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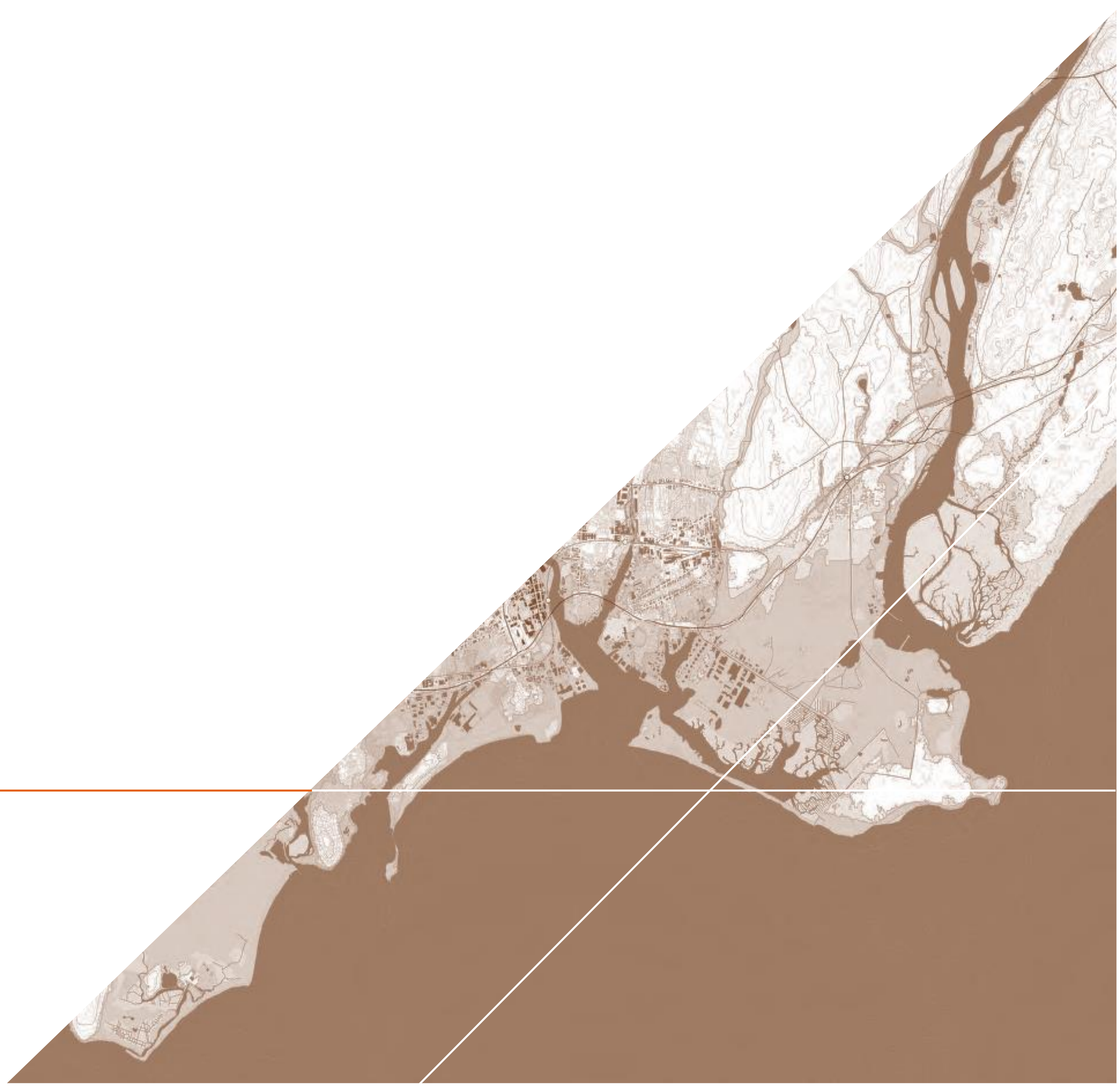
RESILIENT BRIDGEPORT

BENEFIT COST ANALYSIS

METHODOLOGY REPORT

April 21, 2017



BENEFIT COST ANALYSIS

Methodology Report

Macy Fricke, CFM
Management Consultant

Edward Fernandez, CFM
Senior Management Consultant

Hugh Roberts, PE
Associate Vice President

Prepared for:

Connecticut Department of Housing

Prepared by:

Arcadis U.S., Inc.

Our Ref.:

LA003323.0000

Date:

April 21, 2017

VERSION CONTROL

Issue	Revision No	Date Issued	Page No	Description	Reviewed by
001	Rev. 1			Draft	E. Fernandez
002	Rev. 2			Draft	H. Roberts
003	Rev. 3			Final Draft	E. Fernandez

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TABLES AND FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

ARC: American Red Cross

BCA: Benefit Cost Analysis

BCAR: BCA Re-Engineering Report

BCR: Benefit Cost Ratio

BEA: Bureau of Economic Analysis

BLS: Bureau of Labor Statistics

BRV: Building Replacement Value

CDC: Centers for Disease Control

CRV: Contents Replacement Value

CSRV: Contents-to-Structure Ratio Value

CSO: Combined sewer overflow

CSS: Combined sewer system

DDF: Depth-Damage Function

DEEP: Connecticut Department of Energy and Environment

DEM: Digital Elevation Model

DOH: Connecticut Department of Housing

EPA: U.S. Environmental Protection Agency

EIS: Environmental Impact Statement

FAA: Federal Aviation Administration

FEMA: Federal Emergency Management Agency

FIS: Flood Insurance Study

FIRM: Flood Insurance Rate Map

FFE: First Floor Elevation

GCP: Gross city product

GDP: Gross domestic product

GIS: Geographic Information System

HUD: United States Department of Housing and Urban Development

LiDAR: Light Detection and Ranging

MEP: Mechanical/Engineering/Plumbing

NACCS: North Atlantic Coast Comprehensive Study

NAICS: North American Industry Classification System

NAVD88: North American Vertical Datum of 1988

NDR: National Disaster Resilience

NOAA: National Oceanic and Atmospheric Administration

NPV: Net present value

NRCS: Natural Resources Conservation Service

OMB: United States Office of Management and Budget

PTSD: Post-traumatic stress disorder

RBD: Rebuild by Design

SAM: Social Accounting Matrix

SF: Square Feet

SLR: Sea Level Rise

TM: Technical Manual

UDV: Unit Day Value

USACE: U.S. Army Corps of Engineers

WTP: Willingness to Pay

1 INTRODUCTION

During Tropical Storm Irene (Federal Emergency Management Agency [FEMA] Major Disaster Declaration [DR] -4023) and Hurricane Sandy (DR-4087), floodwaters from Long Island Sound inundated roadways, critical infrastructure, businesses, and homes in low-lying areas, directly affecting the South End's residents and businesses. Following the devastation from Hurricane Sandy, the U.S. Department of Housing and Urban Development (HUD) launched Rebuild by Design (RBD) to inspire innovative community and policy-based resilience solutions to protect cities most vulnerable to intense weather events.

HUD awarded the Connecticut Department of Housing (DOH) $10 million to reduce flood risk for the most vulnerable public housing stock in Bridgeport through continued planning and evaluation of long-term resiliency strategies, as well as designing a RBD pilot project aimed at alleviating acute and chronic flooding in the South End neighborhood. To this end, the Resilient Bridgeport Team, led by Waggonner & Ball with Arcadis, Yale Urban Design Workshop and Reed Hilderbrand Landscape Architects, has developed an innovative and multifaceted RBD project in the South End to provide benefits to the neighborhood by means of dry egress and stormwater management.

The Resilient Bridgeport Team completed a benefit cost analysis (BCA) to evaluate the RBD project at its current level of design as part of the design process. The BCA assesses resiliency, social, environmental, and economic benefits that will result from the implementation of the RBD project. In accordance with HUD Notice: CPD-16-06, the BCA uses federally accepted standard figures and methods to assess project benefits.

This appendix serves to provide a detailed description of the BCA methods summarized in the BCA Report, and includes the following principle sections:

- **Section 1 Introduction** includes a BCA overview.
- **Section 2 RBD Project Description** summarizes the RBD project and project costs.
- **Section 3 Resiliency Benefits** includes detailed methodologies used to determine resilient redevelopment and dry egress benefits.
- **Section 4 Value Added** describes in detail the methods used to evaluate social, environmental, and economic benefits.
- **Section 5 Sensitivity Analysis** includes a describes how analysts approached BCA assumptions and the discount rate.
- **Section 6 Double Counting** describes how analysts approached potentially overlapping benefits in the BCA.
- **Section 7 Benefit Cost Analysis Results** presents BCA findings.
- **Section 8 Economic Impact Analysis** is a detailed description of the methodology used to evaluate economic impacts of project implementation.

To facilitate HUD's review of the BCA Summary Report and BCA Methodology Report, analysts completed two crosswalks:

1. **Appendix A: HUD Crosswalk** summarizes the pilot project's benefits, costs, and BCA methods.
2. **Appendix B: BCA Crosswalk** relates CPD Notice 16-06 requirements to report sections.

1.1 Benefit Cost Analysis Overview

A benefit cost analysis (BCA) helps inform sound decision making related to public infrastructure investment. BCA benefits represent the present value of the total expected annual losses avoided and value added over the RBD project's useful life. The BCA accounts for:

- Probabilities of flood events and losses
- Project useful life
- Time value of money (discount rate)

Resiliency benefits are future losses prevented or reduced by the RBD project. Analysts estimate losses avoided for certain modeled flood scenarios, then apply the annual probability of occurrence to losses at each flood scenario to determine expected annual losses avoided. Probability of occurrence refers to the percent chance of an expected flood event being met or exceeded in any given year.

$$Annual\ Resiliency\ Benefits = \sum_{s=1}^{s=4} Expected\ Losses\ Avoided \times Annual\ Probability\ of\ Occurence$$

Where:

S = annual flood event scenario

Analysts project and discount annual benefits and project life-cycle costs[1] over the RBD project's useful life (50 years) using a 7 percent discount rate to find the present value of project benefits. The project useful life is the estimated amount of time the project will be effective. The discount rate determines the time value of money; in other words, the discount rate accounts for the fact that monetary value tomorrow will not be as much as it is in the present. The Office of Management and Budget (OMB) mandates the discount rate to be 7 percent, but HUD also considers a 3 percent discount rate for review per HUD Notice: CPD-16-06.

The BCR is the project's total present value of benefits divided by the project's total present value of life-cycle costs. NPV is the difference between the present value of a project's total benefits and the present value of a project's total life-cycle costs. Both the NPV and BCR inform the RBD project's cost effectiveness and ensure the project is fiscally beneficial.

$$Net\ Present\ Value = Present\ Value\ of\ Project\ Benefits - Present\ Value\ of\ Project\ Costs$$

$$Benefit\ Cost\ Ratio = \frac{Present\ Value\ of\ Project\ Benefits}{Present\ Value\ of\ Project\ Costs}$$

This BCA presents benefits and costs in 2016 dollars. The sections below describe the RBD project and the detailed methods analysts used to determine annual resiliency benefits and value added benefits that Bridgeport will realize once it implements the pilot project.

[1] Project life cycle costs include direct capital costs and operations and maintenance cost over the life of the project.

2 REBUILD BY DESIGN PILOT PROJECT

Through stakeholder meetings, community engagement, mapping, and modeling, the RBD project team has come to understand the different impacts that chronic and acute flooding have on the community, and the risks posed by climate change and sea level rise (SLR). Though the primary intent of the RBD project is to reduce these impacts on the project area, the project team has also designed the project to serve as a proof of concept for broader resilience principles within Bridgeport and the region. The project and the collaboration that it requires will result in the demonstration of best practices for agencies and private entities. It is intended to provide a precedent for future development, as well as encourage the adoption and implementation of updated local policies, zoning regulations, and building code standards by the City of Bridgeport.

Further, the State of Connecticut has committed to developing and implementing a set of resilience performance standards for the RBD project. The State will coordinate the standards developed or the project with those that are being developed for the National Disaster Resilience (NDR)-funded infrastructure of similar nature being implemented in the South End of Bridgeport. Overtime, these performance standards will be refined based on the outcomes of the RBD project and South End NDR project so that they can continually be applied to any future development projects throughout the State.

The RBD project will extend Johnson Street to provide dry egress for future Mariana Village residents out of the FEMA 500-year flood zone, as well as future SLR conditions of 3 feet. The Johnson Street Extension will incorporate green infrastructure, such as bioswales, to divert surface runoff away from the combined sewer system and into a multifunctional stormwater park. Stormwater park components such as terraced basins and underground storage features will retain, delay, and improve the quality of stormwater runoff. Community gathering spaces, play equipment and courts, and walkways in the stormwater park will provide space for community programs, environmental education, and passive and active recreation. The park component will also include new flora and fauna.

The stormwater park will collect surface water, which will be gravity drained to a new pump station located at the southeast corner of South Avenue and Iranistan Avenue. A new underground force main will pump the flow to an existing outfall at Cedar Creek, the Little Regulator Outfall. By removing stormwater from the combined sewer system, a reduced load will be routed to the wastewater treatment plant on the west side of Bridgeport. Similarly, bringing additional stormwater to the head end of Cedar Creek will improve flushing and overall ecological function of the creek. RBD project costs include direct capital costs, as well as operation and maintenance (O&M) costs over the project useful life. **Table 1** summarizes the total value of each cost category. Refer to **Appendix D: Rebuild by Design Pilot Project Cost Estimates** for a detailed description of project costs.

Table 1. Summary of RBD Project Costs

Cost Category	Costs (7 Percent Discount Rate)	Costs (3 Percent Discount Rate)
Capital Costs	$ 8,200,000	$ 8,200,000
Annual O&M Costs	$ 75,000	$ 75,000
Present Value O&M Costs	$ 1,035,060	$ 1,912,620
Total Project Costs	**$ 9,235,060**	**$ 10,112,620**

2.1 Project Timeline

It is anticipated that the RBD project will be completed by the end of 2021. The project has not yet been permitted, but preliminary permitting requirements have been identified and additional permit requirements may be identified during the development of an Environmental Impact Statement (EIS). An aggregated EIS to include both the RBD project and the Bridgeport resilience projects is being funded through the State of Connecticut's National Disaster Resilience Grant award. The State is currently concluding a public procurement process that will result in a consultant team being engaged under contract to complete the Environmental Impact Statement and other tasks designed to move forward the projects funded by both RBD and NDR.

Concurrent to this procurement process, the State's existing consultant team is also advancing the project to a 30% design stage. It is expected that environmental review, preliminary design, and permitting will continue into the last quarter of 2018 and construction will commence in early 2019 and continue into the middle of 2021. A Notice of Intent to Prepare an EIS as required under 24 CFR Part 58.55 is anticipated to be published in the Federal Register in September 2017 thereby launching the public scoping process. **Table 2** below delineates the major milestones for project completion including remaining design and engineering work, permitting, bidding, and construction.

Table 2. RBD Project Milestone Timeline

Activity Milestone	Start Date	End Date
CDBG-DR Action Plan Substantial Amendment	February 2017	June 2017
30 Percent Design Completion	February 2017	June 2017
Resilience Strategies Finalization	December 2016	June 2017
Environmental Impact Statement	June 2017	July 2018
Final Design Documents	July 2017	November 2018
Project Permitting	October 2017	November 2018
RBD Project Construction	November 2018	September 2021

3 RESILIENCY BENEFITS

Resiliency benefits are the result of the RBD project's expected effectiveness at protecting against future flooding impacts. Resiliency benefits are related to resilient redevelopment or dry egress. These benefits are the largest category of benefits quantified for the RBD project. Resilient redevelopment benefits include direct physical damages, displacement costs, mental stress and anxiety, and lost productivity. Dry egress benefits include loss of road service, injuries and fatalities (**Table 3**). The BCA estimates these losses as probabilistic outcomes of flood risk from acute and chronic flood events. This BCA evaluates losses at the 10-precent, 2-percent, 1-percent, and 0.2-percent annual chance flood event, sourced from the Fairfield County Flood Insurance Study (FIS). Analysts calculate resiliency benefits for current or future Marina Village buildings.

Table 3. Resiliency Benefits Matrix

Benefit Category	Measurable Benefit/Metric	Stormwater Park	Johnson Street Extension		Marina Village Redevelopment
			Green Infrastructure	Raised Road	
Resilient Redevelopment	Physical Damages				X
	Displacement Costs				X
	Mental Stress and Anxiety				X
	Lost Productivity				X
Dry Egress	Fatalities			X	
	Injuries			X	
	Loss of Roadway Service			X	

The stormwater park and John Street Extension's green infrastructure contribute to reduced flood risk during chronic flood events, resulting in resiliency benefits. Acute flood events are more severe and result in greater flood impacts; therefore, resiliency benefits for acute flood events inherently capture benefits of lesser magnitude events. As such, analysts have not conducted a separate analysis.

3.1 Resilient Redevelopment

Marina Village, the site of a former public housing development and the future home of a mixed income residential development, is the focal point of the RBD project. The Resilient Bridgeport Team designed project components to benefit the future mixed income redevelopment by reducing stormwater flooding impacts and providing dry egress out of the FEMA 500-year flood zone plus SLR. Because Connecticut building code requires dry egress from the 500-year flood zone for critical developments (e.g., public housing developments), the Johnson Street Extension of the RBD project serves as a catalyst for the resilient redevelopment of the site.

The BCA captures the benefits of the resilient redevelopment by evaluating the flood impacts that would otherwise occur within Marina Village, as well as the economic benefits realized after the redevelopment of the site. The following section describe the methods used to evaluate losses avoided due to resilient redevelopment. Section **5.2.3 Economic Revitalization** describes the economic revitalization methodology.

3.1.1 Direct Physical Damages – Buildings and Contents

Resilient redevelopment will reduce the risk of direct physical damage to the future development on the Marina Village site by reconstructing buildings to the 500-year flood elevation. Direct physical damages include the degradation and destruction of property and are quantified through monetary losses. The BCA categorizes property loss as both structural damage (i.e., damage that applies to real property) and content damage (i.e., damage to personal property or inventory).

Analysts evaluate property losses using Depth Damage Functions (DDFs) developed by the United States Army Corps of Engineers (USACE); DDFs relate the flood depth at a structure to an expected percent damage for structures and contents. This percent damage is applied to a building or contents replacement value to estimate monetary loss. Analysts calculate property damage results using building data as of 2015 and RS Means 2016 replacement cost values.

3.1.1.1 Depth Damage Functions

Analysts calculated expected property losses associated with the Fairfield County FIS flood scenarios using standardized depth-damage functions (DDFs) specific to the characteristics and occupancy of a structure. A DDF correlates the depth, duration, and type of flooding to a percentage of expected damage to a structure and its contents, including inventory. The USACE produces DDFs that analysts can use to model direct physical damages. Following Hurricane Sandy, the USACE developed DDFs specific to the Northeast for coastal flooding in a report titled the North Atlantic Coast Comprehensive Study (NACCS). As this information contains the most current and best available data, analysts used these functions to evaluate direct physical damages. **Figure 1** provides a sample depth damage relationship from the USACE NACCS.

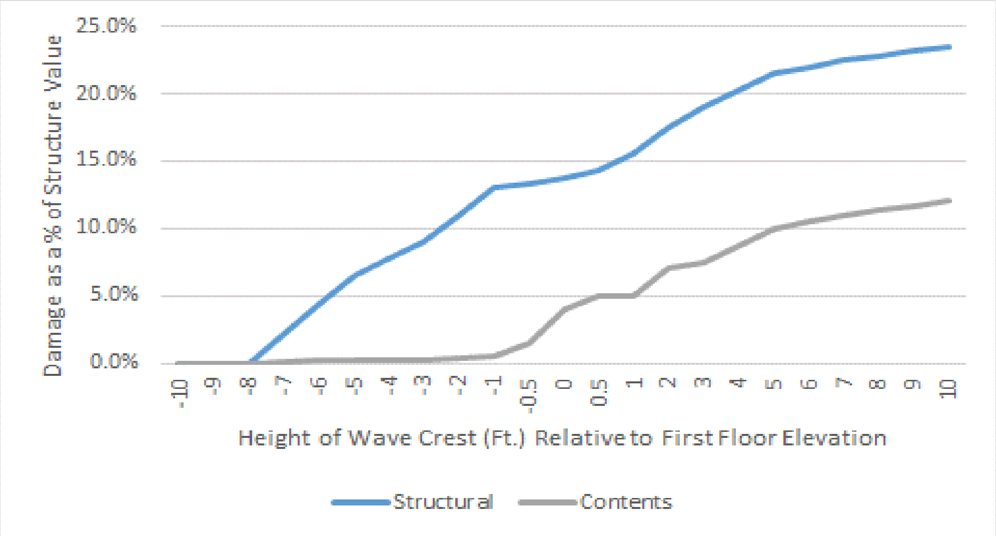

Figure 1. Expected Structural and Contents Damage from Inundation, NACCS Urban High Rise Prototype. Damage at negative flood depths accounts for impacts to mechanical, electrical, and plumbing systems that may be located at or below grade.

3.1.1.2 Data Sources

BCA analysts utilized the following data sources to calculate expected structure, contents, and inventory losses avoided:

- **City of Bridgeport Tax Assessor Data (2015):** Attributes from this dataset used in the direct physical damage analysis include: square footage, number of stories, building elevation, and building use. This dataset also provided building footprints.
- **RS Means Building Construction Cost Data (2016):** This publication provides location-specific building replacement square foot costs for 160 building occupancy types. Using RS Means, analysts calculated building replacement square foot costs for the various structure types in Bridgeport.
- **USACE North Atlantic Coast Comprehensive Study (NACCS) Physical Depth Damage Function Summary Report (2015):** Following Hurricane Sandy, the USACE collected empirical data to estimate the damages that would occur from future events. This report produced damage functions for residential, non-residential, and public property. Analysts used DDFs from this study to estimate direct physical damages.
- **USACE West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (2014):** This study conducted by the USACE produced contents-to-structure ratio values (CSRVs) for residential and non-residential structures. CSRVs are a percentage of the total building replacement values, and analysts used CSVR’s determine total contents replacement values for structures in the project area. While produced for a separate region, analysts determined this study to be the best and most recent data available for use with the DDFs.
- **Connecticut Department of Energy and Environmental Protection Digital Elevation Model (2011):** A Department of Energy and Environmental Protection (DEEP) digital elevation model (DEM) is a model of the ground surface, and provides the ground elevation for structures. The DEM is a raster layer of high-resolution ground elevation data based on information from bare-earth LiDAR elevation data collected and compiled during December 2006 and Spring/Summer 2004.
- **Fairfield County Flood Insurance Study (2013):** provides flood elevations for the 10 percent, 2 percent, 1 percent, and 0.2 percent flood events. Analysts use flood elevations to approximate flood depths inside structures.

3.1.1.3 Approach

Analysts completed the following six steps to conduct the direct physical damages analysis.

1. Develop Asset Inventory

Analysts identified benefitting structures (e.g., the redevelopment of Marina Village) and gathered building attributes necessary for analysis, such as number of stories, area, and building use, from Bridgeport’s tax assessor data (**Table 4**). Analysts used the attributes of the Marina Village building stock prior to demolition as it is the best available data at the time of analysis; analysts assumed the redevelopment of Marina Village will be a similar style and density multi-family housing complex. Analysts merged building footprints and parcel level data using the unique identification number.

Table 4. Building Attributes

Attribute	Analysis Use
Parcel ID	Key location identifier specific to a parcel
Unique ID	Key location identifier specific to a building
Address	Key location identifier
Living Area	Used in square footage analysis and replacement value calculation
Land Occupancy Description	Building use
Land Use Description	Secondary identifier of building use
Number of Stories	Used in square footage analysis

Ground Elevation

Structure grade elevation is an essential field used to estimate the approximate flood depth within structures. To determine the structure grade elevation, analysts extracted the average elevation within a structure footprint from the DEEP DEM.

2. Map Building Use to Depth Damage Functions, Replacement Values, and Hazus Occupancy Types

Buildings may be classified according to both construction features (type) and use (occupancy); analysts use these classifications to determine further information about the structure. For example, BCA analysts mapped land occupancy descriptions to classifications used by RS means to estimate replacement value for a structure. Analysts completed the following mappings based on land occupancy descriptions:

- Land occupancy description to USACE NACCS DDFs. Refer to **Appendix C: Depth Damage Functions** for a listing of land occupancies and damage functions.
- Land occupancy description to contents/inventory value shares described in the USACE Lake Pontchartrain Study to assign the appropriate CSRV's. Refer to **Appendix E: Occupancy Mapping** for the full mapping scheme
- Land occupancy description to Hazus occupancy classes to estimate a replacement value for structures, as well as apply the appropriate business interruption time multipliers, one-time disruption costs, and for certain uses, the percent owner occupancy. Refer to **Appendix E: Occupancy Mapping** for the full mapping scheme.

3. Conduct Square Footage Analysis

Damages must be assessed based on the square footage within a certain number of stories NACCS identifies for each DDF.[2] The number of stories analysed by the DDF is related to the structure type and the expected location and value of mechanical, electrical, and plumbing (MEP) in buildings. A significant portion of a building's value is captured in such assets; damage costs to these assets can therefore be disproportionate to those of other assets. Urban high rise damage functions, for example, analyse damages as a percent of the square footage of the first ten floors given the NACCS assumption that MEP assets are located within the basement or first floor of the structure.

[2] U.S. Army Corps of Engineers. North Atlantic Coast Comprehensive Study (NAACS). http://www.nad.usace.army.mil/CompStudy

To calculate the structure square footage for the analysis, analysts multiplied the square footage per floor by the DDF's number of stories identified by NACCS (**Table 5**) or the total number of stories, whichever is less, for each structure. Analysts use the analysis square footage to calculate the building and contents replacement value, as described in the next steps.

Table 5. USACE NACCS, Number of Stories per Depth Damage Function

DDF No.	Building Types	Stories (for Analysis)
1A-1	Apartment 1-Story, No Basement	1
1A-3	Apartment 3-Story, No Basement	3
2	Commercial Engineered	2
3	Commercial Non-Engineered	1
4A	Urban High Rise	10
4B	Beach High Rise	10
5A	Residential 1-Story, No Basement	1
5B	Residential 2-Story, No Basement	2
6A	Residential 1-Story, With Basement	1
6B	Residential 2-Story, With Basement	2
7A	Building on Open Pile Foundation	1
7B	Building on Pile Foundation with Enclosures	1

Source: North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk. Physical Depth Damage Function Summary Report. January 2015.

4. Determine Building and Contents Replacement Value

Building replacement values (BRVs) and Contents Replacement Values (CRVs) are necessary to place a value on expected damage to buildings. Analysts used RS Means 2016 Square Foot Costs to estimate the BRV.

Building Replacement Value

The BCA Re-engineering Guide defines the BRV as, "the building replacement value for a specific component of the building, expressed in dollars".[3] Analyst used RS Means square foot costs to estimate building replacement values for each Hazus occupancy class[4]. RS Means is a construction cost estimating resource published each year often used by engineers to evaluate different construction cost possibilities. RS Means square foot costs capture labor and material costs, and other information such as city cost

[3] Federal Emergency Management Agency. Benefit Cost Analysis Re-engineering Guide. Full Flood Data. 2009. Located at: http://www.fema.gov/media-library-data/20130726-1738-25045-2254/floodfulldata.pdf
[4] Hazus occupancy classes represent a certain building type based on use, and the FEMA Hazus-MH Flood Technical Manual applies an average square footage to each occupancy class. This average square footage was used to choose the appropriate replacement value per square foot from the RS Means cost data book.

indexes, productivity rates, crew composition, and contractors overhead and profit rates are also available. Analysts used the appropriate RS Means city cost indices of 1.12 for residential uses and 1.09 for commercial uses to accommodate construction conditions in Bridgeport. **Table 6** shows the BRV values determined from RS Means with the city cost index increase for Fairfield County. The building replacement value represents the cost to repair or rebuild damaged buildings in current dollars.

Contents Replacement Value

The USACE NACCS does not include content replacement ratios, therefore analysts used the next best available data. The CRV is based on the contents-to-structure ratio values (CSRV) for residential and non-residential structures from data obtained through surveys in the *West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (***Table 6***).*[5] To calculate the CRV, analysts multiplied the total BRV by the appropriate CSRV, mapped to the Hazus occupancy class. Because the contents values are based on percentages, they increase coincident with an increase in the BRV and do not need to be updated to Bridgeport specific values.

Table 6. Replacement Values

Hazus Occupancy Code	Occupancy Code Description	BRV	CSVR	CRV
RES1	Single Family Dwelling	$130.34	0.69	$89.93
RES2	Mobile Home	$125.17	1.14	$142.70
RES3A	Multi Family Dwelling - Duplex	$107.23	0.69	$73.99
RES3B	Multi Family Dwelling – 3-4 Units	$206.99	0.69	$142.82
RES3C	Multi Family Dwelling – 5-9 Units	$206.99	0.69	$142.82
RES3D	Multi Family Dwelling – 10-19 Units	$197.06	0.69	$135.97
RES3E	Multi Family Dwelling – 20-49 Units	$191.07	0.69	$131.84
RES3F	Multi Family Dwelling – 50+ Units	$184.55	0.69	$127.34
RES4	Temporary Lodging	$192.14	0.69	$132.57
RES5	Institutional Dormitory	$220.99	0.69	$152.49
RES6	Nursing Home	$224.80	0.69	$155.11
COM1	Retail Trade	$127.17	1.19	$151.33
COM2	Wholesale Trade	$123.23	2.07	$255.09
COM3	Personal and Repair Services	$148.21	2.36	$349.78
COM4	Business/Professional/Technical Services	$183.48	0.54	$99.08
COM5	Depository Institutions	$276.60	0.54	$149.36
COM6	Hospital	$394.26	0.54	$212.90
COM7	Medical Office/Clinic	$223.50	0.54	$120.69
COM8	Entertainment & Recreation	$233.01	1.70	$396.13
COM9	Theaters	$195.78	0.54	$105.72

[5] USACE. 2014. West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study – Final Integrated Feasibility Study Report and Environmental Impact Statement. November.

Hazus Occupancy Code	Occupancy Code Description	BRV	CSVR	CRV
COM10	Parking	$82.52	0.54	$44.56
IND1	Heavy	$140.17	2.07	$290.16
IND2	Light	$123.23	2.07	$255.09
IND3	Food/Drugs/Chemicals	$189.91	2.07	$393.10
IND4	Metals/Minerals Processing	$189.91	2.07	$393.10
IND5	High Technology	$189.91	2.07	$393.10
IND6	Construction	$123.23	2.07	$255.09
AGR1	Agriculture	$123.23	N/A	N/A
REL1	Church/Membership Organizations	$197.03	0.55	$108.36
GOV1	General Services	$157.02	0.55	$86.36
GOV2	Emergency Response	$262.05	1.50	$393.07
EDU1	Schools/Libraries	$210.99	1.00	$210.99
EDU2	Colleges/Universities	$185.28	1.00	$185.28

5. Determine Flood Depth

Analysts subtracted grade elevations from the FEMA defined 10 percent, 2 percent, 1 percent, and 0.2 percent flood elevations to determine the expected flood depths in structures. The USACE NACCS DDFs account for expected first floor elevation (FFE) by occupancy type and age, as well as the presence of mechanical, electrical, and plumbing (MEP) located in the basement. Since the DDFs incorporate these building attributes, it is not necessary to account for FFE in the asset inventory. To determine the flood depths, analysts obtained the flood elevation within a building footprint for each flood scenario, and subtracted the average grade elevation from the respective flood elevations to obtain a flood depth for each flood scenario.

6. Estimate Percent Damage and Monetary Losses

As previously mentioned, DDFs are a relationship between the depth of floodwater in a structure and the percent of flood damage. Once BCA analysts established the expected flood depth for each flood scenario, they applied the DDF to estimate the percent of structural or contents damage; this percentage is applied to a structure’s BRV or CRV to produce a physical loss value in dollars. Analysts applied the annual probability of each flood scenario to expected flood impacts to calculate annual benefits (**Table 7**). Ultimately, benefits represent the present value of the sum of expected annual avoided damages over the project useful life.

