assessment/coastal-resilience-resources>)

#### C.5 Post-Resilience Damage and Losses

Remember that very few resilience projects are 100% effective at reducing all future damages and losses - nearly all projects have some residual risk/damages. Post-Resilience damages and losses will depend on the project type and the design level of effectiveness. General rules of thumb for post-resilience damages include:

- Acquisition/Relocation: Zero post-resilience damages
- Elevation: No post-resilience damages until design level of effectiveness is reached, then use minimum pre-resilience damages beginning at design level of effectiveness

- Flood barriers/Dry floodproofing: No pre-resilience damages until design level of effectiveness is reached, then apply pre-resilience damages that would occur at the design flood level
- Wet floodproofing: Reduce pre-resilience damages to reflect reduced cleanup or downtime costs until design level of effectiveness is reached, then apply maximum pre-resilience damages that would occur for that flood level
- Other projects: Generally use no post-resilience damages until design level of effectiveness is reached, then either conservatively assume the maximum pre-resiliency damages once the design level of effectiveness is reached or incrementally increase pre-resiliency damages as RIs increase.

Project effectiveness documentation sources can include engineering or technical reports that indicate design level or effectiveness, or a detailed project scope with plans and specifications