Table 7. Direct Physical Damage Results

Flood Scenario (Percent Annual Chance Event)	Loss Category		Total Direct Physical Damages
	Building Losses	Contents Losses	
10 Percent	$2,007,510	$2,326,120	$4,333,630
2 Percent	$3,285,290	$4,620,570	$7,905,860
1 Percent	$4,003,460	$5,792,100	$9,795,560
0.2 Percent	$6,171,770	$9,453,250	$15,625,020
Annualized Losses Avoided	*$318,840*	*$401,850*	*$16,772,570*

3.1.1.4 Assumptions

BCA analysts made the following assumptions to account for uncertainties and limitation of the analysis:

- The USACE NACCS DDFs account for underground vulnerabilities by applying a percent damage for negative flood depths.
- The NACCS DDFs did not provide percent loss for all flood depth intervals for all occupancies, and provided no percent loss above ten feet of flood depth. As such, analysts developed trend interpolations based on the preceding three available flood depths for missing DDFs. A similar approach was used for flood depth gaps below zero flood depth, using averages between flood depths, where available.
- The DDFs do not assume complete loss beyond 50 percent damage, as is often assumed for use with benefit cost analyses, as well as substantial damage determinations. Further, the analysis does not consider the impacts of codes and standards in restoration. As such, direct physical damage costs may be conservatively low.
- Benefits begin the year Marina Village redevelopment is complete, which is 2023.
- The RBD project life-cycle costs do not include the costs associated with the redevelopment of the Marina Village site. In Connecticut, activities such as the construction of public housing in the floodplain are considered a “critical activity.” Critical activities are regulated to the 500-year flood elevation when applying to the Department of Energy and Environment Protection for a Flood Management Certification.[6] These costs are not included in the analysis, since they are activities associated with the minimum standards per the Regulations of Connecticut State Agencies and not an additional expense to develop to a higher standard.
- Analysts assume the redevelopment of Marina Village will be a similar style and density multi-family housing complex. As such, analysts consider the number of future population and units within the site to be similar. The analysis does not consider an increase in development or population density, resulting in a conservative analysis.

3.1.2 Displacement Costs

Residents of impacted structures may experience displacement costs during the time when a building becomes uninhabitable due to flood damage. Relocation costs are associated with moving a household or a business to a new location and resuming business in that new location. Relocation costs are derived from

[6] Sections 25-68h-1 through 25-68h-3, Regulations of Connecticut State Agencies

displacement time, which is derived from DDFs that relate a depth of flooding to an amount of time a structure is not usable. The overall approach taken to evaluate relocations costs is:

1. Identify flood depths and damage expected at the 10 percent, 2 percent, 1 percent, and 0.2 percent annual chance flood event
2. Determine expected displacement time based on flood depth and building use
3. Calculate relocation costs

3.1.2.1 Data Sources

BCA analysts used the following data sources when evaluating displacement costs:

- **Hazus-MH 3.2 One-time Disruption Cost Defaults:** Hazus provides national one-time relocation costs per square foot based on Hazus occupancy class. These costs are provided in 2006 dollars and have been normalized to 2016 dollars based on inflation. Refer to **Appendix F: Additional Benefit Cost Analysis Resources** for Hazus-MH 3.2 manual excerpts.
- **US Census Bureau American Community Survey 5-Year Estimates (2014):** provided the percent owner occupancy by census block for residential uses. Analysts used Hazus-MH 3.2 default values for commercial structures as local figures were not readily available.
- **Hazus-MH 3.2 Percent Owner Occupancy Defaults:** Hazus provides percent owner occupancy for non-residential uses by Hazus occupancy class (local value not available).
- **Direct Physical Damages:** Flood impacts were modeled for different flood scenarios to determine which structures are expected to flood and the depth of flooding within the structure (see **2.2.1 Direct Physical Damages – Buildings and Contents**).
- **FEMA BCA Toolkit 5.3:** Depth displacement tables were not provided with the USACE NACCS DDFs used in the direct physical damage analysis, therefore analysts extracted displacement tables from the BCA Toolkit to determine displacement time for structures based on flood depth.
- **Local Rental Rates:** Analysts researched local rent rates within the project area and applied these rates by occupancy. An online survey of varied sizes and types of residential spaces currently available for rent within the South End established local residential rental rates. Local commercial rental rates were obtained in the same manner as residential rental rates. Analysts used Loopnet to obtain commercial rental values, and Trulia, and Zillow to conduct the residential survey (all online real estate services).

3.1.2.2 Approach

1. Identify Impacted Structures: The direct physical damages analysis identified structures expected to be impacted at the 10 percent, 2 percent, 1 percent, and 0.2 percent annual chance flood events.

2. Identify Impacted Square Footage: For structures that are expected to experience less than ten feet of flooding, the total impacted square footage is the area of the first floor. Analysts use the total square footage of the first two floors when a structure experiences more than ten feet of flooding.

3. Identify and Apply Percent Owner Occupied by Occupancy: For residential uses, census block level data provided the percent owner occupied. Analysts assigned all non-residential uses default percent owner occupancy obtained from Hazus-MH 3.2.

4. Identify Rental Rates by Occupancy: Analysts categorized available rental units by commercial and residential uses for the project area, and then calculated an average rent price per square foot per year for each use. The results of this analysis indicate that the average annual price per square foot for commercial properties in 2016 is $10.05, and the average annual price per square foot for residential properties in 2016 is $13.13. Analysts converted these values to an average price per square foot per day for use in the relocation cost calculation outlined below.

5. Evaluate Displacement Time: The estimated flood depth within each structure is correlated to USACE depth displacement tables to estimate displacement time for each modeled flood scenario.

6. Process Relocation Costs: Analysts processed relocation costs to building occupants based on occupancy type.[7] Displacement costs, or relocation costs, are a product of percent damage, impacted square footage, disruption costs per occupancy, rental costs, displacement time, and percent owner occupied. Analysts applied the probability of each flood scenario to expected impacts to calculate annual benefits (**Table 8**).

$$\begin{aligned} Relocation\ costs = If\ percent\ damage\ is \\ > 10\ percent{:}\ Impacted\ floor\ area \times (1 - percent\ owner\ occupied) \times disruption\ cost \\ + percent\ owner\ occupied \times (disruption\ cost + rental\ cost \times displacement\ time)] \end{aligned}$$

Table 8. Relocation Costs Avoided

Flood Scenario (Percent Annual Chance Event)	Relocation Costs
10 Percent	-
2 Percent	$18,180
1 Percent	$53,770
0.2 Percent	$124,300
Annualized Losses Avoided	*$1,150*

3.1.2.3 Assumptions

- Relocation costs are only calculated for floors expected to be directly impacted by floodwaters. There are times when the entire structure will be displaced because of flood impacts. As a result, this approach produces conservative results.
- Depth displacement tables used in the analysis do not consider flooding below grade. Utilities and other critical assets may lie below grade. When these areas flood, occupants may be displaced, even if flood waters do not reach above the first floor. The analysis does not capture such displacement.
- The depth displacement tables do not extend beyond 16 feet of flood depth. As such, analysts assume displacement periods for flood depths above 16 feet match the time for displacement at 16 feet.

[7] It is important to note that this equation incorporates only owner-occupied structures when calculating displacement values. The reason for this is that a renter who has been displaced would likely cease to pay rent to the building owner of the damaged property, and instead would pay rent to a new landlord. As such, the renter could reasonably be expected to incur no new rental expenses. Conversely, if the damaged property is owner-occupied, then the owner will have to pay for new rental costs in addition to any existing costs while the building is being repaired. This model assumes that it is unlikely that an occupant will relocate if a building is slightly damaged (less than 10% structure damage).

3.1.3 Mental Stress and Anxiety

Natural disasters threaten or cause loss of health, social, and economic resources, which leads to psychological distress.[8] Research indicates that individuals who experience significant stressors, such as property damage or displacement, are more likely to experience symptoms of mental illness, Post-Traumatic Stress Disorder (PTSD), and higher levels of stress and anxiety after a disaster.[9] Post-Hurricane Sandy research demonstrates there was a measurable spike in mental stress disorders after the event, including PTSD, anxiety, and depression.[10] As mental health issues increase after a disaster, it is expected that mental health treatment costs will also increase. The pilot project is expected to reduce flood impacts to homes and public transportation, and thus reduce risk of mental stress and anxiety post-disaster.

FEMA developed standard values to estimate the treatment costs of mental stress in a post- disaster situation, if a person has personally experienced damage to their residence. The following section describes FEMA's method to evaluate mental stress and anxiety impacts after a flood event.

3.1.3.1 Data Sources

- **FEMA's Final Sustainability Benefits Methodology Report (2012):** This report provides a method to calculate the cost of mental stress and anxiety treatment.
- **Direct Physical Damages:** Analysts use flood depths from Section **2.1.1 Direct Physical Damages – Buildings and Contents** to identify impacted buildings and population.
- **US Census Bureau American Community Survey (ACS) (2014) 5-Year Estimates:** This source provided population by census block.

3.1.3.2 Approach

The principle resource used to conduct the analysis is FEMA's Final Sustainability Benefits Methodology Report that accompanies the FEMA BCA Toolkit. Mental health treatment costs are measured using three factors: cost, prevalence, and course. Prevalence is the percentage of people who experience mental health problems after a disaster event, and course is the rate at which mental health symptoms reduce or increase over time. Cost is the cost of treatment to those who seek it. Analysts completed the following steps to estimate the expect cost of mental health treatment for each flood scenario.

1. Population Analysis

To analyze human impacts for each building, analysts must distribute the total population in the project area to each residential building. To do so, analysts distributed the population (from the 2014 ACS) to each building based on the ratio of a residential building's total square footage to the total residential square footage in the census block that contains the building.

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[8] Hobfoll, S.E. 1989. Conservation of resources: A new attempt at conceptualizing stress. American Psychologist. 44:513–524. [PubMed: 2648906].

[9] Rhodes, J., Chan, C.,Pacson, C., Rouse, C.E., Waters, M., and E. Fussell. 2010.. The Impact of Hurricane Katrina on the mental and physical health of low-income parents in New Orleans. Am J Orthopsychiatry. April; 80(2): 237-247.

10 Beth Israel Medical Center data indicate a 69% spike in psychiatric visits in November 2012. Healthcare Quality Strategies Inc. reviewed Medicare claims before and after Hurricane Sandy in select communities in New Jersey and found that PTSD was up 12.2%, anxiety disorders were up 7.8%, and depression or proxy disorders were up 2.8%.

2. Determine Prevalence Rate and Course

FEMA's Final Sustainability Benefits Methodology Report[11] uses prevalence percentages and mental health expenses from Schoenbaum (2009) to derive a standard value for mental stress and anxiety costs. Prevalence percentages are adjusted over different time periods: mild to moderate impacts will reduce over time as treatment is provided, while severe mental health problems may persist much longer, possibly never being fully resolved.[12] **Table 9** provides a summary of prevalence considering course over four different time periods.[13] The FEMA methodology only captures mental health impacts for the first 30 months because prevalence rates after this period are not available.

Table 9. Mental Health Prevalence Rates After a Disaster

Time after Disaster	Severe	Mild/Moderate
7-12 months	6%	26%
13-18 months	7%	19%
19-24 months	7%	14%
25-30 months	6%	9%

Source: FEMA Updated Social Sustainability Methodology Report

3. Establish Treatment Cost

Schoenbaum provides an estimate of treatment costs in an ideal scenario where all needs are met. FEMA contends that treatment costs from the study must be adjusted to consider only those with mental health problems who will actively seek out treatment (41 percent).[14] FEMA uses the following steps to adjust total treatment costs from Schoenbaum for a percentage of individuals who seek treatment and for prevalence.

$$Cost\ per\ person\ seeking\ treatment = Treatment\ cost\ per\ person^{15} \times 0.41 \times prevalence$$

This methodology is applied to each time period, adjusting for prevalence. Analysts normalized the values provided by FEMA's Final Sustainability Benefits Methodology Report (2012) using the Consumer Pricing Index (CPI) Inflation Calculator,[16] and the costs for both severe and mild/moderate mental health problems over each time period are added together to provide a total treatment cost of $ 2,707 for 30 months. **Table 10** provides a summary of treatment costs in current dollars.

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11 FEMA. 2012. Final Sustainability Benefits Methodology Report. August 23.
12 Schoenbaum, Michael; Butler, Brittany; Kataoka, Sheryl; Norquist, Grayson; Springgate, Benjamin; Sullivan, Greer; Duan, Naihua; Kessler, Ronald; and Kenneth Wells. 2009. Promoting Mental Health Recovery After Hurricanes Katrina and Rita: What Can Be Done at What Cost. Archives of General Psychiatry, Vol. 66, #8, August.
13 FEMA. 2014. Updated Social Benefits Methodology Report. December 18.
14 Wang, Philip S., MD, DrPH; Lane, Michael, MS; Olfson, Mark, MD, MPH; Pincus, Harold A., MD; Wells, Kenneth B., MD, MPH; Kessler, Ronald C., PhD. 2005. Twelve-Month Use of Mental Health Services in the United States: Results from the National Comorbidity Survey Replication. Archives of General Psychiatry, v. 62, June.
A., MD; Wells, Kenneth B., MD, MPH; and Ronald C. Kessler, PhD. 2005. Twelve-Month Use of Mental Health Services in the United States: Results from the National Comorbidity Survey Replication. Archives of General Psychiatry, v. 62, June.
15 Schoenbaum, Michael; Butler, Brittany; Kataoka, Sheryl; Norquist, Grayson; Springgate, Benjamin; Sullivan, Greer; Duan, Naihua; Kessler, Ronald; Wells, Kenneth. 2009. Promoting Mental Health Recovery After Hurricanes Katrina and Rita: What Can Be Done at What Cost. Archives of General Psychiatry, Vol. 66, #8, August 2009.
16 U.S. Bureau of Labor Statistics. Undated. CPI Inflation Calculator. [web page] Located at: http://www.bls.gov/data/inflation_calculator.htm.

Table 10. Cost of Treatment[17] After a Disaster (30 Month Duration), Per Person Expected to Seek Treatment

Time after Disaster	Severe	Mild/Moderate	Total per person
7-12 months	$ 220.00	$ 691.27	$ 911.27
13-18 months	$ 256.66	$ 451.98	$ 708.64
19-24 months	$ 256.66	$ 372.22	$ 628.88
25-30 months	$ 218.89	$ 239.28	$ 458.17
Total			**$ 2,707**

Source: FEMA Updated Social Sustainability Methodology Report

4. Identify Impacted Population and Calculate Costs

Analysts consider the total number of residents in Marina Village projected post-development that experience flooding during a 0.2 percent annual chance event as impacted. The cost per person was applied to the total number of Marina Village residents expected to be impacted by flooding. Per FEMA methodology, analysts do not annualize benefits; rather, benefits at the design level of protection (the 0.2 percent annual chance flood event) are incorporated into the BCR as a one-time benefit: **$1,050,280**.

3.1.3.3 Assumptions

- Research is limited to 30 months after a disaster; therefore, estimated losses avoided are limited to this period. Mental health avoided losses beyond two and a half years after a disaster, though expected, are not valued in this analysis.
- Benefits are calculated for only 41 percent of the impacted population because research indicates that only that portion of the population with mental health issues can be expected to seek treatment. This significantly lowers the calculated treatment costs and does not consider the full costs to society.
- The analysis does not consider population growth.
- The value of treatment is a national figure and does not consider local costs.

3.1.4 Lost Productivity

FEMA's standard values for mental health impacts also include lost productivity due to mental stress and anxiety. Historical impacts indicate that mental health issues will increase after a disaster, and this, paired with research related to lost productivity due to mental illness, indicates that economic productivity can be impacted by an increase in mental health issues post-disaster.[18] A study of 19 countries by the World Health Organization showed a lifetime 32 percent reduction in earnings for respondents with mental illness.[19] Implementation of the RBD project will help reduce the number of stressors caused by natural disasters, thereby reducing mental health impacts. Fewer mental health impacts will reduce lost work productivity.

17 Costs normalized to 2015 dollars using the CPI calculator located at: http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=623.63&year1=2008&year2=2015

[18] Insel, Thomas. Assessing the Economic Costs of Serious Mental Illness. American Journal of Psychiatry. 165:6 June 2008. / Kessler et al. Individual and Societal Effects of Mental Disorders on Earnings on the United States: Results from the National Comorbidity Survey Replication. American Journal of Psychiatry. 165:6. June 2008.

[19] Levinson, et al. 2010. Associations of Serious Mental Illness with Earnings: Results from the WHO World Mental Health Surveys. British Journal of Psychiatry. August; 197(2): 114–121. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2913273

3.1.4.1 Data Sources

- **FEMA's Final Sustainability Benefits Methodology Report (2012):** This report provides a method to calculate the cost of lost productivity after a flood event.
- **US Census Bureau American Community Survey (2014) 5-Year Estimates:** Analysts use the average number of workers per household and persons per household from this data source to determine the number of impacted workers.
- **Direct Physical Damages:** Analysts use flood depths from Section **2.1.1 Direct Physical Damages – Buildings and Contents** to identify impacted buildings and population.
- **Structure Population:** provides the number of people expected to reside in impacted buildings.

3.1.4.2 Approach

FEMA's Final Sustainability Benefits Methodology Report that accompanies the FEMA BCA Toolkit is the primary resource used to estimate lost productivity.

1. Determine the Value of Work Productivity

Analysts first established the value of work productivity per FEMA's methodology:

$$Loss\ of\ Work\ Productivity = (EC_{NA} \times H_{NA}) \times 25.5\%$$

Where:

EC_{NA}: Average Employment Compensation

H_{NA}: Average Number of Hours Worked per Day

FEMA references Levinson et al (2010)[20] in which research was conducted using the World Health Organization's Mental Health Surveys in 19 countries; the study found that individuals in the United States with mental health illnesses experience as much as a 25.5 percent reduction in earnings. The national average for employment compensation in March 2015 was $33.49 per hour.[21] This, multiplied by the average number of hours worked per day (6.9),[22] produces a daily U.S. value of $231.08. Thus, a 25.5 percent reduction in earnings would equal a loss of $58.90 daily, or $1,767 per capita, monthly.

2. Determine Prevalence Rates

Analysts apply $1,767 to the amount of time lost productivity is expected to occur, 30 months. Prevalence factors from Schoenbaum (2009) are used to adjust the value of productivity loss over 30 months, to account for the fact that only a portion of the population will experience mental health impacts post-disaster. The prevalence factor is based on severe mental health issues because there is insufficient literature to document the impacts of mild/moderate mental health issues on productivity.[23] Accounting for prevalence, the value of work productivity for 30 months is **$3,394** per capita, monthly.

20 Levinson, et al. 2010. Associations of Serious Mental Illness with Earnings: Results from the WHO World Mental Health Surveys. British Journal of Psychiatry. August; 197(2): 114–121. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2913273

21 Employer Costs for Employee Compensation. March 2015. United States Department of Labor, Bureau of Labor Statistics.

22 Average week hours of overtime of all employees. Web page. Located at: http://www.bls.gov/news.release/empsit.t18.htm

23 FEMA. 2014. Updated Social Benefits Methodology Report. December 18.

3. Identify Impacted Population

Analysts consider the total population in residential buildings that experience flooding during a 0.2 percent annual chance event as impacted. Population data and the average number of persons per household (2.72) determined the number of households projected to be in the Marina Village redevelopment. Analysts apply the average number of workers per household in Bridgeport (1.35 workers) to the number of households impacted to determine the number of wage earning residents who will experience flooding. The total lost productivity share per worker for 30 months ($3,394) is multiplied by to the number of wage-earning residents who will experience flooding to value productivity losses avoided. Analysis results are **$653,610**; analysts incorporate benefits into the BCR in the same fashion as mental stress and anxiety benefits.

3.1.4.3 Assumptions

- Analysts assumed that the average number of workers per household and the average number of persons per household for Bridgeport is applicable to the project area.
- Value is provided for the first 30 months only because there is insufficient literature available to analyze longer periods of time.
- Prevalence rates are based on severe mental issues because there is insufficient literature related the impacts of mild or moderate mental health problems on work productivity. Thus, analysts consider results as conservative.
- The analysis does not account for population growth.

3.2 Dry Egress

Dry egress is a development practice in Connecticut that requires critical developments, such as public housing, located within the 500-year floodplain, to have a means of evacuation, as well as route for emergency vehicles, constructed to the 500-year flood elevation plus 2 feet.[24] Elevated roads also prevent residents from being stranded during flood events, reduce flood damage, reduce the need for water rescues, and increase public safety. The RBD project will provide dry egress for the Marina Village redevelopment site, as well as a shorter route to access dry egress for Seaside Village residents and adjacent properties. Dry egress will be constructed to the 500-year flood elevation plus 3 feet to account for future SLR. The BCA captures the benefits of dry egress by evaluating the value of road service and avoided casualties.

3.2.1 Loss of Roadway Service

Transportation assets and systems in the South End may flood during both acute and chronic events. Loss of roadway service is a function of the per-hour value of time, detour route, and number of vehicles evacuating. Analysts focused on the future residents of the Marina Village redevelopment that will benefit from dry egress.

24 "A Guide for Higher Standards in Floodplain Management". Association of State Floodplain Managers. October 2010.

3.2.1.1 Data Sources

- **FEMA Benefit-Cost Analysis Re-Engineering (BCAR) Development of Standard Economic Values:** provides a standard value of detour lost time per vehicle.
- **The New England Hurricane Evacuation Study (2016):** provides the average number of vehicles per household and Bridgeport specific evacuation rates.
- **Fairfield County FIS and Flood Insurance Rate Map:** This data is overlaid with buildings to determine potential evacuation routes.
- **Direct Physical Damages:** Analysts used flood depths for each structure to identify impacted buildings and residents.

3.2.1.2 Approach

This FEMA methodology is centered around the value of time, which is described in FEMA's Benefit Cost Analysis Re-Engineering Guide, Development of Standard Economic Values report. In summary, analysts evaluate additional travel time needed for an alternative travel route because floodwaters inundate a roadway. The following equation characterizes roadway loss of service:

$$Roadway\ Loss\ of\ Service = \left[\left((UpPD \times ER) \times VpH \times VT\right) \times DT\right] \times TV$$

Where:

UpPD: Number of Units per Property Description

ER: Expected Evacuation Rate

VpH: Average Number of Vehicles per Household

VT: Vehicle Trips to Evacuate

DT: Delay Time

TV: Hourly Value of Time per Vehicle

1. Evaluate Evacuation Routes and Determine Delay Time

Analysts reviewed the FEMA flood zones and found floodwaters would inundate future Marina Village resident's evacuation route during a 2 percent annual chance flood event. When no alternative route is available, FEMA uses a delay time of 12 hours as a standard value.[25]

2. Identify Impacted Population and Evacuating Vehicles

Analysts apply the average vehicles per household sourced from the New England Hurricane Evacuation Study (2016) to the total the number of households projected to be in Marina Village, determined in Section **2.1.4 Lost Productivity**. Analysts factor evacuation rates into the analysis to account for residents that choose to shelter in place. Analysts assumed vehicles trips during an evacuation scenario to be one.

[25] FEMA Supplement to the Benefit-Cost Analysis Reference Guide (2011). Page 5-14. http://www.fema.gov/media-library-data/1396549910018-c9a089b8a8dfdcf760edcea2ff55ca56/bca_guide_supplement__508_final.pdf

3. Determine the Value of Lost Time

To place a monetary value on lost roadway service, analysts normalized and applied FEMA's value of lost time to the total number of evacuating vehicles: $32.09 per hour.[26] **Table 11** summarizes flood impacts to road service by flood scenario.

Table 11. Loss of Road Service Results by Flood Scenario

10 Percent Annual Chance Event	2 Percent Annual Chance Event	1 Percent Annual Chance Event	0.2 Percent Annual Chance Event	Annual Losses Avoided
-	$82,650	$82,650	$82,650	$10,910

Losses remain consistent across each flood event because the once floodwaters inundate the roadway residents may no longer use the road, regardless of an increase in flood elevation.

3.2.1.3 Assumptions

- Analysts assume one person per each evacuating vehicle, therefore results are conservative.
- FEMA's Supplement to the Benefit-Cost Analysis Reference Guide states that "For road or bridge losses that do not have detours, the number of daily trips should be based on the number of one-way trips, and the delay time should be 12 hours per one-way trip."
- The analysis does not account for population growth.

3.2.2 Casualties

Casualties, which include loss of life and injuries, are an unfortunate risk inherent to hazard events. Flood events are considered some of the most frequently occurring natural hazards, contributing to 44 percent of natural hazard-related fatalities worldwide.

The approach chosen to estimate reduced fatalities within the future Marina Village redevelopment is based on a study completed by the Brno University of Technology in 2013.[27] Through this approach, analysts consider the number of fatalities expected at different flood scenarios. Additional data required to supplement the Brno approach include standard life safety values from the Federal Aviation Administration (FAA): the FAA's Willingness to Pay value for one fatality is $5.8 million.

Casualties also includes injuries related to identified flood events. In October 2014, the CDC published another report titled "Nonfatal Injuries 1 Week after Hurricane Sandy." The report suggests that 10.4 percent of residents in the inundation zone were injured within the first week after Hurricane Sandy, mostly during attempts to evacuate or navigate and clean up debris.

3.2.2.1 Data Sources

- **US Census Bureau ACS 5-Year Estimate:** provides the population expected to reside in the Marina Village redevelopment; estimates are based on building square footage and total population within a census block.
- **The New England Hurricane Evacuation Study (2016):** provides local evacuation rates.

[26] Normalization in this report refers to the process of converts past dollar values to current dollar values using the CPI inflation calculator.
[27] Brazdova, M. and J. Riha. 2014. A simple model for the estimation of the number of fatalities due to floods in central Europe. Nat Hazards Earth Syst Sci. 14. June 12.

- **Federal Aviation Administration (FAA) values:** The Federal Aviation Administration (FAA) categorizes injuries and fatalities as shown in **Table 12**. FEMA has acknowledged the validity of these life safety values and permits their use in benefit cost analyses.
- **CDC injury rates:** The CDC report from October 2014 titled "Nonfatal Injuries 1 Week after Hurricane Sandy" estimates 10.4 percent of residents in the inundation zone were injured within the first week of Hurricane Sandy.
- **Brno University of Technology fatality risk methodology:** the approach is based on three main factors: materials loss, population preparedness, and warning.

3.2.2.2 Injuries

To quantify the value of injuries, analysts developed the below equation based on the CDC study titled "Deaths Associated with Hurricane Sandy". Analysts assumed that all injuries reduced are FAA AIS1 minor injuries. This injury category is the lowest value within the FAA study ($13,590[28]) allowing for a conservative analysis of injuries associated with a flood event.

$$Value\ of\ Injuries = \left(Population \times (1 - Evacuation\ Rate)\right) \times 10.4\% \times \$13{,}590$$

Table 12. FAA Category Levels and Values[29]

Injury Category	Description of Injury	Fraction of WTP Value of Life (Percent)	WTP Value (2008 Dollars)
AIS 1	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).	0.20	$12,000
AIS 2	Major abrasion or laceration of skin; cerebral concussion (unconscious less than 15 minutes); finger or toe crush/amputation; closed pelvic fracture with or without dislocation.	1.55	$90,000
AIS 3	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation.	5.75	$334,000
AIS 4	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours).	18.75	$1,088,000
AIS 5	Spinal cord injury (with cord transection); extensive second- or third- degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).	76.25	$4,423,000
AIS 6	Injuries, which although not fatal within the first 30 days after an accident, ultimately result in death.	100	$5,800,000

[28] Normalized to current dollars using the Consumer Price Index inflation calculator.
[29] Revised Departmental Guidance: Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses. Located at: https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/Revised%20Value%20Of%20Life%20Guidance%20Feburary%202008.pdf

Source: Revised Departmental Guidance: Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses.

3.2.2.2.1 Approach

1. Identify Impacted Population

Analysts consider the number of residents in Marine Village that experience flooding during the 0.2 percent annual chance event and did not evacuate as the impacted population.

2. Estimate and Value Injuries

Analysts apply 10.4 percent to the total impacted population, then the value of injury to determine the monetary cost of injuries. The CDC report *Nonfatal Injuries 1 Week after Hurricane Sandy* found the rate of injuries among impacted persons to be 10.4 percent.[30] **Table 13** summarizes the results of the injury analysis.

Table 13. Injury Analysis Results

Percent Annual Chance Event	Value of Injuries
10 Percent	-
2 Percent	$146,990
1 Percent	$244,510
0.2 Percent	$548,380
Annual Injuries Avoided	*$6,480*

3.2.2.2.2 Assumptions

- The results are based on historical data from a CDC survey conducted 5 to 12 months after Hurricane Sandy. The timing of the evaluation, coupled with the fact that the data is only available for one event, increases uncertainty. Nevertheless, the study performed is in an area like the project area, which means that conditions under which the survey was completed are largely transferable. The survey is thus an appropriate source from which to transfer expected results.
- Injuries reported are only for a one-week period following Hurricane Sandy. The analysis does not account for injuries sustained while repairing damages from Sandy more than one week following the event.
- Estimated injuries are all considered minor; the BCA does not account for moderate or serious injuries.
- The BCA evaluates people with multiple injuries the same as people with only one injury.
- The analysis does not include people in buildings that do not experience flooding, and neither are injuries sustained because of road damage and closures.
- The BCA does not consider worker and transient populations.
- The BCA does not account for population growth.

[30] CDC report titled "Nonfatal Injuries 1 Week after Hurricane Sandy," October 2014, page 1. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6342a4.htm

3.2.2.3 Fatalities

Most existing methodologies that estimate fatalities use two groups of characteristics: hydraulic characteristics such as water depth, rate of water rising, flow velocities, wind, and temperature; and by area characteristics including factors such as population density, land use, warning systems, and vulnerability of the population.[31] Arcadis analysts considered material loss, population preparedness, rate of water rise, and warning capabilities. This approach is the most appropriate because it accounts both for event damage characteristics and the community's capacity to prepare for and react to flood events, both of which relate to vulnerability.

3.2.2.3.1 Approach

The Brno University of Technology approach is based on three main factors: material loss (in dollars), population preparedness, and warning. The equation presented below expresses the relationship of these factors. There are additional factors that are important to consider in estimating the loss of life in a natural hazard event. Nevertheless, factors such as debris, climatic conditions, water quality, and time of day, were not available for analysis due to a lack of data.

The equation for fatality estimates:

$$LOL = 0.075 \times D^{0.384} \times (P+2)^{-3.207} \times (W+2)^{-1.017}$$

Where:

LOL: Loss of Life

D: Material Loss ($)

P: Population Preparedness (aggregated population preparedness factors)

W: Warning (factor-based)

1. Determine D, W, and P Factor

(i) D Factor

The D factor (material loss) consists of building damage and contents loss, which analysts estimated in direct physical damages analysis. For the purposes of this analysis, analysts evaluated only structure and contents damage for residential structures for the appropriate flood scenarios. Analysts assumed these losses reflect both the destructive ability of the event and the number of endangered inhabitants. The analysis does not consider damage to constructed assets, such as roads or utility systems. The values used as D in the formula are listed in **Table 14.**

[31] Jonkman, S.N. and J.K. Vrijling. 2002. Loss of life models for sea and river floods. Flood Defence. Wu et al. (eds) Science Press, New York Ltd.

Table 14. Expected Material Loss (D) Values by Percent Annual Chance Flood Event

Percent Annual Chance Flood Event	Expected Material Loss
10 Percent	$4,333,630
2 Percent	$7,905,860
1 Percent	$9,795,560
0.2 Percent	$15,625,020

(ii) P Factor

The P Factor (population preparedness) expresses the preparedness of the community for flood management and resiliency, and it reflects the population's general awareness of flooding and required preparations. Analyst determined this value by rating eight sub-factors on a scale of -1 to 1 (**Table 16**).

The evaluation of the P sub-factors is based on existing conditions within the project area community. The flood knowledge held by the public in Bridgeport greatly increased after Hurricanes Sandy and Irene. Analysts evaluated the P sub-factors to determine the below ratings for P1 to P8. Because of the frequency and amount of flood prevention and awareness activities present in Bridgeport, analysts assumed that the same P subfactors apply for all four flood scenarios. Analysts found the final P Factor using the equation below, where P is the aggregated preparedness score presented in **Table 15**. **Table 16** describes P subfactors.

$$P = \frac{1}{8} * \sum_{i=1}^{8} Pi$$

Table 15. P Values

P Subfactor	Factor Description	Existing Conditions Evaluation
P_1	Flood awareness and general knowledge of hazards	1
P_2	Flood memory	1
P_3	Existing flood documentation	1
P_4	Understanding of activities and behavior during floods	0
P_5	Initiatives and activities of flood committees	0
P_6	Response to hydrological forecast	0.5
P_7	Response to flood warning	0
P_8	Evacuation and rescue activities	1
Aggregated Preparedness		**2.125**

Table 16. P Factor Descriptions

P_i	Score				
	-1.0	-0.5	0.0	0.5	1.0
P_1	No flood awareness or knowledge about flood hazard, sometimes ignorance	Poor awareness, underestimation of flood hazard	Common flood awareness	Fair knowledge about flood hazards obtained mostly from the media	Excellent knowledge about flood hazards via the media, education, training, etc.
P_2	Area never flooded, no experience with flooding	Area flooded decades ago, poor records concerning flood losses	Area flooded decades ago, good records concerning the risks	Flooding still in the memory of the population	Personal experience with flooding
P_3	Flood extent maps or flood management plans not available	Existing flood extent maps are outdated	Flood extent maps drawn up based on current hydrologic data, but only poor flood management plans exist	Flood extent maps drawn up, flood management and evacuation plans available	Flood extent maps drawn up, updated digital versions of flood management and evacuation plans available
P_4	Individuals have no idea about actions to take during floods	Limited (vague) understanding of what to do during floods	General understanding of what to do before and during a flood	Quite good knowledge of flood management plans and corresponding activities	Perfect knowledge of flood management plans and understand of what to do in the event of flooding, good preparedness
P_5	No flood committee established	Flood committee established but not trained, only equipped with flood fighting facilities	Flood committee established and generally trained, poorly equipped with flood-fighting facilities	Only moderately experienced but trained committee with standard flood fighting facilities	Experienced and well-trained flood committee equipped with flood-fighting facilities
P_6	No response to hydrological forecast, no understanding or belief	Poor understand of hydrological forecast and poor response	Approximate understanding of forecast and adequate response	Fair understanding of hydrological forecast and good response	Very good understanding of hydrological forecast and very good response
P_7	No response to warning, no idea about warning procedures and response	Only poor response to warning, warning system not trusted	Adequate response	Good response to warning	Immediate and fast response to warning
P_8	Rescue system does not exist, no staff or equipment available	Organized rescue system does not exist, volunteer basis, no trained staff available with randomly acquired equipment	Poorly organized but functioning rescue system, basic rescue equipment of adequate quality	Functioning rescue system, trained staff with equipment of fair quality	Efficiently functioning rescue system, well-trained, experienced and well-equipped personnel

(iii) W Factor

The W factor (warning) includes factors that influence warning of the community that an event is forecasted. The contributing factors include a hydrological forecast, the type of warning system employed, the speed of flooding, and the rate of water level rise; as these factors are somewhat based on the frequency and extent of flooding, analysts evaluate the W Factor for each flood scenario. **Table 17** shows the scale of sub-factors.

Table 17. W Factor Descriptions

W_i	Score				
	-1.0	-0.5	0.0	0.5	1.0
W_1	No hydrologic forecast, forecast not possible (e.g. at small catchments)	Only vague and general forecast	General forecast for medium size catchment	Hydrologic forecast provided in a standard way by hydrologic services	Reliable hydrologic forecast based on contemporary technical and modelling techniques
W_2	Flood may arrive within several tens of minutes	Flood arrives faster than 45 min	Flood arrives within several hours	Flood arrives within 1 day	Flood arrives within several days
W_3	Warning system does not exist	Poorly designed and functioning warning system	Only moderately reliable warning system	Fully functioning traditional warning system	Sophisticated warning system including digital online alarm systems
W_4	Water rises at a rate of several meters per hour (floods in 1998, 2009)	Water level rise about 1 m per hour (small catchments in 2013)	Rate of several meters per day	About 1 m per day (floods in 1997, 2002)	Water level rise of several meters over several days

For factor W4, water rise rates are based on event data. **Table 18** provides evaluations for W_1 to W_4 values for each flood scenario. The aggregated effect of Factor W was evaluated using the equation below, here W is the sub-factor score.[32]

$$W = \frac{1}{4} * \sum_{i=1}^{4} Wi$$

Table 18. W Values

W Subfactor	Subfactor Description	Existing Conditions (10 Percent)	Existing Conditions (2 Percent)	Existing Conditions (1 Percent)	Existing Conditions (0.2 Percent)
W_1	Reliability of hydrological forecast	0.5	0.5	0.5	0.5
W_2	Speed of flood arrival	1.0	1.0	1.0	0.5
W_3	Warning system	1.0	1.0	1.0	0.5
W_4	Rate of water level rise	0.0	0.0	0.0	-0.5
Aggregated Warning Factor Score (W Factor for each flood scenario)		**1.38**	**1.38**	**1.38**	**0.25**

32 Brazdova, M. and J. Riha. 2014. A simple model for the estimation of the number of fatalities due to floods in central Europe. Nat Hazards Earth Syst Sci. 14. June 12.

2. Value Loss of Life

Loss of life is estimated for each flood scenario by placing all determined factor values (D, P, and W) into the previously mentioned equation.

For example, the calculation to determine the number of casualties in the 1 percent annual chance event scenario includes:

D Value = $1,608,409,580
P Value = 2.13
W Value = 1.38

$$0.79 = 0.075 * \$1{,}608{,}409{,}580^{0.384} * (2.13 + 2)^{-3.207} * (1.38 + 2)^{-1.017}$$

Analysts apply Federal Aviation Administration's (FAA) Willingness to Pay values for a fatality ($5.8 million) to value loss of life.

Table 19. Estimated Fatalities Avoided by Flood Scenario

Percent Annual Chance Event	Estimated Fatalities	Value of Lost Life
10 Percent	0.08	$564,290
2 Percent	0.10	$710,820
1 Percent	0.11	$771,800
0.2 Percent	0.13	$923,370
Annual Fatalities Avoided	-	*$80,210*

3.2.2.3.2 Assumptions

- The analysis does not account for road and non-structural asset damages.
- Loss of life post-disaster can be affected by many factors not considered in this methodology, including the financial and physical health of the population, mental stress and anxiety, and other factors.
- Fatalities may not be calculated on a per-structure basis due to the nature of P values, which consider the flood preparedness characteristics of the whole study area population.
- The analysis does not account for population growth.

4 VALUE ADDED BENEFITS

Beyond improving Bridgeport's flood resiliency by reducing acute and chronic flood impacts to public housing and residents, the RBD project intends to foster community cohesion, generate economic opportunities, improve the natural environment, and stimulate redevelopment through growth, prosperity, awareness, and beauty. Analysts consider added value benefits, in addition to resiliency benefits, when comprehensively analyzing increased community resilience: Investment in increased flood resilience may foster commercial and residential redevelopment, in turn, promoting a more diverse and healthy economy. A resilient environment can provide protective services that stabilize and contribute to improved air and water quality, and may also help improve resident's health. Community gathering space provides an opportunity for increased social interactions and cohesion, creating additional networks for support during and after disaster events.

Value added benefits include social, environmental, and economic revitalization benefits resulting from the RBD project. These benefits include:

- Social benefits in the form of recreational value;
- Aesthetic benefit generated from making the surroundings more desirable for businesses and residents;
- Environmental benefits in the form of reduced energy use, air pollution, water pollution, and carbon dioxide emissions; and,
- Economic revitalization benefits related to added commercial space.

Table 20 relates RBD project elements to value added benefit categories.

Table 20. Value Added Benefit Matrix

Benefit Category		Measurable Benefit/Metric	Stormwater Park						Johnson Street Extension				Marina Village Redevelopment
			Trees	Shrubs	Green Space	Sidewalks	Playground	Basketball Courts	Trees	Shrubs	Bio-Retention	Sidewalks	
Value Added Benefits	Social	Recreation			X	X	X	X					
		Aesthetic	X	X	X	X	X	X	X	X	X	X	
	Environmental	Water Quality (CSO)			X						X		
		Ecosystem Services	X	X	X				X	X	X		
	Economic	Revitalization											X

4.1 Social Benefits

Urban parks and green space help improve the quality of life and social sustainability of cities by providing recreation opportunities and aesthetic enjoyment, promoting physical health, contributing to psychological well-being, enhancing social ties, and providing opportunities for education.[33] The RBD project's multifunctional stormwater park will be a new public amenity in the neighborhood, and includes basketball courts, a playground, sidewalks, green open spaces, and passive seating areas. The new stormwater park will provide opportunity for residents to participate in recreation activities, environmental education, and community programs, thereby enhancing their health and well-being, increasing social capital[34] and improving the quality of life in the greater community.[35]

4.1.1 Recreation Benefits

Recreation benefits quantify the consumer value of increased outdoor recreation expected to occur after completion of the new stormwater park. There are federally approved methods to quantify the value of new outdoor recreation opportunities: the low value method is based on FEMA's Final Sustainability Benefits Methodology Report, and assigns a value per square foot of recreational space. The high value method uses United States Army Corps of Engineers (USACE) Unit Day Values to value an increase in recreation activity. The medium method is the average results of high and low estimated benefits.

4.1.1.1 Data Sources

- **FEMA's Final Sustainability Benefits Methodology Report (2012):** provides a recreational value per acre of space. Refer to **Appendix F: Additional Benefit Cost Analysis Resources** for a summary of FEMA's standard values.
- **USACE Economic Guidance Memorandum, 16-03, Unit Day Values for Recreation for Fiscal Year 2016 (2015):** provides a daily recreational value by type of recreation activity.
- **RBD Project Design Drawings:** provide the total area of park features.

4.1.1.2 Approach

Analysts implemented two federal methods to evaluate the stormwater parks recreation benefits. These methods are described in detail below.

4.1.1.2.1 FEMA: Low Value Method

FEMA generates an annual recreational value per unit area using nationwide, rural, and urban willingness to pay studies.[36] Analysts normalized[37] and converted FEMA's standard annual recreational value per acre to current dollars per square foot: $0.13. Analysts apply this value to the total area of new park amenities to estimate the annual recreational value. **Table 21** summarizes results of the low value method by park feature.

33 Zhou, X. and M.P. Rana. 2011. Social benefits of urban green space. A conceptual framework of valuation and accessibility measurements. Management of Environmental Quality: An International Journal.
34 Gomez, E., Baur, J.W.R., Hill, E., and S. Georgiev. 2015. Urban Parks and Psychological Sense of Community. Journal of Leisure Research.
35 Lestan, K.A., Erzen, I., and M. Golobic . 2014. The Role of Open Space in Urban Neighbourhoods for Health-Related Lifestyle. 2014. International Journal of Environmental Research and Public Health. June
36 FEMA uses the benefit transfer methodology to apply the results of previously conducted primary studies to another geography.
37 Normalization in this context refers to converting past dollar values to current dollar values using the Consumer Price Index (CPI) Inflation Calculator: http://www.bls.gov/data/inflation_calculator.htm.

Table 21. Stormwater Park Low Annual Recreation Benefit

Park Feature	Square Feet	Annual Recreation Benefit
Playground	11,613	$1,510
Basketball	9,152	$1,190
Sidewalks	6,334	$820
Green Open Space	38,069	$4,950
Total	**65,168**	**$8,470**

4.1.1.2.2 USACE: High Value Method

The USACE produces Unit Day Values (UDV)[38] based on expert or informed opinion and judgement to estimate the average willingness to pay for recreation resources. Analysts calculate recreation benefits by applying the UDV to a park feature's expected useful life. The Federal government generates standardized average estimated useful life values that analysts used for the analysis. [39] UDVs provide a range of possible recreation values based on activity type, general or specialized recreation. Analysts used the lowest value available for general recreation ($3.90) to produce conservative estimates. **Table 22** provides results of the high value method by park feature.

Table 22. Stormwater Park High Annual Recreation Benefit

Park Feature	Expected Useful Life (Years)	Annual Recreation Benefit
Playground	10	$14,240
Basketball	25	$35,590
Sidewalks	50	$71,180
Green Open Space	100	$142,350
Total	**185**	**$263,350**

4.1.1.2.3 Medium Value Method

Analysts found the medium recreation benefit value by averaging the results of the low and high value methods (**Table 23**).

Table 23. Stormwater Park Medium Annual Recreation Benefit

Park Feature	Low Benefit Value	High Benefit Value	Medium Benefit Value
Playground	$1,510	$14,240	$7,870
Basketball	$1,190	$35,590	$18,390
Sidewalks	$820	$71,180	$36,000
Green Open Space	$4,950	$142,350	$73,650
Total	**$8,470**	**$263,350**	**$135,910**

38 United States Army Corps of Engineers. 2016. Economic Guidance Memorandum, 16-03 Unit Day Values for Recreation for Fiscal Year 2016. Located at: http://planning.usace.army.mil/toolbox/library/EGMs/EGM16-03.pdf
39 Fannie Mae. Instructions for Performing A Multifamily Property Conditions Assessment. Appendix F. Estimated Useful Life Tables. Located at: https://www.fanniemae.com/content/guide_form/4099f.pdf

4.1.1.3 Assumptions

- The results of previously conducted studies are applicable to the project area. The FEMA annual recreation value relies on studies that are limited in scope, but FEMA considers these studies applicable nationwide. This approach does not consider location-specific factors known to impact the results of recreation studies, such as population density, age, and income distribution.[40]

4.1.2 Aesthetic Benefits

The RBD project will integrate concepts of green infrastructure into the Johnson Street Extension; thoughtful "green street" design coupled with the new stormwater park will create a more appealing project area to existing and future residents. This attention to aesthetic detail may create a positive effect for residential property and the local economy. One measurable example of an aesthetic benefit that can contribute to this positive effect is attractive views and willingness to pay for these views. The benefits of increased aesthetic amenities, including attractive views, may be quantified through hedonic pricing demonstrated in the housing market, and on a standard value-per-square foot basis.

4.1.2.1 Data Sources

- **FEMA's Final Sustainability Benefits Methodology Report (2012):** provides an aesthetic value per acre of space. Refer to **Appendix F: Additional Benefit Cost Analysis Resources** for a summary of FEMA's standard values.
- **United States Department of Agriculture (USDA) Northeast Community Tree Guide: Benefits, Costs, and Strategic Planting (2007):** provides annual aesthetic value per tree.
- **RBD Project Design Drawings:** provide the total area of park features and total number of new trees.

4.1.2.2 Approach

FEMA's Final Sustainability Benefits Methodology Report uses the benefit transfer methodology[41] to convert results of hedonic pricing studies to a nationwide annual aesthetic value per acre. Analysts normalized this value to 2016 dollars and converted it to square feet; this value is $0.04 per square foot annually. Analysts apply this value to the total area of the new multiuse stormwater park to value aesthetic benefits. **Table 24** summarizes aesthics benefits by project element and feature.

Table 24. Summary of Aesthetic Benefits by Project Element

Project Element	Feature	Square Feet	Annual Aesthetic Benefit
Stormwater Park	Playground	11,613	$470
	Basketball	9,152	$370
	Sidewalks	6,334	$250

[40] Brander, L.M. and M.J. Koetse. 2011. The Value of Urban Open Space: Meta-analyses of contingent valuation and hedonic pricing results. Journal of Environmental Management. 92 (2011) 2763-2773. October

41 The benefit transfer method applies the results of previously conducted primary studies to another geography.

Project Element	Feature	Square Feet	Annual Aesthetic Benefit
	Paving	26,645	$1,070
	Green Open Space	38,069	$1,520
	Shrubs	2,740	$110
Johnson Street Extension	Shrubs	4,720	$190
	Bio-retention	9,372	$380
	Sidewalks	9,334	$370
	Paving	10,286	$410
	Total	**128,265**	**$5,130**

New trees may also increase the aesthetic quality of the surrounding area. The U.S. Forest Service's Northeast Community Tree Guide (2007) provides an annual asethetic value per public tree ($32.84). Analysts normalized this value to 2016 dollars ($38.44), and applied it to the total number of added trees to generate annual benefits. **Table 25** summarizes the annual aesthetic benefit of new trees.

Table 25. Annual Aesthetic Benefits of New Trees

Project Element	Number of Trees	Annual Aesthetic Benefit
Stormwater Park	81	$3,110
Johnson Street Extension	66	$2,540
Total	**147**	**$5,650**

4.1.2.3 Assumptions

- Analysts assumed that the results of previously conducted studies, used by FEMA to determine standard values, are transferable to the project area. FEMA values are based on studies FEMA considers to be applicable nationwide. Research indicates that higher population density results in a considerable increase in the value of urban parks and open space.[42] The analysis does not capture increased value in urban areas due to the use of FEMA standard figures.
- The Northeast Community Tree Guide provides values for small, medium, and large tree. Analysts assumed that the added trees are fully developed medium-sized trees; therefore, the benefits calculated pertain to medium trees.
- The USDA's Northeast Community Tree Guide accounts for tree morbidity over time (33.95 percent); therefore, it is not included as a separate function in the calculation.

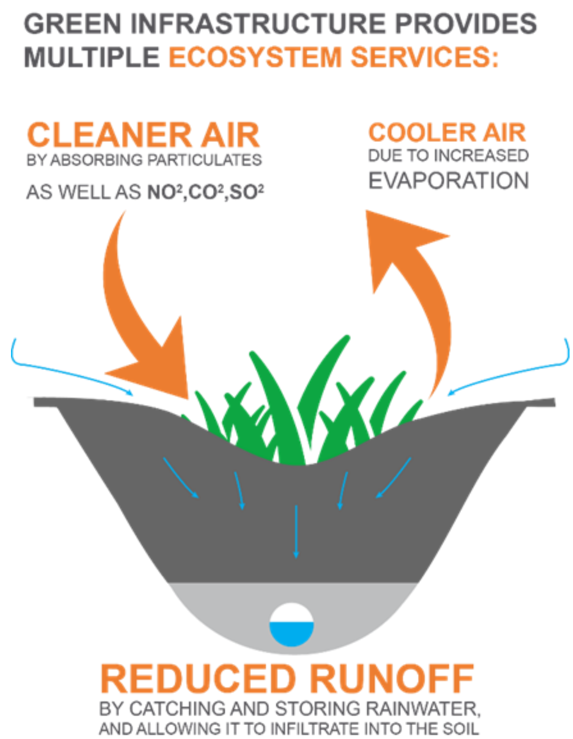
[42] Brander, L.M. and M.J. Koetse. 2011. The Value of Urban Open Space: Meta-analyses of contingent valuation and hedonic pricing results. Journal of Environmental Management. 92 (2011) 2763-2773. October

4.2 Environmental Benefits

The RBD project proposes to add new natural vegetation that will produce a range of environmental benefits, also known as ecosystem goods and services. Ecosystem goods and services provided by natural vegetation may be quantified to estimate their economic benefit to society. Such benefits can be categorized through measures such as carbon sequestration, air pollutant reduction, energy savings, increase in water quality, and pollination. The RBD also implements stormwater management measures that will reduce water treatment needs and environmental impact of CSO events. Environmental benefits are grouped into two categories based on valuation methods: those associated with the ecosystem goods and services and those associated with reduction CSO events.

4.2.1 Ecosystem Goods and Services

Natural capital is the world's stock of natural assets, such as soil, air, water, and all living things that provide a good or service that benefits society. For example, natural capital, such as forests and soils, provide the ecosystem service of filtering water independent of treatment plants.



Ecosystem services are grouped into four broad categories:[43]

- **Provisioning services:** produce physical materials that society uses such as minerals, gases, and living things;
- **Regulating services:** create and maintain a healthy environment such as climate stability and flood protection;
- **Supporting services:** maintain conditions for life such as habitat and genetic diversity; and,
- **Cultural services:** provide meaningful human interaction with nature including spiritual, recreational, aesthetic, educational, and scientific uses. Sections **3.1.1 Recreation Benefits** and **3.1.2 Aesthetic Benefits** describe the methods used to evaluate these benefits.

4.2.1.1 Data Sources

- **FEMA's Final Sustainability Benefits Methodology Report (2012):** provides an annual ecosystem service value per acre of green space. Refer to **Appendix F: Additional Benefit Cost Analysis Resources** for a summary of FEMA's standard values.
- **United States Department of Agriculture (USDA) Northeast Community Tree Guide: Benefits, Costs, and Strategic Planting (2007):** provides annual environmental benefit values per tree.
- **RBD Project Design Drawings:** provide the total area of green space and number of new trees.

[43] Earth Economics. 2015. Earth Economics Ecosystem Valuation Toolkit. [Web page] Located at: http://esvaluation.org/ecosystem-services/

4.2.1.2 Approach

Table 26 summarizes the approach taken to develop a benefit value per vegetative unit.

Table 26. Approach Summary by Vegetative Type

Vegetation Type	Approach
Tree	Annual benefits per tree are sourced from the USDA's Northeast Community Tree Guide (2007).
Vegetation	Annual benefits per vegetative square foot are sourced from FEMA's Final Sustainability Report (2012).

Analysts normalized benefits values to 2016 dollars and converted FEMA's values to square feet (**Table 27**). These values are applied to the area of new vegetation or total number of new trees to estimate environmental benefits (**Table 28** and

Table 29).

Table 27. FEMA's Annual Environmental Ecosystem Service Values

Ecosystem Service	Value per Square Foot	Value per Tree
Regulating Services		
Climate Regulation	$0.0003	$0.94
Water Retention/Flood Hazard Reduction	$0.0072	$10.57
Air Quality	$0.0050	$7.88
Energy Savings	-	32.72
Support Services		
Erosion Control	$0.0016	-
Pollination	$0.0072	-
Total Environmental Ecosystem Service Value	**$0.1937**	**$52.11**

Table 28. RBD Project Elements Contributing Ecosystem Services

Project Element	Vegetative Unit	Count / Area
Johnson Street Extension	Trees	66
	Shrubs	4720
	Bio-Retention	9,372
Stormwater Park	Trees	81
	Shrubs	2,740
	Green Space	38,069

Table 29. Annual Ecosystem Service Benefits provided by the RBD Project

Ecosystem Service	Johnson Street Extension			Stormwater Park			Total
	Street Trees	Shrubs	Bio-Retention	Trees	Shrubs	Green Space	
Climate Regulation	$62	$2	$3	$76	$1	$12	$160
Water Retention/Flood Hazard Reduction	$698	$34	$68	$856	$20	$275	$1,950
Air Quality	$520	$24	$47	$638	$14	$192	$1,440
Erosion Control	-	$8	$15	-	$4	$61	$90
Pollination	-	$34	$67	-	$20	$272	$390
Energy Savings	$2,160	-	-	$2,650	-	-	$4,810
Total	**$3,439**	**$101**	**$200**	**$4,221**	**$58**	**$813**	**$8,830**

4.2.1.3 Assumptions

- The Northeast Community Tree Guide provides values for small, medium, and large tree. Analysts assumed that the added trees are fully developed medium-sized trees; therefore, the benefits calculated pertain to medium trees.
- The USDA's Northeast Community Tree Guide accounts for tree morbidity over time (33.95 percent); therefore, it is not included as a separate function in the calculation.
- The results of previously conducted studies are applicable to the project area. FEMA values are based on studies FEMA considers to be applicable nationwide.

4.2.2 Combined Sewer Overflow Reduction

A significant added benefit of the RBD project is the ability to retain stormwater. The City of Bridgeport currently uses a combined sewer system. When rain events occur, the City's sewer system can become overwhelmed and untreated wastewater can spill into nearby waterways as a relief mechanism to avoid damaging property or treatment plants; this is commonly referred to as a CSO event. The RBD project proposes to implement a stormwater management features that will capture flow, preventing it from entering the combined sewer system and contributing to CSO events. This water quality benefit is not captured in ecosystems services benefits, therefore requiring a separate analysis.

4.2.2.1 Data Sources

- **Bridgeport Long Term Control Plan:** provided information needed to derive a damage cost.
- **RBD Project Modeling:** provided total CSO reduction volume.

4.2.2.2 Approach

CSOs have a major impact on water quality and pose significant health and safety risks. Bridgeport is acting to meet water quality requirements under the Clean Water Act. The City has developed a Long-Term Control Plan to reduce the frequency of CSO events. The Plan reveals it will cost the City $384,900,000 over 30 years to reduce CSO output by 43 million gallons. Given this information, analysts generated a damage cost for CSO abatement: $0.29 per gallon per year. Analysts modeled CSO reduction at the RBD design event (25-year Natural Resources Conservation Service [NRCS] rainfall event), and applied the damage cost to the total volume of CSO reduction to estimate water quality benefits (**Table 30**).

Table 30. Annual Water Quality Benefits

25 Year NRCS event	Volume (gallons)	Annual Water Quality Benefit
Volume Reduction in CSOs at Outfall	620,000	$3,300

4.2.2.3 Assumptions

- The assessment accounts for runoff that will be retained by the stormwater park and green street's bio-retention features, as well as additional system capacity to manage flow.

4.3 Economic Revitalization

The resilient redevelopment of Marina Village includes added commercial space that will generate economic revitalization benefits. These benefits can be measured through anticipated added economic output and employment compensation. Output is the value of industry production, and employment compensation includes wages and benefits for employees.

4.3.1 Data Sources

- **FEMA's Hazus-MH 3.2:** provides a method to estimate economic losses and gains and provides national output and employment compensation values per square foot.

4.3.2 Approach

Phase I of Marine Village redevelopment includes 10,000 square feet of new commercial space. Analysts normalized Hazus' output per square foot per day and employment compensation per square foot per day, and used the equation below calculate the economic benefits of added commercial space. **Table 31** summarizes annual economic revitalization benefits.

$$\begin{aligned} \text{Added Output per Year} \\ &= \text{Added Annual Output or Employment Compensation per Square Foot} \\ &\times \text{Added Space } (SF) \end{aligned}$$

Table 31. Economic Revitalization Benefits

	Marina Village Phase 1	Annual Economic Output
Commercial (square feet)	10,000	$5,400

4.3.3 Assumptions

- The analysis does not account for inflation over time, nor does it consider business turnover, vacancy rates, and changes in future land use for the analysis area.
- Analysts assume revitalization efforts will be successful

5 SENSITIVITY ANALYSIS

The relationship between BCA inputs and outputs requires certain assumptions. To ensure the BCA captures and describes uncertainty related to inputs and outputs, analysts performed a sensitivity analysis. By evaluating a variety of different model inputs, BCA analysts could identify the most appropriate values for use in the analysis and understand how assumptions impact BCA results, and thereby any decisions that may be based on BCA findings. This section provides an understanding of how a change in an uncertain variable will impact the present value of project benefits or costs, and the resulting BCR.

5.1 Analysis Uncertainties, Assumptions, and Limitations

Analysts estimated low, medium, and high benefits when more than one Federal method or value was available to evaluate a project benefit, or when uncertainties result in an alternative assumption in methodology or the use of a different methodology. This BCA report illustrates the range of benefits as low, medium, and high benefit scenarios for the pilot project's recreation and direct physical damage benefits and provides an indication of the differing variables or approaches for these benefits. Analysts limited low, medium-, and high- benefit scenarios to varying Federally approved BCA methods or values; this BCA does not explore the use of values or methods that are not accepted by Federal agencies. **Table 32** presents variable approaches explored during analysis.

Table 32. Summary of Uncertain Variables and Alternative Approaches

Benefit	Variable Approaches	Solution
Direct Physical Benefits	The BRV and CRV can have a significant impact on the monetary value of property loss. Analysts generated low-, medium-, and high- replacement values using 2016 RS Means Square Foot Costs to understand how the replacement value may impact BCA results.	Low Estimate: Economy BRV per square foot: $110.10
		Medium Estimate: Average BRV per square foot: $130.34
		High Estimate: Custom BRV per square foot: $169.74
Recreation Benefits	Analysts can calculate recreational benefits using different methods, such as willingness to pay values related to a specific recreation activity or a value per square foot of recreation space.	Low Estimate: FEMA value per square foot
		Medium Estimate: Average of low and high estimate
		High Estimate: USACE Unit Day Values

5.2 Discount Rates

The discount rate captures social "opportunity costs" (the maximum worth of an input feature as assessed among practical alternative uses), and provides an interpretation of the present value of expected annual benefits and costs. In other words, the discount rate attempts to measure the present value of future benefit, and always assumes that future benefit is of lower value than present benefit.

OMB Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs requires a discount rate of 7 percent. The Federal government last updated this discount rate in the OMB Circular A-94 in 1992. Sources of literature, such as the article *Discount Rate* published by the Association of State Floodplain Managers, emphasize the uncertainty surrounding discount rates. It can also be useful to analyze discount rates used by other federal agencies. The Government Accountability Office (GAO) is a congressional agency that determines its own discount rate policy. The GAO uses the yield of United States Treasury debt with a maturity of the duration of the Project.[44] Appendix C of OMB Circular A-94 (Revised in January of 2015), states that the 30-year interest rate is 1.4 percent.[45] Furthermore it states that, “Programs with durations longer than 30 years may use the 30-year interest rate in calculating the discount rate.”

To analyze the potential impact of assumptions surrounding discount rates, analysts compared the present value of project benefits and costs using two different discount rates recommended by OMB Circular A-94 (7 percent) and HUD Notice: CPD-16-06 (3 percent). **Table 33** summarizes the range of benefits individually using both discount rates, as well as the BCR for each benefit scenario.

Table 33. Summary of Benefit Range and Present Value

Benefit	Bound	Estimated Annual Benefit	Present Value of Benefits	BCR
Discount Rate: 7 Percent				
Direct Physical Damages	Low	$673,630	$8,667,050	1.32
	Medium	$720,690	$9,272,460	1.57
	High	$817,070	$10,512,500	1.91
Recreation	Low	$8,470	$119,240	1.32
	Medium	$135,910	$1,910,160	1.57
	High	$263,350	$3,701,080	1.91
Discount Rate: 3 Percent				
Direct Physical Damages	Low	$673,630	$16,678,350	2.16
	Medium	$720,690	$17,843,370	2.64
	High	$817,070	$20,229,640	3.24
Recreation	Low	$8,470	$247,030	2.16
	Medium	$135,910	$3,292,180	2.64
	High	$263,350	$7,611,340	3.24

[44] Page 4. Located at: http://www.floods.org/PDF/WhitePaper/ASFPM_Discount_%20Rate_Whitepaper_0508.pdf
[45] Web page. Located at: https://www.whitehouse.gov/sites/default/files/omb/memoranda/2015/m-15-05.pdf

6 DOUBLE COUNTING

Duplication of benefits, or "double-counting," may occur when two projects or methodologies of similar purpose have overlapping benefits. Analysts identified and removed double counting from the evaluation to maintain its integrity. Benefits may duplicate because:

1. Benefits calculated in the analysis may duplicate each other if there is overlap in the underlying values used to quantify losses avoided or value added.
2. Bridgeport has implemented or plans to implement a project in the same area with overlapping benefits.

Table 34 identifies potential double counting along with a description of how analysts managed or removed these duplications.

Table 34. Summary of Double-Counting Approach

Benefit	Potential Duplication	Resolution of Duplication
Resiliency Benefits		
Road Service and Casualties	The primary objective of dry egress is to provide residents with a means to evacuate before and after a flood event. There are two benefits associated with dry egress: continuity of road service, valued through lost time, and avoided casualties, valued using the FAA's WTP for life and injuries. In theory, residents that choose to evacuate would not be exposed to the risk of injury or loss of life. Similarly, residents that choose to shelter in place do not benefit from avoided time lost. Therefore, analysts must take care to identify the appropriate population for each analysis.	Analysts used local evacuation rates to address potential overlapping benefits: casualties were estimated for the population not expected to evacuate, and continuity of road service was estimated for the population expected to evacuate before a storm event.
Relocation	Relocation costs may be a double-counting with shelter needs. The relocation approach assumes that all displaced individuals will require alternative living quarters, thus capturing the costs of individuals that may opt or need to go to a shelter.	The BCR does not include costs associated the shelter needs to avoid any possible duplication. Instead, the BCA reports provides estimated population expecting to require public shelter in the case of an event for the benefit of the reader.
Social Benefits		
Recreation	In the future, Bridgeport may implement projects that improve the quality of Seaside Park. Such improvements may impact park visitation and may duplicate recreation benefits for different park sites.	The BCA calculates recreation benefits by unit of stormwater park elements to ensure that the benefits calculated are specific to RBD project only.
Health	Surveys used to determine consumer surplus values for recreation benefits may inherently include a health benefit component. Thus, recreation consumer surplus values may be duplicative with health benefits related to recreation.	The BCA report describes health benefits of recreation space in a quantitative manner, but analysts did not calculate monetary values to be included in the benefit-cost ratio to avoid any risk of double-counting benefits.

7 BENEFIT COST ANALYSIS RESULTS

The BCA finds the RBD project cost effective in each benefit scenario (**Table 36**), indicating the project is a sound investment of public resources.

*The NPV of the RBD project is **$5.4 million**, and the BCR using a 7 percent discount rate is **1.57**.*

The RBD project is expected to provide a range of resiliency, social, environmental, and economic benefits totaling to **$14.6 million** in today's dollars, compared to an overall investment of **$9.2 million**, both at a 7 percent discount rate (**Table 35** and **Table 1**). ***Resilient redevelopment benefits*** comprise 60 percent of the project's overall benefits, while ***social benefits*** comprise 13 percent of the project's overall benefits (**Figure 2**). The BCA reveals the RBD project will reduce acute and chronic flood impacts to future Marina Village development and residents, as well as provide a range of social, environmental, and economic benefits to the South End.

Table 35. Annual and Present Value Benefits for the Medium Benefit Scenario

Benefit	Annualized Benefit	Present Value (7 Percent Discount Rate)	Present Value (3 Percent Discount Rate)
Resiliency Benefits			
Resilient Redevelopment			
Direct Physical Damages	$ 720,690	$ 9,272,460	$ 17,843,370
Displacement	$ 1,150	$ 14,800	$ 28,470
Mental Stress and Anxiety	-	$ 1,050,280	$ 1,050,280
Lost Productivity	-	$ 653,610	$ 653,610
Dry Egress Value			
Evacuation / Roadway Loss of Service	$ 10,910	$ 149,370	$ 270,120
Casualties	$ 86,690	$ 1,115,390	$ 2,146,390
Value Added Benefits			
Social Value			
Recreation Benefits	$ 135,910	$ 1,910,160	$ 3,929,180
Aesthetic Benefits	$ 5,130	$ 71,660	$ 142,700
Environmental Value			
Ecosystem Goods and Services Benefits	$ 8,830	$ 126,030	$ 279,090
CSO Reduction Benefits	$ 3,300	$ 45,630	$ 85,070
Economic Value			
Economic Revitalization Benefits	$ 5,400	$ 69,480	$ 133,700
Total Project Benefits	**$978,010**	**$14,478,870**	**$26,561,980**

Table 36. Benefit Cost Ratio by Benefit Scenario

Scenario	Low Benefit Cost Ratio	Medium Benefit Cost Ratio	High Benefit Cost Ratio
7% Discount Rate			
RBD Project	1.32	1.57	1.91
3% Discount Rate			
RBD Project	2.16	2.64	3.24

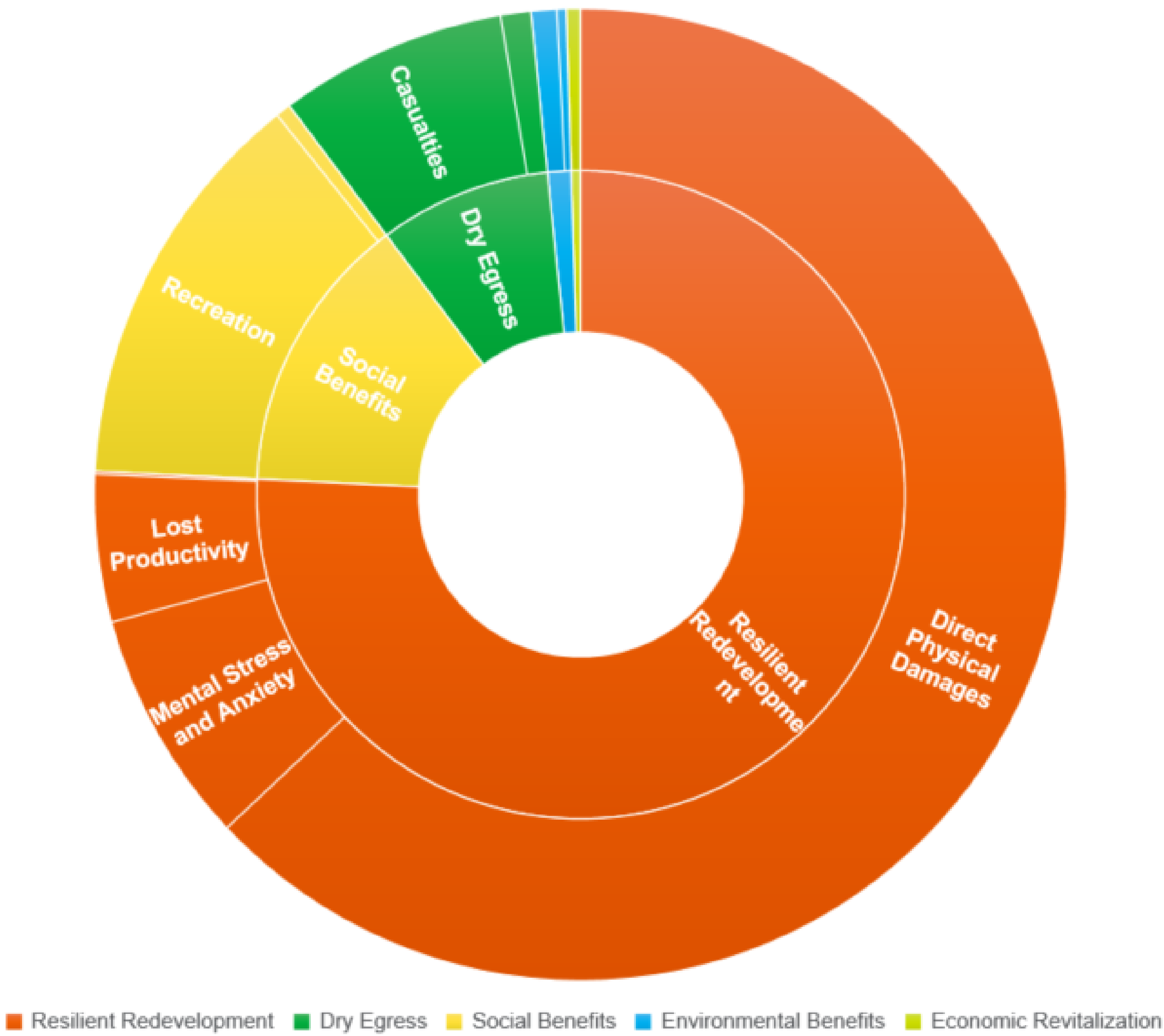


Figure 2. Distribution of RBD Project Benefits, Medium Benefit Scenario

Table 37. Annual and Present Value Benefits for the Low Benefit Scenario

Benefit	Annualized Benefit	Present Value (7 Percent Discount Rate)	Present Value (3 Percent Discount Rate)
Resiliency Benefits			
Resilient Redevelopment			
Direct Physical Damages	$ 673,630	$ 8,667,050	$16,678,350
Displacement	$ 1,150	$ 14,800	$ 28,470
Mental Stress and Anxiety	-	$1,150,430	$1,150,430
Lost Productivity	-	$715,940	$715,940
Dry Egress Value			
Evacuation / Roadway Loss of Service	$ 10,910	$ 149,370	$ 270,120
Casualties	$ 86,690	$ 1,115,390	$ 2,146,390
Value Added Benefits			
Social Value			
Recreation Benefits	$ 8,470	$ 119,240	$ 247,030
Aesthetic Benefits	$ 5,130	$ 71,660	$ 142,700
Environmental Value			
Ecosystem Goods and Services Benefits	$ 8,830	$ 126,030	$ 279,090
CSO Reduction Benefits	$ 3,300	$ 45,630	$ 85,070
Economic Value			
Economic Revitalization Benefits	$ 5,400	$ 69,480	$ 133,700
Total Project Benefits	**$803,510**	**$12,245,030**	**$21,877,300**

Table 38. Annual and Present Value Benefits for the High Benefit Scenario

Benefit	Annualized Benefit	Present Value (7 Percent Discount Rate)	Present Value (3 Percent Discount Rate)
Resiliency Benefits			
Resilient Redevelopment			
Direct Physical Damages	$ 817,070	$ 10,512,500	$ 20,229,640
Displacement	$ 1,150	$ 14,800	$ 28,470
Mental Stress and Anxiety	-	$1,150,430	$1,150,430
Lost Productivity	-	$715,940	$715,940
Dry Egress Value			
Evacuation / Roadway Loss of Service	$ 10,910	$ 149,370	$ 270,120
Casualties	$ 86,690	$ 1,115,390	$ 2,146,390
Value Added Benefits			
Social Value			
Recreation Benefits	$ 263,350	$ 3,701,080	$ 7,611,340
Aesthetic Benefits	$ 5,130	$ 71,660	$ 142,700
Environmental Value			
Ecosystem Goods and Services Benefits	$ 8,830	$ 126,030	$ 279,090
CSO Reduction Benefits	$ 3,300	$ 45,630	$ 85,070
Economic Value			
Economic Revitalization Benefits	$ 5,400	$ 69,480	$ 133,700
Total Project Benefits	**$1,201,830**	**$17,672,320**	**$32,792,900**

8 ECONOMIC IMPACT ANALYSIS

In addition to the benefits of increased resiliency from reduced future disaster loss, project expenditures for construction are expected to stimulate economic activity within Bridgeport and Fairfield County. This economic impact evaluation is accessory to the RBD project; the intent is to evaluate the expected economic benefits generated by project construction in the form of employment, labor income, value added, and sales and revenues (output).

8.1 Project Description

The RBD project includes two main elements: the Johnson Street Extension and a multiuse stormwater park. The Johnson Street Extension will provide dry egress and incorporate green infrastructure, such as bioswales, to divert surface runoff from the combined sewer system and into the multifunctional stormwater park. The 2.5 acre stormwater park will include terraced basins, underground storage features, community gathering space, and recreational features. Flow from the stormwater park will be pumped via a new force main to an existing outfall. Analysts used the cost estimates for the Johnson Street Extension and force main to conduct the economic impact analysis (EIA); detailed cost estimates for the stormwater park were not available at the time of analysis.

8.2 IMPLAN Software and Results

This methodology presents the approach used to model economic impacts for project expenditures. Generally, analysts evaluate the cost of each proposed project element using IMPLAN modeling software to determine the economic impacts that will result from the change in the local economy directly related to project expenditures. IMPLAN software provides economic data and modeling to users for assessing the economic impacts of project implementation in all industry sectors, with the intent of predicting how projects or policies interact with and shape the economy. Analysts used IMPLAN Version 3.1 software, an input-output system that uses a combination with social accounting matrices (SAMs) and economic multipliers to estimate the result of changes or activities in an economic region. SAMs provide a complete picture of the economy and generate multipliers to measure the impacts from one activity for a given sector throughout the entire economy. Analysts used the 2015 Fairfield County Package for the economic impact analysis, which includes the economic profile for each zip code. and **Table 40** below describes the IMPLAN analysis report outputs and types of relationships reported. Each result category presented in **Table 39** is reported in terms of relationships measured, displayed in **Table 40**.

Table 39. Economic Impact Analysis Result Outputs

Analysis Result	Definition
Output	The value of industry production, which varies by industry. For example, the output of the service sector is measured in sales, hospital output is measured in the total service package that a patient receives during their entire length of stay, and output for non-profit organizations is based on the cost of production or the expenses that the organization must incur to operate.
Labor Income	The expected combined income of employment in each industry sector generated by project implementation expenditures. Including wages and benefits for employees and proprietor income.
Value-Added	Measure of the project's contribution to Gross Domestic Product (GDP).
Employment	All jobs (full-time, part-time, and temporary) that are created or lost as a result of an economic activity in the year of the activity.

Table 40. Economic Impact Analysis Relationships Measured

Analysis Result	Definition
Direct Effects	Represents the initial impacts that occur as a result of an economic activity.
Indirect Effects	The impact of direct economic effects on supporting industries, such as those that provide equipment and materials.
Induced Effects	The response to a direct effect that occurs through re-spending of income.

8.3 Approach

Outlined below is the approach to estimate economic impacts of project.

1. **Compare project estimates with IMPLAN industries**

IMPLAN has a total of 440 economic industries, derived from the North American Industry Classification System (NAICS). To run IMPLAN, analysts must choose the economic industry expected to be impacted by a project related activity, and estimate how much that industry will change (in dollars). Evaluating the economic impact of mitigation measures requires analysts to choose economic industries necessary for project design, construction, and maintenance and divide project costs appropriately among those industries. **Table 41** displays the project elements and corresponding economic industries chosen by analysts.

Table 41. Expenditures used in the Economic Impact Analysis

IMPLAN Industry	Planning and Design	Johnson Street Extension	24" RCP	Force Main	Maintenance
30 Stone mining and quarrying	$-	$20,480	$-	$-	$-
31 Sand and gravel mining	$-	$-	$11,040	$-	$-
36 Other nonmetallic materials	$-	$45,080	$-	$-	$-
51 Water, sewage, and other systems	$-	$126,400	$-	$254,240	$-
58 Construction of other new nonresidential structures	$-	$-	$49,600	$-	$-
62 Maintenance and repair construction of nonresidential structures	$-	$42,960	$-	$-	$75,000
64 Maintenance and repair construction of highways, streets, and bridges	$-	$94,520	$-	$-	$-
58 Construction of other new nonresidential structures	$-	$116,880	$-	$106,960	$-
157 Asphalt paving and manufacturing	$-	$163,680	$-	$-	$-
208 Concrete pipe manufacturing	$-	$-	$54,320	$226,800	$-
213 Cut stone and stone product manufacturing	$-	$50,440	$-	$-	$-
326 Street lighting fixtures manufacturing	$-	$64,680	$-	$-	$-
445 Commercial and industrial machinery and equipment rental	$-	$276,560	$172,280	$-	$-
449 Architectural, engineering, and related services	$1,100,000	$-	$-	$-	$-
507 Commercial and industrial machinery and equipment	$-	$35,560	$-	$-	$-

2. Populate IMPLAN model

Analysts created an IMPLAN model and populated the software with appropriate project costs listed in Step 1.

3. Review IMPLAN outputs

Analysts reviewed outputs generated from IMPLAN software for appropriateness. The IMPLAN analysis software evaluates the relationships between employment, labor income, economic output, and value added to GDP three ways: 1) direct impacts, which include industries directly related to mitigation activities; 2) indirect impacts, which include industries that support directly impacted industries; and 3) induced impacts, or benefits created through employee spending.

8.4 Assumptions

Analysts made the below assumptions to run the IMPLAN model accurately.

- Project planning and design will take place from 2016 through 2018. The costs of planning and design are distributed across those three years as described in the project budget.
- Project expenditure inputs are assigned the year of activity completion, IMPLAN outputs are adjusted to 2017 dollars.
- Project construction will occur between 2018 and 2022. Analysts allocated the costs of project construction, including materials, labor, and equipment, equally across those four years to account for temporal differences in project expenditures.
- Analysts applied IMPLAN's Local Purchase Percentage, calculated from the study area's SAM, to all industry sectors. This assumes that a certain percentage of an industry will be purchased locally, discounting commodities or services that are imported from outside of the study area which therefore have no impact on the local economy.

The following caveats apply to the results of the economic impact analysis, and should be considered when evaluating results:

- These results display the expected economic effect of the proposed project on the entirety of Fairfield County.
- The project is in the first stages of planning; the analysis must be considered as preliminary and can be refined as more project details are realized.
- Employment generated by analyzed project expenditures include all full-time, part time, and temporary positions.
- IMPLAN does not account for price elasticities or changes in consumer/industry behavior based on a direct effect, such as changes in spending patterns within sectors not related to project expenditures directly.
- The results presented are those that are associated with the years the project is implemented, and are not projected into the future.

8.5 Results

Analysis results indicate that the Johnson Street Extension and force main, will result in:

- 10 JOBS DIRECTLY RELATED TO THE ACTIVITIES LISTED IN THE **APPROACH**.
- 4 JOBS CREATED IN SUPPORTING INDUSTRIES.
- 5 JOBS CREATED THROUGH EMPLOYEE SPENDING.
- 19 JOBS CREATED TOTAL, WITH $1.8 MILLION IN LABOR INCOME (THIS INCLUDES EMPLOYEE WAGES AND BENEFITS AND PROPRIETOR INCOME).

The top three industries expected to be impacted by project implementation include the ***construction industry, the engineering and architectural services industry, and the water system industry***. As a whole, the project is expected to generate ***$3.7 million in industry production***, creating ***$2.4 million in value added*** (GDP) for Fairfield County.

Figure 3 below offers the results of the economic impact analysis, organized by project activity. These results are presented in percentages to show the contributions that each makes to the whole impact.

Figure 3. Economic Impact Results by Activity, Presented as Percentages

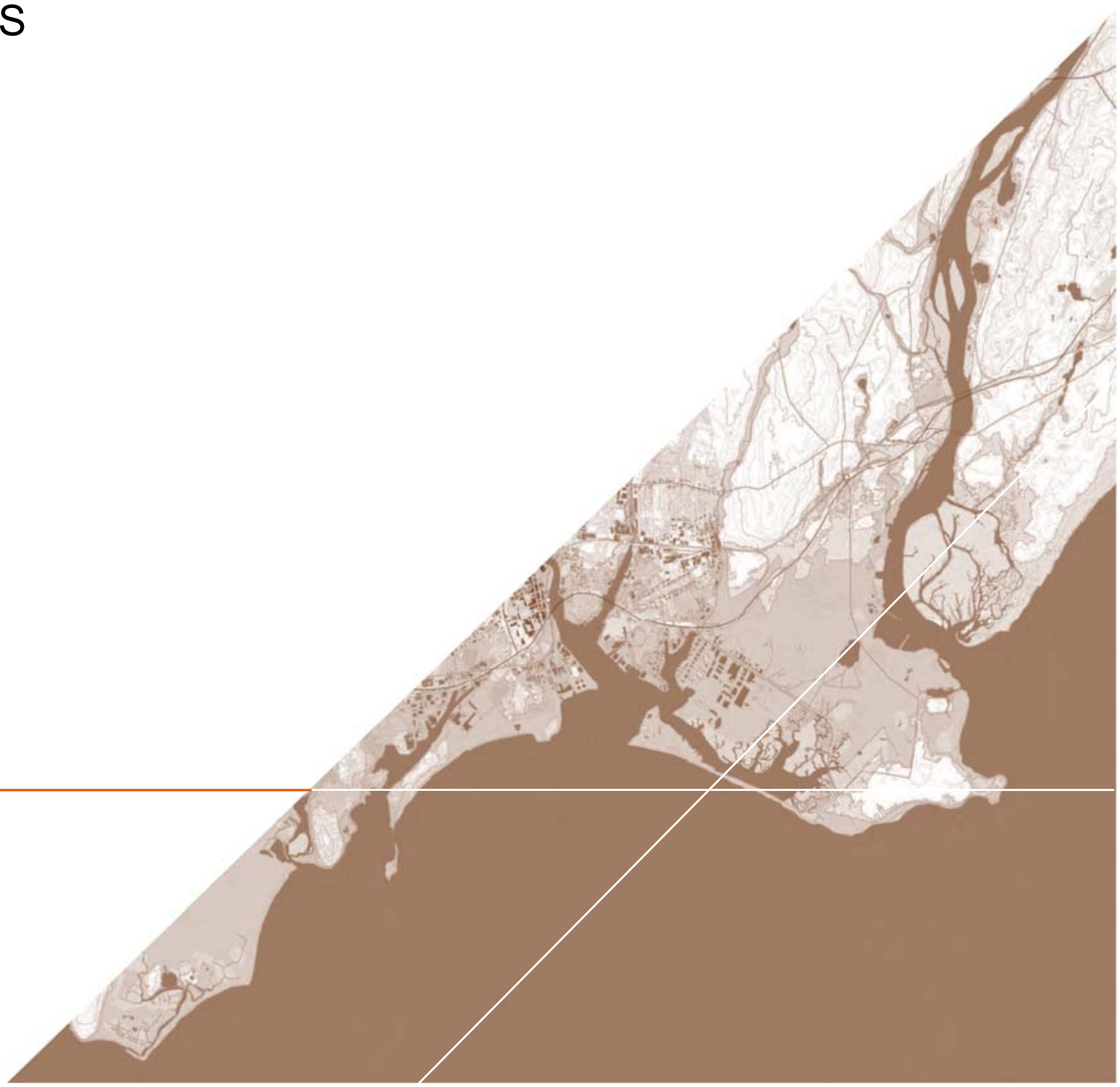
ARCADIS Design & Consultancy for natural and built assets

RESILIENT BRIDGEPORT

BENEFIT COST ANALYSIS METHODOLOGY REPORT

APPENDICES

April 21, 2017



CONTENTS

APPENDIX A

US Housing and Urban Development (HUD) Crosswalk

Costs and Benefits by Category	BCA Section	Qualitative Description of Effect and Rationale for Including in BCA	Quantitative Assessment (Explain basis and/or methodology for calculating Monetized Effect, including data sources, if applicable)	Current monetized effect (if applicable)	Uncertainty
Life Cycle Costs					
Resilient Bridgeport Selected Project	BCA Methodology Report, Section 2 Rebuild by Design Pilot Project	The RBD project will extend Johnson Street to provide dry egress for future Mariana Village residents out of the FEMA 500-year flood zone, as well as future SLR conditions of 3 feet. The Johnson Street Extension will incorporate green infrastructure, such as rain gardens and bioswales, to divert surface runoff away from the combined sewer system and into a multifunctional stormwater park. Stormwater park components such as terraced basins and underground storage features will retain, delay, and improve the quality of stormwater runoff. Community gather spaces, play equipment and courts, and walkways in the stormwater park will provide space for community programs, environmental education, and passive and active recreation. The park component will also include new flora and fauna.	Engineers compiled a detailed cost estimate based on direct capital costs, as well as operation and maintenance (O&M) costs over the project useful life.	**Present Value of Costs: $9,235,060**	**3** Medium uncertainty because the project design is not yet final.
Resiliency Benefits					
Resilient Development					
Direct Physical Damages – Structure	BCA Methodology Report, Section 3.1.1 Direct Physical Damages – Buildings and Contents	Direct physical damages include the degradation and destruction of property and are quantified through monetary losses. The BCA categorizes property loss as both structural damage (damage that applies to real property) and content damage (damage to personal property or inventory).	A structure inventory was created to gather the appropriate information required for the analysis, such as building square footage, use, and stories, using Bridgeport tax assessment data. Analysts compared flood elevations from the Flood Insurance Study (FIS) to grade elevations to determine a flood depth at each structure. The North Atlantic Coastal Comprehensive Study (NACCS) Depth-Damage Functions (DDFs) consider first floor elevations, therefore analysts use ground elevation rather than first floor elevations when estimating flood depth. Building Replacement Values (BRVs) were calculated using RSMeans. The DDFs from the USACE are applied to estimate structure damages associated with the 10 percent, 2 percent, 1 percent, and 0.2 percent annual chance events. The percent of structural damage is related to 1-foot depth above grade increments, which are multiplied by the replacement value for a portion of the structure defined by the DDFs to produce a physical loss value in dollars. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: $318,840** **Present Value of Benefits: $4,102,180**	**3** Medium uncertainty; the methodology used to estimate this benefit is approved by more than one federal agency. Further, property appraiser data provided site-specific structure information, and USACE DDFs specific to the study area were used in the analysis. LiDAR was used to determine grade elevations, with site checks in several areas.
Direct Physical Damages to Buildings - Contents	BCA Methodology Report, Section 3.1.1 Direct Physical Damages – Buildings and Contents	Contents damage is damage that applies to personal property as a direct result of flooding. This is calculated as a function of direct physical damages to structures.	Contents loss is a percentage of the BRV based on the contents-to-structure ratio values from USACE data. DDFs are applied to estimate contents damages associated with each return period. The percent of contents damage is related to 1-foot depth increments, which are multiplied by a contents replacement value to produce a physical loss value in dollars. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: $401,850** **Present Value of Benefits: $5,170,280**	**3** Uncertainties are the same as for Direct Physical Damages to Structures

Costs and Benefits by Category	BCA Section	Qualitative Description of Effect and Rationale for Including in BCA	Quantitative Assessment (Explain basis and/or methodology for calculating Monetized Effect, including data sources, if applicable)	Current monetized effect (if applicable)	Uncertainty
Displacement Costs	BCA Methodology Report, Section 3.1.2 Displacement Costs	Residents of impacted structures may experience displacement costs during the time when a building becomes uninhabitable due to flood damage. Relocation costs are associated with moving a household or a business to a new location and resuming business in that new location. Relocation costs are derived from displacement time, which is derived from DDFs that relate a depth of flooding to an amount of time a structure is not usable.	Analysts identified structures experiencing flood impacts at different flood scenario, and determined the total flooded floor area. Census block level data provided the percent owner occupied for residential structures and Hazus-MH 3.2 provided default owner-occupancies for non-residential uses. Analysts used Zillow and Loopnet to develop location specific rental costs for residential and non-residential structures. Flood depths estimated in the direct physical damage analysis are correlated to USACE displacement DDFs to estimate displacement time for each flood scenario. Analysts processed relocation costs to building occupants based on occupancy type. Analysts applied the probability of each flood scenario to expected impacts to calculate annual benefits. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: $1,150** **Present Value of Benefits: $14,800**	**3** FEMA Hazus methods and FEMA BCA Reference Guide methods applied. Uncertainty is related to post-disaster behavior of residents and businesses.
Mental Stress and Anxiety	BCA Methodology Report, Section 3.1.3 Mental Stress and Anxiety	Natural disasters threaten or cause loss of health, social, and economic resources, which leads to psychological distress. Research indicates that individuals who experience a high number of stressors and property damage are more likely to experience symptoms of mental illness, Post-Traumatic Stress Disorder (PTSD), and higher levels of stress and anxiety. An increase in mental health issues after a disaster will increase mental health treatment costs.	An increase in mental health issues after a disaster will increase mental health treatment costs. Calculations consider prevalence of mental health issues after a disaster, as well as the number of individuals who will seek treatment. Benefits are based on a national standard cost of treatment per person by type of treatment (mild/moderate or severe). The FEMA standard value was normalized and then applied to the number of residents that would be impacted if the RBD project were not implemented. The result of the analysis is avoided mental health treatment costs due to the implementation of the RBD project. The cost of mental health is estimated for 30 months, the amount of time for which literature has been able to estimate the prevalence of mental health impacts after a disaster. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: N/A** **Present Value of Benefits: $1,050,280**	**3** Medium uncertainty; the methodology used for calculating this benefit has been approved by at least one federal agency. This method only considers the percent of the population that is expected to seek treatment and is conservatively low for that reason. Further, the percent of the population expected to seek treatment is a national figure, and not locally specific. Costs are also national and not locally specific. Coping tactics, skills, and support systems vary widely within a given population.
Lost Productivity	BCA Methodology Report, Section 3.1.4 Lost Productivity	Work productivity can be lost due to mental stress and anxiety. Lost work productivity can be avoided by the implementation of the RBD project as stress resulting from damage to homes and disruption of life is expected to be mitigated.	The methodology relies on the results of existing studies to determine the dollar amount of monthly productivity loss due to mental health issues. This is multiplied by the number of affected wage earners based on the number of households impacted by a flood event. The total amount of productivity loss is also estimated for 30 months. The total value is treated in the same manner as mental health treatment costs. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: N/A** **Present Value of Benefits: $653,610**	**3** Medium uncertainty; this method contains the same variables as mental stress and anxiety. Nevertheless, there are multiple international studies to corroborate these results. Impacts may vary based on population affected and nature of disaster.

Costs and Benefits by Category	BCA Section	Qualitative Description of Effect and Rationale for Including in BCA	Quantitative Assessment (Explain basis and/or methodology for calculating Monetized Effect, including data sources, if applicable)	Current monetized effect (if applicable)	Uncertainty
Dry Egress Value					
Transportation	BCA Methodology Report, Section 3.2.1 Loss of Roadway Service	Transportation assets and systems in the South End may flood during both acute and chronic events. Loss of roadway service is a function of the per-hour value of time, detour route, and number of vehicles evacuating. Analysts focused on the residents benefitting from dry egress, those in Marina Village and Seaside Village that are within the FEMA flood zones.	Lost transportation service can be estimated as a function of the lost time to travelers due to disruption to the various transportation networks. The basic economic concept is that personal time has value, regardless of formal employment compensation. Figures are based on FEMA methodologies for BCA. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: $10,910** **Present Value of Benefits: $149,370**	**3** Medium uncertainty; the methodology used for calculating this benefit has been approved by at least one federal agency. Values are derived from national, as opposed to local figures.
Casualties	BCA Methodology Report, Section 3.2.2 Casualties	Casualties, which include loss of life and injuries, are an unfortunate risk inherent to hazard events. Flood events are considered some of the most frequently occurring natural hazards, contributing to 44 percent of natural hazard-related fatalities worldwide.	After an analysis of both the impacts of Hurricane Sandy and the various methodologies available for calculating number of deaths in flood-related disasters, the selected methodology for estimating fatalities is based on a 2013 study conducted by BRNO University. FEMA standard life safety values were used. It is also assumed that there is a 78 percent evacuation rate. Injuries are based on a post-Sandy CDC study of injuries within a week of flooding due to evacuation and clean-up efforts (roughly 10% of the impacted population). See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits:** **Fatalities: $80,210** **Injuries: $6,480** **Present Value of Benefits: $1,115,390**	**3** A standard FEMA value for life was used; however, there are multiple methods for determining the number of possible casualties. In addition, there are many factors post-disaster that could increase or decrease potential casualties, including unpredictable behaviors and population density.
Value Added Benefits					
Social Value					
Recreation	BCA Methodology Report, Section 4.1.1 Recreation Benefits	Open spaces, parks, and the use of these spaces provide recreational benefits. There are several currently accepted methods to value the added recreational benefits of amenities such as those anticipated to be provided by the Project program elements. This BCA used a method that considers residents' willingness to pay for access to recreational uses. Methods under the umbrella of the willingness to pay concept of economic valuation include contingent valuation, hedonic pricing, and value of enjoyment.	Recreation benefits quantify the consumer value of increased outdoor recreation expected as a result of project improvements. Two approaches to value recreation benefits are provided within this methodology. The first method applies FEMA's standard value for recreation benefit per acre to the total amount of new or improved recreation space. The second method estimates an increase in recreation activity based on the type of activities thought to occur at the park using statewide survey data. See BCA Summary Report, Table 1 Summary of Resiliency and Added Value Benefits for data sources.	**Annual Benefits: $135,910** **Present Value of Benefits: $1,910,160**	**3** Medium uncertainty; federal methods and standard values used in the analysis. Uncertainty is related to existing park usage, user habits, and expected increase in park users.

Costs and Benefits by Category	BCA Section	Qualitative Description of Effect and Rationale for Including in BCA	Quantitative Assessment (Explain basis and/or methodology for calculating Monetized Effect, including data sources, if applicable)	Current monetized effect (if applicable)	Uncertainty
Aesthetic	BCA Methodology Report, Section 4.1.2 Aesthetic Benefits	The RBD project will implement flood protection measures that integrate concepts of green infrastructure coupled with the addition of usable park space which will create a more appealing project area to existing and future residents. This attention to aesthetic detail may create a positive effect for residential property and the local economy.	FEMA uses a benefit transfer methodology to obtain an aesthetic value per acre per year of green open space. This value is applied to the area of new park space to value aesthetic benefits. New trees may also increase the aesthetic quality. An annual aesthetic value per public tree was applied to the total number of added trees to generate benefits.	**Annual Benefits: $5,130** **Present Value of Benefits: $71,660**	**3** Medium uncertainty; method to estimate benefits uses a federal methodology. The FEMA method is based on nationally derived figures.
Environmental Value					
Environmental	BCA Methodology Report, Section 4.2.1 Ecosystem Goods and Services	The RBD project proposes to add new natural vegetation that will produce a range of environmental benefits, also known as ecosystem goods and services. Ecosystem goods and services provided by natural vegetation may be quantified to estimate their economic benefit to society. Such benefits can be categorized through measures such as carbon sequestration, air pollutant reduction, energy savings, increase in water quality, and pollination.	Natural capital is the world's stock of natural assets, such as soil, air, water, and all living things that provide a good or service that benefits society. For example, natural capital, such as forests and soils, provide the ecosystem service of filtering water independent of treatment plants. The USDA's Northeast Community Tree Guide (Tree Guide) and FEMA's Final Sustainability Benefits Methodology Report are the sources analysts used to develop environmental benefits for various vegetation types.	**Annual Benefits: $8,830** **Present Value of Benefits: $126,030**	**3** Medium certainty; values used in calculating this benefit are provided by federal and published sources. Local conditions may vary from nationwide standard values.
Combines Sewer Overflow Reduction	BCA Methodology Report, Section 4.2.2 Combines Sewer Overflow Reduction	A significant added benefit of the RBD project is the ability to retain stormwater. The City of Bridgeport currently uses a combined sewer system. When rain events occur, the City's sewer system can become overwhelmed and untreated wastewater can spill into nearby waterways as a relief mechanism to avoid damaging property or treatment plants. The RBD project proposes to implement stormwater management features that will capture flow, preventing it from entering the combined sewer system and contributing to CSO events. This benefit is not captured in ecosystems services benefits, therefore requiring a separate analysis.	The City has developed a Long-Term Control Plan to reduce the frequency of CSO events. The Plan reveals it will cost the City $384,900,000 over 30 years to reduce CSO output by 43 million gallons. Given this information, analysts generated a damage cost for CSO abatement: $0.29 per gallon per year. Analysts modeled CSO reduction and applied the damage cost to the total volume of CSO reduction to estimate water quality benefits.	**Annual Benefits: $3,300** **Present Value of Benefits: $45,630**	**3** Medium certainty; assessment accounts for runoff that will be retained by the stormwater park and green street's bio-retention features. Uncertainty is related to Bridgeport's investment in CSO abatement.
Economic Value					
Economic Revitalization	BCA Methodology Report, Section 4.3 Economic Revitalization	The resilient redevelopment of Marina Village includes added commercial space that will generate economic revitalization benefits.	Economic revitalization benefits can be measured through anticipated added economic output and employment compensation. Commercial output per square foot and employment compensation per square foot are sourced from FEMA's Hazus-MH 3.2 software.	**Annual Benefits: $5,400** **Present Value of Benefits: $69,480**	3 Medium certainty; national values used in calculating this benefit are provided by Federally published sources.

Costs and Benefits by Category	BCA Section	Qualitative Description of Effect and Rationale for Including in BCA	Quantitative Assessment (Explain basis and/or methodology for calculating Monetized Effect, including data sources, if applicable)	Current monetized effect (if applicable)	Uncertainty
Qualitative Benefits					
Health Benefits of Recreation	BCA Summary Report, 4.1 Health Benefits	Several studies have found that physical improvements and increased access to parks can increase both the number of users in the park and the frequency of exercise. There is strong evidence from the Centers for Disease Control and Prevention which demonstrates that access to parks and/or recreation areas results in more exercise taking place at that location. The addition of a public park at the center of the project area has the potential to increase residents' health and physical fitness. It has also been shown that outdoor recreation increases mental health and overall wellbeing.	Population data was used to determine the percentage of adults, seniors, and children. Then the percentage of population in each age group that met physical fitness guidelines was determined. This percentage was used to then determine the increase in the number of residents meeting fitness guidelines for each age category. The increase in population using the physical fitness guidelines was used to determine the healthcare cost savings. The outcome is the avoided health care costs for each age group due to increased physical activity.	Health benefits are considered to duplicate recreation benefits; therefore, the BCA does not place a monetary value on benefits.	**3** Medium uncertainty; federal sources provided the majority of data used. Benefits are based on a conceptualized scenario for project programming, based on public outreach and feasibility.
Emergency Response and Recovery Efforts	BCA Summary Report, 4.2 Emergency Response and Recovery Efforts	During and after both Hurricane Irene and Superstorm Sandy, the South End experienced major flooding that impeded roadway travel in the area due to a significant number of flooded streets. Although no lives were lost due to the flooding situation, floods associated with future coastal storms and low-frequency rainfall events could prevent emergency response vehicles, such as police vehicles, ambulances, and firefighting equipment from reaching vulnerable populations in time.	The addition of a dry egress corridor on Johnson Street will allow residents to evacuate safely, if necessary, during a hazard event. Additionally, mitigating flood risk in the project area will serve to reduce emergency response times and give adequate access to first responders that typically address fallen trees, downed power lines, or other disaster related impacts.	-	**3** Medium uncertainty; this reduction in the need for and cost of emergency services cannot be quantified at this time due to a lack of data from previous flood events.
Affordable Housing	BCA Summary Report, 4.3 Affordable Housing	The project area contains a high concentration of low-income populations, and focuses on the site of the future Marina Village mixed-income housing redevelopment. Given that over half of Marina Village is in the floodplain, dry egress during a 500-year flood event is required for new development. The RBD project would extend Johnson Street from Columbia to Iranistan at an elevation of 15 feet (the FEMA effective Flood Insurance Rate Maps 500-year stillwater elevation of 11.3 feet NAVD88 plus 3 feet to account for SLR), which would provide the Marina Village redevelopment a dry egress corridor, and subsequently allow the new mixed income housing development to be constructed.	The availability of affordable housing in a neighborhood is directly related to the economic resilience of that neighborhood. Studies indicate that the construction of approximately 100 affordable housing units through the Low-Income Housing Tax Credit program can support as many as 30 new jobs in the local economy. Therefore, the availability of housing not only attracts employers to the area, but could also increase the amount of disposable income residents are able to reinvest in the local economy.	-	**4** High uncertainty; the methodology used for capturing the monetary benefits of affordable housing availability is not yet standardized and therefore relies on a heavier amount of uncertainty. BCA analysts felt that due to this uncertainty, it should not be incorporated into the overall BCR
Workforce Benefits	BCA Summary Report, 4.4 Workforce Benefits	The South End has some of the highest unemployment and lowest median household income in Connecticut. There is a distinct lack of economic development in the neighborhood, with very few businesses or employment opportunities for the community. As a result, unemployment in the South End is approximately 30%, higher than 6 times the national average, and almost half of residents are below the poverty level.	The RBD project provides opportunity for economic revitalization to the South End, and with it, job creating economic investment. The redevelopment of Marina Village will include a community center with job-training and education programs. These amenities will attract new residents to the neighborhood, creating a larger potential consumer base. Additionally, when the RBD project is completed and the frequency of flooding is reduced, there will be less risk to businesses of flood-related closures, further incentivizing investment in the neighborhood.	-	**4** It is uncertain to what extent the addition of new jobs will benefit the community. As such, analysts felt that quantifying this value would not rely on a defensible methodology.

Costs and Benefits by Category	BCA Section	Qualitative Description of Effect and Rationale for Including in BCA	Quantitative Assessment (Explain basis and/or methodology for calculating Monetized Effect, including data sources, if applicable)	Current monetized effect (if applicable)	Uncertainty
Historic Preservation	BCA Summary Report, 4.5 Historic Preservation	The Marina Park Historic District is almost entirely within the project area, and contains 14 buildings of historic significance along Park Avenue, all of which are listed on the National Register of Historic Places. Seaside Village is also listed on the National Register of Historic Places, and is immediately adjacent to the project area. It is a housing community that was constructed during World War I and consists of about 200 single-family dwellings. In addition to the Marina Park Historic District and Seaside Village, there are 3 other historic districts in the South End that would be indirectly affected by the RBD project. They are: the Barnum/Palliser Historic District, Seaside Park, and the William D. Bishop Cottage Development Historic District.	The South End includes several important buildings and neighborhoods with rich histories that would benefit from the implementation of the RBD project. The primary purpose of the RBD project is to provide a level of flood protection to citizens of the South End. The historic structures and districts within the vicinity of the project would therefore benefit from this protection.	-	**3** It is uncertain to what extent the historic structures would benefit from the implementation of the RBD project. Additionally, it is difficult to quantify the value of historic structures as there may be hidden value not easily teased out (donations to tour the site, surrounding property value increases, etc.)
Economic Impact Analysis	BCA Summary Report, 4.6 Economic Impact Analysis	Resiliency projects and infrastructure investments have additional economic benefits beyond losses avoided. Implementing such projects often benefit the local and regional economy by providing employment opportunities, increasing economic output (sales and revenues), and contributing to Gross Domestic Product (GDP).	Analysts evaluated the economic impacts of the RBD project using IMPLAN input-output economic modeling software. The IMPLAN software evaluates the relationships between employment, labor income, economic output, and value added to GDP in three ways: 1) direct impacts, which include industries directly related to project implementation; 2) indirect impacts for industries that support those which are directly impacted; and 3), induced impacts, or benefits created through employee spending.	**Present Value of Benefits: $2,442,500**	**3** The software estimates such impacts through multipliers and social accounting matrices; thus, the economic benefits of project implementation cannot be counted toward the Project's BCR. Nevertheless, it is important to identify the employment and economic benefits of resiliency projects to the Bridgeport economy.

APPENDIX B

Benefit Cost Analysis Crosswalk

BCA Narrative Requirements	Location
A description of the process undertaken to prepare the BCA.	
If prepared by a professional technical writer or grant writer in a consulting or contract capacity, please explain how the grantee staff was involved, particularly in preparing or evaluating benefits and costs.	Explanation of the BCA development is provided in the BCA Summary Report, Section 1.2 Benefit Cost Analysis Process Overview, page 1-5.
A description of the proposed, funded project including functionally- or geographically- related elements and estimated useful life.	
What are the key project objectives?	Key project objectives are provided in the BCA Summary Report, Section 1.1.2 Project Objectives, page 1-2.
How is the project specifically designed to address the community's recovery needs and current and future risks and vulnerabilities?	The BCA Summary Report, Section 1.1.4 Project Description, page 1-4 provides detail regarding the community's needs and how these needs will be addressed.
If applicable, what are the geographic boundaries of the project (including any related activities) and/or the area it is designed to serve?	The geographic boundaries are described in the BCA Summary Report, Section 1.1.1 Project Location, page 1-2.
What are the main components of the project plan and how do they interact? What links or supports them?	The main project components and links are described in the BCA Summary Report, Section 1.1.4 Project Description, page 1-4.
Describe how any anticipated changes to local policies, including, but not limited to local zoning/land use or building codes, will address the community's recovery need and/or risks and vulnerabilities, including economic effects.	It is anticipated the installation of this project will encourage the implementation of updated local policies, building codes, and zoning regulations. Refer to the BCA Methodology Report, Section 2 Rebuild by Design Pilot Project, page 2-1.
What is the timeline for completion and/or term of the full proposed project and each component, if applicable?	The major milestones of the RBD project and an understanding of the timeline can be found in the BCA Methodology Report, Section 2.1 Project Timeline, page 2-2.
What is the estimated useful life of the project?	Estimated useful life of the project is provided in the BCA Summary Report, Section 1.1.4.1 Project Useful Life, page 1-5.
Are alternative discount rates used in addition to the 7% base-case discount rate? If so, provide a justification based on the nature of the project as described above.	Discount rate descriptions and explanations are included in BCA Methodology Report, Section 5.2 Discount Rates, page 5-1.
Full project cost, including federal, State, local, and private funding; expected operations and maintenance costs; and other functionally-related costs.	
Full project cost, including federal, State, local, and private funding; expected operations and maintenance costs; and other functionally-related costs.	Project costs, included operations and maintenance, over the life of the project are provided in the BCA Summary Report, Section 3.2 Costs, page 3-2.
A description of the current situation and the problem to be solved (including anticipated changes over the analysis period).	
What are the existing flood, wind, fire, earthquake, climate change or other risks and vulnerabilities in your project area?	The major risks to the project area are described in the BCA Summary Report, Section 2 Risk Context, page 2-1.
What risks is the project designed to reduce?	Descriptions of specific risks to be reduced by the RBD project are included in the BCA Summary Report, Sections 2 Risk Context, page 2-1. A full project description is provided in the BCA Summary Report, Section 1.1.4 Project Description, page 1-4.
What are the existing social conditions/challenges in your area and what populations are vulnerable to the disaster impacts and risks identified above? Are any of these vulnerable populations disproportionately lower income or minority?	Existing social conditions/challenges are discussed in the BCA Summary Report, Section 2.3 Existing Social and Economic Conditions, page 2-3.
How do trends in land-use, housing development and affordability, and/or employment affect disaster recovery or vulnerability to the risks identified above?	Existing social conditions/challenges are discussed in the BCA Summary Report, Section 2.3 Existing Social and Economic Conditions, page 2-3.
A description of the risks to your community if the project and any land use, zoning or building code changes are not implemented, including costs that might be avoided if a disaster similar to Hurricane Sandy struck again.	
What would realistically happen now, in 5 years, in 20 and 50 years if this project is not implemented?	Predictions of the 5-, 20-, and 50-year outcomes are included in the BCA Summary Report, Section 6 No Action Alternative, page 6-1.
What would be the impact on the community as a whole and any vulnerable lower income populations identified above, in particular, if the RBD project is not implemented?	Impacts of inaction are described in the BCA Summary Report, Section 6 No Action Alternative, page 6-1.
For RBD projects with multiple components, are there additive impacts or benefits that will not be realized if this project is not done?	Impacts of inaction are described in the BCA Summary Report, Section 6 No Action Alternative, page 6-1.
Are there any areas of concentrated poverty that will remain adversely affected if the RBD project is not implemented?	Social impacts of inaction are discussed in the BCA Summary Report, Section 6 No Action Alternative, page 6-1.
Estimate the costs that might be avoided if a disaster similar to Hurricane Sandy occurred in the same area, accounting for how development may proceed differently depending on whether the RBD project is implemented.	Cost estimates of inaction are given in the BCA Summary Report, Section 6 No Action Alternative, page 6-2.

A list of the benefits and costs of the RBD project and the rationale for including each, using categories provided.	
Costs	
Lifecycle costs/Project/Investment costs	BCA Summary Report, Section 3.2 Costs, page 3-2. See BCA Methodology Report, Appendix D for detailed cost estimates.
Operations and maintenance costs	
Resiliency Value	
Reduction of expected property damages due to future/repeat disasters	Estimated project resiliency benefits are given in the BCA Summary Report, Section 3.1 Benefits, page 3-1. Full methodologies of these benefits are described in the BCA Methodology Report, Section 3 Resiliency Benefits, page 3-1. Qualitative benefits are also described in the BCA Summary Report, Section 4 Qualitative Benefits, page 4-1.
Reduction of expected casualties from future/repeat disasters	
Value of reduced displacement caused by future/repeat disasters	
Reduced vulnerability of energy and water infrastructure to large- scale outages	
Value of protection from disruptive non-disaster events, such as nuisance flooding	
Environmental Value	
Ecosystem and bio diversity effects	Estimated project environmental benefits are given in the BCA Summary Report, Section 3.1 Benefits, page 3-1. Full methodologies of these benefits are described in the BCA Methodology Report, Section 4.2 Environmental Benefits, page 4-7. Qualitative benefits are also described in the BCA Summary Report, Section 4 Qualitative Benefits, page 4-1.
Reduced energy use	
Noise levels	
Climate change– Reduced Greenhouse Gas emissions	
Air Quality–Reduced criteria pollutants (nitrogen dioxide (NO2), ozone (03), sulfur dioxide (SO2) and particulate matter of aerodynamic diameter of the micrometers or fewer (PM-10)	
Water quality– reduced stormwater runoff	
Social Value	
Reductions in human suffering (lives lost, illness from exposure to environmental contamination, asthma and cancer rates in low-income and minority populations living in areas with greater environmental risk)	Estimated project social benefits are given in the BCA Summary Report, Section 3.1 Benefits, page 3-1. Social benefit methodologies are described in the BCA Methodology Report, Section 4.1 Social Benefits, page 4-3. Qualitative benefits are also described in the BCA Summary Report, Section 4 Qualitative Benefits, page 4-1.
Benefit to low- and moderate-income persons and/or households	
Improved living environment (such as elimination of slum and blight conditions, improved community identity and social cohesion, improved recreational value, greater access to cultural, historic, improved recreational value, greater access to cultural, historic, archaeological sites and landscapes, equal access to resilient community assets)	
Greater housing affordability	
Economic Revitalization Benefits	
Direct effects on local or regional economy (e.g., tourism revenue) net of opportunity costs	Estimated economic benefits are given in the BCA Summary Report, Section 3.1 Benefits, page 3-1. Methodologies are described in the BCA Methodology Report, Section 4.3 Economic Revitalization, page 4-10. Qualitative benefits are also described in the BCA Summary Report, Section 4 Qualitative Benefits, page 4-1.
A description of risks to ongoing benefits from the proposed project	
What are the key risks and uncertainties that may affect the RBD project and how do those risks affect the positive and negative effects of the project? Especially risks resulting from climate change and the cost of loss of function or service provided by the project, if applicable.	Risks to the project are described in the BCA Summary Report, Section 7.1 Risks to Project Benefits, page 7-1.
How well can the RBD project be adapted in case any of these risks occur?	Project adaptability is discussed in the BCA Summary Report, Section 7.1 Risks to Project Benefits, page 7-1.
An assessment of challenges faced with implementing the RBD project	
Are there any political or stakeholder risks that could affect the project's implementation schedule?	Potential challenges to project implementation are discussed in detail in the BCA Summary Report, Section 7.2 Potential Challenges to Project Implementation, page 7-1.
What are the technical risks to this project	
What are the procedural (legal) risks to this project?	
Can the grantee demonstrate broad community support for the project? Are there any political and/or stakeholder issues? Have environmental groups serving low-income and minority populations been included in project planning and alternative development?	

APPENDIX C

Depth Damage Functions

BCA Structure Depth Damage Functions

Description		DDF No.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	-0.5	0	0.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Min	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%	10.0%	16.0%	23.0%	39.0%	45.5%	52.0%	55.5%	59.0%	56.4%	64.0%	71.6%	79.1%	86.7%	94.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Most Likely	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	16.0%	25.0%	35.0%	43.0%	51.5%	60.0%	64.0%	68.0%	64.5%	72.2%	80.0%	87.7%	95.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Max	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.0%	22.0%	38.0%	45.0%	60.0%	67.5%	75.0%	80.0%	85.0%	81.8%	91.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Min	4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	5.0%	25.0%	37.5%	43.8%	50.0%	42.30%	51.76%	61.22%	70.68%	80.14%	89.60%	99.06%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Most Likely	5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%	25.0%	37.5%	90.0%	95.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Max	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	10.0%	21.3%	32.5%	65.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Min	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	7.5%	25.0%	47.5%	61.3%	75.0%	82.5%	90.0%	82.0%	94.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Most Likely	8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	42.5%	60.0%	80.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Max	9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.8%	27.5%	55.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Min	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	7.0%	10.0%	18.0%	19.0%	20.0%	27.5%	35.0%	35.0%	35.0%	35.0%	36%	40%	43%	47%	50%	54%	58%	61%	65%	68%
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Most Likely	11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	8.0%	20.0%	28.0%	28.0%	33.0%	38.0%	42.0%	46.0%	47.3%	48.7%	50.0%	52%	56%	60%	64%	68%	72%	77%	81%	85%	89%
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Max	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0%	12.0%	25.0%	29.0%	30.0%	37.0%	44.0%	47.0%	50.0%	53.3%	56.7%	60.0%										
2 Commerical, Engineered, Inundation Damage	Min	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	12.0%	18.0%	28.0%	30.5%	33.0%	38.0%	43.0%	44.7%	46.3%	48.0%										
2 Commerical, Engineered, Inundation Damage	Most Likely	14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	10.0%	20.0%	30.0%	35.0%	37.5%	40.0%	46.5%	53.0%	54.7%	56.3%	58.0%										
2 Commerical, Engineered, Inundation Damage	Max	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.0%	17.0%	27.0%	36.0%	43.0%	45.5%	48.0%	54.0%	60.0%	63.0%	66.0%	69.0%										
2 Commerical, Engineered, Wave Damage	Min	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	5.0%	13.0%	25.0%	32.5%	40.0%	44.0%	48.0%	50.3%	52.7%	55.0%										
2 Commerical, Engineered, Wave Damage	Most Likely	17	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	9.0%	20.0%	33.0%	44.0%	55.0%	60.0%	65.0%	70.7%	76.3%	82.0%										
2 Commerical, Engineered, Wave Damage	Max	18	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	10.5%	20.0%	30.0%	50.0%	60.0%	70.0%	75.5%	81.0%	84.0%	87.0%	90.0%										
3 Commerical, Non/Pre-Engineered, Inundation Damage	Min	19	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	10.0%	15.0%	20.0%	24.0%	28.0%	31.5%	35.0%	36.7%	38.3%	40.0%										
3 Commerical, Non/Pre-Engineered, Inundation Damage	Most Likely	20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	12.0%	20.0%	28.0%	35.0%	40.0%	45.0%	50.0%	55.0%	56.7%	58.3%	60.0%										
3 Commerical, Non/Pre-Engineered, Inundation Damage	Max	21	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	15.0%	20.0%	30.0%	42.0%	55.0%	60.0%	65.0%	70.0%	75.0%	76.0%	77.0%	78.0%										
3 Commerical, Non/Pre-Engineered, Wave Damage	Min	22	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	2.5%	9.0%	25.0%	35.0%	45.0%	47.5%	50.0%	55.0%	60.0%	65.0%										
3 Commerical, Non/Pre-Engineered, Wave Damage	Most Likely	23	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	12.5%	30.0%	49.0%	62.0%	75.0%	87.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
3 Commerical, Non/Pre-Engineered, Wave Damage	Max	24	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.3%	24.5%	50.0%	80.0%	87.5%	95.0%	97.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
4A - Urban High Rise, Inundation Damage	Min	25	0.0%	0.0%	0.0%	0.2%	0.3%	0.5%	1.1%	1.8%	2.6%	3.5%	3.5%	5.5%	6.8%	8.0%	8.8%	9.5%	9.9%	10.3%	10.9%	11.5%	11.8%	12.2%	12.5%										
4A - Urban High Rise, Inundation Damage	Most Likely	26	0.0%	0.0%	0.0%	2.2%	4.3%	6.5%	7.8%	9.0%	11.0%	13.0%	13.3%	13.8%	14.3%	15.5%	17.5%	19.0%	20.3%	21.5%	22.0%	22.5%	22.8%	23.2%	23.5%										
4A - Urban High Rise, Inundation Damage	Max	27	0.0%	0.0%	0.0%	3.3%	6.7%	10.0%	11.3%	12.5%	14.3%	16.0%	17.8%	18.5%	19.3%	20.0%	22.5%	24.0%	24.5%	25.0%	25.3%	25.5%	25.8%	26.2%	26.5%										
4B - Beach High Rise, Inundation Damage	Min	28	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	2.0%	3.5%	4.5%	5.0%	5.5%	6.0%	6.5%	6.8%	7.2%	7.5%										
4B - Beach High Rise, Inundation Damage	Most Likely	29	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	4.5%	7.0%	7.8%	9.6%	11.5%	12.1%	12.8%	14.0%	15.3%	16.5%										
4B - Beach High Rise, Inundation Damage	Max	30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	7.5%	12.0%	14.0%	14.5%	15.0%	16.1%	17.3%	18.2%	19.1%	20.0%										
4B - Beach High Rise, Wave Damage	Min	31	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	1.8%	2.5%	3.3%	3.9%	4.5%	4.8%	5.0%	5.0%	5.0%	5.0%										
4B - Beach High Rise, Wave Damage	Most Likely	32	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	1.5%	3.3%	5.0%	7.5%	11.0%	12.5%	14.0%	15.0%	16.0%	17.2%	18.3%	19.5%										
4B - Beach High Rise, Wave Damage	Max	33	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	2.5%	6.3%	10.0%	13.5%	17.0%	19.3%	21.5%	24.3%	27.0%	28.3%	29.7%	31.0%										
5A Single Story Residence, No Basement, Inundation Damage	Min	34	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	10.0%	16.0%	20.0%	25.0%	30.0%	36.0%	42.0%	46.3%	50.7%	55.0%										
5A Single Story Residence, No Basement, Inundation Damage	Most Likely	35	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	10.0%	18.0%	28.0%	33.0%	37.5%	42.0%	48.5%	55.0%	58.3%	61.7%	65.0%										
5A Single Story Residence, No Basement, Inundation Damage	Max	36	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	10.0%	20.0%	30.0%	40.0%	45.0%	52.5%	60.0%	77.0%	94.0%	96.0%	98.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
5A Single Story Residence, No Basement, Wave Damage	Min	37	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	20.0%	30.0%	40.0%	55.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%										
5A Single Story Residence, No Basement, Wave Damage	Most Likely	38	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.0%	30.0%	50.0%	90.0%	95.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
5A Single Story Residence, No Basement, Wave Damage	Max	39	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	21.3%	32.5%	65.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Min	40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	5.0%	10.0%	15.0%	30.0%	50.0%	65.0%	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%										
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Most Likely	41	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	7.5%	10.0%	25.0%	40.0%	70.0%	90.0%	95.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Max	42	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	15.0%	20.0%	39.0%	58.0%	94.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
5B Two-Story Residence, No Basement, Inundation Damage	Min	43	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	9.0%	15.0%	20.0%	22.5%	25.0%	32.5%	40.0%	43.3%	46.7%	50.0%										
5B Two-Story Residence, No Basement, Inundation Damage	Most Likely	44	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	5.0%	10.0%	15.0%	20.0%	25.0%	27.5%	30.0%	40.0%	50.0%	53.3%	56.7%	60.0%										
5B Two-Story Residence, No Basement, Inundation Damage	Max	45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	3.0%	8.0%	10.0%	20.0%	25.0%	30.0%	35.0%	40.0%	47.5%	55.0%	60.0%	65.0%	70.0%										
5B Two-Story Residence, No Basement, Wave Damage	Min	46	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	5.0%	7.5%	10.0%	30.0%	40.0%	50.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%										
5B Two-Story Residence, No Basement, Wave Damage	Most Likely	47	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	15.0%	20.0%	28.0%	36.0%	50.0%	86.0%	93.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
5B Two-Story Residence, No Basement, Wave Damage	Max	48	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	15.0%	20.0%	25.0%	37.5%	50.0%	60.0%	94.0%	97.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
6A Single Story Residence, With Basement, Inundation Damage	Min	49	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	2.0%	3.0%	4.0%	5.0%	10.0%	15.0%	25.0%	30.0%	40.0%	50.0%	57.0%	64.0%	71.0%	78.0%	85.0%										
6A Single Story Residence, With Basement, Inundation Damage	Most Likely	50	0.0%	0.0%	1.0%	1.7%	2.3%	3.0%	4.0%	5.0%	7.5%	10.0%	12.0%	18.0%	30.0%	30.0%	35.0%	40.0%	55.0%	70.0%	80.0%	90.0%	91.7%	93.3%	95.0%										
6A Single Story Residence, With Basement, Inundation Damage	Max	51	0.0%	0.0%	2.0%	4.7%	7.3%	10.0%	12.5%	15.0%	16.5%	18.0%	21.0%	30.0%	35.0%	43.0%	50.0%	55.0%	69.5%	84.0%	89.0%	94.0%	96.0%	98.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
6A Single Story Residence, With Basement, Wave Damage	Min	52	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	7.0%	10.0%	12.5%	15.0%	48.0%	60.0%	77.0%	94.0%	94.0%	94.0%	94.0%	94.0%	94.0%										
6A Single Story Residence, With Basement, Wave Damage	Most Likely	53	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	10.0%	15.0%	20.0%	27.5%	35.0%	60.0%	88.0%	94.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
6A Single Story Residence, With Basement, Wave Damage	Max	54	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	15.0%	24.5%	34.0%	44.0%	54.0%	75.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
6B Two-Story Residence, With Basement, Inundation Damage	Min	55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	2.0%	3.0%	4.0%	5.0%	7.0%	15.0%	17.0%	27.0%	33.5%	40.0%	45.0%	50.0%	54.0%	58.0%	62.0%										
6B Two-Story Residence, With Basement, Inundation Damage	Most Likely	56	0.0%	0.0%	0.0%	1.0%	2.0%	3.0%	5.0%	7.0%	8.5%	10.0%	12.0%	15.0%	20.0%	25.0%	30.0%	35.0%	42.5%	50.0%	55.0%	60.0%	63.3%	66.7%	70.0%										
6B Two-Story Residence, With Basement, Inundation Damage	Max	57	0.0%	0.0%	3.0%	4.7%	6.3%	8.0%	9.0%	10.0%	12.5%	15.0%	17.0%	20.0%	30.0%	30.0%	35.0%	40.0%	47.5%	55.0%	60.0%	65.0%	70.0%	75.0%	80.0%										
6B Two-Story Residence, With Basement, Wave Damage	Min	58	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	7.0%	10.0%	12.5%	15.0%	35.0%	60.0%	65.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%										
6B Two-Story Residence, With Basement, Wave Damage	Most Likely	59	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	10.0%	15.0%	20.0%	27.5%	35.0%	60.0%	80.0%	90.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
6B Two-Story Residence, With Basement, Wave Damage	Max	60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	18.0%	26.0%	34.0%	44.0%	54.0%	80.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7A Building on Open Pile Foundation, Inundation Damage	Min	61	0.0%	0.0%	0.0%	0.3%	0.7%	1.0%	1.5%	2.0%	2.0%	2.0%	6.0%	7.0%	12.0%	30.0%	35.0%	40.0%	45.0%	50.0%	55.0%	60.0%	67.3%	74.7%	82.0%										
7A Building on Open Pile Foundation, Inundation Damage	Most Likely	62	0.0%	0.0%	0.0%	0.7%	1.3%	2.0%	3.0%	4.0%	8.0%	12.0%	16.0%	20.0%	28.0%	35.0%	40.0%	60.0%	65.0%	70.0%	75.0%	80.0%	86.7%	93.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7A Building on Open Pile Foundation, Inundation Damage	Max	63	0.0%	0.0%	2.0%	4.7%	7.3%	10.0%	11.0%	12.0%	16.0%	20.0%	25.0%	32.0%	35.0%	55.0%	70.0%	80.0%	90.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7A Building on Open Pile Foundation, Wave Damage	Min	64	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	5.0%	12.5%	20.0%	30.0%	40.0%	80.0%	90.0%	95.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7A Building on Open Pile Foundation, Wave Damage	Most Likely	65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	4.0%	7.0%	10.0%	30.0%	50.0%	60.0%	70.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7A Building on Open Pile Foundation, Wave Damage	Max	66	0.0%	0.0%	0.0%	0.7%	1.3%	2.0%	3.5%	5.0%	17.5%	30.0%	52.5%	75.0%	87.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7B Building on Pile Foundation with Enclosures, Inundation Damage	Min	67	0.0%	0.0%	0.0%	0.3%	0.7%	1.0%	1.5%	2.0%	2.0%	2.0%	6.0%	7.0%	12.0%	30.0%	35.0%	40.0%	45.0%	50.0%	55.0%	60.0%	67.3%	74.7%	82.0%										
7B Building on Pile Foundation with Enclosures, Inundation Damage	Most Likely	68	0.0%	0.0%	0.0%	0.7%	1.3%	2.0%	3.0%	4.0%	8.0%	12.0%	16.0%	20.0%	28.0%	35.0%	40.0%	60.0%	65.0%	70.0%	75.0%	80.0%	86.7%	93.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7B Building on Pile Foundation with Enclosures, Inundation Damage	Max	69	0.0%	0.0%	2.0%	4.7%	7.3%	10.0%	11.0%	12.0%	16.0%	20.0%	25.0%	32.0%	35.0%	55.0%	70.0%	80.0%	90.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7B Building on Pile Foundation with Enclosures, Wave Damage	Min	70	0.0%	0.0%	0.0%	0.7%	1.3%	2.0%	2.0%	2.0%	11.0%	20.0%	22.5%	25.0%	42.5%	60.0%	85.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7B Building on Pile Foundation with Enclosures, Wave Damage	Most Likely	71	0.0%	0.0%	0.0%	2.0%	4.0%	6.0%	10.0%	14.0%	27.0%	40.0%	50.0%	60.0%	72.5%	85.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7B Building on Pile Foundation with Enclosures, Wave Damage	Max	72	0.0%	0.0%	0.0%	3.3%	6.7%	10.0%	15.0%	20.0%	40.0%	60.0%	67.5%	75.0%	87.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Resilient Bridgeport Benefit Cost Analysis Methodology Report, Appendix C: Depth Damage Functions
BCA Content Depth Damage Functions

Description		DDF No.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	-0.5	0	0.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Min	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	10.00%	16.00%	23.00%	39.00%	45.50%	52.00%	55.50%	59.00%	59.00%	59.00%	59.00%										
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Most Likely	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.00%	16.00%	25.00%	35.00%	43.00%	51.50%	60.00%	64.00%	68.00%	68.00%	68.00%	68.00%										
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Max	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.00%	22.00%	38.00%	45.00%	60.00%	67.50%	75.00%	80.00%	85.00%	85.00%	85.00%	85.00%										
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Min	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.75%	17.50%	30.00%	50.00%	60.75%	71.50%	71.50%	71.50%	71.50%	71.50%	71.50%										
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Most Likely	5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.75%	3.50%	16.75%	30.00%	50.00%	90.00%	95.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Max	6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	10.00%	23.75%	37.50%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Min	7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.75%	7.50%	25.00%	47.50%	61.25%	75.00%	82.50%	90.00%	90.00%	90.00%	90.00%										
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Most Likely	8	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.00%	20.00%	42.50%	60.00%	80.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Max	9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.75%	27.50%	55.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Min	10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	5.00%	8.00%	15.00%	20.00%	22.50%	25.00%	27.50%	30.00%	32.3%	34.7%	37%										
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Most Likely	11	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%	10.00%	15.00%	20.00%	25.00%	27.50%	30.00%	32.50%	35.00%	38.3%	41.7%	45%										
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Max	12	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.00%	15.00%	20.00%	25.00%	30.00%	31.00%	32.00%	36.00%	40.00%	43.3%	46.7%	50%										
2 Commerical, Engineered, Inundation Damage - Perishable	Min	13	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	17.00%	28.00%	37.00%	40.00%	43.00%	46.50%	50.00%	50.0%	50.0%	50%										
2 Commerical, Engineered, Inundation Damage - Perishable	Most Likely	14	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	18.00%	35.00%	39.00%	43.00%	45.00%	47.00%	58.50%	70.00%	71.7%	73.3%	75%										
2 Commerical, Engineered, Inundation Damage - Perishable	Max	15	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.00%	28.00%	50.00%	58.00%	65.00%	65.00%	65.00%	77.50%	90.00%	90.0%	90.0%	90%										
2 Commerical, Engineered, Inundation Damage - Non Perishable	Min	16	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.00%	10.00%	22.00%	27.00%	30.00%	33.00%	38.50%	44.00%	45.3%	46.7%	48%										
2 Commerical, Engineered, Inundation Damage - Non Perishable	Most Likely	17	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%	10.00%	13.00%	28.00%	37.00%	40.50%	44.00%	47.00%	50.00%	51.7%	53.3%	55%										
2 Commerical, Engineered, Inundation Damage - Non Perishable	Max	18	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	15.00%	22.00%	35.00%	44.00%	47.00%	50.00%	52.50%	55.00%	60.0%	65.0%	70%										
2 Commerical, Engineered, Wave Damage - Perishable	Min	19	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	10.00%	23.00%	33.00%	38.00%	43.00%	46.50%	50.00%	50.0%	50.0%	50%										
2 Commerical, Engineered, Wave Damage - Perishable	Most Likely	20	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.50%	3.00%	10.50%	18.00%	30.00%	41.00%	58.00%	75.00%	85.00%	95.00%	95.0%	95.0%	95%										
2 Commerical, Engineered, Wave Damage - Perishable	Max	21	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.00%	8.00%	18.00%	28.00%	45.00%	70.00%	85.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2 Commerical, Engineered, Wave Damage - Non -Perishable	Min	22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.50%	9.00%	11.00%	23.00%	29.00%	35.00%	42.50%	50.00%	50.0%	50.0%	50%										
2 Commerical, Engineered, Wave Damage - Non -Perishable	Most Likely	23	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	2.00%	7.00%	12.00%	23.00%	36.00%	47.00%	58.00%	61.50%	65.00%	69.0%	73.0%	77%										
2 Commerical, Engineered, Wave Damage - Non -Perishable	Max	24	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.50%	5.00%	14.00%	23.00%	29.00%	55.00%	77.50%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3 Commerical, Non/Pre-Engineered, Inundation Damage - Perishable	Min	25	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	9.00%	15.00%	23.00%	26.50%	30.00%	32.50%	35.00%	37.0%	39.0%	41%										
3 Commerical, Non/Pre-Engineered, Inundation Damage - Perishable	Most Likely	26	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%	15.00%	30.00%	42.00%	64.00%	67.50%	71.00%	75.50%	80.00%	82.3%	84.7%	87%										
3 Commerical, Non/Pre-Engineered, Inundation Damage - Perishable	Max	27	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.00%	35.00%	54.00%	65.00%	84.00%	89.50%	95.00%	97.00%	99.00%	99.3%	99.7%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3 Commerical, Non/Pre-Engineered, Inundation Damage - Non-Perishable	Min	28	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	7.00%	13.00%	20.00%	25.00%	30.00%	35.00%	40.00%	41.7%	43.3%	45%										
3 Commerical, Non/Pre-Engineered, Inundation Damage - Non-Perishable	Most Likely	29	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	8.00%	12.00%	18.00%	25.00%	32.00%	39.00%	44.50%	50.00%	53.3%	56.7%	60%										
3 Commerical, Non/Pre-Engineered, Inundation Damage - Non-Perishable	Max	30	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.00%	18.00%	28.00%	38.00%	49.00%	56.50%	64.00%	68.00%	72.00%	78.0%	84.0%	90%										
3 Commerical, Non/Pre-Engineered, Wave Damage - Perishable	Min	31	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	10.00%	20.00%	32.50%	41.25%	50.00%	60.00%	70.00%	73.3%	76.7%	80%										
3 Commerical, Non/Pre-Engineered, Wave Damage - Perishable	Most Likely	32	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%	2.50%	11.25%	20.00%	40.00%	60.00%	77.50%	95.00%	97.50%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3 Commerical, Non/Pre-Engineered, Wave Damage - Perishable	Max	33	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.75%	7.50%	21.25%	35.00%	61.00%	95.00%	97.50%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3 Commerical, Non/Pre-Engineered, Wave Damage - Non-Perishable	Min	34	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.75%	7.50%	12.50%	29.00%	34.50%	40.00%	52.50%	65.00%	69.2%	73.3%	78%										
3 Commerical, Non/Pre-Engineered, Wave Damage - Non-Perishable	Most Likely	35	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.25%	2.50%	12.25%	22.00%	27.50%	45.00%	57.50%	70.00%	85.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3 Commerical, Non/Pre-Engineered, Wave Damage - Non-Perishable	Max	36	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.25%	6.50%	18.25%	30.00%	45.00%	90.00%	95.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
4A - Urban High Rise, Inundation Damage	Min	37	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.50%	2.60%	4.00%	5.50%	6.00%	6.50%	7.25%	8.00%	8.3%	8.7%	9.00%										
4A - Urban High Rise, Inundation Damage	Most Likely	38	0.00%	0.00%	0.00%	0.1%	0.2%	0.25%	0.25%	0.25%	0.38%	0.50%	1.50%	4.00%	5.00%	5.00%	7.00%	7.50%	8.75%	10.00%	10.50%	11.00%	11.3%	11.7%	12.00%										
4A - Urban High Rise, Inundation Damage	Max	39	0.00%	0.00%	0.00%	0.2%	0.3%	0.50%	0.88%	1.25%	1.88%	2.50%	3.50%	5.00%	6.00%	8.00%	11.00%	13.50%	14.75%	16.00%	18.00%	20.00%	20.0%	20.0%	20.00%										
4B - Beach High Rise, Inundation Damage	Min	40	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.50%	1.00%	1.50%	2.00%	2.00%	2.00%	2.00%	2.00%	2.2%	2.3%	2.5%										
4B - Beach High Rise, Inundation Damage	Most Likely	41	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.00%	4.00%	4.50%	5.50%	6.25%	7.00%	7.75%	8.50%	8.7%	8.8%	9.0%										
4B - Beach High Rise, Inundation Damage	Max	42	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.50%	5.00%	5.50%	6.50%	8.00%	8.75%	9.50%	9.75%	10.00%	10.0%	10.0%	10.0%										
4B - Beach High Rise, Wave Damage	Min	43	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%	1.25%	1.75%	2.00%	2.00%	2.00%	2.00%	2.00%	2.5%	3.0%	3.5%										
4B - Beach High Rise, Wave Damage	Most Likely	44	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%	1.25%	1.88%	2.50%	5.00%	6.00%	7.00%	8.00%	8.00%	8.00%	8.3%	8.7%	9.0%										
4B - Beach High Rise, Wave Damage	Max	45	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	2.00%	3.50%	5.00%	6.00%	9.00%	9.50%	10.00%	10.00%	10.00%	10.3%	10.7%	11.0%										
5A Single Story Residence, No Basement, Inundation Damage	Min	46	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	18.00%	34.00%	60.00%	70.00%	80.00%	90.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
5A Single Story Residence, No Basement, Inundation Damage	Most Likely	47	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	20.00%	40.00%	60.00%	80.00%	85.00%	90.00%	95.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
5A Single Story Residence, No Basement, Inundation Damage	Max	48	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	30.00%	60.00%	84.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
5A Single Story Residence, No Basement, Wave Damage	Min	49	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.50%	15.00%	35.00%	50.00%	55.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%										
5A Single Story Residence, No Basement, Wave Damage	Most Likely	50	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	20.00%	40.00%	60.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5A Single Story Residence, No Basement, Wave Damage	Max	51	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	25.00%	50.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Min	52	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.50%	5.00%	8.50%	12.00%	40.00%	50.00%	62.50%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%										
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Most Likely	53	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	10.00%	20.00%	30.00%	60.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Max	54	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	15.00%	25.00%	42.50%	60.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5B Two-Story Residence, No Basement, Inundation Damage	Min	55	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	15.00%	25.00%	32.00%	36.00%	40.00%	45.00%	50.00%	53.3%	56.7%	60%										
5B Two-Story Residence, No Basement, Inundation Damage	Most Likely	68	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	12.00%	25.00%	35.00%	45.00%	50.00%	55.00%	62.50%	70.00%	73.3%	76.7%	80%										
5B Two-Story Residence, No Basement, Inundation Damage	Max	57	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	8.00%	20.00%	30.00%	40.00%	60.00%	70.00%	80.00%	90.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
5B Two-Story Residence, No Basement, Wave Damage	Min	58	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.50%	5.00%	10.00%	15.00%	30.00%	40.00%	57.50%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%										
5B Two-Story Residence, No Basement, Wave Damage	Most Likely	59	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	12.50%	20.00%	27.50%	35.00%	45.00%	94.00%	97.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5B Two-Story Residence, No Basement, Wave Damage	Max	60	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	12.00%	18.50%	25.00%	32.50%	40.00%	70.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
6A Single Story Residence, With Basement, Inundation Damage	Min	61	0.00%	0.00%	0.00%	1.0%	2.0%	3.00%	4.00%	5.00%	5.00%	5.00%	5.00%	10.00%	15.00%	30.00%	52.00%	66.00%	73.00%	80.00%	90.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6A Single Story Residence, With Basement, Inundation Damage	Most Likely	62	0.00%	0.00%	0.00%	1.0%	2.0%	3.00%	4.00%	5.00%	10.00%	15.00%	15.00%	15.00%	30.00%	45.00%	64.00%	80.00%	90.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6A Single Story Residence, With Basement, Inundation Damage	Max	63	0.00%	0.00%	5.00%	8.0%	11.0%	14.00%	19.50%	25.00%	27.50%	30.00%	40.00%	48.00%	60.00%	80.00%	90.00%	97.00%	98.50%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6A Single Story Residence, With Basement, Wave Damage	Min	64	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	10.00%	15.00%	20.00%	50.00%	60.00%	80.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
6A Single Story Residence, With Basement, Wave Damage	Most Likely	65	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.00%	25.00%	35.00%	42.50%	50.00%	80.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
6A Single Story Residence, With Basement, Wave Damage	Max	66	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	28.00%	36.00%	44.00%	59.00%	74.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
6B Two-Story Residence, With Basement, Inundation Damage	Min	67	0.00%	0.00%	0.00%	0.7%	1.3%	2.00%	3.50%	5.00%	5.00%	5.00%	5.00%	10.00%	15.00%	20.00%	30.00%	40.00%	45.00%	50.00%	55.00%	60.00%	64.0%	68.0%	72%										
6B Two-Story Residence, With Basement, Inundation Damage	Most Likely	56	0.00%	0.00%	0.00%	1.0%	2.0%	3.00%	4.00%	5.00%	10.00%	15.00%	15.00%	20.00%	30.00%	35.00%	40.00%	50.00%	55.00%	60.00%	65.00%	70.00%	76.7%	83.3%	90%										
6B Two-Story Residence, With Basement, Inundation Damage	Max	69	0.00%	0.00%	2.00%	4.7%	7.3%	10.00%	17.50%	25.00%	25.00%	25.00%	28.00%	34.00%	40.00%	50.00%	60.00%	70.00%	71.00%	72.00%	81.00%	90.00%	93.3%	96.7%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6B Two-Story Residence, With Basement, Wave Damage	Min	70	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%	10.00%	17.50%	25.00%	50.00%	60.00%	72.50%	85.00%	85.00%	85.00%	85.00%	85.00%	85.00%										
6B Two-Story Residence, With Basement, Wave Damage	Most Likely	71	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	12.00%	23.50%	35.00%	45.00%	55.00%	75.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
6B Two-Story Residence, With Basement, Wave Damage	Max	72	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.00%	25.00%	34.50%	44.00%	62.00%	80.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
7A Building on Open Pile Foundation, Inundation Damage	Min	73	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	5.00%	15.00%	30.00%	50.00%	60.00%	77.00%	94.00%	97.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7A Building on Open Pile Foundation, Inundation Damage	Most Likely	74	0.00%	0.00%	0.00%	0.3%	0.7%	1.00%	1.00%	1.00%	1.00%	1.00%	5.00%	10.00%	25.00%	40.00%	50.00%	80.00%	89.00%	98.00%	99.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7A Building on Open Pile Foundation, Inundation Damage	Max	75	0.00%	0.00%	0.00%	0.3%	0.7%	1.00%	1.00%	1.00%	3.00%	5.00%	10.00%	17.00%	30.00%	50.00%	75.00%	90.00%	95.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7A Building on Open Pile Foundation, Wave Damage	Min	76	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.50%	3.00%	4.00%	5.00%	12.50%	20.00%	30.00%	40.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
7A Building on Open Pile Foundation, Wave Damage	Most Likely	77	0.00%	0.00%	0.00%	1.7%	3.3%	5.00%	5.00%	5.00%	12.50%	20.00%	35.00%	50.00%	62.50%	75.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

BCA Content Depth Damage Functions

Description		DDF No.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	-0.5	0	0.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7A Building on Open Pile Foundation, Wave Damage	Max	78	0.00%	0.00%	0.00%	2.7%	5.3%	8.00%	9.00%	10.00%	25.00%	40.00%	57.50%	75.00%	87.50%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
7B Building on Pile Foundation with Enclosures, Inundation Damage	Min	79	0.00%	0.00%	0.00%	0.3%	0.7%	1.00%	1.00%	1.00%	1.50%	2.00%	5.00%	5.00%	15.00%	35.00%	60.00%	70.00%	80.00%	90.00%	95.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7B Building on Pile Foundation with Enclosures, Inundation Damage	Most Likely	80	0.00%	0.00%	0.00%	1.3%	2.7%	4.00%	5.50%	7.00%	9.00%	11.00%	20.00%	20.00%	30.00%	40.00%	75.00%	85.00%	92.50%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7B Building on Pile Foundation with Enclosures, Inundation Damage	Max	81	0.00%	0.00%	0.00%	2.7%	5.3%	8.00%	9.00%	10.00%	15.00%	20.00%	40.00%	50.00%	65.00%	75.00%	80.00%	90.00%	95.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7B Building on Pile Foundation with Enclosures, Wave Damage	Min	82	0.00%	0.00%	0.00%	0.7%	1.3%	2.00%	3.50%	5.00%	6.50%	8.00%	16.50%	25.00%	32.50%	40.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
7B Building on Pile Foundation with Enclosures, Wave Damage	Most Likely	83	0.00%	0.00%	0.00%	1.7%	3.3%	5.00%	7.50%	10.00%	25.00%	40.00%	45.00%	50.00%	62.50%	75.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
7B Building on Pile Foundation with Enclosures, Wave Damage	Max	84	0.00%	0.00%	5.00%	6.7%	8.3%	10.00%	15.00%	20.00%	40.00%	60.00%	67.50%	75.00%	87.50%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

BCA Displacement Depth Damage Functions

Description		DDF No.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Min	1	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Most Likely	2	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A1 Apartments - 1 Story, No Basement, Inundation Damage	Max	3	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Min	4	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Most Likely	5	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-1 Apartments - 1 Story, No Basement, Wave Damage	Max	6	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Min	7	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Most Likely	8	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-1 Apartments - 1 Story, No Basement, Wave Damage - Extended Foundation Wall	Max	9	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Min	10	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Most Likely	11	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
1A-3 Apartments - 3 Story, No Basement, Inundation Damage	Max	12	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Inundation Damage - Perishable	Min	13	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Inundation Damage - Perishable	Most Likely	14	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Inundation Damage - Perishable	Max	15	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Inundation Damage - Non Perishable	Min	16	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Inundation Damage - Non Perishable	Most Likely	17	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Inundation Damage - Non Perishable	Max	18	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Wave Damage - Perishable	Min	19	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Wave Damage - Perishable	Most Likely	20	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Wave Damage - Perishable	Max	21	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Wave Damage - Non -Perishable	Min	22	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Wave Damage - Non -Perishable	Most Likely	23	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
2 Commerical, Engineered, Wave Damage - Non -Perishable	Max	24	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Inundation Damage - Perishable	Min	25	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Inundation Damage - Perishable	Most Likely	26	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Inundation Damage - Perishable	Max	27	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Inundation Damage - Non-Perishable	Min	28	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Inundation Damage - Non-Perishable	Most Likely	29	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Inundation Damage - Non-Perishable	Max	30	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Wave Damage - Perishable	Min	31	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Wave Damage - Perishable	Most Likely	32	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Wave Damage - Perishable	Max	33	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Wave Damage - Non-Perishable	Min	34	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Wave Damage - Non-Perishable	Most Likely	35	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
3 Commerical, Non/Pre-Engineered, Wave Damage - Non-Perishable	Max	36	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4A - Urban High Rise, Inundation Damage	Min	37	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4A - Urban High Rise, Inundation Damage	Most Likely	38	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4A - Urban High Rise, Inundation Damage	Max	39	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4B - Beach High Rise, Inundation Damage	Min	40	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4B - Beach High Rise, Inundation Damage	Most Likely	41	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4B - Beach High Rise, Inundation Damage	Max	42	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4B - Beach High Rise, Wave Damage	Min	43	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4B - Beach High Rise, Wave Damage	Most Likely	44	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
4B - Beach High Rise, Wave Damage	Max	45	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	450	450	450	450	450	450	450	450	450	450
5A Single Story Residence, No Basement, Inundation Damage	Min	46	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Inundation Damage	Most Likely	47	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Inundation Damage	Max	48	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Wave Damage	Min	49	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Wave Damage	Most Likely	50	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Wave Damage	Max	51	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Min	52	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Most Likely	53	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5A Single Story Residence, No Basement, Wave Damage- Extended Foundation Wall	Max	54	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5B Two-Story Residence, No Basement, Inundation Damage	Min	55	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5B Two-Story Residence, No Basement, Inundation Damage	Most Likely	68	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5B Two-Story Residence, No Basement, Inundation Damage	Max	57	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5B Two-Story Residence, No Basement, Wave Damage	Min	58	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5B Two-Story Residence, No Basement, Wave Damage	Most Likely	59	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
5B Two-Story Residence, No Basement, Wave Damage	Max	60	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6A Single Story Residence, With Basement, Inundation Damage	Min	61	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6A Single Story Residence, With Basement, Inundation Damage	Most Likely	62	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6A Single Story Residence, With Basement, Inundation Damage	Max	63	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720

BCA Displacement Depth Damage Functions

Description		DDF No.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6A Single Story Residence, With Basement, Wave Damage	Min	64	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6A Single Story Residence, With Basement, Wave Damage	Most Likely	65	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6A Single Story Residence, With Basement, Wave Damage	Max	66	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6B Two-Story Residence, With Basement, Inundation Damage	Min	67	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6B Two-Story Residence, With Basement, Inundation Damage	Most Likely	56	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6B Two-Story Residence, With Basement, Inundation Damage	Max	69	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6B Two-Story Residence, With Basement, Wave Damage	Min	70	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6B Two-Story Residence, With Basement, Wave Damage	Most Likely	71	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
6B Two-Story Residence, With Basement, Wave Damage	Max	72	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7A Building on Open Pile Foundation, Inundation Damage	Min	73	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7A Building on Open Pile Foundation, Inundation Damage	Most Likely	74	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7A Building on Open Pile Foundation, Inundation Damage	Max	75	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7A Building on Open Pile Foundation, Wave Damage	Min	76	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7A Building on Open Pile Foundation, Wave Damage	Most Likely	77	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7A Building on Open Pile Foundation, Wave Damage	Max	78	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7B Building on Pile Foundation with Enclosures, Inundation Damage	Min	79	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7B Building on Pile Foundation with Enclosures, Inundation Damage	Most Likely	80	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7B Building on Pile Foundation with Enclosures, Inundation Damage	Max	81	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7B Building on Pile Foundation with Enclosures, Wave Damage	Min	82	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7B Building on Pile Foundation with Enclosures, Wave Damage	Most Likely	83	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720
7B Building on Pile Foundation with Enclosures, Wave Damage	Max	84	0	0	0	0	0	0	0	0	0	0	0	45	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	720	720	720	720

APPENDIX D

Rebuild by Design Pilot Project Cost Estimates

Rebuild By Design Project

Bridgeport, CT

Cost Estimate

Summary of All Project Costs

Date: March 17, 2017

Compiled by: SMC

Checked by: RCS

Description	Cost	Cost per LF
Johnson Street Extension	$ 599,700	$ 2,670
24" RCP	$ 166,100	$ 240
16" Force Main	$ 177,600	$ 200

Cost of Work	**$ 943,400.00**	**$ 3,110.00**
Design Contingency (35%)	$ 330,190.00	$ 1,088.50
General Requirements (20%)	$ 188,680.00	$ 622.00
Overhead and Profit (15%)	$ 141,510.00	$ 466.50
Escalation (3%)	$ 28,302.00	$ 93.30
Mobilization	$ 50,000.00	$ -
Maintenance of Traffic	$ 87,500.00	$ -
Pump	$ 2,100,000.00	$ -
Total	**$ 3,869,582.00**	**$ 5,380.30**

Assumptions

- Assumes no contaminated materials disposal
- Assumes normal daytime work hours
- Assumes no temporary security fencing or lighting required
- Assumes adjacent electrical supply for pump station with tap in to system at the pump.
    - No electrical work to connect to power source off site.
- Assumes no unknown buried utilities or relocation of existing utilities

Rebuild By Design Project

Bridgeport, CT

Cost Estimate

Project Component: Johnson Street Extension
Date: March 17, 2017
Compiled by: SMC
Checked by: RCS

JOHNSON STREET EXTENSION						
Description	**Unit**	**Qty**	**Unit Cost**	**Adjusted Unit Cost**	**Cost**	**Cost per LF**
		Rounded Subtotal =			**$ 348,900**	**$ 390**
Earthwork - fill	CY	10759.00	$ 2.32	$ 2.54	$ 27,307.20	$ 30.34
Earthwork - grading	SY	4400.00	$ 0.72	$ 0.79	$ 3,465.79	$ 3.85
Earthwork - hauling	LCY	8868.33	$ 5.96	$ 6.52	$ 57,823.66	$ 64.25
Base Material	CY	733.33	$ 5.92	$ 6.48	$ 4,749.42	$ 5.28
Asphalt Pavement	SY	1100.00	$ 75.00	$ 75.00	$ 82,500.00	$ 91.67
Concrete Formwork - Sidewalk	LF	4480.00	$ 2.77	$ 3.03	$ 13,576.10	$ 15.08
Curb - straight (including forms)	LF	900.00	$ 10.62	$ 11.62	$ 10,456.45	$ 11.62
Curb - radius (including forms)	LF	188.50	$ 17.40	$ 19.04	$ 3,588.13	$ 3.99
Sidewalk	SF	14400.00	$ 2.35	$ 2.57	$ 37,020.96	$ 41.13
Curb Ramps	EA	4.00	$ 5,000.00	$ 5,470.00	$ 21,880.00	$ 24.31
Driveways	SF	600.00	$ 4.85	$ 5.31	$ 3,183.54	$ 3.54
Inlets	EA	8.00	$ 3,000.00	$ 3,000.00	$ 24,000.00	$ 26.67
Electrical Service Extension	LF	900.00	$ 25.00	$ 25.00	$ 22,500.00	$ 25.00
Street Lighting - Pole	EA	10.00	$ 1,861.00	$ 2,035.93	$ 20,359.34	$ 22.62
Street Lighting - Bracket Arm	EA	10.00	$ 238.00	$ 260.37	$ 2,603.72	$ 2.89
Street Lighting - Luminaire	EA	10.00	$ 1,018.00	$ 1,113.69	$ 11,136.92	$ 12.37
Pavement Markings	LF	4600.00	$ 0.53	$ 0.58	$ 2,667.17	$ 2.96

COLUMBIA STREET AND INTERSECTION						
Description	**Unit**	**Qty**	**Unit Cost**	**Adjusted Unit Cost**	**Cost**	**Cost per LF**
		Rounded Subtotal =			**$ 250,800**	**$ 2,280**
Earthwork - fill	CY	483.00	$ 2.32	$ 2.54	$ 1,225.89	$ 11.14
Earthwork - grading	SY	140030.00	$ 0.72	$ 0.79	$ 110,298.83	$ 1,002.72
Earthwork - hauling	LCY	529.85	$ 5.96	$ 6.52	$ 3,454.76	$ 31.41
Base Material	CY	1265.00	$ 5.92	$ 6.48	$ 8,192.75	$ 74.48
Asphalt Pavement	SY	281.11	$ 75.00	$ 75.00	$ 21,083.33	$ 191.67
Concrete Formwork - Sidewalk	LF	578.00	$ 2.77	$ 3.03	$ 1,751.56	$ 15.92
Curb - straight (including forms)	LF	220.00	$ 10.62	$ 11.62	$ 2,556.02	$ 23.24
Sidewalk	SF	1540.00	$ 2.35	$ 2.57	$ 3,959.19	$ 35.99
Driveways	SF	400.00	$ 4.85	$ 5.31	$ 2,122.36	$ 19.29
Inlets	EA	3.00	$ 3,000.00	$ 3,000.00	$ 9,000.00	$ 81.82
Hydrants and water utilities	LS	1.00	$ 80,000.00	$ 80,000.00	$ 80,000.00	$ 727.27
Street Lighting - Pole	EA	2.00	$ 1,861.00	$ 2,035.93	$ 4,071.87	$ 37.02
Street Lighting - Bracket Arm	EA	2.00	$ 238.00	$ 260.37	$ 520.74	$ 4.73
Street Lighting - Luminaire	EA	2.00	$ 1,018.00	$ 1,113.69	$ 2,227.38	$ 20.25
Pavement Markings	LF	440.00	$ 0.53	$ 0.58	$ 255.12	$ 2.32

Cost of Work		**$ 599,538.22**	**$ 2,666.85**
Design Contigency	35.00%	$ 209,838.38	$ 933.40
General Requirements	20.00%	$ 119,907.64	$ 533.37
Overhead and Profit	15.00%	$ 89,930.73	$ 400.03
Escalation	3.00%	$ 17,986.15	$ 80.01
Total		**$ 1,037,201.13**	**$ 4,613.65**

Rebuild By Design Project

Bridgeport, CT

Cost Estimate

Project Component: 24" RCP Installation
Date: March 17, 2017
Compiled by: SMC
Checked by: RCS

24" RCP INSTALLATION						
Description	**Unit**	**Qty**	**Unit Cost**	**Adjusted Unit Cost**	**Cost**	**Cost per LF**
		Rounded Subtotal =			**$ 166,100**	**$ 240**
Excavation	CY	2333.33	$ 6.12	$ 6.70	$ 15,622.32	$ 22.32
Trench Shoring	SF	12600.00	$ 7.91	$ 8.65	$ 109,034.60	$ 155.76
24" RCP	LF	700.00	$ 44.90	$ 49.12	$ 34,384.42	$ 49.12
Fill and Compact	CY	2251.88	$ 2.84	$ 3.11	$ 6,996.52	$ 10.00

Cost of Work		**$ 166,037.86**	**$ 237.20**
Design Contigency	35.00%	$ 58,113.25	$ 83.02
General Requirements	20.00%	$ 33,207.57	$ 47.44
Overhead and Profit	15.00%	$ 24,905.68	$ 35.58
Escalation	3.00%	$ 4,981.14	$ 7.12
Total		**$ 287,245.50**	**$ 410.35**

Rebuild By Design Project

Bridgeport, CT

Cost Estimate

Project Component: 16" Force Main Installation

Date: March 17, 2017

Compiled by: SMC

Checked by: RCS

16" FORCE MAIN INSTALLATION										
Description	Unit	Qty	Unit Cost		Adjusted Unit Cost		Cost		Cost per LF	
		Rounded Subtotal =					**$**	**177,600**	**$**	**200**
16" Force Main	LF	900.00	$	85.39	$	93.42	$	84,074.99	$	93.42
Valves and fittings for force main	LS	1.00	$	75,000.00	$	75,000.00	$	75,000.00	$	83.33
Sidewalk	SF	7200.00	$	2.35	$	2.57	$	18,510.48	$	20.57

Cost of Work		**$**	**177,585.47**	**$**	**197.32**
Design Contigency	35.00%	$	62,154.92	$	69.06
General Requirements	20.00%	$	35,517.09	$	39.46
Overhead and Profit	15.00%	$	26,637.82	$	29.60
Escalation	3.00%	$	5,327.56	$	5.92
Total		**$**	**307,222.87**	**$**	**341.36**

APPENDIX E

Occupancy Mapping

Land Use Code	Description	Hazus Occupancy Code	DDF Category	Occ Mapping	Stories Analysis	BRV	CSRV	CRV	BMRV	% Own Occ	1 Time Disruption Cost	None	Slight	Moderate	Extensive	Complete	Rent/SF/Year	DDF ID	HazusOcc	Output/SF/Day
101	Single Family	RES1	Urban High Rise	101H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
101	Single Family	RES1	Residential 1-Story, No Basement	101L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
101	Single Family	RES1	Residential 2-Story, No Basement	101M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
102	Two Family	RES3A	Urban High Rise	102H	10	$107.23	0.69	$73.99	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3A	0
102	Two Family	RES3A	Residential 1-Story, No Basement	102L	1	$107.23	0.69	$73.99	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	35	RES3A	0
102	Two Family	RES3A	Residential 2-Story, No Basement	102M	2	$107.23	0.69	$73.99	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	44	RES3A	0
103	Three Family	RES3B	Urban High Rise	103H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
103	Three Family	RES3B	Apartment 1-Story, No Basement	103L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3B	0
103	Three Family	RES3B	Apartment 3-Story, No Basement	103M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3B	0
104	Four Family	RES3B	Urban High Rise	104H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
104	Four Family	RES3B	Apartment 1-Story, No Basement	104L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3B	0
104	Four Family	RES3B	Apartment 3-Story, No Basement	104M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3B	0
105	Five Family	RES3C	Urban High Rise	105H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3C	0
105	Five Family	RES3C	Apartment 1-Story, No Basement	105L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3C	0
105	Five Family	RES3C	Apartment 3-Story, No Basement	105M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3C	0
106	Six Family	RES3C	Urban High Rise	106H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3C	0
106	Six Family	RES3C	Apartment 1-Story, No Basement	106L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3C	0
106	Six Family	RES3C	Apartment 3-Story, No Basement	106M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3C	0
107	SFR W/Acc. Apt	RES1	Residential 2-Story, No Basement	107M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
108	Condominium	RES1	Urban High Rise	108H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
108	Condominium	RES1	Apartment 1-Story, No Basement	108L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	2	RES1	0
108	Condominium	RES1	Apartment 3-Story, No Basement	108M	3	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	11	RES1	0
112	Res. Waterfront	RES1	Residential 1-Story, No Basement	112L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
112	Res. Waterfront	RES1	Residential 2-Story, No Basement	112M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
200	Com Mld 94	COM1	Urban High Rise	200H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
200	Com Mld 94	COM1	Commercial Engineered	200L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
200	Com Mld 94	COM1	Commercial Engineered	200M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
202	Comm WF Mdl 95	COM1	Commercial Engineered	202M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
203	Acc Comm Lnd	COM1	Urban High Rise	203H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
203	Acc Comm Lnd	COM1	Commercial Engineered	203L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
203	Acc Comm Lnd	COM1	Commercial Engineered	203M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
205	Comm Condo	COM1	Commercial Engineered	205L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
206	Comm WF Mdl 96	COM1	Commercial Engineered	206L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
215	Retail Strip/Plaza	COM1	Urban High Rise	215H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
215	Retail Strip/Plaza	COM1	Commercial Engineered	215L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
215	Retail Strip/Plaza	COM1	Commercial Engineered	215M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
217	Retail	COM1	Urban High Rise	217H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
217	Retail	COM1	Commercial Engineered	217L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
217	Retail	COM1	Commercial Engineered	217M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
218	Office	COM4	Urban High Rise	218H	10	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	26	COM4	1.2
218	Office	COM4	Commercial Engineered	218M	2	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	14	COM4	1.2
220	Professional Office	COM4	Urban High Rise	220H	10	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	26	COM4	1.2
221	Fast Food	COM8	Commercial Engineered	221L	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	26	COM8	1.29
221	Fast Food	COM8	Urban High Rise	221H	10	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	26	COM8	1.29
222	Marina/Yacht Club	COM8	Commercial Engineered	222L	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	14	COM8	1.29
222	Marina/Yacht Club	COM8	Commercial Engineered	222M	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	14	COM8	1.29
225	Com Garage Shop	COM3	Urban High Rise	225H	10	$148.21	2.36	$349.78	$38.91	55%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	COM3	0.83
225	Com Garage Shop	COM3	Commercial Engineered	225L	2	$148.21	2.36	$349.78	$38.91	55%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	COM3	0.83
225	Com Garage Shop	COM3	Commercial Engineered	225M	2	$148.21	2.36	$349.78	$38.91	55%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	COM3	0.83
228	Funeral Home	COM4	Urban High Rise	228H	10	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	26	COM4	1.2
229	Nursing Home	RES6	Urban High Rise	229H	10	$224.80	0.69	$155.11	$37.74	0%	0.97	0	0	0.5	1	1	$13.13	26	RES6	1.03
229	Nursing Home	RES6	Commercial Engineered	229M	2	$224.80	0.69	$155.11	$37.74	0%	0.97	0	0	0.5	1	1	$13.13	26	RES6	1.03
230	Restaurant/Bar	COM8	Urban High Rise	230H	10	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	26	COM8	1.29
230	Restaurant/Bar	COM8	Commercial Engineered	230L	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	14	COM8	1.29
230	Restaurant/Bar	COM8	Commercial Engineered	230M	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	14	COM8	1.29
231	Bank	COM5	Urban High Rise	231H	10	$276.60	0.54	$149.36	$38.59	75%	1.12	0.5	0.1	0.05	0.03	0.03	$10.05	26	COM5	3.9
232	Theatre	COM9	Commercial Engineered	232L	2	$195.78	0.54	$105.72	$0.00	45%	0	0.5	0.1	1	1	1	$10.05	14	COM9	1.23
237	Hotel/Motel	RES4	Urban High Rise	237H	10	$192.14	0.69	$132.57	$40.99	0%	0.97	0	0	0.5	1	1	$13.13	26	RES4	0.62
245	Gas Mart	COM1	Urban High Rise	245H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
278	Res Style Com	COM1	Urban High Rise	278H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
278	Res Style Com	COM1	Commercial Engineered	278M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
279	Telephone Bldg	COM4	Urban High Rise	279H	10	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	26	COM4	1.2
280	Mix Use Comm	COM1	Urban High Rise	280H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
280	Mix Use Comm	COM1	Commercial Engineered	280M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
282	Office/Retail	COM1	Urban High Rise	282H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
282	Office/Retail	COM1	Commercial Engineered	282M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
286	Assisted Living	RES6	Urban High Rise	286H	10	$224.80	0.69	$155.11	$37.74	0%	0.97	0	0	0.5	1	1	$13.13	26	RES6	1.03
292	Self Storage	IND2	Urban High Rise	292H	10	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	IND2	2.08

Land Use Code	Description	Hazus Occupancy Code	DDF Category	Occ Mapping	Stories Analysis	BRV	CSRV	CRV	BMRV	% Own Occ	1 Time Disruption Cost	None	Slight	Moderate	Extensive	Complete	Rent/SF/Year	DDF ID	HazusOcc	Output/SF/Day
292	Self Storage	IND2	Commercial Non-Engineered	292L	1	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	IND2	2.08
296	Com MDL 96	COM1	Urban High Rise	296H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
296	Com MDL 96	COM1	Commercial Engineered	296L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
299	Vac Comm Lnd	COM1	Urban High Rise	299H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
299	Vac Comm Lnd	COM1	Commercial Engineered	299L	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
299	Vac Comm Lnd	COM1	Commercial Engineered	299M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
300	Industrial Mdl 96	IND1	Urban High Rise	300H	10	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	26	IND1	2.08
300	Industrial Mdl 96	IND1	Commercial Non-Engineered	300L	1	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	20	IND1	2.08
300	Industrial Mdl 96	IND1	Commercial Non-Engineered	300M	1	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	20	IND1	2.08
303	Acc Ind Lnd	IND2	Commercial Non-Engineered	303M	1	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	IND2	2.08
306	Ind WF Mdl 96	IND2	Commercial Non-Engineered	306L	1	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	IND2	2.08
306	Ind WF Mdl 96	IND2	Commercial Non-Engineered	306M	1	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	IND2	2.08
325	Ind Garage/Shop	COM3	Urban High Rise	325H	10	$148.21	2.36	$349.78	$38.91	55%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	COM3	0.83
325	Ind Garage/Shop	COM3	Commercial Non-Engineered	325L	1	$148.21	2.36	$349.78	$38.91	55%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	COM3	0.83
340	Ind/Whs Mdl 96	IND2	Urban High Rise	340H	10	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	IND2	2.08
340	Ind/Whs Mdl 96	IND2	Commercial Non-Engineered	340L	1	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	IND2	2.08
340	Ind/Whs Mdl 96	IND2	Commercial Non-Engineered	340M	1	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	20	IND2	2.08
341	R+D/Indo	IND1	Urban High Rise	341H	10	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	26	IND1	2.08
341	R+D/Indo	IND1	Commercial Non-Engineered	341L	1	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	20	IND1	2.08
341	R+D/Indo	IND1	Commercial Non-Engineered	341M	1	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	20	IND1	2.08
342	Mill Building	IND2	Urban High Rise	342H	10	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	IND2	2.08
342	Mill Building	IND2	Commercial Engineered	342M	2	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	IND2	2.08
343	Manufacturing	IND1	Urban High Rise	343H	10	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	26	IND1	2.08
343	Manufacturing	IND1	Commercial Engineered	343L	2	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	14	IND1	2.08
343	Manufacturing	IND1	Commercial Engineered	343M	2	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	14	IND1	2.08
394	Com/Ind Mdl 94	IND2	Urban High Rise	394H	10	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	IND2	2.08
394	Com/Ind Mdl 94	IND2	Commercial Engineered	394M	2	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	IND2	2.08
396	Com/Ind Mdl 96	IND2	Urban High Rise	396H	10	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	26	IND2	2.08
396	Com/Ind Mdl 96	IND2	Commercial Engineered	396L	2	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	IND2	2.08
396	Com/Ind Mdl 96	IND2	Commercial Engineered	396M	2	$123.23	2.07	$255.09	$33.14	75%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	IND2	2.08
400	Pub Utility	GOV1	Urban High Rise	400H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
400	Pub Utility	GOV1	Commercial Engineered	400L	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
400	Pub Utility	GOV1	Commercial Engineered	400M	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
800	Apartment Mdl 03	RES3D	Urban High Rise	800H	10	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3D	0
800	Apartment Mdl 03	RES3D	Apartment 1-Story, No Basement	800L	1	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3D	0
800	Apartment Mdl 03	RES3D	Apartment 3-Story, No Basement	800M	3	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3D	0
801	Subsidized Apts	RES3D	Urban High Rise	801H	10	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3D	0
801	Subsidized Apts	RES3D	Commercial Engineered	801M	2	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	14	RES3D	0
814	Comm Apts	RES3E	Urban High Rise	814H	10	$191.07	0.69	$131.84	$41.94	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3E	0
814	Comm Apts	RES3E	Apartment 1-Story, No Basement	814L	1	$191.07	0.69	$131.84	$41.94	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3E	0
814	Comm Apts	RES3E	Apartment 3-Story, No Basement	814M	3	$191.07	0.69	$131.84	$41.94	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3E	0
861	Rooming House	RES4	Urban High Rise	861H	10	$192.14	0.69	$132.57	$40.99	0%	0.97	0	0	0.5	1	1	$13.13	26	RES4	0.62
861	Rooming House	RES4	Apartment 1-Story, No Basement	861L	1	$192.14	0.69	$132.57	$40.99	0%	0.97	0	0	0.5	1	1	$13.13	2	RES4	0.62
861	Rooming House	RES4	Apartment 3-Story, No Basement	861M	3	$192.14	0.69	$132.57	$40.99	0%	0.97	0	0	0.5	1	1	$13.13	11	RES4	0.62
862	Co-op	RES3B	Urban High Rise	862H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
862	Co-op	RES3B	Apartment 1-Story, No Basement	862L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3B	0
862	Co-op	RES3B	Apartment 3-Story, No Basement	862M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3B	0
863	Co-op	RES3B	Urban High Rise	863H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
863	Co-op	RES3B	Apartment 1-Story, No Basement	863L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3B	0
863	Co-op	RES3B	Apartment 3-Story, No Basement	863M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3B	0
901	USGovComBldg 94	GOV1	Urban High Rise	901H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
908	US Courthouse	GOV1	Urban High Rise	908H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
909	State Courthouse	GOV1	Urban High Rise	909H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
910	State Com Bldg 96	GOV1	Urban High Rise	910H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
911	State Com Bldg 94	GOV1	Urban High Rise	911H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
911	State Com Bldg 94	GOV1	Commercial Engineered	911L	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
911	State Com Bldg 94	GOV1	Commercial Engineered	911M	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
922	Mun Com Bldg Mdl 94	GOV1	Urban High Rise	922H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83

Land Use Code	Description	Hazus Occupancy Code	DDF Category	Occ Mapping	Stories Analysis	BRV	CSRV	CRV	BMRV	% Own Occ	1 Time Disruption Cost	None	Slight	Moderate	Extensive	Complete	Rent/SF/Year	DDF ID	HazusOcc	Output/SF/Day
922	Mun Com Bldg Mdl 94	GOV1	Commercial Engineered	922L	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
922	Mun Com Bldg Mdl 94	GOV1	Commercial Engineered	922M	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
923	Mun Com Bldg Mdl 96	GOV1	Urban High Rise	923H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
923	Mun Com Bldg Mdl 96	GOV1	Commercial Engineered	923M	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
924	Mun Res Bldg Mdl 01	GOV1	Urban High Rise	924H	10	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	GOV1	0.83
924	Mun Res Bldg Mdl 01	GOV1	Commercial Engineered	924M	2	$197.06	0.69	$135.97	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	GOV1	0.83
928	Fire Dept	GOV2	Urban High Rise	928H	10	$262.05	1.5	$393.07	$35.32	95%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV2	0.95
928	Fire Dept	GOV2	Commercial Engineered	928L	2	$262.05	1.5	$393.07	$35.32	95%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV2	0.95
929	Police Dept	GOV2	Urban High Rise	929H	10	$262.05	1.5	$393.07	$35.32	95%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV2	0.95
930	Garage/ Shop	COM3	Commercial Engineered	930M	2	$148.21	2.36	$349.78	$38.91	55%	1.12	0.5	0.1	0.2	0.3	0.4	$10.05	14	COM3	0.83
933	Public School	GOV1	Commercial Engineered	933M	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
934	Public School Mdl 94	GOV1	Urban High Rise	934H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
934	Public School Mdl 94	GOV1	Commercial Engineered	934M	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
935	Library	GOV1	Urban High Rise	935H	10	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	GOV1	0.83
935	Library	GOV1	Commercial Engineered	935L	2	$157.02	0.55	$86.36	$35.43	70%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	GOV1	0.83
937	Mun Recr Bldg	COM8	Urban High Rise	937H	10	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	26	COM8	1.29
937	Mun Recr Bldg	COM8	Commercial Non-Engineered	937L	1	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	20	COM8	1.29
937	Mun Recr Bldg	COM8	Commercial Non-Engineered	937M	1	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	20	COM8	1.29
941	Hsng Auth 1 Family	RES1	Urban High Rise	941H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
941	Hsng Auth 1 Family	RES1	Residential 1-Story, No Basement	941L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
941	Hsng Auth 1 Family	RES1	Residential 2-Story, No Basement	941M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
942	Hsng Auth 2 Family	RES3A	Urban High Rise	942H	10	$107.23	0.69	$73.99	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3A	0
942	Hsng Auth 2 Family	RES3A	Residential 2-Story, No Basement	942M	2	$107.23	0.69	$73.99	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	44	RES3A	0
943	Hsng Auth 3 Family	RES3B	Urban High Rise	943H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
943	Hsng Auth 3 Family	RES3B	Residential 2-Story, No Basement	943M	2	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
944	Hsng Auth 4 Family	RES3B	Residential 2-Story, No Basement	944M	2	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
944	Hsng Auth 4 Family	RES3B	Urban High Rise	944H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3B	0
947	Hsng Auth Apts Mdl 03	RES3C	Urban High Rise	947H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3C	0
948	Hsng Auth Apts Mdl 94	RES3C	Urban High Rise	948H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3C	0
948	Hsng Auth Apts Mdl 94	RES3C	6B Two-Story Residence, With Basement, Inundation Damage	948L	2	$130.34	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	56	RES3C	0
948	Hsng Auth Apts Mdl 94	RES3C	6B Two-Story Residence, With Basement, Inundation Damage	948M	2	$130.34	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	56	RES3C	0
950	Hospital	COM6	Commercial Engineered	950M	2	$394.26	0.54	$212.90	$40.60	95%	1.61	0.5	0.1	0.5	0.5	0.5	$10.05	14	COM6	1.03
955	Religious Mdl 96	REL1	Urban High Rise	955H	10	$197.03	0.55	$108.36	$39.79	90%	1.12	1	0.2	0.05	0.03	0.03	$10.05	26	REL1	2.06
955	Religious Mdl 96	REL1	Commercial Engineered	955L	2	$197.03	0.55	$108.36	$39.79	90%	1.12	1	0.2	0.05	0.03	0.03	$10.05	14	REL1	2.06
955	Religious Mdl 96	REL1	Commercial Engineered	955M	2	$197.03	0.55	$108.36	$39.79	90%	1.12	1	0.2	0.05	0.03	0.03	$10.05	14	REL1	2.06
957	Religious Hse	RES1	Urban High Rise	957H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
957	Religious Hse	RES1	Residential 1-Story, No Basement	957L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
957	Religious Hse	RES1	Residential 2-Story, No Basement	957M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
958	Religious Mdl 94	REL1	Urban High Rise	958H	10	$197.03	0.55	$108.36	$39.79	90%	1.12	1	0.2	0.05	0.03	0.03	$10.05	26	REL1	2.06
958	Religious Mdl 94	REL1	Commercial Engineered	958L	2	$197.03	0.55	$108.36	$39.79	90%	1.12	1	0.2	0.05	0.03	0.03	$10.05	14	REL1	2.06
958	Religious Mdl 94	REL1	Commercial Engineered	958M	2	$197.03	0.55	$108.36	$39.79	90%	1.12	1	0.2	0.05	0.03	0.03	$10.05	14	REL1	2.06
959	Religious School	EDU1	Urban High Rise	959H	10	$210.99	1	$210.99	$39.02	95%	1.12	0.5	0.1	0.02	0.05	0.05	$10.05	26	EDU1	0
959	Religious School	EDU1	Commercial Engineered	959L	2	$210.99	1	$210.99	$39.02	95%	1.12	0.5	0.1	0.02	0.05	0.05	$10.05	14	EDU1	0
959	Religious School	EDU1	Commercial Engineered	959M	2	$210.99	1	$210.99	$39.02	95%	1.12	0.5	0.1	0.02	0.05	0.05	$10.05	14	EDU1	0
961	Pvt School	EDU1	Urban High Rise	961H	10	$210.99	1	$210.99	$39.02	95%	1.12	0.5	0.1	0.02	0.05	0.05	$10.05	26	EDU1	0
961	Pvt School	EDU1	Commercial Engineered	961L	2	$210.99	1	$210.99	$39.02	95%	1.12	0.5	0.1	0.02	0.05	0.05	$10.05	14	EDU1	0
961	Pvt School	EDU1	Commercial Engineered	961M	2	$210.99	1	$210.99	$39.02	95%	1.12	0.5	0.1	0.02	0.05	0.05	$10.05	14	EDU1	0
962	Pvt School Res	RES5	Urban High Rise	962H	10	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	26	RES5	0
962	Pvt School Res	RES5	Apartment 1-Story, No Basement	962L	1	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	2	RES5	0
962	Pvt School Res	RES5	Apartment 3-Story, No Basement	962M	3	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	11	RES5	0
963	Pvt College Classrm	EDU2	Urban High Rise	963H	10	$185.28	1	$185.28	$41.42	90%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	26	EDU2	0
963	Pvt College Classrm	EDU2	Commercial Engineered	963M	2	$185.28	1	$185.28	$41.42	90%	1.12	0.5	0.1	0.02	0.03	0.03	$10.05	14	EDU2	0
964	Pvt College Offices	COM4	Urban High Rise	964H	10	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	26	COM4	1.2
964	Pvt College Offices	COM4	Commercial Engineered	964M	2	$183.48	0.54	$99.08	$44.91	55%	1.12	0.5	0.1	0.1	0.2	0.3	$10.05	14	COM4	1.2
965	Pvt College Dorms	RES5	Urban High Rise	965H	10	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	26	RES5	0
965	Pvt College Dorms	RES5	Apartment 1-Story, No Basement	965L	1	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	2	RES5	0
965	Pvt College Dorms	RES5	Apartment 3-Story, No Basement	965M	3	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	11	RES5	0
966	Pvt College Res	RES5	Urban High Rise	966H	10	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	26	RES5	0
966	Pvt College Res	RES5	Apartment 1-Story, No Basement	966L	1	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	2	RES5	0
966	Pvt College Res	RES5	Apartment 3-Story, No Basement	966M	3	$220.99	0.69	$152.49	$41.44	0%	0.97	0	0	0.5	1	1	$13.13	11	RES5	0
967	Pvt College Rec Fac	COM8	Urban High Rise	967H	10	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	26	COM8	1.29
967	Pvt College Rec Fac	COM8	Commercial Engineered	967L	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	14	COM8	1.29
967	Pvt College Rec Fac	COM8	Commercial Engineered	967M	2	$233.01	1.7	$396.13	$40.33	55%	0	0.5	0.1	1	1	1	$10.05	14	COM8	1.29
977	Charitable Bldg	RES1	Urban High Rise	977H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
977	Charitable Bldg	RES1	Residential 1-Story, No Basement	977L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
977	Charitable Bldg	RES1	Residential 2-Story, No Basement	977M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
979	Charitable Bldg	RES1	Urban High Rise	979H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
979	Charitable Bldg	RES1	Residential 2-Story, No Basement	979M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
981	Non-Profit Bldg	COM1	Urban High Rise	981H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
982	Non-Profit Res	RES1	Urban High Rise	982H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0

Structure Mapping and Coding

Land Use Code	Description	Hazus Occupancy Code	DDF Category	Occ Mapping	Stories Analysis	BRV	CSRV	CRV	BMRV	% Own Occ	1 Time Disruption Cost	None	Slight	Moderate	Extensive	Complete	Rent/SF/Year	DDF ID	HazusOcc	Output/SF/Day
982	Non-Profit Res	RES1	Commercial Engineered	982M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	14	RES1	0
983	Charitable Bldg Res	RES1	Urban High Rise	983H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
983	Charitable Bldg Res	RES1	Residential 1-Story, No Basement	983L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
983	Charitable Bldg Res	RES1	Residential 2-Story, No Basement	983M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
985	Hsng Auth Condo	RES3C	Urban High Rise	985H	10	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	26	RES3C	0
985	Hsng Auth Condo	RES3C	Apartment 1-Story, No Basement	985L	1	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	2	RES3C	0
985	Hsng Auth Condo	RES3C	Apartment 3-Story, No Basement	985M	3	$206.99	0.69	$142.82	$41.89	35%	0.97	0	0	0.5	1	1	$13.13	11	RES3C	0
993	Exempt Bldg Res	RES1	Urban High Rise	993H	10	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	26	RES1	0
993	Exempt Bldg Res	RES1	Residential 1-Story, No Basement	993L	1	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	35	RES1	0
993	Exempt Bldg Res	RES1	Residential 2-Story, No Basement	993M	2	$130.34	0.69	$89.93	$19.19	75%	0.97	0	0	0.5	1	1	$13.13	44	RES1	0
995	Condo Main	COM1	Urban High Rise	995H	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
995	Condo Main	COM1	Commercial Engineered	995M	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	14	COM1	0.54
200I	Com MDL 96	COM1	Urban High Rise	200IH	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
200I	Com MDL 96	COM1	Commercial Engineered	200IM	2	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
200R	Com Res Mdl	COM1	Urban High Rise	200RH	10	$127.17	1.19	$151.33	$29.27	55%	1.29	0.5	0.1	0.1	0.3	0.4	$10.05	26	COM1	0.54
300C	Industrial Mdl 94	IND1	Urban High Rise	300CH	10	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	26	IND1	2.08
300C	Industrial Mdl 96	IND1	Commercial Non-Engineered	300CL	1	$140.17	2.07	$290.16	$36.13	75%	0	0.5	0.5	1	1	1	$10.05	20	IND1	2.08

APPENDIX F

Additional Benefit Cost Analysis Resources

Federal Emergency Management Agency Value for Ecosystem Services of Green Open Space

FEMA Value for Ecosystem Services of Green Open Space

Ecosystem Service	Study Name	Year	Authors Name	Study Location	Valuation Method	Value per Acre per year (2011)	Value per Square Foot per year (2011)	Value per Acre per year (2015)	Value per Square Foot per year (2015)
Regulating									
Climate Regulation	Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services / Economic Valuation ofSoil Functions Phase 1: Literature Review and Method Development	2008 / 2006	Wilson, S.J. / Harris, D., Crabtree, B., Newell-Price, P.	Ontario, Canada and Global Estimates	Avoided Cost	$13.19	$0.000	$13.99	$0.00
Water Retention/Flood Hazard Reduction	The Economic Benefits of Seattle's Park and Recreation System / The Economic Benefits and Fiscal Impact of Parks and Open Space in Nassau and Suffolk Counties, New York	2011 / 2010	Trust for Public Land	Seattle and two counties in New York State	Avoided Cost	$293.02	$0.007	$310.87	$0.01
Air Quality	Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services / Estimating Cost Effectiveness of Residential Yard Trees for Improving Air Quality in Sacramento, California / The Economic Benefits of Seattle's Park and Recreation System	2006 / 1998 / 2011	Wilson. S.J. / McPherson, E.G., Scott, K.I., Simpson, J.R. / Trust for Public Land	Southern Ontario / Urban Sacramento / Urban Seattle	Avoided Cost	$204.47	$0.005	$216.92	$0.00
Supporting									
Pollination	Economic and Environmental Benefits of Biodiversity	1997	Pimentel D., Wilson, C., McCullum, C., Huang, R., Dwen, P., Flack, J., Tran, Q., Saltman, T., Cliff, B.	National Average	Market Price	$290.08	$0.007	$307.75	$0.01
Erosion Control	Environmental and Economic Costs of Soil Erosion and Conservation Benefits	1995	Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., Blair, R.	U.S. National Estimates	Avoided Cost	$64.88	$0.001	$68.83	$0.00
Cultural									

FEMA Value for Ecosystem Services of Green Open Space

Ecosystem Service	Study Name	Year	Authors Name	Study Location	Valuation Method	Value per Acre per year (2011)	Value per Square Foot per year (2011)	Value per Acre per year (2015)	Value per Square Foot per year (2015)
Recreation/Tourism	Measuring Amenity Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation / Using Contingent Valuation to Estimate a Neighborhood's Willingness to Pay to Preserve Undeveloped Rural Land	1997 / 1997	Ready, R.C., Berger, M.C. / Breffle, W.S., Morey, E.R., Lodder, T.S.	Kentucky Farmland (average of all counties) and Boulder, Colorado	Contingent Valuation and Hedonic Pricing	$5,365.26	$0.123	$5,692.01	$0.13
Aesthetic Values	Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed / The Impact of Open Spaces on Property Values in Portland, Oregon	2006 / 2000	Qiu, Z., Prato, T., Boehm, G. ./ Bolitzer, B., Netusil, N.R.	Rural and Urban Missouri (North of St. Louis) / Urban Portland, Oregon	Hedonic Pricing	$1,622.37	$0.037	$1,721.17	$0.04
Total						**$7,853.27**	**$0.180**	**$8,331.54**	**$0.19**

Federal Emergency Management Agency Value for Relocation, Displacement, and Business Interruption

14.2.8 Relocation Expenses

Relocation expenses in the HAZUS Flood Model are estimated in a manner consistent with the current earthquake model. In the HAZUS99 & HAZUS-MH earthquake model, relocation expenses represent disruption costs to building owners for selected occupancies. These include all occupancies except entertainment (COM8), theatres (COM9), parking facilities (COM10) and heavy industry (IND1). Expenses include "… disruption costs that include the cost of shifting and transferring, and the rental of temporary space". These costs are assumed to be incurred once the building reaches a damage threshold of 10% (beyond damage state "slight" in the earthquake model). Below that threshold, it is assumed unlikely that the occupants will not need to relocate. Relocation losses will be estimated as follows:

$$REL_i = \sum_j \text{ If } \%DAM\text{-}BL_{i,j} > 10\%\text{: } Fa_{i,j} * \begin{bmatrix} (1-\%OO_i)*(DC_i) + \\ \%OO_i*(DC_i + RENT_i * RT_{i,j}) \end{bmatrix} \tag{14-6}$$

where:

REL_i	=	relocation costs for occupancy class i (i = 1-13 and 18-28)
$Fa_{i,j}$	=	floor area of occupancy group i and depth j (in square feet)
$\%DAM\text{-}BL_{i,j}$	=	percent building damage for occupancy i and water depth j (from depth-damage function), ***if greater than 10%.***
Dc_i	=	disruption costs for occupancy i ($\$/ft^2$, column 6 in Table 14.9)
$RT_{i,j}$	=	recovery time (in days) for occupancy i and water depth j (See Table 14.11 for preliminary flood restoration time estimates)
$\%OO_i$	=	percent owner occupied for occupancy i (HAZUS99 Technical Manual Table 15.14, reprinted here as Table 14.10)
$RENT_i$	=	rental cost ($\$/ft^2/day$) for occupancy i (column 5 in Table 14.9)

It should be noted that the default values for rental costs and disruption costs provided in Table 14.9, have been updated from the original development year of 1994 to the year 2006 baseline using CPI scaling, as discussed in Section 14.3.7.

Table 14.10 Rental Costs and Disruption Costs

No.	Label	Occupancy Class	Rental Cost (2006)		Disruption Costs (2006)
			($/ft^2/month)	($/ft^2/day)	($/ft^2)
Residential					
1	RES1	Single-family Dwelling	0.68	0.02	0.82
2	RES2	Mobile Home	0.48	0.02	0.82
3	RES3A	Multi-family Dwelling; Duplex	0.61	0.02	0.82
4	RES3B	Multi-family Dwelling;	0.61	0.02	0.82
5	RES3C	Multi-family Dwelling; 5 - 9 units	0.61	0.02	0.82
6	RES3D	Multi-family Dwelling; 10 - 19 units	0.61	0.02	0.82
7	RES3E	Multi-family Dwelling; 20 - 49 units	0.61	0.02	0.82
8	RES3F	Multi-family Dwelling; 50+ units	0.61	0.02	0.82
9	RES4	Temporary Lodging	2.04	0.07	0.82
10	RES5	Institutional Dormitory	0.41	0.01	0.82
11	RES6	Nursing Home	0.75	0.03	0.82
Commercial					
12	COM1	Retail Trade	1.16	0.04	1.09
13	COM2	Wholesale Trade	0.48	0.02	0.95
14	COM3	Personal and Repair Services	1.36	0.05	0.95
15	COM4	Professional/Technical/ Business	1.36	0.05	0.95
16	COM5	Banks	1.70	0.06	0.95
17	COM6	Hospital	1.36	0.05	1.36
18	COM7	Medial Office/Clinic	1.36	0.05	1.36
19	COM8	Entertainment & Recreation	1.70	0.06	0.00
20	COM9	Theaters	1.70	0.06	0.00
21	COM10	Parking	0.34	0.01	0.00
Industrial					
22	IND1	Heavy	0.20	0.01	0.00
23	IND2	Light	0.27	0.01	0.95
24	IND3	Food/Drugs/Chemicals	0.27	0.01	0.95
25	IND4	Metals/Minerals Processing	0.20	0.01	0.95
26	IND5	High Technology	0.34	0.01	0.95
27	IND6	Construction	0.14	0.00	0.95
Agriculture					
28	AGR1	Agriculture	0.68	0.02	0.68
Religion/Non-Profit					
29	REL1	Church/Membership Organization	1.02	0.03	0.95
Government					
30	GOV1	General Services	1.36	0.05	0.95
31	GOV2	Emergency Response	1.36	0.05	0.95
Education					
32	EDU1	Schools/Libraries	1.02	0.03	0.95
33	EDU2	Colleges/Universities	1.36	0.05	0.95

Table 14.11 Percent Owned Occupied
(ref: NIBS/FEMA HAZUS Technical Manual, Table 15.14)

No.	Label	Occupancy Class	Percent Owner Occupied
Residential			
1	RES1	Single-family Dwelling	75
2	RES2	Mobile Home	85
3	RES3	Multi-family Dwelling	35
4	RES4	Temporary Lodging	0
5	RES5	Institutional Dormitory	0
6	RES6	Nursing Home	0
Commercial			
7	COM1	Retail Trade	55
8	COM2	Wholesale Trade	55
9	COM3	Personal and Repair Services	55
10	COM4	Professional/Technical/ Business Services	55
11	COM5	Banks	75
12	COM6	Hospital	95
13	COM7	Medial Office/Clinic	65
14	COM8	Entertainment & Recreation	55
15	COM9	Theaters	45
16	COM10	Parking	25
Industrial			
17	IND1	Heavy	75
18	IND2	Light	75
19	IND3	Food/Drugs/Chemicals	75
20	IND4	Metals/Minerals Processing	75
21	IND5	High Technology	55
22	IND6	Construction	85
Agriculture			
23	AGR1	Agriculture	95
Religion/Non-Profit			
24	REL1	Church/Membership Organization	90
Government			
25	GOV1	General Services	70
26	GOV2	Emergency Response	95
Education			
27	EDU1	Schools/Libraries	95
28	EDU2	Colleges/Universities	90

14.2.9 Loss of Income

Income-related losses are time-dependent; the losses will depend on the amount of time required to restore business operations. Restoration times include time for physical restoration of the damage to the building, as well as time for clean-up, time required for inspections, permits and the approval process, as well as delays due to contractor availability.

Earthquake damage restoration and flood damage restoration differ in a variety of ways, including:

- Damage due to flooding is likely to be widespread throughout the inundated area; earthquakes will cause differing degrees of damage to structures located within the same area.

- In an earthquake, inventory that does not break can be picked up and sold. Flooded-damaged inventory is usually a total loss.

- An earthquake-damaged business may be able to re-open quickly with undamaged inventory in a new location (e.g., alternate space, parking lot) in parallel with clean up. A flood-damaged business is less likely to re-open during clean up, in particular, re-opening may depend on resupply of inventory.

Because flood damage is fundamentally different than earthquake damage, a flood-specific restoration time model has been developed. The project team has developed draft estimates of required restoration time by occupancy, assumed to vary with flood depth. Here, flood depths are generally examined in increments of four feet, to coincide with likely physical repair strategies. For example, once inundation has exceeded the finished floor and damaged the lower portion of the wall, a sheet of 4x8 dry wall will be laid horizontally to replace the damaged wallboard. The proposed restoration model is provided in Table 14.11 on the following page, and includes restoration time required for physical building restoration, as well as additional time required for clean-up, permitting, contractor availability, and potential hazardous materials issues. (This table corresponds to the existing HAZUS earthquake Table 15.11, Building Recovery Time).

It should be noted that restoration times increase with depth, until the building has reached the 50% damage threshold, beyond which the building is considered a total loss. Once a building reaches 50% damage, it is assumed that the building will be demolished and re-built. For structures, outside the 100-year floodplain, reconstruction can be accomplished at the same site, and will require 18 months; 12 months for physical construction, plus 6 months for damage determination, permits, approvals, etc. If the structure is located within the 100-year floodplain, reconstruction to the original configuration at the same location will not be allowed, and the building is a potential buy-out candidate. Associated political considerations are assumed to add an additional 6-month delay to the reconstruction process, bringing the total time estimate to 24 months.

Future model development will include an assessment as to whether Interruption time multipliers (reduction factors), similar to those used in the earthquake model (Table 15.12 – Building and Service Interruption Time Modifiers), are applicable to flood. For consideration in this process, the project team has reviewed the list of occupancies to determine the dominant restoration element, provided in Table 14.12.

Table 14.12 Flood Restoration Time by Occupancy

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons				Max Total Time	Notes
				Dry-out & Clean up	Insp., permits, Ord., approval	Contr. Avail.	Hazmat Delay		
RES1 (No Base)	0' – 4'		3 to 6	1	2	3		12	
	4' – 8'		6 to 9	1	2	3		15	
	8'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	8'+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
RES1 (W/Base)	(-8') – (-4')		3 to 6	1	2	3		9	No sub-floor repair required
	(-4') – 0'		6 to 9	1	2	3		15	
	0' – 6'		9 to 12	1	2	3		18	
	6'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	6'+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
RES2	0' TO 1'		3 to 6	1	2	3		12	
	1'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	1'+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
RES3 (SM)	0' – 4'		3 to 6	1	2	3		12	Same as RES1
	4' – 8'		6 to 9	1	2	3		15	
	8'+	Outside 100-yr	12	1	2	3		18	
	8'+	Inside 100-yr	18	1	2	3		24	

Table 14.12 Flood Restoration Time by Occupancy (Continued)

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons				Max Total Time	Notes
				Dry-out & Clean up	Insp., permits, Ord., approval	Contr. Avail.	Hazmat Delay		
RES3 (MED) 5-9 & 10-19 units	0' – 4'		5 to 8	1	2	3		14	(RES1*1.2) + 1 Month based on 3-5 units per floor
	4' – 8'		8 to 12	1	2	3		18	
	8' – 12'		12	1	2	3		18	Note: available apt models reach 5-% damage ~ 12'
	12'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12'+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
RES3 (LRG) 20-49 & 50+ units	0' – 4'		5 to 8	1	2	3		14	(RES1*1.2) + 1 Month based on 3-5 units per floor
	4' – 8'		8 to 12	1	2	3		18	(RES1*1.2) + 1 Month based on 3-5 units per floor
	8'+		12	1	2	3		18	Note: available apt models reach 5-% damage ~ 12'
	12'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12'+	Inside 100 yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
RES4	0' – 4'		5 to 8	1	2	3		14	Use RES3 (LRG)
	4' – 8'		8 to 12	1	2	3		18	
	8'+		12	1	2	3		18	
	12'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12'+	Inside 100 yr	18	1	2	3		24	Total loss, subject to buy-out review/political process

Table 14.12 Flood Restoration Time by Occupancy (Continued)

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons				Max Total Time	Notes
				Dry-out & Clean up	Insp., permits, Ord., approval	Contr. Avail.	Hazmat Delay		
RES5 RES6 EDU1 EDU2	0' – 4'		6 to 10	1	2	3		16	Repairs may require less work (fewer partitions & finishes), but have more politics or funding issues. Use RES3 (LRG) but increase 1.2 factor to 1.5
	4' – 8'		10 to 15	1	2	3		21	
	8' – 12'		19	1	2	3		25	
	12'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12'+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
COM1 COM2 COM8 COM9 REL1	0' – 4'		7 to 13	1	2	3		19	Use RES3*2.0 – Longer clean up, but no wood sub-floor, perimeter wall, linoleum. Inventory damaged/destroyed, restoration depends on resupply, damage widespread in inundation area, insurance is a factor.
	4' – 8'		13 to 19	1	2	3		25	
	8'+		25	1	2	3		31	
	12'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12'+	Inside 100 yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
COM3	0' – 4'		3 to 6	1	2	3		12	On average, same as RES1 without a basement.
	4' – 8'		6 to 9	1	2	3		15	
	8'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	8'+	Inside 100 yr	18	1	2	3		24	Total loss, subject to buy-out review/political process

Table 14.12 Flood Restoration Time by Occupancy (Continued)

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons				Max Total Time	Notes
				Dry-out & Clean up	Insp., permits, Ord., approval	Contr. Avail.	Hazmat Delay		
COM4 COM5 COM7 GOV1 GOV2	0’ – 4’		6 to 10	1	2	3		16	Use RES3 (LRG)*1.5 (same as RES5 & RES6)
	4’ – 8’		10 to 15	1	2	3		21	
	8’ – 12’		19	1	2	3		25	
	12’+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12’+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
COM6 (assume w/base)	(-8’) - (-4’)		6	1	2	3		16	Hospitals are highly regulated, have equipment issues. This model represents full repair/restoration, but certain repairs will be prioritized to allow selected operations to begin sooner.
	(-4’) – 0’		12	1	2	3		21	
	0’ – 4’		18	1	2	3		18	
	4’ – 8’		24	1	2	3		24	
COM10	Any > 0’			1				1	Parking lot restoration is not dependent on flood depth, only clean up.
IND1	Any > 0’		1 to 3	1	2		1	7	For heavy industrial, clean up is the primary issue, especially for equipment. Relocation is unlikely. Hazmat is a potential for this occupancy class.
IND2 IND6	Any > 0’		1 to 2	1	2			5	Like heavy industrial except no equipment issues. Totally content issues.
IND3	0’ – 4’		6 to 10	1	2	3	1	17	Like laboratories, perimeter walls. Hazmat a potential issue. Use RES3*1.5 + Hazmat delay. Similar to RES5, RES6, COM4, COM5, COM7.
	4’ – 8’		10 to 15	1	2	3	1	22	
	8’ – 12’		19	1	2	3	1	26	
	12’+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12’+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process

Table 14.12 Flood Restoration Time by Occupancy (Continued)

Occupancy	Depth	Location	Physical Restoration Time (Months)	Add-ons				Max Total Time	Notes
				Dry-out & Clean up	Insp., permits, Ord., approval	Contr. Avail.	Hazmat Delay		
IND4	0' – 4'		6 to 10	1	2	3	2	18	Like IND3, but use a 2-month delay for hazmat.
	4' – 8'		10 to 15	1	2	3	2	27	
	8' – 12'		19	1	2	3	2	26	
	12'+	Outside 100-yr	12	1	2	3		18	Total loss, requires replacement
	12'+	Inside 100-yr	18	1	2	3		24	Total loss, subject to buy-out review/political process
IND5	0' – 4'		7 to 13	1	2	3	2	21	Use RES3*2 + 2-month Hazmat delay. (Similar to COM1, COM2, COM8, COM9.
	4' – 8'		13 to 19	1	2	3	2	27	
	8' – 12'		25	1	2	3	2	33	
	12'+	Outside 100-yr	12	1	2	3	2	20	Total loss, requires replacement
	12'+	Inside 100-yr	18	1	2	3	2	26	Total loss, subject to buy-out review/political process
AGR1	Any > 0'		1 to 2	1	2		2	7	Like IND2 with 2-month hazmat delay,

Table 14.13 Elements Dominating Building and Service Interruption for Floods

Label	Occupancy Class	Element Dominating Restoration
	Residential	
RES1	Single Family Dwelling	Building (+ Utilities)
RES2	Mobile Home	Building (+ Utilities)
RES3	Multi Family Dwelling	Building (+ Utilities)
RES4	Temporary Lodging	Building (+ Utilities)
RES5	Institutional Dormitory	Building (+ Utilities)
RES6	Nursing Home	Building (+ Utilities)
	Commercial	
COM1	Retail Trade	Inventory
COM2	Wholesale Trade	Inventory
COM3	Personal and Repair Services	Inventory/Equipment
COM4	Professional/Technical/ Business Services	Building (+ Utilities)
COM5	Banks/Financial Institutions	Building (+ Utilities)
COM6	Hospital	Building (+ Utilities)/Equipment
COM7	Medical Office/Clinic	Building (+ Utilities)
COM8	Entertainment & Recreation	Building (+ Utilities)/Contents
COM9	Theaters	Building (+ Utilities)/Contents
COM10	Parking	-----
	Industrial	
IND1	Heavy	Equipment
IND2	Light	Inventory
IND3	Food/Drugs/Chemicals	Inventory/Equipment
IND4	Metals/Minerals Processing	Equipment
IND5	High Technology	Inventory/Equipment
IND6	Construction	Building (+ Utilities)
	Agriculture	
AGR1	Agriculture	Inventory/Equipment
	Religion/Non-Profit	
REL1	Church/Membership Organization	Building (+ Utilities)
	Government	
GOV1	General Services	Building (+ Utilities)
GOV2	Emergency Response	Building (+ Utilities)
	Education	
EDU1	Schools/Libraries	Building (+ Utilities)
EDU2	Colleges/Universities	Building (+ Utilities)

Table 15.10: Building Recovery Time (Time in Days)

No.	Label	Occupancy Class	Recovery Time				
			Structural Damage State				
			None	Slight	Moderate	Extensive	Complete
		Residential					
1	RES1	Single Family Dwelling	0	5	120	360	720
2	RES2	Mobile Home	0	5	20	120	240
3-8	RES3a-f	Multi Family Dwelling	0	10	120	480	960
9	RES4	Temporary Lodging	0	10	90	360	480
10	RES5	Institutional Dormitory	0	10	90	360	480
11	RES6	Nursing Home	0	10	120	480	960
		Commercial					
12	COM1	Retail Trade	0	10	90	270	360
13	COM2	Wholesale Trade	0	10	90	270	360
14	COM3	Personal and Repair Services	0	10	90	270	360
15	COM4	Professional/Technical/ Business Services	0	20	90	360	480
16	COM5	Banks/Financial Institutions	0	20	90	180	360
17	COM6	Hospital	0	20	135	540	720
18	COM7	Medical Office/Clinic	0	20	135	270	540
19	COM8	Entertainment & Recreation	0	20	90	180	360
20	COM9	Theaters	0	20	90	180	360
21	COM10	Parking	0	5	60	180	360
		Industrial					
22	IND1	Heavy	0	10	90	240	360
23	IND2	Light	0	10	90	240	360
24	IND3	Food/Drugs/Chemicals	0	10	90	240	360
25	IND4	Metals/Minerals Processing	0	10	90	240	360
26	IND5	High Technology	0	20	135	360	540
27	IND6	Construction	0	10	60	160	320
		Agriculture					
28	AGR1	Agriculture	0	2	20	60	120
		Religion/Non-Profit					
29	REL1	Church/Membership Organization	0	5	120	480	960
		Government					
30	GOV1	General Services	0	10	90	360	480
31	GOV2	Emergency Response	0	10	60	270	360
		Education					
32	EDU1	Schools/Libraries	0	10	90	360	480
33	EDU2	Colleges/Universities	0	10	120	480	960

Repair times differ for similar damage states depending on building occupancy: thus simpler and smaller buildings will take less time to repair than more complex, heavily serviced or larger buildings. It has also been noted that large well-financed corporations can sometimes accelerate the repair time compared to normal construction procedures.

However, establishment of a more realistic repair time does not translate directly into business or service interruption. For some businesses, building repair time is largely irrelevant, because these businesses can rent alternative space or use spare industrial/commercial capacity elsewhere. These factors are reflected in Table 15.11, which provides multipliers to be applied to the values in Table 15.10 to arrive at estimates of business interruption for economic purposes. The factors in Tables 15.9, 15.10, and 15.11 are judgmentally derived, using ATC-13, Table 9.11 as a starting point.

The times resulting from the application of the Table 15.11 multipliers to the times shown in Table 15.10 represent median values for the probability of business or service interruption. For none and slight damage the time loss is assumed to be short, with cleanup by staff, but work can resume while slight repairs are done. For most commercial and industrial businesses that suffer moderate or extensive damage, the business interruption time is shown as short on the assumption that these concerns will find alternate ways of continuing their activities. The values in Table15.11 also reflect the fact that a proportion of business will suffer longer outages or even fail completely. Church and Membership Organizations generally quickly find temporary accommodation, and government offices also resume operating almost at once. It is assumed that hospitals and medical offices can continue operating, perhaps with some temporary rearrangement and departmental relocation if necessary, after moderate damage, but with extensive damage their loss of function time is also assumed to be equal to the total time for repair.

For other businesses and facilities, the interruption time is assumed to be equal to, or approaching, the total time for repair. This applies to residential, entertainment, theaters, parking, and religious facilities whose revenue or continued service, is dependent on the existence and continued operation of the facility.

The modifiers from Table 15.11 are multiplied by extended building construction times as follows:

$$LOF_{ds} = BCT_{ds} * MOD_{ds} \tag{15-13}$$

where:

LOF_{ds}	loss of function for damage state ds
BCT_{ds}	building construction and clean up time for damage state ds (See Table 15.10)
MOD_{ds}	construction time modifiers for damage state ds (See Table 15.11)

The median value applies to a large inventory of facilities. Thus, at moderate damage, some marginal businesses may close, while others will open after a day's cleanup. Even with extensive damage, some businesses will accelerate repair, while a number will also close or be demolished. For example, one might reasonably assume that a URM building that suffers moderate damage is more likely to be demolished than a newer building that suffers moderate, or even, extensive damage. If the URM building is an historic structure its likelihood of survival and repair will probably increase. There will also be a small number of extreme cases: the slightly damaged building that becomes derelict, or the extensively damaged building that continues to function for years, with temporary shoring, until an expensive repair is financed and executed.

Table 15.11: Building and Service Interruption Time Multipliers

No.	Label	Occupancy Class	Construction Time				
			Structural Damage State				
			None	Slight	Moderate	Extensive	Complete
		Residential					
1	RES1	Single Family Dwelling	0	0	0.5	1.0	1.0
2	RES2	Mobile Home	0	0	0.5	1.0	1.0
3-8	RES3a-f	Multi Family Dwelling	0	0	0.5	1.0	1.0
9	RES4	Temporary Lodging	0	0	0.5	1.0	1.0
10	RES5	Institutional Dormitory	0	0	0.5	1.0	1.0
11	RES6	Nursing Home	0	0	0.5	1.0	1.0
		Commercial					
12	COM1	Retail Trade	0.5	0.1	0.1	0.3	0.4
13	COM2	Wholesale Trade	0.5	0.1	0.2	0.3	0.4
14	COM3	Personal and Repair Services	0.5	0.1	0.2	0.3	0.4
15	COM4	Professional/Technical/ Business Services	0.5	0.1	0.1	0.2	0.3
16	COM5	Banks/Financial Institutions	0.5	0.1	0.05	0.03	0.03
17	COM6	Hospital	0.5	0.1	0.5	0.5	0.5
18	COM7	Medical Office/Clinic	0.5	0.1	0.5	0.5	0.5
19	COM8	Entertainment & Recreation	0.5	0.1	1.0	1.0	1.0
20	COM9	Theaters	0.5	0.1	1.0	1.0	1.0
21	COM10	Parking	0.1	0.1	1.0	1.0	1.0
		Industrial					
22	IND1	Heavy	0.5	0.5	1.0	1.0	1.0
23	IND2	Light	0.5	0.1	0.2	0.3	0.4
24	IND3	Food/Drugs/Chemicals	0.5	0.2	0.2	0.3	0.4
25	IND4	Metals/Minerals Processing	0.5	0.2	0.2	0.3	0.4
26	IND5	High Technology	0.5	0.2	0.2	0.3	0.4
27	IND6	Construction	0.5	0.1	0.2	0.3	0.4
		Agriculture					
28	AGR1	Agriculture	0	0	0.05	0.1	0.2
		Religion/Non-Profit					
29	REL1	Church/Membership Organization	1	0.2	0.05	0.03	0.03
		Government					
30	GOV1	General Services	0.5	0.1	0.02	0.03	0.03
31	GOV2	Emergency Response	0.5	0.1	0.02	0.03	0.03
		Education					
32	EDU1	Schools/Libraries	0.5	0.1	0.02	0.05	0.05
33	EDU2	Colleges/Universities	0.5	0.1	0.02	0.03	0.03

15.2.5 Relocation Expenses

Relocation costs may be incurred when the level of building damage is such that the building or portions of the building are unusable while repairs are being made. While relocation costs may include a number of expenses, in this model, only the following

Fannie Mae Estimated Useful Life Tables

INSTRUCTIONS FOR PERFORMING A
MULTIFAMILY PROPERTY CONDITION ASSESSMENT
(Version 2.0)

APPENDIX F

ESTIMATED USEFUL LIFE TABLES

These Estimated Useful Life Tables for multifamily property systems and components are intended to represent standardized average estimated useful life ("EUL") values and are not intended to replace the professional judgment of the PCA Consultant in determining the Effective Age and Remaining Useful Life of the systems and components at the Property. The PCA Consultant should consider preventive maintenance practices, as well as environment, geographic, resident, and other factors when determining Effective Age and Remaining Useful Life of the systems and components of a multifamily Property. In addition to providing guidance on EUL values typically considered capital expenditure items, the EUL tables may include items that are typically considered general maintenance and repair items to be handled by in-house maintenance staff.

Estimated Useful Life (EUL) Tables

FLATWORK, PARKING AREAS AND WALKWAYS	Multifamily / Coop	Seniors	Students
Asphalt pavement	25	25	25
Asphalt seal coat	5	5	5
Concrete pavement	50	50	50
Curbing, asphalt	25	25	25
Curbing, concrete	50	50	50
Parking, stall striping	5	5	5
Parking, gravel surfaced	15	15	15
Security gate (site ingress/egress) - rolling gate / lift arm	10	10	10
Sidewalk, asphalt	25	25	25
Sidewalk, brick paver	30	30	30
Sidewalk, concrete	50	50	50

SITE LIGHTING	Multifamily / Coop	Seniors	Student
Building mounted exterior lighting	10	10	10
Building mounted High Intensity Discharge (HID) lighting	10	20	10
Lighting (pole mounted)	25	25	25

SITE FENCING AND RETAINING WALLS	Multifamily / Coop	Seniors	Students
Bulkhead (barrier) / partition wall /embankment	10	20	10
Fencing, chain-link (4' height)	40	40	40
Fencing, concrete masonry unit (CMU)	30	30	30
Fencing, dumpster enclosure (wood)	12	15	10
Fencing, PVC (6' height)	25	25	25
Fencing, Tennis Court (10' height)-Chain link	40	40	40
Fencing, wood privacy (6' height)	15	20	10
Fencing, wrought iron (4-6' height and decorative)	50	50	50
Retaining walls, 80 lb block type	50	50	50
Retaining walls, concrete masonry unit (CMU) with brick face	40	40	40
Retaining walls, timber (railroad tie)	25	25	25

STRUCTURAL FRAME AND BUILDING ENVELOPE			
BUILDING STRUCTURES	**Multifamily / Coop**	**Seniors**	**Students**
Carports	40	40	40
Canopy, concrete	50	50	50
Canopy, wood / metal	40	40	40
Garages	50	50	50
Storage Sheds	30	30	30
Penthouse (mechanical room)	50	50	50

FOUNDATIONS	Multifamily / Coop	Seniors	Students
Foundations	50+	50+	50+
Waterproofing (foundations)	50+	50+	50+

FRAMING	Multifamily / Coop	Seniors	Students
Brick or block	40	40	40
Precast concrete panel (tilt-up)	40	40	40
Wood floor frame	50+	50+	50+

BUILDING ENVELOPE / CLADDING / EXTERIOR WALL FINISHES	**Multifamily / Coop**	**Seniors**	**Students**
Aluminum Siding	40	40	40
Brownstone	40	40	40
Brick or Stone Veneer	50+	50+	50+
Cement-board siding (Hardi-plank)/ Cementitious (mfgr) siding	45	45	45
Exterior Insulation Finishing Systems (EIFS)	20	20	20
Glass block	40	40	40
Granite block	40	40	40
Insulation, wall	50+	50+	50+
Metal/ glass curtain wall	30	30	30
Painting, Exterior	5-10	5-10	5-10
Pre-cast concrete panel	45	45	45
Stucco systems	50+	50+	50+
Vinyl siding	25	25	25
Wood shingle/ clapboard/ plywood, stucco, composite wood	20	20	20

ROOF SYSTEMS	**Multifamily / Coop**	**Seniors**	**Students**
Asphalt shingle (3-tab)	20	20	20
Built-up roof - Ethylene Propylene Diene Monomer (EPDM) / Thermoplastic Polyolefin (TPO)	20	20	20
Metal	40	40	40
Parapet wall	50+	50+	50+
Caps, copings (aluminum/ terra-cotta) - Parapet	25	25	25
Roof drainage exterior (gutter/ downspout)	10	10	10
Roof drainage interior (drain covers)	30	30	30
Roof railing	25	25	25
Roof structure	50+	50+	50+
Roof hatch	30	30	30
Roof skylight	30	30	30
Slab	50+	50+	50+
Slate, clay, concrete tile	40	40	40
Soffits (wood/ stucco)	20	20	20
Soffits (aluminum or vinyl)	25	25	25
Wood shingles (cedar shake)	25	25	25

DOORS AND WINDOWS	Multifamily / Coop	Seniors	Students
Exterior common door, aluminum and glass	30	30	30
Exterior common door, solid core wood or metal clad	25	25	25
Exterior unit door, solid wood/ metal clad	25	30	20
Residential Sliding Glass Doors	25	30	20
Residential French Glass Doors	25	30	20
Ceilings, open or exterior	30	30	30
Service door (roof)	25	30	20
Storm/ screen doors	7	10	5
Storm/ screen windows	10	15	7
Windows (frames and glazing), vinyl or aluminum	30	30	30

APPURTENANCES:	Multifamily / Coop	Seniors	Students
Chimney	40	40	40
Exterior stairs, wood	15	20	15
Exterior stairs, metal pan- concrete filled	30	30	30
Exterior stairs, concrete	50	50	50
Fire Escapes	40	40	40
Porches, concrete	50	50	50
Wood Decks	20	20	20

AMENITIES	Multifamily / Coop	Senior	Student
Basketball court	25	25	25
Mail kiosk	10	15	10
Mail facility, interior	20	25	20
Pool deck	15	15	15
Pool/ spa plaster liner	8	8	8
Tennis court / basketball court surface (paint markings)	5	7	5
Tennis court Surface (acrylic emulsion)	10	12	10
Tot-lot (playground equipment)	10	15	10
Tot-lot, uncompressed ground cover	2+	3+	2+

MECHANICAL/ELECTRIC/ PLUMBING SYSTEMS

WATER DISTRIBUTION AND DOMESTIC HOT WATER SYSTEMS	Multifamily / Coop	Seniors	Students
Feedwater only (hydronic)	10	10	10
Condensate and feedwater (steam)	Included in boiler	Included in boiler	Included in boiler
Cooling Tower	25	25	25
DHW Circulating Pumps	by size	by size	by size
Domestic Hot Water (DHW) - supply / return	30	30	30
Tank only, dedicated fuel	10	10	10
Exchanger in storage tank	15	15	15
Exchanger in boiler	15	15	15
External tankless	15	15	15
Instantaneous (tankless type)	10	10	10
Domestic Hot Water Storage Tanks, Small (up to 150 gallons)	15	15	15
Domestic Hot Water Storage Tanks, Large (over 150 gallons)	15	15	15
Domestic Cold Water Pumps	15	15	15
Heating Water Circulating Pumps	by size	by size	by size
Heating Water Controller	15	15	15
Hot and Cold Water Distribution	50	50	50
Solar Hot Water	20	20	20
Water Softening and Filtration	15	15	15

SANITARY WASTE AND VENT	Multifamily / Coop	Seniors	Students
Purchased Steam Supply Station	50+	50+	50+
Sanitary Waste and Vent System	50+	50+	50+
Sewage Ejectors	50	50	50

SUMP PUMP	Multifamily / Coop	Seniors	Students
Residential Sump Pump	7	7	7
Commercial Sump Pump	15	15	15

HEATING/COOLING SYSTEM AND CONTROLS	Multifamily / Coop	Senior	Student
Pad/ roof condenser	20	20	20
A/C window unit or through wall	10	10	10
Evaporative Cooler	15	15	15
Fan coil unit, electric	20	20	20
Fan coil unit, hydronic	30	30	30
Furnace (electric heat with A/C)	20	20	20
Furnace (electric heat with A/C)	20	20	20
Furnace (gas heat with A/C)	20	20	20
Packaged terminal air conditioner (PTAC)	15	15	15
Packaged HVAC (roof top units)	20	20	20
Heat pump condensing component	20	20	20
Heater, electric baseboard	25	25	25
Heater, wall mounted electric or gas	20	20	20
Hydronic heat/ electric A/C	20	20	20
Line Dryers	15	15	15
Master TV System	10	10	10
Motorized Valves	12	12	12
Outdoor Temperature Sensor	10	10	10
Pneumatic lines and Controls	30	30	30

BUILDING HEATING WATER TEMPERATURE CONTROLS	Multifamily / Coop	Seniors	Students
Chilled Water Distribution	50+	50+	50+
Chilling Plant	15	15	15
Cooling Tower	25	25	25
Fuel Oil Storage	25	25	25
Fuel Transfer System	25	25	25
Gas Distribution	50+	50+	50+
Heat Sensors	15	15	15
Heat Exchanger	35	35	35
Heating Risers and Distribution	50+	50+	50+

VENTILATION SYSTEMS	Multifamily / Coop	Seniors	Students
Combustion Air, Duct with fixed louvers	30	30	30
Combustion Air, Motor louver and duct	25	25	25
Flue Exhaust	w/boiler	w/boiler	w/boiler
Free Standing Chimney	50+	50+	50+

ELECTRICAL SYSTEMS	Multifamily / Coop	Seniors	Students
Common area	15	15	15
Buzzer/Intercom, central panel	20	20	20
Central Unit Exhaust, roof mounted	15	15	15
Compactors	15	15	15
Dumpsters	10	10	10
Electrical distribution center	40	40	40
Electric main	40	40	40
Emergency Generator	25	25	25
Gas lines	40	40	40
Gas main	40	40	40
Heating supply/ return	40	40	40
Power distribution	40	40	40
Transformer	30	30	30

BOILER ROOM EQUIPMENT	**Multifamily / Coop**	**Seniors**	**Students**
Blowdown and Water Treatment	25	25	25
Boiler Room Pipe Insulation	Included in boiler	Included in boiler	Included in boiler
Boiler Room Piping	Included in boiler	Included in boiler	Included in boiler
Boiler Room Valves	15	15	15
Boiler Temperature Controls	Included in boiler	Included in boiler	Included in boiler

VERTICAL TRANSPORTATION - ELEVATORS	**Multifamily / Coop**	**Senior**	**Student**
Electrical Switchgear	50+	50+	50+
Electrical Wiring	30	30	30
Elevator, Controller, dispatcher	15	20	10
Elevator, Cab	15	20	10
Elevator, Machinery	30	30	30
Elevator, Shaft-way Doors	20	20	20
Elevator, Shaft-way Hoist rails, cables, traveling	25	25	25
Elevator, Shaft-way Hydraulic piston and leveling	25	25	25
BOILERS	**Multifamily / Coop**	**Seniors**	**Students**
Oil-fired, sectional	22	22	22
Gas/ dual fuel, sectional	25	25	25
Oil/ gas/ dual fired, low MBH	30	30	30
Oil/ gas/ dual fired, high MBH	40	40	40
Gas fired atmospheric	25	25	25
Electric	20	20	20

FIRE SAFETY AND FIRE PROTECTION SYSTEMS	Multifamily / Coop	Senior	Student
Call station	10	15	10
Emergency Generator	25	25	25
Emergency Lights	8	10	5
Fire Extinguisher	10	15	5
Fire Pumps	20	20	20
Fire Suppression	50+	50+	50+
Smoke and Fire Detection System, central panel	15	15	15

INTERIOR ELEMENTS (COMMON AREA / DWELLING UNIT)			
INTERIOR / COMMON AREA FINISHES	**Multifamily / Coop**	**Seniors**	**Students**
Common area doors, interior (solid wood/ metal clad)	20	20	20
Common area floors, ceramic / quarry tile, terrazzo	50+	50+	50+
Common area floors, wood (strip or parquet)	30	30	30
Common area floors, resilient tile or sheet	15	15	15
Common area floors, carpet	5	5	5
Common area floors, concrete	50+	50+	50+
Common area railing	20	20	20
Common area ceiling, concrete	50+	50+	50+
Common area ceiling, acoustic tile (drop ceiling), drywall / plaster	10	10	10
Common area countertop and sink	20	20	20
Common area, refrigerator	10	10	10
Common area dishwasher	15	15	10
Common area disposal	5	7	3
Common area kitchen cabinets, wood	15	20	10
Common area walls	15	25	10
Interior railings	20	25	15
Interior lighting	15	20	10
Public bathroom accessories	7	12	5
Public bathroom fixtures	15	20	10

DWELLING FIRE, SAFETY AND SECURITY	Multifamily / Coop	Seniors	Students
Unit Smoke/Fire Detectors *	5	5	5
Unit Carbon Monoxide Detectors *	5	5	5
Unit Buzzer/Intercom	20	20	20

*Tested annually, batteries changed annually.

DWELLING UNIT CEILINGS	Multifamily / Coop	Seniors	Students
Concrete	50+	50+	50+
Acoustic Tile / Drywall / Plaster	10	15	10

DWELLING UNIT FIXTURES	Multifamily / Coop	Senior	Student
Bathroom: Vanity	10	15	10
Bathroom: Fixtures / Faucets	15-20	20+	15-20
Bathroom: Fiberglass Bath / Shower	20	25	18
Bathroom: Toilet	50+	50+	40
Bathroom: Toilet Tank Components	5	5	5
Bathroom: Vent / Exhaust	10	10	10
Interior Doors	15	30	10
Kitchen: Cabinets (wood construction)	20	25	15
Kitchen: Cabinets (particle board)	15	20+	13
Kitchen: Dishwasher	5-10	10-12	5-8
Kitchen: Microwave	10	12	8
Kitchen: Range	15	25	15
Kitchen: Range-hood	10	20	10
Kitchen: Refrigerator	10	20	10
Window covering	3	5	1+

DWELLING UNIT FLOORS	Multifamily / Coop	Senior	Student
Ceramic / Tile / Terrazzo	20	25	20
Wood (strip/ parquet)	15	20	20
Resilient Flooring	10	15	7
Carpet	7	10	3+
Concrete	50+	50+	50+

DWELLING UNIT HVAC AND MECHANICAL EQUIPMENT	Multifamily / Coop	Senior	Student
A/C window unit or through wall	10	10	10
Evaporative cooler	15	15	15
Fan coil unit, electric	20	20	20
Fan coil unit, hydronic	30	30	30
Furnace (electric heat with A/C)	20	20	20
Furnace (gas heat with A/C)	20	20	20
Packaged terminal air conditioner (PTAC)	15	15	15
Packaged HVAC (roof top unit)	15	15	15
Heat pump condensing component	15	15	15
Heater, electric baseboard	25	25	25
Heater, wall mounted electric or gas	20	20	20
Hydronic heat/ electric AC	20	20	20
Unit Electric Panel	50+	50+	50+
Unit Level Boiler	25	25	25
Unit Level Domestic Hot Water	10	15	10
Unit Level Hot Air Furnace	25	25	25
Unit Radiation - Steam/ Hydronic (baseboard or freestanding)	30	30	30
Unit Wiring	30	30	30